Fire Training Notes V1 2024

THEORY OF FIRE

TRIANGLE OF FIRE

Before we can understand the basics of practical fire fighting we must first understand what combustion is and what factors are required to be present in order to achieve combustion.

Combustion can be defined simply as being "a chemical reaction evolving both heat and light energy".

The three factors required to be present in order to achieve combustion are:

- **Heat**
- **Fuel**
- **Oxygen**

FUEL

All matter exists in one of three states - solid, liquid or gaseous form and under the correct conditions almost anything will burn as fuel. The burning rate of fuel depends on configuration or state of division. Finely divided fuels such as dust, powders or shavings will absorb heat more rapidly than bulky materials because of the greater area exposed to heat and, therefore will liberate flammable vapours more quickly and so burning more readily.

Flammable liquids release vapour in much the same way as solid fuels. The rate or release is greater for liquids than solids since liquids have less closely packed molecules and will vaporise more readily. The ease or degree of vaporisation will depend on the product, for example petrol will vaporise more rapidly than fuel oils which, in turn, will release vapours more readily than lubricating oils.

Flammable gases are already in the required vapour state. Only the proper inter-mix with oxygen and heat are required to achieve ignition. A flammable gas must mix with oxygen within its flammable range otherwise ignition cannot take place.

This is called the range of flammability. If there is insufficient gas in the mixture it is said to be too lean and will not burn. This would represent its Lower Exposure Limit (LEL). If the gas to oxygen mix is too great then the mix is said to be too rich and, again, ignition will not take place. This is said to be its Upper Explosive Limit (UEL). The percentage mixes between the two limits is called the explosive range of flammability.

HEAT

Heat is required to act on a fuel in order to commence the chemical reaction which will produce the flammable vapours required for combustion. The amount of heat required to raise a substance to its ignition temperature will vary depending on the substance involved.

OXYGEN

Oxygen is a supporter of combustion and must be present before combustion can be achieved. Normally a 16-20% concentration of oxygen is required to support combustion, but there are products which when subjected to heat and the subsequent chemical decomposition, will liberate its own oxygen supply.

When all three factors are present - fuel, heat and oxygen - in the correct proportions we will have combustion. This is known as the TRIANGLE OF FIRE.

EXTINCTION OF FIRE

STARVATION

Removal of fuel from a fire will in any situation eventually lead to the extinction of a fire.

Effectively we break the fire triangle by 'starving' the fire of fuel.

COOLING

This method is the cheapest and most commonly used method of fire extinguishment. The base of the fire is attacked with water to destroy the ability of the fire to sustain itself. Water is a very effective heat absorber. When properly applied, it absorbs heat from the fuel and as a result, will cool the burning substance to below its critical fire temperature so as to reduce the amount of flammable vapours given off to sustain combustion.

SMOTHERING

The exclusion of oxygen from a fire will bring about its extinction. This can be achieved by:

- Use of inert gases/systems
- Use of fixed installation systems i.e. steam. carbon dioxide, halons etc.
- Use of foam blankets

Care is to be exercised as the smothering of a fire situation produces little or no cooling effect and if the fire is 'opened up' too early, flash over conditions may be present and occur with the consequent inrush of oxygen.

TEMPERATURES

There are three critical temperatures we must be aware of if we are to understand and control the fire fighting operations:

- **Flash Point**
- **Fire Point**
- **Auto-ignition**

FLASH POINT

Flash point can be defined as being the "lowest temperature at which there is sufficient vaporisation of the substance to produce a vapour which will flash momentarily on application of a test flame".

FIRE POINT

Fire point can be defined as being the "lowest temperature at which the heat from the combustion of a burning vapour is capable of producing sufficient vapour to enable combustion to continue". Once this temperature is reached we have reached a point of accelerating combustion and the fire will rapidly grow in intensity.

AUTO-IGNITION

Auto-ignition can simply be defined as being the "lowest temperature at which the substance will catch fire without a source of ignition".

Auto-ignition occurs when the heat generated cannot dissipate resulting in a rise in temperature which increases the rate of reaction until the ignition temperature is reached and combustion commences. A typical example is the fire test in BS 7937 : 2000 Specification for Portable Fire Extinguishers for use on cooking oil fires (Class F).

In essence, a container of cooking oil is heated until the surface of the oil ignites thus, of course, simulating the fairly common accident where a chip pan is left over a source of heat and eventually bursts into flame. In the case of pure sunflower oil the auto-ignition temperature is in the order of 340°C.

