*i*Cone^{2+} Calorimeter

(ISO 5660; ASTM E1354)

firetesting technology

The *i*-series of Cone Calorimeters

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A Judges Scientific plc company

bsi. ISO 9001:2015 Quality Management

bsi. ISO 14001:2015 Environmental Management

Following a successful launch of the *i*Cone *plus* in 2013 and the *i*Cone *mini* and *i*Cone *classic* in 2016, the release of a new model called *i*Cone^{2+} marks the beginning of the next generation of the *i*Cone, offering a further enhanced fire model and heat protective glass screen. It also features the latest technology in control and automation, making it the most advanced, reliable and user-friendly cone calorimeter in the world.

The Cone Calorimeter is the most significant bench-scale instrument in the field of fire testing because it measures important, real properties of the material being tested under a variety of preset fire conditions.

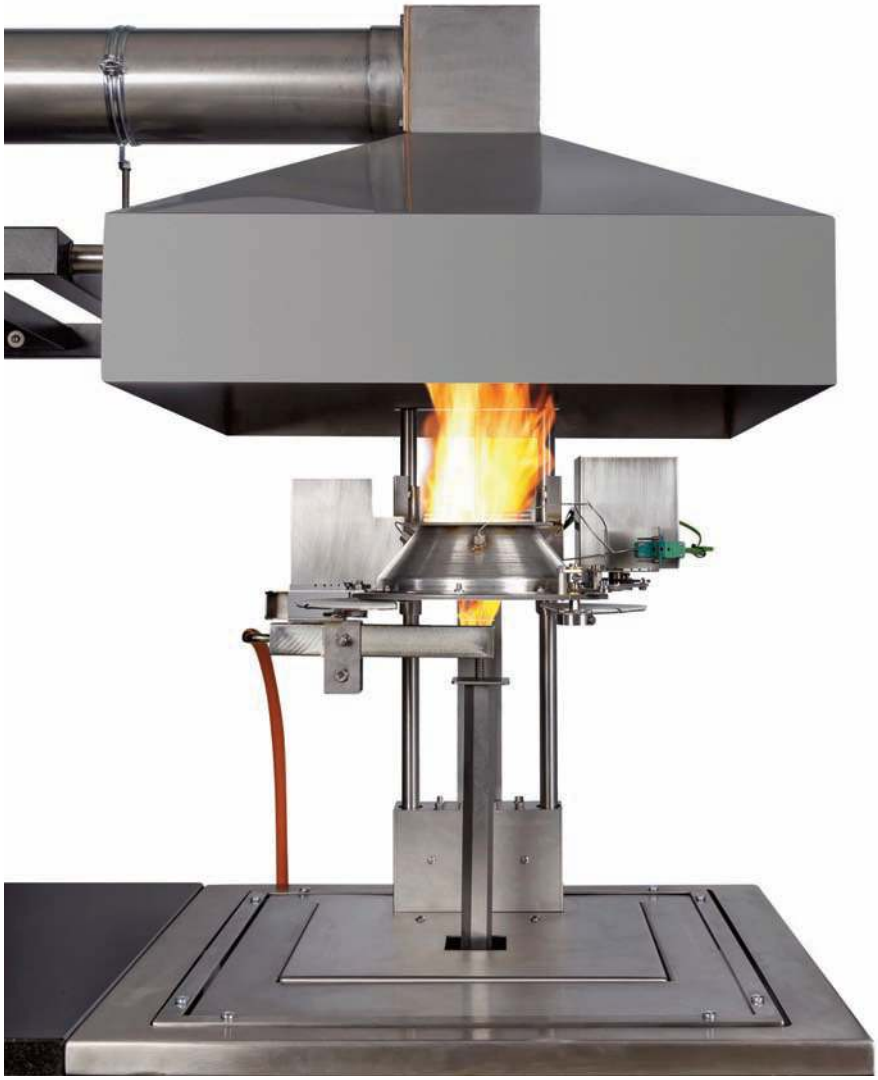
These measurements can be used directly by researchers or they can be used as data for input into correlation or mathematical models, used to predict fire development.

