Safelincs®

Fire & Safety Solutions

Fire Extinguisher Guide

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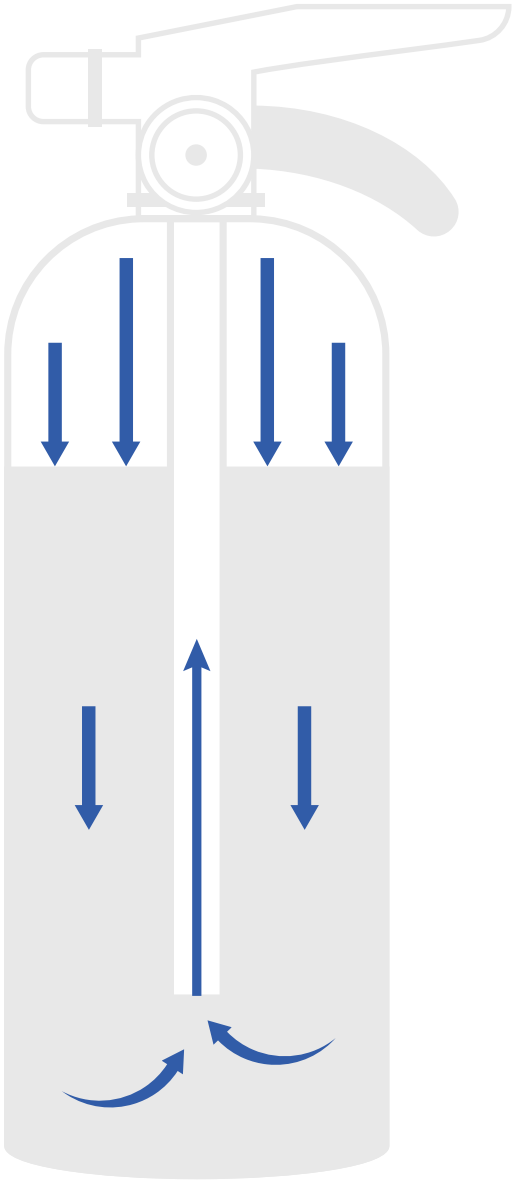
How Are Extinguishers Pressurised?

Stored pressure extinguishers

The cylinder is permanently under pressure, usually at 15 to 20 bar and in general a pressure gauge is fitted to indicate the pressure inside the extinguisher. One exception are CO2 extinguishers which have no pressure gauge.



Pros

- It is easy to determine whether the unit is pressurised. Low costs.

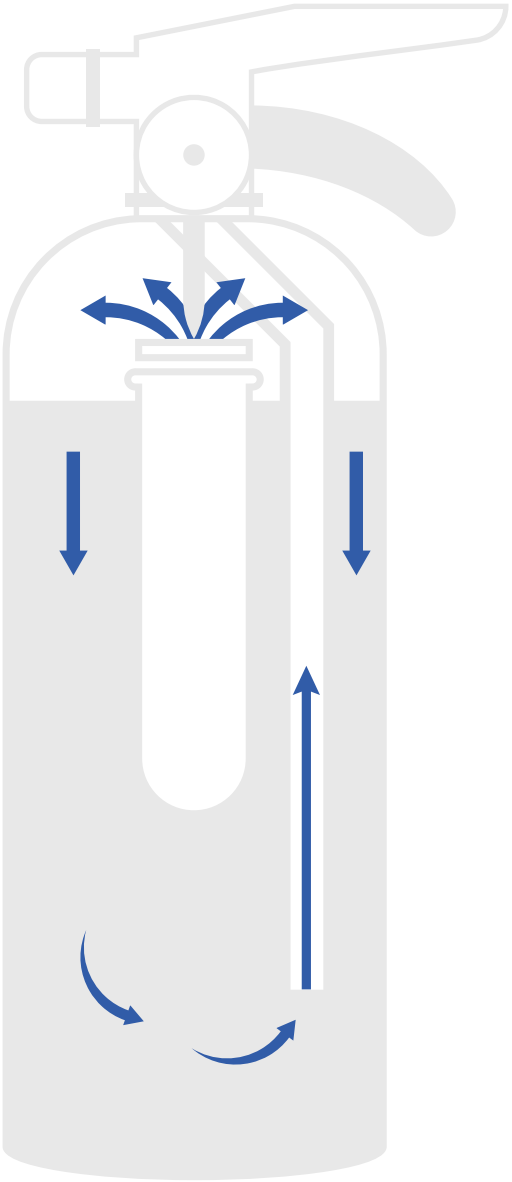
Cons

- Standard portable steel extinguishers need re-filling after 5 years irrespective of whether the media is expired or not. They are difficult to discharge and refill at a customer's site. A lot of extinguishers are therefore service-exchanged and refilled at base. However, some service companies scrap extinguishers after only 5 years, which is an unjustifiable wastage. In contrast P50 service-free extinguishers only need refilling after 10 years and can then be used for another 10 years.

