Common test methods for cables under fire conditions

(EN 50399; IEC 60332-3)

firetesting technology

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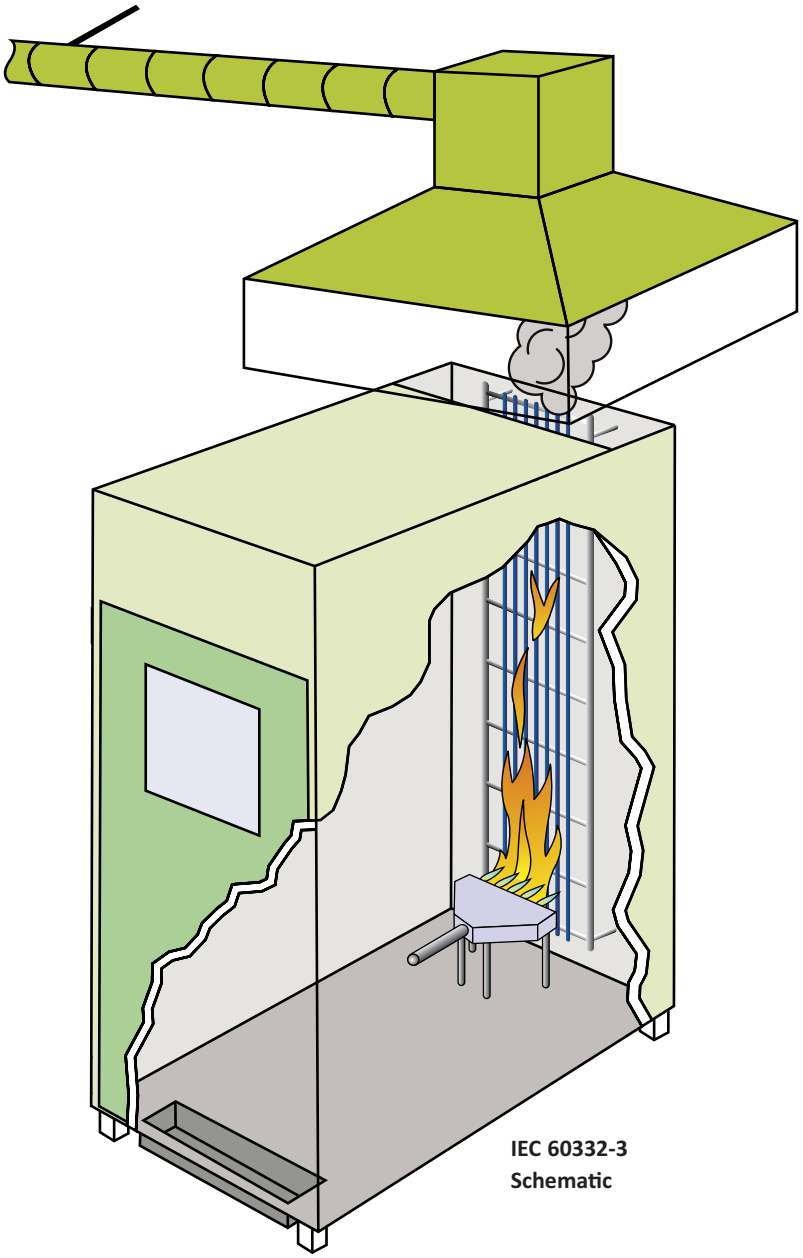
Heat release and smoke production measurement on cables during flame spread test. (Test apparatus also meets IEC 60332-3 series tests specification)

Construction Product Regulations

Traditionally electric cables have not been included or classified in national building regulations. The inclusion of electric cables within the Construction Products Regulations (CPR) changes this situation. Cables are to be tested using 5 test methods, and classified by the provisions of EN 13501-6 which is a parallel standard in the existing CPR classification standard EN 13501-1. EN 13501-6 covers electric cable requirements and defines all the test methods and performance criteria that must be met in order for a cable to meet a particular fire classification (A_{ca}, $B1_{ca}$, $B2_{ca}$, C_{ca}, D_{ca} and E_{ca}).



