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False Alarm Study of Smoke Detectors in Department of Veterans Affairs Medical Centers (VAMCS)

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U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
Center for Fire Research
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*Research Associate sponsored by Underwriters Laboratories, Inc., (retired)

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The authors would like to acknowledge the Department of Veterans Affairs, the Department of the Air Force, and Underwriters Laboratories, Inc. for supporting this timely study. In particular we are thankful for the consultation of Mr. Sam Levinrad of the VA in designing and carrying out the work, and the patience of Mr. Ken Faulstich and Doyle Carington of VA in dealing with the delays in completing this report. Finally, the cooperation of the staff of the participating facilities in gathering and reporting the data on which the study is based is truly appreciated. We hope that the reward for their efforts will be felt in better operating and less false alarm prone fire alarm systems.

FALSE ALARM STUDY OF SMOKE DETECTORS IN DEPARTMENT OF VETERANS AFFAIRS MEDICAL CENTERS (VAMCs)

Peter M. Dubivsky and
Richard W. Bukowski

Abstract

A study of 133 VA Medical Centers (VAMC), out of a total of 172 throughout the U.S., coupled with visits to 20 facilities, was conducted to gather data on false alarms of smoke detectors.

Data collected included name of the detector manufacturer and model number, control unit manufacturer and model number, number and type of detectors installed, where installed, number of false and real alarms for preceding year, date of installation, and policies on smoking, testing, cleaning, and maintenance. VAMC personnel involved with the installations were requested to indicate the maximum level of false alarms that could be tolerated and to provide any recommendations to reduce their occurrence.

The study included a total of approximately 37,000 system type smoke detectors of which 69 percent were of ionization (ion) type and 31 percent photoelectric, 3000 duct detectors (90 percent ion and 10 percent photo), and 1100 smoke detector modules (80 percent ion and 20 percent photo) integral with door holder closers (DHC). Also, included are approximately 100 single station smoke alarms.

Analysis of data collected from operating facilities through forms, site visits, and staff interviews resulted in a series of recommendations which could result in a substantial reduction in observed false alarms. These recommendations include:

1. Since the largest cause of false alarms was related to smoking, strict enforcement of smoking policies could have the greatest impact.
2. Improved maintenance and testing procedures including the performance of service by qualified contractors or formally trained staff, record keeping, and better design practices including detector selection and location.
3. Application of existing system features such as cross zoning, day/night operation, and alarm verification.
4. Better internal coordination of construction activities which produce dust.
5. Improved designs which facilitate cleaning, testing or supervision of sensitivity, more complete instructions for user service, and easier accessibility to customer support.
6. New and modified requirements to be considered by testing/approval laboratories and by code committees.
7. An expanded role of industry associations in customer education and in coordination of activities to address industry-wide problems.

KEY WORDS: sensitivity, false alarms, ionization principle, photoelectric principle, production window, smoke detectors, smoking, testing, lack of cleaning, dust, misapplication, VA Medical Centers (VAMCs).

1. INTRODUCTION

The National Institute of Standards and Technology (formerly National Bureau of Standards), Center for Fire Research (CFR), engaged in a 3 year program sponsored by the Department of Veterans Affairs (VA), U.S. Air Force (USAF), and Underwriters Laboratories to study smoke detector false alarms. Department of Veterans Affairs Medical Centers (VAMCs) were the focus of the study as they represented a broad range of facilities and installed systems, and since they were willing to instruct their individual facilities to cooperate in the assembly of data. A similar data gathering process has recently been initiated among Air Force properties.

The VA is the largest operator of health care facilities in the country. By policy all facilities utilize extensive fire protection systems including sprinklers, smoke control systems, and a large number of smoke detectors.

In recent years the VA has adopted the Fire Safety Evaluation System (FSES), developed at NIST and recognized by the Life Safety Code for health care facilities. To obtain an overall fire safety rating, the FSES system gives credit for fire safety features and penalties where fire protection is lacking. Smoke detectors represent a key fire safety feature which can compensate for deficiencies in certain areas. These smoke detectors provide early warning of fires to enable rapid evacuation of patients in jeopardy, activation of the smoke control systems, and automatic notification of the fire department. This extensive use of smoke detector protection has proved invaluable in protecting both lives and property, but has not been without problems. False alarms from smoke detectors have been a growing problem in large buildings in general, and in health care facilities in particular, over the past few years. In fact, false alarms from smoke detectors are recognized as a leading problem with alarm systems worldwide.

The problem has escalated to the point that some jurisdictions will not allow direct connection of systems with smoke detectors to the fire department, or charge the building owner for each false alarm to which the fire department responds. In some cities the fire department will not respond unless the facility telephones to confirm an alarm. Occupants of buildings with excessive false alarm rates learn to ignore the system, at least until they would see smoke or other evidence of the fire. This can result in delayed response to real fires and the potential for increased life and property loss.

In an attempt to address these problems, the VA and Air Force funded a research study at NIST. Under a mutual research associateship arrangement between Underwriters Laboratories (UL) and National Institute of Standards and Technology, UL assigned an engineer with experience with smoke detectors to conduct the false alarm study and formulate recommendations to reduce the number of false alarms. This would include recommendations to detector manufacturers and standards-writing organizations to eliminate the deficiencies that presently contribute to the false alarm problem. Recommendations were to be based on the collected experience without necessarily any statistical analysis of the data. It was also felt that the report should serve as a general reference document for the staff of facilities who are responsible for fire alarm systems operation and maintenance.

2. BACKGROUND

2.1 HISTORICAL

Prior to World War II the only smoke detectors being used were the projected beam photoelectric (optical) type which were intended to be installed across a ventilating duct in a large building. When there was sufficient smoke in the duct to exceed the threshold level for which the detector was calibrated, the unit went into alarm and its relay contacts transferred to control whatever was desired, such as shutting down the ventilating system, or controlling a smoke barrier door or damper. Its primary function was to shut down the ventilating (air conditioning) system to prevent the spread of smoke throughout a building thereby precluding a panic hazard. These detectors may have been connected to a fire alarm system control unit but their actuation did not result in the system evacuation, alarms being sounded or any signal to the fire department. In those early days automatic heat detectors (thermostats) and manual stations (pull boxes) were employed as the primary initiating devices for a fire alarm system.

It was not until the late 1950s and early 60s that spot type smoke detectors, as distinguished from a projected beam type, were developed. The first optical detector (photoelectric) was developed by an American manufacturer, while the first detector which operated on the ionization principle was developed in Switzerland. Both of these were intended for connection to a fire alarm system control unit the same as the heat detector or manual pull box.

As a result of research studies, such as Operation School Burning conducted by the Los Angeles Fire Department in 1959, the life safety and property protection values of smoke detectors began to be recognized by various authorities through their inclusion into code-mandated applications. This reached a peak in the mid-1970's with the widespread adoption of requirements for residential smoke detectors which were developed in the late 1960's from the system-type units.

Initially the majority of system smoke detectors being manufactured were of the ionization (ion) type because of their generally lower cost and the fact that the incandescent lamp in the optical type needed periodic replacement. Today the state of the art of optical detectors has reached a point where lamps no longer have to be replaced and the cost is comparable to the ion types.

In the 1960's, performance standards of testing laboratories, such as UL 168 [1], published by Underwriters Laboratories, Inc. (UL), listed optical detectors on the basis of sensitivity (threshold response) tests in a smoke box, several electrical tests to check for safety from fire and shock, and some environmental tests comparable to tests then included in the standard for heat detectors. No tests of their ability to detect actual fires were conducted.

In this same period, the UL Requirements for Ion detectors were contained in UL 167 [2] which measured their performance in responding to four flaming fire tests conducted in a large room. Their sensitivity was measured also in a smoke box, configured differently since the response had to be measured under more controlled velocity conditions. The source of the test smoke also varied, with "punk" sticks used to generate gray smoke for optical detectors, and a 7/8 in. (22 mm) wide cotton wick used in the ion smoke box.

During the 1970s performance standards were upgraded based on field experience and recommendations from people knowledgeable in the fire protection field, to require all smoke detectors, regardless of the principle of operation, to be subjected to the four fire tests [3]. Additional performance tests added during that period included a new Smoldering Smoke Test, a common smoke box with improved instrumentation, and limits on the variation in response with varying flow velocity past the detector to further strengthen the standard and assure a greater degree of operational reliability.

With the adoption of the Smoldering Smoke Test, greater emphasis was now placed on the sensitivity aspect which would figure prominently in the susceptibility of smoke detectors to unwanted alarms. This affected the ion detectors more since they are less sensitive to the large particles associated with a smoldering condition. Many ion detector manufacturers, rather than redesigning in order to comply with the smoldering test simply increased the sensitivity of their units. At the same time, the optical detectors now had to comply with the four flaming fires. This necessitated a similar increase in their sensitivity, since photo detectors exhibit a reduced response to the smaller, black particles characteristic of flaming fires. This increase in sensitivity for both types, coupled with the greater number of detectors being installed, has resulted in an increase of false alarms being reported from the field. To further exacerbate the problem many smoke detectors were being misapplied, since installation standards provide only general guidelines on placement. Smoke detectors are commonly installed in areas where they are more susceptible to false activation, such as in kitchens and near shower rooms.

2.2 OTHER FALSE ALARM STUDIES

Several studies on the subject of false alarms have already been conducted with two still underway. While only one of the five reported here is related to a hospital type of environment, the data obtained in the other studies, on causes of false alarms and the remedies being applied, are comparable to the problems encountered in this study. We also note that what is considered a false alarm varies somewhat among researchers. The definition used in this study is presented in section 3.

2.2.1 Study No. 1 (Bukowski and Istvan)

A survey of health care facilities was published by Bukowski and Istvan in 1980 [4]. The data reports in this study covered 7323 detectors, 50 models from 13 manufacturers, approximately 70 percent ionization type, and 30 percent photoelectric (optical) type. Fourteen percent were of the residential type (single station battery operated). Detectors were installed in hospitals (20%) and nursing homes (80%) in seven different geographical locations throughout the U.S. The average age of the systems was approximately 5 years. A capsule summary of the results of the survey follows:

a. No meaningful difference in alarm frequency among 13 manufacturers.

b. False alarm frequency of 4.4 percent (4.4 false alarms per 100 detectors per year) in the health care facilities.

c. False alarm to real alarm ratio was 14:1.

d. No meaningful difference between ionization and photoelectric detectors with regard to real alarm and false alarm frequencies.

e. Higher false alarm rates in basements, kitchens, laundry facilities, and storage rooms.

f. Detectors not cleaned in 46 percent of the facilities. Units were cleaned in 30 percent of facilities, once a year or more. Predominant cleaning methods included compressed air, alcohol wash, or vacuuming.

g. Detectors tested once a year in 88 percent of the facilities with 55 percent reporting detectors tested monthly. Predominant testing by smoke.

h. Detectors tested more frequently had lower false alarm rates than those tested less frequently or not at all.

2.2.2 Study No. 2 (Fry)

One of the earliest published studies was done by Fry [5] in the United Kingdom in 1971. This study included data obtained on false and real alarms by fire departments in England, Wales and Scotland for the year 1968. The study concerned itself only with the number and causes of false alarms and did not consider the number of detectors installed nor the age of the systems. The following results were obtained.

a. A total of 1567 alarms were received of which 1429 were false, 101 were system alarms to real fires and 37 were fires reported by other means.

b. Thirty seven percent of the false alarms were due to excessive heat and smoke, such as from a manufacturing process, 30 percent by defective detectors and control panels, and 11 percent by system testing and maintenance where the fire department was not notified of the activity.

c. The ratio of false to real alarms was 14:1.

2.2.3 Study No. 3 (Miyama and Watanabe)

In 1978, Miyama and Watanabe presented a paper on experiences on smoke detectors in Japan [6]. In addition to testing requirements, the paper included the following data on false alarms of system connected smoke detectors.

a. For the 5-year period between 1969 and 1974 a total of 2,511,488 ion detectors were produced with 1010 false alarms for a percentage for the 5 years of 0.04. A total of 390,018 photo detectors were produced with 112 false alarms for a percentage of 0.03. The low rate of false alarming, which would not be of concern in the U.S., can only be attributed to a much lower sensitivity in Japan, or to some unknown factor.

b. Approximately 53 percent of the false alarms were from an unknown cause while the remaining 47 percent were attributed to the following causes: Meteorological factors (wind, humidity, lightning) 15 percent, Environmental (insects, steam, air conditioning system) 5 percent, Artificial factors (malicious, smoking, outside combustion products) 12 percent, Maintenance people 7 percent, Building Management (remodelling, ignorant manager) 2 percent, Corrosion factors (salt spray [seaside], corrosive gases) 0.5 percent, Device (appliances) 3 percent, Design considerations (location, sensitivity) 1.3 percent, Installation wiring 0.5, and Others 0.7 percent.

2.2.4 Study No. 4 (Breen)

In a recent study, David Breen of Harvard University has reported on his own attempts to reduce false alarms from smoke detectors installed in the university's dormitories [7]. The author addresses three remedies to reduce false alarming; (1) Use of less sensitive units, (2) Use of so-called "hardened" detectors which have been designed to resist the effect of electrical and RF transients, light scattering, dust, steam, and insects, and (3) use of alarm verification circuits. The following results were obtained.

a. Replacement of approximately 155 optical detectors which were calibrated to a nominal sensitivity of 1.5 percent/ft. (0.022 optical density/meter), with units calibrated approximately 50 percent lower, to 2.2 percent/ft. (0.032 optical density/meter), resulted in an average reduction in false alarms of 67 percent.

b. Replacement of detectors calibrated to a nominal sensitivity of 1.5 percent/ft. obscuration with "hardened" detectors at the same nominal sensitivity, resulted in a reduction of approximately 50 percent in false alarms. A total of 113 detectors were involved covering a two year period.

c. Alarm verification modules with a 60-second time delay were installed in two dormitories with a total of 118 detectors. During a 10-month study period a total of 36 false alarms were recorded with a further 78 false alarms prevented by the verification circuit. The reduction of false alarms for one dormitory was approximately 41 percent, and for the other was 75 percent.

d. Typical causes of false alarms included dust-laden air, steam, insect infestation, smoke from non-hostile sources, and cooking.

2.2.5 Study No. 5 (Roberts)

In concurrent work similar to that reported by Breen, Jim Roberts of the North Carolina Department of Insurance also reported on the use of alarm verification, with and without less sensitive detectors in college dormitories [8]. A summary of the results follows:

a. Total of 610 optical detectors calibrated to a nominal sensitivity of 1.2 percent/ft. (0.017 optical density/meter) obscuration. During the first 3 weeks 37 false alarms, about 12 per week. Alarm verification with a 60 second time delay added, false alarms reduced to 1 per week. A total of 111 false alarms were cancelled by the alarm verification. The combination resulted in a 92 percent decrease in false alarms.

b. Same detectors as in par. a. above, except the sensitivity was reduced to a nominal 2.0 percent/ft (0.029 optical density/meter) and the alarm verification delay was changed to 12 seconds. During the next 10 weeks there was only one false alarm.

c. In another dormitory 12 false alarms were obtained in 100 days from a total of 55 optical detectors calibrated to a nominal 2.0 percent/ft obscuration with no alarm verification. With verification only one false alarm was obtained in 150 days. The alarm verification time delay was 12 seconds.

d. In another installation encompassing 115 optical detectors calibrated to a nominal sensitivity of 2.0 percent/ft. obscuration, 12 alarms were obtained in 60 days without alarm verification. With verification the number was reduced to 3 in the same period, with 2 being of a questionable nature, for a reduction of 75 percent.

e. Another case involves four systems which included 631 ionization detectors calibrated to a sensitivity of 1.7 percent/ft. (0.024 optical density/meter) obscuration. During the four months without alarm verification 23 nuisance alarms were obtained. With alarm verification the number was reduced to 3 alarms in 4 months, for an 87 percent reduction. Alarm verification delay was 8-9 seconds. The remaining smoke detectors on campus, another 3500 without alarm verification, have an average false alarm rate more than 8 times higher. The assessment was made that a 2 percent false alarm rate is the practical limit for a dormitory.

2.2.6 Summary

From a review of the five studies, the following assessments can be made.

1. Smoke detectors need testing and cleaning.

2. The lower the sensitivity, the fewer the false alarms.

3. Causes of false alarms are common to many types of installations.

4. "Hardened" detectors, i.e., those which meet the new, more stringent requirements for environmental stability have resulted in a reduction of false alarms.

5. A practical lower limit on false alarms for a dormitory type occupancy is 2 false alarms per 100 detectors per year.

6. The use of an alarm verification circuit results in a significant reduction in false alarms. NOTE: The use of alarm verification must be approved by the local authority having jurisdiction since it results in delay of the alarm signal.

2.3 TECHNICAL BACKGROUND

2.3.1 Principles of Operation

A brief description of the two principles of operation employed in most smoke detectors is presented to help in understanding their susceptibility to false alarming (See Figure 1).

2.3.1.1 Ionization Type

A very small radioactive source, commonly Americium 241, is deposited in a gold-plated foil, and is secured inside the detector chamber. Alpha particles are emitted continuously creating positive and negative ions from the air molecules. An electric potential applied across the sensing chamber results in movement of these ions to the oppositely charged The level of this current is monitored by the electronic circuit of the detector.

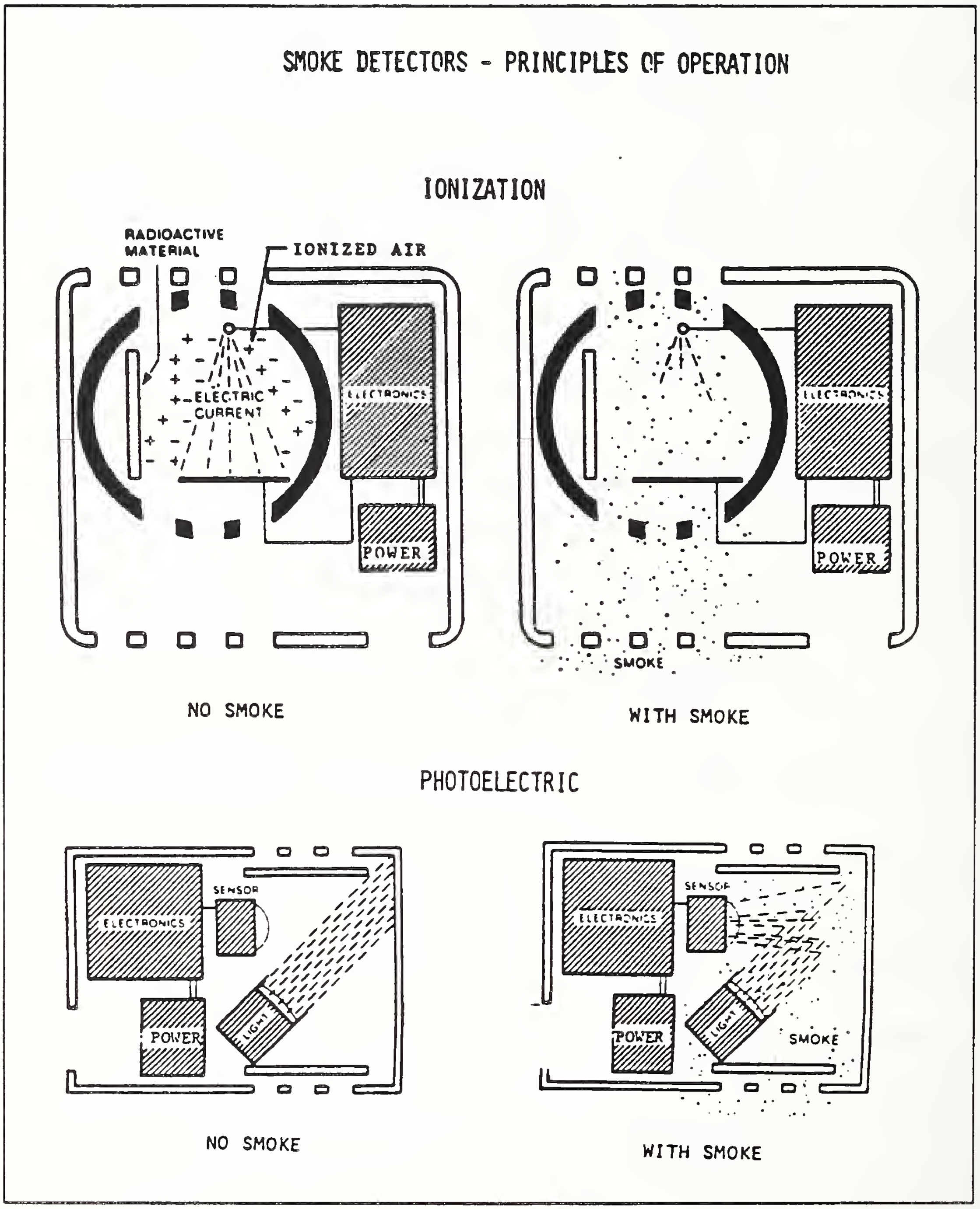

Figure 1 - Ion and Photo Principles of Operation

When smoke particles enter the chamber the ionized air molecules attach themselves to these larger particles which slows their travel and results in a reduction of the charge transfer (current flow). If enough particles enter the chamber to reduce the ionizing current below the preset threshold level, the detector will go into alarm.Any other process which reduces the charge transfer can likewise trigger the alarm. Typical examples include; steam, cooking by-products, exhaust gases, high air movement (which disrupts the ionizing current flow), a large insect which covers the radioactive source interfering with the alpha particles, or smoke particles from a cigarette or cigar.

In general, ionization detectors are more responsive to extremely small (so-called invisible) particles produced by flaming fires, the glowing end of cigarette or cooking. In most cases the user can smell the burning, but there may not be much visible smoke generated before the detector actuates in alarm. Ion detectors are superior in response to flaming fires.

2.3.1.2 Photoelectric (Optical) Type

In spot type photoelectric detectors a light source, such as an LED, is employed in conjunction with a light sensor, such as a photodiode. Both are located in a dark chamber and oriented so that the light from the LED is mostly absorbed by the black chamber interior and does not irradiate the photodiode.

When smoke enters the chamber the light is reflected from the smoke particles onto the photodiode whose conductance changes. If the change is greater than the preset threshold, the detector will alarm. Objects such as cigarette smoke, dust, steam, lint, reflection from a web or insects inside the chamber can trigger a false alarm.

Photo detectors are more sensitive to visible (larger particle size) smoke. The lighter (color) the smoke the more light is reflected and the greater the signal produced. Spot type photo detectors require several times more of black smoke to activate since black smoke absorbs light rather than reflecting it. Optical detectors are superior in response to smoldering fires, such as from a cigarette smoldering on a mattress or sofa.

2.3.2 Smoke Detector Sensitivity

2.3.2.1 Definition

Sensitivity is the measure of the response of a smoke detector. A high sensitivity denotes response to a lower concentration of smoke under identical smoke build-up conditions.

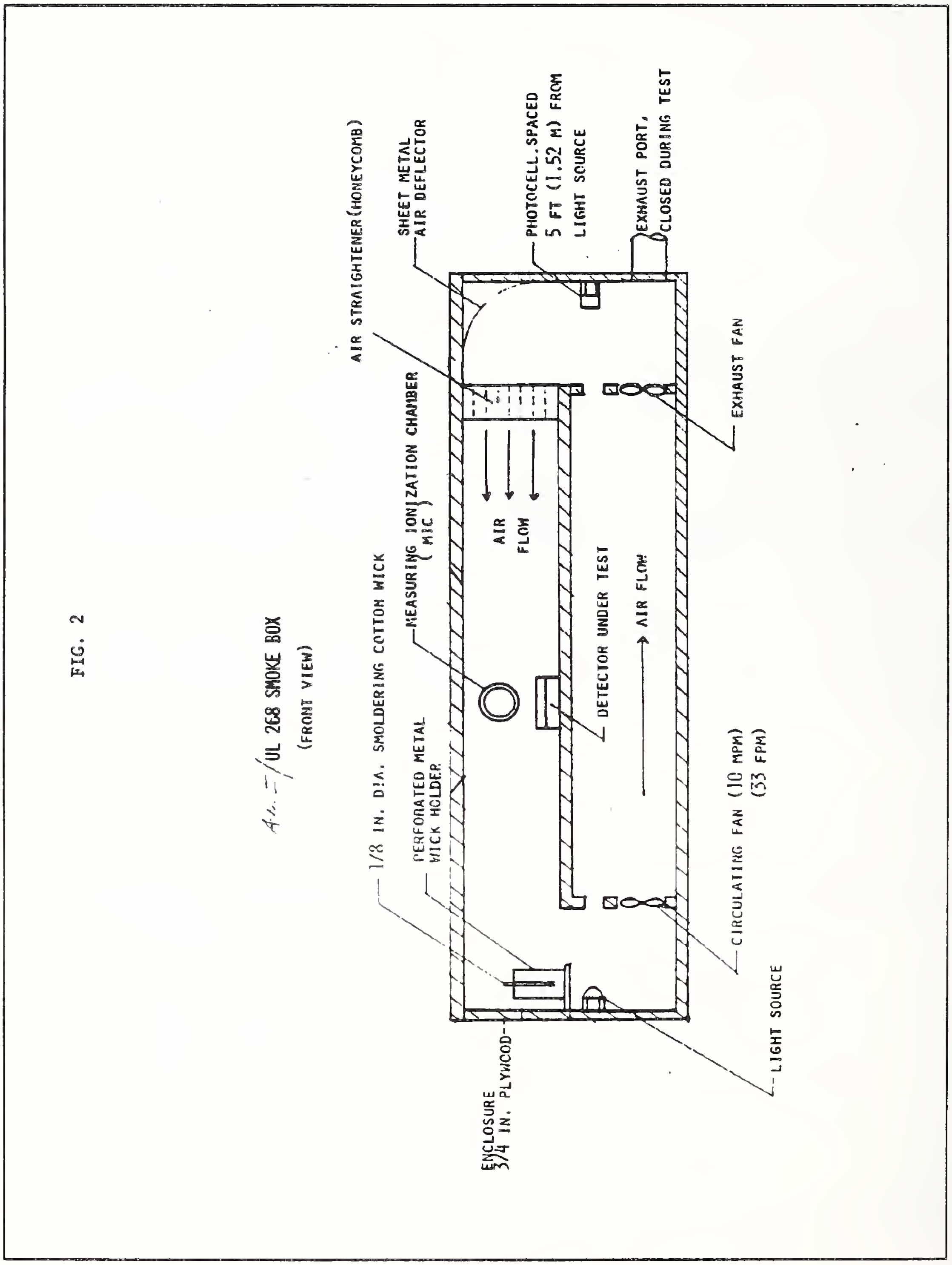

Figure 2 - ANSI/UL 268 Smoke Box

2.3.2.2 Method of Measurement

Detector sensitivity (threshold response) is measured in a smoke box under controlled ambient (23 ± 2'C, 50 ± 20 percent relative humidity, 760 ± 30 mm Hg) and air velocity conditions 32 fpm (10 mpm). Refer to Figure 2 for a cross-section of the smoke box currently used by UL for all smoke detectors.

The source of smoke for the smoke box consists of a 1/8 in. (3.2 mm) cotton wick, approximately 6 in. (15 cm) long, suspended vertically by a thin wire from the top of a perforated metal cylinder employed to minimize the effect of the air velocity on the smoldering (glowing) lower end. Two instruments are employed to measure the quantity of smoke emitted. The visible (large particles) of smoke are measured by a 5 ft. (1.52 m) optical beam, while the small particles (1 micron in diameter and less) are measured by an instrument called a **Measuring Ionization Chamber** (MIC) developed in Switzerland by a manufacturer of ionization detectors.

The detector is oriented in the smoke box so that the least favorable position for smoke entry faces upstream of the circulating air. This position is obtained after conducting preliminary measurements with the unit positioned in each of the four compass positions. The most favorable position for smoke entry is also obtained for use in tests employed to evaluate the resistance to false alarms.

2.3.2.3 Production Window

The ANSI standard ANSI/UL 268 [9] requires that a manufacturer provide 28 samples of detectors which are representative of future production. All 28 samples are subjected to the smoke box (sensitivity) test, and eventually determine the range of future production or the "window" to which the manufacturer is held if the detector complies with all requirements of the standard. A similar smoke box is required at the factory and the two boxes are correlated.

The least sensitive end of the production "window" is determined by compliance with the four flaming and one smoldering smoke tests conducted on the least sensitive samples, while the most sensitive end (closest to alarm) is evaluated with samples subjected to various stability, environmental, and electrical transient tests to see that they do not alarm or that the sensitivity is not changed by more than a prescribed amount. To further evaluate for false alarms, the four most sensitive detectors are subjected to a second smoldering test with the units oriented with the most sensitive direction for smoke entry facing the fire source. No detector is permitted to alarm prior to the smoke level in the vicinity of the detectors reaching the obscuration of 0.5 percent per foot (0.007 optical density/m). This test was developed to minimize a false alarm from the effects of transient smoking.

Assuming that the detector model complies with all of the requirements of the ANSI/UL 268 standard, the manufacturer is permitted to produce units within the sensitivity "window" which was obtained. A follow-up program is then instituted at the factory so that samples from each day's production are subjected to the factory smoke box to see that the production sensitivity is within the limits to which the detector was tested originally.

2.4 TYPES OF SMOKE DETECTORS INVOLVED IN STUDY

The following paragraphs provide a description of the three types of smoke detectors involved in this study.

2.4.1 Spot Type Smoke Detector

A spot type detector is an electronic device containing a means to detect smoke particlulates, housed within a single enclosure. Terminals and/or leads are provided for the connection to a source of power and signal processing. A heat detector may be incorporated as part of the device.

Spot type detectors are intended to be connected to a fire alarm system control unit to which evacuation sounders and other equipment, such as annunciators may be connected. They may also be used to control other fire safety systems such as for release fire doors or smoke dampers.

Spot type detectors may be used for open area protection, such as in corridors, ceiling plenums, underfloor areas of computer rooms, office areas, and the like. They provide protection for the area in which they are installed.

2.4.2 Duct Type Smoke Detectors

Duct type detectors consist of smoke detecting assemblies installed directly inside heating ventilation and air conditioning ducts or mounted inside a housing which is mounted on a duct. The latter are provided with sampling tubes which extend into and sample the air in the duct. The main function of a duct detector is to deenergize the ventilating system or close a smoke damper to prevent the distribution of smoke from a fire through the ducts.

2.4.3 Door Holder Closer Smoke Detector (DHC)

A door holder closer detector consists of a smoke detecting module mounted within a door holder closer commonly used on fire doors. Holes in the DHC enclosure permit the entry of smoke. The main function of these detectors is to release the door to which they are connected.

2.4.4 Age of the Smoke Detectors

Many of the smoke detectors installed in the VAMCs were installed as long ago as 1974; Table 2 includes data on dates of installation. We found that many of the models are obsolete and are no longer being manufactured.

2.5 SMOKE DETECTORS - SHARED RESPONSIBILITY

Unlike other types of electronic appliances, such as a radio where failure results in an inconvenience, a smoke detector is expected to operate reliably to detect a hostile fire situation years after it has been installed. This reliability concept extends for the full life of the product, from its design and fabrication, through its test evaluation, installation, testing, and maintenance.

Unlike other fire alarm initiating devices (heat detectors, manual stations) and sprinklers which require little maintenance, smoke detectors need periodic testing and cleaning. The tradeoff for rapid response to an incipient fire condition is the occasional occurrence of a false alarm, the number of which depends on the detector design, sensitivity, and the degree of testing and maintenance implemented after installation.

The procedures described below relate primarily to engineered smoke detector systems where the manufacturer or his representative (distributor) are involved with the contractor and inspection authority in the final acceptance testing. Such is envisioned by the newly-published manual of Testing Procedure for Protective Signaling Systems, NFPA 72H [10].

Several entities are involved in this shared reliability effort which are described in the following paragraphs:

2.5.1 Manufacturer

The largest share of responsibility falls on the manufacturer since it is he who designs and fabricates the detector with the intention of making a profit. The unit is required to operate reliably under the conditions in which it is to be installed. Extra care is needed to assure that each unit manufactured will function properly when called on to do its job. While nothing being made is 100 percent perfect, the manufacturer is responsible for implementing a stringent quality assurance program to determine that each unit that leaves the factory will operate as intended. This includes screening of the components employed in detectors and testing of the finished product.

The manufacturer also must insure that the detector can be installed in compliance with installation codes and practices in effect at the time. Detailed testing and maintenance (cleaning) instructions should be provided with each unit to assure maintaining of the reliability concept after the unit has been installed. The testing procedure should include a description of the method by which the sensitivity of the detector can be measured bi-annually as required by Par. 8-3.4.2 of NFPA 72E [11]. The cleaning instructions should include a procedure to wash the grime and dirt inside and outside the chamber or provide data on available service companies who can do the job. For detectors which are restricted to use with specific control units, such as 2-wire or so-called "smart detectors," the compatibility aspect should be highlighted in the instructions to prevent misuse.

The manufacturer or his representative are obligated to provide a person knowledgeable with the detector operation for the final acceptance testing required by the local inspection authority.

If a detector manufacturer has no control over the end distribution of his product, other than the distributor to whom he sells, then he is obligated to provide sufficient and clear information to the persons who purchase his detectors. This information should cover proper installation codes and practices, including final acceptance testing of the installed detectors, to minimize misapplication.

In addition, a smoke detector manufacturer is obligated to stand behind his product so that if unit(s) do not perform as intended, the manufacturer will cooperate with the user in resolving any problems that arise, including excessive false alarms. To facilitate this, each manufacturer should provide a toll-free "hot line" telephone number over which a user can report problems and obtain assistance.

2.5.2 Testing Laboratory

The testing agency to whom the detector is submitted for performance evaluation, has the responsibility of evaluating the detector for compliance with the latest requirements of the standard in effect at the time. If requirements need updating because of reports from the field or other reasons, steps should be initiated to include such requirements provided there is technical justification. ANSI/UL 268 standard, which is currently used in the evaluation of smoke detectors, is revised after proposals have been discussed and reviewed with manufacturers, inspection authorities, and anyone having an interest in the subject. An effective date for adoption of new and revised requirements is then established and all subsequent production is required to be in compliance with the changes made.

Persons involved in the development of a performance standard are also required to be familiar with related installation codes so there is no conflict between adopted requirements and acceptance of an installation by local authorities having jurisdiction.

2.5.3 System Designer

In theory the design of a fire alarm (smoke detector) system is supposed to be done by a fire protection engineer, or person having broad experience with smoke detector layouts, taking into consideration the (1) principle of operation,(2) sensitivity level, and (3) environmental conditions anticipated in the installation. Typical examples include:

(a) a smoke detector with a high sensitivity should not be located on a low (7-8 ft.) ceiling of a typical hotel elevator lobby, since people can be expected to smoke in such areas, resulting in false alarms

(b) ionization detectors should not be sited in areas of high air velocity, such as near entrance doorways, or in areas where engine exhausts or cooking by-products would likely be generated, and

(c) smoke detectors should not be installed near sources of steam or dust, such as laundries and linen closets, which could cause false activation. Photo detectors would not be suitable in an area where black smoke would be emitted from flammable liquids.

It is further theorized that the system designer employs the latest nationally recognized guidelines on installation of smoke detectors, as well as any regional, state, or local codes for the area in which the installation is to be located.

It is the responsibility of the designer to determine that smoke detectors which are intended for use only with specific equipment, such as control units, are specified as such.

2.5.4 Contractor

The contractor is responsible for installing the system in accordance with the specifications drawn up by the system designer and in compliance with wiring codes for the area, and testing of the system for acceptable operation. He should not be permitted to substitute alternate detectors since he is not familiar with the nuances involved with detector location and principles of operation. His representative should also be available for the final acceptance testing of the system.

2.5.5 Local Inspection Authority

The responsibility of the local inspector is to determine that the various components which comprise the fire alarm system bear the mark of an acceptable test laboratory, if required, and have been installed in compliance with the local wiring code, as well as any regional or state codes in effect at the time. The inspector should also check that the equipment installed is as specified in the layout drawing of the detector designer. He also has the responsibility of establishing a date for acceptance testing of the system and coordinating this with the contractor and manufacturer.

Inspection authorities should be specifically trained in the operation and use of fire detectors and fire alarm systems.

2.5.6 User

The user likewise has his share of the responsibility for the smoke detector since it is he who will benefit the most from the system by minimizing his losses from fire. Instructions on testing and cleaning accompany the detector. If the instructions are not followed, problems will occur. Currently the state of the art in smoke detector design is such that they need periodic testing and cleaning and it is the responsibility of the user to either have his people do it or have a service contract with an outside agency to do it for him. The user should also educate his people regarding smoking and housekeeping practices intended to minimize false alarms in areas where detectors are installed.

2.5.7 Installation Standards

An organization which promulgates an installation standard has the responsibility to provide clear, concise siting data to assist the designer in the proper layout of detectors, information on method and frequency of testing and cleaning and any other procedures to maintain a system. Siting data should include specific information on locations where detectors would not be suitable because of the likelihood of false alarms. Advantages of one principle over another for a particular location or environmental condition should also be described.

The information should be tailored to the level of understanding of the people who will use the code to minimize the chance of misinterpretation. The committee members are presumably all experts on the subject, but at times the language developed by experts, although it may be understood by themselves, may not necessarily be comprehended by the people who use the code. Accordingly, it is very important that the language in the standard address the understanding of the least experienced person who will use it, taking into consideration that it may be a person with only rudimentary knowledge on the subject.

3. APPROACH

3.1 OBJECTIVES

The overall objective of this study is to identify ways to reduce the rate of false alarming at VA Medical Centers and elsewhere, by improving the operation and reliability of smoke detectors and smoke detector systems. This is divided into the following four sub-objectives:

1. Identify the causes of false alarms.
2. Identify appropriate remedies.
3. Coordinate needed product changes with manufacturers.
4. Coordinate any design and standards changes with appropriate organizations.

Subobjectives 1 and 2 have been completed for the VAMC study. Some of the changes in Subobjectives 3 and 4 are presently in the process of being implemented, while others are included in the RECOMMENDATIONS (Section 8) portion of this report.

3.2 DEFINITIONS

Early in the study, we found that there was no consistent definition of a false alarm either within the industry or among users. In considering appropriate definitions, two seemed necessary; an engineering definition which would be included in a performance or installation standard, and another from the viewpoint of the fire department.

3.2.1 Engineering Definition: A FALSE ALARM IS A FIRE ALARM SIGNAL RESULTING FROM: (1) PARTICLES OF COMBUSTION, SUCH AS SMOKING, COOKING, ENGINE EXHAUST, CONSTRUCTION AND MANUFACTURING PROCESSES, AND THE LIKE, WHICH ORIGINATE FROM A NON-HOSTILE FIRE SITUATION, (CONTROLLED COMBUSTION), OR (2) THE EFFECT OF AN ENVIRONMENTAL PHENOMENON, SUCH AS STEAM, DUST, HIGH AIR VELOCITY, INSECTS, AND THE LIKE, WHICH IMPACTS ON THE PRINCIPLE OF OPERATION, OR (3) FAILURE OF AN INTERNAL COMPONENT.

3.2.2 Fire Dept. Definition: A FALSE ALARM IS ANY FIRE ALARM SIGNAL UNRELATED TO A HOSTILE FIRE SITUATION WHICH RESULTS IN RESPONSE OF FIRE DEPARTMENT EQUIPMENT.

