ANSI/AHRI Standard 1330-2024 (SI)

Performance Rating for Radiant Output of Gas Fired Infrared Heaters

Approved American National Standard
ANSI

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IMPORTANT

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ICS Code: 97.100

Note:

This standard supersedes ANSI/AHRI 1330-2015 (SI).

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors, and users.

Review and Amendment

This standard is subject to review and amendment as technology advances.

2024 Edition

This edition of ANSI/AHRI Standard 1330 (SI), *Performance Rating for Radiant Output of Gas Fired Infrared Heaters*, was prepared by the AHRI 1330 Standard Work Group and the Infrared Heaters Standards Technical Committee. The standard was approved by the Heating Standards Subcommittee on 4 March 2024. This standard was approved as an American National Standard (ANS) on 3 April 2024.

Origin and Development of ANSI/AHRI Standard 1330

In 2011, the Infrared Product Section identified the need for a North American standard for both high and low intensity infrared heaters by adopting Method B of the European standards and developed the first edition that was published in 2015. This is the first revision.

Summary of Changes

ANSI/AHRI Standard 1330-2024 (SI) contains the following updates to the previous edition:

- Added gas-fired multi-burner continuous low intensity radiant tube heaters to the scope
- Use a radiant emission value (REV) instead of an infrared factor
- Updated radiometer equipment and calibration requirements.
- Added references to updated European standards

Committee Personnel

AHRI 1330 Standard Work Group

Company/Organization	Participant	Voting Role
Voting Organizations		
Gas-Fired Products	Martin Brice, Chair	Primary
	Stephan Richter	Alternate
Canadian Standards Association	Judd Smith	Primary
	Doug Bennett	Alternate
Heating, Refrigeration and Air Conditioning Institute of Canada	Pedro Cerna	Primary
	Robert Storey	Alternate
Infrared Dynamics	Robert Cowan	Primary
Intertek	Alex Ussery	Primary
Superior Radiant	George File	Primary
	Kevin Merritt	Alternate
Nonvoting Organizations		
Detroit Radiant Products Company/Brant Radiant	Sarah Pyne	Nonvoter
	Joeseph Wortman	Nonvoter
Infrared Dynamics	Robert Cowan	Nonvoter
Intertek	Alex Ussery	Nonvoter
Modine Manufacturing Company	Jaek Pachniak	Nonvoter
Nortek Global HVAC, LLC	Dan Wild	Nonvoter
	Matt Lattanzi	Nonvoter
Roberts-Gordon, LLC	Mark Murdoch	Nonvoter
	Cyrus Eftekharinia	Nonvoter
Solaronics, Inc.	Tom Martelle	Nonvoter
	Nick Henderson	Nonvoter
Superior Radiant	George File	Nonvoter
	Kevin Merritt	Nonvoter
Panos Fykas		AHRI Staff Liaison

AHRI 1330 Standard Work Group Scope:

The Infrared Heater SWG is responsible for the development and maintenance of ANSI/AHRI 1330 (SI).

Out of scope for this SWG is any product which does not use infrared technology to directly heat conditioned space.

Infrared Heaters Standards Technical Committee

Company/Organization	Participant	Voting Role
Voting Organizations		
Gas-Fired Products	Martin Brice, Chair	Primary
	Stephan Richter	Alternate
Canadian Standards Association	Judd Smith	Primary
	Doug Bennett	Alternate
Detroit Radiant Products Company/Brant Radiant	Sarah Pyne	Primary
	Joeseph Wortman	Alternate
Heating, Refrigeration and Air Conditioning Institute of Canada	Pedro Cerna	Primary
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Infrared Dynamics	Robert Cowan	Primary
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Nortek Global HVAC, LLC	Dan Wild	Primary
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Solaronics, Inc.	Tom Martelle	Primary
	Nick Henderson	Alternate
Superior Radiant	George File	Primary
	Kevin Merritt	Alternate
Panos Fykas		AHRI Staff Liaison

Infrared Heaters Standards Technical Committee Scope:

This committee shall have responsibility for the development and maintenance of AHRI standards and guidelines pertaining to infrared heater products.

Out of scope for this Standards Technical Committee is any product which does not use infrared technology to directly heat conditioned space.

Heating Standards Subcommittee

Company/Organization	Participant	Voting Role
Voting Organizations		
Daikin Comfort Technologies Manufacturing	Robert Glass, Chair	Primary
Rheem	Jason Hall, Vice Chair	Primary
Bradford White	Bryan Ahee	Primary
Gas-Fired Products	Martin Brice	Primary
Lochinvar LLC	Jeff Kleiss	Primary
Mestek, Inc.	Tom Neill	Primary
Crown Boiler Co. LLC	Paul Sohler	Primary
Karl Best		AHRI Staff Liaison

Heating Standards Subcommittee Scope:

The scope of the Heating Standards Subcommittee is standards and guidelines related to the end products that are part of the AHRI Heating Industry Sector. (The definition of and list of products associated with each sector are found at https://ahrinet.org/about-us/ahri-industry-sectors.)

These lists represent the membership at the time the Standards Work Group, Standards Technical Committee, and Standards Subcommittee were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. Membership on these committees shall not in and of itself constitute an endorsement by the committee members or their employers of any document developed by the committee on which the member serves.

Heating Standards Consensus Body

Participant	Company / Organization	Interest Category Classification
Ronald Balneg	California Energy Commission	Regulatory Agency
Philip Cantin	mmic Medical Systems	Consumer/User
Paul Haydock	Carrier Corporation	Product Manufacturer
Caroline Henley	UL Solutions	Testing Laboratory
Jim Kendzel	American Supply Association	General Interest
Stephen Kowalski	Oak Ridge National Laboratory	Testing Laboratory
Jered Ledford	Olson Plumbing and Heating	Consumer/User
Timothy Matthews	Lee Company	General Interest
Reza Mossavi	Viessmann Manufacturing Company (U.S.) INC.	Product Manufacturer
Aniruddh Roy	Energy Solutions	General Interest

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PERFORMANCE RATING STANDARD FOR RADIANT OUTPUT OF GAS FIRED INFRARED HEATERS

Section 1. Purpose

This standard establishes definitions, test requirements, rating requirements, nomenclature, minimum data requirements for *published ratings*, marking and nameplate data, and conformance conditions for i*nfrared heaters*.

Section 2. Scope

This standard applies to *infrared heaters* that are gas-fired *high-intensity infrared heaters*, gas-fired *low-intensity infrared heaters*, and gas-fired multi-burner continuous *low intensity* radiant tube heaters with inputs up to and including 117.5 kW per burner intended for installation and heating of outdoor or indoor spaces.

This standard does not apply to heaters that do not radiate their energy into a single *measuring plane*.

Note: 117.5 kW (400,000 Btu/hr).

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 Expression of Provisions

Terms that provide clear distinctions between requirements, recommendations, permissions, options, and capabilities.

3.1.1 "Can" or "cannot"

Express an option or capability.

3.1.2 "May"

Signifies a permission expressed by the document.

3.1.3 "Must"

Indication of unavoidable situations and does not mean that an external constraint referred to is a requirement of the document.

3.1.4 "Shall" or "shall not"

Indication of mandatory requirements to strictly conform to the standard and where deviation is not permitted.

3.1.5 "Should" or "should not"

Indication of recommendations rather than requirements. In the negative form, a recommendation is the expression of potential choices or courses of action that is not preferred but not prohibited.

3.2 Standard Specific Definitions

3.2.1 Calibration Factor

The results of the calibration provided by an ISO 17025 accredited testing/calibration laboratory consisting of a constant (a) and offset (b).

3.2.2 Gross Radiant Coefficient (GRC)

Heat emitted by the appliance through the *radiation reference plane* divided by the gross heat input of the test gas.

3.2.3 Infrared Heater

A heater that directs the energy output in the form of infrared energy into the area to be heated. Such heaters can be of the vented or unvented type.

3.2.3.1 High-intensity Infrared Heater

An *infrared heater* that has a radiating surface that operates at or above 750°C. This is referred to as a gas-fired overhead luminous radiant heater in the references to European standards.

3.2.3.2 Low-intensity Infrared Radiant Tube Heater

An *infrared heater* that has a radiating surface that operates at temperatures less than 750°C.

3.2.3.2.1 Unitary Infrared Tube Heater

A *low-intensity infrared heater* where combustion takes place within a tube or conduit consisting of a single combustion air blower, flame monitor, and control.

3.2.3.2.2 Multi-Burner Continuous Infrared Tube Heater System

An *infrared heating system* that employs one or more burners, in series or parallel branches, or both, and is connected to a common exhaust.

3.2.4 Multi-burner Branch

A *low intensity* multi-burner continuous radiant tube heater that employs one or more burner segments that only contains the product of combustion generated by this or these segments.

3.2.5 Multi-burner Segment

An individual burner and one or more heat exchanger tubes.

3.2.6 Burner

An individual burner unit incorporating independent flame control and monitoring.

3.2.7 Measuring Cell

The area contained by four adjacent *nodal points* of a *measuring grid*.

3.2.7.1 Measuring Plane

A plane parallel and below the *radiation reference plane*.

3.2.7.2 Measuring Grid

Regular arrangement in the *measuring plane* of straight lines running parallel and perpendicular to the longitudinal axis of the appliance. See Figure 1.

