An Expert System for the Fire Protection Requirements of the National Building Code of Canada 1990

by

Darryl Michael Olynick

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ABSTRACT

In Canada, the standard for fire safety for new buildings, reconstruction of buildings including alteration and additions, and buildings involving a change in occupancy,is established in Part 3, Use and Occupancy of the National Building Code of Canada 1990. While the fire protection requirements contained in this section of the Code are very explicit, inexperienced or infrequent users of the Code often find it confusing and overwhelming because of the number of requirements which apply or seem to apply to a given building. An experienced code user or expert understands what information is relevant and will generally use a systematic process to determine the fire protection requirements that are applicable.

Because the human approach to fire protection analysis is, in fact, systematic and logically sequential, and because the knowledge contained in codes and standards is largely in the form of rules, an expert system can be developed to effectively simulate human competence in fire protection design.

This thesis describes the development of a user-friendly expert system that closely mimics the human approach used in the fire protection analysis of those buildings regulated by Part 3, Use and Occupancy of the National Building Code of Canada 1990. The principal fire protection requirements of the Code have been incorporated into the expert system. The resulting expert system will be useful to the experienced code user as a code assistant, and to the inexperienced or infrequent code user who requires code information when no expert is available.

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CHAPTER 1

Introduction

1.1 General

Construction is one of the largest industries in Canada (Clark 1986). It employs more than 650,000 Canadians and has produced a capital stock of more than $1,100 billion. The efficiency, effectiveness, and cost of construction is clearly a vital concern to all Canadians.

The standards and codes that regulate building construction strongly influence the industry. The ability of user groups to understand and correctly apply these regulations to building design has considerable effect on the success or lack of success of the final product. An increasingly sophisticated public is less willing to accept the latter. Recently, the fire protection aspects of building design have drawn considerable attention.

In Canada, the minimum standard for fire protective design is established in Part 3, Use and Occupancy, of the National Building Code of Canada (NBCC) (NBCC 1990). User groups of this part of the Code include designers, building contractors, regulatory authorities, and building owners and property managers.

While the fire protection requirements contained in this section of the Code are very explicit, inexperienced, or infrequent users often find the Code confusing and overwhelming because of the number of requirements that apply or seem to apply. The frustration in trying to extract specific provisions from the general document leads many users to remark that building requirements are too complex and ambiguous. The Code must, however, take into account a wide variety of buildings and building products. As a legal document it must be written so that it can be enforced under law (Hewitt 1986).

Over the last decade, considerable time, effort, and money have been spent in an effort to make the Code more understandable and easier to use. Some initiatives have focused on training through formal education programs, seminars, and workshops. Others have involved the development of Code commentaries, illustrated codes, and definitive technical information. Despite these efforts, expertise in Part 3 has been slow to develop. Code knowledge and performance exhibited by the different Code user groups still vary widely both among groups and within a group.

The knowledge gap that still exists among and within the different user groups contributes to inappropriate use of the regulations, subjective code interpretations, confusion, litigation, and increased construction costs. It is therefore essential that all building code practitioners develop comparable expertise in the effective and efficient use of the Code.

More recently, attention has turned to the computer in the belief that it is the single most important key to improved performance. While initial emphasis has been on retrieved systems (PTCBS 1990), artificial intelligence (AI) research has exposed the potential of expert systems, the impact of which is only just beginning.

1.2 Present Investigation

This thesis describes the development of a comprehensive expert system for the fire protection requirements contained in Part 3 of the NBCC. It is intended that the expert system be usable by both the novice and the code expert. On the one hand, the expert system provides the technical assistance necessary to raise the level of performance of a novice decision maker to the level of that of an expert. On the other, the program can improve the productivity of an expert decision maker.

A program's user interface has great influence on its acceptance. In the development of the expert system described herein, therefore, considerable emphasis is placed on making the format for eliciting information and presenting conclusions both attractive and easy to understand. The program is made sensitive to the code experience of the user through the extensive use of option <HELP> screens. Graphic illustrations are often used in place of large bodies of text where subjective interpretations are likely to occur.

Chapter 2 provides an overview of knowledge-based systems and expert systems. The components that are unique to these systems are described and expert systems are compared to conventional programs. The chapter concludes with a discussion of Personal Consultant Plus (PcPlus) by Texas Instruments, the expert system shell used to develop this expert system.

Chapter 3 provides a general introduction to building codes and includes a description of the different types of codes. Much of the discussion focuses on the NBCC. The fire safety objectives of Part 3 of the NBCC are introduced and the strategies employed to achieve these objectives are explained and compared to the strategies suggested by the National Fire Protection Association (NFPA) Life Safety Concepts Tree.

In Chapter 4, the process of programming the expert system for the fire protection requirements of the NBCC, using the PcPlus expert system shell program, is described. The chapter concludes with the results of a test conducted to determine whether the use of the expert system improves the performance of novices and code experts seeking fire protection requirements of the NBCC.

The thesis concludes with a brief review of the expert system development. Recommendations for further expansion and development of the expert system are presented.

CHAPTER 2

Expert Systems

2.1 Introduction

This chapter introduces the basic concepts of knowledge-based systems and expert systems. Expert systems are compared with conventional computer programs and the components of an expert system are discussed. Expert system development tools, including programming languages and expert system shells or generators, are described. The chapter concludes with a presentation of the main features of PcPlus, the expert system shell that was used in this project.

2.2 Knowledge-based Systems and Expert Systems

The terms *knowledge-based system* and *expert system* refer to a class of computer programs that represent and reason with knowledge of some specialist subject with a view to solving problems or giving advice (Jackson, 1990). The terms are sometimes used interchangeably, although the former is a more general term.

A knowledge-based system employs knowledge and inferencing to solve problems. When the knowledge and inference procedures are modeled after human experts, the knowledge-based system is called an expert system. It is often difficult to make a clear distinction as to when a knowledge-based system becomes an expert system but, for the most part, it is probably unnecessary to make this distinction. The term

Expert knowledge pertains to objects, relationships, and procedures in some *domain of interest*. Much of this knowledge is acquired through training and experience and typically includes heuristics and shortcuts that the trained expert applies to solve a given problem. The skill of the expert lies in his or her ability to apply only that knowledge necessary to solve the problem and disregard the rest. This type of knowledge is referred to as shallow knowledge.

Most experts, however, have a strong theoretical knowledge on which they can fall back when a problem cannot be solved by shallow knowledge alone. This knowledge is called deep knowledge and tends to be more general than shallow knowledge. A true expert system must represent shallow knowledge; most expert systems, however, employ both experiential shallow knowledge and theoretical deep knowledge.

The effectiveness of an expert system lies in its ability to successfully capture and manipulate the knowledge and strategies that one or more human experts use to answer questions, solve problems, and make decisions.

Expert systems are programmed to mimic closely a human expert in arriving at a solution to a problem. They are generally very interactive and the communication between the user and the program is similar to the dialogue that would take place between a human expert and a client. That is, questions asked, and the order in which they are asked, will follow a logical sequence similar to that of a consultation with a human expert. The answers provided to specific questions will often generate additional questions until, finally, a conclusion is reached.

Similarly to a human expert, the expert system can provide an explanation as to why a particular question is asked. It is also capable of providing the user with an explanation of the step-by-step process used to arrive at the final solution to the problem.

The program may completely fulfil the function of a human expert or it may play the role of an assistant to a human decision maker. The decision maker may be an expert in his or her own right, in which case the program may justify its existence by improving the productivity of the decision maker (Jackson, 1990). Alternately, the expert system may provide the technical assistance necessary to raise the level of performance of a novice decision maker to the level of an expert. This improvement in performance was discussed by Vadas (1992), and is illustrated in Figure 2.1.

2.3 Comparison of Expert Systems and Conventional Programs

Expert systems share some characteristics with traditional software programs. Both kinds of programs reach conclusions. Some traditional programs, like expert systems, are interactive and communicate with the user in natural language. However, there are several fundamental differences.

Conventional computer programs are based on algorithms or clearly defined step-by-step procedures that solve a problem directly. The algorithm simulates the problem subject area or domain and is converted into a sequential list of instructions or program which tell the computer which operations to carry out. The program uses data such as numbers, letters, or words to solve the problem. New data can be used to solve the same problem.

Instead of simulating the problem domain, an expert system simulates human reasoning about the domain. The expert system performs reasoning over symbolic representations of the domain knowledge. Objects, processes, and their relationships are represented by symbols. The symbols are used to create a knowledge base that states facts, concepts, and relationships among them. The reasoning is carried out by software that is kept separate from the knowledge base. This software uses search and pattern-matching techniques. With initial data, the reasoning mechanism searches the knowledge base for specific conditions or patterns. It looks for match-ups that satisfy criteria set up to solve the problem. The separation of domain knowledge from the problem-solving algorithm is a basic characteristic that distinguishes an expert system from a conventional program.

The search techniques employed by expert systems are more random and less organized than the algorithmic approach used by conventional programs. Expert systems make frequent use of heuristics or rules of thumb to improve the efficiency of the problem-solving process. Unlike conventional programs, expert systems have the ability to apply knowledge and ideas contained in the knowledge base whenever the need arises. That is, unplanned but useful interactions in problem solving can occur at any time during a consultation, not just according to some predetermined set of instructions.

Conventional computer programs are best at divergent reasoning (Townsend and Feucht, 1986). Using a small amount of input data, these programs often produce a considerable amount of output. On the other hand, expert systems use convergent reasoning to produce a few results.

Finally, unlike conventional programs, expert systems are expected to offer the user an explanation of how the conclusions were arrived at and why particular questions were asked during the consultation.

2.4 Components of an Expert System

An expert system comprises six components:

a) a knowledge base;

b) an inference engine;

c) a user interface;

d) working memory;

e) an explanation subsystem; and

f) a knowledge acquisition subsystem.

A general block diagram of an expert system is illustrated in Figure 2.2; a detailed explanation of each of these components is provided in the following subsections.

2.4.1 Knowledge Base

The body of knowledge specific to a problem is called the *domain*. The *knowledge base* of an expert system is created from the domain and is a body of knowledge about the domain. The knowledge base in turn defines the boundaries of the expert system problem domain. Problems that lie within these boundaries can be solved by the expert system, while those that lie outside cannot.

Knowledge must be formalized in a symbolic form that can be manipulated by the expert system. This symbolic representation requires both a representation of the current problem state and of the processes that act on the current problem state to transform it into a new problem state.

Knowledge about states and knowledge about actions occur as two kinds, declarative and procedural. Declarative knowledge is a description of facts. It is information about objects and their properties, and the relationships among objects. Procedural knowledge encompasses problem-solving strategies and arithmetical and inferential knowledge. Both kinds of knowledge must be present for the expert system to work.

The formalization of knowledge in a symbolic form is called knowledge representation and takes one of the following forms, used singly or in combination:

a) property lists;

b) rules;

c) semantic nets;

d) frames; and

e) logic.

The most common means of representing knowledge in expert systems is by rules. Rule-based expert systems are a class of expert systems where the main constituent of the knowledge base is a set of rules. That is, the main body of knowledge in the knowledge base is encoded into production rules:

IF: < CONDITIONS >
THEN: < CONCLUSIONS >

Each rule represents a piece of knowledge about the domain and is divided into two parts. The first part of the rule, called the antecedent, expresses a situation or premise while the second part, called the consequent, states a particular action or conclusion that applies if the situation or premise is true.

Declarative knowledge is implicit in the rules. The description of objects and relationships constitutes the antecedents and consequents. These descriptions or facts are entered into the expert system by the user or from a database, or are deduced by the inferencing process. The consequent can contain additional procedural knowledge in the form of various actions which are executed if the antecedent part of the rule is true.

As a knowledge base is modified or expanded, the number of rules in it can become quite large. As a result, the knowledge base often becomes difficult to manage. New rules are frequently redundant or may even contradict rules that already exist in the knowledge base. As the total number of rules grows, the knowledge engineer becomes less aware of the interaction among different rules.

Frames are used to better organize large knowledge bases into smaller, more manageable, blocks of knowledge. A frame can be thought of as a collection of knowledge about a specific object, concept or situation. In this thesis, frames are used to group knowledge related to a particular fire protection topic. For example, a frame may contain the knowledge on fire alarm systems. This frame would contain all the rules and other properties that are associated with fire alarm systems. Depending on the size of the part of the knowledge base on fire alarms, more than one frame may be used to break down the knowledge into a series of smaller manageable frames, referred to as subframes, that are all related to that topic.

The subframes are connected to one another in a hierarchial structure. A subframe structure can be seen in Figure 2.3. This structure allows frames to inherit the properties or values from frames that are higher above them in the hierarchy, and to pass properties or values to other frames that are lower in the hierarchy.

2.4.2 Inference Engine

The *inference engine* is the control mechanism of an expert system. The inference engine implements a search and pattern-matching operation, examining the rules in the knowledge base in a particular sequence in an attempt to find a match to the initial and current conditions in the working memory. As rules matching these conditions are found, the rules are *fired*, thereby initiating the actions specified.

2.4.2.1 Reasoning Mechanisms

A rule-based system reaches its final conclusion through a series of elementary conclusions (Klein and Methlie, 1990). When the deduced fact of one rule is put back into the working memory, a new pattern of data is created which may match with other rules. New facts may be deduced, stored in the workspace, and matched with other rules until a conclusion is reached. This process of linking rules through premises and conclusions is called chaining. Forward and backward chaining are the two modes of chaining used by expert systems.

2.4.2.1.(a) Forward Chaining

In *forward chaining*, the inference engine starts with the facts stored in working memory and then works forward to a conclusion that is supported by the facts. In other words, the inference engine matches the left-hand-side of the rules against the facts in the working memory. When a match is found, the conclusion described in the right-hand-side of the rule is reached or the action specified is carried out. This type of search strategy is often called data-driven or antecedent-driven.

2.4.2.1.(b) Backward Chaining

In *backward chaining*, a conclusion or goal state is assumed at the outset and the inference engine works backward in an attempt to find the facts that support the conclusion. The inference engine finds all rules that assign a value to the assumed goal state in the right-hand-side of the rule and then tries each rule to see which, if any, has conditions on the left-hand-side that can be satisfied by the data. This type of search strategy is often called goal-driven or search-driven.

2.4.3 User Interface

The user interface is the component of the expert system that communicates with the user. Its basic function is to gather information from the user and present the results of a consultation session back to the user.

User interface features include data input, reporting, graphical displays, explanation facilities, and on-line help systems. Two types of dialogues are commonly found:

a) question-and-answer format; and

b) menu format.

In the question-and-answer format, the user interface presents a question which the user answers by typing in information on the keyboard. In menu format, a question is asked and multiple choices are given. The user selects the answer that best fits the question. Some user interfaces incorporate windows or small screens of information within the main video screen.

2.4.4 Working Memory

The working memory is the part of an expert system that contains information about the problem to be solved. A portion of the working memory is the database. The database contains a set of facts that describe the current situation. As the expert system reasons with data, facts may be added, modified or deleted.

The process usually begins with initial data supplied by the user. The inference engine begins a search to match the rules in the knowledge base against this information. As each rule is examined, the actions caused when a rule fires may alter the content of the database, thereby updating the current status of the problem. New facts are now made available to the decision-making process. In many cases, the action of a rule may be a request for additional information from the user. The process concludes when the problem is solved or when a search of all rules in the knowledge base is exhausted.

The database portion of working memory also stores a sequential list of all rules that have been tried in the search process, along with an indication of the rules that are successful. This list, or *trace*, of the rule sequence can be used to provide the user with an explanation of the reasoning process.

2.4.5 Explanation Subsystem

The explanation subsystem provides the means for the expert system to explain to the user how it arrived at a particular conclusion or why a particular question was asked. The explanation of *how* a conclusion is arrived at typically takes the form of displaying a trace of the rules involved in the inference process and the order in which they were fired. The *why* explanation generally identifies the parameter being prompted for and the parameter that depends on this value. It also cites the rule that the inference engine is trying to use, and allows the user to trace the trail of logic backward to the beginning of the consultation.

The explanation subsystem is particularly important when the expert system is used as an assistant to a domain expert or to persons who are generally familiar with the knowledge and vocabulary of the domain. Experts and knowledgeable users frequently expect a certain result and want an explanation when the outcome of a consultation is different from that expected. Similarly, they expect the system to ask questions in a specific sequence. If an unexpected question is asked, they want to know why the information is needed. The ability of the expert system to justify a conclusion or explain itself generates confidence in the system. This ability is of lesser importance to the novice user who is perhaps not likely to challenge a decision. The explanation subsystem does serve, however, as a somewhat crude tutor to the curious novice who wishes to become more knowledgeable in the domain.

Finally, the explanation subsystem is crucial during the development and debugging of an expert system. Its output allows the knowledge engineer and domain expert to examine the logic trail and determine whether the system is getting the right answer for the right reasons. Unless an expert system has a good explanation subsystem, an expert will be unable to assess its general performance or give advice as to how its performance could be improved.

2.4.6 Knowledge Acquisition Subsystem

Knowledge acquisition refers to the transfer and transformation of knowledge from some knowledge source to a program. The knowledge acquisition subsystem is the part of an expert system that allows the knowledge engineer to enter new rules into the knowledge base or to edit existing rules.

In simple systems, this module is no more than an editor or word processor that edits or adds to a file. In more complex systems the knowledge acquisition subsystem has a control feature that ensures that rules added or edited do not conflict with existing rules and that their syntax is consistent with the form required by the inference engine.

2.5 Expert System Development Tools

Early expert systems were developed using programming languages such as LISP or Prolog. Both of these languages are suitable for symbolic processing, which is a common characteristic of problems that are suitable for solution by expert systems.

It soon became apparent that the only component of an expert system that was problem-specific was the knowledge base and that all other components could be used in other expert system applications. These components or programs became known as shells.

An expert system shell, therefore, contains all the basic components needed to support an expert system other than domain specific knowledge. The shell is an expert system with an empty knowledge base. The task of the expert system developer is to translate expert knowledge for the problem domain into rules that conform to the logical and syntactical requirements of the shell (Heikkila and Blewett, 1992). Expert system shells greatly simplify and speed up the creation of an expert system because they eliminate the programming problem and allow the developer to concentrate on building the knowledge base.

Shells vary with respect to knowledge base capacity, reasoning mechanism used, ability to link to external files, graphics capabilities, explanation facilities, methods for dealing with uncertainty, and price. The selection of the shell should be based on the problem to be solved, the abilities of the developer, and the needs of the user.

2.6 Personal Consultant Plus (PcPlus)

Personal Consultant Plus (PcPlus) is the expert system shell used to develop this expert system. PcPlus, developed by Texas Instruments, is a shell that facilitates the development and running of an expert system on a personal computer. The shell can accommodate a knowledge base of any size. The amount of RAM available on a personal computer dictates the knowledge base size and the size of external programs that can be linked to the expert system. The main features of PcPlus are:

a) Backward, forward, and mixed forward-backward inferencing strategies;

b) Meta-rules (special IF-THEN rules that contain information to help PcPlus decide how to order the search for goal parameters) which make the inferencing operations more efficient;

c) Input to expert system by menu selections and/or keyed-in numerical values;

d) Explanation facilities for why a particular question is being asked and an explanation of a particular rule;

e) Explanation facilities for how a particular conclusion was reached;

f) Facilities that allow graphic illustrations to be integrated into the knowledge base;

g) Facilities to link to external programs and files;

h) A facility to rerun consultations that have been saved earlier;

i) A facility to rerun consultations by changing one or more input attributes;

j) Knowledge that is represented in the form of production rules;

k) A simple command language, Abbreviated Rule Language (ARL);

l) A frame structure to organize large or complex knowledge bases;

m) A utility function to resolve rule conflicts;

n) Mapping functions to retrieve information: to operate across frames that are normally inaccessible because of rules of inheritance, and to retrieve information about how the knowledge base works;

o) LISP functions to extend the capability where there is no suitable existing function in the expert system: calculations or a sequence of operations that are placed throughout the knowledge base can be replaced with a LISP function;

p) A trace facility to view the inference operations during a consultation;

q) A build facility to create runtime versions of an expert system.

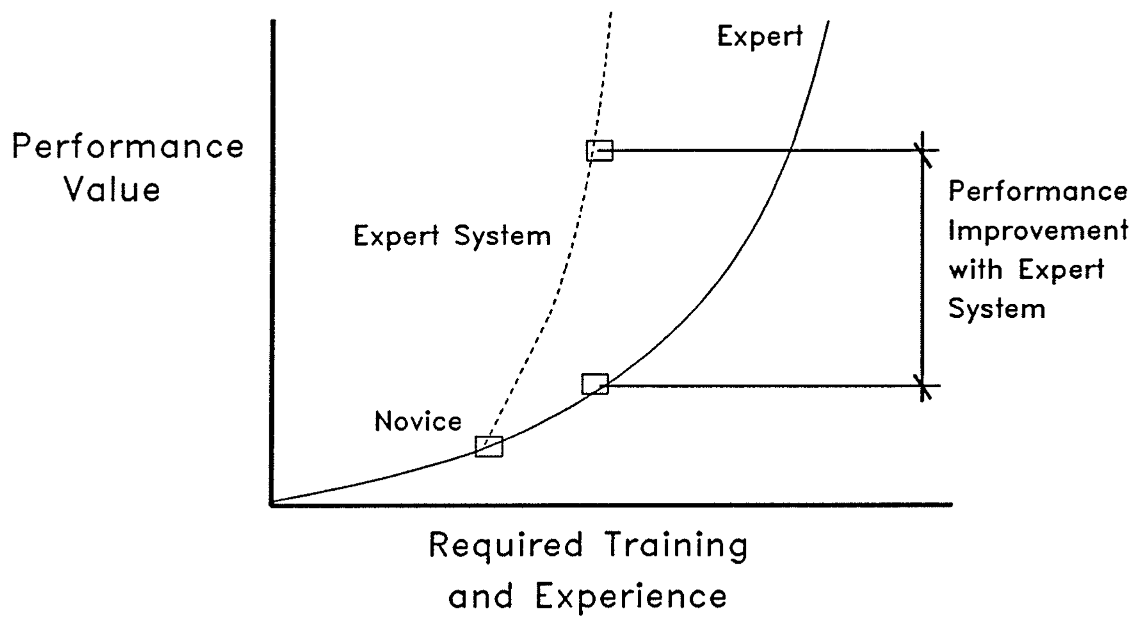


Figure 2.1 Performance Improvement with Expert System

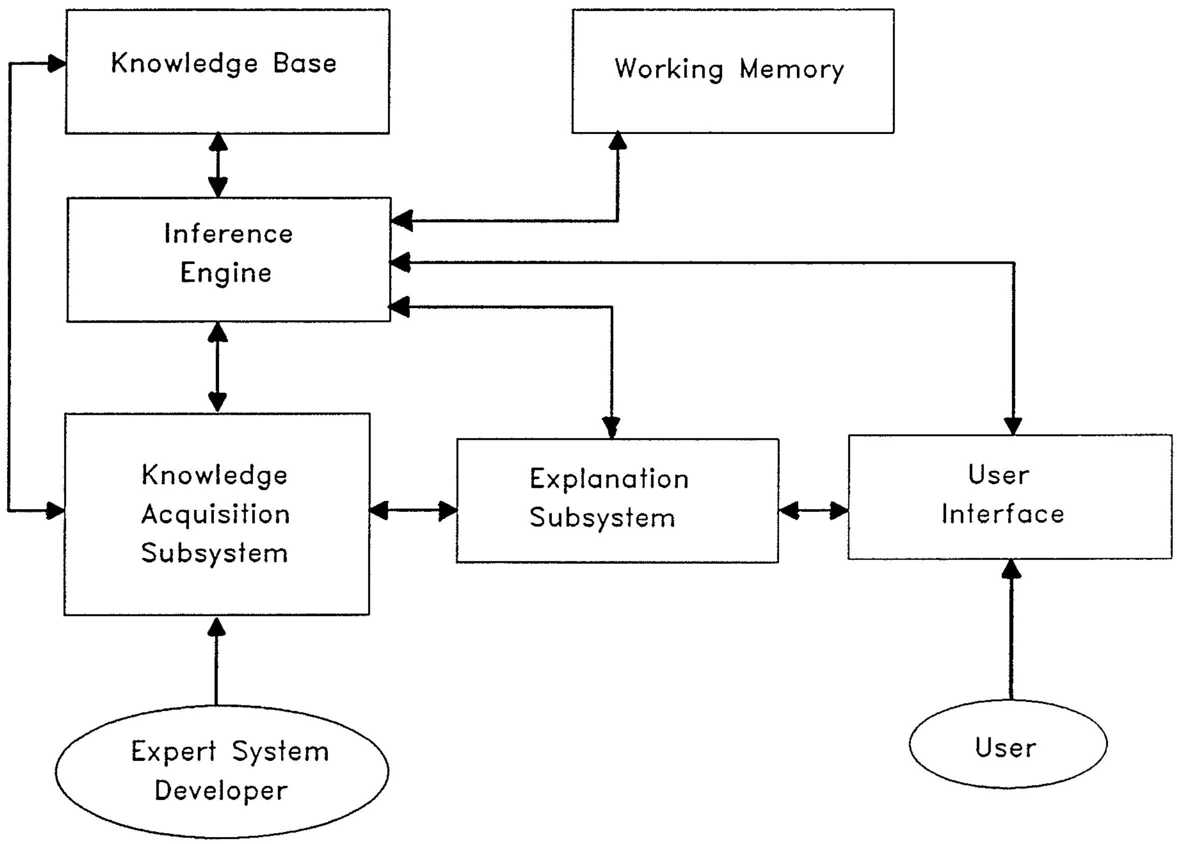


Figure 2.2 Components of an Expert System

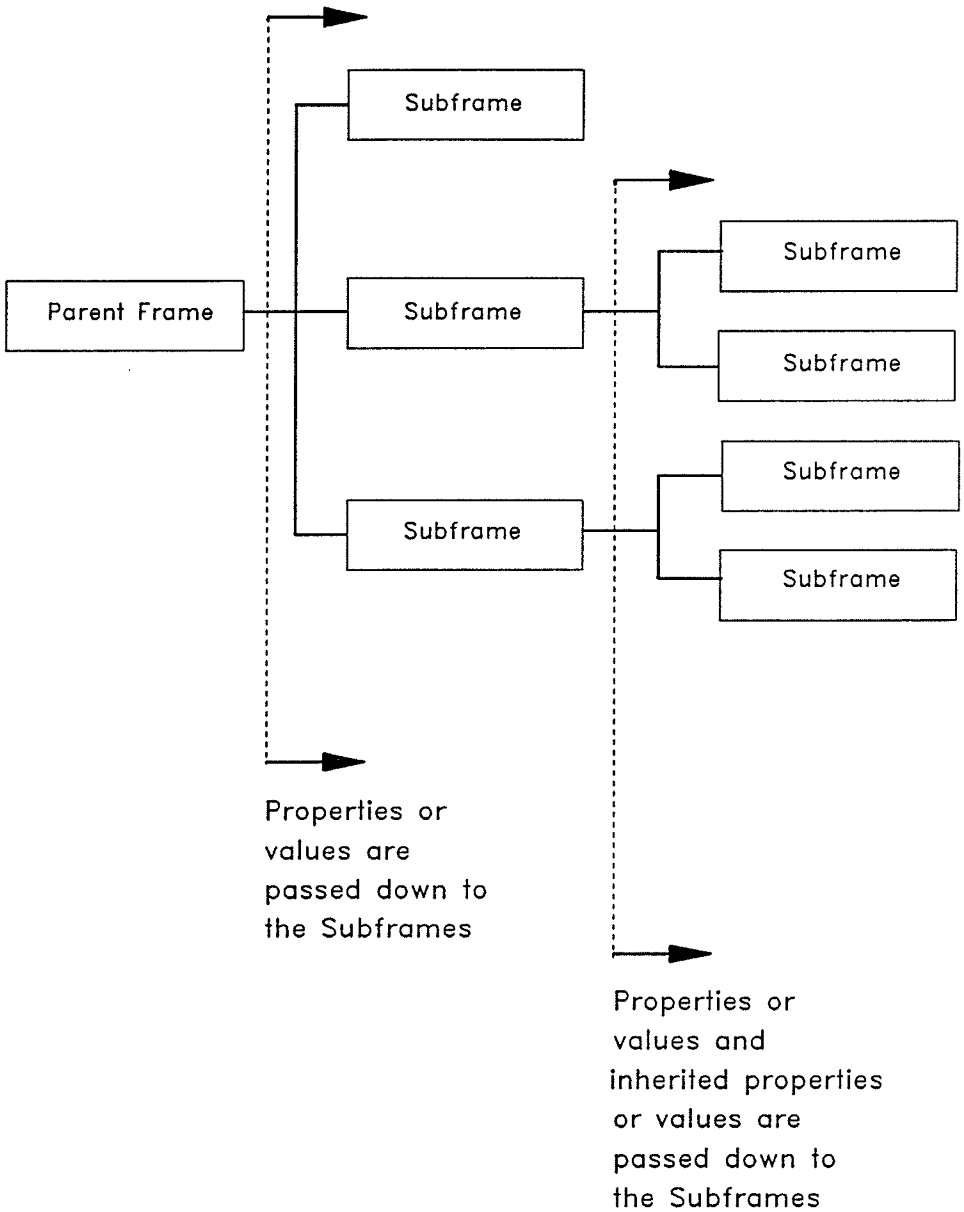


Figure 2.3 Frames in a Hierarchial Structure

CHAPTER 3

Building Codes and Fire Protection

3.1 Introduction

This chapter begins with a general discussion of building codes. The concepts of prescriptive-based and performance-based building codes are introduced and reviewed. The National Building Code of Canada (NBCC) is introduced and a brief history of this document is provided. The system for maintaining and updating the NBCC is explained and the different approaches taken by the various provinces to adopt the NBCC are described.

The latter part of the chapter is devoted to a discussion of the fire safety objectives of Part 3 of the NBCC. The key building attributes that influence the fire safety design strategies incorporated into building construction and design so as to achieve a minimum acceptable level of life safety are introduced. The concept of the National Fire Protection Association (NFPA) Fire Safety Concepts Tree is explained and the fire safety strategies employed by the NBCC are shown to be consistent with the strategies suggested by the Tree.

3.2 Buildings Codes

A building code is a document containing the minimum requirements for public health, fire protection and structural sufficiency. A building code becomes a legal document when it is adopted by government by referencing it by title in legislation, regulations or in a municipal by-law; otherwise it remains a model code.

Model building codes are generally developed by a committee process. The committees draw on the best expertise available in the country and committee members represent every facet of building design and construction. The adopting regulatory authority and code users therefore benefit from the knowledge of many experts that is both progressive and up-to-date.

The building code is under continual review. It is improved and updated through user input, public review processes, and research. Codes normally follow technological developments rather than attempting to lead. This avoids as much as possible putting untried or unproven concepts into law.

Building codes rarely attempt to cover every aspect of building design and construction. They are more safety oriented and aspects such as aesthetics, functionality, and durability are not specified but left to the designers and owners to detail in construction specifications or project manuals. Unique or unusual situations are also not covered in the building code. The code provides that such unusual designs or building features be evaluated using judgement, common sense, and sound engineering or architectural principles. Similarly, most codes accommodate the use of new products, methods of design, or the latest research, provided that the user can demonstrate that the level of performance intended by the code is achieved.

3.2.1 Types of Building Codes

Building codes are generally categorized as being either prescriptive-based or performance-based.

Prescriptive codes state exactly what materials, assemblies of materials, and dimensional arrangements can be used for different building components. The major criticism of prescriptive codes is that they are inflexible and do little to encourage innovation in the design and construction of buildings. Flexibility in the application of code requirements is desirable when dealing with unusual buildings or building features. It is also difficult to apply this type of code to heritage buildings that are undergoing rehabilitation.

While restricting design choices, however, prescriptive codes offer a number of advantages. They are relatively easy to formulate, they can be readily understood and interpreted, and they are relatively easy to enforce. For these reasons, there is a natural tendency to write many code requirements in a prescriptive format.

Performance codes stipulate the level of performance that must be met by the materials, building components, and equipment used in a building. It is believed that such codes foster innovation and take greater advantage of new technology. Performance codes are easier to apply to unusual building situations and to heritage buildings than prescriptive codes. They allow designers the flexibility to select freely materials and components that will achieve a predetermined level of performance.

The task of applying such a code in these situations, however, can be complicated since it is often difficult to quantify the level of performance required. Where a requirement is expressed as a generality without a measurable level of performance, it is deemed a non-verifiable performance requirement. Such requirements are practically impossible to interpret or enforce, and therefore have little practical value.

Whether or not a performance requirement is realistic or not depends on the state of knowledge in the area being regulated. Often, however, knowledge simply does not exist to permit the establishment of realistic or definable levels in strictly performance terms (Hansen, 1991). In cases where requirements are stated in performance terms that cannot be verified, they are often supplemented by deemed-to-satisfy design solutions. In the case of fire safety, as the engineering understanding of the facts that affect fire safety improves, it becomes possible to specify more accurately the performance intended for a safety feature (Mawhinney, 1991).

Most building codes, including the National Building Code of Canada (NBCC), remain a mixture of prescriptive and performance requirements. As the technology of fire safety develops, it can be expected that many prescriptive requirements will give way to performance requirements.

3.3 The National Building Code of Canada

The National Building Code of Canada (NBCC) is a consensus-based model building code. It provides minimum requirements for public health, fire safety, and structural sufficiency. The NBCC applies to new construction, alterations made to existing buildings, and to existing buildings that undergo a change in use.

The NBCC contains both prescriptive requirements and performance requirements. In most cases, the performance requirements are supplemented by deemed-to-satisfy design solutions found in the Appendix to the NBCC or in the Supplement to the NBCC. Provision is also made to allow alternative solutions to a prescriptive code requirement if equivalency can be established.

Equivalency provisions in the NBCC permit a variation to a code requirement providing the designer can demonstrate that the proposed variation will provide a level of performance equivalent to that intended by the code-conforming condition. The level of performance intended by the code is, however, often difficult to quantify. Despite this difficulty, many equivalency evaluations involving fire safety provisions of the NBCC are done on a regular basis in many jurisdictions. Mawhinney (Mawhinney, 1991) has provided a complete discussion on evaluating equivalency requirements and has outlined a process to carry out equivalency evaluations.

This study focuses on the NBCC requirements that are related to fire safety. The minimum standard for fire protective design is established by Part 3, Use and Occupancy of the NBCC. Part 3, applies to all buildings used for assembly, institutional, and high-hazard industrial purposes regardless of the size of the building. Part 3 also applies to any building that is more than 3 storeys high or over 600 m^2 in plan or footprint area.

Fire safety requirements for smaller buildings are found in Part 9, Housing and Small Buildings of the NBCC. Buildings that fall within the scope of Part 9 will not be discussed here.

There is an increasing trend of the NBCC to depend on other reference standards to regulate building construction. The NBCC makes reference to some 215 standards, of which approximately 40 are related to fire safety and are referenced in Part 3. The performance nature of the NBCC is now very much a matter of the performance nature of the growing number of reference standards (Hansen, 1992).

The NBCC also makes frequent reference to the National Fire Code of Canada (NFCC). The NFCC is regarded as a companion document to the NBCC. The NFCC is primarily intended to ensure that the level of fire safety provided by the NBCC is maintained. It also regulates the conduct of activities that cause fire hazards, the combustibility of building furnishings, and the storage and handling of hazardous and dangerous goods.

Reference standards and the NFCC contain many requirements that affect the design and construction of buildings directly. These requirements have been included in this study whenever appropriate.

3.3.1 History of the NBCC

In Canada, building regulations mostly relating to fire hazards have been in use for almost 300 years. However, prior to the first published edition of the NBCC, no uniform code was enforced to regulate building construction in Canada.

Under the terms of the British North America Act, and later the Constitution Act of 1982, the provinces were given the responsibility for regulation of building construction. Historically, the provinces have delegated this responsibility to the municipalities. This left many municipalities having to develop their own building bylaws or building codes. Those municipalities that adopted a building code usually had sufficient construction activity to warrant some form of regulation. During this time, there were as many building codes of varying technical content and sophistication as there were municipalities enforcing these codes.

The lack of uniformity in regulations created many problems for the material producers, building designers, builders, and others in the building industry. Products or design and construction methods that were accepted in one municipality might not be accepted in the next municipality a short distance away.

The idea that building construction could benefit from a uniform set of construction requirements came after the National Housing Act (NHA) was introduced in the 1930's. The NHA was developed to implement uniform house construction standards throughout the country. It became apparent that other types of construction would also benefit from a uniform set of construction requirements. The Department of Finance, the body responsible for the NHA, enlisted the help of the National Research Council of Canada (NRC) to develop a model set of regulations that could be adopted by any jurisdiction in Canada. Together they produced the first edition of the National Building Code of Canada, which was published in 1941.

After the first publication of the NBCC, it was acknowledged that the building code needed to be updated to respond to changes in technology, new developments in structural design, and changing economic conditions in the construction industry. NRC undertook this responsibility and, in 1947, created the Division of Building Research (DBR) as a research and technology information service for the Canadian construction industry. DBR is now known as the Institute for Research in Construction (IRC). In 1948, NRC also established the Associate Committee on the National Building Code (ACNBC) to oversee the development of the NBCC. IRC provides technical and secretarial support to the ACNBC. The second edition of the NBCC was published in 1953 and eight more editions have been published since then.

The Associate Committee on the National Fire Code of Canada (ACNFC) was established in 1956 to oversee the development of the first National Fire Code. The first NFCC was published in 1963 and five more editions have been published since then.

3.3.2 The Associate Committee on the National Building Code

The ACNBC is made up of some 28 individuals representing all facets of the building industry. It gives policy guidance to a number of Standing Committees which are responsible for the technical content of the NBCC.

The composition of each Standing Committee follows a matrix established by a nominating committee of the ACNBC. Each matrix tries to ensure an appropriate mix of expertise by drawing from every major sector of the construction industry. Members are appointed on the basis of their knowledge, experience, and professional interests. The nominating committee also attempts to obtain representation from all regions in Canada.

In the field of fire safety, there are three such Standing Committees, one each on fire protection, occupancy, and fire performance ratings. The first two committees are responsible for Part 3 of the NBCC while the third is responsible for Chapter 2 of the Supplement to the NBCC.

The ACNFC is the companion committee to the ACNBC and comprises some 25 individuals broadly knowledgeable in fire safety matters. Similarly to the ACNBC, the committee provides policy guidance to a number of standing committees which are responsible for the technical content of the NFCC.

In 1992, NRC reorganized the two associate committees into a single committee known as the Canadian Commission on Building and Fire Codes (CCBFC).

3.3.3 The National Building Code of Canada and Provincial Building Codes

The regulation of building construction in Canada remains a matter of provincial and territorial jurisdiction and the NBCC remains a model building code. It becomes a legal document when a provincial or territorial government adopts it. In 1990 the provinces and territories signed memoranda of understanding with NRC acknowledging the desirability of a uniform national code and reaffirming the process and committee framework established to carry out the task. The Provincial and Territorial Committee on Building Standards (PTCBS) was formed to ensure that provincial concerns are taken into account in the NBCC and to ensure an even greater provincial commitment to the national model code.

There is now effective uniformity of building codes in Canada through municipal adoptions of the NBCC. A variety of approaches have been used:

a) **British Columbia** adopts the NBCC with a substantial number of changes and publishes it as the B.C. Building Code.

b) **Alberta and Manitoba** adopt the NBCC by reference, making a few changes and quite a few additions. They publish their own provincial codes as the Alberta Building Code and the Manitoba Building Code.

c) **Saskatchewan, Québec, Nova Scotia, the Yukon and Northwest Territories** all adopt the NBCC by reference, most with little or no change, and do not publish a separate code document.

d) **Ontario** does not formally adopt the NBCC by reference in its Act or Regulations, as do the others, but the Ontario Building Code is copied from the NBCC, with a number of provincial changes and additions.

e) **New Brunswick and Newfoundland** do not have provincial legislation adopting a province-wide building code. However, New Brunswick requires that any municipal building bylaw adopt the NBCC without change. Both provinces automatically update such municipal bylaws when a new edition of the NBCC is published.

f) **Prince Edward Island** is the only province with neither a provincial code nor a program to achieve uniformity of municipal action. However, the larger PEI cities voluntarily adopt the NBCC, thus effectively achieving uniformity.

3.4 Fire Safety Objectives of the NBCC

In fire safety design, building designers must consider four issues, the life safety of the building occupants, property protection, continuity of building operations, and the protection of neighbouring property.

The primary fire safety objective of all building codes, including the NBCC, is the life safety of the building occupants. Property protection is usually an economic consideration, with property insurance companies often establishing minimum standards; the NBCC does not place special emphasis on this issue. Continuity of building operations is again an economic matter, and the extent to which additional fire safety features are considered is a decision made by building owners and their insurers. Protection of neighbouring property is addressed to some degree in the NBCC from the standpoint of preventing a major conflagration and preventing the collapse of a building or part of a building onto neighbouring property.

3.4.1 Life Safety

The requirements of Part 3, Use and Occupancy, of the NBCC are intended to achieve a level of fire protection sufficient to control a building fire and protect endangered occupants. The life safety of building occupants also includes the well-being of fire fighters who may be required to enter a building in a fire condition.

Part 3 implicitly states how much fire protection is necessary in a building by specifying fire resistance, fire suppression, egress dimensions and many other elements of the building design. Taken together, these elements represent the minimum level of safety deemed acceptable to society.

The level of life safety specified by the NBCC can vary considerably. In some cases, it may be necessary only to provide emergency exits from a building while in another case, complex smoke control systems, additional fire resistance, and fire suppression systems may be required.

A number of parameters directly influence the level of fire protection mandated by the NBCC. These factors include:

a) building use or major occupancy classification,

b) building size,

c) building occupant load,

d) fire department access, and

e) building special features.

3.4.1.1 Building Classification by Major Occupancy

Classification of a building by major occupancy is normally the starting point in establishing which of the code requirements should be applied to that building. The major occupancy classification of a building refers to the principal intended use of the building or portion of the building.

The classification system developed for the NBCC takes into account such factors as population density, age and mobility of the building occupants and their state of alertness. It also considers the expected severity of a fire given the activities of the space. The NBCC specifies six major occupancy groups:

a) Group A - Assembly occupancy,

b) Group B - Institutional occupancy,

c) Group C - Residential occupancy,

d) Group D - Business and Personal Services occupancy

e) Group E - Mercantile occupancy, and

f) Group F - Industrial occupancy.

The Assembly, Institutional and Industrial Groups are further subdivided into Divisions. Differences between Divisions within a Group are sometimes more subtle but they are still based on different human activities for different building types.

In all, there are twelve major occupancy classifications. Each of the following classifications represents a general building use that has an associated human activity with a resulting level of hazard.

3.4.1.1.(a) Group A - Assembly Occupancy

The Group A major occupancy classification encompasses all buildings where people congregate or assemble in large numbers. Within the Group A major occupancy classification are four Divisions:

i) **Group A, Division 1**

Assembly buildings intended for the production and viewing of the performing arts are classified as Group A, Division 1 major occupancy. The concentration of people or occupant load may be high and the lighting may be subdued. High concentrations of combustible materials commonly used for stage sets also pose a hazard. In the event of a fire, large numbers of people would have to be evacuated quickly.

ii) **Group A, Division 2**

This is the most general category of assembly type occupancies. Any assembly occupancy that does not fall into Division 1, Division 3, or Division 4, is placed in this classification. Restaurants, schools, churches, community halls, and libraries are examples of buildings included in this category.

iii) **Group A, Division 3**

Arena type occupancies are classified as Group A, Division 3 major occupancy. The fire load in these type of buildings is usually low and large open spaces help to dissipate smoke.

iv) **Group A, Division 4**

Open air structures are classified as Group A, Division 4 major occupancy. This classification would include open air stadiums where the hazard of being trapped in a building with fire and smoke is remote.

3.4.1.1.(b) Group B - Institutional Occupancy

Buildings classified as a Group B major occupancy are all buildings that contain occupants who are institutionalized. Within the Group B classification there are two Divisions:

i) **Group B, Division 1**

Buildings that contain people who are detained for penal or correctional purposes, for involuntary detention, or whose liberties are restricted are classified as Group B, Division 1 major occupancy. Jails and prisons are included in this major occupancy classification. If evacuation takes place, it is usually under supervision.

ii) **Group B, Division 2**

Buildings that contain persons who, because of age, mental, or physical limitations require special care or treatment, are classified as Group B, Division 2 major occupancy. Buildings such as hospitals, infirmaries and homes for the aged are some building uses that would be classified in this major occupancy. In the event of a fire, evacuation is difficult and slow because the building occupants will often require assistance from staff or fire department personnel. In certain cases, evacuation may not be possible or advisable.

3.4.1.1.(c) Group C - Residential Occupancy

Buildings that accommodate sleeping facilities, but excluding those major occupancies covered in Group B institutional occupancies, are classified as Group C major occupancy. Apartments, hotels, motels, boarding houses and other buildings that provide sleeping accommodations, are included in this major occupancy classification. Tenants who occupy this type of building have no control over the lifestyles and activities of others who occupy the same building. Building occupants may be sleeping when the need to evacuate arises. There may be significant delays before occupants are alerted to an emergency and before evacuation can be completed.

3.4.1.1.(d) Group D - Business and Personal Services Occupancy

Buildings that are used for conducting business and rendering of professional services are classified as a Group D major occupancy. Offices, banks, and beauty parlours are examples of buildings in this category. These buildings generally have a low occupant load and fire load when compared to other major occupancy classifications. If an emergency evacuation arises, exiting from the building is generally fast because the occupants are alert. Evacuation usually takes place before a fire is fully developed.

3.4.1.1.(e) Group E - Mercantile Occupancy

Buildings that are used for displaying or selling of retail goods, wares, or merchandise are classified as Group E major occupancy. Buildings that belong to this major occupancy classification include department stores and shops. Compared with other major occupancy classifications, the fire load in mercantile buildings is usually very high. Fire development can be extremely fast. Smoke and fire can quickly cut off escape routes for occupants who are trying to evacuate the building.

3.4.1.1.(f) Group F - Industrial Occupancy

The Group F major occupancy classification encompasses all buildings used for manufacturing of goods, storage facilities, factories, and other industrial purposes. The Group F major occupancy classification is divided into three divisions based on the fire load contained within the building.

i) **Group F, Division 1**

Buildings classified as a Group F, Division 1 major occupancy contain sufficient amount of highly combustible material that is flammable or explosive. This creates a special fire hazard. The NFCC lists materials that are considered to be highly flammable or hazardous and provide special measures to deal with these hazards. For buildings in this category more emphasis is placed on preventing a fire.

ii) **Group F, Division 2**

Buildings that are classified as Group F, Division 2 major occupancy are considered as medium-hazard industrial occupancies. The combustible content of a medium-hazard industrial occupancy is more than 50 kilograms per square metre of floor area. The combustible contents are not considered to constitute a special fire hazard.

iii) **Group F, Division 3**

Buildings that are classified as Group F, Division 3 major occupancy are considered to be low-hazard industrial occupancies. The combustible content of a low-hazard industrial occupancy is less than 50 kilograms per square metre of floor area.

3.4.1.2 Building Size

Building size is a key factor to be considered in establishing the minimum level of life safety protection required for a building. The NBCC assumes that the higher the building, or the greater the building area, the more difficult will be the problems of evacuation and firefighting. Based on this assumption, the level of life safety protection increases as the height and/or area of a building increases. The building size is determined by two parameters:

a) building height, and

b) building area.

3.4.1.2.(a) Building Height

Building height is defined as the number of storeys between the roof and the floor of the first storey. The first storey is described as the uppermost storey having its floor level not more than two metres above grade as shown in Figure 3.1.

Many buildings have mezzanine floors which are defined as intermediate floors between the floor and ceiling of any room or storey. The NBCC contains specific rules for determining whether or not a mezzanine should be considered as a storey in calculating building height.

In determining the building height, roof-top enclosures provided for elevator machinery, stairs leading to the roof-top, and service rooms used for no purpose other than for service to the building, are not considered as a storey in calculating the building height.

3.4.1.2.(b) Building Area

Building area means the greatest horizontal area of a building above grade within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of firewalls. In most cases, the building area will be the footprint area of the main floor. However, there may be buildings where the largest area occurs on other than the main floor. This is illustrated in Figure 3.2.

From the definition, the NBCC allows the building area to be altered by the introduction of firewalls. Firewalls are special fire separations that are used primarily to divide a building into two or more smaller building areas that may be considered to be separate buildings for the purposes of applying the fire protection requirements of the NBCC. This is illustrated in Figure 3.3. The life safety requirements are less restrictive for a large building that is divided into smaller independent building portions by means of firewalls.

3.4.1.3 Building Occupant Load

Occupant load is the number of persons that may be expected to be in a building at any time. Occupant load is determined on the basis of the number of people that the building or part of the building will accommodate. It is therefore related to the major occupancy classification of the building and to the building size. Occupants of service spaces such as furnace rooms and electrical rooms, and of transitory spaces such as corridors and washrooms, are not normally counted since occupants of these areas would normally be accounted for in the regularly occupied portion of the building.

The principal application of occupant load is to determine the number and width of exit facilities that must be provided and to determine the width of access routes leading to an exit from within a floor area. The number of occupants also dictates whether or not a fire alarm system, exit signs, and emergency lighting are to be installed and whether a building may be subject to additional requirements for high buildings.

3.4.1.4 Access for Fire Fighting

The NBCC recognizes that accessibility of a building to firefighting equipment is important from the standpoint of how a fire can be fought. It is much easier to fight a fire in a building when the perimeter of the building is totally accessible than to fight the same fire when only one face of the building is accessible.

Buildings accordingly are said to face one, two, or three streets depending on the percentage of the building perimeter that is within a prescribed distance from the centre line of a street. This is illustrated in Figure 3.4.

The more streets a building faces, the less restrictive the fire protection requirements become.

3.4.1.5 Special Features

Special features refer to building components or building characteristics that affect the level of fire protection required by the NBCC. High buildings, buildings with interconnected floor spaces, and buildings that are sprinklered are all treated differently by the NBCC.

High buildings and buildings that contain an interconnected floor space require a higher level of fire protection than is normally required. On the other hand, the NBCC relaxes many fire protection requirements if an automatic sprinkler system is provided.

3.4.1.5.(a) High Building

Experience has shown that, after a building reaches a certain height, the time required for the complete evacuation of the building can exceed that which is considered necessary for the safe egress of the building occupants. Occupants of a high building, particularly those on upper storeys, may be faced with severe smoke conditions from a fire occurring in storeys below them before their own evacuation is possible. Because of this and other considerations peculiar to high buildings, the NBCC requires additional safety features for these buildings.

Whether or not a building must be classified as a high building depends on the height measured from grade to the floor level of the top storey, the major occupancy classification of the building and in some cases the occupant load. Buildings that contain a Group B, Division 2 occupancy above the third storey are also required to be considered as high buildings.

3.4.1.5.(b) Interconnected Floor Spaces

There is an increasing trend in building design to use interior space to connect a number of floors of a building. This design feature is often referred to as an atrium; however, the NBCC uses the term interconnected floor space. An interconnected floor space is one where two or more levels are open to each other. Modern buildings with atriums are fairly common; however, the interconnected floor space is also encountered in buildings whose floor areas are connected by open stairs and ramps, escalators, and conveyors.

Typically, multi-storey buildings are constructed so that floor assemblies separating the storey levels act as a barrier that delays the spread of fire. However, an interconnected floor space violates this basic principal of fire containment. There is the potential for rapid and progressive development of an uncontrolled fire condition, as well as simultaneous smoke contamination of all open levels of the building. This is illustrated in Figure 3.5. These problems hinder evacuation and firefighting. As well, the main structural components of the building are exposed to a prolonged fire condition. The NBCC therefore requires additional safety features for buildings with interconnected floor spaces.

3.4.1.5.(c) Automatic Sprinkler Systems

The provision of an automatic sprinkler system has a direct influence on many of the fire protection requirements mandated by the NBCC. Because of the demonstrated effectiveness and reliability of these systems, many design requirements are relaxed or waived if an automatic sprinkler system is installed throughout the building or in specific areas of the building.

Automatic sprinkler systems are discussed in more detail in the latter part of this chapter.

3.4.2 The National Fire Protection Association (NFPA) Fire Safety Concepts Tree

In Canada, designers incorporate fire safety into buildings by adhering to the minimum requirements specified in the NBCC and its referenced standards. The factors previously discussed have a direct impact on the level of fire safety mandated by the code or more simply, the requirements that apply or do not apply to a particular building design. Each requirement contributes either directly or indirectly to the life safety of the building occupants and fire fighters. Taken together they are intended to provide a level of life safety that is acceptable to society as a whole.

It is difficult, however, for code users to assess the relative importance of the different code requirements since they are presented on an *ad hoc* basis. The NBCC specifies the design or performance expected of separate building components with no apparent consideration or assessment given to the interrelation of these elements, or of the fact that some components have a higher probability of good performance than others. Many buildings that are designed to minimum code requirements may, in fact, contain fire safety weaknesses that are not readily apparent.

A qualitative evaluation of building fire safety provided by the NBCC requirements is possible if a systems analysis approach is used. A systems approach identifies and organizes the essential elements that must be considered in fire safety design and shows the interrelationship of these elements. It is a methodical step-by-step approach to understanding and solving a wide variety of fire safety problems, and it allows designers to use the code more effectively.

The Fire Safety Concepts Tree, designed by the National Fire Protection Association (NFPA) Committee on Systems Concepts for Fire Protection in Structures, is such a fire safety systems analysis approach (Fire Protection Handbook, 1990).

The Fire Safety Concepts Tree is illustrated in Figure 3.6. The Tree shows the elements that must be considered in building fire safety and the interrelationship of these elements. A building can be analyzed or designed by progressively moving through the various levels of events.

The use of the Tree requires that a fire safety objective be identified. These objectives have been previously introduced as life safety of building occupants, property protection, continuity of building use, and protection of neighbouring property. An example of a life safety objective might be that all building occupants must be safeguarded against the intolerable or untenable effects of a building fire. The Tree then provides the logic required to achieve this objective or goal.

The fire safety objective appears at the top of the tree-like diagram with branches extending downwards from it. These branches connect fire safety design concepts or strategies that will achieve the fire safety objective. The interrelationship of different design strategies is shown by connecting lines going through one of two basic logic gates, the AND gate and the OR gate. The logic flow of the tree is in the upwards direction where the inputs are below the desired outputs. The AND gate indicates that the objective or goal will be satisfied when all strategies or inputs below the gate coexist simultaneously. The OR gate indicates that all of the strategies or inputs listed below the gate will satisfy the objective or goal, but only one of them is sufficient. Lower levels in the Tree do not, therefore, represent a lower level of importance or performance. They represent a means of achieving the next higher level.

Success in achieving the fire safety objective depends on the completeness to which each level of events is satisfied. In theory, any branch will achieve the fire safety objective if it is 100 percent effective. In reality, however, no one system can be relied upon to be 100 percent effective. An effective fire safety system will therefore rely on a combination of different fire safety design strategies.

At the first level of the Tree, it can be seen that the overall fire safety objectives can be achieved either by preventing fire ignition or by managing the impact of the fire. The strategies of the **PREVENT FIRE IGNITION** branch essentially constitute the requirements of the National Fire Code of Canada (NFCC). The strict enforcement of the NFCC greatly reduces the possibility of a fire; however, it cannot provide assurances that a fire will never occur.

When a fire occurs, all emphasis shifts to the **MANAGE FIRE IMPACT** branch of the Tree. The NBCC requirements follow this branch and are designed to limit the consequences of the fire.

3.5 Analysis of the Fire Safety Concepts of the NBCC

The overall fire safety objective of the NBCC is to provide for the life safety of the building occupants and fire fighters. This discussion concentrates on the

MANAGING FIRE IMPACT branch of the NFPA Fire Safety Concepts tree as the means of accomplishing this objective.

Through an OR gate, the Tree divides into two major paths, the **MANAGE FIRE** path and the **MANAGE EXPOSED** path. The Tree, therefore, suggests that the effects of a building fire on building occupants and fire fighters can be minimized if steps are taken to manage those who may be exposed to the harmful effects of the fire.

That is, if means are provided to limit the size of a working fire, in all likelihood the harmful effects of that fire can be eliminated or minimized. If the fire is kept small, building occupants have sufficient time to evacuate and fire fighters can easily extinguish the fire. Alternatively, the same objective can be accomplished if means are provided to evacuate the occupants of the building occupants to a safe place outside of the building or to move them to a safe place within the building. Evacuation routes and areas of refuge within the building can be designed to provide an environment that is free from smoke and fire. Building occupants have time to evacuate and fire fighters are able to access the fire quickly and assist in evacuation.

In theory, the Fire Safety Concepts Tree implies that either of the **MANAGE FIRE** or the **MANAGE EXPOSED** strategies will alone satisfy the higher goal of **MANAGING FIRE IMPACT** and the overall fire safety objective of providing an acceptable level of life safety for building occupants and fire fighters. In reality, however, such levels of complete effectiveness are seldom achieved. All building codes, including the NBCC, contain provisions that are intended to contribute to the fulfilment of both of these objectives.

The successful accomplishment of these objectives depends on:

a) the rate at which a fire can grow to hazardous levels, or the combustibility and flammability of the building and its contents;

b) the effectiveness of room boundaries to resist the passage of heat, smoke, and flames to other parts of the building and the ability of the loadbearing elements to resist collapse;

c) how quickly the building occupants and the fire department are alerted to a fire condition;

d) the effectiveness of the means of egress or evacuation routes; and

e) the effectiveness of the means available to suppress the fire.

Part 3 of the NBCC contains requirements that are intended to address each of these issues.

3.5.1 Combustibility and Flammability

The NBCC places restrictions on the ignitability and combustibility of building materials. It also limits the flammability of wall and ceiling finishes. Controlling the amount of combustible material used in building construction and regulating the flammability of interior finish materials fall under the **CONTROL FUEL** element of the Fire Safety Concepts Tree. Controlling the fuel plays a significant role in the **MANAGE FIRE** branch of the Tree.

3.5.1.1 Noncombustible and Combustible Construction

The NBCC distinguishes between noncombustible construction and combustible construction. In noncombustible construction, building assemblies must be constructed of noncombustible materials. Combustible construction is usually conventional wood frame or heavy timber.

Noncombustible construction contributes to the overall life safety objective by helping to provide sufficient time for building occupants to evacuate and by making fire fighting tasks more manageable by inhibiting fire spread through the building, particularly in concealed spaces. This type of construction, together with adequate fire resistance, is intended to ensure that the building will not sustain excessive damage and collapse before evacuation and fire fighting are complete.

Whether or not a building must be of noncombustible construction depends primarily on the building size. Buildings over a certain height or area are required to be of noncombustible construction. The building area and building height limits below which the building is permitted to be of combustible construction depend on the major occupancy classification, the number of streets the building faces, and whether or not the building is sprinklered. In some cases, the presence of an interconnected floor space may require that the building be of noncombustible construction.

For practical reasons, the NBCC permits some combustible elements in buildings required to be of noncombustible construction. Combustible roofing, exterior cladding, insulation, and a variety of interior finish materials are all permitted, providing certain conditions are met. The key structural elements of the building including columns, floors, and partition walls are required to be of noncombustible construction. Similarly, the exterior walls must be made of noncombustible framing elements.

In a building that the NBCC permits to be of combustible or noncombustible construction, certain high-hazard areas such as linen and refuse chutes and electrical equipment vaults are required to be of noncombustible construction. Finally, to control the spread of fire from one building to another, the NBCC may require that the exterior walls of a building be of noncombustible construction and that they be clad with noncombustible cladding.

3.5.1.2 Flammability of Building Materials

The development of a fire depends to a large extent on the flammability of exposed building materials such as wall and ceiling finishes, light fixtures, and trim and decorative materials in a room. If building interior finishes become involved in the early stages of a fire and burn too quickly, the less time the building occupants have to escape.

To provide building occupants with sufficient time to evacuate, the NBCC imposes limits on the flammability or the flame spread potential of building materials. Laboratory tests are used to assign a relative index of the rate at which a material burns. This index is called the flame-spread rating and is based on two benchmark materials, asbestos and red oak.

Generally, the extent to which the flammability of interior finishes is regulated depends on the building size, the major occupancy classification, and whether the building is sprinklered. The NBCC requirements become more restrictive as the space under consideration becomes more important to the evacuation of the building occupants. Individual rooms have the least restrictive requirements. Public corridors and other egress routes leading from the rooms have more restrictive requirements and actual exit stair enclosures have the strictest requirements.

The NBCC also places limits on the flame-spread rating of certain combustible materials which are permitted to be used in concealed spaces of buildings required to be of noncombustible construction.

The amount of smoke generated in a fire is also an important factor influencing the time available for safe evacuation. The NBCC therefore sets limits on the amount of smoke that can be generated from certain building materials. This is termed the smoke developed classification for the material and is particularly applicable in high buildings.

3.5.2 Compartmentation and Structural Fire Protection

The NBCC specifies compartmentation and structural fire protection as the construction method of controlling the hazards associated with a fully developed fire.

In a fully developed fire, the life safety of the occupants within the room of fire origin is no longer an issue. All emphasis now shifts to containing the fire and products of combustion to the area of origin. Alternatively, the fire could be allowed to spread to other portions of the building or to other floor areas, provided measures are taken to prevent its entry into areas designated as areas of refuge for the building occupants.

These fire protection measures of containment and isolation are commonly referred to as compartmentation and rely on physical barriers or fire separations to retard the spread of fire. Managing the development of the fire by compartmentation falls under the **CONTROL MOVEMENT OF FIRE** element of the Fire Safety Concepts Tree.

A fire compartment, however, is only as effective as the structural assembly that supports it. The structural system of a building must be designed so that its primary load-bearing members will not collapse prematurely in the event of a fire. This fire protection measure is referred to as structural fire protection and falls under the **PROVIDE STRUCTURAL STABILITY** of the Fire Safety Concepts Tree.

The **CONTROL MOVEMENT OF FIRE** and **PROVIDE STRUCTURAL STABILITY** strategies appear under the **CONTROL FIRE BY CONSTRUCTION** objective of the Tree. The **AND** gate indicates that both elements must be provided to achieve this objective.

3.5.2.1 Compartmentation

A fire compartment is defined as an area of a building which is totally separated from the remainder of the building by continuous construction. This area could be a single room, a series of rooms, an entire floor area, an exit enclosure, or a vertical or horizontal service space. Floor-to-floor compartmentation and exit compartmentation are illustrated in Figure 3.7.

The continuous barriers used to form a fire compartment are referred to as fire separations. Most fire separations require a fire-resistance rating. A fire-resistance rating means the time in hours or fraction thereof that a material or assembly of materials will withstand the passage of flame and the transmission of heat. Fire-resistance ratings are generally established by a standard fire test.

For a fire compartment to be effective, it must be continuous. To ensure the integrity of a fire compartment, it is critical that every opening or penetration through the fire separations enclosing the compartment be adequately protected to resist the passage of fire. These include everything from large openings for doors to smaller service penetrations for wiring, piping, and ducts. The NBCC, therefore, requires that every large opening such as a door or window be protected by a closure that has some level of fire resistance so that it can withstand the effects of fire for a specified period of time. The NBCC specifies requirements for such closures as doors, shutters, wired glass, glass block, and fire dampers. The fire resistance for closures is also generally established by a fire test. Holes made in fire separations for electrical wiring, plumbing, and similar services must be fire stopped with fire resistant material.

The compartmentation requirements of the NBCC are quite extensive and are used to accomplish one of two objectives: contain a fire within a compartment, and thereby protect the occupants in the rest of the building; or isolate the building occupants within a compartment from adjacent spaces that may be contaminated by smoke or involved in fire. The major compartmentation requirements of the NBCC are summarized in Table 3.1.

The need to create a fire compartment and the level of fire-resistance required for the fire separations depends primarily on the size of the building or space under consideration, the major occupancy classification of the building, the intended use of specific spaces within the building, and whether or not the building or space is sprinklered.

Code Reference	Requirement	Objective(s)
3.1.3.6	Separation of Major Occupancies	(1) protect assembled institutionalized and sleeping occupants from adjacent hazards; (2) contain mercantile and industrial fire risks.
3.4.4.1.	Separation of Exits	(1) protect evacuating occupants from fire hazards on adjacent floors; (2) provide fire fighters safe access to fire floor.
3.2.2.16. to 3.2.2.62.	Separation of Floors	(1) provide occupants above fire floor time to reach area of safety; (2) control fire size.
3.2.6.11 3.3.3.7.	Separated Zones Within Floor Areas	(1) control fire size when fire compartment is too large and fire fighting is difficult (3.2.6.11.) (2) provide occupants of fire floor more time to evacuate when vertical evacuation is difficult (3.3.3.7.).
3.2.6.3. 3.2.8.5. 3.3.3.8.	Separated Areas of Refuge	(1) provide safe holding areas when: a) high building smoke control option is used (3.2.6.3.); b) floor separation is incomplete and exit capacity inadequate (3.2.8.5.); c) evacuation is impracticable (3.3.3.8.).
3.3.1.1.	Separation of Suites	(1) provide occupants in adjacent suites more time to become aware of fire and evacuate.

3.5.2. 3.5.3.	Separation of Hazardous Spaces	(1)	contain hazards created by:
		a)	service equipment (3.5.2.);
		b)	continuous service spaces (3.5.3.).

Table 3.1 Major Compartmentation Requirements of 1990 NBCC (Designing for Fire Safety 1987)

3.5.2.2 Structural Fire Protection

To ensure that rated fire separations can perform their fire barrier function for a certain period of time, the NBCC requires that all load-bearing elements such as walls, columns, and arches have a fire resistance rating at least equivalent to that required for the supported assembly. Supported assemblies generally include floors and roofs.

This consideration is commonly referred to as structural fire protection. The primary objectives are to provide sufficient time for occupants on the floors above the fire floors to reach an area of safety, and to support the fire separations necessary to control the overall size of the fire. Structural fire protection also minimizes potential damage to adjacent properties.

The same factors that play a role in the assessment of the fire resistance rating considered necessary for fire separation apply equally to the rating of the supporting structural members. Delaying collapse in smaller buildings where occupants can evacuate rapidly is often unnecessary. However, in larger buildings, and in buildings where evacuation may be delayed, a higher level of structural fire protection is required to ensure the life safety of building occupants and fire fighters who are expected to enter the building, assist in evacuation, and extinguish the fire. Where the height of a building or the intended use is such that total evacuation is not possible, collapse of primary structural members must be prevented for the period of fire emergency and beyond.

3.5.3 Fire Alarm and Detection Systems

The life safety of building occupants often depends on how quickly a fire is detected and how quickly the occupants are alerted to the fire condition. The NBCC, therefore, requires that many buildings be equipped with a fire alarm and detection system. The fire alarm and detection system satisfies the **CAUSE MOVEMENT OF EXPOSED** element of the Fire Safety Concepts Tree and is one of the steps necessary to fulfil the **MOVE EXPOSED** objective of the Tree.

Whether or not a fire alarm system is required by the NBCC depends upon the major occupancy classification, the occupant load, and the size of the building. If a building contains more than three storeys, including below grade storeys, a fire alarm system is required regardless of the major occupancy classification or the occupant load.

Activation of the fire alarm system depends on manual pull stations or on automatic detection devices. Heat detectors and smoke detectors are the most common types of automatic detection devices. Heat detectors are designed to sense abnormally high temperatures or a high rate of temperature rise. They are reliable and require little maintenance; however, they will not necessarily detect a fire in its early stages. Smoke detectors detect the products of combustion and therefore activate at a much earlier stage than heat detectors. They are, however, prone to activation from sources other than a real fire, and require regular maintenance. Both heat and smoke detectors are designed to provide a signal to the building fire alarm system.

The NBCC generally requires that either a heat or smoke detector be installed in the more hazardous areas of a building. These areas include storage rooms, service rooms, certain shafts, closets for janitorial supplies, and any other room where hazardous products are stored. Heat detectors are required in every room of a Group A, Division 1 or Group B major occupancy other than sleeping rooms and in every suite of a Group C building more than three storeys high. Smoke detectors are also required in every sleeping room of a Group B major occupancy and in areas requiring a faster alarm such as egress corridors and exits. Smoke detectors are also required in certain recirculating air systems.

Automatic sprinklers are considered to fulfil the requirement for heat detectors. When an automatic sprinkler system is used as part of the fire alarm and detection system, it must be electrically supervised. Electrical supervision ensures that an electrical signal will be transmitted to the fire alarm panel if the control valve is moved, if a pressure loss develops, if the electrical supply to the pumping system fails, if the water supply becomes inadequate, or if the temperature falls sufficiently to cause part of the water supply to freeze.

The NBCC specifies two types of fire alarm systems, the single-stage system and the two-stage system. Activation of a single-stage fire alarm system causes a general alarm to be sounded throughout the building. Activation of a two-stage system first sounds an alert signal to warn those on duty that an emergency exists. The two-stage system allows supervisory staff to verify the nature of the emergency before an evacuation alarm is initiated. If the supervisory personnel do not respond to the alert signal within five minutes, the general alarm is automatically activated. For Group B institutional occupancies, the fire alarm system must be a two-stage system. A single-stage system is required in a Group F, Division 1 high-hazard industrial occupancy. In all other buildings, the choice is arbitrary.

Fire detection and alarm does not necessarily mean that the fire department will be notified. Assembly buildings with high occupant loads, institutional buildings, high buildings, buildings with interconnected floor spaces, and high hazard industrial buildings all have considerable potential for loss of life. It is essential that the fire department be notified immediately if a fire emergency occurs. In these cases, the NBCC requires that the fire alarm system be designed so that activation of an alarm causes a signal to be transmitted to the fire department, a proprietary control centre, or an independent central station.

3.5.4 Means of Egress

The continuous path of travel from any point in a building to a safe destination usually outside of the building is commonly referred to as the means of egress. The NBCC requirements for means of egress are intended to satisfy the **PROVIDE MOVEMENT MEANS** and **PROVIDE SAFE DESTINATION** elements of the Fire Safety Concepts Tree. Coupled with the NBCC requirement for a fire alarm and detection system, the requirements for means of egress are intended to satisfy the **MOVE EXPOSED** branch of the Tree.

The means of egress comprises two components:

a) access to exit, and

b) exits.

3.5.4.1 Access to Exit

Access to exit refers to that part of a means of egress within a floor area that provides access to an exit serving the floor area. More simply, it is the path of travel from any point on a floor area to an exit from that floor area.

Many of the NBCC access to exit requirements depend on whether or not a floor area is under one tenancy or is subdivided into separate tenancies.

A single tenant floor may be used as an open floor area or it may be subdivided into a number of rooms usually served by a corridor leading to the building exits. Access to exit for both of these cases is illustrated in Figure 3.8. Corridors providing access to exit on single tenant floors are referred to as corridors used by the public and are typically found in schools, hospitals, and business offices. The NBCC specifies the number of egress doors required for rooms within the floor area and regulates the design of the corridor.

In a multi-tenant floor, each individual tenancy is referred to as a suite which may consist of one or more rooms. Access to exit from each suite is usually provided by a corridor as illustrated in Figure 3.9. Corridors serving suites are referred to as public corridors. Access to exit from any point within the suite to an egress door serving the suite is regulated by the NBCC. Individual suites are normally served by a corridor which leads to the exits serving the floor area. The corridor serving a multi-tenant floor is referred to as a public corridor. The NBCC normally requires that, from the point where a suite egress door enters a public corridor, it must be possible to travel in opposite directions to separate exits. It also contains a number of requirements pertaining to the public corridor design.

3.5.4.2 Exits

An exit is that part of a means of egress which leads from the floor area to a safe destination. In a single-storey building, the exits are normally exterior doors leading directly to the outside. In multi-storey buildings, floor areas are usually served by exit-stair enclosures. These exit enclosures are completely separate compartments and are not considered part of the floor area that they serve.

The NBCC requires in most cases that every floor area be served by at least two exits. The actual number of exits required, however, depends on the use of the floor area, the occupant load, the area of the floor, and the distance necessary to travel to an exit. The basic principle is that a second exit should be accessible in case the route to the first exit becomes impassable. The greater the distance between exits, the greater the possibility that an exit will be accessible in case of an emergency. The NBCC therefore specifies a minimum distance permitted between exits.

The exit is considered to be the final, most-protected link from a floor area to a safe destination. The exit closure is intended to allow building occupants to evacuate through a clearly marked and well protected route to the exterior of the building without having to re-enter a floor area.

3.5.5 Fire Suppression Requirements

Once a fire condition is detected, the life safety of building occupants often depends on how quickly the fire can be controlled and extinguished. While the building occupants can sometimes extinguish a small fire with hand fire extinguishers, more often than not a small fire grows quickly to a stage where large amounts of water or other suppressant are needed to manage the fire effectively.

Fire suppression is normally accomplished by means of water from automatic sprinkler systems or large hose streams usually applied manually by the fire department. The NBCC contains requirements for automatic sprinkler systems which satisfy the **AUTOMATICALLY SUPPRESS FIRE** element of the Fire Safety Concepts Tree. It also contains requirements for standpipe and hose systems which fulfils the **MANUALLY SUPPRESS FIRE** objective of the Tree.

3.5.5.1 Automatic Sprinkler Systems

Perhaps the most common means of fire suppression is the automatic sprinkler system. The automatic sprinkler is a device for automatically distributing water upon a fire in sufficient quantity to either control the fire or extinguish it completely. Water is fed to the sprinklers by a system of piping that is normally suspended from the ceiling. The sprinklers are placed at intervals along the pipe. Sprinkler heads are normally held closed by a fusible link. Heat from a fire causes the fusible link on one or more sprinkler heads to melt. The head opens and distributes water onto the fire.

Automatic sprinklers that are properly installed and maintained provide a highly effective safeguard against the loss of life and property from fire. They are particularly effective for life safety because they give warning of existence of a fire condition and at the same time apply water to the burning area.

All building codes, including the NBCC, therefore rely on automatic sprinkler systems to contribute to life safety in large area buildings, high buildings, hazardous occupancies, and buildings with high occupant loads. Insurance companies often mandate automatic sprinkler protection where there is a potential for a large fire loss.

The NBCC requires that automatic sprinkler systems be designed, constructed, installed, and tested in conformance with NFPA 13, Installation of Sprinkler Systems.

There are only a few circumstances where the NBCC makes automatic sprinkler protection mandatory. However, there are a number of requirements which are relaxed if a sprinkler system is installed. When a system is installed, the NBCC normally requires complete protection throughout the building. In some cases, however, sprinkler protection need be provided on only a particular portion of a floor area, depending on the hazard being protected or the fire safety objective. The NBCC requirements for full and partial automatic sprinkler protection are summarized in Table 3.2 and Table 3.3, respectively.

3.5.5.2 Standpipe-and-Hose Systems

In small unsprinklered buildings, a fire can usually be easily reached by hose lines from fire hydrants located outside of the building. Evacuation of the building occupants has usually taken place, and the fire can often be brought under control from outside of the building without any undue risk to firefighters.

In larger buildings, this method of fire suppression is not always possible. Evacuation operations may not be complete and the fire may only be accessible from inside the building. Fire conditions can worsen considerably in the time spent laying hose lines from outside the building. In high buildings, it may not be possible to provide the water pressure necessary for effective hose streams. Standpipe and hose systems provide a convenient and effective means to apply water manually to fires in these buildings.

The NBCC requires that all buildings over three storeys in building height or more than 14 metres high, measured from grade to the ceiling of the uppermost storey, be provided with a standpipe-and-hose system. In buildings under three storeys in building height, the requirement for a standpipe-and-hose system depends on the building area and the major occupancy classification. If the building is sprinklered, however, the requirement is waived. The NBCC requires that the design, construction, installation, and testing of standpipe-and-hose systems be in conformance with NFPA 14, Installation of Standpipe and Hose Systems.

Standpipe systems are designed for two types of service. Small 38-mm-diameter hoses attached to the standpipe outlet are intended for use by the building occupants to help control the fire until firefighters arrive. Large 64-mm-diameter hose connections are provided to accommodate hose lines brought into the building by firefighters. Usually a standpipe is designed to supply both large and small hoses, with separate valve outlets provided to connect 38-mm-diameter and 64-mm-diameter hose.

Code Reference	Mandatory Requirement or Relaxation Permitted
3.1.2.3.	Mandatory requirement for arenas used for trade shows or exhibition purposes.
3.1.5.5.	Extended use of combustible cladding permitted.
3.1.5.11.	Relaxation for protection of combustible insulation.
3.1.13.	Relaxation of flame-spread rating for interior finishes.
3.1.14.2.	Combustible materials permitted above metal roof decks.
3.2.2.12.	Sprinklers permitted in lieu of roof rating.
3.2.2.13.	Heavy timber roof permitted.
3.2.2.15.	Buildings with impeded egress zones excluded from Group B, Division 1 construction requirements.
3.2.2.	Increased building area permitted.
3.2.3.11.	Increased unprotected openings permitted.
3.2.5.9.	Waiver of requirement for standpipe and hose systems.
3.2.5.10.	Lower water pressure permitted for standpipe and hose systems.
3.2.6.4.	Waiver of smoke control in high buildings.
3.2.6.8.	Waiver of elevator automatic emergency recall.
3.2.8.2.	Relaxation of interconnected floor space requirements.
3.2.8.6.	Mandatory requirement for buildings with interconnected floor spaces.
3.3.1.1.	Waiver of fire separation requirements.
3.3.1.7.	Waiver of protection on floor areas with a barrier-free path of travel.
3.3.3.7.	Relaxation of compartmentation requirements for hospitals and nursing homes.
3.3.4.2.	Relaxation of floor fire separation requirements in Group C buildings.
3.4.2.5.	Increased travel distance to exit permitted.

Table 3.2 Full Building Suppression

Code Reference	Mandatory Requirement or Relaxation Permitted
3.1.5.12.	Combustible elements in partitions used in non-combustible construction permitted.
3.1.5.15.	Combustible sprinkler piping permitted in non-combustible construction.
3.1.8.6.	Increased size of openings in interior fire separations permitted.
3.1.9.4.	Penetration of fire separation by combustible sprinkler pipe permitted.
3.1.11.6.	Unlimited crawlspace fire compartments permitted.
3.2.1.5.	Unlimited basement fire compartments permitted.
3.2.2.11.	Mandatory requirement to sprinkler basements.
3.2.3.15.	Waiver of exposure requirement in a wall exposed to an adjoining roof.
3.2.3.21.	Occupancy in an underground walkway permitted.
3.2.4.15.	Waiver of elevator alternate floor recall.
3.2.4.16.	Sprinkler head permitted in lieu of heat detector.
3.2.5.3.	Waiver of fire department access.
3.2.5.15.	Mandatory requirement to sprinkler service spaces.
3.2.6.10.	Venting by building exhaust system permitted.
3.2.6.11.	Mandatory sprinkler requirements for high buildings.
3.2.8.2.	Relaxation of requirements for interconnected floor spaces.
3.3.1.4.	Relaxation of public corridor fire separation requirements.

Table 3.3 Partial Building Suppression

Code Reference	Mandatory Requirement or Relaxation Permitted
3.3.2.2.	Relaxation of fire separation requirements for Group A, Division 3 buildings.
3.3.2.5.	Relaxation of fire separation requirements for corridors used by the public.
3.3.2.11.	Relaxation of fire separation requirements for book storage areas in libraries.
3.3.2.13.	Mandatory requirements for sprinklers in Group A, Division 1 buildings.
3.3.3.9.	Mandatory requirement to sprinkler contained use areas.
3.3.4.3.	Mandatory requirement to sprinkler storage rooms in Group C buildings.
3.3.5.4.	Relaxation of fire separation requirements for cutting and welding rooms.
3.3.5.8.	Mandatory requirement to sprinkler below grade storage garages.
3.4.2.5.	Increased travel distances to exit within floor areas permitted.
3.5.2.1.	Relaxation of fire separation requirements with service rooms.
3.5.2.7.	Mandatory requirement to sprinkler combustible refuse storage rooms.
3.5.3.3.	Mandatory requirement to sprinkler linen and refuse chutes.