3.3 DATA BASE FOR STUDY

3.3.1 Data Sheets

The study began with a review of information gathered by VA headquarters from questionnaires circulated to all VA Medical Centers (VAMCs). The data requested included the following:

a. Number of detectors and date installed.
b. Locations where detectors are installed.
c. Identification of the detector by manufacturer, model No., and principle of operation (ion or photo).
d. Control unit (model number) to which detectors are connected.
e. Number of false alarms over the preceding year.
f. Probable causes of these false alarms.
g. Number of fires to which detectors responded over the same period.

After reviewing this initial information, the need for more detail became apparent. Thus, a Supplementary Information sheet was prepared and distributed to the VAMCs. Copies of the initial questionnaire and Supplementary Information sheet are reproduced as Illustrations A and B.

3.3.2 Visits

Twenty medical centers were visited during the course of the study. The hospitals selected included a cross-section of the various facilities operated by the VA. Facilities with a range of reported false alarm experience from few to many were visited in an effort to determine the reasons for the variations. Medical centers in both rural and urban areas were visited, as well as hospitals which included general care, a mixture of general care and psychiatric patients, and those which were strictly for psychiatric care. Most facilities have a number of smoke detector-protected buildings not all of which are medical use. Thus, other occupancies such as residential, office, and storage buildings are also included in the study. Manufacturers of the detectors installed in the facility were invited to accompany us on our visit to see first-hand how their equipment was performing.

Discussions were held with the personnel responsible for the smoke detectors, covering such subjects as testing, maintenance and cleaning, effect of environmental conditions, detector sensitivities, smoking policies, areas of misapplication, problems they encountered, and their recommendations on how to reduce false alarming. This exchange of information was most helpful since it provided data on actual "real world" conditions that exist in the field, and which cannot always be anticipated in the laboratory.

3.3.3 Samples for Tests

During the visits to the VAMCs, detectors were selected and shipped to NIST where they were subjected to a detailed examination. The sensitivity was measured before and after a cleaning operation as recommended by the manufacturer. Some detectors considered as "Defective" were also checked for operation and sensitivity.

ILLUSTRATION A. SMOKE DETECTOR FALSE ALARM DATA SHEET*

VAMC: ____________________

Type of Smoke Detector:

Manufacturer ____________________
Model No. ________________
Manufacturer of Control Panel for Detector ______________
Photoelectric or Ionization _______________
Date Installed (Month/Year) _______________

Detector circuitry: 2 wire ____ or 4 wire ____ (check one)
Note - 4 wire is separate conductors for power and 2 for alarm initiation.

Total Number of this Detector ____

Building No. _____

Occupancy Type of Building ____________________________________

Location of Detector: (Indicate total number of detectors at each location)

Corridors ____
Elevator Lobby ____
Elevator Shaft ____
Smoke Barrier Doors ____
Ducts ____
Computer Room ____
Kitchen ____
Waiting Areas ____
Elevator Machine Room ____
Transformer Vaults/Switchgear Room ____
ICU Suite ____
Patient Room ____
Shops ____
Other ______________ (Please Indicate)

Approximate number of false alarms for this detector (previous year to date):
____

Probable cause of false alarms: (Check one or more)**

Transient Smoke ____
Construction Dust ____
Radio Frequency ____
Unknown ____
Humidity ____
Wind Velocity ____
Lack of Cleaning ____
Defective Detector ____
Insects ____
Transient Electrical ____
Malicious ____
Other ______________ (Please indicate)

Number of actual fires detected with smoke detector (previous year to date):
____

Comments: ____
____
____
____

* Fill out one sheet for each type of detector for each building

** Indicate total number of false alarms for each cause if this information is available

ILLUSTRATION B. SUPPLEMENTARY INFORMATION SHEET - SMOKE DETECTOR FALSE ALARMS

VA MEDICAL CENTER ______________________________ Date __________

Person to contact for questions ______________________ Tel. __________

PLEASE FILL IN THE REQUESTED INFORMATION AS ACCURATELY AS POSSIBLE OTHERWISE THE DATA WILL BE MEANINGLESS AND WILL RESULT IN A DISTORTED ASSESSMENT.

1. Which type(s) of detector, if any, when actuated in alarm, does not result in one or both of the following actions:

   a. Sounding of the fire alarm system evacuation signals ________________

   b. Automatic response of the fire (brigade) department ________________

2. Smoking Policy: Strictly enforced ___ Moderately enforced ___ Not enforced ___

3. Testing Schedule ________________ How tested ________________

4. Cleaning Schedule ________________ How cleaned ________________

5. Type detectors not included in testing or cleaning schedule ______________
   Explain ____

6. Action taken when insect(s) causes an alarm ________________________
   Type insect(s) ____

7. Action taken with unit that alarms from unknown cause ________________

8. False Alarm Comparison - Different Conditions: Include any differences noted in false alarm rates between the indicated conditions and the model number that applies.

   A. Daytime vs. Nighttime (10 pm - 6 am)____________________________
   ____

   B. Winter vs. Summer ____
   ____

   C. Air Conditioned vs. Non-A/C Buildings __________________________
   ____

   D. Low (7-8 ft) vs. High (over 8 ft) Ceilings ______________________
   ____

   E. Low vs. High (over 85%) Relative Humidity ______________________
   ____

   F. Before Cleaning vs. After Cleaning ______________________________
   ____

9. Indicate the 3 main locations (Example: corridor, elevator lobby, elevator shaft, etc.), with related causes, from which the greatest number of false alarms originate. Highest No. first

Location (1) ____________________ (2) ________________ (3) ______________
Cause(s) ____________________ ________________ ______________

10. False alarm difference between ion and photo detectors ____________________
Any preference? _______________________ Explain _________________________

11. Is false alarm rate from present system satisfactory? _____________________
If not, explain ____

12. Recommendations for reducing false alarms in smoke detectors ______________
____
____

PLEASE RETURN FILLED-OUT SHEETS DIRECTLY TO: Mr. Peter M. Dubivsky, UL Research Associate, National Institute of Standards and Technology, Center for Fire Research, Building 224, Room A241, Gaithersburg, MD 20899.

Telephone: AC 301-975-6875 FTS 879-6875

4. RESULTS

4.1 RESPONSE TO DATA COLLECTION EFFORTS

The data presented in this section were compiled from data sheets distributed by VA Headquarters to the 172 VA Medical Centers (VAMCs) currently in operation. Of the 151 that responded, 133 provided valid data, 10 provided data which were considered insufficient to make any kind of assessment, and 8 sent letters indicating that they did not have a false alarm problem.

A problem observed with some of the information provided regarded the smoke detector identification by manufacturer and model number. Not all detectors could be correctly identified for one reason or another. In some instances the model number was incomplete, or a detector base number was provided which is capable of use with several detectors heads, or the model number provided did not correspond to the identified manufacturer, and the like. Many of the detectors included the name of private labelers - usually the producer of the system control unit - who do not manufacture the detector but are permitted to use their name on the product. In many of these cases the original manufacturer could not be identified. In two cases the detector manufacturer had gone out of business. Telephone calls were made to VAMCs and detector manufacturers but the required information could not always be obtained because the detectors were too old, obsolete, or a change in personnel had occurred.

4.2 SUMMARY OF PRINCIPAL FINDINGS

During the course of the study it was determined that two principal factors play a major role in the rate of false alarms; (1) the design and sensitivity of the detector, and (2) testing, cleaning, and operational procedures instituted at the various VAMCs. High false alarm rates result from a highly sensitive detector coupled with a lack of testing and cleaning. A VAMC with lower sensitivity detectors and a regularly-scheduled cleaning and testing program had fewer false alarms.

In order to reduce the rate of false alarming, letters were sent to those manufacturers whose detectors had experienced high alarm rates. They were asked to contact the VAMCs where their detectors were installed and make an effort to reduce the false alarming rate. This reduction could take any of several forms, such as advice on cleaning and testing, reduction of sensitivity, replacement of detectors, relocation, or removal because of misapplication.

A number of lessons were learned through this study which necessitate changes in requirements of existing performance and installation standards, for incorporation into new generations of smoke detectors. Such information has been brought to the attention of the manufacturers through industry associations, such as the National Electrical Manufacturers Association (NEMA). Automatic Fire Alarm Association (AFAA), and to the attention of Underwriters Laboratories Inc. (UL), which is a nationally recognized testing agency who developed ANSI/UL268, Standard for Smoke Detectors for Fire Protective Signaling Systems. The National Fire Protection Association (NFPA) was notified indirectly through UL's Industry Advisory Conference and Fire Council and through NEMA and AFAA meetings. Members of these two bodies serve on NFPA committee 72E, which has jurisdiction for writing an installation code for automatic fire detectors.

This study also concerns itself with identifying factors that result in false alarms. Typical examples include the improper installation, and selection of detectors. There are two primary types of smoke detectors in current use; the optical type, and the ionization type. Each principle has its strong points and shortcomings. As an example ion detectors can be affected by air velocities over 300 fpm (91 mpm), but are very responsive to the small particles emitted from flaming combustion or cooking. Optical detectors are very responsive to large particles, such as from a smoldering fire, but lose much of their effectiveness when subjected to the small particles.

Since detector components and chambers are open to the environment, periodic cleaning and testing are needed to maintain reliability of operation. The frequency of testing and cleaning required are also unknown factors which needed to be addressed.

4.2.1 Origin of the False Alarm

Before blaming the detector, a determination needs to be made whether the false alarms stem from that device or if they are caused by the control unit to which the detectors are connected. False alarms can arise from the panel if there is an electrical incompatibility between the detector and control unit or if the design of the control unit is such that it is affected by electrical transients. For example, there are documented cases where alarms were produced by signals from walkie-talkies, public address systems, or central clock systems inducing sufficient signal in the initiating circuit wiring. While no such cases were found in this study, the facilities were asked to verify that a smoke detector was in alarm before resetting the system.

4.2.2 Observations of False Alarm Factors

Some of the false alarm causes seem obvious. Others have been grouped into families to reduce the list to a manageable number. The following discusses each of the causal categories which were included on the data sheets.

4.2.2.1 SMOKING: Smoking by patients, and sometimes staff and construction workers, is a common problem. Although a false alarm can occur from a single person smoking directly under a detector mounted on an 8-ft. or lower ceiling, this occurs only if the detector sensitivity is fairly high (less than 1 percent per foot - 0.015 optical density per meter). Most false alarms stem from the smoke from two or more persons congregating near a detector. In general, if the sensitivity of an ion and photo detector are equal, the photo detector would be more likely to alarm since it is more responsive to the large, visible smoke particles generated by cigarette smoking. On the other hand, the ion detector would be more responsive to the smaller so-called "invisible" particles emitted from the burning end of the cigarette. If either type of detector has not been cleaned, and a film of dust has accumulated inside the chamber, the detector sensitivity can be increased still further, taking less smoke to produce an alarm.

4.2.2.2 DUST: In most instances it was not possible to identify the source of the dust when the CONSTRUCTION DUST cause was indicated on the form. It might be related to ordinary in-house dust generated from cleaning operations, such as sweeping or dusting. In most instances, however, there was no differentiation between house dust and construction dust. Construction dust can be produced by demolition operations as well as from sanding of newly-installed wall board, etc.

The dust is viewed by the detector in the same manner as smoke particles. In an ion detector the dust particles reduce the ionizing current while in a photo type the light is reflected off the dust particles the same as for smoke particles. Dust is also a major factor in increasing the sensitivity of a detector. In an ion detector the dust, in combination with grease in the air, coats the radioactive source. This reduces the emission rate of the radioactive particles, reducing the ionizing current and increasing the sensitivity. If the accumulation is great enough the emission is reduced to a point where the unit produces an alarm. In a photo unit the dust settles and coats the darkened optical chamber so it becomes more reflective for the light source. With a greater accumulation the reflected light is sufficient to produce and alarm.

4.2.2.3 HUMIDITY: Two main sources of high humidity are observed. One source stems from internally created environments, such as near showers, sources of steam, laundries and kitchen areas. The second source is associated with hot humid weather, usually occurring during the summer months. High humidity is also encountered during late Spring or early Autumn when many VAMCs have not started their air conditioning systems.

Many of the detectors included in the study are older models which had been subjected to an 85 percent relative humidity test in the course of their evaluation under a testing agency compliance program. The requirement has since been increased to a 93 percent relative humidity level.

The threshold response level of any detector can be increased by moisture condensation on the components and the printed wiring board. Very high impedance circuits are involved so that a small leakage path between circuits created by the humidity could have a large effect on the response level. This is further compounded if there is an accumulation of dust on the board and components, since the impedance path is lowered still further.

4.2.2.4 HIGH AIR VELOCITY: Only ionization type detectors are affected by air flow changes through the chamber area. While the extent of the effect depends on the design of the detector chamber, the high air flow carries ions out of the chamber before they can reach the electrode and give up their charge. This results in reduction of the steady state (quiescent) current. The greater the air velocity the greater is the current reduction, and the greater the possibility of a false alarm. Newer "Unipolar" designs are not affected as strongly as the older "bipolar" designs. Photo detectors are not affected by high air velocity except when it is accompanied by dust.

4.2.2.5 DEFECTIVE: Discussions with VAMC personnel disclosed that this seems to be a "catch all" category. In some instances the reason is obvious, such as failure of a defective component, or the unit did not test properly. However, most of the reasons given were that a detector false alarms, is reset, and produces a subsequent false alarm a short time (up to a week) later. Sometimes the detector is cleaned after false alarming. For many, depending on the expertise of the personnel responsible for the maintenance of the system, it is easier to replace a detector than to check further. Lack of familiarity with cleaning procedures is probably a contributing factor.

4.2.2.6 TRANSIENT (Electrical): Some older detectors have insufficient protection from electrical voltage transients induced from lighting strikes, or the operation of electrical equipment in the facility. Usually a small time delay, either in the detector, or in the control unit is sufficient to prevent false triggering. Some false alarms have been caused by the radio frequency (RF) generated by "Walkie Talkies" and cellular radios. Requirements in ANSI/UL 268 have been strengthened to test for such phenomena.

4.2.2.7 LACK OF CLEANING: This cause is usually associated with a gradual increase in the incidence of false alarms. Over a period of time detector sensitivities are increased from an accumulation of dust and dirt until it takes very little smoke to set them into alarm. Following the cleaning the number of false alarms is often reduced.

4.2.2.8 INSECTS: Many of the older detectors do not have insect screens or other deterrents to prevent insects from entering a detector chamber, either through the area where smoke enters, or through the back of the detector where openings are provided for electrical connections. In photo detectors, spiders weave a web inside the dark chamber from which the light is reflected (same as for smoke) onto the receiver. If the web is small enough the detector does not go into alarm, but the sensitivity is increased. Other types of insects which have been reported to have caused false alarms include mites and carpet beetles. Ion detectors have been actuated by larger insects, such as roaches. The roach either interferes with emissions from the radioactive source or disrupts the level of the ionizing current.

Current requirements specify maximum openings of 0.050 in. (1.27 mm) which is comparable to a window screen opening. In addition, the back of the detector is required to be sealed against the entry of insects. If the openings were to be reduced further the entry of smoke from a fire could be inhibited.

4.2.2.9 STEAM: Condensed steam, which is viewed by detectors as equivalent to white smoke, originates from several sources: (1) Near showers or in lavatories, (2) near kitchen washing facilities, (3) in laundry facilities, (4) from sterilizers, and (5) from leaks in steam heating pipes located in mechanical and equipment rooms. The last source is actually a beneficial alarm since it calls attention to a potentially dangerous condition.

4.2.2.10 CONSTRUCTION WORK: False alarms attributed to this category have been identified as originating from sources related to various construction processes, including welding, soldering, sanding, use of machine tools, and painting. Ion type detectors are usually more sensitive to such sources, but where a large quantity of visible products are emitted; such as during soldering and sanding operations, either type will actuate. Construction is an ongoing process at many VAMCs, either for new additions, or revisions to existing facilities.

4.2.2.11 HOUSEKEEPING: This cause stems from such housekeeping chores as, sweeping, washing, waxing/buffing floors, using cleaning solvents, use of spray aerosols, fumigating operations, and related building maintenance work. In most cases ion detectors respond since there is no appreciable amount of visible smoke emitted.

4.2.2.12 COOKING AND BAKING: In addition to particulates emitted from cooking and baking operations, this category includes such related causes as making popcorn, toast, etc. Ion type detectors are more susceptible to such processes since very little visible smoke is usually emitted.

4.2.2.13 OUTSIDE FUMES: Particles of combustion generated outside of the building can be drawn into the building, either through an open window, or through the air intakes of the air-conditioning system, with the latter setting off duct installed detectors. Some typical examples include; incinerator smoke, particles of combustion from outside fires, exhausts from automobile and lawnmower engines.

4.2.2.14 INSIDE FUMES: Includes sources such as fumes from laboratory experiments, cleaning fumes not related to housekeeping, etc. These could actuate either ion or photo detectors, depending on the amount of visible smoke generated.

4.2.2.15 WATER: Covers water entering the detector from any source, for example from a pipe or roof leak, or from condensation. Either ion or photo detectors could be involved.

4.2.2.16 MALICIOUS: When the smoke detector is actuated deliberately, whether from boredom, antagonism, or whatever.

4.2.2.17 MISCELLANEOUS: Covers any sources not described previously. Some examples include: lint in a linen closet, humidifier breakdown in an air-conditioning system, accidental actuation by maintenance personnel, and the like.

4.2.2.18 UNKNOWN: Any non-identifiable cause for a detector actuating, or one that could have been any of the previously described sources. The detector is sometimes checked but in most cases is simply reset. Smoking is usually cited as the suspected cause.

4.2.2.19 COMBINATION OF FACTORS: In all probability a large number of false alarms can be attributed to a combination of contributing factors, such as dust, air velocity (ion only), humidity, and insects, all of which affect the sensitivity of the detector. A small amount of dust increases the sensitivity a small fraction, air velocity increases it still further until the detector may be very close to the alarm threshold level. At that point it may take only a small amount of smoke or combustion particles entering the chamber to trigger an alarm. The sensitivity setting of the detector also plays a major role.

4.3 EFFECT OF SENSITIVITY ON FALSE ALARM CAUSES

4.3.1 General

As defined in ANSI/UL 268, sensitivity is the relative degree of threshold response of a smoke detector. A high sensitivity denotes response to a lower concentration of smoke than a low sensitivity (higher numerical value) under identical smoke build-up conditions.

While not mentioned as a specific cause of false alarms, the sensitivity of a smoke detector is considered the most important underlying factor for all false alarm causes. The factory calibrated sensitivity setting determines the smoke level at which a detector will respond. The higher the sensitivity setting the less smoke is needed to trigger it into alarm. For a low setting, more smoke and a larger fire are needed to set it off. It is therefore reasonable to assume that, since the major current problem with smoke detectors is false alarms, a lower sensitivity calibration will reduce the likelihood of a false alarm. In addition, the lower the setting, the less impact is made on the sensitivity by action of environmental (dust, humidity, insects) and electrical factors (voltage variations, transients) and the like.

In most cases the sensitivity of a smoke detector will increase from exposure to an adverse environmental condition in which it is installed. Factors which can impact on a permanent basis include installation in an environment of high air velocity (ion only), continual high humidity, dust, grease accumulation from cooking or similar byproducts, corrosive fumes and gases such as CO_2 and SO_2, acid fumes, and the like.

If the sensitivity of a detector is high to begin with, as measured under controlled temperature and humidity conditions, and then is further increased after being installed, it will not take very much smoke or products of combustion to set it into alarm. This has occurred with several detector models included in this study, unfortunately models with the greater number of units installed.

4.3.2 Requirements of Performance Standards

ANSI/UL 268, STANDARD FOR SMOKE DETECTORS FOR FIRE PROTECTIVE SIGNALING SYSTEMS, contains the performance requirements against which all of the detectors in this study have been evaluated. This standard requires that the sensitivity of a detector be calibrated within the range of 0.5 percent per ft. (0.0072 optical density/meter) and 4.0 percent per ft. (0.058 optical density/meter), when measured in a smoke box under controlled temperature and humidity conditions and using gray smoke generated from a cotton wick. In addition to these maximum limits, a limiting range of sensitivity is established for each detector model as part of the laboratory testing process. Known as the production window, this is obtained from the range of sensitivity values which pass the full series of tests prescribed in the standard.

Fig. 3 illustrates sensitivity limits with which a detector is required to comply and also shows examples of production ranges (windows).

Many smoke detectors which are included in this study were evaluated under a previous edition of the ANSI/UL 268 standard when the maximum permissible sensitivity was 0.2 percent per ft. obscuration (0.003 optical density/meter). In view of this many detectors have sensitivities which exceed the current 0.5 percent requirement which became effective on March 1, 1985.

The standard recognizes the fact that, depending on the risk involved, there is a need for both highly-sensitive and insensitive detectors. In theory the installation of smoke detectors is intended to be engineered by a qualified fire protection engineer, using nationally-recognized installation codes, such as NFPA 72E. For example, a highly sensitive detector would be installed in a computer room, where smoking is usually prohibited, while an insensitive unit would be installed in areas where there is occasional background smoke, such as an elevator lobby. Unfortunately, this theory has not been practiced, with resulting misapplications which have contributed to the overall problem.

4.3.3 Production Windows

The lower section of Fig. 3 illustrates ten production windows of various widths. These windows are those assigned to smoke detectors involved in this study. The number of detectors of each model are included in the column on the right hand side.
Production windows of 5 ion and 5 photo detectors are shown. The numbers over the center line of each window indicate the nominal production sensitivity settings strived for in the calibration of the detectors at the factory. The middle of the window is usually selected to minimize production time spent in calibration of each unit and to allow for component tolerances. However, actual production sensitivities may vary from the nominal, depending on the time spent in calibrating, the method of calibration, and the quality of components used. In follow-up testing at the factory, any sensitivity measured on the test samples, which is within the limits of the production window, is acceptable.

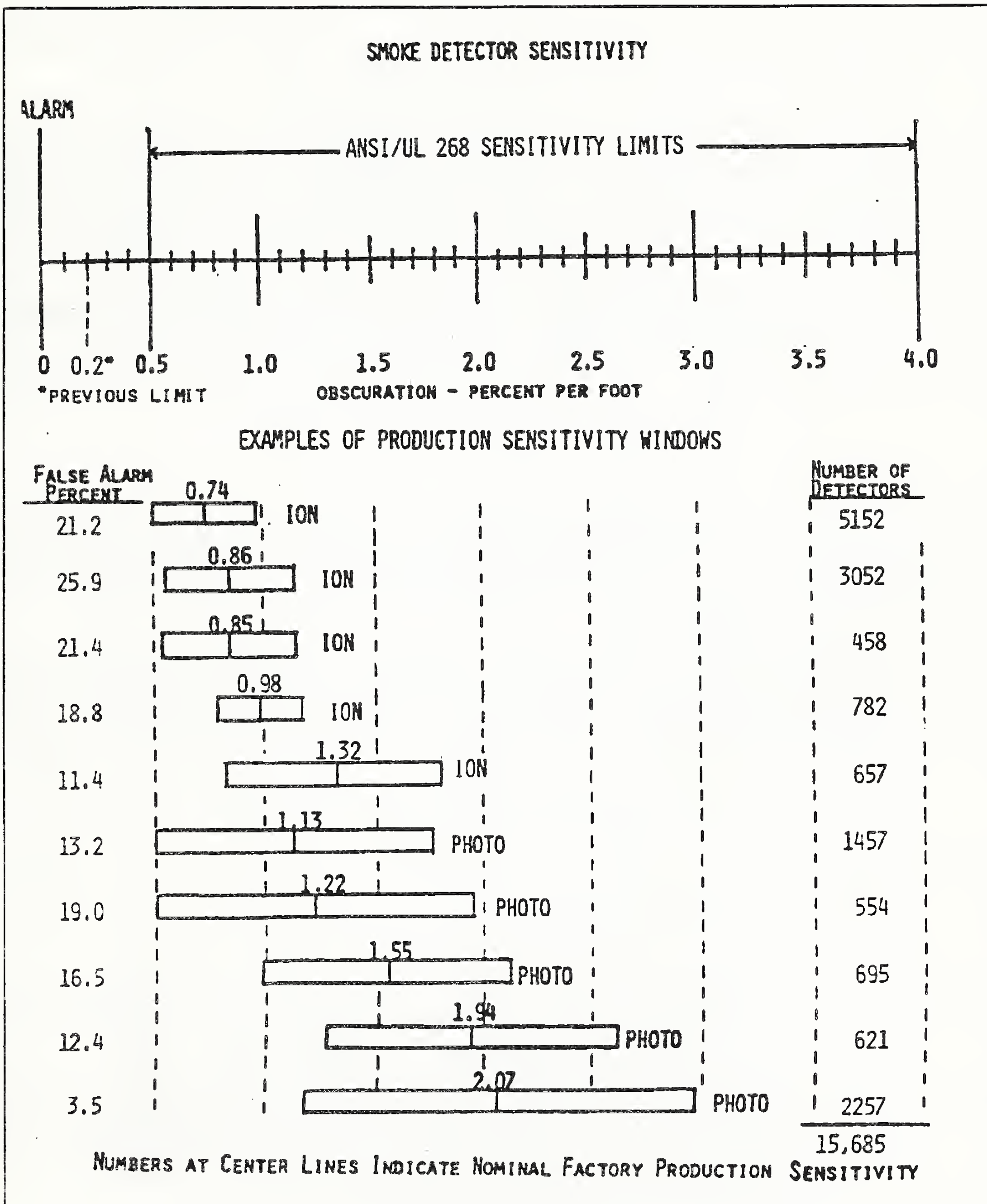

Figure 3 - Smoke Detector Sensitivity and Production Windows

For example, on the topmost ion detector, a measured sensitivity of a production sample could have been as high as 0.48 percent per ft. obscuration (0.007 optical density per meter), or as low as 0.98 percent per ft. obscuration (0.014 optical density per meter). This particular detector complied with the previous edition of ANSI/UL 268 when the maximum permissible sensitivity was 0.2 percent/ft. (0.003 optical density/meter).

All manufacturers, when having their units evaluated for compliance with ANSI/UL 268, strive to obtain as wide a production window as possible to permit a greater flexibility in production calibrating procedures, but it is the detector design which determines the limits. As mentioned earlier in this report ANSI/UL 268 includes tests which establish the limit at the high sensitivity end, and flaming fire and smoldering tests which determine the limit at the insensitive end. It is always at the low sensitivity end of the window where the most difficulty is experienced and where the inherent design of the detector circuit and chamber determine the superiority of one model over another. Ion detectors experience the most difficulty in complying with the smoldering tests but provide excellent response to the flaming fire tests. Photo detectors have no problem with response to the smoldering tests but have the most difficulty in responding to the black smoke fire and smoke box sensitivity tests.

4.3.4 Relation of Sensitivity to False Alarms

The column to the left of the production windows of Fig. 3 includes the actual percentage ratios of false alarms (Number of false alarms per 100 detectors per year) for smoke detectors in this study. Although there are variations from the norm because of factors other than sensitivity, mostly attributed to detector designs, in general, THE LOWER THE PRODUCTION SENSITIVITY, THE FEWER THE FALSE ALARMS.

While the concept of fewer false alarms with lower sensitivities is expected, and is considered the major reason, other factors, such as the effects of dust, air velocity, humidity, transients, corrosion, also contribute to false alarms and it is the electric circuit and physical design of the detector which determine the degree to which a unit is resistant to these other deceptive phenomena.

4.3.5 Nominal Production Sensitivities vs. False Alarm Percentages

Fig. 4 shows a comparison of nominal production sensitivity settings vs. the false alarm rates (percent of installed detectors which will false alarm in a year) for the same detectors included in Fig. 3. The numbers represent the number of detectors of that type.

The curve clearly illustrates that the lower the nominal production sensitivity setting, as represented by the higher numbers, the fewer the numbers of false alarms. The top two ion models of Fig. 3, with the greatest number of installed detectors, exemplify the greatest percentages of false alarms.

In Figure 4, the two horizontal dividing lines, one at the 1.0 and the other at the 1.5 percent per ft. obscuration levels (0.014 and 0.022 optical density/meter), are included to segregate the nominal production sensitivities into three zones; (1) production sensitivities below 1.0 percent per ft. obscuration, (2) production sensitivities between 1.0 and 1.5 percent per ft. obscuration, and (3) production sensitivities greater than 1.5 percent per ft. obscuration.

If the nominal production sensitivity was required to be not greater than 1.0 percent per ft. obscuration (numbers below 1.0), the false alarm rate for the 10 detectors would be decreased by approximately 60 percent.

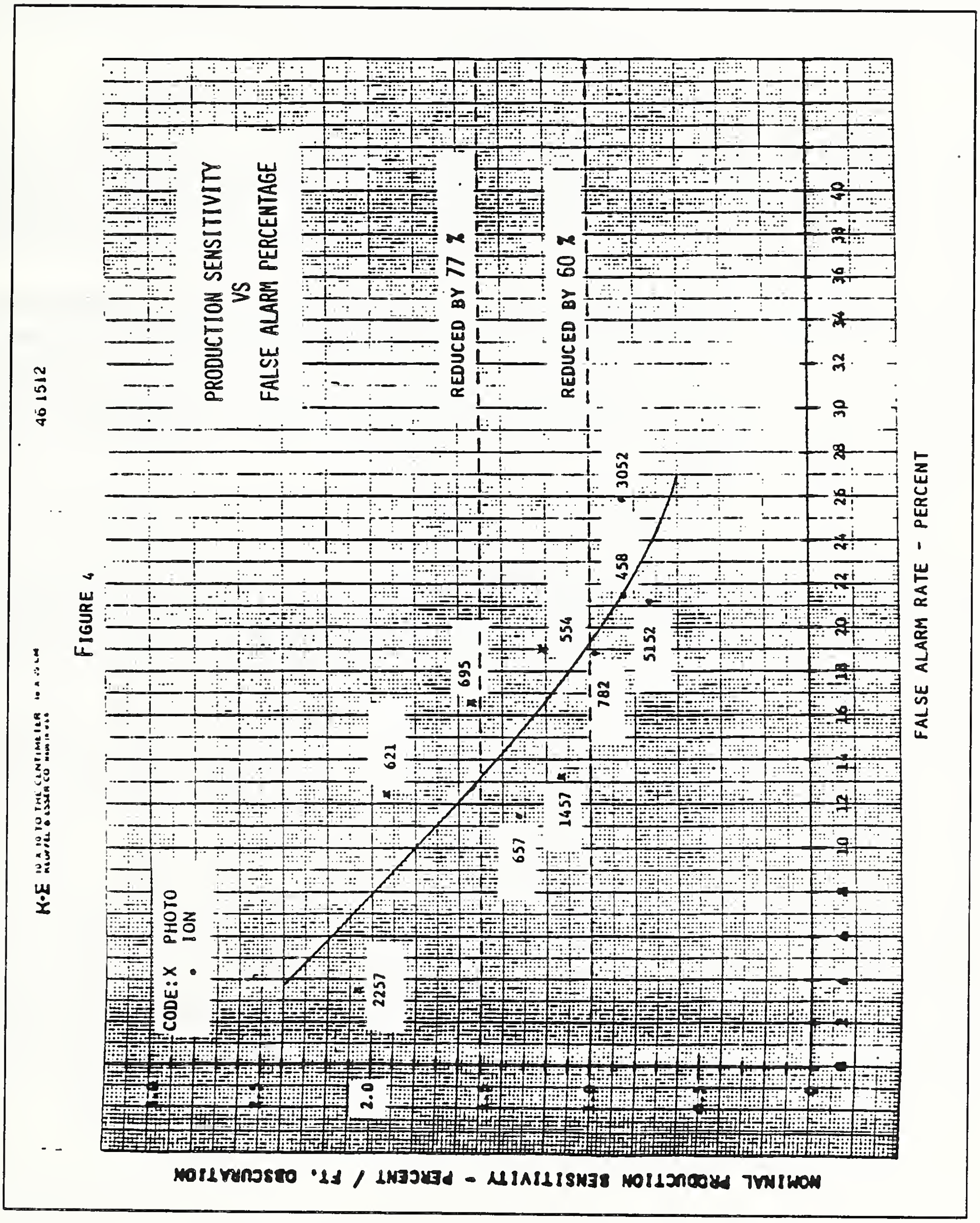

Figure 4 - Production Sensitivity vs. False Alarm Rate

Going one step further, if the nominal production sensitivity had been required to be not less than 1.5 percent per ft. obscuration (0.022 optical density per meter), the false alarm rate for the 10 detectors would have been lowered by approximately 77 percent.

4.3.6 Comparison Between Ion and Photo Production Windows

A comparison between the production windows of ion and photo type detectors in Fig. 3 shows that the ion units have generally narrower production limits which is attributed primarily to detector design and difficulty in complying with the Smoldering Smoke test in the standard. As the ion detector design is improved, the window becomes wider, the production sensitivity setting is reduced and fewer false alarms result.

For the past 3-1/2 years detector manufacturers have been permitted on a temporary basis to widen their production windows, being allowed to reduce their lower production limit by 50 percent or 1 percent per ft. obscuration (0.007 optical density/meter), whichever is less. Since the temporary relaxation is to be eliminated, widening of the windows is possible through additional proposed requirements in ANSI\UL268 which permit an easement of the response to the smoldering test and black smoke tests. These latter requirements are intended to replace the present 50 percent reduction in the lower sensitivity.

4.3.7 Maximum Production Sensitivities vs. False Alarm Percentages

Fig. 5 illustrates a plot of 26 smoke detectors employed in the study. Instead of the minimum or nominal sensitivities, the maximum production sensitivities permitted by the current requirements are plotted since there is no assurance that all units produced will be calibrated lower than the maximum. In a large fire alarm system it does not take many detectors to establish a high false alarm rate.

All the detectors below the 0.5 percent per ft. obscuration level (0.007 optical density per meter) were permitted to be manufactured to the previous edition of the standard which was below 0.5 but not less than 0.2 percent per ft. obscuration (0.003 optical density per meter). The requirement in ANSI\UL268 was changed subsequently to 0.5 but the more sensitive units were already installed and many of them resulted in false alarms.

Under the former requirement of a maximum sensitivity of 0.2 percent per ft. obscuration (0.003 optical density/meter) a total of approximately 8350 detectors were involved resulting in a false alarm reduction of 39 percent. If the maximum sensitivity was further increased to a level of 1.0 percent per ft., the reduction in false alarming would be an additional 39 percent or a total of 78 percent. That would be a significant improvement. Further reductions should be obtained with use of currently manufactured detectors which include improvements in the design to deter the entry of insects, sustain a higher humidity, resistance to most common transients, a marking requirement for the maximum velocity to which they would be subjected in an installation.

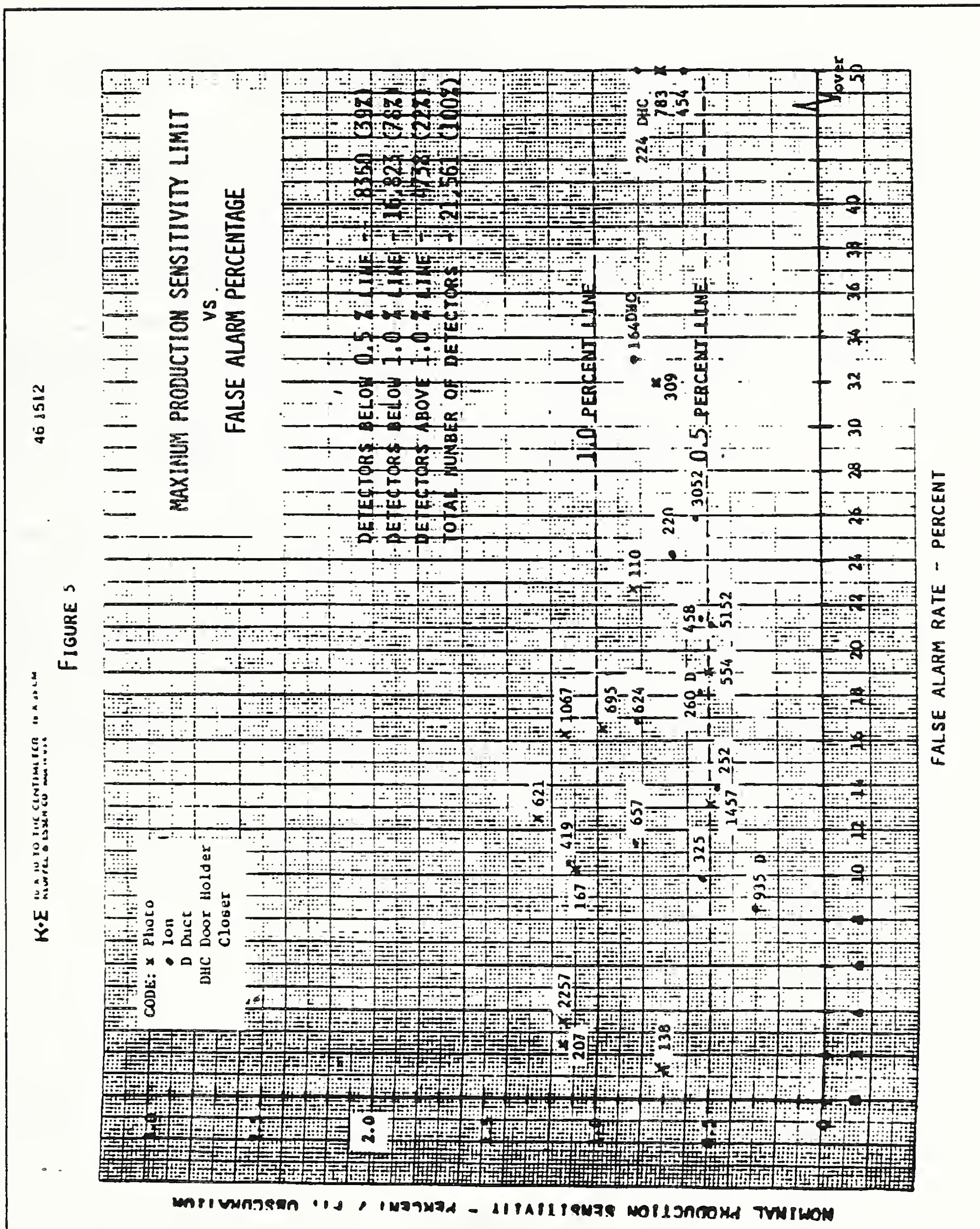

Figure 5 - Sensitivity vs. False Alarm Rate, 3 Levels

4.4 EFFECT OF MISAPPLICATION ON FALSE ALARMS

Smoke detector systems should be designed to preclude installation in areas where detectors would be subject to particles of combustion from deceptive phenomena.

Smoke detector systems are intended to be designed by a person who is knowledgeable in the fire protection field, such as a fire protection engineer, who is familiar with the requirements of local, regional, and national codes on the subject and knows the differences among the various principles of operation. For smoke detectors the most widely recognized and used installation standard is NFPA Standard No. 72 E [11]. The 1987 edition of this standard includes more specific siting guidelines for detectors than the previous editions. These new guidelines should help in reducing false alarms from misapplication.

The following tabulation includes smoke detector locations encountered in VAMCs which resulted in many unnecessary alarms. These are locations where smoke detectors are not suitable for the environment.

TYPICAL SMOKE DETECTOR MISAPPLICATIONS

1. Locations in or near kitchen areas where detectors would false alarm from cooking byproducts or steam.

2. Near sources of steam or high humidity, such as showers, laundries, or sterilizers.

3. In laundries where detectors are subject to lint, wax from dryers, or high humidity.

4. In machine and repair shops where particles of combustion are generated from normal work processes, such as soldering and welding.

