FIRE SAFETY UPGRADING FOR FALLOUT SHELTERS IN BUILDINGS

FINAL REPORT
FMRC SERIAL NO. 15903
NOVEMBER 20, 1964

J. B. Smith, E. W. Cousins, M. J. Miller
and R. M. Newman

LABORATORY REPORT

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OCD REVIEW NOTICE

This report represents some examples of possible methods for upgrading the fire safety of fallout shelters in existing buildings in an emergency period. They are indicative of the extent of solutions and suggest that fire safety upgrading is feasible. However, further study and development is required before operational guidance can be formulated. Publication of this report does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

FACTORY MUTUAL RESEARCH CORPORATION

1151 BOSTON-PROVIDENCE TURNPIKE, NORWOOD, MASS 02062

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FIRE SAFETY UPGRADING

FOR FALLOUT SHELTERS IN BUILDINGS

I SUMMARY

Fallout shelters have been evaluated for their shielding against nuclear radiation and a guide[1] has been prepared for determining the fire hazard to shelter occupants. It is expected that the above guide will reveal deficiencies in fire safety, and it is now desired to suggest remedies for alleviating these deficiencies.

This report suggests methods, mainly untried, for upgrading on an emergency basis the fire safety of existing fallout shelter buildings. The methods suggested are not substitutes for normal peacetime protection which may be: (1) hard to implement, (2) too costly, or (3) incompatible with flexibility of building operations. This report is based on the following concepts: (1) fire exposures to a shelter building from without must be denied entry to the shelter building, (2) fires in a shelter building must be promptly detected and suppressed or extinguished, and (3) occupants must be provided with an environment which will sustain life.

Most of the remedies suggested are passive such as physical barriers to prevent fire entry to the shelter building. Specifically, thermal barriers for window openings, automatic smoke detectors with manual response by fire fighting shelter personnel, and environmental seals for shelter areas are recommended as feasible upgrading remedies. It is expected that the recommended remedies will make it possible to make a large number of shelter buildings fire-safe.

II INTRODUCTION

Scope of Work

The Factory Mutual Research Corporation under Contract No. OCD-PS-64-40, Subtask 1133A, prepared a classification guide for evaluating the fire hazard to fallout shelter occupants. This guide pointed out deficiencies in shelters which could result in unsatisfactory fire exposure to occupants.

It is now desired to suggest remedies to upgrade those shelters where deficiencies exist. This report is an extension of the work previously done to classify shelters. Specifically, the scope of work was "To upgrade the fire safety of fallout shelters in existing buildings." Phase I of this project outlined the work a[illegible]ment, "Perform a comprehensive analysis of specific measures of both an emergency type and a peacetime type for upgrading the fire safety of shelter buildings. The emergency measures are those which could be implemented or installed immediately in an emergency. Some degradation of normal functioning of the building would be allowed for these measures. The peacetime upgrading measures are those which could be implemented during peacetime and which might also enhance fire safety."

III DISCUSSION

A Assumptions

Several assumptions have been made which form the basis for determining the need for fire safety upgrading. These are:

1. Fires are assumed to have occurred from any cause following a nuclear attack.

2. Shelters and shelter buildings will not have sustained blast damage, other than possibly broken windows.

3. The shelter will not be subjected to a "fire storm." That is, "An atmospheric disturbance resulting from hundreds of simultaneous fires such as may occur during incendiary bomb raids."* Such an area would very likely be uninhabitable because of oxygen deficiency and toxic gases.

4. There will be no fire fighting by public fire departments.

5. Public water supplies and electric utilities will be in service.

6. Automatic sprinkler systems, as available, will be in service.

7. Occupants of shelter areas will make periodic fire inspection tours of the shelter building; and in addition, responsible personnel will be familiar with fire-fighting equipment, including operation of automatically and manually controlled sprinkler systems.

8. A fire exposing a shelter building will be of a two hour duration and radiating temperatures from an exposure fire will be in the order of 2000°F.

The failure of public water supplies or electric utilities would have little effect on the upgrading measures proposed in this report. Their only foreseeable effects would be lack of water for hose standpipes or automatic sprinklers (where public water is the sole supply) or loss of lighting or power supply to fire detection systems having electrical components. The loss of automatic sprinkler protection would make it necessary in most instances to provide upgrading measures.

B The Problems

It appears that two main problems must be resolved to insure survival from the standpoint of fire safety for fallout shelter occupants. The first, since people are extremely vulnerable to fire gases, is the necessity for providing respirable air. The second problem is the minimization of heat transmission from fire exposures to the shelter area from fire external to the shelter area. Fire exposures to the shelter area can be from two sources. These are: (1) neighboring properties outside the shelter building, and (2) inside the shelter building itself.

