

Fire resistance

ARPRO is a very versatile material with a broad range of applications (automotive, building, HVAC, furnishing, toys...), and fire resistance is an important property for most of the applications.

Below is the set of technical information that covers fire resistance:

1. [Characteristics of ARPRO Black vs. ARPRO FR](#)
2. Burn rate and fire class of ARPRO for different applications:
 - A. [Automotive: ISO 3795](#)
 - B. Electronics:
 - i. [UL 94 \(ISO 9772\)](#)
 - ii. [Glow wire flammability index: IEC 60695-2-12](#)
 - iii. [Needle flame test: IEC 60695-11-5](#)
 - C. [Building: Euroclasses](#)
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 - E. [Toys: ISO 8124-2](#)
3. [ARPRO effective heat of combustion: ISO 5660-1](#)
4. [ARPRO toxicity of smoke: ISO 5660-1](#)

Note: For more information about the data presented, or any aspect of ARPRO performance, [contact](#) your sales representative.

1. Characteristics of ARPRO Black vs ARPRO FR

| ARPRO Black | ARPRO 4135 FR |
|--|---|
| Not self-extinguishing | Self-extinguishing |
| Increasing ARPRO part density or thickness will lower the burn rate. | Decreasing ARPRO part thickness will make the flame stop quicker. |

ARPRO 4135 FR is a flame retardant grade, free of halogenated components according to UL 746 H.

2. Burn rate and fire class of ARPRO in different applications

Requirements of material flammability standards change from one application to another. Tests are different in terms of flame ignition, test procedures, shape and size of samples, and recorded parameters. Therefore, several standards may be required for one application. In addition, flame performance also depends on thickness and density, of the ARPRO part.

A. Automotive: ISO 3795 (FMVSS 302)

This international standard specifies a method for determining the horizontal burn rate of materials used in the occupant compartment of road vehicles. This method permits the testing of materials and parts of the vehicle interior equipment, individually or in combination, up to a thickness of 13mm.

Test method: ISO 3795

Five 356 x 100 x 12.5mm specimens without moulded surface are mounted horizontally in a U-shaped holder and are exposed to a well-defined low-energy flame for 15 seconds in a combustion chamber. The flame is applied to the free end of the samples. The test determines if and when the flame extinguishes, or the time at which the flame passes a measured distance, resulting in a burn rate in mm/minute.

Tested density: ARPRO Black from 25g/l to 200g/l

Test results:

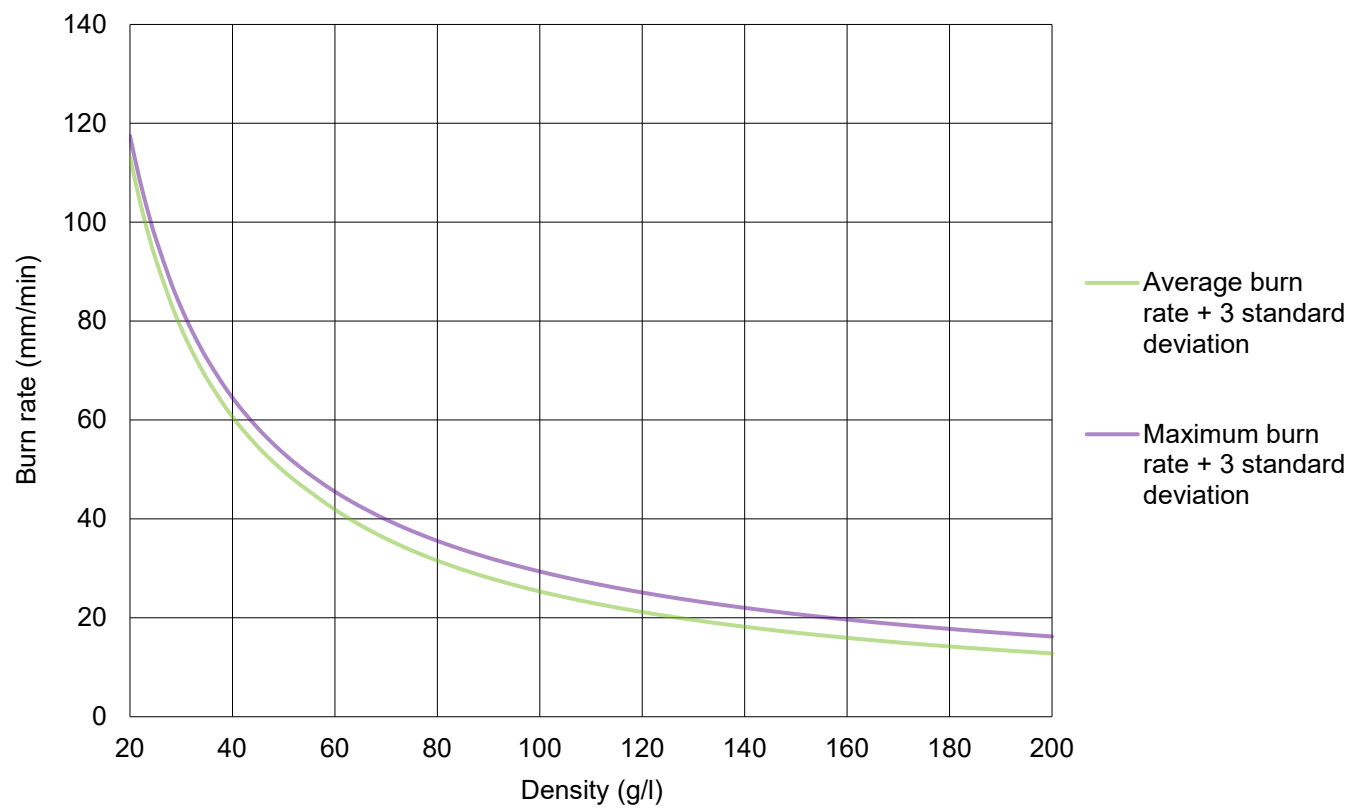
a. Burn rate vs density

To pass the below specifications, we recommend considering the maximum burn rate + 3 standard deviations as it includes the test variation into account. In consequence, ARPRO passes the burn rate criteria presented hereafter, when tested at a thickness of 12.5mm, with a minimum density of:

- 25g/l: to pass the criterion of a maximum burn rate < 100mm/min
- 32g/l: to pass the criterion of a maximum burn rate < 80mm/min

The moulding process variations have to be considered to ensure that the minimum density recommended will be obtained on any moulded part.

