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INSPECT: a New Approach for Fire Safety in Existing Premises

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Fire safety in existing premises is one of the major concerns for the Italian National Fire Corps, not only in terms of intervention in the case of fire, but also for determining specific preventive regulations and countermeasures. This concern is based on the fact that the deterministic regulations that are generally used in Italy for defining prescriptions for new premises are not always easily applicable to existing constructions, and because the use of Fire Safety Engineering simulations seems to be too difficult for widespread application. Alternatively, a vulnerability assessment could be more suitable since it aims to identify the strengths and weaknesses of the premises in terms of fire safety. Consequently, the countermeasures for obtaining predefined levels of safety can be determined and customized. The paper illustrates the INSPECT approach (INspection and Study of Potential Emergency-scenarios for Countermeasure Tailoring) designed by the SPRINT-Lab of the University of Udine, and recently used by the Italian Interior Ministry to write new fire safety regulations. In particular, its effectiveness for safety management and emergency planning is underlined.

1. Introduction

Fire safety in workplaces, buildings and premises is one of the major concerns of legislators in the great part of civilized countries. Appropriately assessing the fire safety is important for management both in ordinary and emergency conditions. For this reason, fire safety regulations aim both to prevent and to prepare an adequate response in the case of fire, so constituting a fundamental point of reference for employers and rescue services.

There are different approaches to define the fire safety rules or standards, and they depend mainly on the Authority designate to their adoption and control (public or private), the typology of document (legislative acts or insurance documents) and their nature (mandatory or voluntary). In Italy, fire safety regulations are defined by legislative acts of the Minister of Interior – National Fire Corps – and currently, they follow or a deterministic and prescriptive approach or a fire safety engineering performance-based approach. Nowadays, the deterministic and prescriptive approach is ordinarily adopted, especially for new premises, as it is simple, certain, rapidly controllable and easily applicable. On the other hand, it has excessive rigidity for application on existing constructions. The fire safety engineering performance-based approach was adopted by Italian legislation in 2007. This approach is based on fire safety engineering and it is characterized by a great flexibility and adaptability. However, it introduces elements of complexity because of some indeterminacy related to the subjective assumptions adopted for developing the analysis. Moreover, its application requires a deeper knowledge of simulation models and the approval by the Authority of control (Italian National Fire Corps). All these reasons make difficult the widespread application of this method.

This dichotomy from an approach that permits certainty but is extremely rigid and an approach more flexible but complex, largely subjective and no easily controllable, defines the two extremes of a gap that should be filled. For individuating the possible solutions the main reference is the fire safety engineering that aims to permit and promote engineered solutions to fire safety problems as stated by Drysdale (2011). A comprehensive review of literature of the methods related to the performace-based approach is

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presented in Hadjisophocleous and Fu (2004). Scientific literature shows also simplified methods, as the index or tabled methods. More recently vulnerability-based methods have been proposed. Some of them, which refer to expert systems, were conceived for fire safety assessment and management in historical centres, such as GriSU (Grimaz and Pini, 1999), but they are considered too complex for widespread application. Check-based methods, such as PASS (Grimaz et al., 2010), further developed by Grimaz and Tosolini (2013) allow assessing only some aspect of fire safety, i.e. egress system. Therefore, it would be useful to define a method which maintains deterministic characteristics, but it is also flexible, easily applicable both for new and existing premises. Such a method should allow also to extend safety checks to all the objectives defined in the Construction Products Directive (CPD, 89/106/EC) and the connected Interpretative Document nr. 2. The method would be useful both for employer and rescue services and easily integrated into regulations. To this aim the method should allow to distinguish and recognise among different situations, identifying the strengths and weaknesses of the premises in terms of fire safety, and to define suitable countermeasures for obtaining predefined levels of safety. In the following, the INSPECT (INspection and Study of Potential Emergency-scenarios for Countermeasure Tailoring) vulnerability-based method, designed by the SPRINT-Lab of the University of Udine and recently used by the Italian Interior Ministry to write new fire safety regulations, will be illustrated.