IEC 60332-3 Schematic

According to EN 13501 Part 6: "Classification using data from reaction to fire tests on electric cables", cables are tested using 5 test methods in which the EN 50399 is the major test protocol for Classes $B1_{ca}$, $B2_{ca}$, C_{ca} and D_{ca}. This test protocol was developed by SP (Sweden), ISSeP (Belgium), CESI (Italy) and Interscience (UK) with the help of **FTT** fire scientists, in an EU funded project called FIPEC, Fire Performance of Electric Cables. The FIPEC project included a study of cable installations and relevant reference scenarios as well as a comprehensive test program of different families of cables. This, together with subsequent industry test programmes, was used in the development of the proposal for the European testing and classification system. The classification utilises the results obtained from IEC 60332-3 test equipment fitted with heat and smoke release measurement instrumentation.

IEC 60332 Series Tests on electric and optical fibre cables under fire conditions

Parts 1 and 2 of IEC 60332 specify methods of test for flame spread characteristics for a single vertical insulated wire or cable. IEC 60332 Part 3 specifies methods of test for the assessment of vertical flame spread of vertically mounted wires or cables, electrical or optical.

Gas mass flow control, ignition and flame detection system mounted on the Gas Diverter plate (cover not shown)

Gas control box mounted on wall

FTT IEC 60332-3 Series Test Apparatus

The test rig comprises of a vertical test chamber of 1000mm (W) × 2000mm (D) × 4000mm (H); the floor of the chamber is raised above ground level. The test chamber is nominally airtight along its sides, air being supplied at the base of the test chamber through an aperture of 800mm × 400mm situated 150mm from the front wall of the test chamber.

The standard requires the air flow rate to be 5000 l/min, measured at the inlet before the test commences. This parameter can be regulated during the test.

An outlet of 300mm × 1000mm is at the rear edge of the top of the test chamber. The back and sides of the test chamber are thermally insulated to give a coefficient of heat transfer of approximately 0.7W/(m^2·K). The distance between the ladder and the rear wall of the chamber is 150mm and between the bottom rung of the ladder and the ground 400mm. Cables can be mounted on two types of ladder; a standard ladder of 500mm width and a wide ladder of 800mm width.

Side view of cable test chamber, hood and ducting

Front view of cable test chamber and hood

This apparatus also consists of all inlet air and exhaust ducting, gas supply and control system, and two 20.5kW propane burners as specified in the IEC 60332-3 standard.

EN 50399 Common test methods for cables under fire conditions – Heat release and smoke production measurement on cables during flame spread test

IEC 60332-3 apparatus can be modified to measure heat release and smoke production by fitting a small instrumented section of ducting into the exhaust system of the rig and using this with associated **FTT** gas analysis instrumentation and software and using a modified test protocol.

The standard specifies the cable mounting methods and both the air inlet duct design and air flow rates into the chamber. The combustion gases are collected in a hood above the test chamber and conveyed through an exhaust system which contains a duct section housing the sampling probes, thermocouples, mass flow probes and smoke measuring system. Test results are calculated from data on continuous measurement of the oxygen consumed and carbon dioxide generated in the combustion process using **FTT**'s data acquisition and analysis software.

The Heat Release and Smoke Production Measurement Apparatus includes:

1. Probe and Sensor Duct Section

A stainless steel duct section of approximate dimensions 0.4m diameter by 0.762m long fitted to an exhaust system. The duct will contain ports for:

- Sampling tube for flue gas extraction (for gas analysis)
- Smoke obscuration system
- Mass flow monitoring
- Thermocouple for measuring exhaust gas temperature

Duct section for EN 50399

19" Gas Analysis Rack

DIN 50055 white light system

By connecting this duct section to the gas analysis rack the client is able to make measurements on the effluent from the rig to determine oxygen consumption and carbon dioxide production in the exhaust duct to calculate heat release and smoke density in the exhaust duct with either the DIN 50055 white light system or laser smoke system.

2. Gas Analysis Instrumentation

Heat release measurement is obtained by sampling combustion products from the exhaust and computing heat release rates from the volume flow rates and the measured oxygen consumption and carbon dioxide generation in the combustion products. Instrumentation is housed in a 19" rack that can be placed in the laboratory.

The 19" rack cabinet contains:

- Paramagnetic oxygen sensor with flow control and by-pass for fast response
- Infrared carbon dioxide sensor (0-10%) with flow control and bypass for fast response
- carbon monoxide sensor (0-1%) with flow control and bypass for fast response (Optional)
- Pressure compensation performed in analyser software

Flue gas conditioning train comprising:

- Soot filtration
- Refrigerant cold trap
- Drying columns
- Pump and waste regulators

Instrumentation for volume flow measurement:

- Bi-directional probe
- Differential pressure transducer

Clients already owning the **FTT** Dual Cone Calorimeter, ISO 9705 Room Corner Test or EN 13823 SBI Test can use their gas analysis instrumentation to measure heat release rate of the EN 50399 test. Alternatively the EN 50399 gas analysis instrumentation can be used with other **FTT** calorimeters (e.g. Dual Cone Calorimeter, ISO 9705, SBI, etc.).