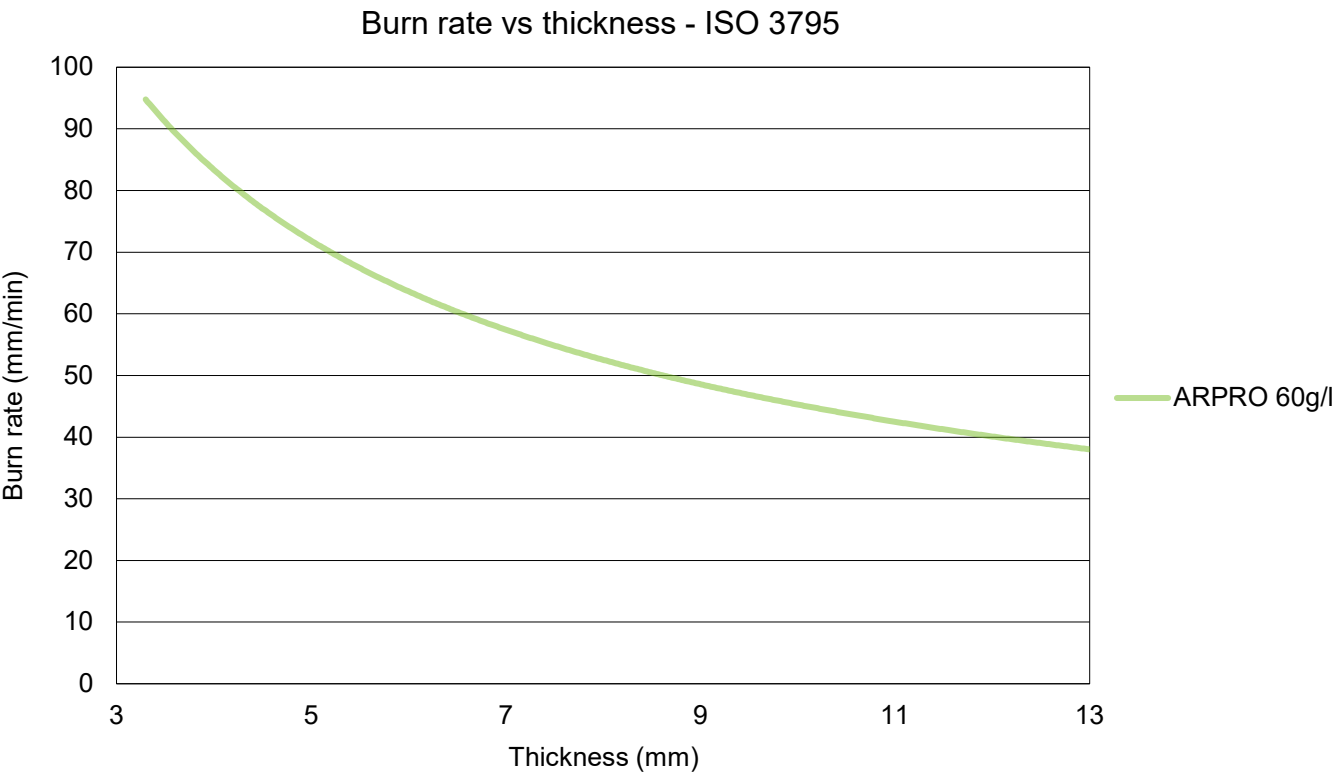
Burn rate vs density - ISO 3795



| Property | Test | Unit | Density (g/l) | | | | | | | | | | | |
|-------------------------|-----------------------|--------|---------------|----|----|----|----|----|-----|-----|-----|-----|-----|-----|
| | | | 20 | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
| Average burn rate + 3 σ | ISO 3795 12.5mm thick | mm/min | 115 | 80 | 60 | 50 | 40 | 30 | 25 | 20 | 18 | 16 | 14 | 13 |
| Max burn rate + 3 σ | ISO 3795 12.5mm thick | mm/min | 120 | 85 | 65 | 55 | 45 | 35 | 30 | 25 | 22 | 20 | 18 | 16 |

b. Burn rate vs thickness

Increasing ARPRO part thickness will lower the burn rate.



B. Electronics:

i. UL 94 (ISO 9772)

The section 12 of UL 94 describes a horizontally oriented burning test procedure. This test is used to compare the relative rate of burning, the extent of burning and the time of burning of cellular polymeric materials, which have a density less than 250g/l. The section 12 of UL 94 is equivalent to ISO 9772.

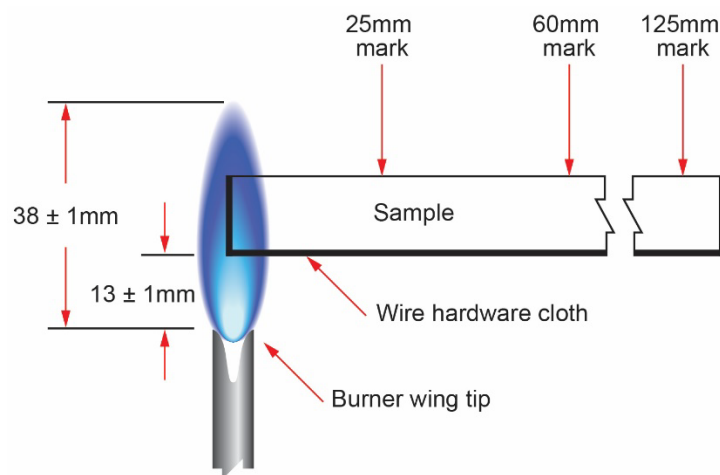
From lowest (least flame-retardant) to highest (most flame-retardant), the following classification system applies:

- HBF: No sample with a burn rate exceeding 40mm/minute over a 100mm span OR each sample ceases to burn before flaming or glowing reaches the 125mm gauge mark
- HF-1 and HF-2: Self-extinguishing behaviour in compliance with the following criteria

| Criterion | HF-1 | HF-2 |
|--|---|---|
| After-flame time | 4/5 samples are $\leq 2s$ 1/5 samples are $\leq 10s$ | 4/5 samples are $\leq 2s$ 1/5 samples are $\leq 10s$ |
| Afterglow time for each individual sample | $\leq 30s$ | $\leq 30s$ |
| Cotton indicator ignited by flaming particles or drops | No | Yes |
| Damaged length for each individual sample | $< 60mm$ | $< 60mm$ |

Test method: Standard test specimens are $150 \pm 5mm$ long by $50 \pm 1mm$ wide, in the minimum and maximum thicknesses covering the thickness range to be considered. Specimens tested by this method are limited to a maximum thickness of 13mm. The flame produced via a burner wing tip having a size of 48mm long by 1.3mm wide. The flame is adjusted to 38mm height. The flame is applied for 60 seconds to the specimen edge. The burning distance and the burn rate are recorded in order to classify the material.