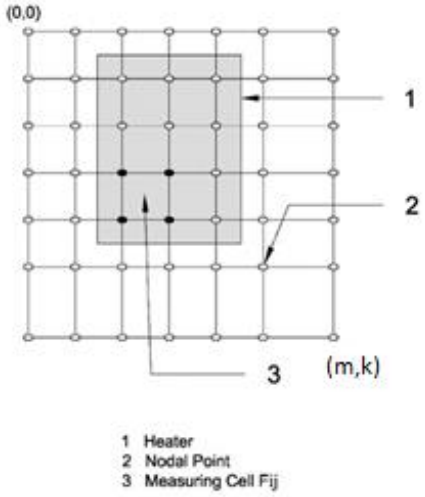


Figure 1 Measuring Grid

3.2.8 Minimum Angle

The minimum installation angle specified by the manufacturer measured from the horizontal plane.

3.2.9 Nodal Point/Node

The intersection of the perpendicular and parallel grid lines on the *measuring plane* where an individual measurement is recorded. Four adjacent *nodal points* confine a *measuring cell*.

3.2.10 Published Rating

A statement of the assigned values of those performance characteristics, under stated *rating conditions*, where a unit can be chosen to fit the application. These values apply to all units of the same nominal size and type (identification) produced by the same manufacturer. This includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated *rating conditions*.

3.2.10.1 Application Rating

A rating based on tests performed at rating conditions other than *standard rating conditions*.

3.2.10.2 Standard Rating

A rating based on tests performed at *standard rating conditions*.

3.2.11 Radiation Reference Plane

Flat surface bounded by the lower edge of the reflector or, in the case where radiant parts project below this lower edge of the reflector, the flat surface touching the lowest radiant part (refer to Figure 2).

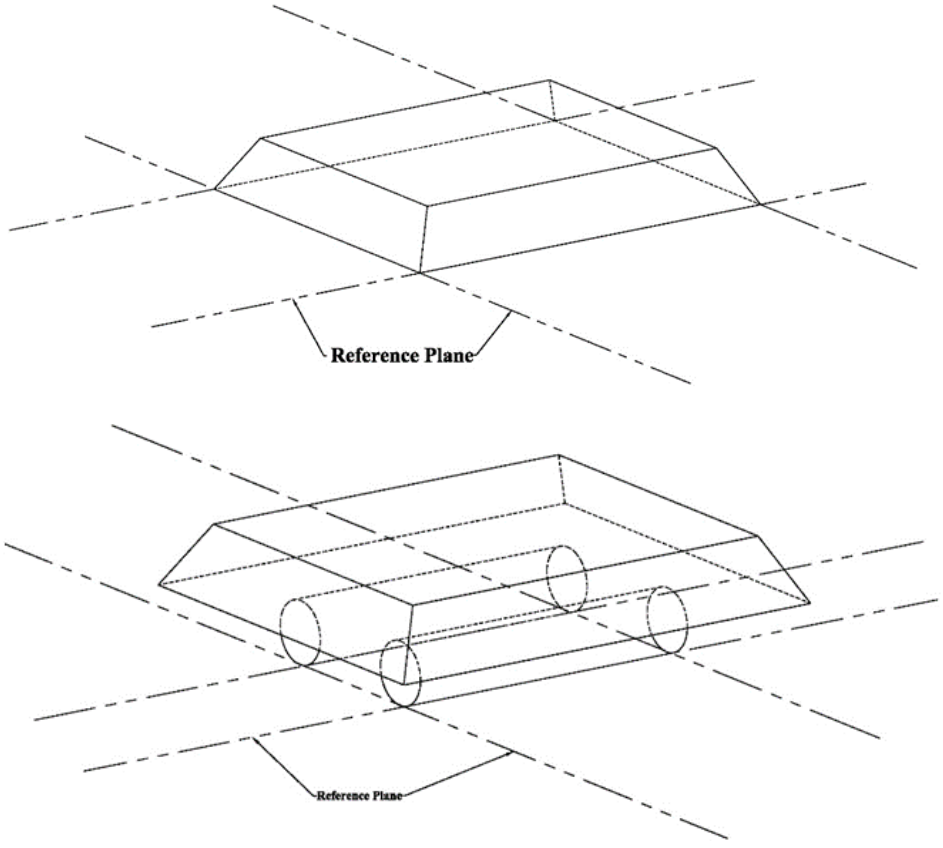


Figure 2 Radiation Reference Plane

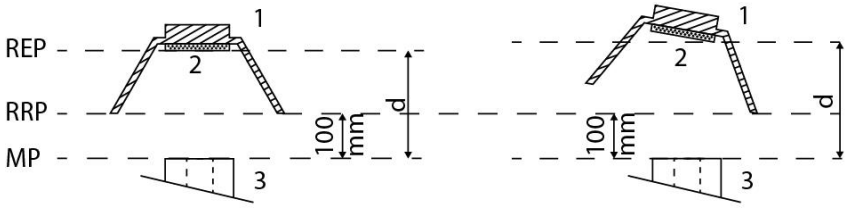
3.2.12 Radiation Emitter Plane

3.2.12.1 High Intensity Emitter Plane

Flat horizontal surface defined by the lower edge of the radiant surface of the burner of the radiant heater. See Figure 3.

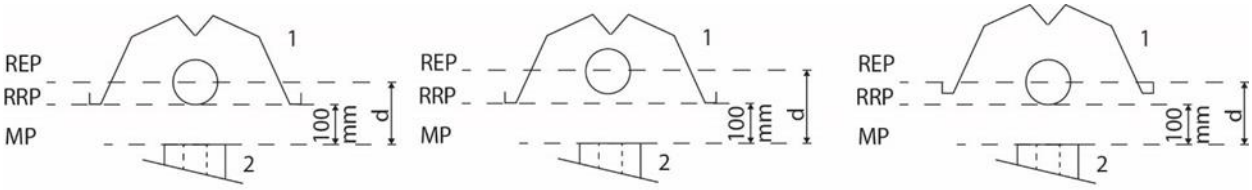
3.2.12.2 Low Intensity Emitter Plane

Flat horizontal plane defined by the axis of the radiant tubes of the tube heater. See Figure 4.



Key: 1 - Heater, 2 - Infrared Emitter, 3 - Radiometer, REP - Radiant Emitter Plane, RRP - Radiant Reference Plane, MP - Measuring Plane

Figure 3 High Intensity Radiation Emitter Plane



Key: 1 - Heater, 2 - Radiometer, REP - Radiant Emitter Plane, RRP - Radiant Reference Plane, MP - Measuring Plane

Figure 4 Low Intensity Radiation Emitter Plane

3.2.13 Rating Conditions

Any set of operating conditions where a single level of performance results and causes only that level of performance to occur.

3.2.13.1 Standard Rating Condition

Rating conditions used as the basis of comparison for performance characteristics.

Section 4. Classifications

Published ratings shall be verified by tests conducted in accordance with the test method described in Appendix C and in accordance with the rating requirements of Section 5.

Section 5. Test Requirements

5.1 Rating Requirements

The radiant emission value (REV) shall be published to one decimal place.

5.2 Standard Ratings

Standard ratings shall be established at the operating conditions specified in Section C.4. All *standard ratings* shall be verified by tests in accordance with Appendix C.

Section 6. Rating Requirements

This standard does not have any applicable rating requirements.

Section 7. Minimum Data Requirements for Published Ratings

As a minimum, *published ratings* shall include all *standard ratings*. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 1330". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 1330". *Application ratings* within the scope of the standard shall include a statement of the conditions under which the ratings apply.

The following shall be recorded for each appropriate model(s):

1) Model number
2) Heat input, kW
3) Length of heat exchanger tube including length of U-bends and elbows measured through the center line (radiant tube *infrared heaters* only) (m)
4) Radiant emission value
5) *Minimum angle* shall be specified if the heater is not tested in a horizontal position (Deg)
6) Air-metering device (multi-burner continuous heaters only)

Section 8. Marking and Nameplate Data

As a minimum, the appliance shall display the manufacturer's name, model number, radiant emission value, heat input, and *minimum angle*. This information can be provided on multiple markings, if required.

8.1 Radiant Tube Infrared Heaters

For *radiant tube infrared heaters*, the appliance shall display the configuration (straight or U-tube), and heat exchanger length.

8.2 Multi-burner Branch Heaters

For *multi-burner branch* heaters, the appliance shall display the air metering device(s).

Section 9. Conformance Conditions

While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's Purpose (Section 1) and Scope (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

Section 10. Nomenclature

Table 1 Nomenclature

Symbol	Title	Unit
a	Constant	—
A_{TOT}	Total radiant correction factor for water vapor and CO_2 in air	—
b	Signal offset	—
d	Thickness of radiation gas layer	mm
H_s	Gross calorific value of the test gas (at 15 °C, 1013.25 mbar, dry gas)	kWh/m^3
p	Gas supply pressure	mbar
p_a	Atmospheric pressure	mbar
Q_M	Measured heat input based on the net calorific value of the test gas	W
$Q_{(R)C}$	Radiant output after correction for absorption of radiation in air	W
$Q_{(R)M}$	Radiant output	W
t_g	Gas temperature at measuring point	°C
GRC	*Gross radiant coefficient*	%
$GRC_{nom,i}$	*Gross radiant coefficient* per branch at nominal heat input	%
REV	Radiant emission value	—

APPENDIX A. REFERENCES – NORMATIVE

This appendix lists all standards, handbooks, and other publications essential to the development and implementation of the standard. All references in this appendix are part of the standard.