Table 3.3 (Continued) Partial Building Suppression

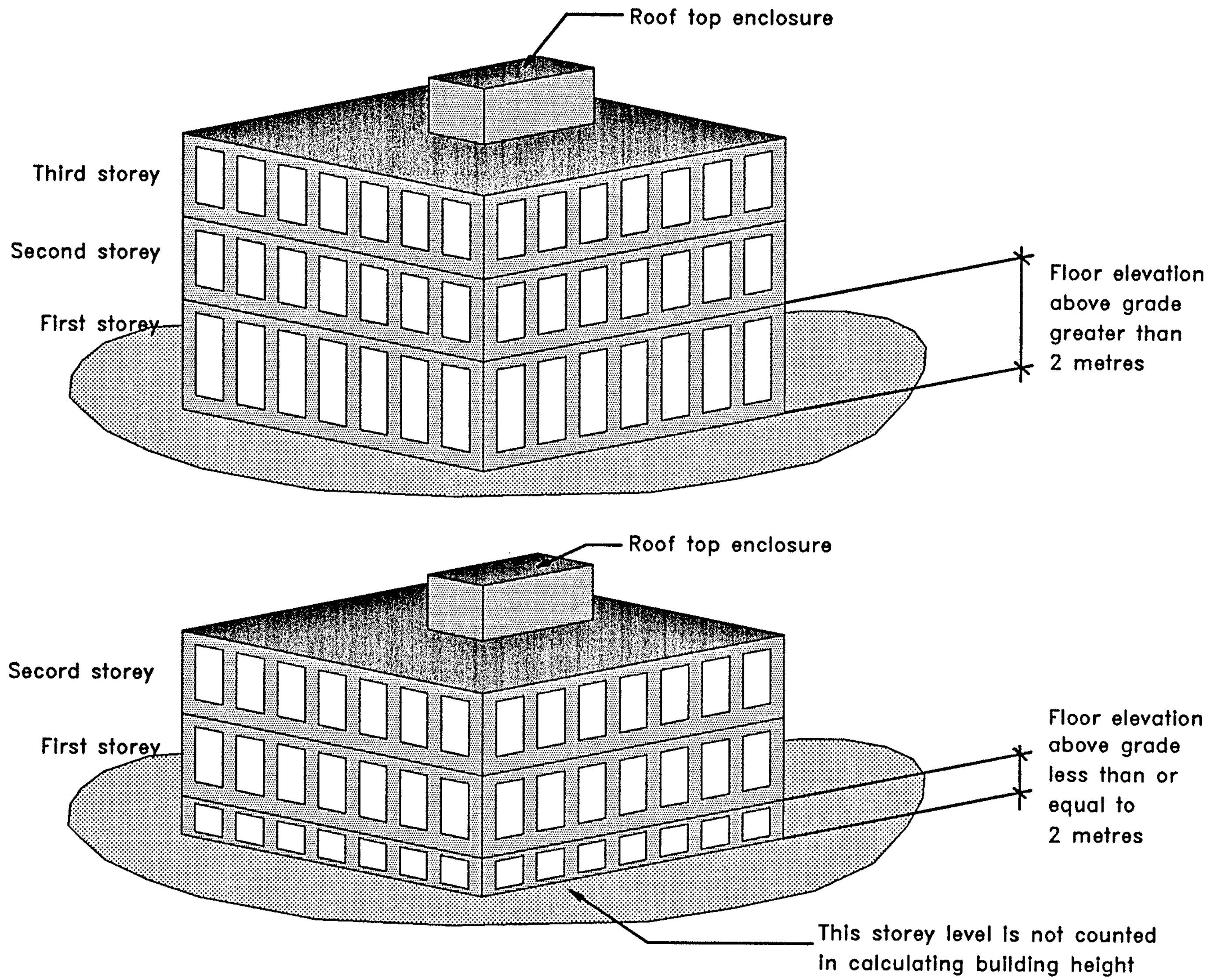


Figure 3.1 Building Height

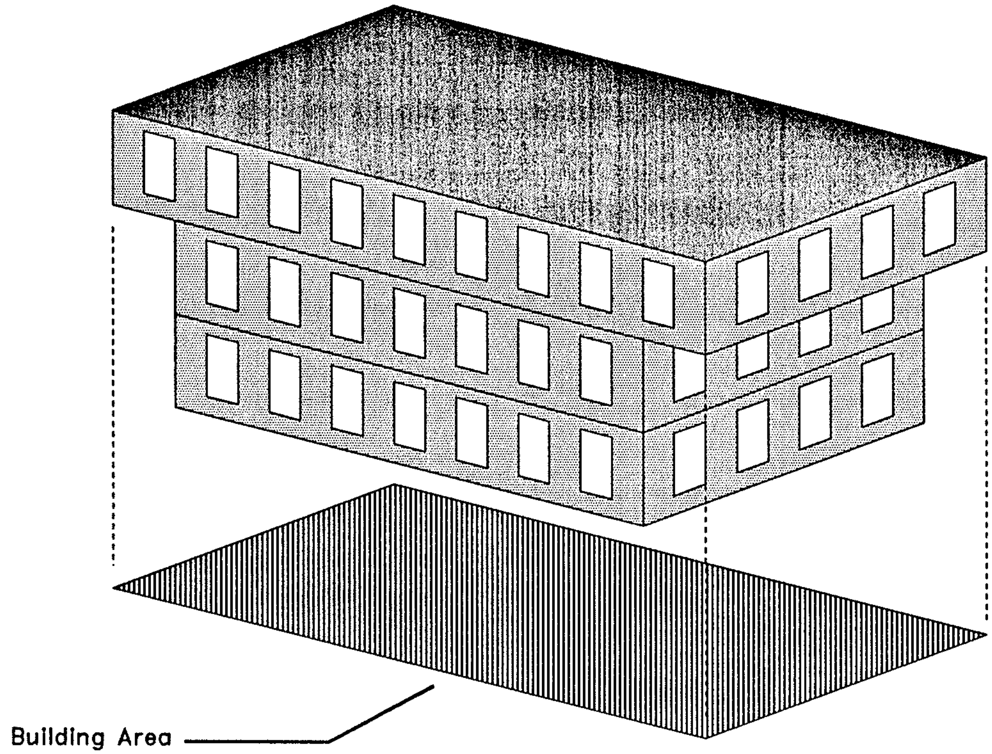


Figure 3.2 Building Area

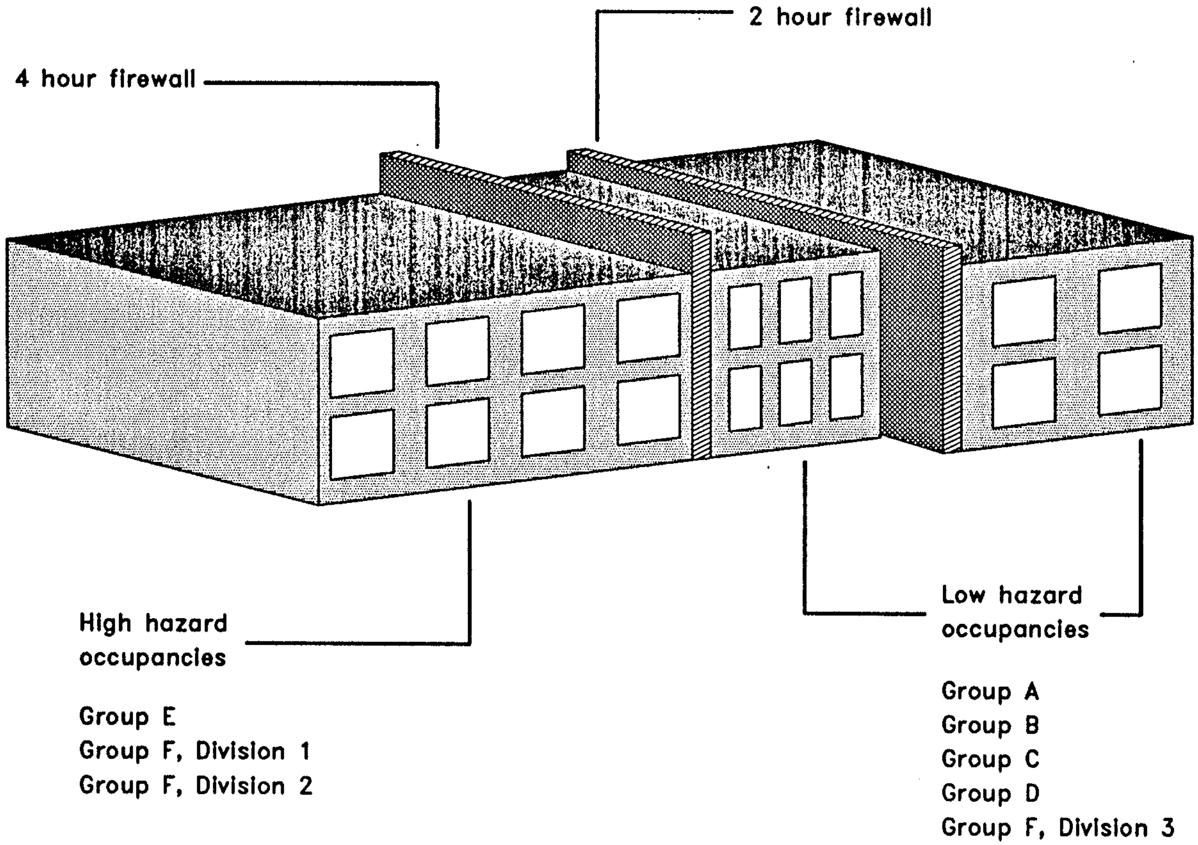


Figure 3.3 Building Divided by a Firewall

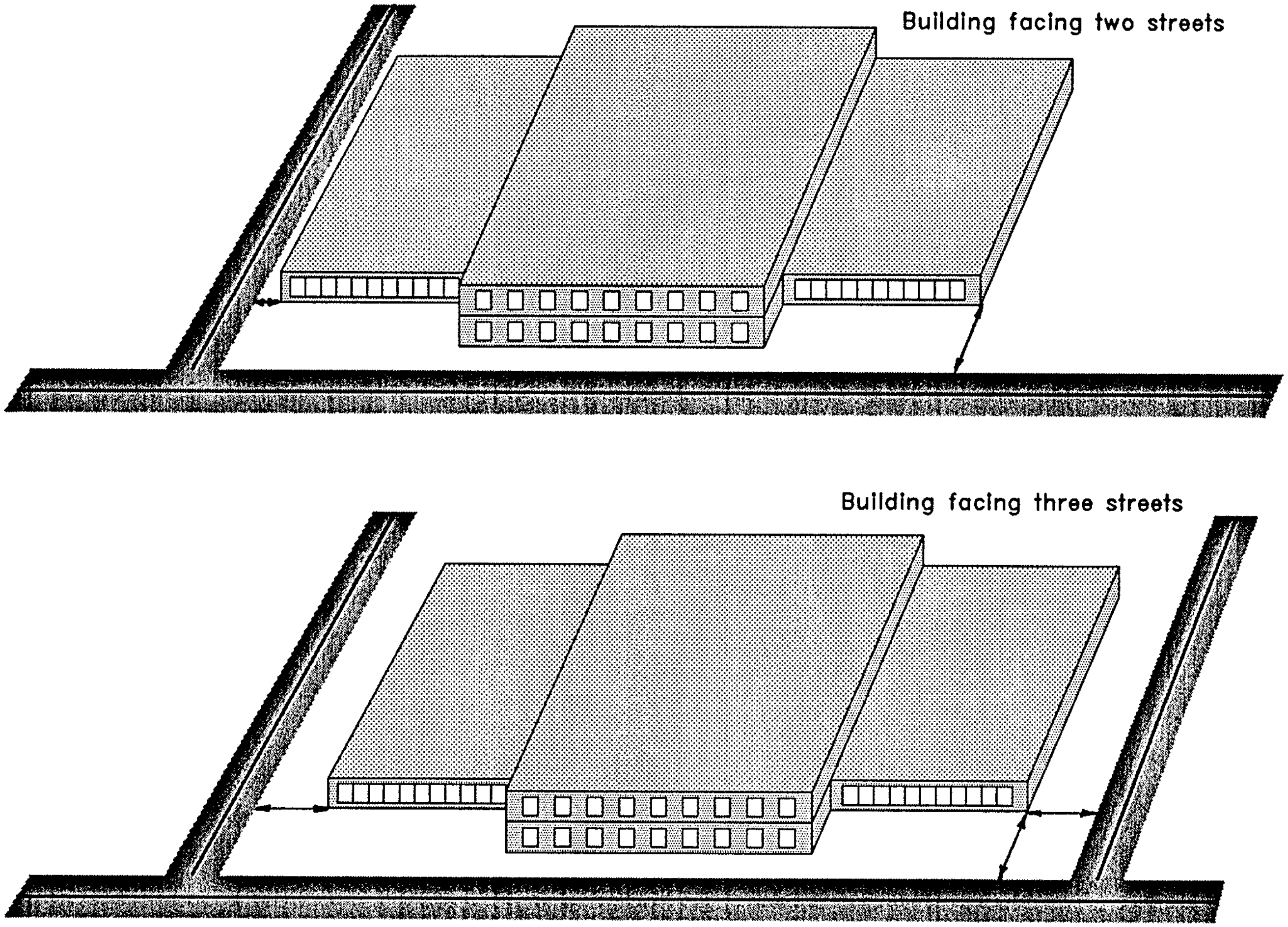
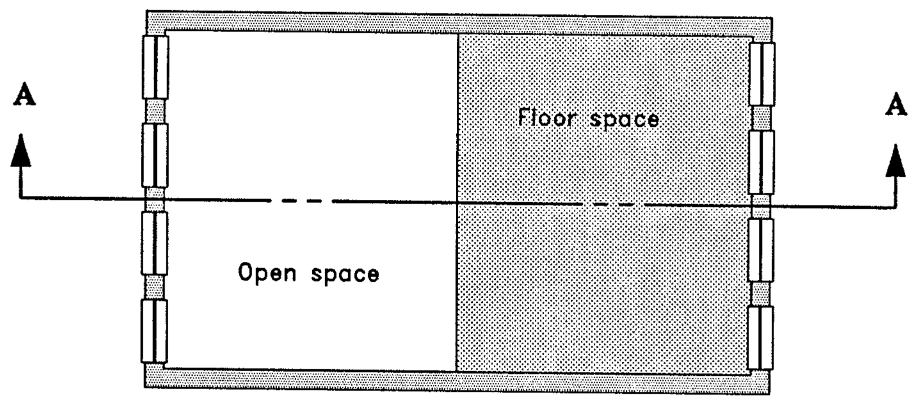
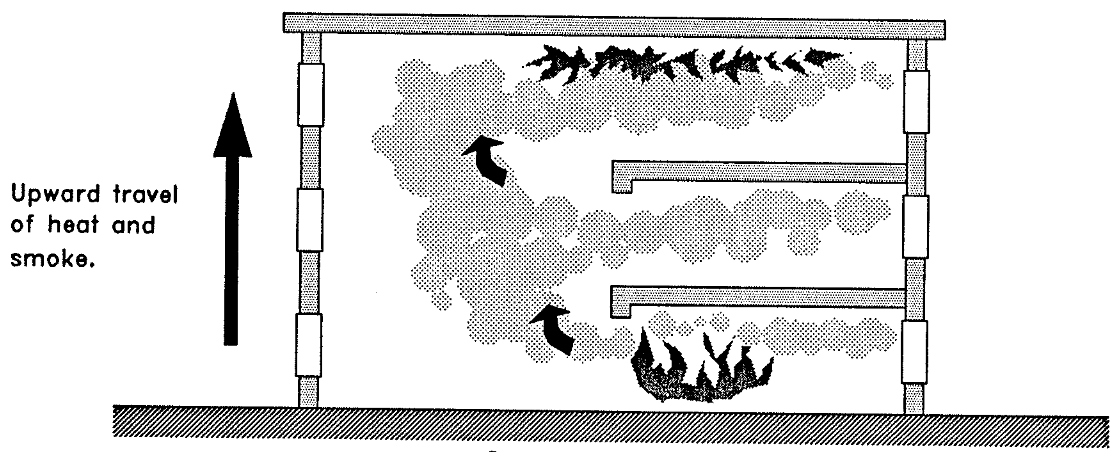


Figure 3.4 Street Access to Building



Plan View of Interconnected Floor Space



Cross Section A–A

Figure 3.5 Heat and Smoke Movement to Other Floor Levels

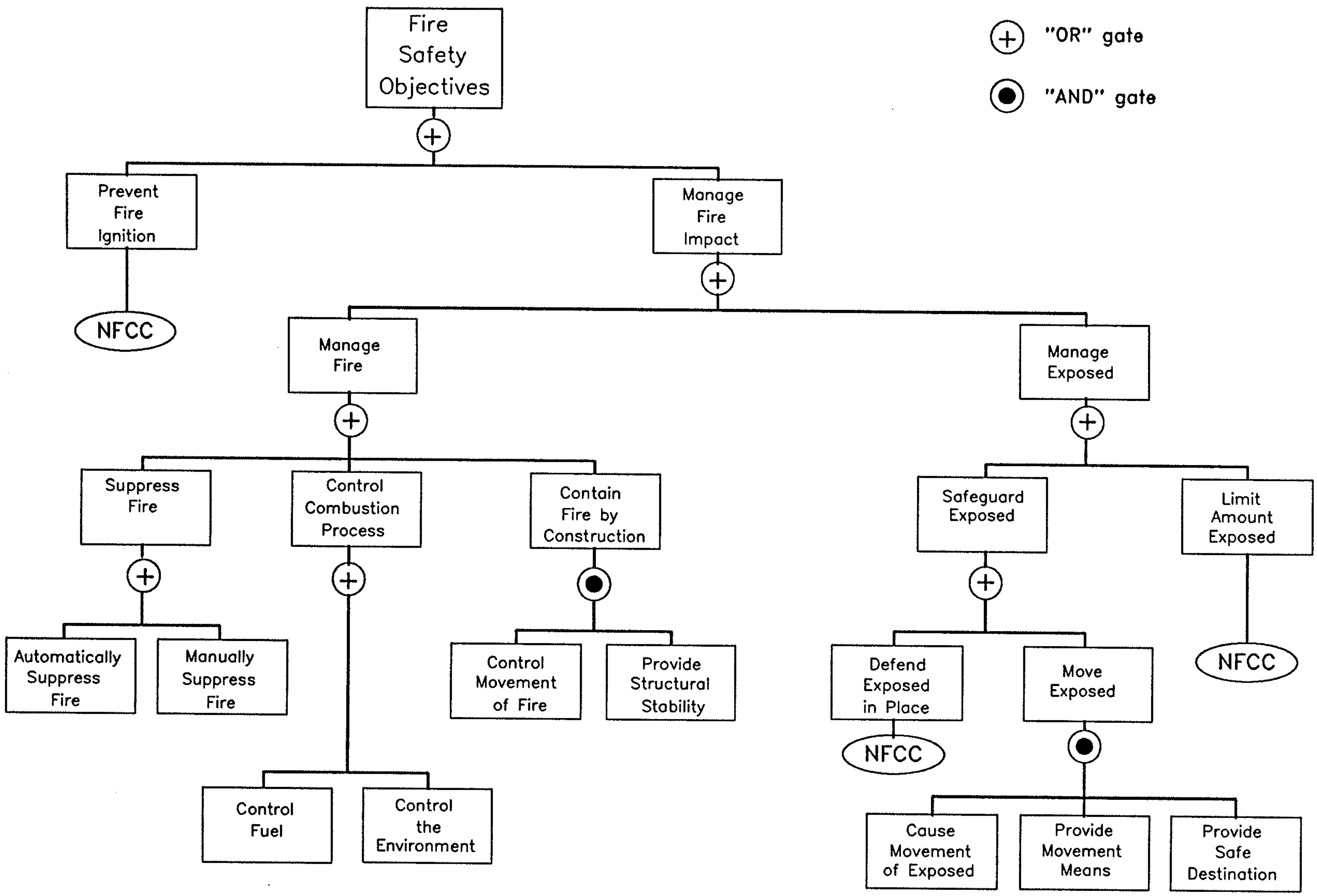


Figure 3.6 NFPA Fire Safety Concepts Tree

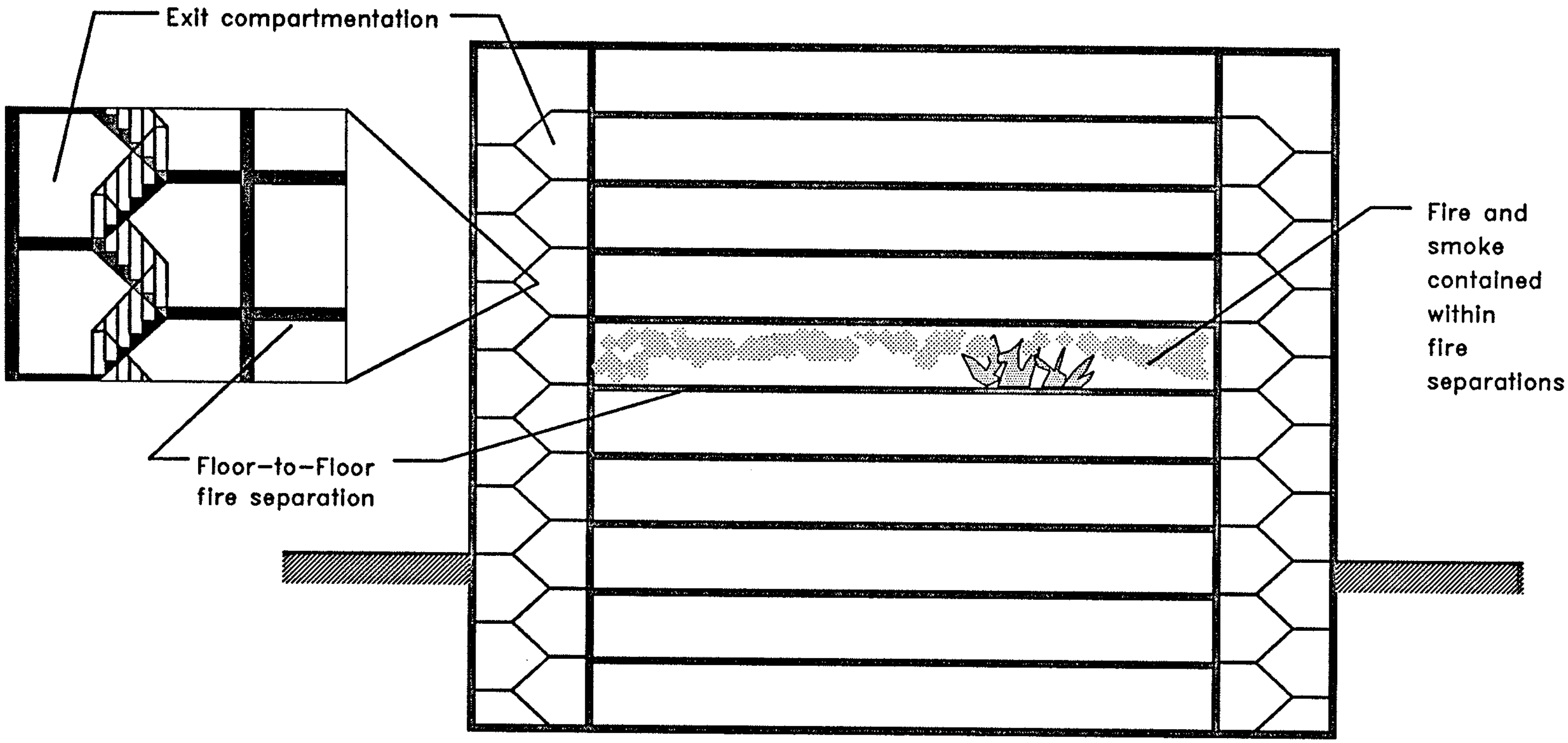
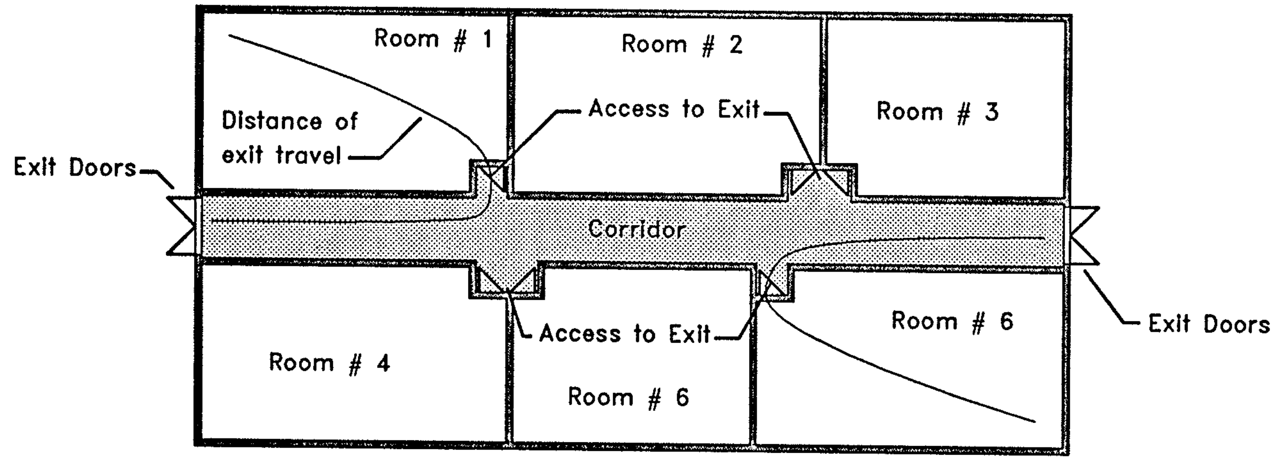
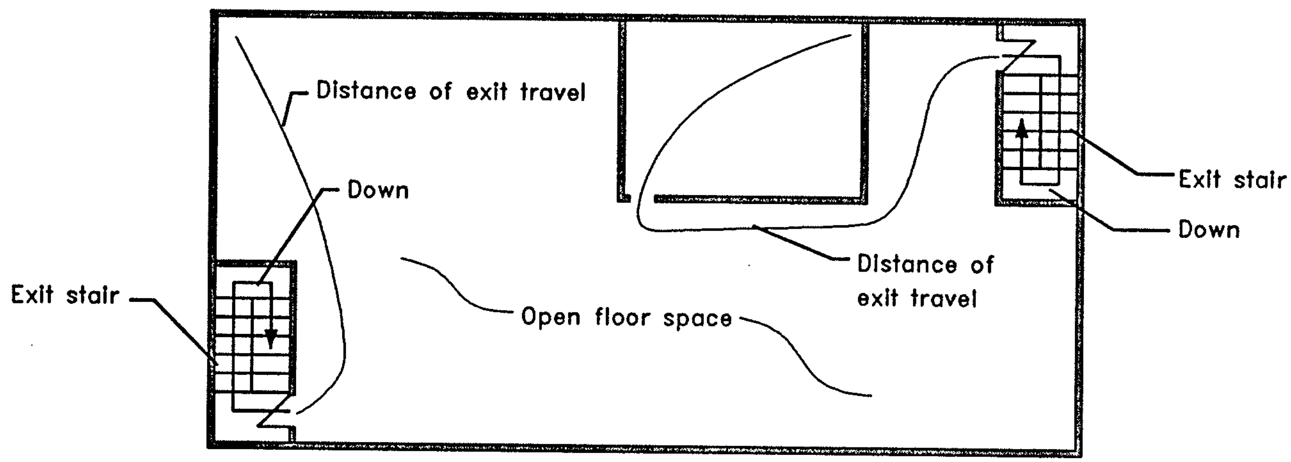


Figure 3.7 Floor-to-Floor and Exit Compartmentation

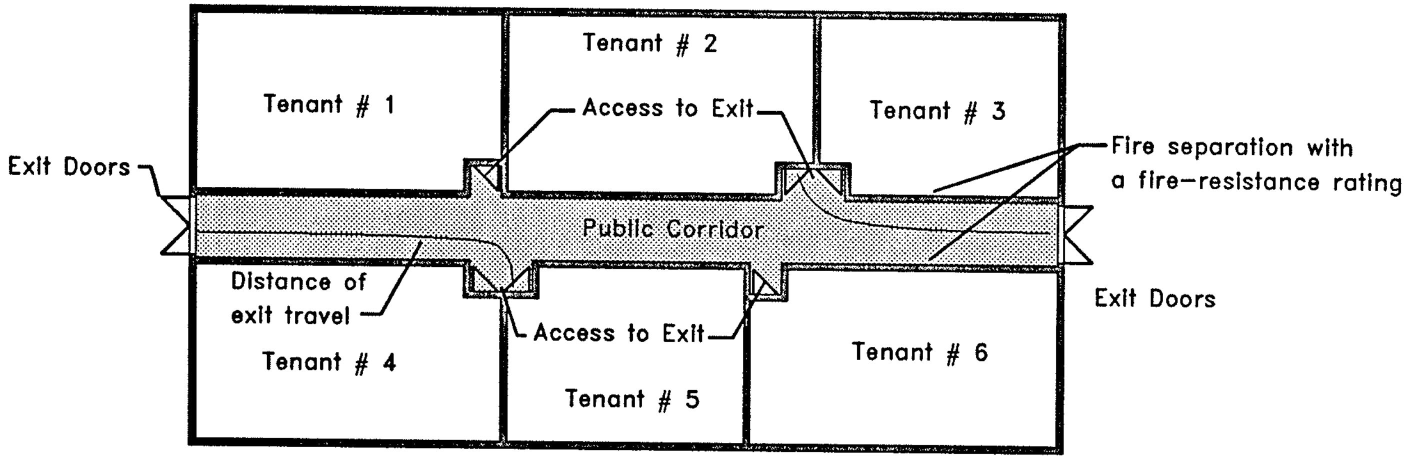


Single tenant floor space served by a corridor.

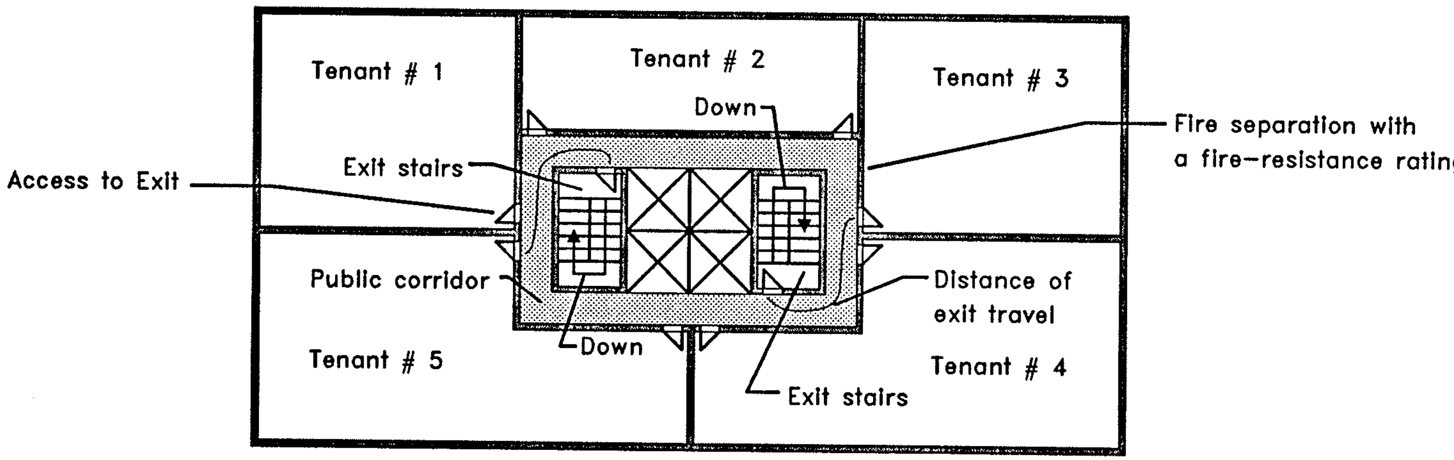


Single tenant floor space

Figure 3.8 Access to Exit for Single Tenant Floor Spaces



Multi-tenant floor space served by a public corridor.



Multi-tenant floor space served by a public corridor in a multi-storey building.

Figure 3.9 Access to Exit for Multi-Tenant Floor Spaces

CHAPTER 4

Development of the Expert System

4.1 Introduction

This chapter presents the development of the expert system, including a definition of the domain that is incorporated into the expert system knowledge base and a discussion of knowledge acquisition. This discussion shows how knowledge is acquired by the knowledge engineer-driven approach and gradually shifting to the expert-driven approach. The knowledge base on Part 3 of the Code is broken down into fire protection topics that are treated as subproblems. The decision tree is introduced and the manner in which subproblems are structured and organized into decision trees is explained. Finally, programming of the decision trees into the knowledge base is presented.

There are two phases of testing the knowledge base. The first phase ensures that the expert sytem uses a logical sequence in asking questions and that the conclusions reached are correct. This phase of testing is performed by the knowledge engineer and the code expert. The second phase is performed by the user and checks the functionality of the system by assessing user acceptance of the expert system.

The user interface of the developed expert system is introduced. The interface is shown to be sensitive to the two types of users, the expert and the novice. The chapter concludes with a presentation of a small test consultation. This test compares the effectiveness of the system in giving complete and accurate solutions with that of the manual process of consulting the Code. The test involved four participants, two experts and two novices.

4.2 Definition of the Domain

The *National Building Code of Canada* (NBCC 1990) is the principal source of knowledge used to build the present expert system. The NBCC is divided into nine chapters or *Parts*. Each Part is further subdivided into *Sections, Subsections, Articles, Sentences, Clauses,* and *Subclauses*. Since the fire protection requirements pertaining to building design are found primarily within Part 3, *Use and Occupancy*, the domain of the knowledge base is defined by this Part of the NBCC.

Part 3 of the NBCC is, in itself, very large and complex, containing many sections and subsections that are somewhat independent of each other. This facilitated an incremental approach to the development of the knowledge base. The idea behind this approach was to build up the knowledge base by working with manageable blocks of knowledge.

The problem domain was initially narrowed to Section 3.2, *Size and Occupancy Requirements for Fire Safety* (Olynick, Pinkney, and Frye 1989). This section of the NBCC provides the structural fire protection requirements for buildings and is generally regarded as the starting point in the determination of the fire protection requirements applicable to a given building. The expert system was then expanded incrementally as other sections and subsections were added to the knowledge base. The current status of the knowledge base is reflected in the program main menu and submenu choices, which are illustrated in Figure 4.1.

During the program development, it became obvious that the knowledge base would be incomplete unless portions of other regulations were included. The National Fire Code of Canada (NFCC 1990), Canadian Standards Association (CSA) standards, and National Fire Protection Association (NFPA) standards are frequently referred to by the NBCC and all contain information which is pertinent to the domain and must be considered to achieve a satisfactory level of fire safety in a building. The domain was therefore expanded to include many of the requirements found in these documents.

4.3 Knowledge Acquisition

The two knowledge acquisition approaches referred to in Chapter 2 were used herein, namely, the knowledge engineer-driven approach and the expert-driven approach.

4.3.1 Knowledge Engineer-driven Approach

In the early stages of development of this expert system, the knowledge engineer (that is, the author) had only limited experience and training in the domain. During this stage of development, knowledge acquisition followed the more classical or knowledge engineer-driven approach where the knowledge engineer relies on direct interaction with the domain expert to elicit the domain knowledge.

While Part 3 of the Code remained the principal resource for building the knowledge base, the knowledge engineer had to rely on considerable input from domain experts because of the complexity and generality of the Code. Expertise in the fire protection requirements of the Code is relatively scarce. Experienced building-department plan checkers are the most knowledgeable user group.

The Part 3 plan examiners of the City of Winnipeg provided this expertise. The average plan examination experience of this group of Code practitioners exceeds twenty years. They are fully familiar with the intent of Code requirements, the requirements that are most frequently interpreted incorrectly or overlooked, requirements that govern in a particular situation, and the most efficient sequence in which to conduct a plan review.

The City of Winnipeg plan examiners use a structured process when they conduct a Part 3 analysis of a building design. A Part 3 manual checklist, illustrated in Appendix A (City of Winnipeg, 1990), reflects this process. The process allows the plan examiner to quickly eliminate those Code requirements that are not applicable and to focus on the requirements that are. The primary construction requirements are determined before dealing with more specific issues. Plan examiners can be confident in making some conclusions about Code compliance even at an early stage of plan review.

In the beginning, the knowledge transfer was relatively slow. The transfer was facilitated through numerous discussions and interviews with experienced plan examiners. Because the knowledge engineer was involved in day-to-day plan examination, much of the discussion related to actual plan review. Additional knowledge was acquired by study of the Code and Code commentaries, interpretation memoranda, and other definitive technical information.

4.3.2 Expert-driven Approach

As the knowledge engineer developed expertise in the domain, the method of knowledge acquisition gradually shifted to what is known as the expert-driven approach. In this approach the expert encodes his or her own knowledge and enters it directly into the computer.

For over one year the knowledge engineer worked as a plan examiner. Working in the day-to-day plan examination environment, he developed plan examination skills comparable to those of the fire protection experts. He became comfortable with domain terminology, the short cuts, and the trouble spots.

While discussions and interviews with Code experts still took place, they were more productive than in the early stages. In many cases, discussions took place only after a prototype for a portion of the Code was programmed.

In addition to the considerable improvement in domain expertise by the knowledge engineer, several of the plan examiners became knowledgeable about expert systems and were able to appreciate and understand the development process. This led to an overall improvement to the knowledge acquisition phase of this project.

4.4 Structuring the Knowledge Base

In the development of this expert system, the global problem of determining what requirements apply to a given building design are divided into a number of subproblems. Each subproblem represents an independent fire protection topic. A fire protection requirement found in the NBCC is the solution to an independent fire protection problem and makes a contribution to the overall fire safety of the building.

PcPlus allows knowledge to be organized into frames and subframes. In this expert system, each fire protection topic is represented by one or more subframes connected to a single root frame. Knowledge pertaining to a fire protection topic was organized into more than one subframe where the efficiency of the inferencing process could be improved or where it became difficult to control the knowledge base and the relationship of the rules because of the large number of rules.

The current knowledge base is represented by 58 subframes linked to one root frame. This frame structure is illustrated in Appendix B. A brief description of the fire protection topic and objective of each subframe is also provided.

In addition to allowing the incremental development of the knowledge base, structuring the knowledge base in a frame format improves the overall organization and efficiency of the expert system. More importantly, it will facilitate updating of the knowledge base when the Code changes.

4.4.1 Decision Tree Development

A decision tree represents the way that an expert typically thinks about and approaches a problem. It is a diagrammatic representation of the reasoning process that the expert follows to conclude a solution to a problem or to reach a goal state.

In this thesis, decision trees were developed for each fire protection topic and are illustrated in Appendix C. In some cases, more than one decision tree was used to organize and represent a more complex fire protection topic.

A typical decision tree is illustrated in Figures 4.2(a) and 4.2(b). All parameters that can influence the outcome of the reasoning process must be identified and accounted for in the decision tree. The number of levels in the tree depends on the number of parameter-value relationships that must be known before a final goal state is reached. User responses to questions posed in the decision tree determine the path to be taken through the tree. The tree must therefore reflect all possible values that can be assigned to the different parameters. Each path connects different parameter-value relationships to a conclusion or *goal state*. The goal state is achieved when a value is assigned to a subproblem goal parameter. That is, for a given set of parameter-value relationships a Code requirement is determined to be applicable or not applicable.

Parameter-value relationships are established by user responses to system prompts for information. The order in which information is requested in the decision tree should reflect the order in which a Code expert would normally request information in a consultation with a client. Experts generally prefer to ask the minimum number of questions necessary to reach a conclusion, provided the conclusion can be reached with absolute certainty. Information that has the highest value in reaching a goal state is therefore requested first. Prompts for this information appear at a higher level of the decision tree. Information that is less likely to contribute to a goal state is requested later, and only if necessary. Prompts for this information appear at a lower level in the tree. This is illustrated in the next section.

In most cases, only one path through the decision tree is possible. There are, however, some cases where parameter-value relationships allow more than one path through the decision tree, leading to different valid goal states. If one goal state is preferred over another, then this conflict must be resolved when rules are constructed from the decision tree.

Developing a decision tree to represent a fire protection topic is the most important task to be completed before programming of the knowledge base can begin. Although the decision tree is sometimes time-consuming to develop, it has several advantages: this format is easily understood by code experts and an error in logic can be detected quickly; it is immediately evident whether the Code is silent on a particular requirement or contradicts itself; modifications of the knowledge base are simplified if the Code changes; and programming becomes relatively simple.

4.4.1.1 Decision Tree Example: Order in which Questions are asked

As an illustratation of the importance of constructing decision trees that reflect the order in which an expert requests information from a user in a consultation, consider the following example:

> **Example:**
> Article 3.2.4.1 of the NBCC is used to determine when a given building requires a fire alarm system. To simplify this example, only a portion of the Article is used;
>
> **Determination of Requirement for a Fire Alarm System**
> 3.2.4.1.(1) ... a fire alarm system shall be installed ... in buildings containing:
> a) a contained use area;
> b) an impeded egress zone;
> c) an interconnected floor space required to conform to Articles 3.2.8.3 to 3.2.8.9;
> d) more than three storeys, including storeys below grade;
> e) a total occupant load of more than 300 ...; or
> f) an occupant load of more than 150 above or below the first storey ...

Two decision trees constructed to represent this Article are illustrated in Figure 4.3(a) and Figure 4.3(b).

From experience, a Code expert knows that most buildings which require a fire alarm system do so because of the occupant load or because they are higher than three storeys. Only very rarely will a fire alarm system be required because of the presence of contained use areas, impeded egress zones, or interconnected floor spaces. The expert would therefore ask questions about occupant load and building height before asking about the presence of these building features. This experiential knowledge is reflected in the construction of the decision illustrated by Figure 4.3(b).

Rules generated from either of these trees will provide the correct conclusion. However, the order in which the expert system requests information from the user will be different.

From Figure 4.3(a) the rule entered in the knowledge base is as follows:

IF: CONT_IMPED = YES OR INTER_FL = YES OR STOREY = YES OR OCC_LOAD = YES OR ABOVE_BELOW = YES

THEN: FIRE ALARM SYSTEM IS REQUIRED

The sequence of user prompts generated by the rule is determined by the order in which each parameter appears in the premise part of the rule. The order in which questions are asked is as follows:

QUESTION 1. Does the building contain either a
i) contained use area or
ii) impeded egress zone

QUESTION 2. Does the building contain an interconnected floor space required to conform to Articles 3.2.8.3 to 3.2.8.9.?

(*Note: Articles 3.2.8.3. to 3.2.8.9. are special fire protection provisions for interconnected floor spaces. In the expert system a help function is provided for the user.*)

QUESTION 3. Does this building contain more than three storeys including storeys below grade?

QUESTION 4. Does the total occupant load of the building exceed 300 persons?

QUESTION 5. Does the total occupant load above or below the first storey exceed 150 persons?

From Figure 4.3(b) the rule entered in the knowledge base is as follows:

IF: **OCC_LOAD** = YES OR **STOREY** = YES OR **ABOVE_BELOW** = YES OR **INTER_FL** = YES OR **CONT_IMPED** = YES

THEN: FIRE ALARM SYSTEM IS REQUIRED

Similarly, the sequence of questions generated from the rule shown above is as follows:

QUESTION 1. Does the total occupant load of the building exceed 300 persons?

QUESTION 2. Does this building contain more than three storeys including storeys below grade?

QUESTION 3. Does the total occupant load above or below the first storey exceed 150 persons?

QUESTION 4. Does the building contain an interconnected floor space required to conform to Articles 3.2.8.3. to 3.2.8.9.?

(*Note: Articles 3.2.8.3. to 3.2.8.9. are special fire protection provisions for interconnected floor spaces. In the expert system a help function is provided for the user.*)

QUESTION 5. Does the building contain either a
i) contained use area or
ii) impeded egress zone

4.4.1.2. Decision Tree Example: Rule Conflict

Rule conflict occurs when more than one rule can fire and the inference engine must make a choice of which to apply. Such conflict must be resolved or the consultation may end with other than the desired conclusion. Rule conflict was relatively rare in the development of this expert system. It did occur, however when Subsection 3.2.2., *Building Size and Construction Relative to Occupancy*, of Part 3 of the NBCC was added to the knowledge base.

This Subsection contains the minimum structural fire protection regulations for a building. This minimum level of protection can depend on the following user-supplied information: the major occupancy classification of the building, the building height, the building area, whether or not the building is sprinkler protected, and the number of streets the building faces.

For a given major occupancy classification, several levels of fire protection can apply. That is, a building may be constructed with a level of structural fire protection greater than required without violating the Code. Designers, in most cases, are interested in the minimum applicable requirements of the Code.

To illustrate this, consider the following rules developed from a decision tree:

```
RULE058    IF: CLASS = GROUP D
                  AND
           BLDGHT = 2 STOREY
                  AND
           AREA ≤ 800
                  AND
           STREET = 1
           THEN: STRUCTURAL FIRE PROTECTION REQUIRED
           ARTICLE 3.2.3.39.
```

RULE059 IF: **CLASS** = GROUP D
AND
BLDGHT = 2 STOREY
AND
AREA $\leq$ 2400
AND
STREET = 1
THEN: STRUCTURAL FIRE PROTECTION REQUIRED
ARTICLE 3.2.2.40.

RULE060 IF: **CLASS** = GROUP D
AND
BLDGHT = 2 STOREY
AND
AREA $\leq$ 7200
AND
STREET = 1
THEN: STRUCTURAL FIRE PROTECTION REQUIRED
ARTICLE 3.2.2.41.

RULE061 IF: **CLASS** = GROUP D
AND
BLDGHT = 2 STOREY
AND
AREA $\geq$ 7200
AND
STREET = 1
THEN: STRUCTURAL FIRE PROTECTION REQUIRED
ARTICLE 3.2.2.42.

Consider also the following user data in Table 4.1.

The user-supplied information will cause any of the rules listed to fire. The construction requirements specified by Article 3.2.2.39 are the minimum structural fire protection requirements applicable; however, only RULE058 comes to this desired conclusion. The other rules conclude higher requirement levels of structural fire protection to which the building can also be built without violating the Code.

To ensure that the minimum applicable requirements are concluded, the order in which rules are tried by the inference engine cannot be left to chance.

Parameter	Prompt	User Response
CLASS	What is the major occupancy classification for the building?	GROUP D
BLDGHT	What is the building height in storeys?	2 STOREY
AREA	What is the building area in square metres?	700
SPRINK	Is the building sprinklered protected?	NO
STREET	How many streets is the building facing?	1

NOTE: (*In the example the information as to sprinkler protection status is not required by the rules*).

Table 4.1 User Responses for Structural Fire Protection Requirements

PcPlus will try rules in the order in which they are entered into the knowledge base. Rule conflict can therefore be resolved by entering the rules according to a desired sequence. This method is satisfactory providing rules are not edited once they have been entered into the knowledge base. Editing a rule may change its order in the knowledge base and therefore lead to unexpected results.

PcPlus provides two methods to overcome this problem: a UTILITY property or DOBEFORE property can be assigned to all rules that may be in conflict.

PcPlus can force the inference engine to try rules in a predetermined order by assigning a UTILITY value to a rule or to a number of rules. The UTILITY property is a numerical ranking system. The UTILITY property utilizes integers that range from -100 through 100. During the inferencing process, the inference engine will try the rule with the highest UTILITY value first. It then tries other rules according to decreasing order of UTILITY value.

In this example, the UTILITY property is implemented by assigning higher UTILITY rankings to those rules that conclude the minimum permissible level of structural fire protection. Rules that conclude higher levels of protection are ranked with lower UTILITY values.

Utility Value	Reasoning Strategy	Level of Structural Fire Protection Concluded
100	Test **RULE058** First	Lowest Level Article 3.2.2.39.
90	Test **RULE059** Second	Article 3.2.2.40.
80	Test **RULE060** Third	Article 3.2.2.41.
70	Test **RULE061** Last	Highest Level Article 3.2.2.42.

Table 4.2 Reasoning Strategy Controlled by Rule UTILITY Property

RULE058 concludes the lowest level of structural fire protection and is therefore ranked with a UTILITY value of 100. The next level of protection is concluded by RULE059 which has a UTILITY value of 90. RULE060 has a UTILITY value of 80 and RULE061 which concludes the highest level of structural fire protection has the lowest UTILITY value in this rule grouping. In this arrangement, the rules are tried in the desired order. That is, the lowest permissible level of fire protection will always be concluded, as shown in Table 4.2.

The DOBEFORE property is a list of specific rules that PcPlus will try before trying the current rule. There can be one or more rules listed in the DOBEFORE property. While searching for a parameter-value, PcPlus may come across a rule that has a DOBEFORE property. The rules listed in this property are arranged in a defined order which are to be tried in turn. These rules may also contain a DOBEFORE property that leads to other rules to be tried. A rule in the list will be tried provided the current parameter being traced is found in the IF part of that rule; otherwise it is rejected and the next rule in the DOBEFORE property is then tried. If all rules listed are tested and failed, PcPlus will then try the current rule that was temporarily abandoned.

In this example, those rules that conclude a higher level of structural fire protection than RULE058 are all assigned a DOBEFORE property as tabulated in Table 4.3.

In this rule grouping, RULE058 will always be tried first even if the sequence in which rules are tested is modified.

PcPlus provides these two options because the UTILITY property is a general ranking system for rules to be tried but the DOBEFORE property tries rules in a particular order, taking into account the parameter currently being traced.

Reasoning Strategy	DOBEFORE Property	Level of Structural Fire Protection Concluded
RULE058		Lowest Level Article 3.2.2.39.
RULE059 check DOBEFORE Property	RULE058	Article 3.2.2.40.
RULE060 check DOBEFORE Property	RULE059	Article 3.2.2.41.
RULE061 check DOBEFORE Property	RULE060	Highest Level Article 3.2.2.42.

Table 4.3. Reasoning Strategy Controlled by Rule DOBEFORE Property

In this expert system both the UTILITY property and the DOBEFORE property are used. For this expert system the decision of what type of property to be used is not critical. It becomes important where the DOBEFORE property is used to determine the order of two rules that have the same UTILITY property value. The DOBEFORE property sorts the rules after they have been sorted by the UTILITY property. In this thesis, the simultaneous use of both properties in a rule was not necessary.

4.5 Programming and Testing

Programming the knowledge base is the task of the knowledge engineer. After each knowledge base increment is entered into the NBCC expert system, testing is then conducted by both the domain experts and the knowledge engineer. A second phase of testing is performed by novices. This phase of testing determines user acceptance of the expert system.

4.5.1 Programming

Incorporating the decision trees into the knowledge base using the expert system shell is a relatively simple task. Programming involves entering parameters, expected parameter-values, system properties and functions, operands and the resulting goal states or conclusions.

4.5.1.1 Rule Generation from the Decision Tree

The knowledge base initially structured and organized into decision trees is programmed into IF-THEN rules for the NBCC expert system. Consequent or backward-chaining rules and antecedent or forward-chaining rules are used in combination to represent all the decision trees in this thesis.

To represent the decision tree paths into the IF parts of a rule is a matter of entering the various parameter-value relationships linked to other parameter-value relationships with operands. The conclusions at the end of a decision tree path, including other resulting actions, are programmed into the THEN part of a rule. The decision trees are then in an encoded form that PcPlus is able to use.

The number of backward-chaining rules that are needed to program a decision tree into the knowledge base usually is the same number of paths that lead to a conclusion. In other words, a backward-chaining rule is programmed for each parameter-value relationship linked together forming a path. However, in some developed decision trees, more than one path with different combinations of parameter-value relationships lead to the same conclusion. In such cases, a single backward-chaining rule is programmed.

In a backward-chaining rule, parameter-values are usually assigned to parameters by the method of prompts. The user of the expert system will give a parameter-value to a parameter by answering the question the parameter represents symbolically. The parameters in this expert system have three *value kinds*. The first value kind that can be assigned to a parameter is a YES/NO type. The second is a menu selection. This menu contains all possible answers or choices a knowledge engineer programs to be assigned to a parameter. In all cases, there are at least two choices a user can select from the list. The third value kind that can be assigned to a parameter is a numerical value.

There are two purposes for using forward-chaining rules to represent parts of the decision tree in this expert system. The first is to give additional regulations at particular times during a consultation; the regulations given are not the solution to the problem, but are necessary for the user to view or to be made aware of. The second is to make the knowledge base more efficient. Under certain occurrences of parameter-value relations, values to other parameters can be given automatically. This reduces the number of prompts or questions necessary. As a result, the inference engine of the expert system will deduce fewer rules, hence increasing inferencing speed.

4.5.1.2 Inferencing Process

As an example of an inferencing process, consider the decision tree illustrated in Figures 4.4(a) and 4.4(b) that was developed for the NBCC knowledge base. This decision tree contains the requirements for emergency operation of elevators and has one goal parameter. The goal parameter for this part of the knowledge base is **EMERG-ELE** and is contained in the THEN part of the rules. The value that is given to the goal parameter is a Code regulation for the emergency operation of elevators.

Seven rules are generated from this decision tree. Six of the rules are backward-chaining rules that contain the parameter-value relations that lead to a conclusion. The seventh is a forward-chaining one that gives additional information to the user. The seven generated rules are shown below.

RULE574 (Backward-chaining)
IF: **ELEHB** = YES AND **ELESPRK** = YES
THEN: **EMERG-ELE** = SENTENCE 3.2.6.8.(1) TO (4)

RULE575 (Forward-chaining)
IF: **ELESPRK** = NO
THEN: SHOW SENTENCES 3.2.6.8.(1) TO (7)

RULE576 (Backward-chaining)
IF: **ELEHB** = YES AND **ELESPRK** = NO
AND **ELEFL** = NO
THEN: **EMERG-ELE** = SENTENCES 3.2.4.15.(1) & (2)

RULE577 (Backward-chaining)
IF: **ELEHB** = YES AND **ELESPRK** = NO
AND **ELEFL** = YES
THEN: **EMERG-ELE** = SENTENCE 3.2.4.15.(3).

RULE578 (Backward-chaining)
IF: **ELEHB** = NO AND **ELE!HB** = YES
AND **ELEFL** = YES
THEN: **EMERG-ELE** = SENTENCE 3.2.4.15.(3).

RULE579 (Backward-chaining)
IF: **ELEHB** = NO AND **ELE!HB** = YES
AND **ELEFL** = NO
THEN: **EMERG-ELE** = SENTENCE 3.2.4.15.(1) & (2)

RULE580 (Backward-chaining)
IF: **ELEHB** = NO AND **ELE!HB** = NO
THEN: **EMERG-ELE** = NO REQUIREMENTS

When a consultation begins, PcPlus tries to find a value for the goal parameter. In a backward-chaining knowledge base, this search method for a value for the goal parameter is the force that drives the consultation forward. In the knowledge base, a rule must contain a goal parameter and a value in its THEN part. When PcPlus finds a rule that gives the goal parameter a value, it tries that rule to determine whether its IF premise is true. In this case, PcPlus tries to find a value for the goal parameter **EMERG-ELE.**

In order to test a rule, PcPlus needs to find the values for the parameters in the IF statement of a rule. As PcPlus searches for the values, it may need to try other rules that give values to the parameters. In this case, all parameters have a prompt property. PcPlus will present a question to the user for a value to be assigned to the parameter.

When the IF statement of a tried rule becomes true, PcPlus fires the rule by executing the actions found in the THEN statement. This backward-chaining process continues until PcPlus determines a value for the goal parameter.

If the expert system has additional goal parameters, PcPlus repeats the process of testing rules and searching for parameter-values until the values of other goal parameters are determined.

To demonstrate the backward-chaining seach process, consider RULE574 only. The other backward-chaining rules are the same as RULE574 except those rules contain different linked parameter-value relationships representing other paths found in the decision tree.

The following sequence of events in a backward-chaining process occurs during a consultation is presented. Assume that PcPlus begins the inferencing process by testing RULE574 first, and in this example it will be found true.

STEP 1 When the consultation begins, PcPlus begins to search for a value for the goal parameter, **EMERG-ELE.**

STEP 2 PcPlus looks for a rule that gives **EMERG-ELE** a value. The value is an applicable code regulation.

STEP 3 PcPlus begins testing the found rule. In this case it is assumed RULE574 is first tested.

For the premise of RULE574 to be true, the values of parameters **ELEHB** and **ELESPRK** must have the value of YES.

STEP 4 PcPlus searches for a value for parameter **ELEHB.**

No rule in this case sets a value for the parameter **ELEHB,** but a prompt has been defined for the parameter : "Is this a high building?"

STEP 5 PcPlus presents the prompt to the user. Assume that the response is YES.

STEP 6 PcPlus now searches for a value for the parameter **ELESPRK.**

No rule sets a value for the parameter **ELESPRK,** but a prompt has been defined for the parameter: "Is the building sprinklered?"

STEP 7 PcPlus presents the prompt to the client. Assume that the response to the prompt is YES.

STEP 8 The premise of RULE574 passes, and PcPlus fires the rule, setting the value of the goal parameter **EMERG-ELE** to Sentence 3.2.6.8.(1) to (4).

The text in the THEN statement of RULE 574 will be presented to the user.

STEP 9 The consultation ends, because the goal parameter **EMERG-ELE** has a value. Because the goal parameter has a value, no other rules having the goal parameter **EMERG-ELE** need be tried.

In this decision tree there is only one forward-chaining rule, RULE575. This type of rule does not have a goal parameter in the THEN statement. Forward-chaining rules have many purposes in a knowledge base; in this case, the forward-chaining rule is used to signal the time to display a Code regulation to the user.

To demonstrate the forward-chaining reasoning mechanism, consider the only antecedent rule generated for this the decision tree. RULE575 is used to display information to the user. No value is given to the goal parameter **EMERG-ELE** by this rule.

During a consultation, the following sequences of events occurs when PcPlus fires RULE575.

STEP 1 When the consultation begins, PcPlus begins to search for a value for the goal parameter **EMERG-ELE.**

STEP 2 PcPlus looks for a rule in a backward-chaining knowledge base that gives **EMERG-ELE** a value. In this case, assume PcPlus starts with RULE576.

During the consultation at this point, the parameter **ELEHB** has the value YES.

STEP 3 In the consultation PcPlus searches for the next parameter in the IF statement of RULE576.

The parameter **ELESPRK** has a prompt property as follows: "Is the building sprinklered?"

STEP 4 PcPlus presents the prompt to the user. Assume the response is NO.

In this case the building is not sprinklered.

STEP 5 Because the value of **ELESPRK** is known, PcPlus tests all antecedent rules having this parameter in the IF statement. In this section of the knowledge base, the antecedent RULE575 is tried.

STEP 6 PcPlus already knows the value of **ELESPRK** is NO, which is determined by the backward-chaining reasoning mechanism.

Now PcPlus tries RULE575, the antecedent rule.

RULE575 passes, the rule is fired, and a message is displayed on the screen:

> "Manual Emergency Recall is required for all elevators serving storeys above the first. Automatic Emergency Recall is required since the building is not sprinklered."

STEP 7 PcPlus continues to search for a value for the goal parameter **EMERG-ELE** to finish the consultation session with the user.

4.5.1.3 Developer Interface

PcPlus has an interactive developer interface that has many selection menus for the knowledge engineer to choose from. The interface prompts the knowledge engineer to enter names and property values for parameters and frames, and to enter IF-THEN rule statements to create a comprehensive expert system. With this interface, domain knowledge is entered and modified with ease.

In the initial stages of creating a comprehensive expert system, PcPlus will not prompt the knowledge engineer to add special properties and PcPlus functions to the knowledge base. Where desired, the knowledge engineer must manually select these properties and PcPlus functions. For example, meta-rules, and properties for rules such as the ANTECEDENT (forward-chaining rule) property, UTILITY property and the DOBEFORE property are some of the special properties that PcPlus offers. However, when a special property is selected to be included in the knowledge base, the developer interface will then prompt for all necessary values associated with that property.

4.5.1.3.(a) PcPlus development interface for creating a root frame or subframe

At the start of creating a new knowledge base, PcPlus will prompt the knowledge engineer to input the initial values that are required for the knowledge base.

First, PcPlus will ask for the value of the DOMAIN variable. This value appears as the heading at the top of the screen. In this thesis, the value of the domain variable entered is **"National Building Code of Canada (NBCC)"**. The value of the domain variable applies to the entire knowledge base and the value is requested only once.

PcPlus then prompts for a name to be given to the root frame. In the NBCC expert system, MENU is the name given.

As part of creating the root frame, PcPlus prompts for the *translation property* value for the frame. The translation property is a text string that describes the purpose or the content of that frame. PcPlus uses the translation property value in some of its explanation facilities.

After the initial property values for the root frame have been entered, the developer interface prompts for the goal parameters of the root frame. Because of the number of subframes in this knowledge base, the root frame is programmed only to access subframes in the knowledge base. The goal parameters in the root frame are not solution-to-problem orientated but, are used to determine the fire protection problem topic. The selection for a problem topic is made by a prompted main menu. Depending on the choice made in the main menu, other submenus are prompted. After the user makes a selection, the appropriate backward-chaining rule is fired, where the goal parameters are given values causing the inference engine to access one or more subframes containing rules that are associated with the selected problem topic.

Once the programming for the root frame is completed, the knowledge base can then be expanded by adding subframes to the root frame. The additional subframes are programmed in a hierarchical structure. PcPlus can graphically display all subframes in a tree-like structure for the knowledge engineer. This graphic display allows the knowledge engineer to view the relationships between all subframes and the root frame. Using this display, the knowledge engineer is able to add a new subframe to the appropriate subframe or parent frame previously programmed.

The programming procedure to add a new frame to the knowledge base is the same as for the root frame when creating a new knowledge base. When adding a subframe to the knowledge base, PcPlus prompts only for the name, the translation property and the goal parameters. The goal parameters contained in the subframes are solution-to-problem orientated which provide the solutions for selected fire protection problem topics.

4.5.1.3.(b) PcPlus development interface for adding rules to the knowledge base

When adding a rule to a frame in the knowledge base, PcPlus prompts the knowledge engineer to enter the IF and THEN properties, in that order. The IF-THEN property values are created by entering parameter names, parameter-values, and Abbreviated Rule Language (ARL) functions. PcPlus provides an edit facility to check whether or not the newly entered rule is valid. If a name of a new parameter is not previously defined in the knowledge base, the edit facility prompts the knowledge engineer to define that parameter after entering the rule. In some cases, if an ARL function is entered incorrectly, or an operand is used in the wrong way, an error message will appear giving an option of re-editing at this point. This facility ensures that all rules entered into the knowledge base are valid.

4.5.1.3.(c) PcPlus development interface for adding parameters to the knowledge base

When adding a parameter to either the root frame or a subframe, PcPlus prompts for the basic information about the parameter. PcPlus first prompts for the name of the parameter being added, then the translation property. The value entered for the translation property describes the parameter, where it may be used later in translating rules into an English format, and responding to a "why" query.

Next, a *prompt property* is requested to be entered. The value of the prompt property is a phase which is in the form of a query. PcPlus presents this property when tracing for a parameter-value to be assigned to the parameter.

The last parameter property to be entered is the TYPE property. The TYPE property is parameter-values that are assigned to a parameter. For example, YES/NO are parameter-values that can be entered for this property.

4.5.2 Testing

There are two phases of testing an expert system which are very important.

The first phase of testing took place after each new rule and subframe was added to the knowledge base. Testing is not a separate phase of programming but it occurs in a continuous and concurrent manner throughout the knowledge base programming.

The obvious objective of testing is to ensure that the expert system gives the correct results. Even though the decision trees developed account for all possible parameter-value relationships that lead to a goal state or conclusion, the expert system may inference the generated rules in the knowledge base in unexpected ways. Continuous test consultations will expose incorrect or undesired conclusions or prompts not presented in the order which would mimic a human expert. This testing usually requires the programmer to add special ARL functions in the knowledge base to correct these situations as they arise. An example of a error in the knowledge base is conflicting rules.

PcPlus offers two facilities to find errors in the knowledge base. The first facility translates the rules in the knowledge base into an English statement. This permits the programmer to see how PcPlus will interpret the rules. English translations are produced by using the translation property of each parameter programmed into the rule. The IF-THEN statements are a series of parameter-value relationships that are connected by operands. The clause statements are the encoded expressions of the decision tree paths. If the IF-THEN statements do not represent the decision tree path correctly, modifications must be made. Such modifications usually require a re-evaluation of the use of operands that form the links between parameter-value relationships of a path.

The second facility used to debug the knowledge base is the TRACE command. This facility generates a written record of the logical flow of a consultation as it works toward a conclusion.

An example where PcPlus uses the parameters and rules to determine the regulations for emergency operations of elevators is given in Appendix D.

A second testing phase is conducted to assess whether the system is of some value to the user. The system can be rendered useless if the interface is hard to understand, if the domain terminology is not well known, or if the conclusions are meaningless because the way they are presented creates confusion.

Graphical and textual help functions are programmed into the expert system to avoid creating user interface confusion. If an expert system has no help facilities, constraints will be imposed on its functionality and it will become useless because it is hard to understand. A novice finding the interface confusing will then probably abandon the system, turning to the human expert for advice.

The expert system is being tested at selected Department of National Defence (DND) Canadian Air Force Bases. On these bases there are fire prevention officers who enforce the NBCC 1990 regulations on DND-owned buildings. Code compliance checks for building alterations and new construction are some of the tasks assumed by these officers.

The experience of these officers is not at the same level as that of the City of Winnipeg plan examiners. Having these officers using the system is an asset, in that they point out the difficult and hard-to-understand areas of the system, where as City of Winnipeg plan examiners, being the experts, might not be sensitive to them.

4.6 User Interface

The ease with which a user can use an expert system program, respond to queries, and understand the conclusions reached at the end of a consultation session depends on the user interface. The user interface consists of such items as menu generators, natural language modules, and graphic presentation modules.

A number of options usually exist for the user interface method. The input method may be a simple query mode where the expert system elicits information by asking the user to respond to a direct question. Alternatively, the interface may be graphics oriented, where the user is requested to enter information at specific locations on a graphics screen. Other options include data input by means of a spreadsheet or database file. The developer must keep in mind that the format for eliciting information and presenting conclusions must be attractive and easily understood by the expert system user. Since many potential users are wary and distrustful of computers, the favour that the expert system achieves will often depend on the user interface.

In the development of an expert system for a building code, it is necessary to be sensitive to the code experience of the user. Experienced code users will become annoyed if the system is overly helpful or if they perceive that too many trivial questions are asked before a conclusion is reached. They generally prefer a system designed on the assumption that the user will understand and respond correctly to a system prompt. While this approach is perhaps desirable for the knowledgeable code practitioner, it may be inappropriate for an inexperienced code user. The novice must often be asked several questions to ensure that correct information is provided. An interface that is insensitive to the novice will result in incorrect input information. The novice relying on the expert system will not be given the correct requirements that reflect the current problem.

In this expert system, input information is generally requested in a simple query mode rather than by means of a graphical interface. However, the user is usually provided with a graphical <**HELP**> option if assistance in responding to a prompt is required.

To demonstrate how the optional help screen is used, consider the following example. The YES/NO type prompt displayed is used to tell the expert system whether or not fire alarm continuity throughout the entire building is required. The prompt shown below is presented in the following manner:

"Is the building separated by a vertical 1 hour fire separation that separates the entire building with no openings in the fire separation to permit access between the two separated portions?"
<F1 HELP>

YES
NO

The novice may be able to answer this question with confidence. However, if he/she is unsure how to answer the question, he/she can simply use the **F1** function key to view the help display. In this case the **<F1 HELP>** function invokes a graphical display (Figure 4.5(a)) that illustrates two building situations involving vertical one-hour fire separation.

The conclusions given to the user during and at the end of a consultation are either a text module, a graphic module, or a combination of the two. Figure 4.5(b) is an example of a graphic displayed at the end of a consultation on **Fire Alarms Systems.** This screen is displayed only where multi-zone fire alarms are required and illustrates a typical multi-zone fire alarm system.

4.7 Comparison of Manual and Expert-System-Aided Consultation

A test was carried out to compare the manual consultation process with the Code to an expert-system-aided consultation. The test was conducted to assess the relative effectiveness of both novices and experts with and without the help of the expert system. To measure effectiveness, the times required to solve a problem and the accuracy and completeness of the problem solution were recorded.

Four persons from the City of Winnipeg, Planning Department participated in the test. Two were experts with twenty or more years of experience in the problem domain. The two novices had only limited working knowledge of the Part 3 requirements; however, both had a reasonable understanding of the domain terminology.

The test consisted of two simple building Code problems. The test problems were set up in such a way that the accuracy of the solution depended on the correct interpretation of Code definitions. The two test problems used are illustrated in Figures 4.6(a) and 4.6(b).

Each test participant was assigned the two test problems. However, one test problem was solved by consulting with the expert system and the other by consulting with the Code manually. In Table 4.4, the means by which the test participants solved the two test problems are tabulated. The time taken to solve the test problems and the accuracy and completeness of the solution reached are also included.

By using the expert system, the time taken by a novice to solve the two test problems was substantially reduced. Furthermore, all applicable regulations were found and were correct. The use of the expert system had improved the performance of the novice to a level of an expert. This improvement in performance corroborates Figure 2.1. The accuracy and completeness of the problem solution is the same as those achieved by an expert; the time it takes to solve a problem reduces as the novice becomes familiar with the problem domain.

	Manual	Time min.	Expert System	Time min.
NOVICE 1	Test Problem 1	22	Test Problem 2	12
	Incomplete solution		Complete solution	
NOVICE 2	Test Problem 2	15	Test Problem 1	12
	Incomplete solution		Complete solution	
EXPERT 1	Test Problem 1	4	Test Problem 2	5
	Complete solution		Complete solution	
EXPERT 2	Test Problem 2	3	Test Problem 1	5
	Complete solution		Complete solution	
EXPERT 3			Test Problem 2	2
			Complete solution	
			Test Problem 1	1
			Complete solution	

(Note: Expert 1 and Expert 2 are not familiar with the expert system. Expert 3 is familiar with the expert system.)

Table 4.4 Test Problem Schedule and Time Required to find a Solution

Even the use of the expert system the novice participants took more time than the expert participants. This is because the novice participants used the help functions more frequently: the time was spent reading material presented. The expert participants using the expert system required less time because the help functions were not used at all.

The time taken for an expert to solve each problem using the expert system was slightly greater than the time taken to solve the problem manually. The problem solution times recorded in Table 4.4 are for first-time users of the expert system; thus lack of familiarity with the expert system itself probably accounts for the increased times.

A separate test was conducted to check the time it takes for an expert to solve the same two test problems using the expert system. This expert (that is, Expert 3) has had considerable experience in the use of the expert system and its user interface. The time required to solve the two test problems by the expert is included in Table 4.4.

Evidently an improvement in solution time will occur as the expert becomes accustomed to the user interface and confident of the conclusions reached by the expert system. It is clear that the expert system is valuable to both novices and experts of the problem domain. For the novice, the value rests in performance improvement where solution time is reduced and solutions are complete and accurate. For the expert, errors such as misreading a table or forgetting to include a relevant Code requirement are eliminated when the expert system is used. Even though the accuracy depends on the input data which is provided by the user, consulting with the expert system forces the expert to answer questions that are relevant for that project. As a result, all Code requirements are then brought forth for review by the expert.

- **BUILDING ATTRIBUTES**
  - *Building Area*
  - *Building Height*
  - *Number of Streets*
  - *Occupancy Classification*
  - *Occupant Load*
  - *High Building Requirement*
- **BUILDING FEATURES**
  - *Firewall Requirements*
  - *Mezzanine Requirements*
  - *Heavy Timber Design Requirements*
- **CONSTRUCTION COMPONENTS**
  - *Wire Glass Requirements*
  - *Interior Finish Requirements*
  - *Fire Separation Requirements*
  - *Exterior Cladding Requirements*
- **EXITING REQUIREMENTS**
  - *Capacity of Exits*
  - *Distance Between Exits*
  - *Location of Exits*
  - *Number of Exits*
  - *Types of Exits*
- **PROVISIONS FOR FIRE FIGHTING**
- **LIFE SAFETY REQUIREMENTS**
  - *Fire Alarm Requirements*
  - *Mandatory Provisions Requiring Sprinkler Protection*
  - *Standpipe and Hose System Requirements*
  - *Emergency Power System Requirements*
  - *Emergency Elevator Operation Requirements*
- **SPATIAL SEPARATION REQUIREMENTS**
- **STRUCTURAL FIRE PROTECTION REQUIREMENTS**

Figure 4.1 Menu Selection

3.2.5. Provisions for Fire Fighting

Goal parameters to be solved

ACCESS1
Access panels to building required.

ACCESS2
Access to basement required.

ACCESS3
Access to roofs required.

parameter: BLDSPNK
PROMPT
Is the building sprinklered ?

YES

RULE685
Goal Parameter *ACCESS1*
3.2.5.5. Access Routes
Direct access from the outdoors to above and below grade floor levels are not required on any storey that is sprinklered.
REDUNDANT GOAL PARAMETERS
ACCESS2, ACCESS3

NO

parameter #ST
Graphic Help File PFF1.GRI
PROMPT
How many streets is this building required to face for the purposes of classification of Subsection 3.2.2. ?
(a) One street
(b) Two streets
(c) Three streets

(a) One street

RULE686
Goal Parameter *ACCESS1*
Graphic Illustration File PFF2.GRI
3.2.5.1. Access to Above Grade Storeys
Every storey above grade having its floor level less than 25 m above grade must be provided with direct access for fire fighting from the outdoors. Access shall be by means of one unobstructed window or access panel in the wall required to face the street.

(b) Two streets
(c) Three streets

RULE687
Goal Parameter *ACCESS1*
Graphic Illustration File PFF3.GRI
3.2.5.1. Access to Above Grade Storeys
Every above grade storey having its floor level less than 25 m above grade must be provided with direct access for fire fighting from the outdoors Access shall be by means of one unobstructed window or access panel for each 15 m of wall required to face a street.

1

Figure 4.2(a) Decision Tree for Provisions for Fire Fighting

3.2.5. Provisions for Fire Fighting

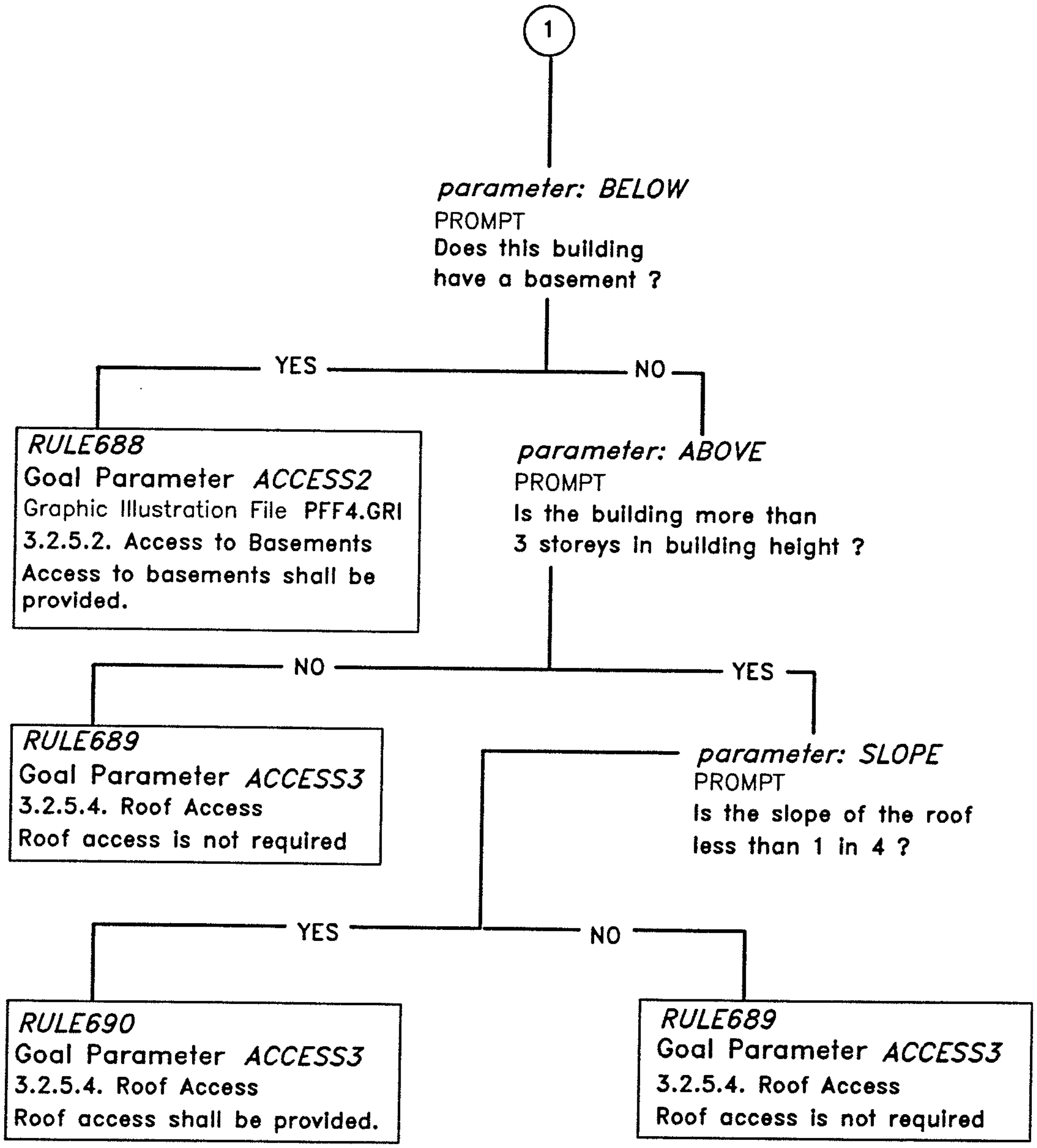


Figure 4.2(b) Decision Tree for Provisions for Fire Fighting

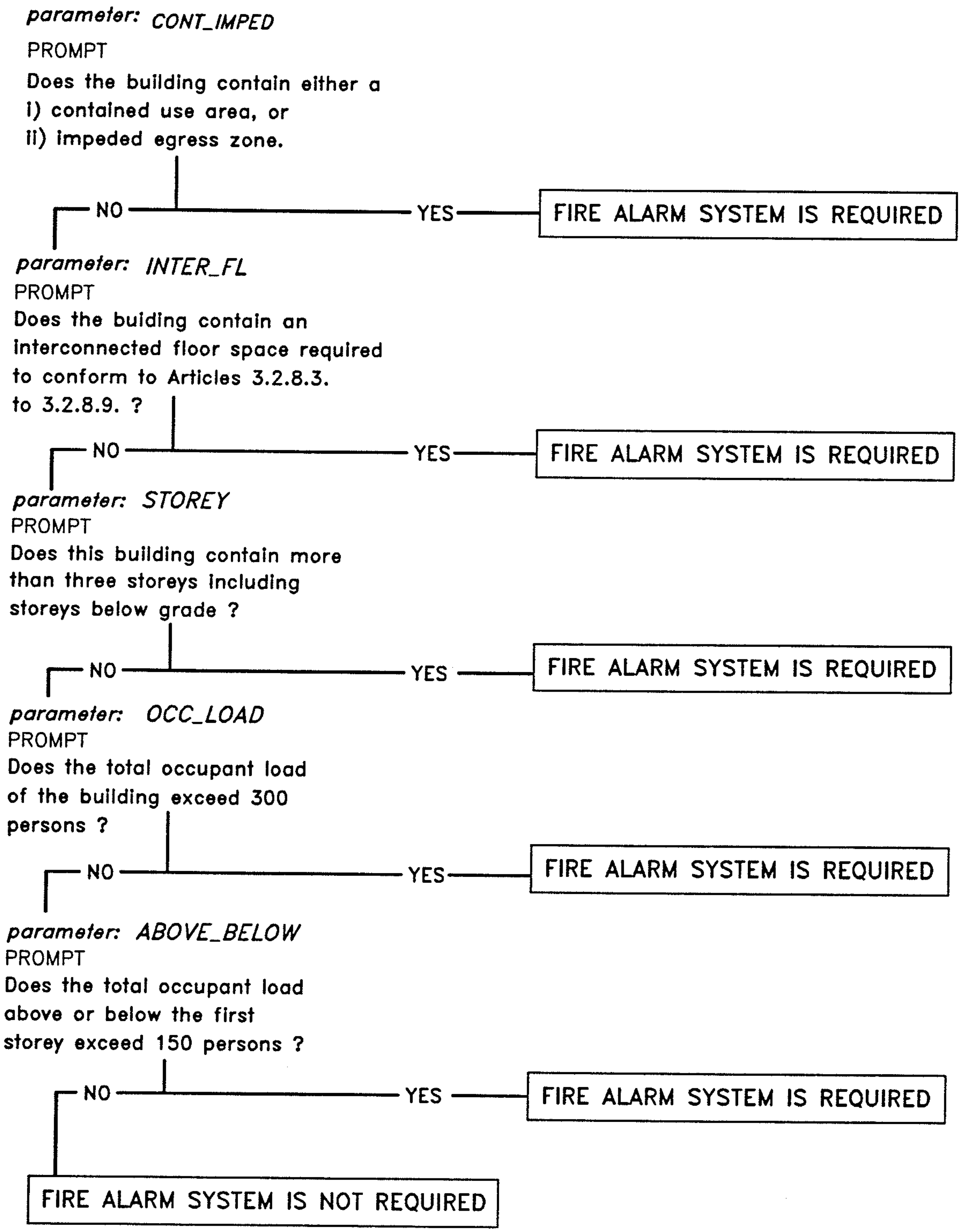


Figure 4.3(a) Decision Tree - constructed directly from Code Article 3.2.4.1.

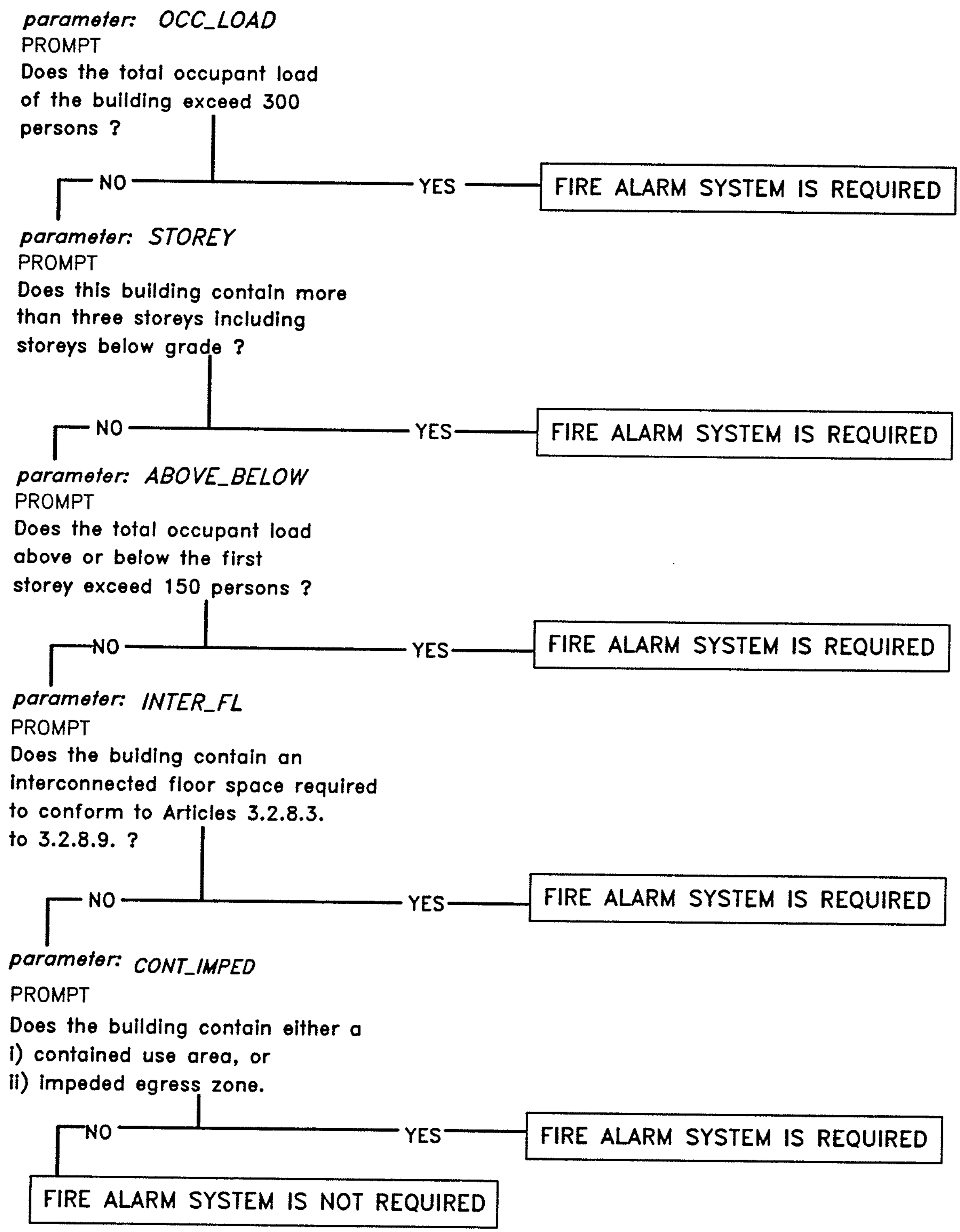


Figure 4.3(b) Decision Tree - constructed from Article 3.2.4.1. with reordered user prompts to reflect experiential knowledge

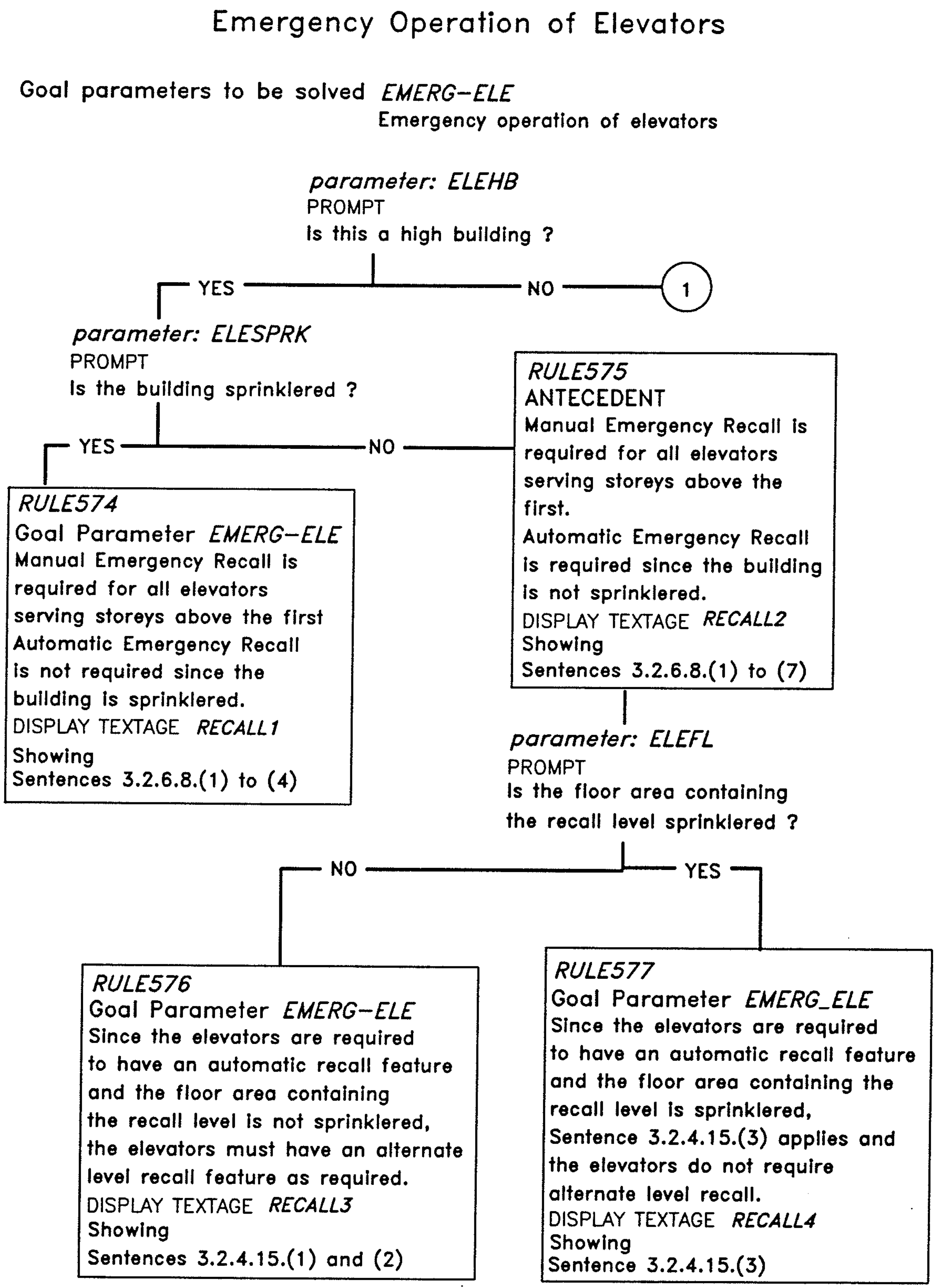


Figure 4.4(a) Decision Tree for Emergency Operation of Elevators

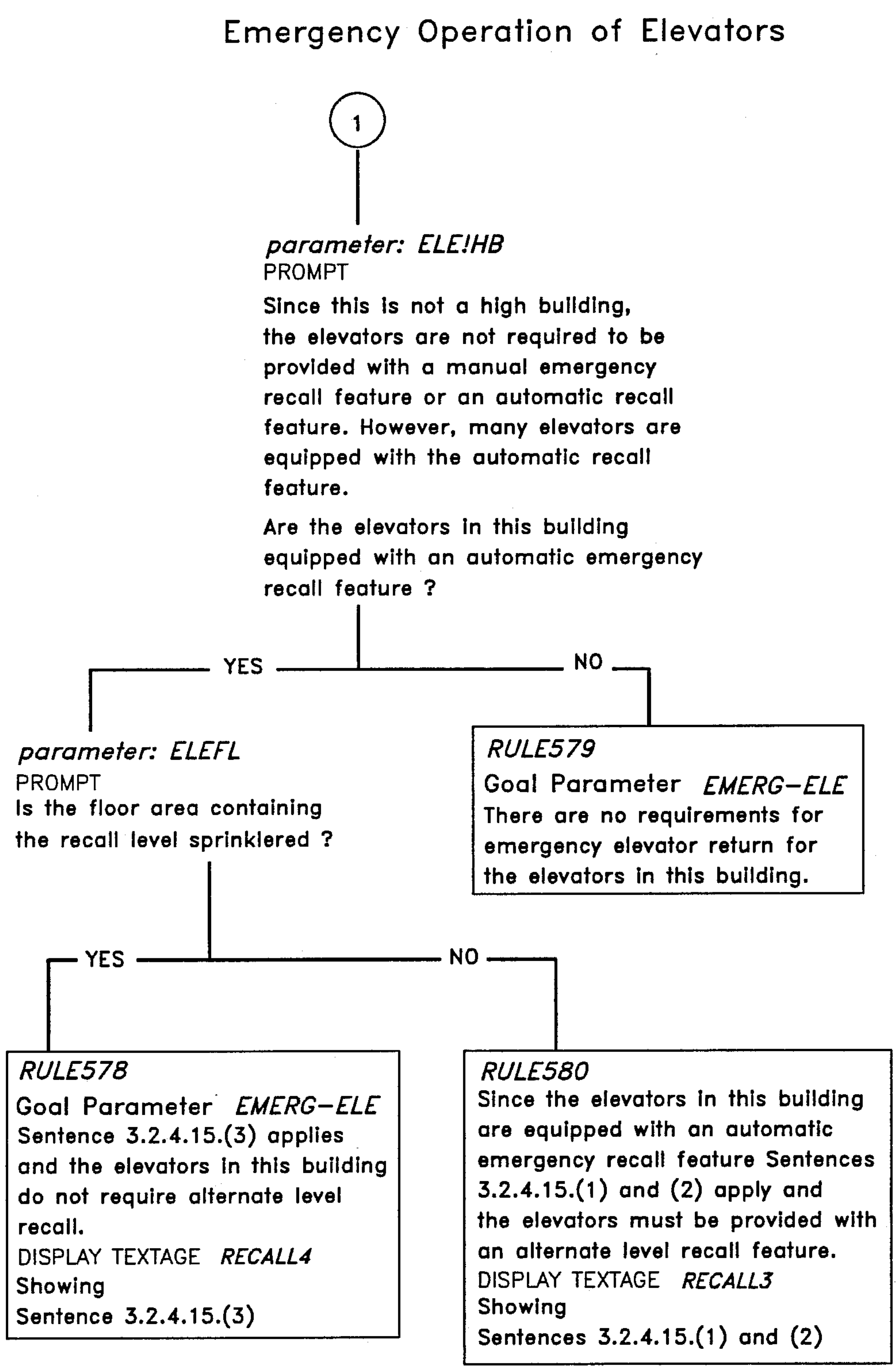


Figure 4.4(b) Decision Tree for Emergency Operation of Elevators

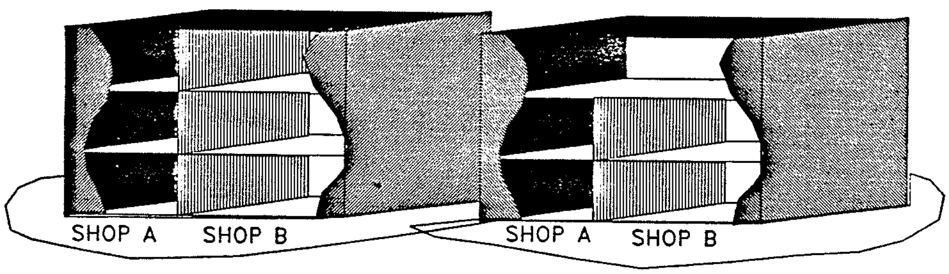
NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

FIRE ALARM REQUIREMENTS FOR VERTICALLY DIVIDED BUILDING

1 h fire separations extending through all storeys, no access openings through separations.

FIRE ALARM REQUIREMENTS FOR VERTICALLY DIVIDED BUILDING WITH ACCESS THROUGH SEPARATION

1 h fire separation with access opening on 3rd storey



Each shop considered as a separate building for the purposes of determining fire alarm requirements.

Shops A and B must be considered as one building for the purpose of determining fire alarm requirements.

** End - press ENTER to contine.

Figure 4.5(a) 1 Hour Fire Separation

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

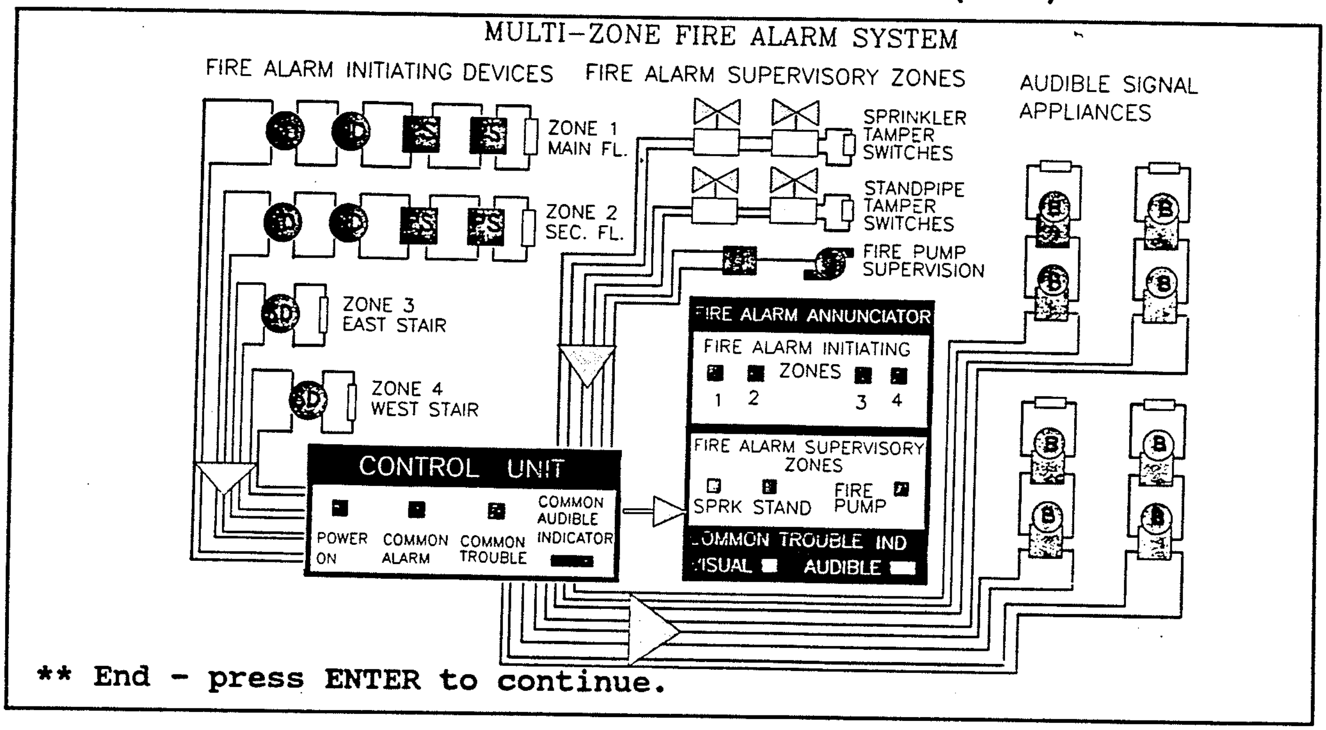
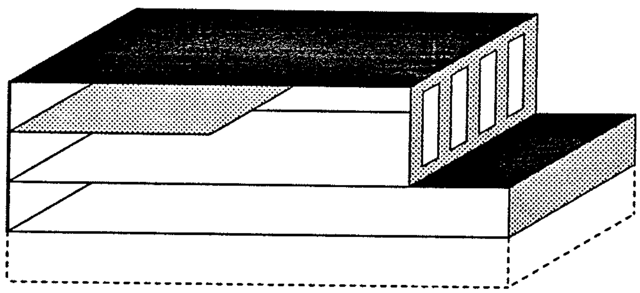


Figure 4.5(b) Multi-Zone Fire Alarm System

Proposed Office Building



Determine all structural fire protection requirements for this office building.

* No sprinkler protection
* 2 Streets

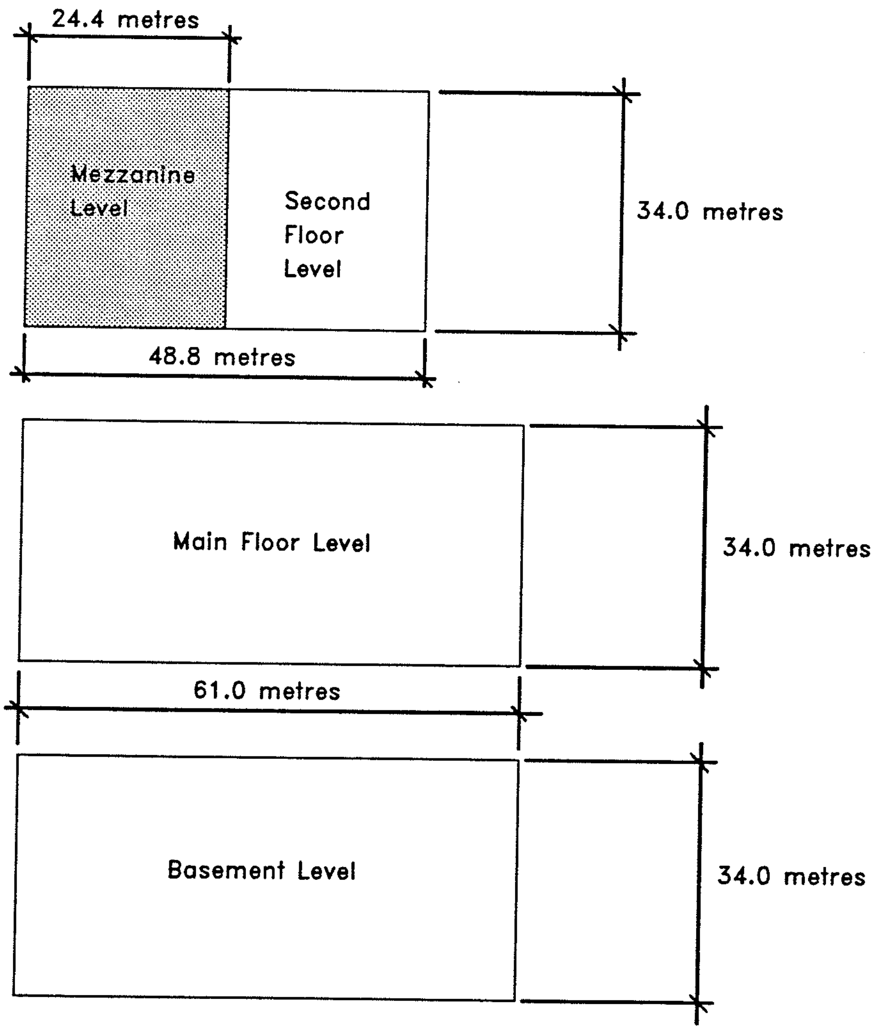
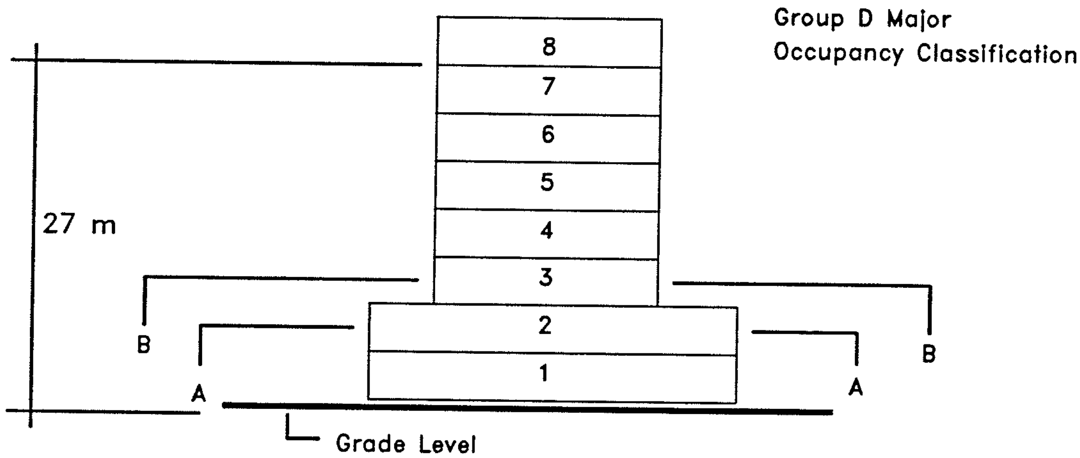
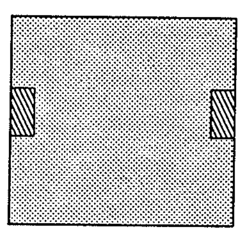


Figure 4.6(a) Test Problem 1

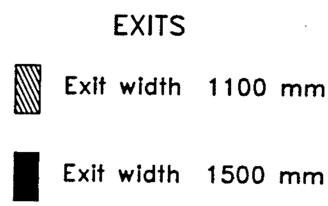
Determine whether this building is required to comply with the additional regulations for buildings classified as a high building.

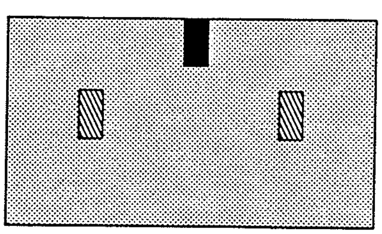
Article 3.2.6.1. Application, outlines the criteria for buildings to be classified as a high building.