5. In linen closets where subjected to dust and lint.

6. Close (less than 3 feet) to air supply vents where sources of moving air and dirt are prevalent. Air could also negate detector response in a real fire.

7. Directly over ash trays in elevator lobbies.

8. In smoking areas.

9. In laboratories where fumes and smoke from experiments are generated.

10. In areas of high air movement, such as loading platforms or exit doors. Applies to ion detectors only.

11. Inside lavatories where humidity from hot water is common.

12. In garages or similar areas where exhaust gases may be present.

13. In locations exposed to outdoor conditions, such as tunnels, or louvered roof top equipment rooms, where subjected to weather insects, and dust.

14. Inside inaccessible areas such as ducts or elevator shafts which preclude proper cleaning and testing.

15. In the fresh air intake ducts which are close to sources of exhaust gases, such as from automobiles and lawnmowers.

16. (Close to less than 6 feet from) the edge of a door leading to a designated smoking area, since smoke spillover from the area could enter the detector.

17. In areas of continuous high temperature (over 100'F - 38'C).

4.5 FALSE ALARM CAUSES - CORRECTABLE BY USER AT INSTALLATION

Causes of false alarms can be segregated into two categories: (1) false alarms resulting from a deficiency in the design of the detector and over which the user has no control, and (2) false alarms from correctable causes over which the user has a measure of control. Examples of non-correctable causes which stem from detector design include; high air velocity (ion only), high humidity and electrical transients. Examples of correctable causes include; cooking byproducts, housekeeping operations, and emission of aerosols or fumes.

Smoking seems to represent a gray area. On the one hand a detector should not be so highly sensitive that it is actuated from one smoker nearby unless he deliberately blows smoke into the unit. On the other hand, cumulative smoke from two or more people smoking in a small area might be expected to activate a more sensitive detector. Where early warning of a fire is especially crucial (such as in a hospital) it may be necessary to limit smoking through a no-smoking policy.

The false alarm causes tabulated below, together with the percentages, are included to illustrate the percentage by which false alarms might be reduced at the VAMCs if more stringent operational policies are implemented at the installations. Smoking is being included since all medical centers have smoking policies in various degrees of enforcement. The percentages were extracted from Table 16.

CORRECTABLE FALSE ALARM CAUSES

	False Alarm Causes	Percentages
Smoking		33
	Construction Work & dust (estimated)	9
	Lack of Cleaning	2
	Housekeeping	2
	Cooking Related	2
	Miscellaneous (estimated)	2
	Unknown (estimated 75 percent from smoking)	15
	Total	65

Conservatively, it is estimated that a reduction from 50 to 60 percent in the number of false alarms could be realized immediately, through enforcement of smoking policies, establishment of a maintenance program, and the education of employees on housekeeping and construction operations.

4.6 EFFECT OF ENVIRONMENTAL CONDITIONS ON FALSE ALARM RATES

The following data were obtained from information received in the Supplementary Information Sheets and visits to VAMCs in response to questions regarding differences in false alarm rates under each of the following conditions:

A. Daytime vs. Nighttime (10 PM - 6 AM)
B. Winter vs. Summer
C. Air Conditioned (A/C) vs. Non Air Conditioned Buildings
D. Low (7-8 ft.) vs. High (over 8 ft.) Ceilings. (2.1 - 2.4 / over 2.4 meters)
E. Low vs. High (over 85%) Relative Humidity
F. Before vs. After Cleaning

4.6.1 Daytime vs. Nighttime

Of the 51 VAMCs which provided data, approximately 75 percent indicated more false alarms during the day. Of 10 VAMCs which provided specific numbers or percentages, the average percentage was 82 percent false alarms during the day and 18 percent during nighttime. Accordingly, the ratio between day and night is approximately 4:1.

Primary reasons cited for the difference was that more smoking occurs during the day as well as alarms from construction work. In general, the more activity the greater the number of alarms.

4.6.2 Winter vs. Summer

Of 52 VAMCs that provided data, 20 (38 percent) indicated more alarms in summer, 9 (17 percent) indicated more in winter, 22 (42 percent) had no difference, and 1 (2 percent) does not have a winter.

Many of the alarms during summer are caused by high humidity, with some additionally from wind and construction dust. Winter false alarms resulted more from smoking, (since patients stay inside more, from wintry drafts, and condensation when the temperature is below 32°F (0°C).

4.6.3 Air Conditioned vs. Non-Air Conditioned Buildings

Most facilities have all buildings air conditioned, particularly in the southern regions. Of 30 responses, 8 (27 percent) indicated more false alarms in air conditioned buildings, 7 (23 percent) had more false alarms in non-air conditioned buildings or when the air conditioning was shut off, and 15 (50 percent) expressed no difference.

Cause of false alarms in air conditioned buildings included wind near doors, path of cool air (presume condensed air), dust and steam. For non-air conditioned buildings wind from open windows was cited as a cause. It follows also that humidity would be a factor.

4.6.4 Low vs. High Ceilings

Of 40 responses 12 (30 percent) had more false alarms in areas with low ceilings, 6 (15 percent) in areas with higher than 8 ft. (2.4 m) ceilings, and the remaining 22 (55 percent) did not indicate a difference. In many hospitals there may only be one ceiling height so a comparison was not possible.

During visits to VAMCs it was indicated and obvious that most of the false alarms were attributed to smoking since the detectors exhibited the tell-tale yellow nicotine/tar discolorations associated with cigarette smoking.

4.6.5 High vs. Low Humidity

Thirty eight VAMCs provided data. Twenty (53 percent) had false alarms from high humidity, surprisingly two (5 percent) had false alarms caused by low humidity, and 16 (42 percent) expressed no difference.

Causes of false alarms included steam, continuous 85 percent or higher humidity, and malfunctions of air handling system (duct detector alarm).

4.6.6 Before vs. After Cleaning

Of 45 responses, 20 (45 percent) had fewer false alarms after cleaning, 19 (42 percent) indicated no difference, and 6 (13 percent) did not have a cleaning program. One VAMC had some false alarms right after cleaning and then the detectors stabilized. This can be attributed to lack of sufficient drying time after cleaning. Eight other VAMCs indicated that the question was not applicable which implies that they did not have an established cleaning program.

4.7 DETAILED COMPILATION OF RESPONSES

The following tables reflect the various data extracted from the 133 VAMCs involved in the study. Refer to Tables 12 and 13 for identification codes for detector locations and false alarm causes. NOTE: Due to their length, tables 1, 2, and 3 are presented at the end of this report.

4.7.1 Table 1 - Summary of Data From Individual VAMCs

This table summarizes the data received from each VAMC. Some gaps appear in the assigned numbers since the data for the assigned VAMC were not usable.

The letters in the first column indicate the type of facility identified on the last page of the table.

Because of lack of space only the three major locations and causes of false alarms are indicated. Locations and causes which do not include a numerical value reflect the fact that the categories were checked off rather than indicating a specific number of locations or causes.

The false alarm percentage is based on the number of false alarms per 100 detectors for the one year period.

4.7.2 Table 2 - Smoke Detector False Alarm Summary by Detector Model

This table provides a comparison of false alarm percentages for the same detector model installed in different VAMCs. Where the information was available the year of installation is also included.

The large differences in false alarm percentages depend largely on the locations where installed, the smoking, testing, and cleaning policies instituted, and the general operational discipline maintained at the particular VAMC.

There does not appear to be any particular correlation or trend in comparing the year of installation with the percentage of false alarms.

4.7.3 Table 3 - Summary of Smoke Detector Performance by Manufacturer

Table 3 provides a comparison among the various detector models of the false alarm rates among different types of detectors and principles of operation. Some detector models, probably due to design and the principle of operation, exhibit a greater propensity for false alarming than others.

4.7.4 Table 4 - Performance of Spot Type Photoelectric Detectors

The data in this table provide a comparison of false alarm percentages among spot type smoke detectors operating on the photoelectric principle.

4.7.5 Table 5 - Performance of Spot Type Ionization Detectors

The false alarm percentage variation for the ionization type detectors is not as pronounced as for the photoelectric type when the greater number of detectors are considered. This may mean that designs of ion type detectors do not vary greatly among manufacturers with respect to false alarms.

4.7.6 Table 6 - Performance of Photoelectric Duct Smoke Detectors

Although the total number of duct detectors is fairly small, manufacturer D's detectors are either too sensitive, are not periodically cleaned, or a combination of both. Past experience has shown that a large amount of smoke is necessary to actuate a duct detector due to the dilution of the smoke in the air stream.

4.7.7 Table 7 - Performance of Ionization Duct Smoke Detectors

The abnormally high percentage of false alarms for duct detectors using the ionization principle of operation might be attributed to high sensitivity settings, lack of testing and cleaning, or intake of outside exhaust fumes into the ventilating and air conditioning systems.

4.7.8 Table 8 - Performance of Photoelectric Door Closer Detectors

While the statistical base is very small, the high false alarm percentage for this type detector raises questions regarding their suitability for the intended application.

4.7.9 Table 9 - Performance of Ionization Door Holder Closer Detectors

There is an observed, generally high false alarm rate for this application. One of the main problems with this type detector is that it is installed at a height of approximately 80 inches (203 cm) where it is subject to transient smoking. Since doorways are natural congregating points in hospitals, smoking as well as higher than normal air velocities passing through the doorway may be the cause.

4.7.10 Table 10 - Summary of Questionnaire Data Sheet Canvass

Table 10 is a composite of all the usable data extracted from the questionnaire data sheets returned from the VAMCs. Data relative to each type of detector are included below:

4.7.10.1 Spot Type Detectors - Approximately twice as many ion type spot detectors are installed as compared to the photoelectric type. Spot type units constitute approximately 89 percent of total number involved in study, and 87 percent of the false alarm total.

4.7.10.2 Duct Type Detectors - Comprise approximately 8 percent of total number of detectors. The false alarm rate is approximately 6 percent of the total.

4.7.10.3 Detector Integral with Door Holders Closers - Consist of approximately 3 percent of the total number of detectors and 7 percent of the false alarm total.

4.7.10.4 Photoelectric vs. Ionization Types - Overall, there does not appear to be any substantive difference with respect to false alarms between ion and photo detectors. If the abnormal data of VAMC No. 18 were not included, the false alarm rate for the spot type photo would be 14.4; and 14.1 for the ion type. A comparison between the two principles for the duct type and detectors integral with door holder-closers shows approximately a 50 percent reduction in the use of the photo type. However, the number of photo detectors employed is too low to be statistically significant.

A review of Table 1 disclosed the following comparative false alarm percentages due to smoking between photo and ion type detectors. These data were extracted only from data which included the specific numbers of false alarms related to smoking.

Type Detector	VAMCs	Detector Models	Detectors/total	Ratio
Ion	42	35	463/6764	6.8
Photo	15	10	175/1176	14.9

From the above data it is readily apparent that photo type units are more than twice as susceptible to alarms from smoking as ion type units. This is to be expected since photo type detectors are more responsive to large particles of combustion which are emitted from smoldering sources, like a cigarette or smoldering mattress, while the ion types respond better to small particles of combustion, such as emitted from a flaming fire, cooking and the like.

It should be noted that false alarms from smoking are more prevalent with photo detectors regardless of the fact that, in general, the production sensitivity of photo detectors is much lower than ion detectors as illustrated in Fig. 3.

TABLE 4

SUMMARY OF PERFORMANCE - - - PHOTOELECTRIC SPOT (OPEN AREA) TYPE SMOKE DETECTORS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
A	7	13	372	954	40.0
B	2	20	715	2240	31.9
C	6	27	246	3036	8.1
D	7	32	295	1764	16.7
E	3	7	26	583	4.5
F	3	4	105	415	25.3
G	1	3	17	25	68.0
H	3	6	23	189	12.2
K	3	6	15	182	8.2
N	2	7	54	544	9.9
P	1	1	4	31	12.9
R	1	1	2	12	16.7
U	1	1	3	34	8.8
V	1	1	3	263	1.1
Z	1	1	2	16	12.5
AA	1	1	0	8	0.0
BB	1	2	2	22	9.1
CC	1	1	2	4	50.0
TOTALS	45	134	1886	10322	18.3

TABLE 5

SUMMARY OF PERFORMANCE - - - IONIZATION SPOT (OPEN AREA) TYPE SMOKE DETECTORS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
A	3	32	1124	5236	21.5
B	5	60	913	5611	16.3
C	1	1	0	15	0.0
E	6	23	325	3009	10.8
F	5	16	148	1299	11.4
G	10	37	363	2078	17.5
H	3	17	131	878	14.9
J	8	16	115	669	17.2
K	5	9	125	1231	10.2
L	3	3	5	33	15.2
N	4	13	161	916	17.6
P	2	6	83	911	9.1
Q	2	2	6	30	20.0
R	5	6	41	252	16.3
S	1	5	18	279	6.5
T	1	1	26	30	86.7
W	1	1	3	12	25.0
Y	1	1	3	50	6.0
BB	1	1	0	18	0.0
CC	1	1	0	10	0.0
DD	1	1	0	11	0.0
EE	1	1	0	113	0.0
FF	1	1	0	7	0.0
GG*	2	2	0	58	0.0
HH*	1	1	0	25	0.0
JJ*	1	1	0	9	0.0
TOTALS					
Systems Type	71	294	3590	22,698	15.8
*Single Station Type	4	4	0	92	0.0
TOTALS	75	298	3590	22,790	15.8

TABLE 6

SUMMARY OF PERFORMANCE - - - PHOTOELECTRIC DUCT SMOKE DETECTORS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
B	1	3	2	138	1.4
D	2	3	15	160	9.4
TOTALS					
	3	6	17	298	5.7

TABLE 7

SUMMARY OF PERFORMANCE - - - IONIZATION DUCT SMOKE DETECTORS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
A	2	13	86	965	8.9
B	2	13	78	469	16.6
E	2	4	4	165	2.4
F	2	6	25	140	17.9
G	9	25	51	349	14.6
J	2	5	3	78	3.8
K	2	3	3	229	1.3
N	1	5	23	66	34.8
P	2	3	75	76	98.7
R	2	3	12	171	7.0
TOTALS					
	26	80	357	2708	13.2

TABLE 8

SUMMARY OF PERFORMANCE - - - PHOTOELECTRIC DETECTORS INTEGRAL WITH DOOR HOLDER CLOSERS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
L	4	4	44	186	23.7
M	1	1	5	24	20.8
TOTALS					
	5	5	49	210	23.3

TABLE 9

SUMMARY OF PERFORMANCE - - - IONIZATION DETECTORS INTEGRAL WITH DOOR HOLDER CLOSERS

Detector Mfr.	No. of Models	No. of Installations	Total No. of False Alarms	Total No. of Smoke Detectors	False Alarms Percentage
L	7	16	342	650	52.6
M	6	7	54	164	32.9
X	1	1	3	50	6.0
TOTALS					
	14	24	399	864	34.6

TABLE 10

SUMMARY OF QUESTIONNAIRE DATA SHEET CANVASS

TOTAL NUMBER OF VAMC's CANVASSED		172
RESPONSES (Broken down as follows)		
Valid Data	133	
Insufficient Data	10	
No False Alarm Problem (Letter)	8	

DETECTOR DATA

Type Detector	Prinicple	Number of Detectors	Number of False Alarms	Percentage* False Alarms
Spot (Open Area)	Photo	10,322	1886	18.3
	Ion	22,698	3590	15.8
Totals		33,020	5476	16.6
Duct	Photo	298	17	5.7
	Ion	2,708	357	13.2
Totals		3,006	374	12.4
(DHC) Door Holder-Closer	Photo	210	49	23.3
	Ion	864	399	46.2
Totals		1,074	448	41.7
Single Station	Ion	92	0	0.0

Number of Detector Manufacturers	34
Number of Detector Models	155

FALSE ALARM DATA

Total Number of Detectors	37,192
Total Number of All Types Alarms	6,697
Total Number of False Alarms	6,298
False Alarm Percentage Rate (Total Alarms/False Alarms)	94.0
False Alarms to Number of Detectors, percent	16.9*

REAL ALARM DATA

Number of Real Fires Detected	399
Ratio of False Alarms to Real Alarms (6298/399)	15.8/1

* Percentage is based on number of false alarms per 100 detectors per year.

4.7.10.5 Overall False Alarm Percentage - Assuming all data received were based on a period of one year, the overall false alarm percentage becomes 16.9 false alarms per 100 detectors per year or a total of 16.9 percent per year.

Discussions with the safety officers at approximately 20 VAMCs included a question of what false alarm level would be acceptable. Coupled with a similar question included in the Supplementary Information Sheets, a nominal level of approximately 4.0 percent per year was identified. See Table 25.

4.7.10.6 Ratio of False Alarms to Real Alarms - The ratio of false alarms to real alarms is calculated to be 15.8/1. In two earlier studies: Fry of the UK conducted in 1972, and Bukowski and Istvan of the US (NIST) conducted in 1980, both reported a ratio of 14/1.

4.7.11 Table 11 - False Alarm Performance by Type of Care at VAMCs

Table 11 provides a comparison of false alarm percentages among different types of care facilities. The false alarm rates for VAMCs which include psychiatric care are approximately double those for general care facilities. This is not unexpected since wards with psychiatric patients are locked at night and the patients are permitted to smoke. It was also noted during visits that psychiatric patients, where permitted, have a tendency to roam into general care areas with cigarettes in their hands and are therefore likely to set off a detector in a corridor or elevator lobby.

Table 11 - Summary of Smoke Detector False Alarm Performance
(By Type of Care at Facility)

Type of Care at Facility	Number of VAMCs	Number of False Alarms	Number of Detectors	False Alarm Rate Percent
General Care	99	3679	24,927	14.8
Psychiatric Care	19	1945	6,541	29.7
Combination General/ Psychiatric Care	1	119	425	28.0
General Care/ Domiciliary	11	504	4,235	11.9
Outpatient Clinic	1	20	315	6.3
Prosthesis Center	1	22	230	9.6
Domiciliary	1	54	451	12.0

Table 12 - Locations Of Smoke Detectors
(With Identification Codes)

Code	Detector Location
APT	Apartment/Resident Rooms
ATT	Attic
AUD	Auditorium
BSM	Basement
CLNC	Clinic
CF	Conference/Meeting Room
CP	Computer Room
CR	Corridor
DHC	Detector Module Integral with Door Holder Closer
DNG	Dining Area/Room
DOM	Domiciliaries (Patient's Living Quarters/Room with no Cooking)
DCT	Duct
ELC	Electric Closet
EL	Elevator Lobby
EM	Elevator Machine Room
ENT	Entertainment Area (Theaters, Bowling Alleys, etc.)
ES	Elevator Shaft
EMG	Emergency Room
EQ	Equipment Room (Telephone equip., Generators, etc.)
GAR	Garage
K	Kitchen/Cafeteria Food Area
ICU	ICU Suite
LAB	Laboratory
LAV	Lavatory/bathroom
LNC	Linen Closet
LDR	Laundry
MKR	Mechanical Room (Air Conditioning Equip.)
OFC	Office Area
PR	Patient Room
P	Penthouse
PHRC	Pharmacy
PLN	Ceiling or Floor Plenum
REC	Recreation/Day Room or Social Hall
SD	Smoke Door (usually one on each side)
SHP	Shops (Repair Machine, etc.)
SLP	Sleeping/Resident Room (Hospital Staff)
STR	Stairway
SVC	Service Areas (Bays, servicing air conditioning equipment)
ST	Storage Areas/Supply Rooms
TV	Transformer Vault/Switchgear Room
TUN	Tunnel, such as between buildings
WA	Waiting Areas
WRH	Warehouse

Table 13 - Causes Of False Alarms
(With Identification Codes)

Code	Cause of False Alarm
AHS	Air Handling System Malfunction
K	Cooking and Baking By Products
CW	Construction Work (Dust, welding, soldering, etc.)
DF	Defective Detector (Component failure, fails to operate)
D	Dust (Non-construction type)
EX	Engine Exhaust
W	High Air Velocity, over 300 cfm
H	High Humidity, over 85 percent
HS	High Sensitivity (Overly sensitive)
TEMP	High Temperature
HK	Housekeeping (Waxing, buffing, cleaning fumes, solvents, aerosols)
I	Insects (spiders, mites, carpet beetles, silver-fish, gnats)
LC	Lack of Cleaning (false alarm signals VAMC cleaning is needed)
M	Malicious
S	Smoking (cigarette, cigar, pipe)
ST	Steam (Steam pipe leak, shower, sterilizers, laundry)
T	Transient (Lightning, power bumps [voltage variations], RF)
UK	Unknown
WT	Water in detector (Roof leaks, condensation, etc)
MNT	Maintenance (Accidental actuation by maintenance people.

4.8 FALSE ALARM CAUSES

4.8.1 Table 14 - False Alarm Causes, Questionnaire Data Sheets

Examination of the original questionnaire data sheets received from the various VAMCs, showed a great variation in detail. Some data sheets included the specific number of detectors applicable to a location, as well as the cause of the false alarm, while others merely checked off the appropriate boxes (See Table 1) as per the following examples:

Numerical Count Method

Location: Corridors 14, Elevator Lobbies 6, Patient Rooms 10, etc.

Causes: Smoking 4, Wind Velocity 2, Transients 1, Construction Dust 4, etc.

Check-Off Method

Location: Corridors x, Elevator Lobbies x, Patient Rooms x, etc.

Causes: Smoking x, Wind Velocity x, Transients x, Construction Dust x, etc.

In view of the above Table 14 is separated into two sections, with a basis for comparison. The Numerical-Count Method is more accurate although only about 7 percent of the total number of detectors are involved. In some data sheets it was possible to identify the type of false alarm when only one cause was checked.

The number of false alarms shown for the Check-Off Method represents only the number of checks ("x") per detector model per building or floor. They do not represent the actual number of false alarms for a particular VAMC. For example, if 20 false alarms occurred in a building out of a total of 100 detectors of that model installed, and only the SMOKING and WIND VELOCITY categories were checked off as the false alarm causes, there was no way to identify the specific number for each cause. Accordingly, the number and percentage of false alarms represented by a check mark can vary widely from one (1) to whatever number of false alarms occurred. Since the check-off method represents the majority of false alarm causes, it does indicate the frequency of the causes that occurred, but not the correct number of false alarms.

Smoking is the leading cause of false alarms with approximately one third of all alarms attributed to this cause. This is based primarily on the data from 62 VAMCs by the numerical-count method.

The false alarms attributed to the DUST, CONSTRUCTION WORK, and LACK OF CLEANING categories are not as definitive as desired since CONSTRUCTION DUST was the only related category which appeared on the original questionnaire data sheets (Illus. A). Accordingly, there was no distinction made in the data between construction type and non-construction type dusts. The best available information, where the distinction is made, is included in TABLE 16 which data were extracted from the Supplementary Information sheets and discussions during VAMC visits. If the false alarm percentages for the three categories were added the total would be approximately 14 percent which simply reflects the fact that a scheduled cleaning and testing program is needed.

One particular model, the one with the most detectors installed, has produced the majority of false alarms related to high air velocity.

SUMMARY OF FALSE ALARM CAUSES - EXTRACTED FROM ORIGINAL DATA SHEETS

FALSE ALARM CAUSE	By Numerical Count Method			By Check-off Method		
	Number of VAMCs	Number of False Alarms	Percent of Total False Alarms	Number of VAMCs	Number of checked False Alarms	Percent of Total
Smoking	62	871	32.1	38	150	19.3
Dust	50	286	10.5	35	130	16.7
Humidity	24	240	8.8	20	96	12.3
High Air Velocity	29	208	7.7	22	101	13.0
Defective	41	202	7.4	26	107	13.7
Construction Work	24	57	2.1	9	10	1.3
Transient (Elect.)	17	53	2.0	7	9	1.2
Lack of Cleaning	18	51	1.9	13	102	13.1
Insects	14	44	1.6	6	12	1.5
Steam	12	44	1.6	6	12	1.5
Housekeeping	12	40	1.5	2	4	0.5
Malicious	14	27	1.0	8	12	1.5
Cooking	7	18	0.7	2	2	0.3
Unknown	44	528	19.5	16	24	3.1
Water in Detector	5	22	0.8	1	1	0.1
Miscellaneous	11	21	0.8	7	7	0.9
Totals		2712	100	-	779	100

TABLE 15

SUMMARY OF FALSE ALARM CAUSES

EXTRACTED FROM SUPPLEMENTARY INFORMATION SHEETS AND VISITS

No.	False Alarm Cause	Number of VAMCs	Three principal False Alarm Causes				
			1	2	3	Totals	Perc Tot
1	Smoking	46	32	21	11	64	33.
2	Construction Work	19	7	13	3	23	12
3	High Air Velocity	14	10	9	4	23	12
4.	Dust (Non-construction)	12	7	5	5	17	8
5.	High Humidity	8	3	4	4	11	5
6	Cooking Byproducts	9	3	2	5	10	5
7	Steam	8	1	3	5	9	4
8	Unknown	7	1	3	5	9	4
9	Malicious	4	2	0	4	6	3
10	Housekeeping	4	3	0	1	4	2
11	Lack of Cleaning	3	1	1	1	3	1
12	Insects	2	1	0	2	3	1
13	Outside Fumes	2	1	2	0	3	1
14	Inside Fumes	2	0	1	1	2	1
15	Transients (Electrical)	1	1	0	0	1	0
16	Air Hndlng. System Malfunct.	1	0	0	1	1	0
17	Lint	1	1	0	0	1	0
18	Defective	1	0	0	1	1	0
	Totals	62	74	64	54	191	

The number of false alarms from high humidity is fairly significant. This cause is related to the design of the detector. More stringent performance requirements have already been adopted in ANSI/UL268 to address the problem.

False alarms from unknown causes is the second highest percentage. Upon investigation of a false alarm, the detector in alarm could be identified but the cause of the alarm could not. It is estimated that a high percentage was caused by smoking.

4.8.2 Table 15 - False Alarm Causes, Supplementary Sheets and Visits

The subject of false alarm causes was explored further in the supplementary data collected from the VAMCs and during the site visits. These data, presented in table 15, are equivalent to the checked-off alarms in Table 14 since they do not represent a numerical value of the number of false alarms but only a particular VAMC. The data are based on information received from a total of 62 VAMCs, including those visited. It should also be noted that the data are based on more current information received approximately a year after the original questionnaire data sheets were distributed. During that period ongoing changes in detectors had been taking place in some VAMCs.

4.8.3 False Alarm Causes - Estimated Percentages

Table 16 includes the major causes of false alarms with approximate percentages. Most of the numbers are based on the data provided in Table 14 by the numerical-count method modified by the Check-off method and information from visits to VAMCs and extracted from the Supplementary Information Sheets.

Smoking, particularly in corridors and lobbies, is by far the most prevalent cause of false alarms.

Of the 20 percent attributed to UNKNOWN it is estimated that at least 50-75 percent would be additionally related to smoking for an overall estimate of 45 to 50 percent of all false alarms.

4.9 SMOKE DETECTOR LOCATIONS

Table 17 provides the number of detectors and the percentage of the whole for the indicated locations. Except for the locations that constitute less than 0.1 percent of the total, the locations are in sequential descending order.

The total number of detectors included in the table is 29,657 and represents a total of 117 VAMCs. This total is based on specific numbers provided by the VAMCs in the questionnaire data sheets. The remaining VAMCs who returned data sheets did not provide specific numerical data except in a few instances where only one location was involved, to determine the number of detectors for a specific location. Had the information been available, it would not have substantially affected the percentage for each location since the first five locations (26,288) constitutes approximately 89 percent of the total.

Since many VAMCs did not make a distinction between corridor detectors installed for open area protection and spot type smoke-door detectors mounted in the corridor on each side of a fire door, adding the two together results in an overall sum of 17,590 corridor detectors, or 59.3 percent of the total obtained by the numerical count method.

In general, detectors employed for the release of smoke doors consist either of a ceiling-mounted unit on each side of a corridor door, or a smoke detector module installed integral with the door-holder-closer mechanism. The latter type requires only one detector per door but the detecting module is only 80 inches (2.1 m) above the floor so it is more susceptible to a false alarm from transient smoking than a ceiling-mounted unit installed at an average height of 8 ft. (2.4 m).

Table 16 - False Alarm Percentages

Ranking	Cause of False Alarm		Percent
1	Smoking		33
2	Unknown		20
3	Dust Related:		
	a. Ordinary & construction dust	12	
	b. Lack of Cleaning	2	14
4	High Air Velocity		8
5	Humidity		8
6	Construction Work		3
7	Housekeeping		2
8	Cooking and Baking Byproducts		2
9	Malicious		1.5
10	Defective		1.5
11	Insects		1.5
12	Transients		1.5
13	Steam		1.5
14	Miscellaneous		2.5

a. Lint
b. Inside fumes (non-housekeeping type)
c. Outside fumes
d. Malfunction
e. Water in detector
f. Laundry driers
g. Aerosols
h. Accidental (Maintenance & Repair shop)
i. Overly Sensitive
j. High Temperature
k. Loose Wire
l. Exhaust Fan Shut Down

Table 17 - Summary Of Detector Locations

Smoke Detector Location	Number of Detectors	Percent of Totals
Corridors	11,083	37.4
Smoke Doors: Spot Type Door Holder Closer Type	6,507 1,046	21.9 3.5
Ducts	3,833	12.9
Patient Rooms	2,060	6.9
Elevator Lobbies	1,759	5.9
Mechanical Rooms	327	1.1
Waiting Areas	307	1.0
Computer Rooms	277	0.9
Attics	267	0.9
Kitchen Areas	205	0.9
Transformer Vaults/Switchgear Rooms	187	0.6
Elevator Shafts	182	0.6
Shops, machine, repair	181	0.6
Labs	161	0.5
ICU Suites	153	0.5
Elevator Machine Rooms	124	0.4
Ceiling Plenums	104	0.4
Domiciliaries	100	0.3
Sleeping Rooms, hospital staff	91	0.3
Office Areas	87	0.3
Laundries	76	0.3
Electrical Closets	70	0.2
Stairwells	65	0.2
Apartments, hospital staff	58	0.2
Equipment Protection	54	0.2
Recreational Areas, Social Halls, Dayrooms	53	0.2
Dining Areas	49	0.2
Service Bays	48	0.2
Warehouse	38	0.1
Storage areas, rooms, facilities	32	0.1

Table 17 Continued

Miscellaneous Locations below 0.1 Percent

Basements		
Pharmacies		
Residences, Director, staff, etc		
Penthouse		
Conference and Meeting Rooms		
Lavatories		
Entertainment Areas, Theaters, Bowling Areas		
Emergency Rooms		
Tunnels (Connection between buildings)		
Linen Closets		
Auditoriums		
Clinics		
Garages		
Miscellaneous Total	103	0.3
TOTALS	29,657	100.0

4.10 FALSE ALARM CAUSES WITH RELATED LOCATIONS

Tables 18 and 19 include data extracted from the Supplementary Information Sheets since the original questionnaire data sheets did not relate the type of false alarm to a specific location. As indicated previously, identification of the type of false alarm in the Supplementary Information Sheets does not represent a specific number of false alarms but only the main three causes of false alarms at a particular installation. For example, a total of 100 false alarms may have been obtained with the three most prevalent being the ones identified in the table. In reality therefore, each false alarm cause included in the table represents a greater number of false alarms than shown.
The total number is based on a canvass of 62 VAMCs, including 20 visits so that the data represent approximately 47 percent of the total number of VAMCs which provided valid data.

Almost 50 percent of all false alarms originate from detectors installed in corridors, including those integral with door holder closers.

Table 18 - False Alarm Causes with Related Locations

EXTRACTED FROM SUPPLEMENTARY INFORMATION SHEETS AND VISITS

Cause of False Alarm	Detector Location	No. of False Alarms	Percent to Total
Smoking	Corridors (inc. smoking door)	30	15.7
	Lobbies (elev. and main)	24	12.6
	Patient Rooms	5	2.6
	Mechanical & Equip. Rms.	1	0.5
	Waiting Areas	1	0.5
	Elevator Shafts	1	0.5
	Dayrooms	1	0.5
	Library	1	0.5
	TOTAL	64	33.5
High Air Velocity	Corridors	12	6.3
	Lobbies	4	2.1
	Exit Areas	2	1.0
	Elevator Shafts	2	1.0
	Tunnels	2	1.0
	Patient Rooms	1	0.5
	TOTAL	23	12.0
Dust (non construction)	Corridor	5	2.6
	Duct	4	2.1
	Mechanical & Equip. Rms.	2	1.0
	Ceiling Plenums	2	1.0
	Lobbies	2	1.0
	Tunnels	2	1.0
	TOTAL	17	8.9
Housekeeping	Corridors	3	1.6
Insects	Corridors	3	1.6

Table 18 - Continued

Cause of False Alarm	Detector Location	No. of False Alarms	Percent to Total
Construction Work	Corridors	15	7.9
	Mechanical & Equip. Rms.	3	1.6
	Lobbies	2	1.0
	Duct	1	0.5
	Sub-basement	1	0.5
	Elevator Shaft	1	0.5
	TOTAL	23	12.0
High Humidity	Corridors	4	2.1
	Ducts	2	1.0
	Lobbies	1	0.5
	Patient Rooms	1	0.5
	Storage Room	1	0.5
	Lavatory	1	0.5
	Recreation Room	1	0.5
	TOTAL	11	5.8
Cooking Byproducts	Kitchen Areas	6	3.1
	Corridors	3	1.5
	Dining Areas	1	0.5
	Patient Rooms	1	0.5
	TOTAL	11	5.8
Steam	Mechanical & Equipment Rooms	3	1.6
	Ducts	2	1.0
	Kitchen Areas	2	1.0
	Tunnels	1	1.0
	Service Areas	1	0.5
	TOTAL	9	4.7

Table 18 - Continued

Cause of False Alarm	Detector Location	No. of False Alarms	Percent to Total
Outside Fumes (Exh)	Duct	3	1.6
Inside Fumes	Corridor	1	0.5
	Lab	1	0.5
	TOTAL	2	1.0
Lack of Cleaning	Corridors	2	1.0
	Ceiling Plenums	1	0.5
	TOTAL	3	1.6
Unknown	Corridors	5	2.6
	Patient Rooms	2	1.0
	Duct	1	0.5
	Elevator Shaft	1	0.5
	TOTAL	9	4.7
Malicious	Corridors	6	3.1
Transient (Electrical)	Corridors	1	0.5
Lint	Laundry	1	0.5
Air Hndling. Sys. Malf.	Duct	1	0.5
Defective	Corridors	1	0.5
	TOTAL	191	

Table 19 - Summary Of False Alarms per Location

EXTRACTED FROM SUPPLEMENTARY INFORMATION SHEETS AND VISITS

Detector Location	No. of False Alarms	Percentage of Total
Corridors (including smoke doors)	91	47.6
Lobbies (Elevator and Main)	33	17.3
Ducts	14	7.3
Patient Rooms	10	5.2
Mechanical and Equipment Rooms	9	4.7
Kitchen Areas	8	4.2
Elevator Shafts	5	2.6
Tunnels	5	2.6
Ceiling Plenums	3	1.6
Recreational Areas (Dayrooms, etc)	2	1.0
Exit Areas	2	1.0
Waiting Areas	1	0.5
Dining Areas	1	0.5
Service Areas	1	0.5
Basements	1	0.5
Storage Areas	1	0.5
Lavatories	1	0.5
Laundries	1	0.5
Laboratories	1	0.5
Libraries	1	0.5
TOTALS	191	100

Table 20 - Smoke Detector Models Considered Overly Sensitive

Detector Model	Application	Ion or Photo	Max. Production Sens. %/ft. Obsc.	(Opt. Dens./m)
A - 2	Spot	Photo	0.98	(0.014)
B - 1	Spot	Ion	0.50	(0.007)
L - 10	DHC	Ion	0.32	(0.005)
A - 1	Spot	Ion	0.48	(0.007)
H - 1	Spot	Ion	0.55	(0.008)
B - 1	Spot	Ion	0.50	(0.007)
A - 1	Spot	Ion	0.48	(0.007)
A - 1	Spot	Ion	0.48	(0.007)
A - 1	Spot	Ion	0.48	(0.007)
L - 5	DHC	Ion	0.80	(0.011)
B - 1	Spot	Ion	0.50	(0.007)
B - 2	Spot	Photo	0.70	(0.010)
D - 4	Spot	Photo	1.10	(0.016)
A - 8	Duct	Ion	0.30	(0.004)
M - 2,3,4,7	DHC	Ion	0.83	(0.012)

DHC - Smoke detector integral with door holder closer.

4.11 DETECTOR MODELS CONSIDERED OVERLY SENSITIVE

The information in Table 20 was received in response to the question posed during VAMC visits as to which smoke detector models were considered too sensitive for the application.

Of 20 VAMCs visited, 8 did not consider any of the models installed in their facility as being overly sensitive. The remaining 12 provided the information in the table.

The maximum production sensitivity values in the table are based on the current method of measurement described in ANSI/UL 268 standard.

Maximum sensitivity numerical values below the presently-required 0.5 percent per ft. obscuration (0.007 optical density/meter) were in effect for the models under a previous less stringent requirement of 0.2 percent per ft. obscuration (0.003 optical density/meter). Duct detectors are permitted to have lower than a 0.5 percent per ft. obscuration in view of the dilution factor in ducts.

The detector models are fairly consistent with the models included in Fig. 5 in that detectors with maximum production sensitivities below 1,0 percent per ft. obscuration (0.014 optical density/meter) are related to an abnormal number of false alarms.

4.12 MISCELLANEOUS

The following paragraphs will provide details on various other subjects included in the SUPPLEMENTARY SHEETS and visits:

4.12.1 Response of Fire Department

In almost all instances, initiation of an alarm from a smoke detector results in automatic response of either the city or township fire department or the in-house fire department, when provided. Exceptions occur during testing or during periods of construction or renovation.

4.12.2 False Alarms from Control Units

Although it was indicated that there have been some problems with control units indicating circuit trouble, there was only one isolated instance cited of false alarms from that source. The actual cause was a "bump" in the power line. It is assumed that this was a transient in the supply voltage. Some VAMCs were unhappy with their present "older" systems because of a myriad of troubles which were not explained. Other installations had parts of a system replaced, and replacement of detectors from another manufacturer.

4.12.3 System Operation for Alarm

Almost all of the medical centers seem to have a coded system in which alarm bells are energized for several rounds in a code to alert personnel of the type and location of the alarm signal. This arrangement seems to be preferable to a continuous sounding bell from the view point of disruption and annoyance.

4.12.4 Detectors Not Connected to Fire Alarm System

In almost all VAMC installations all smoke detectors, when actuated in alarm, result in response of the fire department. Some exceptions include the following:

1. Zones shut down due to construction.

2. Some duct detector installations. In one installation, the VAMC does not have any confidence in their operation and they have been disconnected.

3. Single Station smoke detectors installed in living quarters.

4. Zones out of operation due to modification of the fire alarm system.

5. Detectors with too many false alarms.

6. Some detectors in elevator lobbies (Those used for elevator capture).

7. One VAMC has a pre-signal type system because of too many false alarms.

8. Some detectors in elevator shafts due to inaccessibility for testing and cleaning.

4.12.5 Insects

Data on false alarms caused by insects were obtained from 62 VAMCs, which included 20 visits. Eighteen of the 62 reported one or more false alarms from such insects as spiders, roaches, gnats, carpet beetles, silverfish, and red ants.