A.1. *ASHRAE Terminology*. ASHRAE. Accessed March 28, 2022. https://www.ashrae.org/technicalresources/free-resources/ashrae-terminology

A.2. BS EN 416:2019, *Gas-fired overhead radiant tube heaters and radiant tube heaters for non-domestic use - safety and energy efficiency*, 2019, European Committee for Standardization, Rue de la Science 23, B-1040 Brussels.

A.3. BS EN 419:2019, *Gas-fired overhead luminous radiant heaters for non-domestic use — Safety and energy efficiency*, 2019, European Committee for Standardization, Rue de la Science 23, B-1040 Brussels.

A.4. BS EN 17175:2019, *Gas-fired overhead radiant strip heaters and multi-burner continuous radiant tube heater systems for non-domestic use — Safety and energy efficiency*, 2019, European Committee for Standardization, Rue de la Science 23, B-1040 Brussels.

A.5. ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*, 2005, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

This appendix lists standards, handbooks, and other publications that can provide useful information and background but are not essential for the use of this standard. All references in this appendix are not part of the standard.

None

APPENDIX C. METHODS OF TESTING FOR RATING INFRARED HEATERS – NORMATIVE

C.1. Purpose

This appendix provides a method of testing for *infrared heaters.*

C.2. Scope

Refer to Section 2 of the standard.

C.3. Test Equipment

All information on radiometer equipment can be obtained from Appendix D and Appendix E on this standard.

C.4. Measuring Grid

C.4.1. High Intensity Heater

For standard high intensity heaters up to a maximum size of 3 m length, a standard grid of 100 x 100 mm step shall be used.

For heaters that have a *measuring grid* of less than 100 positions based on a 100 x 100 mm grid, a grid of 50 x 50 mm shall be used.

C.4.2. Radiant Tube Heaters

For continuous tube heaters up to a maximum size of 10m length, a standard grid of 100 x 100 mm step shall be used.

For large tube heaters (length > 10m) the signal gradients over the longitudinal axis downstream a distance of 10 m from the burner are low. For these heaters, a grid of 100 x 100 mm step shall be used for the first 10 m of the heater downstream the burner. For the rest of the heater a grid of 100 mm width and maximum 500 mm length can be used.

C.4.3. Multi-burner Continuous Low-Intensity

For continuous tube heaters up to a maximum size of 10m length a standard grid of 100 x 100 mm step shall be used.

For large tube heaters (length > 10m) the signal gradients over the longitudinal axis downstream a distance of 10 m from the burner are low. For these heaters, a grid of 100 x 100 mm step shall be used for the first 10 m of the heater downstream the burner and for all bends or elbows of the heater. For the rest of the straight areas of the heater a grid of 100 mm width and maximum 1 000 mm length can be used.

C.4.4. Radiometer Measurement Positions

The irradiance measurement positions shall be established as below.

C.4.4.1. Measuring Plane

The radiometer shall be setup such that the *measuring plane* is 100 mm ± 3 mm below the *radiation reference plane*. See Figure 5 through Figure 8.

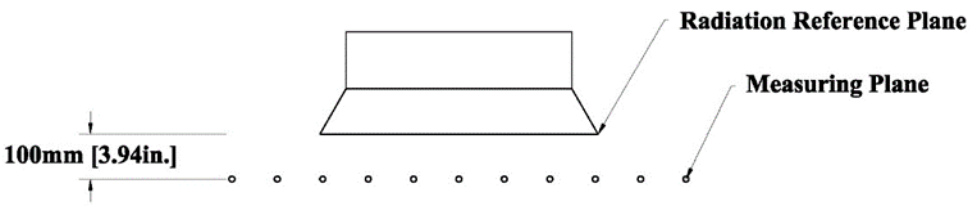


Figure 5 Radiation Reference Plane and Measuring Plane of a Horizontally Mounted High Intensity Infrared Heater

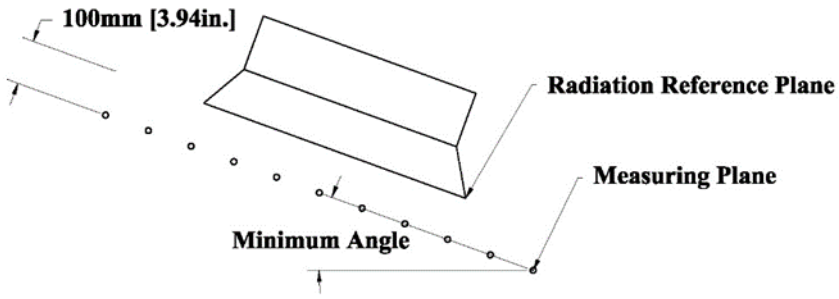


Figure 6 Radiation Reference Plane and Measuring Plane of an Angle Mounted High Intensity Infrared Heater

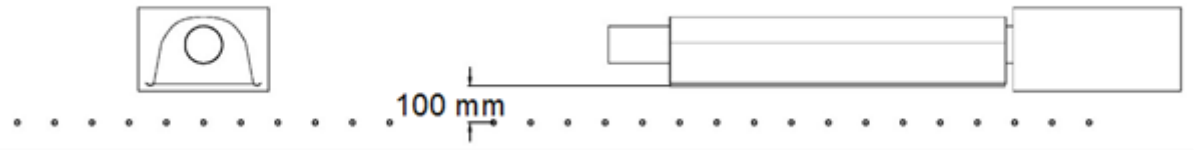


Figure 7 Measuring Plane of a Horizontally Mounted Low Intensity Infrared Heater

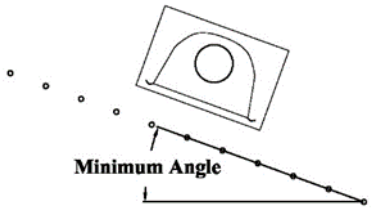


Figure 8 Measuring Plane of an Angle Mounted Low Intensity Infrared Heater

C.4.4.2. Measuring Grid

Nodal points of the *measuring grid* are located at the intersection of the perpendicular and parallel grid lines such that the distance between all adjacent *node* points on these lines is 100 mm ± 2 mm. The cell size can vary based on the physical dimensions of the heater; however the cell dimensions shall remain equal, and the tolerance shall be constant for all cell sizes at ± 2 mm. For example, 50 ± 2 mm. In each case a measurement of at least 100 positions is taken. For determination of the size of *measuring grid* the 1%-rule is relevant.

The *measuring grid* in the *measuring plane* shall be established in the following manner:

1) Establish the center line of the reference plane
2) Locate a series of *node* points equally spaced along the center line
3) Expand the *measuring grid* perpendicular to the center line locating additional *nodal points* until the measurement is less than 1% of the maximum measured irradiance under the appliance

4) Establish additional *nodal points* longitudinally along the center line of the heater locating additional *node* points until the measurement is less than 1% of the maximum measured irradiance under the appliance

5) The (0,0) *nodal point* is located at one corner of the measurement grid

C.5. Test Requirements and Operating Conditions

C.5.1. General

The test shall be carried out with the appliance mounted horizontally in accordance with the manufacturer's instructions, or if the appliance is not intended to mount horizontally then the test shall be carried out at the minimum mounting angle from the horizontal. The appliance shall be suspended at least 1.2 m above the floor. The suspension material shall not interrupt a free viewing field of the radiometer to the emitted radiation of the heater. If a manufacturer specifies an *infrared heater* can be both vented and unvented, the heater shall be set up with a one-meter vent length. The construction of the test equipment shall be stable enough to accommodate the radiant heat of the appliance without effecting the relative position of the radiometer. The radiometer shall be thermally insulated from the test equipment to prevent heat transfer from the test equipment to the sensor.

C.5.2. Working Area

The test shall be carried out in a working area having a floor with a non-metallic surface. The working area shall be of a size to allow installation of the appliance and shall:

1) Provide ventilation to remove the combustion products and heat generated by the appliance

2) Have an ambient air temperature of 20°C ± 5°C measured outside the direct radiation from the *infrared heater* being tested

3) Have an airflow around the temperature and relative humidity sensors shall be less than 0.25 m/s

4) Be free from influence of other radiant sources such as other radiant heaters

C.5.3. Thermal Equilibrium of the Radiometer

The temperature of the sensor shall be determined during the entire measurement period and recorded at each measurement point. Adjust the temperature of the coolant water through the probe to maintain a sensor temperature within the range of 20°C ± 0.5°C during the measurement period.

C.5.4. Nitrogen Purging of Sphere

During measurement and calibration, the nitrogen flow shall be kept at 25 ± 10 L/h.

The temperature of the nitrogen flow at the entrance of the radiometer shall be kept within the limits of 20°C ± 3°C. This is achieved by thermal protection of the N2 supply tubing against irradiance of the tested heater and by positioning the N_2 supply tubing directly nearby or in contact with the water-cooling supply tubing.

The nitrogen shall be dry and have a minimum purity of 99.9% (N_2 – 3,0 quality or better).

C.5.5. Steady State Conditions

The *infrared heater* shall be operated until the heater attains the steady state condition as defined by the manufacturer. If not defined by the manufacturer, the *infrared heater* shall be operated for a minimum period of thirty minutes.

C.5.6. Heat Input

The appliance shall be tested with natural gas unless approved for propane gas use only. Determine the actual higher heating value in kWh/m^3 for the gas to be used in the test with an error not greater than ± 1%. Heat input (Q_m) shall be adjusted to be ± 2% of the nameplate rating.