Directly measured properties include:

- Heat release rate
- Time to ignition
- Mass loss rate
- Smoke release rate
- Effective heat of combustion
- Rates of release of combustion gas (e.g. carbon oxides)

International standards have been published describing the equipment and several national standardisation bodies have now published product standards for use of the Cone Calorimeter in assessing performances of finished products.

- Furniture (ASTM E1474)
- Wall lining materials (ASTM E1740)
- Prison mattresses (ASTM F1550)
- Electric Cables (ASTM D6113)
- Railway rolling-stock applications (EN 45545-2)
- Maritime applications (IMO)



FTT's Contribution to the Development of Calorimetry

In the mid 1980s **FTT** Directors worked with Babrauskas and other colleagues to help develop international test standards based upon oxygen consumption calorimetry.

They also designed European prototypes and Stanton Redcroft's commercial Cone Calorimeter. **FTT** has been the world's leading manufacturer of all calorimeters, including full scale calorimeters (e.g. Furniture Calorimeter, the ISO 9705 Room Corner test and the SBI) since 1989. Throughout this period **FTT** scientists and engineers have worked on several calorimetry research projects and contributed extensively to International, European, ASTM and British Standardisation groups.

FTT has supplied more than 400 Cone Calorimeters to customers, in more than 40 countries, for both research studies and testing in accordance with fire safety standards. **FTT**'s specialist calorimetry design engineers ensure their products integrate new developments.

FTT's production engineers are the world's most experienced Cone Calorimeter builders and its team of specialist service engineers ensure that **FTT** calorimeters are promptly maintained, on all five continents.

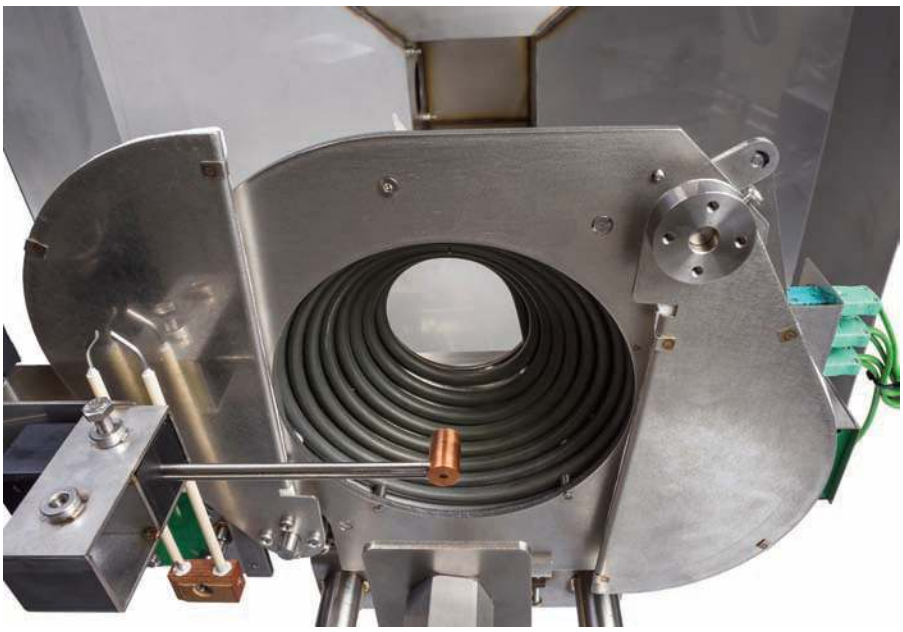
Cone Calorimeter

The name "Cone Calorimeter" was derived from the shape of the truncated conical heater that Babrauskas used to irradiate the test specimen (100mm × 100mm) at fluxes up to 75-100kW/m^2 in the bench-scale oxygen consumption calorimeter that he and his co-workers developed at NIST. The **FTT** Cone Calorimeter has all the advantages of the conventional single purpose Cone Calorimeter and has been produced to be the most easily maintained unit in the marketplace. It fits into the smallest labs and is easy to operate using the **FTT** user-friendly, menu driven software, which guides users through the calibration, testing and reporting protocols. The apparatus meets all existing Standards (including ISO 5660-1, ASTM E1354, ASTM E1474, ASTM E1740, ASTM F1550, ASTM D5485, ASTM D6113, CAN ULC 135 and BS 476 Part 15).