How Are Extinguishers Pressurised?

Cartridge extinguishers

No pressure in the main cylinder until the extinguisher is used, when an internal cartridge containing a propellant gas is pierced and the cylinder is rapidly put under pressure and discharges.



Pros

- Allows opening and closing of extinguisher for inspection without having to discharge media. Easy re-fill and recommission after use without need for nitrogen gas tanks.
- Sometimes used offshore (e.g. boats, oil platforms) because it is essential to have working fire fighting equipment at all times, even after use.

Cons

- More expensive to purchase.
- No judgement can be made from the outside whether the unit is fit for use.
- Sudden pressurisation can be scary and lead to bursting.

The exception – CO2 extinguishers

CO2 extinguishers only contain the actual fire fighting media – carbon dioxide gas at very high pressure (up to 55 bar).

At room temperature and at 55bar the CO2 is neither a proper gas nor a liquid. As a result you cannot ‘hear’ any liquid ‘sloshing’ to know whether the CO2 has been used or might have leaked out. Since there is also no pressure gauge, it is only possible to determine whether the extinguisher is filled by measuring the weight.

The reason no gauge is fitted is that as CO2 is discharged/leaked, more of the non-liquid non-gas mix turns into gas to take its place. The result is that the gas pressure stays constant until the CO2 is virtually all gone. So the gauge reading would be the same all the way through to empty.

In a traditional extinguisher, if the extinguishant escapes then pressure is also lost in the process. But with CO2 this only leads to a pressurised extinguisher with no extinguishant!

So the only way of knowing whether the extinguisher is still filled is to compare the weight with the manufactured weight (more later).

Types of Extinguishers

- Water
- Water with additive (improves performance, not anti-freeze properties)
- Water mist (normal water or de-ionised water)
- AFFF foam
- CO_2
- Powder
- Wet chemical
- Media for burning metal

Water Exinguishers

Ordinary tap water. Almost exclusively rated for Class A fires only.

Pros

- Cheap and can be easily discharged (although in theory the water has to be still treated as waste water).

Cons

- Not very strong fire fighting rating.
- Traditional wisdom is that “water and electricity do not mix”. However, if the extinguisher has been di-electrically tested, water is perfectly safe on live electrical equipment (more later).

NOTE: There have never been any known incidents of electric shock from water-based extinguishers used on live electrical equipment. In reality the RCD (fuse) is likely to trip out, cutting the power.

9Ltr Water Fire Extinguisher - UltraFire

View

Water with Additive Extinguishers

Foaming agent additives are added to increase performance by lowering surface tension so that water spreads out better and soaks in more.

Pros

- Improved fire rating allows for smaller and therefore lighter fire extinguishers. Risk of electric shock is already low with water, but formation of spray will lower this even further.
- UltraFire water with additive extinguishers are low risk even in pure form (typically mild skin irritation). Users only encounter diluted additive and direct contact should be minimal, so the risk is even lower.

Cons

- Chemicals used vary by manufacturer and are often unknown.
- service engineers should still exercise caution due to their frequency of contact and use of pure additive. Follow PPE and handling recommendations made in the COSHH assessments.

3Ltr Water Fire Exintinguisher with Additive - UltraFire

View

6Ltr Water Fire Exintinguisher with Additive - UltraFire

View

Water with Additive Extinguishers

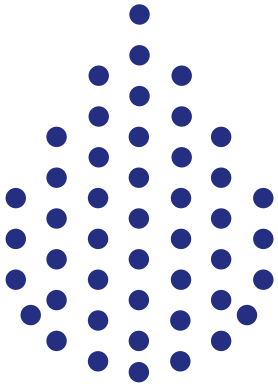
BS 5306-9 (Code of Practice for recharging of portable fire extinguishers) recommends that the manufacturer's original additive should be used in refilling where possible. Any alternative should be approved by the manufacturer.