C.6. Test Procedure

C.6.1. Measuring Principle

Radiant output is determined by means of a radiometric method where the irradiance in the *measuring plane* is measured and the measured values are integrated over the area of the *measuring grid*.

C.6.2. Radiant Output Measurement

Immediately following verification that the *infrared heater* has reached steady state conditions, use the radiometer to measure the radiant output at each *nodal point* in the *measuring plane*. The measured value of radiant output at each *node* shall be recorded.

The radiometer axis shall not incline by more than two degrees from perpendicular to the measurement plane.

Note: The measuring sequence should be recorded using an automatic system.

During the measurement procedure at one heat input stage and at one reference gas the room air temperature and the humidity shall be recorded at least three times:

1) When starting the measurement procedure
2) Halfway through the measurement procedure
3) At the end of the measurement procedure

Air temperature and humidity needed for the absorption calculation are taken as average values of these measurements. The individual measurement of the air temperature shall always fulfill the requirements of keeping an ambient air temperature of 20°C ± 5°C during the complete test.

The electric signal of the sensor shall be taken when the mean value of a series of five signals, taken equally spread within 2.5 seconds (so every 0.5 seconds), is within ± 1% of the mean value of a next series of five signals. As soon as this is the case the mean value of the last series is taken as the measurement value.

In case the appliance is a single stage heater the values for heat input, radiant output and emissions of the combustion are taken at nominal heat input.

Note: In the case of a range rated, two stage or modulating heater, the values for heat input, radiant output, and combustion emissions can be taken at nominal heat input and minimum heat input. This is optional.

C.7. Calculation of Radiant Emission Value

The methods for calculating the radiant emission value varies depending on the appliance type being tested. Table 2 contains the cross-references necessary to calculate radiant emission values for *unitary infrared tube heaters*, *high-intensity infrared heaters*, and *multi-burner continuous infrared tube heater systems*.

Table 2 Cross-References for Calculation of Radiant Emission Value

AHRI 1330-2024 (SI) Sections	Unitary Infrared Tube Heater – EN 416-2019	High-Intensity Infrared Heater – EN 419-2019	Multi-Burner Continuous Infrared Tube Heater System – EN 17175-2019
Section C.7.1 Calculation of Heat Input	Section 7.5.1	Section 7.6.1	Section 7.5.1
Section C.7.2 Calculation of Radiant Output	Section 7.5.2	Section 7.6.2	Section 7.5.2
Section C.7.3.1 General.	Section 7.5.3.1	Section 7.6.3.1	Section 7.5.3.1
Section C.7.3.2 *GRC* at Nominal Heat Input	Section 7.5.3.2	Section 7.6.3.2	Section 7.5.3.2
Section C.7.3.3 *GRC* at Minimum Heat Input.	Section 7.5.3.3	Section 7.6.3.3	Section 7.5.3.3

C.7.1. Calculation of Heat Input

The actual heat input Q_M of the appliance shall be calculated as prescribed in Table 2 according to the appliance type being tested.

Where H_i in the formula is the net calorific value of the test gas in MJ/m^3, use Hs the gross calorific value of the test gas in MJ/m^3. The result Q_m is the actual gross heat input with respect to the actual gross calorific value in Watt (W).

C.7.2. Calculation of Radiant Output

The radiant output $Q_{(R)M}$ shall be calculated as prescribed in Table 2 according to the appliance type being tested.

C.7.3. Calculation of GRC

C.7.3.1. General

The *GRC* of the appliance shall be calculated as prescribed in Table 2 according to the appliance type being tested.

C.7.3.2. GRC at Nominal Heat Input

The *GRC* at nominal heat input shall be calculated as prescribed in Table 2 according to the appliance type being tested.

C.7.3.3. GRC at Minimum Heat Input

For appliances with modulating or two stage control the *GRC* at minimum heat input can be determined as prescribed in Table 2 according to the appliance type being tested.

C.7.4. Calculation of Multi-burner GRC

Continuous radiant tube heaters consisting of a combination of various radiant tube heater segments of different heat inputs and lengths in various tube heater branches.

C.7.4.1. Branch with Multi-burner In Series

For a branch with multi-burner in series, the *GRC* of the branch is calculated from the radiant output of the entire branch divided by the heat input of burner(s) in the entire branch taken during the irradiance measurement. The size of the *measuring plane*, covering the radiant tube and tail pipe, shall be determined individually per branch by the provision that the radiant intensity taken at the borders of the *measuring plane* is smaller than 1% of the maximum intensity taken in the plane under the heater (1%-rule). The heat inputs of all individual burners shall be measured independently during the test.

The heat input Q_M for the individual burners is calculated as prescribed in Section C.7.1.

The heat output $Q_{(R)M}$ for the branch is calculated as prescribed in Section C.7.2.

The radiant output at reference conditions $Q_{(R)C}$ for the branch is calculated as prescribed in Section C.7.3.

The *GRC* is calculated as prescribed in Section C.7.3. See Equation 1.

$$\mathbf{GRC_{nom,i}} = \frac{Q_{(R)C}}{\sum_{i=1}^{i=n} Q_M} \qquad \mathbf{1}$$

Where:

$GRC_{nom,i}$ is the *GRC* per branch at nominal heat input, expressed in %

Q_M is the measured heat input in W of the individual burners

$Q_{(R)C}$ is the radiant output at reference conditions (in dry air) in W

C.7.4.2. In Series Multi-burner System Equations

For an in series multi-burner system the simplified method for measuring the radiant output is to test the first segment only. The first segment has the lowest efficiency of all the segments in the system and is therefore a conservative value to represent the system. The air metering device(s) of the burner shall match that of the recorded branch.

The size of the *measuring plane*, covering the radiant tube, shall be determined individually for the segment by the provision that the radiant intensity taken at the borders of the *measuring plane* is smaller than 1% of the maximum intensity taken in the plane under the heater (1%-rule).

The heat input Q_M for the individual burners is calculated as prescribed in Section C.7.1.

The heat output $Q_{(R)M}$ for the branch is calculated as prescribed in Section C.7.2.

The radiant output at reference conditions $Q_{(R)C}$ for the branch is calculated as prescribed in Section C.7.3.

The *GRC* is calculated as prescribed in Section C7.3.

C.7.4.3. Branch with Multi-burner in Parallel

For a branch with multi-burner in parallel, the *GRC* of the branch is calculated from the radiant output of the entire branch divided by the heat input of burner(s) in the entire branch taken during the irradiance measurement. The size of the *measuring plane*, covering the radiant tube and tail pipe, shall be determined individually per branch by the provision that the radiant intensity taken at the borders of the *measuring plane* is smaller than 1% of the maximum intensity taken in the plane under the heater (1%-rule) The heat inputs of all individual burners shall be measured independently during the test.

The heat input Q_M for the individual burners is calculated as prescribed in Section C.7.1.

The heat output $Q_{(R)M}$ for the branch is calculated as prescribed in Section C.7.2.

The radiant output at reference conditions $Q_{(R)C}$ for the branch is calculated as prescribed in Section C.7.3.

The requirements when multiple branches are used to calculate a system GRC are:

1) There must be the same number of burners in the branch as the measured branch.
2) Use the same heat input burners at the same locations as the measured branch.
3) Have individual segment lengths that are equal to or longer than the segment lengths of the measured branch.

The *GRC* is calculated as prescribed in Section C.7.3.

C.7.4.4. Parallel Multi-burner System

For a parallel multi-burner system, the simplified method for measuring the radiant output is to test an individual segment only. An individual segment has a lower efficiency than segments connected downstream where the products of combustion are combined in the system, and this is therefore a conservative value to represent the system.

The size of the *measuring plane*, covering the radiant tube, shall be determined individually for the segment by the provision that the radiant intensity taken at the borders of the *measuring plane* is smaller than 1% of the maximum intensity taken in the plane under the heater (1%-rule).

The heat input Q_M for the individual burners is calculated as prescribed in Section C.7.1.

The heat output $Q_{(R)M}$ for the branch is calculated as prescribed in Section C.7.2.

The radiant output at reference conditions $Q_{(R)C}$ for the branch is calculated as prescribed in Section C.7.3.

The *GRC* is calculated as prescribed in Section C.7.3.

C.7.5. Calculation of Radiant Emission Value

The radiant emission value of the appliance respective of the system is shown in Equation 2.

$$\mathrm{REV} = \frac{(0.94 \cdot GRC) + 0.19}{(0.46 \cdot GRC) + 0.45} \cdot 100 \qquad \textbf{2}$$

Where:

REV is the radiant emission value

GRC is the *gross radiant coefficient*

APPENDIX D. RADIOMETER EQUIPMENT – NORMATIVE

D.1. Radiometer Design

The principal radiometer features shall be designed as prescribed below according to the type of appliance being tested.

D.1.1. Unitary Infrared Tube Heater

See section J.1 of EN 416-2019.

D.1.2. High-intensity Infrared Heater

See section G.1 of EN 419-2019.

D.1.3. Multi-burner Continuous Infrared Tube Heater System

See section J.1 of EN 17175-2019.

D.2. Radiometer Construction

The thermal protection housing for the radiometer shall be designed as prescribed below according to the type of appliance being tested.

D.2.1. Unitary Infrared Tube Heater

See section 7.3.3.2.5 of EN 416-2019.

D.2.2. High-intensity Infrared Heater

See section 7.4.3.2.5 of EN 419-2019.

D.2.3. Multi-burner Continuous Infrared Tube Heater System

See section 7.3.3.2.5 of EN 17175-2019.