Building on this expertise we provide customers with automated instruments that utilise state-of-the-art technology and we continuously strive to improve the efficiency and accuracy of the fire test process. The **FTT** ***i***Cone Calorimeters have been developed as an industry-leading next generation of Cone Calorimeters. It features an interactive and intuitive interface, sophisticated and flexible control options, and built-in data acquisition technology for robust data collection, analysis and reporting.

FTT's ***i***Cone^{2+} is the most advanced automatic Cone Calorimeter in the ***i***Cone range.

It has been designed using decades of **FTT**'s experience in calorimetry. It incorporates many features not previously seen by fire testing laboratories while being compact, accurate, reliable and easily maintained.



Base view of conical heater

A full system consists of:

Conical Heater

- 5kW electrical heating element wound in the form of a truncated cone, rated 5000W at 230V with a heat output up to 75-100kW/m^2
- Motorised height adjustment and control via 4" touchscreen during test for materials that intumesce
- Facility for testing horizontally or vertically orientated specimens

Temperature Controller

- Software controls the temperature of the conical heater to give the desired heat flux via 3 type-K thermocouples and a 3-term (PID) temperature controller
- A temperature profile during the test, consisting of up to 10 steps (e.g. 10kW/m^2 up to 75-100kW/m^2), can be set using the ConeCalc software
- Cone temperatures relating to heat fluxes are established before the test using the Heat Flux Calibration routine in the ConeCalc software

Motorised Heat Shield

- Automatic/Manual control of a split shutter mechanism via 4" touchscreen or ConeCalc software to protect specimen from heat exposure before test
- Ensures the initial mass measurement is stable and the operator has additional time for system checks before starting the test. This added time is very important for easily-ignitable samples, which often ignite prematurely if a shutter mechanism is not used.

Specimen Holders

- Made of stainless steel
- For specimens 100mm × 100mm up to 50mm thick, in the horizontal and vertical orientation

Specimen Spacers

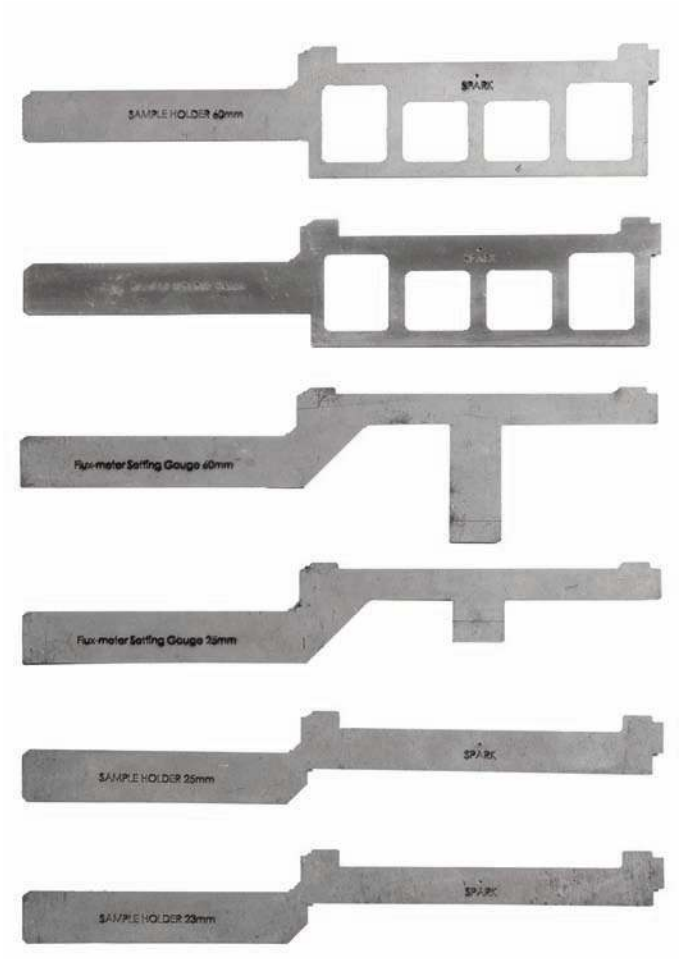
- A set of 6 different specimen spacers are provided for easy and precise adjustment