The below picture displays the setup of the apparatus for UL94 horizontal testing.



Test results:

- **ARPRO Black = HBF**

Tested between 55g/l and 140g/l (for a minimum thickness of 8mm)

- **ARPRO 4135 FR = HF-1**

Tested between 20g/l and 60g/l (for a minimum thickness of 3mm)

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ii. Glow wire flammability index of ARPRO: IEC 60695-2-12 (GWFI), IEC 60695-2-13 (GWIT)

The Glow Wire Flammability Index (GWFI) and the Glow Wire Ignition Temperature (GWIT) provide a way of comparing the temperatures at which materials ignite. The apparatus simulates the effect of heat that could be released by electrical components.

Test method: IEC 60695-2-10

The IEC (International Electrotechnical Commission) is the international standard and conformity assessment body for all fields of electrotechnology.

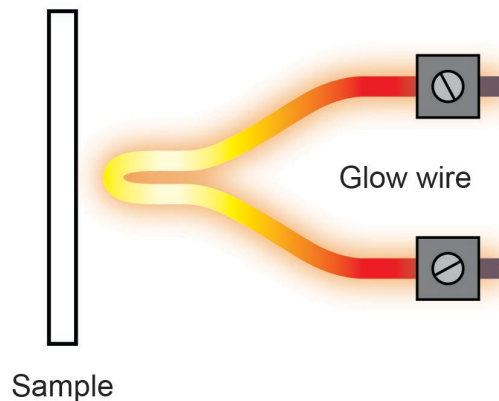
The glow wire is heated to a specific temperature. The test sample is held for 30 seconds against the glow wire. A cotton is placed beneath the sample to determine the effect of burning drops.

The Glow Wire Flammability Index (GWFI) is the highest temperature that satisfies one of the following conditions:

- There is no flame and no glowing (no ignition).
- Burning / glowing is less than 30 seconds after removal of the glow wire and cotton does not ignite.

The Glow Wire Ignition Temperature (GWIT) is set 25°C higher than the maximum temperature at which the glow wire does not cause material burning for more than 5 seconds during three tests.

For the GWFI and GWIT determination, three tests are performed.



Test results:

- ARPRO Black – Effect of density:

| ARPRO Black 3mm | Tested density (g/l) | | |
|--------------------|----------------------|-----|-----|
| | 60 | 80 | 130 |
| GWFI (°C) | 825 | 800 | 800 |
| GWIT (°C) | 850 | n/a | n/a |

- Effect of ARPRO grades and thickness:

| Tested ARPRO grade | Thickness (mm) | | |
|-----------------------|----------------|-----|-----|
| | 3 | 15 | 30 |
| ARPRO Black 60g/l | | | |
| • GWFI (°C) | 825 | 750 | 775 |
| • GWIT (°C) | 850 | 775 | 800 |
| ARPRO 4135 FR 60g/l | | | |
| • GWFI (°C) | 775 | 960 | n/a |
| • GWIT (°C) | 750 | 875 | n/a |
| ARPRO 5135 ESDP 60g/l | | | |
| • GWFI (°C) | n/a | 675 | n/a |
| • GWIT (°C) | n/a | 700 | n/a |

iii. Needle flame test: IEC 60695-11-5

The test is performed to determine if a small flame, that may arise from other ignited components, will cause ignition of the material or if the material will present limited burning and no fire spreading.

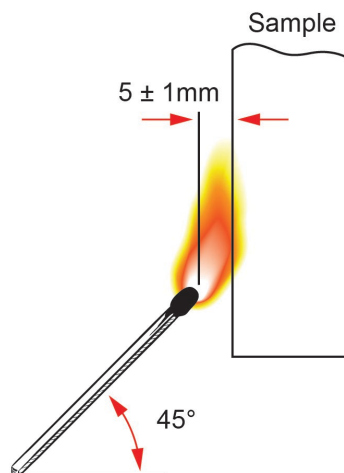
The time of flame application and acceptance criteria (burning duration) depend on individual product specification.