In all cases the detector was cleaned either by vacuuming, blown air, or by disassembly. Areas were fumigated as needed. Roaches were rare. Most false alarms were equally divided between photo and ion detectors.

False alarms from insects does not appear to be a major problem since nearly all indicated that the alarms from insects were isolated cases.

4.12.6 False Alarms - Unknown Causes

If more than one (1) false alarm occurs from the same detector within a short period of time (up to several days), any one of the following procedures takes place:

1. Detector is replaced with same or newer model.

2. Unit is examined by electric shop, cleaned and reinstalled. If it false alarms again soon after, it is replaced.

3. Returned to manufacturer. (Presuming system is still under warranty).

In most instances, if a detector gives two or more false alarms within a short time period, it is considered defective and replaced without any intermediate cleaning operation.

4.12.7 Preference Between Ion and Photo Detectors

The following information was received in reply to the question of preference between ion and photo type detectors. Data were extracted from the Supplementary Information Sheets. A total of 59 VAMCs provided data.

Type Preference	Number	Percentage
Photo	33	55.9
Ion	1	1.7
No Preference	16	27.1
No Basis for Comparison Only one type used	9	15.3
	59	100.0

4.12.8 Miscellaneous Comments from VAMCs

The following are representative comments received with the original questionnaire data sheets.

1. Photo detectors removed from area where false alarms occurred from sources of steam and humidity.

2. Incidents of false alarms have dropped dramatically since newer replacement model was set at least sensitive point.

3. Number of false alarms decreased after cleaning.

4. The extreme sensitivity of these detectors (A-1) will require frequent cleaning to reduce number of false alarms.

5. Elevator detectors turned off due to large number of false alarms and access to cleaning.

6. Difficult to identify false alarm cause since NO SMOKING policy is not enforced.

7. Duct detectors located in extremely hard-to-get-at locations. Cannot be cleaned. Require remote test switch to test for operation.

8. Detector too sensitive. One half of detectors replaced, false alarms dropped to zero.

9. Ion modules replaced with photo on all door holder closer smoke detectors. No false alarms since.

10. Two detectors removed from training class where exhaust gases were present. False alarms dropped to zero.

11. Number of false alarms reduced significantly due to preventative maintenance program. Cleaning and testing on a regular program.

12. Detectors obsolete. Price too high for parts, when obtained.

13. Duct detector sensitivity very high. Will require frequent cleaning.

14. Most alarms caused by wind velocity. (ion type). Cross wind in detector area.

15. Wind velocity from fans caused false alarms.

16. A very good detector (A-3)

17. Ultra sensitive detector. Being replaced.

18. Corrective actions taken to reduce false alarms. (1) detectors repositioned, (2) contractors to notify engineering when work in progress.

19. False alarm from insects. Detector cleaned and tested to prevent recurrence.

20. Humidity and Transients major causes of false alarms.

21. Detector known to activate from steam and small amounts of cooking smoke.

22. Photo detectors removed since repeated false alarms from steam and humidity.

23. False alarms caused by smoking in elevator lobby.

24. False alarms caused by steam and airborne corrosive acids on printed wiring board.

25. Photo detectors substituted when ion detector too sensitive or faulty.

26. No false alarms from photo detectors which replaced ion type.

27. Number of false alarms decreased from 1/day in summer to 1/week in Jan-Feb-March.

28. Ion detector near ovens changed to photo.

29. False alarms from contractor work.

30. Sensitivity drifting considered biggest problem at this site.

31. Changed to heat detectors in kitchen.

32. Pieced-together system. Some components over 10 years old.

33. Most false alarms caused by smoking in elevator lobby. Detectors removed.

34. Of 58 unnecessary alarms for year, detectors in elevator lobbies contributed to 24 and 23 to persons smoking under detectors. For next 3 months 8 alarms; 3 by construction work, 2 by dust, 1 HVAC, and two from unknown causes after detectors removed from lobbies and smoking regulations enforced.

35. Exhaust from kitchen oven a constant problem.

36. Patients smoking near or under detectors. Several similar comments.

37. Almost no problem. Occasionally 1 is oversensitive and is replaced.

38. We feel we have a reliable system.

39. All alarms caused by 2 detectors, both in corridors.

40. Some causes of false alarms: incinerator smoke, laundry vent, buffing of floors, exhaust fan shutdown, steam sterilizer leaks, elevator shaft dust, HVAC duct dust.

41. System being replaced. Reason; old.

42. Being replaced with units less likely to false alarm. Same manufacturer.

43. Practically no false alarms at facility. Cleaning and testing quarterly.

44. False alarms from severe wind in tunnels caused by open door, wind from fans to dry floors, ceiling tile dust and pest control sprays.

45. In most cases valid reason for alarm actuation. We are learning to live with smoke detectors.

46. We like photo detectors better for problem areas. More will be installed as funds become available.

47. False alarm from transient during lightning storm.

48. Patients smoking under detectors caused false alarms. Detector within normal sensitivity limits.

49. Detectors controlling smoke doors wired so they do not activate fire alarm systems, but only close the smoke barrier door.

50. Most false alarms due to smoking near elevators and day rooms.

51. (Telephone conversation)-Initially there is a matter of education of the staff assigned to a new smoke detector system. People are not familiar with the problems that can result in false alarms. This also includes people like nurses who cause false alarms by use of chemicals in detector areas. Once this is done the number of false alarms drop. Also cannot completely enforce NO SMOKING policy since there are not enough security personnel to do the job.

4.12.9 Recommendations by VAMCs

The following multiple recommendations were obtained from a review of the Supplementary Information sheets and visits to VAMCs. Total of 62 VAMCs involved. Numbers in parentheses indicate number of VAMCs who commented.

1. Better enforcement of smoking policy. (16)
2. Replace ion with photo detectors or use photo detectors. (14)
3. Notification of Safety Engineer prior to construction. (9)
4. Reduce detector sensitivity. (9)
5. Better planning on placement of detectors to prevent misapplication. (5)
6. Service contract with outside agency for testing and cleaning. (5)
7. Use of a separable head or cover for easier cleaning. (4)
8. Detector should be provided with variable sensitivity or multiple sensitivity. (2)
9. Relocate detectors. (2)
10. Institute proper maintenance and cleaning procedures. (2)
11. Too many detectors, not enough people. (2)

The following were single recommendations:

12. Common base for ion and photo for easier replacement.
13. Ion detector not suitable for smoking or cooking areas.
14. Better trained people.
15. Better housekeeping.
16. Need humidity-resistant detectors.
17. Minimum 5 ft. for detectors from a smoke door since it is a congregating point for patients and casual smoking will activate detectors.
18. Use of a smart detector which rings local alarm and then allows itself to clear.
19. Cross zoning with 2 detectors if alarm is sent off premises.
20. False alarms from insects reduced 70 percent by use of insect repellant tape inside detector.

21. Access to interior of duct housing should not be gained by breaking of airtight seal for testing and cleaning. Too time consuming and resealing not always effective.

22. Overly restrictive maintenance and cleaning procedures inhibit regular cleaning because of prohibitive costs.

23. Sensitivity of smoke detector should be such that it does not false alarm from ordinary smoking.

24. Control unit panels should be required to have surge protection.

25. Multiple station detector which causes the alarm should have a red alarm energized to identify unit that caused the alarm. Saves time for firemen in trouble shooting.

26. Need maintenance program to increase reliability.

27. Recommend this detector not be installed in VA hospitals. Too sensitive. Too many nuisance alarms and danger posed to fire department personnel.

28. If a manufacturer no longer makes a detector model then he should be required that superseding models are compatible with bases of obsolete models.

4.13 SENSITIVITY MEASUREMENTS ON DETECTORS FROM VAMCs

During visits to VAMCs requests were made for one or more samples of detectors with which a high rate of false alarms was associated. The intent was to verify the sensitivity of the detectors after having been installed for one or more years. The dirtiest and most discolored units were selected.

In most cases the samples submitted for test were units which had been replaced for one reason or another and unfortunately some were inoperative. In other instances samples were not available.

Most samples sent from the VAMC were those with the highest false alarm rate since the two models utilized there are still being produced and there is concern that the sensitivity of the detectors was the major factor for the false alarms.

Each operational sample was placed in the NIST smoke box with the most favorable position for smoke entry facing the oncoming air flow. The unit was then energized from a rated source of supply voltage and the optical density (percent/ft. obscuration) as well as the reading of the measuring ionization chamber, were recorded at the time of actuation as determined by energization of the alarm LED. The NIST smoke box is comparable in construction to the smoke box described in ANSI/UL 268 standard. Two 1/8 diameter (3.2 mm) smoldering cotton wicks provided the combustion particles for the test. From two to five trials were conducted on each sample depending on the variations in the readings.

The sensitivity measurement was made on each sample under each of the following conditions:

A. as received from the VAMC,

B. after vacuuming,

C. after cleaning with high pressure (100 psi) air,

D. after washing the chamber area with a Q tip dipped in alcohol, including the printed wiring board.

For conditions B and C the cover was removed, where possible. For condition D the chamber cover was removed, where possible. After the washing, the unit was air dried overnight before conducting the sensitivity measurement.

Refer to Tables 26 and 27 for the results.

Of 38 detectors tested, 29 were ion and 9 were photo. Eleven of the ion were below 1 percent/ft. obscuration (false alarm range between 7.5 and 111 percent, twelve between 1 - 2 percent (false alarm range 7.5 - 111 percent), and six were over 2 percent (false alarm range between 4.9 and 7.5 percent), as determined from the questionnaire data sheets.

Of 9 photo detectors 1 had a sensitivity below 1.0 percent per ft. obscuration (no data on false alarm rate), 2 detectors were between 1 - 2 percent per foot obscuration (15.4 percent false alarm rate), 5 between 2 - 3 percent per foot (all one model at one VAMC with a false alarm rate of 309 percent), and 1 detector with an abnormally low sensitivity of 8.85 Percent per foot obscuration, and for which there were no false alarm data. False alarm data were not available since the detector models sent in for test were never reported on in the initial data sheet survey. All detector sensitivities, except for sample no. 23, were within the limits of 0.5 and 4.0 percent per foot obscuration required in ANSI\UL 268.

A summary of the data in Table 27 is included in the following tabulation:

Conditioning		Sensitivity Decrease	Sensitivity Increase	No Change
After Vacuuming		15	15	3
After Air Blowing		16	12	5
After Washing		23	8	2
	Totals	54	35	10
	Percentages	55	35	10

Although the results are mixed, in the majority of cases, the sensitivity was reduced after some form of cleaning.

Photo 1 illustrates a sample of a detector before cleaning, while Photo 2 shows the same detector after it was cleaned. The outside of the unit had an extremely heavy yellow stain, suspected to be a nicotine/tar buildup, and a heavy film of dust inside the pc board cover which can only be removed by washing, not by vacuuming or blown air. A small section of dusty area was cleaned to show contrast. Heavy clusters of lint are apparent on the printed wiring board and around the chamber insect filter. The unit appeared as if it had never been cleaned. The sensitivity measurements are included in Table 27 under manufacturer E, sample no. 44.

The condition of sample No. 44 indicates the need for a comprehensive washing of detector components.

TABLE 26 - SENSITIVITY MEASUREMENTS - SAMPLES FROM VAMC INSTALLATIONS

Detector Mfr.	Model No.	Ion or Photo	Sample No.	VAMC	Obscuration - percent per foot				Sensitivity Change, % / ft.			Comment:
					As rec'd. (1)	After Vac. (2)	After Air (3)	After Wash (4)	1 - 2	1 - 3	1 - 4	
B	5	I	11	106	2.23	2.09	2.23	2.40	6	0	- 8	--- Note 1
			12	106	2.17	2.29	2.33	2.15	- 6	- 7	1	--- Note 1
B	1	I	13	21	0.86	0.98	1.04	NR	-14	-21	-	--- Note 1
			14	21	0.92	0.86	0.98	1.04	5	- 7	-13	--- Note 1
			33	18	NA	NA	NA	1.13	-	-	-	↑ Note 4
			34	18	1.10	1.10	1.53	1.20	0	-39	- 9	--- Note 7
			35	18	0.98	0.86	0.92	0.98	12	6	0	--- Note 1
			36	18	1.04	1.19	1.04	0.92	-14	0	12	--- Note 1
			37	18	0.92	0.86	0.94	0.95	7	- 2	- 3	--- Note 1
E	3	I	4	39	1.78	1.53	1.66	2.02	14	7	-13	↓
			6	39	2.21	2.40	2.15	2.64	- 6	3	-19	↓
			7	39	2.40	3.58	3.58	3.95	-49	-49	-65	↓
E	1	I	5	39	0.79	0.86	0.79	1.10	- 8	0	-39	↓

TABLE 26 - SENSITIVITY MEASUREMENTS - SAMPLES FROM VAMC INSTALLATIONS

Detector Mfr.	Model No.	Ion or Photo	Sample No.	VAMC	Obscuration - percent per foot				Sensitivity Change, % / ft.			Comment:
					As rec'd. (1)	After Vac. (2)	After Air (3)	After Wash (4)	1 - 2	1 - 3	1 - 4	
E	#	I	44	45	1.74	1.72	1.73	2.09	1	1	-14	↓
			45	45	1.41	1.38	1.38	1.41	2	2	0	---
			46	45	1.41	1.30	1.30	2.04	6	6	-45	↓
E	2	I	9	39	1.35	1.35	1.29	1.47	0	4	- 9	--- Note 1
			43	45	0.90	0.87	1.04	1.14	3	-16	-27	↓
G	2	I	25	15	NA	NA	NA	0.98	-	-	-	--- Note 2
			26	15	1.10	1.13	1.13	1.35	- 3	- 3	-23	Note 2
			27	15	1.22	1.41	1.50	1.25	-16	-23	- 7	Note 2
			28	15	1.37	1.37	1.37	1.38	0	0	1	--- Note 2
F	6	I	30	8	1.66	1.16	1.53	1.61	30	8	3	Notes 3 and 7
			31	8	NA	NA	NA	1.57	-	-	-	↑ Note 4
A	2	I	1	12	FA	FA	1.45	1.86	-	-	(3-4) -28	↓

[illegible] questionnaire data sheets did not include any data on model.

TABLE 26 - SENSITIVITY MEASUREMENTS - SAMPLES FROM VAMC INSTALLATIONS

Detector Mfr.	Model No.	Ion or Photo	Sample No.	VAMC	Obscuration - percent per foot				Sensitivity Change, % / ft.			Comment:
					As rec'd. (1)	After Vac. (2)	After Air (3)	After Wash (4)	1 - 2	1 - 3	1 - 4	
B	4	P	40	18	0.86	1.41	1.66	0.57	-64	-93	34	Note 7
			41	18	1.84	1.90	1.96	2.11	- 3	- 7	-15	--- Note 1
B	2	P	15	18	2.64	2.40	2.64	2.46	9	0	7	- - -
			16	18	2.46	2.42	2.43	2.58	2	1	- 5	- - -
			38	18	2.89	3.95	3.70	3.42	-37	-28	-18	↓
			39	18	2.27	2.33	2.52	2.78	- 3	-11	-22	↓
			47	18	2.58	2.64	2.71	2.09	- 1	- 5	19	Note 7
D	4	P	48	118	1.35	1.72	1.24	1.47	-27	8	- 9	Note 7
C	1	P	23	1	8.85	8.59	8.92	11.39	3	- 1	-28	Note 6

TABLE 26 - SENSITIVITY MEASUREMENTS - SAMPLES FROM VAMC INSTALLATIONS

Detector Mfr.	Model No.	Ion or Photo	Sample No.	VAMC	Obscuration - percent per foot				Sensitivity Change, % / ft.			Comment
					As rec'd. (1)	After Vac. (2)	After Air (3)	After Wash (4)	1 - 2	1 - 3	1 - 4	
A	1	I	2	12	0.73	0.76	0.82	0.79	- 4	-12	- 8	- - - Note 1
			20	1	No alarm 7.37	No alarm 8.92	No alarm 8.92	0.98	-	-	-	↑ Note 4
			22	1	3.58	2.77	1.96	1.41	23	45	61	↑
			32	41	0.64	0.61	0.61	0.94	5	5	-47	↓

CODE: Decrease in Sensitivity ↓

CODE: Increase in Sensitivity ↑

- - - No Definitive Change in Sensitivity

NA No Alarm up to 4.0 percent/ft. obscuration (0.058 optical density/m).

FA False Alarm

Note 1 - Where positive and negative readings are shown for a particular sample, the variations are attributed to normal tolerance deviations in smoke box readings resulting from operator technique and/or ambient conditions, and relatively short (0.5 meter) beam length. Overall effect on sensitivity is indicated by direction of arrow.

Note 2 - Interior of detector chamber was not accessible for washing. Cleaned as best as possible.

Note 3 - Unit LED not operational to denote an alarm condition. Alarm could be identified by "click" sound of relay.

Note 4 - Unit operational only after washing with alcohol. Evidently dirt or film build up occurred on radioactive source which was eliminated during washing.

Note 5 - Increase in sensitivity after washing attributed to incomplete drying of printed wiring board. Normally, removal of dust would reduce reflective factor in chamber and result in a decrease of sensitivity. All samples cleaned the same way.

Note 6 - Sensitivity evidently adjusted beyond acceptable limits. Minimum sensitivity permitted in ANSI/UL 268 smoke box is 4.0 percent per foot obscuration. Currently, production sensitivity permitted to be 50 percent or a maximum of 1 percent per foot lower, whichever is less, than the minimum production sensitivity permitted for the model.

Note 7 - Data inconclusive.

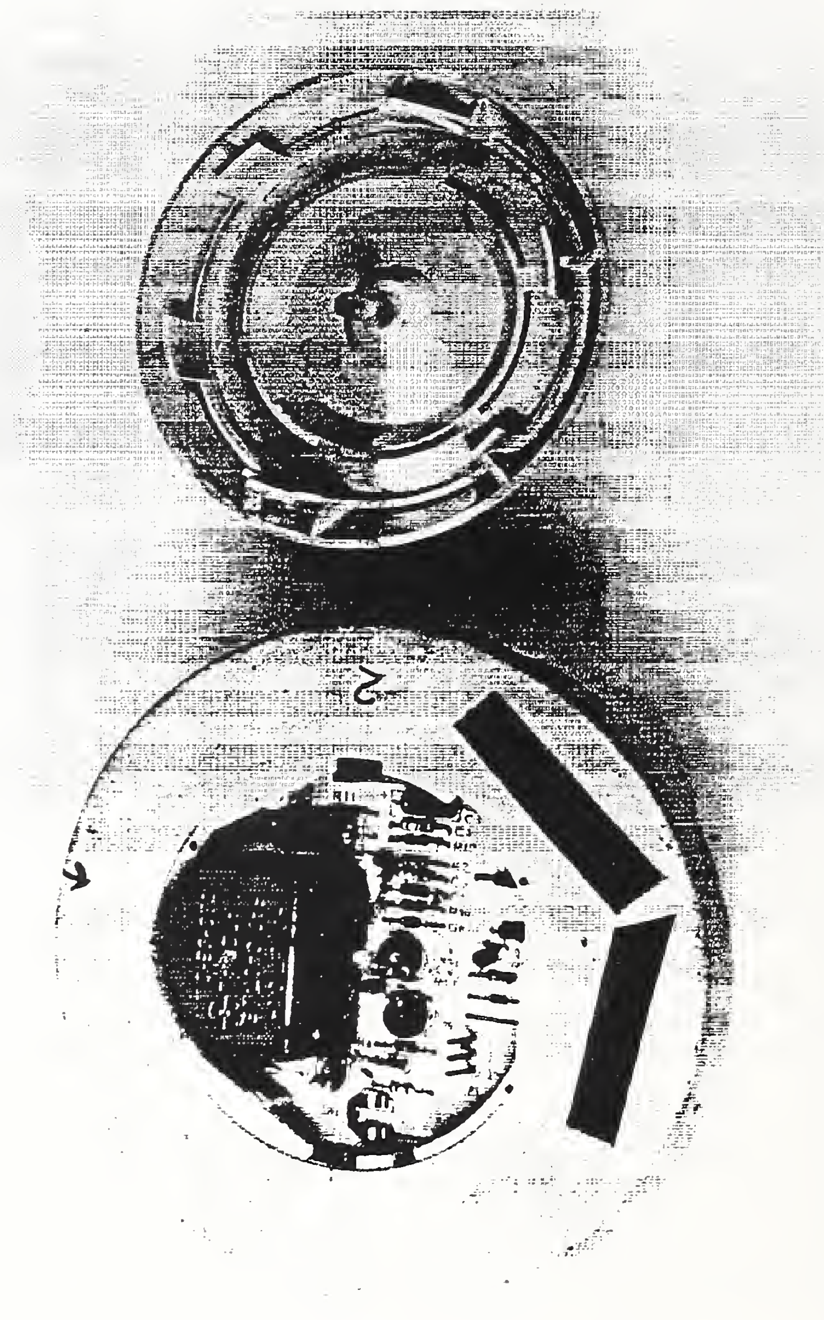

Photo 1 - Dirty Detector as Found in a Facility

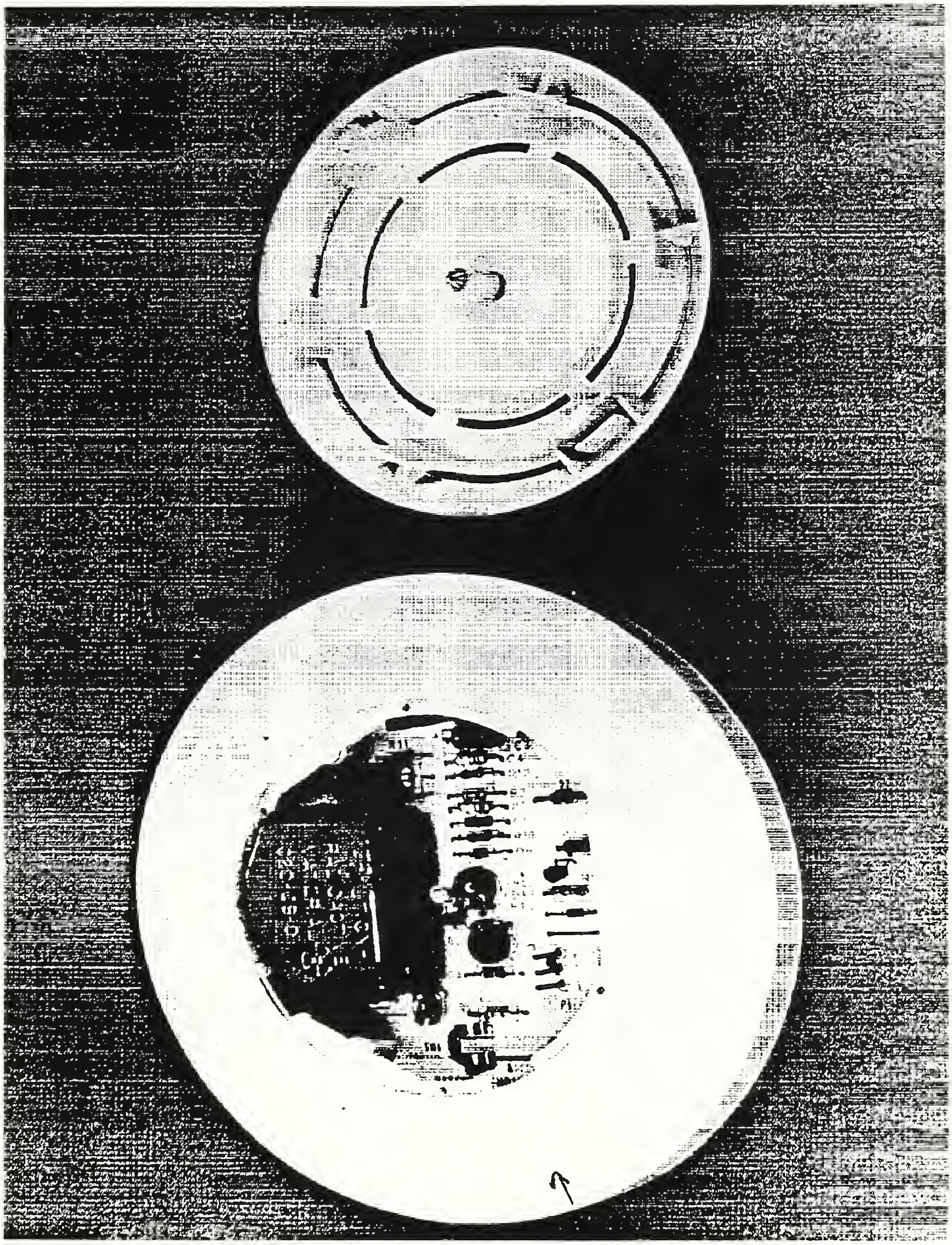

Photo 2 - Same Detector After Cleaning

5. VAMC OPERATIONAL POLICIES

A review of the original questionnaire data sheets returned from the VAMCs disclosed that many false alarms were caused by smoking, dust, and lack of cleaning. To obtain more definitive data, questions regarding the smoking, testing and cleaning policies were included in the Supplementary Information Sheets. More detailed information on the same subjects was also obtained during visits to 20 VAMCs. Those data have been combined in Table 22 and are summarized below.

5.1 SMOKING POLICIES

All VAMCs have some form of smoking policy since it is required in government buildings. However, it is the difficulties in enforcement of the policy which has a bearing on the number of false alarms resulting from smoking. Observations made during visits disclosed that, in general, patients smoked in designated areas but some have a tendency to drift away from the area into no-smoking zones. They keep the cigarette cupped in their hand presumably to keep from being detected by hospital staff. This is commonplace in elevator lobbies, where patients in general care facilities and even psychiatric patients who have run of the hospital during daytime hours, travel from one floor to another. It is understandably difficult for the staff to be on the lookout for violators since there is a large amount of traffic in the corridors during the daytime.

In psychiatric wards, smoking is usually permitted in dayroom areas but many patients were observed to be smoking in corridors where smoke detectors were installed. Whether the smoking policy can be enforced more stringently in such wards is debatable since in many hospitals there is insufficient staff to be constantly on the alert for violators. An attitude of tolerance also seems to prevail since smoking seems to be one of the few pleasures left to the patients. During nighttime hours, the psychiatric wards are locked and the patients smoke at will anywhere.

Usually the false alarms do not stem from a patient passing under a detector with a cigarette. An alarm occurs if two or more smoke near a detector or one patient is smoking directly under a unit, particularly in rooms with 8 ft. or lower ceilings. Many tunnel and basement ceilings are fairly low (7 to 7-1/2 ft.), and many false alarms occur in such areas, especially at doorways, since these seem to be natural congregating points. A smoke detector which has been subjected to abnormal smoking can often be recognized by the tell-tale yellowish color which probably results from a combination of tars and nicotine. These are especially prevalent in dining rooms with low ceilings where smoking is permitted, and in psychiatric wards.

Table 21 provides a comparison of false alarm rates vs. degree of enforcement of the smoking policy at installations where smoking was the specific cause of a false alarm. The data were summarized from Tables 1 and 22.

Table 21 - Smoking Policy vs. False Alarm Rates

Smoking Policy	No. of VAMCs	No. of False Alarms From Smoking	False Alarm Rate No. of False Alarms/ Installation
Strictly Enforced	9	11	1.2
Moderately Enforced	35	126	3.6
Not Enforced	2	10	5.0

Table 22 - Testing/Cleaning/Smoking Policies vs. False Alarm Rates
(Data From Supplementary Information Sheets - Visits)

VAMC No.	Smoking Policy	Testing Policy		Cleaning Policy		F.A. Rate - Percent
		Frequency	Method	Frequency	Method	
1	NE	Random	Aerosol	At F.A.	Air-30 psi	138.
3	NE	Random	Aerosol	Visual Insp. Random	Brush	88.6
5	SE	2/yr.	Aerosol	None	-	30.0
8	NE	1/2 yrs.	Aerosol	Random	Air	32.7
9	ME	None	-	None	-	28.9
10	ME	1/yr.	Analyzer	1/yr.	Vacuum	21.9
11A	ME	4/yr.(100)	Aerosol	2/yr.(100)	Air/Alcohol(S)	25.5
11C	ME	4/yr.(100)	Aerosol	Not yet established	New System	0.0
12	NE	Random	Aerosol	At F.A.	Brush	72.7
15	ME	4/yr.	Aerosol	At F.A.	Air	54.5
16	SE	4/yr.(100)	Aerosol	At F.A.	Alcohol	22.6
17	SE	2/yr.	Aerosol	2/yr.	Air	14.8
18	NE	4/yr.	Aerosol(S)	1/yr.(100)	Degreaser then Air (S)	155.
20	NE	2/yr.	Aerosol	1/yr.	Air	14.2
21	ME	Random	Aerosol(S)	Random	Vacuum(S)	9.0
22	ME	1/yr.	Aerosol	1/yr.	Air	52.0
23	NE	None	-	None	-	37.3
24	ME	1/yr.	Smoke	2/yr.	Air	11.8

Table 22 Continued
(Data From Supplementary Information Sheets - Visits)

VAMC No.	Smoking Policy	Testing Policy Frequency	Testing Policy Method	Cleaning Policy Frequency	Cleaning Policy Method	F.A. Rate - Percent
30	SE	4/yr.	Aerosol	None	-	25.0
31	ME	4/yr.(100)	Aerosol, meter, magnet	4/yr.	Air	28.5
33	ME	2/yr.	Aerosol-meter	At F.A.	Air	18.2
34	SE	2/yr.	Aerosol-smoke	2/yr.	Air/alcohol	22.4
36	ME	None	-	None	Air	7.7
38	ME	4/yr.	Aerosol	None	-	21.1
39	SE	2/yr.	Smoke Test Fixture	None	-	12.2
41	ME	4/yr.(100)	Aerosol	None	-	39.1
43	ME	2/yr.	Aerosol	None	-	11.5
45	ME	2/yr.(100)	Aerosol, meter, magnet(S)	2/yr.	Air(S)	7.5
47	ME	4/yr.	Aerosol	Random	Air	3.1
49	ME	2/yr.	Aerosol	1/yr.	Wiping	5.7
53	SE	1/yr.	Aerosol	None	Wash exterior vacuum	0.0
56	ME	4/yr.100%	Aerosol, magnet	1/yr.	Air/alcohol	6.7
63	ME	Random	Smoke	At F.A.	Air	11.2
64	SE	4/yr.	Aerosol	2/yr.	Vacuum	0.0
68	ME	1/yr.	Smoke	1/yr.	Vacuum	1.1
69	ME	1/yr.	Smoke	1/yr.	Alcohol	1.5

Table 22 Continued
(Data From Supplementary Information Sheets - Visits)

VAMC No.	Smoking Policy	Testing Policy		Cleaning Policy		F.A. Rate - Percent
		Frequency	Method	Frequency	Method	
70	ME	2/yr.	Aerosol	None	-	2.5
75	ME	4/yr.	Aerosol	None	-	0.0
77	SE	4/yr.	Magnet	As needed	Alcohol	0.9
78	ME	4/yr.	Aerosol	None	-	0.0
79	ME	Random	Aerosol	Random	Vacuum	9.9
83	ME	4/yr.	Aerosol	None	-	50.0
86	NE	Random	Aerosol	None	-	3.5
90	ME	1/yr.	Aerosol	2/yr.	Air	14.6
92	ME	4/yr.	Pulsing Light	4/yr.	Air	16.1
93	ME	2/yr.	Aerosol	None	-	4.9
97	ME	2/yr.	Meter, test button	Random	Air	14.6
99	SE	4/yr.	Cigarette	Random	Vacuum	12.5
100	ME	None	-	None	-	4.8
103	ME	1/yr.	Cigarette	Random	Air	11.6
104	ME	4/yr.(100)	Aerosol(S)	2/yr.	Air	7.1
105	ME	4/yr.	Aerosol	None	-	18.3
106	ME	2/yr.	Aerosol	2/yr.	Vacuum(S)	6.9
107	ME	4/yr.	Aerosol	At Alarm	Air/alcohol	8.0

Table 22 Continued
(Data From Supplementary Information Sheets - Visits)

VAMC No.	Smoking Policy	Testing Policy		Cleaning Policy		F.A. Rate - Percent
		Frequency	Method	Frequency	Method	
108	SE	2/yr.	Smoke	2/yr.	Air	12.2
110	ME	4/yr.	Magnet, Smoke	Random	Air	11.1
111	ME	4/yr.	Meter	4/yr.	Vacuum	8.7
118	ME	2/yr.	Aerosol	2/yr.	Wiped outside	21.7
132	ME	1/2yrs.	Aerosol	1/yr.	Alcohol	24.8
133	SE	4/yr.	Smoke	4/yr.	Wiped outside	7.5
136	ME	Random	Aerosol	Random	Air	61.4
137	SE	4/yr.	Aerosol	2/yr.	Air	16.8
139	ME	2/yr.	Aerosol, magnet	1/yr.	Vacuum	13.1

CODE: Smoking Policies: NE - Not Enforced
ME - Moderately Enforced
SE - Strictly Enforced

Testing/Cleaning: S - Service Contract

100 - One hundred percent of all detectors tested or cleaned during indicated period.

5.2 TESTING POLICIES

While the data from the Supplementary Information Sheets may indicate a quarterly, semi-annual, or even monthly testing, it does not necessarily mean that 100 percent of all installed detectors were tested during that period. When this subject was discussed during visits to VAMCs and in telephone conversations, indications were that only a percentage of the units were tested. This could not be verified for all installations. However, where (100) is indicated for an installation in Table 22, 100 percent of all detectors were tested for the indicated period.

Where a combination of test methods are used for a VAMC, it means that a portion of the installation is tested under two or more of the various methods described, depending on the design of the detector.

5.2.1 Smoke Detector Test Methods Available

Method	Description
Smoke Detector Analyzer	A commercially available test equipment developed at NIST which nebulizes (atomizes) a non-toxic mineral oil into a fine mist, whose concentration is measured and translated into a percent per foot obscuration level or a mass concentration of particles in milligrams per cubic meter. The mist is generated in the housing and exits via a flexible vacuum hose which terminates in a transparent plastic shroud intended to cover the detector to be tested. Calibration curves with the unit provide a relationship which translate its readings to obscuration levels included in ANSI standard UL/268. By keeping a record of the test dates and concentrations for the detectors tested it is possible to quantify any shifts in sensitivity between test periods. In normal testing the unit would require a rolling table and locations where a source of AC power was available. The unit could also be employed in a fixed location as a test station whereby the detector head would be removed and brought to the station for test. This would only be practical for a separable detector.
Metering Test Means	All detectors are required to have some form of test means by which the sensitivity of the unit can be either measured or approximated. One of the means used is in the form of an electrical measurement. The measurement may be made at access points on the detector or, for removable detectors heads, an interface is permitted by which an electrical measurement of sensitivity is attained. This electrical measurement can readily be translated into an obscuration level, the range of which would be included in the instructions provided with each detector. This method also provides a quantitative measurement of sensitivity. Also included in this group would be a detector with a pulsing LED. The number of pulses per minute, which can be readily monitored externally by visual means, vary with the sensitivity of the unit.
Mechanical Test Means	Another commonly used test means in detectors is mechanically actuated. For example, a calibrated light-colored wire can be moved into the chamber area of an optical detector. The light source reflects off the wire onto the photodiode (receiver) and the unit goes into alarm. The detector sensitivity under this condition is checked by the testing

laboratory. Movement of the wire is achieved by a push button, magnet, etc. In an ion type detector a plunger is pushed into the chamber area where a quiescent (steady state) ionizing current is flowing, which disrupts the current and an alarm signal is obtained. The level of obscuration with the inserted plunger is also recorded. The requirement is that the level of sensitivity at which the unit goes into alarm from a mechanical test means is not to exceed 6 percent per foot obscuration using gray smoke. This is equivalent to an optical density of 0.088 per meter. This test method indicates whether a detector is still operational for alarm but does not show if the unit is drifting toward a false alarm or toward the insensitive direction.

Smoke

Test smoke generated from a cigarette, "punk" stick, or some equivalent means, such as a cotton wick. The smoke generator is hand held to provide a GO - NO/GO type of test.

Test Fixture (Punk Sticks)

The fixture consists of a telescoping hollow tube, the top of which terminates in a transparent plastic shroud which is intended to cover the detector under test. The bottom of the assembly includes a battery operated fan and a combustion chamber in which is placed a smoldering fabricated "punk" stick. A replaceable filter is used to filter the smoke from tars and is changed every two sticks. Smoke from the chamber travels up the tube, envelops the detector, and the time is recorded when the unit goes into alarm. Time-of-response criteria can be developed from testing newly-installed detectors. Although this unit was fabricated for a specified manufacturer's detectors, it is adaptable to most units simply by providing a large-enough shroud. Following actuation, the smoke source can be cut off and clean air sent to clear the unit.

Test Fixture (Aerosol Spray)

This unit was also developed for a specific manufacturer's detectors but can be adapted to other detectors which can fit inside the rubber boot which is located at the top of a cylinder attached to a wooden extension pole. Inside the cylinder is an aerosol can which is actuated by a framework assembly to release a spray. When the framework assembly is pushed against the bottom of the detector (1 sec. recommended), a spray is released which envelops the detector head. The flexible rubber boot is needed to maintain coverage over the detector with the pressure released. Time-of-response also can be developed with this apparatus from data obtained on newly- installed detectors.

Canned Aerosol (Hand Held)

This is the most popular method of testing in VAMCs. It consists simply of a 2.5 ounce can of pressurized aerosol spray which emits particles capable of actuating both photo and ion detectors. The spray is simply directed against the side of the detector to determine whether it actuates. It is a GO-NO/GO type of test. Some detector manufacturers object to its use since they contend that the spray leaves an "oily film" on the detector which can have an adverse effect on the sensitivity. CAUTION notice on the can indicates it is to be used no closer than 3 ft. from the detector.

Extension apparatus is available from the manufacturer for testing at high ceilings.

Supervision of Detector Sensitivity

This type of detector was not encountered during visits or included in any of the questionnaire data sheets originally distributed to all VAMCs. No type of field testing is necessary for this so called "smart detector" which provides an analog reading of its sensitivity at a central location. The sensitivity is usually set and adjustable at the control unit. If the sensitivity drifts by more than a precalibrated amount, either in the more or less sensitive direction, a trouble (not alarm) signal is obtained from the control unit indicating that the unit needs cleaning or other service. Each detector is periodically questioned by the control unit periodically to determine whether it is still operational for alarm. If a detector is dirty the control unit will be notified in the form of a trouble signal. While it cannot indicate if an accumulation of lint or dust has built up on the outside screen, this can be uncovered during scheduled inspection trips. No detectors to date have been observed where the accumulation is so extensive that it would seriously inhibit the entry of smoke.

5.2.2 Analysis of Testing Policies

Refer to Tables 22 and 23 for a comparison of the various methods and frequencies of testing vs. the false alarm rates obtained from Supplementary Information Sheets and visits.

5.2.2.1 Smoke Detector Analyzer: Several VAMCs have had this equipment issued but are not using it. In the two installations where it is being used its use is limited to measurement of the response time and not the sensitivity. Some of the reasons cited for its non use include: too bulky and cumbersome, takes too much time, requires extra person for test (not available). Would require long extension cords in busy corridors and therefore not practical.

In discussing the use of the analyzer with the people responsible for its use the impression is left that the equipment in many instances is too sophisticated for the people involved who are employees of the "Electric Shop" and may have been working at that job for a short time.

