

NFPA 550

Guide to the Fire Safety Concepts Tree

1995 Edition



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An International Codes and Standards Organization

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NFPA 550
Guide to the
Fire Safety Concepts Tree
1995 Edition

This edition of NFPA 550, *Guide to the Fire Safety Concepts Tree*, was prepared by the Standards Council and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 14-16, 1994, in Toronto, Ontario, Canada. It was issued by the Standards Council on January 13, 1995, with an effective date of February 7, 1995, and supersedes all previous editions.

The 1995 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 550

The NFPA Committee on Systems Concepts was organized to be responsible for developing systems concepts and criteria for fire protection in structures. A primary accomplishment of this committee was the development of the NFPA Fire Safety Concepts Tree. This guide to the Fire Safety Concepts Tree was developed by the Committee on Systems Concepts in 1985. Appreciation is extended to Dr. John M. Watts, Jr., of the Fire Safety Institute for his major contribution to the contents of this document.

The Committee on Systems Concepts was discharged in October 1990, and the Standards Council assumed the responsibility for this document.

The 1995 edition represents a reconfirmation of the 1986 edition with editorial clarifications.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

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NOTICE: Information on referenced publications can be found in Chapter 8 and Appendix A..

Chapter 1 Introduction

1-1 General. The critical need for reliability in the U.S. space program generated a new discipline known as System Safety Analysis. Many analytical approaches to safety have evolved in this new field. One of the more powerful tools is Fault Tree Analysis. Fault Tree Analysis uses a tree-like diagram to describe the relationships of events that can lead to a system failure (*see Appendix B*). The NFPA Fire Safety Concepts Tree uses a similar diagram to show relationships of fire prevention and fire damage control strategies.

Fire safety features such as construction type, combustibility of contents, protection devices, and characteristics of occupants traditionally have been considered independently of one another. This can lead to unnecessary duplication of protection. On the other hand, gaps in protection can exist when these pieces do not come together adequately, as evidenced by the large losses that continue to occur.

The distinct advantage of the Fire Safety Concepts Tree is its systems approach to fire safety. Rather than considering each feature of fire safety separately, the Fire Safety Concepts Tree examines all of them and demonstrates how they influence the achievement of fire safety goals and objectives.

1-2 Scope and Application. The Fire Safety Concepts Tree is useful in providing an overall structure with which to analyze the potential impact of various codes and standards on a particular fire safety problem. It can identify gaps and areas of redundancy in alternative fire protection strategies as an aid in making fire safety decisions. The use of the Fire Safety Concepts Tree should be accompanied by the application of sound fire protection engineering principles.

1-3 Purpose. This guide is intended to answer questions that have been asked during the past twenty years and to stimulate new questions. Fire safety is not a static concept but evolves with the expansion of our knowledge of the nature of fire and with the imagination of the fire safety practitioner.

Chapter 2 Background

2-1 General. In the 1960s, there was growing awareness that modern high-rise buildings designed in accordance with building codes and standards were deficient in fire safety protection. In response, a special workshop and follow-up conference of selected experts was convened to consider systematic ways of developing new or revised approaches to fire safety. These conferences, held in 1971, were brainstorming sessions that had the objective of producing a logical framework for providing adequate fire safety in high-rise structures. They were the stimulus for the organization of a special NFPA committee with the scope of being "responsible for developing systems concepts and criteria for fire protection in structures." A

primary accomplishment of the Committee on Systems Concepts was development of the NFPA Fire Safety Concepts Tree.

2-2 Current Application. The original committee document, published in 1974, was a logic diagram referred to as the "Decision Tree." This term was used to identify the tree as an aid to fire safety decision-making. While the Decision Tree incorporated the logic and structure of a fault tree, it described paths leading to success rather than failure. Another important distinction separating the Decision Tree from a fault tree was that components of fire safety are not always well-defined events to which a probability of occurrence can be assigned. In order to emphasize that the tree components are concepts rather than events, it was renamed the Fire Safety Concepts Tree when it was revised and updated in 1980.

The NFPA Fire Safety Concepts Tree is printed on a single large sheet of paper and folded approximately into letter size. Unfolding and spreading out the tree permits the entire fire safety process to be viewed at once.

Chapter 3 Structure of the Fire Safety Concepts Tree

3-1 Fire Safety Objectives. At the top of the NFPA Fire Safety Concepts Tree is a box labeled "FIRE SAFETY OBJECTIVE(S)." The logic of the tree is directed toward the achievement of specified objectives, as in the recognized approach of "Management by Objectives" (MBO). In this case, the concern is for managing the fire risk. The concept is that the clearer the idea one has of the objective, the greater the chance of achieving it. The three basic fire safety objectives are life safety, property protection, and operational continuity. More specific operating objectives might include averting a catastrophic loss, avoiding public anxiety, preserving for posterity, and environmental protection.

Strategies for achieving fire safety objectives are divided into two categories: PREVENT FIRE IGNITION and MANAGE FIRE IMPACT. These concepts are connected through an "OR gate" to the fire safety objectives. This is shown on the printed tree by the lines drawn from the top of the boxes labeled PREVENT FIRE IGNITION and MANAGE FIRE IMPACT, which join together and lead upward through a circle with a plus symbol in it to the box labeled FIRE SAFETY OBJECTIVE(S) (*see Figure 3-1*). The circle containing the plus symbol ($\oplus$) is used to designate an OR gate. An OR gate is a logic operation whereby any of several inputs will produce a specified output. Thus, the logic of the tree is that fire safety objectives can be accomplished by preventing a fire from starting *or* by managing the impact of the fire. Note that although there is a tendency to read the tree from the top down, the logic flow is upward, i.e., the inputs are below the outputs.

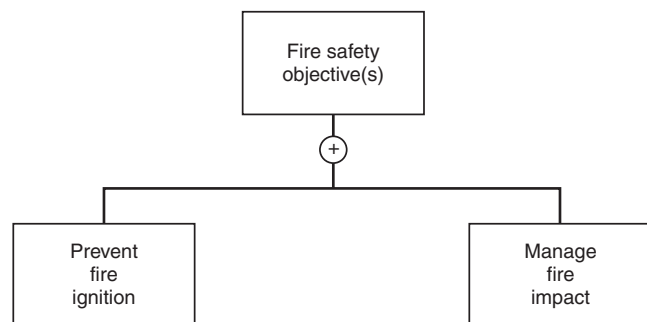


Figure 3-1 Top gate of Fire Safety Concepts Tree.