Water Mist Extinguishers

Mist is made of very fine water droplets (<20 microns). It has been used successfully for years in high pressure kitchen misting systems. Portable water mist extinguishers replicate the fine particles of these systems but at a much lower pressure.

Pros

- The droplets evaporate very close to or on the burning material, cooling the surface rapidly and displacing oxygen. They also absorb smoke particles, visibly ‘cleaning’ the air.
- Broad application. Class A rating (more powerful than normal water), and electrically safe. Also tested and proven effective on class B and C.



Cons

- While some are Class F (fat fires) rated, we do not recommend water mist on deep fat fryers etc, as the water droplets can still cause violent fat fire eruptions.

Water Mist Extinguishers

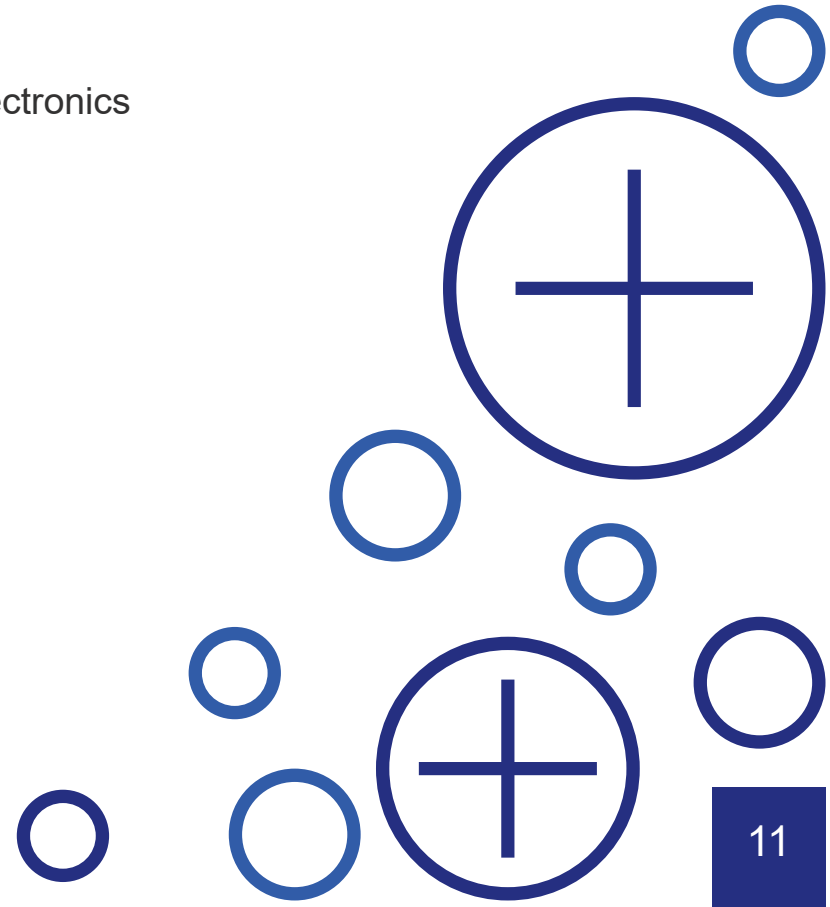
When filled with de-ionised water, water mist extinguishers can be deployed on live electrical equipment of up to 1000 Volt.

Pros

- Completely non-conductive
- Residue-free. Simply soak it up or let it dry out
- Completely free of additional chemicals.

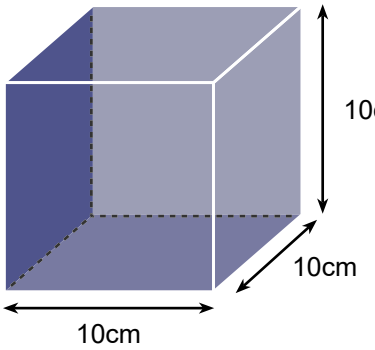
Cons

- Can still damage some sensitive electronics



Why does water mist work so well?