In using this instrument the question of calibration has been raised as compared with the ANSI Standard UL 268 smoke box on which sensitivities are based and marked on the detectors. Different analyzers will provide different results. There is no specific calibrating standard available to which all the analyzer units can be calibrated. The VA may specify a maximum sensitivity of a smoke detector that can be installed in a medical center but the value measured depends on the particular analyzer used to make the measurement. Presently each analyzer has to be calibrated to a specific detector model whose sensitivity has been measured in the ANSI/UL 268 smoke box.

There was also one other item in question with use of the analyzer. When it was originally developed the aerosol generated from the unit was dioctyl-pthalate. The use of this aerosol was questioned as being a possible carcinogen so its use was discontinued. Later development work resulted in a mineral oil being used which is not harmful. With the use of the mineral oil it is also necessary to use two calibration curves; one for ion, and one for photo detectors.

The results from the use of the smoke detector analyzer cannot be used as a basis of comparison since the sensitivity is not measured quantitatively as intended. The use of a time factor may provide a rough guideline, but even between the two installations that use the instrument, the time range considered acceptable varied.

5.2.2.2 Hand-Held Canned Aerosol: Approximately two thirds of the VAMCs which reported use this method because it is quick and simple to use. However, its use is associated with the highest false alarm rate, when compared on a method to method basis. The false alarm rate using the aerosol is approximately twice as much as smoke and three times as much as using the test means provided with each detector. Even when used in combination with a detector test feature it is still higher than if the test feature alone was used. There is a suspicion that the use of the aerosol may have a detrimental effect on the sensitivity. However, since it was presumably used correctly by the people under a service contract, it can only be concluded that the test distance was less than 3 ft. for those installations with high false alarm rates.

5.2.2.3 Combination of Methods: A comparison of the use of the aerosol spray in installations with a service contract illustrates a substantive difference in the false alarm rate with those that perform testing with the aerosol with their own staff. The difference could be attributed to inconsistent use of the aerosol product stemming from less experience.

5.2.2.4 Detector Test Means: While use of the detector test means is based on only three installations, it appears that a test method without the use of any foreign particles is desirable.

5.2.2.5 Frequency of Testing: The false alarm rates for RANDOM and NO TESTING were combined since they essentially represent minimal or no scheduled testing.

While it may be normally expected that the false alarm rate would be lower with an increase in the testing frequency, a comparison of the Quarterly, Semi-Annual, and Annual test frequencies discloses a higher false alarm rate with the higher frequency of testing. One possible explanation is that misapplied aerosol may have had an adverse effect on the detectors. Accordingly, another column was added to Table 23 which includes the percentage of medical centers that use the aerosol test method. It shows that the false alarm rate increases with an increase in the number of users. The data from the bi-annual testing frequency cannot be considered as valid since only two installations are involved.

Table 23 - Summary of Testing Policies in VAMC's
(Supplementary Information Sheets and Visits)

METHOD OF TESTING

Test Method	Number of VAMC's	Number of False Alarms	Number of Detectors	Avg. False Alarm Rate-Percent
Aerosol Spray	37	2189	10,790	20.0
Smoke	9	217	2,110	10.3
Test Means in Detector	3	84	1,294	6.5
Aerosol-Smoke Test Feature	8#	400	2,791	14.3
*Gemini Analyzer	1	97	442	21.9
Aerosol (Service Contract)	3	222	2,723	8.2

*Employed to measure time of response only, not level of sensitivity.

#One VAMC uses GEMINI unit for 10 percent of testing. Also uses time factor for response and not sensitivity.

FREQUENCY OF TESTING

Test Frequency	No. of VAMC's	No. of False Alarms	No. of Detectors	Average False Alarms Rate-Percent	Percent VAMC's that Test By Aerosol
Quarterly	24	1052	6,419	16.4	64
Semi-annually	16	923	6,773	13.6	56
Annually	8	225	1,779	12.6	38
Bi-annually	2	149	495	30.0	100
**No Testing and Random Testing	12	1033	3,953	26.1	75

**No scheduled testing policy. Testing is done usually after a false alarm occurs. May encompass one or more detectors.

5.3 CLEANING POLICIES

5.3.1 Discussion

The frequency of cleaning varied widely among VAMCs, from quarterly to none. From discussions with personnel involved with the smoke detector systems the impression was obtained that the majority of medical centers do minimal cleaning, and when cleaning is done, it consists only of either vacuuming or blowing out dirt and dust by compressed air.

Cleaning by compressed air consists of either hand held canned air, similar to an aerosol can obtained at photo stores which is used to clean camera lenses, or compressed air available on site. The latter method is used on separable heads which were removed for cleaning.

Brush cleaning does not consist of anything more than brushing the outside of the detector to remove dust and lint. The same would be true for wiping the exterior.

Alcohol is employed to clean the interior of detectors. The detector head is removed, the dust and dirt blown out by compressed air or vacuuming, and the interior sensing components wiped with a cotton swab dipped in alcohol.

From all indications it appears that many duct detectors are rarely if ever cleaned. The primary reason is that many duct detectors are installed in fairly inaccessible locations where it would take a considerable effort to access. This is compounded by the fact that many duct detector housings have many screws that have to be removed, and the seal gasket disturbed, to gain access to the interior sensing compartment where the detector head is installed. One VAMC visited indicated it does not have any confidence in duct detectors and has disconnected them.

5.3.2 Analysis of Cleaning Policies

Please refer to Tables 22 and 24 for a comparison of the various methods and frequencies of cleaning vs. the false alarm rates obtained from the Supplementary Information Sheets and visits to VAMCs.

5.3.2.1 Frequency of Cleaning: Essentially little difference was noted among cleaning quarterly, semi-annually, and annually. However, a scheduled cleaning program is required, at least on an annual basis, to reduce the number of false alarms, as evidenced by the significant difference between cleaning and no cleaning.

5.3.2.2 Method of Cleaning: A substantial difference in false alarm rate was observed between cleaning by compressed air, with or without supplementary cleaning by alcohol, vs. vacuuming. Evidently, the air blown inside the detector does not remove the lint and dust as well as the vacuuming. Although the brush cleaning method was used by only two installations the false alarm rate is more likely related to the detector sensitivity and other factors not related to cleaning.

5.3.2.3 Exceptions: A comparison between the two installations which show the two extremes of false alarm rates illustrate what might be called an ideal controlled situation vs. an installation that requires major changes. Each of five probable causes accounts for the differences:

1. The major difference is that VAMC No. 1 is a 100 percent psychiatric facility while VAMC No. 2 is for general care and includes domiciliaries.

2. The smoking policy at VAMC No. 1 is moderately enforced, while at VAMC No. 2 it is strictly enforced.

3. VAMC No. 1 is presently undergoing a major renovation which would add to the dust deposits inside the detector, thereby increasing the sensitivity and number of false alarms.

4. Although the frequency of testing is the same for each, VAMC No. 1 employs an aerosol test means which may have an adverse effect.

5. Although VAMC No. 1 has a service contract with an outside agency for scheduled cleaning, a degreaser is used which may have an effect on detector response. The degreaser employed is the type used to clean electronic equipment. Further testing in this area is needed.

Each installation includes two detector models; one ion, one photo. The two ion detectors are the same model from the same manufacturer, while the two photo units are from different manufacturers. All three models are still presently listed by UL. The detectors in VAMC No. 1 were installed in 1984 while in VAMC No. 2, they were installed in 1982. The false alarm rate for the ion model in VAMC No. 1 is 439FA/417 detectors, for a false alarm rate of 105 percent. In VAMC No. 2 the same detector model had a rate of 2FA/48 units or 4.2 percent. The average production sensitivity of the ion model, is under one percent per foot, as measured in the ANSI/UL 268 smoke box, or 0.014 optical density per meter.

Based on the above information, it can only be assumed that the major difference for the vast discrepancy between the two installations is the fact that VAMC No. 1 is 100 percent psychiatric, has a more liberal smoking policy which is probably more difficult to enforce, coupled with the major renovation presently underway.

A total of 25 responses were received to the question whether there was any difference noted in the false alarm rate before and after cleaning. The following data were received:

Number of Responses	Type of Response	Cleaning Methods Used
13	No difference	Air (4), Vacuum (4), Wiping (2), Alcohol (3)
*9	Fewer after	Air (7), Alcohol (1), Returned to mfr. (1)
**3	Fewer before	Air (1), Vacuum (1), Alcohol(1)

* Two of the VAMCs provided specific data. At one hospital the rate dropped from 10 to 1. At the other hospital the false alarm rate dropped from 26 to 23. In the latter case evidently there were false alarm problems from other sources besides lack of cleaning.

** The VAMC which employed alcohol for cleaning indicated the alarms were received shortly after cleaning. It is assumed that the unit was not sufficiently dry since there were no alarms subsequently.

One installation, which employs a highly sensitive detector which has a poor record of false alarms in many other installations, reported only one false alarm that for the preceding year and that was from a known cause. All units were swabbed with alcohol, including the radioactive source, four times a year, coupled with an electrical measurement of the sensitivity. Four units have been replaced within the past year since the sensitivity drifted out of the manufacturer's specification.

Table 24 - Summary of Cleaning Policies in VAMC's
(Supplementary Information Sheets and Visits)

METHOD OF CLEANING

Method	Number of VAMC's	Number of False Alarms	Number of Detectors	Avg. False Alarm Rate-Percent
Compressed Air	22	1558	8218	19.0
Vacuuming	9	430	3996	10.8
Brush Cleaning	2	407	493	82.6
Wiping of Exterior	4	141	950	14.8
Air-Alcohol (Interior)	8	300	2344	12.1

FREQUENCY OF CLEANING

Frequency	Number of VAMC's	Number of False Alarms	Number of Detectors	Avg. False Alarm Rate-Percent
Quarterly	4	187	872	21.4***
Semi-annually	12	708	5236	13.5
Annually	9	320	2509	12.8
*Random/No Cleaning	36	2130	10531	20.2

*No scheduled cleaning policy. One or more detectors cleaned after a false alarm.
***Percentage falls to 11.9 if one VAMC is discounted.

EXCEPTIONS

The following two installations, which illustrate the extremes in false alarming, are included to show a comparison of testing and cleaning policies instituted at both installations. Both installations include both ion and photo detectors, one model of each type, with the ion detector being common to both VAMC's. These VAMC's were not included in the preceding Tables to prevent distortion of the data.

Condition		# VAMC 1	VAMC 2
No. of False Alarms		863	7
No. of Detectors		553	782
False Alarm Rate-Percent		156	0.9
Testing :	Method	Aerosol	Magnet
	Frequency	Quarterly	Quarterly
Cleaning:	Method	Canned Degreaser/air	Vacuuming/Cleaned internally
	Frequency	Annually	As needed**

#Testing and cleaning under service contract.
**At sign of false alarm entire group in area is vacuumed and cleaned internally.

5.4 FALSE ALARM TOLERANCE LEVEL

The data in Table 25 were obtained in response to the question as to what would be considered the maximum alarm rate which the VAMC could tolerate. The information was obtained in discussions during visits to VAMCs.

Since the information garnered during the visits was approximately one year after receipt of the questionnaire data sheets, it should be borne in mind that the failure rates improved over the one year period as many of the VAMCs visited were undergoing renovations and some have instituted programs for replacement of detectors.

These data are included to show a comparison of the false alarm levels which can be tolerated by the various VAMCs. From the percentages in the table it is obvious that most of the higher percentages are based simply on an optimistic number which would be considered an improvement (reduction in number of false alarms) for that facility. This is illustrated by the percent differences column.

Table 25 - False Alarm Tolerance

Tolerated False Alarm Rate	Tolerated False Alarm Rate/year	Number of Detectors	False Alarm Rate 1985-1986 - %	Tolerated False Alarm Rate - %	Percent Differ.	Type Facility
1.5/month	18	306	88.6	5.9	-82.7	G
4/year	4	204	37.3	2.0	-35.3	G
1/month	12	261	30.0	4.6	-25.4	G
1/week	52	56	138.0	93.0	-45.0	G
20/year	20	530	7.0	3.8	- 3.2	G
2/month	24	451	54.5	5.3	-49.2	G
2.5/month	30	271	39.1	11.1	-28.0	P
10/month	120	330	32.7	36.4	+ 3.7	P
1/quarter	4	528	28.5	0.8	-27.7	G/DOM
3/week	156	553	155.0	28.2	-126.8	P
3/month	36	520	7.5	6.9	- 0.6	G
4/month	48	605	21.7	7.9	-13.8	P
1/month	12	111	28.9	10.8	-18.1	G
1/week	52	187	72.7	27.8	-44.9	G
1/month	12	202	3.5	5.9	+ 2.4	G/P
1/3 month	4	272	Not Avail.	1.5	-	G
Zero	0	181	0.0	0.0	0.0	G
1/month	12	1376	9.2	0.9	- 8.3	G
2/month	24	363	61.4	6.6	-54.8	G
4/month	48	541	12.2	8.9	- 3.3	G

Code: G - General Care

P - Psychiatric Care

DOM - Domiciliary

Percent False Alarm Rates are Number of False Alarms per 100 detectors per year.

6. REMEDIES FOR FALSE ALARMS FOR VAMCs

6.1 REMEDY AT SYSTEM CONTROL UNIT - ALARM VERIFICATION OPTION

To reduce the number of false alarms from smoke detectors in VA Medical Centers from such momentary transient causes as a cloud of smoke or dust, surge of high velocity air when an outside door is opened, electrical transients, aerosol spray, and possibly even transient insect migrations through a detector chamber, an ALARM VERIFICATION (CONFIRMATION) circuit or module can be added between the control unit and the smoke detector circuit.

Alarm verification (confirmation) consists of a module or interface card added to a fire alarm control unit, intended to monitor initiating device circuits so that any alarm signal from a smoke detector is confirmed by the system one or more times before a general alarm is sounded. It is also possible to provide this feature wholly within the detector itself. The maximum time delay permitted by an alarm verification circuit is 60 seconds.

To illustrate how this feature operates, consider a system with 50 smoke detectors connected to zone 3 of a control unit which includes an alarm verification circuit. A person smoking in the corridor accidentally sets off detector No. 44. If an alarm verification circuit was not used, the system alarm bells would sound immediately. With alarm verification the circuit is shut down for a pre-determined time span between ten and 60 seconds. Let us assume the alarm verification is preset for 30 seconds. After being off for 30 seconds the circuit is reenergized by the control unit, and, if the detector is still in an alarm state - assuming the smoke concentration inside the chamber has not dissipated below the alarm threshold level - the detector will transmit another alarm signal, and the system would go into alarm. However, if the smoke inside the detector chamber has dissipated below the alarm threshold level, the detector is automatically restored to normal when the detector circuit is reenergized.

Before adding an alarm verification feature to a fire alarm system it is required that the local authority having jurisdiction approve the arrangement, since many inspection authorities will not permit any type of delay in the actuation of a fire alarm system, particularly in a health care facility.

In many smoke detector circuits there may be other alarm initiating devices connected, such as heat detectors and manual stations (pull boxes). Since the alarm verification cannot distinguish between these devices and smoke detectors, the alarm delay would also apply when they are actuated. Thus systems with alarm verification must often be re-wired to segregate smoke detectors and other initiating devices on separate circuits.

In the event that a particular installation is plagued with false alarms, it may be appropriate to select an alarm verification delay of 10-15 seconds which the inspection authority may permit in lieu of replacing all the detectors or eliminating the protection altogether.

Alarm verification, with a maximum delay up to 30 seconds has only recently been permitted for smoke detectors in ANSI/UL268.

6.2 OTHER OPTIONS AVAILABLE TO VAMCs

Several additional options are available to those VAMCs which have an unacceptable false alarm rate. These are discussed below:

6.2.1 Detector Replacement

Many VAMCs are currently implementing a detector replacement program for detectors which have a high rate of false alarms, or are considered too old and require excessive maintenance. The rate of replacement is usually dependent on budgetary constraints.

If the decision is made to replace a detector, then the sensitivity of the new detector should be as low as possible. The manufacturer should be queried regarding the range of sensitivity for the model and a sensitivity selected which is near the low end of the range. Another consideration is whether to replace the unit with a detector using the same principle of operation (photo or ion), or switch to a different principle.

If a 2-wire detector is being replaced with another 2-wire detector, then it must be determined prior to installation whether the replacement detector is compatible with the control unit being used. All 2-wire detectors are required to be tested for compatibility with a specific control unit. They will not operate with all control units.

6.2.2 Highly-Sensitive Detectors

If there is a prevalence of false alarms, regardless of the fact that a scheduled cleaning and testing program have been in force, then the likelihood is that the detector is too sensitive for the application and should be replaced in accordance with the guidelines in Section 6.2.1.

6.2.3 Misapplied Detectors

Detectors located in areas where false alarms originate from misapplication, such as cooking related, steam from showers or laundries, smoking areas, and the like, should either be replaced by a heat detector, relocated, or eliminated altogether. If an ion detector is located in an area where high air velocity is encountered frequently, such as near an outside entrance door, then it may be replaced by a photo unit since they are not affected by high air movement.

6.2.4 Cross Zoning of Detectors

Connection of signaling circuits of two (or more) smoke detectors so that it will require both detectors to be in an alarm condition before the system alarm circuit is energized is often referred to as cross zoning. While usually employed where the system is used to activate an extinguishing system, it can also be used to reduce false alarms.

6.2.5 Pre-Signal Operation

The pre-signal mode of operation has historically been used subject to acceptance by the authority having jurisdiction, for investigating the source of an alarm signal to determine whether it is a real or false alarm, before any other action is taken. If no action is taken within a preset period, such as 2 or 3 minutes, the system evacuation alarms are automatically energized.

The preliminary notification (pre-signal) of the alarm is sent to a designated location, usually where the source of the signal can be identified, such as on a light annunciator, and where there is a responsible person on duty at all times, who can investigate the source of the alarm. If a hostile fire is found the system evacuation signals are energized by means of key-operated switches located at each manual station, or simply by letting the time expire.

Pre-signal system operation is usually used during the day, in locations such as schools where there may be a prevalence of false alarms, and people are on duty. During non-occupied hours, the system is reverted to an automatic mode of operation.

Pre-signal systems are also commonly used in hotels on a 24-hour basis, since a desk clerk is always on duty. Smoke detectors in the rooms are connected to a fire detector annunciator which alerts the attendant by an audible sounder. The attendant then takes immediate steps to verify the type of alarm. If a hostile fire is found he energizes the general alarm and calls the fire department. Historically, pre-signal systems have not been permitted by the code in health care facilities, so this is not an available option unless the AHJ can be convinced that the delay imposed is acceptable; such as in a fully-sprinklered building.

6.2.6 Removal

Where smoke detectors are installed which are not specifically required by code or VA policy, one option would be simply to remove them.

6.3 IMMEDIATE STEPS WHICH CAN BE TAKEN BY VAMCs

A list of the various causes of false alarms encountered in VAMCs are listed below together with proposed remedies. Multiple options are listed in order of priority. These remedies can be implemented immediately to reduce false alarms. Other options which can be used are described in Section 6.2.

False Alarms Cause	Proposed Remedies
Smoking	1. Implement and <u>enforce</u> stringent smoking policy for entire medical center. Smoking to be permitted in designated smoking areas only. 2. Add Alarm Verification or pre-signal operation for detectors installed in locked psychiatric area. Also in general care areas if the smoking policy is not enforced.
Dust Related	Institute scheduled testing and cleaning program of all (non-construction)detectors least once per year.
Lack of Cleaning	Institute scheduled testing and cleaning program of all detectors at least once per year.
High Air Velocity	Only ion detectors are affected. Change to photo detector with low sensitivity. If photo detector actuate then dust or smoke is being carried in the air stream.
Humidity	Either replace detectors with more current units that have been evaluated for at least a 93 percent humidity or relocate. Contact manufacturer for additional information.

Construction Work	Internal VAMC communication needed between safety officer and VAMC contact with contractor to either disconnect zone or connection to the fire department for that zone, or cover the detectors near construction area but add a CAUTION marking on cover to remove when work is done. With the use of a cover extraneous dust will not enter the detector chamber and make it more sensitive.
Housekeeping	Post written guidelines to hospital and maintenance staff regarding housekeeping procedures such as cleaning, spraying, and the like to be followed to prevent false alarms.
Cooking Related	Replacement of ion detectors with photo type. If false alarms still persist either relocate detectors or cooking source, or change to heat detectors.
Malicious	Internal VAMC problem. Stricter smoking policy may help.
Defective	Replace unit. If considered defective from repeat false alarms check sensitivity level since detector may simply need cleaning.
Insects	Fumigate area. If insects become a continual problem replace unit with detector having insect screen or equivalent. Insect repellant or insecticide tape or strips on or in the detector have been found to be effective for a year or two.
Transients	Add Alarm Verification or replace with transient-resistant detector. Contact detector manufacturer or supplier for transient resistance information.
Steam	Misapplication. Relocate detector away from steam source.
Lint	Either replace detector or increase cleaning schedule.
Inside Fumes	Same as for Housekeeping. If detector is ion type, replace with photo unit.
Outside Fumes	If ion type replace with photo unit or secure against fumes entry.
Water in Detector	Either relocate or place seal between back of detector and mounting surface to prevent entry of water.
Laundry Dryers	Misapplication. Replace with heat detector suitable for temperature involved.
Hot Areas	If normal ambient temperature exceeds 100 F (38 C), replace with heat detector.
Fan Shutdown	Scheduled cleaning of duct detectors should be implemented.
Unknown	Assume most of such causes result from smoking. More stringent enforcement of smoking policy or addition of Alarm Verification.
High Sensitivity	Add Alarm Verification. If false alarms still persist, replace units with less sensitive detectors.

6.4 REMEDIES THROUGH PRODUCT STANDARDS

6.4.1 Discussion

In addition to remedies which can be applied at the VAMC, other remedies related to performance and installation have been or are being incorporated into ANSI/UL268 to address areas where the requirements needed strengthening in order to curtail the increasing number of false alarms being reported from the field.

Because of rapid changes in the state-of-the-art of detector design, such as the current use of integrated circuits, as well as changes in requirements of performance standard ANSI/UL268, most detectors currently sold represent designs which are less than about 5 years old. Each new model contained improvements of one type or another. Many of the latest changes have addressed the false alarming aspect which was becoming very evident in the early 1980's.

In view of the above, many of the detectors presently installed in VAMCs are obsolete and no longer being manufactured. In other instances, not only is the detector obsolete but the manufacturer either has gone out of business or has discontinued making smoke detectors. Accordingly many replacement units are not available and another manufacturer's detectors have been used to maintain the system. This results in many problems since different detector manufacturers provide different testing and cleaning guidelines. Because of this many systems have been declared obsolete by the VA and replacement systems are being installed.

6.4.2 Changes in ANSI/UL 268

Changes in the requirements for smoke detectors which have been adopted within the past few years, and to which most of the detectors installed presently in VAMCs have not been tested are tabulated below:

1. Testing at higher velocities (1000 and 2000 fpm) with the maximum velocity to be marked on the unit.

2. Maximum opening into detector chamber to minimize false alarms from insects is restricted to 0.050 in. (1.27 mm) which is the width of a household window screen. If the opening was made smaller it could inhibit the entry of smoke.

3. Maximum sensitivity allowed in production reduced from 0.2 to 0.5 percent/ft. obscuration (0.003 to 0.007 optical density/meter).

4. Additional smoldering test added to determine that a detector, particularly a photoelectric type, does not alarm prior to a smoke build up of 0.50 percent/ft. in the detector area using detectors calibrated to the maximum sensitivity. This test is representative of a smoke build up such as may occur during a meeting or in a lounge where people may be smoking.

5. Humidity exposure has been increased from 85 percent at 30C for 72 hours to 96 hours at 93 percent and 40 C.

6. An optional alarm verification feature is now permitted in the standard to permit culling of alarms from transient smoke and dust clouds. A maximum delay of 30 seconds is permitted.

7. On two-wire detectors, which require evaluation with the specific control units with which they are to be employed, tests have been added to check for false alarms.

8. Additional transient test added to evaluate transients on the lines extending to the detectors. In addition, the effect of radio frequency (RF) on detector actuation has been made more stringent.

9. Back of detector, through which forced air from the conduit system or insects can enter, is now required to be sealed to prevent both.

10. Higher minimum sensitivity will be available for detectors since the detection limit in the Smoldering Test will be extended to 10 percent/ft. (0.15 OD/m). For photo detectors the black smoke limit has been extended to permit a wider production window.

11. Detector sensitivity will be required to be more specifically marked on the unit to assist designers in siting detectors.

12. Supervision of the detector sensitivity (optional) will require that a trouble signal be obtained if the sensitivity changes by more than 50 percent in either direction. This would be very useful in monitoring the dust/dirt buildup. A trouble signal would indicate to the user that either the detector circuit parameters had changed or that cleaning was required.

13. More specific cleaning instructions will be required for the user and tests conducted so that the described cleaning procedure does not affect the sensitivity.

6.4.3 Changes in NFPA 72E

Additional changes have been recently incorporated in NFPA 72E, Standard for AUTOMATIC FIRE DETECTORS, to assist designers of fire alarm systems in siting of smoke detectors. The changes include the following:

1. Inclusion of detailed field wiring connection diagrams to minimize errors during installation.

2. Drawings added to show proper installation and mounting of smoke detectors in sub-floor installations.

3. Expanded guidelines included in Chapter 8 on inspection, testing, and maintenance of detectors.

4. Additional guidelines included in Appendix A relating to common sources from which false alarms can occur as well as the effects of environmental conditions on detectors.

6.4.4 Assistance of Smoke Detector Manufacturers

In an effort to determine the help that manufacturers can offer with present installations letter requests have been sent to 16 detector manufacturers and/or private labelers of smoke detectors to contact the various VAMCs/where an abnormal number of false alarms have been experienced with their units. From all indications the manufacturers are cooperating in the mutual effort to reduce false alarms.

During various visits to problem installations, detector manufacturers were invited to send a representative along to learn more about the problems being encountered with their units. The resulting exchange of information was beneficial for all concerned.

7. SUMMARY OF FINDINGS

7.1 DISCUSSION

A review of the data gathered in this study has disclosed that smoke detectors have no problem responding to hostile incipient fire situations, such as small pieces of paper burning in an ash tray. This protection is an accepted fact in fire protection.

The greatest current problem with smoke detectors in VAMCs, as well as in other public buildings, is the high prevalence of unwanted (false) alarms which has disenchanted many VAMC Safety Officers, staff, and fire service people. In the more severe cases detectors have been disconnected, negating protection. In the least, the "cry wolf" syndrome can result in delayed action in the case of a real fire. Conversely, there are many VAMCs who are satisfied with their present systems and accept their false alarms on the premise that the detector is doing the job for which it was designed. The fact that many VAMCs are satisfied with their systems implies that the concept of smoke detector usage, even with some false alarms, is viable.

7.2 FALSE ALARM CONTRIBUTING FACTORS

Essentially there are four contributing factors to false alarms in VAMCs. These are tabulated below in order of descending impact:

1. High Sensitivity
2. Environmental Factors
3. Misapplication
4. Internal Education and Communication

Although specific causes, such as smoking, may cause up to 50 percent or more of the total number of false alarms, the reason for a detector actuating from smoking is related to either one or more of the above factors. For example, a highly sensitive detector, which has not been cleaned for several years is more likely to be actuated by a smoker than a less sensitive unit since the dust build up has further increased the sensitivity. If the same detector was located in an area of high humidity, the sensitivity would be increased still further.

7.2.1 High Sensitivity

High sensitivity is the greatest contributing factor to false alarms since it is common to all smoke detectors and all false alarms. Changes are needed in this area since the data in Fig. 5 show that a reduction in false alarms of almost 80 percent is attainable if the <u>maximum</u> production sensitivity is reduced to 1.0 percent/ft. obscuration (0.014 optical density/meter). This assessment is made not on the false alarm data for obsolete detectors, which were evaluated under previously-applied requirements, but on the false alarm percentages for presently-manufactured units which have been installed in VAMCs. Sensitivity reduction will require some changes in future designs and tighter calibration procedures.

Although manufacturers claim that more stability and fewer false alarms have resulted from the easing of production sensitivities permitted by UL (in UL Bulletin, Subj: 268, dated June 30, 1987), it only reinforces the precept that **the lower the sensitivity, the fewer the number of false alarms.** This is further confirmed in False Alarm Studies 4 and 5 described in Section 2 of this report.

However, lowering of the nominal sensitivity of smoke detectors will make them less responsive to real fires. This tradeoff of warning time to real fires for reduced false alarms **must** be evaluated for its impact on overall life safety. Experience to date indicates that the sensitivity level of detectors in current use (which are less sensitive than those produced 5 to 10 years ago) are providing acceptable warning times for real fires. But the low fire incidence rate, particularly in heath care facilities, means that this evidence is not yet conclusive.

7.2.2 Environmental Factors

The inherent open design of smoke detectors permits not only the entry of particles of combustion from a hostile fire but also non-fire produced particles found in environments in which detectors are located, to which detectors also respond. Examples include dusts, steam, cooking by-products, fumes, and the like.

The present state of the art in smoke detector design is at a level where a unit cannot distinguish between combustion particles from a real fire and these deceptive phenomena. However, detector design has improved to a level where a detector sensitivity can be monitored to determine the effect of dust and equivalent buildup inside the chamber. This sensitivity supervision aspect is included in the so-called SMART detectors which operate only with specific control units. It does not appear that any of the VAMCs have such detectors installed.

In view of the above, smoke detectors require periodic testing and cleaning to prevent an increase in sensitivity and to assure a free path for entry of combustion particles. The data in Table 23 indicate that periodic testing results in a reduction in false alarms of approximately 50 percent, while Table 24 shows that implementation of a regularly scheduled cleaning program, at least once per year, results in a false alarm reduction of approximately 40 percent.

7.2.3 Misapplication

Since current smoke detectors cannot distinguish between particles from hostile and non-hostile fires, the placement of smoke detectors is a major concern in reducing false alarms. Two entities are involved in this effort; the system designer, and the installation standard(s) used. Theoretically the designer is supposed to be a fire protection engineer, or an equivalent person with experience. However, in practice, most of the detector designs are the responsibility of an electrical engineer with some rudimentary knowledge in detectors who supervises draftsmen who actually lay out the system. Although it is presumed that many use the applicable installation standard, NFPA 72E (AUTOMATIC FIRE DETECTORS), either there is a very loose interpretation of the standard or the standard is not used. This is evidenced by the locations in which some detectors were found in such areas as lavatories, kitchens, and garages.

7.2.4 Internal Education and Communication

All large smoke detector installations experience an increased number of false alarms during the initial "shakedown" period after a system is put into service. However, once the staff becomes familiar with some of the nuances of detector false alarming, they exercise more caution in subsequent operations with a resulting decrease in false alarms. Although reduced to some extent, false alarms still persist in many VAMCs from such causes as cleaning solvents, housekeeping duties, use of aerosols, and the like. Accordingly, hospital and maintenance staff should be apprised of various causes by posted notices or an equivalent educational arrangement.

One very common recent cause for alarms has been attributed to construction work. A contractor begins to work in a smoke detector protected area without notifying the safety officer in charge of the system. A communication arrangement is needed to preclude such events.

7.2.5 Allocation of False Alarms

On the basis of the data included in Table 17, the causes of false alarms in the VAMCs can be grouped as follows. High sensitivity is considered the underlying factor for all the causes.

CAUSES OF FALSE ALARMS	ESTIMATED PERCENTAGE
Smoking	50
Environmental	25
Misapplication	13
Lack of internal education & communication	7
Miscellaneous	5

By implementing a stringently-enforced smoking policy and regularly scheduled testing and cleaning policy of at least once per year, replacing detectors which are: overly sensitive, experience false alarm from high air velocity, affected by humidity, and provide information on causes of false alarms to staff and outside contractors, it is estimated that the number of false alarms would be reduced by approximately 80 percent or more.

7.3 SMOKING POLICIES

All VAMCs have a smoking policy since it is required by VA policy, the Life Safety Code (31-4.4), and generally in all government buildings. However, it is the degree of enforcement of that policy which has a bearing on the false alarm rate. The stricter the policy, the fewer the number of false alarms. Table 21 shows a comparison of enforcement vs. the false alarm rate.

In view of the high percentage of false alarms from smoking, each VAMC should strive to enforce rigidly the policy at all levels, if the number of false alarms is to be substantially reduced.

7.4 TESTING POLICIES

From discussions during the visits to VAMCs, it is apparent that a substantial number of VAMCs do not implement a comprehensive scheduled testing policy, encompassing all installed units. Some skepticism has to be applied to the data in Table 23 since it is contrary to anticipated results. For example, if all other factors are the same, the false alarm rate associated with quarterly testing and sensitivity adjustment should not be greater than for semi-annual or annual testing. One installation, which operates a semi-annual testing and cleaning program, and whose installation consists of a highly sensitive detector, had no false alarms for the entire year. The sensitivity is checked by the electrical measurement method recommended by the manufacturer.

The use of an aerosol spray seems to be the most popular method of testing since it is quick and easy. However it is associated with the largest number of false alarms (Table 23). This may be attributed to improper use, (less than 3 ft. (1 m)), since the false alarm rate was substantially less when the aerosol was used by an outside organization under service contract. Many detector manufacturers do not recommend the use of the aerosol on their units.

Using the test means built into the detector reflects the least number of false alarms although it cannot be considered statistically significant since only 3 VAMCs were involved. Testing instructions are included with each detector.

Although available at many VAMCs the smoke detector analyzer is not being used. The principal complaints are that it is too cumbersome, needs 3 people for testing, takes too long, and similar comments. One of the problems associated with its use is the calibration aspect which will need resolving, since each unit made may have a slightly different threshold level. The impression was also left that the instrument appears to be too sophisticated for electric shop people who service the detectors.

Testing is usually the responsibility of the safety officer at each VAMC. Indications from visits disclosed that in some VAMCs insufficient personnel were available to do the testing and the services of an outside agency would be desirable. Some VAMCs already have such a service. In the event that presently installed problem detectors are replaced with analog type "smart" detectors, the testing could be reduced significantly in these systems. The sensitivity of each detector is monitored continuously, with any abnormal change automatically transmitted to the control unit, resulting in a trouble rather than an alarm signal.

7.5 CLEANING POLICIES

The data from Table 24 shows that approximately 59 percent of the VAMCs which provided input on the subject either do not clean, clean only the detector which false alarms, or implement occasional random cleaning.

A substantial difference in false alarm rates exists between cleaning and not cleaning. If the data from one VAMC (18) were to be discounted it can be concluded that there is negligible difference among quarterly, semi-annual, and annual cleaning. In view of the above, an annual cleaning schedule should be sufficient for most general care areas. More frequent cleaning may be needed for other areas where dust build up is a problem. This would be ascertained during the periodic testing phase of the detectors.

Vacuuming seems to be the most appropriate method of cleaning as compared to compressed air. Cleaning of the interior with alcohol reduces the number of false alarms, although not as anticipated. However, it is necessary that the sensitivity level be checked after cleaning to verify that the cleaning operation has not adversely affected the threshold response.

The reason for some fairly high false alarm rates, even after annual cleaning, is attributed to the fact that many detectors false alarmed through causes other than those related to cleaning, such as smoke and environmental factors.

The benefits of cleaning can best be summed up by the following comment received from one of the VAMCs in response to the questionnaire data sheets received in 1986; "Our number of false alarms have been reduced significantly since March 1985 due to our preventive maintenance program. Cleaning and testing of all smoke detectors on a regular basis using Fire Department personnel has had a tremendous impact."

7.6 DUCT DETECTORS

Normally duct detectors would not be expected to false alarm in view of the dilution of smoke inside the duct. A substantial amount of smoke is needed inside of a room before a duct detector installed in the ventilating system for the room is actuated.

In view of the higher than normal sensitivity settings for duct detectors, as reflected by two units plotted in Fig. 5, coupled with the fact that the majority of VAMCs do little or no cleaning of the units, it is concluded that most of the false alarms can be attributed to these factors. The main reason why detectors are not cleaned is their inaccessibility. One VAMC indicated that duct detectors were disconnected from the system since they did not have any confidence in their use.

7.7 DETECTORS INTEGRAL WITH DOOR HOLDER CLOSERS

Detectors incorporated into door holder closers exhibit the highest false alarm rate when compared to open area and duct detectors. This is attributed to their high sensitivity setting, which is comparable to that for duct detectors and over-sensitive open area types. Also important is their location where they are normally installed at the top of a door frame only a little more than 1 foot (0.3 m) above where a person of average height would be puffing on a cigarette. False alarms have occurred since doorways are natural congregating points for patients. When installed in corridor fire door closers, the sensitivity is increased not only from the higher velocities encountered, but also from a more rapid accumulation of air-borne dust particles.

7.8 PHOTO VS. ION DETECTORS

The survey of approximately 30,000 detectors, excluding one VAMC because of an abnormal number of false alarms, indicates there is little difference in false alarm percentages between the photo and ion types. See Table 10 and Par. 4.6.10.4. The negligible difference exists despite the generally lower production sensitivities employed for photo detectors as illustrated in Fig. 3.

Since false alarms from smoking represent approximately 50 percent of all causes, and since the susceptibility of photo detectors to false alarm from smoking is twice that for the ion types as summarized in Par. 4.6.10.4, it can be deduced that a substantial number of false alarms for the photo types resulted from smoking. This assessment is made regardless of the fact that the sensitivity of the photo detectors was about twice as low as the ion types based on comparison of spot type units in Table 20.

7.9 FALSE ALARM GOAL

The following data were obtained from a review of the 133 VAMCs in Table I.

No. of VAMCs	Percent of Total	False Alarm Percentage
35	26.3	over 10.0
59	44.4	Maximum 10.0
27	20.3	Maximum 4.0
12	9.0	Maximum 1.1

Based on discussions with VAMC representatives (See section 5 and Table 25) and a review of other false alarm studies described in section 2, it appears that the first practical false alarm rate goal to attain is 4 percent during the first year, or 4 false alarms per 100 detectors per year. For an installation of 300 detectors this translates to a total of 12 false alarms per year or 1 false alarm per month. This estimate assumes that each VAMC will implement many of the procedures described in section 7. Since 27 VAMCs have already reached this goal, it is not unrealistic.

At the end of the second year, by which time most of the recommendations and remedies, including detector replacement, have been implemented, the false alarm rate could be cut in half, to 2 percent. Further reductions would probably require new generations of detectors with lower sensitivities and replacement of obsolete units; for which a reasonable goal would be a false alarm of 1 percent.

While ideally the goal which should be strived for is ZERO false alarms, this is an unrealistic from a practical standpoint in view of the large numbers of people involved, the type of environment and patients, and the myriad of unforseen sources of false alarms.

Based upon the two to one ratio of false alarms between general care and psychiatric care hospitals, the best that can be hoped for in psychiatric units is double the false alarm rate.

7.10 FEATURES OF AN IMPROVED DETECTOR

Based on the findings of this study, a "wish list" of features for an improved detector can be made. This detector should be designed to minimize the effects of the major causal factors related to false alarms: (1) High Sensitivity, and (2) Effect of Environmental Forces, including dust and dirt.

Considering the present state-of-the-art, smoke detectors currently being designed should include the following features:

1. Supervision of sensitivity, with a trouble signal produced in the event of an abnormal change.

2. Better protection from condensation and electrical transients.

3. Maximum sensitivity of 2.0 percent per ft. obscuration (0.029 optical density per meter) for photo type and 1.0 percent per ft. (0.015 OD/m) for ion type.