Section B–B
Typical Floors (3,4,5,6,7,8)





Section A–A
Typical Floors (1,2)

OCCUPANT LOAD

Floor	Persons
1	400
2	400
3	200
4	200
5	200
6	200
7	200
8	200

Figure 4.6(b) Test Problem 2

CHAPTER 5

Summary, Conclusions, and Suggestions for Further Development

5.1 Summary and Conclusions

A comprehensive expert system has been developed for the fire protection requirements mandated by the 1990 National Building Code of Canada (NBCC). The domain of the expert system was limited to Part 3, Use and Occupancy of the NBCC, however, requirements pertaining to fire protection that are found in other codes and standards have been included in the expert system knowledge base whenever appropriate. The expert system was developed for use by both the novice and the code expert.

In the early stages of development, knowledge acquisition followed the more traditional expert-driven approach. During this period, the knowledge engineer relied on the City of Winnipeg Part 3 **Plan Examiners** to explain the intent, organization, and effective use of the code. As the knowledge engineer worked with the NBCC and became more knowledgeable about the domain, knowledge acquisition shifted to an expert-driven approach. The knowledge engineer was now familiar with the NBCC fire safety requirements, the intent of these requirements, the approach code experts use in conducting a code analysis, and where errors are most frequently made. Development of the expert system proceeded at a much faster rate.

The structure of the NBCC facilitated an incremental approach to the development of the knowledge base. Each independent fire protection topic was represented by a separate frame in the knowledge base. Subproblems within a topic were represented by subframes where the efficiency of the expert system could be improved.

One of the important aspects of this study was the development of decision trees for each fire protection topic. The decision tree approach made programming relatively simple and in several instances it identified areas where the NBCC was silent on a particular requirement. In a few cases, it could be said that a decision tree refined expert thinking about a code requirement. Every effort was made to have the expert system request information in the same order in which a code expert would request information. This consideration was important in the construction of the decision trees.

It is believed that user acceptance of this expert system will depend on the ease with which a user can use the program, respond to queries, and understand the conclusions reached at the end of a consultation. Considerable emphasis was therefore placed on the development of the user interface. Wherever possible, user prompts have been phrased in such a way that selection of either a YES/NO response can be made. However, when a simple YES/NO response is not appropriate, the user is required to key in a single numerical value, or select from a menu list of choices. The majority of user prompts have been supplemented by optional <HELP> screen display. It is expected that novice and first time users of the expert system will seek assistance from the <HELP> screens, while experienced users who are generally familiar with NBCC terminology will likely only make occasional use of this facility.

The conclusions are always presented by means of a text module, however, in some cases, a graphical illustration is also provided. Graphic illustrations are used to clarify and support the conclusions presented. The chances that a user will misunderstand a conclusion are reduced. This technique of using an illustration to explain a code requirement has been successfully used in a number of illustrated building codes.

During the development stage of the expert system, many test consultations were conducted by NBCC experts. This type of testing determined if the expert system was reaching the correct conclusion. The logical sequence of the user prompts was also checked. Field testing of the completed expert system has recently begun at the Department of National Defence, the City of Winnipeg Department of Civic Properties, and Labour Canada. It is anticipated that field testing will verify consultation results and that feedback will help to improve the user interface.

The results of the simple performance tests described in Chapter 4 indicate the expert system substantially improves the performance of the novice. The tests also indicate that the expert system is a useful assistant to code experts once they become familiar with the program.

The objectives in the development of this expert system have been to improve the productivity of a code expert by providing a useful tool and to provide the expert assistance necessary to improve the performance of the novice. Whether these objectives will be accomplished and what impact this program will have on the construction industry remain to be seen; however, initial response has been encouraging.

5.2 Suggestions for Further Study and Development

The present expert system provides the user with the fire protection requirements of the NBCC; however, there are some improvements that can be made. First, the present expert system can currently produce a printed summary of the input data and consultation results from only part of the knowledge base. It would be beneficial to expand this capability to the entire knowledge base. Second, the scope of the knowledge base should be expanded to include Chapter 2 *Fire-Performance Ratings* and Chapter 3 *Measures for Fire Safety in High Buildings* of the Supplement to the NBCC. Third, the knowledge base should be linked to external databases, conventional programs, and other expert systems where appropriate. For example, computer programs containing mathematical models that calculate evacuation times of building occupants or smoke development in highrise buildings could be useful in the expert system. Finally, the expert system should be updated when the eleventh edition of the NBCC is published in 1995.

The integration of this expert system with a computer aided design (CAD) system should be considered. Both systems operating in a multi-tasking environment would allow the user to freely work between the CAD environment and the consultation environment of the expert system. Access to either of the two systems could be accomplished by providing a choice between the CAD window and the expert system window that would appear on the computer screen simultaneously. Alternatively, access to the expert system could be by means of a menu choice in the CAD environment.

The use of an expert system to check code compliance of plans drawn in the CAD environment should also be investigated. Dimensional data from a CAD drawing would be used as input information to the expert system. This would be particularly useful in exit design, stair design, and the many other design aspects that are based on dimensional criteria. This capability would also be useful in compliance checking of drawings of existing buildings.

The current expert system could be linked to one of the text retrieval systems currently on the market. These systems are able to search and retrieve specified blocks of text from an electronic version of the NBCC. During a code consultation with the expert system, certain code requirements are determined to be applicable. After the consultation is finished, these requirements could be retrieved from the electronic version of the NBCC and compiled into a summary version of the NBCC that is applicable to the building being analyzed. This would eliminate the need to store large amounts of text information in the expert system knowledge base.

The development of building-specific expert systems should be considered. Unlike the expert system that has been developed here, a building-specific expert system would apply to a single-use building such as a hospital, school, or high-hazard industrial building. Such expert systems would be particularly useful to designers who specialize in the design of these buildings. Specialized design knowledge that is acquired from experience could be included in the knowledge base along with NBCC requirements.

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Appendix A

Part 3 checklist used for determining all applicable fire protection Code requirements manually.

PART 3 CHECKLIST - NBC 90-M5

1. Occupancy Classification

Major occupancy(ies) ______ **Date** ______ **P-X Job** ______

Area of building ______ **Address** ______

______ **Letter of insp/cert** ______

No. of storeys ______ **Arch/Eng** ______

No. of streets ______ Sprinklered: Y ☐ N ☐ **High-rise measure** ______

Classification(s) of Building: Major occupancy - ______

Minor occupancy - ______

2. Height & Area Requirements - Subsection 3.2.2.

a. Type of construction required: combustible; non-combustible ______
b. Division of basement/crawl space - 3.2.1.5/3.1.11.6. - ______
c. Floor assembly above basement 3.2.1.4. ______
d. Other floor assemblies ______
e. Balconies & mezzanines ______
f. Roof Assembly ______
g. Roof deck assembly - 3.1.14.2.(1). ______
h. Load bearing walls & columns ______

3. Spatial Separation - Subsection 3.2.3.

Wall	L.D.	Area: L/H	(Allow) % Openings	(Act) % Openings	F.R.R.
North					
South					
East					
West					

a. Combustible projections 3.2.3.6. ______
b. Foamed plastic in exterior wall 3.2.3.7.(3). ______
c. Exterior walls meeting at a fire compartment 3.2.3.14. ______
d. Wall exposed to adjoining roof 3.2.3.15. ______

Comments: ______

4. Requirements of Exits - Section 3.4

a. Minimum No. required 3.4.2.1.(1) & (2) ______
b. Mezzanine exits 3.4.2.2. ______
c. Distance between exits (1/2 Diagonal) 3.4.2.3. ______
d. Location of exits (travel distance) 3.4.2.5.(1) & (2). ______
e. 1 exit not to contribute more than 1/2 3.4.2.5.(3). ______
f. Reduction of exit width 3.4.3.6. ______
g. Guards: non-climbable 3.4.6.5.(7). ______
h. Door swing in exit 3.4.6.11. ______
i. Sliding door in exit 3.4.6.13. ______
j. Release hardware 3.4.6.15. ______
k. Door openable from inside without key 3.4.7.12.(14). ______

l. Stair requirements

	Stair No. 1	Stair No. 2	Stair No. 3
rise: max. 200 mm			
run: min. 230 mm			
width: min. 900 mm to 1100 mm(>3 storeys)			
No. of handrails			
handrail height: 800 mm to 920 mm			
guardrail height (stair): 920 mm			
guardrail height (landing): 1070 mm			
opening under guard: 100 mm or 200 mm			

m. Fire separation of exits: 3.4.4.1. ______

n. Exit capacity: 3.4.3.5. ______

5. **Electrical Systems**
   a. Fire alarm and detection systems 3.2.4.1.(1). ______
   b. Emergency lighting 3.2.7.3.(1). ______
   c. Exit signs 3.4.5.1.(1). ______

6. **Provisions for Fire Fighting**
   a. Provision of street or yard 3.2.2.6. ______
   b. Requirement for standpipe Table 3.2.5.A. ______

7. **Construction Types**
   a. Protection of foam plastic (combust. const.) 3.1.4.2. ______
   b. Combustible elements in non-combust. const. 3.1.5. ______
   c. Combustible cladding 3.1.5.5. ______
   d. Combustible insulation protection 3.1.5.11. ______
   e. Continuity of vertical F.S. (exc. vert. shaft) 3.1.8.3.(1) to (2). ______
   f. Wired-glass 3.1.8.14.(1). ______
   g. Firewall 3.1.10.2. ______
   h. Firewall parapet 3.1.10.4. ______
   i. Combustibles crossing firewall 3.1.10.7.(1). ______
   j. Combustible projections at firewall 3.1.10.7.(2). ______
   k. Firestops in concealed spaces 3.1.11.5. ______
   l. Flame-spread ratings 3.1.13.2. ______

8. **Service Facilities** - Section 3.5
   a. Fuel-fired appliances (Service room) 3.5.2.1. ____
   b. Boiler under exit 3.5.2.4. ____
   c. Incinerator rooms 3.5.2.6. ____
   d. Storage room (combustible refuse) 3.5.2.7. ____
   e. Vertical Service Shaft 3.5.3.1. ____
   f. Linen and refuse chutes 3.5.3.3. ____
   g. Horizontal service space 3.5.4.2. ____
   h. Access 3.5.4.4. to 3.5.4.6. ____
   i. Service and Auxiliary rooms not to open into exit 3.4.4.4.(7). ____

9. **Fire Safety Requirements within Floor Areas - Section 3.3**
   a. Separation of suites 3.3.1.1. ____
   b. Access for roof, platform, etc. 3.3.1.3.(1) to (7). ____
   c. Travel in opposite direction to 2 exits 3.3.1.3.(9). ____
   d. Public corridor - fire separation(s) 3.3.1.4. ____
   e. Two egress doorways from suites 3.3.1.5. ____
   f. Width of public corridors - 1100 mm 3.3.1.9.(1). ____
   g. Dead-end corridor - 6 m 3.3.1.9.(7). ____
   h. Door swing 3.3.1.10. ____
   i. Guards: height/non-climbable 3.3.1.17.(1). to (4). ____
   j. Glass doors, side lights 3.3.1.18.(1). to (5). ____
   k. Openable windows 3.3.1.18.(6). & (7). ____
   l. Assembly occupancy - Subsection 3.3.2. ____
   m. Institutional Occupancy - Subsection 3.3.3. ____
   n. Residential Occupancy - Subsection 3.3.4. (note: sentence 3.7.3.3.(2). - door clearance for disabled) ____

o. Industrial Occupancy - Subsection 3.3.5.

10. Mezzanine and Openings through Floor Assemblies - Subsection 3.2.8.

11. Plumbing Facilities - Subsection 3.6.4.

12. Barrier-Free Design - Section 3.7.

a. Protection of Floor Area - 3.3.1.7.(1).(a). - Elevator open to vestibule 3.2.6.9.(3).(b).
- Elevator open to corridor 3.2.6.9.(3).(c).
(b). - Floor area with smoke zone 3.3.3.6.(8) & (9).
(c). - Residential balcony
(d). - Ramp

b. Barrier-Free Access-Entrance 3.7.1.2.(1) & (2).

c. Ramps 3.7.3.4.(1) to (3).

d. Spaces in Seating Area 3.7.3.6.(1).

e. Assistive Listening Devices 3.7.3.7.(1) & (2).

f. Water Closet Stalls 3.7.3.8.(1).

g. Water Closet 3.7.3.9.(1).

h. Lavatories 3.7.3.10.(1).

i. Special Washrooms 3.7.3.11.(1).

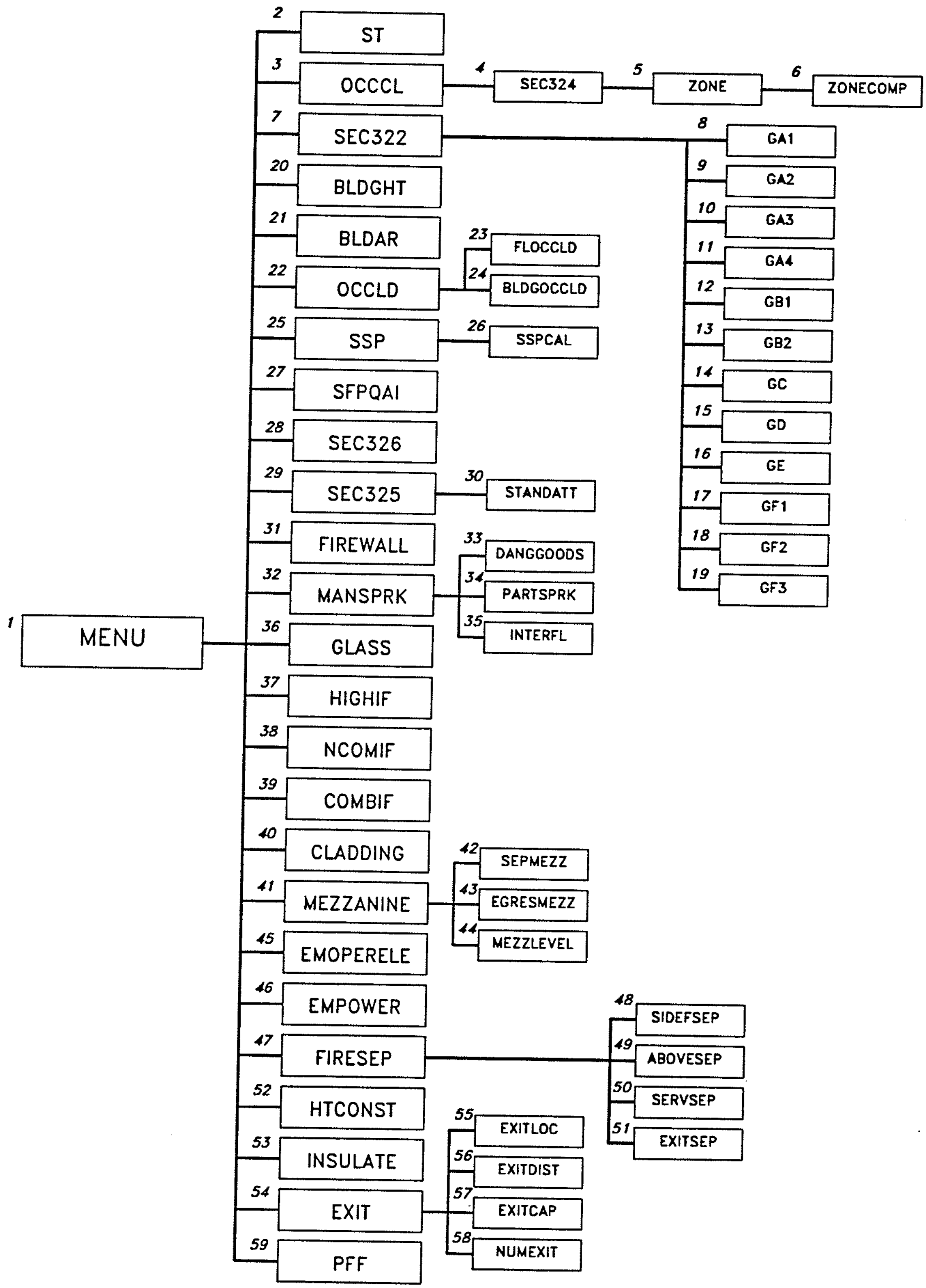
j Showers 3.7.3.12.(1).

13. Miscellaneous

Appendix B

Frame organization with description of knowledge content and use of each frame.

Knowledge Base Frame Organization



1. **MENU**

Contains 45 Parameters and 51 Rules.

MENU is the root frame for the knowledge base of the present expert system. This frame allows the user to access any part of the knowledge base containing Part 3 requirements of the NBCC.

2. **ST** (Article 3.2.2.6.)

Contains 5 Parameters and 3 Rules.

The **ST** subframe contains knowledge on *Article 3.2.2.6 Streets* for determining the number of streets a building faces. A calculation is made when a user is unable to enter the number of streets directly.

3. **OCCL** (Subsection 3.1.2.)

Contains 34 Parameters and 19 Rules.

The **OCCL** subframe contains knowledge on *Subsection 3.1.2 Classification of Buildings or Parts of Buildings by Major Occupancy*. This frame assists the user to correctly classify a building to a Group or a Division.

4. **SEC324** (Subsection 3.2.4.)

Contains 47 Parameters and 33 Rules.

The **SEC324** subframe contains knowledge on *Subsection 3.2.4 Fire Alarms and Detection System*. This frame determines whether a fire alarm is required for a building. Additional regulations on fire alarms are also included.

5. **ZONE** (Sentence 3.2.4.8.(4))

Contains 7 Parameters and 9 Rules.

The **ZONE** subframe linked to the parent frame **SEC324** contains knowledge to calculate the minimum number of annunciator zone indicators for an open floor area.

6. **ZONECOMP** (Sentence 3.2.4.8.(4))

Contains 2 Parameters and 1 Rule.

The **ZONECOMP** subframe linked to the parent frame **ZONE** contains knowledge to calculate the minimum number of annunciator zones indicators for a floor area divided by fire separations.

7. **SEC322** (Subsection 3.2.2.)

Contains 9 Parameters and 23 Rules.

The **SEC322** subframe contains knowledge to determine the minimum structural fire protection requirements of *Subsection 3.2.2 Building Size and Construction Relative to Occupancy*. To find this requirement the frame is programmed to access one of the twelve subframes **(GA1, GA2, GA3, GA4, GB1, GB2, GC, GD, GE, GF1, GF2, GF3).**

8. **GA1** (Articles 3.2.2.16., 3.2.2.17. and 3.2.2.18.)

Contains 5 Parameters and 3 Rules.

The **GA1** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group A, Division 1.

9. **GA2** (Articles 3.2.2.19., 3.2.2.20., 3.2.2.21., 3.2.2.22. and 3.2.2.23.)

Contains 3 Parameters and 7 Rules.

The **GA2** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group A, Division 2.

10. **GA3** (Articles 3.2.2.24., 3.2.2.25., 3.2.2.26. and 3.2.2.27.)

Contains 3 Parameters and 6 Rules.

The **GA3** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group A, Division 3.

11. **GA4** (Article 3.2.2.28.)

Contains 2 Parameters and 1 Rule.

The **GA4** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group A, Division 4.

12. **GB1** (Article 3.2.2.29.)

Contains 2 Parameters and 1 Rule.

The **GB1** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group B, Division 1.

13. **GB2** (Articles 3.2.2.30., 3.2.2.31., 3.2.2.32. and 3.2.2.33.)

Contains 3 Parameters and 6 Rules.

The **GB2** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group B, Division 2.

14. **GC** (Articles 3.2.2.34., 3.2.2.35., 3.2.2.36., 3.2.2.37. and 3.2.2.38.)

Contains 3 Parameters and 7 Rules.

The **GC** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group C.

15. **GD** (Articles 3.2.2.39., 3.2.2.40., 3.2.2.41. and 3.2.2.42.)

Contains 3 Parameters and 6 Rules.

The **GD** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group D.

16. **GE** (Articles 3.2.2.43., 3.2.2.44., 3.2.2.45. and 3.2.2.46.)

Contains 3 Parameters and 6 Rules.

The **GE** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group E.

17. **GF1** (Articles 3.2.2.47., 3.2.2.48., 3.2.2.49. and 3.2.2.50.)

Contains 3 Parameters and 8 Rules.

The **GF1** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group F, Division 1.

18. **GF2** (Articles 3.2.2.51., 3.2.2.52., 3.2.2.53., 3.2.2.54. and 3.2.2.55.)

Contains 3 Parameters and 8 Rules.

The **GF2** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group F, Division 2.

19. **GF3** (Articles 3.2.2.56., 3.2.2.57., 3.2.2.58., 3.2.2.59., 3.2.2.60., 3.2.2.61. and 3.2.2.62.)

Contains 5 Parameters and 9 Rules.

The **GF3** subframe linked to the parent frame **SEC322** contains the structural fire protection requirements for buildings classified Group F, Division 3.

20. **BLDGHT** (Article 3.2.1.1.)

Contains 15 Parameters and 21 Rules.

The **BLDGHT** subframe contains knowledge on *Article 3.2.1.1 Exceptions to Building Height in Storeys*. This frame assists the user to correctly calculate the building height in terms of storeys.

21. **BLDAR** (Defined Code term *Building Area*)

Contains 5 Parameters and 5 Rules.

The **BLDAR** subframe contains knowledge to assist the user to correctly determine the building area in square metres.

22. **OCCLD** (Subsection 3.1.16.)

Contains 15 Parameters and 21 Rules.

The **OCCLD** subframe contains knowledge on *Subsection 3.1.16. Occupant Load*. This frame assists the user to calculate the occupant load for any occupancy classification.

23. **FLOCCLD**

Contains 1 Parameter and 1 Rule.

The **FLOCCLD** subframe linked to the parent frame **OCCLD** calculates the occupant load for a floor area.

24. **BLDGOCCLD**

Contains 2 Parameters and 1 Rule.

The **BLDGOCCLD** subframe linked to the parent frame **OCCLD** calculates the aggregate occupant load for a building.

25. **SSP** (Subsection 3.2.3.)

Contains 16 Parameters and 12 Rules.

The **SSP** subframe contains knowledge on *Subsection 3.2.3 Spatial Separation and Exposure Protection of Buildings*.

26. **SSPCAL**

Contains 1 Parameter and 1 Rule.

The **SSPCAL** subframe linked to the parent frame **SSP** executes an external Fortran program called **LIMIT61.**

27. **SFPQA1** (Subsection 3.2.2.)

Contains 8 Parameters and 19 Rules.

The **SFPQA1** subframe contains knowledge to determine the minimum structural fire protection requirements. This subframe caters to the experienced code users who know the Code definitions which facilitates building attributes to be entered quickly.

28. **SEC326** (Subsection 3.2.6.)

Contains 10 Parameters and 10 Rules.

The **SEC326** subframe contains knowledge on *Article 3.2.6.1 Application for High Buildings*. This frame assists the user to check whether a building is subject to additional requirements for high rise buildings.

29. **SEC325** (Subsection 3.2.5.)

Contains 7 Parameters and 18 Rules.

The **SEC325** subframe contains knowledge on *Article 3.2.5.9 Standpipe and Hose Systems*. This frame assists the user to determine whether a standpipe and hose system is required.

30. **STANDATT** (Articles 3.2.5.9., 3.2.5.10. and 3.2.5.11.)

Contains 15 Parameters and 21 Rules.

The **STANDATT** subframe linked to the parent frame **SEC325** contains additional knowledge on standpipe and hose systems requirements.

31. **FIREWALL** (Subsection 3.1.10.)

Contains 16 Parameters and 15 Rules.

The **FIREWALL** subframe contains knowledge on *Subsection 3.1.10 Firewalls* to assist the user in determining all firewall requirements.

32. **MANSPRK** (Subsection 3.2.2., Article 3.1.2.3., 3.2.6.2)

Contains 15 Parameters and 7 Rules.

The **MANSPRK** subframe assists the user when sprinkler protection is required for the building.

33. **PARTSPRK** (Articles 5.6.2.4., 5.11.1.5., 5.14.1.1. and 5.15.6.1. of the NFCC)

Contains 3 Parameters and 11 Rules.

The **PARTSPRK** subframe linked to the parent frame **MANSPRK** assists the user to determine whether a building is subject to partial sprinkler protection.

34. **INTERFL** (Subsection 3.2.8.)

Contains 7 Parameters and 11 Rules.

The **INTERFL** subframe linked to the parent frame **MANSPRK** assists the user whether a building containing an interconnected floor space requires sprinkler protection.

35. **DANGGOODS** (Article 3.3.3.2., 3.3.4.3., 3.3.6.9., 3.3.5.5., 5.4.1.3., 5.4.3.1 and 5.5.6.1. of the NFCC)

Contains 9 Parameters and 12 Rules.

The **DANGGOODS** subframe linked to the parent frame **MANSPRK** contains knowledge on regulations for the storage of materials classified as dangerous goods. This frame advises the user storage areas containing such materials may be subjected to sprinkler protection.

36. **GLASS** (Article 3.1.8.14.)

Contains 13 Parameters and 13 Rules.

The **GLASS** subframe contains knowledge on the requirements on *Article 3.1.8.14 Wired Glass and Glass Block.*

37. **HIGHIF** (Subsection 3.1.12.)

Contains 3 Parameters and 24 Rules.

The **HIGHIF** is 1 of 3 subframes containing knowledge on interior flame spread ratings. This subframe applies to buildings that are subject to additional requirements because they are classified as high buildings.

38. **NCOMIF** (Subsection 3.1.12.)

Contains 3 Parameters and 13 Rules.

The **NCOMIF** is 2 of 3 subframes containing knowledge on interior flame spread ratings. This subframe applies to buildings limited to construction materials that are noncombustible.

39. **COMBIF** (Subsection 3.1.12.)

Contains 3 Parameters and 14 Rules.

The **COMBIF** is 3 of 3 subframes containing knowledge on interior flame spread ratings. This subframe applies to buildings permitted to be constructed with combustible materials.

40. **MEZZANINE** (Subsection 3.2.8.)

Contains 14 Parameters and 9 Rules.

The **MEZZANINE** is a parent frame to three other subframes in the knowledge base. This subframe contains knowledge on *Subsection 3.2.8 Mezzanines and Openings Through Floor Assemblies.* This frame assists the user to determine whether mezzanine level contributes to the building height in storeys.

41. **SEPMEZZ** (Article 3.2.8.2.)

Contains 1 Parameters and 12 Rules.

SEPMEZZ is 1 of 3 subframes linked to parent frame **MEZZANINE.** This frame contains knowledge on fire separations required for a mezzanine level.

42. **EGRESMEZZ** (Article 3.4.2.2.)

Contains 3 Parameters and 18 Rules.

The **EGRESMEZZ** is 2 of 3 subframes linked to parent frame **MEZZANINE.** This frame contains knowledge on egress requirements from the mezzanine level.

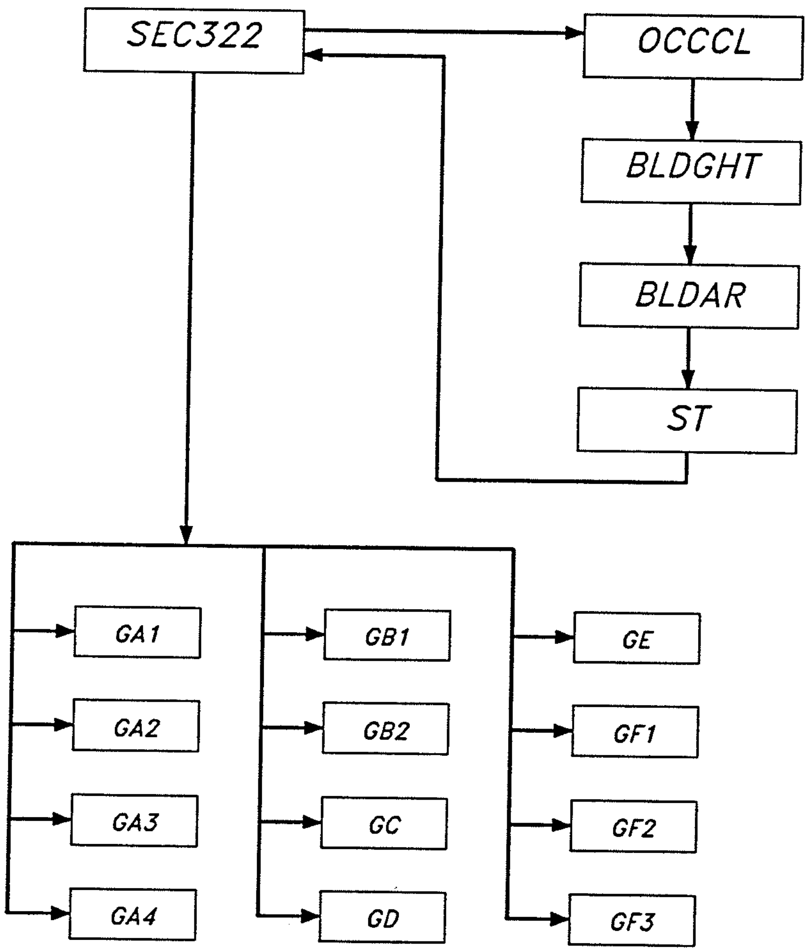
Appendix C

Decision trees developed for each fire protection topic entered into the knowledge base.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

Goal parameter to be solved *ART*
Structural fire protection requirements from Subsection 3.2.2.

Inference order of subframes

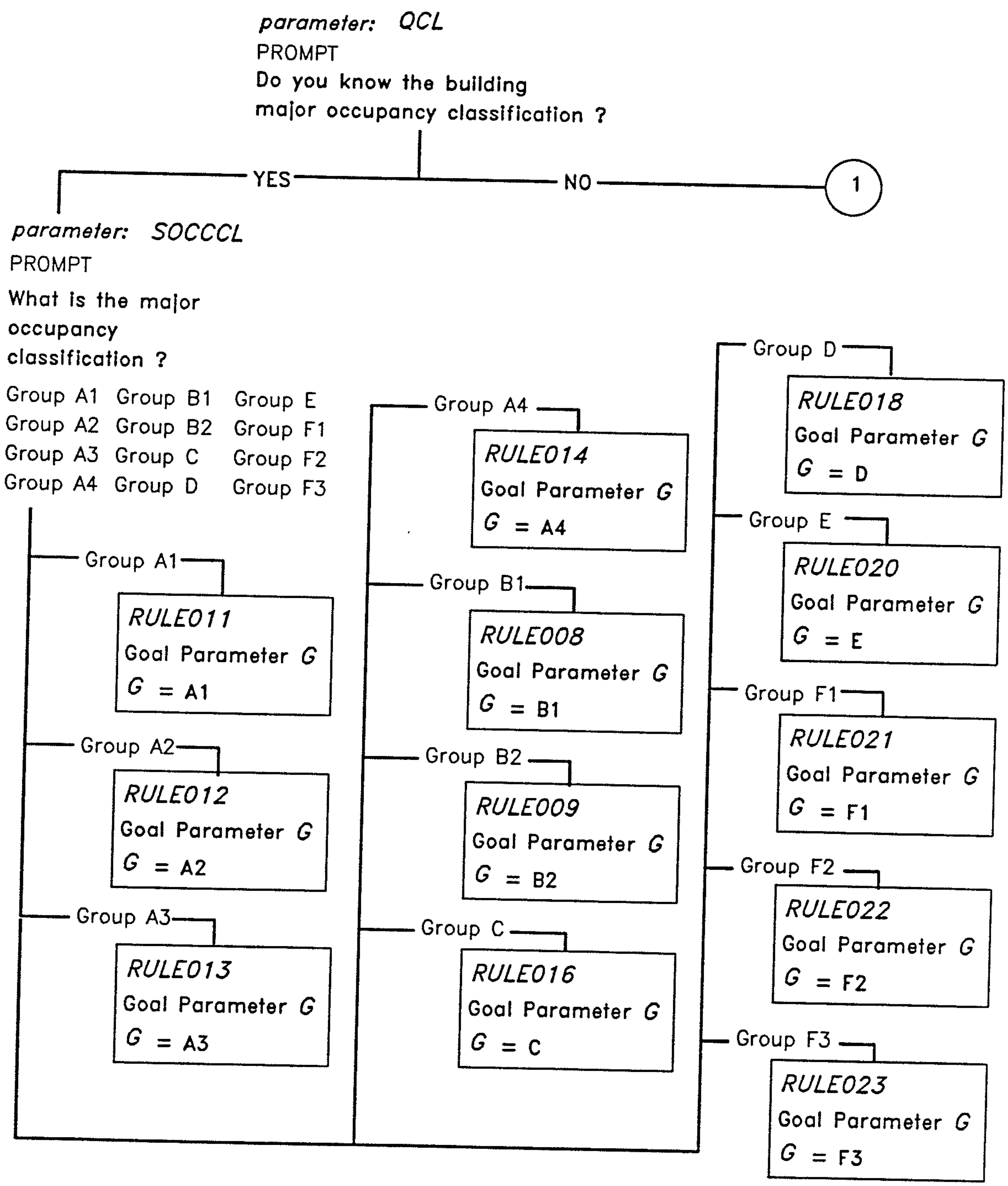


Occupancy Classification

Goal parameters to be solved *G*

To determine the classification of the building.

OCCCL



Occupancy Classification

1

A

parameter: GOCCCL
PROMPT
Select a general use or intended use for the building from the following list.
< F1 HELP >
Assembly
Institutional
Residential
Business and Personal Services
Mercantile
Industrial

Assembly — 2

parameter: GAOC1
PROMPT
The Code has four divisions for Assembly occupancies; Group A, Divisions 1, 2, 3, and 4.
Group A, Division 1
Assembly occupancies intended for the production viewing of the performing arts. The following are examples of building uses classified as Group A, Division 1. <Examples: Motion picture theartres, ..>

Is this classification consistent with your building use ?

NO — YES

RULE011
Goal Parameter *G*
G = A1

parameter: GAOC2
PROMPT
Assembly occupancies not else where classified. The following are examples of building uses classified as Group A, Division 2.
<Examples: Art galleries, Auditoria, Churches,...>
Is this classification consistent with your building use ?

NO — YES

RULE012
Goal Parameter *G*
G = A2

a1

Occupancy Classification

a1

parameter: GAOC3
PROMPT
Assembly occupancies of the arena type. The following are examples of building uses classified as Group A, Division 3.
<Examples: Indoor swimming pools with or without spectator seating, Arenas, and rinks.>

Is this classification consistent with your building use ?

NO — YES

RULE013
Goal Parameter *G*
G = A3

parameter: GAOC4
PROMPT
Assembly occupancies in which provision is made for the congregation or gathering of persons for the purpose of participating in or viewing open air activities. The following are examples of building uses classified as Group A, Division 4.
<Examples: Amusement park structures, Bleachers, Grandstands, Reviewing stands and Stadia.>

Is this classification consistent with your building use ?

NO — YES

RULE014
Goal Parameter *G*
G = A4

A

Occupancy Classification

2

Institutional — 3

parameter: GBOC1

PROMPT

The Code has two divisions for Institutional occupancies; Group B, Divisions 1 and 2.

Group B, Division 1

Institutional occupancies in which persons are under restraint or are incapable of self preservation because of security measures not under their control. The following are examples of building uses classified as Group B, Division 1.

<Examples: Jails, Penitentiaries, Prisons,...>

Is this classification consistent with your building use ?

NO — YES

RULE008

Goal Parameter *G*

G = B1

parameter: GBOC2

PROMPT

Group B, Division 2

Institutional occupancies in which persons because of mental or physical limitations require special care or treatment. The following are examples of building uses classified as Group B, Division 2.

<Examples: Children's custodial homes, Hospitals,...>

Is this classification consistent with your building use ?

NO — YES

RULE009

Goal Parameter *G*

G = B2

A

Occupancy Classification

3

Residential — *parameter: GCOC*

PROMPT

You have selected Residential or Group C major occupancy.

Group C

The following are examples of building uses classified as Group C.

<Examples: Apartments, Boarding houses, Motels,...>

Is this classification consistent with your building use ?

A — NO — YES — *RULE016* Goal Parameter *G* — *G* = C

Business and Personal Services — *parameter: GDOC*

PROMPT

You have selected Business and Personal Services or Group D major occupancy.

Group D

The following are examples of building uses classified as Group D.

<Examples: Banks, Offices, Medical Offices,...>

Is this classification consistent with your building use ?

A — NO — YES — *RULE018* Goal Parameter *G* — *G* = D

Mercantile — *parameter: GEOC*

PROMPT

You have selected Mercantile or Group E major occupancy.

Group E

The following are examples of building uses classified as Group E.

<Examples: Department stores, Exhibition halls,...>

Is this classification consistent with your building use ?

A — NO — YES — *RULE020* Goal Parameter *G* — *G* = E

4

Occupancy Classification

4

Industrial

parameter: GFOC1

PROMPT

The Code has three divisions for Industrial occupancies.
Group F, Divisions 1, 2 and 3

Group F, Division 1

High hazard industrial occupancy containing sufficient quantities of highly combustible and flammable or explosive materials which, because of their inherent characteristics constitute a special fire hazard. The following are examples of building uses classified as Group F, Division 1.

<Examples: Bulk plants for flammable liquids,...>

Is this classification consistent with your building use ?

NO — YES

RULE021
Goal Parameter *G*
G = F1

parameter: GFOC2

PROMPT

Medium hazard industrial occupancies has combustible content that is more than 50 kg/sq metres or 1200 MJ/sq metre of floor area and is not classified as high hazard industrial occupancy. The following are examples of building uses classified as Group F, Division 2.

<Examples: Aircraft hangers, Warehouses,...>

Is this classification consistent with your building use ?

NO — YES

RULE022
Goal Parameter *G*
G = F2

parameter: GFOC3

PROMPT

Low hazard industrial occupancy having combustible content that is not more than 50 kg/sq metres or 1200 MJ/sq metres of floor area. The following are examples of building uses classified as Group F, Division 3.

<Examples: Creameries, Power plants,...>

Is this classification consistent with your building use ?

A — NO — YES

RULE023
Goal Parameter *G*
G = F3

Building Height

Goal parameters to be solved *BH*

To determine building height in storeys.

BHS

To determine the number of storey levels above and below grade level.

BLDGHT

parameter: QBLDGH
PROMPT
Do you know the building height ?
< F1 HELP >
GRAPHIC HELP FILE
BLDGH.GRI

YES

parameter: QBLDGHY
PROMPT
Enter the number of storeys above grade.
< F1 HELP >
GRAPHIC HELP FILE
BLDGHM1.GRI
(numerical value to be entered)

parameter: BLDGB
PROMPT
Is there a basement level or a crawl space below the first storey ?

Basement level
Crawl space
Neither

2

NO

parameter: BLDGH
PROMPT
How many storeys are there above grade level ?
(numerical value to be entered)

parameter: QBLDGM
PROMPT
Is there a mezzanine level ?
< F1 HELP >

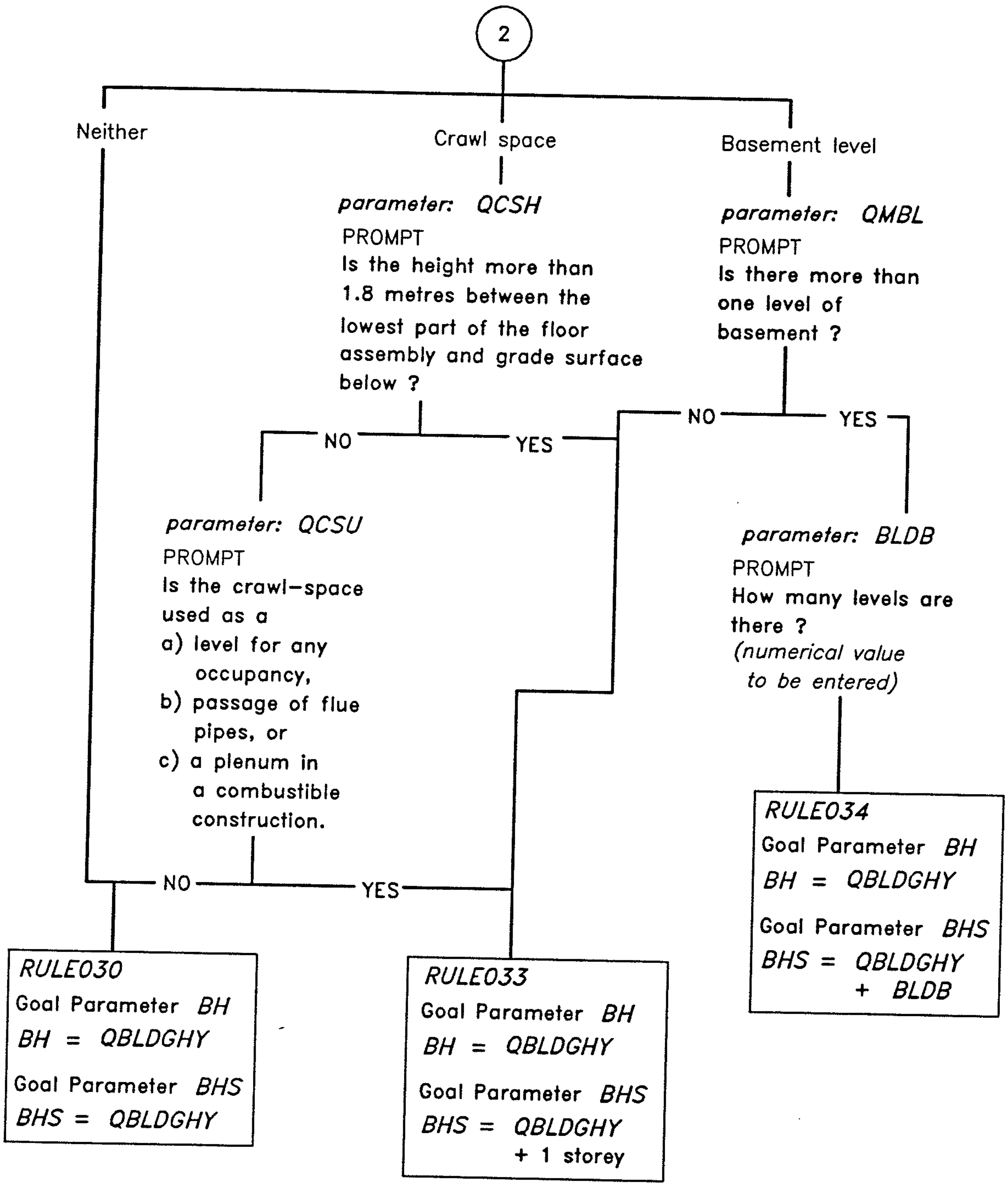
YES

3

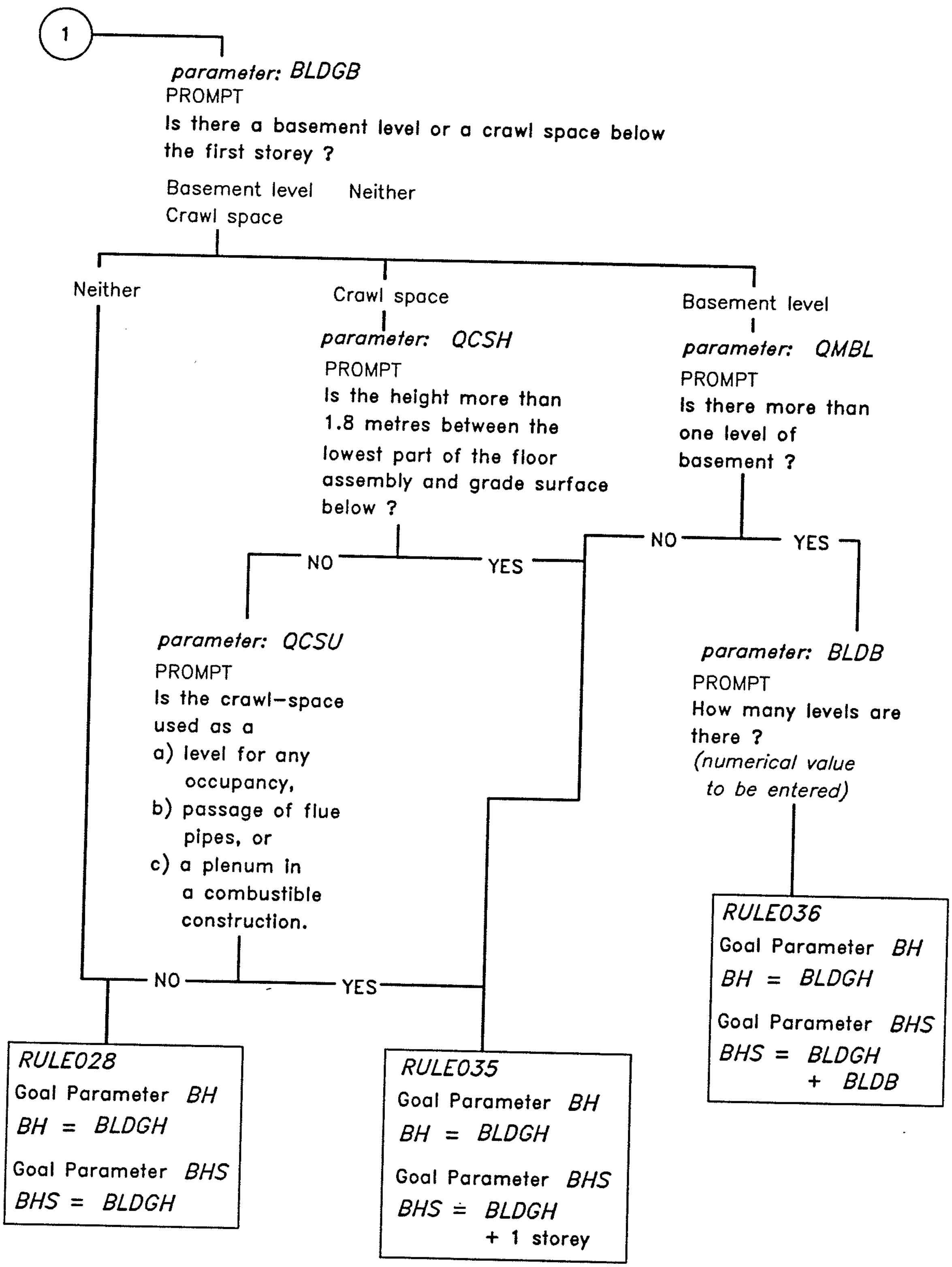
NO

1

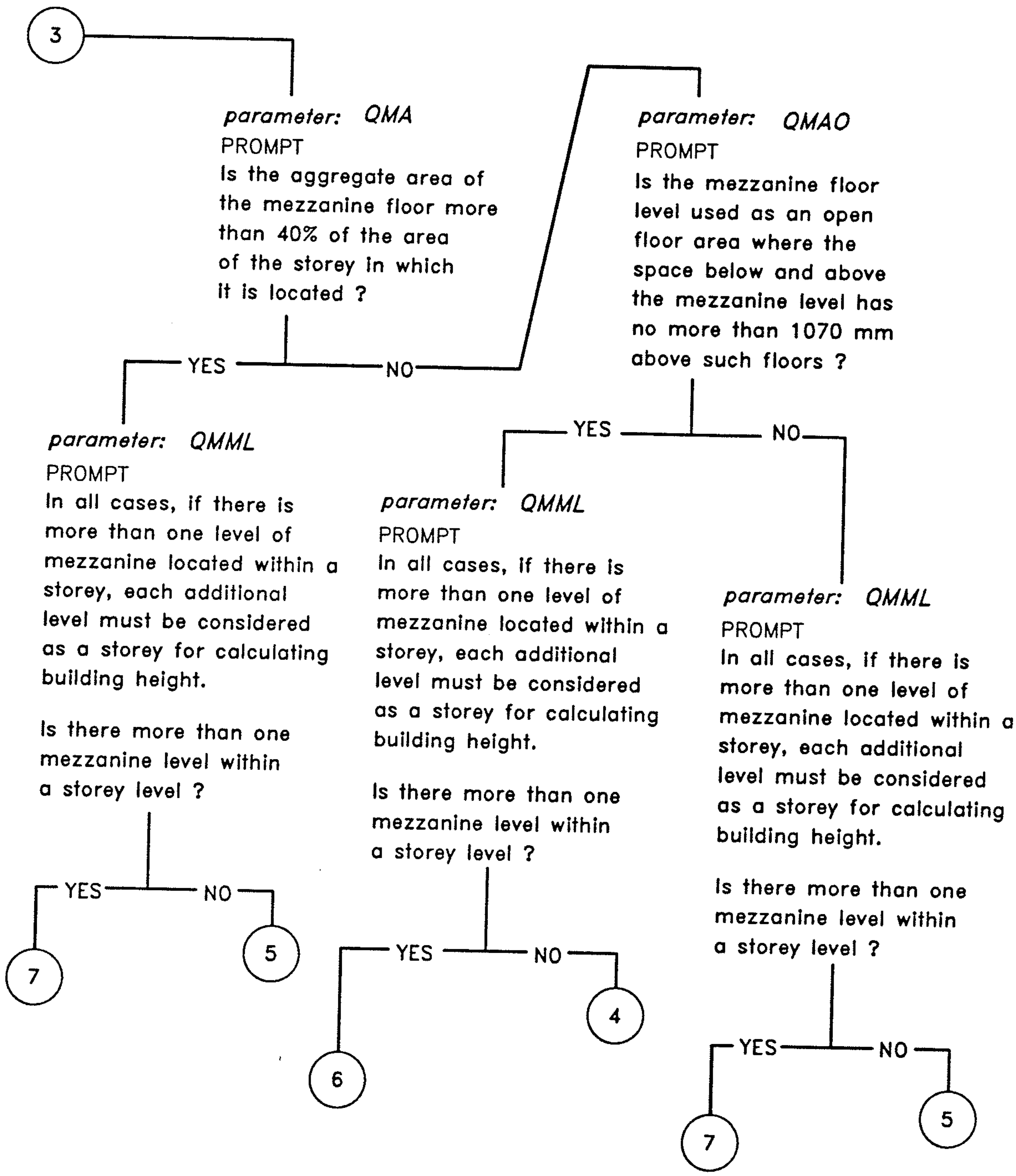
Building Height



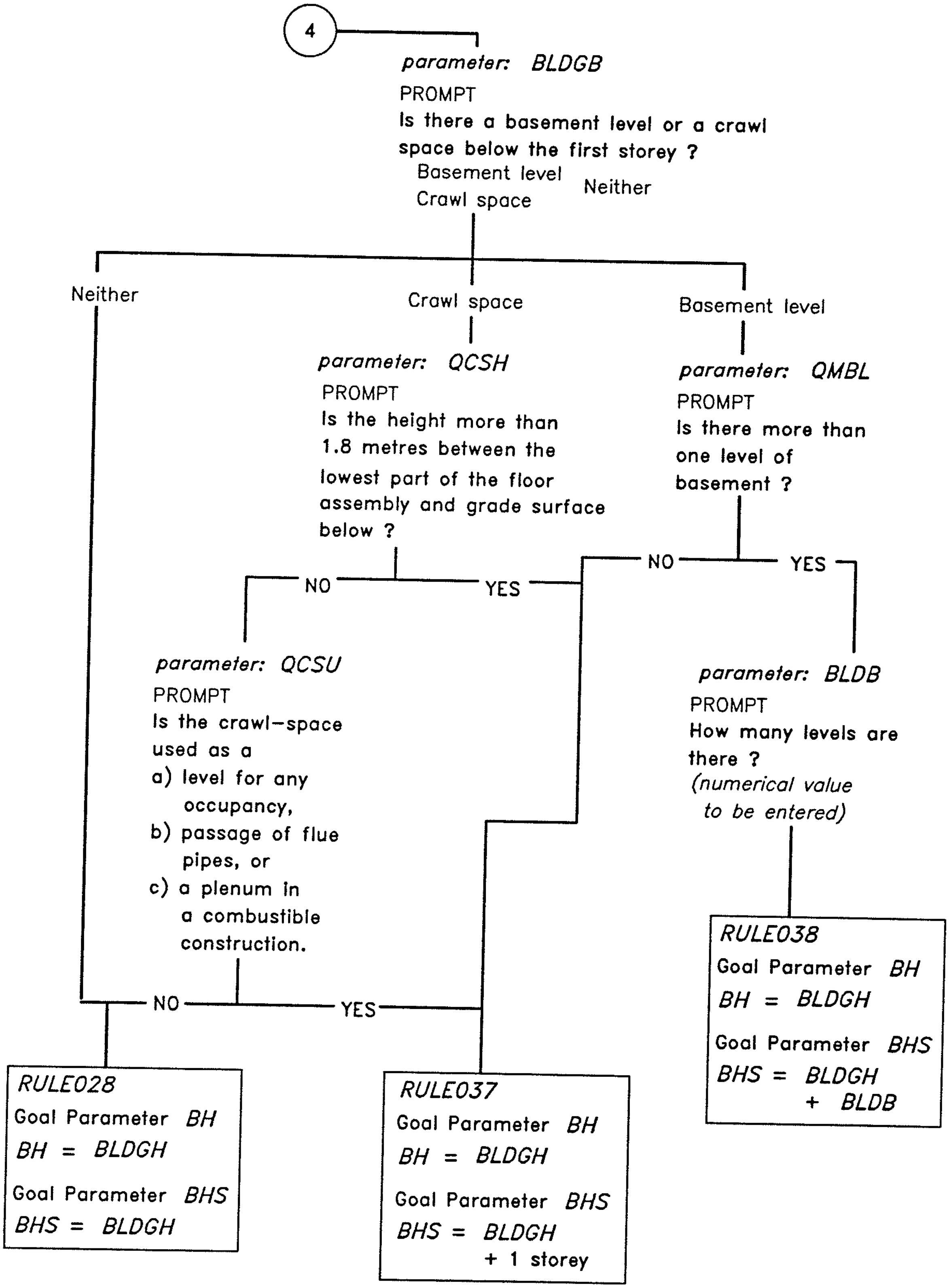
Building Height



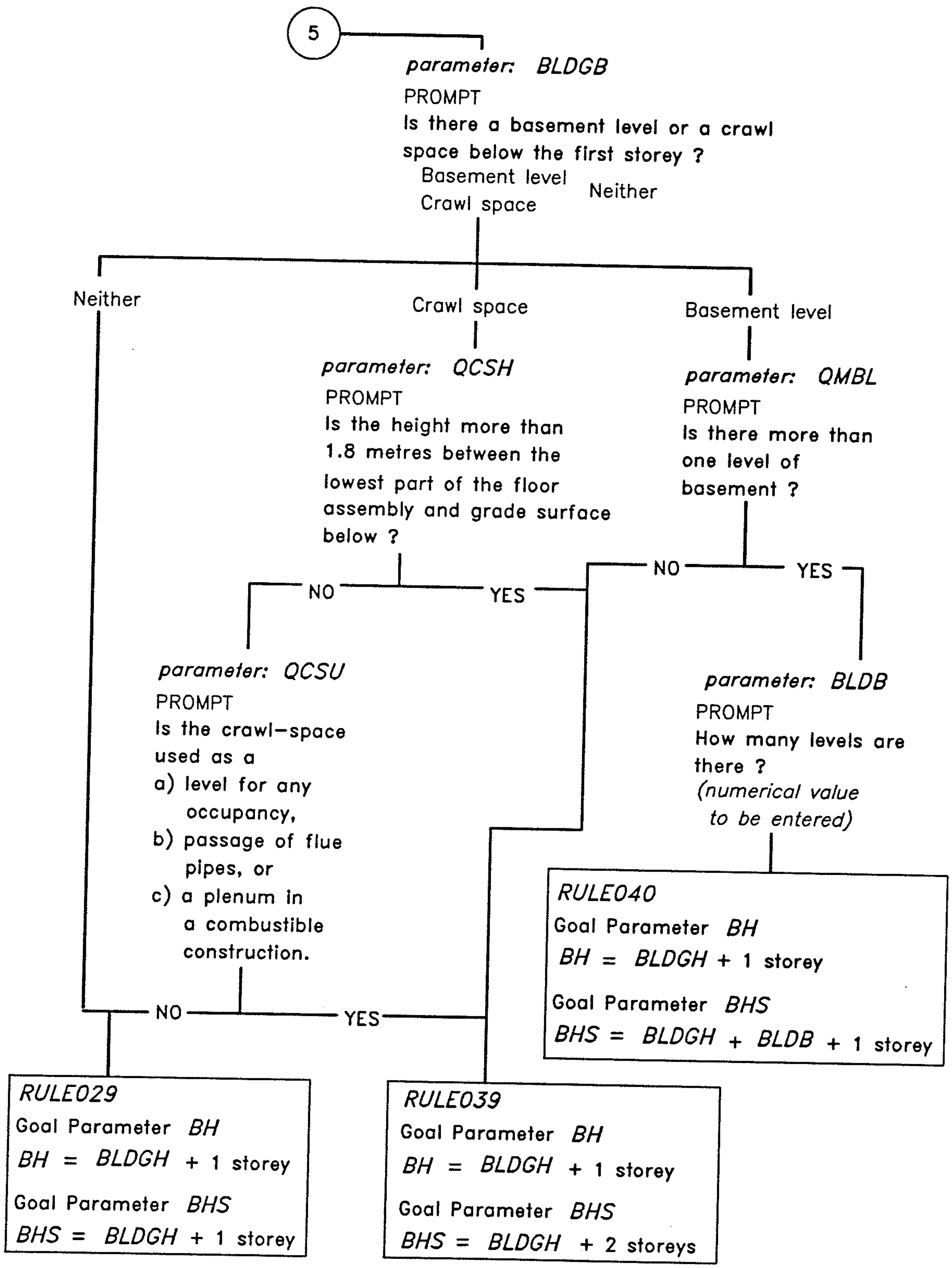
Building Height



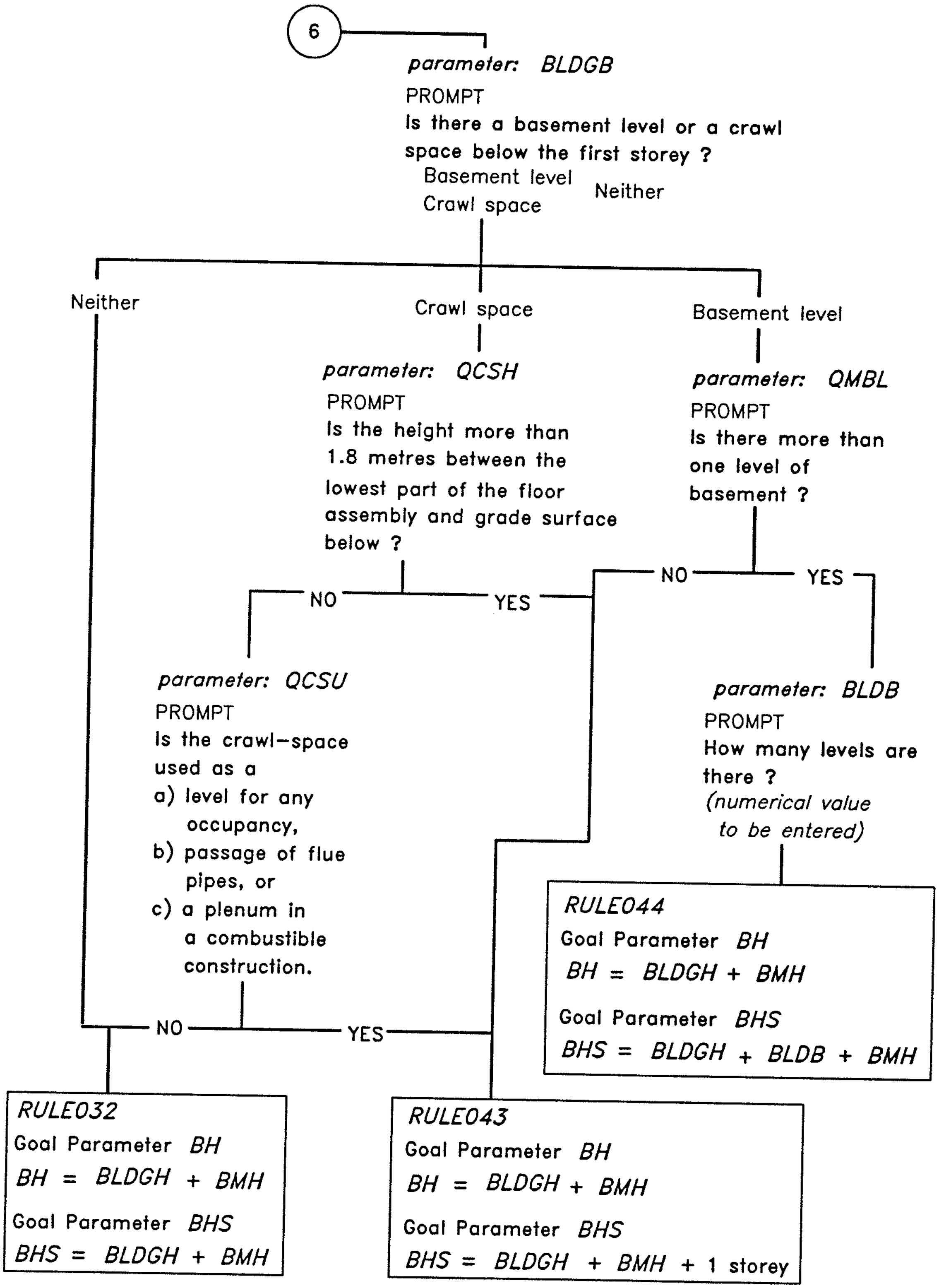
Building Height



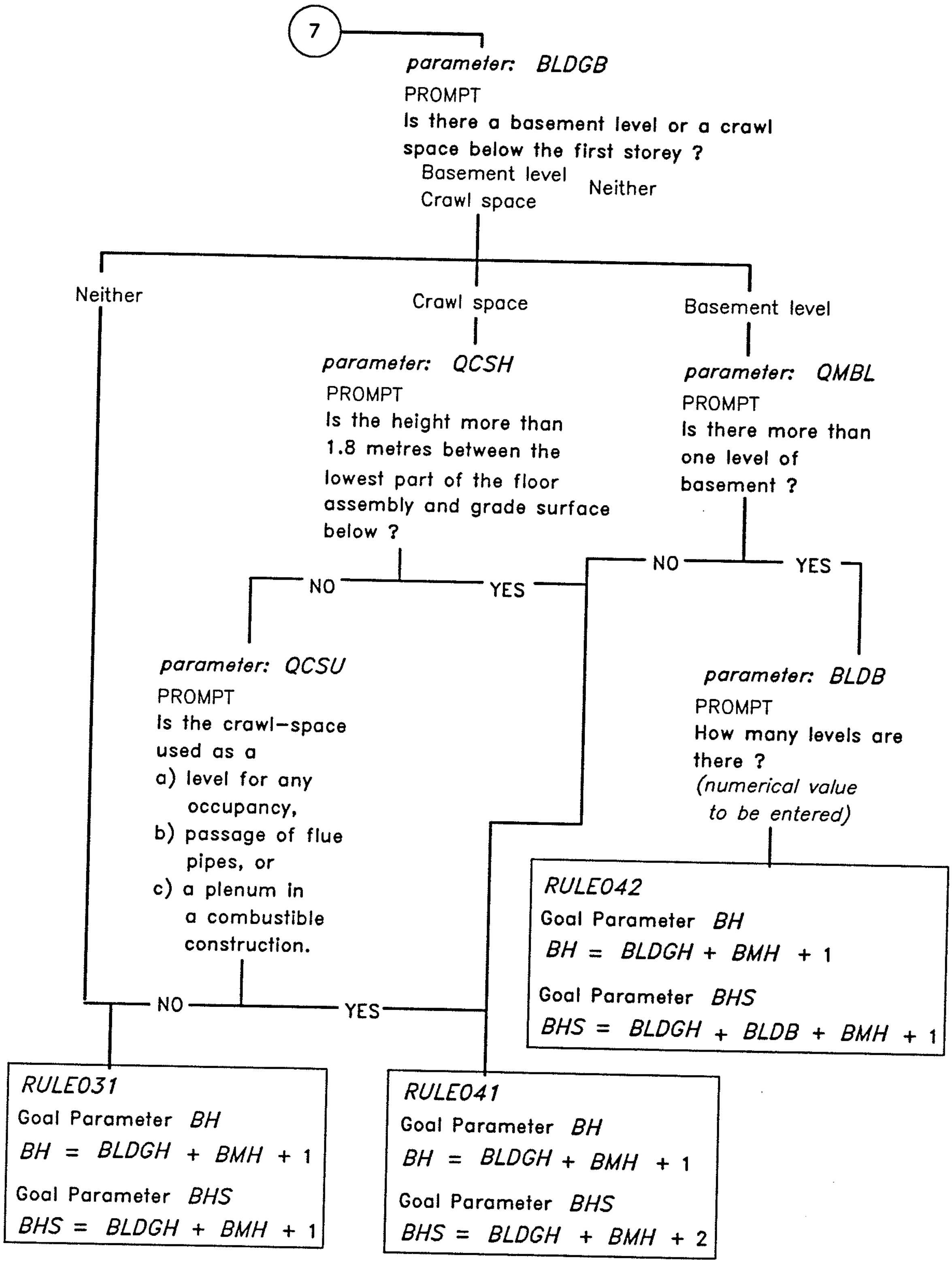
Building Height



Building Height



Building Height



Building Area

Goal parameter to be solved *BLDGAR*

To enter the correct building area.

BLDAR

parameter: BLDEA
PROMPT
What is the building area ?
< F1 HELP >
GRAPHIC HELP FILE
BAREA.GRI
(numerical value to be entered)

parameter: BSPRK
PROMPT
Is the building sprinkler protected ?

YES — NO

RULE047
Goal Parameter *BLDGAR*
BLDGAR = YES

parameter: SDG
PROMPT
Are there any dangerous goods stored in the building ?
< F1 HELP >

YES — NO

parameter: CSDG
PROMPT
Are there rooms or storage areas designated for storing and/or handling dangerous goods, where
a) the total area is devoted the storage of such dangerous goods is greater than 100 m^2 or
b) such substances like nitrocellulose based products exceeding 50 kg., or oxidizing substances are kept.

RULE046
Goal Parameter *BLDGAR*
BLDGAR = NO

NO

YES

RULE048
Goal Parameter *BLDGAR*
BLDGAR = YES
A sprinkler system for a room or storage area is required according to Article 3.3.6.9. Fire Suppression Systems of the NFCC 1990.

Subsection 3.2.2.6. Streets

Goal parameter to be solved *NS*

To determine the number of streets the building faces.

ST

parameter: QSTR

PROMPT

Do you know the number of streets the building is considered to be facing ?

NO

parameter: BPS

PROMPT

What is the building perimeter that faces an adjacent street within a 15 metre range ?

< F1 HELP >

GRAPHIC HELP FILE

STR.GRI

(numerical value to be entered)

parameter: BP

PROMPT

What is the building perimeter ?

< F1 HELP >

GRAPHIC HELP FILE

BLDP.GRI

(numerical value to be entered)

(BPS/BP) < 0.50

RULE002

Goal Parameter *NS*

This building faces 1 street.

(BPS/BP) >= 0.50 or *(BPS/BP)* < 0.75

RULE003

Goal Parameter *NS*

This building faces 2 streets.

(BPS/BP) >= 0.75

RULE004

Goal Parameter *NS*

This building faces 3 streets.

YES

parameter: KNS

PROMPT

Input the number of streets.

1 Street
2 Streets
3 Streets

1 Street

RULE002

Goal Parameter *NS*

This building faces 1 street.

2 Streets

RULE003

Goal Parameter *NS*

This building faces 2 streets.

3 Streets

RULE004

Goal Parameter *NS*

This building faces 3 streets.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GA1

parameter: QA16

PROMPT

A building classified as a Group A, Division 1 shall conform to Sentence 3.2.2.16.(2) Assembly Buildings, Division 1, 1 Storey provided the building:

(a) is not more than 1 storey in building height

(b) has no part of the auditorium floor more than 5 metres above or below grade level,

(c) has no occupancy above or below the auditorium other than one which serves it or is dependent on it, and

(d) is one in which the occupant load of the auditorium floor is not more than 300 persons.

Is this consistent with your building use ?

NO — YES

RULE089
Goal Parameter *ART*
ART = Article 3.2.2.16.

parameter: QA17

PROMPT

A building classified as a Group A, Division 1 shall conform to Sentence 3.2.2.16.(2) Assembly Buildings, Division 1, 1 Storey provided the building:

(a) has less than 40% of the area of the building as a 2 storeys for the purpose of:

i) development of productions including preparation of and costumes and rehearsal or performers,

ii) organization of performers, scenery and sound equipment before and during performance,

iii) preparation by performers for a performance,

iv) managerial functions of policy making and administration , or

v) public facilities such as toilets and rest rooms,

b) has no occpancy above or below the auditorium other than one which serves or is dependent on it,

c) is not more than 600 m^2 in building area,

d) is one in which the occupant load is not more than 600 persons.

Is this consistent with your building use ?

YES

RULE090
Goal Parameter *ART*
ART = Article 3.2.2.17.

NO

RULE091
Goal Parameter *ART*
ART = Article 3.2.2.18.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GA2

	BLDGAR		BSPRK NO
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 400	<= 500	<= 600

RULE080
Goal Parameter ART
ART = Article 3.2.2.19.

	BLDGAR		BSPRK NO
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 400	<= 500	<= 600
2	<= 400	<= 500	<= 600

RULE081
Goal Parameter ART
ART = Article 3.2.2.20.

	BLDGAR		BSPRK NO
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 1600	<= 2000	<= 2400
2	<= 800	<= 1000	<= 1200

	BLDGAR		BSPRK YES
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 3200	<= 4000	<= 4800
2	<= 1600	<= 2000	<= 2400

RULE082
Goal Parameter ART
ART = Article 3.2.2.21.

	BLDGAR		BSPRK NO
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	> 1600	> 2000	> 2400
2	> 800	> 1000	> 1200

	BLDGAR		BSPRK YES
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	> 3200	> 4000	> 4800
2	> 1600	> 2000	> 2400

BLDGHT			
3			
4			
5			

RULE083
Goal Parameter ART
ART = Article 3.2.2.22.

BLDGHT			
>= 6			

RULE084
Goal Parameter ART
ART = Article 3.2.2.23.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GA3

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 1000	<= 1250	<= 1500

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
1	<= 2000	<= 2500	<= 3000

RULE085
Goal Parameter *ART*
ART = Article 3.2.2.24.

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 2400	<= 3000	<= 3600

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
1	<= 4800	<= 6000	<= 7200

RULE086
Goal Parameter *ART*
ART = Article 3.2.2.25.

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 4000	<= 5000	<= 6000
2	<= 2000	<= 2500	<= 3000

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
2	<= 8000	<= 10000	<= 12000
1	<= 4000	<= 5000	<= 6000

RULE087
Goal Parameter *ART*
ART = Article 3.2.2.26.

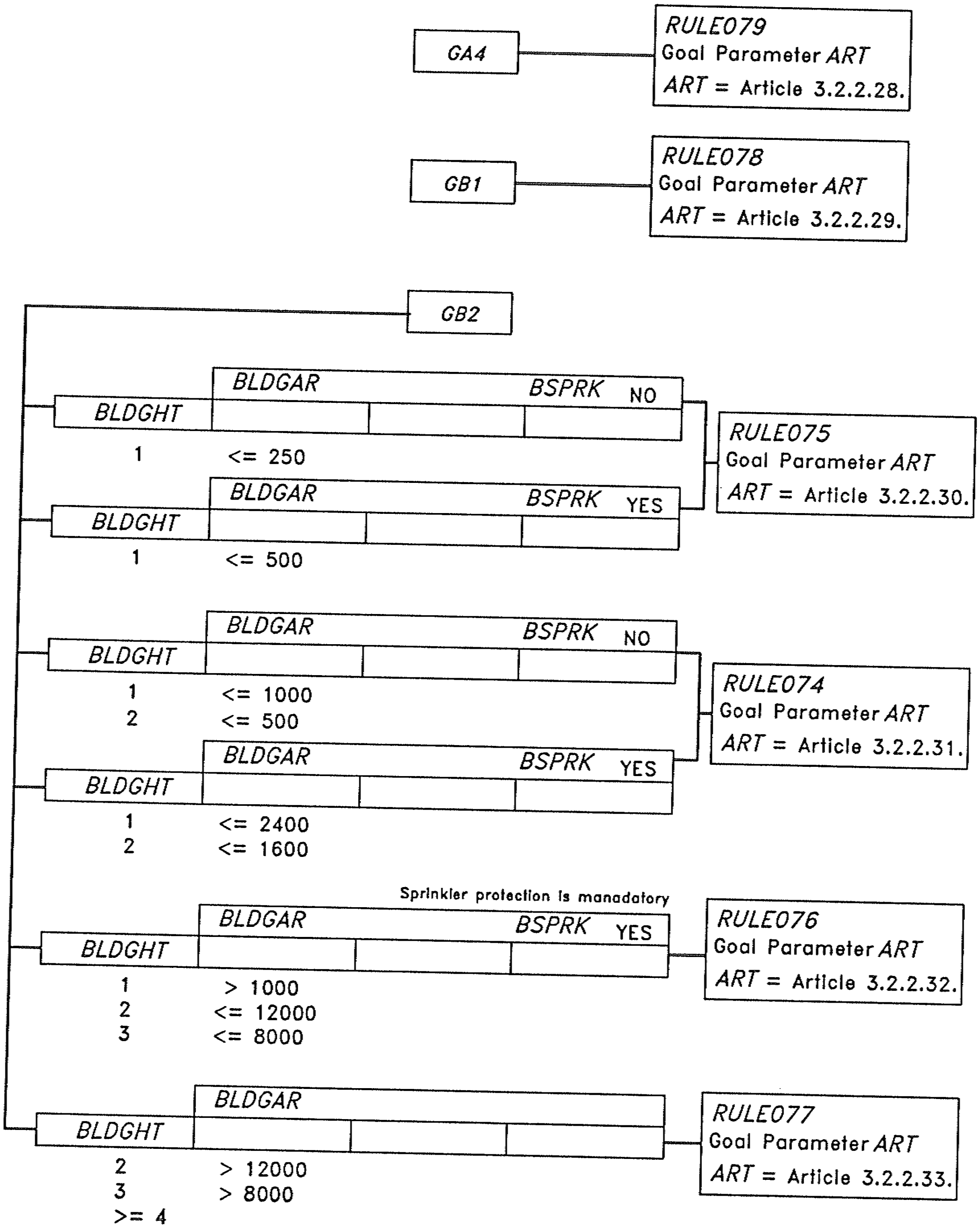
BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	> 4000	> 5000	> 6000
2	> 2000	> 2500	> 3000

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
2	> 8000	> 10000	> 12000
1	> 4000	> 5000	> 6000

BLDGHT			
>= 3			

RULE088
Goal Parameter *ART*
ART = Article 3.2.2.27.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy



Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GC

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1800	<= 2250	<= 2700
2	<= 900	<= 1125	<= 1350
3	<= 600	<= 750	<= 900

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 3600	<= 4500	<= 5400
2	<= 1800	<= 2250	<= 2700
3	<= 1200	<= 1500	<= 1800

RULE052
Goal Parameter *ART*
ART = Article 3.2.2.34.

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 2400	<= 3000	<= 3600
2	<= 1200	<= 1500	<= 1800
3	<= 800	<= 1000	<= 1200

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 2400	<= 3000	<= 3600
3	<= 1600	<= 2000	<= 2400

RULE053
Goal Parameter *ART*
ART = Article 3.2.2.35.

Sprinkler Protection is mandatory

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1200	<= 1500	<= 1800
2	<= 1200	<= 1500	<= 1800
3	<= 1200	<= 1500	<= 1800
4	<= 1200	<= 1500	<= 1800

RULE054
Goal Parameter *ART*
ART = Article 3.2.2.36.

1

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

1

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	> 2400	> 3000	> 3600
2	<= 6000	> 1500	> 1800
3	<= 4000	<= 5000	<= 6000
4	<= 3000	<= 3750	<= 4500
5	<= 2400	<= 3000	<= 3600
6	<= 2000	<= 2500	<= 3000

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	> 4800	> 6000	> 7200
2	<= 12000	> 3000	> 3600
3	<= 8000	<= 10000	<= 12000
4	<= 6000	<= 7500	<= 9000
5	<= 4800	<= 6000	<= 7200
6	<= 4000	<= 5000	<= 6000

RULE055
Goal Parameter *ART*
ART = Article 3.2.2.37.

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
2	> 6000		
3	> 4000	> 5000	> 6000
4	> 3000	> 3750	> 4500
5	> 2400	> 3000	> 3600
6	> 2000	> 2500	> 3000

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
2	> 12000		
3	> 8000	> 10000	> 12000
4	> 6000	> 7500	> 9000
5	> 4800	> 6000	> 7200
6	> 4000	> 5000	> 6000

RULE056
Goal Parameter *ART*
ART = Article 3.2.2.38.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GD

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1000	<= 1250	<= 1200
2	<= 800	<= 1000	<= 1500

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 2000	<= 2500	<= 3000
2	<= 1600	<= 2000	<= 2400

RULE026
Goal Parameter *ART*
ART = Article 3.2.2.39.

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 2400	<= 3000	<= 3600
3	<= 1600	<= 2000	<= 2400

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 9600	<= 12000	<= 14400
2	<= 4800	<= 6000	<= 7200
3	<= 3200	<= 4000	<= 4800

RULE015
Goal Parameter *ART*
ART = Article 3.2.2.40.

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	> 4800	> 6000	> 7200
2	<= 7200	> 3000	> 3600
3	<= 4800	<= 6000	<= 7200
4	<= 3600	<= 4500	<= 5400
5	<= 2800	<= 3600	<= 4320
6	<= 2400	<= 3000	<= 3600

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	> 9600	> 12000	> 14400
2	<= 14400	> 6000	> 7200
3	<= 9600	<= 12000	<= 14400
4	<= 7200	<= 9000	<= 10800
5	<= 5600	<= 7200	<= 8640
6	<= 4800	<= 6000	<= 7200

RULE017
Goal Parameter *ART*
ART = Article 3.2.2.41.

1

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

1

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
2	> 7200		
3	> 4800	> 6000	> 7200
4	> 3600	> 4500	> 5400
5	> 2800	> 3600	> 4320
6	> 2400	> 3000	> 3600

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
2	> 14400		
3	> 9600	> 12000	> 14400
4	> 7200	> 9000	> 10800
5	> 5600	> 7200	> 8640
6	> 4800	> 6000	> 7200

BLDGHT			
>= 7			

RULE025
Goal Parameter *ART*
ART = Article 3.2.2.42.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GE

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1000	<= 1250	<= 1500
2	<= 600	<= 750	<= 900

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 2000	<= 2500	<= 3000
2	<= 1200	<= 1500	<= 1800

RULE005
Goal Parameter *ART*
ART = Article 3.2.2.43.

	BLDGAR		*BSPRK* NO
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1500	<= 1500	<= 1500
2	<= 1200	<= 1500	<= 1500
3	<= 800	<= 1000	<= 1200

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 2400	<= 3000	<= 3600
3	<= 1600	<= 2000	<= 2400

RULE006
Goal Parameter *ART*
ART = Article 3.2.2.44.

	BLDGAR		*BSPRK* NO
BLDGHT			
1	<= 1500		
2	<= 1500		
3	<= 1500		

	BLDGAR		*BSPRK* YES
BLDGHT	*NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	> 4800	<= 6000	<= 7200
2	<= 7500	> 3000	> 3600
3	<= 5000	<= 6250	<= 7500
4	<= 3750	<= 4688	<= 5625
5	<= 3000	<= 3750	<= 4500
6	<= 2500	<= 3125	<= 3750

RULE007
Goal Parameter *ART*
ART = Article 3.2.2.45.

1

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

1

Sprinkler protection is mandatory

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
2	> 7500		
3	> 5000	> 6250	> 7500
4	> 3750	> 4688	> 5625
5	> 3000	> 3750	> 4500
6	> 2500	> 3125	> 3750
>= 7			

RULE050
Goal Parameter *ART*
ART = Article 3.2.2.46.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GF1

BLDGHT	*BLDGAR*		*BSPRK* NO
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 800	<= 1000	<= 1200
2	<= 400	<= 500	<= 600

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1600	<= 2000	<= 2400
2	<= 800	<= 1000	<= 1200

RULE057
Goal Parameter *ART*
ART = Article 3.2.2.47.

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 2400	<= 3000	<= 3600
2	<= 1200	<= 1500	<= 1800
3	<= 800	<= 1000	<= 1200

RULE058
Goal Parameter *ART*
ART = Article 3.2.2.48.

BLDGHT	*BLDGAR*		*BSPRK* NO
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 2400	<= 3000	<= 3600
2	<= 1200	<= 1500	<= 1800
3	<= 800	<= 1000	<= 1200
4	<= 600	<= 750	<= 900

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 2400	<= 3000	<= 3600
3	<= 1600	<= 2000	<= 2400
4	<= 1200	<= 1500	<= 1800

RULE059
Goal Parameter *ART*
ART = Article 3.2.2.49.

Maximum building height for F1 major occupancy classification is 4 storeys and sprinklered.

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 6000	<= 7500	<= 9000
2	<= 3000	<= 3750	<= 4500
3	<= 2000	<= 2500	<= 3000
4	<= 1500	<= 1875	<= 2250

RULE060
Goal Parameter *ART*
ART = Article 3.2.2.50.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GF2

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 1000	<= 1250	<= 1500
2	<= 600	<= 750	<= 900

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
1	<= 3000	<= 3750	<= 4500
2	<= 1200	<= 1500	<= 1800

RULE062
Goal Parameter *ART*
ART = Article 3.2.2.51.

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 3200	<= 4000	<= 4800
2	<= 1600	<= 2000	<= 2400
3	<= 1070	<= 1340	<= 1600
4	<= 800	<= 1000	<= 1200

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
1	<= 6400	<= 8000	<= 9600
2	<= 3200	<= 4000	<= 4800
3	<= 2140	<= 2680	<= 3200
4	<= 1600	<= 2000	<= 2400

RULE063
Goal Parameter *ART*
ART = Article 3.2.2.52.

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* NO *NS* 3 Streets
1	<= 6000	<= 7500	<= 9000
2	<= 3000	<= 3750	<= 4500
3	<= 2000	<= 2500	<= 3000
4	<= 1500	<= 1875	<= 2250

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*BSPRK* YES *NS* 3 Streets
1	<= 12000	<= 15000	<= 18000
2	<= 6000	<= 7500	<= 9000
3	<= 4000	<= 5000	<= 6000
4	<= 3000	<= 3750	<= 4500

RULE064
Goal Parameter *ART*
ART = Article 3.2.2.53.

1

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

1

	BLDGAR		BSPRK NO
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 9000	<= 11250	<= 13500
2	<= 4500	<= 5625	<= 6750
3	<= 3000	<= 3750	<= 4500
4	<= 2250	<= 2812	<= 3375
5	<= 1800	<= 2250	<= 2700
6	<= 1500	<= 1875	<= 2250

	BLDGAR		BSPRK YES
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	<= 18000	<= 22500	<= 27000
2	<= 9000	<= 11250	<= 13500
3	<= 6000	<= 7500	<= 9000
4	<= 4500	<= 5625	<= 6750
5	<= 3600	<= 4500	<= 5400
6	<= 3000	<= 3750	<= 4500

RULE065
Goal Parameter *ART*
ART = Article 3.2.2.54.

Sprinkler protection is mandatory

	BLDGAR		BSPRK YES
BLDGHT	NS 1 Street	NS 2 Streets	NS 3 Streets
1	> 18000	> 22500	> 27000
2	> 9000	> 11250	> 13500
3	> 6000	> 7500	> 9000
4	> 4500	> 5625	> 6750
5	> 3600	> 4500	> 5400
6	> 3000	> 3750	> 4500
>= 7			

RULE066
Goal Parameter *ART*
ART = Article 3.2.2.55.

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

GF3

BLDGHT	*BLDGAR*		*BSPRK* NO
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 1600	<= 2000	<= 2400
2	<= 800	<= 1000	<= 1200

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 1600	<= 2000	<= 2400

RULE068
Goal Parameter *ART*
ART = Article 3.2.2.56.

BLDGHT	*BLDGAR*		*BSPRK* NO
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 4800	<= 6000	<= 7200
2	<= 2400	<= 3000	<= 3600
3	<= 1600	<= 2000	<= 2400
4	<= 1200	<= 1500	<= 1800

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 9600	<= 12000	<= 14400
2	<= 4800	<= 6000	<= 7200
3	<= 3200	<= 4000	<= 4800
4	<= 2400	<= 3000	<= 3600

RULE070
Goal Parameter *ART*
ART = Article 3.2.2.57.

BLDGHT	*BLDGAR*		*BSPRK* NO
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 5600	<= 7000	<= 8400

BLDGHT	*BLDGAR*		*BSPRK* YES
	NS 1 Street	*NS* 2 Streets	*NS* 3 Streets
1	<= 11200	<= 14000	<= 16800

RULE069
Goal Parameter *ART*
ART = Article 3.2.2.58.

1

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

IF:: *BLDGHT* = 1 (storey)
and *BLDGAR* <= 10000 m^2 — 1

parameter: *LFLOF3*

PROMPT

A building classified as Group F, Division 3
shall conform to Sentence 3.2.2.59.(2) provided
the building:
(a) is not more than 1 storey in building height,
(b) is used soley for low fire load occupancies
such as,
(i) power generating plants, or
(ii) plants for the manufacturing or storage
of noncombustible materials such as asbestos,
brick, cement, concrete, or steel.
(c) is not limited in building area.

Is this classification consistent with your
building use ?

NO — YES — *RULE071*
Goal Parameter *ART*
ART = Article 3.2.2.59.

parameter: SGF3

PROMPT

A building used as a storage garage with all storeys
constructed as open-air storeys and having no other
occupancy above it is permitted to have its floor,
wall, ceiling and roof assemblies constructed without
a fire-resistance rating provided the building is
(a) of noncombustible construction,
(b) not more than 22 metres high, measured between
grade and the ceiling level of the top storey,
(c) not more than 10,000 m^2 in building area, and
(d) designed so that every portion of each floor
area is within 60 m of an exterior wall opening.
< F1 HELP >

Is this classification consistent with your
building use ?

YES — *RULE112*
Goal Parameter *ART*
ART = Article 3.2.2.60.

NO — 2

Subsection 3.2.2. Building Size and Construction Relative to Occupancy

2

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
			BSPRK NO
1	> 5600	> 7000	> 8400
2	<= 7200	<= 9000	<= 10800
3	<= 4800	<= 6000	<= 7200
4	<= 3600	<= 4500	<= 5400
5	<= 2880	<= 3600	<= 4320
6	<= 2400	<= 3000	<= 3600

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
			BSPRK YES
1	> 11200	> 14000	> 16800
2	<= 14400	<= 18000	<= 21600
3	<= 9600	<= 12000	<= 14400
4	<= 7200	<= 9000	<= 10800
5	<= 3760	<= 7200	<= 8640
6	<= 4800	<= 6000	<= 7200

RULE072
Goal Parameter *ART*
ART = Article 3.2.2.61.

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
			BSPRK YES
2	> 7200	> 9000	> 10800
3	> 4800	> 6000	> 7200
4	> 3600	> 4500	> 5400
5	> 2880	> 3600	> 4320
6	> 2400	> 3000	> 3600
>= 7			

BLDGHT	*BLDGAR* *NS* 1 Street	*NS* 2 Streets	*NS* 3 Streets
			BSPRK YES
2	> 14400	> 18000	> 21600
3	> 9600	> 12000	> 14400
4	> 7200	> 9000	> 10800
5	> 3760	> 7200	> 8640
6	> 4800	> 6000	> 7200
>= 7			

RULE073
Goal Parameter *ART*
ART = Article 3.2.2.62.

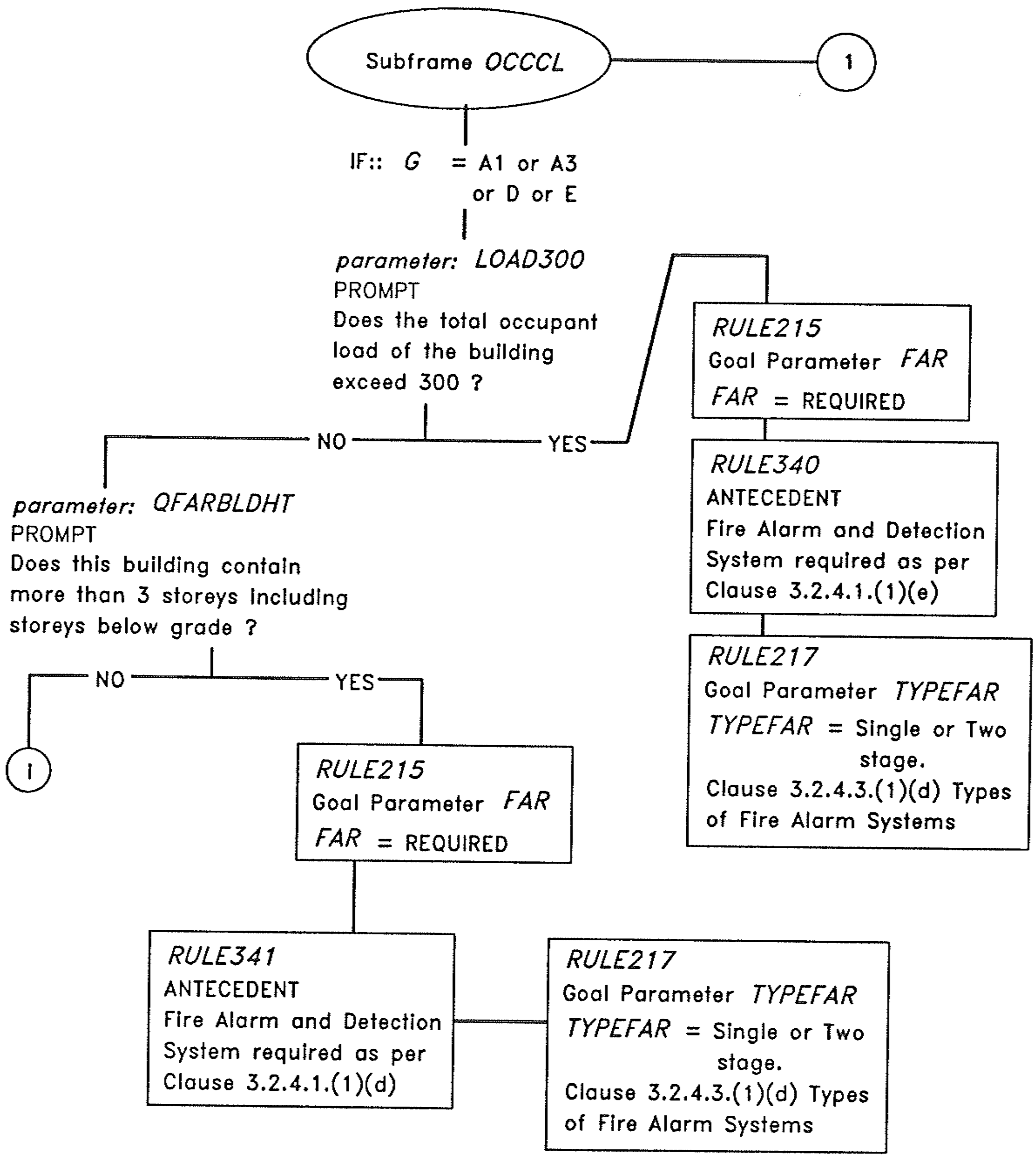
Subsection 3.2.4 Fire Alarm and Detection Systems

Goal parameters to be solved *FAR*

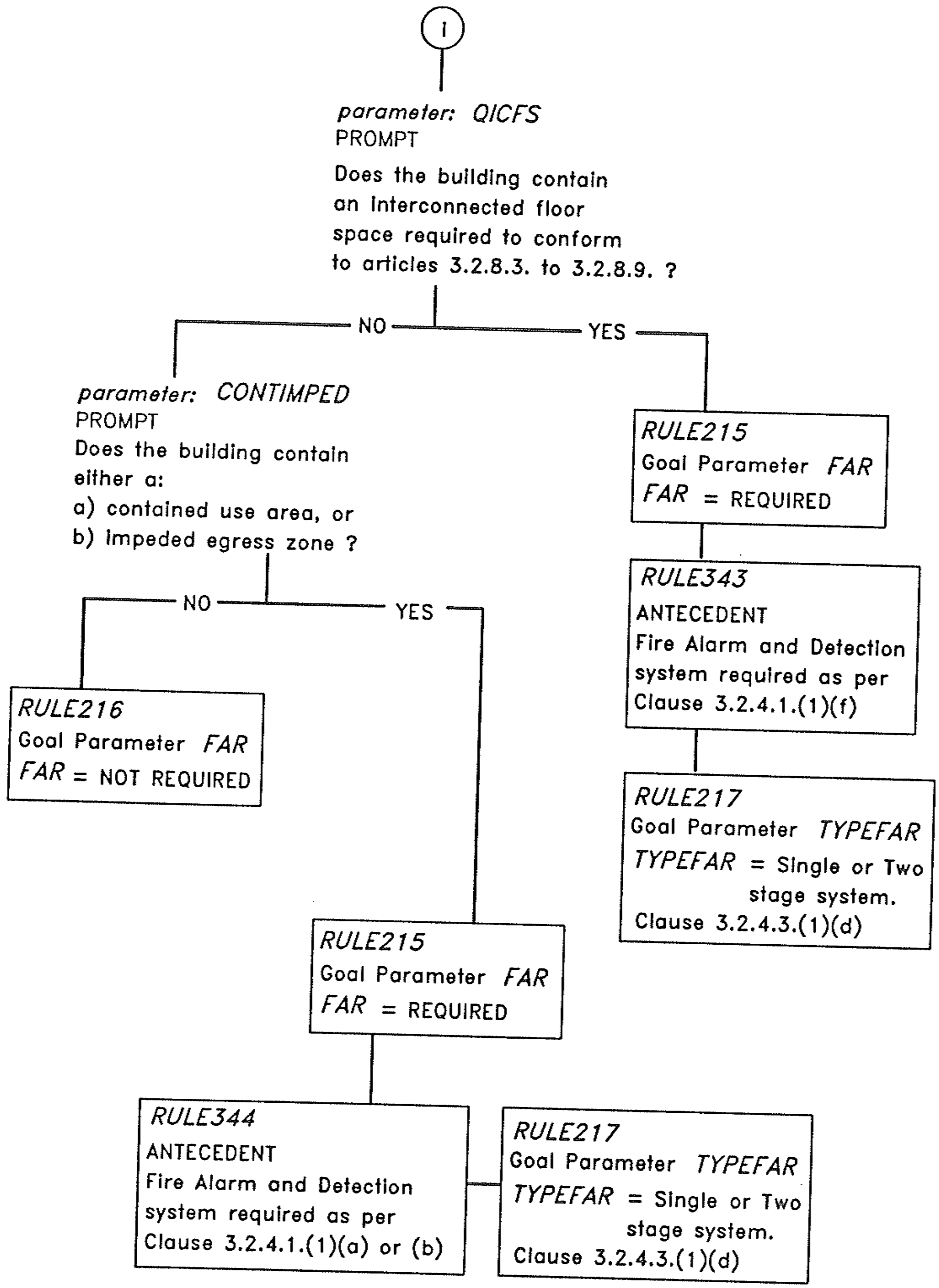
To determine whether a fire alarm and detection system is required to be installed in the building.

