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FIRE HAZARD AND SECURITY

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Abstract: *Best management practices in conditions of forest sustainable development include the adaptation of strategy for forest fire fighting and control. In order to assess the forest fire hazard and security levels, an important part is represented by management strategies regarding security objectives and safety objectives. Implementation of such management objectives refers to understanding and knowledge of fire propagation and control mechanisms. In this context, the current paper presents a state of the art procedure of fire prevention and control, with measures which could be applied in forestry.*

Key words: *fire hazard, security, prevention, behaviour, control.*

1. Introduction

Fire represents an initiated burning process, determined by a well defined cause, on which control is lost and which provokes material damages, and for whose interruption, an extinguishing action is necessary [3-5].

Burning as a phenomenon associated to a fire, is defined as the exothermic reaction between a combustive substance and a carburant, generally along with flames or/and incandescence or/and smoke emission [6].

The security of a technical system, *S*, as performance, represents its ability of not producing critical or catastrophic events [3].

The association between fire and technical system security defines the system's fire security (Fire Safety) [1], [2].

Many of the events which take place during a fire involve human activity indoors, which imply the existence of humans and material assets. In this case there can be considered the building's fire security (in a larger sense, some engineering constructions: tunnels, viaducts etc.).

As in the case of any technical system, each building can be associated with a certain level of fire security.

2. Fire Security Objectives

The main objectives of fire security are represented by fire prevention and fire protection [1-6]. The above mentioned objectives can be attained when fire does not occur (by applying prevention measures) or when fire is extinguished before it takes great proportions (by applying protection measures).

2.1. Fire Safety Objectives - Fire Protection Perspective

The first fire security objective, regarded from the fire protection perspective refers to reducing (limiting) to acceptable levels the destruction and victims production probability (including property loses) in case of a fire.

In many civilised countries, in case of fire, the environment protection problem

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takes an important role. The way in which life and property protection is regarded, varies from country to country and depends on the building type and destination.

In the past, fire protection norms were focused on the property protection rather than on life protection.

The new optics adopted by national codes refers to life protection prior to property protection [3], [4]. From this perspective, many codes (laws) consider that building damages represent the owner's or insurance company's problem.

The distinction between life and property protection becomes important in conditions in which the owner is not aware of the probable extension of the building and its content destruction.

2.2. Fire Safety Objectives - Life Protection Perspective

Frequently, life protection presents as objective the realization of a safe salvage, which involves the following:

- persons' alert regarding the fire and the provision of evacuation routes; evacuation routes must not be affected by fire or its compounds from certain points to safety zones;
- protection of persons which are not capable of saving themselves (hospitals, handicapped persons);
- protection of persons from the neighbouring buildings;

In this context, the normative prescriptions must consider the fire intervention forces' safety.

2.3. Fire Safety Objectives - Property Protection Perspective

Property protection has as objective the protection of structure and other building components as well as its mobile content. Also, property protection refers to the necessary protection for the neighbouring buildings and properties (a superior protection level must be provided when it is important that the objective be quickly rehabilitated after fire). In many cases an important objective is represented by business interruption or no recoverable asset loses.

Very important losses could appear in case of great destructions regarding energy distribution and telecommunication routes [1], [2].

2.4. Fire Safety Objectives - Environment Protection Perspective

Environment protection has as objective the limitation of its destruction (in case of a major fire), preoccupations in this direction being the following: pollution gas emissions, pollution with fire extinguishment substances. The best way to avoid these aspects is by extinguishing the fire when it is still small.

3. Behaviour of Fire Affected System

3.1. Fire Development Process

Fire security objectives from the protection perspective can be attained through the realization of a combination between active and passive protection measures.

Active protection measures control fire or its effects by actions realized by persons or automatic devices.

Passive protection measures control fire and its effects by structure and/or component elements of the installation or building themselves during fire development.

Typical development of a fire into a building is described below as an introduction to the protection measures problem [4].

Not all the fires present such development due the fact that some prematurely reach the exterior and others

do not attain the flash-over because the flammable elements are too small or isolated, or there is not sufficient air for combustion sustaining. If a room has large widows, the heat generated by fire may lead to their breaking, thus appearing in this way the so called back-draft.

3.2. Fire Behaviour

In the incipient period occurs the potential combustible heating in the presence of some heat sources and favourable conditions [1-3]. The ignition represents the start of flame combustion (flame appearing) which realizes the transition to fire growth period. During this period, most fires are slowly spreading, at the beginning to flammable surfaces (slow combustion) then quicker as the fire grows, generating a radiant temperature field (from flames and hot gases) on to other flammable elements (developed fire). If the upper temperature level reaches 600 ºC, the combustion velocity grows faster leading to flash-over moment, which constitutes the transition from burning period (generalised fire) [1-2].

Burning velocity in fire growth period is generally controlled by the burning surfaces' nature, whereas in the complete development period, the temperatures and heat flux in the room attain great values, and all the surfaces are burning, the heat spreading velocity being influenced by the available ventilation.

This burning period presents the greatest impact on the structural and compartment elements.