Load Cell

- Mass measurements are taken using a strain gauge load cell with a resolution better than 0.01g
- Mounted on an independent table to avoid any vibration from exhaust fan

Spark Ignition

- 10 kV spark generator fitted with a safety cutout device
- Automatic positioning and control of spark igniter via 4" touchscreen or ConeCalc software to ignite the combustion gases from the specimen



Specimen spacers

4" touchscreen

Glass Protective Screen

- Made of heat resistant glass
- Manual and automatic control via 4" touchscreen or ConeCalc software
- Provides a large draft-free environment around the fire model
- When in the lower position, the screens are retracted below the large working granite surface which allows unrestricted access to the fire model
- Screen assembly rises from below the working surface to enclose the specimen area on all four sides

Exhaust System

- Manufactured from stainless steel for long life
- Comprising large hood (to ensure all combustion gases collected), gas sampling ring probe, exhaust fan (with adjustable flow controls from 0-50g/s, at a resolution of at least 0.1g/s) and an orifice plate flow measurement (thermocouple and differential pressure transducer)
- Normal operation is at a nominal 24 ℓ/s (range 0-50 ℓ/s)

Gas Sampling

- Comprising soot filters, pump, moisture (CO_2 removal traps if not measured) and mass flow controller (MFC). The MFC allows maximum control of flow to the analyser during calibration and test reducing errors and drift

Combustion Gas Analysis

- Paramagnetic oxygen analyser with a range of 0-25% O_2 and a performance compliant with the standards
- Nondispersive infrared detectors with a range of 0-10% CO_2 and 0-1% CO (option)
- Developed specifically for **FTT** calorimeter this analyser features low drift, low noise and fast response

Smoke Obscuration

- Measured with a laser system, using Silicon photodiodes, and a 0.5mW Helium-Neon laser, with main and reference (compensating) photo detectors
- Supplied with alignment cradle and 0.3, 0.8 neutral density filters for calibration

Heat Flux Meter

- For setting the irradiance level at the surface of the specimens
- The heat flux is automatically set using the ConeCalc software, heat flux meter and temperature controller

Calibration Burner

- For calibrating the rate of heat release measured by the apparatus using methane of 99.5% purity. Mass flow of methane is controlled via ConeCalc software and a mass flow controller for optimising accuracy of the system calibration

4" Colour Touchscreen and PLC Control System

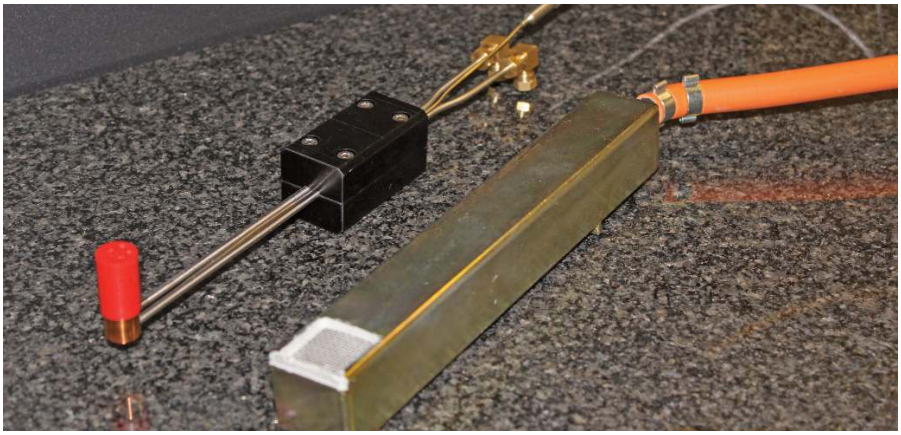
- Simple to use HMI user interface and set-up menus for operating the Cone Calorimeter and providing control and display of all main system parameters, e.g.
  - Frequency of Exhaust Blower
  - Spark igniter positioning (in-out) and control (on-off)
  - Fire Model Heat Shield control
  - Fire Model Glass Protection Screen control
  - Height adjustment of Heater
  - Water flow indicator for Heat Flux Meter
  - Fire Model Protection Alarm System

