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EXPOSURE80A: A COMPUTER PROGRAM VERSION OF NFPA 80A

Richard L. Smith

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
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Table of Contents

A. Introduction 1

B. Description of NFPA 80A 1987 Edition 2

B.1. Basic Problem 3

B.2. Assumptions 4

B.3. Shortcomings 5

C. Description of EXPOSURE80A 6

C.1. Appearance 6

C.2. Key Program Components 7

D. Summary 9

References 11

Appendix: Computer Code for EXPOSURE80A 20

ABSTRACT

This report describes a computer program, EXPOSURE80A, written in Symbolics Common Lisp, that leads the user through NFPA 80A: Recommended Practice for Protection of Buildings from Exterior Fire Exposures. EXPOSURE80A is designed for use by fire protection professionals. It tells the user whether two buildings comply with the recommendations of NFPA 80A and if they do not, it suggests changes that will bring the buildings into compliance. EXPOSURE80A is easier to use than the written version of NFPA 80A since an understanding of 80A is not required. The approach used in EXPOSURE80A provides valuable information about the knowledge required of the user and the appropriate interface for the targeted class of users of an expert system, EXPOSURE, which is described in a separate report.

Key Words: fire codes, building codes, exposure, computer programs

A. Introduction

This report is one of three which summarizes the technical accomplishments achieved on an Air Force contract entitled "Fire Protection Design Assessment System." The project objective, briefly, was to develop an expert system to determine fire safety specifications for the design of buildings. This report describes a computer program, EXPOSURE80A, which is a bureaucratic system as opposed to an expert system. The other two reports deal with EXPOSURE [1] (an expert system version of NFPA 80A) and the calculation of the radiation from a fire incident on a building [2].

Fire safety building codes are the keystone of fire safety. However, regardless of the value of written fire codes they have serious shortcomings [3] [4]. Some of their major problems are:

1. They are hard to interpret, understand, and/or apply;
2. They do not cover all applications; and
3. They require a substantial understanding of fire codes and fire protection engineering to bring a building into full compliance.

The main users of fire codes include architects, building owners, code officials, and fire protection professionals. Some of these users do not have familiarity with the codes to comply efficiently and accurately with them. The innovative design of some buildings requires the application of state-of-the-art technology to demonstrate their level of fire safety. Fire science and fire protection engineering are highly complex and sometimes empirical technologies. The correct application of the most appropriate technology is challenging even for many fire protection professionals so it is clearly often difficult for the other users.

Many aspects of building design are being automated. It is inevitable that some computerized form of fire codes will come into widespread use [5]. Because of the complexity of the problem and the need to deal with exact and inexact knowledge, one promising form for this automation to take is that of an expert system [4] [6].

Three possible types of computer programs for the automating of fire codes are a bureaucratic system, an expert compliance checker system, and an expert fire safety system. We will describe these in turn.

A bureaucratic system program is one that insists on a rigid adherence to the rules, form, and routines explicitly called for by the written fire code. This type is made by converting the fire code into a computer program based on a strict straight-

forward interpretation of the written word. This type of system requires no expertise in either

* interpretation of fire codes to ensure acceptance by the authority having jurisdiction or
* appropriate fire protection engineering technology.

The development of an expert compliance checker system computer program requires an expert in compliance checking. The Center for Fire Research did not have such an expert available so this type of expert system was not studied.

The third type of system, an expert system program, is based on an expert's in the application of fire protection engineering that addresses the same problem as the fire codes. EXPOSURE is this type of program and is discussed in a separate publication [1].

An expert system is more sophisticated and its development requires that the following key issues be dealt with.

1. How to acquire the public knowledge, which can be obtained from the literature, and the private knowledge, which can only be obtained from the expert.

2. How to acquire only the necessary information about the buildings and their environment the user.

3. How to avoid the need for the user to have more than a layman's knowledge of fire safety. For example the input should be restricted to such data as physical dimensions or the type of building material used in construction rather than the identification of a fire compartment. The identification of a fire compartment requires the user to determine such things as the duration of fire in various spaces and whether the physical barriers will contain the fire for the duration of the fire.

The development of the first type of system, a bureaucratic system computer program version of NFPA 80A, begins to address some of these issues.

B. Description of NFPA 80A 1987 Edition

The particular fire code selected for this project is the one that deals with the prevention of the spread of fire from a burning structure to a neighboring structure. In the past major conflagrations have often resulted when fires have spread to neighboring buildings. The potential for five spread to a neighboring building is, therefore, of primary concern when evaluating the fire safety of any building. Also, after rescuing

people from a burning building, a fire department's top priority is to stop the spread of the fire to adjacent structures [7].

As its title indicates NFPA 80A: Recommended Practice for Protection of Buildings from Exterior Fire Exposures [8] is a recommended practice not a NFPA fire code. NFPA states that recommended practices generally can be considered as good engineering practice. According to NFPA a recommended practice is only advisory and therefore it uses the word "should" to indicate recommendations. In contrast a NFPA codes or standards uses "shall".

NFPA 80A gives a spectrum of recommendations from rather detailed "shoulds" requiring little interpretation or analysis to rather general approaches for the control of the spread of fire. In the program EXPOSURE80A, we have adopted the position that if a pair of buildings complies with all the explicit "shoulds" of 80A then it is said to comply with or satisfy 80A.

Although NFPA 13-1987, Standard for the Installation of Sprinkler Systems, and NFPA 80-1986, Standard for Fire Doors and Windows are considered part of 80A their requirements have not been included in our present work.

B.1. Basic Problem

The basic problem of exterior fire exposure involves two buildings. In the application of 80A one building is assumed to burn, the exposing building, while the other is the exposed building, and then the roles of the buildings are reversed.

We can define a fire containment compartment as a region of a burning building which has physical surfaces that enclose and will contain any fire expected to occur within it. If one of these surfaces is an exterior wall, that surface need not contain the fire. The extreme limit in size for a fire containment compartment is the entire building. Normally a complex building will have a number of fire containment compartments.

To determine if a pair of buildings comply with 80A, one of the buildings is assumed to be burning. Then all the fire containment compartments in this building that have a surface on the exposing wall are identified. For each of these compartments the width and height on the exposing wall are determined. In addition, the fire severity is determined (see section 2-2.4 of NFPA 80A) for each compartment using the average fire load and the average flame spread and Table 2-2.4 of 80A. Then the percentage of the area of the exposing wall of the compartment devoted to door, windows, and other openings is determined. These quantities are used to obtain a "guide number" from Table 2-3 in 80A. The minimum allowed separation between the buildings is determined by multiplying this guide number by the smaller of the compartment's

height or width and then adding 5 feet. The minimum separations for all the compartments are determined and the largest minimum separation identified. If the actual or planned separation is less than the largest minimum separation for any of the compartments in both buildings, then additional protection is recommended.

80A gives various credits that can be applied to the minimum separation distance for various means of protection. For example, if the exposing building has an automatic sprinkler system, the required separation is zero or if the exposed wall is a frame or combustible wall, then the installation of an automatic deluge water curtain over the entire wall reduces the required separation by half.

If one building is taller than the other, additional unspecified protection is required in some cases.

B.2. Assumptions

In the forward of 80A is the statement: "The hazards of exposure to a structure from adjacent exposing fires and the almost numberless variety of conditions under which such exposure may occur render impossible the formulations of any simple table, formulae, or set of rules that will adequately cover all conditions." To reduce the general problem to a manageable one, the following assumptions were made:

1. There is effective fire fighting activity.

2. Fire is spread between buildings by piloted ignition or by direct contact with the flames from the burning building.

3. All combustible materials have a pilot ignition threshold equal to that of oven dried wood, i.e. 0.3 cal/sq cm/sec or 66 Btu/sq ft/min.

4. The exposed and exposing walls are parallel.

5. Openings are assumed to be uniformly distributed over the exposing wall and that the separation between openings will be no more than one-third of the separation between the two buildings.

6. Only buildings with walls capable of fitting into the following categories are considered:
   1) frame or combustible,
   2) fire-resistive wall (3 hour minimum),
   3) veneered wall (combustible construction covered by a minimum of four inches of masonry), or
   4) non-combustible (fire resistance less than 3 hours.

In addition, the user must be able to determine if the walls can contain the fire:

1) less than 20 minutes,
2) 20 minutes or more, but less than the duration of the fire, or
3) the duration of the fire.

7. All fires can be classified as one of three severities (light, moderate, or severe) by using either the average combustible load per unit area or the average flame spread rating.

8. Only one wall of the burning building exposes one wall on the exposed building.

9. Any door, window, and other opening of a building transmits without attenuation the radiation of the fire within the compartment containing the opening.

The underling physics of 80A is that the burning building radiates through the openings in the exposing wall as a blackbody. The fire severity and the percentage opening for each compartment determines the temperature of this blackbody or the source radiation flux. The guide number multiplied by the minimum of the exposing height or width gives the separation which is approximately equal to the maximum distance for which the maximum radiation falling on the exposed wall is 0.3 cal/sq cm/sec.

The determination of the radiation level on the exposed wall requires the calculation of the configuration factor. This involves evaluating a complicated integral. In order to reduce this general problem to a simpler one which could be resolved with one table instead of many tables, assumptions such as 4 and 5 above were made.

B.3. Shortcomings

One major shortcoming resulting from the above assumptions is that 80A is directly applicable to only a small subset of all the problems of interest. For example, many neighboring buildings do not have parallel walls. Also, a combustible wall is not given credit for having a pilot ignition threshold higher than wood.

Another major shortcoming is that if the requirements of 80A are not satisfied, there is no guidance on how to determine the level of risk associated with the non-compliance.

A shortcoming common to many fire codes is that the user is required to not only know and understand the entire particular fire code with all its requirements and caveats, but he must also know and understand all fire codes so that in the process of satisfying one code he does not violate another.

EXPOSURE80A deals with some of the shortcomings in that the user need only answer the questions to comply with NFPA 80A. It does not address the larger issue of compliance with all codes.

C. Description of EXPOSURE80A

EXPOSURE80A was developed on a Symbolics computer and was written in Symbolics Common Lisp[1]. In particular, significant use was made of Genera windowing and menu facilities.

C.1. Appearance

The first thing the user sees when running EXPOSURE80A is an introduction screen as shown in Figure 1. The user can either type commands in the command window towards the bottom of the screen or use a mouse to click on the commands shown in the second window from the top. The user need not type in the entire command since the program has the ability to complete the command. Thus to enter the command "instructions", typing i <return> is sufficient.

Clicking on "instructions", brings up the screen shown in Figure 2 which explains what a fire containment compartment is and how to use the program to obtain compliance with 80A.

Clicking on the command "start" brings up the screen shown in Figure 3. This menu of questions extends beyond what can be shown in one full screen. The scroll key brings up the continuation as shown in Figure 4.

All the questions have default answers. In the case of multiple choice of answers, the default answer is in bold type. To change the answer for one of these, the mouse must be clicked on the desired answer. For the non-multiple choice questions, the mouse must be clicked on the indicated answer and the desired answer typed followed by a <return>. If the typed answer is not appropriate, the program will not accept the answer and requests an answer of the correct form or range.