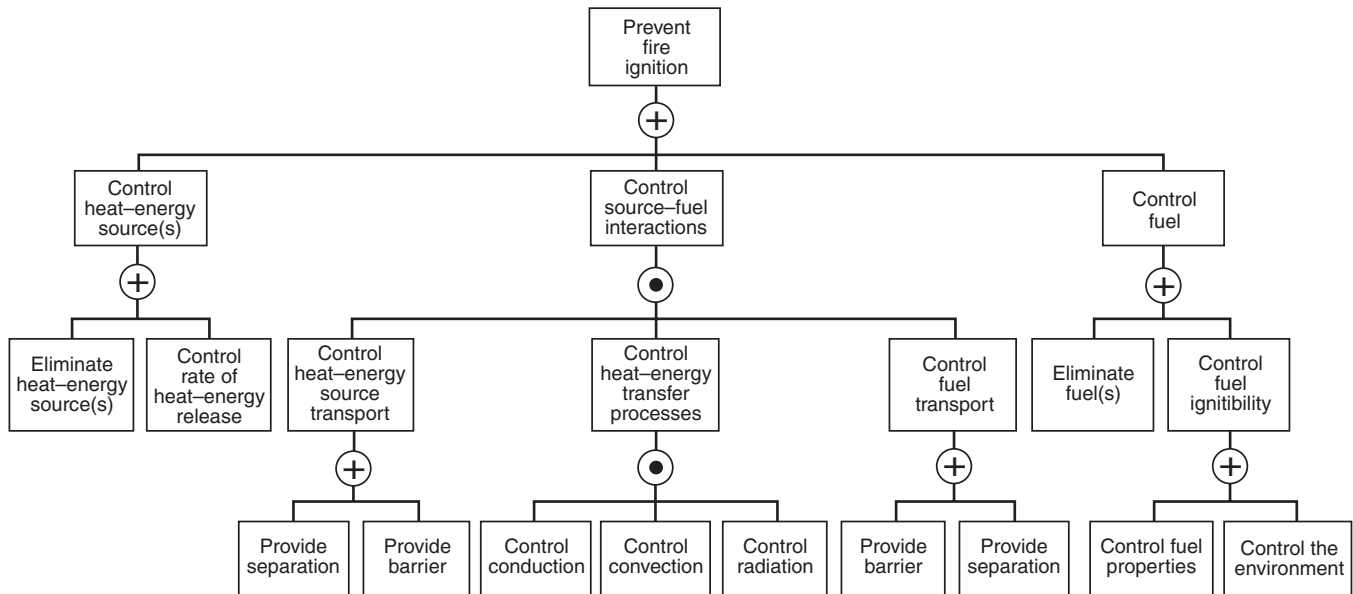


Figure 3-2(a) Prevent fire ignition branch of Fire Safety Concepts Tree.

The OR gate is the “inclusive or,” which means that all the concepts below the gate can be included, but only one of them is necessary. In theory, this implies that either prevention or management alone could be followed to achieve the objective. However, theoretically, it is not possible to achieve perfect prevention or management. In practice, principles of both fire prevention and fire impact management usually are applied together. The likelihood of achieving fire safety objectives is increased by the presence of both principles. This practice is an example of reliability through redundancy, e.g., using both a belt and suspenders to hold up a pair of pants. Thus, OR gates in the Fire Safety Concepts Tree indicate where reliability of achieving an objective is improved by implementation of more than one strategy. It is also important to note that the inputs to an OR gate are exhaustive. This means they encompass every possible way of achieving the indicated output.

3-2 Prevent Fire Ignition. The PREVENT FIRE IGNITION branch of the Fire Safety Concepts Tree includes measures representative of a fire prevention code. Fire safety measures included in this branch of the tree require continuous monitoring to ensure their effectiveness. The responsibility, therefore, is more the owner’s or occupant’s than the designer’s.

Ignition results from a heat source in contact with, or sufficiently close to, a combustible substance. Thus, PREVENT FIRE IGNITION branches into CONTROL HEAT-ENERGY SOURCE(S), CONTROL SOURCE-FUEL INTERACTIONS, or CONTROL FUEL [see Figure 3-2(a)]. Again, the OR gate indicates that any one of these three strategies, if carried out fully, is sufficient to prevent ignition, but use of more than one will improve the chances of prevention.

For example, control of heat-energy sources can be achieved by eliminating them. This also achieves the prevention of fire ignition, and no other strategy is needed. However,

there is a reliability associated with the strategy of eliminating all heat-energy sources, i.e., it is possible that somehow an ignition source might find its way into the protected area. If the control fuel strategy also is applied, then the reliability that ignition will be prevented is increased.

CONTROL SOURCE-FUEL INTERACTIONS is the output of an “AND gate” with input strategies of CONTROL HEAT-ENERGY SOURCE TRANSPORT, CONTROL HEAT-ENERGY TRANSFER PROCESSES, and CONTROL FUEL TRANSPORT. On the printed tree, the symbol for an AND gate is a circle with a dot in the middle (●). The AND gate is the logic operation that indicates all of the inputs must coexist simultaneously in order to produce the output. This means that the heat source should not be allowed to move too close to the fuel, excessive heat should be prevented from being transferred to the fuel, *and* the fuel should not be allowed to move too close to the heat source. All these concepts are necessary to achieve control of source-fuel interactions; there is no redundancy. AND gates in the Fire Safety Concepts Tree represent checklists of items that are necessary to achieve the output objective or strategy.

The plus and dot symbols used for OR gates and AND gates [see Figure 3-2(b)] also are used in fault trees. They are the standard symbols for these logic operations, which are used in electronic circuit diagrams and Boolean algebra. They are derived from the algebra of probabilities. (See Appendix C.)

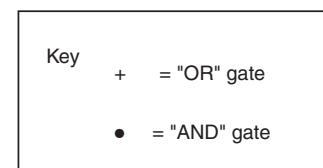


Figure 3-2(b) Logic symbols used in Fire Safety Concepts Tree.

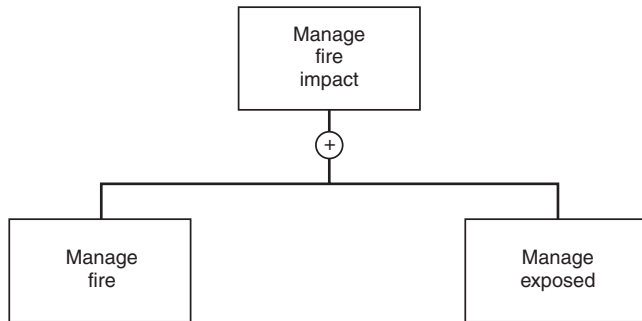


Figure 3-3 Major branches of manage fire impact.