Data Acquisition

- Data Acquisition/Switch Unit featuring a 3-slot cardcage with up to 6½ digit (22 bit) internal DMM enabling up to 120 single-ended or 48 double-ended measurements. Scan rates up to 250 channels/s are available with a USB and Ethernet interface as standard. All readings can be automatically time stamped and can be stored in a non-volatile 50,000-reading memory

ConeCalc Software

- User-friendly Windows based ConeCalc user interface with push-button actions, data entry fields and capable of:
  - Instrument control and showing status of the instrument
  - Fully automatic calibration of gas analysis instrumentation and storage of calibration results
  - Fully automatic C-factor calibration with the use of mass flow controller
  - C-factor calibration via pool fire (ethanol) routine
  - Collecting data generated during a test
  - Calculating the required parameters
  - Averaging of multiple tests
  - Presenting the results in a manner in accordance with ISO 5660-1, ASTM E1354 and EN 45545-2
  - Exporting calculated data to CSV (comma separated variable) files for quick transfer to spreadsheets.



Heat flux meter and calibration burner

Test Parameters

- Heat flux (kW/m^2)
- Flow rate in exhaust duct (ℓ/s)
- C-factor (m$^{1/2}$ · kg$^{1/2}$ · K$^{1/2}$)
- Ignition time and extinction time (s)
- Heat release rate (kW/m^2)
- Smoke production rate (m^2/s)
- Mass loss, Mass loss rate (g, g/s)
- Effective heat of combustion (MJ/kg)
- Specific extinction area (m^2/kg)
- CO_2 yield (kg/kg)
- CO yield (kg/kg)
- Total heat release (MJ/m^2)
- MARHE (kW/m^2) [Maximum average rate of heat evolved]
- Total oxygen consumption (g)

Options

- Integrated 17" Touchscreen and 1u keyboard with touchpad and drawer
- Integrated Computer system
- Integrated Carbon Dioxide and Carbon Monoxide – NDIR gas analysers
- Sartorius Load Cell (increased range)
- Soot Mass Sampling
- Large Cone Fire Model (ISO/TS 5660-4, ASTM E2965) – for testing samples 150mm × 150mm and gives uniform heat flux over entire sample surface
- Controlled Atmosphere Attachment – for testing specimens in low oxygen atmospheres (0-21%) that may be found in well developed fires, or for studying the effects of gaseous suppressants or other dynamic controlled-atmosphere environments. The cone assembly is located on top of the enclosure with exhaust gas exiting through the cone only. The cabinet replaces the conventional cone assembly but uses the same controllers as the normal cone. There is a door on the front of the assembly with a viewing window. Changing between the standard fire model and this unit is simple.