2. The INSPECT approach

2.1 Principles

INSPECT approach arises from the consideration that the best countermeasures are those which allow you to cope with the problem and to group the universe of cases in a set of reference categories. The approach is based on the fire safety engineering principles defined by NFPA and Society of Fire Protection Engineering in the Handbook of Fire Protection Engineering (2008) and it is consistent with the approach of risk assessment introduced by UNESCO that sets up the safety evaluation on the following factors: hazard, vulnerability and exposure (Fournier D'Albe, 1979). The idea is to identify countermeasures according to a categorization of the potential emergency scenarios. This categorization should consider three main characterizations: a) potential critical scenarios (associated with possible adverse events and exposure conditions), b) functional vulnerability (that is the specific characteristics of the site for facilitating external rescue support) and c) grade of interdependence with the surrounding context.

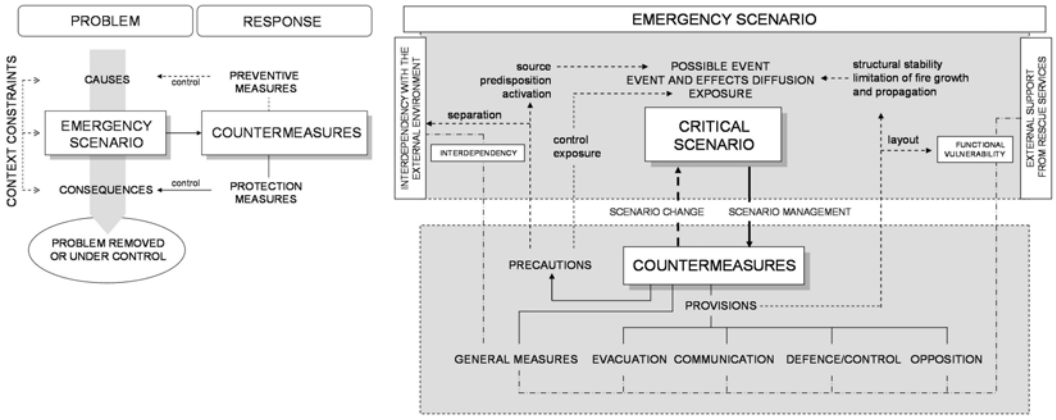

Figure 1: INSPECT approach: the idea (left) and logical framework (right).

The countermeasures necessary to cope with the specific emergency scenario should include both preventive measures for controlling the causes, and protection measures for limiting the consequences. Boundary conditions and constraints must be taken in to account.

The identification of the real situation within a set of pre-categorized reference scenarios allows choosing the safety countermeasures according to the actual needs, due to the link between countermeasures proposed and emergency scenario. Countermeasures are divided into general measures, precautions, and provisions (escape, communication, defense, opposition) as shown in Figure 1. More specifically, the INSPECT approach is based on the conceptual framework of the Fundamental Process of Damage Generation (FPDG) shown in Figure 2, first proposed by Grimaz and Pini (1999) and subsequently applied

to develop a framework for the design of crowded premises (Grimaz, 2009a) and to develop an integrated approach to design fire safety buildings (Grimaz and Crosilla, 2009b).