3-3 Manage Fire Impact. The MANAGE FIRE IMPACT side of the tree has two major branches as inputs to an OR gate: MANAGE FIRE and MANAGE EXPOSED (see Figure 3-3). This is the basic approach to loss control, i.e., to limit the magnitude of the hazard or to minimize the effects.

3-3.1 Manage Fire. The objectives of the MANAGE FIRE strategy are to reduce hazards associated with fire growth and spread, and to thereby reduce the impact of the fire. Approaches to fire management are (1) control the rate of production of smoke and heat through alteration of the fuel or the environment, (2) control the combustion process by manual or automatic suppression, and (3) control fire propagation with venting or containment, or both (see Figure 3-3.1). Again, the OR gate indicates that these strategies can be applied simultaneously for increased reliability of managing the fire.

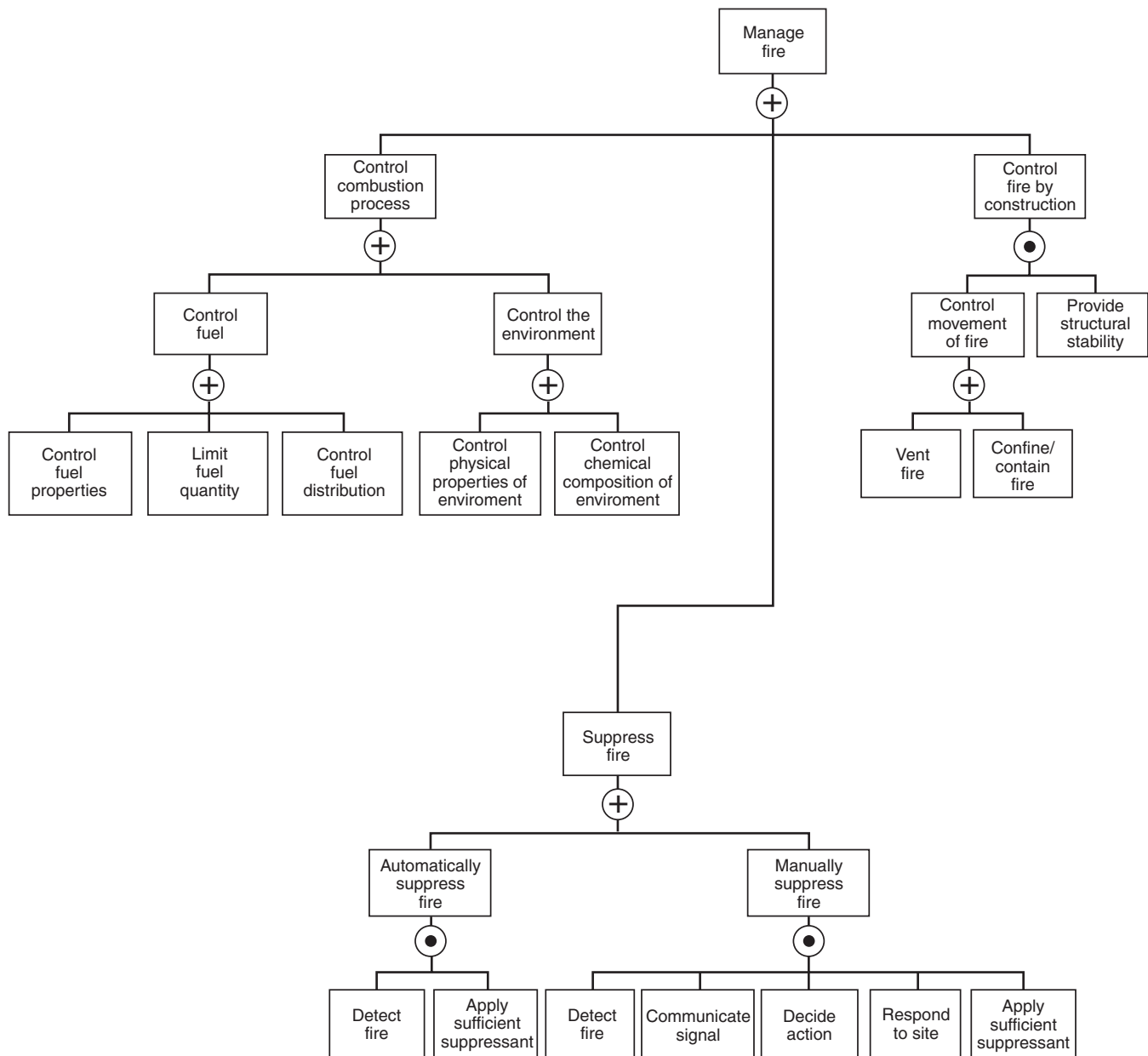


Figure 3-3.1 Manage fire branch of Fire Safety Concepts Tree.