17" touchscreen PC and ConeCalc software

The Cone Calorimeter is fitted with a gas mixing attachment to mix air and nitrogen which can be supplied at flows between 0-200ℓ/min to the chamber. The gas supply lines are fitted with flow meters and flowstat

Large Cone Fire Model and Control Unit

flow controllers and a mixing chamber. These are external to the enclosure chamber and housed in a mobile control unit

- FTIR – The **FTT** FTIR is an advanced gas analyser used for continuous measurement of combustion gases in conjunction with **FTT**'s Cone Calorimeter, Smoke Density Chamber or SBI. The analysis of gases in fire effluents is very complex and challenging due to the great number of different organic and inorganic 17" touchscreen PC and ConeCalc software chemicals which these atmospheres can contain. **FTT**'s FTIR is fully configurable to meet the requirements of several international standards including ISO 19702, ISO 9705 and EN 45545-2. It is capable for individual analysis of airborne concentrations of CO, CO_2, NO, NO_2, SO_2, HCl, HF, Phenol, Acrolein, water vapour, etc. The **FTT** FTIR is a modular construction comprising of FTIR gas analyser, heated sampling unit and a touch screen PC which are mounted in a 19" rack
- Cone Corrosimeter. Built in accordance with ASTM D5485 and used for assessing the corrosive potential of combustion products

FTIR Combustion Gas Analysis System

Controlled Atmosphere Attachment

Flexibility with FTT Calorimeters

All modern heat release measurements use oxygen consumption calorimetry. The analysis and instrumentation used for quantitative oxygen, carbon monoxide and carbon dioxide measurements in both large and small calorimetry have similar specifications. Thus a single set of instrumentation can be used for many tests. **FTT**'s *i*Cone *plus* houses the common gas analysis instrumentation, higher capacity pumps and gas handling filtration required for Large Scale Calorimeters [e.g. ISO 9705, Furniture Calorimeters, Cable Propagation Rigs (EN 50399), SBI Apparatus (EN 13823)] in a separate rack from the main Cone Calorimeter housing. The instrumentation can then conveniently be used both for *i*Cone^{2+} and Large Scale Calorimeters.

Gas Analysis Rack

When used with the Cone Calorimeter, the analysis rack is elegantly located with the *i*Cone^{2+} unit. When required for the Large Scale Calorimeter this gas analysis rack is quickly decoupled from the *i*Cone^{2+} main frame and transferred, on the factory-fitted castors, to the new location for equally quick connection to power and sampling lines of the larger calorimeter.

FTT calorimeters are designed to have interchangeable modules that give our clients maximum operational or upgrade flexibility. The analysis systems of the *i*Cone^{2+} can be transported to large calorimeters within minutes. Almost all ducted rigs like the IEC 60332-3 can be readily converted to large calorimeters by use of the rack from the *i*Cone^{2+} and an instrumented duct insert which **FTT** provide. The latter houses all necessary gas sampling, temperature and duct flow rate probes.

Features of *i*Cone^{2+}

- Remote cone assembly positioning control, so that heater-specimen surface separation can be adjusted pre- and mid-test, to facilitate testing of intumescing or thermally distorting specimens
- Programmable heat flux exposure. Up to 10 consecutive heat flux ramping or holding can be programmed
- Motorised heat shield to protect specimen from heat exposure before test
- Automatic positioning and control of spark igniter to ignite the combustion gases from the specimen
- Retractable 4-sided heat resistant glass protective screen which provides a draft-free environment around the fire model with clear viewing from all sides
- Heat resistant glass protective screen manually or electronically controlled
- 4" colour touchscreen test control panel adjacent to specimen supplements principal computer control
- Automatic calibration by ConeCalc Software
- Load cell resolution of 0.01g and load capacity up to 8.2kg (Sartorius cell)
- Load cell mounted on an independent table to avoid any vibration from exhaust fan
- All round access to specimen platform for specimen preparation and cleaning
- Easy to clean large, highly durable black granite working surface
- Fire model protection alarm system
- Online support and remote control of instruments from **FTT** for internet connected system
- Optional post-test specimen fume cupboard (N_2 purged)
- Optional larger Cone fire model for testing specimens with very low heat release rates. 150mm × 150mm specimens are exposed to uniform heat flux over entire surface

Unrivalled Experience in Design and Manufacturing

FTT's site in East Grinstead, is home to the largest group of fire scientists and instrumentation design engineers working on fire testing instrumentation, and is at the heart of our design and manufacturing. For almost 30 years **FTT** has provided the highest quality instruments and service for fire testing and research professionals worldwide, directly and through its extensive global sales and support network.