The menu reacts to the answers as they are entered. For example, if in answering the first question the name "Warehouse 609" is entered in place of "building-1", then everywhere in the menu

---

[1] Note: Certain commercial products are identified in this report in order to adequately specify the computer programs. Such identification does not imply recommendation by the National Institute of Standards and Technology, nor does it imply that these products identified are necessarily the best available for the purpose.

where "building-1" previously appeared, "Warehouse 609" will now appear. Also, if an answer to one question removes the need to ask another question, that question disappears. An extreme example of this is shown in Figure 5. If the user indicates that both buildings have sprinkler systems, the remaining questions disappear.

When the user has finished answering the questions, he clicks on "done" which is found near the bottom of the screen. Typical responses are shown in Figures 6 and 7. Figure 6 shows the response includes the required minimum separation and the designed separation, a statement that 80A is not satisfied, and two possible actions that could be taken to bring the buildings into compliance. Figure 7 shows the response for buildings for which 80A is satisfied for the chosen compartment in the exposing building. It also contains a statement that for the buildings to be in compliance, all compartments must be in compliance.

A hidden advantage of EXPOSURE80A over the written version of 80A is that the use of the guide number table is automated. After the necessary information has been entered the program looks up the appropriate table value, does any required interpolation, and computes the minimum separation distance. A non-hidden advantage is the ease of use. The user doesn't have to trace the logic or check that he has covered all relevant requirements. This is done by the program.

C.2. Key Program Components

The entire computer program for EXPOSURE80A with comments is in the Appendix. A brief description of all the major components of this program is given below. Figure 8. shows the calling protocol of these functions. Reproduced below are the start of the components followed by a brief explanation of the code.

```
(DW:DEFINE-PROGRAM-FRAMEWORK EXPOSURE80A ... )
```

This function handles such chores as providing the super structure that allows the user to name the program, call it into action with a select key, name the state variables, and define the various panes in the EXPOSURE80A window.

```
(defmethod (all-of-exposure80a ... )
```

This function which is called by clicking on start address the heart of the problem. It displays and operates the menu of questions that the user must answer. This function makes extensive use of the accepting values menu of Genera. This

function reacts to the answers as entered by updating the menu after each entry so unnecessary questions are dropped. Also, the type of entry and sometimes its range of values are specified so inappropriate answers cannot be entered. It also calls other functions to determine if the fire compartments comply with NFPA 80A.

(defmethod (percent-opening ...)

This function determines the percentage of the wall that is devoted to openings. It is used in the function guide-number.

(defmethod (classification-severity ...)

This function classifies the severity of the burning compartment according to NFPA 80A scheme involving fire load and fire spread. It also is used in the function guide-number.

(defmethod (height-width-ratio ...)

This function computes the height to width or width to height ratio as needed. It also is used in the function guide-number.

(defmethod (guide-number ...)

This function determines the guide number to use from NFPA 80A's Table 2-3. It interpolates if there is a need. It is called by the function unprotected-minimum-separation.

(defmethod (unprotected-minimum-separation ...)

The unprotected minimum separation is computed by multiplying the guide number by the smaller of the height or width and then adding five feet. It is called by the function all-of-exposure80a.

(defmethod (adjusted-minimum-separation ...)

The adjusted minimum separation is determined based upon additional information about the buildings. This is accomplished by using an implementation of the adjustments factors found in section 4-2 of NFPA 80A. It is called by the function all-of-exposure80a.

(defmethod (solution-exposure ...)

This function contains the logical tree structure of NFPA 80A. Here the adjusted minimum separation is compared with the actual separation to see if it is adequate. The possibility of the buildings having different heights is taken into account here also. If the buildings do not comply with NFPA 80A, they can always be made to comply by either increasing the separation to the required minimum or by adding automatic sprinklers to either buildings that do not have them. It is called by the function all-of-exposure80a.

This completes the description of the major components of EXPOSURE80A.

D. Summary

A bureaucratic system computer program for NFPA 80A has been developed. The program is clearly easier to use than the written version of NFPA 80A. Limited testing (not described in this report) has shown that the computer program version produced the same results as strict application of the written version.

The advantages of this bureaucratic system are:

* Understanding NFPA 80A is not required to check if a building is in compliance.

* It is consistent. It always give the same results for the same input.

* It does try to minimize the information called for from the user.

Its disadvantages are:

* The program can not deal with fringe cases of 80A, i.e., situations not explicitly covered by NFPA 80A, but for which general guidance is provided.

* Not being able to handle fringe cases, it has no capability to deal with the many situations which lie well outside the domain of 80A.

* It requires considerable specialized knowledge to correctly answer the questions of EXPOSURE80A, e.g., the user must be able to identify all relevant fire containment compartments. This requires an extensive knowledge of fire protection engineering. Programs requiring this type of input will have limited usefulness.

A bureaucratic system can be useful for acquiring significant domain knowledge if it can be developed in a reasonably short time. It is a useful tool to use to simulate the domain expert into providing more relevant public knowledge and his own private knowledge. While a bureaucratic system may evolve into an expert system, we believe that a more typical scenario is that after a short time of using it, it will be abandoned.

The user interface should not present the user with a multitude of information at one time. It should present only a small amount unless it is in a form that people can readily process such as some graphic information.

Finally, EXPOSURE80A was useful in helping to identify where additional knowledge processing capability is needed so that the user will not have to make high level judgments such as what are all the fire compartments. The requirements for the Air Force contract called for input of a simpler nature. This lead to the development of the expert system program EXPOSURE [1].

References

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[8] NFPA 80A: Recommended Practice for Protection of Buildings from Exterior Fire Exposures National Fire Codes Vol 9 (1989), National Fire Protection Association Batterymarch Park, Quincy, MA 02269