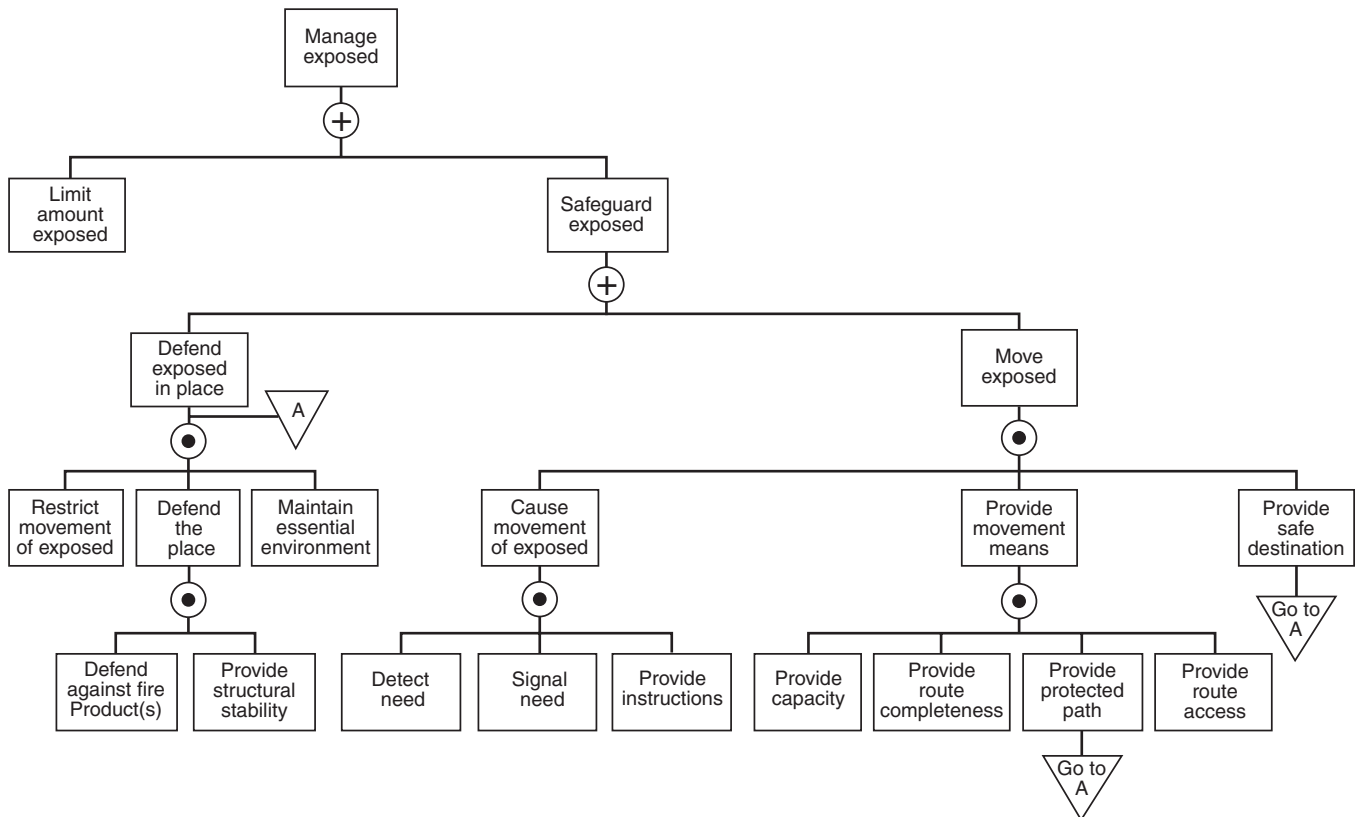


Figure 3-3.2(a) Manage exposed branch of Fire Safety Concepts Tree.

3-3.2 Manage Exposed. MANAGE EXPOSED means to coordinate measures involving any or all of the items specified in the fire safety objectives, e.g., people, property, activities, or other valuable considerations. The MANAGE EXPOSED branch is achieved by either limiting the number of individuals and amount of property that are exposed or safeguarding all persons and property subject to exposure [see Figure 3-3.2(a)]. In the case of property or immobile persons, such as nonambulatory hospital patients, the exposed is safeguarded most often by defending the occupied space from fire exposure. “Hardening against fire” is another term for the strategy of making the exposed resistant to the effects of fire. For more mobile occupants, the most common strategy for safeguarding the exposed is to relocate the exposed while protecting the route for the duration of transit.

The transfer symbol labeled “entry point” in the key to the Fire Safety Concepts Tree is shown in Figure 3-3.2(b).

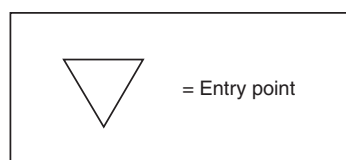


Figure 3-3.2(b) Transfer symbol.

This transfer symbol indicates where portions of the tree are repeated. In Figure 3-3.2(a), the portion of the tree under the element DEFEND EXPOSED IN PLACE is repeated under the elements PROVIDE SAFE DESTINATION and PROVIDE PROTECTED PATH.

Chapter 4 Applications

4-1 General. The Fire Safety Concepts Tree is a general qualitative guide to fire safety. It is a flexible tool that can be used in a number of different ways.

4-2 Communications. Perhaps the most important use of the tree is for communication with architects and other professionals involved in building design and management. Codes and standards are not intended to be tutorial; they presume a significant level of comprehension of the principles of fire protection engineering. The Fire Safety Concepts Tree is a simple visual representation of the total concept of fire safety incorporated in codes and standards. It can be used as a means of communication between fire safety specialists and others to help identify the role of specific requirements. The tree can be considered as a first level of education in fire protection engineering, i.e., as an introduction to the full breadth of the subject.

4-3 Code Equivalency. A more specific application of the Fire Safety Concepts Tree is its use as an adjunct to building codes. An important feature in building codes is the provision for “equivalencies.” Equivalency clauses state that alternatives to specified code requirements are acceptable if they provide a degree of fire safety equivalent to that of the code. The Fire Safety Concepts Tree provides a guide to the determination of equivalency. OR gates indicate where more than one means of accomplishing a strategy in the tree is possible. A decrease in the quality or quantity of one input to an OR gate can be balanced by an increase in another input to the same gate. However, it should be emphasized that this application is

subjective. Comparative values of tradeoffs usually are determined by experienced judgment. The importance of the tree is that it provides guidance in which concepts to assess.

4-4 Building Management. The Fire Safety Concepts Tree can be used to assess fire safety in an existing building. Inputs to AND gates in the tree comprise a checklist of required components that should be maintained in order to accomplish their respective strategies. Thus, in a structure for which particular strategies are identified as necessary to achieve fire safety objectives, appraisal of inputs to those strategies constitutes a fire safety assessment of the structure.

4-5 Building Design. Ideally, the Fire Safety Concepts Tree is a design tool. Once basic fire safety objectives for a building are identified, the designer can analyze the alternative tree paths through which these objectives can be met. Examination of the OR gates in the tree indicates where alternative strategies exist and where redundancies can be built into the design to improve reliability. The tree then can be used to communicate the fire safety concepts of the design to management and code officials.

4-6 Research. Another application of the Fire Safety Concepts Tree is as a research tool. The tree can be used to classify fire safety strategies as a guide for research activities. In one case, an investigation to determine alternatives to federal fire safety requirements for housing projects began with an analysis of residential fire safety using the Fire Safety Concepts Tree. In another research project, qualitative techniques of fault tree analysis were applied to the Fire Safety Concepts Tree to produce an exhaustive set of fire safety strategies to compare the effectiveness of specific fire safety variables. A similar approach was used to link fire safety objectives with specific features in a study of hospital fire safety in the United Kingdom.

4-7 Other Applications. The applications described above represent only some of the more common uses of the Fire Safety Concepts Tree. In addition, the tree has been used or proposed for use as a guide to code organization, standards organization, information retrieval, curriculum development, marketing, indexing, and fire investigation. A major U.S. corporation adapted the Fire Safety Concepts Tree as a table of contents to their "Fire Safety Practices," and the U.S. Department of State developed an approach based on the Fire Safety Concepts Tree to evaluate their foreign property. Among the more than 10,000 trees that have been "planted" (i.e., distributed) by NFPA, there are hundreds of different applications likely, limited in scope only by the imagination of the user.