4. Separable head and base, designed to permit washing of dust and grime by the user.

5. Adjustable alarm verification feature which can be by-passed.

6. Electronics designed to minimize sensitivity drift.

7. If possible, the detector should be able to discriminate between products of combustion from a real fire and deceptive phenomena. This would likely require some type of pattern recognition capability.

One or more of these features could be incorporated into the control unit to which the detector is connected.

8. RECOMMENDATIONS

The following recommendations are made based on the results of the study. Because of the large number they are segregated to address the appropriate organization.

8.1 RECOMMENDATIONS TO VAMCs

8.1.1 Methods of Testing

The following methods and frequency of field testing are recommended, where appropriate to the VAMC. Chapter 8 of NFPA 72E, [11] requires testing of the sensitivity of smoke detectors after one year, and in alternate years thereafter. It also requires that testing be conducted at least annually. This implies that in those alternate years where the sensitivity (quantitative measurement) is not required, a GO - NO/GO type test would be sufficient. The recommended test methods therefore, have been segregated to accommodate both aspects. In using the various test methods the initial measurements will provide the value with which subsequent readings will be compared.

8.1.1.1 Quantitative (Sensitivity) Type Test Method

A. SMOKE DETECTOR ANALYZER: 100 percent testing of sensitivity (not on a time response basis). Supplementary testing by smoke is not necessary since the particle size of the test aerosol is equivalent to smoke particles.

B. METERING FACILITIES: 100 percent measurement of detector sensitivity by electrical facilities provided with unit. Supplemented by smoke test (cigarette, punk stick, cotton wick, etc.) on 5 percent of detectors located in different zones during each test period. Different detectors are to be smoke tested during each test period. The smoke test is simply a verification of operation from smoke.

C. MECHANICAL TEST MEANS: 100 percent testing by the mechanical test means provided with a detector (magnet, pushbutton, etc.) supplemented by testing of 5 percent of the units using the smoke detector analyzer since the mechanical means provides only a relative sensitivity measurement. The analyzer is to be used on different detectors in different zones for each test period.
NOTE: In lieu of an analyzer, supplementary testing may be conducted by Methods D or E described below.

D. TEST FIXTURE WITH PUNK STICK: 100 percent testing of detectors. Response time range limits required to be included in detector manufacturer's instructions.

E. TEST FIXTURE WITH AEROSOL CAN: 100 percent testing of detectors. Response range required to be included in detector manufacturer's instructions.

F. ANALOG DETECTORS: Testing by smoke would only be required on 5 percent of installed detectors if the sensitivity of the detector was supervised (monitored) by the control unit so that a trouble signal would be obtained if the pre-calibrated sensitivity varied more in either direction by a predetermined amount. This would apply to future detectors which may be installed in VAMCs.

8.1.1.2 GO - NO/GO Type Test Method

G. DETECTOR TEST MEANS: Metering facilities or mechanical test means without any supplementary testing.

H. CANNED AEROSOL SPRAY: Same time of discharge (1-2 seconds) is to be applied to all detectors and the can held a minimum of 3 ft. (1 m) from the detector under test. Time of response is to be recorded for a rough estimate of any change in response to previous tests. Delays in response after spray is applied have to be taken into consideration. CAUTION: This type of test is to be permitted only with concurrence of the detector manufacturer.

I. SMOKE: Test to be conducted using sources of smoke such as cigarettes, punk sticks, cotton rope or wick, and the like. Times of response are to be recorded and compared to previous years.

J. COMBINATION OF TEST METHODS: Any combination of test methods G, H, and I.

K. OTHER TEST METHOD: Any other test method acceptable to the manufacturer and the VA.

8.1.1.3 Frequency of Testing

All installed smoke detectors, including duct detectors and detectors integral with door holder closers are to be tested on an annual basis. A record of response is to be maintained for comparison purposes.

The quantitative type test method is to be employed the year the testing schedule is first implemented, and the GO - NO/GO method used the second year. The two methods are then to be alternated in subsequent years. If desired, the quantitative method can be used for all testing.

The testing schedule may be done on a monthly, quarterly, semi-annual, or annual basis, whichever is suitable for the VAMC. One VAMC indicated that they test the operation of the fire alarm system every day, and each day a different fire alarm initiating device is actuated. By the end of the year most, if not all of the smoke detectors would be tested.

8.1.2 Cleaning and Maintenance

A regularly scheduled cleaning and maintenance program should be established at each VAMC. For most applications an annual cleaning program is recommended. In less clean environments, semi-annual cleaning may be warranted. This can be determined by the quantitative sensitivity measurements during the testing program.

Detector yellow tar/nicotine coatings will most likely require cleaning of the chamber area since the coating may have affected the threshold response. Following cleaning, the detector sensitivity is to be rechecked to determine that the cleaning operation did not adversely affect response. The detector manufacturer is to be contacted for his recommendations.

The manufacturer's instructions are to be followed with respect to the method of cleaning and measurement of the sensitivity. If the instructions have been lost the manufacturer should be contacted for his recommendations.

8.1.3 Service Contracts

It is recommended that a service contract be let for the testing, cleaning, and maintenance of the smoke detector system, so that experienced people trained for the purpose are used otherwise, at least three (3) staff people (1 supervisor and two workers) should be trained to perform the testing, cleaning, and periodic maintenance. Many facilities have a high changeover in personnel assigned to the testing and maintenance of the smoke detector system and consequently the training, which was available when the system was first installed, is lost in transition. As an example, a substantial number of the VAMCs visited were not aware that it was possible to test their detector by an electrical or mechanical means provided integral with the unit. They simply rely on the canned-aerosol method. Some installations had experienced people who had been involved with their system for several years. These would be the facilities where outside service would not be needed. Many VAMCs indicated that they do not have sufficient manpower to do the job required.

8.1.4 Area for Testing and Cleaning Detectors

To facilitate the testing and maintenance, it is recommended that each VAMC set aside a specific area for the testing and cleaning operation. This area should include all the necessary test and cleaning equipment as well as the detector manufacturer's testing and cleaning instructions and any other data necessary for the purpose. When not in use, the equipment and instructions should be stored in a closed cabinet.

To facilitate testing and cleaning, and to provide protection during the maintenance process, it is recommended that approximately 5 percent of the number of any model detector installed in a VAMC be kept on hand to serve as replacements during the testing and cleaning process. For example, while 12 detectors are being cleaned and tested, 12 have been installed in their place.

8.1.5 Record of Installed Detectors

Since many of the VAMCs did not even know how many detectors were actually installed in their facility, it is recommended that a record be kept of the smoke detector system, showing the name and model number of the detectors employed, where installed, data of installation, date of replacement (if a change is made), principle of operation (ion or photo), and some form of ID for quick identification. As an example a typical ID number could be 12-3-ECR5 (translated to building 12, 3rd floor, east corridor, detector number 5), or some equivalent form of coding. The use of the detector serial number is an equivalent method.

8.1.6 Log of Testing and Cleaning

It is recommended that a running log be kept of the testing and cleaning of each detector in the system to assure that each unit undergoes the scheduled test and cleaning process and none are overlooked.

8.1.7 Log of Smoke Detector Response

As part of this project a quarterly log of smoke detector response, both to real fires and false alarms, has been sent to NIST for the year 1987. This has provided an excellent record of information, both on the sources and magnitude of real fires, and on the causes which initiated false alarms. Many of these false alarms are correctable since they were initiated from sources related to housekeeping at the hospital (buffing of floors, fumes from cleaning solvents, steam from showers, exhaust fumes drawn into the duct system from outside, etc). This information can be reviewed to determine corrective measures that can be implemented.

8.1.8 Overly-Sensitive Detectors

Overly sensitive detectors, those from which an abnormal number of false alarms still occur after being cleaned, should be replaced. The addition of alarm verification may help but in the long run, replacement with less-sensitive more-current units, will result in fewer false alarms.

8.1.9 Defective Detectors

Before a detector is determined to be defective, usually because it went into alarm more than once, it should be removed, cleaned, and the sensitivity checked. If it continues to false alarm after cleaning, it should be replaced with a less sensitive unit.

8.1.10 Detector Misapplication and Relocation

1. Ash trays in elevator lobbies or in any areas where smoke detectors are installed which are frequently used as receptacles for paper wrappers that are often ignited by a lit cigarette, should either be removed or replaced with sand filled receptacles where extinguishment of cigarettes is more assured.

2. Smoke detectors in lobbies located almost directly over a cigarette receptacle should be moved to the center of the lobby or off center to reduce the likelihood of a false alarm from discarded smoking materials.

3. Prior to installing a detector near an air supply register a preliminary test should be conducted using test smoke to determine whether the air flow inhibits detector response.

4. Detectors installed near doorways leading to designated smoking area should be located at least 6 ft. (1.83 m) from the edge of the doorway.

5. Detectors should not be specified for installation near sources of steam or continuous high humidity. Examples include: near showers, steam sterilizer rooms, laundries, washing facilities, and the like.

6. Detectors should not be installed close to areas of cooking or baking. Miscellaneous appliances, such as toasters or popcorn machines should not be permitted where smoke from their normal use can be sensed by a detector.

7. Because of the presence of products of combustion from construction and repair work, detectors should not be installed in machine or repair shops.

8. Low sensitivity units may be permitted in equipment rooms and elevator machine rooms only if the cleanliness of the rooms is maintained, otherwise false alarms from dust will result. Such detectors may require more than an annual cleaning.

9. Smoke detectors should not be installed in elevator shafts in view of the dirty environment and inaccessibility of the unit for servicing and testing.

10. Detectors should not be installed in linen closets and similar storerooms where dust and lint are common.

11. Smoke detectors should not be installed in designated smoking areas.

12. Detectors should not be installed in locations which are exposed to extreme outdoor temperature and humidity conditions.

13. Ion detectors should not be installed near windows or areas of likely high air movement, such as near exit doors.

8.1.11 Miscellaneous

1. Appropriate arrangements should be made with contractors to alert the VAMC safety officer prior to starting work in areas where detectors are installed. The units in the work area should either be covered or the zone disconnected to prevent false alarms.

2. If insects are entering detectors through the rear mounting holes and causing false alarms, either the use of a sealant (gasket) between the ceiling and the rear of the detector, or a sealing compound to cover the holes, is needed.

3. For those VAMCs that have a smoke detector analyzer, the safety officer and staff involved with testing and maintenance should become familiar with its operation. If any questions arise contact the manufacturer.[12]

4. All VAMC personnel who use the canned aerosol method of testing detector response should be sure to hold the nozzle at least 3 ft. (0.9 m) from the detector to prevent an oily film deposit inside the chamber from the test aerosol.

8.2 RECOMMENDATIONS TO THE VA CENTRAL OFFICE

In addition to the following, please also refer to the recommendations to the VAMCs in Section 8.1.

8.2.1 Smoking Policy

VAMCs should be instructed that a stringent smoking policy is needed if false alarms from the most prevalent cause are to be reduced.

8.2.2 Cleaning Policy

An annual cleaning policy should be implemented as soon as possible for all detectors. See Sections 8.1.2 and 8.1.3, and 8.1.4 for additional information.

8.2.3 Installation, Maintenance and Alarm Records

An up-to-date record should be maintained of the detector location, maintenance, and alarms to determine any trends from which false alarms could result. See Sections 8.25, 8.26 and 8.27.

It is recommended that an annual log of false and real alarms initiated from smoke detectors be sent to the VA central office in Washington, DC for the previous year. The same form as used previously would be sufficient for this purpose. This annual log, coupled with the log for testing and cleaning, will provide comprehensive record of smoke detector performance.

8.2.4 Cross Zoning Operation

Primarily because it does not appear that smoking will be completely controlled, particularly in psychiatric wards, cross zoning (at least two detectors required to be in an alarm condition before an alarm signal is transmitted) is recommended in elevator lobbies, psychiatric wards, and any other areas where protection is needed but smoking may be a problem. In many cases this will double the cost of detectors. If cross zoning is not feasible then detectors with a low sensitivity should be used in combination with alarm verification.

8.2.5 Day/Night Operation

During the day VA hospital patient care areas and other areas, such as corridors and elevator lobbies, are under continuous supervision. A large staff is on duty continuously and, if a fire occurred in these locations, it would be discovered quickly. Unfortunately, also because of the high activity, more false alarms occur in the day.

During nighttime hours, although there are people on duty, it is usually a skeleton staff which may not be able to cover all areas to discern a fire.
Accordingly, the recommendation being made is to consider a system of differing Day/Night operation. During the day the fire alarm signal from a smoke detector would be transmitted to the nurse's station or some other monitored location. Here, the people on duty can verify the nature of the alarm and reset the system in the event of false alarm. The circuit should to arranged so that, in the event no positive action is taken within 1 to 2 minutes after the fire signal comes in, the system evacuation signals would be energized automatically.

For detectors in locations not accessible to patients or the public, actuation of a detector could automatically result in the system alarm being energized.
During nighttime operation the entire system would revert to automatic actuation. Selection of the hours for changeover from one to the other would be at the discretion of the VA central office. However, it should be noted that this arrangement would be considered a pre-signal system and thus prohibited by current codes in health care facilities.

8.2.6 Alarm Verification

If available, alarm verification should be added to control units in VAMCs with high false alarm rates even after implementation of more stringent smoking and cleaning policies. Alarm verification in psychiatric hospitals would help in reducing false alarms from smoking. If added, the alarm verification circuit should be capable of being by passed in the event it is no longer needed. If it is to be added in one or more hospitals on an experimental basis, then a counter should be included to record the number of times the circuit was effective without an alarm being transmitted. Since detector manufacturers are now permitted to add alarm verification to new detectors being produced, consideration should be given to specifying such units as replacements in problem areas, if they are compatible with the system.

8.2.7 Duct Detectors

In future specifications for detectors employed to control smoke spread, Par. 9-1.3 of NFPA 72E-1987 recommends the use of open area type units in lieu of duct detectors. If duct detectors are specified, they should be installed in accessible locations where they can be readily tested and serviced. Many of the duct detectors observed on visits to VAMCs were inaccessible for testing and cleaning.

8.2.8 Detectors Integral with Door Holders Closers

Based on past experience, if smoking is not going to be eliminated at the VAMCs, door holder-closer type detectors should not be connected to the fire alarm system, but only serve to release the associated doors. Actuation of the detector, however, should be indicated at the nurse's station or other similar staffed location. An arrangement like this would be allowed by Chapter 7 of the Life Safety Code, but is prohibited in health care occupancies.

8.2.9 Construction Work

Appropriate arrangements should be made with contractors to alert the safety officer prior to starting work in areas protected by smoke detectors. The units in the area should be either covered temporarily or the zone disconnected to prevent false alarms.

8.2.10 Future Systems

Since high sensitivity, lack of testing, and lack of cleaning are the three main underlying factors which result in false alarms, it is recommended that any new VAMC systems which have not as yet been designed consider the use of an Analog System. In this type system the detectors (really sensors) provide an analog representation of a measured smoke level or other fire signature. The system control unit determines trouble, normal pre alarm, or alarm conditions for each sensor. Such systems also determine the threshold sensitivity level for each sensor, which can be altered if the environment or occupancy warrants. If dirt or dust accumulation changes the sensitivity, the condition can be indicated.

In such an analog system the signal processing capability is enhanced to discriminate between alarm and non-alarm conditions. This type of system would reduce the need for testing and cleaning detectors to only those which required it. The control unit, coupled with the analog information capability, results in a self-supervised system. Only a periodic visual inspection would be needed to determine if the chamber exterior was blocked by dust or lint.

8.2.11 Detectors with Separable Heads and Bases

In future new or revised installations, detectors with separable heads and bases should be specified to facilitate easy cleaning or replacement.

Also the separable heads should not be installed in the bases until after the construction phase and clean up. This will prevent accumulation of construction dust inside the chamber.

8.3 RECOMMENDATIONS TO DETECTOR MANUFACTURERS

8.3.1 Calibration of Production Sensitivity

Currently most, if not all, manufacturers of smoke detectors try to obtain as wide a production window as possible and use the middle of the window as the calibration point during production. The midpoint of the window is used to allow for variations in calibration procedures, tolerances of components employed, and to minimize the time spent on each unit.

In view of the experiences with false alarms in the VAMCs, and since it is recognized that lower sensitivities result in fewer alarms, it is recommended that future factory sensitivity calibrations be directed toward the less sensitive end of the production window, such as illustrated in Fig. 6. This may take slightly more time but should more than compensate for the time and expense related to field problems.

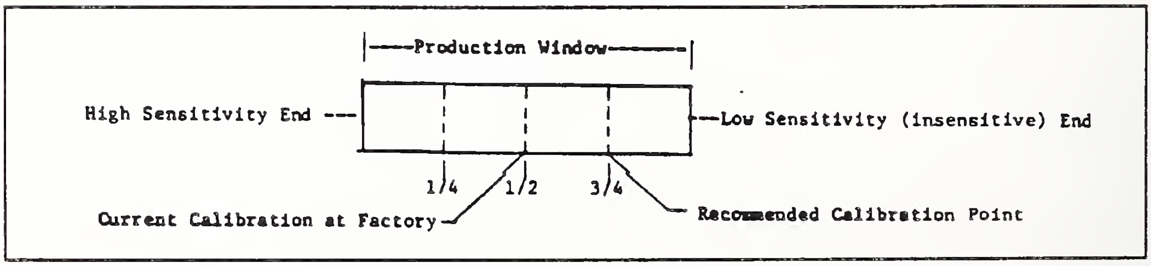

Figure 6 - Suggested Production Sensitivity Point

8.3.2 Design of Detectors for Testing and Cleaning

8.3.2.1 Field Measurement of Sensitivity

Since sensitivity is a critical factor in false alarms, the method of measurement in the field should be more exact to tell the user if the detector is drifting toward an alarm state. Accordingly, detectors should be designed to permit the user to make an electrical measurement of the sensitivity. Except for periodic spot confirmations with smoke, this will avoid the need to use other test means with which a manufacturer may not agree (canned aerosols). The test means (holes in cover, receptacle), should be accessible from the outside of the unit with the detector installed as intended.

8.3.2.2 Design to Permit Cleaning

All manufacturers agree that detectors need periodic cleaning. It should also be recognized that detectors also require some form of a washing procedure, in addition to a vacuuming, to maintain the effectiveness of the unit. See Par. 8-4 of NFPA 72E-1987. There have also been many cases where it has been necessary to replace the detector because of one fault or another.

After discussing the subject with VAMC personnel and assessing the overall benefits and disadvantages, the following physical design improvements are recommended:

1. Separable heads and bases to permit easy removal for cleaning, testing, or replacement. See Fig. 7.

2. Detector Chambers and sensing components should either be accessible for cleaning or, if inaccessible, the sensing assembly should be designed to be immersed in a washing solution by the user.

3. If a manufacturer makes both ion and photo detectors, the base should be common to both to permit easy substitution. This would be needed in the event of misapplication. The capability to substitute a heat detector with the same base is desirable.

4. The bases and detector heads of separable assemblies should be packaged separately. The boxes or covers containing the heads should be marked to warn that the heads should not be installed until after the final construction clean-up.

8.3.3 Alarm Verification Circuit

All smoke detectors intended to be installed in general use areas should be provided with an alarm verification circuit which can be manually by-passed. This will permit the user to activate alarm verification in the event of problems with false alarms or, de-activate it if the local inspection authority does not permit alarm verification.

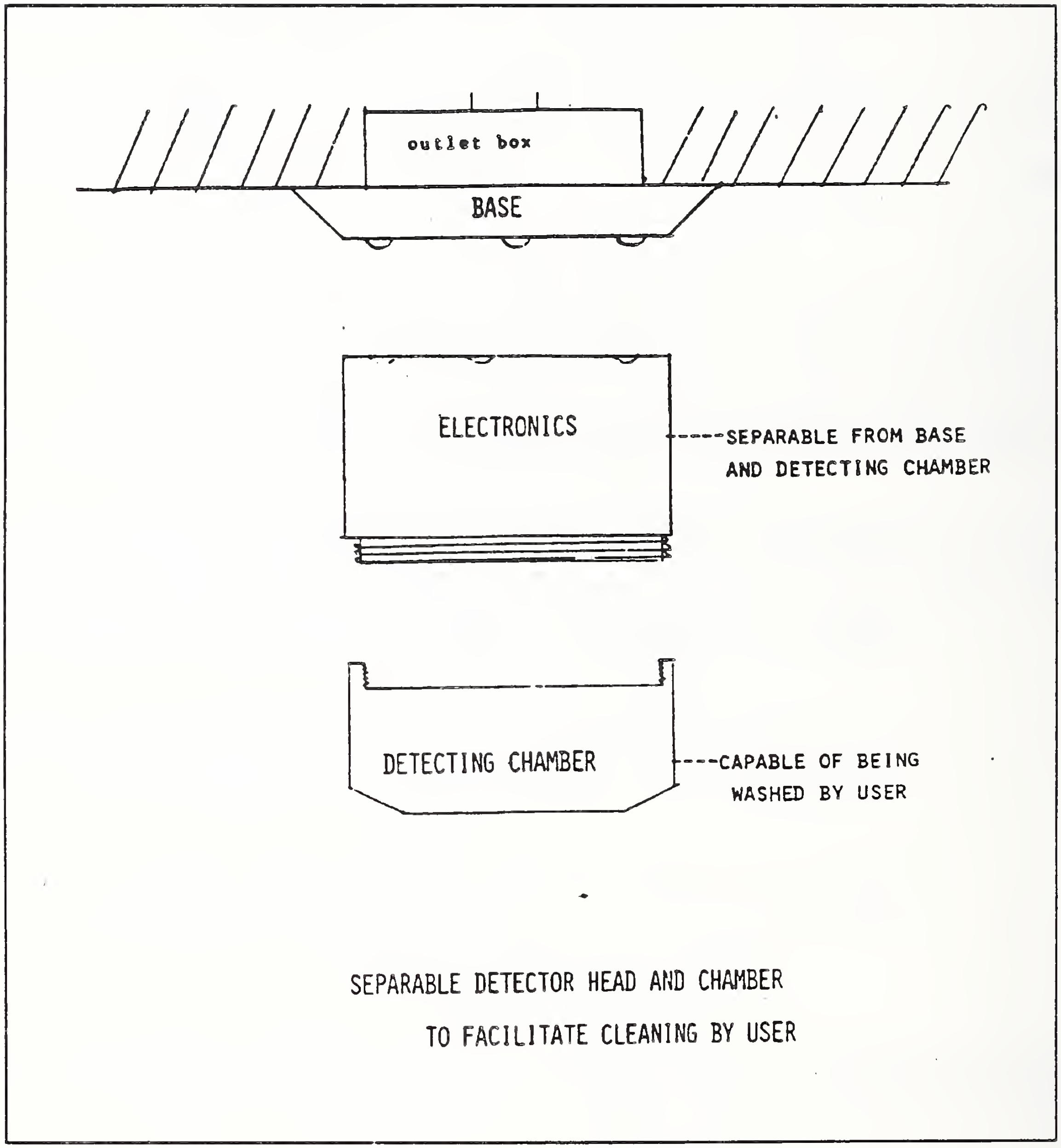

Figure 7 - Example of Detector with Separable Parts

If alarm verification is to be incorporated into the system control unit, it should be designed to distinguish between actuation of a smoke detector, which will result in delay of the alarm signal, and actuation of another type of initiating device on the same circuit, such as a manual box or heat detector. This will permit mixing of smoke detectors and manual stations in new installations and replacement of problem detectors in existing systems. A by-pass switch is also recommended, plus some form of counter, to indicate the number of false alarms culled by the circuit.

8.3.4 Testing and Cleaning Instructions

8.3.4.1 Video Taped Instructions

With the proliferation of video cameras and recorders, and the teaching benefits derived therefrom, consideration should be given to providing a video tape of the testing, cleaning, and installation procedures for a detector model or series of models. This would have a greater impact on installation and maintenance personnel than written instructions. The tape should walk the viewer through all aspects of servicing, testing, and wiring the detector, including disassembly and reassembly. Separate tapes should be provided for each detector model. These "video instructions" could be used at the bench, as servicing was taking place. If successful, similar tapes should be produced for the control unit and for other complex system components.

8.3.4.2 Written Instructions

If a videotape of the testing and cleaning instructions is not provided, then more specific instructions are needed for the user, related to air cleaning of the detector as well as cleaning of grease and grime from inside the chamber. If such are not provided, the detector manufacturer should inform people buying his product that a service contract is necessary with references to companies in the area that can provide such service.

8.3.5 Supervision of Sensitivity

Although a manufacturer can provide the most concise instructions on testing and cleaning there is no assurance that the instructions will be followed. In view of this it is recommended that future designs of smoke detectors take the following factors into consideration:

1. Intelligent or analog system type where the sensitivity status of a sensor is determined by the connected control unit. If the sensitivity drifts out of a specified range, a trouble signal would be sent alerting the user that cleaning or maintenance is required.

2. Design of a so-called SMART DETECTOR SYSTEM where each detector contains sufficient signal processing capability to discriminate an alarm from non-alarm conditions.

8.3.6 Accessibility to Customers

The owner of a fire alarm system must be able to contact the equipment manufacturer for information about the system. The name and address provided on many of the larger system components may be that of the distributor. This is often insufficient. Thus, it is recommended that each manufacturer establish a toll-free number for customers to call when they need information. This number should be prominently displayed on the major components of the system, such as the control unit and detectors.

8.4 RECOMMENDATIONS TO SMOKE DETECTOR SYSTEM DESIGNERS

In addition to the guidelines on smoke detector locations included in applicable installation codes, such as NFPA 70 (NEC), and 72E, regional, and local codes, the designer of smoke detector systems should be knowledgeable in the areas of detector installation and to minimize false alarms. Specific factors which should be considered for each system design include:

1. The principles of operation and the deceptive phenomena that can result in false alarms or curtail response.

2. The sensitivity of the detector for a particular location should be taken into account. The lower the sensitivity, the fewer the number of false alarms.

3. If smoking is permitted in elevator lobbies, low (less than 8 ft) corridors, or similar areas, consideration should be given to wiring two detectors in a cross zone type arrangement, or the use of alarm verification.

4. Both control units and smoke detectors with alarm verification are optionally available to minimize false alarms. The local inspection authority is to be consulted prior to use.

5. Two-wire detectors can only be used with the specific control units referenced in the detector instructions.

6. Actuation of a 2-wire detector in a zone could prevent functional operation of devices, such as dampers or ventilating equipment, controlled by another detector in the same zone.

7. Smoke detectors require periodic testing and cleaning, including washing of the chamber area. The detector selected should be designed with this in mind.

8. Prior to selecting a detector for a particular installation, the detector manufacturer's instructions should be reviewed for any restrictions on the installation.

9. Detectors sensitive to air velocity should not be installed near doorways or other openings to the outside from which wind may blow onto the detector.

10. A designer should be familiar with listing information on the detector published by the testing agency which evaluated the unit in the compliance with performance standard, ANSI/UL268.

11. Detectors should be located out of the direct air flow from forced air registers which will not only prevent combustion particles from entering the detector but also carry dust and other dirt into the unit. Preliminary test smoke to determine detector response is recommended.

12. The use of additional transient protection should be considered, in areas of high thunderstorm activity.

13. Smoke detectors should only be installed where they will be accessible for testing and cleaning. Simply specifying a duct detector at a particular location is not practical if the duct is in an inaccessible area.

14. To preclude a build up of dust and dirt in the chambers of new detectors, the designers drawings should specify that the detectors should not be installed until after all construction work that will generate dust has been completed. If separable detector heads are not used then it will be necessary that some form of cover protection be specified on the drawings which are to be removed when the system is energized.

8.5 RECOMMENDATIONS TO TESTING AGENCIES

8.5.1 Production Sensitivity

As a result of the data presented in Figs. 3, 4, 5, and Table 20, the following change to ANSI/UL268 standard have been transmitted to the appropriate authorities at UL:

> The maximum upper sensitivity limit requirement for the Sensitivity Test be changed from the present 0.5 to 1.0 percent per foot obscuration (0.007 to 0.014 optical density per meter) using gray smoke as long as these less sensitive detectors are used where there will be no adverse effects on life safety.

The following is a possible exception to above recommendation.

> EXCEPTION: Detectors with maximum sensitivities higher (lower number) than 1.0 percent per foot (0.014 optical Density per meter), but not less 0.5 percent per foot obscuration (0.007 optical density per meter) are permitted if the unit is marked prominently where it would be visible after installation with the following or equivalent working. HIGHLY SENSITIVE DETECTOR - FOR RESTRICTED APPLICATION.

Fig. 5 shows that a false alarm reduction of 78 percent would be achieved if the maximum production sensitivity were to be revised to 1.0 percent per ft. obscuration (0.014 optical density/meter) from the present 0.5 percent per ft. obscuration (0.007 optical density/meter). This more stringent requirement would apply to spot (open area) type detectors and detector modules integral with door holders closers and not to duct detectors.

A reduction of the nominal production sensitivity setting to 1.0 percent per ft. obscuration (0.014 optical density/meter), which would reduce the number of false alarms by 60 percent, is insufficient since it would not preclude the manufacture of detectors with sensitivities below 1.0 percent/ft.

Imposing a maximum sensitivity requirement of 1.0 percent per foot obscuration would affect many of the ion detectors in this study which have narrow production windows and maximum production sensitivities of less than 1 percent. However, the majority of ion detectors in the study are obsolete and more current units should be able to meet the requirement for the following reasons:

1. Ion detector design can be improved as evidenced by the wider windows of more current units.

2. Recently adopted revisions to ANSI/UL268 standard are intended to permit wider production windows for both ion and photo detectors. Since these proposals constitute a relaxation of requirements, no compliance review will be necessary, and they will become effective upon adoption.

3. Some manufacturers of ion detectors with narrow production windows will need to apply more stringent procedures in calibrating the sensitivity setting at the factory. While most manufacturers calibrate in the middle of the production window, it will now be necessary to establish sensitivity settings near the low (insensitive) end of the window. See Par. 8.41 and Fig. 6.

8.5.2 Detector Orientation (Sensitivity Test)

Because of false alarm problems, more emphasis is needed at the high sensitivity end in the Sensitivity test. Currently, the smoke box measurement is made with the detector oriented with the least favorable position facing the oncoming air flow. While this may be suitable for the low end of the sensitivity requirement, it is not appropriate for the high sensitivity end. This is because of the wide difference in sensitivity between the least favorable and most favorable positions. A measurement in the most favorable position could result in sensitivity readings higher (lower number) than the current requirement of 0.5 percent/ft. (0.007 optical density/meter).

Thus, it is recommended that detectors calibrated at the high sensitivity end be measured with the most favorable position facing the oncoming air flow, to evaluate for the propensity to false alarming. Low sensitivity detectors should be measured in the least favorable position for selection of the fire test samples. The most favorable position should then be applied to the other tests in the standard which specify smoke box tests.

8.5.3 Combination Dust/Humidity Test

It has been stated by a detector manufacturer that, while a detector may not false alarm from separate exposure to high humidity or dust, the combination of the two would be more likely to result in a false alarm. Accordingly it is recommended that humidity tests followed by a sensitivity test be conducted on ion and photo samples, before and after exposure to the Dust test. If a combination test is feasible it should be added to the standard since it is more representative of "real world" conditions.

8.5.4 Test Feature

Currently the sensitivity test feature addresses only the low end of the sensitivity spectrum. In view of the need to reduce false alarms, a requirement should be added that operation of the test means is not to result in a sensitivity higher than 1 percent per foot obscuration (0.0072 optical density per meter).

8.5.5 Smoldering Smoke Test Without Alarm

In view of the recommendation in Par. 8.6.1, the Smoldering Smoke test using maximum sensitivity detectors should be revised to require that the installed detectors should not alarm prior to an obscuration of 1.0 percent per foot (0.014 optical density per meter), measured in the detector area.

8.5.6 Duct Detector Design

A common complaint about duct detector maintenance was that they were not tested or cleaned because "a lot of screws had to be removed" or a "seal had to be broken" to gain access to the interior. If the allegation is true, requirements in the standard for duct detectors should be revised to reflect a more practical access for testing and cleaning.

8.5.7 Multiple Station Smoke Detectors

While the majority of detectors in VAMCs are of the system-connected type, there are some facilities, like domiciliaries and staff residence rooms, where single and multiple station units are installed. A comment made was that when detectors wired in a multiple station configuration went into alarm, it was not possible to identify the unit which initiated the alarm and it took considerable time to check all connected units to find the source of the false alarm.

Thus, it is recommended that ANSI/UL 217 [14] standard be revised to specify that a detector which initiates the alarm in a multiple station configuration, be identified.

8.5.8 Sensitivity Marking

In order to assist the designer and inspection authority to prevent misapplication of detectors, the calibrated sensitivity of each unit should be marked on the detector in percent per foot obscuration and the equivalent optical density per meter. Merely specifying a production range will not help since many manufacturers have wide ranges. Although it would probably mean more time spent in calibration, the false alarm statistics from this study require corrective measures. A tolerance of 25 per cent from the marked setting may be appropriate.

8.5.9 Cleaning and Testing Instruction

More comprehensive testing and cleaning instructions should be provided by the manufacturers in literature which accompanies their detectors. This should include specific means of testing. The cleaning instructions should specify how to clean grease, tars/nicotine from inside the chamber. Merely stating that a unit should be vacuumed is insufficient. If the manufacturer does not wish the user to disassemble the unit for cleaning, then the instructions should specify detailed alternatives.

8.5.10 Humidity Test with Condensation

Since humidity is a major contributor to false alarms, a humidity test with condensation is needed in ANSI/UL 268. Such a test has been discussed previously with industry (UL Industry Advisory Conference). Since test data indicate that many detectors have been designed which will not false alarm when they are subjected to this condition, it is recommended that the test be added to the standard.

8.6 RECOMMENDATIONS TO NFPA 72E COMMITTEE

The present state-of-the-art of smoke detectors is that they are unable to distinguish among the various hostile and non-hostile products to which they respond and consequently their placement is of the utmost importance. The following sections describe areas where requirements in NFPA 72E should be strengthened.

8.6.1 Smoke Detector Locations

One of the major contributors to false alarms in the VA study has been detectors which have been misapplied; i.e., located in areas where they should not be installed. This is not restricted to hospitals but extends to smoke detector installations in general. The level of sensitivity and limitations of the principles of operation have not been addressed in the standard in great depth. Although additional guidelines have been included in Chapter 8 of the 1987 edition, it is not enough, since guidelines are subject to interpretation by system designers which can vary as much as among the committee members.

Chapter 4 subcommittee on smoke detectors held several meetings and had developed a long list of locations where placement of smoke detectors would or would not be suitable which was believed would help a system designer. It should be realized that a great number of fire detection systems are not designed by fire protection engineers who are familiar with smoke detector and their principles of operation. Except for detectors sold over distributors' counters, smoke detector systems are usually laid out under the supervision of an electrical engineer who has had no formal training in detector applications. In view of this the committee should provide installation and siting data tailored to the experience and capabilities of the people actually involved with system designs and not to a theoretical ideal. It is therefore recommended that more definitive information on smoke detector locations and types of detectors to be used be included in NFPA 72E.

8.6.2 Levels of Sensitivity

Since the sensitivity is the major factor in causing false alarms, its application should be accorded equal importance. The three levels of sensitivity developed by the smoke detector subcommittee was a step in the right direction and should be given reconsideration so that smoke detectors could be sited, taking their sensitivity into consideration. In the event that a maximum sensitivity of 1.0 percent/ft. obscuration is adopted in ANSI/UL 268 Standard, then two levels (high and low) may be more practical.

8.6.3 Two-Wire Duct Detectors

A Note or equivalent should be added to Chapter 9 to the effect that not more than one 2-wire duct detector should be connected in the same circuit since actuation of the first will shunt the circuit and prevent the others on the same circuit from performing their intended function.

8.6.4 Spare Detectors for Testing and Cleaning Operations

A recommendation should be included in 72E that spare detectors be available which have a known sensitivity, and against which detectors to be tested can be compared. In addition, the spare detectors can be used to replace those temporarily removed for testing and cleaning. For example, in an installation of 300 detectors of one model, if 10 spares were available, they could replace 10 detectors which need testing and cleaning. The removed detectors can then be tested and cleaned in a designated area specifically equipped for that purpose. After cleaning and testing, the detectors would be returned to their original locations, and the next lot of 10 would go through the same procedure. This would apply only to detectors employing separable heads and bases.

8.6.5 Cross-Zoning of Smoke Detectors

As a result of the VAMC study, it was found that there are locations where detectors are more prone to false alarm than in others. This is primarily related to smoking, regardless of the fact that NO SMOKING policies may be in effect. Typical locations include elevator lobbies, waiting areas, and areas where combustion particles would be more prevalent. For such areas a recommendation should be included in 72E to the effect that cross zoning of two detectors should be considered to minimize false alarms. In lieu of cross zoning, an alternative would be to recommend a maximum detector sensitivity.

8.6.6 Post Installation Inspection

Since the smoke detector system design may not necessarily be in conformance with the intent of the guidelines, and as changes in physical configurations often occur in construction which may impact on the location of the smoke detectors, a requirement should be added to NFPA 72E that an inspection of the detector layout be made by both the contractor/system designer and the local authority having jurisdiction or an equivalent qualified agency. Such an inspection should verify that the detectors are in compliance with the installation guidelines of Chapters 4, 8, 9, and the Appendix A section of NFPA 72E. If detectors are installed in areas where they are likely to false alarm, they should be relocated. This would also apply to the accessibility of duct detectors.

8.7 RECOMMENDATIONS TO INDUSTRY ASSOCIATIONS

The following recommendations are being made to industry associations, such as the NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA), and AUTOMATIC FIRE ALARM ASSOCIATION (AFAA), which include a high percentage of manufacturers of fire alarm equipment, such as smoke detectors. The members who are detector manufacturers are also the most familiar with field problems associated with false alarming.

8.7.1 Education Booklet or Videotape

Since there are numerous common factors associated with the principles of operation, cleaning and maintenance and testing of smoke detectors, as well as the causes of false alarms, a booklet, or videotape, or both, should be developed by the industry. This would serve as an education tool for the user, inspection authority, system designer, servicing organizations, and the like relating to the following aspects of smoke detectors:

A. Principles of Operation
B. Installation Locations (Siting).
C. Methods and Frequency of Testing.
D. Methods and Frequency of Cleaning.
E. Factors Causing False Actuation:
   1. High Sensitivity
   2. Smoking
   3. Environmental Factors (Dust, Wind, Steam, etc).
   4. Housekeeping Factors (solvents, cooking, etc.).
F. Installation connections for 2 and 4 wire detectors.

8.7.2 Standardized Base for Separable Detectors

It is recommended that requirements for a standardized base be developed to permit interchangeability of different manufacturers' detectors with the same base, somewhat comparable to the various types of fuseholders commonly available. This would reduce the cost of rewiring of bases in the event different detectors are used in the same installation and replacement or interchangeability is needed. The physical configuration could vary among different manufacturers but the cavity where the head is to be inserted should be compatible with all heads.

The standardized base concept could also be extended to duct housing, into which open area heads can be inserted, (provided that they had been tested for compliance with ANSI/UL268A [13] standard), as well as for heat detectors in the event the location is not suitable for smoke detectors.