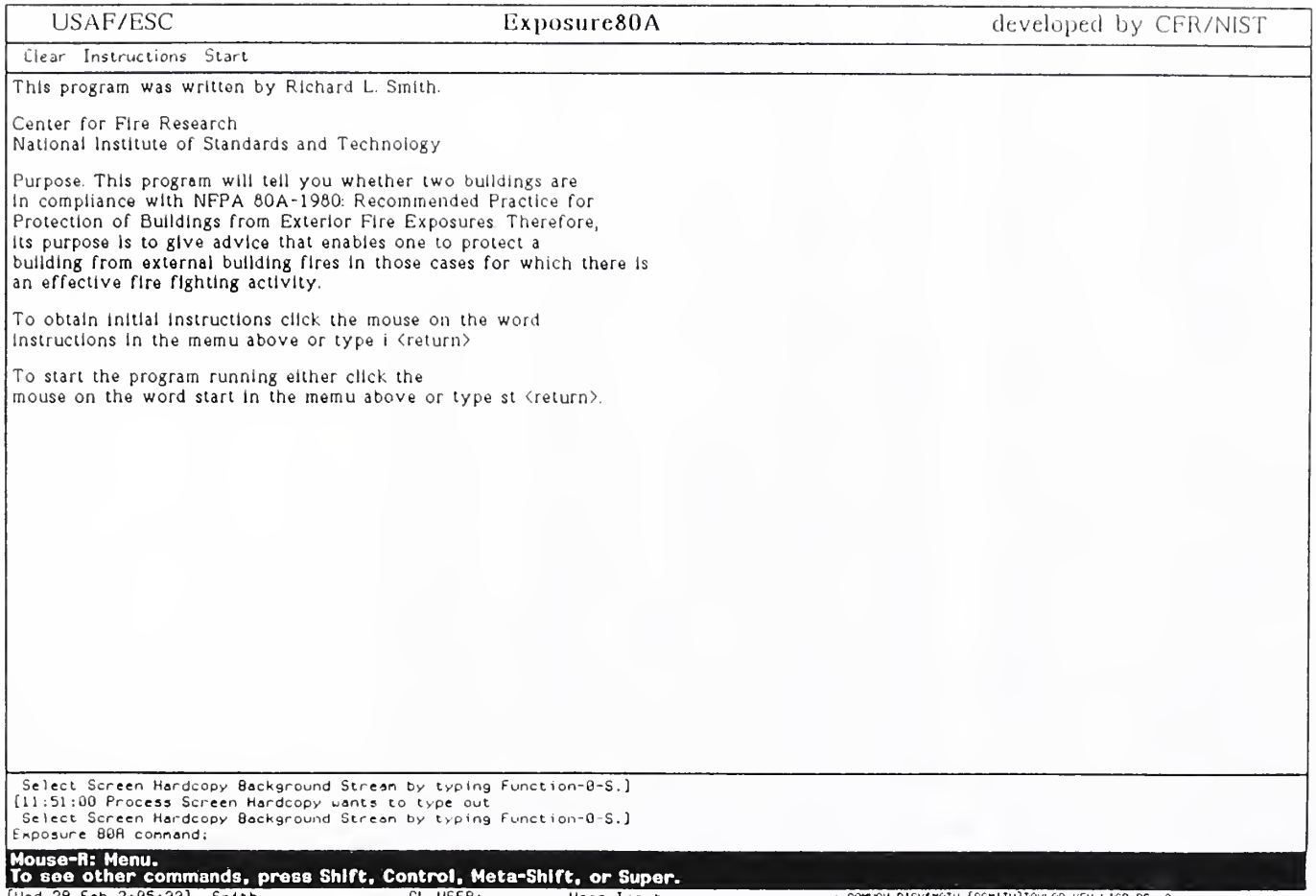

Figure 1. Introduction Screen

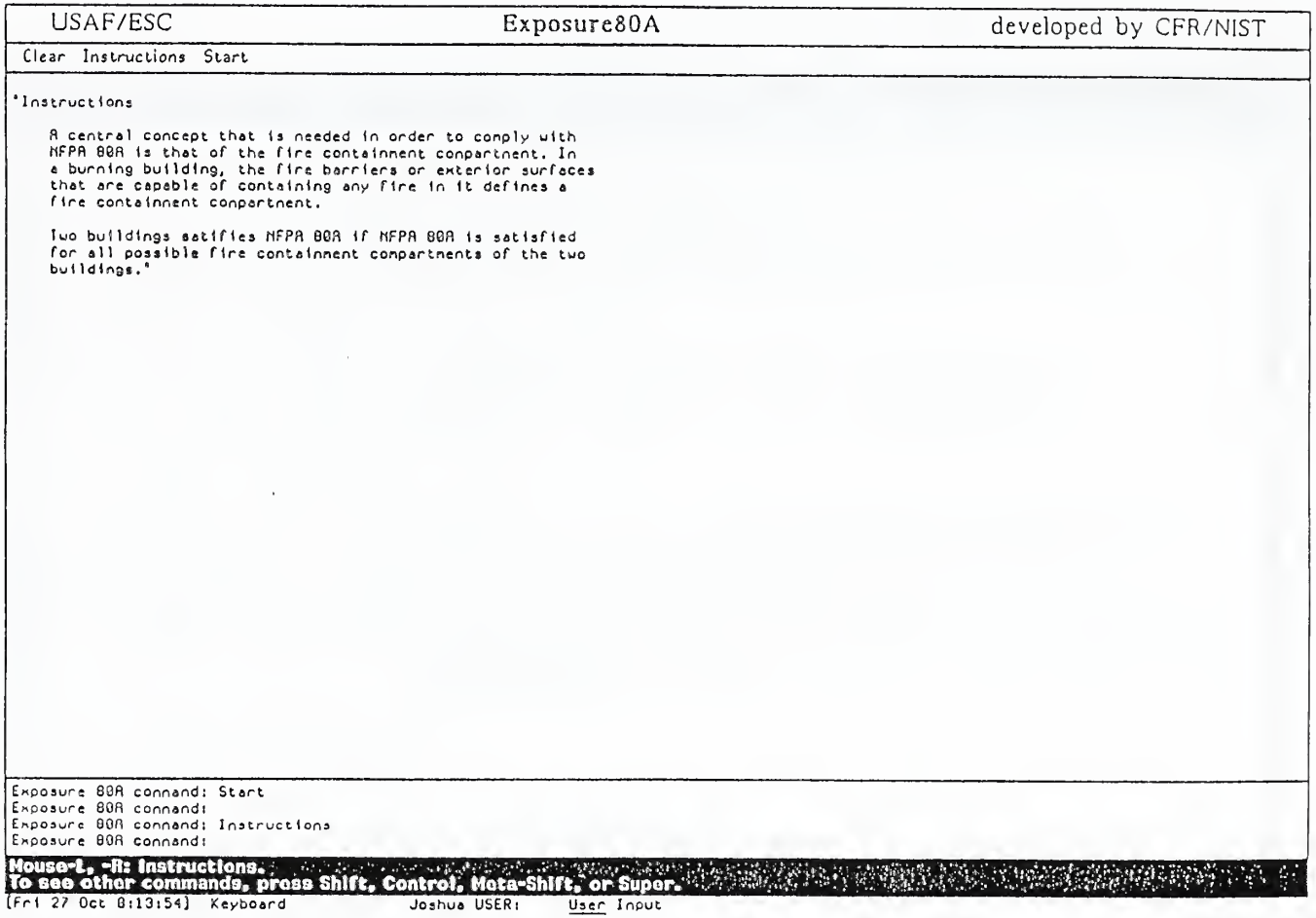

Figure 2. Instruction Screen

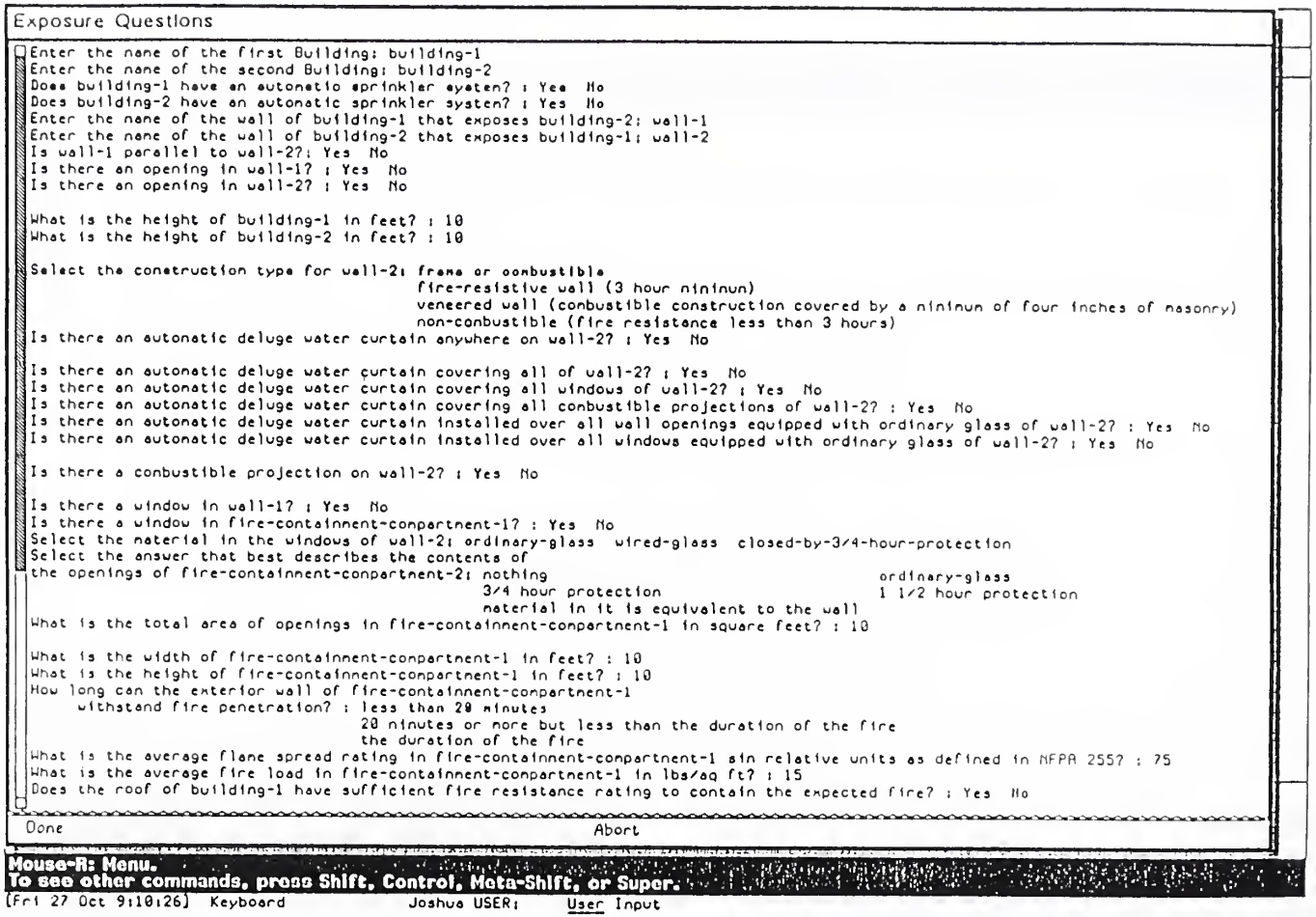

Figure 3. First Menu Screen

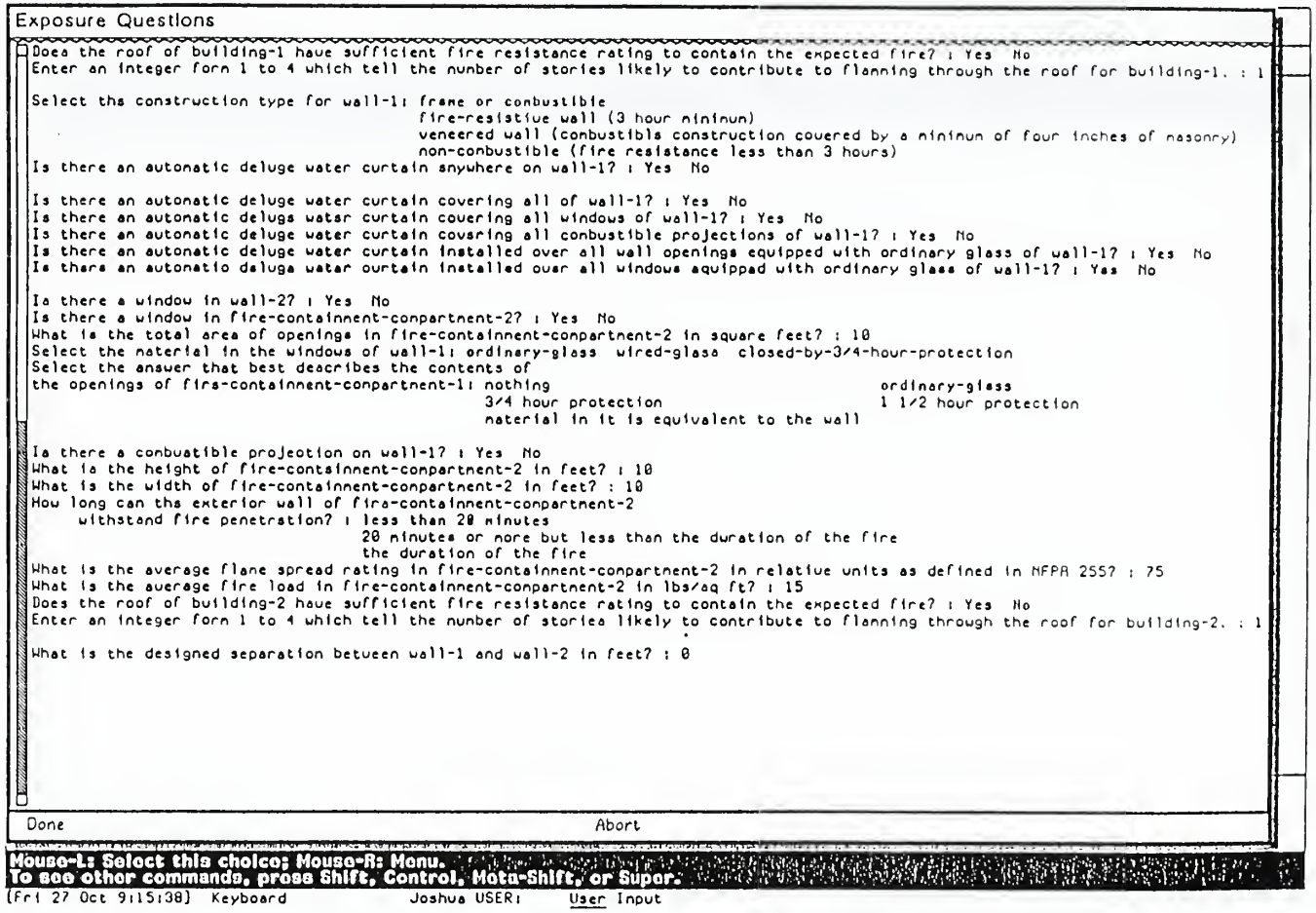

Figure 4. Second Menu Screen

Figure 5. Minimum Question Set Screen

Figure 6. Conclusion Screen for Buildings of Equal Height

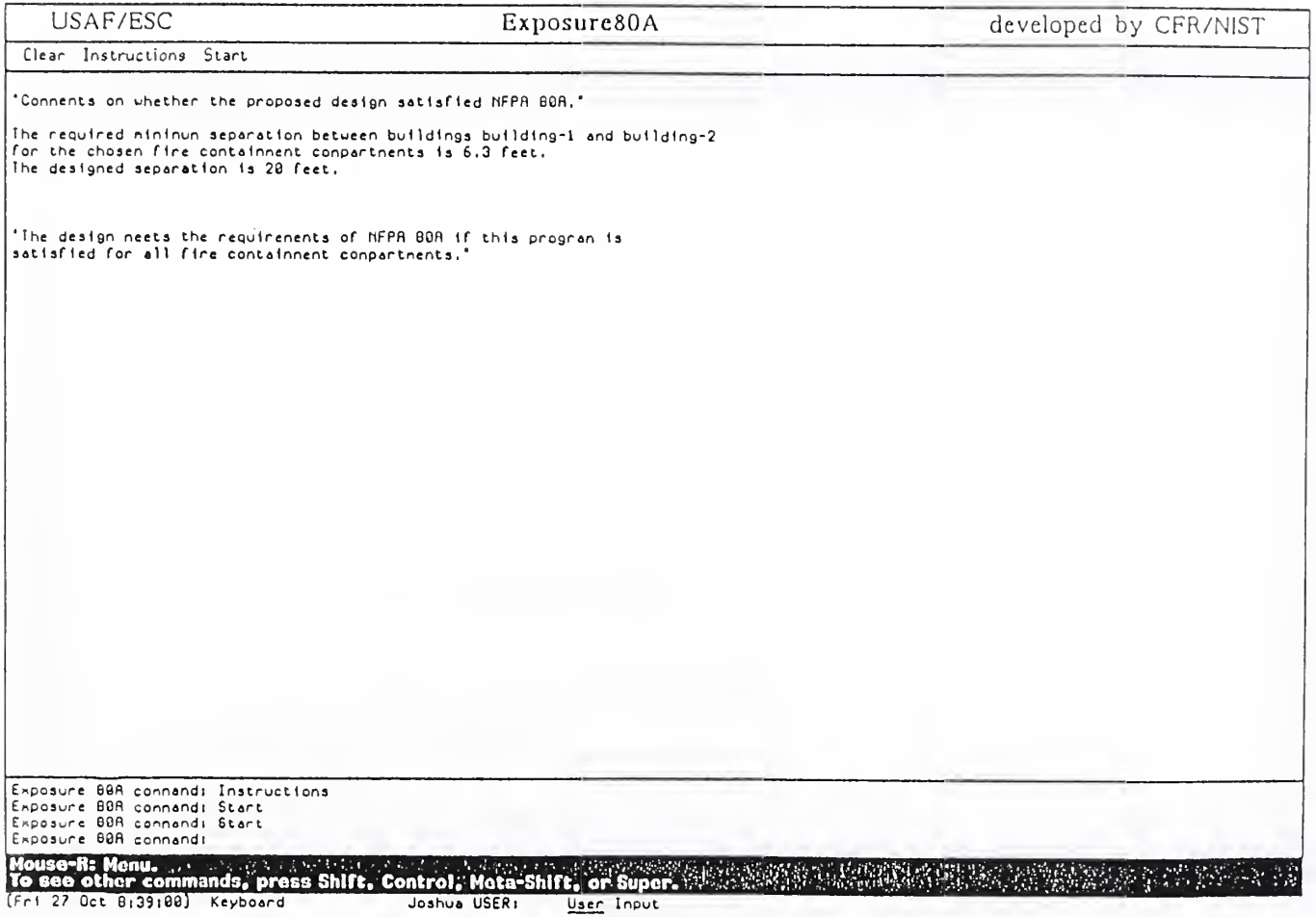

Figure 7. Conditional Compliance Screen

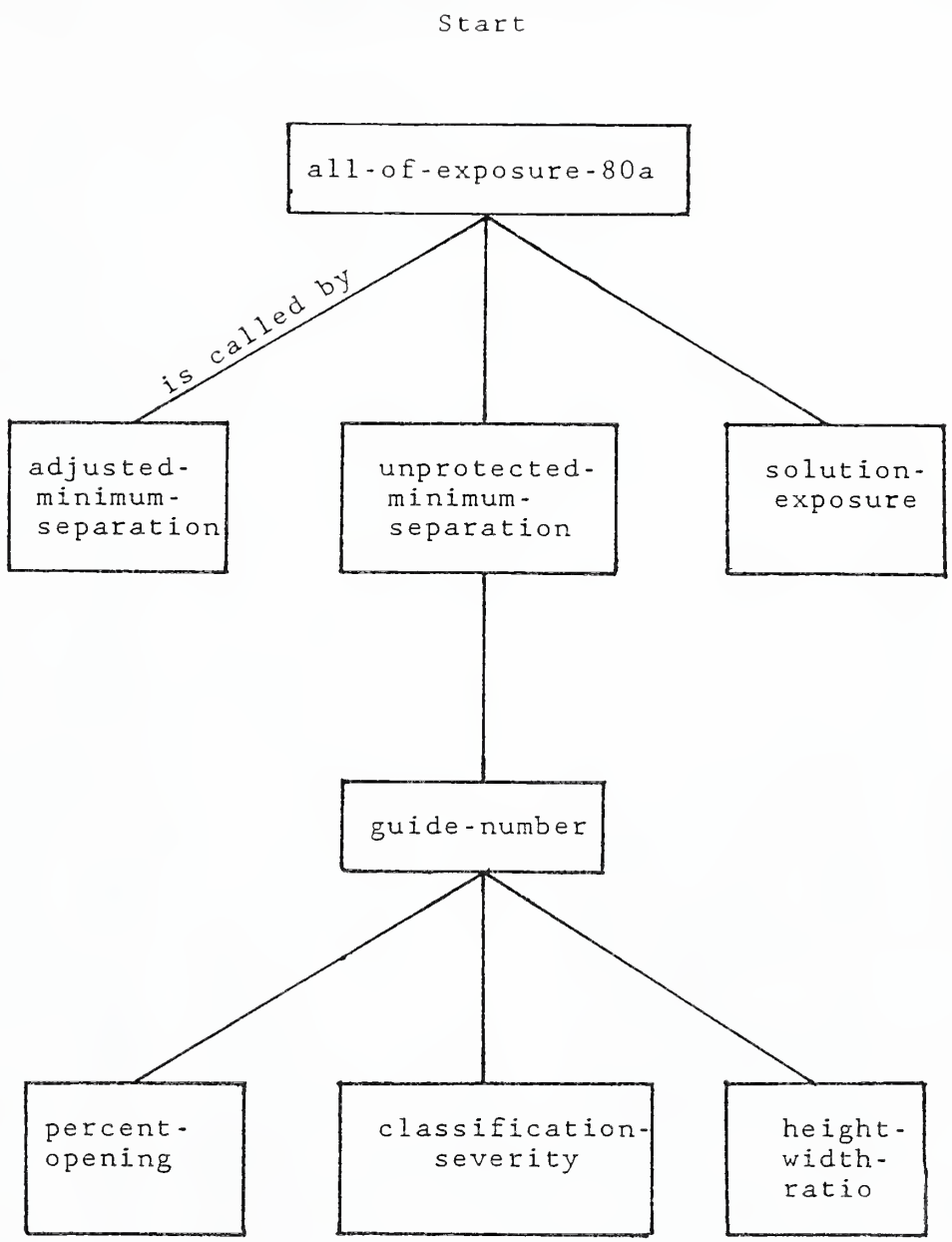

Figure 8. Calling Protocol of Main Functions

Appendix: Computer Code for EXPOSURE80A

```
;;; We use program frame up to be selected by select shift *.
;;; This brings up a screen with the following title: Exposure 80A.

(DW:DEFINE-PROGRAM-FRAMEWORK EXPOSURE80A
  :pretty-name "Exposure 80A"
  :SELECT-KEY  #\*
  :COMMAND-TABLE
  (:INHERIT-FROM
    '("colon full command" "standard arguments" "input editor compatibility")
   :KBD-ACCELERATOR-P 'NIL)
  :COMMAND-DEFINER T
  :top-level (EXPOSURE80A-top-level)
  :STATE-VARIABLES ((building-1-name "building-1")
                    (building-2-name "building-2")
                    (bldg-1-wall "wall-1")
                    (bldg-2-wall "wall-2")
                    (walls-parallel )
                    (fire-fighting)
                    (wall-separation)
                    (bldg-1-sprinkler nil)
                    (bldg-2-sprinkler nil)
                    (wall-1-construction )
                    (wall-2-construction )
                    (height-bldg-1)
                    (height-bldg-2)
                    (bldg-1-fire-containment-compartment
                      "fire-containment-compartment-1")
                    (bldg-2-fire-containment-compartment
                      "fire-containment-compartment-2")
                    (width-fire-containment-compartment-1 )
                    (width-fire-containment-compartment-2 )
                    (height-fire-containment-compartment-1)
                    (height-fire-containment-compartment-2)
                    (any-wall-1-automatic-deluge-water-curtain)
                    (any-wall-2-automatic-deluge-water-curtain)
                    (wall-1-automatic-deluge-water-curtain nil)
                    ;; need to supply default values
                    ;; because if question is not ask we get inconsitent answer
                    (wall-2-automatic-deluge-water-curtain nil)
                    (wall-1-automatic-deluge-water-curtain-windows nil)
                    (wall-2-automatic-deluge-water-curtain-windows nil)
                    (wall-1-automatic-deluge-water-curtain-openings nil)
                    (wall-2-automatic-deluge-water-curtain-openings nil)
                    ;; next two refer to automatic-deluge-water-curtains
                    (water-curtain-is-installed-over-on-all-wall-1-openings-
```

```
  equipped-with-ordinary-glass nil)
(water-curtain-is-installed-over-on-all-wall-2-openings-
  equipped-with-ordinary-glass nil)
(water-curtain-is-installed-over-on-all-wall-1-windows-
  equipped-with-ordinary-glass nil)
(water-curtain-is-installed-over-on-all-wall-2-windows-
  equipped-with-ordinary-glass nil)
(average-flame-spread-rating-compartment-1 )
(average-flame-spread-rating-compartment-2 )
(fire-load-compartment-1 )
(fire-load-compartment-2 )
(wall-1-openings )
(wall-2-openings)
(wall-1-combustible-projections )
(wall-2-combustible-projections )
(wall-1-water-curtain-all-combustible-projections )
(wall-2-water-curtain-all-combustible-projections )
(classification-severity-bldg-1)
(classification-severity-bldg-2)
(compartment-1-h-w-ratio )
(compartment-2-h-w-ratio )
(guide-number-compartment-1)
(guide-number-compartment-2)
(unprotected-minimum-separation-compartment1)
(unprotected-minimum-separation-compartment2)
(adjusted-minimum-separation-compartment-1)
(adjusted-minimum-separation-compartment-2)
(all-compartment-1-openings-have )
(all-compartment-2-openings-have )
(wall-1-windows)
(wall-2-windows)
(fire-containment-compartment-1-windows )
(fire-containment-compartment-2-windows )
(material-windows-compartment-1 )
(material-windows-compartment-2 )
(area-of-openings-fire-containment-compartment-1)
(area-of-openings-fire-containment-compartment-2)
(percentage-openings-compartment-1)
(percentage-openings-compartment-2)
(compartment-1-wall-fire-resistance)
(compartment-2-wall-fire-resistance)
(exposure-array)
(roof-fire-resistance-bldg-1)
(roof-fire-resistance-bldg-2)
(number-of-floors-flames-roof-bldg-1)
(number-of-floors-flames-roof-bldg-2)
```

```
                    (height-of-taller-bldg-protection-bldg-1)
                    (height-of-taller-bldg-protection-bldg-2)
                    (wall-1-additional-protection )
                    (wall-2-additional-protection )
                    (required-minimum-separation )
                    (potential-exposure-problem-bldg-1 )
                    (potential-exposure-problem-bldg-2 ))
  :PANES
  ((PANE-1 :TITLE
           :default-character-style '(:dutch :roman :very-large)
           :REDISPLAY-STRING
           "USAF/ESC                    Exposure80A                    developed by CFR/NI
ST"
           :HEIGHT-IN-LINES 1 :REDISPLAY-AFTER-COMMANDS
           NIL)
   (PANE-2 :COMMAND-MENU :MENU-LEVEL :TOP-LEVEL)
   (CHANNEL :DISPLAY)
   (PANE-4 :INTERACTOR :HEIGHT-IN-LINES 4))
  :CONFIGURATIONS
  '((DW::MAIN
      (:LAYOUT (DW::MAIN :COLUMN PANE-1 PANE-2 CHANNEL PANE-4))
      (:SIZES
        (DW::MAIN (PANE-1 1 :LINES) (PANE-2 :ASK-WINDOW SELF :SIZE-FOR-PANE PANE-2)
                  (PANE-4 4 :LINES) :THEN (CHANNEL :EVEN))))))

(setq exposure-array
  (make-array '(14 17)
    :initial-contents
    '((0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0)          ;implicited in the table
      ( .36  .4   .44  .46  .48  .49  .5   .51  .51  .51  .51  .51  .51  .51  .51  .51  .51)
      ( .6   .66  .73  .79  .84  .88  .9   .92  .93  .94  .94  .95  .95  .95  .95  .95  .95)
      ( .76  .85  .94  1.02 1.1  1.17 1.23 1.27 1.3  1.32 1.33 1.33 1.34 1.34 1.34 1.34 1.34)
      ( .9   1.0  1.11 1.22 1.33 1.42 1.51 1.58 1.63 1.66 1.69 1.7  1.71 1.71 1.71 1.71 1.71)
      (1.02  1.14 1.26 1.39 1.52 1.64 1.76 1.85 1.93 1.99 2.03 2.05 2.07 2.08 2.08 2.08 2.08)
      (1.22  1.37 1.52 1.68 1.85 2.02 2.18 2.34 2.48 2.59 2.67 2.73 2.77 2.79 2.80 2.81 2.81)
      (1.39  1.56 1.74 1.93 2.13 2.34 2.55 2.76 2.95 3.12 3.26 3.36 3.43 3.48 3.51 3.52 3.53)
      (1.55  1.73 1.94 2.15 2.38 2.63 2.88 3.13 3.37 3.6  3.79 3.95 4.07 4.15 4.2  4.22 4.24)
      (1.82  2.04 2.28 2.54 2.82 3.12 3.44 3.77 4.11 4.43 4.74 5.01 5.24 5.41 5.52 5.6  5.64)
      (2.05  2.3  2.57 2.87 3.2  3.55 3.93 4.33 4.74 5.16 5.56 5.95 6.29 6.56 6.77 6.92 7.01)
      (2.26  2.54 2.84 3.17 3.54 3.93 4.36 4.82 5.3  5.8  6.3  6.78 7.23 7.63 7.94 8.18 8.34)
      (2.63  2.95 3.31 3.7  4.13 4.61 5.12 5.68 6.28 6.91 7.57 8.24 8.89 9.51 10.05 10.5 10.84)
      (2.96  3.32 3.72 4.16 4.65 5.19 5.78 6.43 7.13 7.88 8.67 9.5  10.33 11.15 11.91 12.59 13.15))))

(define-exposure80A-command (com-clear :menu-accelerator t) ()
  (send (dw:get-program-pane 'channel) :clear-history))
```

```
(define-exposure80A-command (com-instructions :menu-accelerator t) ()
   (send (dw:get-program-pane 'channel) :clear-history)
   (instructions))

(defun instructions ()
  (print
    "Instructions

    A central concept that is needed in order to comply with
    NFPA 80A is that of the fire containment compartment. In
    a burning building, the fire barriers or exterior surfaces
    that are capable of containing any fire in it defines a
    fire containment compartment.

    Two buildings satifies NFPA 80A if NFPA 80A is satisfied
    for all possible fire containment compartments of the two
    buildings."))


(define-exposure80A-command (com-start :menu-accelerator t) ()
   (send (dw:get-program-pane 'channel) :clear-history)
   (all-of-exposure80a self))
;;;
;;; It also shows an introductory screen(s) showing credits,
;;; purpose, and instructions.
;;;

(defmethod (EXPOSURE80A-top-level exposure80a) (&rest options)
  (send dw:*program-frame* :redisplay t)  ;This restores the title and menu items