Chapter 5 Limitations

5-1 General. The NFPA Fire Safety Concepts Tree has met with some success as a comprehensive qualitative guide to fire safety. It allows identification of alternatives and combinations of fire safety as well as the identification of redundancies and gaps. However, there are significant limitations to its application.

5-2 Interaction of Concepts. The tree structure does not adequately consider multiple interactions of fire safety concepts, i.e., concepts that are inputs to more than one strategy. This is most apparent in regard to the combined contribution of detection systems to the management of fire and to the management of the exposed. The logic tree approach does not

portray lateral influences of fire safety components, i.e., concepts at the same level in the tree that affect each other.

5-3 Time Factors. One of the major limitations of fire safety trees is the lack of chronological sequences. Fire safety depends on the elimination of combustion products and people coexisting in the same place at the same time. That is, avoidance of fire casualties depends on the avoidance of exposure in both space and time. One can either endure a fire or escape it. To escape a fire means to move faster than the fire and its products of combustion. The temporal aspect of fire development is not represented in the Fire Safety Concepts Tree.

The Fire Safety Concepts Tree does not indicate where inputs to AND gates need to be sequential. For example, the basic elements that are inputs to MANUALLY SUPPRESS FIRE have an implied order in which they should occur. No distinction is made to identify AND gates where this implicit order exists.

5-4 Objectives. The NFPA Fire Safety Concepts Tree is limited in its ability to deal simultaneously with multiple objectives. There can be ten or more distinct fire safety objectives for buildings, each requiring a different course of action. Although a series of trees can be used to evaluate the success of achieving each objective individually, there is no convenient way to deal with multiple objectives collectively.

5-5 Quantification. Ideally, the Fire Safety Concepts Tree could be quantified like a fault tree. However, assigning probabilities or other numerical measures to fire safety tree "concepts" is much more difficult than identifying probabilities for fault tree "events." It is unlikely that the NFPA tree in its present form will be satisfactorily quantified in the near future.

Chapter 6 Use of the Tree

6-1 General. There are many methods for using the Fire Safety Concepts Tree. These range from cursory visual examination, through systematic consideration of each concept, to adaption for quantitative analysis. This section illustrates one systematic approach to qualitative assessment of fire safety. The references in Appendix A describe other approaches to using the tree.

6-2 A Procedure. The following procedure is a step-by-step approach for one way in which the Fire Safety Concepts Tree can be used to evaluate fire safety. It should not be inferred that this is the only way the tree can be used. As indicated previously, there is a wide variety of applications and methods for using the Fire Safety Concepts Tree.

6-2.1 Step One. Define the objectives. This is the most important step in making any decision. It is difficult to find the best solution to the wrong problem. This question should be asked: "What do I want the fire safety system to do?" (e.g., provide a high level of assurance that operations will not be interrupted; meet the intention of the code; minimize the possibility of a multiple fatality fire; etc.).

6-2.2 Step Two. Assess each of the lowest elements in the tree, i.e., all elements that do not have any inputs. For the particular structure in question, estimate the extent to which each basic element is present as a fire safety feature. For example, consider a simple scale made up of four categories: nonexistent, below standard, standard, and above standard, where

“standard” indicates an appropriate level of consensus. Next, label each of the lowest elements according to its applicable category. Evaluation should include consideration of the reliability of fire safety systems to perform as designed.

6-2.3 Step Three. Where the lowest level elements are inputs to an OR gate, the value of the output will be at least as high as the highest valued input. For example, if compliance with the strategy ELIMINATE HEAT-ENERGY SOURCE(S) is only partial, it might be evaluated as “below standard.” Similarly, if the only heat-energy source is electricity and the installation is in accordance with NFPA 70, *National Electrical Code*®, CONTROL RATE OF HEAT-ENERGY RELEASE could qualify as “standard.” Therefore, CONTROL HEAT-ENERGY SOURCE(S) as the output of an OR gate would be rated as at least “standard.”

6-2.4 Step Four. Where the lowest level elements are inputs to an AND gate, the quality of the output is limited to that of the least valued input. For example, consider an automatic sprinkler system with appropriately temperature-rated sprinklers spaced according to NFPA 13, *Standard for the Installation of Sprinkler Systems*. The strategy DETECT FIRE then could be considered “standard.” If, however, the water supply to the sprinkler system is inadequate, APPLY SUFFICIENT SUPPRESSANT would be considered “below standard” and, therefore, AUTOMATICALLY SUPPRESS FIRE as an output of an AND gate also would be considered “below standard.”

Thus, the AND gate represents a situation where the chain is only as strong as its weakest link. An OR gate, on the other hand, is analogous to a pair of pants held up by both belt and suspenders. The pants will not fall down if either one breaks.

6-2.5 Step Five. Proceed “up” the tree in this manner, qualifying each output on the basis of the quality of the inputs and the logic gate that connects them. When each element has been evaluated, the entire tree can be examined to determine where improvements should be made to meet fire safety objectives. Alternatively, in the design stage, move down the tree, making certain that strategies are present that will yield the desired objectives.

Evaluation should include reliability assessment, such as examining the effect of system failures on achievement of objectives. For example, what happens to the various outputs if the alarm system fails, i.e., SIGNAL NEED is rated “nonexistent?”

6-3 Example. The use of the Fire Safety Concepts Tree in this manner is illustrated by examining fire prevention in a hypothetical computer facility. That is, consideration is given only to the PREVENT FIRE IGNITION branch of the tree, demonstrating how a partial tree can be used for evaluation of a particular strategy.

6-3.1 Objectives. The first step is to identify the objectives. The general goal is to provide life safety, property protection, and operational continuity through prevention of the occurrence of fire. More specifically, in this example, the Fire Safety Concepts Tree is used to identify a “standard” level of fire prevention for a data processing center and to identify ways to raise the level of fire prevention in the facility to “above standard.” Concern for the reliability of the fire prevention design also is addressed. In other words, the identified fire safety objectives are those implicit in national codes and standards, and the most effective ways to exceed this identified level of fire prevention are sought.

6-3.2 Heat-Energy Sources. On the left side of the PREVENT FIRE IGNITION branch, there are two basic strategies or lower elements dealing with ignition sources. The first strategy is ELIMINATE HEAT-ENERGY SOURCE(S). In a computer facility, it is standard practice to prohibit heating appliances, smoking, and any other open flame-type of ignition source. Provisions should include a security program with adequate attention to the potential for arson. If these features are satisfactorily in place, this strategy can be assessed as “standard.”