Test method: A 12mm flame is applied for 5, 10, 20, 30, 60 or 120 seconds, according to the product specification, on a representative surface of the sample. A wrapping tissue (lightweight and strong wrapping paper between 12g/m² and 30g/m²) is placed 200mm underneath the sample. 3 test samples, representative of final application are tested.

Duration of burning denotes the time interval from the moment the test flame is removed from the test specimen, until the last flames have extinguished and the glowing of the test specimen, the specified layer and/or the surrounding parts, is no longer visible.

To pass the test one of the following criteria shall be met:

- No flame and no glowing of the specimen and no ignition of the wrapping tissue.
- Flames or glowing extinguish within 30s after the needle flame removal and no ignition of the wrapping tissue.



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Fire resistance properties

Test results:

- ARPRO 4135 FR at 60g/l, with a flame applied for 30 seconds:

| Sample thickness (mm) | 6 | 50 |
|---------------------------|---|----|
| Duration of burning (sec) | 0 | 0 |

- ARPRO Black at 80g/l, with a flame applied for 30 seconds:

| Sample thickness (mm) | 10 | 50 |
|---------------------------|----|----|
| Duration of burning (sec) | 0 | 0 |

ARPRO Black at 60g/l and tested at 10mm and 50mm burns completely for a duration of more than 30 seconds.

C. Buildings: Euroclasses EN 13501-1

EN 13501-1 is the European building code standard that defines flammability of building materials and fire resistance of building elements.

Possible classifications for the EN 13501-1 standard are:

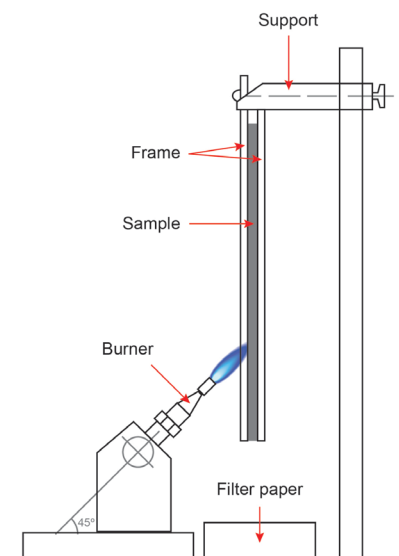
- Euroclass F: no performance criteria.
- Euroclass E: acceptable fire reaction to the attack of a small flame for a short period of time.
- Euroclass D: products satisfying criteria for class E and capable of resisting, for a longer period, a small flame attack without substantial flame spread. In addition, they are also capable of undergoing thermal attack by a single burning item with sufficiently delayed and limited heat release.
- Euroclass C: products satisfying criteria for class D and under single thermal attack by a single burning item, they have limited lateral spread of flame.
- Euroclass B: products satisfying criteria for class C and more stringent requirements on the Fire Growth Rate (FIGRA) and on Total Heat Release (THR).
- Euroclass A2: products satisfying criteria for class B. In addition, under conditions of a fully developed fire these products will not significantly contribute to the fire load and fire growth.
- Euroclass A1: materials are considered incombustible.

According to the class level, different tests have to be performed. The sub-index “s” and “d” are classifications for smoke development and dripping.

Test methods:

- **ISO 11925-2:** Ignition test with a small flame

The test takes place inside a test chamber where the test sample is mounted vertically. The test sample is subjected to edge and/or surface exposure from a gas flame. During the test, time of ignition, burning droplets and whether the flames reach the top marking of the test sample within a prescribed time period or not, are registered. For classifications E or F, the test consists of 15s of flame application. For the classification E, there shall be no flame spread beyond 150mm measured vertically from the point of application of the test flame within 20s from the time of flame application. For the classification F, the product fails to obtain the classification E when tested according to ISO 11925-2.



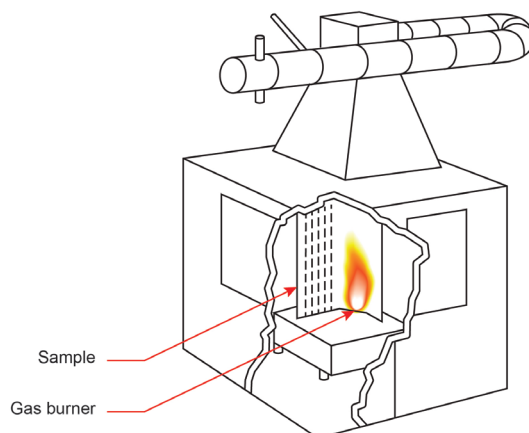
For classes E and F, only the ignition test with a small flame is required. For classes A1, A2, B, C and D the test EN 13823 is required.