TYPEFAR

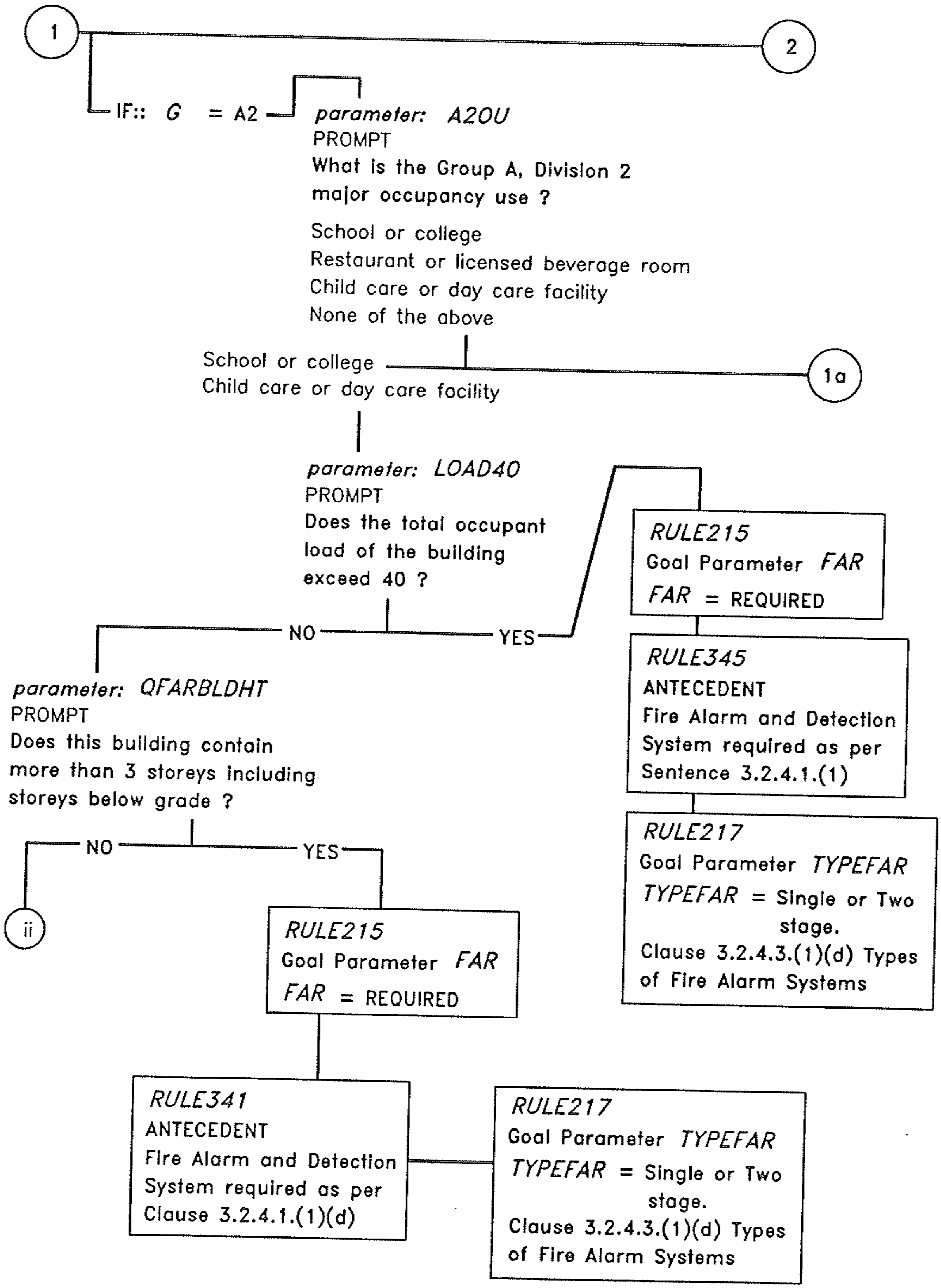
To determine the type of fire alarm and detection system to be installed.



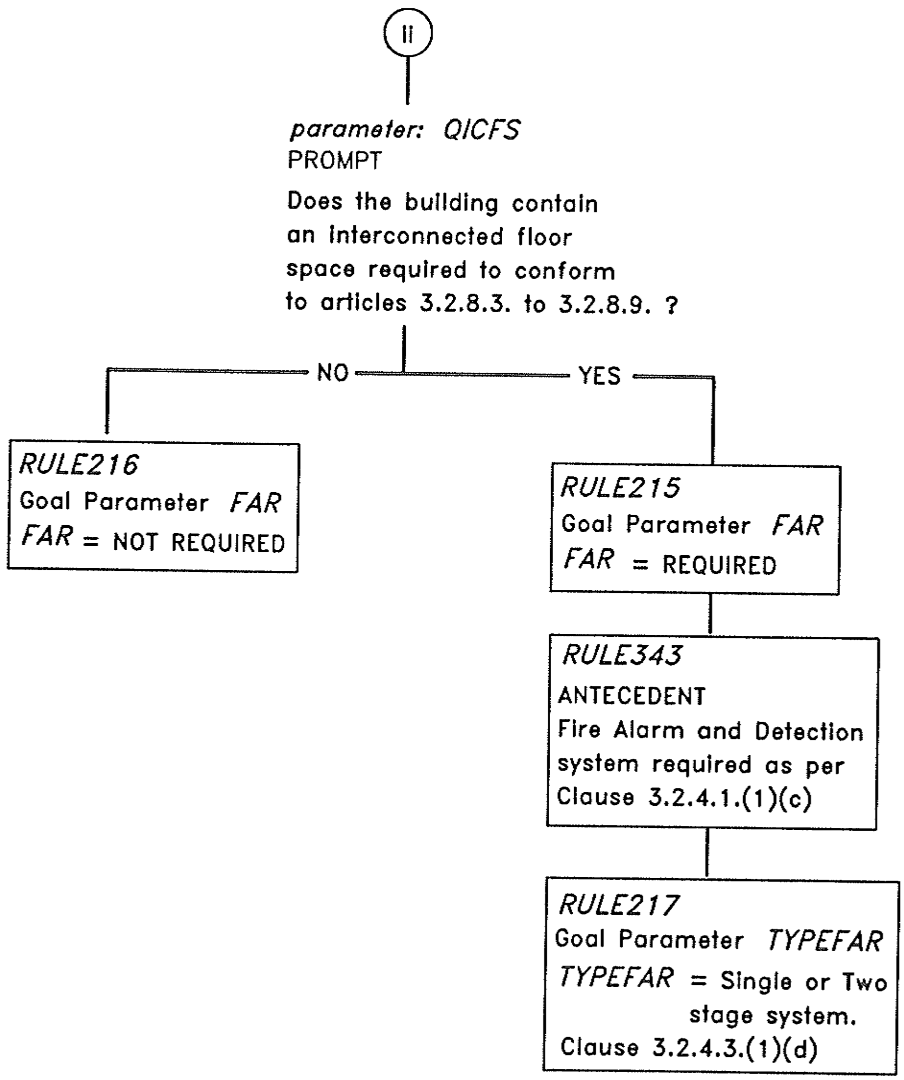
Subsection 3.2.4 Fire Alarm and Detection Systems



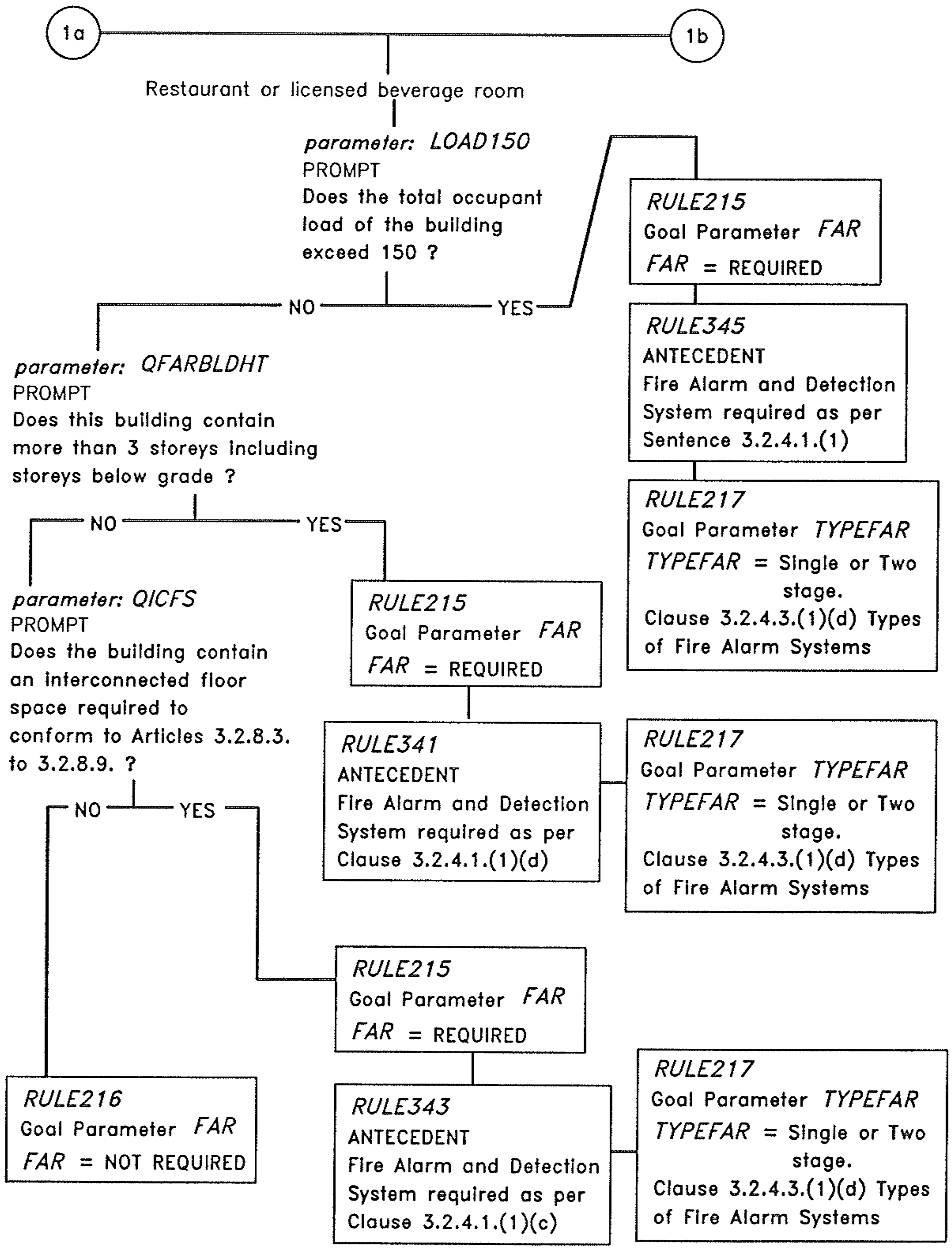
Subsection 3.2.4 Fire Alarm and Detection Systems



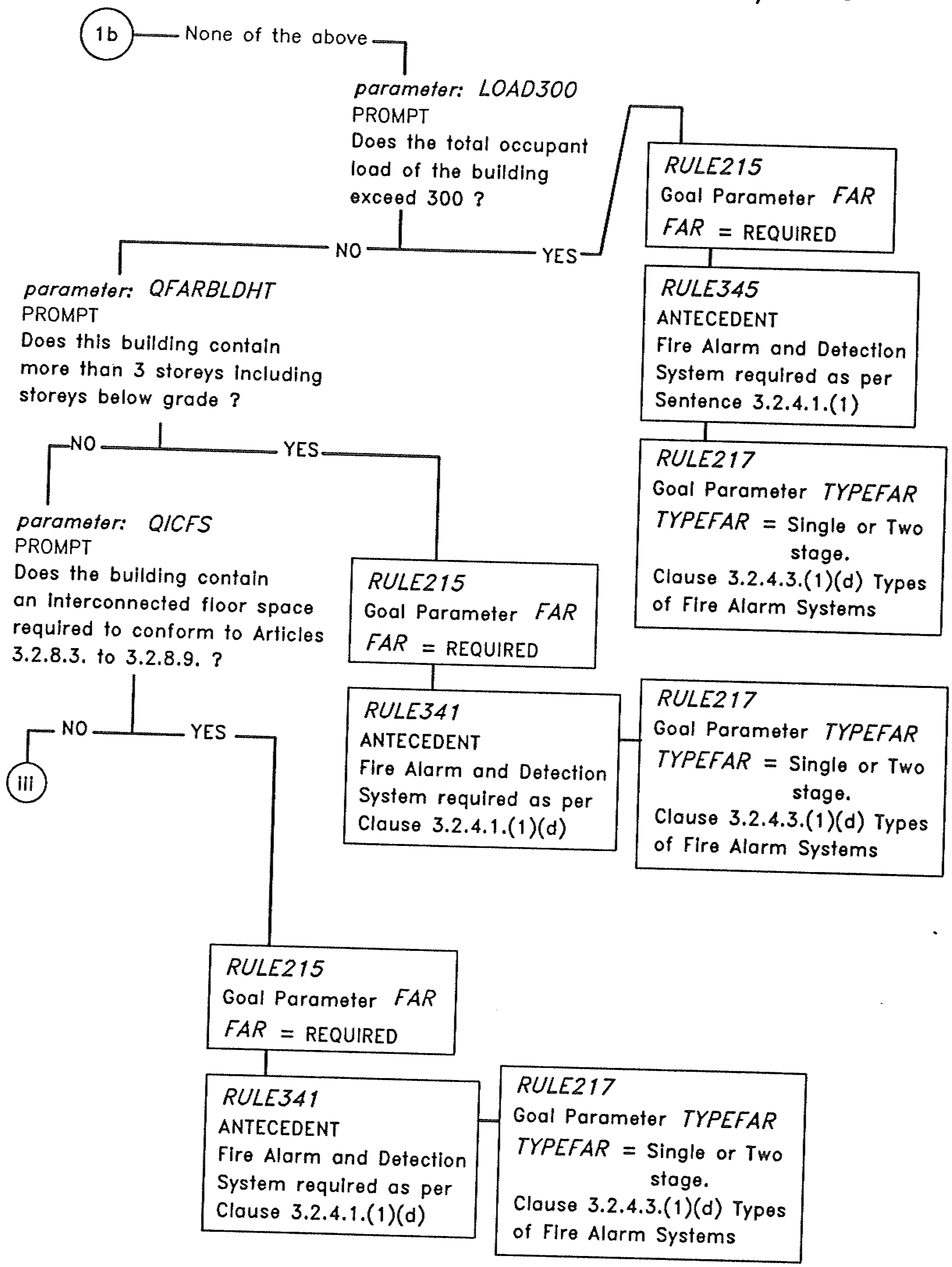
Subsection 3.2.4 Fire Alarm and Detection Systems



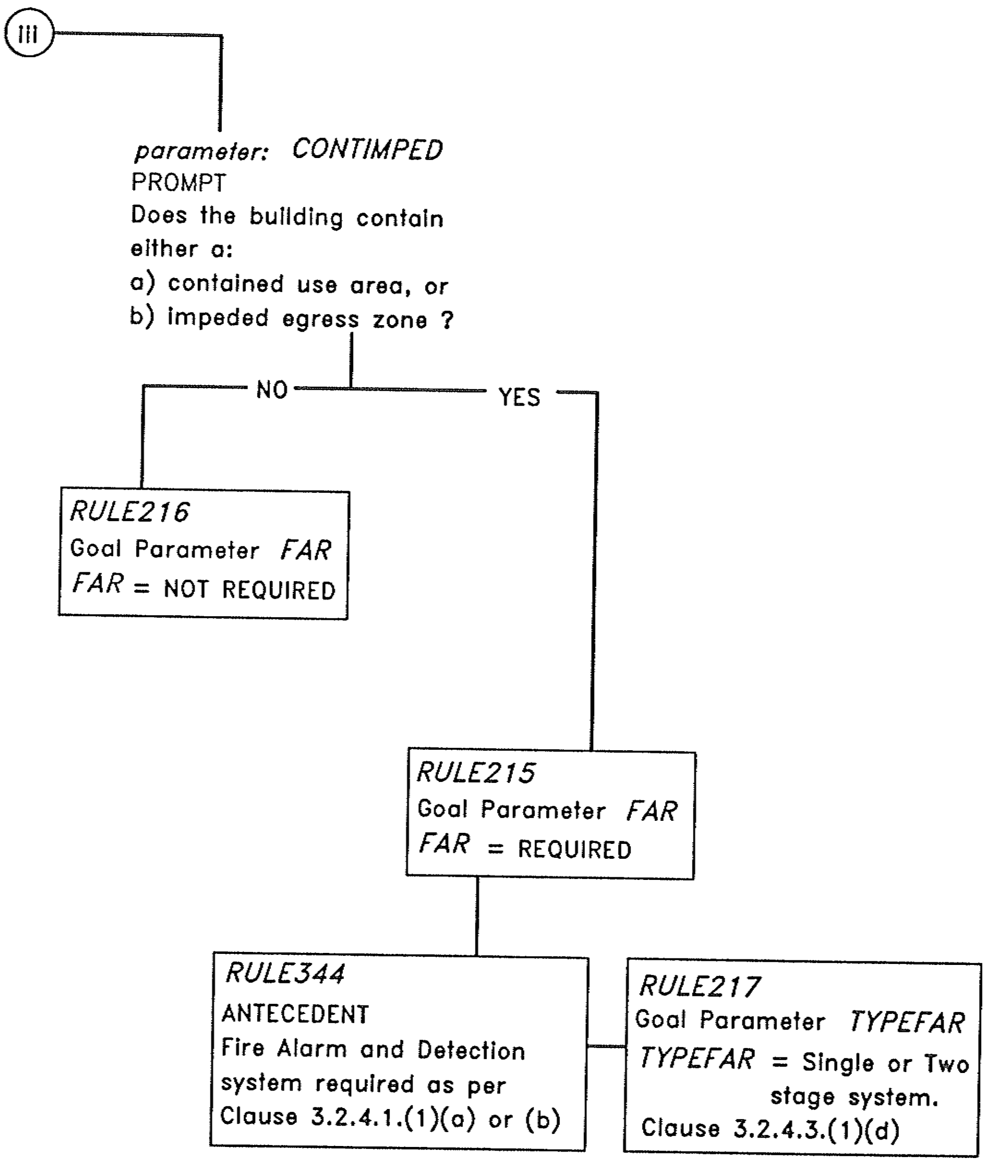
Subsection 3.2.4 Fire Alarm and Detection Systems



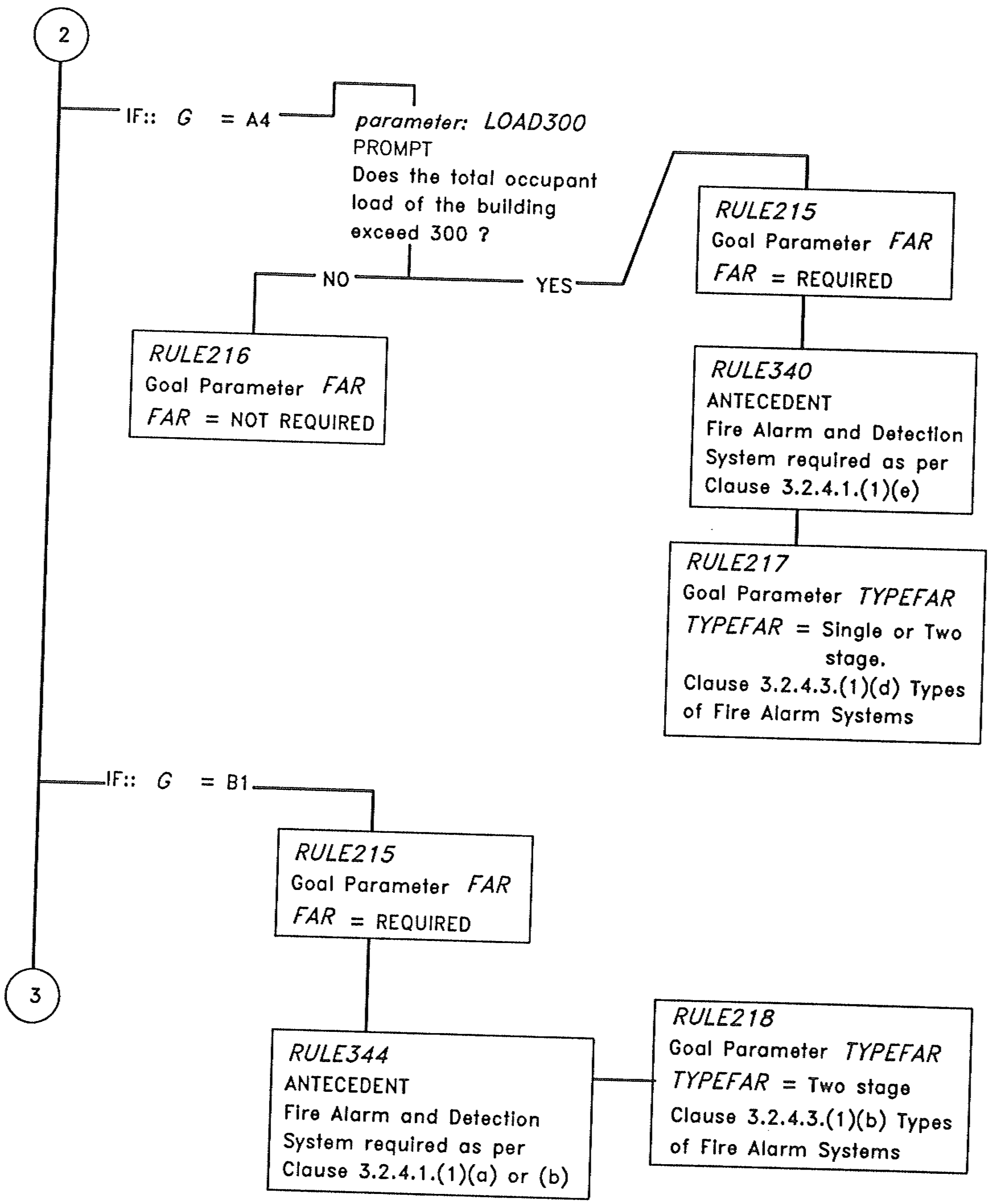
Subsection 3.2.4 Fire Alarm and Detection Systems



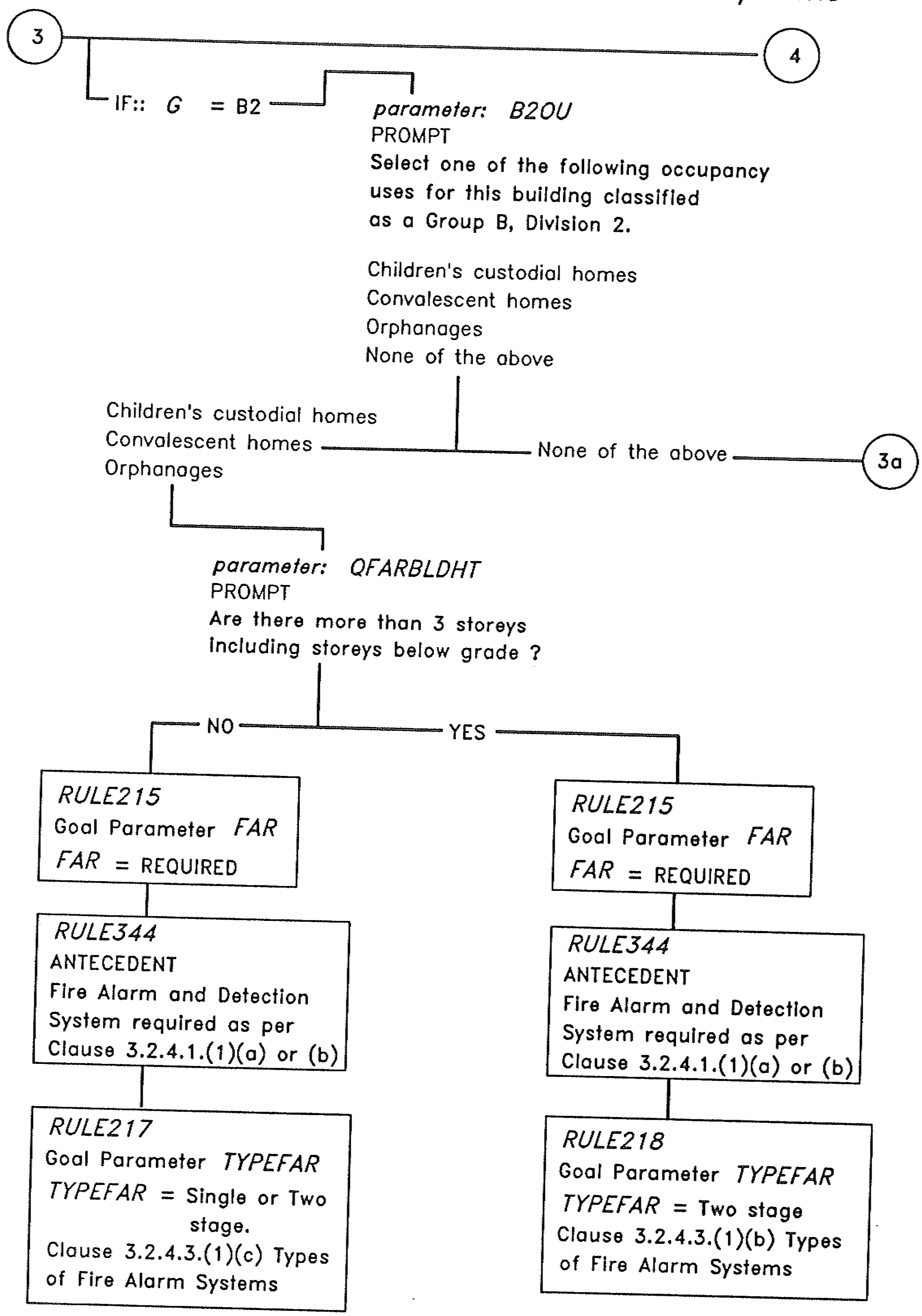
Subsection 3.2.4 Fire Alarm and Detection Systems



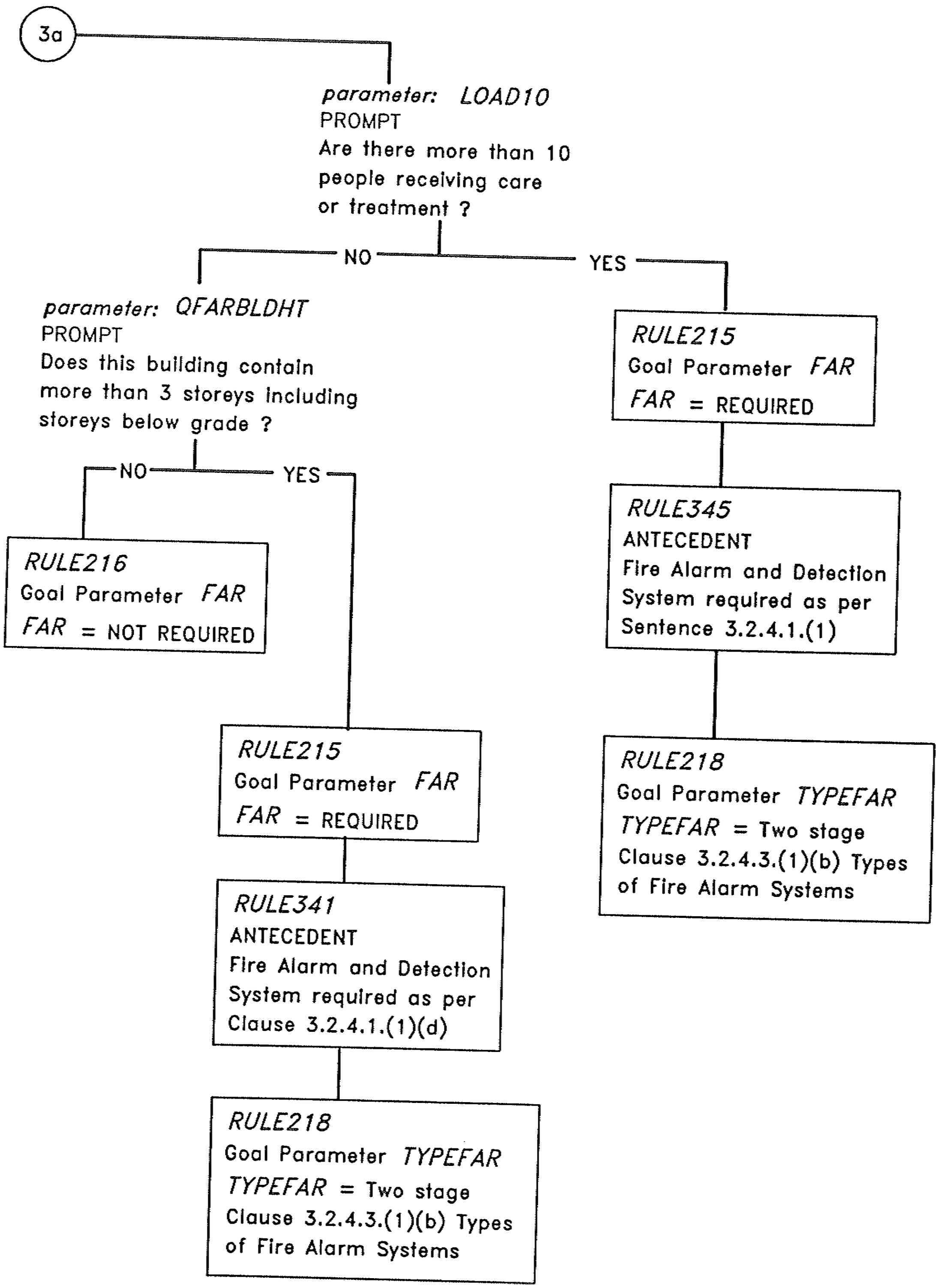
Subsection 3.2.4 Fire Alarm and Detection Systems



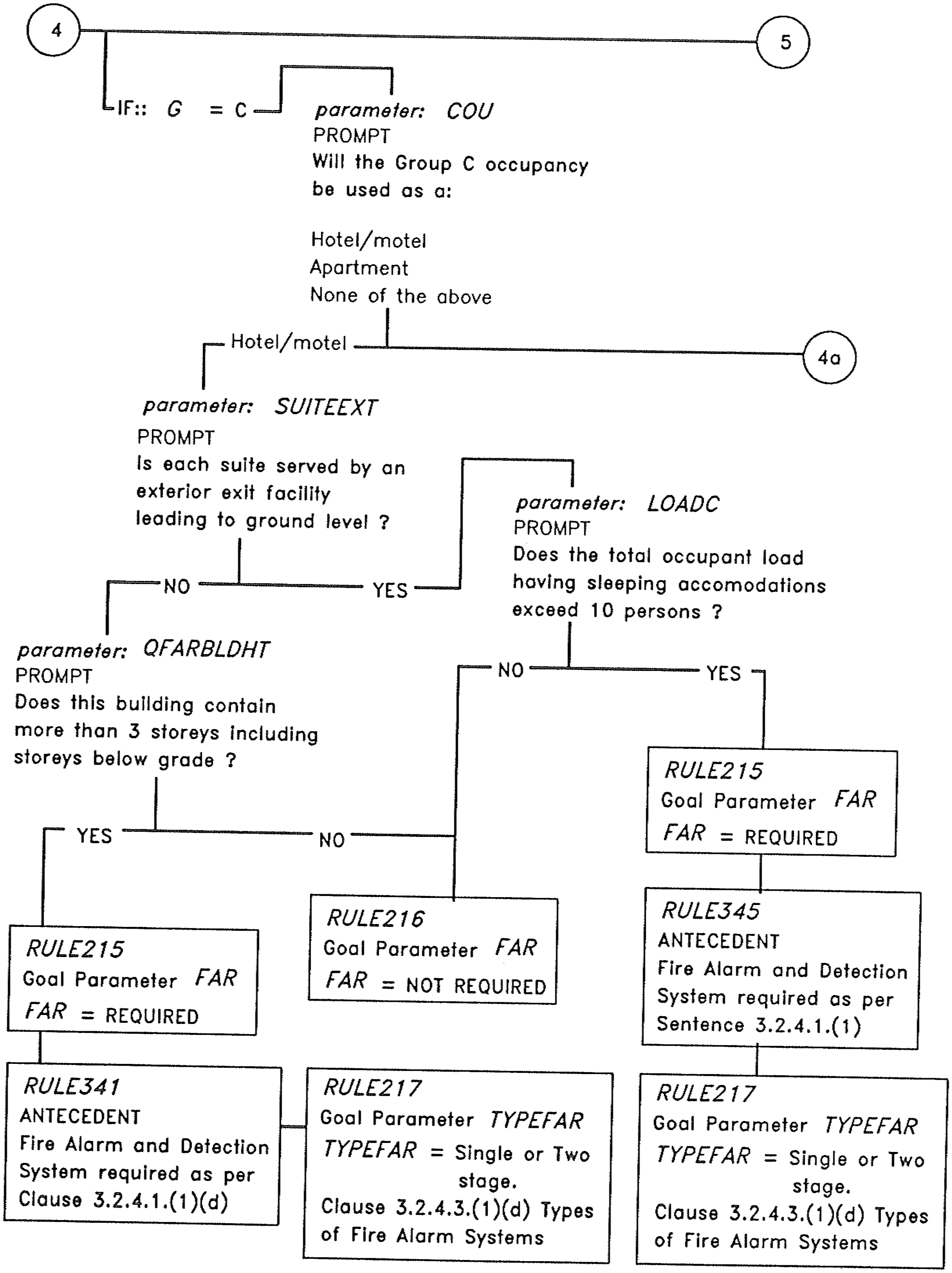
Subsection 3.2.4 Fire Alarm and Detection Systems



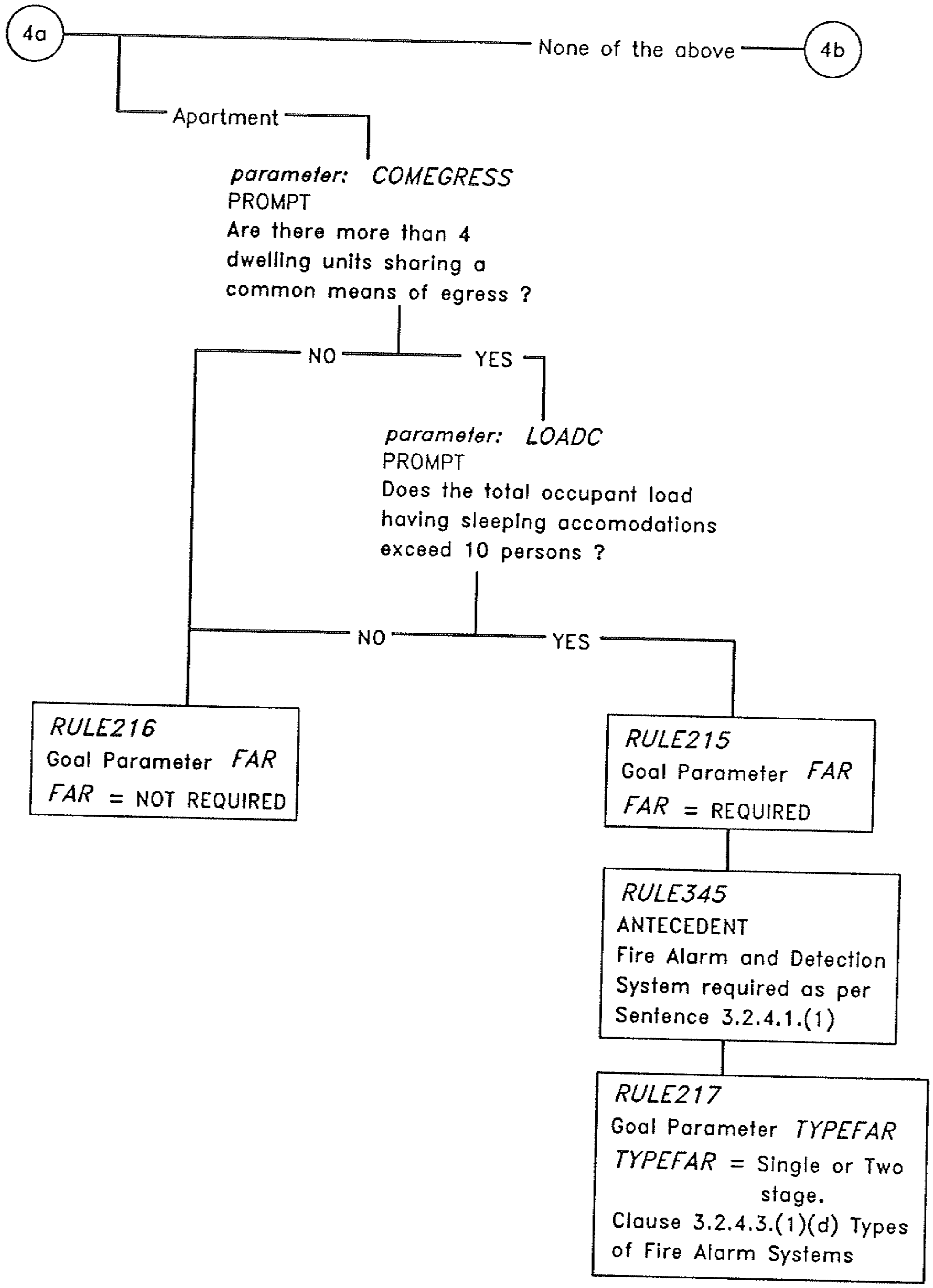
Subsection 3.2.4 Fire Alarm and Detection Systems



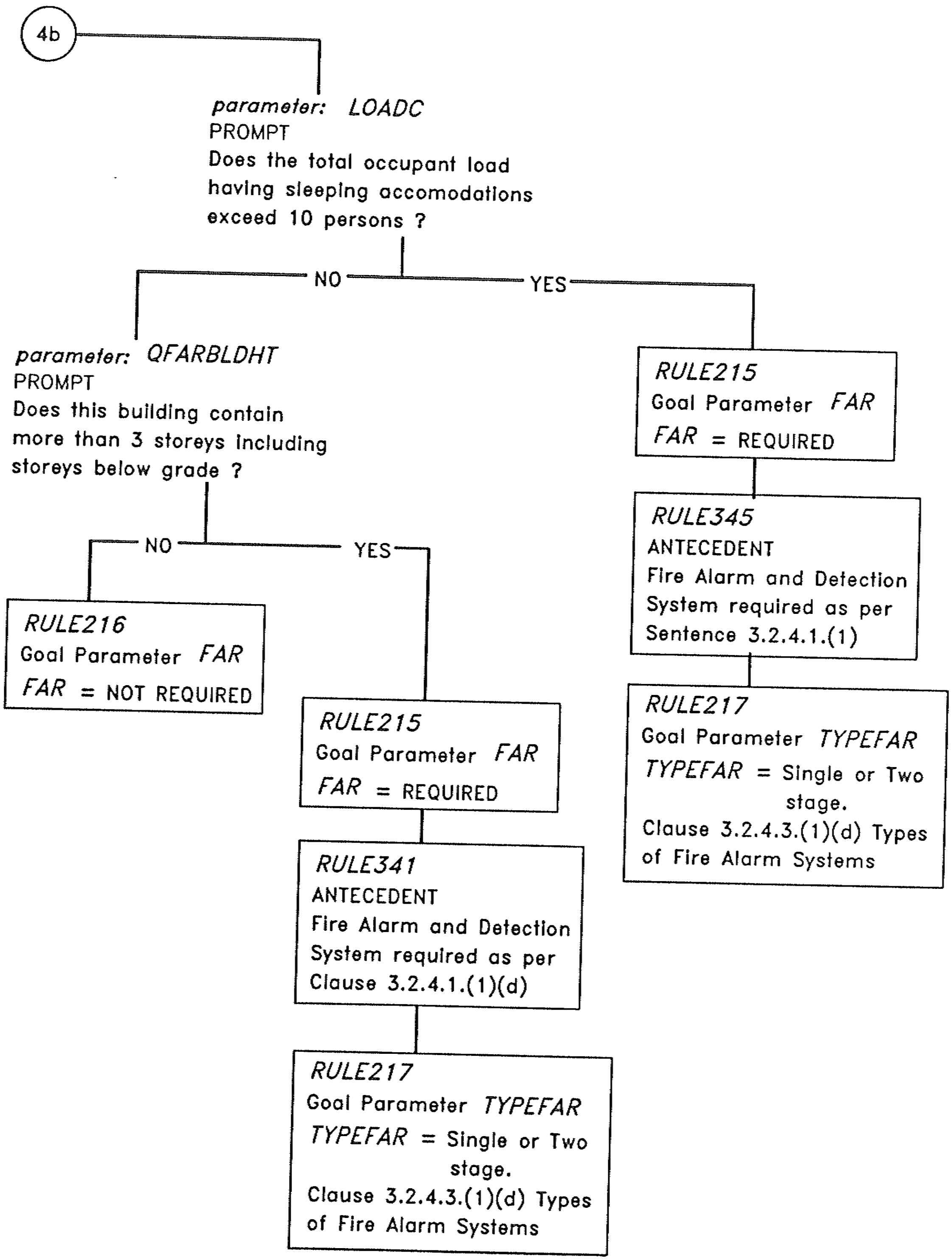
Subsection 3.2.4 Fire Alarm and Detection Systems



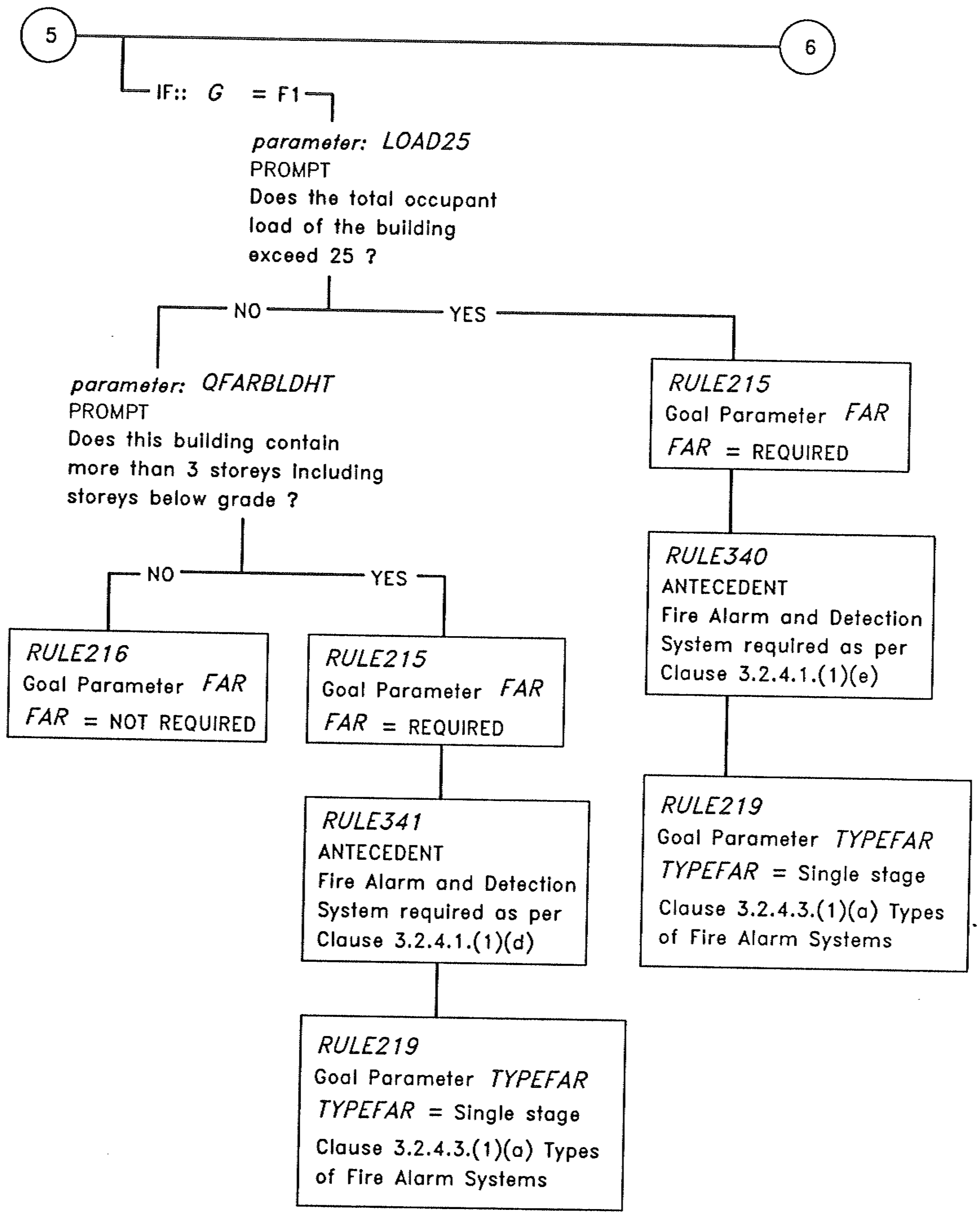
Subsection 3.2.4 Fire Alarm and Detection Systems



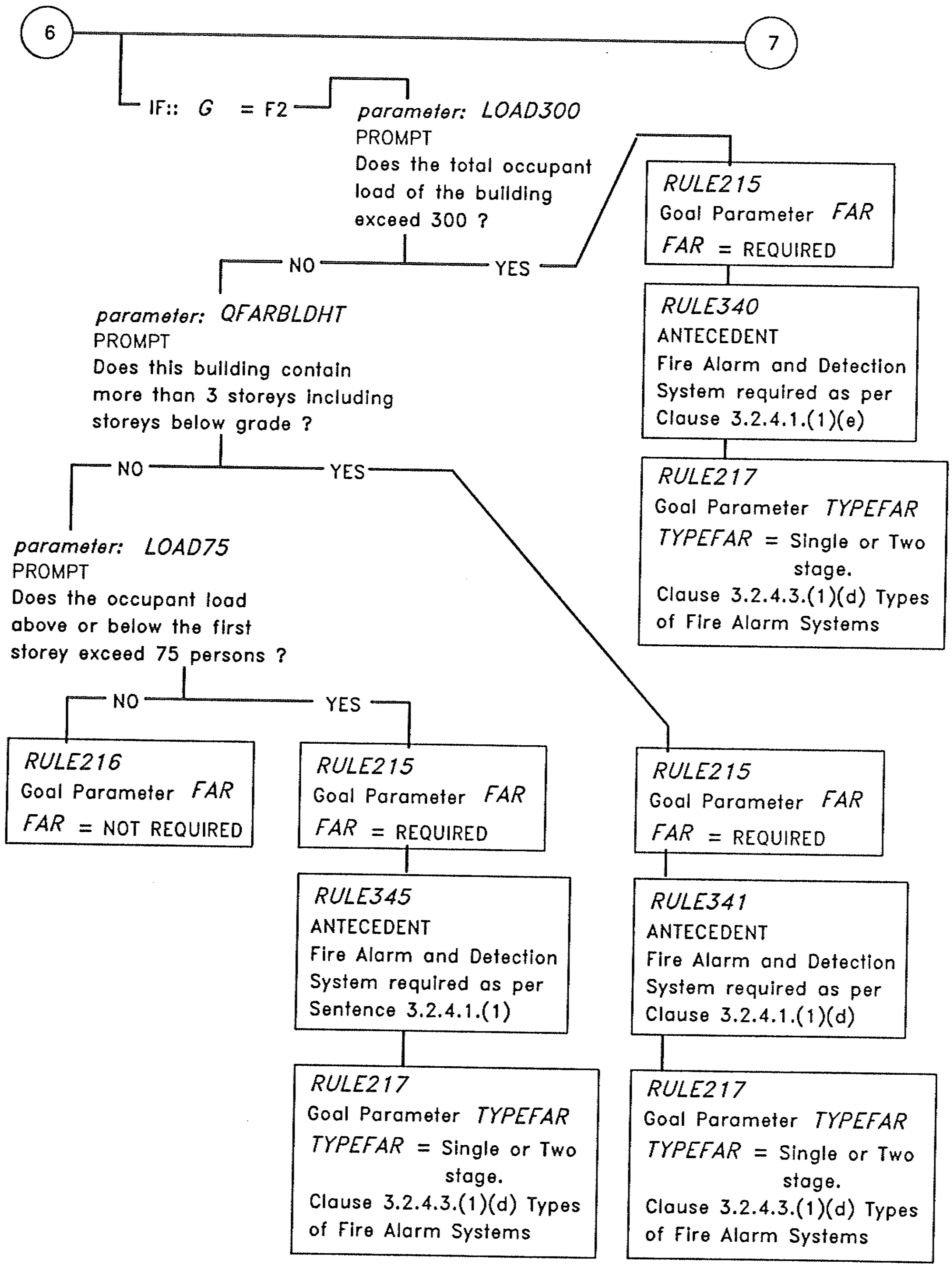
Subsection 3.2.4 Fire Alarm and Detection Systems



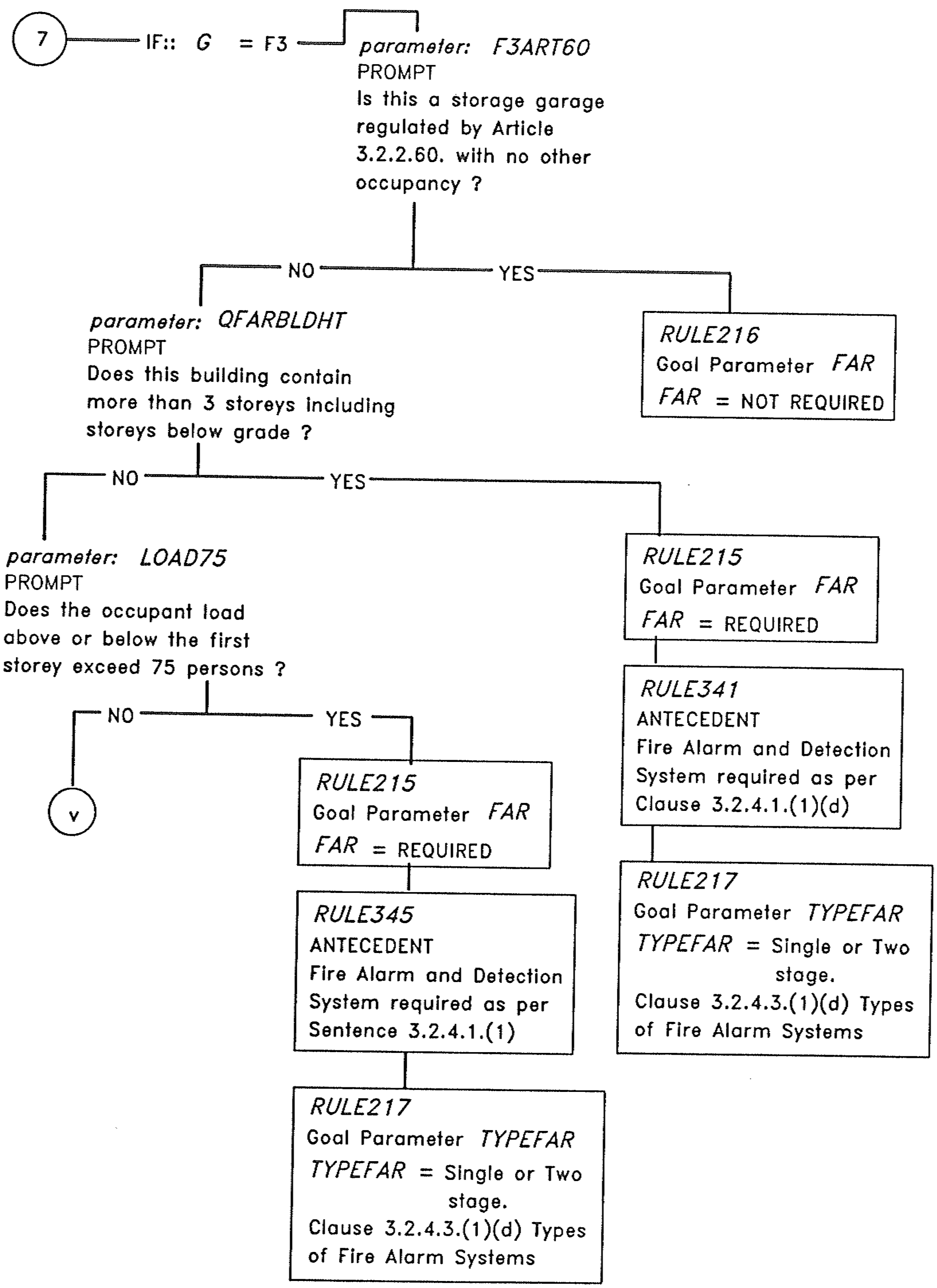
Subsection 3.2.4 Fire Alarm and Detection Systems



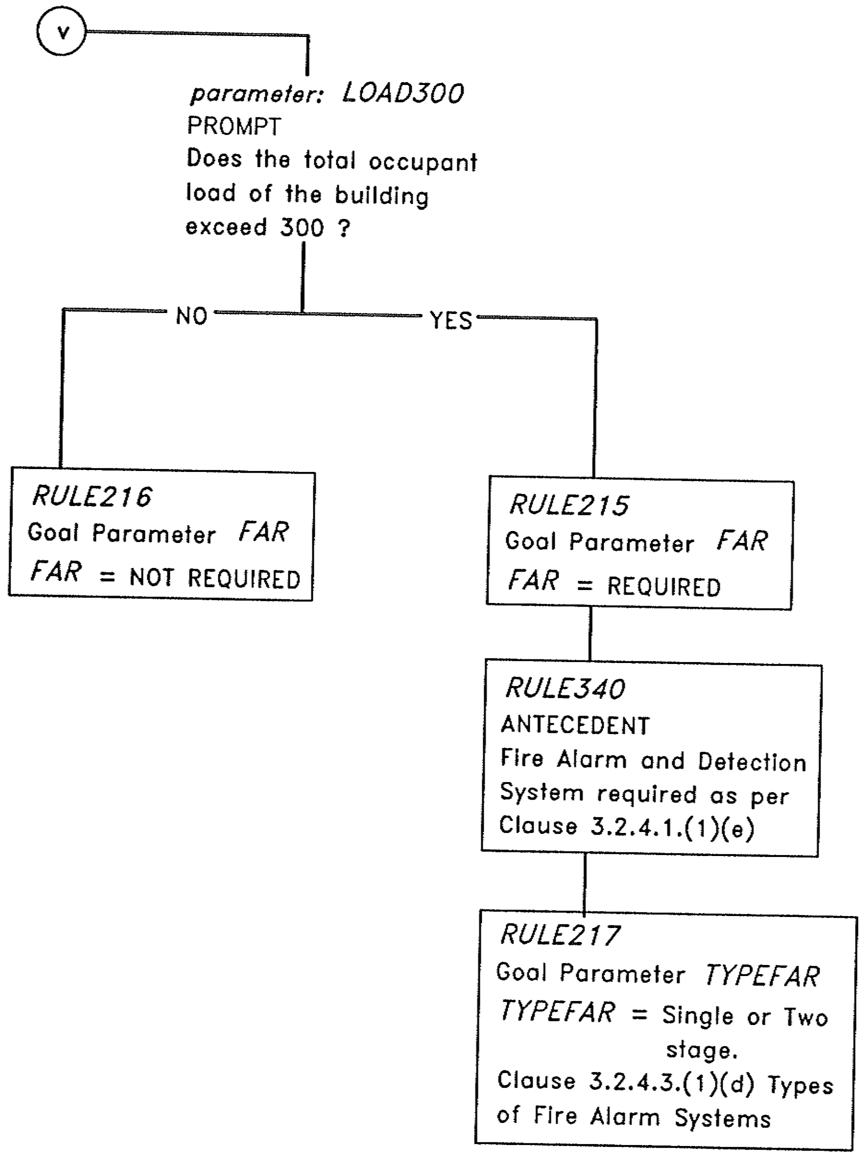
Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems



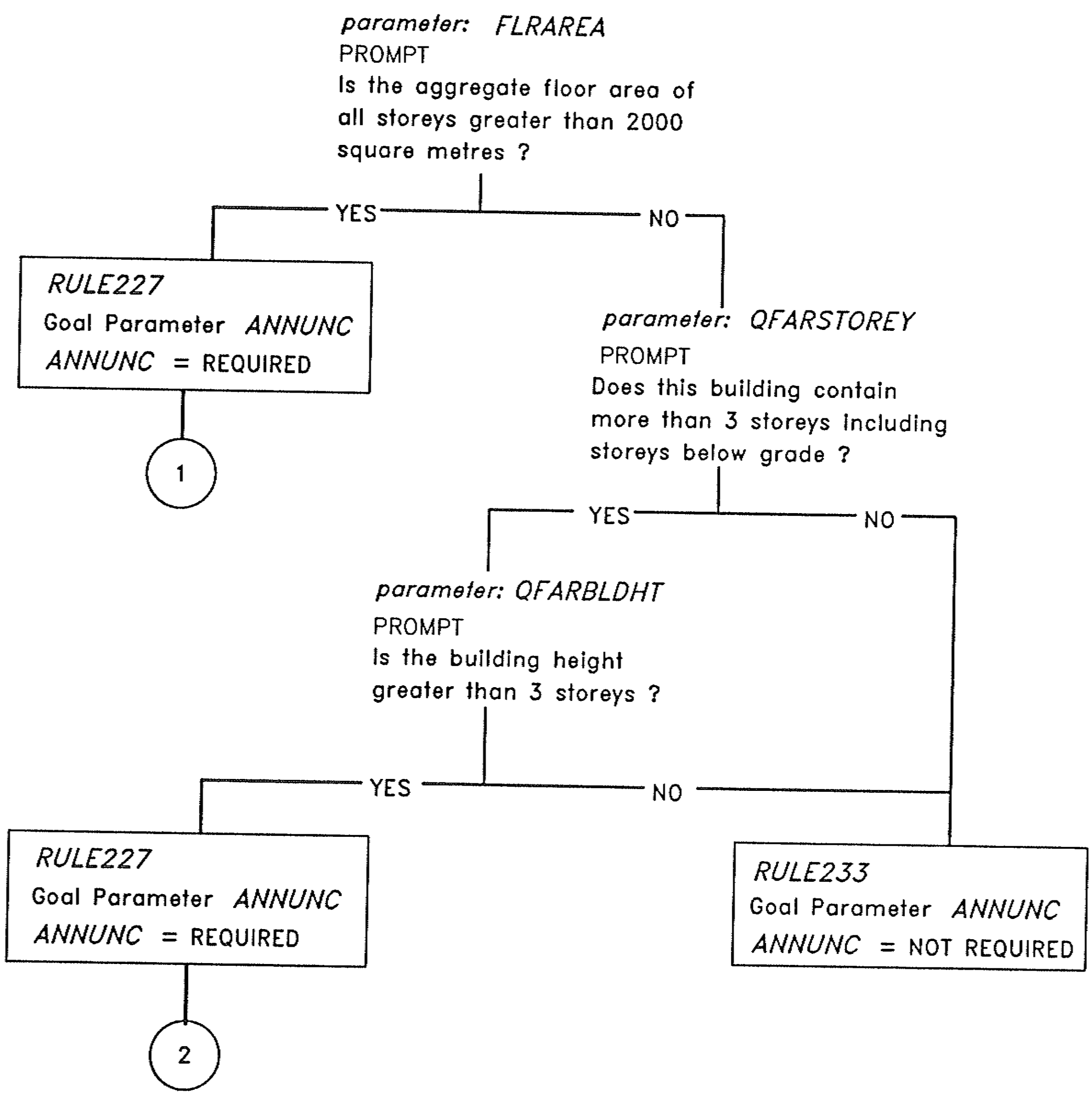
Subsection 3.2.4 Fire Alarm and Detection Systems

Goal parameters to be solved when *FAR* = YES

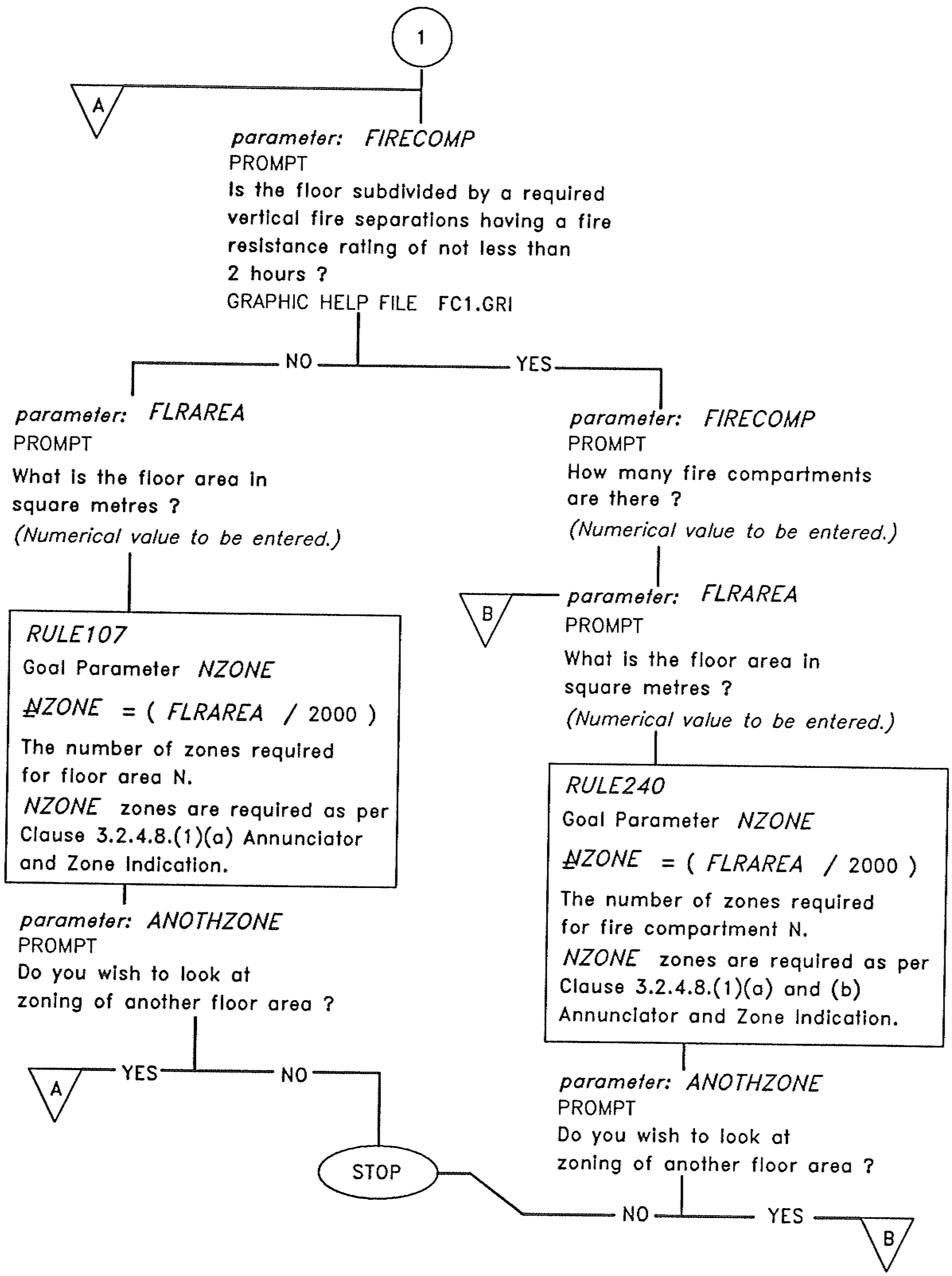
ANNUNC
To determine whether an annunciator is required

NZONE
To determine the number of zones.

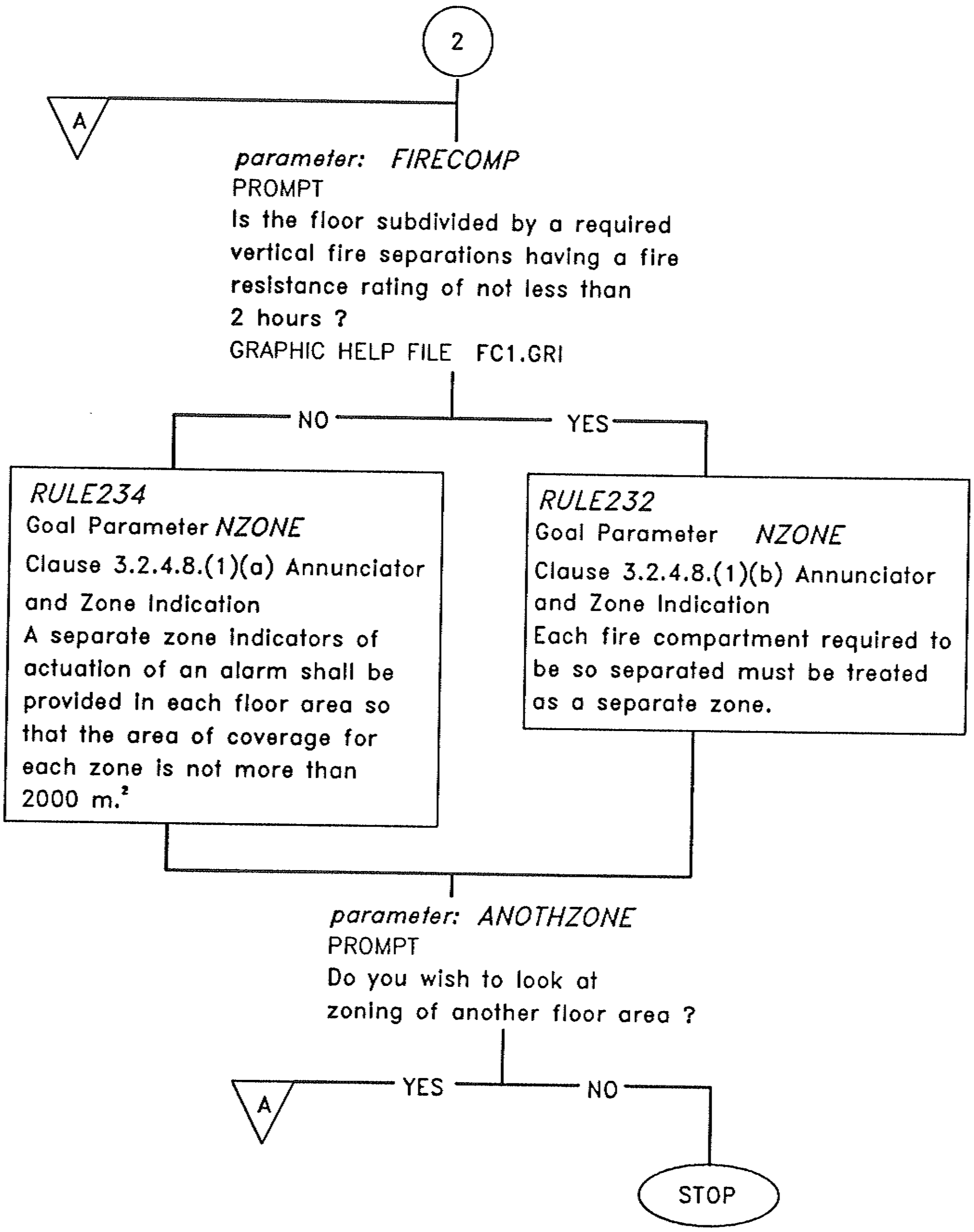
(If the value for parameter QFARBLDHT is known intially)



Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems

Goal parameters to be solved when *FAR* = YES

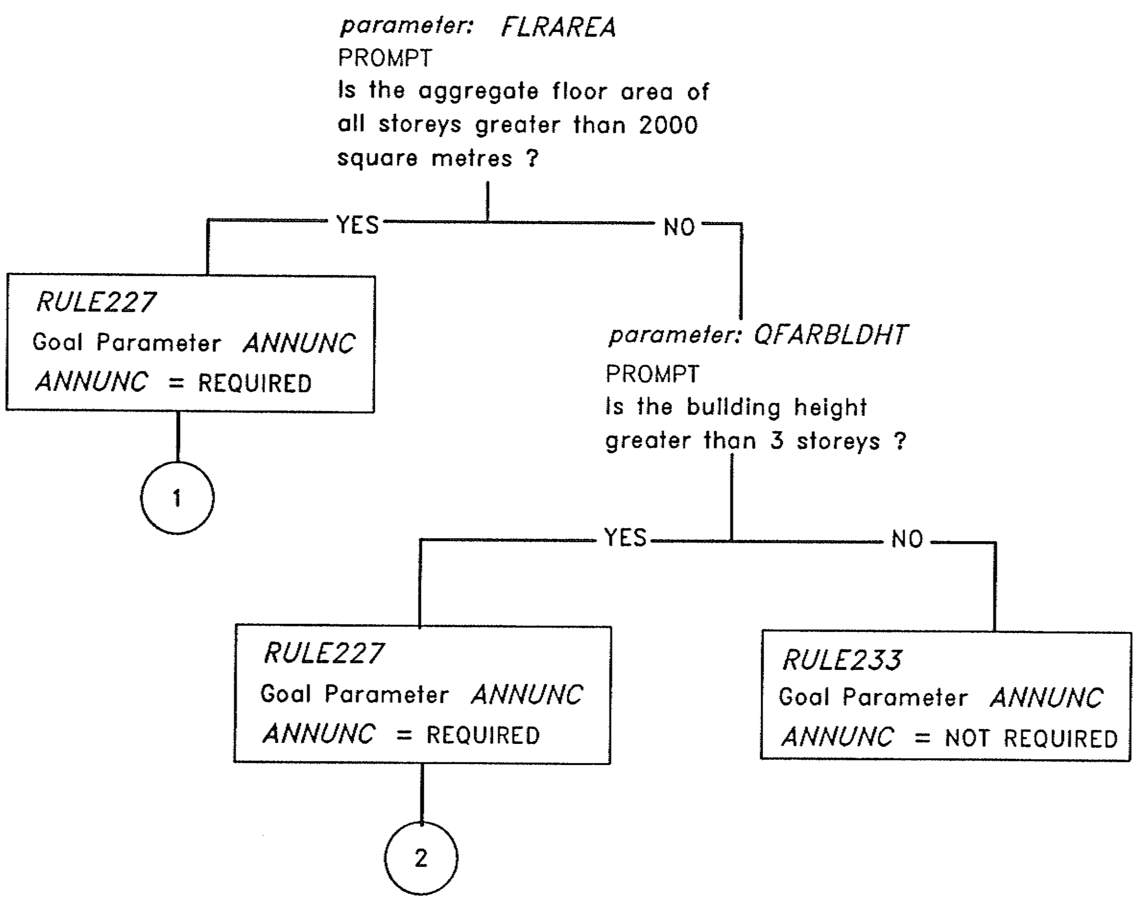
ANNUNC

To determine whether an annunciator is required

NZONE

To determine the number of zones.

(If the value for parameter QFARBLDHT is not known intially)



Subsection 3.2.4 Fire Alarm and Detection Systems

Goal parameters to be solved when *FAR* = YES

ANNUNC = YES

ADDCONIMP

Zone indication required for areas designated as impeded or contained use areas.

ADDAIRSYS

Zone indication required for air handling systems equipped with required smoke detectors.

ADDSHAFT

Zone indication required vertical service shafts.

parameter: CONTIMPED

PROMPT

Are there any contained use areas
or impeded egress zones in this building ?

YES

RULE238
Goal parameter *ADDCONIMP*
contained use areas and impeded egress zones must be indicated by a separate zone on the annunciator panel.

NO

parameter: AIRHANDSYS

PROMPT

Does this building have an air handling system ?

YES

parameter: SDAIRHAND

PROMPT

Is the air handling system required
to be equipped with smoke detectors ?

YES

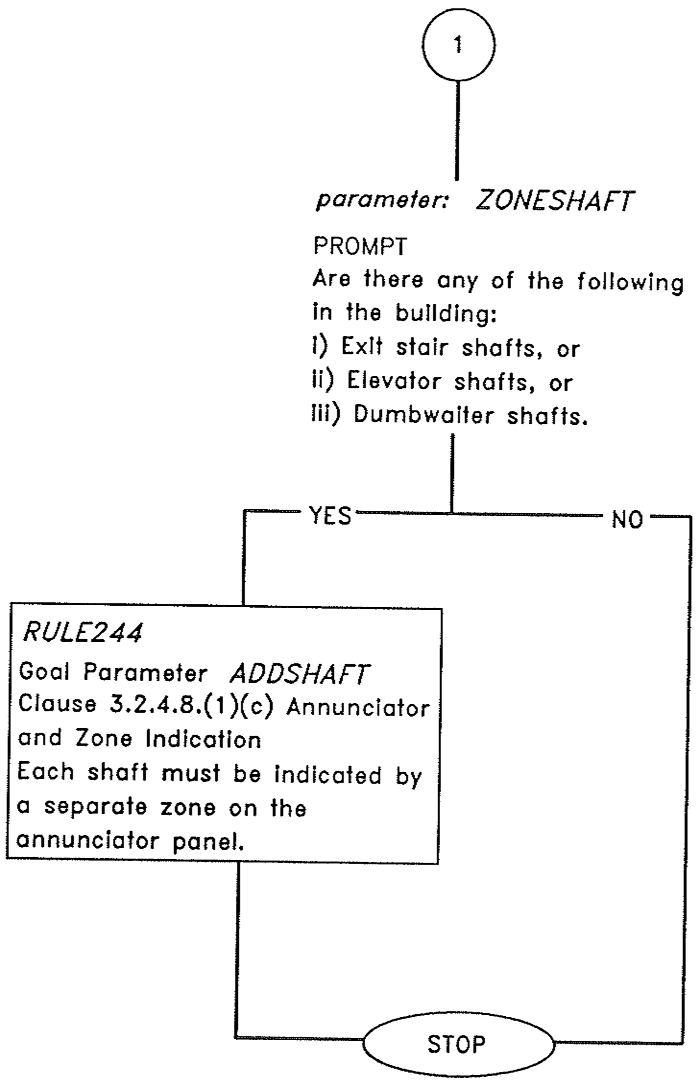
RULE239
Goal parameter *ADDAIRSYS*
Clause 3.2.4.8.(1)(d) Annunciator and Zone Indication
The air handling system must be indicated by a separate zone on the annunciator panel.

NO

NO

1

Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems

parameter: FARFIRWALL
PROMPT
Is the building under consideration
subdivided by firewalls ?
< F1 HELP >
GRAPHIC HELP FILE FIRWALL2.GRI

YES

RULE106
Sentence 3.2.4.2.(1) Continuity of Fire Alarm System
Each portion of a building that is subdivided by a firewall shall be treated as a separate building for the purposes of Subsection 3.2.4., provided there are no openings through the firewall other than for piping, tubing, wiring and totally enclosed raceways.

NO

parameter: QFARBLDHT
PROMPT
Is the building more than
3 storeys in building height ?
< F1 HELP >
GRAPHIC HELP FILE BLDHT.GRI

NO

parameter: QFARSEP
PROMPT
Is the building subdivided by any vertical 1 hour fire separations that are continuous through all storeys of the building and having no openings through the fire separation other than for piping, tubing, wiring and totally enclosed raceways ?

YES

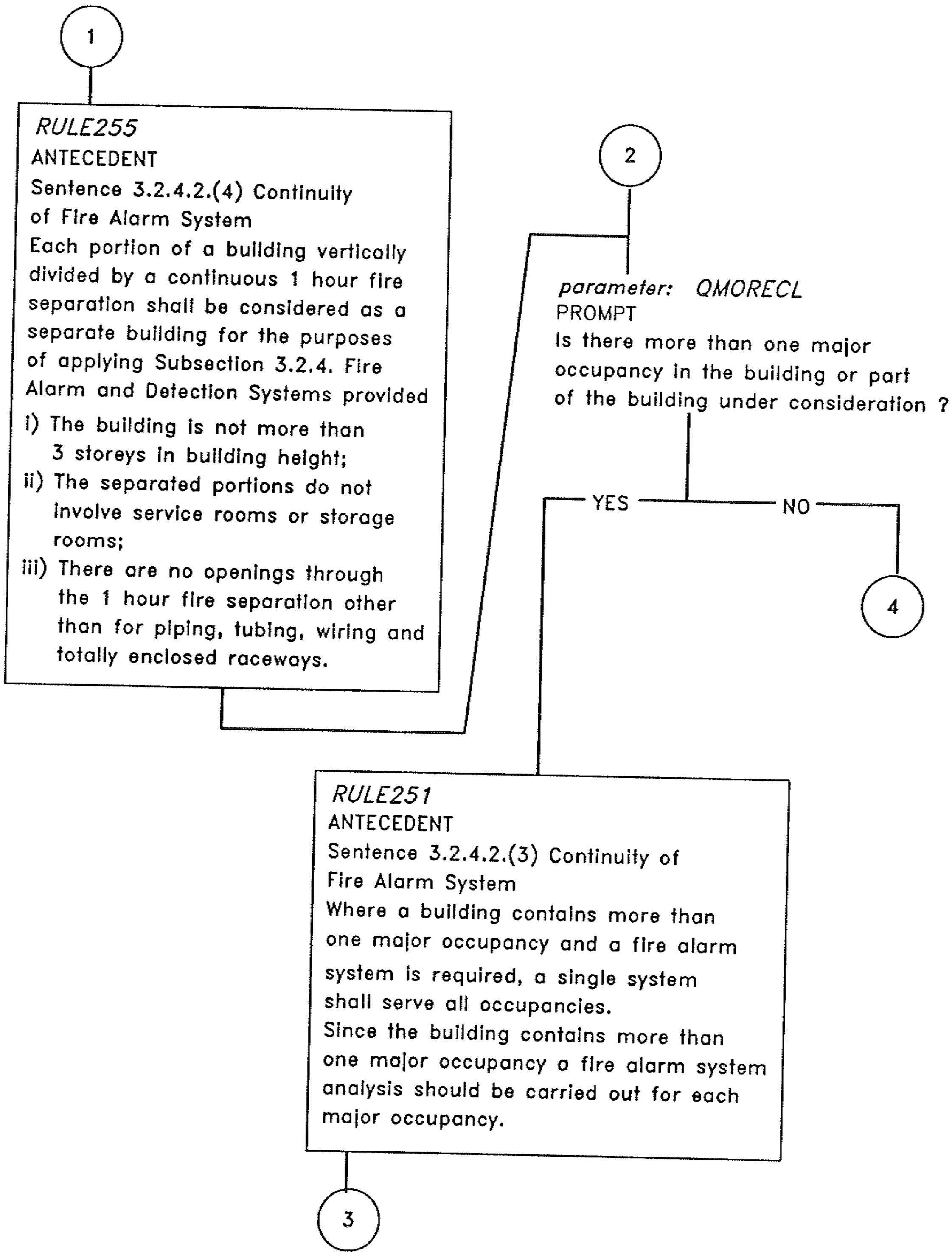
1

NO

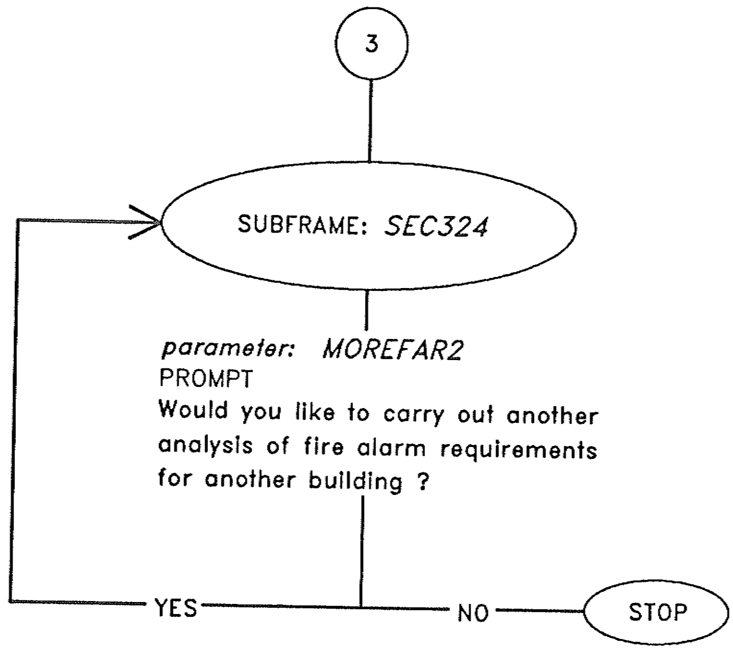
YES

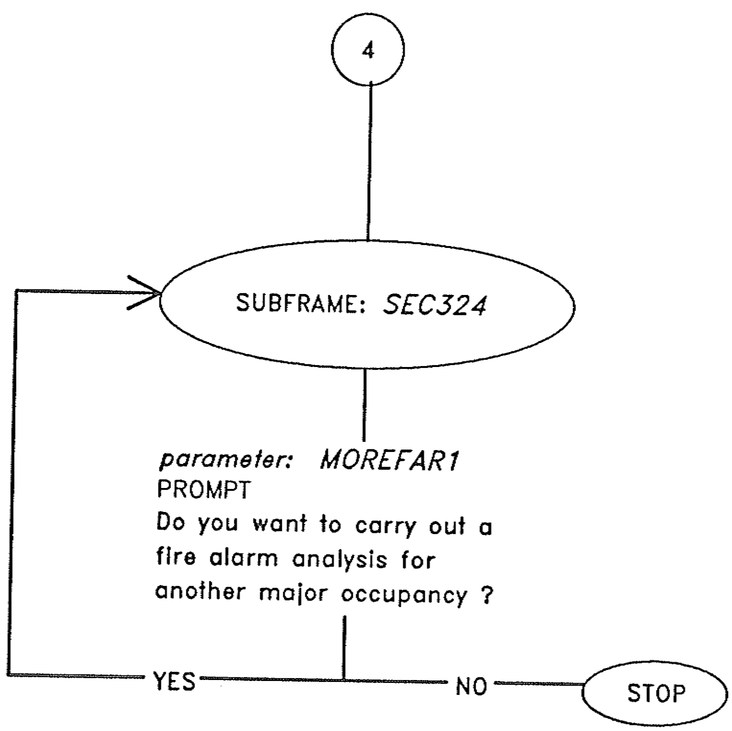
2

Subsection 3.2.4 Fire Alarm and Detection Systems



Subsection 3.2.4 Fire Alarm and Detection Systems





Spatial Separation and Exposure Protection of Buildings Subsection 3.2.3.

Goal parameters to be solved *TREACH*
Double percentage of unprotected opens for fire fighting facilities reaching building within 10 minutes.

EXPOSE
To determine the area of exposing building face to be used.

LIMSTRATE
To determine if a fire-resistance rating for an exposing building face, facing a street is required.

WGLASS
Double percentage of unprotected openings permitted if wire glazing or glass block is used.

COMBPROJ
Additional requirements for combustible projections.

parameter: TIME
PROMPT
Can fire fighting facilities reach the building within 10 minutes of the alarm being received ?

YES — NO

RULE446
Goal Parameter *TREACH*
Sentence 3.2.3.1.(5) Limiting Distance and Area of Unprotected Openings
Calculations need not be adjusted.

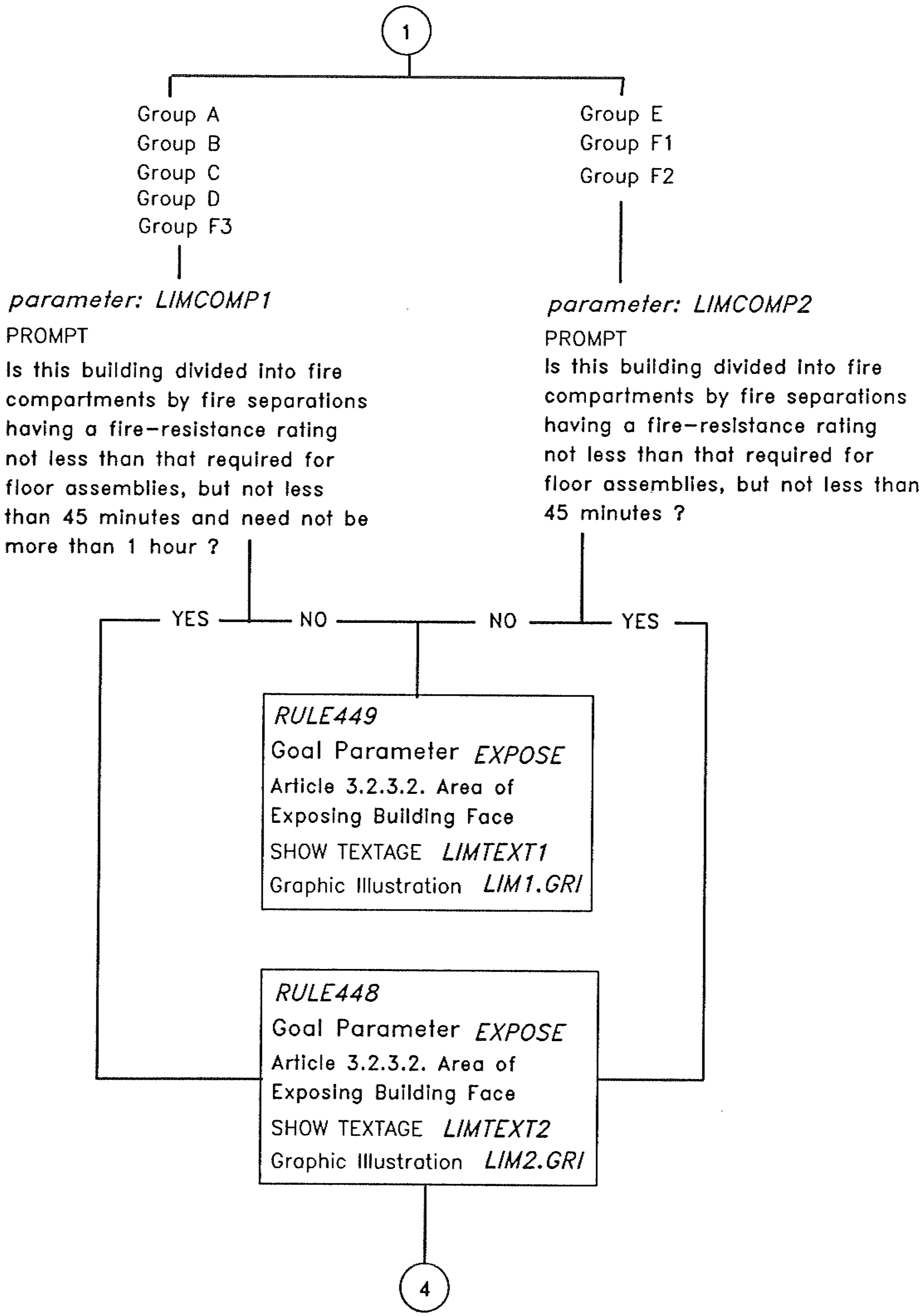
RULE447
Goal Parameter *TREACH*
Sentence 3.2.3.1.(5) Limiting Distance and Area of Unprotected Openings
Calculations may doubled.

parameter: LIMOCC
PROMPT
What is the building major classification ?