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*"A Selection of Fire Terminology" by Warren Y. Kimball, National Fire Protection Association, Boston, Mass.

C General Approach

The approach to the first problem is to isolate the shelter occupants from noxious gases by providing an "envelope" around them. A respirable air supply must be provided for the envelope.

Fires external to the shelter area, which constitute the second problem, must be controlled or protected against to accomplish two objectives. These are: (1) the prevention of unallowable heat exposures which could destroy the integrity of the shelter envelope, and (2) the prevention of the collapse of the shelter building which could endanger the shelter area.

The philosophy of fire protection and control, as far as this report is concerned, is to keep fires external to the shelter building from entering the shelter building, and to suppress all fires which may originate in the shelter building to prevent any heat exposure to the shelter area. It does not appear possible with the present state of the art to predict fire duration with corresponding temperatures at a given time. For example, fully ventilated fires with fire loadings of 8 lbs. per square foot of building floor area tend to a limiting temperature of approximately 2000°F.[2] Fire tests made by the National Research Council Canada, Division of Building Research, showed a rapid drop in temperature 18 minutes after the start of fires in mainly dwelling-type structures.[3] It must be assumed, however, that with the many factors affecting development and intensity of exposing fires that the above 18 minute figure is not reliable for all fire exposures. One of the strongly influencing factors on duration is the amount of combustibles.[4] Where exposure severity dictates elimination of window openings[1], this report assumes an immediate 2000°F exposure to the exterior of shelter building walls and a duration of two hours with abrupt temperature decay. The allowable temperature at the unexposed shelter building wall face is 150°F. This is considered a reasonable human tolerance temperature[5] and appears to be a reasonable temperature limit since it is not known how close the shelter area perimeter may be to the building walls.

Although fires in the shelter building are expected to be quickly suppressed, there would be development of smoke and toxic gases from which people must be protected. Therefore the shelter envelope need only be designed for insuring respiratory air - not for heat exposures.

D Limitations

Fire protection within the shelter area is not included in the upgrading measures at the request of the Office of Civil Defense under the reasoning that as the shelter area will be continuously occupied and under constant surveillance, any fire would be quickly discovered and could be handled by the occupants using manual fire fighting equipment.

Factors affecting the habitability of a shelter are smoke, toxic or irritiating gases, high temperature and moisture content and lack of oxygen. Although thresholds have been generally established for carbon monoxide inhalation and anoxia, there is little knowledge of the effects of the great number of toxic or irritating gases on people. The evolution of gases is dependent on several factors, including kinds and amounts of combustibles; many of these are not well understood, and it would be extremely difficult, if not impossible, to predict these factors. This supports the conservative approach that the isolation of people in the shelter is mandatory.

E Proposed Solutions For The Problems

Standard protective measures such as generally accepted fire wall construction, which are generally well-known, are not emphasized in this report. This is because they may be too costly or too difficult to implement. They might also interfere with flexibility of building operations. Where these objections are not valid, such standard measures would offer the best solutions for fire safety upgrading. The solutions which are proposed in this section of the report are for extra-ordinary situations, i.e., Civil Defense emergencies, and are untried but are promising and may require testing.

1. Provision of Respiratory Air

a. Isolation of Shelter Area from Shelter Building

In some cases shelter buildings will have "core" shelter areas which are completely divorced from the building proper. In these cases, no further physical isolation will be necessary with the possible exception of providing gas seals such as hair felt around doors.

In some cases the shelter area will coincide or nearly coincide with the exterior shelter building walls for the shelter story (for example, a basement shelter). In this case, the envelope for the shelter area would be adequately provided by the building walls.

Where stairways or other openings between stories are not enclosed, enclosures such as wood hatch covers with gasketing such as ordinary hair felt stripping should be provided to exclude fire gases from shelter stories.

Where the shelter area must be a considerable distance inside the building perimeter, separate partitioning may be necessary to provide an envelope. Cellophane would be a light, economical, easily installed envelope material and has a maximum continuous service temperature of 375°F. Prefabricated panels of gypsum board could also be used. An aluminum foil type insulation may also be suitable.

b. Atmosphere for Shelter Area.

A comprehensive report[8] has been written which suggests the use of oxygen from high pressure gas cylinders for breathing. Use of various regulators is also discussed. A system of carbon dioxide removal using Baralyme is recommended. This same report also suggests slightly overpressuring the shelter area with excess oxygen. This would exclude fire gases where an envelope is provided for the shelter area.