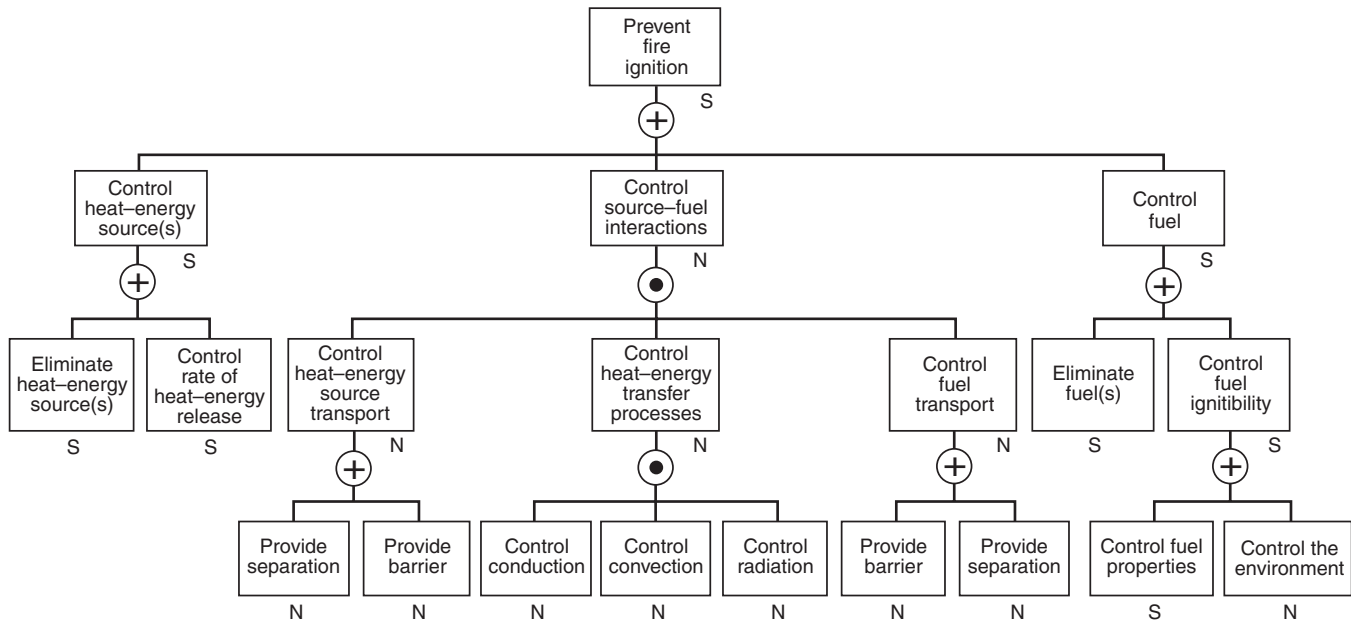
To improve on this level of assessment necessitates elimination of every potential ignition source including electricity. It is, of course, not feasible to eliminate completely the possibility of electrical ignition sources in a computer facility where electrically powered equipment is the nature of the occupancy. It is, however, possible to reduce the likelihood of an ignition by controlling the use of electricity. One way to do this is to conform to NFPA 70, *National Electrical Code*, Article 645, “Electronic Computer/Data Processing Equipment.” If these measures are taken, the strategy CONTROL RATE OF HEAT-ENERGY RELEASE can be considered as “standard.” It would be technically possible, though perhaps not practical, to improve the value of this element by using an intrinsically safe electrical system such as described in ANSI/UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations* (an intrinsically safe electrical system is one that does not release sufficient energy to ignite the combustibles in the environment).

6-3.3 Fuel. Consider the CONTROL FUEL branch of PREVENT FIRE IGNITION. Common combustibles in computer facilities include paper, plastic insulation on wiring, certain components or parts of equipment, and plastic media such as tape and disks. Section 4-1 of NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*, identifies materials and equipment that may be permitted in a computer room. Compliance with NFPA 75 can be considered as a “standard” level for the strategy ELIMINATE FUEL(S).

Parts of Chapter 5 of NFPA 75 address the limits of flame spread and flash point for materials used in computer equipment. Compliance with these requirements can be construed as a “standard” level of the strategy CONTROL FUEL PROPERTIES.

Avoidance of flammable gases and oxygen-enriched atmospheres can be considered as “standard” for CONTROL THE ENVIRONMENT, although these ordinarily are not concerns in a computer facility. An “above standard” strategy is a habitable atmosphere that does not support combustion, as suggested for spacecraft and similar occupancies.

6-3.4 Source-Fuel Interactions. Control of heat transfer between ignition sources and combustibles is not a common strategy in computer facilities. It is very difficult to isolate combustible media and components from the electrical power without significant alteration of construction or procedures. For example, the electrical insulating properties of polyvinylchloride make it a most efficient material to have in contact with electrical conductors, even though it is combustible. Thus, all of the basic strategies under the CONTROL SOURCE-FUEL INTERACTIONS branch could be classified as “nonexistent.” Note that, even though certain valuable media are sometimes stored in a fire-resistive container, this is primarily a strategy for managing the exposed, which is not likely to contribute significantly to preventing ignition.



Key A = Above standard
S = Standard
B = Below standard
N = Nonexistent

Figure 6-3.5 Fire prevention in a computer facility.

6-3.5 Results. The results of this process are shown in Figure 6-3.5. Now that a qualitative assessment of each lowest element in the PREVENT FIRE IGNITION branch has been made, it is possible to follow the procedures of steps 3 and 4 to evaluate the results. Input of a “standard” element (in this case, there are two) to CONTROL HEAT-ENERGY SOURCE(S) indicates that the output element also is “standard.” On the other side, “standard” inputs also indicate that CONTROL FUEL is “standard.” With only “nonexistent” elements as inputs, CONTROL SOURCE-FUEL INTERACTIONS is “nonexistent.” Then, the final OR gate leading to PREVENT FIRE IGNITION has two “standard” inputs so the output is “standard” (only one “standard” input is needed to be considered “standard,” since it is an OR gate).

The results shown on the diagram can lead to several conclusions:

(a) Prevention of fire in the computer facility meets a level arbitrarily identified as “standard,” and reliability is provided by redundant (duplicate) “standard” inputs to the OR gate that yield PREVENT FIRE IGNITION.

(b) A “standard” level of CONTROL SOURCE-FUEL INTERACTIONS provides a third degree of redundancy.