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- **EN 13823:** Single burning item

The single burning item test according to EN 13823 consists of lighting a fire at the corner of two plates (1,500 x 1,000mm and 1,500 x 495mm) mounted at right angles. A gas burner with a heat release rate of 30kW is located in the corner during testing. The test time is 21 minutes. The combustion gases are collected through a hood where heat release rate and smoke production are measured.



Test results:

- ARPRO Black:

| Sample thickness (mm) | Tested density (g/l) | | | | |
|-----------------------|----------------------|----|----|----|-----|
| | 20 | 30 | 45 | 60 | 120 |
| 10 | F | F | F | E | E |
| 15 | F | F | F | E | E |
| 20 | F | E | E | E | E |
| 30 | F | E | E | E | E |
| 60 | E | E | E | E | E |

- ARPRO White:

| Sample thickness (mm) | Tested density 70g/l |
|-----------------------|----------------------|
| 10 | E |

- ARPRO 4135 FR

| Sample thickness (mm) | Tested density (g/l) | |
|-----------------------|----------------------|---------|
| | 40 | 60 |
| 10 | C s1 d0 | C s1 d0 |
| 30 | E | E |

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D. Aircraft: certification specification CS25 for large aeroplanes

This certification specifies a method for determining the vertical burning behaviour of materials used in interior compartments occupied by crew or passengers, along with the corresponding requirements.

Test method: CS25.853 App. F Part I (b)

Three samples are mounted vertically in a metal frame and the lower edge of the samples, representative of the actual cross-section of the material or part as installed in the aeroplane, is exposed to the action of a calibrated flame for a certain time, depending on the application. The test determines the average burning length, the average flame time after removal of the flame source, and the dripping extinguishing time.

a. CS25.853 App. F Part I (a) (1) (ii) – 12 seconds vertical burning

Test results: ARPRO 4135 FR

Flame applied for 12 seconds. ARPRO 4135 FR passes the CS25.853 App. F Part I (a) (1) (ii) criteria, at a thickness of 13mm and at a density of 40 and 60g/l.

| Test criterion | Unit | Requirement | Tested density 40g/l | Tested density 60g/l |
|-----------------------------|------|-------------|----------------------|----------------------|
| Burnt length | cm | 20, max | 6 | 6 |
| After-flame time | s | 15, max | 0 | 0 |
| Dripping extinguishing time | s | 5, max | 0 | 0 |

b. CS25.853 App. F Part I (a) (1) (i) – 60 seconds vertical burning

Test results: ARPRO 4135 FR

Flame applied for 60 seconds. ARPRO 4135 FR passes the CS25.853 App. F Part I (a) (1) (i) criteria, at a thickness of 13mm and at a density 60g/l.

| Test criterion | Unit | Requirement | Tested density 60g/l |
|-----------------------------|------|-------------|----------------------|
| Burnt length | cm | 15, max | 10 |
| After-flame time | s | 15, max | 0 |
| Dripping extinguishing time | s | 3, max | 0 |

E. Toys: ISO 8124-2

Test method: Testing is carried out in a specified flammability chamber after a pre-conditioning at a temperature of $20 \pm 5^{\circ}\text{C}$ and a relative humidity of $65 \pm 5\%$ RH for at least seven hours. A flame of 50mm is applied during 5 seconds on a moulded ARPRO block, placed horizontally. Upon removal of the flame, the time of any continued burning is recorded.

