The International Association of Fire Chief's

RESIDENTIAL SMOKE ALARM REPORT

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Prepared by a Special Subcommittee of the Automatic Detection Committee of the International Association of Fire Chiefs

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Over the past several years, there has been an ever-increasing number of smoke alarms advertised, purchased and installed in single family dwellings. In many instances, fire and building codes have set requirements for such installations.

The interest in personal and family fire protection is probably at an all-time high. As a consequence, citizens are turning to their fire departments for information.
This presents a fine opportunity for excellent communication and understanding between the fire department and the public, but it also presents a challenge that is not without problem.

Fire service personnel, under the direction of the fire chief, are being asked which detector to buy, how many detectors should be bought, where should they be installed, and should an ionization, photoelectric, gas or heat detector be purchased? The public expects the fire department to be able to answer those questions intelligently, and it intends to rely on those recommendations.

One way or another, fire service leaders are expected to see that reliable answers to these questions are provided. Unfortunately, too many fire departments, including some seemingly progressive departments, are not in a position to give good answers based on solid information.

Recognizing this, a policy statement (see the August *1977* issue of this magazine, page 14) was passed by the board of directors and the membership of the International Association of Fire Chiefs (IAFC) in 1977. This statement outlined a suggested position which would allow fire chiefs to fulfill their responsibilities to their constituencies, yet protect their departments and themselves. The statement also indicated action to be taken by the Automatic Detection Committee to help the fire chief become better able to serve the public in this important area.

Furthermore, the committee was ordered by the president of the IAFC (Chief John Swindle at the time) to test, evaluate and distribute, at the earliest possible moment, information pertaining to automatic fire detection equipment, including those areas where promotion and advertising is misleading the fire chief and the public.

This report is the first of several steps being taken to fulfill that presidential mandate. It has been prepared by a special subcommittee of the IAFC Automatic Fire Detection Committee.

Some Basic Thoughts About Automatic Fire Alarms

It must be recognized that people are poor fire detectors if they are not awake. It is a well-established fact that the vast majority of fatal fires occur during the hours when people are asleep. The victims usually die because they are not aware of the fire in time to escape its deadly by-products, namely smoke, heat and toxic gases. Automatic fire detection and early warning equipment (simply called a fire alarm) alert the sleeping occupants to the fire *in enough time so that people can take proper escape actions.* Fire alarms are successful when they give enough time to escape and are followed by proper evacuation procedures.

While that statement seems axiomatic, it is important to understand that some types of devices or equipment, because of either their nature or their installation, activate long after the fire has started. In such cases, the warning may not allow enough time for the occupants to escape.

The ability to escape from a fire is related to the tenability of the escape routes. Such tenability traditionally is measured in terms of the quantity of smoke and heat present in the area of escape, and the toxic content of the air. Based upon School Burning #2 (tests conducted by the City of Los Angeles in the late 1950's), a smoke density obscuration (a means of measuring smoke by the obscuration of a light beam) of 4% has been considered the maximum limit for successful activation of smoke detection devices. Generally, it takes temperatures of more than 135°F to activate heat-detecting devices in normal environments. Tests indicate toxic gas buildup generally follows these detectable limits of heat or smoke. Therefore, activation of fire alarms from these amounts of smoke or heat, allowing ample time to put escape routes into practice, would be considered successful (refer to Appendix A).

It is important to note that, when one measures tenability in terms of heat and smoke, in real life fires it is possible to have a fire that starts as a very slow, smoldering fire (a cigarette on a mattress) which produces copious amounts of smoke before there is a significant temperature rise. The time interval may be as long as a couple of hours. However, it is unlikely that a fire producing heat (a flaming fire such as a match in a waste basket) also would not produce measurable amounts of smoke.

To understand which fire detection equipment will provide the most certain degree of successful operation, it is necessary to understand two elements of fire alarm installation, namely a systems approach versus single station units, and detection technique.

What is an Automatic Fire Detection System?

An automatic fire detection system is a variety of elements joined to detect the fire automatically and sound an early warning. Generally, it consists of a central control panel (in the case of an electrical system, this control panel would allow operation on regular household current and should provide emergency backup power to protect against a power failure). It also allows supervision of the circuits (a method of

checking itself out, and providing some warning should a trouble situation arise) to ensure that all elements are working properly. Interconnected to the control panel are a series of detection devices (types to be discussed later). When these devices detect a fire, the sounding devices are activated through the control panel to provide early warning in the sleeping and other occupied areas regardless of where the fire originates. It is obvious that the closer to the point of origin a fire is detected, without allowing extra time for the products of combustion to travel to a distant detector, the greater the available escape time.