(c) Ways exist to improve certain elements to “above standard,” but all the current “standard” elements need to be improved to provide consistent reliability.

This same process could be applied to other branches or to the entire Fire Safety Concepts Tree. However, it is important to keep in mind that this approach is not a general solution to any fire problem. The Fire Safety Concepts Tree provides support for a specific decision. It is a tool for examining a particular situation to discover possible alternatives, but it does not condone such alternatives automatically. Each situation is unique, and

the tree can be used to provide a structure for an analysis based on accepted principles of fire protection engineering.

Chapter 7 Additional Information

7-1 General. In order to provide an understanding of each concept in the tree, additional information was appended to the Fire Safety Concepts Tree published in 1980. This information appears in three parts: a description of elements in the tree, a glossary of terms, and an administrative action guide.

7-2 Description of Elements in the Fire Safety Concepts Tree. Descriptions of tree elements or concepts have been provided to help convey the intent of the Systems Concepts Committee. These descriptions are intended as a guide to the thinking that framed the tree and should not restrict alternative interpretation of the concepts if such alternative descriptions are based on appropriate fire protection engineering principles. For example, it might be appropriate to a specific application of the tree to define PREVENT FIRE IGNITION in terms of a flame height or a rate of heat release. At the same time, this is the only published source of definitions of these concepts and is, therefore, a step toward better communication through common understanding.

The Fire Safety Concepts Tree (A Qualitative Guide to Fire Safety Strategies)

The following set of descriptions is presented to offer the Systems Concepts Committee’s best guidance on the application of the Fire Safety Concepts Tree. It is not intended to force a narrow or singular interpretation on those who find sound value in a broader or otherwise more relevant application of the elements in the Tree. This system of definitions is

consistent with the thinking that the committee applied in naming the elements and terms used.

It will be noted that some of the lower level Tree elements are not defined here, but the essential terms used therein are defined in the Glossary.

Description of Elements in the Fire Safety Concepts Tree

Accomplish by Administrative Action means to eliminate, *limit*, *control*, or accomplish other actions referenced in the Fire Safety Concepts Tree.

Apply Sufficient Suppressant (*automatically*) means to *automatically* perform *suppressive* action in response to *automatic* detection.

Apply Sufficient Suppressant (*to manually suppress*) means to *manually* perform *suppressive* action given response to the proper site.

Automatically Suppress Fire means to *automatically* perform actions on a *fire* process in order to *limit* the growth of or to extinguish the *fire*.

Cause Movement of Exposed means to initiate movement of the *exposed* to and along a safe path.

Communicate Signal means to transmit knowledge of a detected *fire* via human or *automatic* or a combination of human and *automatic* means to a responsible recipient of the information.

Confine/Contain Fire means to provide building construction features and built-in equipment in order to *limit* the *fire* or *fire products*, or both, to within the *barriers* surrounding the area where the *fire* originated.

Control Combustion Process means to *control* the inherent *fire* behavior.

Control Fire by Construction means to *control* the growth of the *fire* and the movement of *fire products* by performing actions involving building construction features and built-in equipment without intentionally acting upon the inherent *fire* process.

Control Fuel (Manage Fire) means to influence the combustion process by *pre-ignition control* of the inherent or situational characteristics of the *fuel*.

Control Fuel (Prevent Fire Ignition) means to *limit* the characteristics and uses of *fuel(s)*.

Control Fuel Distribution means to *control* the arrangement of the *fuel* within its environment.

Control Fuel Ignitability means to *control* the ease of *ignition* of *fuels* that are present.

Control Fuel Properties means to *control* the inherent properties of the *fuel*.

Control Fuel Transport means to prevent the *fuel* from moving to a location where *ignition* can result.

Control Heat-Energy Sources means to *limit* the characteristics and uses of *heat-energy sources*.

Control Heat-Energy Source Transport means to prevent the *heat-energy source* from moving to a location where an *ignition* can result.

Control Heat-Energy Transfer Processes means to alter the rate(s) at which the *fuel(s)* receives heat by *control* of the *heat transfer* mechanisms, such that *ignition* cannot result.

Control Movement of Fire means to *control* the movement of *fire* or *fire products*, or both, by providing and (where a normal functional necessity) activating building construction features and built-in equipment.

Control Rate of Heat-Energy Release means to *control* the rate of thermal energy release of existing *heat-energy sources*.

Control Source-Fuel Interactions means to *control* the relationships of *source* and *fuel* so as to *limit* the *heat* communicated from the *source* to the *fuel* in order that *fuel* temperature remains below that required for *ignition*.

Control the Environment means *control* of the inherent or situational characteristics of the environment.

Decide Action means to determine a proper reaction given the communication of the existence of a *fire*.

Defend Against Fire Products means to *safeguard* the *exposed* using measures that prevent the presence of, or *control* the impact of, *fire products* at the *place*.

Defend Exposed in Place means to *defend* the *exposed* in the *place(s)* where they were located at the time of *ignition*.

Defend the Place (*of the exposed*) means to *defend* the *place* occupied by the *exposed*.

Detect Fire (*to manually suppress fire*) means to identify the presence of *fire* either by human observation or by *automatic* mechanism(s).

Detect Fire (*automatically*) means to identify the presence of *fire* without reliance on human observation.

Eliminate Fuel(s) means to eliminate all *fuel*.

Eliminate Heat-Energy Source(s) means to eliminate all places, materials, or objects at which thermal energy can originate or from which thermal energy can be transferred.

Limit Amount Exposed means to *limit* the maximum amount of *exposed*.

Limit Fuel Quantity means to *limit* the amount of *fuel* that potentially can become involved in *fire*.

Maintain Essential Environment means to ensure the sufficient prevention, removal, dissipation, or neutralization of adverse conditions, other than *fire* or *fire products*, or both, as experienced by the *exposed* within the *place*.

Manage Exposed means to coordinate measures directly involving the *exposed*.

Manage Fire means to coordinate measures for *control* of the *fire* or *fire products*, or both.

Manage Fire Impact means to coordinate measures to *limit* any harm directly or indirectly resulting from *fire* or *fire products*, or both.

Manually Suppress Fire means to *manually* perform actions on a *fire* process in order to *limit* the growth of or to extinguish the *fire*.

Move Exposed means to safely relocate the *exposed* to safety.

Prevent Fire Ignition means to prevent initiation of destructive and *uncontrolled burning*.

Provide Movement Means means to provide the facilities necessary for a safe path through which the *exposed* can be relocated.

Provide Safe Destination (for the *exposed*) means to provide a safe location to receive the *exposed*.