3. Smoke Measurement Systems

FTT offers two smoke measurement system options, laser or white light systems. The laser system is similar to that used in the Cone Calorimeter and complies with that specified in ISO 5660. The white light system is similar to that used in the SBI test and constructed to DIN 50055.

- **Density Photometric System DIN 50055**
  A photometric system consisting of a white light source and lens, a silicon photodiode detector, along with housings and controls.

  The photodiode detector consists of an achromatic system of lenses, a silicon photo-electric cell and a high-gain low-noise amplifier. The latter is capable of measuring relative light intensity against time as percentage transmission continuously over the ranges to be studied. The system has a linear response with respect to transmission and an accuracy

Test chamber interior detail with propane burner

of better than ±1.5% of the maximum reading. The photodiode is housed in an assembly with a collimating lens, in a tube mounting on the side of the exhaust duct.

- **Laser Smoke System**
  As an alternative to the DIN 50055 system, a laser smoke system can be used.
  It features a 0.5mW Helium Neon laser smoke and support system, power supplies, calibration and zeroing device for smoke extinction coefficient. The detector output is designed with a Main and Compensating Detector to eliminate drift and is supplied with 0.3 and 0.8 neutral density filters for calibrating the unit. Calibration and calculation of the associated smoke obscuration parameters can be performed by **FTT** software.

4. Data Acquisition and Analysis Software

The signals are collected using a Data Acquisition Unit. A Windows based software package enables data acquisition and analysis to determine the various parameters needed for heat release determination.

5. Burner Gas Control Unit

The system supplied comprises of a gas flow control and ignition system for the burner. A spark igniter is provided and a type-K thermocouple monitors the presence of a flame. Two mass flow controllers (MFCs) control the propane gas and air flow and a Venturi air gas mixer.

Each MFC is housed on the 'Gas Diverter' plate fitted on the outside wall of the test chamber. This is normally protected behind a cover.

The Gas Control Box enables each gas to have 3 pre-set levels. After pre-setting, the burner output can be switched between these levels. It also houses the numerous power supply units for the MFCs and solenoid valves, the ignition system and controls for the safety features.

The signals from the MFCs are displayed on screen using **FTT** CableSoft software, which shows the mass flow rate of the respective gas and the corresponding heat output and facilitates any required adjustment. The mass flow rate of each gas is also stored by the software enabling heat release from the burner to be subtracted from the total measured heat release rate (of specimen and burner) so that the heat release rate from the specimen alone can be determined.

CableSoft Software

The **FTT** EN 50399 test apparatus uses sophisticated instrumentation and we supply the CableSoft software package to make the calibration and use of the instrument as easy as possible.

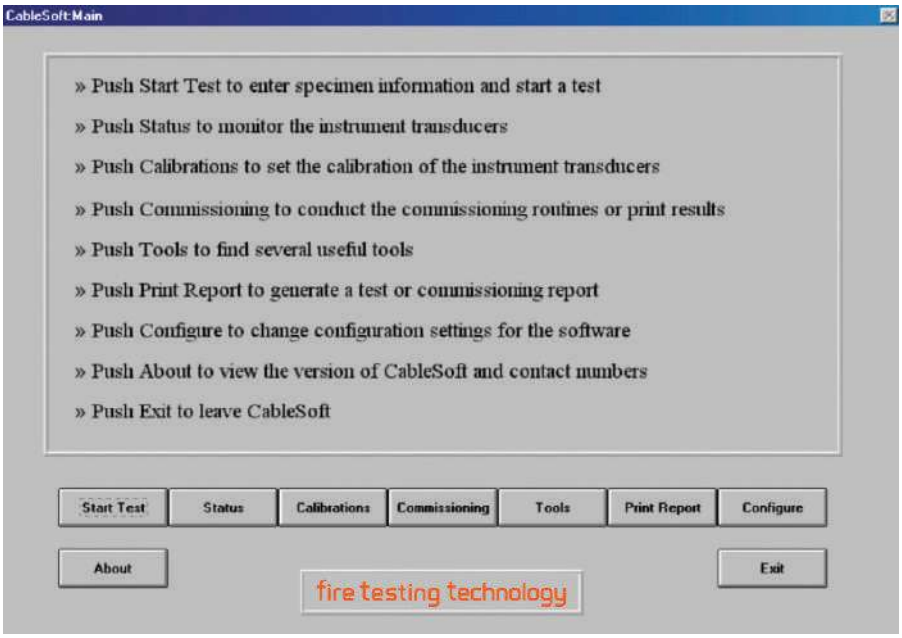
CableSoft is a powerful, yet easy to use, Microsoft Windows based application that allows the user to perform most operations required on the apparatus with a computer. It is based on push buttons and Windows data entry boxes and selectors and capable of:

