

Fire-fighting Training Manual





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Abbreviations/ Acronyms

R	- Right
L	- Left
Fig.	- Figure
n ^o	- Number
p.	- Page

ESEnfVC- Viana do Castelo's Nurses' College

FDSS (RIA) - Fire Detectors and Sprinkler Systems (Reds de Incêndio Armadas)

Figure and Table Index

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Introductory Note

There's an old saying that prevention is always more effective and cheaper than the cure.

The irrefutability of the popular aphorism quoted above, the growing preoccupation with questions based on safety and the fact that collective and personal safety are an inherent principle of basic human necessities, in the concept of citizenship and in communal and individual wellbeing, makes training in this area play a role of extreme importance.

According to this perspective ESEnfVC, in the context of its social and pedagogic functions, worries about creating conditions for the creation and consolidation of safety habits within the school community.

This manual was elaborated, due to this preoccupation, with the intention of collecting a conjunction of guides which may help the development of training regarding elementary aspects of safety, such as, first intervention means and safety signs. Thus, the purpose of this document is to:

- Contribute towards training in the safety area;
- Collect information, norms and bibliographical sources necessary to train the school community in this area;
- Create a document, in writing, that serves as a basis for training regarding means of first interventions and safety signs/symbols.

This manual is divided in five captures which deal with the following aspects: **fire/conflagration** – definition and its importance/ damage to Humanity; **phenomenology of combustion** – approach the aspects susceptible to influence this reaction: **fire classes** – reference to the types of fires related to combustible materials; **fire extinction** – explanation of the methods/means and agents used to put out/control fires; **safety signs and symbols** – principle aspects to be taken into consideration regarding the interpretation/identification of evacuation signs and extinction devices are referenced.

We hope this manual will be easy to consult and turn into a valuable informative instrument and promote a better culture on the responsibility of safety.

1 Fire | Conflagration





very same discovery. However, when Men loose control of a Fire, conflagration starts, with all the losses and damage that it can cause. Therefore, we can say that conflagration is all or any type of non circumscribed fire, considered a reaction of combustion, in other words, a chemical reaction initiated and developed by an activated reaction, capable of combining a combustible element with an oxidizing agent. Besides heat, fire emits smoke and/or flames and gases, which can reach “Dantesque” proportions and be difficult to control.

2 Phenomenology of Combustion

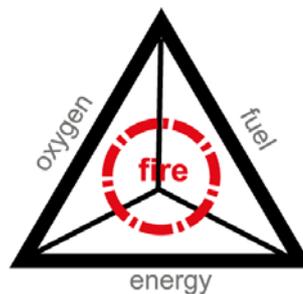


Table nº 1 – Components of the fire triangle

Fuel	All and any type of substance, which in the presence of oxygen and activation energy is capable of burning.
Oxygen	It is the gas, that when present, causes fuel to burn, in its general form oxygen is considered a typical oxidizing agent found in normal air (in an approximate proportion of 21%).
Activation energy	It is the source of energy that when manifested in the form of heat can provoke the ignition of combustibles.

These three components form the **Triangle of Fire**. This representation was acceptable for a long time; meanwhile, many anomalous phenomena produced during a fire can not be completely explained by this triangle.

A union sustained by these three elements, leads to the fourth element, the **Chain reaction**, which is produced in a continuous manner.



The reason for using a tetrahedron and not a square is that each of the four elements is directly adjacent and in connection with the others, as indicated in the figure above.

2.1 | Forms of Combustion

Combustion becomes easy if the combustible element has the following characteristics: division state of the material, for example a piece of paper burns quicker if it is torn into small pieces. In addition, if you close the doors and windows of a room which contains a fire's focal point, without renewing the oxidizing agent, the velocity of the fire diminishes. Therefore, we can conclude that the velocity of combustion depends on two factors: the division

degree of the combustible and the degree of renewal or supply of the oxidizing agent.

The reactions of combustion can be classified into five types, according to its velocity.