If the fire is not extinguished, the fuel is depleted and temperatures are dropping, these aspects representing the fire regression period, when combustion velocity depends on fuel quantity in a greater measure than on space ventilation.

A conceptual schema regarding security and fire control is presented in Figure 1.

3.3. Human Behaviour

In the room in which the fire starts, the human factor can observe the signals of a possible fire in its incipient stage. Many fires are observed in time by inhabitants in the incipient period, and can be extinguished by removing the fuel or fire source. After ignition, the fire will become more obvious, and the inhabitants can extinguish it only when it is relatively small (if they are awake and able to move). Once the fire grows, extending to furniture and other objects, it cannot be manually extinguished but the inhabitants have the necessary time to evacuate the building. The conditions from a room in which the fire is started are becoming dangerous for life during the fire growth period. After the flashover, survival is not possible due to extreme conditions regarding temperature and toxic gases. If the inhabitants are not in the room in which the fire starts, the latter will be randomly discovered, usually when it has great amplitude. In order to preserve life in case of a fire, it is essential to detect the fire and the inhabitants to be alerted and offered sufficient information in order to determine their moving to a safer place before the attaining of an uncontrolled situation [1-2].

3.4. Fire Detection

In the incipient fire period, there is possible human detection by visualisation or through smelling. Ignition can be automatically detected in case of very sensitive equipments based on smoke absorption.

In fire growth period, its detection is possible by inhabitants and/or smoke sensors and/or heat sensors strategically placed in the room. Smoke detectors are generally more sensitive than heat sensors, especially for smaller fires, when smoke can be a hazard for life.

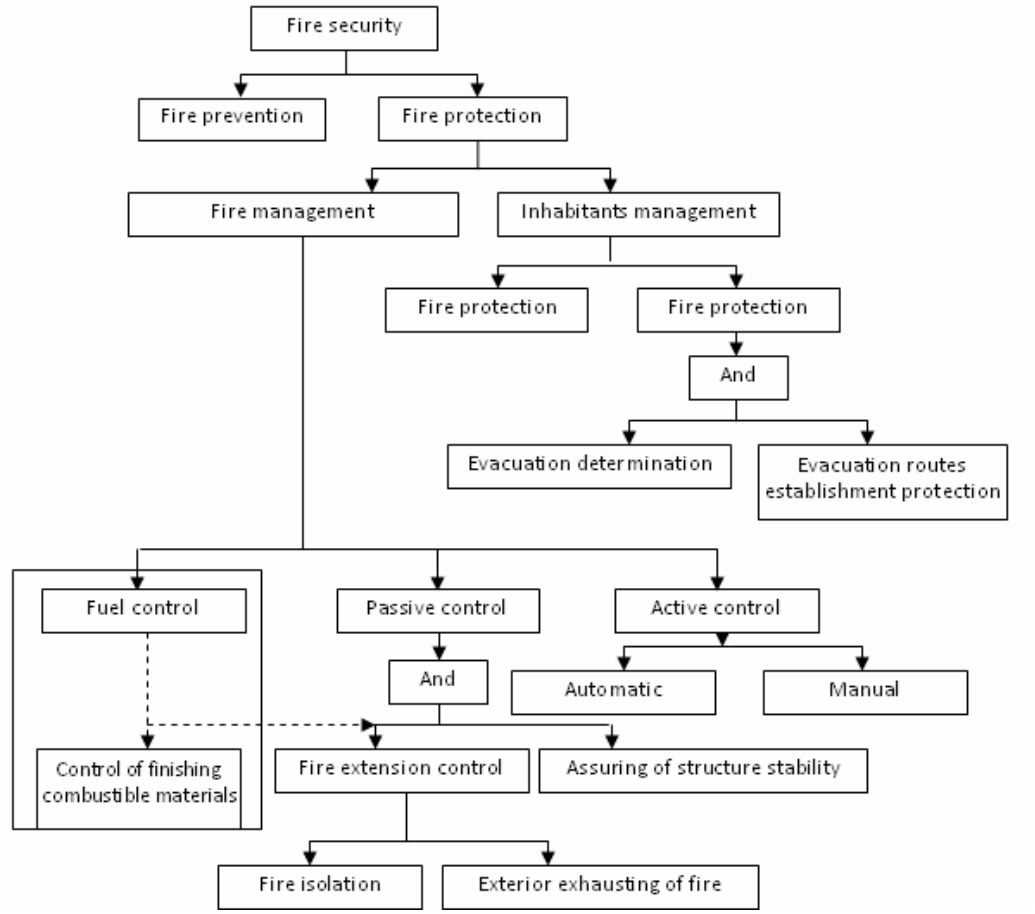

Fig. 1. *Conceptual tree regarding fire security*

After flash-over, fire detection can be realized by neighbours [1-2], [4].

3.5. Active Control

In the incipient fire period, the active control refers to measures which involve human personnel and automatic devices.

In case of flames, the best active protection measure is the endowment with an automatic sprinklers system which distributes water on a certain local area. Such systems extinguish most of the fires and prevent fire spreading. These systems must act in the incipient phase of the fire due to limited calculated amount of water.