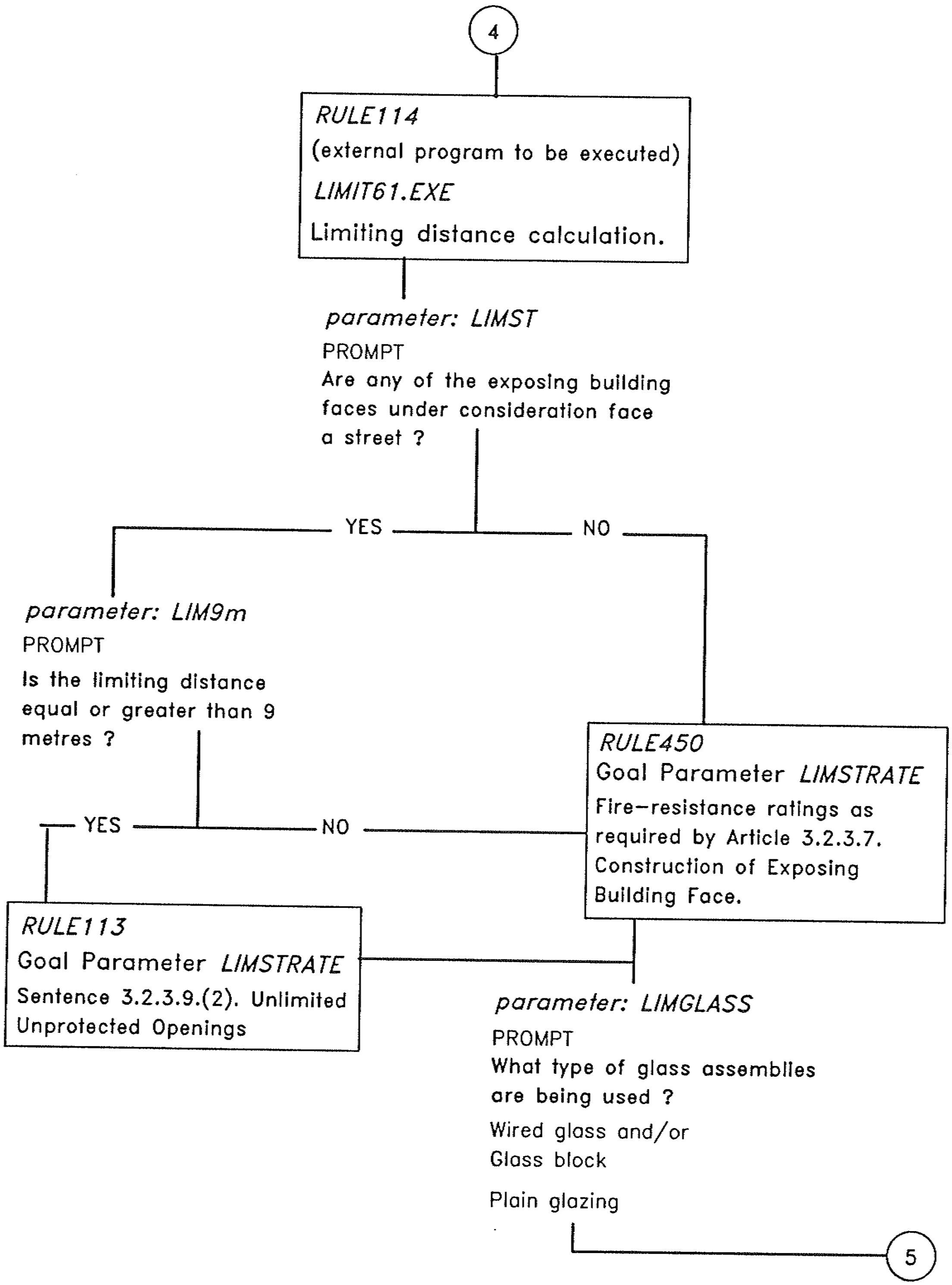
Group A
Group B
Group C
Group D
Group E
Group F1
Group F2
Group F3

1

Spatial Separation and Exposure Protection of Buildings Subsection 3.2.3.



Spatial Separation and Exposure Protection of Buildings Subsection 3.2.3.



Spatial Separation and Exposure Protection of Buildings Subsection 3.2.3.

5

Wired glass and/or Glass block

Plain glazing

RULE451
Goal Parameter *WGLASS*
Sentence 3.2.3.11.(2) Increasing Openings Permitted
The maximum area of unprotected openings in any exposing building face is permitted to be doubled where such openings are glazed with glass block or with wired glass conforming to the requirements of Article 3.1.8.14. Wired Glass and Glass Block

RULE452
Goal Parameter *WGLASS*
Sentence 3.2.3.11.(2). Increasing Openings Permitted
The maximum area of unprotected openings in any exposing building face as specified in calculations.

parameter: LIMPROJ
PROMPT
Is there any combustible projections on the exterior wall that are more than 1 metre above grade level such as

- Balconies,
- Platforms,
- Canopies,
- Eave projections and
- Stairs.

6

Spatial Separation and Exposure Protection of Buildings Subsection 3.2.3.

6

YES

RULE453

Goal Parameter *COMBPROJ*

Article 3.2.3.6. Combustible Projection Restrictions

Such combustible projections could expose an adjacent building to fire spread, shall not be permitted within 1.2 metres of the property line or the centreline of a public way, or within 2.4. metres of a combustible projection on another building on the same property.

SHOW TEXTAGE *LIMTEXT3*

NO

parameter: LIMSTRUC

PROMPT

Are there structural members, such as beams, columns and arches placed wholly or partly outside an exterior face of a building

< F1 HELP >

NO

RULE454

Goal Parameter *COMBPROJ*

There is no other additional requirements for spatial separation to consider.

YES

RULE455

Goal Parameter *COMBPROJ*

Sentence 3.2.3.8.(2) Protection of Structural Members

Structural members that are less than 3 metres from the property line or centreline of a public thoroughfare shall be protected from exterior fire by fire protection having a fire-resistance rating not less than that required for their protection from inside fires in conformance with Articles 3.2.2.16. to 3.2.2.60. or by fire protection having a fire-resistance of not less than 1 hour, or which ever is the greater.

Sentence 3.2.3.8.(3). Structural members of heavy timber construction need not be covered with noncombustible cladding.

Standpipe and Hose Systems

Goal parameters to be solved *STAND*

To determine whether a standpipe and hose system is required.

STANCLASS

To determine the standpipe and hose system classification.

NUMSTAND

To determine the number of hose stations.

HOSESTA

To determine the hose station locations.

TROUBLE

To determine whether a trouble signal to the fire alarm annunciator panel is required.

FIRECONN

Fire department connection requirements to standpipe and hose system.

STANSIZE

To determine the diameter of standpipe required.

STANZONE

To determine the number standpipe zones required.

parameter: STANOCC

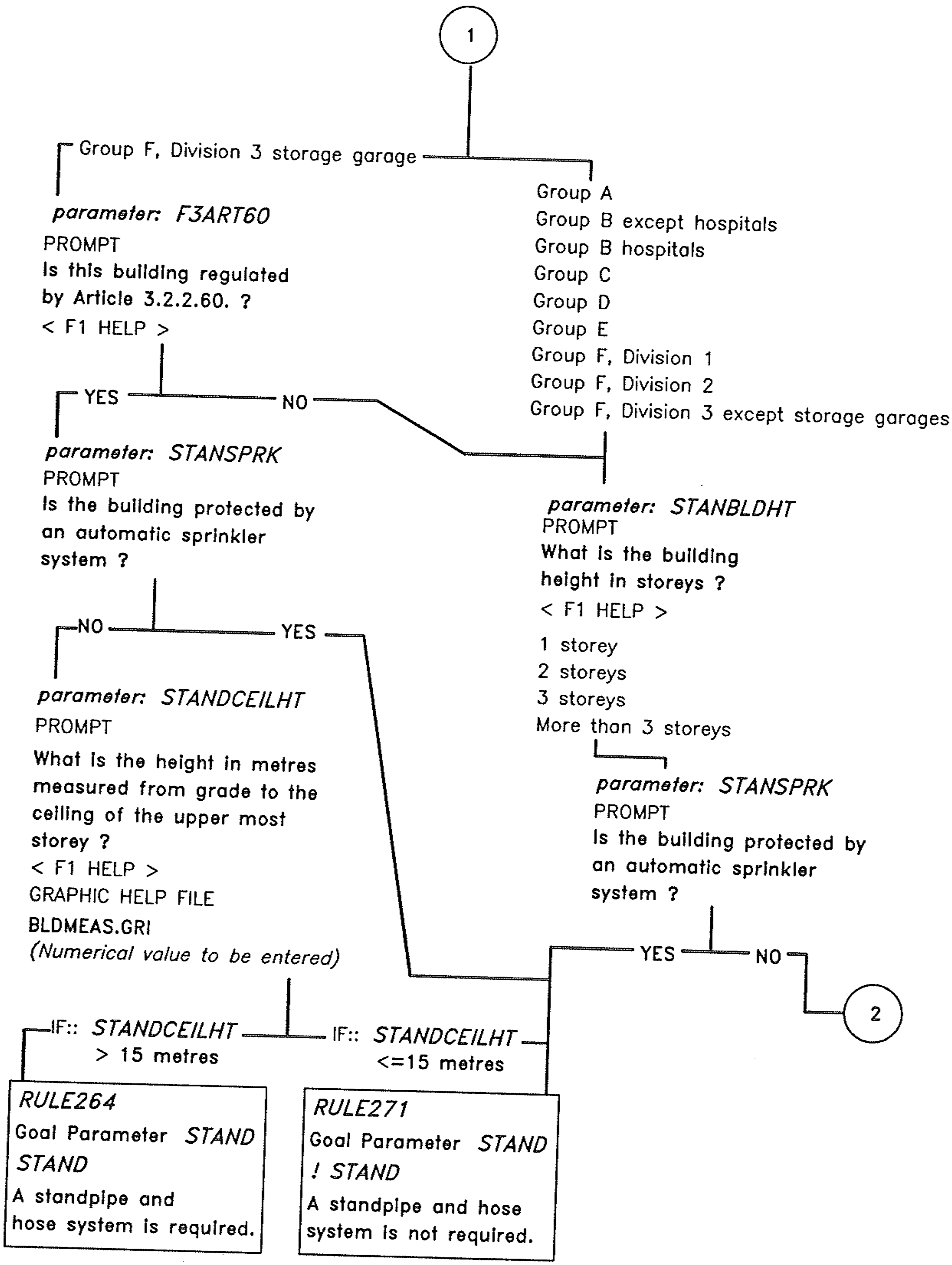
PROMPT

What is the occupancy classification ?

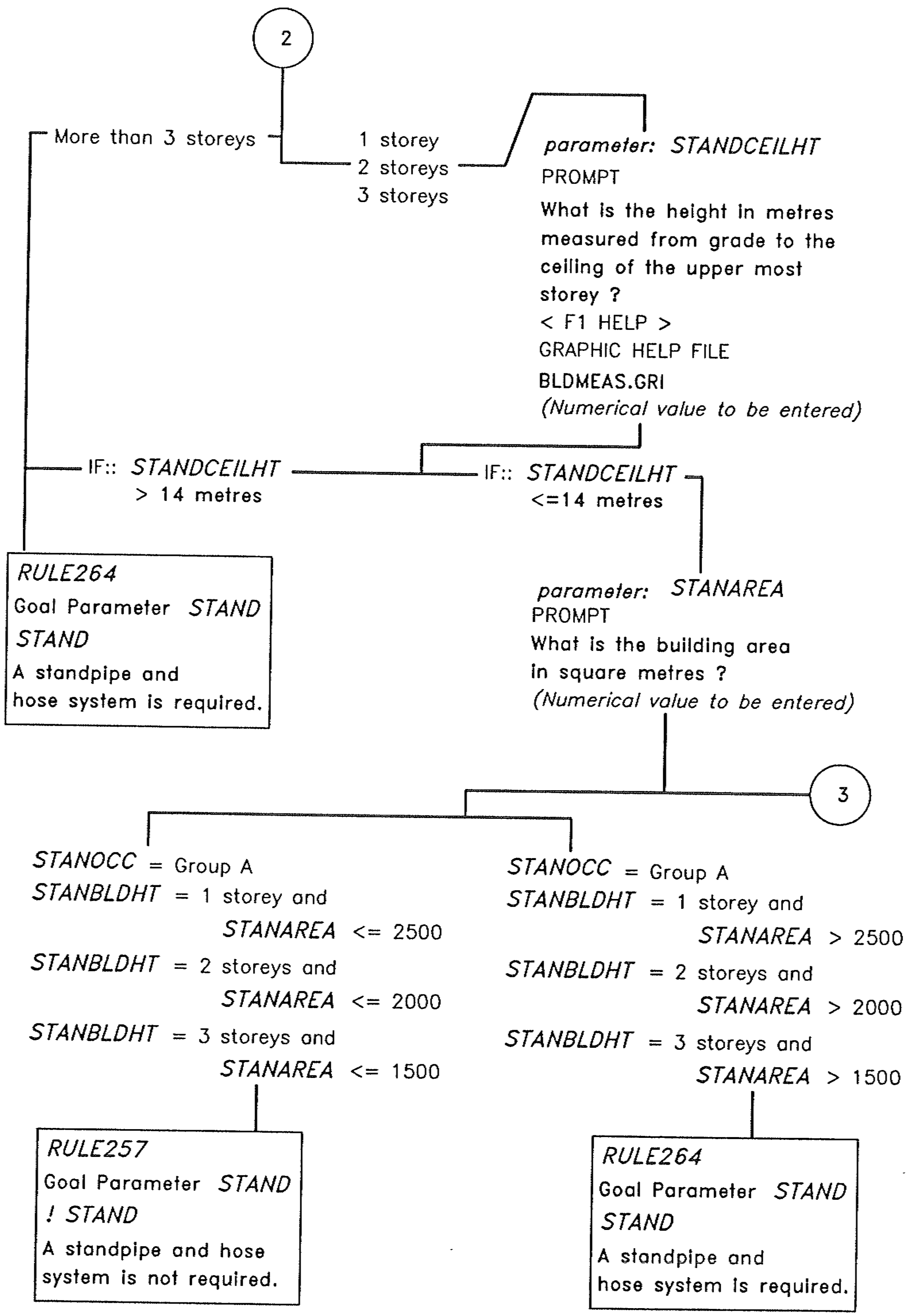
Group A
Group B except hospitals
Group B hospitals
Group C
Group D
Group E
Group F, Division 1
Group F, Division 2
Group F, Division 3 except storage garages
Group F, Division 3 storage garage

1

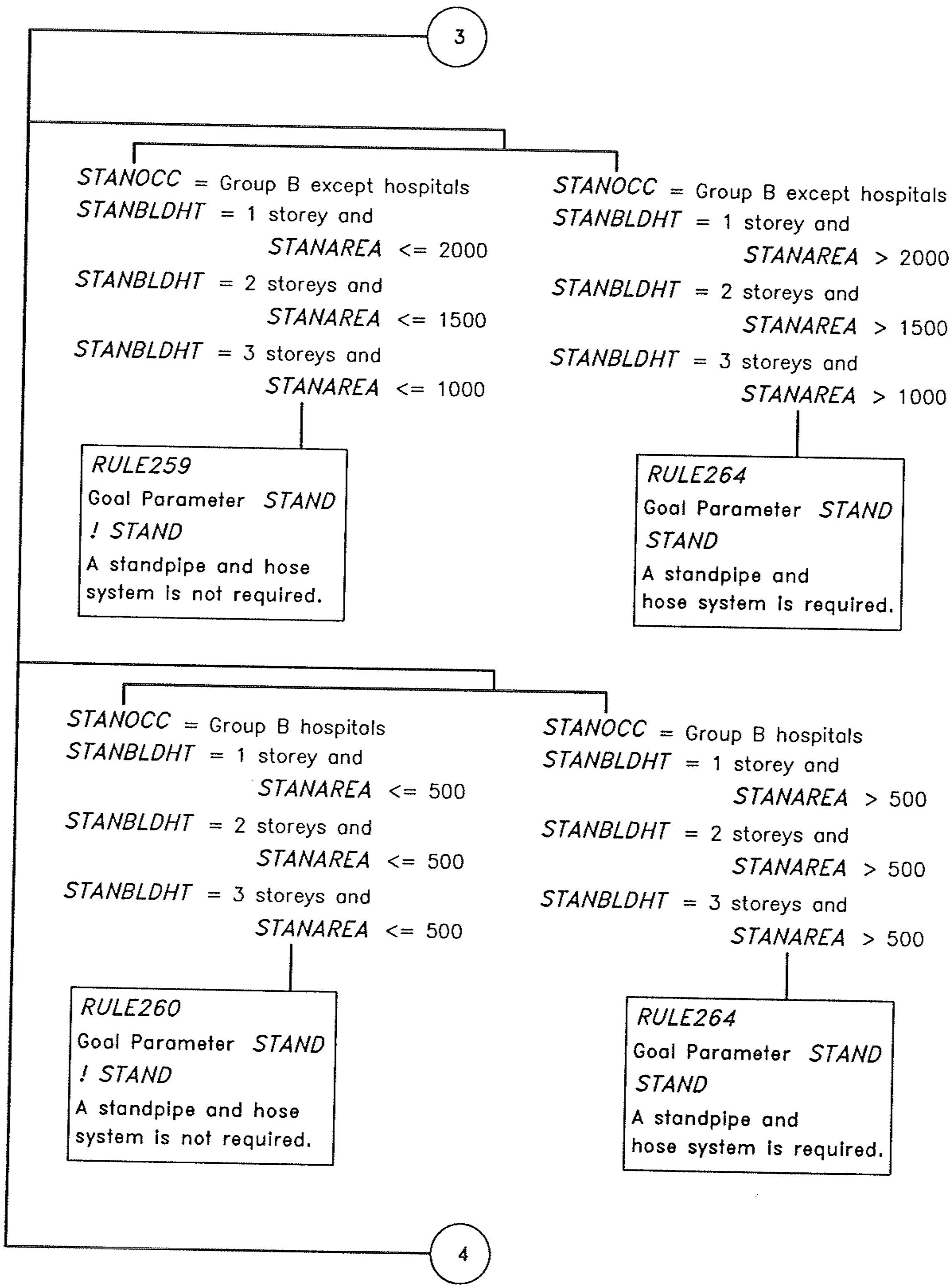
Standpipe and Hose Systems



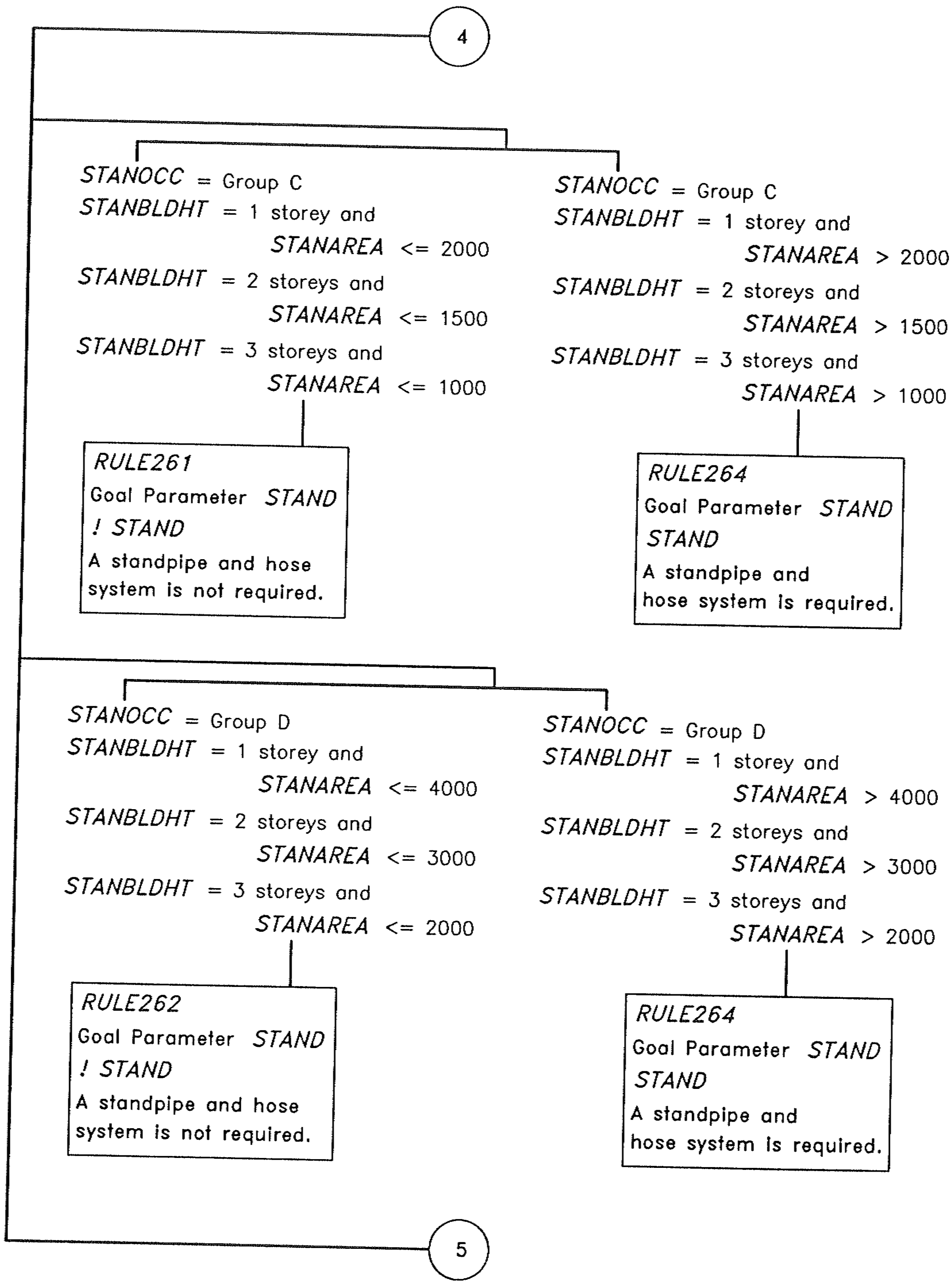
Standpipe and Hose Systems



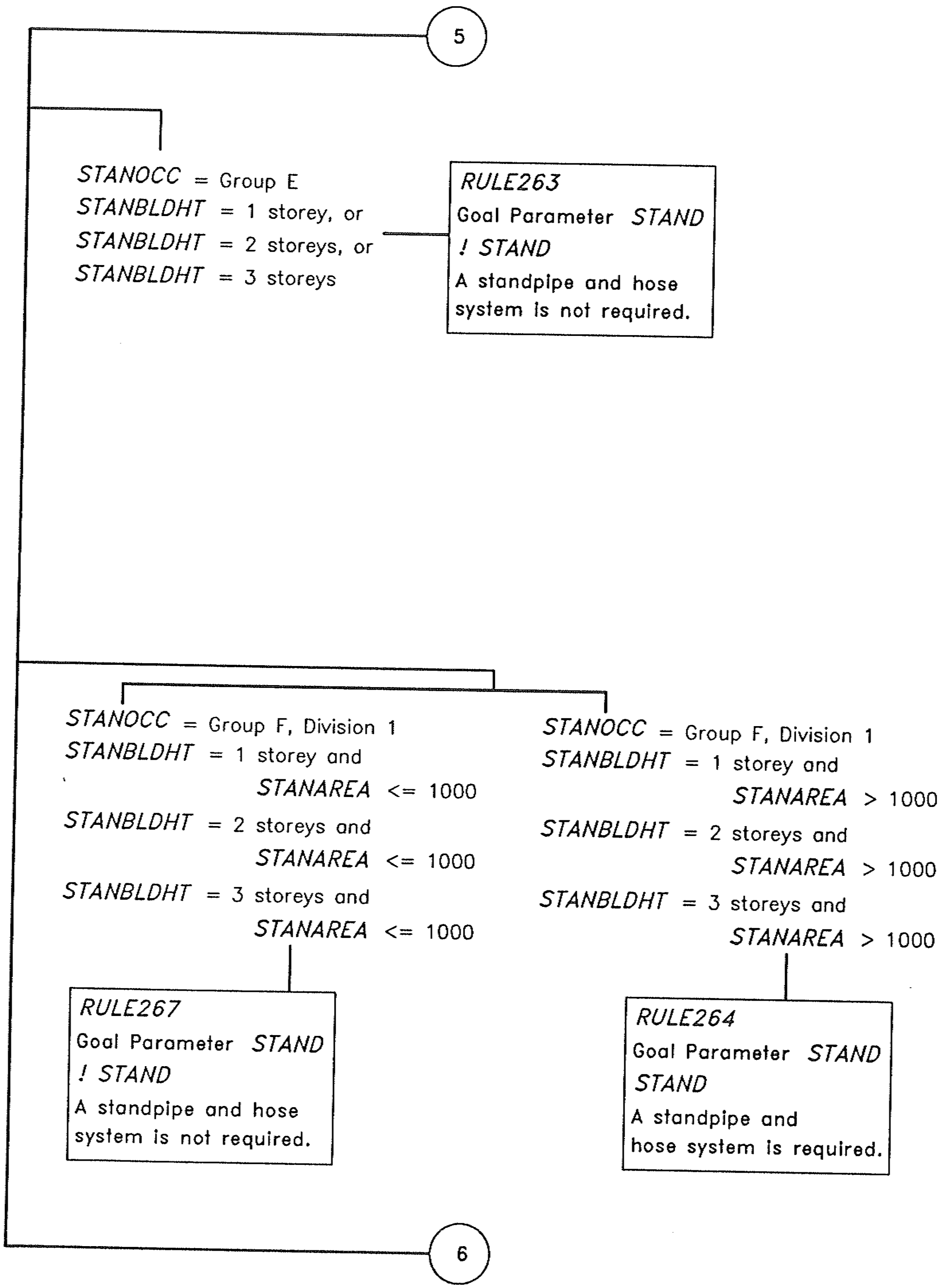
Standpipe and Hose Systems



Standpipe and Hose Systems



Standpipe and Hose Systems



Standpipe and Hose Systems

6

STANOCC = Group F, Division 2
STANBLDHT = 1 storey and *STANAREA* <= 2000
STANBLDHT = 2 storeys and *STANAREA* <= 1500
STANBLDHT = 3 storeys and *STANAREA* <= 1000

RULE265
Goal Parameter *STAND*
! STAND
A standpipe and hose system is not required.

STANOCC = Group F, Division 2
STANBLDHT = 1 storey and *STANAREA* > 2000
STANBLDHT = 2 storeys and *STANAREA* > 1500
STANBLDHT = 3 storeys and *STANAREA* > 1000

RULE264
Goal Parameter *STAND*
STAND
A standpipe and hose system is required.

STANOCC = Group F, Division 3 except storage garages
STANBLDHT = 1 storey and *STANAREA* <= 3000
STANBLDHT = 2 storeys and *STANAREA* <= 2000
STANBLDHT = 3 storeys and *STANAREA* <= 1000

RULE266
Goal Parameter *STAND*
! STAND
A standpipe and hose system is not required.

STANOCC = Group F, Division 3 except storage garages
STANBLDHT = 1 storey and *STANAREA* > 3000
STANBLDHT = 2 storeys and *STANAREA* > 2000
STANBLDHT = 3 storeys and *STANAREA* > 1000

RULE264
Goal Parameter *STAND*
STAND
A standpipe and hose system is required.

Standpipe and Hose Systems

parameter: *STANCEILHT*
PROMPT
What is the height in metres
measured from grade to the ceiling
of the upper most storey ?
< F1 HELP >
GRAPHIC HELP FILE
BLDMEAS.GRI
(Numerical value to be entered)

IF:: *STANCEILHT* <= 25

IF:: *STANCEILHT* > 25

parameter: *STANAREA*
PROMPT
What is the building area
in square metres ?
(Numerical value to be entered)

IF:: *STANAREA* <= 4000

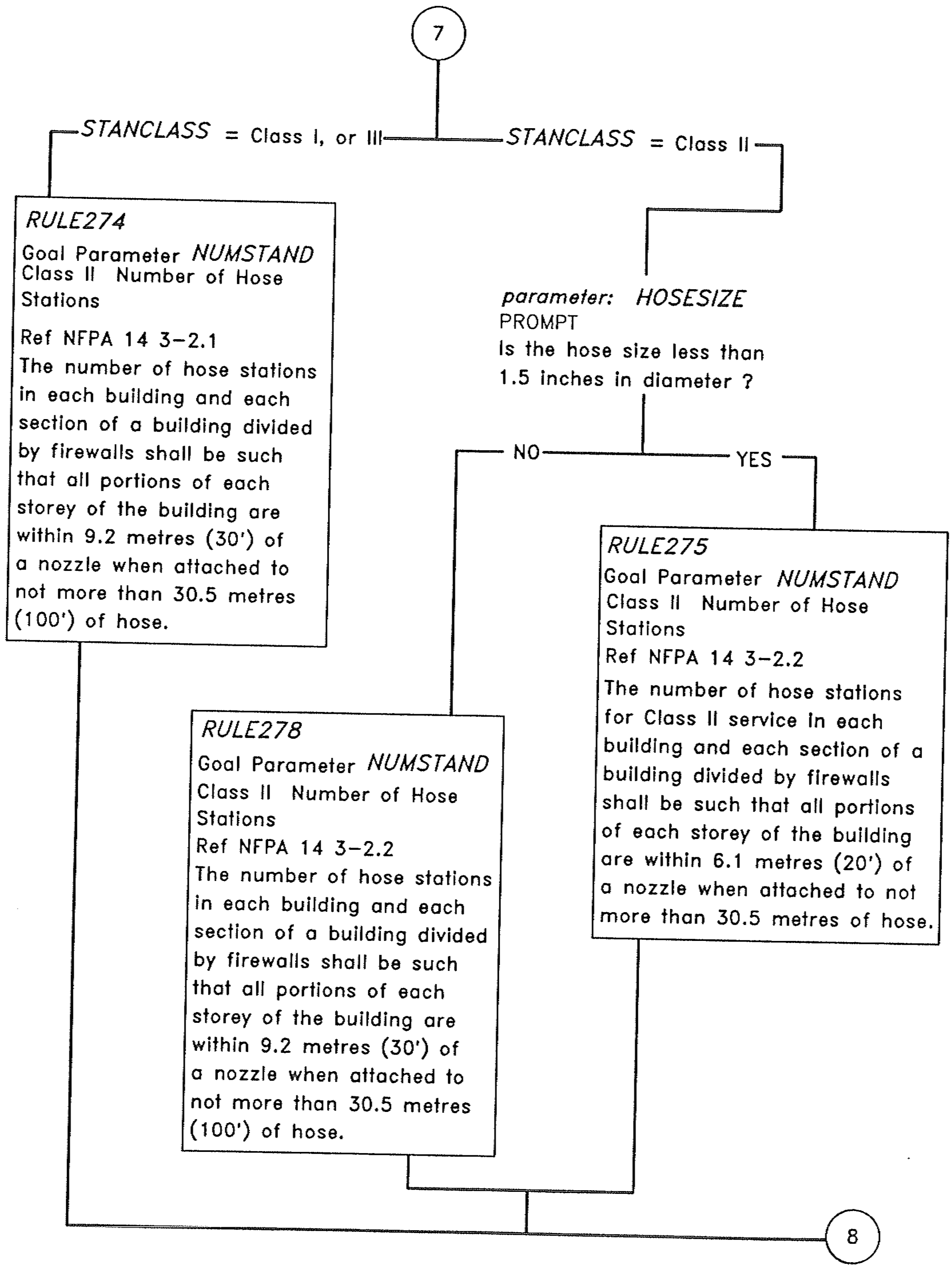
IF:: *STANAREA* > 4000

RULE273
Goal Parameter *STANCLASS*
3.2.5.10 Standpipe and Hose
System Design.
Standpipe classifications that
may be used are:
Class I, or
Class II, or
Class III

RULE272
Goal Parameter *STANCLASS*
3.2.5.10 Standpipe and Hose
System Design.
Standpipe classifications that
may be used are:
Class I, or
Class III

7

Standpipe and Hose Systems



Standpipe and Hose Systems

parameter: *PRESSEXIT*

PROMPT

Are any of the exit stairs
in this building required to
be protected by pressurized
vestibules ?

< F1 HELP >

NO — YES

NO	YES
RULE277 Goal Parameter *HOSESTA* 3.2.5.11.(1) Hose Stations and Cabinets hose stations are required to located in or near exits.	*RULE276* Goal Parameter *HOSESTA* 3.2.5.11.(1) Hose Stations and Cabinets Where a pressurized vestibule is provided adjacent to exit stairs the hose station shall be located within the pressurized vestibule.

Standpipe and Hose Systems

parameter: *STANFAR*
PROMPT
Is this building required
to have a fire alarm
system ?

NO — YES

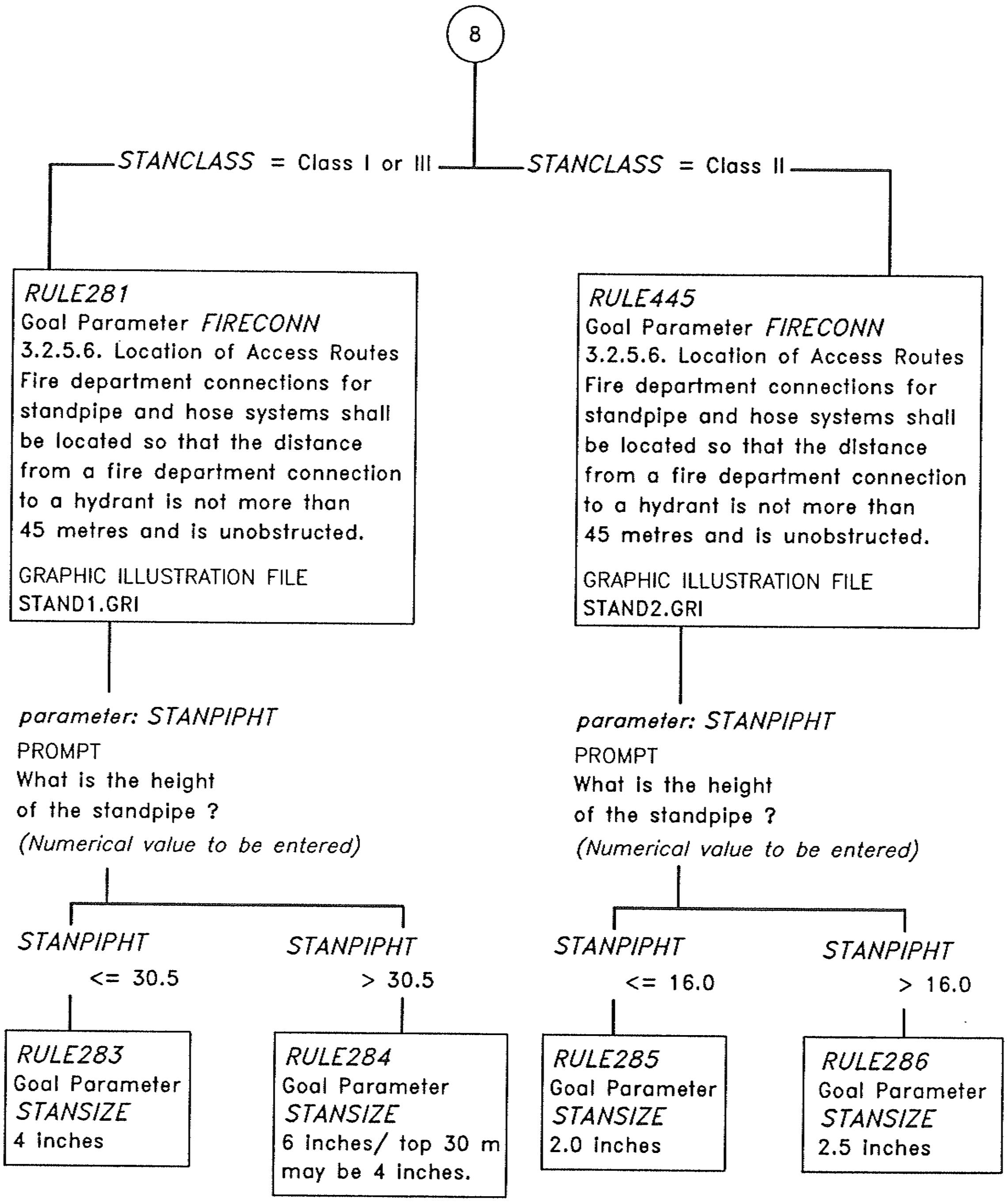
parameter: *STANANNUN*
PROMPT
Is the fire alarm system
required to have an
annunciator ?

NO — YES

RULE280
Goal Parameter *TROUBLE*
! TROUBLE
3.2.5.12. Trouble Singal
Annunciator for Valves
An electrically supervised
switch for transmitting a
trouble signal to the annunciator
in the event of movement of the
valve is not required.

RULE279
Goal Parameter *TROUBLE*
TROUBLE
3.2.5.12. Trouble Singal
Annunciator for Valves
Where a fire alarm system is
required to have an annunciator
by Sentence 3.2.4.8.(1), except
for hose valves, all valves
controlling water supplies in a
standpipe and hose system shall
be equipped with an electrically
supervised switch for transmitting
a trouble signal to the
annunciator in the event of
movement of the valve.

Standpipe and Hose Systems



Standpipe and Hose Systems

parameter: STANCEILHT
PROMPT
What is the height in metres
measured from grade to the ceiling
of the upper most storey ?
< F1 HELP >
GRAPHIC HELP FILE
BLDMEAS.GRI
(Numerical value to be entered)

IF:: *STANCEILHT* > 70

IF:: *STANCEILHT* <= 70

RULE287
Goal Parameter *STANZONE*
Single zone permitted
provided the standpipe
height does not exceed
83.6 metres.

parameter: STANPIPHT
PROMPT
What is the height
of the standpipe ?
(Numerical value to be entered)

IF:: *STANPIPHT* > 86.3

IF:: *STANPIPHT* <= 86.3

RULE289
Goal Parameter *STANZONE*
A multi zone standpipe is
required.

RULE288
Goal Parameter *STANZONE*
A single zone standpipe
is permitted.

Firewalls Subsection 3.1.10.

Goal parameters to be solved *FRRFW*

To determine the fire–resistance rating for a fire wall.

PARAPET

To determine the required parapet height for a fire wall penetrating the roof assembly.

OPENING

To determine the aggregate width of openings permitted in a firewall.

FWCONST

Firewall construction details.

parameter: FWOCC

PROMPT

Does the building contain a Group E, or Group F, Division 1 or 2 occupancy?

YES

RULE302
Goal Parameter *FRRFW*
Sentence 3.1.10.2.(1). and (3)
Prevention of Firewall Collapse
Fire–resistance rating required
4 hours.

NO

RULE303
Goal Parameter *FRRFW*
Sentence 3.1.10.2.(1). and (2)
Prevention of Firewall Collapse
Fire–resistance rating required
2 hours.

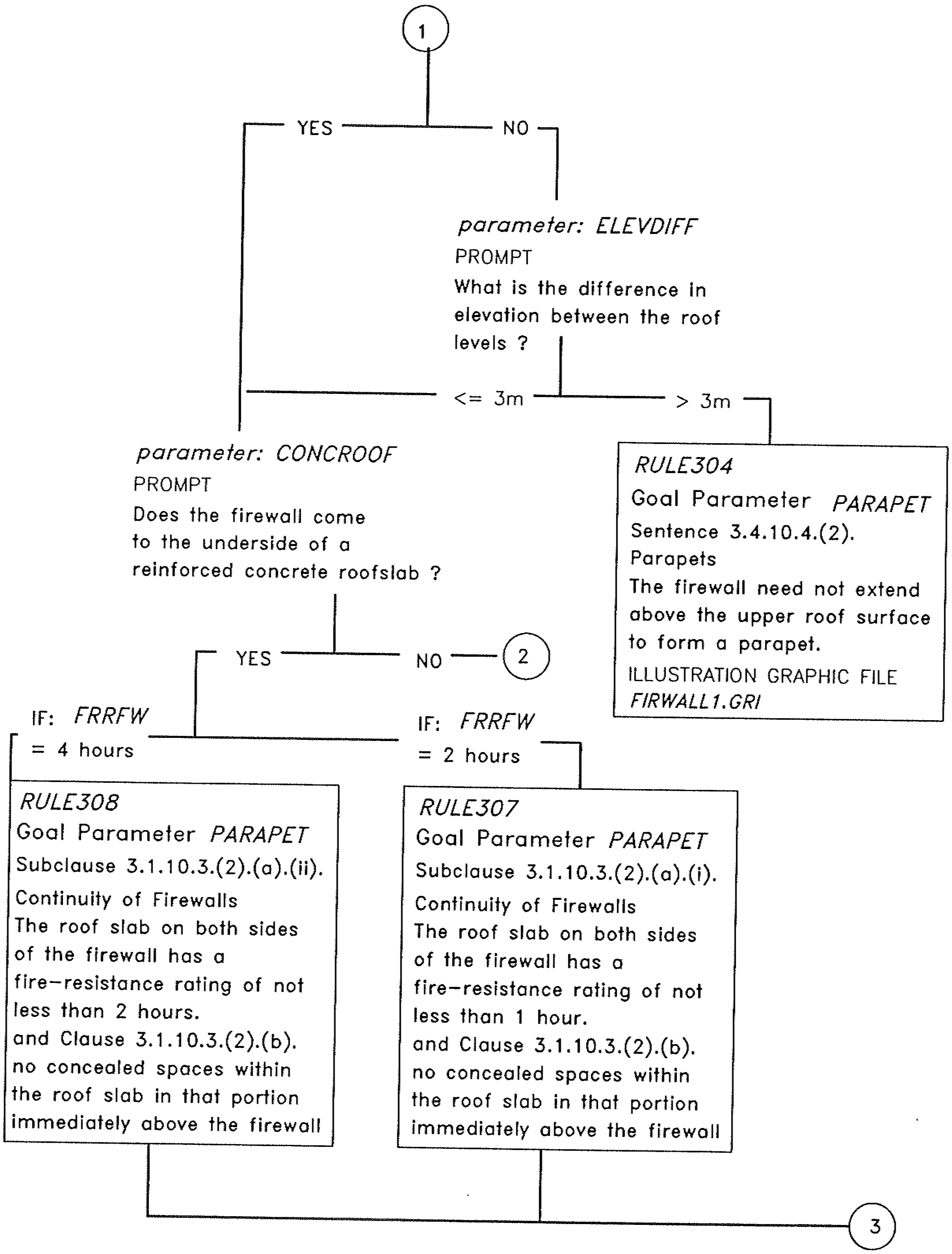
parameter: RFELE

PROMPT

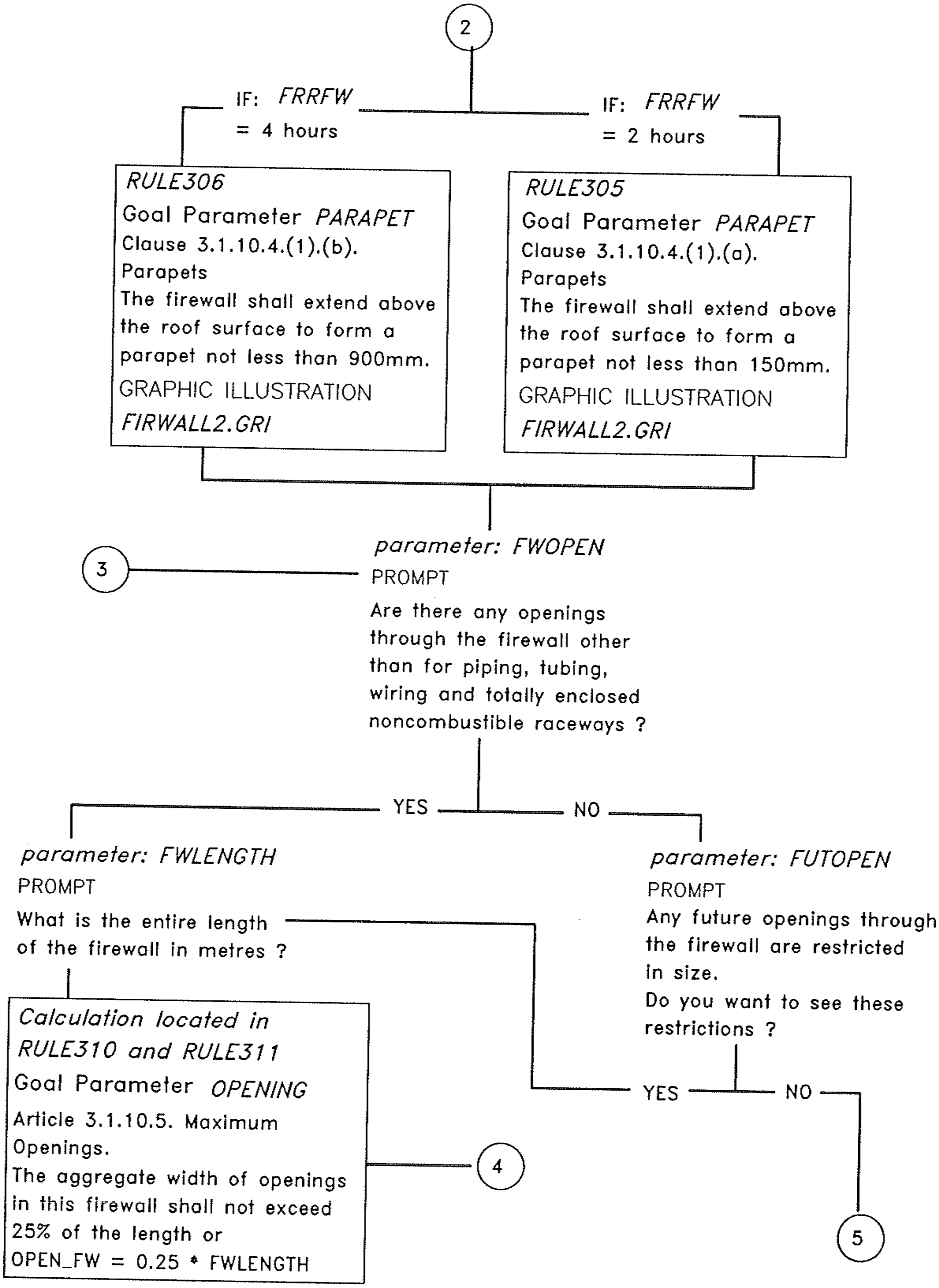
Are the roof levels at the same elevation ?

1

Firewalls Subsection 3.1.10.



Firewalls Subsection 3.1.10.



Firewalls Subsection 3.1.10.

4

parameter: FWSPRK

PROMPT

Are the fire compartments on both sides of the firewall sprinklered ?

YES — NO

RULE311

Sentence 3.1.8.6.(2).

Maximum Openings

The size of an opening in an interior fire separation required to be protected with a closure shall be not more than 22 m^2, with no dimension more than 6m.

RULE310

Sentence 3.1.8.6.(1).

Maximum Openings

The size of an opening in an interior fire separation required to be protected with a closure shall be not more than 11 m^2, with no dimension more than 3.7m.

RULE314

TEXTAGE = *FWALLTEXT4*

NOTE: Because there are openings through the firewall for other than piping tubing wiring and totally enclosed noncombustible raceways, Sentence 3.2.4.2.(1). Continuity of Fire Alarm System requires that for the purposes of a fire alarm system the floor areas on either side of the firewall shall be treated as though they are in the same building.

5

Firewalls Subsection 3.1.10.

5

parameter: FWBASE

PROMPT

Does this building have a basement that is used primarily as a storage garage ?

YES

NO

RULE313

Goal Parameter *FWCONST*

Sentence 3.1.10.3.(1).
Continuity of Firewalls
The firewall must extend from the ground continuously throught all storeys including below grade storeys.

RULE312

Goal Parameter *FWCONST*

Article 3.2.1.2. Storage Garage Considered as a Separate Building.
Allows a basement that is used primarily as a storage garage to be considered as a separate building provided the above the basement and the exterior walls of the adjoining ground level are constructed as a fire separation of masonary or concrete having a fire resistance rating of not less than 2 hours.

Sentence 3.1.10.3.(1).
Continuity of Firewalls
allows a firewall to terminate at the floor assembly immediately above the storage garage treated as a separate building.

GRAPHIC ILLUSTRATION FILE
FIEWALL3.GRI

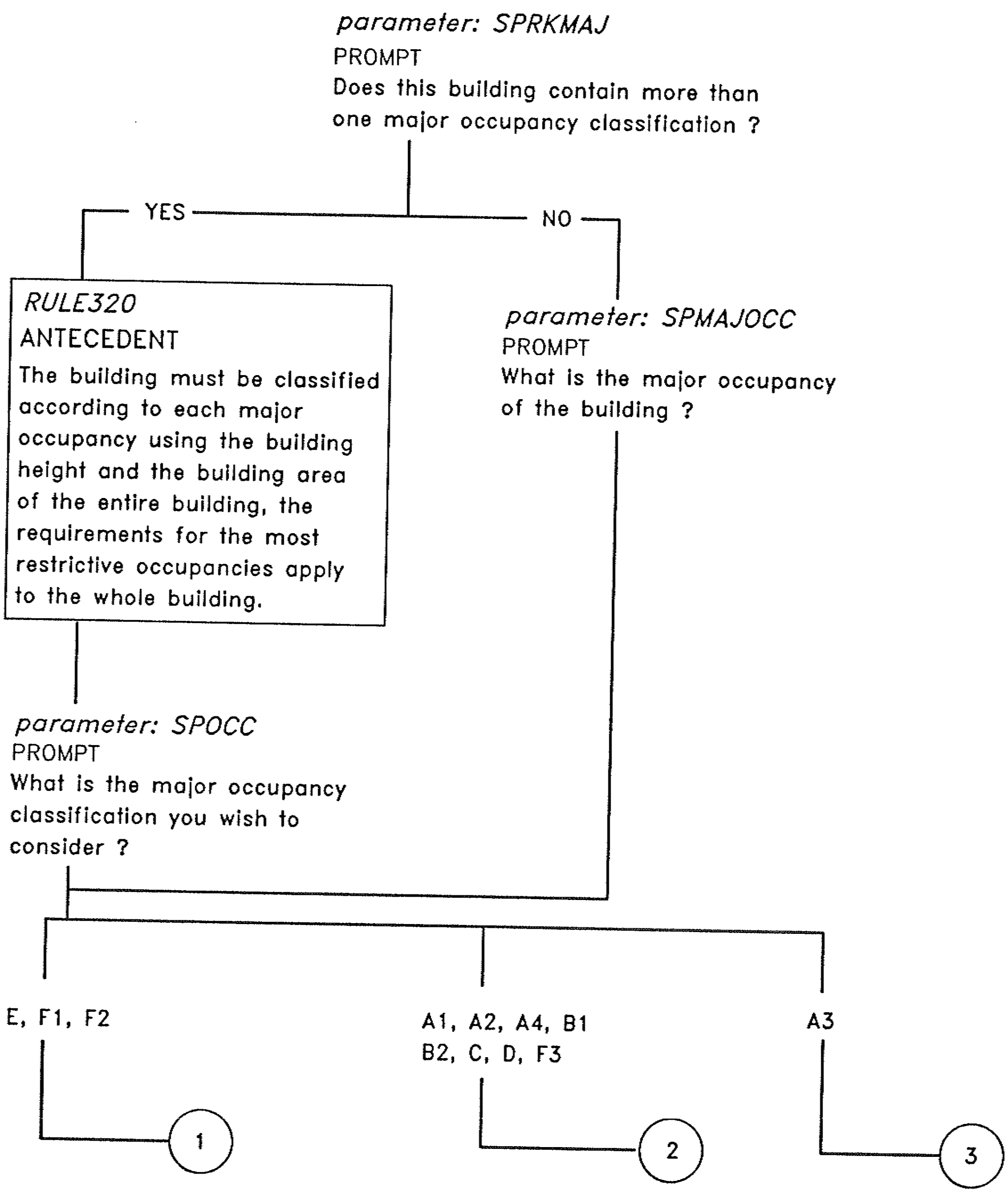
Mandatory Requirements to Sprinkler a Building

Goal parameter to be solved *SPRINKK*

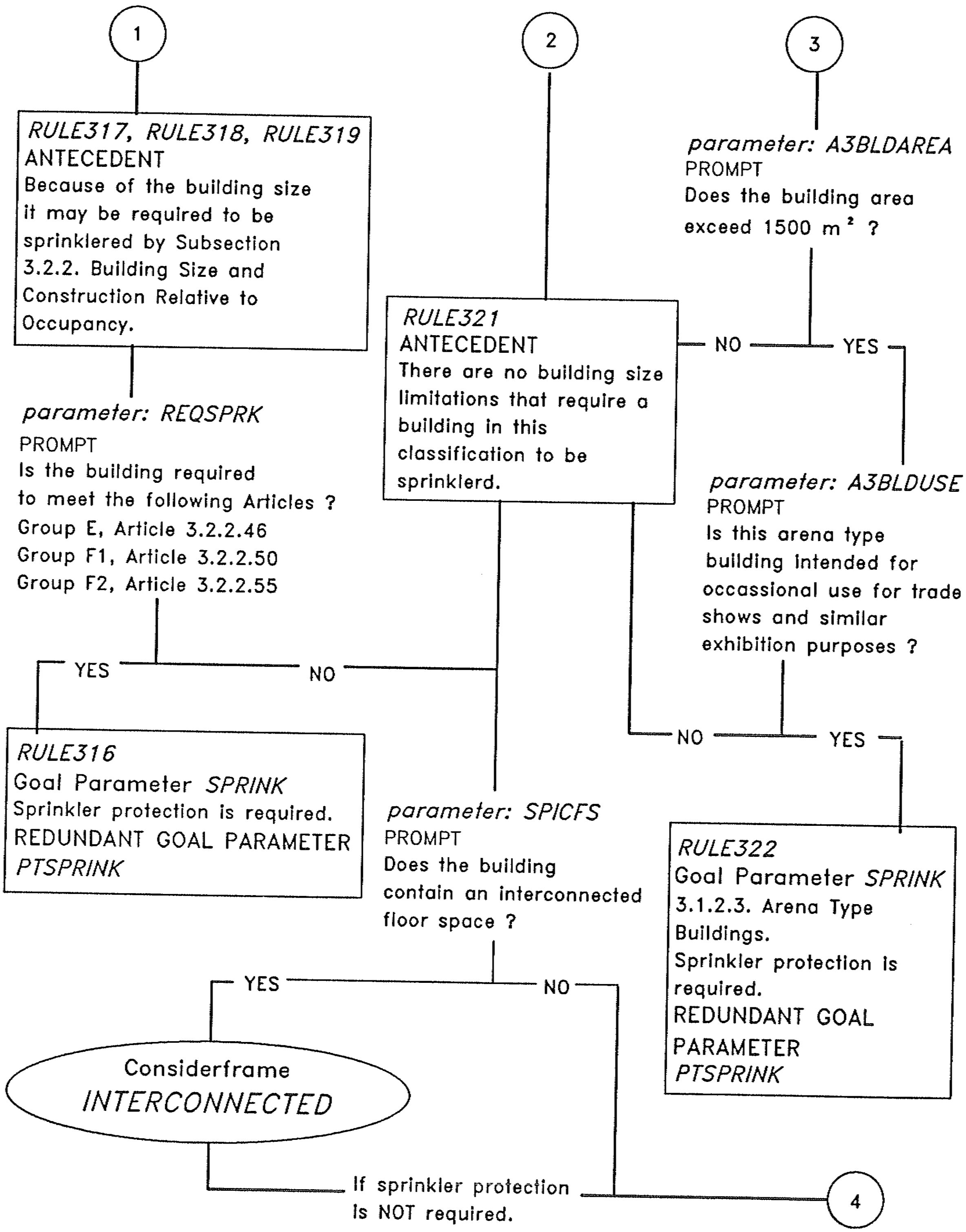
To determine whether the building requires sprinkler protection.

PTSPRINK

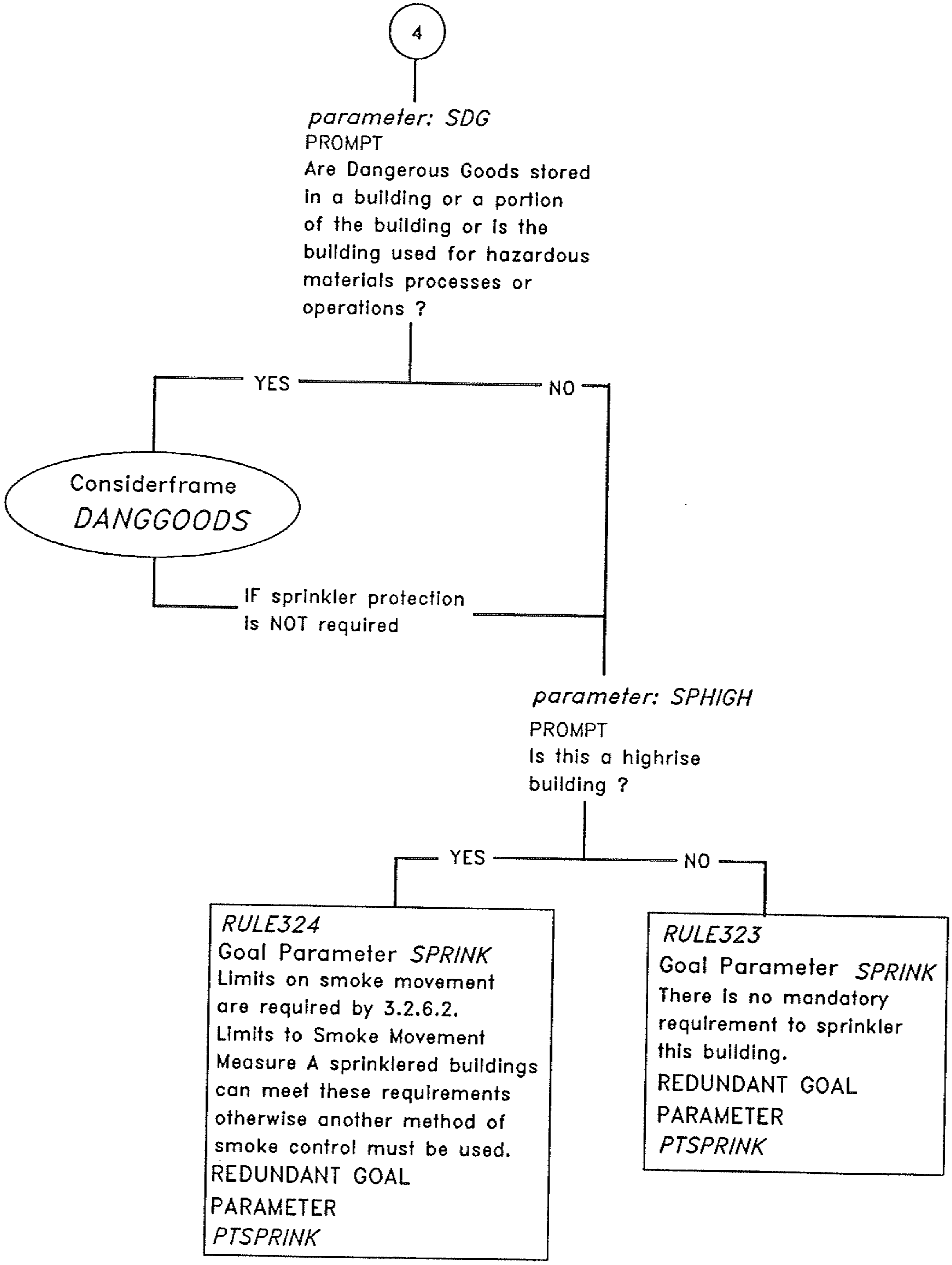
To determine whether the building requires partial sprinkler protection.



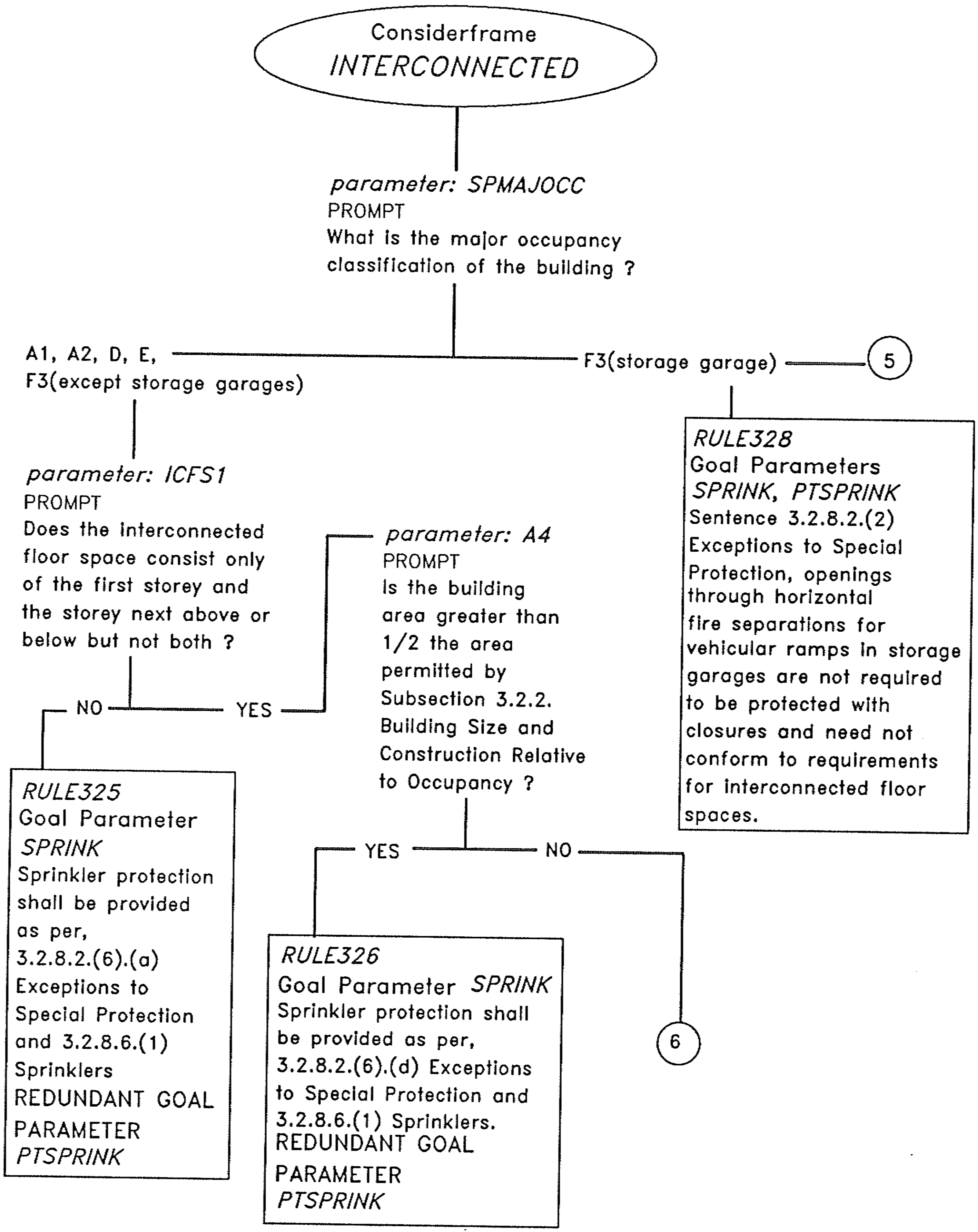
Mandatory Requirements to Sprinkler a Building



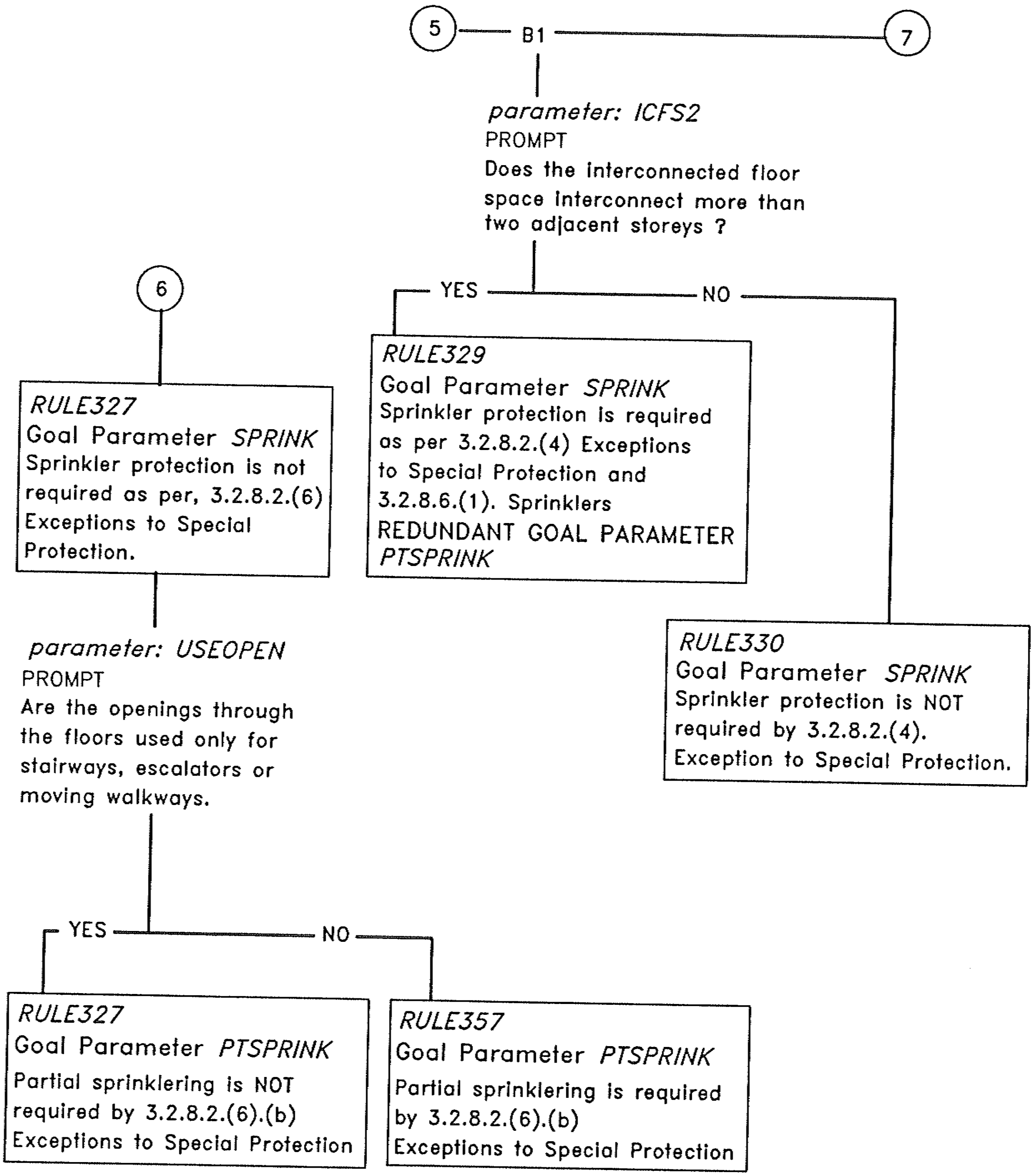
Mandatory Requirements to Sprinkler a Building



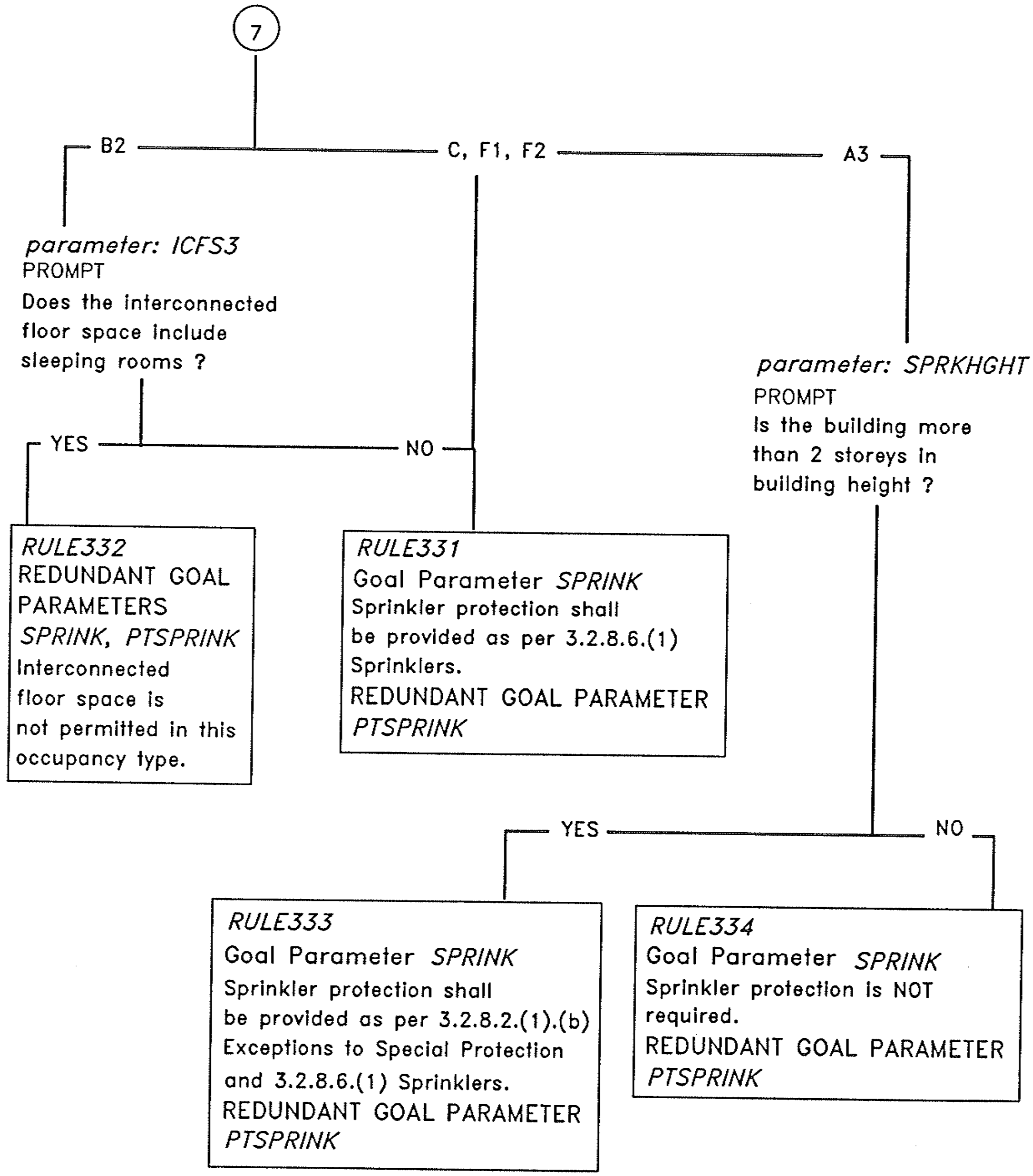
Mandatory Requirements to Sprinkler a Building



Mandatory Requirements to Sprinkler a Building



Mandatory Requirements to Sprinkler a Building



Mandatory Requirements to Sprinkler a Building

Considerframe
DANGGOODS

parameter: TYPDANG
PROMPT
Is the building or part of the building used for the short to long term storage of raw materials, goods in process or finished goods as classified below ?

(a) Class I, II, III or IV commodities or Group A, B or C plastics, elastomers or rubber in conformance with NFPA-231 "Standard for General Storage".
(b) Rubber tires
(c) Level 1, 2, or 3 aerosals
(d) Dangerous goods
(e) Prepackaged containers of distilled beverage alcohols

(a) and (e)

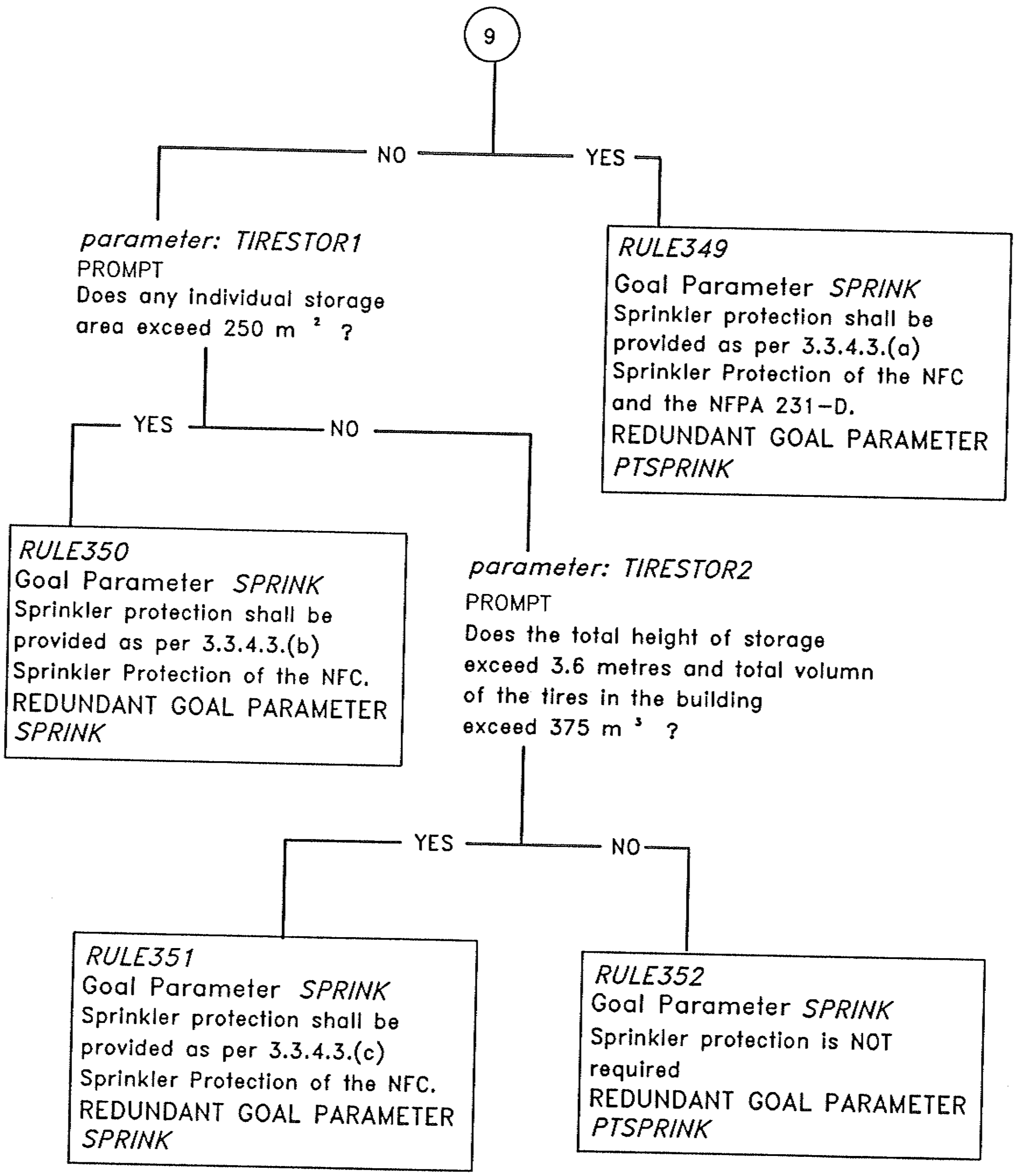
RULE348
ANTECEDENT
Article 3.3.3.2. Individual Storage Areas and Table 3.3.A. of the NATIONAL FIRE CODE of CANADA place limits on height and area limits for individual storage areas for these products in sprinklered and in unsprinklered buildings.

(b) — 8

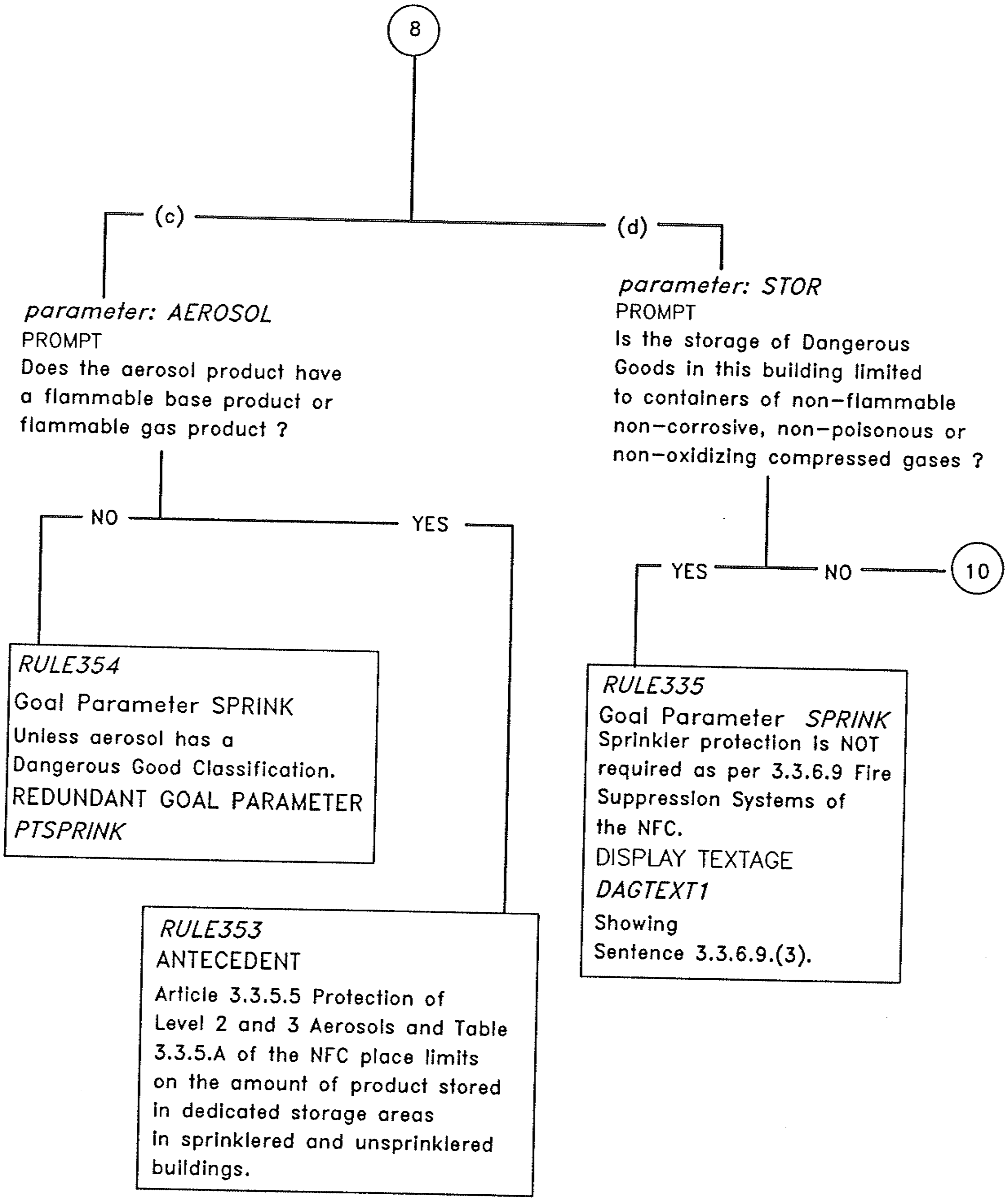
parameter: TIRESTOR
PROMPT
Does the aggregate area of individual storage areas in the building exceed 500 m^2 ?

9

Mandatory Requirements to Sprinkler a Building



Mandatory Requirements to Sprinkler a Building



Mandatory Requirements to Sprinkler a Building

10

parameter: STORAREA
PROMPT
Does the sum of the individual storage areas used for the storage of Dangerous Goods exceed 100 m^2 ?

NO

parameter: TYPDANG!
PROMPT
Does the Dangerous Good involve
(a) More than 50 kg of of nitrocellulose based product or
(b) 600 t of bagged ammonium nitrate.

YES

RULE336
Goal Parameter *SPRINK*
Sprinkler protection shall be provided as per 3.3.6.9.(1) Fire Suppression Systems of the NFC.
DISPLAY TEXTAGE *DANGTEXT2*
Showing Sentence 3.3.6.9.(1)
REDUNDANT GOAL PARAMETER
PTSPRINK

YES

RULE337
Goal Parameter *SPRINK*
Sprinkler protection shall be provided as per 5.4.1.3. Fire Suppression Systems, 5.4.3.1.(2) Storage of Raw Materials and 5.5.6.1 Fire Suppression Systems of the NFC.
DISPLAY TEXTAGE *DANGTEXT3*
Showing Articles 5.4.1.3., 5.5.6.1 and Sentence 5.4.3.1.(2).
REDUNDANT GOAL PARAMETER
PTSPRINK

NO

parameter: TYPDANG2
PROMPT
Does the Dangerous Goods involve any of the following
(a) Dip tanks with flammable contents
(b) Oxidizers
(c) Flammable compressed gases or
(d) Paint spray booths.

11

Mandatory Requirements to Sprinkler a Building

11

YES — NO

RULE338
Goal Parameter *SPRINK*
PTSPRINK
Partial sprinkler protection shall be provided as per 5.6.2.4 Indoor Storage of Flammable Compressed Gases, 5.11.1.5. Fire Suppression Systems, 5.14.1.1. Fire Separations and Fire Suppression Systems and 5.15.6.1. Fire Suppression Systems.
DISPLAY TEXTAGE *DANGTEXT4*
Showing Articles 5.6.2.4, 5.11.1.5, 5.14.1.1. and 5.15.6.1.

RULE339
Goal Parameters *SPRINK*
PTSPRINK
Full and partial sprinkler protection is NOT required.

Wired Glass or Glass Block in Fire Separations

Goal parameter to be solved *GL* Wired glass or glass block requirements.

parameter: SEPLOCAL
PROMPT
Is the fire separation part of:
(a) An exit enclosure
(b) A firewall
(c) Between a dead end corridor and an adjacent occupancy
(d) None of the above

1

An exit enclosure

parameter: EXITENCL
PROMPT
Is the exit enclosure protected by a vestibule or enclosed cooridor ?

NO — YES — 2

parameter: SEP1 — A
PROMPT
Is the building more than 3 storeys in building height ?

NO — YES

RULE369
Goal Parameter *GL*
Table 3.1.8.B. The maximum area of wire glass in the door to exit enclosure is no more than 8000 cm^2
Maximum aggregate area of wired glass panel and glass block not in a door is no more than 8000 cm^2
No limit on temperature rise on unexposed side of the door.
DISPLAY TEXTAGE *GLTEXT1*

parameter: SEPRATE1
PROMPT
Is the minimum required protection rating of the door to the stair enclosure more than 45 min?

YES

RULE370
Goal Parameter *GL*
Table 3.1.8.B. The maximum area of wire glass in the door to exit enclosure is no more than 645 cm^2
Maximum aggregate area of wired glass panel and glass block not in a door is no more than 645 cm^2
Limit on temperature rise on unexposed side of the door.
(Maximum 250°C after 1 hour)
DISPLAY TEXTAGE *GLTEXT2*

NO

RULE371
Goal Parameter *GL*
Table 3.1.8.B. The maximum area of wire glass in the door to exit enclosure is no more than 645 cm^2
Maximum aggregate area of wired glass panel and glass block not in a door is no more than 645 cm^2
Limit on temperature rise on unexposed side of the door.
(Maximum 250°C after 30 minutes.)
DISPLAY TEXTAGE *GLTEXT3*

Wired Glass or Glass Block in Fire Separations

2

parameter: *SEP2*
PROMPT
Does the vestibule or corridor contain an occupancy ?

GOTO A — YES

NO

parameter: *SEPRATE2*
PROMPT
Is the vestibule or corridor separated from the remainder of the floor area by a fire separation having a fire-resistance rating of not less than 45 minutes ?

GOTO A — NO

YES

RULE372
Goal Parameter *GL*
3.1.8.17. Temperature Rise and Area Limits Waived
Temperature rise and glass area limits between the exit enclosure and vestibule or corridor are waived provided the vestibule or corridor separation has no wired glass or glass block within 3 metres of the door to the exit enclosure.
DISPLAY TEXTAGE *GLTEXT4*

Wired Glass or Glass Block in Fire Separations

1

3

IF:: *SEPLOCAL* = A firewall

parameter: *SEP3*
PROMPT
Is the glass located in a door ?

NO

RULE374
Goal Parameter *GL*
Table 3.1.8.B.
Wired glass and/or glass block is not permitted in a firewall.
DISPLAY TEXTAGE *GLTEXT5*

YES

parameter: *SEPRATE3*
PROMPT
What is the fire rating of the firewall ?

(a) 2 hours
(b) 4 hours

(a) 2 hours

RULE375
Goal Parameter *GL*
Table 3.1.8.B.
The door is required to have a fire resistance rating of 1.5 hours as per Sentence 3.1.8.4.(2) Determination of Ratings and Table 3.1.8.A.
Maximum temperature rise on unexposed side of door is 250 °C after 30 minutes. as per Article 3.1.8.15. Temperature Rise Limit for Doors.
Maximum area of glass in the door is 645 cm^2.
Wired glass or glass block if not located in door.
DISPLAY TEXTAGE *GLTEXT6*

(b) 4 hours

RULE376
Goal Parameter *GL*
Table 3.1.8.B.
The door is required to have a fire resistance rating of 3.0 hours as per Sentence 3.1.8.4.(2) Determination of Ratings and Table 3.1.8.A.
Maximum temperature rise on unexposed side of door is 250 °C after 1 hour. as per Article 3.1.8.15. Temperature Rise Limit for Doors.
Wired glass or glass block is not permitted in a door.
DISPLAY TEXTAGE *GLTEXT6*

Wired Glass or Glass Block in Fire Separations

3

4

IF:: *SEPLOCAL* = Between a dead end corridor and adjacent occupancy

parameter: *SEP5*

PROMPT

What is the fire-resistance rating of the fire separation between the dead-end corridor and the adjacent occupancy ?

(a) Less than 45 minutes
(b) 45 minutes
(c) Greater than 45 minutes

(a) Less than 45 minutes

RULE377

Goal Parameter *GL*

Table 3.1.8.B.

No limit on area of glass in door.

No limit on area of wired glass panels and glass block not located in a door.

No limit on temperature rise on unexposed side of door.

(b) 45 minutes

RULE378

Goal Parameter *GL*

Table 3.1.8.B.

Maximum area of wired glass in the door is not greater than 645 cm^2.

Maximum aggregate area of wired glass panels and glass block not in door is not greater than 645 cm^2.

Maximum temperature rise on unexposed side of door is 250 °C after 30 minutes.

(c) Greater than 45 minutes

RULE379

Goal Parameter *GL*

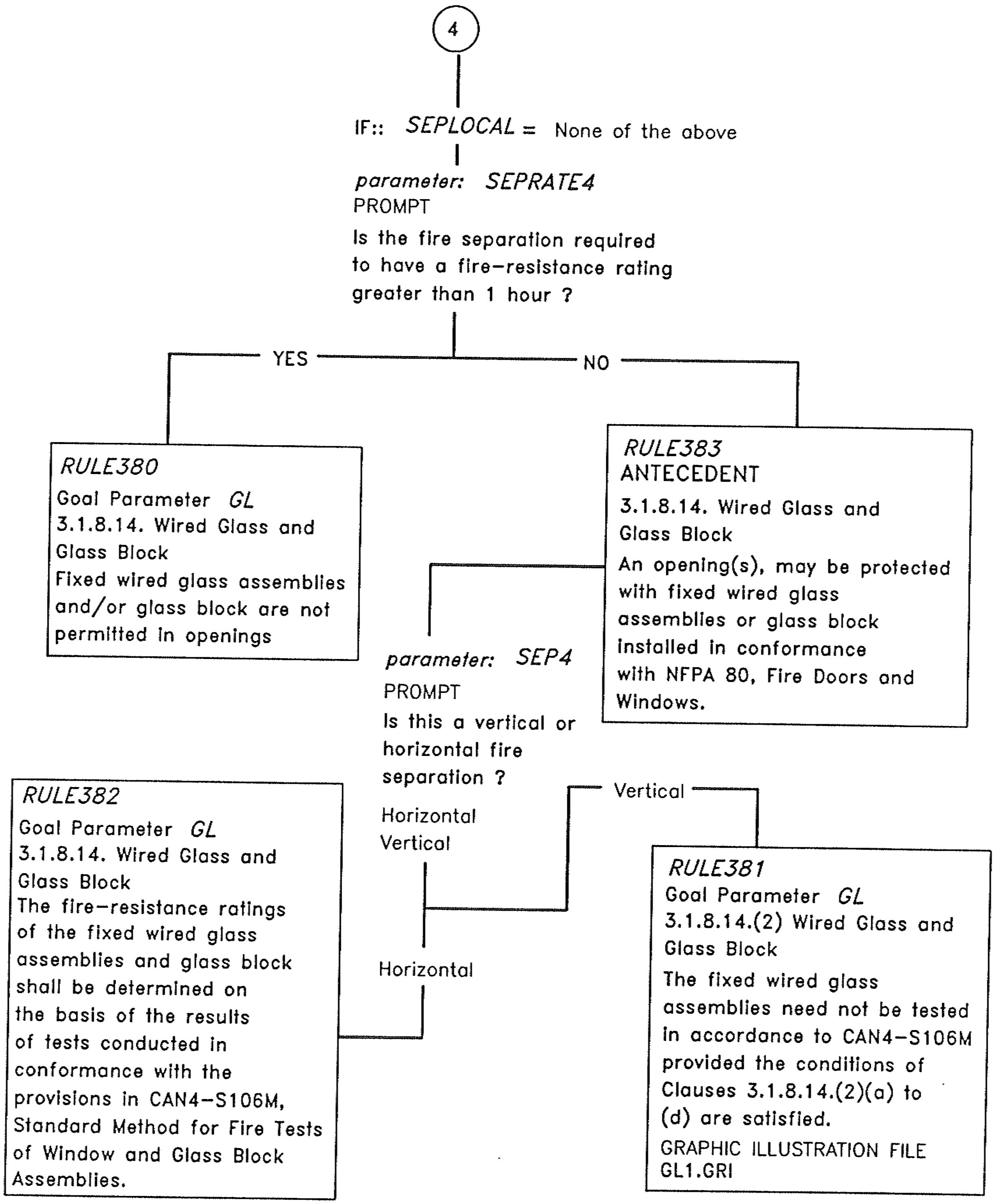
Table 3.1.8.B.

Maximum area of wired glass in the door is not greater than 645 cm^2.

Maximum aggregate area of wired glass panels and glass block not in door is not greater than 645 cm^2.

Maximum temperature rise on unexposed side of door is 250 °C after 1 hour.

Wired Glass or Glass Block in Fire Separations



Flamespread Ratings for Combustible Buildings

Goal parameter to be solved *INFIN1*

To determine the flame spread limits of interior finishes for combustible building.

parameter: LOCIF
PROMPT
Is the interior finish located in:
a) Group A, Division 1 occupancy, or
b) Group B occupancy, or
c) Group C occupancy, or
d) Exit, or
e) Exit lobby, or
f) Exterior exit passageway, or
g) Corridors, or
h) Vertical service spaces, or
i) Covered vehicular passageways, or
j) Underground walkways, or
k) None of the above.

Group A, Division 1 occupancy

1

parameter: IFSPRK
PROMPT
Is the building sprinklered?

YES

NO

RULE389
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 150
Floors – No requirement
Doors – FSR = 150
Light diffussers and lenses – FSR = 150
Glazing – FSR = 150
Skylights – FSR = 150
GRAPHIC ILLUSTRATION FILE FSR1.GRI

RULE390
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 75
Floors – No requirement
Doors – FSR = 75
Light diffussers and lenses – FSR = 75
Glazing – FSR = 75
Skylights – FSR = 75
3.1.13.2.(4) up to 10% of the total wall area and 10% of the total a flame spread rating of not more than 150.
3.1.13.2.(5). Combustible doors, skylights glazing and light diffusers and lenses are to be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
GRAPHIC ILLUSTRATION FILE FSR2.GRI

Flamespread Ratings for Combustible Buildings

1

Group B occupancy

parameter: *IFSPRK*
PROMPT
Is the building sprinklered ?