Tiny droplets have a HUGE surface area compared to a single large body of water…

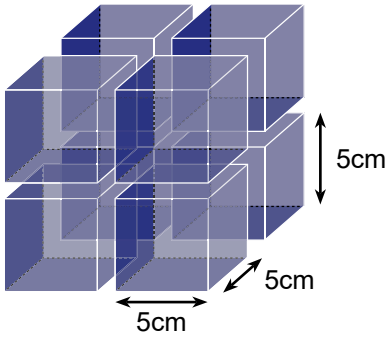


Volume: 10x10x10cm = 1 litre

Surface Area: 10x10cm = 100 sq cm x 6 sides = 600 sq cm = 1 sheet of A4 paper

Volume: 8 x 5cm^3 cubes = 8 x 125cm^3 = 1 litre

Surface Area: 5x5cm = 25 sq cm x 6 sides = 150 sq cm
x 8 cubes = 1200 sq cm
Same volume -> Double surface area



By the time we've shrunk down to droplets of 25 microns (0.0025cm),1 litre = 122 billion droplets = 2,400,000 sq cm = 4000 sheets of paper! (That's nearly 21 car parking spaces)

Water Mist Extinguishers

When filled with de-ionised water, water mist extinguishers can be deployed on live electrical equipment of up to 1000 Volt.

Pros

- Completely non-conductive
- Residue-free. Simply soak it up or let it dry out
- Completely free of additional chemicals

Cons

- Still can damage some sensitive electronics

1Ltr Water Mist Fire Extinguisher - UltraFire

View

3Ltr Water Mist Fire Extinguisher - UltraFire

View

6Ltr Water Mist Fire Extinguisher - UltraFire

View

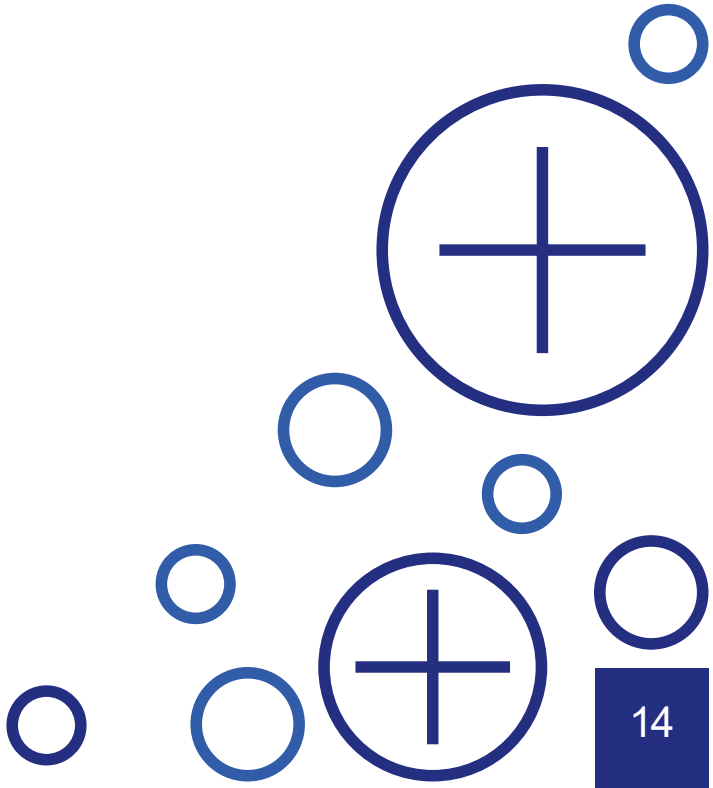
What is de-ionised water?

Deionised = Pure water without impurities and with most of the free electrons removed Free electrons are needed to conduct electricity.

Ions are needed to conduct electricity.

De-ionised water is also largely bacteria-free – De-ionised water is deadly to small organisms like bacteria.

Improved firefighting performance – Experience suggests that de-ionised water fights fires better than tap water.



AFFF Foam Extinguishers

AFFF = **Aqueous Film Forming Foam**

Foaming agent reduces surface tension, allowing extinguishant to spread more easily and quickly. The foam evaporates, reducing the heat of the fire, and stops oxygen reaching the fire. The foam is eventually destroyed by the heat at which point reignition may occur, but much more resistant than water.

Foam = Progressive extinction of fire (cumulative effect). Using a foam extinguisher but not extinguishing the fire completely will still reduce the intensity of the fire.

Traditionally made with PFOS and PFOA fluorosurfactants which were recognised as carcinogenic and affecting the immune system. These are slowly phased out.
All suitable for Class A and B fires, some are also certified as electrically safe.