- Showing the status of the instrument
- Calibrating the instrument and storage of calibration results
- Collecting data generated during a test
- Calculating the required parameters
- Presenting the results required by the Standards

All the functions available in CableSoft can be accessed from the Main Menu which offers 7 options:

- **Start Test**

This allows quick and easy setup of a test with the cable and ignition



Main menu of CableSoft

burner or a set of dummy tests which should be conducted every day to check the system is working correctly.

- **Status**

This displays the signals from all the transducers and shows the exhaust volume flow rate, inlet air volume flow rate, the heat release rate from the burner, the mean duct temperature and the extinction coefficient.

- **Calibrations**

This allows the user to calibrate the transducers in the system. These are oxygen, carbon dioxide and (if fitted) carbon monoxide cells, differential pressure transducer, smoke system (white light or laser) and the gas and air mass flow meters (if fitted). Each transducer should be calibrated to ensure the validity of the test results.

- **Commissioning**

A set of three commissioning routines are performed to determine the k_t constant used in the calculation of the exhaust volume flow rate before using the test apparatus and after any major changes. These three sets of commissioning routines are determining the flow profile, conducting propane burns at three different heat release levels, and a methanol pool burn. The commissioning results can also be viewed and reports printed.

- **Tools**

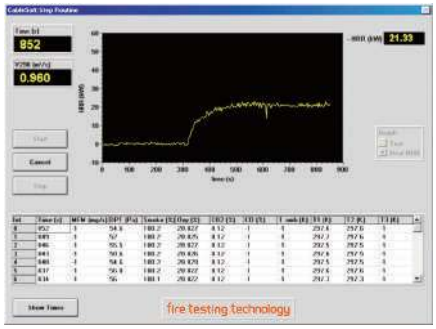
This gives access to the useful tools of Oxygen analyser drift calculator, Smoke system drift calculator, Commissioning kt calculator and Gas flow calculator.

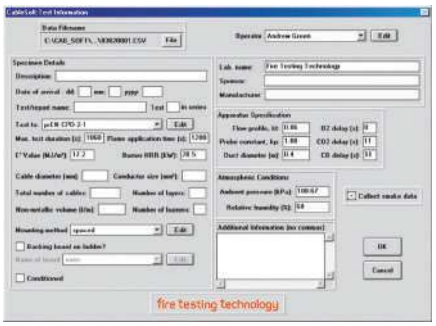
- **Print Report**

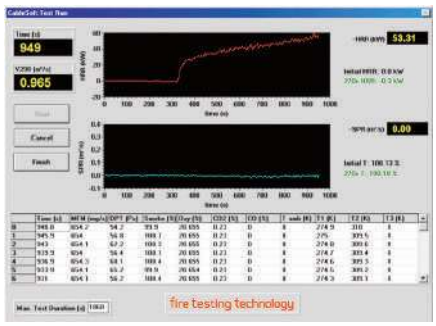
The results from a cable test, a daily check test or the three commissioning tests can be viewed and reports printed.

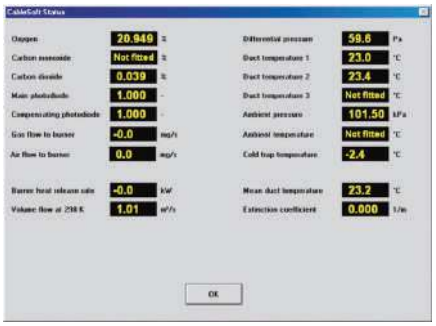
- **Configure**

This allows settings for the software and system to be viewed and modified.