YES

RULE391
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame–Spread Rating
and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 150
Floors – No requirements
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
GRAPHIC ILLUSTRATION FILE FSR5.GRI

NO

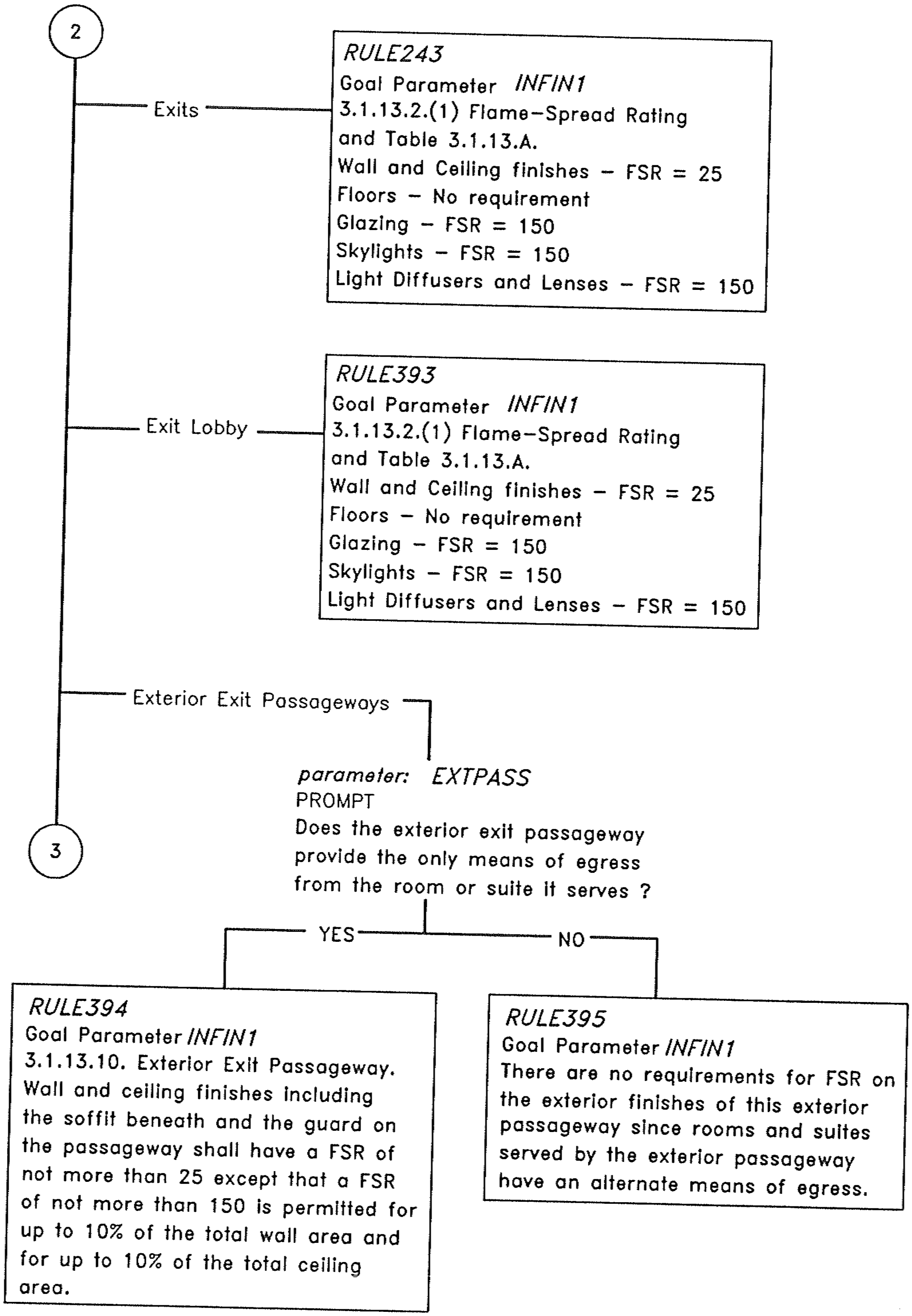
RULE392
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame–Spread Rating
and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 75
Floors – No requirements
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses shall not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
GRAPHIC ILLUSTRATION FILE FSR6.GRI

Group C occupancy

RULE271
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame–Spread Rating
Wall and Ceiling finishes – FSR = 150
Floors – No requirements
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors not within
Dwelling units – FSR = 200
3.1.13.2.(3) Doors within dwelling
units – No requirements
3.1.13.4. Light Diffusers and Lenses
GRAPHIC ILLUSTRATION FILE FSR7.GRI

2

Flamespread Ratings for Combustible Buildings



Flamespread Ratings for Combustible Buildings

3 — 4

Corridor

parameter: IFSPRK
PROMPT
Is the building sprinklered ?

YES — NO

parameter: CORRUSE
PROMPT
Is the corridor one of the following ?
i) Public corridor
ii) Corridor used by the public in assembly or institutional occupancies.
iii) Corridors serving classrooms or sleeping rooms in institutional occupancies.

NO — YES

RULE391
Goal Parameter *INFIN1*
3.1.13.6.(1) Corridors
Wall an Ceiling finishes – FSR = 150
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Flame-Spread Rating
Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses

RULE396
Goal Parameter *INFIN1*
3.1.13.6.(1) Corridors
Wall finishes (including occupancies in the corridor) – FSR = 75 or FSR = 25 on the upper half of the wall and 150 on the lower half of the wall.
3.1.13.2.(2) Flame-Spread Rating
Doors – FSR = 200
Floors – No requirement
3.1.13.6.(2) Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses need not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.

Flamespread Ratings for Combustible Buildings

4

Vertical service spaces

RULE397
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.

Covered vehicular passageways

parameter: *ROOFVEH*
PROMPT
Is the roof assembly of heavy timber construction ?

YES

RULE398
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Walls – FSR = 25
Roof – Heavy timber roof assembly meets the requirements for FSR.
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.

NO

RULE399
Goal Parameter *INFIN1*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Walls and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses need not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.

5

Flamespread Ratings for Combustible Buildings

5

- Underground Walkways

  RULE400
  Goal Parameter *INFIN1*
  3.1.13.9. Underground Walkways
  except for paint, thge interior wall
  finishes of an underground walkway
  shall be of noncombustible construction.

- None of the above

  RULE391
  Goal Parameter *INFIN1*
  3.1.13.2.(1) Flame-Spread Rating
  Wall and Ceiling finishes – FSR = 150
  Floors – No requirement
  Glazing – FSR = 150
  Skylights – FSR = 150
  3.1.13.2.(2) Doors – FSR = 200
  3.1.13.4. Light Diffusers and Lenses

Flamespread Ratings for Noncombustible Buildings

Goal parameter to be solved *INFIN2*

To determine the flame spread limits of interior finishes for noncombustible building.

parameter: LOCIF
PROMPT
Is the interior finish located in:
a) Group A, Division 1 occupancy, or
b) Group B occupancy, or
c) Group C occupancy, or
d) Exit, or
e) Exit lobby, or
f) Exterior exit passageway, or
g) Corridors, or
h) Vertical service spaces, or
i) Covered vehicular passageways, or
j) Underground walkways, or
k) None of the above.

Group A, Division 1 occupancy

1

parameter: IFSPRK
PROMPT
Is the building sprinklered?

YES

NO

RULE460
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 150
Floors – No requirement
Doors – FSR = 150
Light diffussers and lenses – FSR = 150
Glazing – FSR = 150
Skylights – FSR = 150
GRAPHIC ILLUSTRATION FILE FSR1.GRI

RULE461
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 75
Floors – No requirement
Doors – FSR = 75
Light diffussers and lenses – FSR = 75
Glazing – FSR = 75
Skylights – FSR = 75
3.1.13.2.(4) up to 10% of the total wall area and 10% of the total a flame spread rating of not more than 150.
3.1.13.2.(5). Combustible doors, skylights glazing and light diffusers and lenses are to be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
GRAPHIC ILLUSTRATION FILE FSR2.GRI

Flamespread Ratings for Noncombustible Buildings

1

Group B occupancy

parameter: IFSPRK
PROMPT
Is the building sprinklered ?

YES

RULE462
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame–Spread Rating and Table 3.1.13.A.
Wall finishes – FSR = 150
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling – FSR = 150
Floors – No requirements
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
GRAPHIC ILLUSTRATION FILE FSR3.GRI

NO

RULE463
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame–Spread Rating and Table 3.1.13.A.
Wall finishes – FSR = 75
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling – FSR = 25
Fire–retardant treated wood permitted except that not more than 10% of the ceiling area within each fire compartment is permitted to have a Flame–spread rating of not more than 150
Floors – No requirements
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
GRAPHIC ILLUSTRATION FILE FSR4.GRI

Group C occupancy

RULE464
Goal Parameter *INFIN2*
Sentence 3.1.13.2.(1) Flame–Spread Rating
Wall finishes – FSR = 150
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling – FSR = 25
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
Sentence 3.1.13.2.(2)
Doors – No FSR required where doors located within dwelling units
Doors – FSR = 200 for doors not located within the dwelling unit
Article 3.1.13.4. Light Diffusers and Lenses
GRAPHIC ILLUSTRATION FILE FSR8.GRI

2

Flamespread Ratings for Noncombustible Buildings

(2)

Exits

RULE465
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame–Spread Rating
and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
Light Diffusers and Lenses – FSR = 150

Exit Lobby

RULE466
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame–Spread Rating
and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
Light Diffusers and Lenses – FSR = 150

Exterior Exit Passageways

parameter: *EXTPASS*
PROMPT
Does the exterior exit passageway
provide the only means of egress
from the room or suite it serves ?

(3)

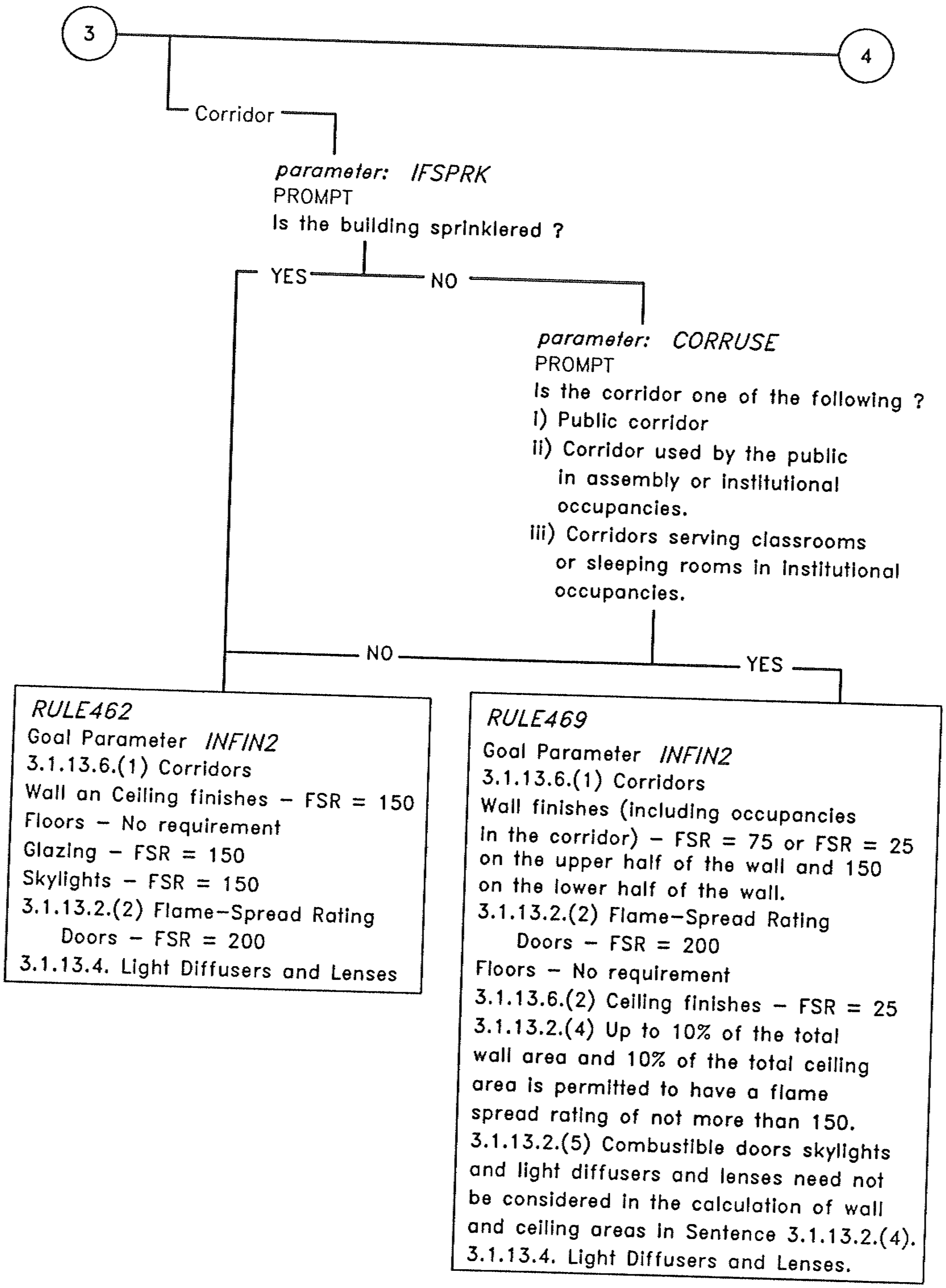
YES

RULE467
Goal Parameter *INFIN2*
3.1.13.10. Exterior Exit Passageway.
Wall and ceiling finishes including
the soffit beneath and the guard on
the passageway shall have a FSR of
not more than 25 except that a FSR
of not more than 150 is permitted for
up to 10% of the total wall area and
for up to 10% of the total ceiling
area.

NO

RULE468
Goal Parameter *INFIN2*
There are no requirements for FSR on
the exterior finishes of this exterior
passageway since rooms and suites
served by the exterior passageway
have an alternate means of egress.

Flamespread Ratings for Noncombustible Buildings



Flamespread Ratings for Noncombustible Buildings

4

Vertical service spaces

RULE470
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.

Covered vehicular passageways

parameter: *ROOFVEH*
PROMPT
Is the roof assembly of heavy timber construction ?

YES

RULE471
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Walls – FSR = 25
Roof – Heavy timber roof assembly meets the requirements for FSR.
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.

NO

RULE472
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Walls and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses need not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.

5

Flamespread Ratings for Noncombustible Buildings

5

Underground Walkways

RULE473
Goal Parameter *INFIN2*
3.1.13.9. Underground Walkways
except for paint, thge interior wall
finishes of an underground walkway
shall be of noncombustible construction.

None of the above

RULE474
Goal Parameter *INFIN2*
3.1.13.2.(1) Flame-Spread Rating
Wall and Ceiling finishes - FSR = 150
Floors - No requirement
Glazing - FSR = 150
Skylights - FSR = 150
3.1.13.2.(2) Doors - FSR = 200
3.1.13.4. Light Diffusers and Lenses

Flamespread Ratings for High Buildings

Goal parameter to be solved *INFIN3*

To determine the flame spread limits of interior finishes for high buildings.

parameter: LOCIF

PROMPT

Is the interior finish located in:

a) Group A, Division 1 occupancy, or
b) Group B occupancy, or
c) Group C occupancy, or
d) Exit, or
e) Exit lobby, or
f) Exterior exit passageway, or
g) Corridors, or
h) Vertical service spaces, or
i) Covered vehicular passageways, or
j) Underground walkways, or
k) Vestibules
l) None of the above.

Group A, Division 1 occupancy

1

parameter: HBIFSPRK

PROMPT

Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

YES

NO

RULE581

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 150

Floors – No requirement

Doors – FSR = 150

Light diffussers and lenses – FSR = 150

Glazing – FSR = 150

Skylights – FSR = 150

Smoke Developed Classification

Wall Surface – No limit

Ceiling Surface – No limit

Floor Surface – No limit

GRAPHIC ILLUSTRATION FILE FSR1.GRI

RULE582

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 75

Floors – No requirement

Doors – FSR = 75

Light diffussers and lenses – FSR = 75

Glazing – FSR = 75

Skylights – FSR = 75

3.1.13.2.(4) up to 10% of the total wall area and 10% of the total a flame spread rating of not more than 150.

3.1.13.2.(5). Combustible doors, skylights glazing and light diffusers and lenses are to be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).

Smoke Developed Classification

Wall Surface – 300

Ceiling Surface – 50

Floor Surface – No limit

GRAPHIC ILLUSTRATION FILE FSR2.GRI

Flamespread Ratings for High Buildings

1 — 2

Group B occupancy

parameter: HBIFSPRK
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings?

YES

RULE583
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall finishes – FSR = 150
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling – FSR = 150
Floors – No requirements
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit
GRAPHIC ILLUSTRATION FILE FSR3.GRI

NO

RULE584
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall finishes – FSR = 75
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling – FSR = 25
Fire-retardant treated wood permitted except that not more than 10% of the ceiling area within each fire compartment is permitted to have a Flame-spread rating of not more than 150
Floors – No requirements
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit
GRAPHIC ILLUSTRATION FILE FSR4.GRI

Flamespread Ratings for High Buildings

2 — 3

Group C occupancy

parameter: HBIFSPRK
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

YES — NO

RULE586
Goal Parameter *INFIN3*
Sentence 3.1.13.2.(1) Flame-Spread Rating
Wall finishes - FSR = 150
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling - FSR = 25
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
Sentence 3.1.13.2.(2)
Doors - No FSR required where doors located within dwelling units
Doors - FSR = 200 for doors not located within the dwelling unit
Article 3.1.13.4. Light Diffusers and Lenses
Smoke Developed Classification
Wall Surface - No limit
Ceiling Surface - No limit
Floor Surface - No limit
GRAPHIC ILLUSTRATION FILE FSR8.GRI

RULE585
Goal Parameter *INFIN3*
Sentence 3.1.13.2.(1) Flame-Spread Rating
Wall finishes - FSR = 150
Sentence 3.1.5.10.(3) Combustible Interior Finishes
Ceiling - FSR = 25
Sentence 3.1.5.4.(1) Combustible Glazing and Skylights
Sentence 3.1.13.2.(2)
Doors - No FSR required where doors located within dwelling units
Doors - FSR = 200 for doors not located within the dwelling unit
Article 3.1.13.4. Light Diffusers and Lenses
Smoke Developed Classification
Wall Surface - 300
Ceiling Surface - 50
Floor Surface - No limit
GRAPHIC ILLUSTRATION FILE FSR8.GRI

Flamespread Ratings for High Buildings

3

Exits

parameter: HBIFSPRK

PROMPT

Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

YES

RULE588

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 25

Floors – No requirement

Glazing – FSR = 150

Skylights – FSR = 150

Light Diffusers and Lenses – FSR = 150

Smoke Developed Classification

Wall Surface – No limit

Ceiling Surface – No limit

Floor Surface – No limit

NO

RULE587

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 25

Floors – No requirement

Glazing – FSR = 150

Skylights – FSR = 150

Light Diffusers and Lenses – FSR = 150

Smoke Developed Classification

Wall Surface – 50

Ceiling Surface – 50

Floor Surface – 50

Exit Lobby

parameter: HBIFSPRK

PROMPT

Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

4

YES

RULE589

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 25

Floors – No requirement

Glazing – FSR = 150

Skylights – FSR = 150

Light Diffusers and Lenses – FSR = 150

Smoke Developed Classification

Wall Surface – No limit

Ceiling Surface – No limit

Floor Surface – No limit

NO

RULE590

Goal Parameter *INFIN3*

3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.

Wall and Ceiling finishes – FSR = 25

Floors – No requirement

Glazing – FSR = 150

Skylights – FSR = 150

Light Diffusers and Lenses – FSR = 150

Smoke Developed Classification

Wall Surface – 50

Ceiling Surface – 50

Floor Surface – 50

Flamespread Ratings for High Buildings

4

5

Exterior Exit Passageways

parameter: *EXTPASS*
PROMPT
Does the exterior exit passageway provide the only means of egress from the room or suite it serves ?

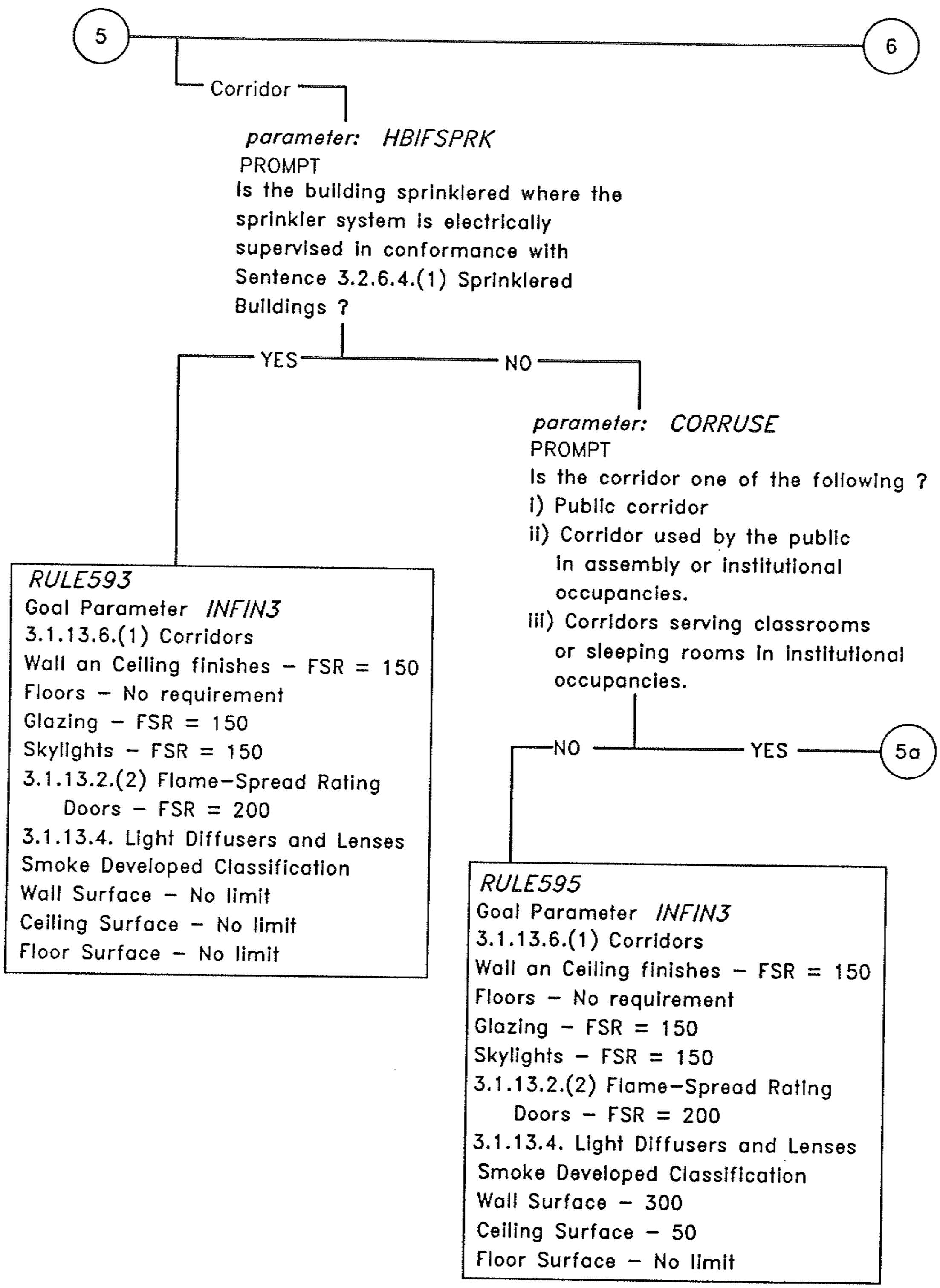
YES

NO

RULE591
Goal Parameter *INFIN3*
3.1.13.10. Exterior Exit Passageway. Wall and ceiling finishes including the soffit beneath and the guard on the passageway shall have a FSR of not more than 25 except that a FSR of not more than 150 is permitted for up to 10% of the total wall area and for up to 10% of the total ceiling area.

RULE592
Goal Parameter *INFIN3*
There are no requirements for FSR on the exterior finishes of this exterior passageway since rooms and suites served by the exterior passageway have an alternate means of egress.

Flamespread Ratings for High Buildings



Flamespread Ratings for High Buildings

5a

RULE594

Goal Parameter *INFIN3*
3.1.13.6.(1) Corridors
Wall finishes (including occupancies in the corridor) – FSR = 75 or FSR = 25 on the upper half of the wall and 150 on the lower half of the wall.
3.1.13.2.(2) Flame–Spread Rating
Doors – FSR = 200
Floors – No requirement
3.1.13.6.(2) Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses need not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.
Smoke Developed Classification
Wall Surface – 100
Ceiling Surface – 50
Floor Surface – 500

Flamespread Ratings for High Buildings

6

Vertical service spaces

parameter: HBIFSPRK
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

NO

RULE597
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit

YES

RULE596
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Wall and Ceiling finishes – FSR = 25
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
Smoke Developed Classification
Wall Surface – No limit
Ceiling Surface – No limit
Floor Surface – No limit

Covered vehicular passageways

7

parameter: HBIFSPRK
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

NO

6a

YES

RULE598
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating and Table 3.1.13.A.
Walls and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.2.(4) Up to 10% of the total wall area and 10% of the total ceiling area is permitted to have a flame spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights and light diffusers and lenses need not be considered in the calculation of wall and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.
Smoke Developed Classification
Wall Surface – No limit
Ceiling Surface – No limit
Floor Surface – No limit

Flamespread Ratings for High Buildings

6a

RULE599
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame–Spread Rating
and Table 3.1.13.A.
Walls and Ceiling finishes – FSR = 25
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.2.(4) Up to 10% of the total
wall area and 10% of the total ceiling
area is permitted to have a flame
spread rating of not more than 150.
3.1.13.2.(5) Combustible doors skylights
and light diffusers and lenses need not
be considered in the calculation of wall
and ceiling areas in Sentence 3.1.13.2.(4).
3.1.13.4. Light Diffusers and Lenses.
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit

Flamespread Ratings for High Buildings

7

- Underground Walkways

parameter: *HBIFSPRK*
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

YES

RULE602
Goal Parameter *INFIN3*
3.1.13.9. Underground Walkways
except for paint, thge interior wall finishes of an underground walkway shall be of noncombustible construction.
Smoke Developed Classification
Wall Surface – No limit
Ceiling Surface – No limit
Floor Surface – No limit

NO

RULE603
Goal Parameter *INFIN3*
3.1.13.9. Underground Walkways
except for paint, thge interior wall finishes of an underground walkway shall be of noncombustible construction.
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit

- None of the above

parameter: *HBIFSPRK*
PROMPT
Is the building sprinklered where the sprinkler system is electrically supervised in conformance with Sentence 3.2.6.4.(1) Sprinklered Buildings ?

YES

RULE600
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating
Wall and Ceiling finishes – FSR = 150
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
Smoke Developed Classification
Wall Surface – No limit
Ceiling Surface – No limit
Floor Surface – No limit

NO

RULE601
Goal Parameter *INFIN3*
3.1.13.2.(1) Flame-Spread Rating
Wall and Ceiling finishes – FSR = 150
Floors – No requirement
Glazing – FSR = 150
Skylights – FSR = 150
3.1.13.2.(2) Doors – FSR = 200
3.1.13.4. Light Diffusers and Lenses
Smoke Developed Classification
Wall Surface – 300
Ceiling Surface – 50
Floor Surface – No limit

Exterior Cladding Requirements

Goal parameter to be solved *TYPCLAD* Type of exterior cladding permitted.

parameter: %OPEN
PROMPT
Is the percentage of unprotected openings permitted in the exterior wall under Article 3.2.3.7. greater than 25 % ?

NO

parameter: FOAM
PROMPT
Is foamed plastic used in Exposing Building Face ?

NO

RULE456
Goal Parameter
TYPCLAD
3.2.3.7. Construction of Exposing Building Face Noncombustible cladding is required.

YES

parameter: CLADHT
PROMPT
What is the building height ?

3 storeys or less
4 to 6 storeys NOT sprinklerd
4 to 6 storeys sprinklered
Over 6 storeys

3 storeys or less

RULE456
Goal Parameter *TYPCLAD*
3.2.3.7. Construction of Exposing Building Face Noncombustible cladding is required.

4 to 6 storeys NOT sprinklerd
4 to 6 storeys sprinklered
Over 6 storeys

RULE458
Goal Parameter *TYPCLAD*
3.2.7.2. Construction of Exposing Building Face Noncombustible cladding required and must meet Clauses 3.2.3.7.(a) or (c)

YES

parameter: REQCONST
PROMPT
Is the building required to be of noncombustible construction by Subsection 3.2.2 ?

NO

RULE457
Goal Parameter
TYPCLAD
3.2.3.7. Construction of Exposing Building Face Combustible cladding is permitted.

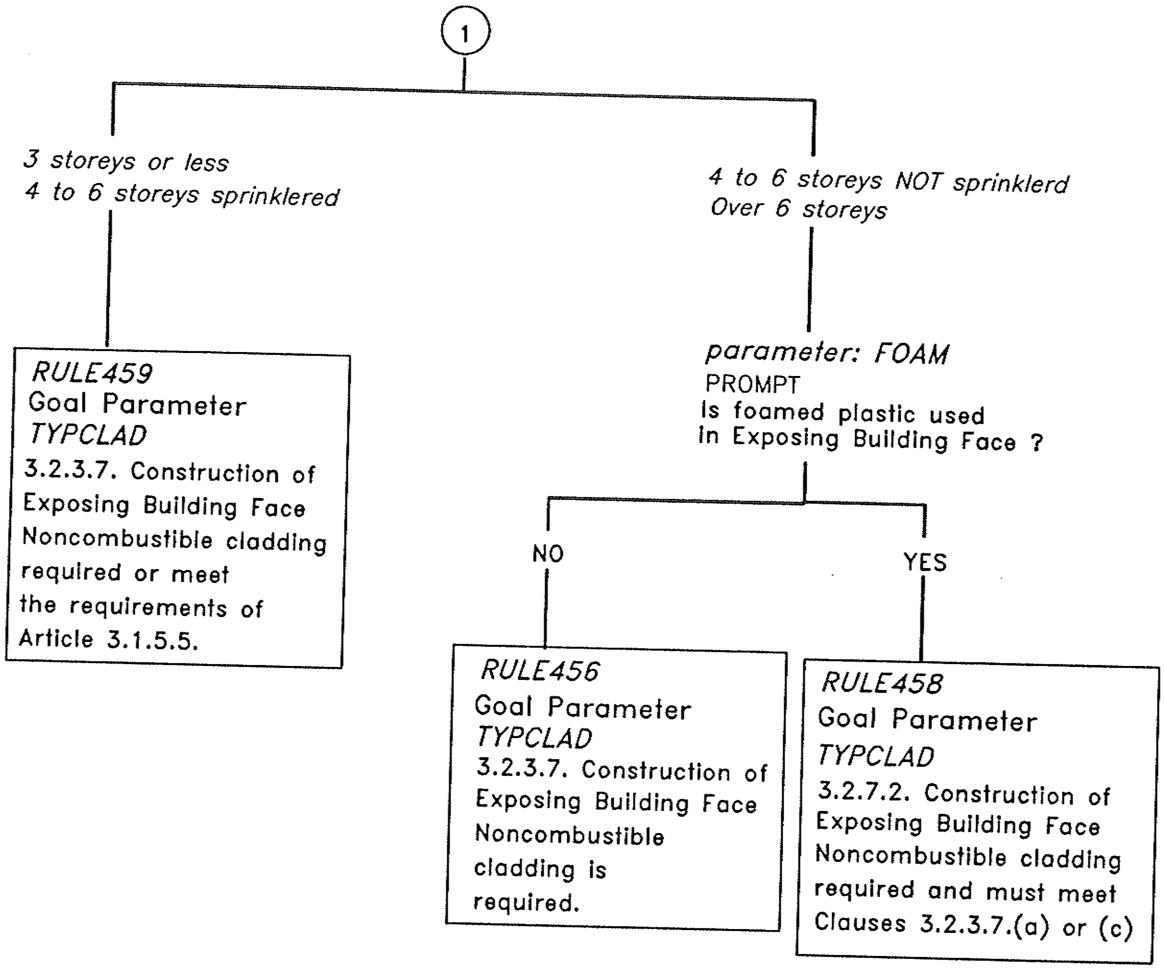
YES

parameter: CLADHT
PROMPT
What is the building height ?

3 storeys or less
4 to 6 storeys NOT sprinklerd
4 to 6 storeys sprinklered
Over 6 storeys

1

Exterior Cladding Requirements



Mezzanines

Goal parameter to be solved *STOREY*

To determine whether or not a mezzanine level is counted as a storey level for building height calculation.

parameter: LEVEL

PROMPT

Is more than one level of mezzanine provided in this storey ?

< F1 HELP >

Graphic Help File *MEZZ1.GRI*

YES

NO

RULE402

Sentence 3.2.1.1.(5) Exceptions to Building Height in Storeys

Requires that where more than one level of mezzanine is provided in a storey, each level additional to the first shall be considered as a storey in calculating building height

RULE404

The first level of mezzanine within this storey must be checked to see if it must be considered as a storey in calculating building height.

parameter: AREAFL

PROMPT

What is the area of the storey in which the first level of mezzanine is located ?

< F1 HELP >

Graphic Help File *MEZZ2.GRI*

parameter: AREAMEZZ

PROMPT

What is the aggregate area of mezzanine floor ?

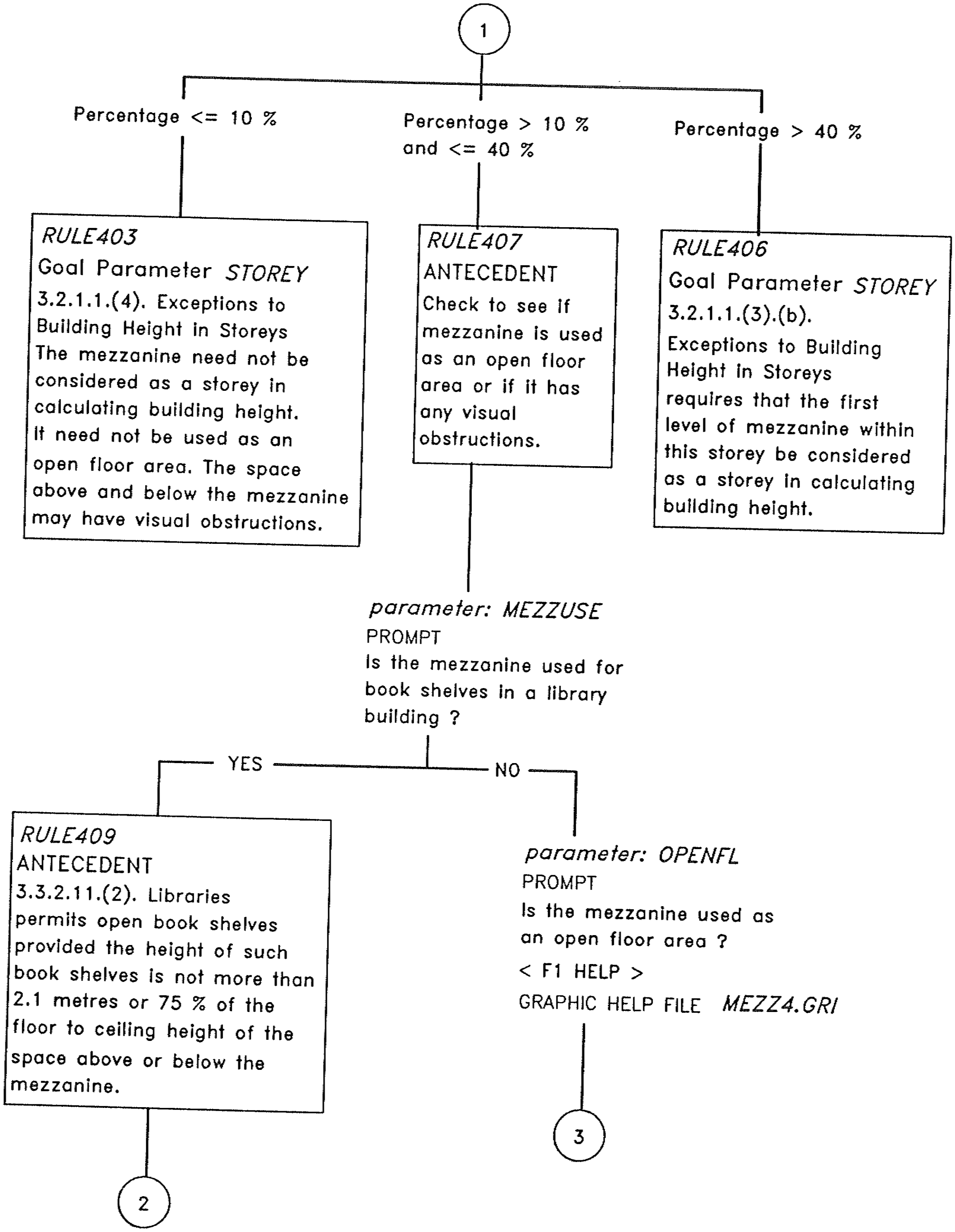
< F1 HELP >

Graphic Help File *MEZZ3.GRI*

$$\text{PERCENTAGE} = \frac{AREAMEZZ}{AREAFL} \times 100$$

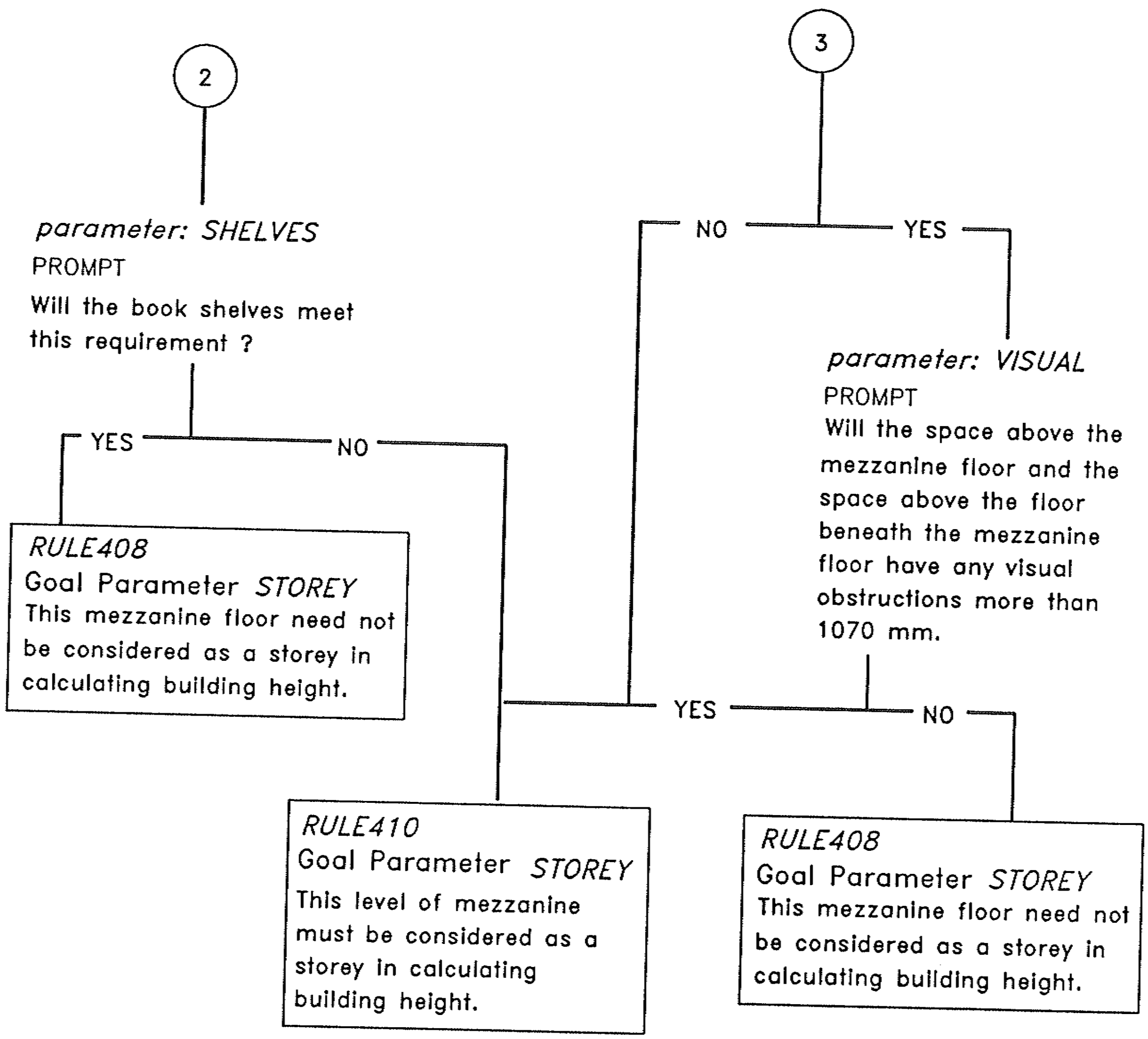
1

Mezzanines



1
Percentage <= 10 %
Percentage > 10 % and <= 40 %
Percentage > 40 %
RULE403
Goal Parameter STOREY
3.2.1.1.(4). Exceptions to Building Height in Storeys
The mezzanine need not be considered as a storey in calculating building height.
It need not be used as an open floor area. The space above and below the mezzanine may have visual obstructions.
RULE407
ANTECEDENT
Check to see if mezzanine is used as an open floor area or if it has any visual obstructions.
RULE406
Goal Parameter STOREY
3.2.1.1.(3).(b).
Exceptions to Building Height in Storeys
requires that the first level of mezzanine within this storey be considered as a storey in calculating building height.
parameter: MEZZUSE
PROMPT
Is the mezzanine used for book shelves in a library building ?
YES
NO
RULE409
ANTECEDENT
3.3.2.11.(2). Libraries
permits open book shelves provided the height of such book shelves is not more than 2.1 metres or 75 % of the floor to ceiling height of the space above or below the mezzanine.
parameter: OPENFL
PROMPT
Is the mezzanine used as an open floor area ?
< F1 HELP >
GRAPHIC HELP FILE MEZZ4.GRI
2
3

Mezzanines

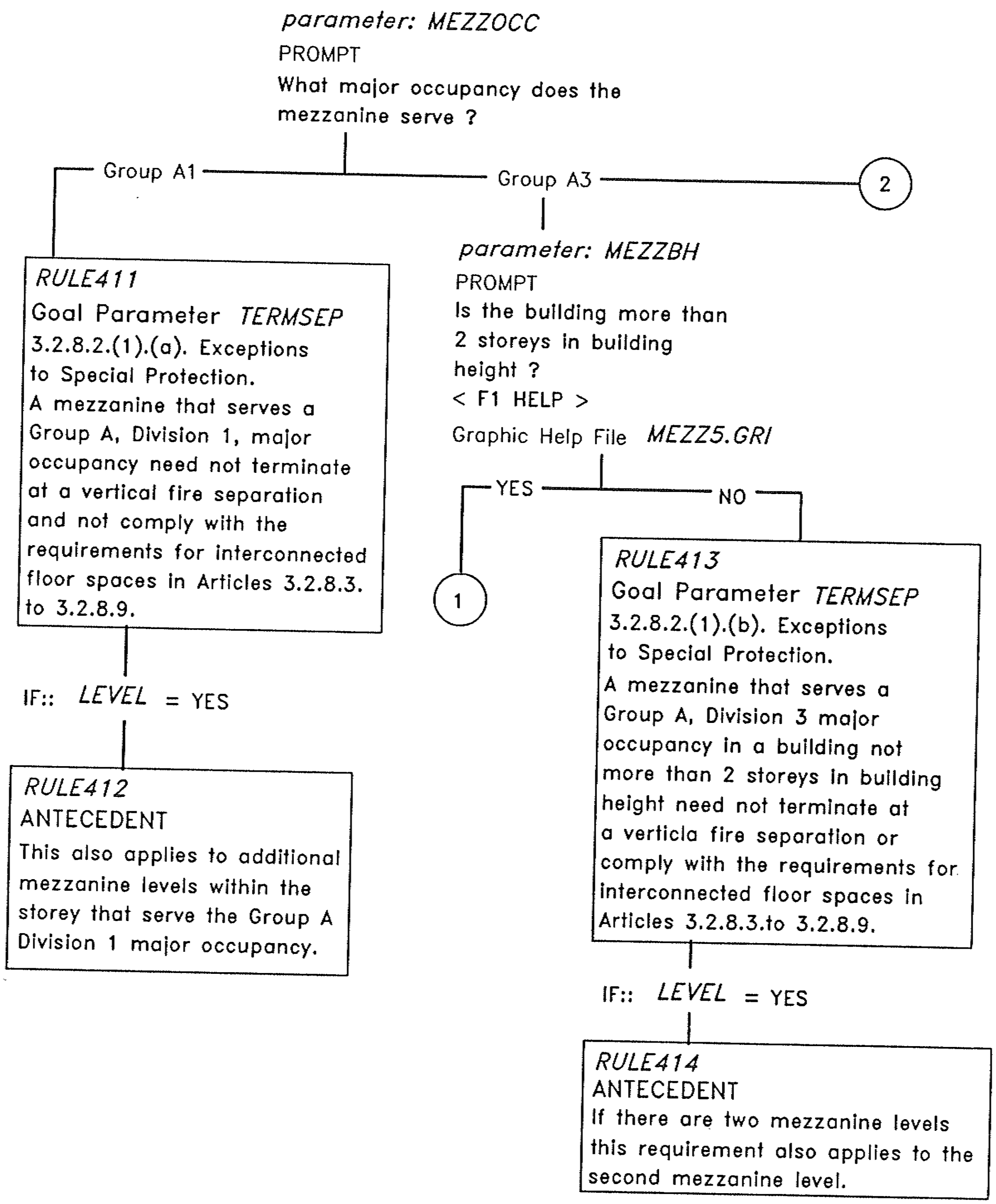


2
parameter: SHELVES
PROMPT
Will the book shelves meet this requirement ?
YES
NO
RULE408
Goal Parameter STOREY
This mezzanine floor need not be considered as a storey in calculating building height.
3
NO
YES
parameter: VISUAL
PROMPT
Will the space above the mezzanine floor and the space above the floor beneath the mezzanine floor have any visual obstructions more than 1070 mm.
YES
NO
RULE410
Goal Parameter STOREY
This level of mezzanine must be considered as a storey in calculating building height.
RULE408
Goal Parameter STOREY
This mezzanine floor need not be considered as a storey in calculating building height.

Fire Separation of Mezzanines

Goal parameter to be solved. *TERMSEP*

To determine whether the mezzanine level is required to terminate at a vertical fire separation.



Fire Separation of Mezzanines

1

IF:: *LEVEL* = NO

IF:: *LEVEL* = YES

3

IF:: Goal Parameter
STOREY = NO

parameter: MA500
PROMPT
Is the area of the mezzanine
more than 500 metres ?

NO

YES

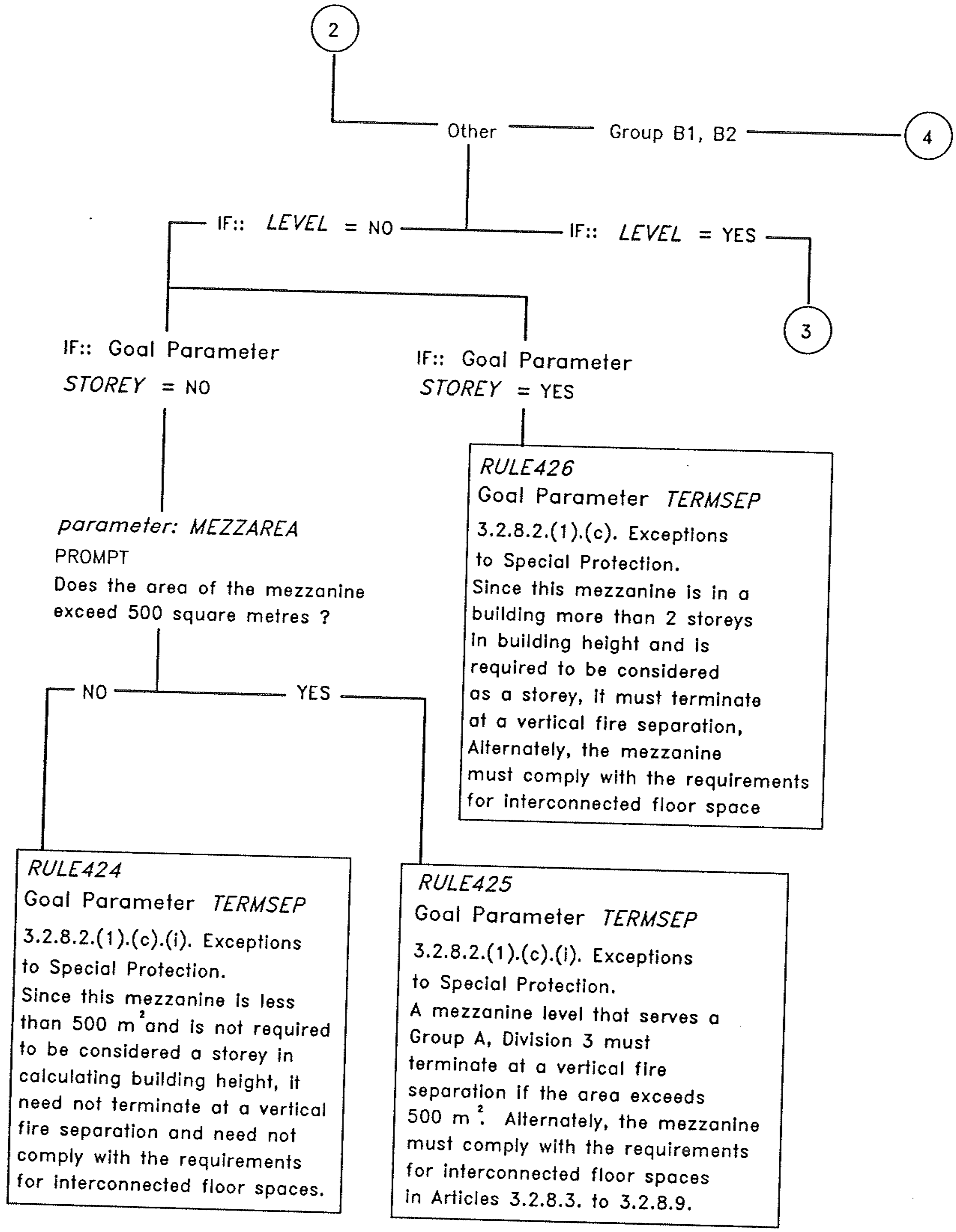
IF:: Goal Parameter
STOREY = YES

RULE415
Goal Parameter *TERMSEP*
3.2.8.2.(1).(c). Exceptions
to Special Protection.
Since this mezzanine is in a
building more than 2 storeys
in building height and is
required to be considered
as a storey, it must terminate
at a vertical fire separation,
Alternately, the mezzanine
must comply with the requirements
for interconnected floor space

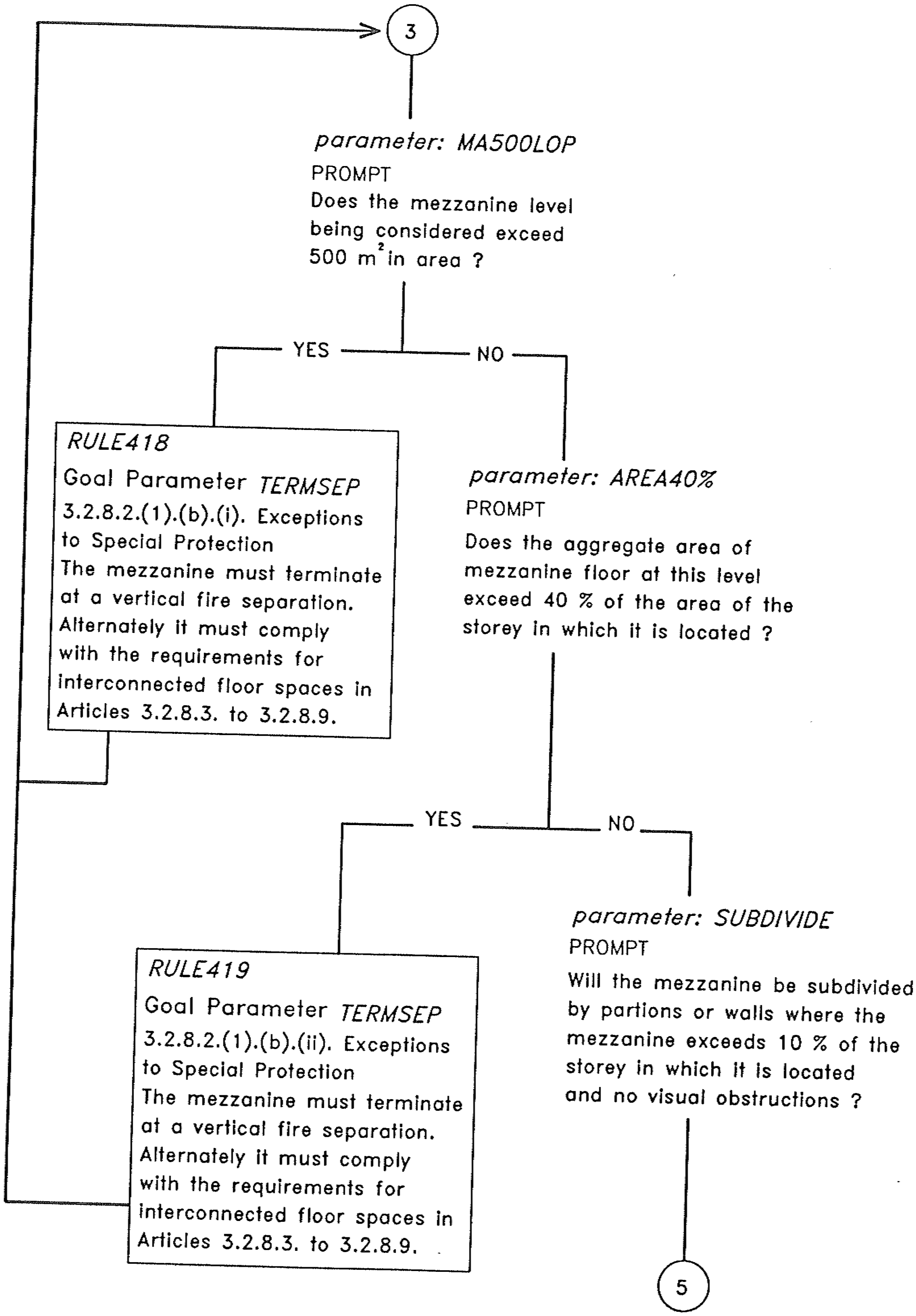
RULE417
Goal Parameter *TERMSEP*
3.2.8.2.(1).(c).(i). Exceptions
to Special Protection.
Since this mezzanine is less
than 500 m^2 and is not required
to be considered a storey in
calculating building height, it
need not terminate at a vertical
fire separation and need not
comply with the requirements
for interconnected floor spaces.

RULE416
Goal Parameter *TERMSEP*
3.2.8.2.(1).(c).(i). Exceptions
to Special Protection.
A mezzanine level that serves a
Group A, Division 3 must
terminate at a vertical fire
separation if the area exceeds
500 m^2. Alternately, the mezzanine
must comply with the requirements
for interconnected floor spaces
in Articles 3.2.8.3. to 3.2.8.9.

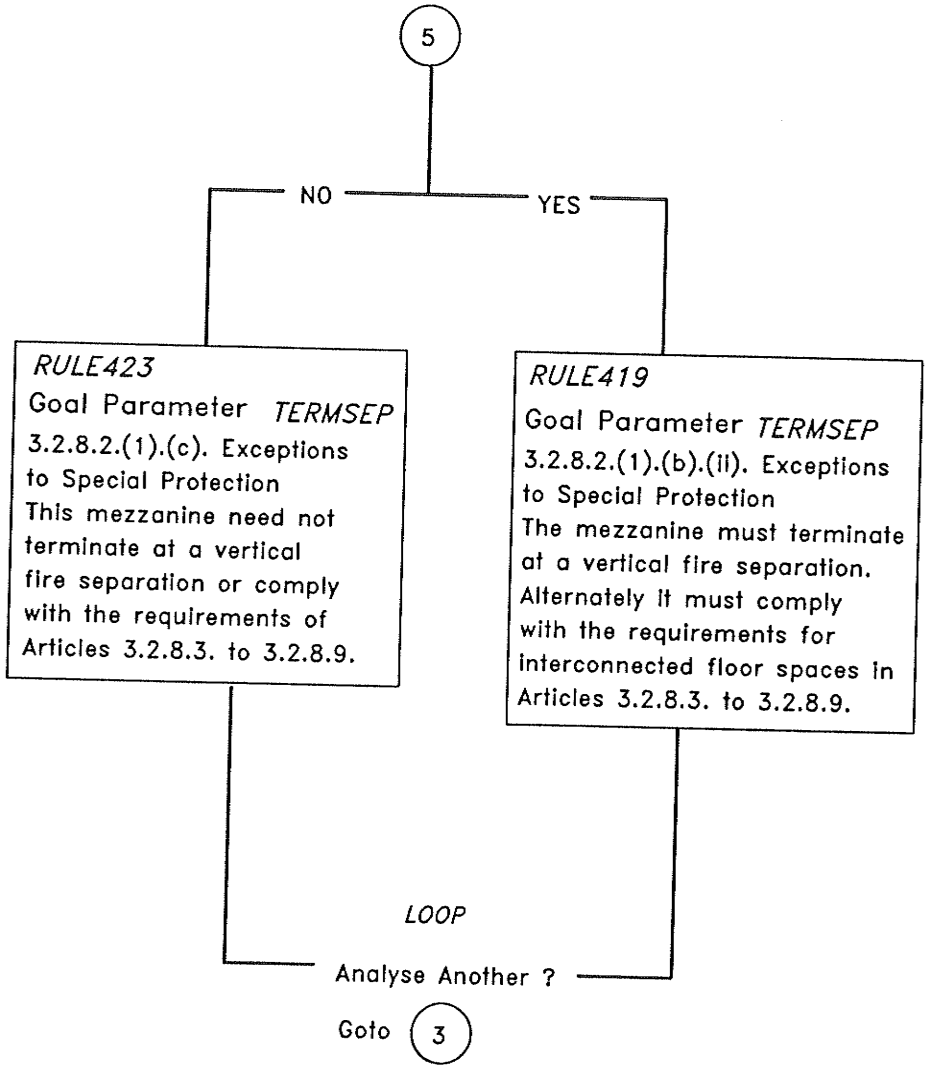
Fire Separation of Mezzanines



Fire Separation of Mezzanines



Fire Separation of Mezzanines



Fire Separation of Mezzanines

4

IF:: *LEVEL* = YES

RULE421
Goal Parameter *TERMSEP*
3.2.8.1.(1). Exceptions to
Special Protection
The mezzanine must terminate at a vertical fire separation or be constructed in such away that it conforms to the requirements for interconnected floor spaces in Articles 3.2.8.3. to 3.2.8.9.

IF:: *LEVEL* = NO

RULE422
Goal Parameter *TERMSEP*
3.2.8.1.(1). Exceptions to
Special Protection
All mezzanine levels must terminate at a vertical fire separation or be constructed in such away that it conforms to the requirements for interconnected floor spaces in Articles 3.2.8.3. to 3.2.8.9.

Mezzanine Egress

Goal parameter to be solved *MEZZEXIT*

To determine whether or not a mezzanine level be provided with exits on the same basis as for other floor areas.

From the previous analysis is the mezzanine required to terminate at a vertical fire separation ?

IF:: *TERMSEP* = YES

RULE427
Goal Parameter *MEZZEXIT*
3.4.2.2.(1). and 3.4.2.2.(2).(a).
Mezzanine Exiting
The mezzanine floor shall be provided with exits on the same basis as for other floor areas.

IF:: *TERMSEP* = NO

parameter: MEZZLOAD
PROMPT
Will the occupant load of the mezzanine exceed 60 people or will the area of this mezzanine exceed 200 m^2 ?

NO

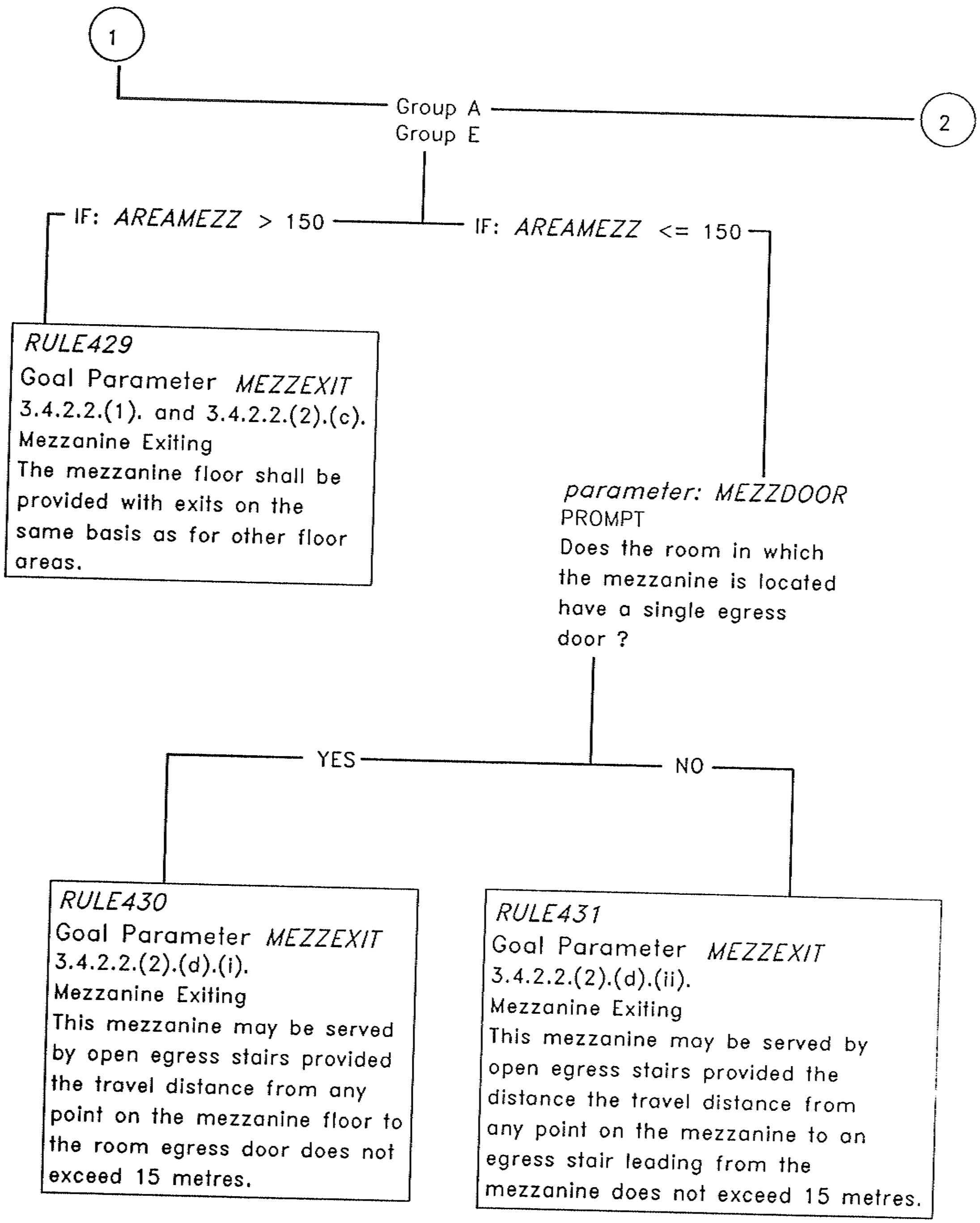
parameter: USE
PROMPT
What is the occupancy of the mezzanine floor ?
Group A
Group C
Group D
Group E
Group F, Division 1
Group F, Division 2
Group F, Division 3

1

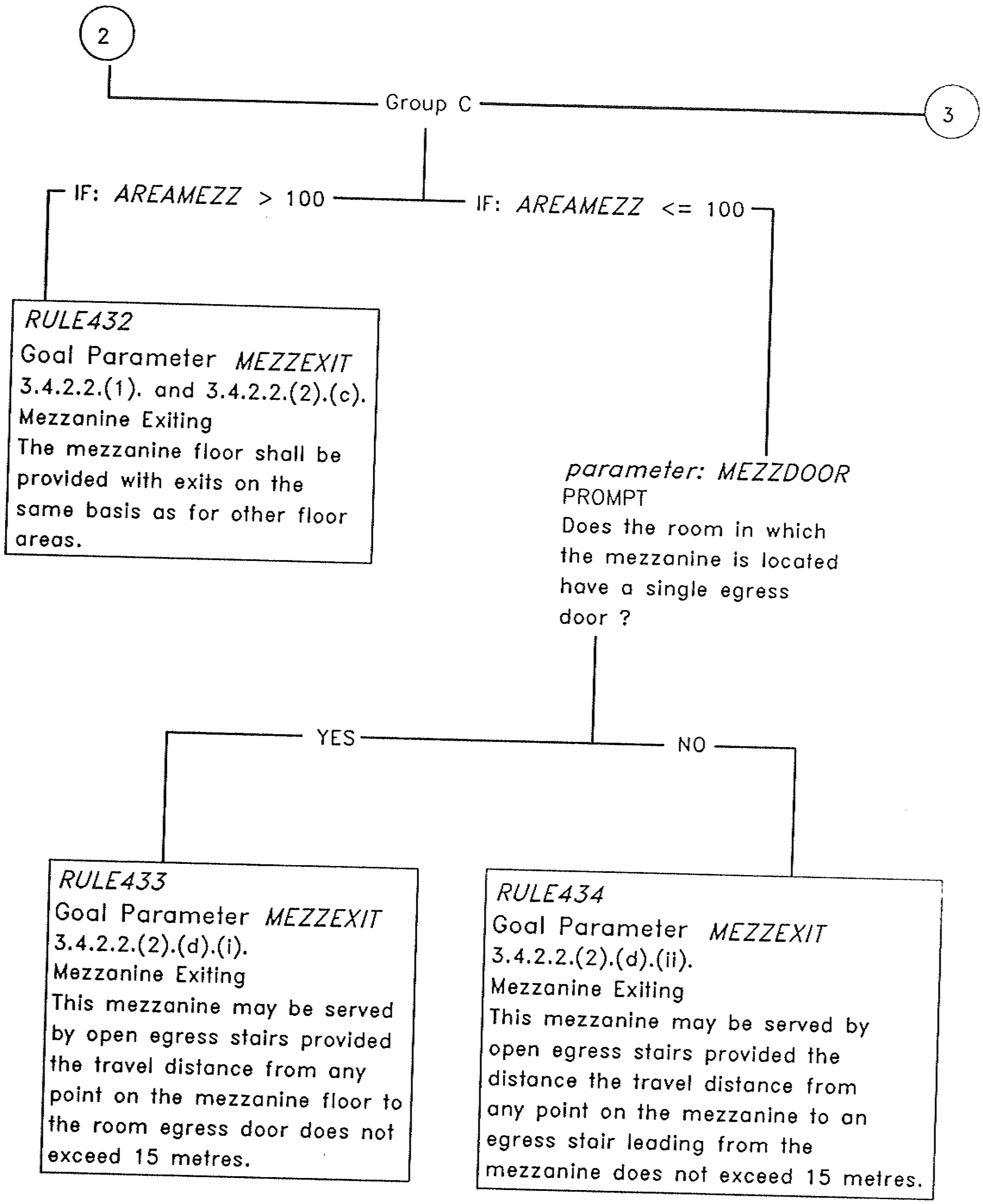
YES

RULE428
Goal Parameter *MEZZEXIT*
3.4.2.2.(1) and 3.4.2.2.(2).(b),(c)
Mezzanine Exiting
The mezzanine floor shall be provided with exits on the same basis as for other floor areas.

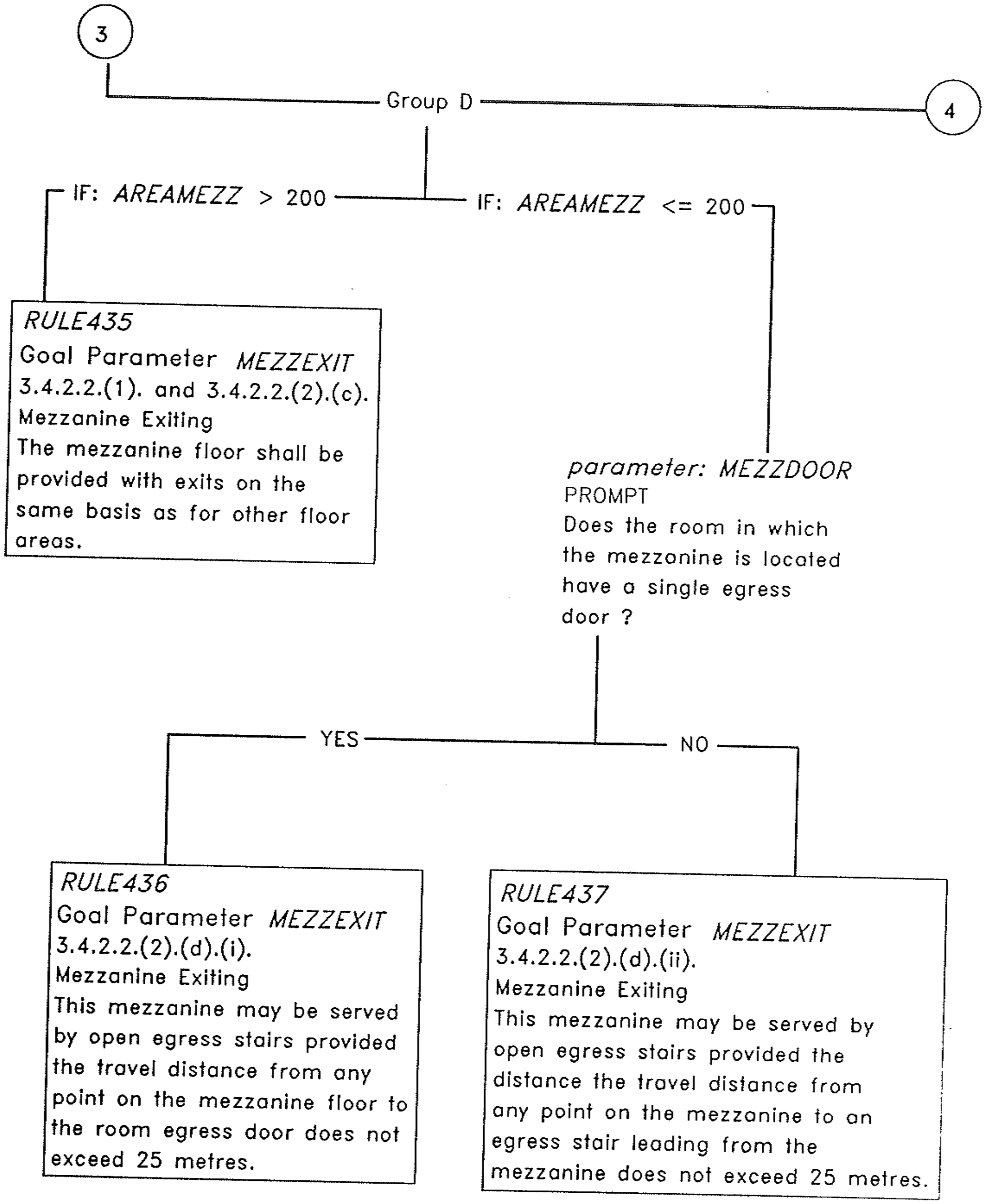
Mezzanine Egress



Mezzanine Egress



Mezzanine Egress



Mezzanine Egress

4

Group F, Division 2

5

IF: *AREAMEZZ* > 100

RULE438
Goal Parameter *MEZZEXIT*
3.4.2.2.(1). and 3.4.2.2.(2).(c).
Mezzanine Exiting
The mezzanine floor shall be provided with exits on the same basis as for other floor areas.

IF: *AREAMEZZ* <= 100

parameter: MEZZDOOR
PROMPT
Does the room in which the mezzanine is located have a single egress door ?

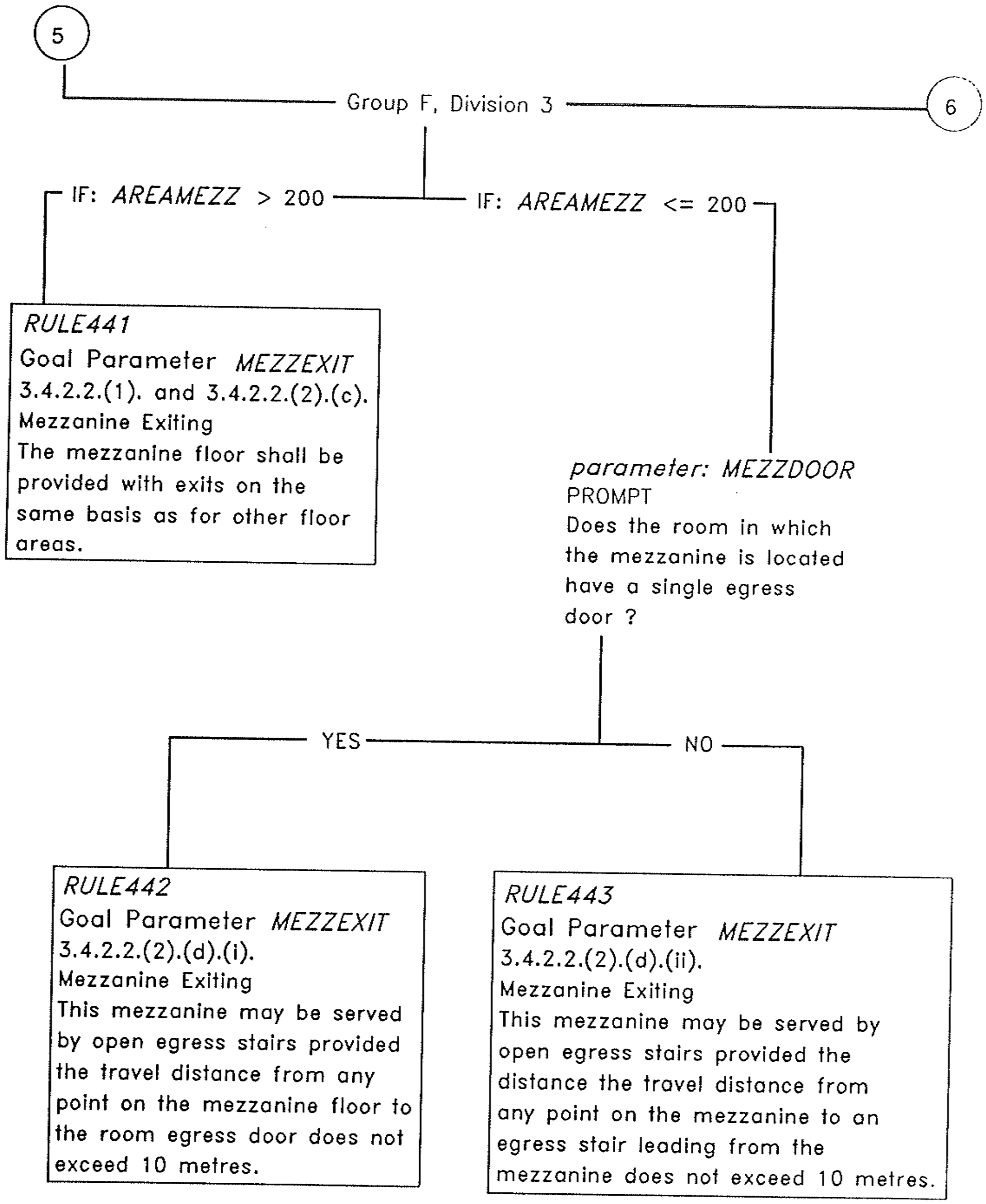
YES

RULE439
Goal Parameter *MEZZEXIT*
3.4.2.2.(2).(d).(i).
Mezzanine Exiting
This mezzanine may be served by open egress stairs provided the travel distance from any point on the mezzanine floor to the room egress door does not exceed 10 metres.

NO

RULE440
Goal Parameter *MEZZEXIT*
3.4.2.2.(2).(d).(ii).
Mezzanine Exiting
This mezzanine may be served by open egress stairs provided the distance the travel distance from any point on the mezzanine to an egress stair leading from the mezzanine does not exceed 10 metres.

Mezzanine Egress



Mezzanine Egress

6

Group F, Division 1

RULE444
Goal Parameter *MEZZEXIT*
3.4.2.2.(1). Mezzanine
Exiting
The mezzanine floor shall be
provided with exits on the
same basis as for other floor
areas.

Emergency Operation of Elevators

Goal parameters to be solved *EMERG–ELE*
Emergency operation of elevators

parameter: ELEHB
PROMPT
Is this a high building ?

YES — NO — 1

parameter: ELESPRK
PROMPT
Is the building sprinklered ?

YES — NO

RULE574
Goal Parameter *EMERG–ELE*
Manual Emergency Recall is required for all elevators serving storeys above the first
Automatic Emergency Recall is not required since the building is sprinklered.
DISPLAY TEXTAGE *RECALL1*
Showing
Sentences 3.2.6.8.(1) to (4)

RULE575
ANTECEDENT
Manual Emergency Recall is required for all elevators serving storeys above the first.
Automatic Emergency Recall is required since the building is not sprinklered.
DISPLAY TEXTAGE *RECALL2*
Showing
Sentences 3.2.6.8.(1) to (7)

parameter: ELEFL
PROMPT
Is the floor area containing the recall level sprinklered ?

NO — YES

RULE576
Goal Parameter *EMERG–ELE*
Since the elevators are required to have an automatic recall feature and the floor area containing the recall level is not sprinklered, the elevators must have an alternate level recall feature as required.
DISPLAY TEXTAGE *RECALL3*
Showing
Sentences 3.2.4.15.(1) and (2)

RULE577
Goal Parameter *EMERG_ELE*
Since the elevators are required to have an automatic recall feature and the floor area containing the recall level is sprinklered, Sentence 3.2.4.15.(3) applies and the elevators do not require alternate level recall.
DISPLAY TEXTAGE *RECALL4*
Showing
Sentence 3.2.4.15.(3)

Emergency Operation of Elevators

1

parameter: ELE!HB
PROMPT
Since this is not a high building, the elevators are not required to be provided with a manual emergency recall feature or an automatic recall feature. However, many elevators are equipped with the automatic recall feature.

Are the elevators in this building equipped with an automatic emergency recall feature ?

YES

parameter: ELEFL
PROMPT
Is the floor area containing the recall level sprinklered ?

YES

RULE578
Goal Parameter *EMERG–ELE*
Sentence 3.2.4.15.(3) applies and the elevators in this building do not require alternate level recall.
DISPLAY TEXTAGE *RECALL4*
Showing
Sentence 3.2.4.15.(3)

NO

RULE580
Since the elevators in this building are equipped with an automatic emergency recall feature Sentences 3.2.4.15.(1) and (2) apply and the elevators must be provided with an alternate level recall feature.
DISPLAY TEXTAGE *RECALL3*
Showing
Sentences 3.2.4.15.(1) and (2)

NO

RULE579
Goal Parameter *EMERG–ELE*
There are no requirements for emergency elevator return for the elevators in this building.

Emergency Power Systems Subsection 3.2.7.

Goal parameters to be solved

EPLIGHT
3.2.7.4. Emergency power to emergency lighting

EPFALARM
3.2.7.8. Emergency power to fire alarm system

EPVOICE
3.2.7.8.(5). Emergency power to voice communication

EPELEVATE
3.2.7.9.(1).(a). Emergency power to elevators

EPSMOKE
3.2.7.9.(1).(c). Emergency power for smoke control

EPVENT
3.2.7.9.(1).(d). Emergency power smoke venting

EPWATER
3.2.7.9.(1).(b). Emergency power for fire pumps

EPEXIT
3.4.5.1.(4).(b). Emergency power for exit lights

parameter: HIGHBLDG
PROMPT
Is this a high building ?
< F1 HELP >

YES

RULE474
Goal Parameter
EPLIGHT (all high buildings require emergency lighting.)
Time duration = 2 hours, 3.2.7.4.(1).(a)
Power supply by batteries or generator
Supervision no requirement
EPFALARM (all high buildings require fire alarm system.)
Time duration = 2 hours, 3.2.7.8.(3).(a)
Power supply 3.2.7.8.(2).
Supervision = 24 hours 3.2.7.8.(3).

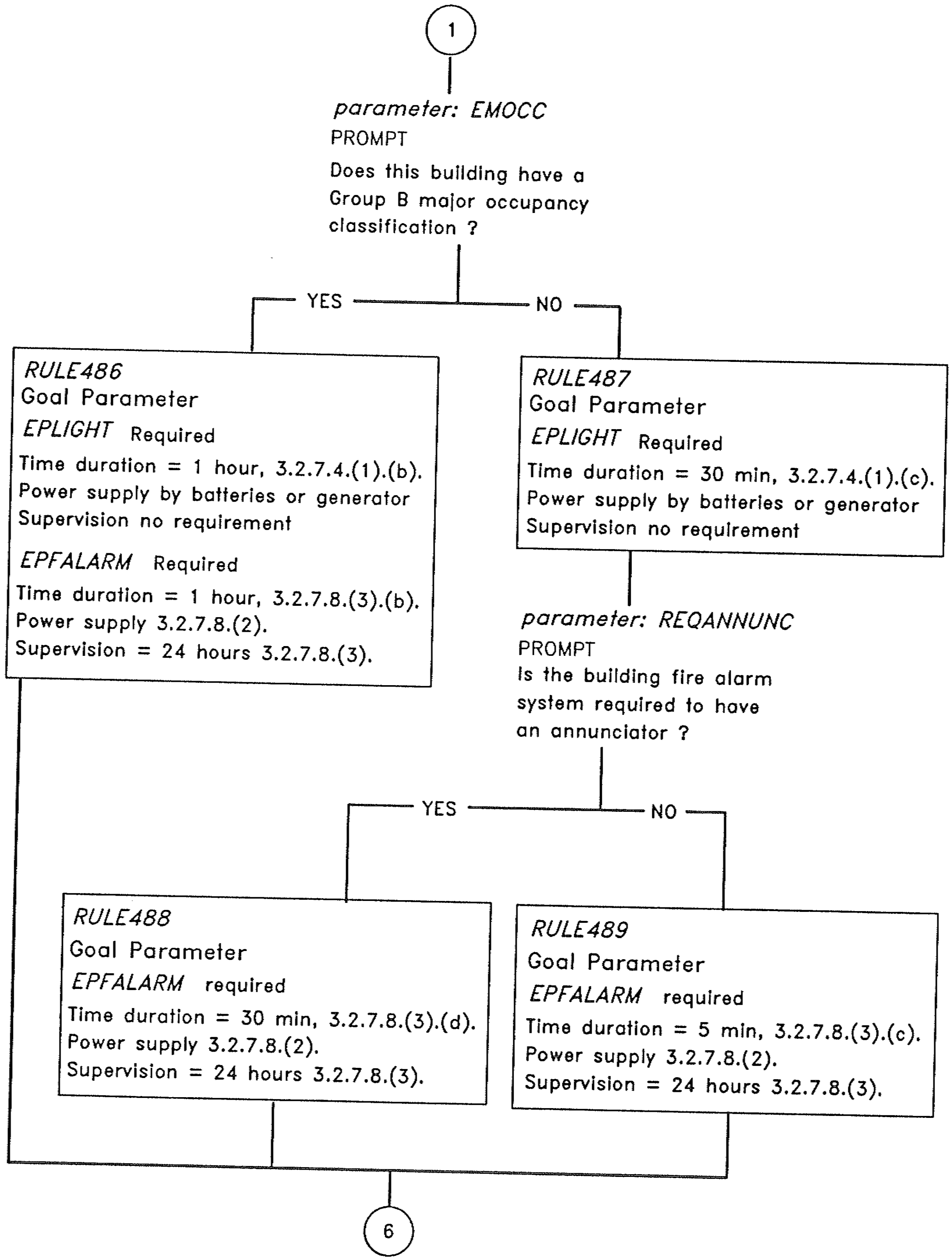
2

NO

RULE485
Goal Parameters
EPVENT not required
EPVOICE not required
EPSMOKE not required
EPELEV not required

1

Emergency Power Systems Subsection 3.2.7.



Emergency Power Systems Subsection 3.2.7.

6

parameter: STAN/SPRK

PROMPT

Does the building have a sprinkler and/or standpipe system ?

YES — NO

parameter: POWST/SP

PROMPT

Does the water supply to the sprinkler and/or standpipe system depend on electrical power supplied to the building ?

RULE491
Goal Parameter
EPWATER not required

YES — NO

RULE491
Goal Parameter
EPWATER not required

RULE490
Goal Parameter
EPWATER Required
Time duration = 2 hours, 3.2.7.9.(1).(b).
Power supply by generator
Supervision = 24 hours.

Emergency Power Systems Subsection 3.2.7.

2

parameter: HBMEAR

PROMPT

What is the height of the building measured from grade to the floor level of the top storey ?

< F1 HELP >

> 36 metres
<= 36 metres

> 36 metres

RULE475
Goal Parameter
EPVOICE Required 3.2.6.13.
Time duration = 2 hours, 3.2.7.8.(5).
Power supply by batteries or generator
Supervision 24 hours
TEXTAGE *EMTEXT1*
3.2.7.8.(7). Emergency Power Supply
If the emergency power supply is supplied by batteries, the batteries shall be sized to provide the total energy consumed by the maximum possible electrical supervision current plus the trouble signal current for 24 hours followed by 30 minutes of continuous voice communication

3

<= 36 metres

parameter: FLRGRP,B

PROMPT

Does the building contain a floor area or part of a floor area located above the third storey and designedor intended as a Group B, Division 2 occupancy ?

YES

RULE475
Goal Parameter
EPVOICE Required 3.2.6.13.
Time duration = 2 hours, 3.2.7.8.(5).
Power supply by batteries or generator
Supervision 24 hours

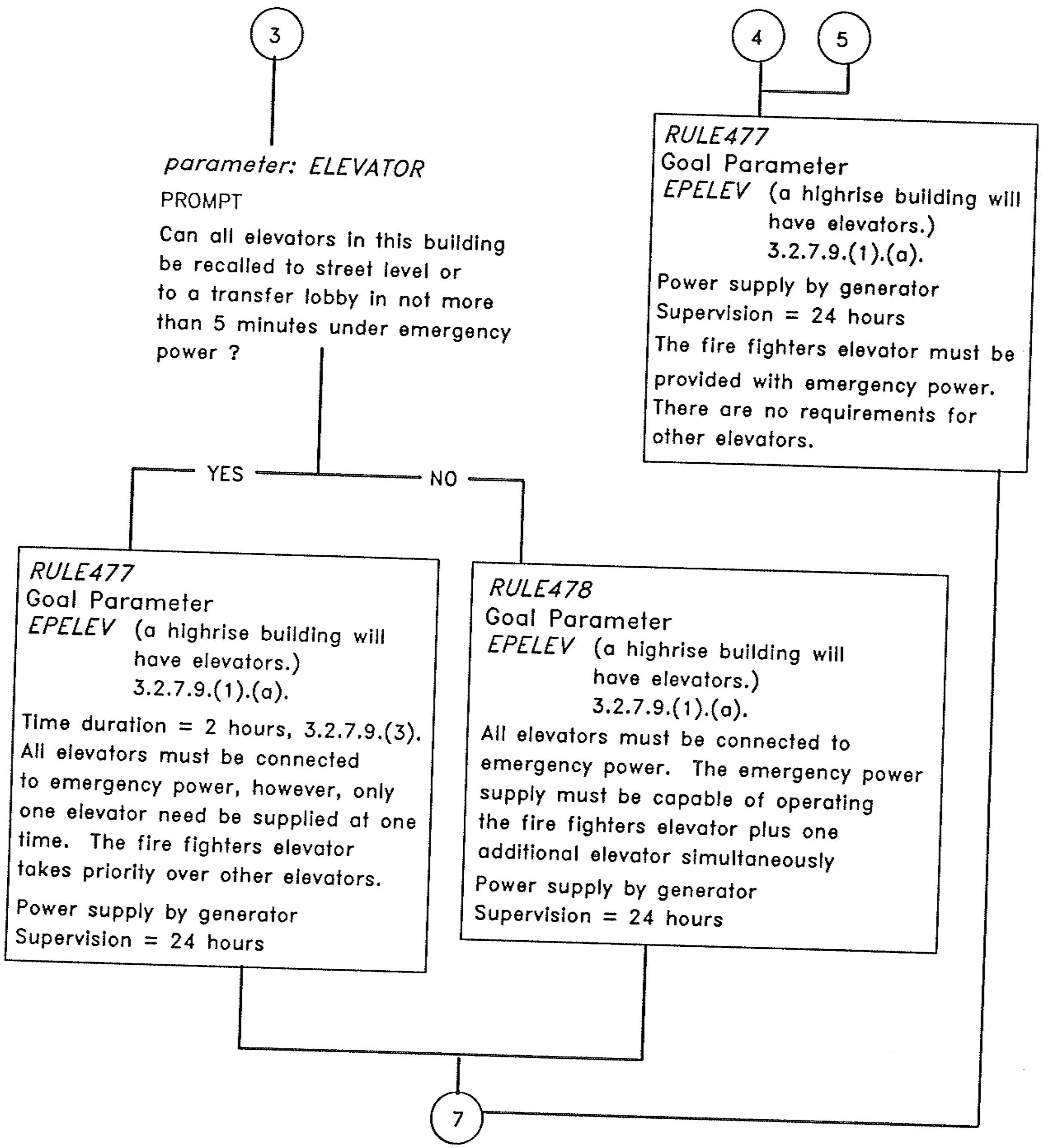
4

NO

RULE476
Goal Parameter
EPVOICE No requirement

5

Emergency Power Systems Subsection 3.2.7.



7

RULE481
Goal Parameter
EPWATER (A high building will require a standpipe and/or sprinkler system)
Time duration = 2 hours, 3.2.7.9.(1).(b).
Supervision = 24 hours
An emergency generator is required to supply emergency power for the operation of the standpipe and/or sprinkler system where the water supply depends on electrical power supplied to the building.

parameter: VENT
PROMPT
Will venting of the floor areas in this high building be provided by mechanical means ?
< F1 HELP >

YES NO

RULE482
Goal Parameter
EPVENT Required
Time duration = 2 hours, 3.2.7.9.(1).(d).
Power supply by generator
Supervision = 24 hours

RULE483
Goal Parameter
EPVENT not required

RULE484
Goal Parameter
EPSMOKE (High buildings require smoke control measure.)
Time duration = 2 hours, 3.2.7.9.(1).(c).
Power supply by generator
Supervision = 24 hours
Fans and other electrical equipment used to maintain air quality in
(a) floor areas,
(b) exit stairs, and/or
(c) fire fighters elevator
are required to be provided with emergency power from an emergency generator.

Fire Separation of Major Occupancies

Goal parameters to be solved *SEPFRR*

To determine the fire resistance rating required between major occupancies.

MAJSEP

To determine the fire resistance rating required between major occupancies based on the requirements of Subsection 3.2.2.

parameter: FSEPMAJ

PROMPT

Do the major occupancies being considered occur one above the other or side by side ?

< F1 HELP >

Graphic Help Screen *FSEP1.GRI*

Side by side — One above the other

RULE496

ANTECEDENT

In a building containing more than one major occupancy, Sentence 3.1.3.6.(1) Separation of Major Occupancies, requires that the wall assembly between the two major occupancies be constructed as a fire separation with a fire resistance rating conforming to Table 3.1.3.A.

REDUNDANT GOAL PARAMETER

MAJSEP

parameter: MAJ1

PROMPT

What is the first major occupancy ?

parameter: MAJ2

PROMPT

What is the second major occupancy ?