2ltr Foam Fire Extinguisher - UltraFire

View

6ltr Foam Fire Extinguisher - UltraFire

View

9ltr Foam Fire Extinguisher - UltraFire

View

CO2 – carbon dioxide

Inert gas, removes oxygen from fire. However, it does favour re-ignition as the gas dissipates quickly and the surfaces are not well cooled down. Scary to use, short bursts only, and basically not very successful.

Pros

- No residue
- Safe on electrical, good for computer servers

Cons

- Sensitive electronics can still be damaged
- Freezing horn/tube can lead to frost injury
- Powerful ejection can spread burning materials
- Hot materials can re-ignite after CO2 dissipation
- Risk of CO2 poisoning (not asphyxiation!)

The danger of servicing CO2

As mentioned earlier, due to the non-gas/non-liquid nature of CO2 a gauge would be ineffective. So the contents can only be determined by weighing the extinguisher. This requires very fine scales and the horn must be removed for the weighing. This is dangerous, as the horn acts as a ‘dampener’ should the extinguisher be accidentally triggered.

Discharging a CO2 extinguisher without a horn creates a violent recoil that can lead to serious injury.

CO2 Extinguishers

Risk of CO2 poisoning (not asphyxiation!)

A German industry study highlighted the danger of CO2 poisoning rather than asphyxiation (lack of oxygen), the latter of which had been believed to be the main danger before this study. A discharge in a small room can increase the CO2 concentration to a dangerous level. As a guide, poisoning symptoms are to be expected from 4% CO2 volume and a risk of death from 8% volume. Such small increases of CO2 levels do not play any role in asphyxiation but can kill due to poisoning.

The tests also proved that the previous room volume-related estimation for safe application of CO2 extinguishers had to be changed to an area-related method, as room heights above 2m were found to be of minimal impact on the safety of the CO2 extinguisher application.

The overall conclusion was that a 2 kg CO2 fire extinguisher requires at least 11 sq metres of free floor space and a 5 kg CO2 fire extinguisher requires at least 27.5 sq metres of free floor space to be regarded as safe. Free floor space being the visible area of the floor not covered by solid objects.

2kg CO2 Fire Extinguisher - UltraFire

View

5kg CO2 Fire Extinguisher - UltraFire

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Excellent knock-down of B and C fires, mostly rated for A as well.
Also electrically safe. Sounds ideal for many scenarios BUT…

- BS 5306-8: 2012 states “not recommended for indoors” due to impairment to vision and respiration
- Powder is so fine it gets deeply ingrained and is virtually impossible to be removed entirely, particularly from soft materials. When it encounters moisture (everywhere!) which makes it much more chemically active, its acidity will gradually erode the material.

Works by smothering fire by preventing oxygen reaching it, as well as some chemical suppression. However, if air can still be drawn from underneath the fire, smothering from the top will be much less effective, e.g. soft furniture.

Powder – The problem with solids

Compacting, caking and lumping
Powder is the only solid extinguishant, so is this a problem if left for long periods? We are familiar with sugar, flour and other powders suffering from moisture absorption, turning lumpy, or forming a solid top layer. In an extinguisher, this would be disastrous.

BS EN 615 is a standard dedicated to powder extinguishers (not including Class D) which must be passed on top of BS EN 3. It defines a host of specifications and tests to ensure these issues do not arise.

And to simulate long periods without disturbance, powders (and all other extinguishers) are subject to a “compacting “ procedure before testing.

Re-charged vs New

Refills after discharge and at full service?

Though chemical agents greatly reduce caking and clumping, there is still reluctance to refill powder units since exposing powder to the air means exposing it to moisture.

When discharged, even during a refurb in a factory, powder gets into the valve mechanism. When subsequently re-charged, the mechanism cannot be 100% free of powder residue. This can lead to small leaks. It is also a very messy process.

On balance, it is easy to see why the industry avoids re-charging and replaces powder extinguishers with new after 5 years. However, such a waste of resources should trigger a re-consideration and a move towards water-mist extinguishers.

4kg Powder Extinguisher - UltraFire

View

6kg Powder Extinguisher - UltraFire

View

9kg Powder Extinguisher - UltraFire

View

Wet Chemical Extinguishers

Specifically designed for cooking oils and fats (Class F) fires. Some are rated for Class A or Class B fires as well, but these risks can be handled more effectively and safely by much cheaper foam/water extinguishers.

Due to risk of spreading burning oil, the extinguishant is ejected at low pressure. Some models feature a long lance for safer application. Fire is extinguished by the process of Saponification.