  (let ((doc-pane (dw:get-program-pane 'CHANNEL)))
    (setf (send doc-pane :end-of-page-mode) :truncate)
    (setf (send doc-pane :more-p) nil)
    (send doc-pane :clear-history)
    (send doc-pane :set-viewport-position 0 0)
    (format doc-pane  "This program was written by Richard L. Smith.~%Harold E. Nelson served as the expert consultant on~%fire tech
nology and codes.~%Center for Fire Research~%National Institute of Standards and Technology~%~%Purpose: This program will tell you w
hether two buildings are~%in compliance with NFPA 80A-1980: Recommended Practice for~%Protection of Buildings from Exterior Fire Ex
posures. Therefore,~%its purpose is to give advice that enables one to protect a~%building from external building fires in those cases for whi
ch there is~%an effective fire fighting activity.~%~%To obtain initial instructions click the mouse on the word~%instructions in the memu ab
ove or type i <return>.~%~%To start the program running either click the~%mouse on the word start in the memu above or type st <return>."
)
    (setf (send doc-pane :end-of-page-mode) :scroll)
    (setf (send doc-pane :more-p) t))
  (apply #'dw:default-command-top-level self options))    ;this makes the memu items active
```

```
(defmethod (all-of-exposure80a exposure80a) ()
  (let ((doc-pane (dw:get-program-pane 'CHANNEL)))
    (send doc-pane :clear-history)
    (dw:accepting-values
      (t :own-window t
         :label "Exposure Questions"
         :resynchronize-every-pass t)
      (setq building-1-name
            (accept 'string
                    :Prompt "Enter the name of the first Building"
                    :default "building-1" ;^^ like to enter default value automatically?
                    :display-default t))
      (setq building-2-name
            (accept 'string
                    :Prompt "Enter the name of the second Building"
                    :default "building-2"
                    :display-default t))
      (setq bldg-1-sprinkler
            (accept 'boolean
                    :prompt (format nil "Does ~D have an automatic sprinkler system? " building-1-name)
                    :default nil
                    :display-default t))
      (setq bldg-2-sprinkler
            (accept 'boolean
                    :prompt (format nil "Does ~D have an automatic sprinkler system? " building-2-name)
                    :default nil
                    :display-default t))
      (cond
        ((not
           (and bldg-1-sprinkler bldg-2-sprinkler ))
         (setq bldg-1-wall
               (accept 'string
                       :Prompt (format nil "Enter the name of the wall of ~D that exposes ~D" building-1-name buildin
g-2-name)
                       :default "wall-1"
                       :display-default t))
         (setq bldg-2-wall
               (accept 'string
                       :Prompt (format nil "Enter the name of the wall of ~D that exposes ~D" building-2-name buildin
g-1-name)
                       :default "wall-2"
                       :display-default t))
         (setq walls-parallel
               (accept 'boolean
                       :prompt (format nil "Is ~D parallel to ~D?" bldg-1-wall bldg-2-wall)
```

```
                    :default t
                    :display-default t))
        (setq fire-fighting
              (accept 'boolean
                    :prompt (format nil "Is there an effective fire fighting activity available?")
                    :default t
                    :display-default t))
        (cond
          ((and walls-parallel fire-fighting)
           (setq wall-1-openings
                 (accept 'boolean
                         :prompt (format nil "Is there an opening in ~D? " bldg-1-wall)
                         :default t
                         :display-default t))
           (setq wall-2-openings
                 (accept 'boolean
                         :prompt (format nil "Is there an opening in ~D? " bldg-2-wall)
                         :default t
                         :display-default t))
           (terpri)
           (setq height-bldg-1
                 (accept '((number 0))   ;number ≥ 0
                         :prompt (format nil "What is the height of ~D in feet? "
                                         building-1-name)
                         :default 20))

           (setq height-bldg-2
                 (accept '((number 0))   ;number ≥ 0
                         :prompt (format nil "What is the height of ~D in feet? "
                                         building-2-name)
                         :default 20))
           (terpri)
;;;-------------------------------------------------------------
           (cond
             ((not bldg-1-sprinkler)
              (setq wall-2-construction
                    (accept '((member "frame or combustible" "fire-resistive wall (3 hour minimum)"
                                      "veneered wall (combustible construction covered by a minimum of four inches o
f masonry)"
                                      "non-combustible (fire resistance less than 3 hours)"))
                            :Prompt (format nil "Select the construction type for ~D" bldg-2-wall)
                            :default "frame or combustible"
                            :display-default t))
;;;--------------------automatic deluge water curtain --------------------
              (setq any-wall-2-automatic-deluge-water-curtain
                    (accept 'boolean
```

```
                                :prompt (format nil "Is there an automatic deluge water curtain anywhere on ~D? " bldg-2
-wall)
                                :default nil
                                :display-default t))
                (cond
                  (any-wall-2-automatic-deluge-water-curtain
                   (terpri)
                   (setq wall-2-automatic-deluge-water-curtain
                         (accept 'boolean
                                 :prompt (format nil "Is there an automatic deluge water curtain covering all of ~D? "
 bldg-2-wall)
                                 :default any-wall-2-automatic-deluge-water-curtain
                                 :display-default t))
                   (setq wall-2-automatic-deluge-water-curtain-windows
                         (accept 'boolean
                                 :prompt
                                 (format nil "Is there an automatic deluge water curtain covering all windows of ~D? "
 bldg-2-wall)
                                 :default wall-2-automatic-deluge-water-curtain
                                 :display-default t))
                   (setq wall-2-water-curtain-all-combustible-projections
                         (accept 'boolean
                                 :prompt
                                 (format nil "Is there an automatic deluge water curtain covering all combustible proj
ections of ~D? " bldg-2-wall)
                                 :default wall-2-automatic-deluge-water-curtain
                                 :display-default t))
                   (setq water-curtain-is-installed-over-on-all-wall-2-openings-equipped-with-ordinary-glass
                         (accept 'boolean
                                 :prompt
                                 (format nil "Is there an automatic deluge water curtain installed over all wall openi
ngs equipped with ordinary glass of ~D? " bldg-2-wall)
                                 :default wall-2-automatic-deluge-water-curtain
                                 :display-default t))
                   (setq water-curtain-is-installed-over-on-all-wall-2-windows-equipped-with-ordinary-glass
                         (accept 'boolean
                                 :prompt
                                 (format nil "Is there an automatic deluge water curtain installed over all windows eq
uipped with ordinary glass of ~D? " bldg-2-wall)
                                 :default wall-2-automatic-deluge-water-curtain
                                 :display-default t))
                   (terpri)))