1

RULE497

ANTECEDENT

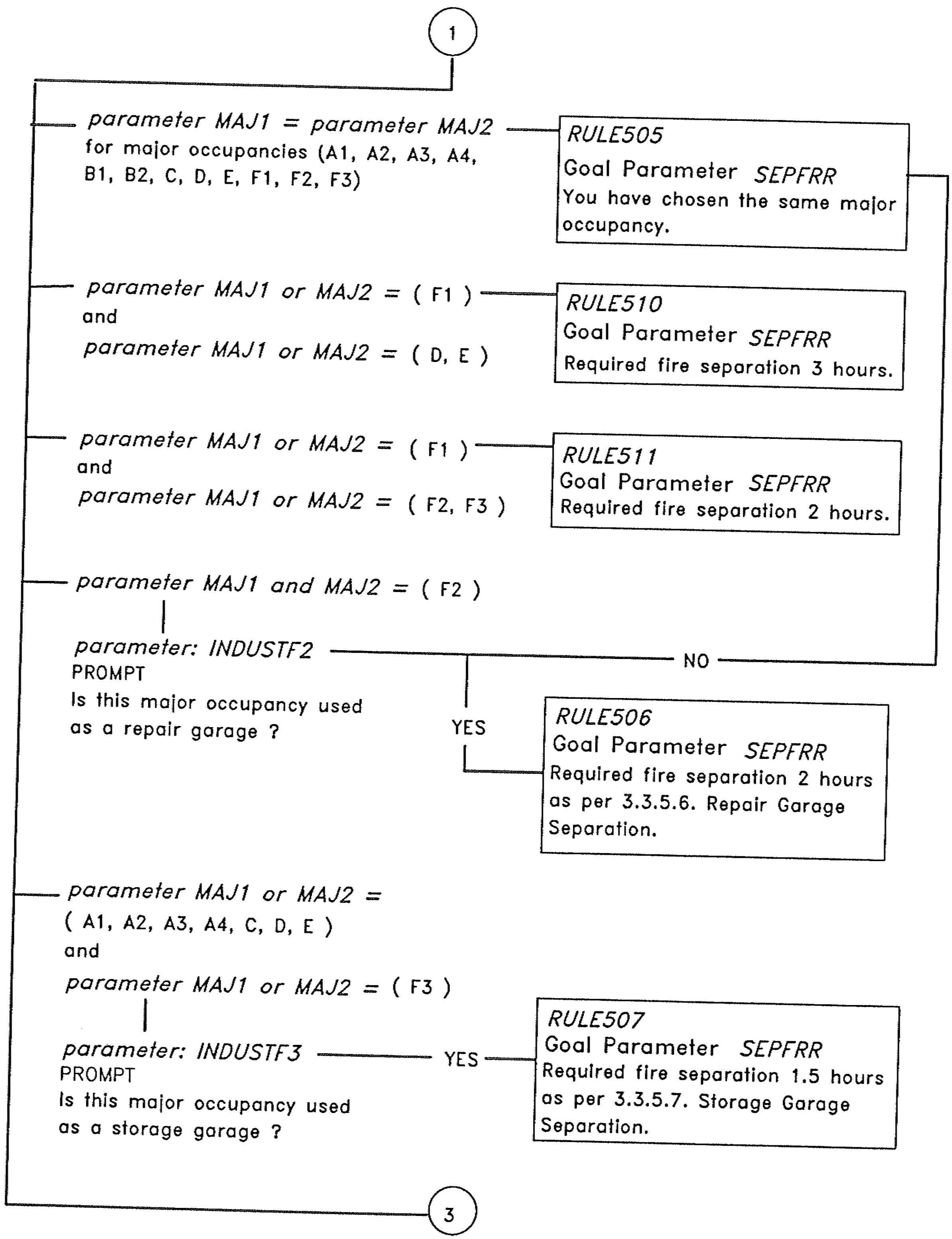
In a building containing more than one major occupancy, Sentence 3.1.3.6.(1) Separation of Major Occupancies requires that the floor between the two major occupancies be constructed as a fire separation with a fire resistance rating conforming to Table 3.1.3.A.

Sentence 3.1.3.4.(2) Superimposed Major Occupancies requires that where one major occupancy is located above another, the floor assembly between such major occupancies shall be determined on the basis of 3.2.2. for the lower major occupancy.

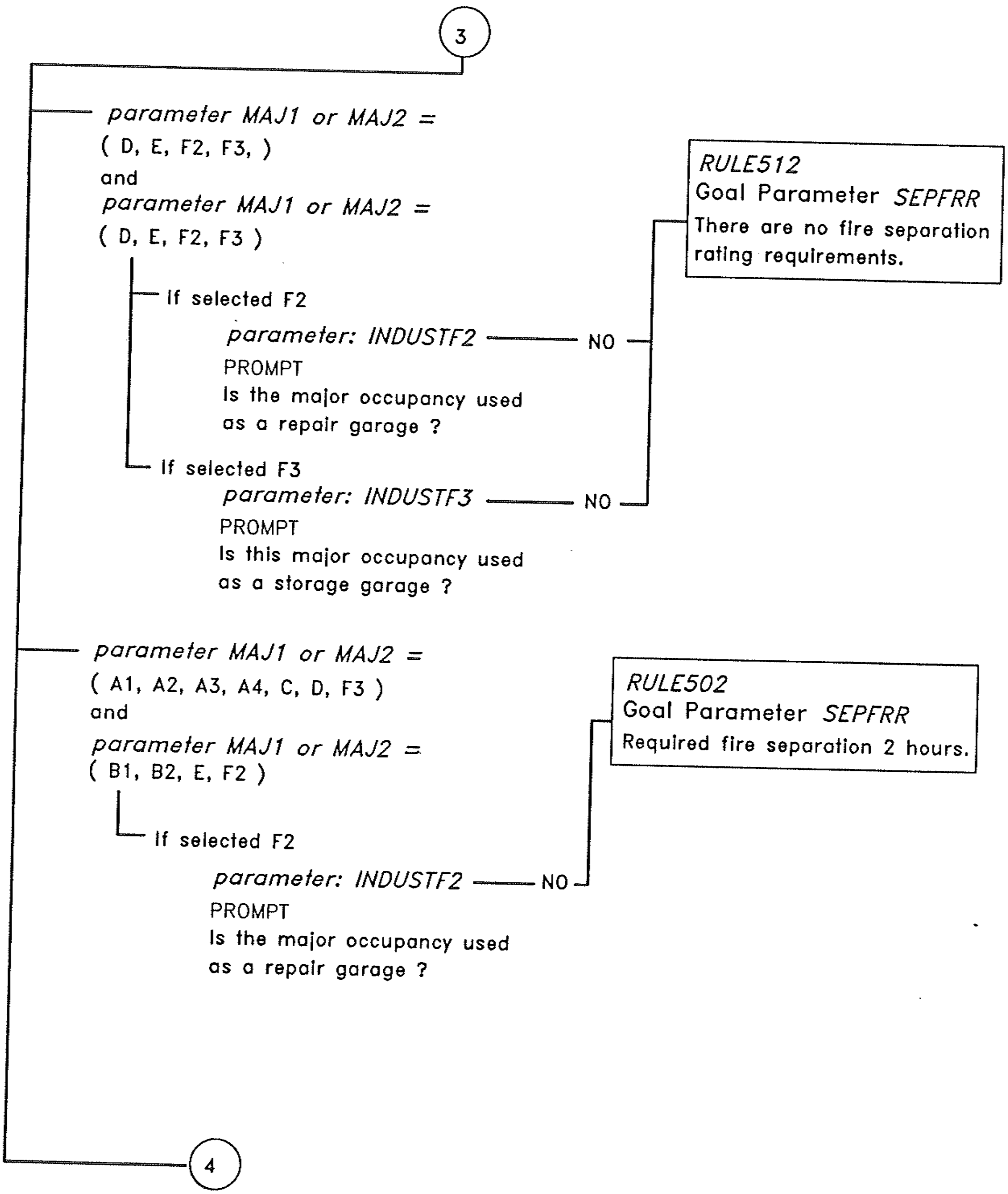
For many buildings the fire resistance rating for floor assemblies determined on the basis of Subsection 3.2.2 Size and Occupancy Requirements for Fire Safety may govern.

2

Fire Separation of Major Occupancies



Fire Separation of Major Occupancies



Fire Separation of Major Occupancies

4

parameter MAJ1 or MAJ2 =
(A1, A2, A3, A4, C, D, F3)
and
parameter MAJ1 or MAJ2 =
(A1, A2, A3, A4, C, D, F3)

RULE503
Goal Parameter *SEPFRR*
Required fire separation 1 hours.

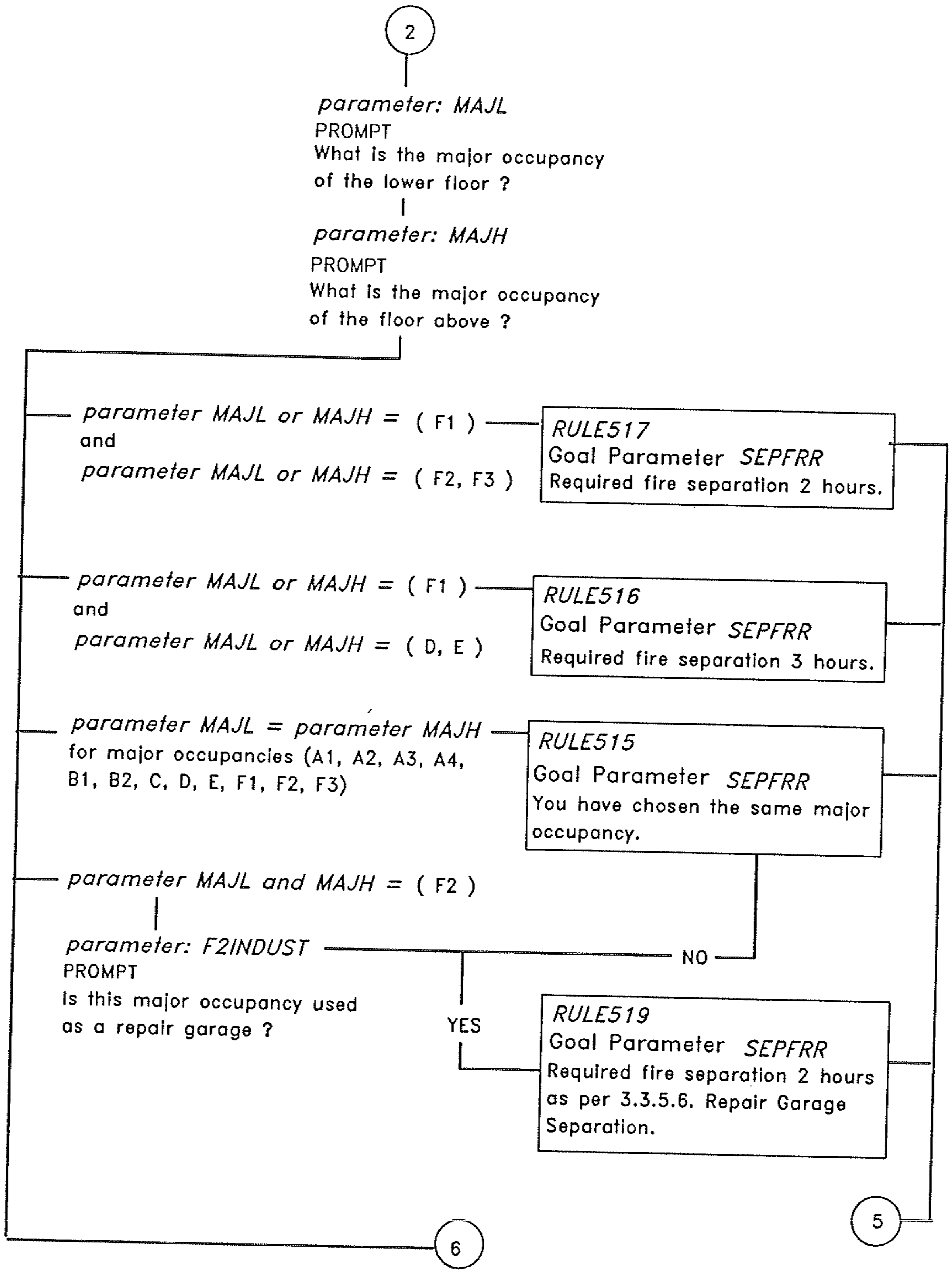
If selected F3 — NO

parameter: INDUSTF3
PROMPT
Is this major occupancy used
as a storage garage ?

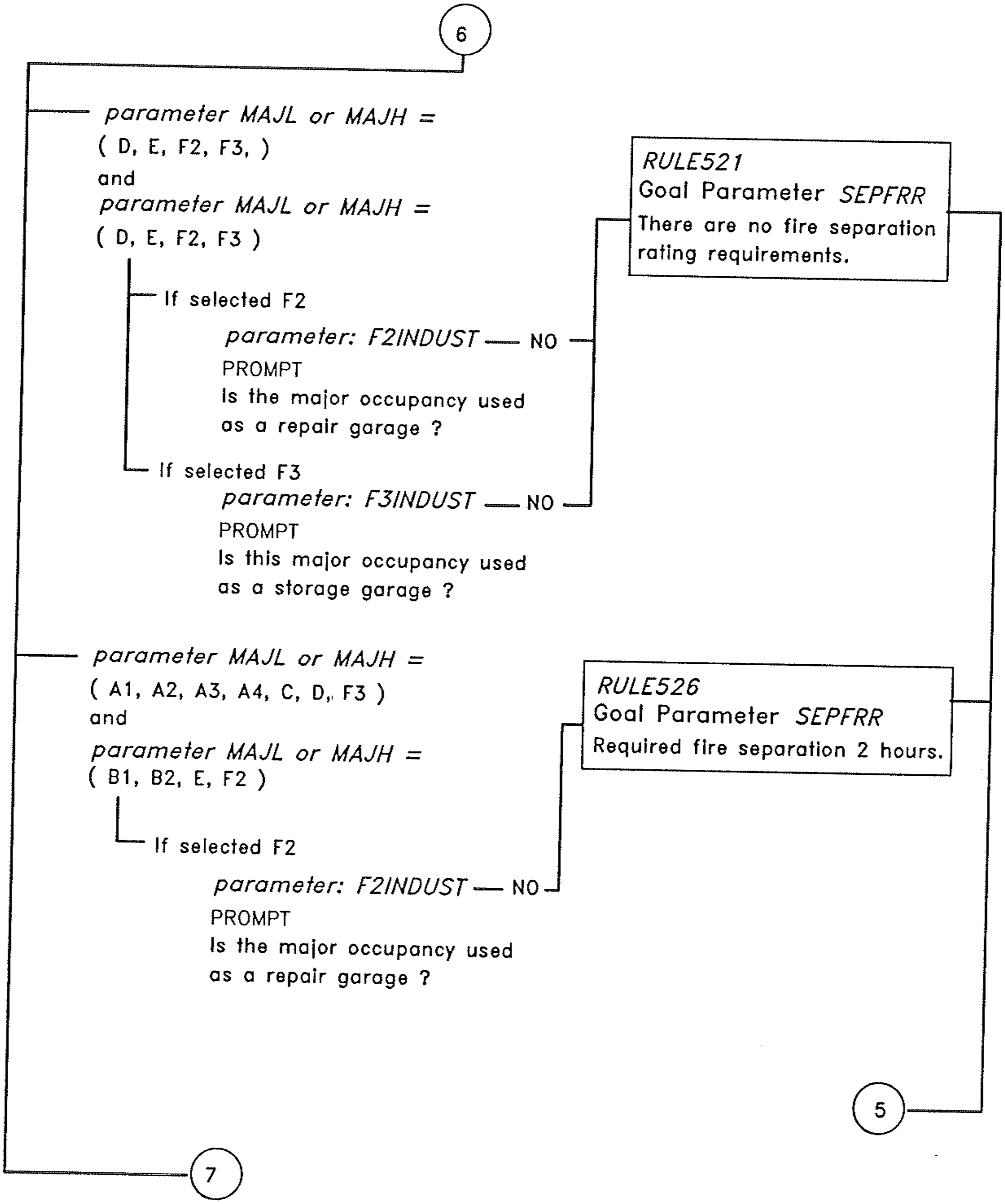
parameter MAJ1 or MAJ2 = (F1)
and
parameter MAJ1 or MAJ2 =
(A1, A2, A3, A4, B1, B2, C)

RULE504
Goal Parameter *SEPFRR*
No major occupancy of Group F,
Division 1 shall be contained within
a building with any occupancy
classified as Group A, B or C.

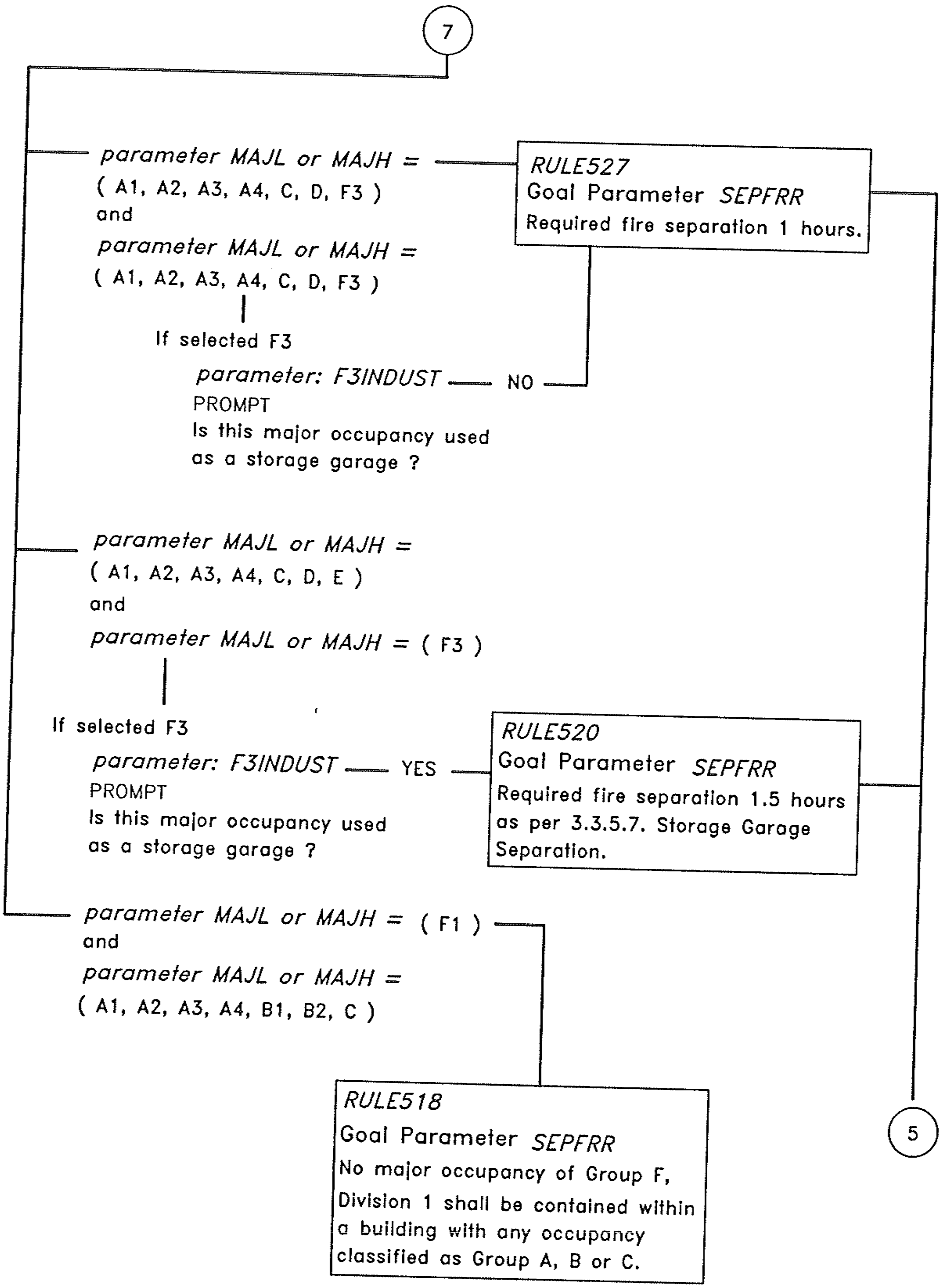
Fire Separation of Major Occupancies



Fire Separation of Major Occupancies



Fire Separation of Major Occupancies



Fire Separation of Major Occupancies

5

Goal Parameter *SEPFRR*
may equal to
1.5 hours, 1 hour, or
No fire resistance requirement
and
parameter MAJL =
(A1, A2, A3, C, D, F3)

RULE558
It is necessary to check Subsection 3.2.2. Building Size and Construction Relative to Occupancy, for the fire-resistance rating of the floor assembly between the major occupancies. A fire-resistance of 2 hours between the major occupancies may be required.

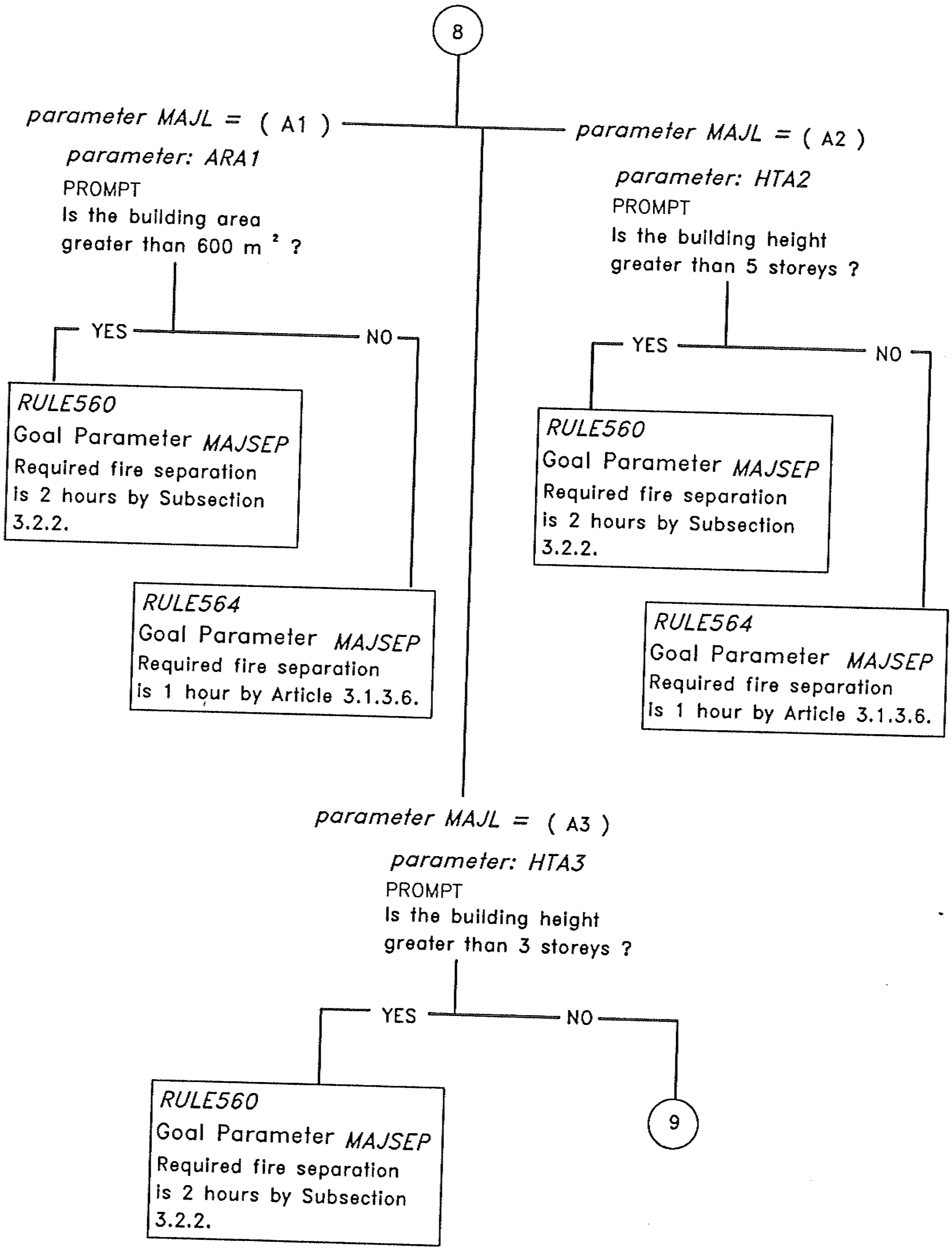
Goal Parameter *SEPFRR*
may equal to
2 hours or No fire-resistance requirement.
and
parameter MAJL =
(E, F1, F2)

RULE559
It is necessary to check Subsection 3.2.2. Building Size and Construction Relative to Occupancy, for the fire-resistance rating of the floor assembly between the major occupancies. A fire-resistance of 3 hours between the major occupancies may be required.

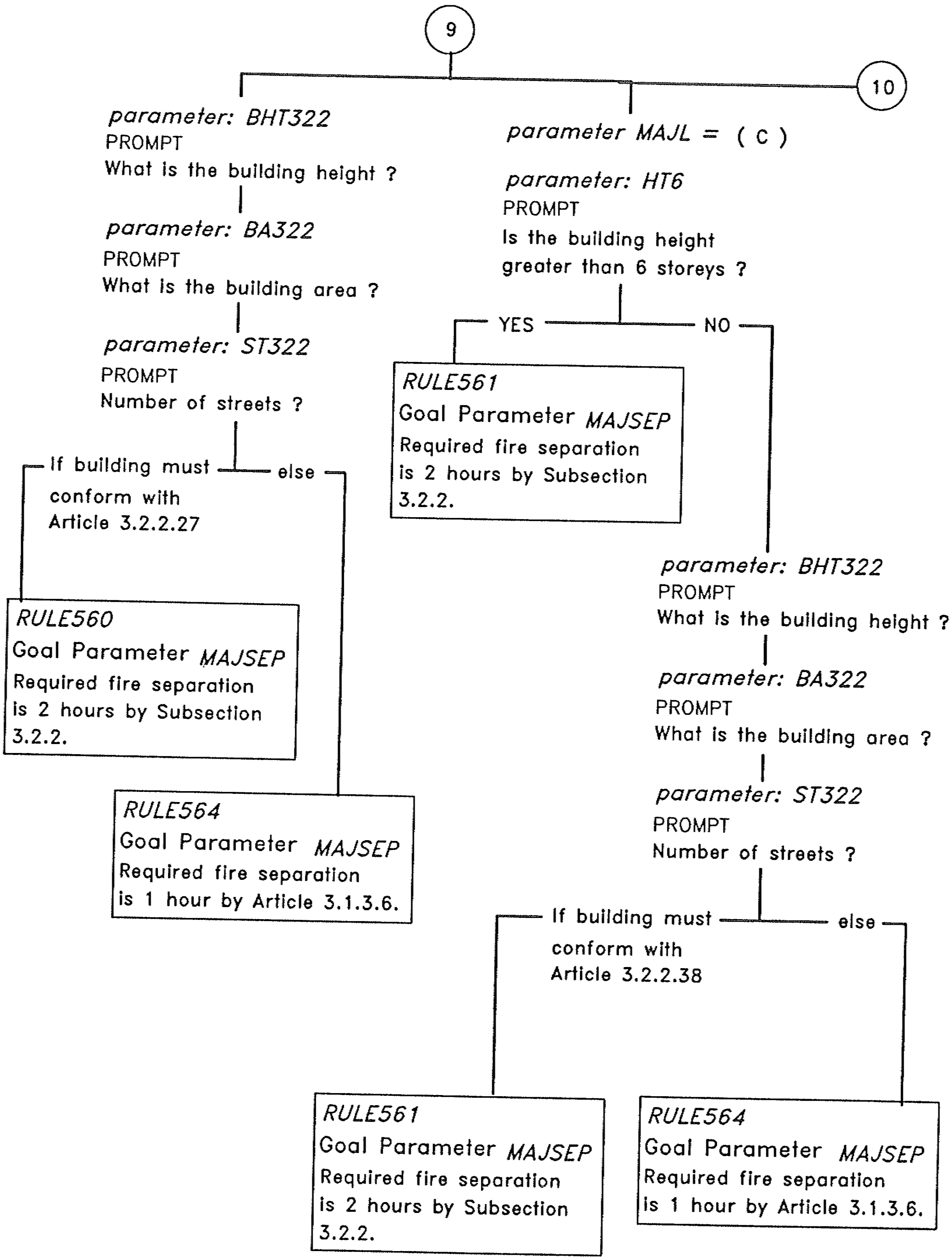
RULE565
ANTECEDENT
Article 3.1.3.4. Superimposed Major Occupancies.
In any building in which one major occupancy is located entirely above another major occupancy, the requirements in Subsection 3.2.2. for each portion of the building containing a major occupancy shall apply to that portion as if the entire building was of that major occupancy.
Graphic Help Screen *FSEP3.GRI*

8

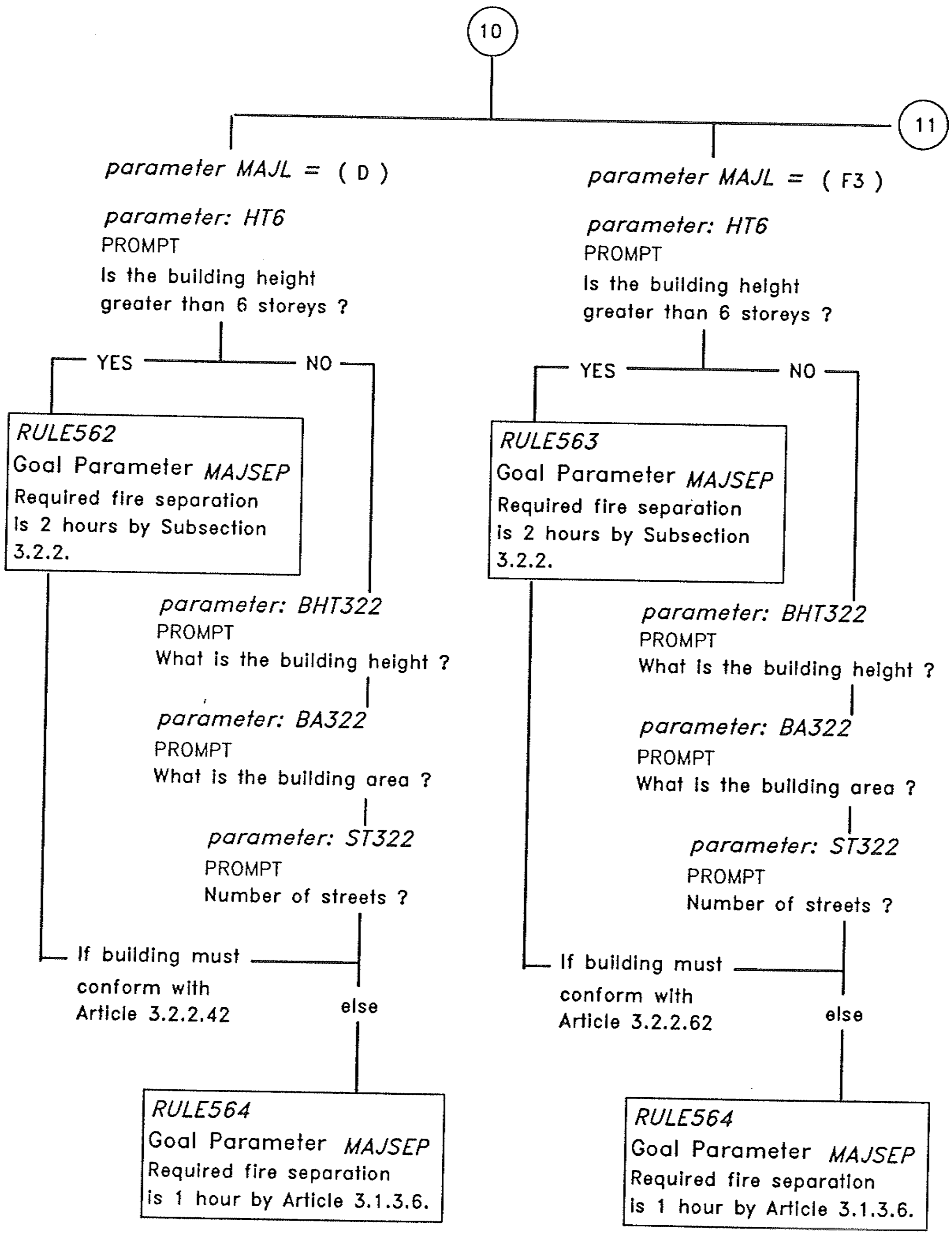
Fire Separation of Major Occupancies



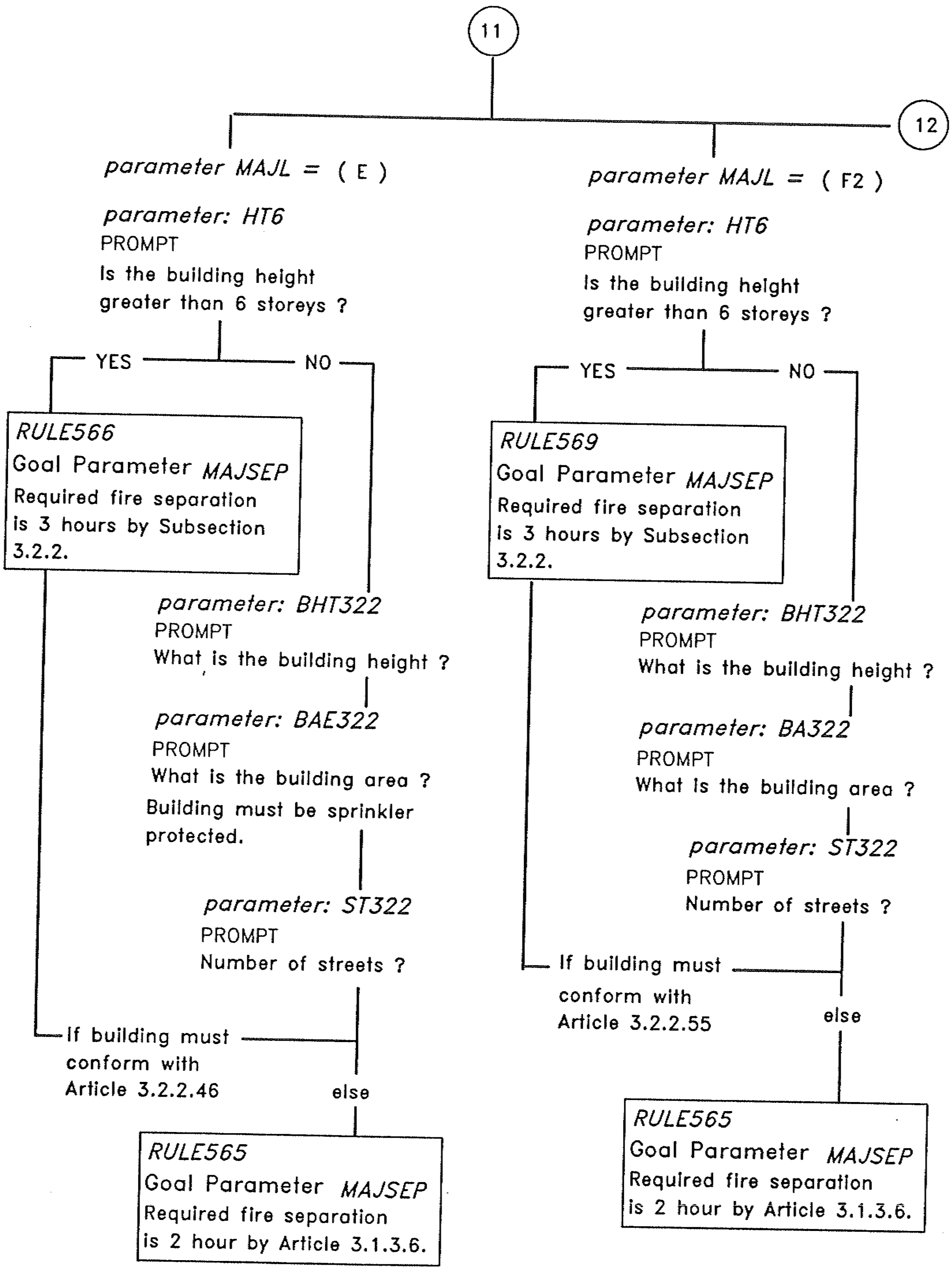
Fire Separation of Major Occupancies



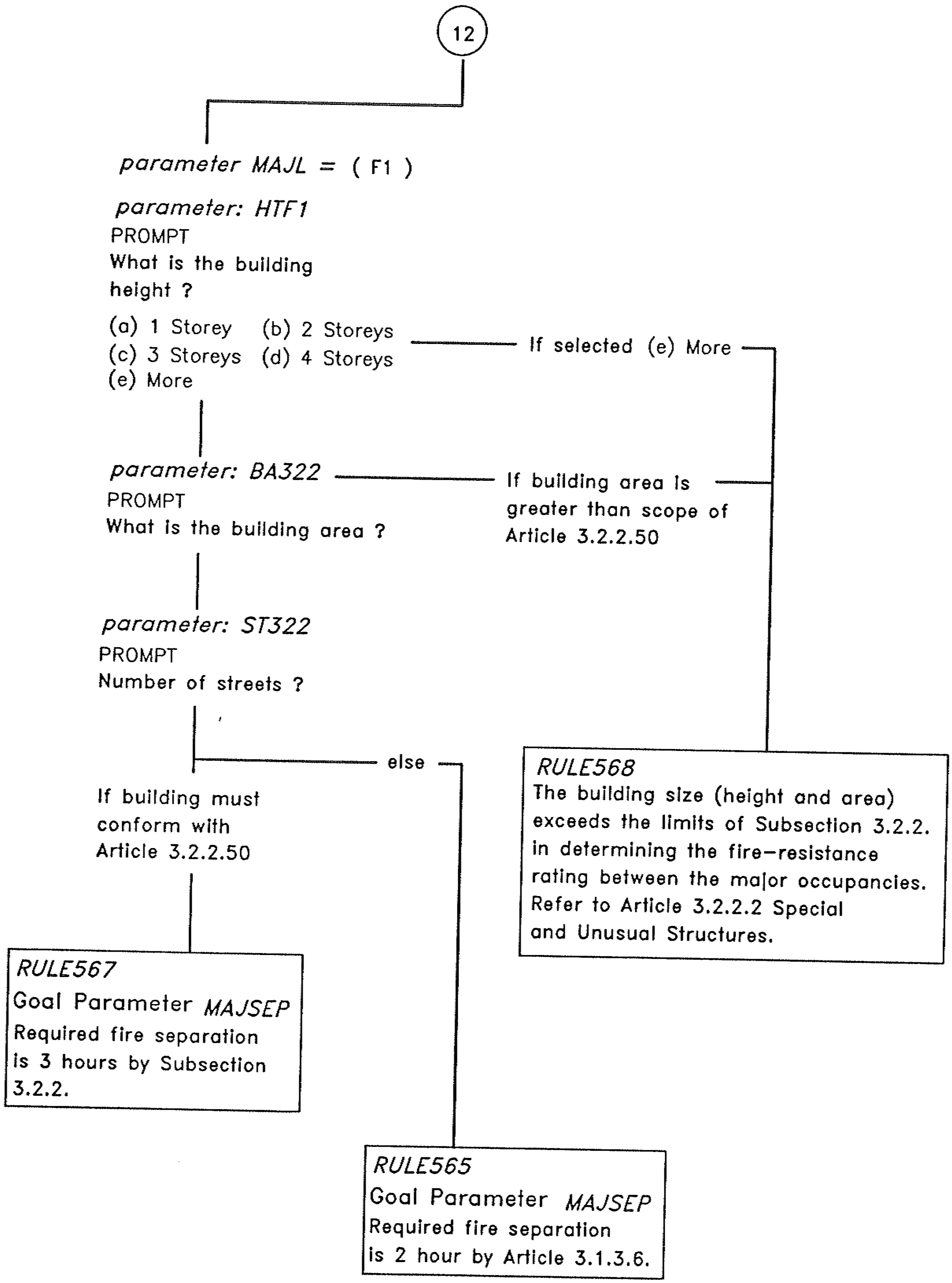
Fire Separation of Major Occupancies



Fire Separation of Major Occupancies



Fire Separation of Major Occupancies



Fire Separation of Service Spaces

Goal Parameter to be solved *FSEPSEV*

To determine the required fire–resistance rating for the service space.

parameter: SERVICE

PROMPT

What is the intended use of the service room ?

A Room containing a Fuel Fired Appliance
B Incinerator Room
C Combustible Refuse Storage Room
D Elevator Machine Room
E Electrical Equipment Room
F None of the Above

A

1

parameter: SOL–FUEL

PROMPT

Is the appliance a solid fuel fired appliance ?

YES

NO

parameter: APP–LOC

PROMPT

Is the appliance located in a
– repair garage
– storage garage or
– any location where the appliance could be exposed to flammable gases or vapours ?

YES

NO

A1

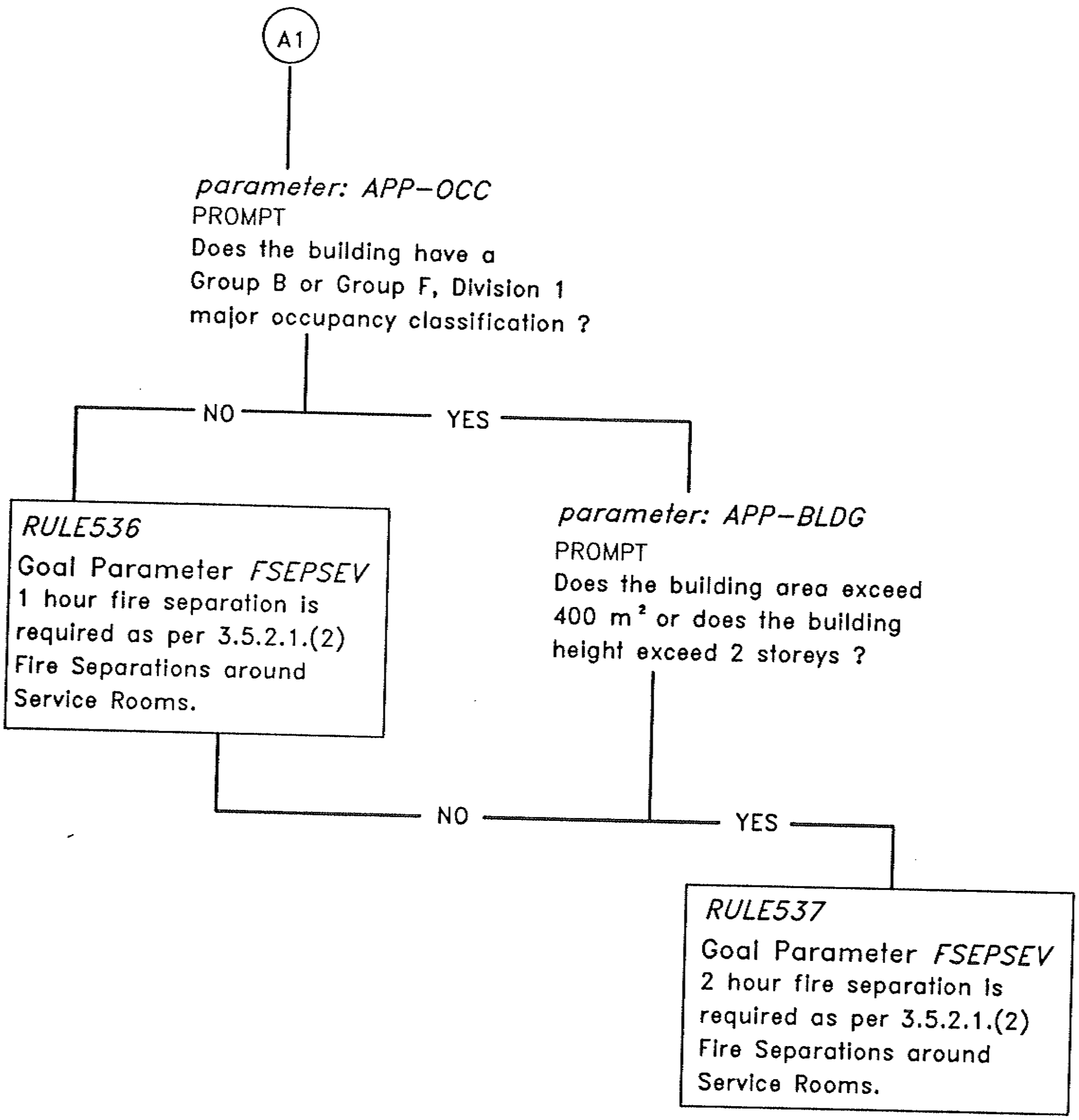
parameter: APP–OCC

PROMPT

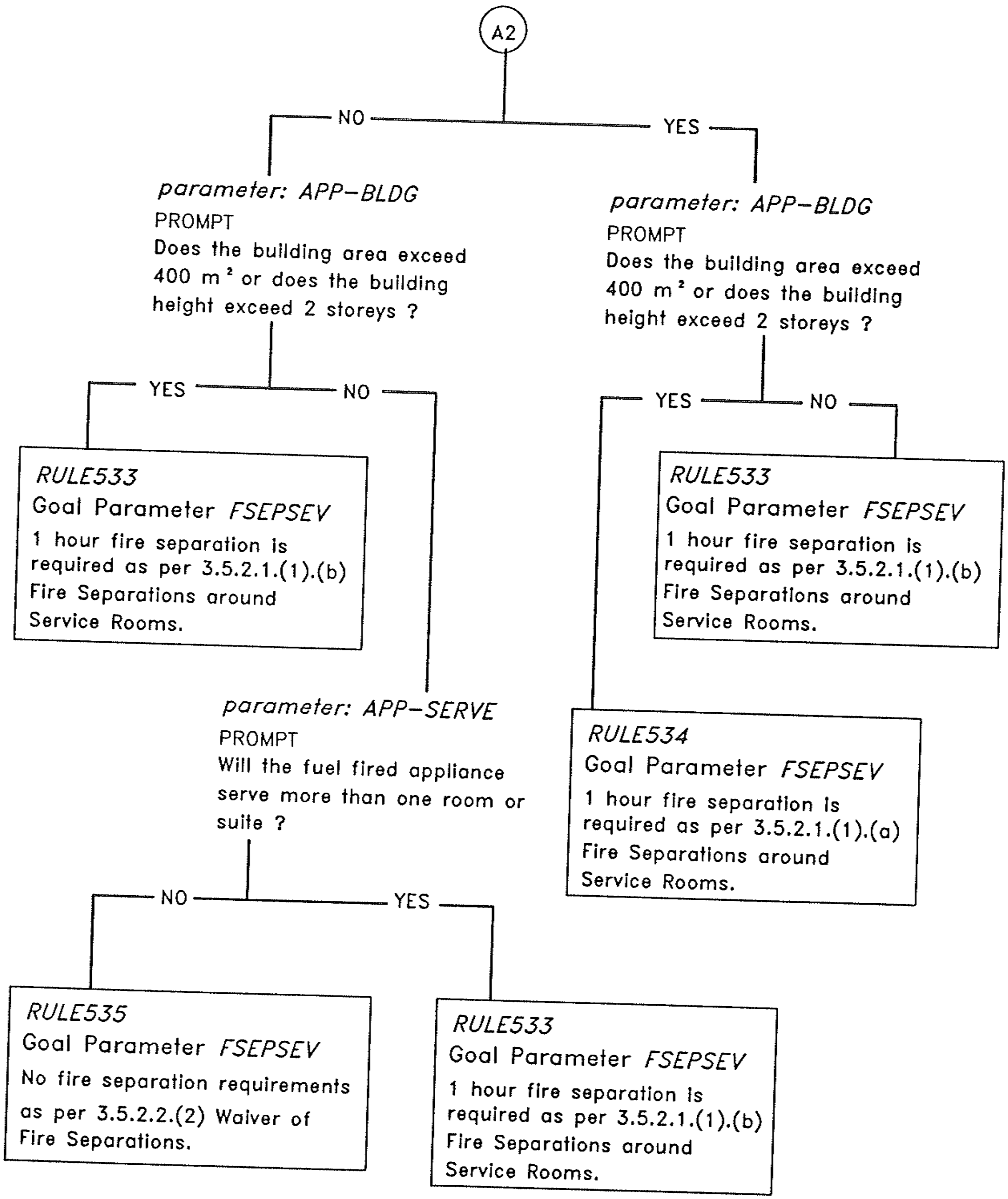
Does the building have a Group B or Group F, Division 1 major occupancy classification ?

A2

Fire Separation of Service Spaces



Fire Separation of Service Spaces



Fire Separation of Service Spaces

1

B

RULE538

Goal Parameter *FSEPSEV*

A 2 hour fire separation is required.

3.5.2.6.(1) Incinerator Rooms.

Service rooms containing an incinerator shall be separated from the remainder of the building by a fire separation having a fire separation having a fire-resistance rating of not less than 2 hours.

3.5.2.6.(2) Incinerator Rooms

Service rooms containing an incinerator shall not contain other fuel fired appliances.

C

2

parameter: CHUTEROOM

PROMPT

Does a refuse chute discharge into this room ?

YES

RULE540

Goal Parameter *FSEPSEV*

A 2 hour fire separation is required. 3.5.3.3.(9). Linen and Refuse Chutes.

A refuse chute shall discharge only into a room or bin separated from the remainder of the building by a fire separation with a fire-resistance rating of not less than 2 hours.

NO

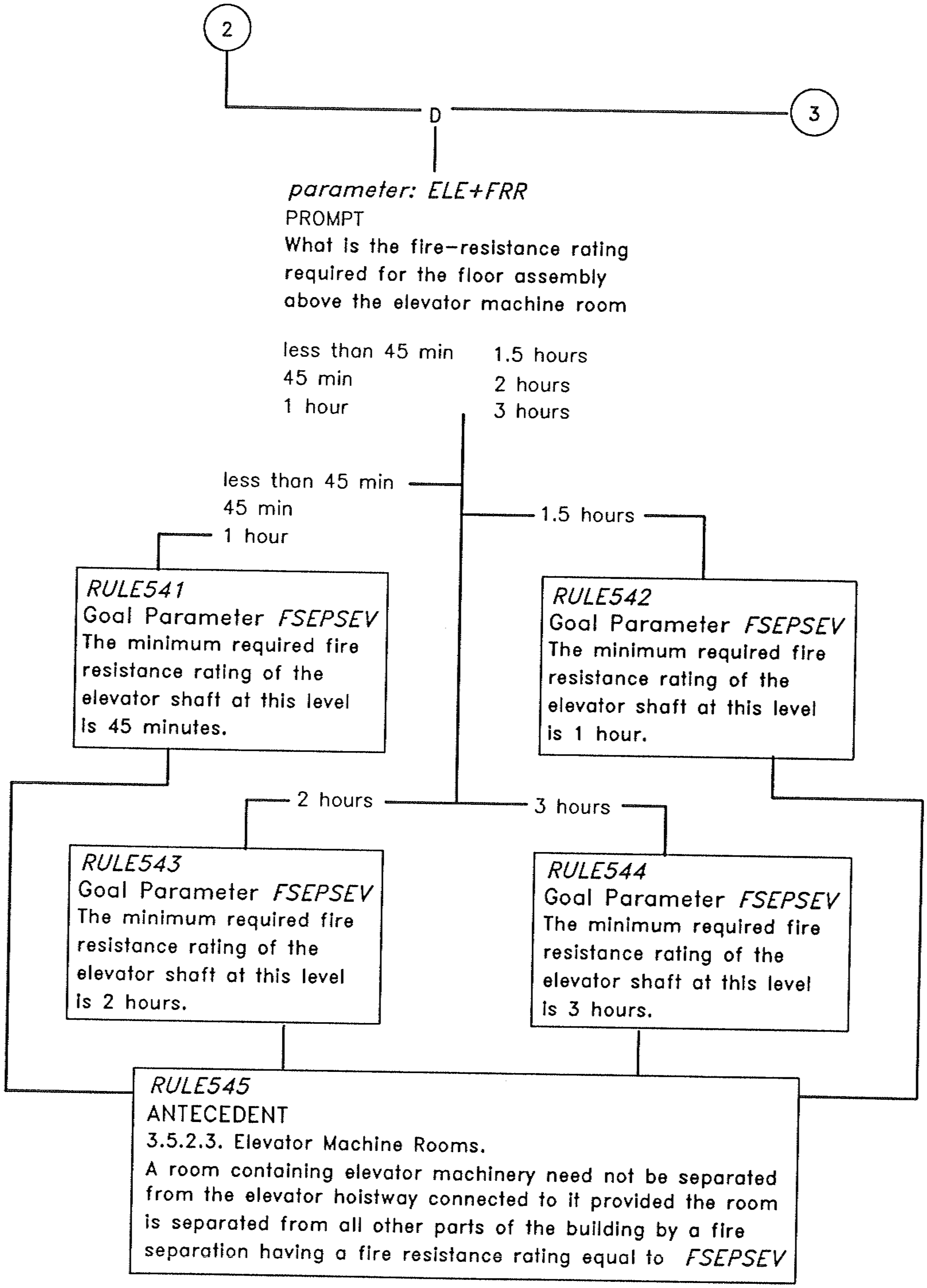
RULE539

Goal Parameter *FSEPSEV*

A 1 hour fire separation is required.

3.5.2.7. Combustible Refuse Storage. Rooms for the temporary storage of combustible refuse such as garbage or waste paper shall be separated from the remainder of the building by a fire separation with a fire-resistance rating of not less than 1 hour and be sprinklered

Fire Separation of Service Spaces



Fire Separation of Service Spaces

3

E

parameter: ELE-VAULT
PROMPT
Is the vault provided with an automatic fire extinguishing system ?

YES

RULE546
Goal Parameter *FSEPSEV*
3.5.2.9.(1). Electrical Equipment Vaults
The electrical equipment vault shall be separated from the remainder of the building by a fire separation of solid masonary or concrete construction having a fire-resistance rating of not less than 2 hours.

NO

RULE547
Goal Parameter *FSEPSEV*
3.5.2.9.(1). Electrical Equipment Vaults
The electrical equipment vault shall be separated from the remainder of the building by a fire separation of solid masonary or concrete construction having a fire-resistance rating of not less than 3 hours.

F

parameter: ROOM-SERV
PROMPT
Is the floor area containing the service room sprinklered ?

YES

RULE548
Goal Parameter *FSEPSEV*
3.5.2.1.(3) Fire Separations around Service Rooms
No fire separation requirements apply to this service room.

NO

RULE549
Goal Parameter *FSEPSEV*
3.5.2.1.(3) Fire Separations around Service Rooms
This service room shall be separated from the remainder of the building by a fire separation having a fire-resistance rating of not less than 1 hour.
3.5.2.2.(3). Waiver of Fire Separations
The requirements for a 1 hour fire separation if the room contains a limited quantity of service equipment and the service equipment does not cause a fire hazard.

Fire Resistance Rating for Exits

parameter: SINGST

PROMPT

Is this a single storey building ?

YES / NO

YES:

RULE571

Goal Parameter *FSEPSEV*

Sentence 3.4.4.(1). Fire–Resistance Rating of Exit Separations
The fire–resistance rating for the fire separation no less than that required by Subsection 3.2.2. but in no case shall the fire–resistance be less than 45 minutes.

NO:

RULE572

Goal Parameter *FSEPSEV*

Sentence 3.4.4.1.(1). Fire–Resistance Rating of Exit Separations
The exit stairs shall be separated from each adjacent floor area by a fire separation having a fire–resistance rating not less than that required for the floor assembly
Sentence 3.4.4.1.(2). The fire–resistance rating of the fire separation need not be more than 2 hours.

Graphic Illustration *FSEP4.GRI*

Heavy Timber Construction

Goal parameter to be solved *HEAVYTIM*

To determine the actural dimensions for solid-sawn lumber assemblies.

parameter: COMPERMIT

PROMPT

Is combustible construction permitted ?

< F1 HELP >

YES

RULE550

ANTECEDENT

3.1.4.5. Haevy Timber Construction Alternative

Heavy timber construction may be used as an alternative where the combustible construction is required to have a fire resistance rating of not more than 45 minutes.

NO

RULE549

Goal Parameter *HEAVYTIM*

Heavy timber construction is not permitted.

parameter: HTASSEM

PROMPT

What is the assembly to be supported by the heavy timber construction ?

Roof only

Floors

Floors plus roofs

Roof only

1

Floors

Floors plus roofs

2

Heavy Timber Construction

1

parameter: HTELEM1

PROMPT

What is the structural element ?

A – Columns
B – Arches supported on the top of walls or abutments
C – Beams girders and trusses
D – Arches supported at or near the roof line

A — *RULE551*
Gaol Parameter
HEAVYTIM
Column
Solid Sawn 140mm X 191mm
Glued–Laminated 130mm X 190mm
Round 180mm Ø

B — *RULE552*
Gaol Parameter
HEAVYTIM
Solid Sawn 89mm X 140mm
Glued–Laminated 80mm X 152mm

C — *RULE553*
Gaol Parameter
HEAVYTIM
Solid Sawn 89mm X 140mm
Glued–Laminated 80mm X 152mm

D — *RULE554*
Gaol Parameter
HEAVYTIM
Solid Sawn 140mm X 140mm
Glued–Laminated 130mm X 152mm

2

parameter: HTELEM2

PROMPT

What is the structural element ?

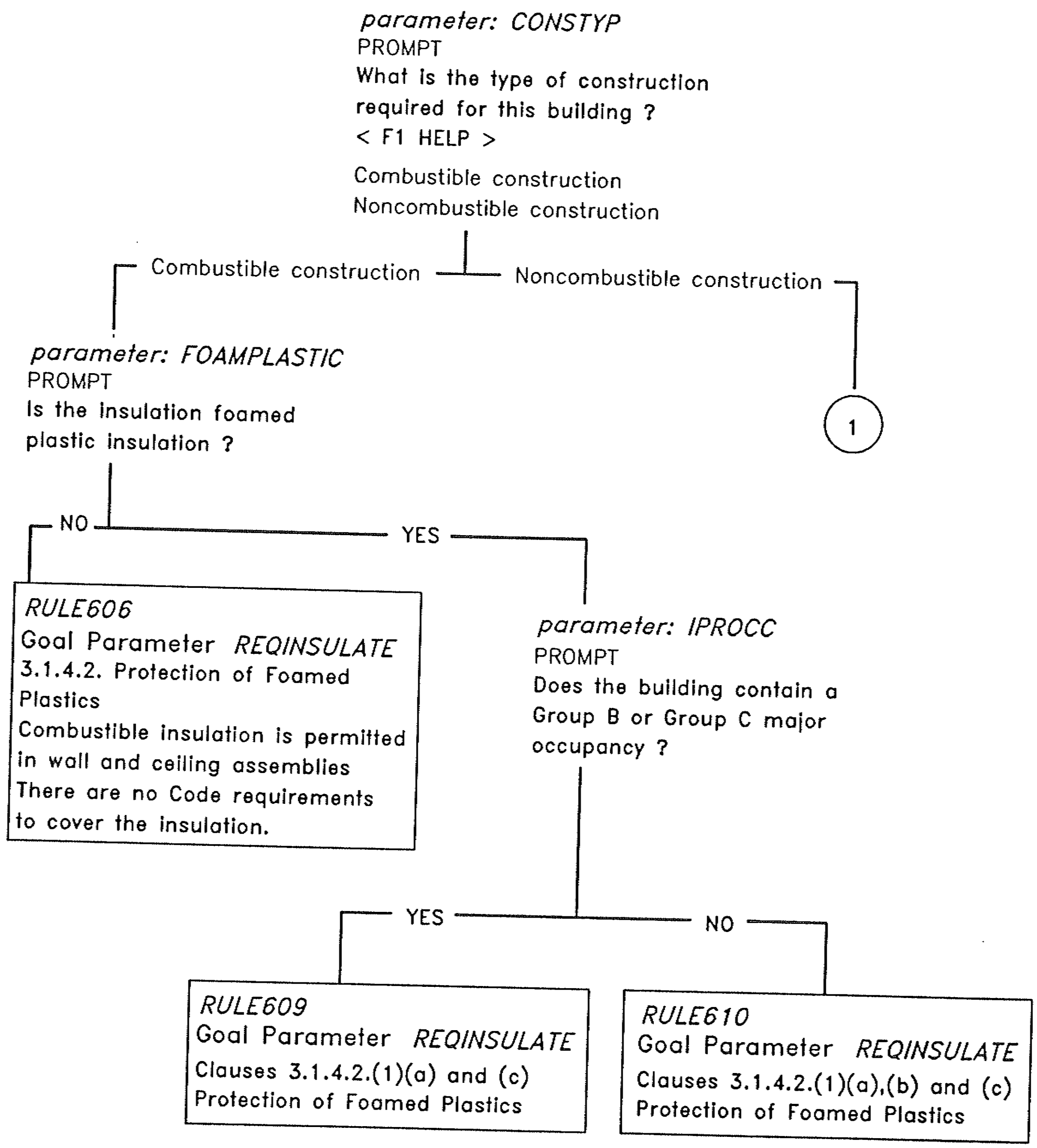
A – Columns
B – Beams, girders, trusses and arches

A — *RULE555*
Gaol Parameter
HEAVYTIM
Column
Solid Sawn 191mm X 191mm
Glued–Laminated 175mm X 190mm
Round 200mm Ø

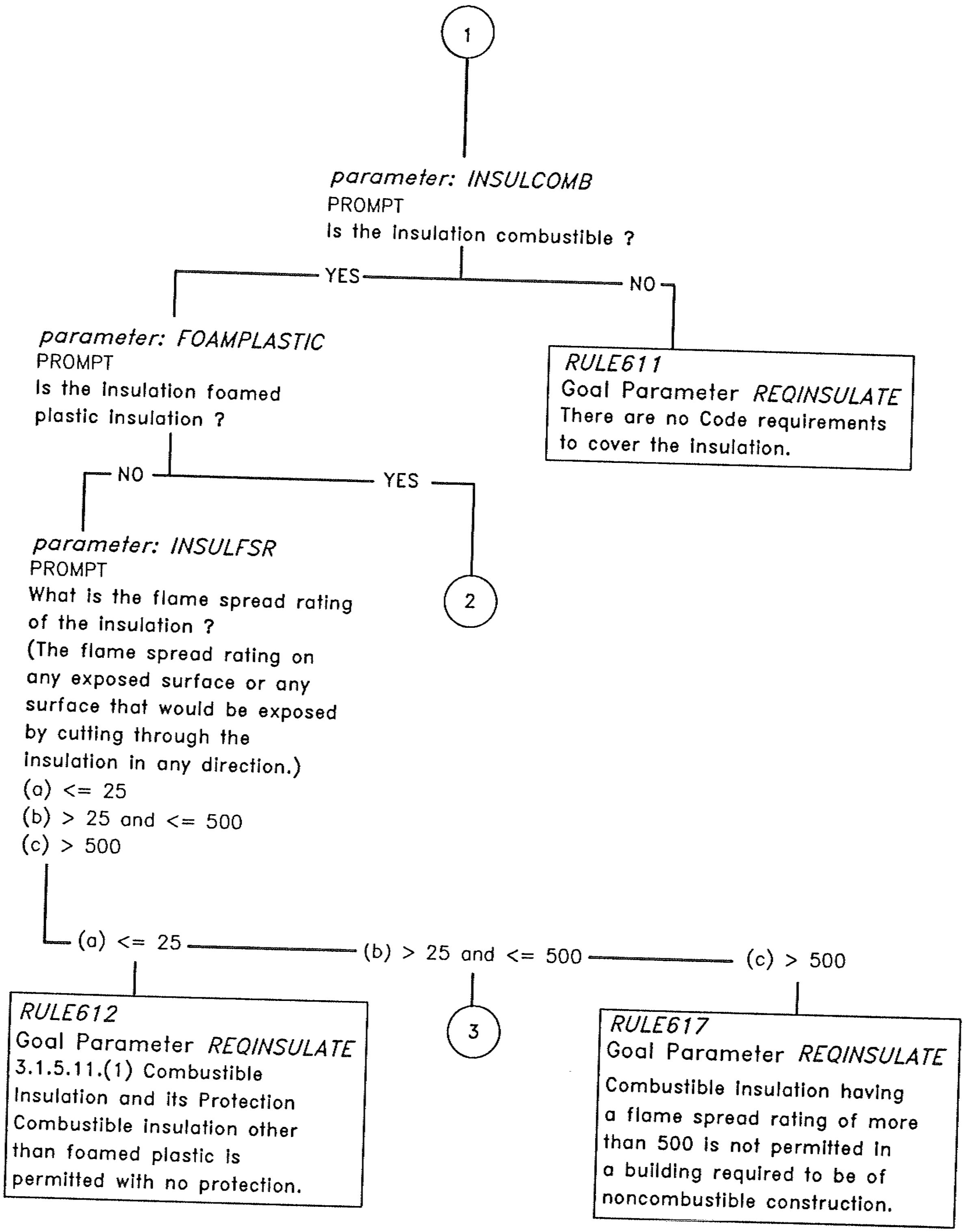
B — *RULE556*
Gaol Parameter
HEAVYTIM
Solid Sawn 140mm X 241mm or 191mm X 191mm
Glued–Laminated 130mm X 228mm or 175mm X 190mm

Protection of Insulation

Goal parameter to be solved *REQINSULATE*
Protection requirements for insulation.



Protection of Insulation



Protection of Insulation

2

parameter: INSULFSR
PROMPT
What is the flame spread rating of the insulation ?
(The flame spread rating on any exposed surface or any surface that would be exposed by cutting through the insulation in any direction.)
(a) <= 25
(b) > 25 and <= 500
(c) > 500

(a) <= 25

RULE614
Goal Parameter *REQINSULATE*
Sentence 3.1.5.11.(2) Combustible Insulation and its Protection

(b) > 25 and <= 500

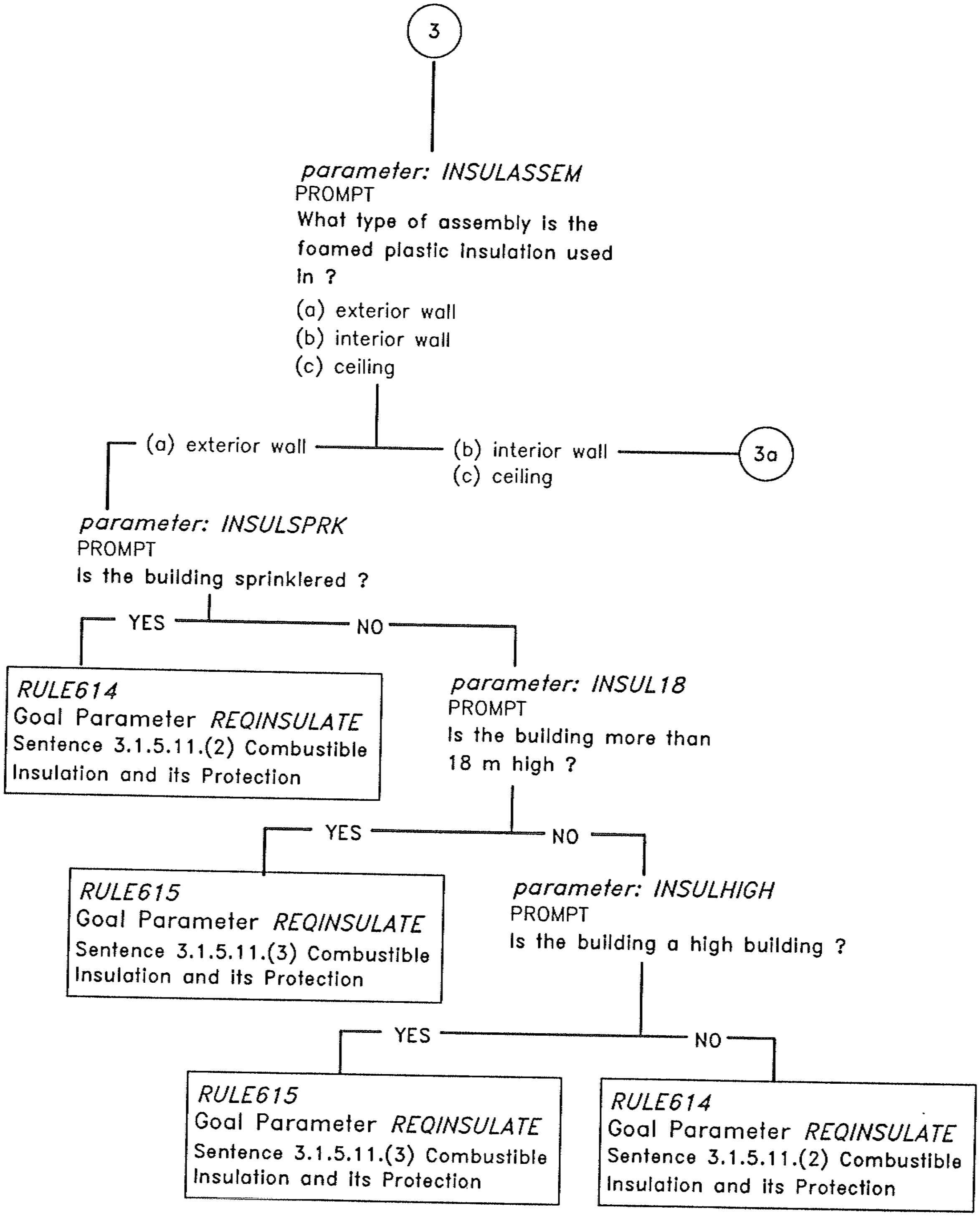
(c) > 500

RULE617
Goal Parameter *REQINSULATE*
Combustible insulation having a flame spread rating of more than 500 is not permitted in a building required to be of noncombustible construction.

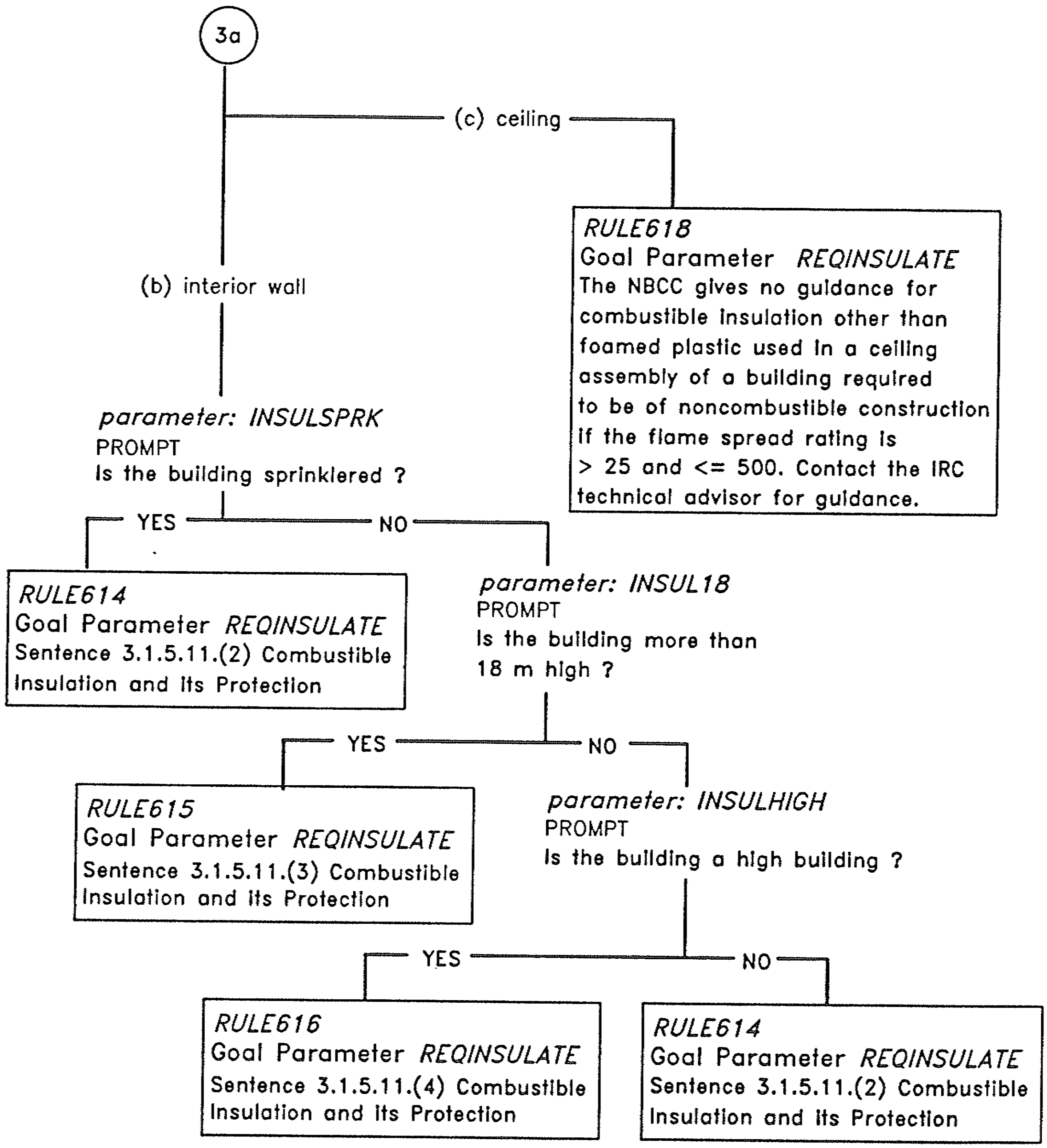
parameter: INSULASSEM
PROMPT
What type of assembly is the foamed plastic insulation used in ?
(a) exterior wall
(b) interior wall
(c) ceiling

4

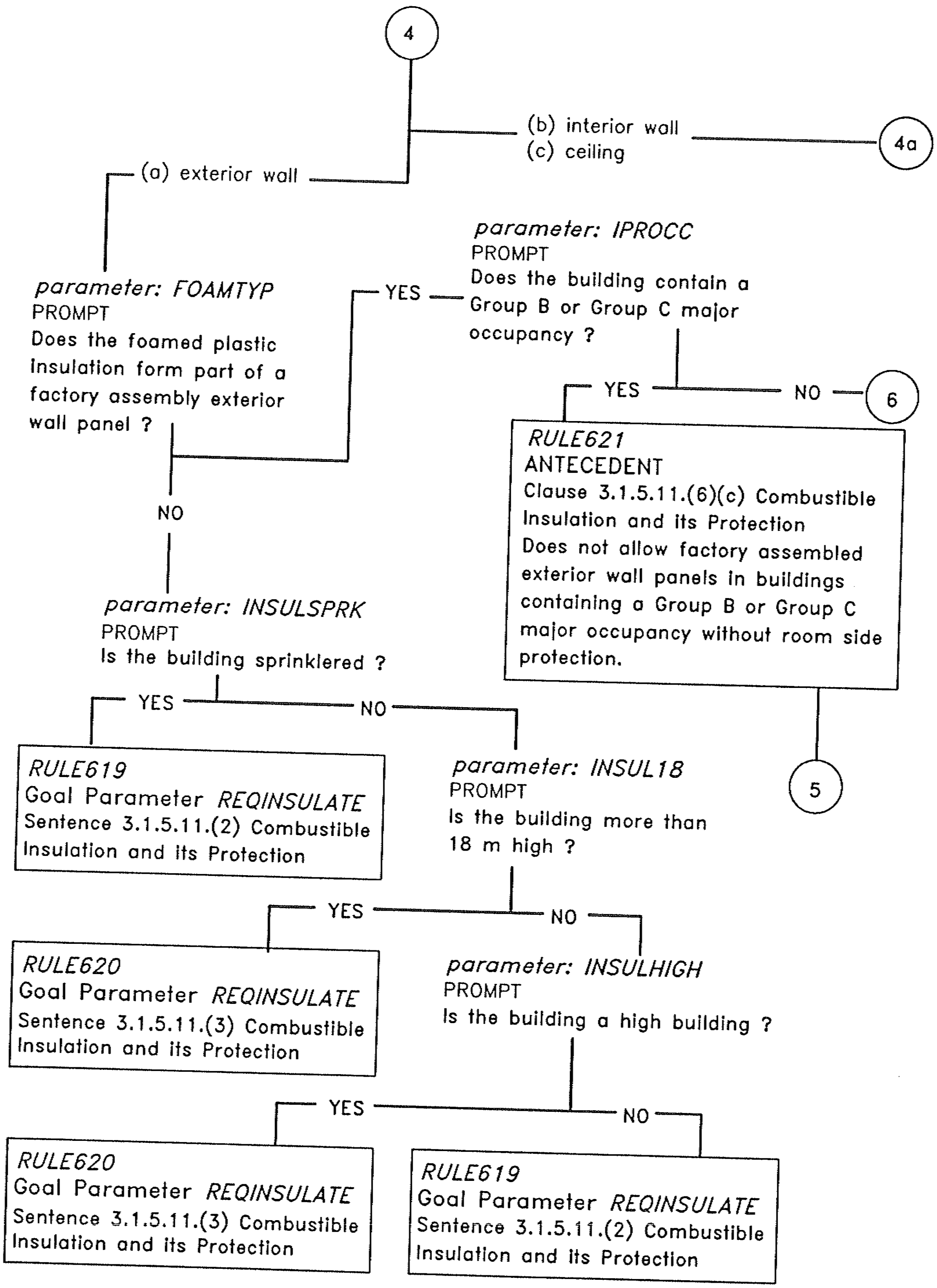
Protection of Insulation



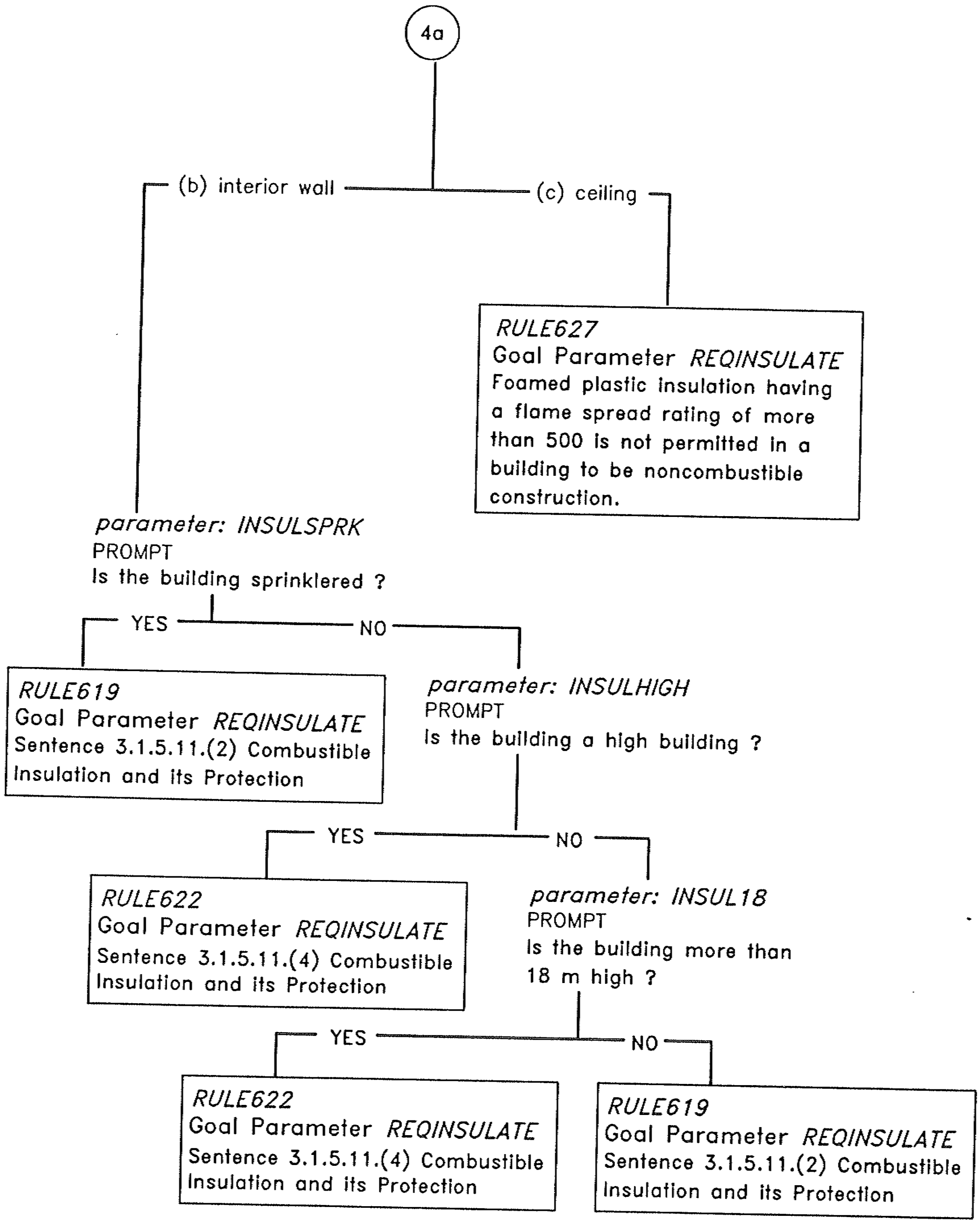
Protection of Insulation



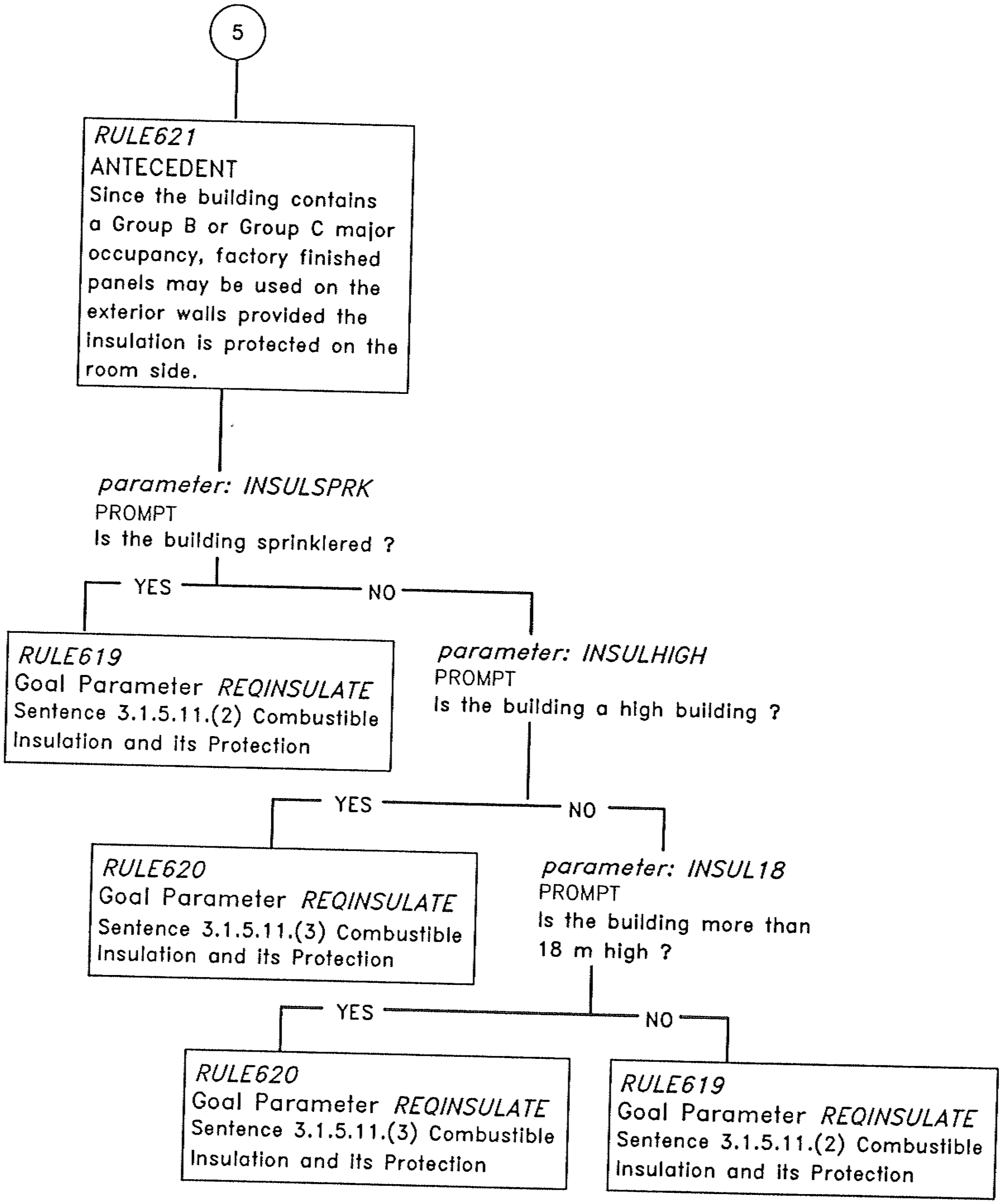
Protection of Insulation



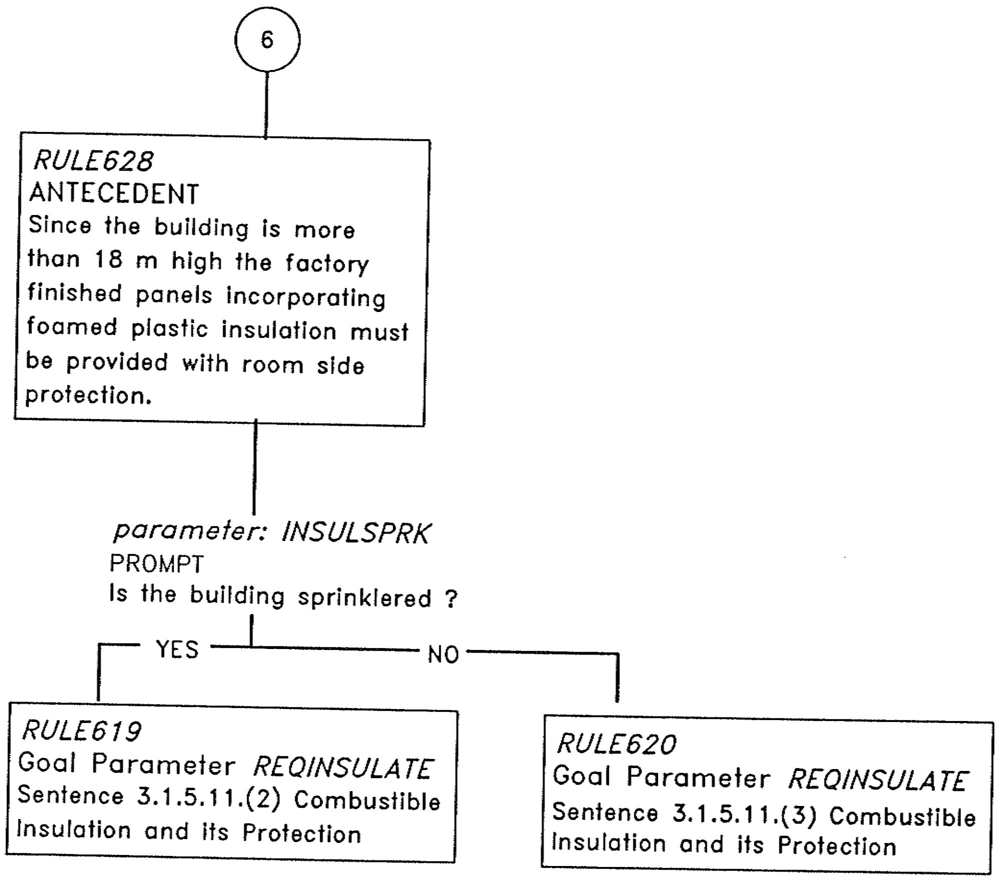
Protection of Insulation



Protection of Insulation



Protection of Insulation



Types of Exits

Goal parameter to be solved *SELEXIT*

To assist the user on types of exit facilities

parameter: EXITYPE
PROMPT
Sentence 3.4.1.4.(1) Types of Exits states that an exit from a floor area shall be one of the following used singly or in combination.
a) an exterior doorway,
b) an exterior passageway,
c) an exterior stairway,
d) an exterior ramp,
e) a fire escape,
f) a horizontal exit,
g) an interior passageway,
h) an interior ramp, or
i) an interior stairway.

Would you like to see some typical exiting arrangements ?

YES — NO — *RETURN TO EXIT MENU*

parameter: EXITSTOR
PROMPT
Is the building more than one storey including below grade storeys ?

NO — YES — 1

parameter: MULTITEN
PROMPT
Is this a multi tenant building ?

2

Types of Exits

1

RULE682

ANTECEDENT

Multi storey buildings generally have enclosed exit stairs that serve all floor areas and lead directly to the outdoors.

GRAPHIC ILLUSTRATION FILE EXIT21.GRI

One of the exit stairs may lead through a lobby if certain conditions are met.

parameter: MULTITENFL

PROMPT

Are any of the floors multi tenant floors ?

YES

RULE683

Goal Parameter *SELEXIT*

Access to exit for typical above grade floors in a multi tenant multi storey building is by means of a public corridor.

The exit consists of the door to the stair enclosure, the interior stair and a door at the bottom of the stair to the stair to the exterior of the building.

GRAPHIC ILLUSTRATION FILES
EXIT19.GRI
EXIT20.GRI

NO

RULE681

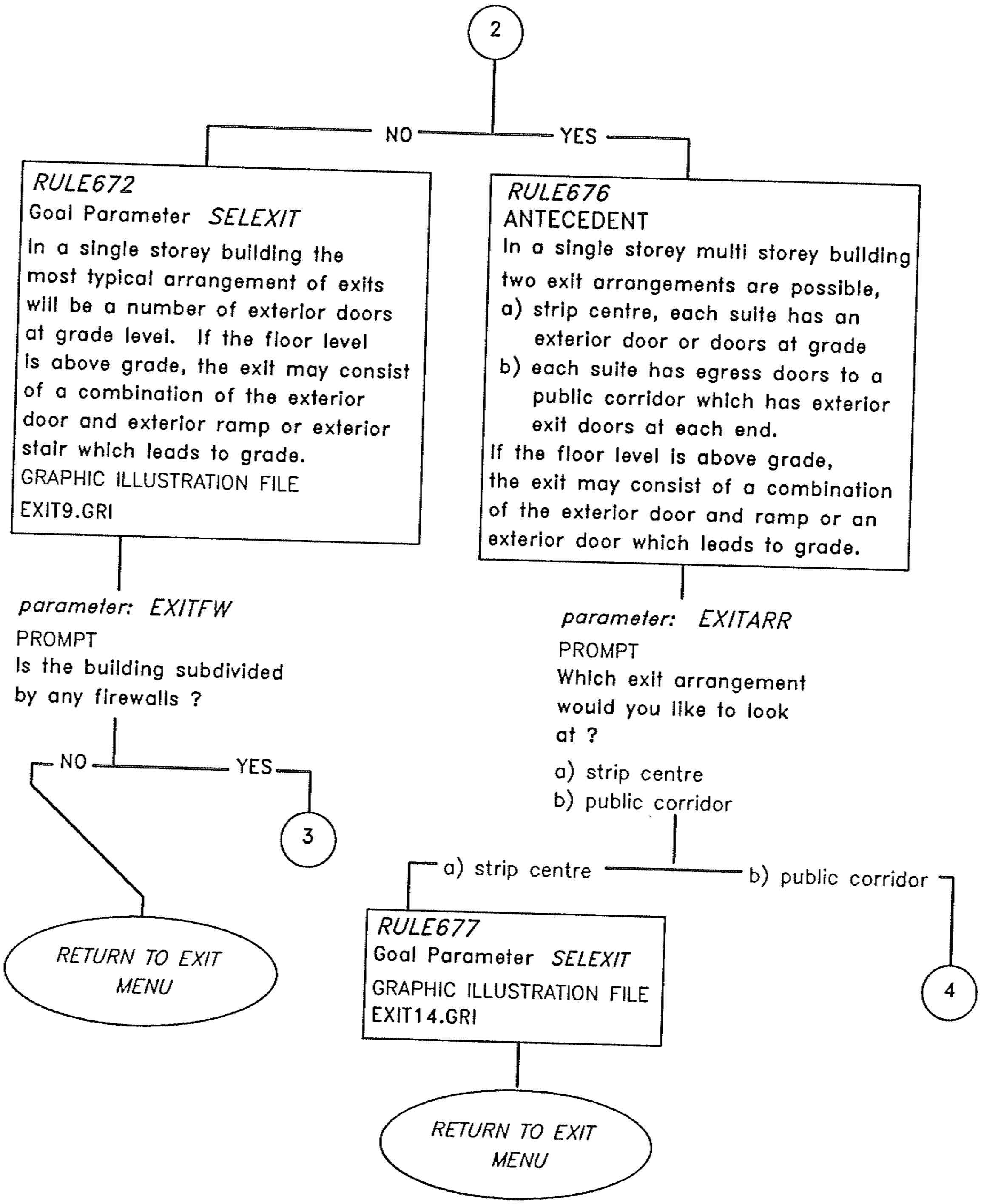
Goal Parameter *SELEXIT*

Single tenant floors in multi storey buildings have various arrangements for access to exits. The floor may be completely open. In this case there may be an infinite number of travel paths to the exits serving the floor. Alternately, the floor may be partitioned into rooms and corridors. Since the floor is under a single tenancy, the corridor is not a public corridor.