Saponification: The alkaline chemical reacts with the free fatty acids in the cooking oils to create a soapy foam on the surface.

6Ltr Wet Chemical Fire Extinguisher - UltraFire

View

Class D

All Class D extinguishers are powder extinguishers designed to deal with difficult metal swarf fires. There are two types:

- M28 = for most metals, e.g. aluminium, magnesium, sodium
- L2 = for metallic lithium (NOT lithium ion as found in rechargeable batteries)

Note: 1) M28 must not be used on lithium fires. 2) Lithium (the metal) is not the same as Lithium Ion (found in rechargeable batteries).
Metals can burn? They can indeed, and they burn exceedingly hot. Sodium burns at more than 800°C, aluminium can burn hotter than 3,000°C.
When metals are found in the form of swarf or powder, the very high surface area means they absorb heat much more easily. So ignition becomes much easier compared to a large solid lump of metal. Common scenarios are workshops and manufacturing.

Why not use standard extinguishers? Above 200-250ºC, ordinary powder decomposes into noxious gases such as ammonia and sulphur dioxide, as well as phosphoric acid. Extreme temperatures (above 2,000ºC) can cause water to split into H and O2 which is explosive.

How does Class D (Specialist) Powder work?

The powder forms a glassy crust over the burning metal to exclude oxygen, but contains additives to prevent it from combining with the metal itself.
The powder does not remove heat. Once covered using a low pressure lance, the heat will remain trapped under the crust and only escape slowly – assuming it doesn't burn through the surface it is on.
An extinguisher marked for Class D use cannot be designated for use on any other class of fire (BS EN 3).

How are ratings & certifications established?

Testing and rating methods for each class are defined under BS EN 3.
Classes of fire are defined under BS EN 2, recap as follows:

- Class A: Solid materials which typically burn with glowing embers
- Class B: Liquids (e.g. fuels, lubricants) or liquefiable solids (e.g. wax, grease, shoe polish, and thermoplastics like polyethylene, polystyrene, PVC)
- Class C: Flammable gases
- Class D: Flammable metals (e.g. aluminium, potassium, magnesium, lithium), especially as powders and swarfs
- Class F: Combustible cooking media (e.g. cooking fats and oils, grease)
- Electrical: Involving electricity (a source of ignition, not fuel)

Performance Testing

Before testing begins, all extinguishers are…

- Subject to a “compaction procedure” to simulate having been left standing for long periods (dropped vertically on its base onto a steel plate 500 times from a height of 15mm)
- Stored at 20°C for 24 hours
- Used within 5 minutes of being removed from storage

Any other stipulations? Each test and performance criteria is defined in minute detail. Some standards can be a bit slow to keep up with changing technologies (Class F and water mists being a great example – see test video) but in general they can be relied upon.

How are Class A ratings determined?

What does the A rating mean?
An extinguisher can put out a fire of a “crib” of sticks that is 546mm high x 500mm wide. The rating is determined by the different length of the crib it can extinguish, e.g. 1.3m long = 13A rating, 2.7m long = 27A, etc. Maximum of 5.5m = 55A rating.

How are Class B ratings determined?

A Class B extinguisher has been shown to extinguish a volume of liquid equal to the B rating, i.e. 34B = 34 litres of burning liquid extinguished. The test “pools” vary in diameter but the depth is always the same.

Real world – Studies show that extinguishers are never as effective as in test & rating setups, so for Class B rated units a de-rating factor is applied that reduces the number above. This makes the recommendations for extinguishers ratings much higher than simply Litres of Flammable Liquid equals B Rating.

How are Class C ratings determined?

There is no rating or test procedure defined in any standard.
“Reference to the suitability for use on Class C fires are at the manufacturer’s discretion…” (BS EN 3)
“…but must also conform to Class B” (BS EN 3 and 615). You cannot have an extinguisher that is only Class C.

How are Class D ratings determined?

BS EN3 states that metal fires are so specific (the metal involved, its form such as swarf, shavings or powder, the configuration of the fire) that no test can be defined. Efficiency of Class D extinguishers should be established on a case-by-case basis.
BS EN3 also states that an extinguisher claiming Class D use should not be marked for any other class of fire.

How are Class F ratings determined?

Ratings: Based on 4 benchmark tests – 5, 15, 40 and 75 litres of burning sunflower oil. The oil is heated until it catches fire on its own (not with a spark or flame), then the fire is allowed to establish, then the test begins.