Provide Separation (*fuel* transport) means to provide and maintain a *separation* between the *fuel* and the *source* by measures acting only upon the *fuel*.

Provide Separation (*source* transport) means to provide and maintain a *separation* between the *source* and the *fuel* by measures acting only upon the *source*.

Provide Structural Stability means to maintain the effectiveness of building construction features and built-in equipment.

Respond to Site means to respond to the proper site from which to *manually* initiate suppressive action.

Restrict Movement of Exposed means to prevent movement of the *exposed* beyond the boundaries of the *defended place*.

Safeguard Exposed means to act upon the *exposed* and the immediate surroundings of the *exposed* to *protect* the *exposed* against *fire impacts*.

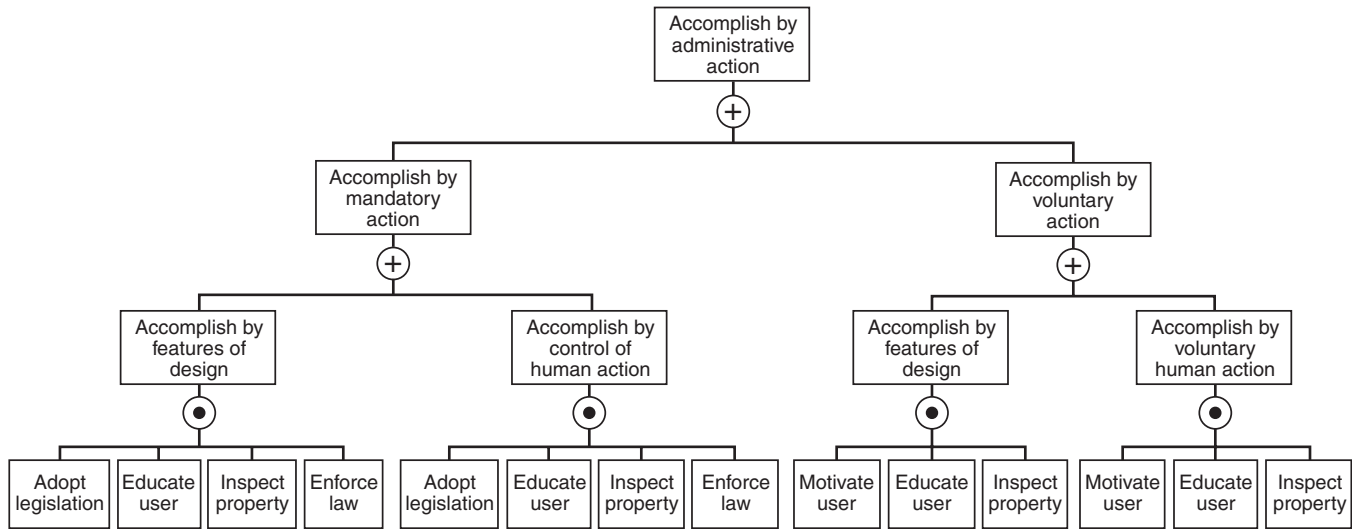


Figure 7-4 Administration action guide.

Suppress Fire means to perform actions on a *fire* process in order to *limit* the growth of or to extinguish the *fire*.

Vent Fire means to provide building construction features and built-in equipment that can *control fire* by removal of the *fire* or *fire products*, or both.

7-3 Glossary. Italicized terms in the descriptions of Fire Safety Concepts Tree elements are defined in the glossary. As in the case of the descriptions, these definitions are subject to interpretation, but to a lesser degree.

Automatic (automatically) means occurring without need of human action.

Barrier means a material obstacle (as opposed to *separation*).

Burning means continuous combustion including smoldering.

Capacity (of a *place* or location) means the maximum number or amount of *exposed* that a *place* or location can accommodate.

Capacity (of a route or path) means the maximum flow rate of *exposed* that a route or path can handle.

Conduction means a transfer of heat from a region of higher temperature through a material by a molecular mechanism not involving bulk motion to a region of lower temperature.

Control means to *limit*, affect, or alter the referenced factor(s).

Convection means transfer of heat by bulk motion of a fluid induced by mechanical devices or by gravitational effects due to nonuniform temperatures in the fluid.

Defend, as used in the Tree, means to *safeguard* the *exposed* using only those measures that prevent or *control fire impact* on the location of the *exposed*, without acting on the *fire* itself (see *safeguard*).

Exposed means any or all of the items specified in the fire safety objectives (e.g., persons, pieces of property, activities, or other valuable considerations).

Fire means any instance of destructive and *uncontrolled burning*, including explosions.

Fire Impact is a term used to denote the direct or indirect results of *fire*.

Fire Products, as used in the Tree, means flame, heat, smoke, and gas.

Fire Safety means the measures taken to *protect* the *exposed* so as to satisfy a specified objective.

Fuel means a substance that yields heat through combustion.

Heat-Energy is a term used to indicate that only the thermal forms of energy are of concern.

Heat-Energy Source (*source*) means any *place*, material, or object at which *heat-energy* can originate or from which *heat-energy* can be transferred.

Heat-Energy Transfer Process means the exchange of thermal energy from the *source* to the *fuel* by the mechanisms of *conduction*, *convection*, or *radiation*, or all three.

Ignitibility means the ease with which *fuel* undergoes *ignition*.

Ignition means the momentary event when *fire* first occurs.

Immobilize means to fix in place, so that no movement can occur.

Limit means to prescribe a minimum or maximum size, quantity, number, mass, extent or other dimension.

Manage means to coordinate broadly-ranging available methods toward accomplishment of objectives.

Manual means employing human action.

Place means an area within designated boundaries containing *exposed*.

Protect means the use of any or all available measures to *limit fire impact*.

Radiation means the combined process of emission, transmission, and absorption of energy traveling by electromagnetic wave propagation (for example, infrared radiation) between a region of higher temperature and a region of lower temperature.

Safe Destination means a *protected place* of adequate capacity.

Safeguard as used in the Tree, means to *protect* the *exposed* by using only those measures directly involving the *exposed*, without acting on the *fire* itself (see *defend*).

Separation means an intervening space (as opposed to *barrier*).

Source — See *Heat-Energy Source*.

Suppression means extinguishment or active *limitation* of *fire* growth.

Thermal Energy — See *Heat-Energy*.

Transport means the movement of either the *heat-energy source* or the *fuel*.

7-4 Administrative Action Guide (see Figure 7-4). The Administrative Action Guide uses the logic format to show various ways to regulate or promote fire safety strategies. It is intended as a generalized guide to encourage any of the measures described in the Fire Safety Concepts Tree.