2. Fire Exposures from Neighboring Properties

Where the classification guide indicates that the severity of the fire exposure from a neighboring property is such that windows in the shelter building facing this exposure require either closing, fire shutters or fire doors, it appears possible that one or both of two conditions can exist. The first is that flame impingement may be expected on exposed shelter building windows. The second is that shelter building windows may be subjected to a radiator having a temperature approaching 1100°C (approximately 2000°F). Such a radiator can produce a maximum of 4 calories per square centimeter per second on the windows. Assuming that this radiation is instantaneously imposed and persists for two hours, a wall of 8-inch brick initially at 75°F would reach a temperature of 145°F at the unexposed face.[6] Such temperatures should not present a heat exposure to shelter occupants.

If fire exposures are so severe that window openings must be eliminated in a masonry wall,[1] noncombustible insulating barriers must be provided at any opening. Various methods and materials were considered for this purpose. The most practical and efficient barrier for a window opening might be a noncombustible insulation such as vermiculite or perlite in wire mesh bags to provide a 9-inch thick panel. The use of insulating panels of honeycomb construction or insulation-filled and air-evacuated should also be investigated.*

In cases where severity of fire exposure from neighboring properties is less and would require only wired glass in metal sash windows, several insulating media might be employed. Window shades of such sandwich type construction as aluminum foil with glass fibre or intumescent fire retardant paint membranes are suggested.*

Where a sprinklered, combustible shelter building has smooth surface roof covering, a covering of gravel or slag will provide suitable protection against flying fire brands.

3. Fire Exposures from Shelter Building to Shelter Area

Because of the limited number of shelter spaces available in a combustible building** with respect to building volume, it does not appear economically feasible to provide fire safety upgrading measures unless such buildings are now protected by automatic sprinkler systems. Fire-resistive buildings will probably have a large proportion of their volume devoted to shelter areas. Consequently, upgrading of these buildings can be economically feasible. A survey made of 102 stocked shelters in various cities disclosed that over 90 per cent were located in buildings of fire-resistive construction.[7]

There appear to be two approaches to fire control in the shelter building: first, a fixed automatic fire suppression system; second, prompt discovery of a small fire with control and extinguishment accomplished by the shelter occupants. Of the two approaches, a preliminary cost analysis indicates a system of prompt discovery (detection) with control and extinguishment by occupants to be more economical. However, a novel fixed automatic fire suppression system might well be feasible.

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* See Appendix "A"

** Combustible buildings refers to roofs and floors and includes (3) classes of the National Building Code, i.e., heavy timber construction, ordinary construction and wood-frame construction.

a. Fire Detection

There are two methods of accomplishing early fire detection. The first is to provide watch service or fire tours by shelter occupants. If this method were used, continuous tours of the entire shelter building might very well be needed depending upon the nature and quantity of combustible materials in the building occupancy. Continuous tours would mean the following of one person by another so that they were always in sight of one another.

Continuous fire tours would present some problems of exposure from radioactivity to personnel, which would make it necessary to monitor radioactivity of the shelter building outside shelter areas, provide dosimeters for these persons making tours, and make it necessary to keep records of personnel exposures. Treatment of fire watch tours is included in a report by Varley and Maatman,[7] but no consideration is given to nuclear radiation exposures to personnel. A solution to this problem, but outside the province of this report, would be to upgrade the radioactive shielding to make the entire shelter building habitable.

The second method of detecting a fire in its incipient stage would be through use of smoke detectors, preferably using the air ionization principle. These detectors give the shortest response of any type and would be connected to a constantly attended alarm indicator in the shelter area. Occupants, upon receipt of a signal, would immediately respond with hand extinguishing equipment to extinguish the fire. Of the methods proposed for early fire detection, the smoke detection system seems to have the most merit. This conclusion is based on existing shelters not being habitable throughout because of radiation exposure to personnel, thus making continuous fire tours impractical and on the fact that air ionization type smoke detectors respond more quickly than other types.

b. Fire Suppression and Extinguishment

As mentioned earlier, prompt response to a fire signal is imperative, particularly where fixed automatic fire suppression equipment is absent. Hand extinguishing equipment must be available, in good operating order and sufficient in quantity. Shelter personnel must be familiar with the use of this equipment and the equipment must be easily accessible. In addition, personnel should be familiar with the layout of the shelter building and have access to all parts of the building. Smoke masks will be necessary for those selected as fire fighters.