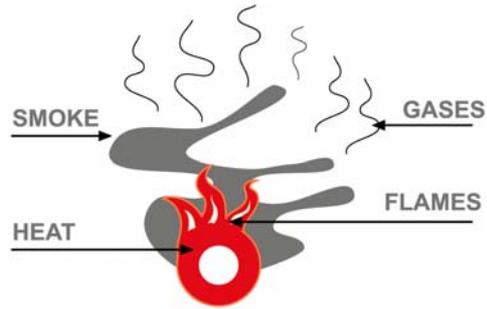
Table nº 2 – Types of Combustion

Spontaneous combustion	A chemical reaction between organic materials in which the concentration of temperature can reach the ignition temperature without the introduction of external heat.
Slow combustion	Is reproduced in sufficiently low temperatures in which the emission of light does not occur (oxidation of metals and fermentation).
Live combustion	Produces a strong emission of light, incandescent and with flames.
Deflagration	Live combustion, in which the propagation velocity is inferior to the speed of sound (340 m/s).
Explosion	Live combustion with the propagation velocity superior to the speed of sound, in which the mixture of gases with the air has ideal conditions. The explosion is without a doubt, a sudden and violent dilation exercised on the area in which it takes place, destroying it and producing a loud noise (detonation).

The proper and visible results of combustion are: smoke, flames, heat and gases.

2.2 | Manifestations and combustion products

In most cases, the smoke and gas released are more dangerous for the individual than the actual flames. Smoke is an irritant and can provoke damage to the respiratory system and/or irritate eyes. Gases may be toxic, such as carbon monoxide, the principle cause of victims during fires.



Combustion products can be shown either isolated, or together, in the following form:

Gases: result from the modification in the composition of the combustible.

Smoke: appears due to incomplete combustion, in which small particles become visible, varying in colour, size and quantity.

Flames: the most visible result of combustion. It is a zone of incandescent gases visible around the surface of the material in combustion. Flames are no more than the combustion of gas.

Heat: is the energy released by combustion, being primarily responsible for the spread of fire considering that it heats up the entire environment, in addition to combustible products which may be present, elevating its temperatures to flammable temperatures and therefore allowing the fire to continue.

After referring to the processes that trigger fires, the following presents the forms of classifying them.

3 | Fire Classes



Considering the various combustible materials, it has been internationally agreed to group these according to the following:

Table nº 3 – Types of Combustion

Class A	Class B	Class C	Class D
Solid Combustibles (generally of organic origin)	Liquid Combustibles or easily Liquefied Solids	Gaseous Combustibles	Metal Combustibles
<ul style="list-style-type: none"> ▪ Wood ▪ Coal ▪ Paper ▪ Cloth ▪ Straw ▪ ... 	<ul style="list-style-type: none"> ▪ Gasoline ▪ Varnishes ▪ Wax ▪ Alcohol ▪ Tar ▪ ... 	<ul style="list-style-type: none"> ▪ Butane ▪ Propane ▪ Acetylene ▪ Hydrogen ▪ Hexane ▪ ... 	<ul style="list-style-type: none"> ▪ Magnesium ▪ Aluminium ▪ Sodium ▪ Uranium ▪ Lithium ▪ ...



The four mentioned classes are going to facilitate the selection of the most adequate strategy applicable to extinguish a certain fire.

Each category requires an appropriate way of extinction and method.

4 | Fire Extinction



methods that will act upon one or more of these elements in order to extinguish a fire.

4.1 | Extinction Methods

There are four methods to extinguish a fire (each one valid for one or more fire classes).

Table nº 4 – Extinction Methods

Cooling	It is the most common method and consists in lowering the temperature of the combustible element and the environment, below its ignition point.
Smothering/ extinguishing	It is the method which consists in isolating the combustible element and oxygen, or reduces their concentration within the environment.
Dilution or elimination of combustible element	It is the method which consists in separating the combustible element from the heat source or the environment of the fire.
Control of flames or interruption of the chain reaction	This method modifies the chemical reaction, altering the release of free radicals produced in the combustion and therefore delaying its development.