Tested density: ARPRO at 60g/l

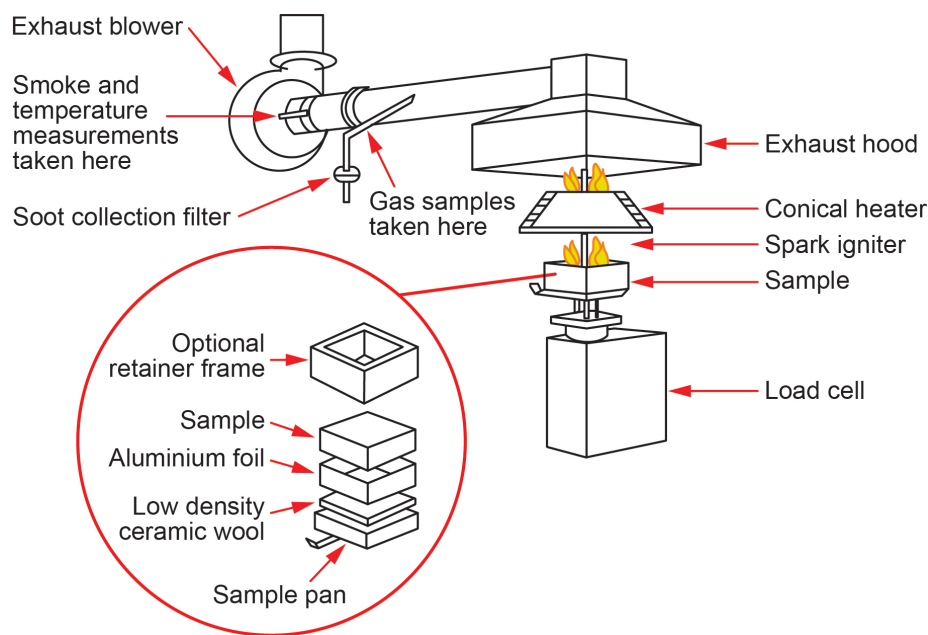
| Grade | Result* |
|-------------------------|---------|
| ARPRO 5135 | Pass |
| ARPRO 4133 | Pass |
| ARPRO 3133 | Pass |
| ARPRO 1133 Blueberry | Pass |
| ARPRO 1133 Dragon Fruit | Pass |
| ARPRO 1133 Orange | Pass |
| ARPRO 1133 Lemon | Pass |
| ARPRO 1133 Lime | Pass |

* Tests performed by an accredited laboratory on ARPRO blocks of 400 x 300 x 80mm with moulded surface.

3. ARPRO effective heat of combustion: ISO 5660-1

ISO 5660-1 specifies a method for assessing the heat release rate of a sample exposed in the horizontal orientation to controlled levels of irradiance with an external igniter. The heat release rate is determined by the measurement of the oxygen consumption derived from the oxygen concentration and the flow rate in the combustion product stream. The “time to ignition” (sustained flaming) is also measured in this test.

Test method: Three samples of 100 x 100 x 25mm have to be tested. The surface of the tested specimen is exposed to a constant level of heat irradiance, within the range 0-100kW/m², from a conical heater. Volatile gases from the heated specimen are ignited by an electrical spark igniter.



Test results:

- ARPRO Black

| | Tested density (g/l) | |
|--|----------------------|----|
| | 50 | 70 |
| Average effective heat of combustion (MJ/kg) | 39 | 40 |

- ARPRO 4135 FR

| | 60g/l |
|--|-------|
| Average effective heat of combustion (MJ/kg) | 34 |

4. ARPRO toxicity of smoke: ISO 5660-1

During its combustion, ARPRO emits gases. Analysis of the gases emitted during combustion enables the determination of whether the smoke produced is toxic or not.

Test method: ISO 5660-1

As in point 3, the surface of the three test specimens of 100 x 100 x 25mm are exposed to a constant level of heat irradiance of 35kW/m² within the range 0 - 100kW/m², from a conical heater. Volatile gases from the heated sample are ignited by an electrical spark igniter and analysed by FTIR (Fourier Transform Infra-Red spectroscopy) during the combustion.

Tested density: ARPRO Black and White at 70g/l

Test results: the following gases have been detected at the described level:

| Gas | ARPRO Black 70g/l | ARPRO White 70g/l |
|-------------------------|-------------------|-------------------|
| CO (kg/kg) | 0.029 | 0.027 |
| CO ₂ (kg/kg) | 2.45 | 2.55 |

The following gases have not been detected:

| Gas | Detection limit (ppm) |
|--|-----------------------|
| NO Nitric Oxide | 2.22 |
| NO ₂ Nitrogen Dioxide | 1.97 |
| NH ₃ Ammonia | 1.75 |
| N ₂ O Nitrous Oxide | 0.53 |
| SO ₂ Sulphur Dioxide | 1.12 |
| HCN Hydrogen Cyanide | 1.42 |
| HCOH Formaldehyde (Methanal) | 7.00 |
| HCL Hydrochloric Acid | 1.54 |
| CH ₄ Methane | 4.75 |
| C ₂ H ₂ Acetylene (Ethyne) | 5.28 |
| C ₂ H ₄ Ethylene (Ethene) | 21.13 |

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