The advantages of a proper automatic fire warning system include that extra escape time and the sounding of an alarm in the sleeping and other occupied areas regardless of where the fire originates. This can include an audible device outside the home or connected to a fire department or central alarm station to ring help more quickly. This is especially important where children, the elderly, handicapped or those under the influence of alcohol, drugs or medication are concerned.

What is a Single Station Unit?

A single station unit contains a detection element, a power source and a sounding device. Smoke alarms (either ionization or photoelectric) can be battery-operated or operated from household current. (To the subcommittee's knowledge, only two dual-power source single station smoke detectors are available as of this writing, a fact which this subcommittee feels is unfortunate because dual-power obviously provides the greatest guarantee of uninterrupted power.) Single station, heat-activated devices are usually either windup, spring-loaded or powered by an inert gas.

A single station unit sometimes is referred to as a self-contained unit. It is obvious that a single station unit is designed to detect a fire within its area of coverage and sound an alarm *in that same area.* This, of course, *highlights* one of the weaknesses of a single station unit, audibility. If such a unit is located in the basement of a home and the doors are closed between it and the sleeping area, can it be heard? In the case of practically all the smoke alarms on the market, the answer is probably no (Refer to Appendix A).

The advantage of a single station detector is cost. Since the unit is self - contained, it is possible to install one device which can cost anywhere from $9.99 to more than $100.

Because of the spot protection offered by the single station unit, some people are installing multiple detectors. While this may be called a system by some, it is not a system because it is not interconnected. However, because of the poor audibility of many single station devices, many now are capable of being interconnected so that when one sounds; all the alarms in a residence are activated. This does approach the system concept, put it has several major differences. One, it is not supervised, so that if one of the detectors involved in either detecting or sounding is not working, or if the wiring between the detectors is broken, no one will be aware of the trouble conditions. Two, no method of sounding outside alarms or connection to a fire department is available, nor is any special equipment for the handicapped.

There is a line carrier connected system of single station units designed to detect a fire in one home and sound a system in a neighboring home. However, this system also is not supervised and will work only if both homes are operating on the same power line transformer. Additionally, the system is subject to false activation by stray electrical current.

Before discussing the pros and cons of a system versus single station units, it is necessary to describe the major categories of detecting elements. For the purposes of household protection, heat and smoke detectors are the two major categories of detector types.

Heat Detectors

A heat detector will activate when the temperature within the area of its coverage becomes abnormally higher. Heat detectors bear an Underwriters Laboratories or Factory Mutual label indicating a recommended tested coverage called the listed coverage, e.g., 30x30 feet or 900 square feet, or 50x50 feet or 2500 square feet. In addition, heat detectors bear the Underwriters Laboratories or Factory Mutual label showing the temperature at which the detector is designed to activate, e.g.135°F or 195°F where the ambient temperature is higher.

There are two generic types of heat detectors. The first is the spot type (usually electrical), designed to be wired into a system. The second is a detector, usually self-contained and powered by either inert gas or a spring. Heat detectors activate according to type. These are:

- **Fixed temperature**
  Designed to activate when the temperature in the area of coverage reaches a certain point, i.e., 135°F. It may be a thermal couple or fusible link type in which the temperature melts a specially designed connection.

- **Rate of rise**
  This consists of a bellows which reacts to abnormally changing air pressure. It is designed to detect a very rapid rise in temperature, usually 15° in a minute.

- **Combination fixed temperature and rate of rise**
  This is self-explanatory and works on both of the above principles. One caution-in a combination detector, the fixed temperature portion usually does not have the same listed coverage as the rate of rise portion.

Heat detectors obviously will not react to the slow, smoldering, smoky buildup of a fire, but will react when the combustion reaches a

point of rapid heat buildup. Therefore, heat detectors should be used only to supplement primary smoke detector coverage in such areas as closets, garages and attics.

Photoelectric Smoke Detector

A photoelectric smoke detector activates when visible smoke from a fire enters the detector. It is sensitive to a smoldering fire as well as the smoke generated by an open flame fire.

Ionization Detector

An ionization detector activates in response to invisible particles created by combustion. It is sensitive to an open flame fire. Contrary to some advertisements, tests conducted by various fire departments and other organizations indicate that this detector does not respond quickly to smoldering fires, often not until smoke within the area builds up to a substantial density which may interfere with escape.