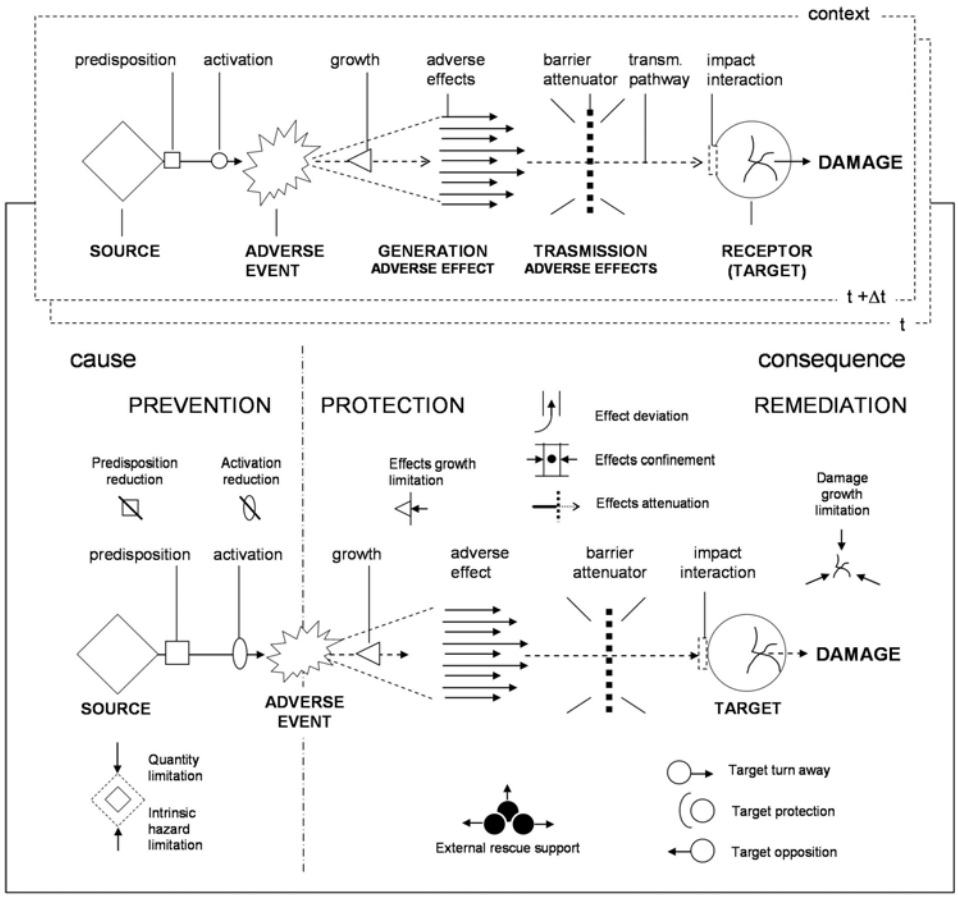

Figure 2: Conceptual framework of fundamental process of damage generation (above). Prevention and protection measures referred to the conceptual framework of fundamental process of damage generation (below).

This conceptual framework allows classifying the various countermeasures for prevention and protection according to their function or action in the specific phase of the process as shown in the lower part of Figure 2. FPDG permits to consider different targets e.g. people or assets, therefore damage assessment and countermeasures identification could be focused separately for each target considered.
INSPECT can be applied without simulations by numerical models (FSE – Fire Safety Engineering modeling) and it provides a rapid assessment, at macroscopic level, through the recognition of specific scenarios of reference. In order to identify strengths and weaknesses of the system, a vulnerability-based analysis must be carried out, considering the various components of the system (physical, logistics and organizational, managerial and context) and their interrelationships. For this reasons, INSPECT approach can be considered as an evaluative method in the framework of fire safety engineering approach.

2.2 Structure of the approach

INSPECT approach includes two phases:

- phase A: substantial characterization and categorization in terms of fire protection;
- phase B: definition of fire safety countermeasures for the various categories defined in the previous phase.

The categorization results from a systematic analysis of the premises that are divided into sectors which are functionally homogeneous areas. In the phase A, the categorization is done comparing the case

analysed with a group of pre-codified reference scenarios, defined and differentiated according to the following three main aspects.
The first is the interdependency premise-context: it allows us to take into account the level of interdependence between premises, activities and external environment, the presence of separation elements which may avoid the spread of an event from inside to outside or vice versa.
The second is the potential critical scenario inside the premise: it allows us to describe the type of accident scenario, in terms of adversity and exposure. In this analysis, the following elements are considered: a) type of adversity scenario of potential fire; b) type of potential exposure of people or property; c) presence of specific critical points. The level of adversity must take into account both the anthropogenic elements (assets, equipment, substances, etc.) and natural environment (conditions of the ground, presence of vegetation, threes, forest, etc.).
The third aspect is the location and lay-out of the premise: these features allow us to take into account the factors that could influence the external rescue support and therefore could highlight the need of a more autonomous internal emergency response to deal with the potential critical scenario. In the analysis the following elements are considered: a) premise accessibility by the external rescue services; b) premise lay-out (internal viability and pathway system); c) premise extension.