IV CONCLUSIONS

A A total of six different remedies are suggested for upgrading measures in this report. There are one analytical and five experimental remedies. The one analytical remedy is the provision of gravel or slag roof covering for a combustible, sprinklered building. The five experimental remedies are: (1) envelope materials for the shelter area; (2) insulation in wire mesh bags, (3) insulating panels, (4) sandwich type construction window shades, and (5) detection system(s). They are expected to make existing fallout shelter buildings, now felt to be deficient, relatively safe for occupants in the event of fire and are expected to be relatively inexpensive and easy to install. Some of these measures will require testing. Tests will undoubtedly lead to additional ideas for upgrading.

B The need for further investigation and research on fire spread in conflagration situations is confirmed in connection with the findings in this report. It is understood that this problem is assigned to other groups.

C The desirability of liaison between groups responsible for upgrading blast resistance and fire safety of shelters is confirmed and additional liaison with those responsible for radiation shielding upgrading would be advantageous. Studies made in the preparation of this report indicate that some cost savings could be realized, for example, if a fire barrier could be constructed which would have some value as a radiation shielding device as well as providing protection from blast.

V RECOMMENDATIONS

A Upgrading measures outlined in the report should be investigated and tested as needed.

B Testing of the following measures is recommended:

1. Insulating panels of honeycomb construction or insulation filled and air evacuated.

2. Window shades of sandwich type construction such as aluminum foil with glass fibre or intumescent fire retardant paint membranes.

3. Smoke detection systems.

4. Shelter area "envelope" materials such as cellophane, gypsum board and aluminum foil.

5. Novel fixed automatic fire suppression systems.

RMN:vjc

PROJECT DIRECTOR : J. B. Smith

ASSOCIATE PROJECT DIRECTOR : E. W. Cousins

PROJECT ENGINEERS : M. J. Miller
R. M. Newman

REPORT BY : R. M. Newman

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REFERENCES

1. Smith, J. B., Cousins, E. W., and Newman, R. M., "Fire Hazard to Fallout Shelter Occupants: A Classification Guide", Office of Civil Defense, Contract No. OCD-PS-64-40, April 3, 1964.

2. Law, Margaret, "Heat Radiation from Fires and Building Separation", Joint Fire Research Organization, Technical Paper No. 5, p. 4,

3. Shorter, G. W., McGuire, J. H., Hutcheon, N. B., and Legget, R. F., "The St. Lawrence Burns", National Fire Protection Quarterly, v. 53, 1960, p. 313

4. National Bureau of Standards, Report BMS92, "Fire Resistance Classifications of Building Constructions", p. 9, Table 5.

5. Taylor, C. L, (Lt.), "Human Tolerance for Short Exposures to Heat", AD410729, p. 25.

6. Ingersoll, L. R., Zobell, O. J., and Ingersoll, A. C., "Heat Conduction", McGraw-Hill, New York (1948) p. 132.

7. Varley, R. B. and Maatman, G. L., "Shelter Fire Vulnerability-Specific Fire Limiting Activities for Occupants", Office of Civil Defense, Contract No. OCD-OS-62-210, Sept. 9, 1964.

8. Charanian, T. R. and Zeff, J. D., "Experimental Evaluation of Environmental Control Systems for Closed Shelters", Office of Civil Defense, Contract No. OCD-PS-64-6, July 1964.

Fire exposure barriers suggested on pages 4 and 5 of the report are:

1. Vermiculite or perlite in wire mesh bags.

2. Honeycomb panels.

3. Insulation-filled, air-evacuated panels.

4. Aluminum foil with glass fibre membranes.

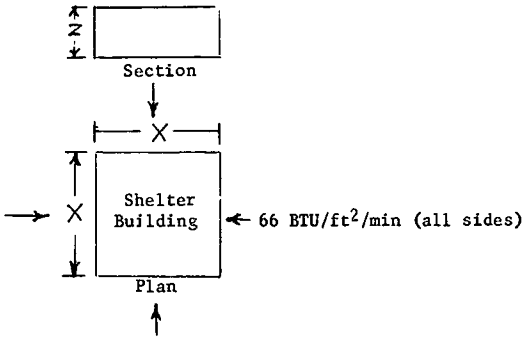
5. Aluminum foil with intumescent fire-retardant paint membranes.

The first three of the above are suggested as substitutes for bricking up window openings. This protection would be needed where fire exposure temperatures might approximate 2000°F and a limitation of 150°F is imposed for the interior surface.

The last two items on the above list are suggested where radiated heat from an exposure fire must be protected against. Such situations will exist wherever temperatures at inside surfaces of exterior walls can exceed 150°F. In a great number of cases, where distances between shelter buildings and exposing properties are sufficient to prevent pilot ignition of cellulosic materials at the shelter building wall[1], temperatures will be higher than humans can tolerate. Thus, plain glass and wired glass windows will need additional heat insulation. The sample calculation below, based on a building receiving radiant energy at a rate to just meet the criterion for pilot ignition, i.e.,

$$.3\ cal/cm^2/\ sec \quad or \quad 66\ BTU/ft^2/min$$

indicates the absurdity of the building size. Calculations are based on exposure to all four walls with 100 per cent windows with no heat losses.