Any ejection of burning materials fails the test.

Note: Any extinguisher given an F rating must also be de-electrically tested to comply with BS EN 3 and gain its Kitemark.

Electrically Safe Extinguishers

In terms of electrical safety, extinguishers are either:

- Water based – Including additive, foam, water mist, wet chem
- Other – CO2, powder, clean gas

What needs di-electrically testing? To be suitable for electrical appliances up to 1000V, anything water-based needs di-electrically testing. All other extinguishing chemicals may bear electrical symbol by default. If a water-based extinguisher is not di-electrically tested (or fails the test), it must be marked as 'Not Suitable for electrical equipment'.

Water + Electricity = Safe, permitted and recommended? The tests are extremely stringent and can be trusted. BS EN 7-3 (performance & testing) and BS 5306-8 (selection & positioning) state that tested water based units may be used safely up to 1,000V at 1m.
Don't forget – De-Ionised water (i.e. water mist) by its very nature cannot conduct electricity.

Di-electrical testing – What is it?
Procedure: Run a current of 35,000 Volts between a plate and earth, fire the extinguisher at the plate and measure the current between extinguisher and earth.

What is a Pass? The current must not be higher than 0.5mA.
The extinguisher can then safely be used on live electrics of 1000V AC as long as the user stays one meter away from the electrical equipment.

What Extinguishers are Needed?

Commercially, the types, numbers, ratings and locations of extinguishers must be determined by a **Competent Person** conducting a formal survey or Fire Risk Assessment **(FRA)**

“Competent person” is a legal definition, meaning someone who has the Knowledge, Skills, Training and Experience to do the job correctly.

Fire Risk Assessment should identify any

1. People at risk
2. What the fire hazards are (e.g. sources of ignition, fuel sources, locations, means of escape)
3. Evaluate the risks (how likely is it that the hazards will lead to injury)
4. Determine what measures are needed to lower the risks to acceptable levels and act upon those decisions

So what types, ratings and numbers are sufficient?

Little is defined in actual law stating what must be done (where failing to do so would be a criminal act). Only that enough must be done to reduce and mitigate the risks. Some use this as an excuse to do little or nothing.

However, if something goes wrong then the court will determine whether the provision was sufficient. The burden is on the accused to prove that it was.

Often, following the ‘best practice’ laid down in standards such as BS 5306 pt 8 will be sufficient. Where the standard has not caught up yet with technical development (service-free extinguishers, water mists etc), the manufacturers’ instruction should be used.

Minimum numbers and ratings apply to A, B and F risks only. Why? Because class A risks are everywhere, and the size of class B and F risks can be easily measured or calculated. If electrical risk is present, extinguishers marked as electrically safe must be present. This will include almost all scenarios.

Class C risks are difficult to quantify due to the unpredictability of flammable gases. Class D risks are relatively rare. To determine what cover is needed for these risks, the judgement of fire experts familiar with the risks at hand is critical.

How many Class A extinguishers

Class A is **by far the most common** fire risk – the room your are in and the chair you are sitting on are solid combustible materials – so in virtually every scenario their installation must be considered.

- Up to 400m2 floor area, BS 5306-8 defines a minimum of…
    - 2 per floor (except in very small spaces, e.g. a kiosk)
    - A combined minimum of 26A, but NOT a single unit of >26A

- Above 400m2 the rating is Floor Area (m2) x 0.065

Like any other class of fire, if there are substantial additional Class A hazards (e.g. piles of cardboard) then extra cover must be considered.

How many Class B extinguishers

Class B extinguishers must be placed wherever there are Class B risks. There are formulas to establish what and where, but they are highly complex.

In summary, there are two types of risk – Contained and Uncontained:

- **Contained** = where there is a means to capture the spread of the liquid, e.g. bunds or gullies
- **Uncontained** = where spillage of the entire contents is possible

The only way to determine exactly what is needed is through a formal **Fire Risk Assessment** and **Site Survey** by a competent person.

How many Class F extinguishers

Even though ratings are based on **volume**, BS 5306-8 establishes its size and number recommendations according to **surface area!**

Recommended numbers and ratings are indicated by table, but this only goes up to 0.4m2 requiring 2 x 75F rated units. Above this, automated suppression systems are recommended.