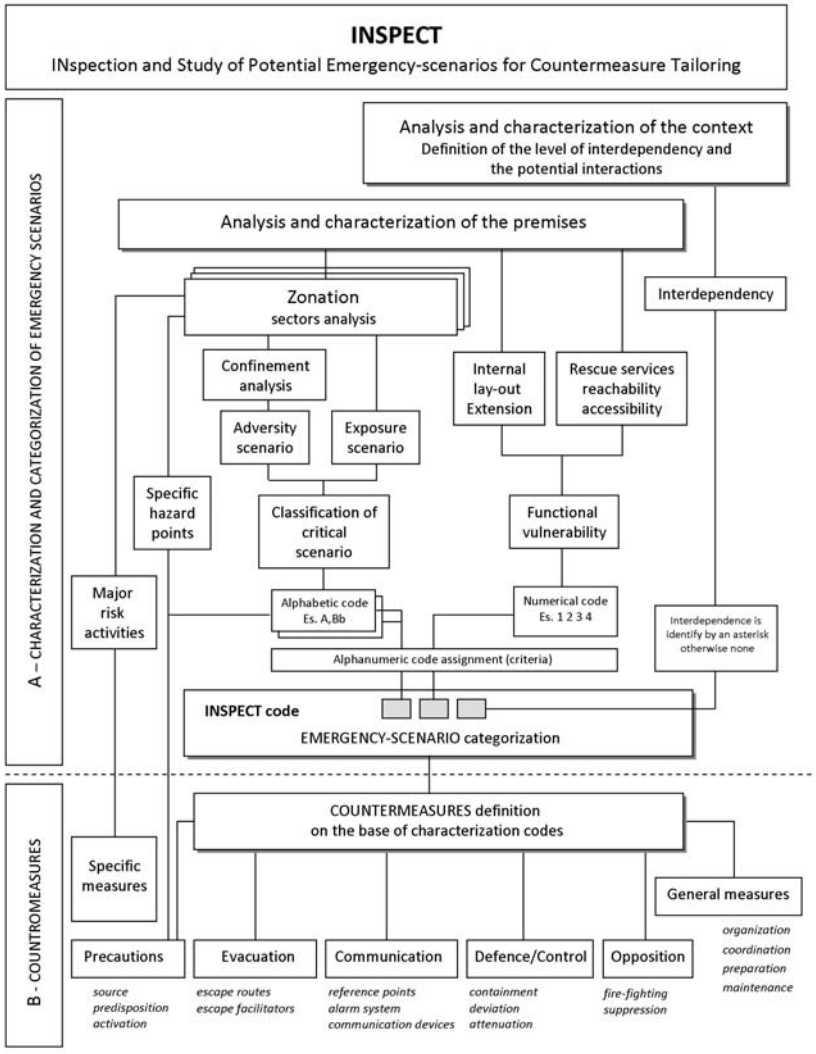

Figure 3: Flow-chart of INSPECT approach.