Quality

- World-class manufacturing in accordance with multiple international and national standards, including: EN, ISO & ASTM
- ISO 14001, ISO 9001 certified

Integrity

- A dedicated team passionate about fire testing instrumentation and continuous product improvement
- Delivering reliable, robust and easy-to-use instruments for the past 30 years

Excellence

- A world-class team made up of qualified fire scientists, mechanical, electrical and electronic fire instrument design engineers and production, installation and maintenance engineers

Global

- World-wide distribution network for global sales, installations, training, maintenance and technical support
- Leading global supplier of the Cone Calorimeter, Large Scale Calorimeter, NBS Smoke Chamber and Oxygen Index

Truncated Conical Heater and Fire Model

Element

- 5kW electrical heating element

Heater

- Heat flux up to 75-100kW/m^2
- Motorised height adjustment and control via 4" touchscreen during test for materials that intumesce
- Heat flux can be gradually increased during test in 10 pre-determined steps and automatically controlled via software, e.g. 10kW/m^2 increases up to 100kW/m^2

Heat shield

- Motorised
- Automatic/Manual control via 4" touchscreen or software to protect specimen from heat exposure before test

Spark igniter

- Automatic positioning and control via 4" touchscreen or software to ignite the combustion gases from the specimen
- Spark gap of 3.0mm located 13mm above the centre of the specimen

Heat resistant glass protective screen

- Manual and automatic control via 4" touchscreen or software
- Provides a draft-free environment around the fire model
- When in the lower position, the screens are retracted below the large working granite surface and allows unrestricted access to the fire model
- Screen assembly rises from below the working surface to enclose the specimen area on all four sides

Large cone fire model (optional)

- For testing samples 150mm × 150mm
- Uniform heat flux over entire surface

Specimen Holder, Weighing Device & Specimen Handling

Specimen holder

- A square pan with an opening of 106mm × 106mm at the top, and a depth of 25mm, constructed from stainless steel

Retainer edge frame

- A stainless steel frame with inside dimension 111mm × 111mm, and opening of 94mm × 94mm

Sample size

- 100mm × 100mm

Sample thickness

- Up to 50mm

Load cell

- Resolution of 0.01g
- Mounted on an independent table to avoid any vibration from exhaust fan

Load capacity

- Up to 8.2kg (Sartorius Load Cell)
- Up to 5.0kg (Standard Load Cell)

*i*Trap

- Moisture removal controlled by a microprocessor with built-in stainless steel heat exchanger
- Adjustable set-point temperature
- Status display

Black granite working surface

- Easy to clean, durable
- Additional working space compared with traditional Cone Calorimeters

Exhaust Gas System with Flow Measuring Instrumentation

Duct diameter

- 114mm

Nominal exhaust flow rate

- 24 ℓ/s

Orifice plate

- Internal diameter 57mm located in chimney to measure duct flow

Sampling ring

- 685mm from the hood, contains 12 small holes with a diameter of 2.2mm

Gas sampling apparatus

- Incorporates a pump, soot filter, moisture and CO_2 removal traps, mass flow controller (for precise control of flow to analyser and reducing drift) controlled via software

Soot mass sampling (optional)

- Operated by mass flow controller automatically from software

Calibration Burner

Construction

- A tube with a 500mm^2 square orifice covered with wire gauze

Control

- Methane flow controlled at required heat release using a mass flow controller

Instrumentation for Oxygen and Gas Analysis

19" Gas analysis rack

- Detachable to be used with other large scale calorimeters, e.g. SBI, Room Corner test, etc.