;;;-------------------------------------------------------------
                (setq wall-2-combustible-projections
                      (accept 'boolean
                              :prompt (format nil "Is there a combustible projection on ~D? " bldg-2-wall)
```

```
                              :default t
                              :display-default t))
                    (terpri)
;;;-------------------- openings ------------------------------
                    (cond
                      (wall-1-openings
                       (setq wall-1-windows
                             (accept 'boolean
                                     :prompt (format nil "Is there a window in ~D? " bldg-1-wall)
                                     :default wall-1-openings
                                     :display-default t))

                       (setq fire-containment-compartment-1-windows
                             (accept 'boolean
                                     :prompt (format nil "Is there a window in ~D? " bldg-1-fire-containment-compartment)
                                     :default wall-1-windows
                                     :display-default t))
                       (setq material-windows-compartment-1
                             (accept '((member "ordinary-glass" "wired-glass" "closed-by-3/4-hour-protection"))
                                     :Prompt (format nil "Select the material in the windows of ~D" bldg-1-wall)
                                     :default "ordinary-glass"
                                     :display-default t))
                       (setq all-compartment-1-openings-have
                             (accept '((member "nothing" "ordinary-glass"
                                               "3/4 hour protection" "1 1/2 hour protection"
                                               "material in it is equivalent to the wall"))
                                     :Prompt (format nil "Select the answer that best describes the contents of ~%the open
ings of ~D" bldg-1-fire-containment-compartment)
                                     :default "ordinary-glass"
                                     :display-default t))
                       (setq area-of-openings-fire-containment-compartment-1
                             (accept '((number 0))      ;number ≥ 0
                                     :prompt (format nil "What is the total area of openings in ~D in square feet? "
                                                     bldg-1-fire-containment-compartment)
                                     :default 10
                                     :display-default t))))
                    (terpri)
;;;-------------------------------------------------------------
                    (setq width-fire-containment-compartment-1
                          (accept '((number 0));number ≥ 0
                                  :prompt (format nil "What is the width of ~D in feet? "
                                                  bldg-1-fire-containment-compartment)
                                  :default 100
                                  :display-default t))
                    (setq height-fire-containment-compartment-1
                          (accept '((number 0));number ≥ 0
```

```
                        :prompt (format nil "What is the height of ~D in feet? "
                                        bldg-1-fire-containment-compartment)
                        :default height-bldg-1
                        :display-default t))
            (setq compartment-1-wall-fire-resistance
                  (accept '((member "less than 20 minutes"
                                    "20 minutes or more but less than the duration of the fire"
                                    "the duration of the fire"))
                        :Prompt (format nil "How long can the exterior wall of ~D ~%     withstand fire penetrat
ion? "
                                        bldg-1-fire-containment-compartment)
                        :default "less than 20 minutes"
                        :display-default t))
            (setq average-flame-spread-rating-compartment-1
                  (accept '((number 0));number ≥ 0
                        :prompt (format nil "What is the average flame spread rating in ~D sin relative units as
 defined in NFPA 255? "
                                        bldg-1-fire-containment-compartment)
                        :default 75
                        :display-default t))
            (setq fire-load-compartment-1
                  (accept '((number 0));number ≥ 0
                        :prompt (format nil "What is the average fire load in ~D in lbs/sq ft? "
                                        bldg-1-fire-containment-compartment)
                        :default 15
                        :display-default t))
            (setq roof-fire-resistance-bldg-1
                  (accept 'boolean
                        :prompt (format nil "Does the roof of ~D have sufficient fire resistance rating to conta
in the expected fire? " building-1-name)
                        :default nil
                        :display-default t))
            (cond ((not roof-fire-resistance-bldg-1)
                   (setq number-of-floors-flames-roof-bldg-1
                         (accept '((integer 1 4))      ;this doesn't allow interpolation
                                 :Prompt (format nil "Enter an integer from 1 to 4 which tells the number of stori
es likely to contribute to flamming through the roof for ~D. " building-1-name)
                                 :default 1
                                 :display-default t))))
            ))
          (terpri)
;;;-------------------------------------------------------------
          (cond ((not bldg-2-sprinkler)
                 (setq wall-1-construction
                       (accept '((member "frame or combustible" "fire-resistive wall (3 hour minimum)"
                                         "veneered wall (combustible construction covered by a minimum of four inch
```

```
es of masonry)"
                                        "non-combustible (fire resistance less than 3 hours)"))
                                :Prompt (format nil "Select the construction type for ~D" bldg-1-wall)
                                :default "frame or combustible"
                                :display-default t))
;;;--------------------automatic deluge water curtain --------------------
                    (setq any-wall-1-automatic-deluge-water-curtain
                          (accept 'boolean
                                :prompt (format nil "Is there an automatic deluge water curtain anywhere on ~D? " bl
dg-1-wall)
                                :default nil
                                :display-default t))
                    (cond (any-wall-1-automatic-deluge-water-curtain
                           (terpri)
                           (setq wall-1-automatic-deluge-water-curtain
                                 (accept 'boolean
                                        :prompt (format nil "Is there an automatic deluge water curtain covering all
of ~D? " bldg-1-wall)
                                        :default any-wall-1-automatic-deluge-water-curtain
                                        :display-default t))
                           (setq wall-1-automatic-deluge-water-curtain-windows
                                 (accept 'boolean
                                        :prompt
                                        (format nil "Is there an automatic deluge water curtain covering all windows
of ~D? " bldg-1-wall)
                                        :default wall-1-automatic-deluge-water-curtain
                                        :display-default t))
                           (setq wall-1-water-curtain-all-combustible-projections
                                 (accept 'boolean
                                        :prompt
                                        (format nil "Is there an automatic deluge water curtain covering all combusti