At the end of the analysis and characterization process, we proceed with the categorization of the premise. Each category is expressed as an alphanumeric code that characterizes the premise for the subsequent identification of the countermeasures.
The code consists of three main elements.
First a capital letter (or two letters – capital the first and small the second one) that indicates the worst emergency scenario present. In the case of double letters, the first refers to adversity, the second one to exposure. If possible, the alphabetic code must be evocative of the essential characteristics of the emergency scenario (for example: “F” for “Forest”; “C” for “Combined” (anthropogenic and natural), “Nc” for “Normal adversity with presence of crowds”, “Do” for “adversity of Dangerous substances with only occasional presence of people”, etc.).
Second, a number from 1 to 4: it represents an indicative level of functional vulnerability defined according to the following criteria: 1 (promptly supportable) if the location and lay-out allow the internal organization to rely on prompt assistance by external rescuers; 2 (supportable) if the location and lay-out allow the internal organization to rely on assistance from the external rescuers in time for the management of the event; 3 (self-managed) if location and lay-out do not allow the internal organization to rely on external rescue assistance in time for the management of the event but there are not particular difficulties and complexities in dealing with the event; 4 (critical self-managed) if the location and lay-out do not allow the internal organization to rely on an external rescue assistance in time for the management of the event or there is particular difficulty and complexity in dealing with the event.
Third, an asterisk: if an interdependence with the context is evaluate.
Phase B defines the minimum and tailored safety measures associated with the various fire safety categories (codes) defined in the previous phase (phase A). The safety level of the analysed situation is assessed with reference to fire safety goals, through specific vulnerability checks. These checks allow to choose among alternative strategies and solutions to achieve predefined safety levels. If the checks point out some criticalities, more detailed analyses could be performed by means of FSE numerical methods.
The safety measures are designed to prevent the generation of a specific emergency scenario and to define the conditions necessary to adequately manage the response to the event in case of occurrence. The safety measures are distinguished in: general organization, precautions, evacuation, communication, and opposition. Figure 3 shows the diagram that summarizes the steps of the method.

3. First application for regulation purposes

The INSPECT approach was used for regulation purposes for the case of external premises and in particular for breakers yards and campsites. In particular, INSPECT was applied for defining an alternative approach that provide a plurality of predefined solutions directly related to a set of different emergency scenarios (Figure 4).

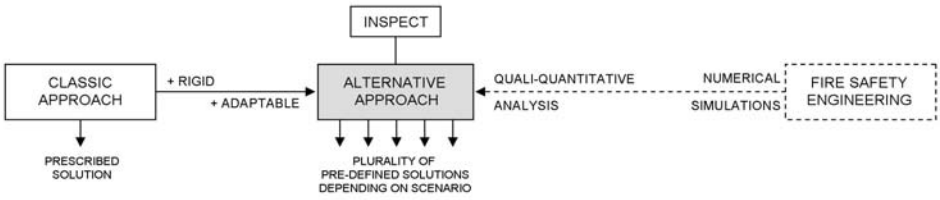

Figure 4: The use of INSPECT approach in the Italian fire safety regulations.

The Italian name of the first application of the approach is “Metodo proporzionale mediante categorizzazione sostanziale ai fini antincendio”. The method was positively assessed by the Scientific and Technical Committee of the Italian Ministry of Interior. The method permits at the same time both to maintain the deterministic characteristics and to allow more flexibility than the classical prescriptive rules, by introducing pre-coded emergency scenarios with tailored countermeasures defined on the basis of objective parameters.
The method is a useful decision support tool for managers, who can decide how to handle fire safety choosing the best solution among various pre-coded ones.
In particular, employers can define the fire safety strategy, by changing or coping with the emergency scenario through tailored preventive and protective countermeasures. Furthermore, the emergency

scenario characterization allows employers to be aware of the type of adverse events they may have to cope with and of the constraints for the support of external rescue services in case of fire.
Moreover the method permits to evaluate the interaction between premise and surrounding environment, i.e. the spread of fire in the forest for campsites in forest areas, and the impact of huge columns of smoke on the main routes in the case of breakers yard sites close to motorways or railways.

4. Final considerations

A new approach, based on a categorization of the emergency scenarios has been introduced in the Italian fire safety legislation. The categorization procedure and corresponding countermeasures identification are defined, for the different cases, directly by the competent Authority (Italian National Fire Corp). This approach allows an easy check on the proper application of the procedures by the Authority. On the other hand, employers can identify countermeasures tailored on the specific emergency scenario in a more flexible way.
The emergency scenarios concept is directly useful for safety management and emergency planning aims. Furthermore the method is useful to employers who can choose the best solutions basing on a cost-benefits analysis.
The method represents a reasonable meeting point between the certainty of the deterministic codes and the flexibility of the fire safety engineering.
Moreover the evaluation of the interaction premise-surrounding environment is very important in terms of public safety and environment protection. For these reasons the method has been appreciated both by the Italian National Fire Corp and the employers' associations involved.

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