Combination Photoelectric/ Ionization Detector

This detector, as the name implies, uses both an ionization and photoelectric element.

Combustible Gas Detector

Commonly referred to as a Taguchi gas sensor (TGS) and advertised as a gas and smoke detector, this device can detect such combustible gases as methane and propane. It has proven unreliable as a fire or smoke detector, so has been removed from such classification by the National Fire Protection Association and recognized testing laboratories.

Which Detector Should be Recommended?

If experienced fire chiefs knew where and how a fire was going to start, they would be in perfect position to answer this question. Unfortunately, there is no easy answer. Thus, fire chiefs must recommend that citizens have the best protection possible.

What is the Best Protection?

The best protection is a complete automatic detection system consisting of various types of detectors throughout the building. It should consist primarily of multiple smoke detectors augmented by reliable heat detectors. The primary smoke detectors should be located in hallways, bedrooms, stairways, living rooms and other occupied areas. A smoke detector or heat detector then should be placed in every other room of the house, including closets, attics, kitchens, garages and basements. Each *and every room!* Anything less is not complete protection and fire chiefs must recommend complete protection (Refer to Appendix A).

The subcommittee firmly believes that fire chiefs, as responsible, knowledgeable public safety officials, must recommend complete protection. What other choice do they have?

Because of inherent design problems, such as a tendency to sound false alarms, some manufacturers of smoke detectors provide, in their installation instructions, a caution not to install their smoke detectors in kitchens, attics, boiler rooms or garages. There is a caution against installing smoke detectors in areas where temperatures go below 40°F or above 100°F.

This subcommittee has no objection to installing photoelectric smoke detectors in kitchens because they are not likely to activate from normal cooking smoke or self-cleaning ovens. However, if it is found that a photoelectric detector is sensitive to certain cooking smoke, replace it with a heat detector. Many serious fires originate in kitchens and the area should be protected properly (Refer to Appendix C).

The subcommittee believes the fire chief should recommend further that the system consist of interconnected components and be supervised by either an Underwriters Laboratories - or Factory Mutual-approved control panel equipped with a rechargeable battery to take over in case of a power failure. In addition, the bells or horns must be loud enough to be heard throughout the building above all other normal noises.

The wiring in the system should be supervised electrically, so that a trouble signal will be sounded for any malfunction in the system.

The system described above is not really expensive, particularly because it is an investment in the best life safety protection a family can provide when combined with an emergency escape plan. A good, properly installed automatic fire and smoke detection system compares in price to a color television. The fire chief should remind citizens that if they are willing to spend a substantial amount for a color television, it is a wise investment to protect the lives of the family against the hazard of the television and all the other appliances and fire threats in a home.

What is the Least Protection?

The least protection is one detector located in an area of the building where the fire is going to start. While this is not very practical, it is an answer to the question. It is almost the same as saying that one sprinkler head will protect a 25,000 square foot supermarket if it is put in the right place.

Is There a Middle Ground For Protection?

If a fire department could not buy the most expensive aerial ladder, it obviously would not settle for a step-ladder and a bicycle. It would seek an apparatus somewhere in between.

Good automatic fire protection should be considered in a similar manner.

Start with the best and most desirable, a complete system, and *slowly and intelligently* let the citizen remove detectors and related equipment in the least likely areas of fire origin until the affordable level of investment is reached. This is not easy, but by proceeding in this manner, when the citizens remove detectors, they then are aware that they are removing protection right up to the point where they bring their detection down to one smoke detector. Then the citizens should know, without a shadow of a doubt,

that they have the least protection that money can buy. *There* is *nothing less!* Then let them be aware that if they install the single smoke detector in the hallway outside their bedroom, close the door and go to bed, they have virtually no protection if the fire starts in their bedroom.

But, remind the citizens that if they choose the minimum amount of protection now, they can add to the protection next month and the following month and the month after that, until they have raised the level of protection to meet their financial ability and desired level of protection. However, it probably would make better sense to invest in a system initially.

It is important for the fire chief to recommend that people who have extra dollars invest them in complete protection. Fire chiefs should not let those precious dollars be wasted on clever marketing gimmicks that seem attractive, but, in reality, provide little or no protection.

What Should a Smoke Detector Do?

The NFPA's Standard *#74, Household Fire Warning Equipment,* specifies installation and technical requirements. Among other items, it requires that smoke detectors respond before smoke obscuration reaches four percent per foot.