APPENDIX E. RADIOMETER CALIBRATION – NORMATIVE

E.1. Radiometer Calibration Procedure

The radiometer shall be calibrated as prescribed below according to the type of appliance being tested.

E.1.1. Unitary Infrared Tube Heater

See section K.1 of EN 416-2019.

E.1.2. High-intensity Infrared Heater

See section H.1 of EN 419-2019.

E.1.3. Multi-burner Continuous Infrared Tube Heater System

See section K.1 of EN 17175-2019.

E.2. Black Body Calibration Equipment and Procedure

The black body equipment shall be calibrated as prescribed below according to the type of appliance being tested.

E.2.1. Unitary Infrared Tube Heater

See section K.2 of EN 416-2019.

E.2.2. High-intensity Infrared Heater

See section H.2 of EN 419-2019.

E.2.3. Multi-burner Continuous Infrared Tube Heater System

See section K.2 of EN 17175-2019.

E.3. Calibration Procedure in Detail

A detailed description of the procedure to conduct calibration measurements can be found in the following sections depending on the type of product being tested.

E.3.1. Unitary Infrared Tube Heater

See section K.3 of EN 416-2019.

E.3.2. High-intensity Infrared Heater

See section H.3 of EN 419-2019.

E.3.3. Multi-burner Continuous Infrared Tube Heater System

See section K.3 of EN 17175-2019.

APPENDIX F. RADIANT HEAT OUTPUT DATA EXAMPLES OF DATA RECORDING FORMATS – INFORMATIVE

F.1. Examples of Information

F.1.1. Test and Appliance Data

Figure 9 shows an example format that can be used for recording test and appliance data.

Test Laboratory:_____	
Manufacturer:_____	Technician:_____
Heater Type: _____	Test date:_____
Supplier: _____	Tube configuration:_____
Model:_____	Tube diameter (m):_____
Heater length (m):_____	Orifice size (m):_____
Heater width (m):_____	Vent length (if applicable):_____
Nominal heat input (kW):_____	Vent diameter (if applicable):_____
Air metering device(s) configuration: _____	Reflector profile:_____
Fresh air intake length (if applicable):_____	Reflector insulation (if applicable):_____
Fresh air intake diameter (if applicable):_____	Heater angle (if not horizontal):_____
Test gas gross calorific value at 15°C and 1013.25 mbar (kWh/m^3):_____	

Figure 9 Example of Format to Record Test and Appliance Data

F.1.2. Radiometer Technical Data

Figure 10 shows an example format that can be used for recording radiometer technical data.

Radiometer name/number:_____	
Sensor type:_____	
Cooling system:_____	
Calibration certificate:_____	
Calibration Factor, a·x+b:_____	
Nitrogen gas flow rate (L/h):_____	
Sensor temperature (°C): _____	Sensor temperature calibration (°C):_____
Chopper frequency (Hz):_____	
Amplifier Voltage (V):____	
Radiometer Sensitivity (S):_____	

Figure 10 Example of Format to Record Radiometer Technical Data

F.1.3. Measuring Plane Technical Data

Figure 11 shows an example format that can be used for recording *measuring plane* technical data.

Number of measuring points (parallel with the longitudinal axis):_____	
Number of measuring points (perpendicular with longitudinal axis): _____	
Measurement from start of heater to first column of *nodes* (mm): _____	
Measuring grid length (m): _____	*Measuring grid* width (m):_____
Number of *measuring cells*: _____	*Measuring cell* area (m^2): _____
Measuring grid area (m^2): _____ Distance d between measuring plane and heater *radiation emitter plane* (mm): _____	
Irradiance present in the outliner lines smaller than 1% of the maximum value (Yes/No):_____	

Figure 11 Example of Format for Recording Measuring Plane Technical Data

F.2. Measurement Results

F.2.1. Test Ambient Conditions

Figure 12 shows an example format that can be used for recording test ambient conditions.

Parameter	Test Number				
	1	2	3	4	5
Air Temperature at start (°C)					
Air Temperature at end (°C)					
Ambient humidity at start (%)					
Ambient humidity at end (%)					
Atmospheric pressure (p_a) at start (mbar)					
Atmospheric pressure (p_a) at end (mbar)					

Figure 12 Example of Format for Recording Test Ambient Conditions Data

F.2.2. Gas/Heat Input Data

Figure 13 shows an example format that can be used for recording gas/heat input data.

Parameter	Test Number				
	1	2	3	4	5
Gas Category					
Gross calorific value H_s (kWh/m^3)					
Gas flow at ambient conditions (m^3/h)					
Gas temperature, t_g (°C)					
Gas flow at 15°C and 1013 mbar, (m^3/h)					
Heat input Q (kW)					
Supply gas pressure (mbar)					
Manifold gas pressure (mbar)					

Figure 13 Example of Format for Recording Gas/Heat Input Data

F.2.3. Absorption of Water Vapor and CO2 Data

Figure 14 shows an example format that can be used for recording absorption of water vapor and CO_2 data.

Parameter	Test Number				
	1	2	3	4	5
Thickness of radiating gas layer, d (mm)					
Partial pressure of water vapor in ambient air pressure (mbar)					
Radiant correction factor for water vapor and CO_2 air, τ_{total}					

Figure 14 Example of Format for Recording Absorption of Water Vapor and CO_2 Data

F.2.4. Irradiation Measurement Data

Figure 15 shows and example format that can be used for recording absorption of irradiation measurement data.

Parameter	Test Number				
	1	2	3	4	5
Sensor temperature, t_s, at start, (°C)					
Sensor temperature, t_s, at start, (°C)					
Measured radiant output, $Q_{(R)M}$ (W)					
Measured radiant output after correction for absorption, $Q_{(R)C}$ (W)					
Gross radiant coefficient, GRC					
Radiant Emission Value, REV					

Figure 15 Example of Format for Irradiation Measurement Data

APPENDIX G. TOLERANCES OF EQUIPMENT MEASUREMENTS – NORMATIVE

G.1. Tolerances of Equipment Measurements

The tolerances of equipment measurements shall be carried out using equipment with the maximum tolerances as prescribed below according to the type of appliance being tested.

G.1.1. Unitary Infrared Tube Heater

See Annex S of EN 416-2019.

G.1.2. High-intensity Infrared Heater

See Annex N of EN 419-2019.

G.1.3. Multi-burner Continuous Infrared Tube Heater System

See Annex S of EN 17175-2019.

APPENDIX H. SYSTEM ARRANGEMENT – INFORMATIVE

This appendix describes the continuous *low intensity* radiant systems in series and parallel configurations (see Figure 16 and Figure 17).

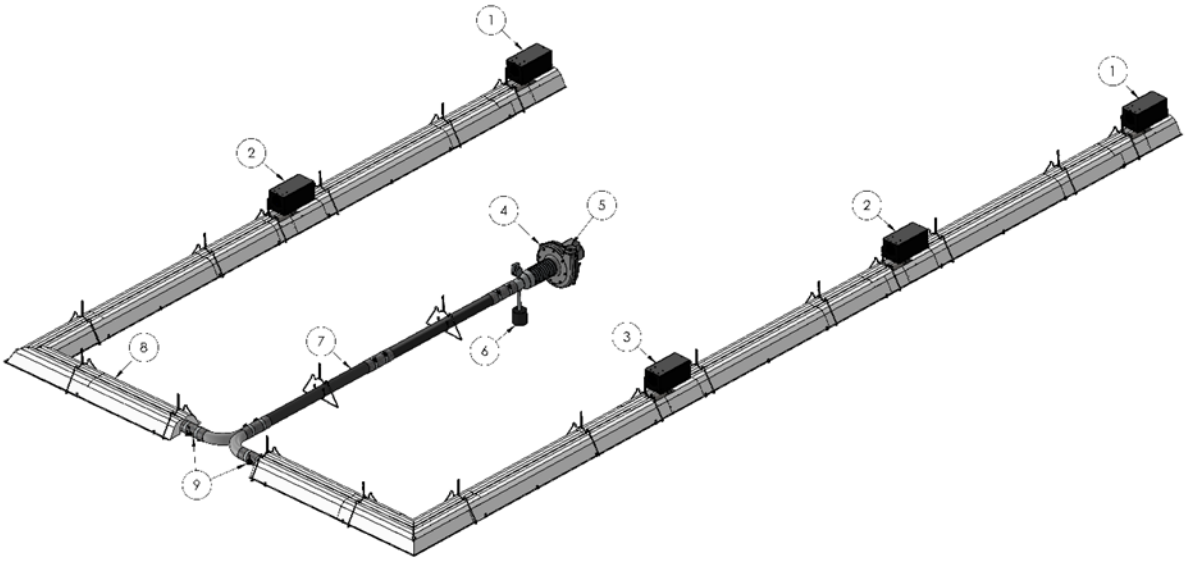


Figure 16 Continuous Low Intensity Radiant Tube Heaters in Series Configuration

Key for Figure 16:

1) Burner 1
2) Burner 2
3) Burner 3
4) Vacuum fan
5) Flue
6) Condensate trap
7) Common duct
8) Reflector over tube
9) Damper