Technical Specification

IEC 60332-3/ EN 50399 Burning Behaviour of Bunched Cable Test

Burners	
Burner	Two 10" ribbon burners • 20.5 kW • Spark ignition • Thermocouple and solenoid valve interlock system for gas safety
Propane Supply System	PLC gas control system
	Venturi mixer
	Mass flow controllers • Burner 1: 0.06-1.2 g/sec for propane • Burner 2: 0.035-0.7 g/sec for propane • Air: 0.21-4.2 g/sec for air

Enclosure and Air Supply	
Enclosure	Vertical test chamber 1000 mm W × 2000 mm D × 4000 mm H; the floor of the chamber is raised above ground level.
	Nominally airtight along its sides, air being admitted at the base of the test chamber through an aperture of 800 mm × 400 mm situated 150 mm from the front wall of the test chamber.
Air Supply	Single inlet centrifugal fan • 480 m^3/hr • Altivar 30 W inverter
Ladder Types	There are two types of ladder; a standard ladder of 500 mm width and a wide ladder of 800 mm width
Ladder Lifting	Electric winch (Max 500 kg) Pulley system

Control Unit	
Control Unit	Solid state gas control system with PLC control 5V PSU 4 process control meters to display process parameters 2 Type K temperature controllers for interlock and safety

Heat Release and Smoke Measurement (For EN 50399 only)	
Analyser	Gas analyser • Paramagnetic oxygen sensor with flow control and by-pass for fast response and pressure compensation • Infrared carbon dioxide (0-10%) sensor with flow control and by-pass for fast response • Can also be supplied with infrared carbon monoxide (0-1%) sensor with flow control and by-pass for fast response
Gas Sampling	Double ended sample pump (diaphragm) • Max flow: 33.0 l/min • Pressure: 2.5 bar Soot filter • Primary: 93% efficiency at 0.01 µm • Secondary: 100% efficiency at 0.3µm Water removal • Chiller unit • Drying columns with desiccant Pressure controller relief valve • Relief pressure 0.07-0.7 bar
Probe and Sensor Duct Section	Stainless steel duct section of approximate dimensions 0.4 m diameter by 0.762 m length containing ports for: 1. Sampling tube for flue gas extraction (for gas analysis) 2. Smoke obscuration system 3. Volume flow monitoring 4. Thermocouple for measuring exhaust gas temperature 5. Thermocouple for measuring gas temperature at smoke measuring position
	By connecting this duct section to an **FTT** gas analysis rack the user is able to make measurements on the effluent from the rig to determine oxygen consumption and carbon dioxide production for calculating heat release and smoke density in the exhaust duct.
Data Acquisition	Signals are collected using a Keysight data acquisition/switch unit • 3-slot cardcage • Scan rates up to 250 channels/s are available with a 115 kbaud RS232 and PCI GPIB interface as standard

Heat Release and Smoke Measurement (For EN 50399 only)	
Smoke Density Photometric System DIN 50055	Light source • Gas filled tungsten filament lamp • Power provided and regulated by a triple output power supply with accuracy ±5% • Housed with an appropriate collimating lens to ensure parallel light projection across the duct, in one of the tube mounting sites on the side of the exhaust duct Photodetector • Achromatic system of lenses • Silicon photo-electric cell and a high-gain low-noise amplifier, which is capable of continuously measuring relative light intensity against time as percentage transmission over the ranges to be studied • Linear response with respect to transmission and an accuracy of better than ±1.5% of the maximum reading • Housed in an assembly with a collimating lens, in one of the tube mounting sites on the side of the exhaust duct • Power provided by a regulated triple output power supply with accuracy ±5% • Active area: 3.6 × 3.6 mm • Spectral response rate: 320 – 1100 nm Calibrated filters • 0.04 Neutral Density • 0.10 Neutral Density • 0.30 Neutral Density • 0.50 Neutral Density • 0.80 Neutral Density • 2.00 Neutral Density
Laser Smoke Measurement (Option)	Light source • 0.5 mW He Ne laser • 632.8 nm Photodetector • Silicon photodiodes Calibrated filters • 0.30 Neutral Density • 0.80 Neutral Density

SEVICES REQUIRED	
Extraction	Connected to the **FTT** electric cable fire test rig Continuous extraction of a volume flow of 0.50m³/sec to 2m³/sec
Electrical Power	230VAC 50/60 Hz 10A at the control panel
Air Supply	Pressure regulated clean, oil-free shop air at a maximum flow rate of 200 l/min Alternatively, a small compressor situated on the roof
Gas Supply	Commercial propane 95% minimum purity at a pressure between 3-4 bar

Due to **FTT**'s continuous development policy, technical changes could be made without prior notice.

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