The validity of this standard has been reaffirmed in numerous tests attended and/or conducted by members of the International Association of Fire Chiefs, even though Underwriters Laboratories now lists detectors that will respond to smoke obscuration levels of seven percent. However, how can one tell if a detector complies with NFPA *#74?* This sounds easy, but it is not, since the fire service is told continually that a UL label identifies the "good" detectors. Surprisingly enough, at present, Underwriters Laboratories only tests detectors under scientifically repeatable laboratory conditions which do not necessarily indicate how the detector performs under actual fire conditions.

So, there are two standards - NFPA's #74 requiring detectors to react to four percent or less smoke obscuration, and a UL standard listing detectors at seven percent smoke obscuration. What are the conditions in a building at four percent and seven percent? This is similar to asking what gasoline smells like. There is no easy answer. The only answer to the four percent and seven percent question is that it is not very pleasant at four percent, and seven percent is even less pleasant. There is also a lack of visibility apparent at this level. In the subcommittee's opinion, this could lead to panic conditions, especially when one wakes up from a sound sleep.

The subcommittee urges the NFPA to continue requiring the four percent level and urges Underwriters
Laboratories to reconsider the present seven percent listing and return to its original four percent requirement.

At the same time, the subcommittee is attempting to find a way to require the manufacturer of the device to mark, on the detector and on the advertising, the percentages at which the detector will activate from both an open flame fire and a smoldering fire. In this way, the citizens and the fire chiefs will know what to expect from the detector. The subcommittee asks nothing more than the same kind of requirements presently applicable to heat detectors.

Advertising

The subcommittee is concerned with some smoke detector advertisements. The subcommittee felt that some advertising claims were too strong and, in some cases, deceptive and misleading to the public, resulting in a false sense of security. The subcommittee refers specifically to those advertisements which imply that, in all cases, a single smoke detector will be sufficient to save everybody when a fire breaks out, or those advertisements which state that certain detectors will react before there is visible smoke, heat or flame, when, in reality, these detectors might be extremely slow to activate in a smoldering fire. In fact, they might be so slow to activate in a smoldering fire that lives may be in danger.

The Fire Chief's Recommendation

What kind of detector should the fire chief recommend - ionization or photoelectric? The answer to this question, in the subcommittee's opinion, is clear. However, before this question is answered, it is necessary to discuss test data and information.

Tests and demonstrations conducted by federal agencies, fire departments, manufacturers and consumer organizations have resulted in conflicting answers. Some of the answers indicate that ionization is more effective; some state the photoelectric is more effective; some state you need a combination of both detectors; and some state you get equal protection with either. These contradictory results have confused both the citizen and the fire chief.

The subcommittee has investigated several laboratory tests and the operation of various types of detectors under actual fire conditions. The test results have conflicted, primarily because the results of tests conducted in laboratory conditions and actual fire conditions did not seem to match. And, although UL lists detectors that meet its test procedure, there are many detectors that do not produce the expected results under actual fire conditions.

The subcommittee is aware of many detectors being sold today that will not meet the requirements of the NFPA or the recommendations of the IAFC Automatic Detection Committee when they are subjected to actual smoke conditions from a slow-burning, smoldering fire. But, the detectors will meet the requirements when they are subjected to smoke from an open flame. It is the subcommittee's belief that only the photoelectric detector will meet the requirements reliably when subjected to both open flame and smoldering fires.

The subcommittee believes this has been proven time after time throughout the country in actual tests conducted by manufacturers and fire departments (see Appendix A).

Hard to believe? It certainly is. Skeptical fire chiefs can verify this belief with minimum effort and time. Locate a typical, vacant, two or three-story house and install various types of automatic smoke detectors in the second floor hallway as advertisements advise. Then go down to the first floor, throw a cigarette on a couch and stand by to see what happens. See what the conditions are when the alarms activate, *but do not hurry the fire with a match; do not open and close doors; keep the conditions stagnant as they would be in the middle of the night with everyone sleeping; and, above all, do not hurry the fire with a match or a charcoal lighter rod. Let the fire take its natural course. Again and again, do not rush the fire! In an hour or two, a world of information will be gained.*

This test will show that most photoelectric detectors, operated by battery, will detect the smoke at about one and one-half to three percent smoke obscuration, which is good. The test will show that the photoelectric detectors, operated by household current, will activate between two and four percent, which is still good. But, the test also will show that many ionization detectors will not activate until the smoke obscuration reaches 10, 15, 16, 17, 20 and sometimes 25%.