GRAPHIC ILLUSTRATION FILE
EXIT17.GRI
EXIT18.GRI

RETURN TO EXIT MENU

Types of Exits



Types of Exits

4

RULE678
ANTECEDENT
GRAPHIC ILLUSTRATION FILE
EXIT13.GRI

RULE679
ANTECEDENT
If this is a large building, travel distances to the exits at either end of the public corridor may be excessive or additional exits must be provided to accommodate higher occupant loads.

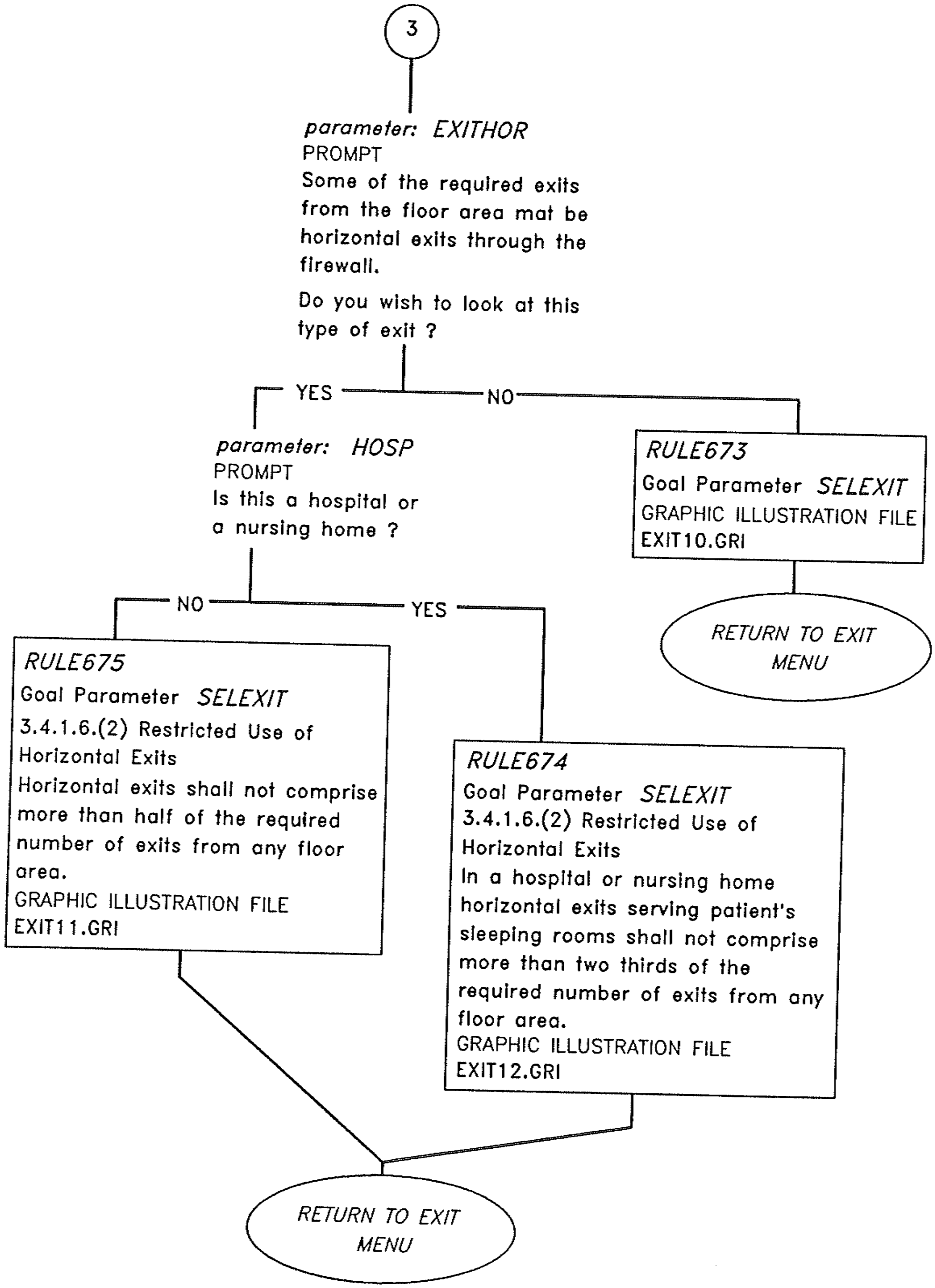
In this case, interior exit passageways leading from the public corridor may be provided.

GRAPHIC ILLUSTRATION FILE
EXIT16.GRI

RULE680
Goal Parameter *SELEXIT*
While it is unusual, the floor area may be subdivided by a firewall and horizontal exits are permitted.
GRAPHIC ILLUSTRATION FILE
EXIT15.GRI

RETURN TO EXIT MENU

Types of Exits



Location of Exits
(Travel Distance to an Exit)

Goal parameter to be solved *DISTREQ*
The maximum travel distance to an exit.

parameter: EXITOCC
PROMPT
What is the occupancy classification of the space under consideration ?
< F1 HELP >

Group A1 Group B1 Group E
Group A2 Group B2 Group F1
Group A3 Group C Group F2
Group A4 Group D Group F3 Group F3 (storage garage)

Group F1

RULE631
Goal Parameter *DISTREQ*
3.4.2.5.(1)(a) Location of Exits
Travel distance shall be not more than 25 metres.
Graphic Illustration File
EXIT8.GRI

Group F3 (storage garage)

parameter: EXITART60
PROMPT
Does the strorage garage meet Article 3.2.2.60. ?
< F1 HELP >

YES

parameter: ATTEND
PROMPT
Are persons other than parking lot attendents permitted above the street level ?

YES

RULE635
Goal Parameter *DISTREQ*
3.4.2.5.(1)(e) Location of Exits
Travel distance shall be not more than 60 metres.

NO

RULE636
Goal Parameter *DISTREQ*
3.3.5.5.(7) Repair and Storage Garages.
The floor levels need only be served by 2 exits. There is no limitation on the travel distance to an exit.

NO

parameter: EXITSPRK
PROMPT
Is the floor area sprinklered ?

YES

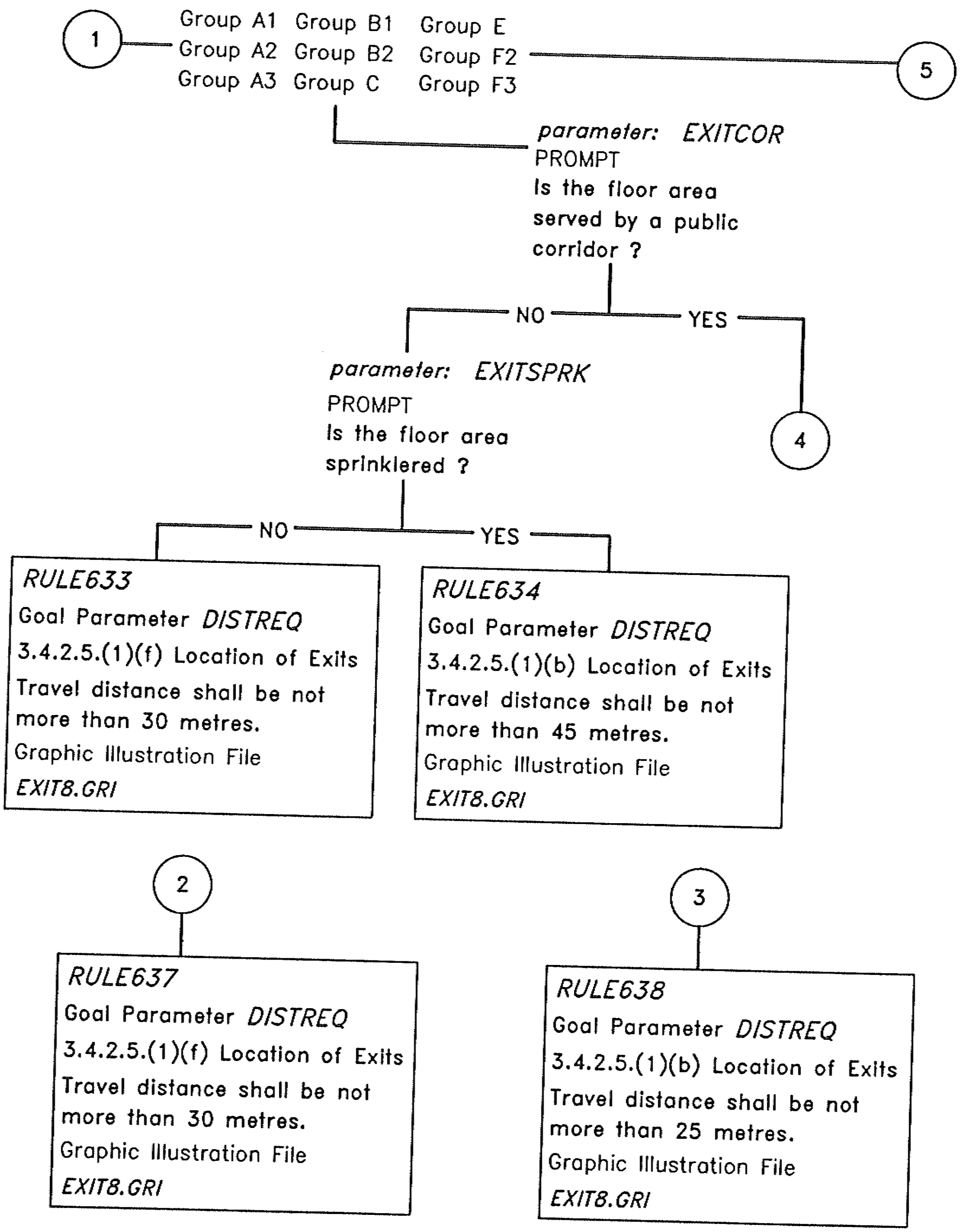
2

NO

3

1

Location of Exits
(Travel Distance to an Exit)



Location of Exits
(Travel Distance to an Exit)

5 — Group D — Group A1

parameter: *EXITCOR*
PROMPT
Is the floor area served by a public corridor ?

NO — YES — 6

parameter: *EXITSPRK*
PROMPT
Is the floor area sprinklered ?

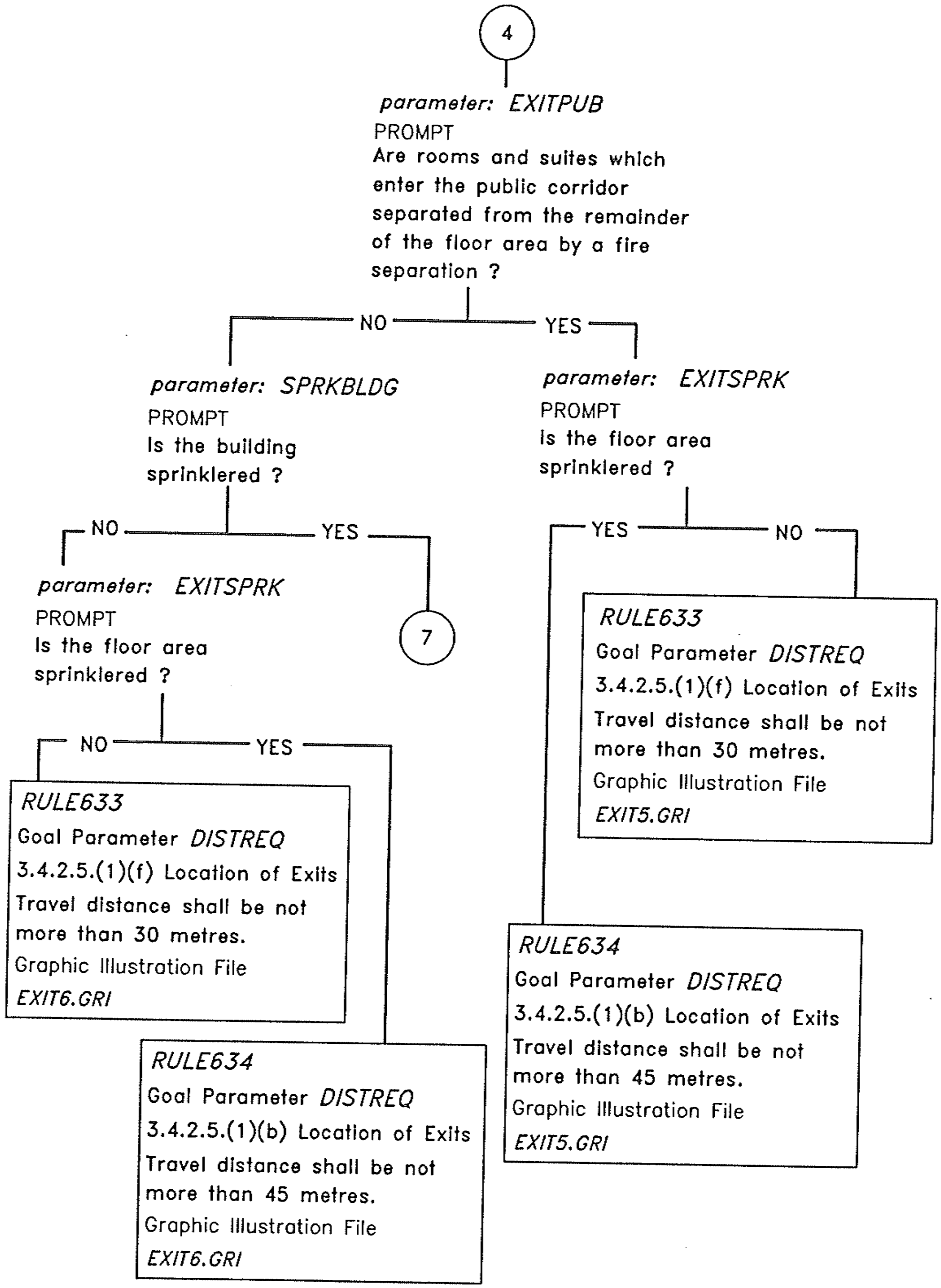
NO — YES

RULE641
Goal Parameter *DISTREQ*
3.4.2.5.(1)(c) Location of Exits
Travel distance shall be not more than 40 metres.
Graphic Illustration File
EXIT8.GRI

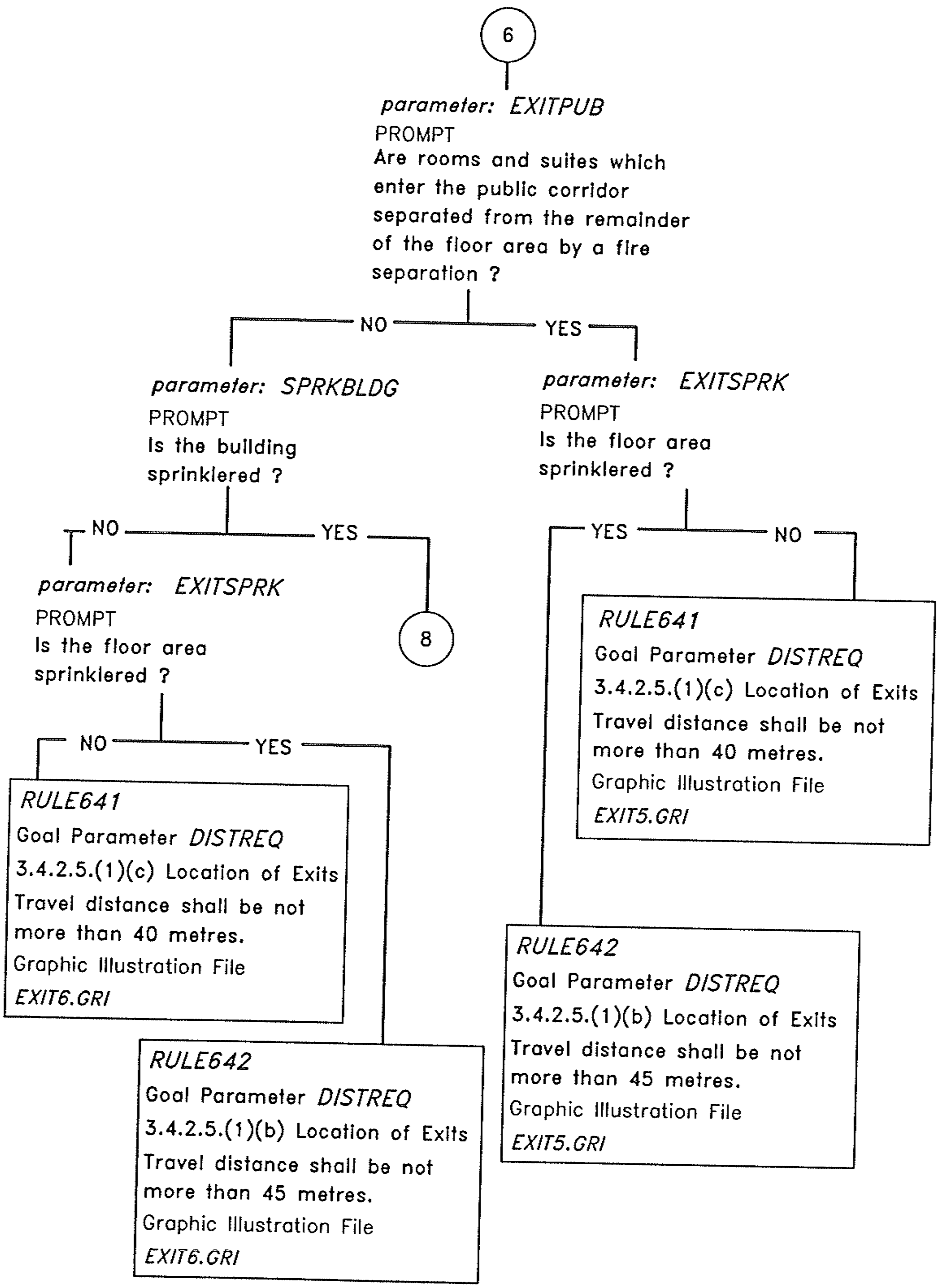
RULE642
Goal Parameter *DISTREQ*
3.4.2.5.(1)(b) Location of Exits
Travel distance shall be not more than 45 metres.
Graphic Illustration File
EXIT8.GRI

RULE640
Goal Parameter *DISTREQ*
3.3.2.9.(2) Outdoor Places of Assembly
In every Group A, Division 4 occupancy, every seat shall be located so that the travel distance is not more than 45 metres measured along the path of travel from the seat to
a) the ground,
b) an exit
c) an opening to a passageway leading from the seating area,
d) an opening through the seating deck structure such as a portal or vomitory.

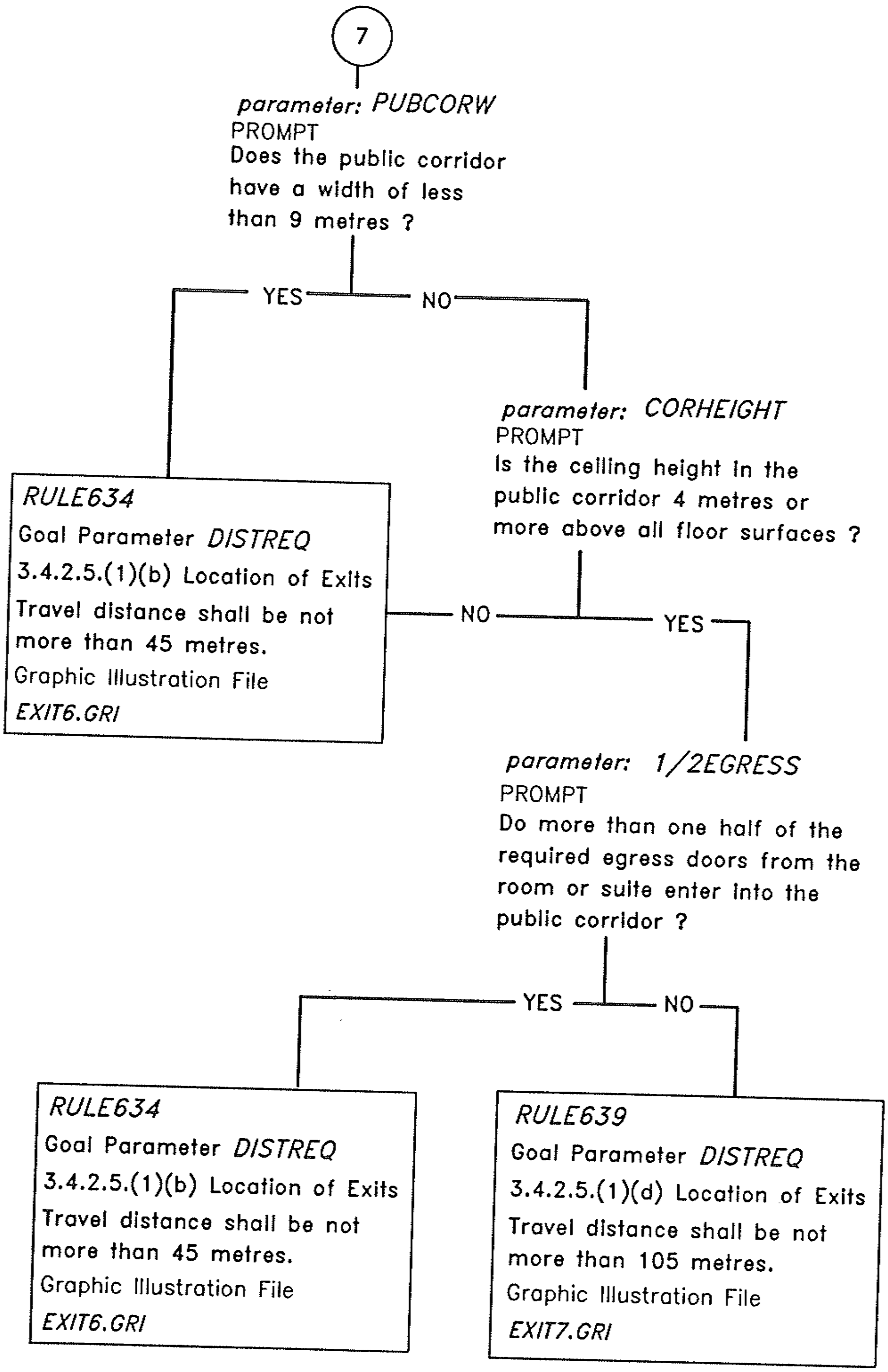
Location of Exits
(Travel Distance to an Exit)



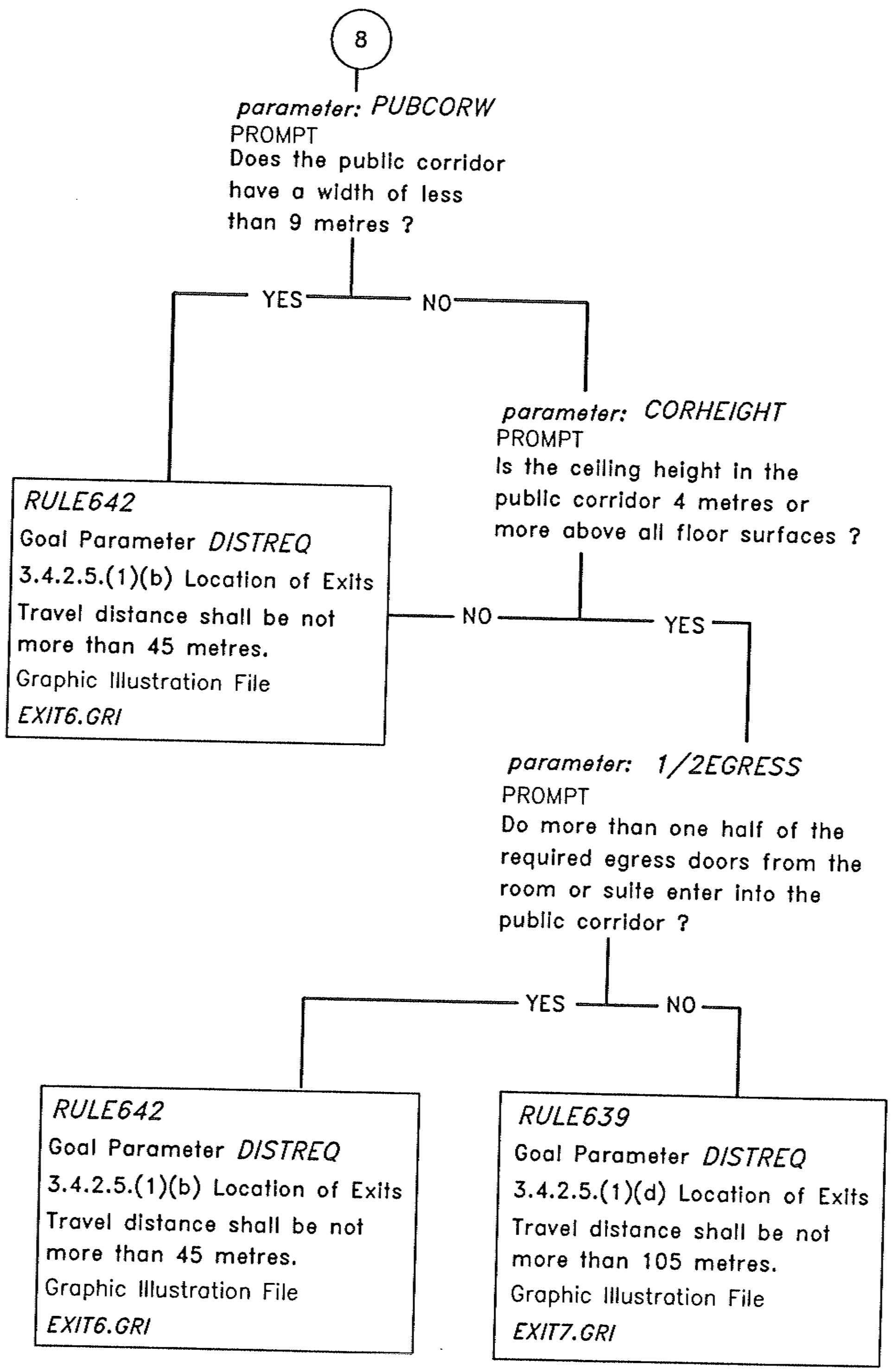
Location of Exits
(Travel Distance to an Exit)



Location of Exits
(Travel Distance to an Exit)



Location of Exits
(Travel Distance to an Exit)



Distance Between Exits

Goal parameter to be solved *DISTEXIT*

To determine the minimum distance permitted between required exits.

parameter: DISTSEP
PROMPT
Is the floor area divided by a fire separation so that it is necessary to pass through it to travel from one exit to another ?
< F1 HELP >
DISPLAY GRAPHIC FILE EXIT4.GRI

YES

RULE643
Goal Parameter *DISTEXIT*
The minimum distance between exits does not apply.

NO

parameter: DISTCOR
PROMPT
Is the floor area served by a public corridor ?

YES

parameter: DIAG
PROMPT
What is the maximum diagonal of the floor area ?
(numerical value entered)

RULE644
Goal Parameter *DISTEXIT*
3.4.2.3.(1)(a) Distance between Exits.
DISTEXIT = *DIAG* / 2
GRAPHIC ILLUSTRATION FILE
EXIT2.GRI

NO

parameter: DIAG
PROMPT
What is the maximum diagonal of the floor area ?
(numerical value entered)

IF:: *DISTEXIT* = *DIAG* / 2 > 9 metres

RULE645
Goal Parameter *DISTEXIT*
3.4.2.3.(1)(b) Distance between Exits.
DISTEXIT = *DIAG* / 2
GRAPHIC ILLUSTRATION FILE
EXIT3.GRI

IF:: *DISTEXIT* = *DIAG* / 2 < 9 metres

RULE646
Goal Parameter *DISTEXIT*
3.4.2.3.(1)(b) Distance between Exits.
DISTEXIT= 9 metres
GRAPHIC ILLUSTRATION FILE
EXIT3.GRI

Exit Capacity

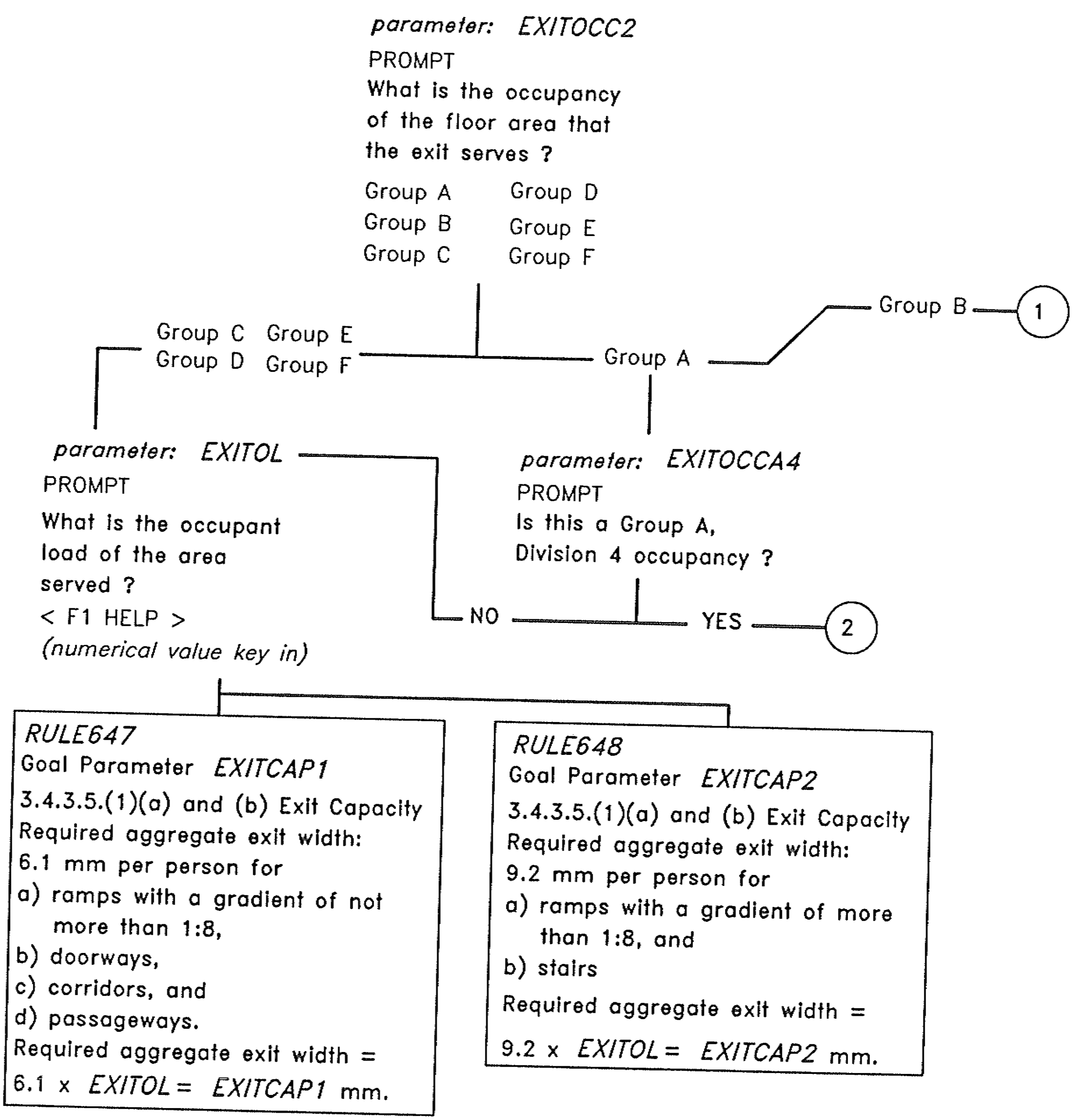
Goal parameters to be solved

EXITCAP1

Required exit width for ramps (less than 1:8 gradient) doorways, corridors and passageways.

EXITCAP2

Required exit width for ramps (greater than 1:8 gradient) and stairs.



Exit Capacity

parameter: EXITOL
PROMPT
1 — What is the occupant load of the area served ?
< F1 HELP >
(numerical value key in)

RULE649
Goal Parameter *EXITCAP1*
3.4.3.5.(2) Exit Capacity
Required aggregate exit width:
18.4 mm per person for
a) ramps,
b) doorways,
c) corridors,
d) passageways and
e) stairs.
Required aggregate exit width =
18.1 x *EXITOL* = *EXITCAP1* mm.

parameter: EXITOL
PROMPT
2 — What is the occupant load of the area served ?
< F1 HELP >
(numerical value key in)

RULE650
Goal Parameter *EXITCAP1*
3.4.3.5.(3)(a) and (b) Exit Capacity
Required aggregate exit width:
1.8 mm per person for
a) aisles,
b) stairs other than exit stairs,
c) ramps,
d) passageways invomitories, and
e) exits.
Required aggregate exit width =
1.8 x *EXITOL* = *EXITCAP1* mm.

RULE651
Goal Parameter *EXITCAP2*
3.4.3.5.(3)(a) and (b) Exit Capacity
Required aggregate exit width:
2.4 mm per person for
a) exit stairs
Required aggregate exit width =
2.4 x *EXITOL* = *EXITCAP2* mm.

Number of Exits Required

Goal parameter to be solved *EXITNUM*

To determine the number of exits required.

parameter: EXITSING
PROMPT
Would you like to see if the floor area under consideration is permitted to be served by a single exit ?

NO

RULE652
Goal Parameter *EXITNUM*
The floor area is served by more than one exit.
THE NUMBER OF EXITS OF EXITS REQUIRED MAY DEPEND ON
a) Travel distance to the exit.
b) The exit capacity required for the floor occupant load.

YES

parameter: EXITGPC
PROMPT
Does the building have a Group C major occupancy classification ?

NO

parameter: EXITOL60
PROMPT
Will the total occupant load served by the exit exceed 60 people ?

YES

RULE653
Goal Parameter *EXITNUM*
3.4.2.1.(2) Minimum Number of Exits
This floor area shall be served by not less than 2 exits.
THE NUMBER OF EXITS REQUIRED IS GOVERNED BY TRAVEL DISTANCE AND REQUIRED EXIT CAPACITY

NO

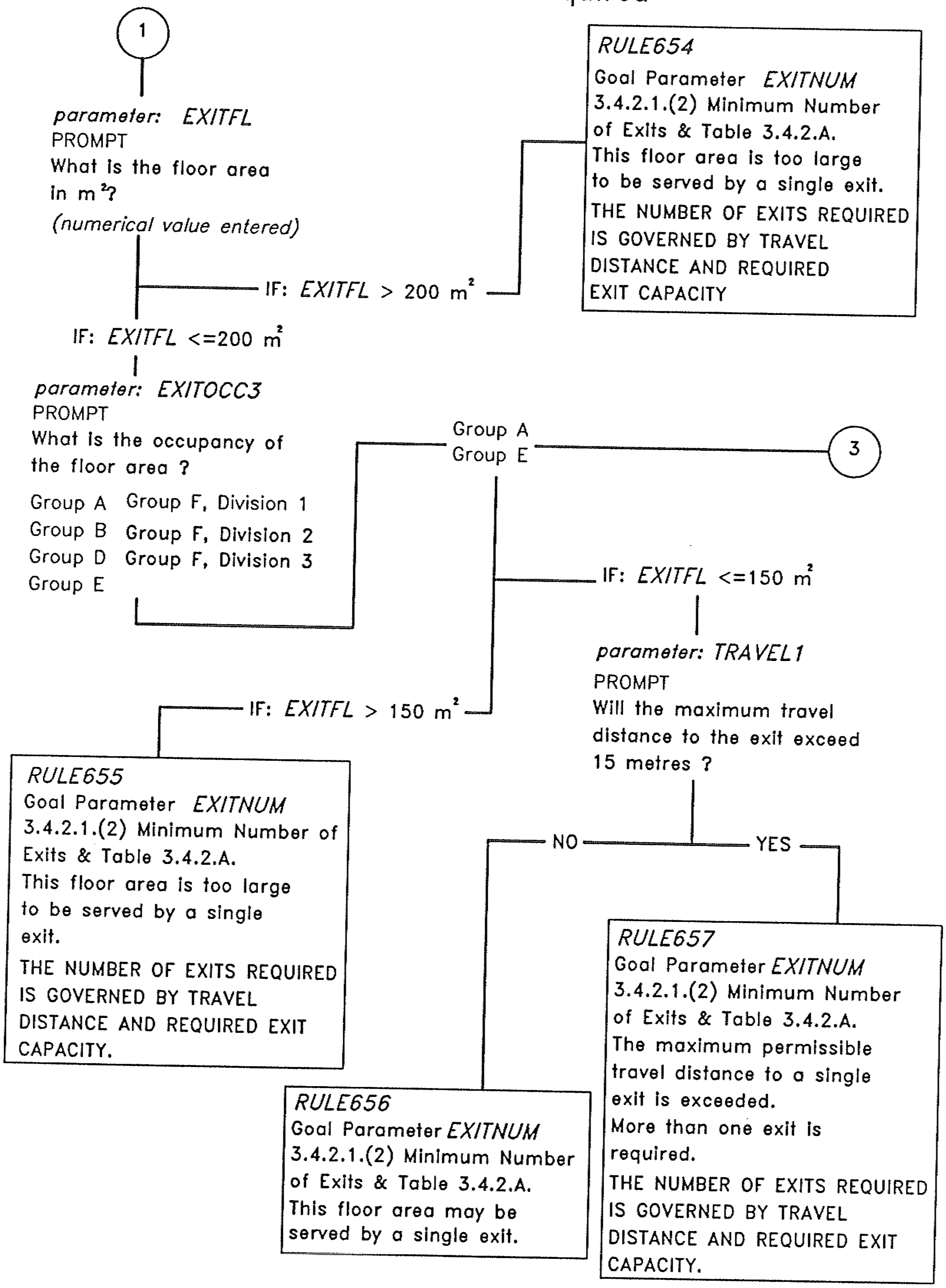
parameter: EXITFL
PROMPT
What is the floor area in m^2?
(numerical value entered)

1

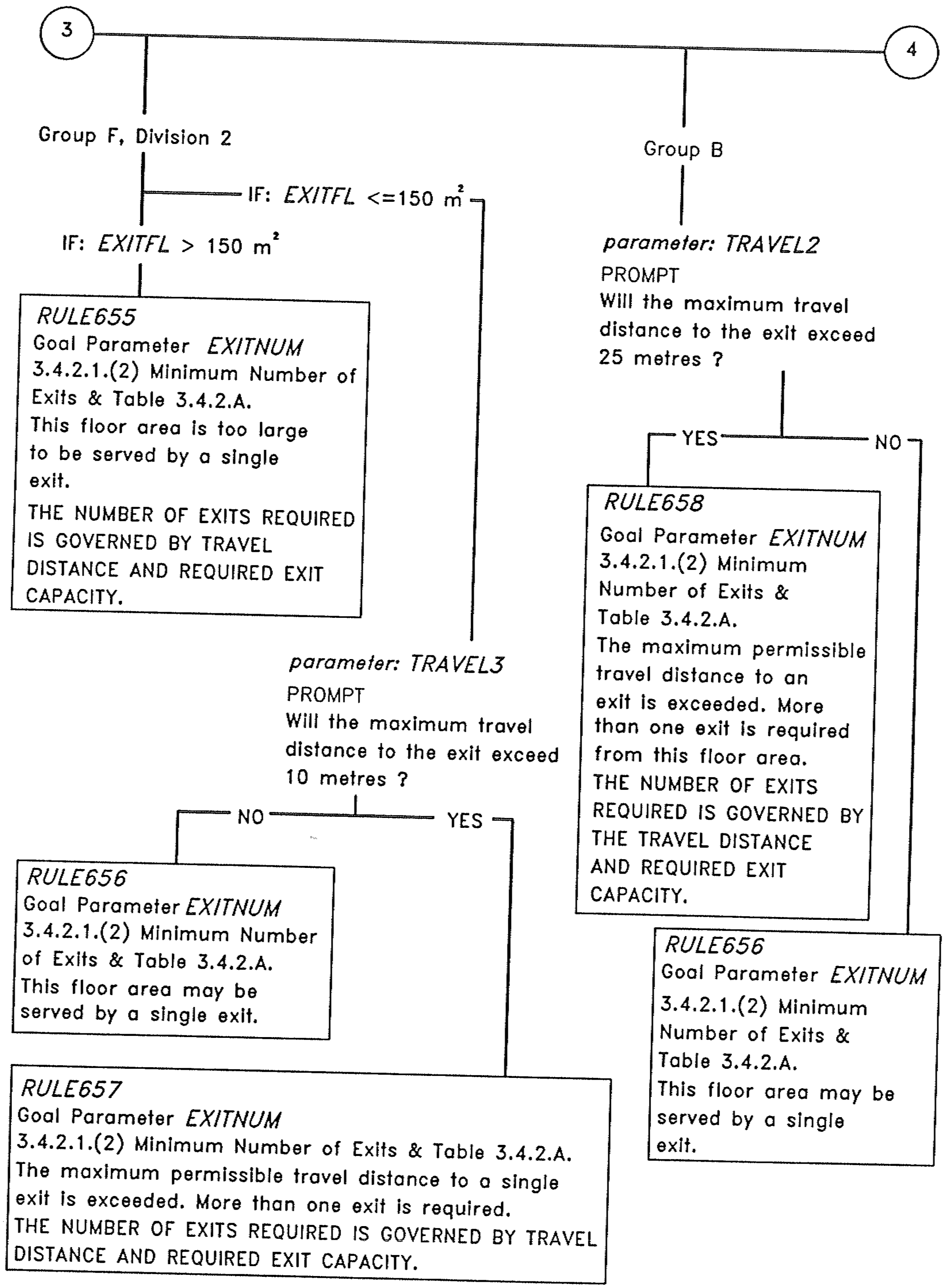
YES

2

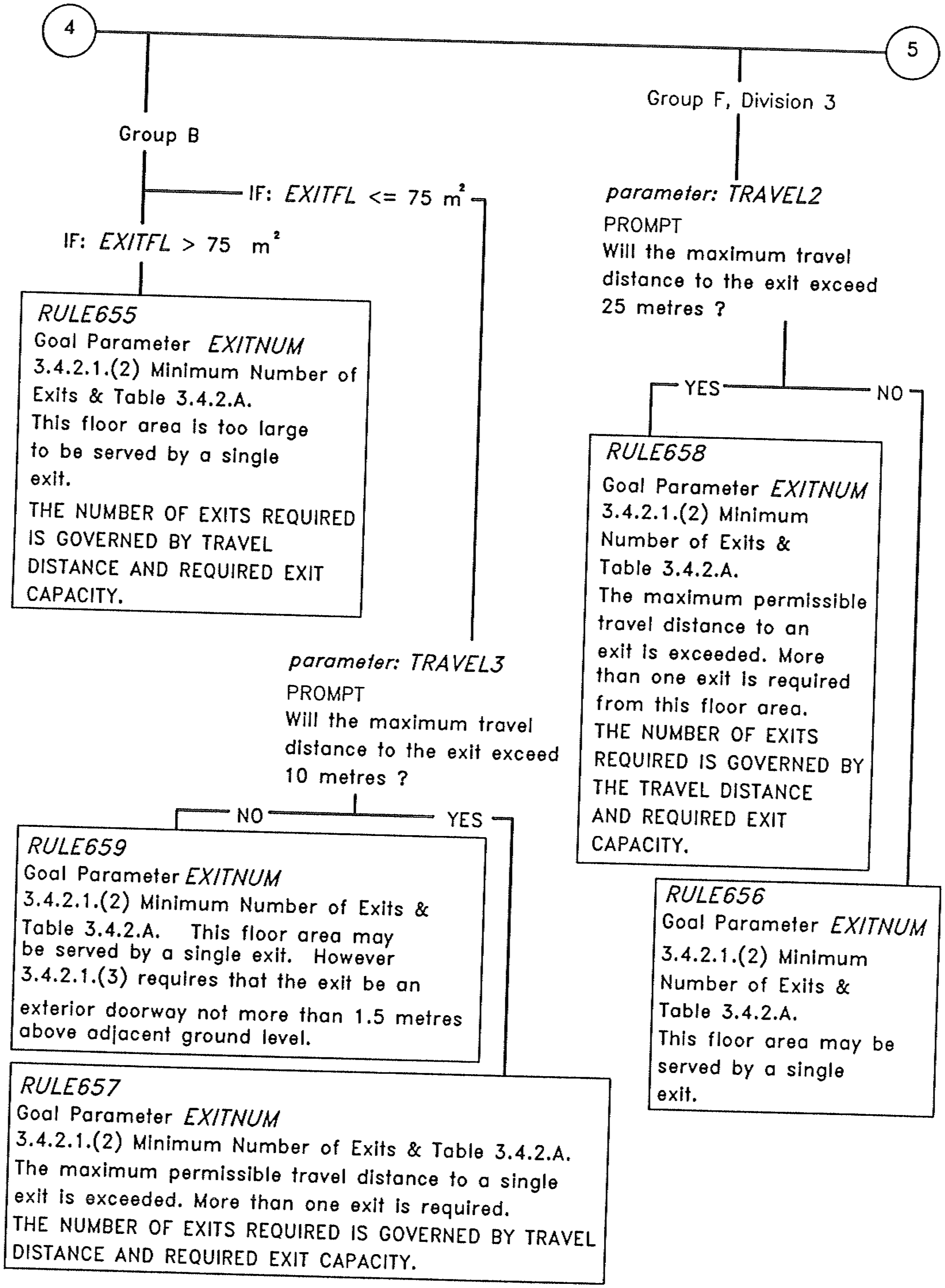
Number of Exits Required



Number of Exits Required



Number of Exits Required



Number of Exits Required

5

Group F, Division 1

RULE660
Goal Parameter *EXITNUM*
The occupancy of the floor area
is Group F, Division 1.
Tis floor area must be served
by not less than 2 exits.
THE NUMBER OF EXITS REQUIRED
IS GOVERNED BY TRAVEL DISTANCE
AND REQUIRED EXIT CAPACITY.

3.2.5. Provisions for Fire Fighting

Goal parameters to be solved

ACCESS1
Access panels to building required.

ACCESS2
Access to basement required.

ACCESS3
Access to roofs required.

parameter: BLDSPNK
PROMPT
Is the building sprinklered ?

YES

RULE685
Goal Parameter *ACCESS1*
3.2.5.5. Access Routes
Direct access from the outdoors to above and below grade floor levels are not required on any storey that is sprinklered.
REDUNDANT GOAL PARAMETERS
ACCESS2, ACCESS3

NO

parameter #ST
Graphic Help File PFF1.GRI
PROMPT
How many streets is this building required to face for the purposes of classification of Subsection 3.2.2. ?
(a) One street
(b) Two streets
(c) Three streets

(a) One street

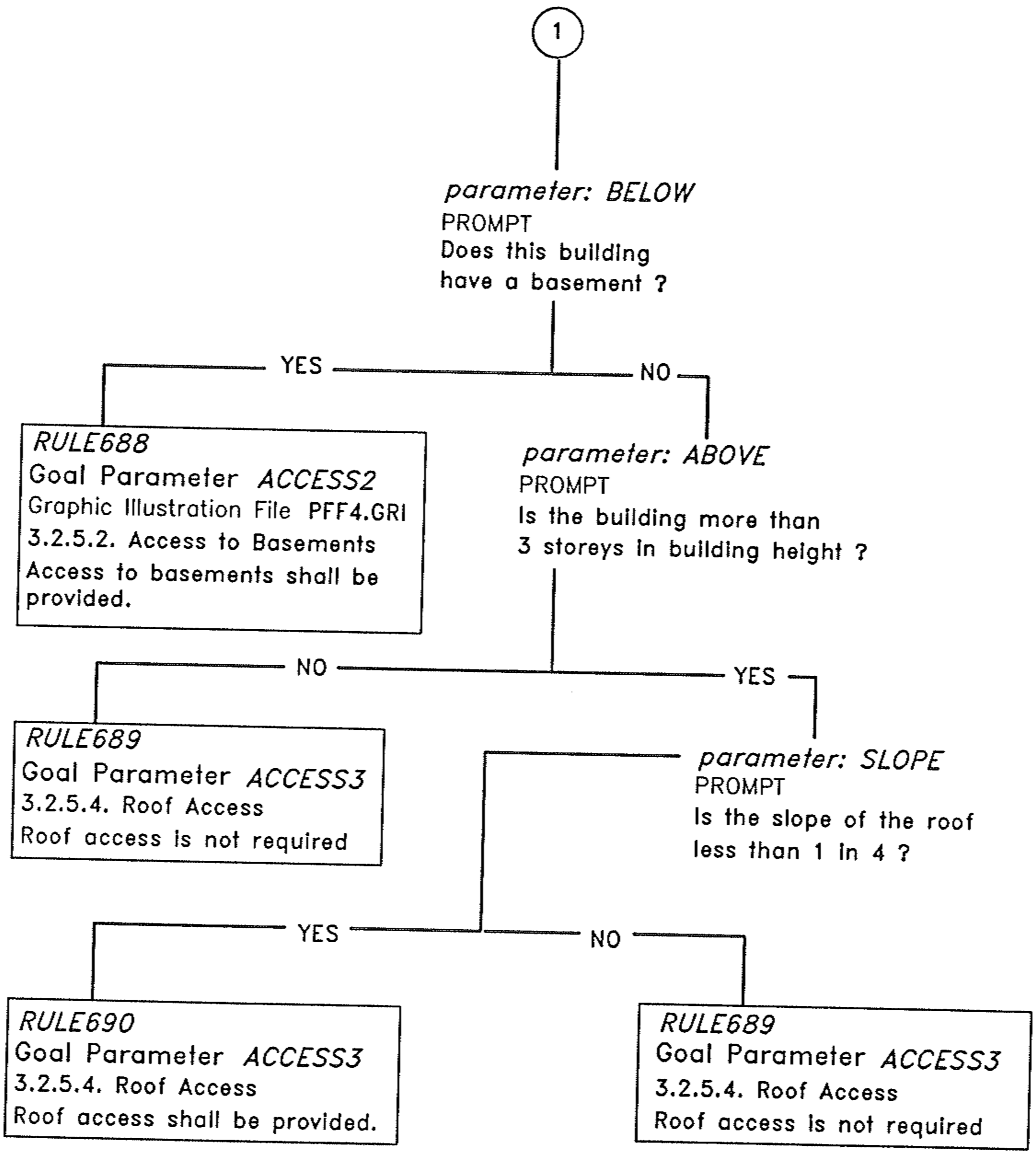
RULE686
Goal Parameter *ACCESS1*
Graphic Illustration File PFF2.GRI
3.2.5.1. Access to Above Grade Storeys
Every storey above grade having its floor level less than 25 m above grade must be provided with direct access for fire fighting from the outdoors.
Access shall be by means of one unobstructed window or access panel in the wall required to face the street.

(b) Two streets
(c) Three streets

RULE687
Goal Parameter *ACCESS1*
Graphic Illustration File PFF3.GRI
3.2.5.1. Access to Above Grade Storeys
Every above grade storey having its floor level less than 25 m above grade must be provided with direct access for fire fighting from the outdoors
Access shall be by means of one unobstructed window or access panel for each 15 m of wall required to face a street.

1

3.2.5. Provisions for Fire Fighting

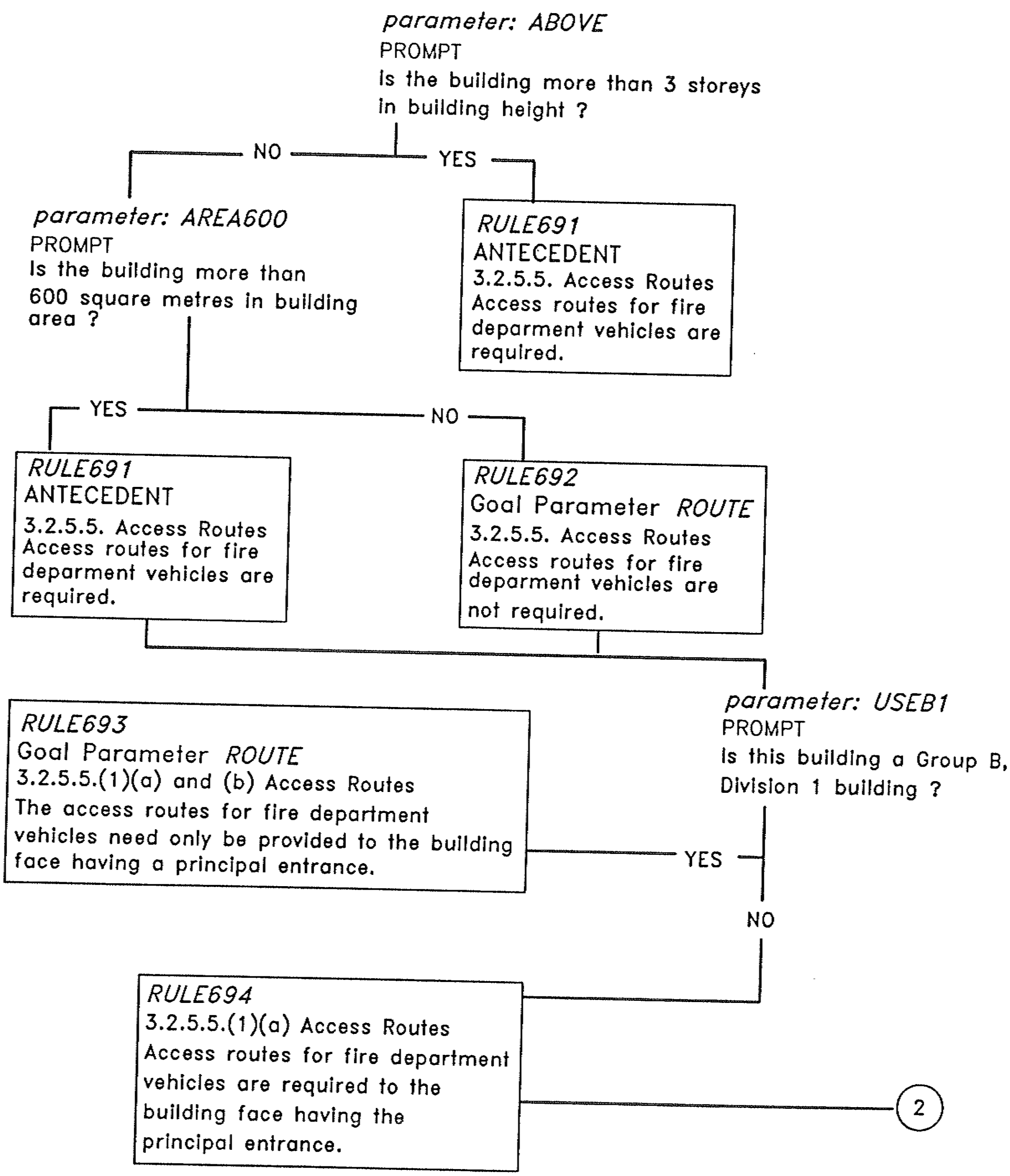


3.2.5.5. Access Routes

Goal Parameter to be solved

ROUTE

Access routes are required or not.



3.2.5.5. Access Routes

2

parameter: #ST
Graphic Help File PFF1.GRI
PROMPT
How many streets is this building required to face for the purposes of classification of Subsection 3.2.2. ?
(a) One street
(b) Two streets
(c) Three streets

(a) One street

RULE695
Goal Parameter *ROUTE*
3.2.5.5.(1)(a) and (b)
Access Routes
Since the building is only required to face one street access routes for fire department vehicles need only be provided to the building face having the principal entrance.

(b) Two streets
(c) Three streets

parameter: BLDSPNK
Is the building sprinklered ?

NO

RULE697
Goal Parameter *ROUTE*
3.2.5.5.(1)(a) and (b)
Access Routes
Since this building is required to face more than one street and since it is not sprinklered, access routes for fire department vehicles must be provided to each building face required to face a street.

YES

RULE696
Goal Parameter *ROUTE*
3.2.5.5.(1)(a) and (b)
Access Routes
Since this building is sprinklered, access routes for fire department vehicles need only be provided to the building face having the principal entrance.

3.2.5.6. Location of Access Routes

Goal parameters to be solved *Locate1*
Location of the access route to building.

Locate2
Access routes to be located adjacent to Standpipe / Sprinkler connections.

parameter: BLDSPNK
PROMPT
Is the building sprinklered ?

YES

RULE699
Goal Parameter *LOCATE1*
3.2.5.6.(1) Location of Access Routes
The access route required to the principal entrance must be not less than 3 m and not more than 15 m measured from the closest portion of the access route to the principal entrance.

4

NO

parameter: #ST
Graphic Help File PFF1.GRI
PROMPT
How many streets is this building requiredto face for the purposes of classification of Subsection 3.2.2. ?
(a) One street
(b) Two streets
(c) Three streets

(a) One street

RULE700
Goal Parameter *LOCATE1*
3.2.5.6.(1) Location of Access Routes
Principal entrance and access openings required in building face that faces a street are located not less than 3 m and not more than 15 m from the closest portion of the access route.

(b) Two streets
(c) Three streets

RULE701
Goal Parameter *LOCATE1*
3.2.5.6.(1) Location of Access Routes
Principal entrance and access openings required in building face that faces a street are located not less than 3 m and not more than 15 m from on all faces required to face a street.

parameter: FDCONN
PROMPT
Does the building have a standpipe system with a fire department connection ?

3

3.2.5.6. Location of Access Routes

4

parameter: FDCONN

PROMPT

Does the building have a standpipe system with a fire department connection ?

YES / NO

RULE702

Goal Parameter *LOCATE2*

3.2.5.16.(1), (2) Fire Department Connections

Graphic Illustration File STAND1.GRI

3.2.5.6.(2)(a) Location of Access Routes

Access routes shall be provided to every building with a fire department connection, a fire department pumper vehicle can be located adjacent to the hydrants described in Article 3.2.5.16.

RULE703

Goal Parameter *LOCATE2*

3.2.5.16.(2) Fire Department Connections

Graphic Illustration File STAND2.GRI

3.2.5.6.(2)(b),(c) Location of Access Routes

Access routes shall be provided to every building so that the length of the access route from a hydrant to the vehicle plus the unobstructed pathe of travel for fire fighter from the vehicle to the building is not more than 90 m, and the unobstructed path of travel for the fire fighter from the vehicle to the building is not more than 45 m.

3

YES / NO

RULE702

Goal Parameter

3.2.5.16.(1) Fire Department Connections

Graphic Illustration File STAND1.GRI

3.2.5.6.(2)(a) Location of Access Routes

Access routes shall be provided to every building with a fire department connection, a fire department pumper vehicle can be located adjacent to the hydrants described in Article 3.2.5.16.

RULE704

Goal Parameter *LOCATE2*

3.2.5.6.(2)(b),(c) Location of Access Routes

Access routes shall be provided to every building so that the length of the access route from a hydrant to the vehicle plus the unobstructed pathe of travel for fire fighter from the vehicle to the building is not more than 90 m, and the unobstructed path of travel for the fire fighter from the vehicle to the building is not more than 45 m.

3.2.5.7. Access Route Design

Goal parameter to be solved *ROUTDES*
Access route design

parameter: SEEROUTE
PROMPT
Graphic Help File PFF5.GRI
Do you want to see the access route design requirements ?

YES

RULE698
Goal Parameter *ROUTDES*
3.2.5.6. Location of Access Routes
Graphic Illustration File PFF5.GRI
(Show graphics to illustrate Article 3.2.5.7.)

NO

Stop

Appendix D

Trace Command demonstration showing the inference engine search for a conclusion on emergency operations of elevators.

In this example there will be several lines of information that appear in the trace output of a consultation with PcPlus on emergency operations of elevators. The programmer would have this information directed to a screen or to a printer. The first line of the TRACE indicates that PcPlus is in the correct area of the knowledge base.

```
Frame  EMOPERELE-1   created under MENU-1
```

The trace output shown below shows that PcPlus will trace the goal parameter, **EMERG-ELE**. It will begin by tracing the rules that deduce the goal parameter: RULE576, RULE577, RULE574, RULE578, RULE579, RULE580.

```
Trace the following goals: EMERG-ELE
Tracing parameter          : EMOPERELE-1 EMERG-ELE
Try the rules that deduce EMOPERELE-1 EMERG-ELE:
RULE576 RULE577 RULE574 RULE578 RULE579 RULE580
```

The first step is to test the premise of RULE576. To test the premise, PcPlus begins to trace the **ELEHB** parameter.

```
Testing rule premise: EMOPERELE-1 RULE 576
Tracing parameter   : EMOPERELE-1 ELEHB
```

The next trace report, shown below, shows that PcPlus has set the value of **ELEHB** to YES and has begun tracing the **ELESPRK** parameter.

```
=== USER ENTRY ===      : EMOPERELE-1 ELEHB = (YES 100)
Setting parameter       : EMOPERELE-1 ELEHB = YES cf 100
End tracing parameter: EMOPERELE-1 ELEHB
Tracing parameter       : EMOPERELE-1 ELESPRK
```

The next trace output, below, shows that PcPlus has set the **ELESPRK** parameter to NO which causes the premise of RULE575 to be true. RULE575 is a forward-chaining rule that is fired at this point.

```
=== USER ENTRY ===      : EMOPERELE-1 ELESPRK = (NO 100)
Setting parameter       : EMOPERELE-1 ELESPRK = NO cf 100
Try the marked antecedent rules EMOPERELE-1 RULE 575
Testing rule premise : EMOPERELE-1 RULE 575
Apply action            : EMOPERELE-1 RULE 575 TALLY 100
```

The action specified in the THEN statement of RULE575 is to give a message to the user. The following message is given at this point in the consultation.

```
Manual emergency recall is required for all elevators
serving storeys above the first.  Automatic emergency
recall is required since the building is not sprinklered.

Article 3.2.6.8.  Emergency Operation of Elevators

(1)  Manual emergency recall shall be provided for all
     elevators serving storeys above the first storey.
(2)  Key-operated switches for emergency recall shall be
     provided in a conspicuous location at each elevator
     lobby on the recall level and at the central alarm
     and control facility required in Article 3.2.6.12.
(3)  In-car emergency service switches shall be provided
     in all elevator cars.
(4)  Keys to operate the switches shall be provided in a
     suitably identified box conspicuously located on
     the outside of an elevator shaft near the central
     alarm and control facility, and an additional key
     or keys shall be kept at the central alarm and
     control facility.
(5)  Automatic emergency recall shall be provided for
```

all elevators serving storeys above the first storey in unsprinklered buildings.

(6) The automatic emergency recall feature shall be actuated by:

(a) smoke detectors installed in each elevator lobby on each storey or

(b) the building fire alarm system

(7) Smoke detectors shall be designed as part of the building fire alarm system.

PcPlus has not completed testing RULE576 yet. It continues on tracing **ELEFL** parameter after the user has finished reading the message given by RULE575.

```
Completed action       : EMOPERELE-1 RULE 575
End of marked antecedent rules
End tracing parameter: EMOPERELE-1 ELESPRK
Mark the following antecedent rules for
     ELESPRK: RULE 575
Tracing parameter      : EMOPERELE-1 ELEFL
```

The trace output below shows that the value of the parameter **ELEFL** has been set to NO. The premise of RULE576, setting the value of the goal parameter **EMERG-ELE** to YES. This emergency operation for elevators is required for this building.

```
=== USER ENTRY ===     : EMOPERELE-1 ELEFL = (NO 100)
Setting parameter      : EMOPERELE-1 ELEFL = NO cf 100
Try the marked antecedent rules EMOPERELE-1 RULE 575
Rule already fired     : EMOPERELE-1 RULE 575
End of marked antecedent rules
End tracing parameter: EMOPERELE-1 ELEFL
Apply action           : EMOPERELE-1 RULE 576 TALLY 100
Setting parameter    : EMOPERELE-1 EMERG-ELE = YES cf 100
```

The message below is displayed for the user to read. This is the second action performed by RULE576.

Since the elevators are required to have an automatic recall feature, and the floor area containing the recall level is not sprinklered, the elevators must have an alternate level recall feature as required by Sentences 3.2.4.15.(1) and (2).

Article 3.2.4.15. Elevator Emergency Return

(1) Buildings having elevators that serve storeys above the first storey and that are equipped with an automatic emergency recall feature, smoke detectors shall be installed in the elevator lobbies on the recall level so that when these detectors are actuated, the elevators will automatically return directly to an alternate floor level.
(2) Smoke detectors shall be designed as part of the building fire alarm system.

The last few lines of trace output show that PcPlus has stopped tracing the goal parameter **EMERG-ELE**. This means the consultation to determine a value for **EMERG-ELE** has been completed.

```
Completed action: EMOPERELE-1 RULE 576
Deduced or No rules left for EMOPERELE-1 EMERG-ELE
End tracing parameter: EMOPERELE-1 EMERG-ELE
Goal trace complete for frame: EMOPERELE-1
```

Appendix E

Sample consultation run of the expert system to determine all Code requirements on Provisions for Fire Fighting (Subsection 3.2.5. of the NBCC 1990).

E.1 Expert System Consultation Demostration

In this Appendix a demonstration of a consultation is provided. This demonstration features: the user interface prompts, help screens, and output screens. Consider the following problem:

> **Problem:**
> The user wishes to determine all applicable Code requirements on Provisions for Fire Fighting.
>
> **Building Characteristics:**
> Building Height: *2 storeys*
> Basement Level: *NO*
> Major Occupancy Classification: *Group D*
> Sprinkler protection: *NO*
> Standpipe system: *NO*
> Building area: *1000* m^2

E.2 Consultation Commands

Various commands are available to the expert system user. The user simply has to press the keyboard function key **<F2>** to have the command window appear. The user can position the cursor to highlight the desired command on the list and execute the command by pressing the **<ENTER>** key.

Two command windows are avaliable to the user. The first command window is shown in Figure E.1 and appears if the **<F2>** function key is pressed during the consultation process.

If the **<F2>** function key is pressed at the end of the consultation process when all goal parameters have been solved for, the second command window will appear. This window is illustrated in Figure E.2. The user commands are listed in Table E.1.

E.3 NBCC Knowledge Base and Loading the PcPlus Expert System

To run this expert system, there must be at least 4.0 megabytes of space available on the hard drive. This is the amount of space required for the runtime version of the program. The runtime version is a compiled expert system where consultations can only take place and modifications to the knowledge base can not be made. To load this expert system onto the hard drive, a 3.5 inch high density drive is required. The runtime version is stored on three 3.5 inch high density diskettes. Each diskette listed below contains one of three parts of the NBCC expert system.

DISKETTE 1 of 3 Runtime Diskette
Diskette contains the PcPlus software to access the NBCC knowledge base.

DISKETTE 2 of 3 NBCC Knowledge Base Diskette
Diskette contains the knowledge base on Part 3 of the National Building Code of Canada (1990).

DISKETTE 3 of 3 Graphic Screen Diskette
Diskette contains the graphic screens which are used in help screens and illustrating conclusions.

E.4 Installation of the Expert System

To install the runtime version of the NBCC expert system a two step procedure must be followed as listed below.

STEP 1 Using DOS make a directory in the hard-drive.
(ie. **C:\PCPLUS**)

STEP 2 Copy all three diskettes onto the computer hard-drive.
(ie. **A:\COPY *.* C:\PCPLUS**)

When the installation of the NBCC expert system is complete, consultation with the expert system can begin by typing the command **CONSULT** (ie. C:\PCPLUS>**CONSULT**) and then pressing the **<ENTER>** key. A screen will appear showing the knowledge base name **NBCC**. The next step required is pressing the **<ENTER>** key which will access the **NBCC** knowledge base for consultation.

E.5 Selecting the Fire Protection Topic or Section from the NBCC Knowledge Base

After the NBCC expert system is started, the first screen to appear is shown in Figure E.3. This screen is the title screen for the program.

At the bottom of the screen is a command line. Executing the command line causes the consultation process to continue. In this case, the **<ENTER>** key is pressed.

The second screen to appear is shown in Figure E.4. This screen advises the user of the purpose of the expert system and has the heading, Current Objective. The screen explains the purpose of the NBCC.

The screen shown in Figure E.5 is a menu of options available to the user. Each menu option is a section or a topic of the NBCC that the user may wish to use. In this case the section of the NBCC *Provisions for Fire Fighting* is selected. As illustrated in Figure E.6, this screen shows the user the part of the knowledge base consultation will take place.

E.6 Access to Above Grade Storeys

The screen shown in Figure E.7 is the first prompt screen where the user is required to respond to a question. The user is asked if the building is sprinklered. This is one of the first pieces of information that the expert system must know about the building to determine all applicable code requirements on *Provision for Fire Fighting.*

A **<NO>** response to the prompt tells the expert system that the building is not sprinkler protected. The second prompt shown in Figure E.8 now appears. The user must select one of the three choices listed on the screen. If the user is unsure as to how to answer the question, the **<F1>** function key is pressed causing the help screen to appear as shown in Figure E.9. This screen illustrates what is being asked in the prompt.

The help screen is cleared by pressing the **<ENTER>** key. The user in this case selects the first choice from the list provided.

The next screen to appear is shown in Figure E.10, concluding to the user that *Article 3.2.5.1. Access to Above Grade Storeys* is applicable. The following screen as shown in Figure E.11 appears after the user presses the **<ENTER>** key. This screen illustrates the Article presented in the previous screen.

E.7 Access to Basement

The expert system now prompts the user whether or not the building has a basement. In this case there is no basement, hence the user simply responds by selecting <NO>. This is shown in Figure E.12.

E.8 Access to All Roof Areas

The following prompt to appear is illustrated in Figure E.13 and allows the user to indicate to the expert system whether or not the building height is greater than 3 storeys. Since the building has a building height of 2 storeys, the user selects **<NO>**.

The second conclusion the expert system makes is shown in Figure E.14. This screen appearing simply states to the user *Article 3.2.5.4. Roof Access* need not be considered to comply with the NBCC.

E.9 Access Route for Fire Department Vehicles

The next prompt to appear on the screen is shown in Figure E.15. This prompt allows the user to indicate the area of the building. Since the building area is 1000 m^2, the user answers the question by selecting **<YES>** indicating to the expert system the building is indeed greater than 600 m^2.

A third conclusion is made by the expert system. In Figure E.16, the building must conform with *Article 3.2.5.5. Access Routes.*

As illustrated in Figure E.17, the expert system prompts the user about the use of the building. In this case the building under consideration is an office building classified as a Group D, and does not contain any other occupancy that can be classified as Group B, Division 1. This prompt is answered by the user selecting **<NO>**.

The fourth conclusion to be made about the *Provisions for Fire Fighting* is shown to the user in the following screens illustrated in Figures E.18(a) and E.18(b).

E.10 Location of Access Routes

The fifth conclusion the expert system makes is shown in Figure E.19 which displays *Sentence 3.2.5.6.(1) Location of Access Routes* being an applicable requirement for this building. The expert system then continues to ask the user if the building has a standpipe system with a fire department connection. In this case, shown in Figure E.20 the user selects **<NO>**. The next two screens that appear are illustrated in Figures E.21(a) and E.21(b). The first screen informs the user a graphic illustration of the applicable Clause is to appear in the second screen.

E.11 Access Route Design

The last segment of this consultation the expert system checks to see if the user is interested in viewing the access route requirements.

The user may answer <NO> to the prompt shown in Figure E.22(a), causing the consultation on this fire protection topic to be completed. However, a <YES> response is choosen, having the consultation end with the screen displaying graphically *Article 3.2.5.7. Access Route Design*. This screen is shown in Figure E.22(b).

Command Name	Availability
CONTINTUE	Alawys
GET PLAYBACK FILE	At the title screen and the Current objective screen
HOW	During the consultation at the Conclusions screen
NEW START	During the consultation and at the Conclusions screen
PRINT CONCLUSIONS	At the Conclusions screen
QUIT	Always
REVIEW	During the consultation and at the Conclusions screen
SAVE PLAYBACK FILE	During the Consultation and at the Conclusions screen
TRACE ON	Always, if TRACE OFF has been selected
TRACE OFF	Always, if TRACE ON has been selected
WHY	At any prompt during the consultation

NOTE: (*The consultation commands are approriate only at certain times during the consultation. The following table lists the commands and when they are available.*)

Table E.1 Consultation Commands

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Commands

CONTINUE
HOW
TRACE OFF
PRINT CONCLUSIONS
REVIEW
SAVE PLAYBACK FILE
NEW START
QUIT

Figure E.1 Commands Screen During Consultation

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Commands

CONTINUE
WHY
HOW
TRACE NO
REVIEW
SAVE PLAYBACK FILE
NEW START
QUIT

Figure E.2 Commands Screen End of Consultation

```
NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

                    A PROTOTYPE EXPERT SYSTEM
                        FOR PART 3 OF THE
                      NATIONAL BUILDING CODE
                           of CANADA
                             1990

                          Version 1.0

                            University of Manitoba
                            City of Winnipeg
                            DND Air Command Headquarters Winnipeg

                                           D.M. Olynick
                                           M.J. Frye
                                           R.B. Pinkney

** End - press ENTER to continue.
```

Figure E.3 Title Screen

```
          NATIONAL BUILDING CODE of CANADA 1990 (NBCC)
Current objective

  The NATIONAL BUILDING CODE of CANADA (NBCC) is a set of minimum
  provisions respecting the safety of buildings with reference to
  public health, fire protection and structural sufficiency.  Its
  primary purpose  is the promotion  of public safety through the
  application of appropriate uniform standards throughout Canada.

  The Code is divided into 9 parts. A decimal numbering system has
  been used throughout the Code. This is illustrated as follows;
            3.                     Part
            3.5                    Section
            3.5.1                  Subsection
            3.5.1.6                Article
            3.5.1.6.(1)            Sentence
            3.5.1.6.(1)(e)         Clause
            3.5.1.6.(1)(e)(i)      Subclause
  This expert system prototype has been developed to assist the
  user in the application of fire protection requirements
  contained in Part 3 of the NBCC to building design.

** End - press ENTER to continue.
```

Figure E.4 NBCC Expert System Current Objective Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Main menu selection:

Please select the one part of the NBCC that you
are interested in.

< F1 HELP >

Building attributes
Building features
Construction components
Exiting requirements
Health requirements
Life safety systems
Provisions for Fire Fighting
Spatial separation
Structural fire protection


1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.
```

Figure E.5 Menu Selection Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Provisions for Fire Fighting

** End - press ENTER to continue.
```

Figure E.6 Provisions for Fire Fighting

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Is the building sprinklered ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.

Figure E.7 Sprinkler Prompt Screen

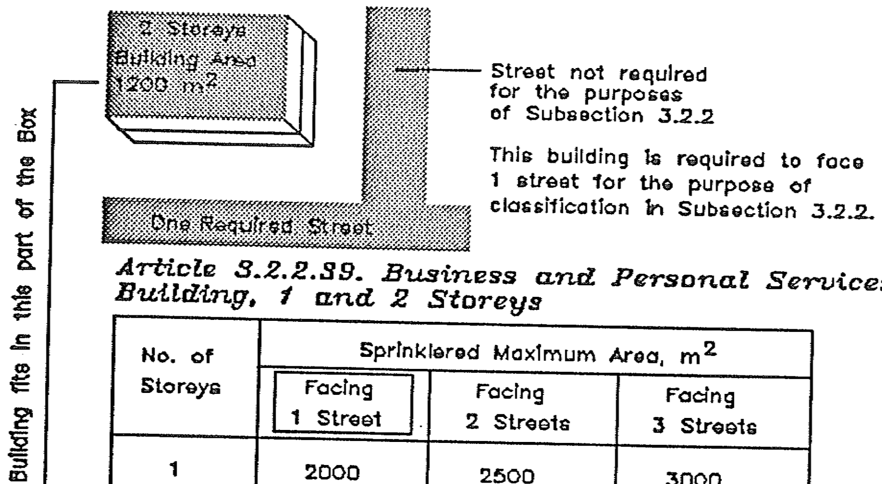
NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
How many streets is this building required
to face for the purposes of classification
in Subsection 3.2.2. ?
< F1 HELP >

1 street
2 streets
3 streets

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.
```

Figure E.8 Street Prompt Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

REQUIRED STREET ACCESS



Article 3.2.2.39. Business and Personal Services Building, 1 and 2 Storeys

No. of Storeys	Sprinklered Maximum Area, m^2		
	Facing 1 Street	Facing 2 Streets	Facing 3 Streets
1	2000	2500	3000
2	1600	2000	2400

press ENTER to continue.

Figure E.9 Help Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Article 3.2.5.1. Access to Above Grade Storeys
Every storey above grade having its floor level less than 25 metres above grade must be provided with direct access for the fire fighting from the out doors. Access shall be by means of one unobstructed window or access panel in the wall required to face the street.

** End - press ENTER to continue.

Figure E.10 Access to Above Grade Storey Conclusion Screen

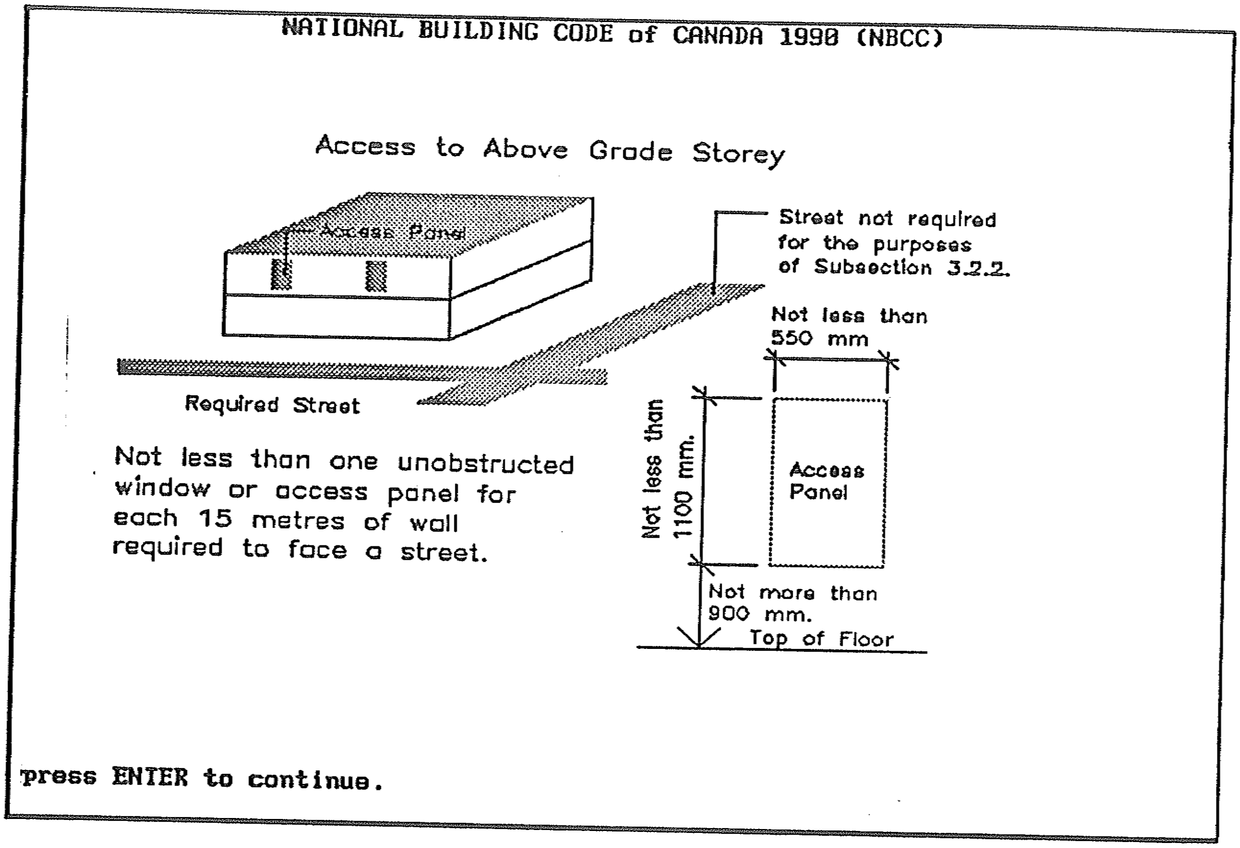


Figure E.11 Graphic Illustration Conslusion Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Does this building have a basement ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.

Figure E.12 Basement Prompt Screen

```
NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Is the building more than 3 storeys in
building height ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.
```

Figure E.13 Building Height Prompt Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Article 3.2.5.4. Roof Access
Direct access to all roof areas from the floor area immediately is not required.

** End - press ENTER to continue.

Figure E.14 Roof Access Conclusion Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Is the building more than 600 square metres
in building area ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.

Figure E.15 Building Area Prompt Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Article 3.2.5.5. Access Routes
Access routes for fire department vehicles are required.






** End - press ENTER to continue.
```

Figure E.16 Access Routes Conclusion Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Is the building a Group B, Division 1 building ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.

Figure E.17 Occupancy Type Prompt Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Clause 3.2.5.5.(1)(a) Access Routes
The access route for fire department vehicles are required to
the building face having the principal entrance.

** End - press ENTER to continue.
```

Figure E.18(a) Access Route for Fire Department Vehicles Conclusions Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Clause 3.2.5.5.(1)(a) and (b) Access Routes
Since the building is only required to face one street. access routes for fire department vehicles need only be provided to the building face having the principal entrance.

** End - press ENTER to continue.

Figure E.18(b) Access Route for Fire Department Vehicles Conclusions Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Sentence 3.2.5.6.(1) Location of Access Routes
Principal entrance and access openings required in building face that faces a street are located not less than 3 metres and not more than 15 metres from the closest portion of the access route.

** End - press ENTER to continue.

Figure E.19 Location of Access Routes Conclusion Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Does the building have a standpipe system
with a fire department connection ?

YES
NO




1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.
```

Figure E.20 Standpipe Prompt Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

```
Clauses 3.2.5.6.(2)(b) and (c) Location of Access Routes
The next screen illustrates Clause 3.2.5.6.(2)(b) and (c)




** End - press ENTER to continue.
```

Figure E.21(a) Fire Department Connection Conclusion Screen

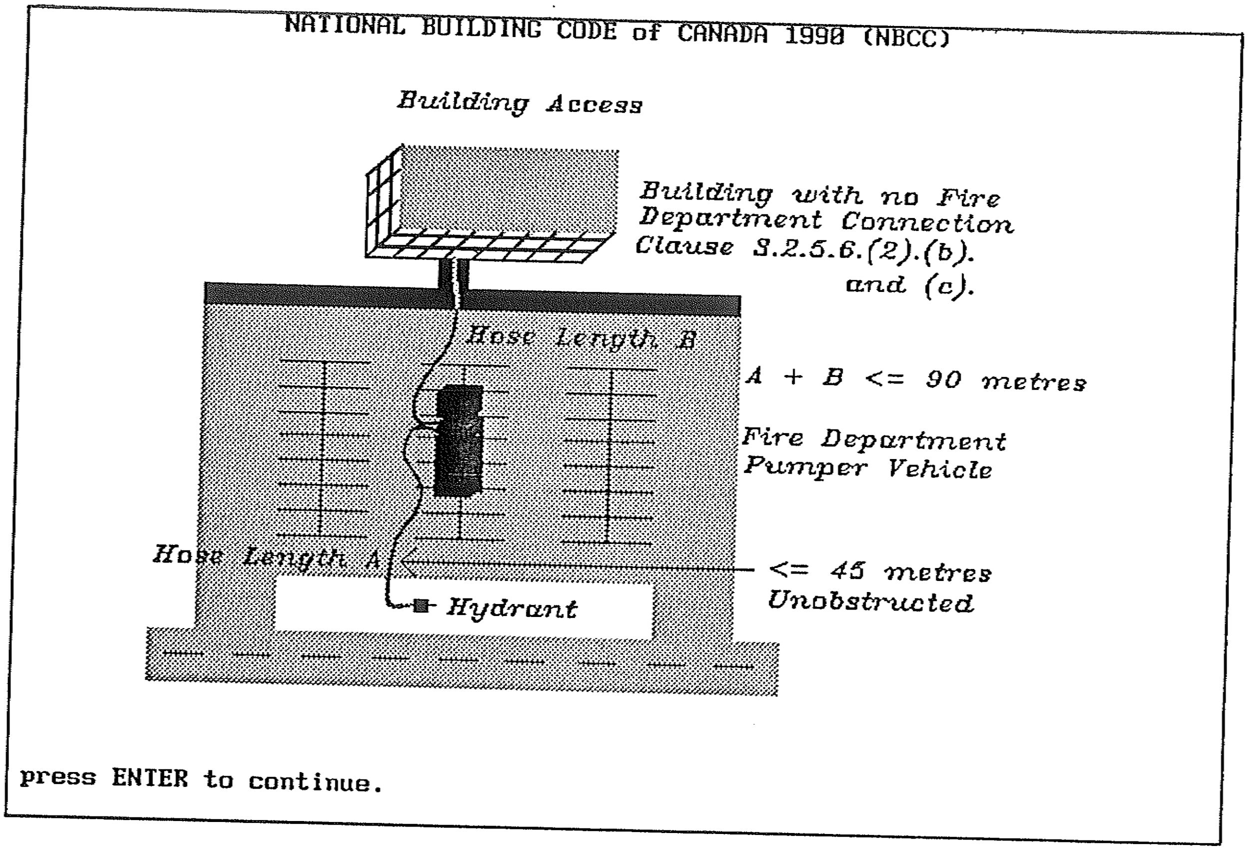


Figure E.21(b) Fire Department Connection Conclusion Screen

NATIONAL BUILDING CODE of CANADA 1990 (NBCC)

Do you want to see the access route
design requirements ?

YES
NO

1. Use arrow key or first letter of item to position the cursor.
2. press ENTER to continue.

Figure E.22(a) Access Route Design Requirements

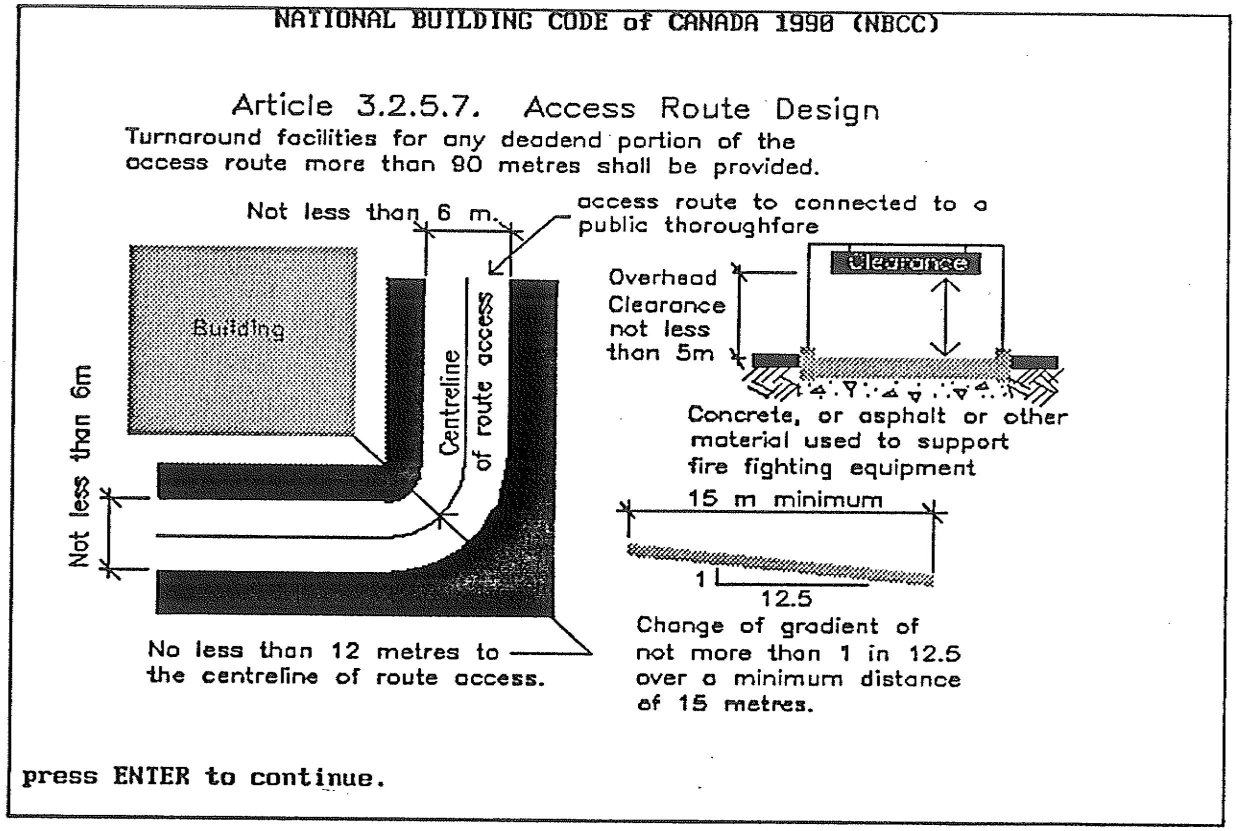


Figure E.22(b) Access Route Design Requirements

Appendix F

The minimum personal computer hardware to develop and to run consultations using the expert system shell PcPlus.

In this Appendix, the minimum system configuration requirements for both the development of the expert system and the consultation with the expert system are provided.

Development of the Expert System

The development of the expert system required an AT-class personal computer (that is, 80286-, or 80386-based computer). The minimum development system requirements that were used to develop the expert system are as follows:

a) one double-sided, double density diskette drive;

b) a hard drive with at least 1.5 megabytes of available work space;

c) a minimum of 640 kilobytes of memory is required; up to 1.5 megabytes of additional extended or expanded memory;

d) a personal computer DOS version 2.1 or greater for IBM, and compatible computers.

Consultation with the Expert System

To run a consultation with the expert system using the **NBCC1990** knowledge base, requires an AT-class personal computer (that is, 80286-, or 80386-based computer). The minimum system requirements to consult with the expert system are as follows:

a) a hard drive with at least 4.0 megabytes of available storage space for the **NBCC1990** knowledge base and the PcPlus software;

b) a minimum of 2.0 megabytes of RAM extended or expanded;

c) a graphics capability minimum VGA or greater to accommodate the graphic illustrations used by the expert system;

d) a personal computer DOS version 2.1 or greater for IBM, and compatible computers.

Incompatible Hardware

The PcPlus software will not run on a 80486-based computer. When executed, PcPlus works with a scheme program called PC Scheme. PC Scheme is the first of two software programs which are loaded into the memory of the computer. PcPlus is second program to be loaded. When the PC Scheme program is started on a 486-computer, an **out of memory** message appears. A number of people have investigated this problem.

The most probable cause of this **out of memory** problem appears to be an incompatibility problem exists between PC Scheme software and the *cache memory* of the 486-computer. PC Scheme is a program that is capable of self modifying its code when it runs. The cache memory of the 486-computer is unable to accommodate PC Scheme because of the techinques that are used to bring the program instructions and data into the cache memory from the main memory when they are required in processing.

This problem does not occur with 80286- and 80386-based computers, because these computers normally have no cache memory facilities. If cache memory is present, the memory access techinques are different from the 80486-based computers.

Todate, PC Scheme has been converted to a Borland Turbo C compiler from the initial software which it was written in the Microsoft C compiler. This work was carried out by a group in Switzerland in an attempt to have the PC Scheme software run on a 486-computer. However, at this time, full compatibility between the rewritten PC Scheme and the PcPlus software running on a 486-computer has not been achieved.

Texas Instruments has recently sold all the rights to PC Scheme to a company called IBAKU. This company specializes in scheme type programs and may in the future rewrite PC Scheme to work on 486-computers and other improved personal computers.

A second incompatibility has been found to exist between some newer Disk Operating System (DOS) versions containing memory manager software and the PC Scheme program. An out of memory message appears shortly after execution of the program has begun. This problem occurs because the memory manager cannot support the self modifying code characteristics of PC Scheme. The problem can be overcome by disabling the memory manager software or using an earlier version of DOS.