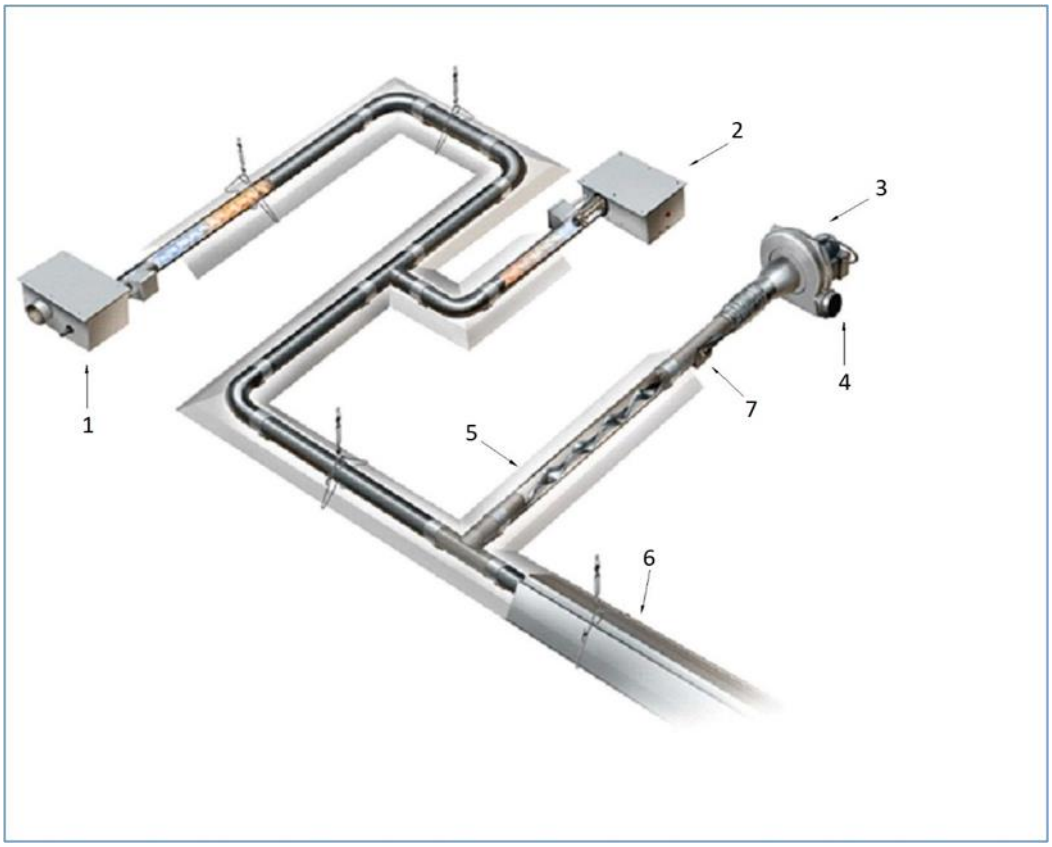


Figure 17 Continuous Low Intensity Radiant Tube Heaters in Parallel Configuration

Key for Figure 17:

1) Burner 1
2) Burner 2
3) Vacuum fan
4) Flue
5) Common duct
6) Reflector over tube
7) Damper

APPENDIX I. MULTI-BURNER CONTINUOUS LOW-INTENSITY HEATER EXAMPLE CALCULATIONS – INFORMATIVE

The following are worked examples for calculating REV for multi-burner continuous *low-intensity* heaters.

I.1. Series Multi-burner Branch Measurement

I.1.1. Branch A Example

For the branch below the heat input of each burner is individually measured. The branch heat output is measured with a grid of 100mm x 100mm. The *GRC* is calculated for the branch and the REV is then calculated for the branch in accordance with Section C.7.4.1. See Figure 18 for Branch A.

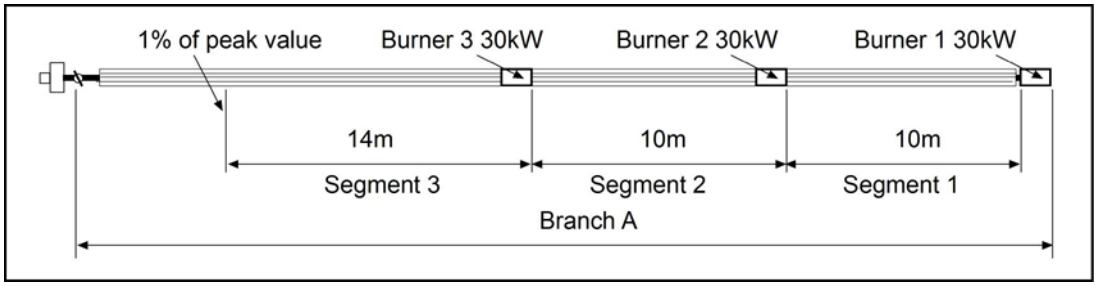


Figure 18 Branch A

Example of recorded data for Branch A is shown in Table 3.

Table 3 Example of Recorded Data for Branch A

Information	Recorded Data
Heater type	Multi-burner in series
Measurement type	Branch method
Number of burners	3
Heat input burner 1	30 kW
Length of segment 1	10 m
Heat input burner 2	30 kW
Length of segment 2	10 m
Heat input burner 3	30 kW
Length of segment 3	14 m
REV	Calculated value from Equation 2

I.1.2. Branch B Example

See Figure 19 for Branch B.

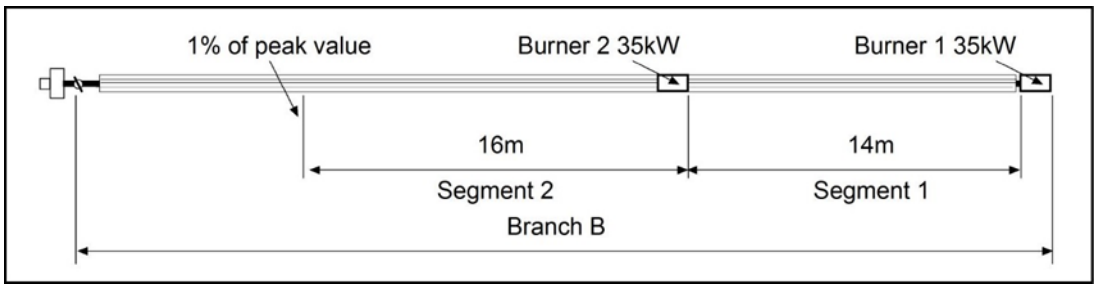


Figure 19 Branch B

Example of recorded data for Branch B is shown in Table 4.

Table 4 Example of Recorded Data for Branch B

Information	Recorded Data
Heater type	Multi-burner in series
Measurement type	Branch method
Number of burners	2
Heat input burner 1	35 kW
Length of segment 1	14 m
Heat input burner 2	35 kW
Length of segment 2	16 m
REV	Calculated value from Equation 2

I.1.3. Application for System Calculations for Series Multi-burner Branch Measurement

Figure 20 shows an example of two identical branches that are used to make up a system. In this case, the system REV is equal to the branch A REV.

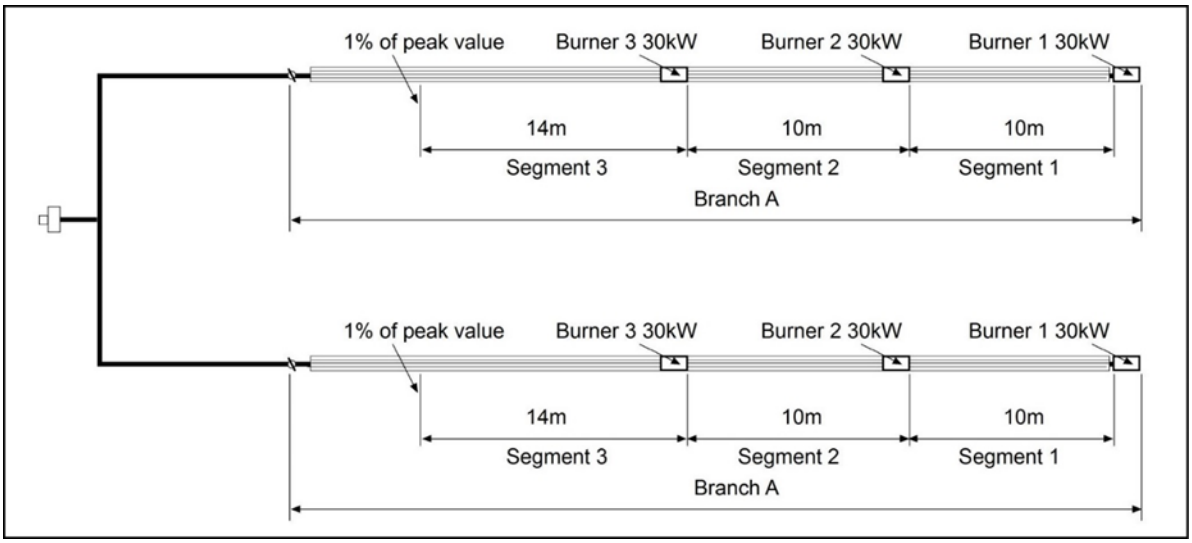


Figure 20 Example of Two Branches Identical to Branch A

I.1.4. Tool for System Calculation for Series Multi-burner Branch Measurement

Table 5 shows a tool that can be used to calculate the system and a combination of branches A and B.

Table 5 Tool for System Calculation for Combination of Branch A and Branch B

Branch	Heat Input Measured (kW)	Length (m)	Heat Output (kW)
Branch A	90	34	$Q_{(R)C-A}$
Branch B	70	30	$Q_{(R)C-B}$
—	—	**Sum Output**	$Q_{(R)C-A} + Q_{(R)C-B}$
—	—	**Sum Input**	160
—	—	**Sum REV**	Calculate value from Equation 2

Data from these two branches can be used to calculate REV of a system provided the same combination of heat input and number of burners are in the branch and heat exchanger lengths are equal to or longer than the measured branch. See Figure 21.