Knowing the fundamentals of extinction, the following is questioned, what is used to put out the fire?

4.2 | Extinguishing Agents

There are various extinguishing agents which have a specific action on each of the four elements stated above (Tetrahedron of fire), which are used to manufacture the first intervention devices (portable extinguishers, detection devices and networks).

The selection of the appropriate agent fundamentally depends on the fire class and the characteristics of the combustible element, as shown in Table 5. This table is intended to give a global view of the link between fire classes and the efficiency of extinguishing agents and devices available.

Table n° 5 – Adequacy between the type of fire and the extinguishing agents

Fire Classes	Extinction Method	Extinguishing Agents							
		Dry Chemical			CO ₂	Foam	Water		Halons
		A B C	B C	Special (Metal Powder)			Jet	Pulverizing	
A	Cooling or Flame Control	Yes Excellent	No	No	No	Yes	Yes	Yes Excellent	Yes
		Fast Reduction of Flames	Only Controls Small Surfaces	-	Only Controls Small Surfaces	Has an extinguishing and cooling action	Good penetration, fast cooling of combustibles and cinder		Fast Reduction of Flames
B	Flame Control, Extinguishing, Cooling	Yes Excellent	Yes Excellent	No	Yes	Yes Excellent	No	Yes	Yes
		Cloud powder protects operator	Cloud powder protects operator	-	Does not leave residues, does not contaminate food	Foam cover prevents fire from reigniting and cools off the liquid combustibles	Jet spreads the fire	Forms a Vapour Cloud which cools and inhibits	Fast Reduction of Flames
		Fast Reduction of Flames							
C	Flame Control	Yes	Yes	No	Yes	No	No	No	Yes
D	Lack of O ₂ or Cooling	No	No	Yes Excellent	No	No	No	No	No
		DANGER EXPLOSION			Forms a Crust on the Metals and Eliminates O ₂	DANGER EXPLOSION			

Fires Involving Electricity	Flame Control	Yes	Yes	No	Yes Excellent	No	No	Admissible	Yes Excellent
		Non conductible up to 6000 V		-	Non-conductible does not leave residues	Conductor	Conductor	Up to 500 V	Non-conductible does not leave residues

4.3 | Means of First Intervention

Portable extinguishers, detection devices and networks are considered means of first intervention. In the case of portable extinguishers, such as the case of FDSS's, verify, before use, if they are adequate for the type of fire according to the extinguishing agent. In the case of FDSS's, such as water and portable extinguishers, the inscription on the device should be consulted which includes besides the fire classes its capacity, inspection date and users' instructions.

Table nº 6 – Means of first intervention

Means of 1 st Intervention	Extinguishing Agent	General Use Procedures
<p>Portable Extinguishers</p> <ul style="list-style-type: none"> ▪ Dry Chemical ▪ CO₂ ▪ Foam ▪ Water ▪ Halons 		<p>Verify adequacy to the type of fire</p> <p>Maintain extinguisher in a vertical position</p> <p>Short discharge to verify that its in working order</p> <p>After taking individual safety measures (not to become encircled by the fire and observe the wind direction), advance in the fire's direction</p> <p>Aim at the base of the fire, not the flames</p>
<p>Fire Detectors and Sprinkler Systems (FDSS)</p>	<ul style="list-style-type: none"> ▪ Water 	<p>Verify adequacy to the type of fire</p> <p>Open metal casing and release the fire hose reel</p> <p>Open the nozzle and stretch the hose in direction of the fire's centre</p> <p>Open the water valve</p> <p>After taking individual safety precautions (not to become encircled by the fire and observe the wind direction), advance in the fire's direction</p> <p>Aim at the base of the fire, not the flames</p>

These devices are available at the location and destined to be used in first interventions and can be used either by those who use the installations, or by the first intervention teams.