In the case of smoke, the active control supposes the existence and functioning of exhausters or other smoke removing devices from affected areas. Active control of smoke may need complex systems in order to assure the evacuation of smoke and toxic substances from buildings without recirculation through other safe zones of the building. Inhabitants can prevent ignition and actively control the spreading of some small scale fires. Firemen can actively control or extinguish a fire only if they reach the event location before the fire grows. In the entire detection and extinguishing process, time represents an important factor.

3.6. Passive Control

Passive control of a fire refers to measures which involve the existence or some specific systems in structures and/or in the component elements of the building, and does not involve human intervention [1-2], [4].

Before flash-over, the passive control includes the usage of adequate materials for building and finishing. After flash-over, the passive control is realized by building subassemblies and fireproof structures.

4. Fire Qualitative and Quantitative Assessment

4.1. Qualitative Assessment

A modality for fire security illustration is represented by fire scenario analysis. This method analyzes the unfavourable situations having the greatest occurrence probability. In each scenario, the forecasted fire and smoke growth and spreading is compared with fire detection and inhabitants' movement, by considering all the active and passive protection measures which are necessary to satisfy performance requirements.

4.2. Quantitative Fire Assessment - Fire Hazard

In any fire security study a quantitative assessment becomes necessary in order to establish the system's fire insurance. This way, the analysed system can be assessed by considering its safety. Quantitative assessment generated a discipline which has been widely developed lately. The quantitative assessment of fire safety begins from fire hazard analysis which can be based on historical data for the studied building (which are extremely limited). In this situation, fire security can be quantified using logical structures. For fire security assessment, software applications could be employed using probabilistic calculations for the above mentioned scenarios. These applications are more useful for research than design.

In the absence of simple probabilistic designing methods, most of design calculations are deterministic, using adequate insurance factors [3]. Designers are used to this calculus method due the fact that it is similar to that used in structural resistance deterministic design.

4.3. Fire Security Concept Schema

One of the most durable schemas regarding fire security was developed under the name of Fire Safety Concepts Tree by NFPA (National Fire Protection Association) in 1997. According to this schema, there are presented certain levels as follows:

- Level 1 - start.
- Level 2 - underlines that fire protection is not necessary if ignition can be prevented, otherwise the fire must be minimized. In reality there will always exist unplanned ignitions but their appearing probability can be reduced by fire prevention programs.
- Level 3 - shows that fire protection can be realized by fire management or inhabitants management (persons and assets).
- Level 4 - shows that persons and assets can be protected against fire by their movement. Generally persons are relocated when this is possible. A current practice for big buildings consists in people's movement to a safer area. Most of the assets must be protected on site. In order to move the inhabitants, the fire must be detected, people must be alerted and a safe passage must exist (Level 5).
- Level 6 refers to three options for fire control. The first one indicates that the fire

source can be controlled by limiting its geometry or fuel quantity, the second option refers to fire extinguishment and the third to fire control by constructive measures.

- Level 7 indicates the way in which the fire can be extinguished: manually or automatically. In both cases the extinguishment process depends on rapid detection and the application of a sufficient amount of fire extinguishing material (usually water).

- Level 8 shows that in order to control the fire from construction, it is necessary to control fire movement and at the same time to assure structural stability. Fire extending can be limited by fuel limitation in interior finishing materials.

- Level 9 underlines two strategies for fire movement control: fire isolation or exterior exhausting. Fire exhausting is a strategy which is useful for fires impact reduction, especially in one storey buildings, or on the last level in case of multi-storey buildings. Exhausting can be assured by a mechanic active system, or by a passive system based on plastic materials melting. In both situations, the exhausting can increase the local severity of the fire but fire extending and thermal impact on the entire building are limited.

Fire isolation represents the main protection method. The walls of most of the buildings are fireproofed, limiting the fire in the room in which it started. Small fires prevention represents one of the most important components of a fire security strategy.

Fire extending in surrounding buildings must be prevented by limiting the openings in exterior walls.

Smoke movement can be controlled through exhaustion or isolation. Smoke elimination represents an important strategy in fires in which the flames' dimension was reduced by automatic extinguishment systems. Building pressuring or smoke barriers can be used for smoke extending prevention [1-2], [4].

References

1. Băulescu, P.: *Stingerea incendiilor* (*Fire Extinguishment*). Bucureşti. Editura Tehnică, 1981.
2. Băulescu, P., Călinescu, V.: *Prevenirea incendiilor* (*Fire Prevention*). Bucureşti. Editura Tehnică, 1979.
3. Pyne, S.J.: *Introduction to Wildlife Fire. Fire Management in US*. New York. John Wiley and Sons, 1984.
4. Tatu, P., et al.: *Manualul pompierilor* (*Firemen Manual*). Bucureşti. Redacţia pubicaţiilor pentru construcţii, 1972.
5. Velez, R., et al.: *La defensa contra incendios forestales, fundamentos y experiencias* (*Forest Fires Safety, Fundaments and Experience*). Madrid. McGraw Hill, 2000.
6. *** SR-ISO 8421/1.