8.7.3 Pooling of Manufacturers' Knowledge

Since detector manufacturers learn first hand of problems that occur with their smoke detectors in the field, such as causes of false alarms, misapplication, and the like, they should pool the knowledge accumulated over the years and the association should prepare a booklet which system designers, contractors, inspection authorities, and code-writing committees can use in smoke detector applications.

9. WHAT DOES THE FUTURE HOLD

9.1 ARE SMOKE DETECTORS REALLY NEEDED?

Smoke detectors are needed since they save lives, reduce property loss substantially, and provide warning in the very early stages of a potentially hazardous condition. There is a need for their use in the overall fire protection arena. But in some installations they might be over-utilized, and a reduction in the numbers of detectors provided could be made without sacrificing safety.

9.2 FUTURE GENERATION DETECTORS

Although not necessarily reflected by the VA study, the design of smoke detectors is being improved to minimize the effect of false-alarm-causing phenomena. Requirements in performance and installation standards are also being strengthened toward the same goal. In-house experiences in the VAMCs have already led to a reduction in false alarms. Public and legislated pressure against smoking will relegate that cause into the background.

Future generations of detectors will be less likely to false alarm from deceptive phenomena for the following reasons:

A. Less sensitive detectors will be made possible as a result of improved designs and more relaxed performance requirements.

B. Alarm Verification techniques which have already resulted in a reduction of false alarms will become almost universally applied.

C. The intelligent (analog) system type sensor will provide supervision (monitoring) of its own sensitivity. A trouble signal will be obtained at the control panel when the sensor needs cleaning or if the sensitivity has shifted more than a predetermined amount.

D. Detectors will be able to discriminate between real fires and non-fire conditions.

10. SUPPLEMENTAL ACTIVITIES

As with other research projects, this one has generated interest in related work which will be the subject of a future report.

10.1 CONTAMINATION TESTS ON SMOKE DETECTORS

Discussions at various VAMCs which were visited disclosed that a variety of test methods were being employed on smoke detectors. These are tabulated below:

- A. Canned aerosols (two types)
- B. Test feature built into detector
- C. Smoldering incense (punk) stick
- D. Test smoke (cigarettes)
- E. Smoke Detector Analyzer (Test apparatus developed at NIST)

Some detector manufacturers object to the use of the canned aerosol. They contend that an oily residue is formed inside the chamber which would affect the sensitivity. Therefore, it was decided to conduct a test program to evaluate the contamination aspect, not only of the canned aerosol, but also of all the various test devices being used; except the test features built into the detectors. This test program has been started and a report of the findings will be issued when completed.

10.2 ADDITIONAL TESTS ON SMOKE DETECTORS

a. Using detectors with varied sensitivities and both principles of operation, studies will be conducted to determine the relationship between the distance one or more cigarettes are held below a detector and its propensity to false alarm.

b. In view of a reported fire scenario where a smoke detector allegedly did not actuate from so-called "cold smoke", smoke box tests are planned to evaluate detector response under such conditions.

c. Tests will be conducted on detectors mounted on a ceiling at various distances from a heating/ventilating register to determine the minimum distance where the turbulent air has no effect on detector response. Present NFPA requirement is a minimum of 3 ft. (0.91 m). 72E.

d. Smoke box tests will be conducted on ion and photo detectors with various sensitivities to determine the restart times of detectors after different periods of deenergization such as may occur in alarm verification circuits.

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   b. Measuring Techniques for the Response Threshold Value of Smoke Detectors. Franz J. Kraus.

   c. Aerosol Technology in Fire Research and Detection. Benjamin Y. H. Liu.

   d. The Separated Ionization Chamber. Peter E. Burry.

   e. Large - Scale Laboratory Fire Tests of Smoke Detectors. Richard W. Bukowski.

   f. Generalized Characterization of Smoke Entry and Response for Products -of-Combustion Detectors. Gunnar Heskestad.

   g. A Survey of Ambient Conditions Affecting Fire Detectors. Peter E. Burry.

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TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 1	A	1	I	Spot	77	56	137.5	EL	SD	-	W	S	D
G 2	B	1	I	Spot	2	6	33.3	SD	-	-	D	-	-
	B	2	P	Spot	63	190	33.2	87 CR	68 SD	27 EL	S	D	UK
	R	1	I	Duct	0	37	0.0	32 Ducts	5 ES	-	-	-	-
					65	233	27.9						
G 3	A	4	P	Spot	260	123	211.	40 PR	35 SD	8 EL	S	M	DF
	A	5	I	Spot	10	20	50.0	12 WA	5 CR	3 K	W	-	-
	A	8	I	Duct	1	80	1.3	Duct	-	-	LC	-	-
	L	1	P	DHC	0	83	0.0	83 SD	-	-	-	-	-
					271	306	88.6						
G 4	A	1	I	Spot	70	172	40.7	CR	SD	EL	W	S	D
	D	7	P	Spot	0	4	0.0	Pent House	-	-	-	-	-
	C	1	P	Spot	0	5	0.0	OFC	Sewer Plant	SH	-	-	-
					70	181	38.7						

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					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 5	J	10	I	Spot	47	187	25.1	CR	WA	EL	S	D	UK
	D	1	P	Spot	20	25	80.0	ST	EQ	EM	D	UK	-
	B	3	I	Spot	10	19	52.6	CR	-	-	DF	-	-
	B	5	I	Spot	2	30	13.3	CR	EL	-	S	UK	-
					79	261	30.0						
G 6	E	2	I	Spot	0	30	0.0	22 PR	4 SD	2 WA	-	-	-
	E	8	P	Duct	6	7	85.7	Ducts	-	-	4 DF	2 UK	-
	B	1	I	Spot	6	4	150.0	4 SD	-	-	6 D	-	-
	D	1	P	Spot	2	6	33.3	5 EL	1 ES	-	2 I	-	-
					14	47	29.8						
G 7	L	3	I	DHC	110	184	59.8	184 SD	-	-	S	D	LC
	E	2	I	Spot	23	106	21.7	47 PR	26 WA	30 File Room	S	D	LC
	R	3	I	Spot	5	13	35.4	CR	-	-	S	D	LC
	G	15	I	Spot	24	50	48.0	50 CR	-	-	S	D	LC
	T	1	I	Spot	26	30	86.7	30 CR	-	-	S	W	LC
	G	15	I	Duct	2	18	11.1	Duct	-	-	D	LC	-
					190	401	47.4						

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					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 8	F	7	P	Spot	97	282	34.4	177 SD	119 CR	46 EL	S	H	HK
	B	2	P	Spot	5	31	16.3	31 LDR	-	-	Lint	H	-
	G	21	I	Spot	6	17	35.3	8 CR	4 SD	5 CP	S	H	M
					108	330	32.7						
G 9	A	2	P	Spot	25	71	35.2	CR	EL	SD	D	ST	LC
	A	3	P	Spot	7	30	23.3	CR	CP	EL	D	ST	UK
	B	3	I	Spot	0	10	0.0	CR	EL	SD	-	-	-
					32	111	28.9						
P 10	K	4	I	Spot	53	220	24.0	134 SD	34 CR	6 MKR	40 S	7 ST	2 H
	K	7	I	Spot	27	51	52.9	41 EL	10 ES	-	26 S	-	-
	B	8	I	Duct	17	171	9.9	Duct	-	-	S	ST	D
					97	442	21.9						
P 11A	A	1	I	Spot	97	356	27.3	304 CR	35 EL	6 SD	13 S	12 W	20 DF
	A	8	I	Duct	8	59	13.6	Duct	-	-	4 W	2 S	1 T
	C	2	P	Spot	23	87	26.4	48 MKR	14 TV	11 EM	11 D	3 H	3 DF
					128	502	25.5						

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					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 11C	B	1	I	Spot	0	100	0.0	53 SD	15 EL	27 WRH	-	-	-
G 12	A	1	I	Spot	94	152	61.8	47 SD	34 EL	8 CR	10+ W	S	D
	C	3	P	Spot	42	35	120.0	1 WA	4 REC	1 EL	10 S	LC	D
					136	187	72.7						
G 13	B	3	I	Spot	6	535	1.1	278 SD	134 CR	86 EL	5 HK	1 ST	-
OPC 14	P	4	I	Spot	17	265	6.4	SD	EL	EM	S	H	UK
	Y	1	I	Spot	3	50	6.0	SD	EM	TV	UK	-	-
					20	315	6.3						
G 15	G	14	I	Duct	0	46	0.0	Ducts	-	-	-	-	-
	G	2	I	Spot	246	222	111.	111 SD	73 CR	23 EL	102 H	111 UK	12 S
	G	19	I	Duct	0	26	0.0	Ducts	-	-	-	-	-
	B	2	P	Spot	0	148	0.0	115 CR	6 EL	25 SD	S	S/H	H
	C	2	P	Spot	0	3	0.0	-	EQ	-	-	-	-
	H	1	I	Spot	0	6	0.0	CP	-	-	-	-	-
					246	451	54.5						

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G/Dom 16	A	1	I	Spot	0	12	0.0	12 SLP	-	-	-	-	-
	P	1	I	Spot	14	76	18.4	70 SLP	3 CR	3 Duct	S	I	UK
	G	20	I	Duct	0	39	0.0	39 Duct	-	-	-	-	-
	G	5	P	Spot	11	12	91.7	6 CR	2 WA	1 EM	3 S	2 D	4 UK
	G	2	I	Spot	0	6	0.0	6 CR	-	-	-	-	-
	G	4	I	Spot	2	63	3.2	63 CR	-	-	1 UK	1 DF	-
	A	8	I	Duct	0	16	0.0	16 Duct	-	-	-	-	-
	A	2	P	Spot	1	13	7.7	9 SLP	2 CR	-	1 S	-	-
	B	4	P	Spot	0	5	0.0	4 CR	1 WA	-	-	-	-
	B	2	P	Spot	4	4	100.0	4 CR	-	-	3 D	1 H	-
	B	1	I	Spot	1	9	11.1	5 CR	2 WA	2 0	1 UK		
	A	3	P	Spot	43	17	253	8 ST	4 WA	3 CR	12 I	7 S	22 UK
	J	1	I	Spot	0	13	0.0	8 SD	5 CR	-	-	-	-
	B	3	I	Spot	1	20	5.0	11 CR	7 WA	2 LAB	UK	-	-
	G	18	I	Duct	0	4	0.0	Duct	-	-	-	-	-
	F	5	I	Spot	4	45	8.9	29 CR	5 WA	1 ST	4 UK	-	-

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
16 G/Dom cont'd	H	1	I	Spot	0	4	0.0	CP	-	-	-	-	-
					81	358	22.6						
G 17	A	1	I	Spot	111	520	21.4	248 PR	195 CR	38 WA	51 W	5 D	53 UK
	A	3	P	Spot	0	228	0.0	125 CR	84 PR	19 REC			
					111	748	14.8						
P 18	B	1	I	Spot	440	417	106	177 CR	118 SD	63 EL	24 LC	23 H	16 S
	B	2	P	Spot	423	136	311.0	23 ES	19 EM	18 CR	23 LC	20 H	19 W
					863	553	155.1						
G 19	A	1	I	Spot	20	80	25.0	46 SD	16 CR	14 EL	S	D	W
	C	2	P	Spot	0	66	0.0	42 CR	8 SD	6 WA	-	-	-
	B	1	I	Spot	4	20	20.0	8 CR	6 SD	4 WA	D	W	I
	D	4	P	Spot	5	34	14.7	19 CR	15 Other	-	D	I	UK
					29	200	14.5						

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G 20	N	1	I	Spot	16	90	17.8	83 SD	3 EM	3 ST	S	D	T
	H	3	P	Spot	3	9	33.0	9 EL	-	-	S	-	-
	S	1	I	Spot	4	39	10.3	14 CR	8 SD	6 MKR	S	CW	-
	C	1	P	Spot	1	25	4.0	21 MKR	2 EM	2 ES	S	-	-
	Z	1	P	Spot	2	16	12.5	10 CP	6 EQ	-	CW	-	-
	B	8	I	Duct	0	4	0.0	Duct	-	-	-	-	-
					26	183	14.2						
G 21	B	4	P	Spot	121	1274	9.5	248 CR	296 SD	48 EL	S	D	I
	F	1	P	Spot	5	102	4.9	61 CR	16 WA	4 K	S	LC	UK
					126	1376	9.2						
P 22	L	1	I	DHC	20	26	76.9	26 SD	-	-	8 S	3 UK	6 DF
	Q	1	I	Spot	6	15	40.0	13 SD	2 EL	-	3 S	1 D	2 UK
	K	7	I	Spot	0	5	0.0	3 EL	2 EM	-	-	-	-
	B	1	I	Spot	0	4	0.0	4 EL	-	-	-	-	-
					26	50	52.0						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 23	H	1	I	Spot	60	121	49.6	24 EL	16 SD	8 SH	S	CW	-
	B	1	I	Spot	16	76	21.0	56 CR	12 SH	2 WA	10 S	1 D	5 DF
	G	1	I	Spot	0	9	0.0	WA	OFC	CHAPEL	-	-	-
					76	204	37.3						
G 24	A	1	I	Spot	4	12	33.3	12 SD	-	-	2 DF	2 CW	-
	B	1	I	Spot	46	411	11.2	295 SD	101 CR	4 EQ	9 CW	8 W	4 S
	B	2	P	Spot	0	1	0.0	1 SD	-	-	-	-	-
					50	424	11.8						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G/Dom 25	HH	I	I	SS	0	25	0.0	25 CR	-	-	-	-	-
	K	6	I	Duct	0	28	0.0	Ducts	-	-	-	-	-
	K	2	I	Spot	0	166	0.0	166 CR	-	-	-	-	-
	J	1	I	Spot	29	24	121.	16 CR	4 K	4 REC	29 S	-	-
	K	5	P	Spot	0	74	0.0	54 TV	20 MKR	-	-	-	-
	L	3	I	DHC	14	33	42.4	33 SD	-	-	TEMP	D	UK
	B	9	I	Duct	0	22	0.0	Duct	-	-	-	-	-
	K	8	P	Spot	0	16	0.0	16 MKR	-	-	-	-	-
	K	7	I	Spot	0	178	0.0	133 CR	34 EL	11 ES	-	-	-
	K	9	I	Duct	0	101	0.0	Duct	-	-	-	-	-
	K	10	P	Spot	0	3	0.0	2 EM	1 EL	-	-	-	-
					43	670	6.4						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 26	C	2	P	Spot	81	395	20.5	149 SD	57 CR	48 EL	S	CR	I
	A	8	I	Duct	3	96	3.1	Ducts	-	-	LC	M	-
	G	17	I	Duct	6	9	66.7	Ducts	-	-	UK	-	-
	A	10	I	Spot	0	7	0.0	7 CR	-	-	-	-	-
	N	2	I	Spot	0	8	0.0	CP	-	-	-	-	-
					90	515	17.5						
G 27	N	3	P	Spot	12	217	5.5	232 CR	155 SD	131 EL	S	D	UK
	N	1	I	Spot/Duct	43	257	16.7	120 CR	94 SD	23 Duct	S	D	HK
	B	6	I	Spot	5	61	8.2	WRH	-	-	S	W	DF
					60	535	11.2						
G 28	G	2	I	Spot	12	115	10.4	CR	-	-	WT	D	-
	G	3	I	Spot	4	83	4.8	CR	SD	-	S	D	-
	E	10	I	Spot	4	9	44.4	EL	-	-	UK	-	-
	G	8	I	Spot	0	27	0.0	Duct	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 28 cont'd	G	17	I	Duct	0	10	0.0	Duct	-	-	-	-	-
	F	9	I	Duct	0	6	0.0	Duct	-	-	-	-	-
	BB	1	I	Spot	0	18	0.0	EL	SD	-	-	-	-
	N	2	I	Spot	0	10	0.0	CR	-	-	-	-	-
	AA	1	P	Spot	0	8	0.0	TV	-	-	-	-	-
	D	5	P	Spot	0	9	0.0	ELC	-	-	-	-	-
	F	10	I	Duct	10	12	83.3	Ducts	-	-	UK	-	-
	B	5	I	Spot	6	31	19.4	CR	EL	SD	CW	EX	-
	B	1	I	Spot	6	4	150.0	CR	EL	SD	S	K	D
					42	342	12.3						
P 29	A	1	I	Spot	46	232	19.8	128 CR	45 PR	16 EL	24 W	14 S	7 D
	D	7	P	Spot	9	19	27.6	2 K	7 CR	2 WA	8 S	-	-
	CC	1	I	Spot	0	10	0.0	CR	TV	-	-	-	-
	P	1	I	Spot	0	9	0.0	7 SH	1 WA	1 D	-	-	-
					55	270	20.4						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 30	A	5	I	Spot	23	63	36.5	9 CR	8 SD	8 TV	8 S	9 H	1 W
	L	5	I	DHC	7	32	21.9	32 SD	-	-	3 D	1 S	3 DF
	J	2	I	Duct	0	25	0.0	Ducts	-	-	-	-	-
					30	120	25.0						
G/Dom 31	A	1	I	Spot	43	156	27.6	84 CR	20 K	7 EL	4 W	2 I	2 WT
	A	6	P	Spot	6	17	35.3	12 SD	5 CR	-	5 UK	1 D	-
	B	4	P	Spot	45	98	45.9	33 LDR	33 DNG	7 GAR	29 UK	7 ST	2 K
	F	6	I	Spot	52	257	20.2	206 CR	14 BSM	11 EL	22 UK	11 H	3 WT
					146	528	28.5						
G 32	B	1	I	Spot	27	202	13.4	99 SD	27 EL	12 PR	S	CW	UK
P 33	A	1	I	Spot	88	501	17.6	266 SD	102 CR	98 PR	29 W	16 D	13 H
	S	1	I	Spot	9	88	10.2	48 PR	30 Duct	SD	4 H	2 D	2 W
	D	5	P	Spot	14	22	63.6	22 WA	-	-	14 S	-	-
					111	611	18.2						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 34	R	4	I	Duct	11	57	19.3	Duct	-	-	UK	DF	-
	D	1	P	Spot	4	10	40.0	CR	ES	EM	3 CW	1 DF	-
					15	67	22.4						
P 35	P	1	I	Spot	44	487	9.0	163 CR	162 ATT	98 SD	S	D	H
P 36	B	1	I	Spot	51	666	7.7	393 CR	74 PR	12 WA	11 S	9 D	5 H
G/Dom 37	D	1	I	Spot	79	368	21.5	93 CR	88 ATT	73 PR	24 S	14 D	10 LC
G 38	N	2	I	Spot	10	14	71.4	4 WA	3 CR	3 EL	9 S	3 W	-
	N	1	I	Spot	0	7	0.0	5 CR	2 WA	-	-	-	-
	L	9	I	DHC	2	36	5.6	33 SD	3 WRH	-	2 S	-	-
					12	57	21.1						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 39	E	3	I	Spot	21	281	7.5	CR	CP	SD	D	DF	-
	E	2	I	Spot	14	66	21.2	CR	EL	ES	D	W	H
	E	7	I	Duct	2	40	5.0	Ducts	-	-	H	T	-
	D	1	P	Duct	0	6	0.0	Duct	-	-	-	-	-
	H	6	I	Duct	1	88	1.1	CR	WA	EL	DF	-	-
	G	19	P	Duct	28	60	46.7	Duct	-	-	S	D	H
					66	541	12.2						
P 40	B	4	P	Spot	23	55	41.8	41 SD	11 EL	10 CR	S	D	UK
	J	5	I	Duct	3	14	21.4	Duct	-	-	D	-	-
	J	6	I	Spot	9	61	14.8	20 CR	17 SD	11 WA	S	UK	-
	D	2	I	Spot	5	62	8.1	38 CR	18 EL	4 TV	S	M	UK
	B	9	I	Duct	1	19	5.3	Duct	-	-	UK	-	-
	B	5	I	Duct	3	24	12.5	24 SD	-	-	M	UK	-
	B	2	P	Duct	0	7	0.0	5 EL	1 ES	-	-	-	-
					44	242	18.2						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 41	A	1	I	Spot	98	210	46.7	67 CR	32 EL	27 SD	S	W	D
	A	10	I	Duct	7	23	30.4	Ducts	-	-	ST	UK	-
	DD	1	P	Spot	0	11	0.0	6 STR	1 CR	1 LAB	-	-	-
	C	5	P	Spot	1	27	3.7	22 STR	4 CP	1 EL	CW	-	-
					106	271	39.1						
G 42	A	1	I	Spot	32	95	33.7	CR	SD	EL	18 S	2 D	1 W
	H	2	I	Spot	17	107	15.9	CR	SD	EL	S	H	CW
	G	4	I	Spot	9	46	19.6	CR	SD	EL	S	CW	M
					58	248	19.4						
G 43	J	1	I	Spot	6	140	4.3	CR	EL	WA	6 DF	-	-
	D	5	P	Spot	8	50	16.0	ELC	TV	-	S	DF	-
	B	8	I	Duct	25	135	18.5	Ducts	-	-	K	S	H
	F	6	I	Spot	4	46	8.7	CR	EL	PR	4 DF	-	-
	M	6	I	DHC	3	19	15.8	19 SD	-	-	3 S	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 43 cont'd	H	1	I	Spot	0	6	0.0	CP	-	-	-	-	-
	CC	2	P	Spot	0	5	0.0	TV	-	-	-	-	-
					46	401	115						
G 45	E	* 1, 2, 3	I	Spot	39	520	7.5	CR	EL	WA	S	CW	H

* Numbers per model not provided.

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 47	D	1	P	Spot	10	309	3.2	195 CR	15 ICU	10 SD	S	D	LC
	F	5	I	Spot	4	146	2.7	72 CR	27 EL	25 SD	S	W	D
					14	455	3.1						
G 49	A	1	I	Spot	7	124	5.7	105 SD	13 CR	3 PR	S	W	H
G 50	G	4	I	Spot	0	125	0.0	97 CR	8 ICU	7 EL	-	-	-
G 51	F	8	I	Spot	0	24	0.0	20 EL	2 EM	2 TV	-	-	-
G 52	K	3	I	Spot	30	384	7.8	CR	WA	-	H	-	-
G 53	E	6	I	Spot	0	32	0.0	28 SD	4 EL	-	-	-	-
	B	3	I	Spot	0	81	0.0	60 SD	12 EL	2 EM	-	-	-
	J	1	I	Spot/Duct	0	35	0.0	25 CR	6 SD	4 DCT	-	-	-
	C	6	P	Spot	0	33	0.0	21 OFC	6 CR	6 LAV	-	-	-
					0	181	0.0						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 54	J	7	I	Duct	2	25	8.0	Ducts	-	-	2 DF	-	-
	B	4	P	Spot	0	4	0.0	2 MKR	1 TV	1 EMG	-	-	-
	EE	1	I	Spot/Duct	0	113	0.0	82 CR	16 EL	10 Ducts	-	-	-
	B	1	I	Spot	0	49	0.0	31 CR	12 SD	4 EL	-	-	-
					2	191	1.1						
G 55	C	3	P	Spot	65	590	11.0	323 CR	36 EL	25 ES	S	D	LC
G 56	H	6	P	Spot	0	7	0.0	5 CR	2 SH	-	-	-	-
	D	8	P	Duct	7	111	6.3	Ducts	-	-	4 D	1 S	1 H
	C	1	P	Spot	0	5	0.0	5 CR	-	-	-	-	-
	D	2	P	Spot	5	57	8.8	57 SD	-	-	2 D	2 LC	1 DF
					12	180	6.7						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 57	B	1	I	Spot	5	230	2.2	60 SD	60 PR	39 CR	2 S	1 HK	1 I
G 58	B	3	I	Spot	0	82	0.0	42 CR	17 EL	8 PR	-	-	-
G 59	A	1	I	Spot	2	15	13.3	6 SD	2 CR	4 LAB	1 M	1 DF	-
	P	2	P	Spot	4	31	12.9	16 SD	7 CR	4 CP	1 S	1 D	1 M
					6	46	13.0						
G 60	B	3	I	Spot	7	221	3.2	113 CR	70 SD	17 EL	S	CW	M
G 62	B	3	I	Spot	1	83	1.2	68 CR	14 SD	1 EL	1 T	-	-
	B	1	I	Spot	2	17	11.8	13 CR	2 SD	1 EL	1 D	1 H/W	-
					3	100	3.0						
G 63	N	3	P	Spot	1	2	50.0	2 P	-	-	LC	-	-
	N	1	I	Spot/Duct	12	114	10.5	35 SD	11 CR	29 Ducts	1 S	4 D	4 HK
					13	116	11.2						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 64	B	2	P	Spot	0	56	0.0	27 CR	22 SD	4 WA	-	-	-
	D	4	P	Spot/Duct	0	50	0.0	12 EL	11 Ducts	3 ES	-	-	-
					0	106	0.0						
PC 65	E	2	I	Spot	22	230	9.6	SD	-	-	11 S	3 LC	3 D
G 66	F	8	I	Spot	9	125	7.2	37 CR	28 EL	8 WA	5 S	2 CW	M
	X	1	I	DHC	6	150	4.0	150 SD	-	-	5 S	1 UK	-
	E	3	I	Spot/Duct	5	60	8.3	48 CR	8 Ducts	2 EM	S	H	DF
	J	1	I	Spot	0	40	0.0	22 CR	8 WA	3 TV	-	-	-
					20	375	5.3						
G 67	C	1	P	Spot	10	147	6.8	CR	EL	WA	S	D	I
	C	3	P	Spot	8	70	11.4	CR	SD	EL	S	D	UK
					18	217	8.3						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G/Dom 68	B	5	I	Spot	1	154	0.7	SD	CR	WA	HK	-	-
	B	1	I	Spot	1	15	6.7	SD	-	-	I	-	-
	G	17	I	Duct	0	17	0.0	Ducts	-	-	-	-	-
					2	186	1.1						
G 69	G	9	I	Spot	2	135	1.5	79 CR	8 STR	6 OFC	CW	UK	-
G 70	E	1	I	Spot	5	154	3.4	78 SD	39 CR	27 EL	5 D	-	-
	E	4	P	Spot	0	44	00	4 CP	4 WP	4 STR	-	-	-
					5	198	2.5						
G/Dom 71	G	3	I	Spot	3	139	2.2	62 SD	52 CR	13 ES	3 S	-	-
G 72	G	3	I	Spot	6	72	8.3	75 CR	10 SD	5 WA	D	UK	ST
	G	4	I	Spot	0	81	0.0	17 CR	13 TV	16 PR	-	-	-
					6	153	3.9						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G/P 74	E	5	P	Spot	15	250	6.0	75 MKR	13 EM	8 TV	D	LC	T
	E	6	I	Spot/Duct	104	175	59.0	112 CR	20 WA	14 EL	S	LC	T
					119	425	28.0						
G 75	G	3	I	Spot	0	14	0.0	8 SD	3 EL	2 ICU	-	-	-
	G	2	I	Spot	0	8	0.0	4 SD	4 Pent	-	-	-	-
	G	18	I	Duct	0	5	0.0	Duct	-	-	-	-	-
	F	5	I	Spot	0	53	0.0	41 CR	12 SD	-	-	-	-
	P	1	I	Spot	0	1	0.0	TV	-	-	-	-	-
	J	2	I	Duct	0	3	0.0	Duct	-	-	-	-	-
	F	10	I	Duct	0	3	0.0	Duct	-	-	-	-	-
	P	5	I	Duct	0	4	0.0	Duct	-	-	-	-	-
					0	91	0.0						
G/Dom 77	C	1	P	Spot	5	734	0.7	716 CR	20 WRH	12 EL	3 UK	2 WT	-
	B	1	I	Spot	2	48	4.2	48 CR	4 DNG	-	UKN	-	-
					7	782	0.9						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 78	B	3	I	Spot	0	5	0.0	2 SD	1 CR	2 STR	-	-	-
	A	1	I	Spot	0	10	0.0	6 CR	2 SD	2 ATT	-	-	-
	D	7	P	Spot	0	2	0.0	2 BSM	-	-	-	-	-
	D	4	P	Spot	0	5	0.0	3 CR	2 ES	-	-	-	-
					0	22	0.0						
G 79	G	12	I	Spot	9	91	9.9	CR	WA	SLP	4 W	2 CW	2 UK
G 80	E	5	I	Spot	0	32	0.0	15 SD	8 EL	5 CR	-	-	-
	B	3	I	Spot	0	46	0.0	18 SD	10 CR	2 PR	-	-	-
	B	9	I	Duct	9	10	90.0	Duct	-	-	3 D	2 M	3 W
	B	1	I	Spot	0	11	0.0	2 SD	2 CR	1 EM	-	-	-
					9	99	9.1						
G 81	G	4	I	Spot	0	10	0.0	7 CR	2 CP	1 ST	-	-	-
	G	2	I	Spot	0	5	0.0	5 CR	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 81 cont'd	C	1	P	Spot	0	8	0.0	2 SD	TV	-	-	-	-
	G	20	I	Duct	0	2	0.0	Duct	-	-	-	-	-
	B	5	I	Spot	0	14	0.0	5 EM	2 SD	4 EQ	-	-	-
	B	6	I	Spot	4	6	66.7	6 SD	-	-	2 S	2 D	-
					4	45	8.9						
G 82	F	7	P	Spot	2	27	7.4	9 CR	6 EL	6 CP	2 UK	-	-
	F	6	I	Spot	3	65	4.6	44 SD	10 EL	7 CR	1 D	2 UK	-
	B	8	P	Duct	0	3	0.0	Ducts	-	-	-	-	-
					5	95	5.3						
G 83	BB	2	P	Spot	2	4	50.0	4 OFC	-	-	T	1 DF	-
G/Dom 85	L	1	I	DHC	8	12	66.7	12 SD	-	-	6 S	1 W	1 D
	U	1	P	Spot	3	34	8.8	15 PR	10 OFC	8 CR	S	D	DF
	R	5	I	Spot	4	14	28.6	11 EL	3 EM	-	3 S	1 CW	-
					15	60	25.0						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 86	E	3	I	Spot	2	98	2.0	78 SD	10 CR	6 EL	2 UK	-	-
	B	2	P	Spot	1	48	2.1	38 CR	10 SD	-	DF	-	-
	G	4	I	Spot	1	34	2.9	18 CR	16 SD	-	T	-	-
	C	4	P	Spot	3	22	13.6	13 EL	7 CR	2 OFC	S	UK	DF
					7	202	3.5						
P 89	H	1	I	Spot	10	75	13.3	53 CR	9 EL	3 WA	2 S	3 D	5 CW
	J	6	I	Spot	11	14	78.6	10 SD	2 EL	2 CR	6 CW	4 D	1 S
	G	16	I	Duct	3	14	21.4	Ducts	-	-	DF	-	-
	F	6	I	Spot	4	18	22.2	8 EL	7 SD	1 CR	2 D	1 S	1 CW
	D	1	P	Spot	5	16	31.3	10 EQ	3 ST	2 TV	3 S	2 D	-
					33	137	24.1						
G 90	R	6	I	Spot	28	170	16.5	CR	SD	SH	S	CW	W
	D	2	P	Spot	0	24	0.0	STR	CR	SD	-	-	-
	G	10	I	Spot	2	12	16.7	CR	SD	-	LC	-	-
					30	206	14.6						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 91	N	2	I	Spot	1	4	25.0	4 ENT	-	-	UK	-	-
	A	1	I	Spot	2	34	5.9	20 CR	10 SD	2 PR	D	UK	-
	A	7	P	Spot	1	10	10.0	5 K	2 CR	2 DNG	ST	-	-
	F	4	I	Spot	5	70	7.1	22 CR	30 SD	6 WA	S	D	HK
	V	1	P	Spot	3	263	1.1	192 PR	54 CR	7 K	2 K	1 D	-
	E	5	I	Spot	0	7	0.0	7 EL	-	-	-	-	-
	S	1	I	Spot	1	17	5.9	5 CR	4 SD	2 EM	-	-	-
	B	1	I	Spot	0	10	0.0	9 CR	1 BSM	-	-	-	-
	N	7	I	Spot	8	22	36.4	-	-	-	2 S	3 I	1 W
					20	437	4.6						
G 92	L	5	I	DHC	25	132	18.9	132 SD	-	-	12 D	7 W	4 DF
	H	2	I	Spot	0	23	0.0	18 STR	2 LDR	3 ES	-	-	-
					25	155	16.1						
P 93	B	3	I	Spot	0	112	0.0	100 CR	4 EL	-	-	-	-
	G	5	P	Spot	6	10	60.0	10 LDR	-	-	6 HK	-	-
					6	122	4.9						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 94	A	1	I	Spot	15	129	11.6	33 PR	24 CR	15 SD	4 S	4 LC	2 W
	A	4	P	Spot	1	42	2.4	28 SD	7 CF	5 EL	3 K	-	-
	H	2	I	Spot/Duct	0	39	0.0	10 Ducts	7 OFC	3 EL	-	-	-
	C	4	P	Spot/Duct	0	11	0.0	8 LAB	3 CR	-	-	-	-
	FF	1	I	Spot/Duct	0	7	0.0	SH	-	-	-	-	-
					16	228	7.0						
G 95	B	6	I	Spot	13	88	14.8	77 SD	5 K	1 EL	3 S	1 CW	.8 UK
	B	8	P	Duct	0	120	0.0	Ducts	-	-	-	-	-
					13	208	6.3						
G 96	D	2	P	Spot	3	53	5.7	22 SD	12 CR	9 EL	T	UK	DF
	J	8	I	Duct	5	13	38.5	Duct	-	-	W	H	DF
					8	66	12.1						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 97	D	1	P	Spot/Duct	44	225	19.6	122 SD	97 Ducts	6 CP	13 S	10 D	5 ST
	H	3	P	Spot/Duct	3	4	75.0	4 CR	-	-	1 ST	2 D	-
	S	1	I	Spot/Duct	5	110	4.5	88 SD	22 LAB	-	1 S	2 DF	2 FUM
	G	4	I	Spot/Duct	0	13	0.0	13 EL	-	-	-	-	-
	G	20	I	Duct	0	5	0.0	Duct	-	-	-	-	-
					52	357	14.6						
G 98	G	4	I	Spot	0	70	0.0	36 OFC	12 CR	7 ENT	-	-	-
	G	6	I	Spot	4	13	30.8	12 MKR	1 ES	-	4 UK	-	-
	G	3	I	Spot	3	40	7.5	24 SD	10 REC	4 CR	3 S	-	-
	G	2	I	Spot	1	56	1.8	33 PR	8 SD	5 K	UK	-	-
	G	5	P	Spot	0	3	0.0	3 LAB	-	-	-	-	-
	G	17	I	Duct	0	4	0.0	Duct	-	-	-	-	-
	G	19	I	Duct	0	16	0.0	Ducts	-	-	-	-	-
					8	202	4.0						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G/Dom 99	A	1	I	Spot	8	68	11.8	30 SD	13 SH	10 EL	5 W	3 S	2 WT
	F	3	P	Spot	1	4	25.0	2 CR	2 EL	-	WT	-	-
					9	72	12.5						
G 100	A	1	I	Spot	12	251	4.8	67 CR	52 SD	14 EL	4 S	4 W	4 D
G 101	P	1	I	Spot	10	73	13.7	32 CR	21 SD	11 EL	3 D	2 H	5 UK
	H	5	I	Spot	3	37	8.1	15 CR	14 LAB	2 SD	2 D	1 HK	-
	H	4	P	Spot	0	59	0.0	59 CR	-	-	-	-	-
					13	169	7.1						
G 102	B	7	I	Spot	4	105	3.8	62 SD	9 CR	7 EL	1 D	2 I	1 T
G 103	L	4	I	DHC	10	30	33.3	30 SD	-	-	2 S	2 LC	2 D
	G	2	I	Spot	2	26	7.7	10 CR	6 CP	6 ES	2 DF	-	-
	M	4	I	DHC	2	9	22.2	9 SD	-	-	2 DF	-	-
	C	7	I	Spot	0	15	0.0	EL	-	-	-	-	-
	J	5	I	Duct	0	35	0.0	Duct	-	-	-	-	-
	G	13	I	Duct	4	35	11.4	9 Duct	-	-	2 S	2 D	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 103 cont'd					18	155	11.6						
G 104	A	1	I	Spot	45	508	8.9	387 SD	35 WA	29 EL	17 S	6 W	15 UK
	A	3	P	Spot	11	120	9.2	50 ELC	48 SVC	6 SD	5 DF	3 ST	3 EX
	A	8	I	Duct	1	175	0.6	Duct	-	-	1 FUM	-	-
					57	803	7.1						
G 105	B	3	I	Spot	0	10	0.0	10 SD	-	-	-	-	-
	A	1	I	Spot	49	253	19.4	98 SD	104 PLC	26 EL	S	W	D
	C	1	P	Spot	1	10	10.0	8 EL	2 TV	-	D	-	-
					50	273	18.3						
G 106	D	3	P	Spot	0	9	0.0	9 ES	-	-	-	-	-
	A	8	I	Duct	0	54	0.0	Duct	-	-	-	-	-
	A	3	P	Spot	16	226	4.4	156 CR	48 SD	15 EL	2 S	2 DF	8 UK
	B	5	I	Spot	7	124	5.6	39 CR	21 SD	3 EL	2 W	2 UK	1 K
	D	2	P	Spot	1	15	6.7	7 TV	5 EMG	2 K	UK	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 106 cont'd	B	9	I	Duct	4	76	5.3	Ducts	-	-	2 H	1 S	2 UK
	E	3	I	Spot	6	20	30.0	8 CR	4 SD	3 BSM	4 H	1 S	1 DF
	G	21	I	Duct	3	6	50.0	Ducts	-	-	2 H	1 UK	-
					37	530	7.0						
G 107	K	5	P	Spot	3	38	7.9	10 MKR	8 ATT	8 TV	3 T	-	-
	K	1	I	Spot/Duct	11	137	8.0	70 CR	28 Ducts	10 ST	S	D	5 T
					14	175	8.0						
Dom 108	B	6	I	Spot	27	347	7.8	180 CR	134 SD	28 APT	5 D	3 S	3 K
	F	10	I	Duct	0	5	0.0	Duct	-	-	-	-	-
	B	2	P	Spot	17	59	28.8	42 DOM	6 APT	1 CP	10 S	4 D	3 UK
	B	1	I	Spot	10	40	25.0	24 CR	10 SD	-	2 K	1 ST	2 HK
					54	451	12.0						
G 109	G	18	I	Duct	4	13	30.8	Duct	-	-	1 H	3 UK	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 109 cont'd	D	5	P	Spot	3	29	10.3	23 CR	4 ST	2 TUN	3 S	-	-
	B	3	I	Spot	0	15	0.0	15 CR	-	-	-	-	-
	L	1	I	DHC	0	2	0.0	2 SD	-	-	-	-	-
	D	8	P	Duct	8	43	18.6	Duct	-	-	H	DF	-
	L	3	P	DHC	1	2	50.0	2 SD	-	-	D	-	-
	Q	2	I	Spot	0	15	0.0	15 CP	-	-	-	-	-
					16	119	13.4						
P 110	A	8	I	Duct	10	174	5.7	Duct	-	-	5 LC	4 CW	1 DF
	F	6	I	Spot	25	142	17.6	97 CR	21 EL	4 TV	9 S	7 HS	3 M
					35	316	11.1						
G 111	F	5	I	Spot	0	7	0.0	CR	-	-	-	-	-
	F	2	I	Spot	0	23	0.0	20 CR	3 TV	-	-	-	-
	B	4	P	Spot	2	14	14.3	10 CP	4 ST	-	2 CW	-	-
	L	3	I	DHC	0	5	0.0	5 SD	-	-	-	-	-
	G	17	I	Duct	0	1	0.0	Duct	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 111 cont'd	L	12	I	Spot	0	4	0.0	CR	-	-	-	-	-
	G	21	I	Duct	0	1	0.0	Duct	-	-	-	-	-
	J	9	I	Spot	0	17	0.0	CR	-	-	-	-	-
	J	3	I	Spot	3	35	8.6	25 CR	10 SD	-	3 S	-	-
	R	1	I	Duct	3	6	50.0	Duct	-	-	-	-	-
	F	10	I	Duct	0	10	0.0	Duct	-	-	-	-	-
	L	8	I	Spot	5	26	19.2	CR	-	-	S	-	-
					13	149	8.7						
G 112	D	8	I	Duct	0	6	0.0	Duct	-	-	-	-	-
	J	2	I	Duct	0	1	0.0	Duct	-	-	-	-	-
	G	17	I	Duct	0	3	0.0	Duct	-	-	-	-	-
	G	20	I	Duct	0	3	0.0	Duct	-	-	-	-	-
	B	9	I	Duct	0	1	0.0	Duct	-	-	-	-	-
	G	18	I	Duct	0	1	0.0	Duct	-	-	-	-	-
	N	7	I	Duct	0	1	0.0	Duct	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 112 cont'd	G	2	I	Spot	0	9	0.0	7 PR	1 WA	1 CL RM	-	-	-
	H	1	I	Spot	0	16	0.0	16 CR	-	-	-	-	-
	B	1	I	Spot	0	4	0.0	4 CR	-	-	-	-	-
	B	3	I	Spot	0	47	0.0	22 SD	10 EL	9 CR	-	-	-
	B	5	I	Spot	1	11	9.1	4 EL	3 ES	3 EM	UK	-	-
	B	4	P	Spot	2	7	28.6	5 OFC	1 CR	1 EL	UK	-	-
	P	5	I	Duct	0	2	0.0	Duct	-	-	-	-	-
					3	112	2.7						
G/Dom 113	A	1	I	Spot	65	554	11.7	493 CR	23 ES	21 EM	W	D	UK
	N	6	I	Spot	3	88	3.4	85 CR	2 ES	1 EM	UK	-	-
					68	642	10.6						
G 114	B	3	I	Spot	7	38	18.4	24 CR	6 ES	3 STR	5 CW	2 S	-
	E	3	I	Spot	1	10	10.0	8 CR	2 BSM	-	H	-	-
	E	2	I	Spot	3	52	5.8	24 SD	10 EL	6 TV	3 CW	-	-
	G	3	I	Spot	4	73	5.5	40 SD	32 CR	1 OFC	2 S	1 D	1 M