If a smoke obscuration meter is not available, use experience and background in smoke conditions and give the results a good subjective opinion. Again, this is hard to believe, and is adverse to some advertising and some national tests, but try it.

As a result of these tests, and despite the fact that they are in conflict with federal government tests, consumer testing facilities, fire chiefs, fire fighters, manufacturers and advertisements, the subcommittee maintains that most ionization detectors will not respond quickly to a slow, smoldering fire under actual residential fire conditions.

Therefore, because of the present state of the art in detecting smoke, the Subcommittee on Smoke Detection can take no other course but to recommend the installation of photoelectric detectors. The subcommittee makes this recommendation because most home fires start from a smoldering source, and because the photoelectric detectors are sensitive to open flame fires as well as smoldering flames (Refer to Appendix B).

A Final Thought

The subcommittee is aware of the fact that carbon monoxide increases rapidly with the buildup of heat. This has been confirmed by the recently completed fire tests in Los Angeles.

With this in mind, it is imperative that smoke be detected and a fire warning given at the earliest possible time before there is a substantial heat buildup.

Further, to be consistent with NFPA Standard #74, the subcommittee feels it is imperative to detect smoke as early as possible, and so concurs with the NFPA's four percent or less smoke obscuration level.

Appendix A

Since the formulation of this report, the results of a series of fire tests held in California have been published. These tests deserve some comment by the subcommittee. While it is gratifying that the IAFC Automatic Fire Detection Committee was instrumental in starting these tests, and the IAFC Foundation was a substantial source of funding, the major credit belongs to the Los Angeles City Fire Department, under Chief Engineer John C. Gerard (a member of the IAFC and this subcommittee), who was responsible for the actual conduct of these tests with the sponsorship of the California Fire Chiefs Association.

The subcommittee recommends study of these tests to the serious students of automatic fire detection. Simply stated, the series of tests was conducted in homes about to be demolished after condemnation by the Los Angeles Airport Authority. The homes were furnished fully and the tests were conducted in a realistic manner.

The tests were instrumented and produced test data that will take years of further analysis before producing all possible information. However, essentially the tests and their conclusions are applicable to the needs of fire chiefs. The subcommittee particularly points to the fact that the conclusions reached by the Los Angeles tests coincide with the recommendations of this subcommittee report. Namely:

1. A full system of multiple photoelectric smoke detectors, supported by heat detectors, affords the best protection for a family against the threat of fire.
2. Aside from the question of detection techniques and capabilities, a sampling of single station units showed their audibility to be poor enough to negate their widespread use in most residences unless interconnected. Once more, this proves the necessity of a systems approach.

Appendix B

What about the use of a combination photoelectric/ionization detector?

Some new devices are being offered which reportedly combine the detecting techniques of both types. Taken at first glance, this would seem to be an obvious answer to the "which is best" question. The subcommittee does not think it is such an obvious answer and does not think the combination detector is best, for a number of reasons.

First, when compared to ionization detectors, a photoelectric detector will detect flaming fires in an acceptable manner, and in a superior manner in smoldering fires. Therefore, what is to be gained by adding an ionization element to a good photoelectric element? In the subcommittee's opinion, nothing. In

fact, the subcommittee believes there are at least two disadvantages:

1. Cost - why add anything that will not improve the performance
2. False alarm potential, while this report touches very lightly on the false alarm question, it has been established that the ionization detector has a considerably higher potential for false alarms. It does not make sense to add that disadvantage to an already sufficient photoelectric detector.

Appendix C

It is the responsibility of the supplier or installing contractor to provide the owner with instruction charts describing the operation, method and frequency of testing, and proper maintenance of household fire warning equipment. Periodic inspection, testing and maintenance, however, are the responsibility of the occupant and its importance cannot be overemphasized.

Tests and inspections of other than battery-operated detectors should be made at least once a month. Battery-operated detectors should be inspected and tested once a week. It should be understood that the test button on most detectors simply tests the alarm function, and is not an indication of whether the detector will activate in a smoke condition. Simply stated, the only absolutely positive test is the presence of actual smoke.

Dust, cobwebs and other foreign materials, which might cling to the detector and possibly inhibit its efficiency, can be removed by either blowing air through the detector or by light vacuuming. No interior cleaning or maintenance should be required except for the normal periodic changing of batteries in battery-powered units.

Generally, if one follows the instructions supplied by the supplier or installing contractor, units should provide reliable protection indefinitely. However, as stated above, regular testing and maintenance on a continual basis is an absolute must.