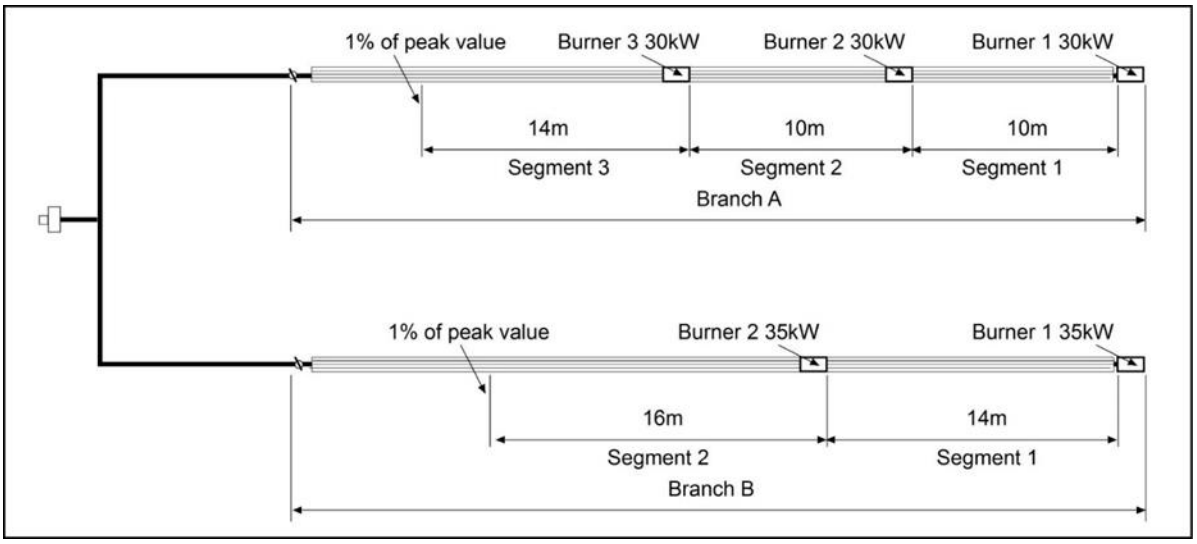


Figure 21 Example of Branch A and Branch B

I.2. Series Multi-burner Segment Measurement

I.2.1. Example Using Series Multi-burner Segment Measurement

Figure 22 shows the different methods for setting up a series segment for test either with a complete branch set up or as an individual segment using a damper to set the correct vacuum for the first burner.

For the segment below the heat input of burner 1 is measured. The segment heat output is measured with a grid of 100 mm x 100 mm. The *GRC* is calculated for the segment and the REV is then calculated as defined in Section C.7.4.2. See Table 6 and Table 7.

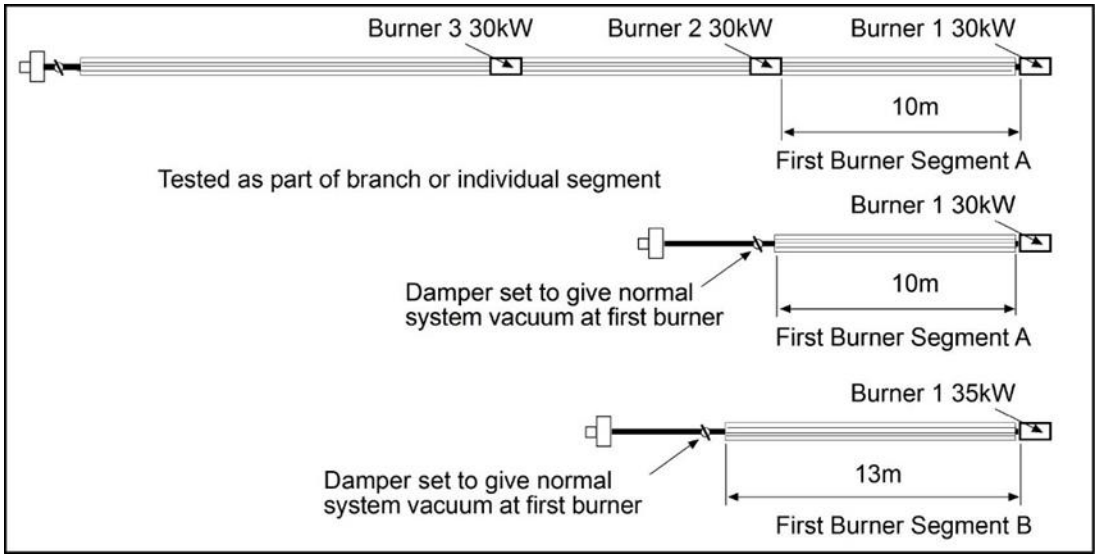


Figure 22 First Multi-burner Branch Segment A and Segment B

Table 6 Example of Recorded Data for Multi-burner Branch Segment A

Information	Recorded Data
Heater type	Multi-burner in series
Measurement type	Simplified method
Heat input burner 1	30 kW
Length of segment 1	10 m
REV	Calculated value from Equation 2

Table 7 Example of Recorded Data for Multi-burner Branch Segment B

Information	Recorded Data
Heater type	Multi-burner in series
Measurement type	Simplified method
Heat input burner 1	35 kW
Length of segment 1	13 m
REV	Calculated value from Equation 2

I.2.2. Application for System Calculations for Series Multi-burner Segment Measurement

By using the two measured segments because each are shorter than or equal to the segments measured, the system can be calculated as shown below. See Figure 23 and Table 8.

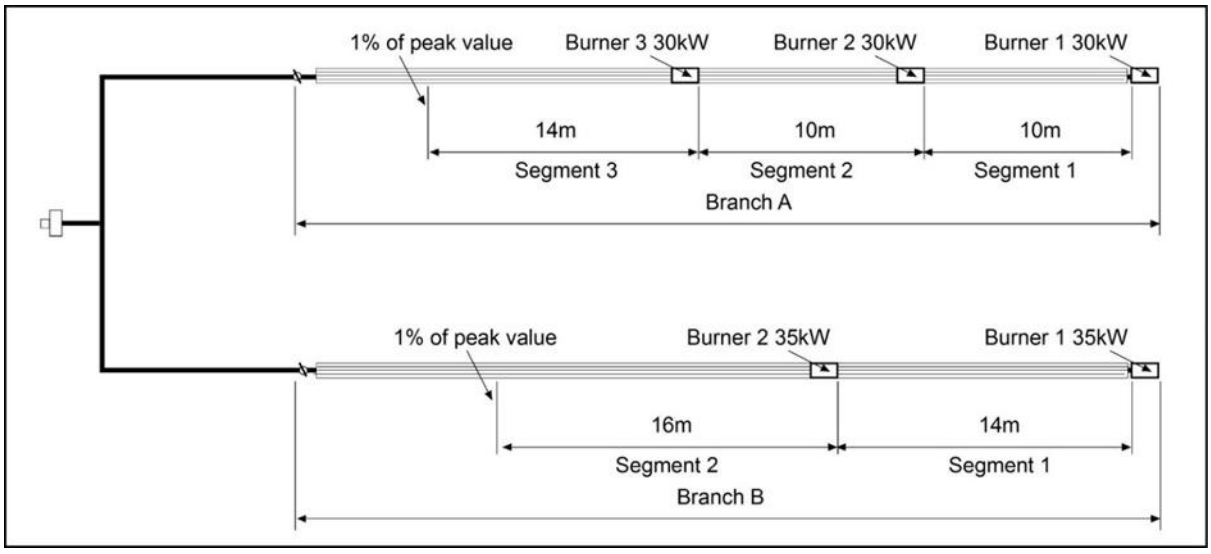


Figure 23 Example Using Two Measured Segments Shorter Than or Equal to Segments Measured

Table 8 Tool for System Calculation for Two Segments

Branch	Heat Input (kW)	Length (m)	Heat Output (kW)
Segment 1 Branch A	30	10	$Q_{(R)C\text{-}A}$
Segment 2 Branch A	30	10	$Q_{(R)C\text{-}A}$
Segment 3 Branch A	30	14	$Q_{(R)C\text{-}A}$
Segment 1 Branch B	35	14	$Q_{(R)C\text{-}B}$
Segment 2 Branch B	35	16	$Q_{(R)C\text{-}B}$
—	—	**Sum Output**	$3(Q_{(R)C\text{-}A}) + 2(Q_{(R)C\text{-}B})$
—	—	**Sum Input**	160
—	—	**System REV**	Calculated value from Equation 2

I.3. Parallel Multi-burner Branch Measurement

I.3.1. Example of Parallel Multi-burner Branch Measurement

For the branch below the heat input of each burner is individually measured. The branch heat output is measured with a grid of 100 mm x 100 mm. Measurements are taken along the branch until the readings is less than 1% of peak value. The *GRC* is calculated for the branch and the *REV* is then calculated for the branch as defined in Section C.7.4.3. See Figure 24 and Table 9.