ble projections of ~D? " bldg-1-wall)
                                        :default wall-1-automatic-deluge-water-curtain
                                        :display-default t))
                           (setq water-curtain-is-installed-over-on-all-wall-1-openings-equipped-with-ordinary-glass
                                 (accept 'boolean
                                        :prompt
                                        (format nil "Is there an automatic deluge water curtain installed over all wa
ll openings equipped with ordinary glass of ~D? " bldg-1-wall)
                                        :default wall-1-automatic-deluge-water-curtain
                                        :display-default t))
                           (setq water-curtain-is-installed-over-on-all-wall-1-windows-equipped-with-ordinary-glass
                                 (accept 'boolean
                                        :prompt
                                        (format nil "Is there an automatic deluge water curtain installed over all wi
ndows equipped with ordinary glass of ~D? " bldg-1-wall)
```

```
                                        :default wall-1-automatic-deluge-water-curtain
                                        :display-default t))
                                (terpri)))
;;;------------------- openings ----------------------------------
                        (cond (wall-2-openings
                                (setq wall-2-windows
                                      (accept 'boolean
                                              :prompt (format nil "Is there a window in ~D? " bldg-2-wall)
                                              :default wall-2-openings
                                              :display-default t))
                                (setq fire-containment-compartment-2-windows
                                      (accept 'boolean
                                              :prompt (format nil "Is there a window in ~D? " bldg-2-fire-containment-compa
rtment)
                                              :default wall-2-windows
                                              :display-default t))
                                (setq area-of-openings-fire-containment-compartment-2
                                      (accept '((number 0))     ;number ≥ 0
                                              :prompt (format nil "What is the total area of openings in ~D in square feet?
 "
                                                              bldg-2-fire-containment-compartment)
                                              :default 10
                                              :display-default t))
                                (setq material-windows-compartment-2
                                      (accept '((member "ordinary-glass" "wired-glass"
                                                        "closed-by-3/4-hour-protection"))
                                              :Prompt (format nil "Select the material in the windows of ~D" bldg-2-wall)
                                              :default "ordinary-glass"
                                              :display-default t))
                                (setq all-compartment-2-openings-have
                                      (accept '((member "nothing" "ordinary-glass"
                                                        "3/4 hour protection" "1 1/2 hour protection"
                                                        "material in it is equivalent to the wall"))
                                              :Prompt (format nil "Select the answer that best describes the contents of ~%
the openings of ~D" bldg-2-fire-containment-compartment)
                                              :default "ordinary-glass"
                                              :display-default t))))
                        (terpri)
;;;-----------------------------------------------------------
                        (setq wall-1-combustible-projections
                              (accept 'boolean
                                      :prompt (format nil "Is there a combustible projection on ~D? " bldg-1-wall)
                                      :default t
                                      :display-default t))
                        (setq width-fire-containment-compartment-2
                              (accept '((number 0))     ;number ≥ 0
```

```
                                :prompt (format nil "What is the width of ~D in feet? "
                                                bldg-2-fire-containment-compartment)
                                :default 100
                                :display-default t))
                        (setq height-fire-containment-compartment-2
                              (accept '((number 0))     ;number ≥ 0
                                :prompt (format nil "What is the height of ~D in feet? "
                                                bldg-2-fire-containment-compartment)
                                :default height-bldg-2
                                :display-default t))
                        (setq compartment-2-wall-fire-resistance
                              (accept '((member "less than 20 minutes"
                                                "20 minutes or more but less than the duration of the fire"
                                                "the duration of the fire"))
                                :Prompt (format nil "How long can the exterior wall of ~D ~%     withstand fire pene
tration? "
                                                bldg-2-fire-containment-compartment)
                                :default "less than 20 minutes"
                                :display-default t))
                        (setq average-flame-spread-rating-compartment-2
                              (accept '((number 0))     ;number ≥ 0
                                :prompt (format nil "What is the average flame spread rating in ~D in relative units
 as defined in NFPA 255? "
                                                bldg-2-fire-containment-compartment)
                                :default 75
                                :display-default t))
                        (setq fire-load-compartment-2
                              (accept '((number 0))     ;number ≥ 0
                                :prompt (format nil "What is the average fire load in ~D in lbs/sq ft? "
                                                bldg-2-fire-containment-compartment)
                                :default 15
                                :display-default t))
                        (setq roof-fire-resistance-bldg-2
                              (accept 'boolean
                                :prompt (format nil "Does the roof of ~D have sufficient fire resistance rating to c
ontain the expected fire? " building-2-name)
                                :default nil
                                :display-default t))
                        (cond ((not roof-fire-resistance-bldg-2)
                               (setq number-of-floors-flames-roof-bldg-2
                                     (accept '((integer 1 4))  ;this doesn't allow interpolation
                                             :Prompt (format nil "Enter an integer from 1 to 4 which tells the number of s
tories likely to contribute to flamming through the roof for ~D. " building-2-name)
                                             :default 1
                                             :display-default t))))))
                (terpri)
```

```
;;;-------------------------------------------------------------
            (setq wall-separation
                  (accept '((number 0))   ;number ≥ 0
                          :prompt (format nil "What is the designed separation between ~D and ~D in feet? "
                                          bldg-1-wall bldg-2-wall)
                          :default 0)))))))
    (unprotected-minimum-separation self)
    (adjusted-minimum-separation self)
    (solution-exposure self)))
```