Assuming dry air and initial temperature of 75°F, 1.0 lb = 13.475 cu ft.

Enthalpy = 10.331 BTU/lb at 75°F

Enthalpy = 28.376 BTU/lb at 150°F

28.376-10.331 = 18.045 BTU to raise 1.0 lb dry air to 150°F

1.0 cu ft dry air = $\frac{1}{13.475}$ = .0742 lbs.

Wall surface area of building = 4(xz)

If z = 10 ft, surface area = 40x

For each square foot of wall, radiation = 66 BTU/min. If exposure time is considered to be two hours, 120 $\times$ 66 = 7920 BTU/sq ft.

Then $\frac{7920 \times 13.475}{10.045}$ = 5914 cu ft of air needed/sq ft of wall.

$\frac{\text{Building volume}}{\text{sq ft wall}} = \frac{5914}{1}$, or

$\frac{x^2z}{4(xz)} = \frac{5914}{1}$, or $x = 4 \times \frac{5914}{1}$ = 23,656 ft.

Therefore the building would need to have dimensions of 23,656 ft $\times$ 23,656 ft. to limit dry air temperature to 150°F.

Data on thermal conductivites and diffusivities at temperatures of 2000°F and for materials not generally used for high temperature applications are not readily available. This lack of data supports the report recommendation that fire barrier assemblies be tested.

Material - Vermiculite in wire mesh bags

Application - Barriers for window openings (Substitute for masonry)

$T = T_s[1-S(z)]$*

Where T = Temperature of unexposed face

T_s = Temperature of exposed face

S(z) = Function of z = $\frac{\alpha t}{\ell^2}$*

* "Heat Conduction" by L. R. Ingersoll, O. J. Zobell and A. C. Ingersoll, McGraw-Hill, New York (1948) p. 127

If T = 150°F and T_s = 2000°F (see page 6),

then:

$$150 = 2000 \left[1 - S(z) \right]$$

S(x) = .925, then x = .029

k = .116** , ρ = 10** , c_p = .2788$^\Delta$ (for 1075°F air)

$$\alpha = \text{Diffusivity} = \frac{k}{\rho \times c_p} = \frac{.116}{10 \times .2788} = .0416$$

$$x = \frac{.0416 \times 2 \text{ (hours)}}{\ell^2}$$

$$\ell^2 = \frac{.0416 \times 2}{.029} = 2.869$$

ℓ = 1.694 = twice barrier thickness

Barrier thickness = .5 × 1.694 = .85 ft = 10.2 in.

Material - Glass Foam Blocks

Application - Barriers for window openings ((Substitute for masonry)

$$T = T_s \left[1 - S(z) \right] *$$

150 = 2000 [1 - S (z)] and,

S(x) = .925, x = .029

k = .133**, ρ = 9**, c_p = .2788$^\Delta$ (for 1075°F air)

$$\alpha = \text{Diffusivity} = \frac{k}{\rho \times c_p} = \frac{.133}{9 \times .2788} = .053$$

$$x = \frac{\alpha t^*}{\ell^2} = \frac{.053 \times 2 \text{ (hours)}}{\ell^2}$$

$$\ell^2 = \frac{.053 \times 2}{.029} = 3.655$$

ℓ = 1.91 = twice barrier thickness
Barrier thickness = .5 × 1.91 = .95 ft. = 11.5 in.

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* "Heat Conduction" by L. R. Ingersoll, O. J. Zobell and A. C. Ingersoll, McGraw-Hill, New York (1948) p. 127

** "Thermophysical Properties of Thermal Insulating Materials" by J. B. Loser, C. E. Moeller and M. B. Thompson, USAF Contract No. AF33(657)-10478, Project No. 7381, p. 245 Ref. 050 and p. 104, Ref. 042.

Δ "Psychrometric Tables and Charts" by O. T. Zimmerman and Irvin Lavine, Industrial Research Service, 1945, p. 8

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13 ABSTRACT Fallout shelters have been evaluated for their shielding against nuclear radiation and a report, "Fire Hazard to Fallout Shelter Occupants: A Classification Guide," has been prepared by the Factory Mutual Research Corporation, dated April 3, 1964, for determining the fire hazard to shelter occupants. It is expected that the above guide will reveal deficiencies in fire safety, and it is now desired to suggest remedies for alleviating these deficiencies. (U)

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