Area (m2)	Rating
0.015	1 x 5F
0.02	2 x 5F
0.04	1 x 25F
0.06	1 x 40F
0.11	1 x 75F
0.18	2 x 40F
0.24	2 x 75F
0.27	2 x 75F
0.3	2 x 75F
0.4	2 x 75F

Unrated fire risks

Class C (flammable gases), Class D (flammable metals), Electrical

Provision must be made to address the risks present.

Where these risks have no ratings, the judgement of a competent person experienced in those risks must be used to establish what extinguishers, how many, what size and where.

Traditional combination fire points versus modern single-extinguisher fire points

Traditional steel extinguishers are often installed in combination fire points (a water-based extinguisher for Class A risks plus a CO_2 extinguisher for electrical risks).

This is not only expensive but can also lead to the wrong extinguisher being used in an emergency.

Safelincs recommends single-extinguisher solutions consisting of one water-based extinguisher with di-electric certificate to cover all risks. This is usually a de-ionised water mist or a P50 foam.

Lithium ion batteries are rechargeable (e.g. phone, laptop)
Note: In contrast, simple Lithium batteries are single use only (typically long life, e.g. ST622)

They do not contain any “free lithium metal” so they are not a metal fire hazard (i.e. not a Class D hazard). The electrolyte fluid containing the ions is flammable. When electrically charged (even partially) they can contain a huge amount of energy that is released upon failure.

Fire can begin due to: Manufacturing defects (the Samsung Galaxy Note 7 tablet), Electrical abuse (charging too much or too quickly), Thermal abuse (the myth of freezing them to improve performance), or Physical damage.

Lithium Ion batteries – Is the fire out?

In a failing Lithium Ion (Li-ion) battery the cells will suffer **thermal runaway** which typically follows the same pattern: **1)** Voltage drop and rise in temp. **2)** Venting / Off-gassing (this is flammable gas, it is not smoke). **3)** Flare. **4)** Steady burn. **5)** Flash fireball. **6)** Explosion.

Temperatures are high and the cells are closely packed, so cascade failure is likely (thermal propagation). In this case a li-on battery fire will continue until all the cells have failed, with periods in between where it appears to be extinguished.

The size of the battery determines how long this will take. It has been known for electric vehicle fires to continue reigniting weeks later.

Li-ion battery fires – What can be done?

How to extinguish? Measures are primarily aimed at cooling during thermal runaway, followed by containment, trying to prevent the spread of damage until the battery has exhausted its supply of fuel and energy.

Placing portable devices like phones and laptop batteries into a water bath will both contain the fire and absorb the heat. For large items like electric vehicles, the policy of many fire and rescue services is to leave the vehicle at the side of the road to burn itself out!

Positioning of Extinguishers

Must be available at all times, and usually:

- Conspicuously located on brackets, floor stands or in cabinets
- Where they will readily be seen on escape routes
- Near to room exits, corridors, stairways, lobbies and landings
- In similar positions on each floor (for similar floors)

Class B, D, F and Elec extinguishers should be located so that the correct extinguisher for the likely fire risk is the first to be encountered, i.e. wet chem near to cooking oil fire risk, and not water, foam or CO2.

Heights:

4kg and below = handle around 1.5m from floor
Over 4kg = handle around 1.0m from floor.

Travel Distances

Position near to hazard but not so close as to be inaccessible in a fire.
In general, the maximum distances between fire and appropriate extinguishers are:

- Class **A** : 30 m
- Class **B** : 10 m
- Class **C** : 30 m
- Class **D** : Case-by-case basis
- Class **F** : 10 m
- **Electrical** : 10 m

P50 Service-Free Extinguishers

Traditional steel extinguishers must be serviced every year, as they only have a single pressure gauge, tend to corrode and can dint. Contact with the metal can also lead to deterioration of the extinguishent. Traditional extinguishers therefore also require a 5 yearly refill (CO2 10 year refurb).

P50 Service-Free Extinguishers have double gauges, cannot dint and the walls are inert i.e. they do not react chemically with the contents in the extinguisher. Not only do the not require servicing, they also only need refilling after ten years rather than the standard 5 years. This halves the chemical usage over the lifespan of the extinguishers.

Service-Free 2ltr Foam Fire Extinguisher - Britannia P50

View

Service-Free 2kg Powder Fire Extinguisher - Britannia P50

View

Service-Free 6ltr Wet Chemical Fire Extinguisher - Britannia P50

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