;;;Procedure: Percentage Opening
;;; Determine percent of opening in exposing surface.

```
(defmethod (percent-opening exposure80a)()
  (setq percentage-openings-compartment-1
        (* 100 (/ area-of-openings-fire-containment-compartment-1
           (* width-fire-containment-compartment-1
              height-fire-containment-compartment-1))))
  (setq percentage-openings-compartment-2
        (* 100 (/ area-of-openings-fire-containment-compartment-2
           (* width-fire-containment-compartment-2
              height-fire-containment-compartment-2)))))
```



```
(defmethod (classification-severity exposure80a)()
  (cond ((or (or (=  fire-load-compartment-1 15) (>  fire-load-compartment-1 15))
             (or (= average-flame-spread-rating-compartment-1 75)
                 (> average-flame-spread-rating-compartment-1 75)))
         (setq classification-severity-bldg-1 'severe))
        ((or (or (=  fire-load-compartment-1 7) (>  fire-load-compartment-1 7))
             (or (= average-flame-spread-rating-compartment-1 26)
                 (> average-flame-spread-rating-compartment-1 26)))
         (setq classification-severity-bldg-1 'moderate))
        (t (setq classification-severity-bldg-1 'light)))
  (cond ((or (or (=  fire-load-compartment-2 15) (>  fire-load-compartment-2 15))
             (or (= average-flame-spread-rating-compartment-2 75)
                 (> average-flame-spread-rating-compartment-2 75)))
         (setq classification-severity-bldg-2 'severe))
        ((or (or (=  fire-load-compartment-2 7) (>  fire-load-compartment-2 7))
             (or (= average-flame-spread-rating-compartment-2 26)
                 (> average-flame-spread-rating-compartment-2 26)))
         (setq classification-severity-bldg-2 'moderate))
        (t (setq classification-severity-bldg-2 'light))))
```