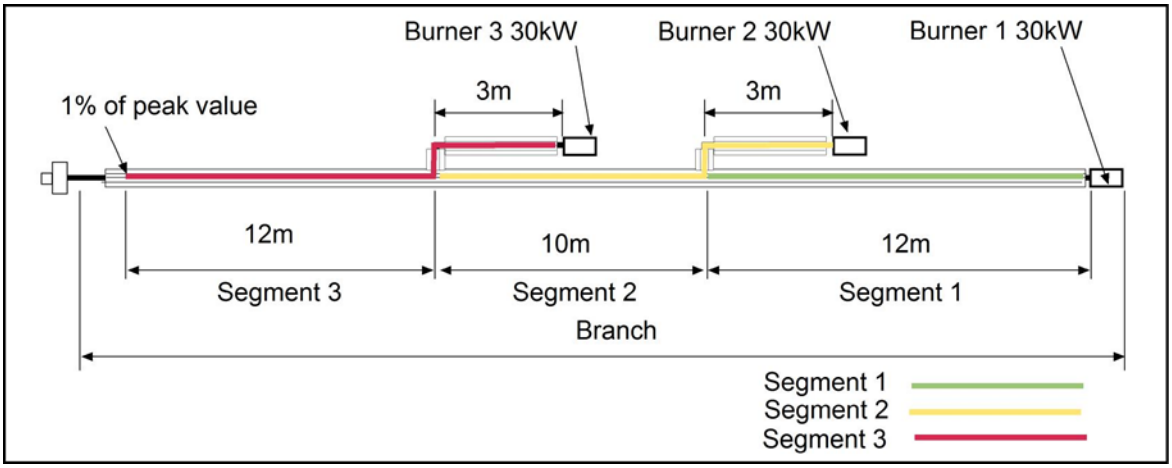


Figure 24 Example Parallel Multi-burner Branch

Table 9 Example of Recorded Data for Parallel Multi-burner Branch

Information	Recorded Data
Heater type	Multi-burner in parallel
Measurement type	Branch method
Number of burners	3
Heat input burner 1	30 kW
Length of segment 1	12 m
Heat input burner 2	30 kW
Length of segment 2	13 m
Heat input burner 3	30 kW
Length of segment 3	15 m
REV	Calculated value from Equation 2

I.3.2. Application for System Calculations for Parallel Multi-burner Branch Measurement

Multiple branches can be used to calculate a system REV using the method referenced in Section I.1. See requirements in Section C.7.4.3.

I.3.3. Parallel Multi-burner Simplified Measurement

Figure 25 below shows the methods for setting up a parallel segment to test as individual segment using a damper to set the correct vacuum for the burner. For the simplified method the air metering device(s) of burner one must match that of the recorded *multi-burner branch*.

For the segment below the heat input of the burner is measured. The segment heat output is measured with a grid of 100 mm x 100 mm. Measurements are taken for the segment until the readings is less than 1% of peak value. The *GRC* is calculated for the segment and the *REV* is then calculated for the segment as defined in Section C.7.4.4.

The manufacturer can measure segments for individual heat inputs at multiple lengths as shown in the 30 kW example diagram Figure 26.

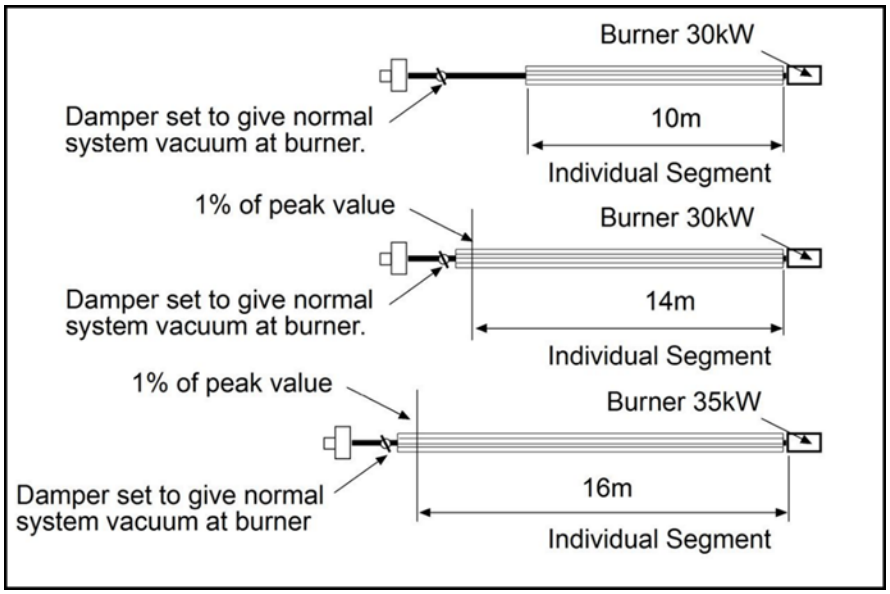


Figure 25 Methods for Setting Up a Parallel Segment to Test as Individual Segment

Table 10 Example of Recorded Data for Parallel Multi-burner with Individual Segment 30 kW at 10 m Length

Required Information	Recorded Data
Heater type	Multi-burner in parallel
Measurement type	Simplified method
Heat input burner 1	30 kW
Length of segment 1	10 m
REV	Calculated value from Equation 2

Table 11 shows an example of recorded data for parallel multi-burner with individual segment 30 kW at 14 m length.

Table 11 Example Recorded Data for Parallel Multi-burner with Individual Segment 30 kW at 14 m Length

Information	Recorded Data
Heater type	Multi-burner in parallel
Measurement type	Simplified method
Heat input burner 1	30 kW
Length of segment 1	14 m
REV	Calculated value from Equation 2

Table 12 shows an example of recorded data for parallel multi-burner with individual segment 30 kW at 10 m length.

Table 12 Example Recorded Data for Parallel Multi-burner with Individual Segment 35 kW at 16 m Length

Information	Recorded Data
Heater type	Multi-burner in parallel
Measurement type	Simplified method
Heat input burner 1	35 kW
Length of segment 1	16 m
REV	Calculated value from Equation 2

I.3.4. Application for System Calculations for Parallel Multi-burner Simplified Measurement

Using the three measured segments the system can be calculated as shown below in Figure 26 and Table 13.

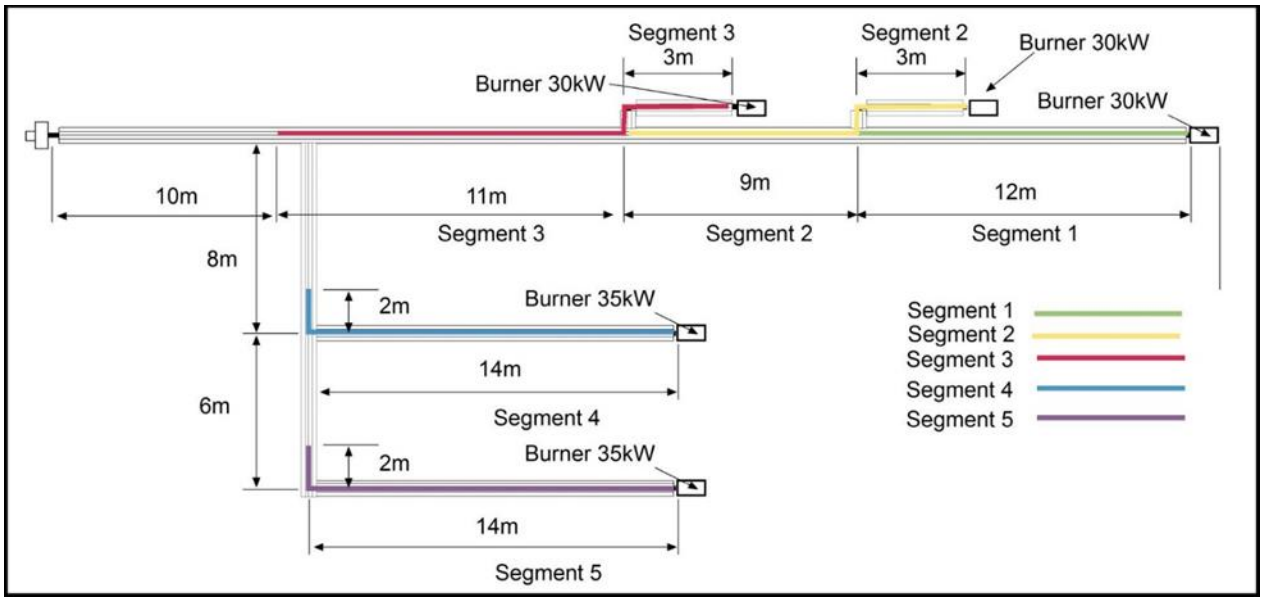


Figure 26 Application for System Calculations for Parallel Multi-burner Using Three Measured Segments

Table 13 Tool for System Calculation for Parallel Multi-burner Using Three Measured Segments

Branch	Heat Input (kW)	Length (m)	Heat Output (kW)	Comments
Segment 1	30	12	$Q_{(R)C-1}$	Use data for 30 kW @ 10 m length
Segment 2	30	12	$Q_{(R)C-2}$	Use data for 30 kW @ 10 m length
Segment 3	30	14	$Q_{(R)C-3}$	Use data for 30 kW @ 14 m length
Segment 4	35	16	$Q_{(R)C-4}$	Use data for 35 kW @ 16 m length
Segment 5	35	16	$Q_{(R)C-5}$	Use data for 35 kW @ 16 m length
—	—	**Sum Output**	$\sum Q_{(R)C}$	—
—	—	**Sum Input**	160	—
—	—	**System REV**	Calculated value from Equation 2	