SPONTANEOUS COMBUSTION

Spontaneous combustion can be defined as an outbreak of fire without application of heat from an external source. Spontaneous combustion may occur when combustible matter such as hay or coal is stored in bulk. It begins with a slow oxidation process (as bacterial fermentation or atmospheric oxidation) under conditions not permitting ready dissipation of heat e.g. the centre of a haystack or a pile of oily rags.

FIRE SPREAD

Having achieved combustion by all three legs of the triangle being present in the correct proportions we now have to deal with fire spread. This can be achieved by one or more of the following:

- **Radiation**
- **Convection**
- **Conduction**

RADIATION

Heat radiation is the transfer of heat from a source across an intervening space, no material substance being involved. The heat travels outward from the fire in the same manner as light, this is in straight lines. When it contacts a body it is absorbed, reflected or transmitted. Absorbed heat raises the temperature of the absorbing body, if this absorption of heat is allowed to continue then combustion may result with fire spread some distance away from the fire source.

CONVECTION

Convection of heat through the motion of heated matter i.e. through the motion of smoke. air, gases etc., produced by the fire. The fire produces lighter than air gases that will rise towards high parts of a building. As these hot gases rise then cool gases and air will fall, so feeding the fire with a convection 'draught' cycle and also risk spreading the fire at higher levels.

Smoke, gases, etc., can travel great distances via doors and open hatches/windows and can start fires en route.

CONDUCTION

Conduction is the transfer of heat through a solid body. Metal is an excellent conductor, heat transfer by conduction is a real hazard with fire spread through RSJs, steel doors, shutters and walls.

With timely and careful application of water spray to affected areas heat transference by conduction can be greatly retarded. A water spray pattern absorbs more heat from the affected metal because the smaller water droplets present a greater surface area. At the same time, less water is used so creating less water damage to premises.

CLASSES OF FIRE AND EXAMPLES OF SUBSTANCES

SOLIDS	LIQUIDS*	GASES	METALS	COOKING OILS
Class A	**Class B**	**Class C**	**Class D**	**Class F**
Coal	Petrol	Propane	Magnesium	Olive Oil
Wood	Diesel	Acetylene	Titanium	Sunflower Oil
Hay	Solvents	Methane	Cadmium	Butter
Leather	Methylated Spirit	Hydrogen	Zirconium	Lard
Rubber	Adhesives	Ammonia	Lithium	
Solid Plastics	Paraffin	Butane	Cobalt	
Wool	Paint		Sodium	
Straw				
Paper	Grease*			
Cloth	Wax*			
Grain	Shoe Polish *			
SuQar				
Leaves				

*** Denotes liquefiable solid substance**

FIRES, EXTINGUISHERS AND PREFERENCES

CLASS	EXAMPLE	PREFERRED EXTINGUISHER	REASON
A-Solids	Tyres	Spray Foam	Cools, smothers. Can be used on associated risks.
B- Liquids	Paints, Varnish	ABC Dry Powder	Fast knock down, long throw. Can be used on associated risk. Wide operating temperature range.
8-Liquids (Water soluble)	Alcohol, Solvents	ABC Dry Powder Alcohol Resistant Foam	Fast knock down, long throw. Wide operating temperature range. Can be used on associated risk. Prevents re-ignition.
B - Liquefiable Solids*	Molten Tar, Grease, Wax, Shoe Polish	ABC Dry Powder	Fast knock down, long throw. Can be used on associated risk. Wide operating temperature range
C-Gases	Propane, Butane	ABC Dry Powder in trained hands. Best extinguished by closing valve.	Fast knock down, long throw. Can be used on associated risk. Wide operating temperature range. Remove the fuel source.
D-Metals	Magnesium, Lithium	Specialist Dry Powder and low velocity applicator	Applicator reduces the velocity of the powder allowing it to be sprinkled.
F-Cooking Oils	Sunflower Oil, Olive Oil, Lard	Wet Chemical Extinguisher	Turns oil into a soap. Fast knock down. Cools, smothers.

FIRE WARDEN

Day-to-day role:

- To keep an eye on the general fire safety of the area, building or floor the warden has been allocated,
- Keep an eye on corridors and walkways to ensure combustible materials are not stored there,
- Monitor escape routes to see they are kept free of obstructions,
- Check that fire doors are not tied, propped or wedged open where they should not be,
- To check that final exit doors are not obstructed,
- To check that extinguishers are where they should be and no obvious misuse or defect has occurred,
- During scheduled fire alarm tests over a period of weeks or months, check that the alarm can be heard in all rooms and all parts of their allocated area,
- Possibly assist with the creation of personal emergency evacuation plans (PEEPs) if requested.
- Possibly assist with fire risk assessments (FRA) if requested.