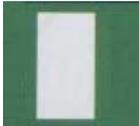
The location and identification of these devices, as well as the evacuation routes, are regulated by a part of the emergency plan and have proper safety signs.

5 | Safety Signs and Symbols



The safety signs presented in this chapter are related to situations of fire and panic generators. Therefore, those which indicate means of evacuation will be addressed, as well as those which indicate fire-fighting equipment, in view of Portuguese and International norms which have common aspects, such as colour and forms. In addition, there are also graphic symbols which can be associated, giving rise to a variety of signs that are possible of being created.

Table nº 7 – Symbology used in Safety Signs

Signs	Symbols	Forms and Colours	Description
Evacuation Means		Background: Green Symbol: White	Emergency Exit
			Emergency Stairs
Fire-fighting Equipment		Background: Red Symbol: White	Fire-hose
			Extinguisher
Common Symbology	  	Background: Red or Green (according to the type of signal associated to it) Symbol: White	Arrows indicate a route or a location. Vertical and upwards: in front Vertical and downwards: exit Horizontal to the right: right Horizontal to the left: left Oblique downwards: lower level (floor) Oblique upwards: upper level (floor)

The school should have autonomous illuminated blocks that guarantee a sufficient level of light, conditions for an evacuation in an orderly fashion, with the least human casualties possible.

Using the above mentioned symbology, it is possible to create an enormous diversity of signs; the following table shows some examples with their respective description.

Table nº 8 – Symbology used in Safety Signs

Signs	Symbols	Description
Evacuation Means		Emergency stairs to the lower floor
		Emergency Exit (Indicates the location)
		Emergency Exit to the left
		Emergency Exit and Stairs on the lower floor
Fire-fighting Equipment		Extinguisher to the left
		Fire hose (indicates the location)

Safety signs are fundamental factors, in which the recognition of obstacles is viable and indicates the route to follow for a correct evacuation, avoiding personal accidents and reducing panic.

6 | Final Note





With such a vast and complex theme like safety, speaking of fire situations or other panic generators is no less than a drop in the ocean, but the importance of human life is not measured by statistics.

Helping to protect through training, is undoubtedly more beneficial than bearing in mind the rescue.

Educating, to care for all elements of life is ESEnfVC's motto. The greatest pretention of this manual is being able to contribute in some way, in this noble intention through training/information.

We hope that this manual is not an end in itself, but instead an instrument to be consulted, and flexible in the sense that it can be constantly altered and restructured in order to promote change.

Bibliographical References



GUERRA, António Matos- *Segurança e Protecção Individual*, Vol. VIII: Manual de Formação Inicial do Bombeiro. Sintra: Escola Nacional de Bombeiros, 2002, 87 pag.

GUERRA, António Matos- *Fenomenologia da Combustão*, Vol. VII: Manual de Formação Inicial do Bombeiro. Sintra: Escola Nacional de Bombeiros, 2002, 75 pag.

Norma Portuguesa- Segurança contra incêndio, Sinais de Segurança. NP 3992: Instituto Português da Qualidade. Lisboa: Certitecna, 1994, 10 pag.

Norma Portuguesa- Segurança contra incêndio, Utilização dos extintores de incêndio Portáteis . NP 3064: Instituto Português da Qualidade. Lisboa: Certitecna, 1989, 9 pag.

PORTUGAL, Ministério da Administração Interna, Serviço Nacional de Protecção Civil – *Plano de emergência para estabelecimentos de ensino*. Lisboa: SNPC, 1995, 48 pag.

Sinalização fotoluminescente. SINALUX®, 123 pag.

Manual de Segurança, Higiene e Saude no Trabalho. Lisboa: UGT, 1999, 503 pag.

GOMES, Artur – *Ventilação táctica*, Vol. XII: Manual de Formação inicial do Bombeiro. Sintra: Escola Nacional de Bombeiros, 2002 62 pag.

CHIAVENATO, Adalberto- *Recursos Humanos*, 4ª Ed. São Paulo: Ed. Atlas, 1997 643 pag.

Technical Sheet





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