Oxygen analyser

- Paramagnetic type with a range of 0-25% Oxygen. t_{10}-t_{90} response time less than 12s. Drift typically less than 20ppm in 30 minutes
- Low noise. Specially designed by Servomex solely for **FTT**

Carbon dioxide (optional)

- Non-dispersive infrared type with a range of 0-10%. Fast response. Specially designed by Servomex solely for **FTT**

Carbon monoxide (optional)

- Non-dispersive infrared with a range of 0-1%. Fast response. Specially designed by Servomex solely for **FTT**

Smoke Density Measurement

Light source

- 0.5mW Helium-Neon laser beam

Detector

- Silicone photodiode

Data Logger

Resolution

- Up to 22 bits

Recording time

- Up to 250 channels per second

Storage

- Raw data recorded for each test is stored and can be retrieved

4" Colour Touch Screen and PLC Control System

Simple to use HMI user interface and set-up menus for operating the Cone Calorimeter and providing control and display of all main system parameters, e.g.

- Frequency of Exhaust Blower
- Spark igniter positioning and control
- Fire Model Shield control
- Fire Model Glass Screen control
- Height adjustment of Heater

17" Touch Screen PC (inside Gas Analysis Rack)

User-friendly Windows based ConeCalc user interface with push-button actions and data entry fields and capable of:

- Instrument control and showing status of the instrument
- Fully automatic calibration of gas analysis instrumentation and storage of calibration results
- A temperature profile during the test, consisting of up to 10 steps, can be set in order to automatically set the heat flux onto the specimen
- Fully automatic C-factor calibration with the use of mass flow controller
- C-factor calibration via pool fire (ethanol) routine
- Collecting data generated during a test
- Calculating the required parameters
- Presenting the results in a manner in accordance by ASTM E1354, ISO 5660-1 & 2 and EN 45545-2

Test Parameters

- Heat flux (kW/m^2)
- Flow rate in exhaust duct (ℓ/s)
- C-factor ($m^{1/2} \cdot kg^{1/2} \cdot K^{1/2}$)
- Ignition time and extinction time (s)
- Heat release rate (kW/m^2)
- Smoke production rate (m^2/s)
- Mass loss, Mass loss rate (g, g/s)
- Effective heat of combustion (MJ/kg)
- Specific extinction area (m^2/kg)
- CO_2 yield (kg/kg)
- CO yield (kg/kg)
- Total heat release (MJ/m^2)
- MARHE (kW/m^2)
  [Maximum average rate of heat evolved]
- Total oxygen consumption (g)

Vitiated Atmosphere System (optional)

For testing reduced oxygen atmospheres – 0% to 21%

FTIR Toxicity Test Apparatus (optional)

Measuring Principle

- FTIR (Fourier Transform Infrared)

Performance

- Unlimited simultaneous analysis of multiple gases
- Pre-loaded analysis for 21 gas species
- User-friendly and comprehensive software package to enhance gas analysis
- Detachable 19" rack system which can be disconnected and used with other fire test applications

Zero Point Calibration

- 24 hours, calibration with Nitrogen (5.0 or higher N_2 recommended)

Zero Point Drift

- < 2% of measuring range per zero point calibration interval

Sensitivity Drift

- None

Linearity Deviation

- < 2% of measuring range

Temperature Drifts

- < 2% of measuring range per 10 K temperature change

Pressure Influence

- Pressure measured and compensated for in gas cell

Gas Species:

- H_2O
- SO_2
- CH_4
- Phenol
- CO_2
- HCl
- C_2H_6
- Acrolein
- CO
- HCN
- C_3H_8
- COF_2
- NO
- HBr
- C_2H_4
- NO_2
- HF
- C_6H_{14}
- N_2O
- NH_3
- HCHO

Service Requirements

Electric:

220-250VAC, 28A, 50/60 Hz. Single Phase for the main frame
220-250VAC, 6A, 50/60 Hz. Single Phase for the gas analysis rack

Water:

210 kPa (30 psi)

Exhaust Extraction:

250-500 ℓ/s

Standard Gases:

Oxygen-free Nitrogen, Methane (UHP 99.5%)

Optional:

CO 0.85%, CO_2 8.5%, balance nitrogen

Due to the continuous development policy of FTT technical changes could be made without prior notice.