Role when the fire alarm sounds:

- Put on the yellow high-visibility armband or vest.
- Sweep through their allocated area, turning off equipment and closing doors/windows in passing but not delaying your own escape unduly, while encouraging people to leave via the nearest fire escape route. The fire warden should normally be the last person off their floor.
- The first fire warden to the assembly point is to assume the fire marshal role.
- Checking all accessible rooms including toilets and offices to make sure people are beginning their evacuation,
- Checking any refuge in their area in case someone is waiting for assistance to evacuate.
- Reporting to the person in charge of the evacuation, at the assembly area or just outside the building, to advise their area is clear (or to report anyone who can't or won't leave the building)
- To assist the officer in charge with crowd control, verbally encouraging people towards the assembly area.
- To take part in any post-alarm de-briefing to identify any shortcomings in the evacuation procedures.

Typical Periodic Checks

Fire Fighting Equipment
User Checks
Monthly inspections should include checks that each extinguisher:

- Is located in the designated place.
- Is unobstructed.
- Has operating instructions which are clean and legible.
- Is not obviously damaged.
- If a gauge is fitted that the gauge needle is in the operable range or position (usually a green area).
- Has seals or tamper indicators which are not broken or missing.

This should be recorded and any issues rectified.
Note: Where tampering is likely (schools, public houses etc.) user checks should be carried out on a weekly basis.

Competent person/company
Fire Extinguishers should be subject to annual servicing by a competent person.

Fire Alarm System
User Checks
Weekly fire alarm user tests should include:

- Every week a manual call point should be operated to ensure the alarm sounds throughout the building.
- The weekly test should be carried out at approximately the same time each week and occupants should be instructed that they must report any instance of poor audibility of the fire signal.
- A different call-point must be used at each test so that all manual call-points on the system are tested in rotation.
- The duration for which the fire signal is audible will not normally exceed one minute. Occupants of the building must be advised of this so that a prolonged fire signal at the time of the weekly test will indicate a fire alarm and not a test.

This should be recorded and any issues rectified.

Competent person/company
Fire alarm systems should be subject to six-monthly servicing by a competent person.

Fire Doors
User Checks
Carry out monthly checks on all fire doors and exits. Check:

- That there is no obvious damage to the door (or frame) and that the door fits evenly into the frame.
- That the door closes fully into the frame using the closing device (where fitted) and that the door closes from any angle.
- That intumescent seals or intumescent & smoke seals are in place and in good condition to both sides and top of the door.
- That any signage fitted is unobstructed and legible.

This should be recorded and any issues rectified.

Emergency Lighting
User Checks
Each month, each emergency light and illuminated exit sign should be energised from its battery by simulation of a failure of the supply to the normal lighting for a period sufficient only to ensure that each lamp is illuminated. At the end of this test period the supply to the normal lighting should be restored and any indicator lamp or device checked to ensure that it is showing that the normal supply has been restored.

Competent person/company
Emergency lighting systems should be subject to annual maintenance by a competent person. This includes a full duration discharge test - typically either 1 or 3 hours.

Portable electrical equipment (anything with a plug on it)
Competent person/company
Portable appliance testing should be carried out "periodically". It should be determined how frequently the company are to carry out this work; detail it in the fire policy and then adhere to it.
Note: There is nothing to state that this work should be carried out annually. The frequency of checks may be more or less frequent depending on the portable equipment in question. i.e. computer leads v site power tools.

Electrical Wiring
Competent person/company
The electrical wiring in your building should be subject periodically by a competent electrical contractor. Frequencies vary depending on type of building/use.

Domestic	10 vears
Residential Accommodation	5 years
Commercial	5 years
Offices	5 years
Shoos	5 years
Laboratories	5 years
Village Hall	5 years
Pubs/Bars	5 years
Educational Establishment	3 years
Hospitals	3 vears
Industrial	3 years
Cinemas	3 vears
Public Entertainment	3 years
Theatres	3 vears
Leisure Complexes	3 years
Swimming Pools	Annually
Petrol Stations	Annually

Gas Appliances/equipment
Competent person/company
Any gas appliances should be subject to an annual inspection by a gas safe registered engineer.

Note: The above checks are the ones most common in the workplace; there are other checks that may apply to your workplace that are not detailed. i.e. dust/fume extraction etc. Any checks/inspections that are required should be highlighted in a fire risk assessment.