;;;Procedure to determine width/height or height/width ratio.

```
(defmethod (height-width-ratio exposure80a)()
  (cond ((or (= (/ height-fire-containment-compartment-1
                   width-fire-containment-compartment-1) 1)
             (> (/ height-fire-containment-compartment-1
                   width-fire-containment-compartment-1) 1))
         (setq compartment-1-h-w-ratio
               (* 1.0 (/ height-fire-containment-compartment-1
                         width-fire-containment-compartment-1))))
        (t (setq compartment-1-h-w-ratio
                 (* 1.0 (/ width-fire-containment-compartment-1
                           height-fire-containment-compartment-1)))))
  (cond ((or (= (/ height-fire-containment-compartment-2
                   width-fire-containment-compartment-2) 1)
             (> (/ height-fire-containment-compartment-2
                   width-fire-containment-compartment-2) 1))
         (setq compartment-2-h-w-ratio
               (* 1.0 (/ height-fire-containment-compartment-2
                         width-fire-containment-compartment-2))))
        (t (setq compartment-2-h-w-ratio
                 (* 1.0 (/ width-fire-containment-compartment-2
                           height-fire-containment-compartment-2))))))
```



```
;;;
;;;Procedure to Look up value in table
;;;
;;;Procedure to interpolate for values
;;;
;;; Determine the ratio of width vs. height or height vs. width. Use whichever is
;;; greater then 1.
;;;
;;; Determine guide number from table 2-3
;;;

(defun array-index (variable table-list)
  (let* ((upper-limit (length table-list)))
    (cond ((> variable (car (last table-list))) (- upper-limit 1))        ;off scale high
          ((member variable table-list :test #'=) ;if it is a column heading
           (- upper-limit (length (member variable table-list :test #'=))))
          (t (loop for i from 0 to (- upper-limit 1)      ;fall between columns
                   do                      ; we need this for interpolation
                (cond ((< variable (cadr table-list))
                       (return (+ i (/ (- variable (car table-list))
                                       (- (cadr table-list) (car table-list))))))
                      (t (setq table-list (cdr table-list))))))))))
```

```
;;; For the column heading we have

(defun column-index (width-height-ratio)
  (let* ((column-list
          (list 1.0 1.3 1.6 2.0 2.5 3.2 4.0 5 6 8 10 13 16 20 25 32 40)))
    (array-index width-height-ratio column-list)))

(defun row-index (severity percentage-openings)
  ;; We added 0 to each of the following lists
  (let* ((row-list-light (list 0 20 30 40 50 60 80 100))
         (row-list-moderate (list 0 10 15 20 25 30 40 50 60 80 100))
         (row-list-severe (list 0 5 7.5 10 12.5 15 20 25 30 40 50 60 80 100)))
    (cond ((equal severity 'light) (array-index percentage-openings row-list-light))
          ((equal severity 'moderate)
           (array-index percentage-openings row-list-moderate))
          ((equal severity 'severe)
           (array-index percentage-openings row-list-severe)))))

(defun guide-number-f (severity percentage-openings width-height-ratio)
  (let* ((row-number (row-index severity percentage-openings))
         (column-number (column-index width-height-ratio))
         (row-low (floor row-number))
         (row-upper (ceiling row-number))
         (column-low (floor column-number))
         (column-upper (ceiling column-number))
         (array-ll (aref EXPOSURE-ARRAY row-low column-low))
         (array-lu (aref EXPOSURE-ARRAY row-low column-upper))
         (array-ul (aref EXPOSURE-ARRAY row-upper column-low))
         (array-uu (aref EXPOSURE-ARRAY row-upper column-upper))
         (array-low-interpolated
           (+ array-ll (* (- column-number column-low) (- array-lu array-ll))))
         (array-upper-interpolated
           (+ array-ul (* (- column-number column-low) (- array-uu array-ul)))))
    (+ array-low-interpolated
       (* (- row-number row-low) (- array-upper-interpolated
                                    array-low-interpolated)))))

(defmethod (guide-number exposure80a) ()
  (height-width-ratio self)
  (classification-severity self)
  (percent-opening self)                    ;this ensures the percentage opening has a value
  (setq guide-number-compartment-1
        (guide-number-f classification-severity-bldg-1
                        percentage-openings-compartment-1 compartment-1-h-w-ratio))
  (setq guide-number-compartment-2
        (guide-number-f classification-severity-bldg-2
```

```
                    percentage-openings-compartment-2 compartment-2-h-w-ratio)))

;;; Determine unprotected minimum separation as = guide-number * (lesser of
;;; w or h) + 5 feet

(defmethod (unprotected-minimum-separation EXPOSURE80A) ()
  (guide-number self)                    ;to insure we have needed values
  (setq unprotected-minimum-separation-compartment1
        (+ (* guide-number-compartment-1
              (min width-fire-containment-compartment-1
                   height-fire-containment-compartment-1)) 5))
  (setq unprotected-minimum-separation-compartment2
        (+ (* guide-number-compartment-2
              (min width-fire-containment-compartment-2
                   height-fire-containment-compartment-2)) 5)))
```

```
(defmethod (adjusted-minimum-separation EXPOSURE80A) ()
  (setq adjusted-minimum-separation-compartment-1  ;fire in compartment 1
        ;; first case that allow zero separation
        (cond (bldg-1-sprinkler 0)        ;if sprinklered, then separation is 0
              ((and (equal wall-1-construction
                           "fire-resistive wall (3 hour minimum)")
                    (not wall-1-openings)) 0)
              ;; Now we consider those cases whose separation is 5 feet
              ((and wall-2-automatic-deluge-water-curtain
                    (not wall-2-openings)) 5)
              ((and wall-2-automatic-deluge-water-curtain
                    (equal material-windows-compartment-2 "wired-glass")) 5)
              ((and wall-2-automatic-deluge-water-curtain
                    (equal material-windows-compartment-2
                           "closed-by-3/4-hour-protection")) 5)
              ((and (equal
                      wall-2-construction
                      "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                    (not wall-2-openings) ;same as closing all openings with material ≡ wall
                    (not wall-2-combustible-projections)) 5)
              ((and (equal
                      wall-2-construction
                      "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                    wall-2-automatic-deluge-water-curtain-windows
                    wall-2-water-curtain-all-combustible-projections
                    (equal material-windows-compartment-2 "wired-glass")) 5)
              ((and (equal
                      wall-2-construction
                      "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                    wall-2-automatic-deluge-water-curtain-windows
                    wall-2-water-curtain-all-combustible-projections
                    (equal material-windows-compartment-2 "closed-by-3/4-hour-protection")) 5)
              ((and (equal
                      wall-2-construction
                      "fire-resistive wall (3 hour minimum)")
                    wall-2-water-curtain-all-combustible-projections
                    (equal material-windows-compartment-2 "closed-by-3/4-hour-protection")) 5)
              ((and (equal
                      wall-2-construction
                      "fire-resistive wall (3 hour minimum)")
                    wall-2-automatic-deluge-water-curtain-windows
                    wall-2-water-curtain-all-combustible-projections
                    (equal material-windows-compartment-2 "wired-glass")) 5)
              ;; now we turn to 75% reduction
              ((and (equal
```

```
        wall-2-construction
        "fire-resistive wall (3 hour minimum)")
      (equal all-compartment-2-openings-have  "1 1/2 hour protection"))      ;wall 2 openings^^??
 ;;may not have openings  need to fix this
 (cond ((> (* .25 unprotected-minimum-separation-compartment1) 10) 10)
       (t (* .25 unprotected-minimum-separation-compartment1))))
;; Now we turn to 50% reduction
((and (equal wall-2-construction    ;1
             "frame or combustible")
      wall-2-automatic-deluge-water-curtain)
 ;; it does add any thing to say the wall has plain glass windows
 (* .5 unprotected-minimum-separation-compartment1))
((and (equal                ;2
        wall-2-construction
        "non-combustible (fire resistance less than 3 hours)")
      (or (equal all-compartment-2-openings-have "material in it is equivalent to the wall")
          (equal all-compartment-2-openings-have "3/4 hour protection"))
      (not wall-2-combustible-projections))
 (* .5 unprotected-minimum-separation-compartment1))
((and (equal                ; 3
        wall-2-construction
        "non-combustible (fire resistance less than 3 hours)")
      water-curtain-is-installed-over-on-all-wall-2-openings-equipped-with-ordinary-glass
      wall-2-water-curtain-all-combustible-projections)
 (* .5 unprotected-minimum-separation-compartment1))
((and (equal                ;4
        wall-2-construction
        "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
      (equal all-compartment-2-openings-have "3/4 hour protection")
      (not wall-2-combustible-projections))
 (* .5 unprotected-minimum-separation-compartment1))
((and (equal                ;5
        wall-2-construction
        "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
      water-curtain-is-installed-over-on-all-wall-2-openings-equipped-with-ordinary-glass
      wall-2-water-curtain-all-combustible-projections)
 (* .5 unprotected-minimum-separation-compartment1))
((and (equal                ;6
        wall-2-construction
        "fire-resistive wall (3 hour minimum)")
      (equal all-compartment-2-openings-have "3/4 hour protection"))
 (cond ((> (* .5 unprotected-minimum-separation-compartment1) 20) 20)
       (t (* .5 unprotected-minimum-separation-compartment1))))
((and (equal                ;7
        wall-2-construction
        "fire-resistive wall (3 hour minimum)")
```

```
                water-curtain-is-installed-over-on-all-wall-2-windows-equipped-with-ordinary-glass
                wall-2-water-curtain-all-combustible-projections)
           (* .5 unprotected-minimum-separation-compartment1))
          (t unprotected-minimum-separation-compartment1)))
;; now we deal with the next unit
(setq adjusted-minimum-separation-compartment-2
      ;; first case that allow zero separation
      (cond (bldg-2-sprinkler 0)        ;if sprinkler separation is 0
            ((and (equal wall-2-construction
                         "fire-resistive wall (3 hour minimum)")
                  (not wall-2-openings)) 0)
           ;; Now we consider those cases whose separation is 5 feet
            ((and wall-1-automatic-deluge-water-curtain
                  (not wall-1-openings)) 5)
            ((and wall-1-automatic-deluge-water-curtain
                  (equal material-windows-compartment-1 "wired-glass")) 5)
            ((and wall-1-automatic-deluge-water-curtain
                  (equal material-windows-compartment-1 "closed-by-3/4-hour-protection")) 5)
            ((and (equal
                    wall-1-construction
                    "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                  (not wall-1-openings) ;same as closing all openings with material ≡ wall
                  (not wall-1-combustible-projections)) 5)
            ((and (equal
                    wall-1-construction
                    "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                  wall-1-automatic-deluge-water-curtain-windows
                  wall-1-water-curtain-all-combustible-projections
                  (equal material-windows-compartment-1 "wired-glass")) 5)
            ((and (equal
                    wall-1-construction
                    "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
                  wall-1-automatic-deluge-water-curtain-windows
                  wall-1-water-curtain-all-combustible-projections
                  (equal material-windows-compartment-1 "closed-by-3/4-hour-protection")) 5)
            ((and (equal
                    wall-1-construction
                    "fire-resistive wall (3 hour minimum)")
                  wall-1-water-curtain-all-combustible-projections
                  (equal material-windows-compartment-1 "closed-by-3/4-hour-protection")) 5)
            ((and (equal
                    wall-1-construction
                    "fire-resistive wall (3 hour minimum)")
                  wall-1-automatic-deluge-water-curtain-windows
                  wall-1-water-curtain-all-combustible-projections
                  (equal material-windows-compartment-1 "wired-glass")) 5)
```

```
;; now we turn to 75% reduction
((and (equal
        wall-1-construction
        "fire-resistive wall (3 hour minimum)")
      (equal all-compartment-1-openings-have  "1 1/2 hour protection"))
 (cond ((> (* .25 unprotected-minimum-separation-compartment2) 10) 10)
       (t (* .25 unprotected-minimum-separation-compartment2))))
;; Now we turn to 50% reduction
((and (equal wall-1-construction    ;1
             "frame or combustible")
      wall-1-automatic-deluge-water-curtain)
 ;; it does add any thing to say the wall has plain glass windows
 (* .5 unprotected-minimum-separation-compartment2))
((and (equal                ;2
        wall-1-construction
        "non-combustible (fire resistance less than 3 hours)")
      (or (equal all-compartment-1-openings-have "material in it is equivalent to the wall")
          (equal all-compartment-1-openings-have "3/4 hour protection"))
      (not wall-1-combustible-projections))
 (* .5 unprotected-minimum-separation-compartment2))
((and (equal                ; 3
        wall-1-construction
        "non-combustible (fire resistance less than 3 hours)")
      water-curtain-is-installed-over-on-all-wall-1-openings-equipped-with-ordinary-glass
      wall-1-water-curtain-all-combustible-projections)
 (* .5 unprotected-minimum-separation-compartment2))
((and (equal                ;4
        wall-1-construction
        "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
      (equal all-compartment-1-openings-have "3/4 hour protection")
      (not wall-1-combustible-projections))
 (* .5 unprotected-minimum-separation-compartment2))
((and (equal                ;5
        wall-1-construction
        "veneered wall (combustible construction covered by a minimum of four inches of masonry)")
      water-curtain-is-installed-over-on-all-wall-1-openings-equipped-with-ordinary-glass
      wall-1-water-curtain-all-combustible-projections)
 (* .5 unprotected-minimum-separation-compartment2))
((and (equal                ;6
        wall-1-construction
        "fire-resistive wall (3 hour minimum)")
      (equal all-compartment-1-openings-have "3/4 hour protection"))
 (cond ((> (* .5 unprotected-minimum-separation-compartment2) 20) 20)
       (t (* .5 unprotected-minimum-separation-compartment2))))
((and (equal                ;7
        wall-1-construction
```

```
          "fire-resistive wall (3 hour minimum)")
        water-curtain-is-installed-over-on-all-wall-1-windows-equipped-with-ordinary-glass
        wall-1-water-curtain-all-combustible-projections)
   (* .5 unprotected-minimum-separation-compartment2))
  (t unprotected-minimum-separation-compartment2))))
```

```
(defmethod (solution-exposure EXPOSURE80A) ()
  (print "Comments on whether the proposed design satisfied NFPA 80A.")
  (terpri) (terpri)
  (let ((adj-sep
          (max adjusted-minimum-separation-compartment-1 adjusted-minimum-separation-compartment-2))
        (doc-pane (dw:get-program-pane 'CHANNEL)))
    ;; possible taller protection
    (cond ((not walls-parallel)
           (format doc-pane "Because the walls are not parallel, 80A does not apply to this case."))
          ((not fire-fighting)
           (format doc-pane "Because there is not an effective fire fighting activity available, 80A does not apply t
o this case."))
          ((and bldg-1-sprinkler bldg-2-sprinkler); If both buildings are sprinklered - done
           (terpri) (print "The design meets the requirements of NFPA 80A."))
          ((= height-bldg-1 height-bldg-2) (format doc-pane "The required minimum separation between buildings ~D and
 ~D~%
for the chosen fire containment compartments is ~D feet. ~%The designed separation is ~D feet."
                                                   building-1-name building-2-name
                                                   adj-sep wall-separation)
           (terpri) (terpri)
           (cond ((> adj-sep wall-separation)
                  (format doc-pane "The design does not satisfy NFPA 80A. Additional protection is required.~%Possibl
e steps to bring the design into compliance are:~%~% ")
                  (format doc-pane  "~%Increase the separation of the buildings to the minimum required, ~D feet.~%~%
or~%~%" adj-sep)
                  (cond ((and (not bldg-1-sprinkler) (not bldg-2-sprinkler))
                         (format doc-pane "~%Install an automatic sprinkler system in ~D and ~D.~%"
                                 building-1-name building-2-name))
                        ((not bldg-1-sprinkler)
                         (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-1-name))
                        ((not bldg-2-sprinkler)
                         (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-2-name))))
                 (t (terpri)(print "The design meets the requirements of NFPA 80A if this program is
satisfied for all fire containment compartments."))))
          ((and (not roof-fire-resistance-bldg-1)(> height-bldg-2 height-bldg-1))
           (cond ((= 1 number-of-floors-flames-roof-bldg-1)
                  (setq height-of-taller-bldg-protection-bldg-2 25))
                 ((= 2 number-of-floors-flames-roof-bldg-1)
                  (setq height-of-taller-bldg-protection-bldg-2 32))
                 ((= 3 number-of-floors-flames-roof-bldg-1)
                  (setq height-of-taller-bldg-protection-bldg-2 40))
                 ((= 4 number-of-floors-flames-roof-bldg-1)
                  (setq height-of-taller-bldg-protection-bldg-2 47)))
           (let ((new-adj-sep (max height-of-taller-bldg-protection-bldg-2 adj-sep)))
             (cond ((> new-adj-sep wall-separation)
```

```
                    (format doc-pane "The design does not satisfy NFPA 80A. ~%The designed separation is ~D feet.~%~%
Additional protection is required.~%~%Possible steps to bring the design into compliance are:~%~%" wall-separation)
                    (format doc-pane "The required minimum separation between buildings ~D ~%and ~D is ~D feet if add
itional protection is~%provided on ~D beginning at a height of ~D feet ~%and going to a Height of ~D feet. Otherwise
the ~%separation must be ~D feet. ~%~%Or~%" building-1-name building-2-name adj-sep building-2-name height-bldg-1
 (cond ((< height-bldg-2 (+ height-bldg-1 height-of-taller-bldg-protection-bldg-2))
        height-bldg-2)
       (t (+ height-bldg-1 height-of-taller-bldg-protection-bldg-2))) new-adj-sep)
                    (cond ((and (not bldg-1-sprinkler) (not bldg-2-sprinkler))
                           (format doc-pane "~%Install an automatic sprinkler system in ~D and ~D.~%"
                                   building-1-name building-2-name))
                          ((not bldg-1-sprinkler)
                           (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-1-name))
                          ((not bldg-2-sprinkler)
                           (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-2-name))))
                   (t (terpri)(print "The design meets the requirements of NFPA 80A if this program is
satisfied for all fire containment compartments.")))))
          ((and (not roof-fire-resistance-bldg-2)(> height-bldg-1 height-bldg-2))
           (cond ((= 1 number-of-floors-flames-roof-bldg-2)
                  (setq height-of-taller-bldg-protection-bldg-1 25))
                 ((= 2 number-of-floors-flames-roof-bldg-2)
                  (setq height-of-taller-bldg-protection-bldg-1 32))
                 ((= 3 number-of-floors-flames-roof-bldg-2)
                  (setq height-of-taller-bldg-protection-bldg-1 40))
                 ((= 4 number-of-floors-flames-roof-bldg-2)
                  (setq height-of-taller-bldg-protection-bldg-1 47)))
           (let ((new-adj-sep (max height-of-taller-bldg-protection-bldg-1 adj-sep)))
             (cond ((> new-adj-sep wall-separation)
                    (format doc-pane "The design does not satisfy NFPA 80A. ~%The designed separation is ~D feet.~%~%
Additional protection is required.~%~%Possible steps to bring the design into compliance are:~%~%" wall-separation)
                    (format doc-pane "The required minimum separation between buildings ~D ~%and ~D is ~D feet if add
itional protection is ~%provided on ~D beginning at a height of ~D feet ~%and going to a Height of ~D feet. Otherwise
 the ~%separation must be ~D feet. ~%~%Or~%" building-1-name building-2-name adj-sep building-1-name height-bldg-2
 (cond ((< height-bldg-1 (+ height-bldg-2 height-of-taller-bldg-protection-bldg-1))
        height-bldg-1)
       (t (+ height-bldg-2 height-of-taller-bldg-protection-bldg-1))) new-adj-sep)
                    (cond ((and (not bldg-1-sprinkler) (not bldg-2-sprinkler))
                           (format doc-pane "~%Install an automatic sprinkler system in ~D and ~D.~%"
                                   building-1-name building-2-name))
                          ((not bldg-1-sprinkler)
                           (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-1-name))
                          ((not bldg-2-sprinkler)
                           (format doc-pane "~%Install an automatic sprinkler system in ~D.~%" building-2-name))))
                   (t (terpri)(print "The design meets the requirements of NFPA 80A if this program is
satisfied for all fire containment compartments.")))))))))
```

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This report describes a computer program, EXPOSURE80A, written in Symbolics Common Lisp, that leads the user through NFPA 80A: Recommended Practice for Protection of Buildings from Exterior Fire Exposures. EXPOSURE80A is designed for use by fire protection professionals. It tells the user whether two buildings comply with the recommendations of NFPA 80A and if they do not, it suggests changes that will bring the buildings into compliance. EXPOSURE80A is easier to use than the written version of NFPA 80A since an understanding of 80A is not required. The approach used in EXPOSURE80A provides valuable information about the knowledge required of the user and the appropriate interface for the targeted class of users of an expert system, EXPOSURE, which is described in a separate report

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

fire codes; building codes; exposure; computer programs

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