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 114 cont'd	E	7	I	Duct	0	6	0.0	Duct	-	-	-	-	-
					15	179	8.4						
G 115	N	7	I	Duct	2	14	14.3	Duct	-	-	H	UK	-
	B	8	I	Duct	0	1	0.0	Duct	-	-	-	-	-
	B	9	I	Duct	3	7	42.9	Duct	-	-	UK	-	-
	B	3	I	Spot	7	53	13.2	34 SD	11 STR	2 K	S	CW	H
	D	6	P	Spot	1	21	4.8	18 EL	3 ES	-	UK	-	-
	H	1	I	Spot	0	6	0.0	6 CP	-	-	-	-	-
					13	102	12.7						
G 116	A	1	I	Spot	0	128	0.0	110 CR	6 SD	3 EL	-	-	-
	A	11	I	Spot	1	1	100	LNC	-	-	CW	-	-
					1	129	0.8						
G 117	A	1	I	Spot	21	138	15.2	87 SD	18 CR	14 LAB	7 S	5 D	8 UK
	A	12	P	Spot	1	47	2.1	33 CR	13 SD	1 ES	CW	-	-
	A	8	I	Duct	1	8	12.5	Duct	-	-	UK	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 117 cont'd	A	9	P	Spot	0	10	0.0	6 EL	1 SD	1 ES	-	-	-
	C	2	P	Spot	1	3	33.3	ICU	-	-	UK	-	-
					24	206	11.7						
P 118	W	1	I	Spot	3	12	25.0	8 EL	2 ES	-	3 S	-	-
	C	1	P	Spot	0	229	0.0	112 CR	111 PR	5 EM	-	-	-
	D	4	P	Spot	12	78	15.4	41 CR	18 SD	6 EL	7 D	5 UK	-
	B	8	P	Duct	2	15	13.3	Ducts	-	-	AHS	-	-
	A	8	I	Duct	52	139	37.4	Ducts	-	-	22 S	30 UK	-
	M	7	I	DHC	28	24	117.0	20 CR	2 EL	2 REC	21 S	7 UK	-
	M	2	I	DHC	15	23	65.2	15 CR	4 SD	2 EL	7 S	8 UK	-
	M	3	I	DHC	6	34	17.6	31 CR	2 EL	1 WA	3 S	3 UK	-
	M	4	I	DHC	1	20	5.0	10 EL	6 CR	3 K	1 UK	-	-
	A	1	I	Spot	11	5	220.0	3 EL	1 ES	1 EM	10 S	1 UK	-
	G	11	I	Spot	1	12	8.3	12 EL	-	-	S	-	-
	J	4	I	Spot	0	2	0.0	2 BSM	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 118 cont'd	L	13	I	Spot	0	3	0.0	3 CR	-	-	-	-	-
	JJ	1	I	Single Station	0	9	0.0	Direct Resid.	-	-	-	-	-
					131	605	21.7						
G 119	B	1	I	Spot	114	308	37.0	118 CR	75 SD	46 EL	12 S	7 W	3 H
	R	2	I	Duct	0	109	0.0	Duct	-	-	-	-	-
					114	417	27.3						
G/Dom 120	A	8	I	Duct	0	14	0.0	Duct	-	-	-	-	-
	A	1	I	Spot	10	54	18.5	36 CR	11 SD	4 ES	7 D	2 S	-
	H	1	I	Spot	28	200	14.0	115 PR	61 CR	10 ST	17 S	7 D	2 I
	H	3	P	Spot	0	10	0.0	5 CLNC	2 EQ	2 TV	-	-	-
	H	2	I	Spot/Duct	8	95	8.4	52 Ducts	42 SD	2 ES	5 S	1 ST	2 UK
	D	1	P	Spot	0	11	0.0	7 P	4 TV	-	-	-	-
	B	1	I	Spot	0	22	0.0	10 SD	6 EL	3 Duct	-	-	-
	B	2	P	Spot	0	1	0.0	1 TV	-	-	-	-	-
	K	5	P	Spot	0	5	0.0	3 OFC	2 CR	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G/Dom 120 cont'd	R	8	I	Duct	1	5	0.0	Duct	-	-	-	-	-
	D	7	P	Spot	4	13	30.8	13 TV	-	-	D	-	-
					51	430	11.9						
G 121	B	8	I	Duct	5	49	10.2	Duct	-	-	2 K	1 D	2 DF
	D	2	P	Spot	5	39	12.8	13 CR	12 TV	2 ST	5 T	-	-
	F	6	I	Spot	0	38	0.0	10 CR	10 PHRC	9 LAB	-	-	-
	D	1	P	Spot	6	52	11.5	52 MKR	-	-	2 WT	4 DF	-
	B	1	I	Spot	10	75	13.3	62 CR	13 EL	-	6 S	2 D	1 LC
	F	5	I	Spot	6	78	7.7	50 CR	5 EL	19 Other	2 S	4 DF	-
	F	10	I	Duct	15	104	14.4	Duct	-	-	4 S	2 D	5 DF
					47	435	10.8						
P 122	N	5	P	Spot	0	14	0.0	11 OFC	4 TV	3 CR	-	-	-
	N	3	P	Spot	28	249	11.2	128 CR	18 EL	17 PR	14 S	2 D	7 UK
	M	5	P	DHC	5	24	20.8	24 SD	-	-	2 S	-	3 UK
	N	1	I	Spot	21	58	36.2	47 CR	4 EL	4 TV	10 S	3 I	2 D

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
P 122 cont'd	N	7	I	Duct	0	6	0.0	Ducts	-	-	-	-	-
					54	351	15.4						
G 123	N	3	P	Spot/Duct	2	37	5.4	8 CR	8 SD	14 Duct	ST	DF	-
	F	6	I	Spot	17	58	29.3	16 SD	11 EL	10 CR	T	D	DF
	B	3	I	Spot	10	11	91	6 OF	4 CP	1 TV	T	UK	DF
					29	106	27.4						
G 124	B	2	P	Spot	9	96	9.4	32 CR	11 EL	11 K	4 S	3 D	2 UK
	B	1	I	Spot	0	11	0.0	11 WHR	-	-	-	-	-
	C	1	P	Spot	1	52	1.9	34 CR	10 EL	5 K	DF	-	-
	N	7	I	Duct	13	23	56.5	Duct	-	-	12 DF	1 S	-
	N	3	P	Spot	1	1	100	1 ENT	-	-	S	-	-
	G	2	I	Spot	4	4	100	4 WA	-	-	4 S	-	-
	E	5	P	Spot	0	15	0.0	15 ICU	-	-	-	-	-
					28	202	13.9						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 125	D	1	P	Spot	4	39	10.3	29 EL	4 SH	2 EM	1 S	3 UK	-
	C	1	P	Spot	1	19	5.3	13 CR	6 BSM	-	I	-	-
	B	9	I	Duct	6	31	19.4	Duct	-	-	2 S	2 D	2 DF
	H	2	I	Spot	7	61	11.5	61 CR	-	-	3 S	2 I	2 DF
	M	1	I	DHC	0	35	0.0	DHC	-	-	-	-	-
					18	185	9.7						
P 126	G	4	I	Spot	9	48	18.8	16 EL	16 TV	8 EM	1 S	2 W	6 UK
	C	1	P	Spot	1	16	6.3	7 CR	9 ATT	-	I	-	-
	L	4	I	DHC	8	18	44.4	18 SD	-	-	5 S	3 D	-
					18	82	22.0						
G 127	L	4	I	DHC	4	39	10.3	39 SD	-	-	UK	-	-
	L	5	I	DHC	6	9	67.0	9 SD	-	-	3 D	1 DF	2 UK
	B	3	I	Spot	2	44	4.5	44 CR	-	-	2 UK	-	-
	J	6	I	Spot	0	8	0.0	8 EL	-	-	-	-	-
	B	1	I	Spot	0	6	0.0	6 EL	-	-	-	-	-
					12	106	11.3						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 128	N	1	I	Spot	19	55	34.5	19 CR	24 SD	5 EL	3 S	1 LC	2 D
	B	9	I	Duct	8	43	20.3	Duct	-	-	7 UK	1 LC	-
					27	98	27.6						
G 129	G	4	I	Spot	2	165	1.2	162 CR	3 CP	-	S	-	-
	G	3	I	Spot	2	35	5.7	BSM	SH	TV	S	H	-
	N	4	I	Spot	0	10	0.0	2 CR	8 ICU	-	-	-	-
					4	210	1.9						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 130	L	7	P	DHC	6	18	33.3	18 SD	-	-	LC	D	ST
	H	3	I	Spot	14	70	20.0	22 CR	13 EL	4 EQ	HS	S	D
					20	88	22.7						
G 131	G	3	I	Spot	3	133	2.3	115 SD	14 EL	2 CR	2 T	1 M	-
	H	1	I	Spot	0	2	0.0	2 CP	-	-	-	-	-
	G	8	I	Spot	0	16	0.0	SD	-	-	-	-	-
	G	7	I	Duct	1	9	11.1	Ducts	-	-	Not Provided	-	-
					4	150	2.7						
G 132	A	1	I	Spot	41	117	35.0	94 CR	10 EL	3 TV	14 UK	5 S	6 W
	C	1	P	Spot	0	20	0.0	12 REC	16 CR	-	-	-	-
	GG	2	I	Single Station	0	28	0.0	16 CR	12 REC	-	-	-	-
					41	165	24.8						
G 133	R	1	P	Duct	2	12	16.7	Duct	-	-	2 ST	-	-
	D	2	P	Spot	0	14	0.0	14 SD	-	-	-	-	-
	J	6	I	Spot	0	2	0.0	2 TV	-	-	-	-	-

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 133 cont'd	R	7	I	Spot	1	12	8.3	8 EL	3 SD	1 CR	1 CW	-	-
					3	40	7.5						
G 134	E	3	I	Spot/Ducts	25	587	4.3	301 CR	118 Ducts	20 EL	15 H	5 S	5 LC
	K	2	I	Spot/Duct	0	74	0.0	44 CR	24 Duct	6 SD	-	-	-
	GG	1	I	Single Station	0	30	0.0	24 APT	6 BSM	-	-	-	-
					25	691	3.6						
G 135	E	11	I	Duct	2	10	20.0	Duct	-	-	T	-	-
	C	4	P	Spot	2	174	1.1	120 SD	48 EL	6 K	2 DF	-	-
					4	184	2.2						
G 136	P	3	I	Duct	75	70	107	Duct	-	-	H	W	D
	K	5	P	Spot	12	46	26.1	17 CR	11 EL	7 MKR	H	D	-
	K	2	I	Spot	4	16	25.0	12 CR	2 MKR	2 TV	H	-	-
	K	6	I	Duct	3	100	0.0	Duct	-	-	H	D	-
	G	2	I	Spot	0	3	26.1	3 CP	-	-	-	-	-
	L	10	I	Spot	125	70	176	64 SD	4 EL	2 EM	S	D	H

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data No. FA	False Alarm Data No. Det.	False Alarm Data Percent	Main Detector Locations 1	Main Detector Locations 2	Main Detector Locations 3	Main False Alarm Causes 1	Main False Alarm Causes 2	Main False Alarm Causes 3
G 136 cont'd	L	11	P	Spot	4	58	6.9	20 ELC	30 MKR	4 EM	S	D	-
					223	363	61.4						
G 137	B	1	I	Spot/Duct	46	274	16.8	216 SD	44 Ducts	7 WA	16 S	4 M	10 DF
G 138	N	1	I	Spot	36	201	17.9	125 CR	24 EL	21 SD	S	W	M
	N	3	P	Spot	10	24	41.7	23 CR	1 SD	-	S	M	-
					46	225	20.4						
G 139	E	1	I	Spot	3	131	2.3	113 SD	16 EL	2 ES	2 S	1 CW	-
	E	5	P	Spot	5	66	7.6	56 MKR	8 TV	2 EM	LC	I	UK
	E	11	P	Duct	0	109	0.0	Ducts	-	-	-	-	-
	B	1	I	Spot	0	17	0.0	SD	-	-	-	-	-
	A	8	I	Duct	3	120	2.5	Ducts	-	-	UK	-	-
	A	1	I	Spot	77	210	36.7	116 SD	90 CR	4 ES	Mostly S	W	CW
	D	7	P	Spot	49	141	34.8	75 MKR	22 SD	20 CR	Mostly S	CW	-
	C	1	P	Spot	0	250	0.0	225 CR	25 PR	-	-	-	-
					137	1044	13.1						

TABLE I - SUMMARY OF DATA FROM INDIVIDUAL VAMC'S

VAMC No.	Detect. Mfr.	Detect. Model	Ion or Photo	Type (Applic.)	False Alarm Data			Main Detector Locations			Main False Alarm Causes		
					No. FA	No. Det.	Percent	1	2	3	1	2	3
G 140	E	3	I	Spot	4	30	13.3	30 EL	-	-	S	-	-
	E	4	P	Spot	44	254	17.3	161 SD	28 EL	20 CR	S	W	M
	L	6	I	DHC	2	20	10.0	20 SD	-	-	S	-	-
	G	17	I	Duct	0	2	0.0	2 Duct	-	-	-	-	-
	B	1	I	Spot	0	7	0.0	7 CP	-	-	-	-	-
	B	2	P	Spot	0	6	0.0	6 CP	-	-	-	-	-
					50	319	15.7						
G 141	S	1	I	Spot	0	25	0.0	25 EL	-	-	-	-	-
	L	2	P	DHC	34	27	126	27 SD	-	-	S	H	M
	E	4	P	Spot	0	121	0.0	108 SD	3 CR	10 0	-	-	-
	E	9	P	Spot	0	206	0.0	186 CR	10 SD	10 DNG	-	-	-
					34	379	9.0						

CODES -

- Spot - Ceiling mount detector - open area type
- Duct - Detector installed in ventilating duct
- DHC - Detector integral with door-holder-closer
- CL RM - Class Room
- G - General Care
- P - Psychiatric
- Dom - Domiciliary
- PC - Prosthesis Center
- OPC - Outpatient Clinic

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
A	1	I	1	1981	77	56	138
			4	1980	70	172	40.7
			11	1983	97	356	27.3
			12	1983	94	152	61.8
			16	-	0	12	0.0
			17	1978	111	520	21.4
			19	1976	20	80	25.0
			24	1980	4	12	33.3
			29	1980	46	232	19.8
			31	1978	43	156	27.6
			33	1976	88	501	17.6
			41	1983	98	210	46.7
			42	1984	32	95	33.7
			49	-	7	124	5.7
			59	1982	2	15	13.3
			78	1981	0	10	0.0
			91	1977	2	34	5.9
			94	1979	15	129	11.6
			99	1978	8	68	11.8
			100	1982	12	251	4.8
			104	1983	45	508	8.9
			105	1983	49	253	19.4
			113	1980	65	554	11.7
			116	1977	0	128	0.0
			117	1976	21	138	15.2
			118	1976	11	5	220
			120	1984	10	54	18.5
			132	1979	41	117	35 0
			139	1982	77	210	38.7
Totals			29	-	1090	5152	21.2

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
A	2	P	9	1978	25	71	35.2
			16	-	1	13	7.7
Totals			2	-	26	84	30.2
A	3	P	9	1985	7	30	23.3
			16	-	43	17	253
			17	1985	0	228	0.0
			104	1983	11	120	9.2
			106	1983	16	226	4.4
Totals			5	-	77	621	12.4
A	4	P	3	1983	260	123	211
			94	1978	1	42	2.4
Totals			2	-	261	165	158
A	5	I	3	1980	10	20	50.0
			30	1981	23	63	36.5
Totals			2	-	33	83	39.8
A	6	P	31	1978	6	17	35.3
A	7	P	91	1984	1	10	10.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
A	8	I	3	1980	1	80	1.3
	Duct		11A	1982	8	59	13.6
			16	-	0	16	0.0
			26	1984	3	96	3.1
			104	1983	1	175	0.6
			106	1983	0	54	0.0
			110	1980	10	174	5.7
			117	1985	1	8	12.5
			118	1976	52	139	37.4
			120	1984	0	14	0.0
			139	1982	3	120	2.5
Totals			11	-	79	935	8.4
A	9	P	117	1986	0	10	0.0
A	10	I	26	1983	0	7	0.0
	Duct	I	41	1983	7	23	30.4
Totals			2	-	7	30	23.3
A	11	I	116	1986	1	1	100
A	12	P	117	1986	1	47	2.1

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
B	1	I	2	1983	2	6	33.3
			6	1983	6	4	150
			11C	1980	0	100	0.0
			16	-	1	9	11.1
			18	1984	440	417	106
			19	1985	4	20	20.0
			22	1983	0	4	0.0
			23	-	16	76	21.0
			24	1983	46	411	11.2
			28	1984	6	4	150
			32	1985	27	202	13.4
			36	1984	51	666	7.7
			54	1984	0	49	0.0
			57	1980	5	230	2.2
			62	1984	2	17	11.8
			68	1985	1	15	6.7
			77	1982	2	48	4.2
			80	1981	0	11	0.0
			91	1984	0	10	0.0
			108	1982	10	40	25.0
			112	1984	0	4	0.0
			119	1984	114	308	37.0
			120	1983	0	22	0.0
			121	-	10	75	13.3
			124	1985	0	11	0.0
			127	-	0	6	0.0
			137	1985	46	273	16.8
			139	1984	0	17	0.0
			140	1984	0	7	0.0
Totals			29	-	789	3062	3.7

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
B	2	P	2	1985	63	190	33.2
			8	1985	5	31	16.3
			15	1984	0	148	0.0
			16	Ukn.	4	4	100
			18	1984	423	136	311
			24	1986	0	1	0.0
			40	1985	0	7	0.0
			64	1985	0	56	0.0
			86	1985	1	48	2.1
			108	1985	17	59	28.8
			120	1983	0	1	0.0
			124	1985	9	96	9.4
			140	1984	0	6	0.0
Totals			13		522	783	66.7
B	3	I	5	1976	10	19	52.6
			9	1976	0	10	0.0
			13	1977	6	535	1.1
			16	-	1	20	5.0
			40	1978	0	6	0.0
			53	1978	0	81	0.0
			58	-	0	82	0.0
			60	1984	7	221	3.2
			62	1976	1	83	1.2
			78	-	0	5	0.0
			80	1981	0	46	0.0
			93	1976	0	112	0.0
			105	1976	0	10	0.0
			109	1978	0	15	0.0
			112	1976	0	47	0.0
			114	1974	7	38	18.4
			123	1985	10	11	91.0
			127	1978	2	44	4.5
Totals			18	-	44	1385	3.2

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
B	4	P	16	-	0	5	0.0
			21	1983	121	1274	9.5
			31	1978	45	98	45.9
			40	1984	23	55	41.8
			54	1984	0	4	0.0
			111	1979	2	14	14.3
			112	1984	2	7	28.6
Totals			7	-	193	1457	13.2
B	5	I	5	1978	2	30	13.3
			28	1978	6	31	19.4
			40	1978	3	24	12.5
			68	1978	1	154	0.7
			81	1977	0	140	0.0
			106	1977	7	124	5.6
			112	1982	1	11	9.1
Totals			7	-	20	514	3.9
B	6	I	27	1981	5	61	8.2
			81	1984	4	6	66.7
			95	1981	13	88	14.8
			108	1982	27	347	7.8
Totals			4	-	49	502	9.8
B	7	I	102	1978	4	105	3.8
			115	1976	7	53	13.2
Totals			2	-	11	158	7.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
B	8	I	10	1984	17	71	9.9
	Duct	I	20	1982	0	4	0.0
		I	43	1984	25	135	18.5
		P	82	1980	0	3	0.0
		P	95	1983	0	120	0.0
		I	115	1982	0	1	0.0
		P	118	1985	2	15	13.3
		I	121	-	5	49	10.2
Totals			8	-	49	398	12.3
B	9	I	25	1979	0	22	0.0
	Duct		40	1979	1	13	7.7
			80	-	9	10	90.0
			106	1973	5	96	5.2
			112	1976	0	1	0.0
			115	1974	3	7	42.9
			125	1977	6	31	19.4
			128	1980	8	43	20.3
Totals			8	-	32	223	14.3

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
C	1	P	4	1976	0	5	0.0
			20	1981	1	25	4.0
			56	1979	0	5	0.0
			67	1978	10	147	6.8
			77	1978	5	734	0.7
			81	1981	0	8	0.0
			105	1983	1	10	10.0
			118	1980	0	229	0.0
			124	1977	1	52	1.9
			125	1984	1	19	5.3
			126	1979	1	16	6.3
			132	1985	0	20	0.0
			139	1985	0	250	0.0
Totals			13	-	20	1520	1.3
C	2	P	11	1983	23	87	26.4
			15	1980	0	3	0.0
			19	1979	0	66	0.0
			26	1984	81	395	20.5
			117	1986	1	3	33.3
Totals			5	-	105	554	19.0
C	3	P	12	1983	42	35	120
			55	1983	65	590	11.0
			67	1984	8	70	11.4
Totals			3	-	115	695	16.5
C	4	P	86	1980	3	22	13.6
			94	1984	0	11	0.0
			135	1977	2	174	1.1
Totals			3	-	5	207	2.4

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
C	5	P	41	1985	1	27	3.7
C	6	P	53	1976	0	33	0.0
C	7	I	103	1981	0	15	0.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
D	1	P	5	1979	20	25	80.0
			6	1983	2	6	33.3
			34	1985	4	10	40.0
			37	1981	79	368	21.5
			39	-	0	6	0.0
			47	1978	10	309	3.2
			89	1984	5	16	31.3
			97	1983	44	225	19.6
			120	1981	0	11	0.0
			121	-	6	52	11.5
			125	1981	5	39	12.8
Totals			11	-	175	1067	16.4
D	2	P	40	1978	5	62	8.1
			56	1979	5	57	8.8
			90	1980	0	24	0.0
			106	1979	1	15	6.7
			121	-	5	39	12.8
			133	-	0	14	0.0
Totals			6	-	16	211	7.6
D	3	P	106	1983	0	9	0.0
D	4	P	19	1985	5	34	14.7
			64	1985	0	50	0.0
			78	-	0	5	0.0
			118	1979	12	78	15.4
Totals			4	-	17	167	10.2
D	5	P	28	1983	0	9	0.0
			33	1983	14	22	63.6
			43	1984	8	50	16.0
			109	1983	3	29	10.3

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
Totals			4	-	25	110	22.7
D	6	P	115	1982	1	21	4.8
D	7	P	4	1980	0	4	0.0
			29	1980	9	19	47.4
			78	1981	0	2	0.0
			120	1984	4	13	30.8
			139	1982	49	141	34.8
Totals			5	-	62	179	34.6
D	8	P	56	1979	7	111	6.3
	Duct		109	1983	8	43	18.6
			112	1978	0	6	0.0
Totals			3	-	15	160	9.4

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
E	1	I	45	1973	13*	173*	7.5
			70	1982	5	154	3.2
			139	1983	3	131	2.3
Totals			3	-	21	458	4.6
E	2	I	7	1978	23	106	21.7
			39	-	14	66	21.2
			45	1973	13*	173	7.5
			65	1978	22	230	9.6
			114	1976	3	52	5.8
Totals			5		75	627	12.0
E	3	I	6	1983	0	30	0.0
			39	-	21	281	7.5
			45	1973	13*	173*	7.5
			66	1981	5	60	8.3
			86	-	2	98	2.0
			106	1977	6	20	30.0
			114	1976	1	10	10.0
			134	-	25	587	4.3
			140	1981	4	30	13.3
Totals			9	-	77	1289	6.0

* Split evenly among 3 models. Specific information not available.

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
E	4	I	70	1982	0	44	0.0
			140	1984	44	254	17.3
			141	1982	0	121	0.0
Totals			3	-	44	419	10.5
E	5	P	74	1979	15	250	6.0
			80	-	0	32	0.0
			91	1977	0	7	0.0
			124	1980	0	15	0.0
			139	1983	5	66	7.6
Totals			5	-	20	370	5.4
E	6	I	53	-	0	32	0.0
			74	1979	104	175	59.0
Totals			2	-	104	207	50.2
E	7	I	39	1985	2	40	5.0
	Duct		114	1985	0	6	0.0
Totals			2	-	2	46	4.3
E	8	P	6	1983	6	7	85.7
E	9	P	141	1986	0	206	0.0
E	10	I	28	1984	4	9	44.4
E	11	I	135	1980	2	10	20.0
	Duct		139	1983	0	109	0.0
Totals			2	-	2	119	1.7

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
F	1	P	21	1980	5	102	4.9
F	2	I	111	1976	0	23	0.0
F	3	P	99	1982	1	4	25.0
F	4	I	91	1977	5	70	7.1
F	5	I	16	-	4	45	8.9
			47	1978	4	146	2.7
			75	-	0	53	0.0
			111	1976	0	7	0.0
			121	-	6	78	7.7
Totals			5	-	29	433	6.7
F	6	I	31	1978	52	257	20.2
			43	1976	4	46	8.7
			82	1981	3	65	4.6
			89	1984	4	18	22.2
			110	1980	25	142	17.6
			121	-	0	38	0.0
			123	1985	17	58	29.3
Totals			7	-	105	624	16.8
F	7	P	8	1977	97	282	34.4
			82	1985	2	27	7.4
Totals			2	-	99	309	32.0
F	8	I	51	1982	0	24	0.0
			66	1976	9	125	7.2
Totals			2	-	9	149	6.0
F	9 Duct	I	28	1985	0	6	0.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
F	10	I	28	1983	10	12	83.3
		Duct	75	-	0	3	0.0
			108	1982	0	5	0.0
			111	1980	0	10	0.0
			121	-	15	104	14.4
Totals			5	-	25	134	18.6

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
G	1	I	23	-	0	9	0.0
G	2	I	15	1977	246	222	111
			16	-	0	6	0.0
			28	1983	12	115	10.4
			75	-	0	8	0.0
			81	1979	0	5	0.0
			98	1985	1	56	1.8
			103	-	2	26	7.7
			112	1983	0	9	0.0
			124	1979	4	4	100
			136	1983	0	3	0.0
Totals			10	-	265	454	58.4
G	3	I	28	1977	4	83	4.8
			71	1975	3	139	2.2
			72	1980	6	79	7.6
			98	1977	3	40	7.5
			114	1975	4	73	5.5
			129	-	2	35	5.7
			131	1975	3	133	2.3
Totals			7	-	25	582	4.3
G	4	I	8	1977	6	17	35.3
			16	-	2	63	3.2
			42	1976	9	46	19.6
			50	-	0	125	0.0
			72	1980	0	81	0.0
			81	1981	0	10	0.0
			86	1986	1	34	2.9
			97	1979	0	13	0.0
			98	1981	0	70	0.0
			126	1980	9	48	18.8
			129	-	2	165	1.2

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
Totals			11	-	29	672	4.3
G	5	P	16	-	11	12	91.7
			93	1984	6	10	60.0
			98	1984	0	3	0.0
Totals			3	-	17	25	68.0
G	6	I	98	1981	4	13	30.8
G	7 Duct	I	131	1975	1	9	11.1
G	8	I	28	1965	0	27	0.0
			131	1976	0	16	0.0
Totals			2	-	0	43	0.0
G	9	I	69	1977	2	135	1.5
G	10	I	90	-	2	12	16.7
G	11	I	118	1976	1	12	8.3
G	12	I	79	1977	9	91	9.9
G	13 Duct	I	103	-	4	35	11.4
G	14	I	15	1980	0	46	0.0
	Duct	I	75	-	0	14	0.0
Totals			2	-	0	60	0.0
G	15	I	7	1983	26	48	38.2
G	16 Duct	I	89	1984	3	14	21.4

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
G	17	I	26	1976	6	9	66.7
	Duct		28	1983	0	10	0.0
			68	1978	0	17	0.0
			98	1981	0	4	0.0
			111	1982	0	1	0.0
			112	1984	0	3	0.0
			140	1984	0	2	0.0
Totals			7	-	6	46	13.0
G	18	I	16	-	0	4	0.0
	Duct		75	-	0	5	0.0
			109	1976	4	13	30.8
			112	1975	0	1	0.0
Totals			4	-	4	23	17.4
G	19	I	15	1980	0	26	0.0
	Duct		39	-	28	60	46.7
			98	1981	0	16	0.0
Totals			3	-	28	102	27.5
G	20	I	16	-	0	39	0.0
	Duct		81	1981	0	2	0.0
			97	1979	0	5	0.0
			112	1981	0	3	0.0
Totals			4	-	0	49	0.0
G	21	I	106	1974	3	6	50.0
	Duct	I	111	1982	0	1	0.0
Totals			2	-	3	7	42.9

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL (cont'd)

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
H	1	I	15	1984	0	6	0.0
			16	-	0	4	0.0
			23	-	60	121	49.6
			43	1982	0	6	0.0
			89	1980	10	75	13.3
			112	1984	0	16	0.0
			115	1984	0	6	0.0
			120	1984	28	200	14.0
			131	1984	0	2	0.0
			139	1982	0	22	0.0
Totals			10	-	98	458	21.4
H	2	I	42	1978	17	107	15.9
			92	1975	0	23	0.0
			94	1981	0	39	0.0
			120	1981	8	95	8.4
			125	1981	7	61	11.5
Totals			5	-	32	325	9.8
H	3	P	20	1981	3	9	33.3
			97	1985	3	4	75.0
			120	1984	0	10	0.0
			130	1986	14	70	20.0
Totals			4	-	20	93	21.5
H	4	P	101	1984	0	59	0.0
H	5	P	101	1978	3	37	8.1
H	6	P	39	-	1	88	1.1
			56	1986	0	7	0.0
Totals			2	-	1	95	1.1

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
J	1	I	16	-	0	13	0.0
			25	1982	29	24	121
			43	1984	6	140	4.3
			53	1983	0	35	0.0
			66	1984	0	40	0.0
Totals			5	-	35	252	13.9
J	2 (Duct)	I	30	1980	0	25	0.0
			75	-	0	3	0.0
			112	1982	0	1	0.0
Totals			3	-	0	29	0.0
J	3	I	111	1976	3	35	8.6
J	4	I	118	1985	0	2	0.0
J	5 (Duct)	I	40	1983	3	14	21.4
			103	1984	0	35	0.0
Totals			2	-	3	49	6.1
J	6	I	40	1984	9	61	14.8
			89	1980	11	14	78.6
			127	1978	0	8	0.0
			133	-	0	2	0.0
Totals			4	-	20	85	23.5
J	7	I	54	1984	2	25	8.0
J	8	I	96	1980	5	13	38.5
J	9	I	96	1977	3	53	5.7
J	10	I	5	1984	47	187	25.1
J	11	I	111	1976	0	17	0.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
K	1	I	107	1983	11	137	8.0
K	2	I	25	1979	0	166	0.0
			134	1984	0	74	0.0
			136	1982	4	16	25.0
Totals			4	-	4	256	1.6
K	3	I	52	-	30	384	7.8
K	4	I	10	1984	53	220	24.0
K	5	P	25	1979	0	74	0.0
			107	1983	3	38	7.9
			120	1984	0	5	0.0
			136	1982	12	46	26.1
Totals			4	-	15	163	9.2
K	6	I	25	1979	0	28	0.0
	Duct		136	1982	3	100	3.0
Totals			2	-	3	128	2.3
K	7	I	10	1984	27	51	52.9
			22	1983	0	5	0.0
			25	1983	0	178	0.0
Totals			3	-	27	234	11.5
K	8	P	25	1979	0	16	0.0
K	9	I	25	1983	0	101	0.0
Duct							
K	10	P	25	1983	0	3	0.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
L	1	P	3	1983	0	83	0.0
		I	22	1980	20	26	76.9
DHC		I	85	1982	8	12	66.7
		I	109	1983	0	2	0.0
Totals			4	-	28	123	22.8
L	2	P	141	1982	34	27	126
DHC							
L	3	I	7	1978	110	184	59.8
DHC			25	1979	14	33	42.4
			109	1982	1	2	50.0
			111	1982	0	5	0.0
Totals			4	-	125	224	55.8
L	4	I	103	1975	10	30	33.3
DHC		I	126	1978	8	18	44.4
		I	127	1976	4	39	10.3
Totals			3	-	22	87	25.3
L	5	I	30	1977	7	32	21.9
DHC			92	1975	25	132	18.9
			127	1976	6	9	67.0
Totals			3	-	38	173	22.0
L	6	I	140	1984	2	20	10.0
DHC							
L	7	P	130	1986	6	18	33.3
DHC							
L	8	I	111	1976	5	26	19.2

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
L	9	I	38	1976	2	36	5.6
DHC							
L	10	I	136	1983	125	70	176
DHC							
L	11	P	136	1983	4	58	6.9
DHC							
L	12	I	111	1979	0	4	0.0
L	13	I	118	1979	0	3	0.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
M	1	I	125	1977	0	35	0.0
DHC							
M	2	I	118	1977	15	23	65.2
DHC							
M	3	I	118	1976	6	34	17.6
DHC							
M	4	I	103	1979	2	9	22.2
DHC			118	1977	1	20	5.0
Totals			2		2	29	6.9
M	5	P	122	1977	5	24	20.8
DHC							
M	6	I	43	1980	3	19	15.8
DHC							
M	7	I	118	1977	28	24	117
DHC							

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
N	1	I	20	-	16	90	17.8
			27	1978	43	257	16.7
			38	-	0	7	0.0
			63	1973	12	114	10.5
			122	1977	21	58	36.2
			128	1976	19	55	34.5
			138	1976	36	201	17.9
Totals			7	-	147	782	18.8
N	2	I	26	1984	0	8	0.0
			28	1984	0	10	0.0
			38	-	10	14	71.4
			91	1980	1	4	25.0
Totals			4	-	11	36	30.6
N	3	P	27	1985	12	217	5.5
			63	1984	1	2	50.0
			122	1977	28	249	11.2
			123	1985	2	37	5.4
			124	1977	1	1	100
			138	1976	10	24	41.7
Totals			6	-	54	530	10.2
N	4	I	129	-	0	10	0.0
N	5	P	122	1985	0	14	0.0
N	6	I	113	1981	3	88	3.4
N	7	I	91	1980	8	22	36.4
Duct			112	1981	0	1	0.0
			115	1980	2	14	14.3
			122	-	0	6	0.0
			124	1975	13	23	56.5
Totals			5	-	23	66	34.8

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
P	1	I	16	-	14	76	18.4
			29	1981	0	9	0.0
			35	1976	44	487	9.0
			75	-	0	1	0.0
			101	1978	10	73	13.7
Totals			5	-	68	646	10.5
P	2	P	59	1973	4	31	12.9
P	3	I	136	1983	75	70	107
	Duct						
P	4	I	14	-	17	265	6.4
P	5	I	75	-	0	4	0.0
	Duct		112	1980	0	2	0.0
Totals			2	-	0	6	0.0
Q	1	I	22	1983	6	15	0.0
Q	2	I	109	1985	0	15	0.0
Totals			2	-	6	30	20.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
R	1	I	2	1984	0	37	0.0
		I	111	1984	3	6	50.0
		P	133	-	2	12	16.7
Totals			3	-	5	55	9.1
R	2 Duct	I	119	1984	0	109	0.0
R	3	I	7	1980	5	13	35.4
R	4 Duct	I	34	-	11	57	19.3
R	5	I	85	1979	4	14	28.6
R	6	I	90	1980	28	170	16.5
R	7	I	133	-	1	12	8.3
R	8 Duct	I	120	-	1	5	20.0

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
S	1	I	20	1979	4	39	10.3
		I	33	1976	9	88	10.2
		I	91	1984	1	17	5.9
		I	97	1979	5	110	4.5
		I	141	1979	0	25	0.0
Totals			5	-	19	279	6.8
T	1	I	7	1985	26	30	86.7
U	1	P	85	1984	3	34	8.8
V	1	P	91	1985	3	263	1.1
W	1	I	118	1977	3	12	25.0
X	1	I	66	1976	6	150	4.0
Y	1	I	14	1975	3	50	6.0
Z	1	P	20	1985	2	16	12.5

TABLE 2 - SMOKE DETECTOR FALSE ALARM SUMMARY - VA MEDICAL CENTERS
BY DETECTOR MODEL

Detector Mfr.	Model No.	Ion or Photo	VAMC	Year Installed	Number of False Alarms	Number of Detectors	False Al. Percentage
AA	1	P	28	1986	0	8	0.0
BB	1	I	28	1983	0	18	0.0
BB	2	P	83	-	2	4	50.0
Totals			2	-	2	22	9.1
CC	1	I	29	1985	0	10	0.0
CC	2	P	43	1984	0	5	0.0
Totals			2	-	0	15	0.0
DD	1	I	41	1983	0	11	0.0
EE	1	I	54	1978	0	113	0.0
FF	1	I	94	1974	0	7	0.0
GG*	1	I	134	1986	0	30	0.0
GG*	2	I	132	1978	0	28	0.0
Totals			2	-	0	58	0.0
HH*	1	I	25	1984	0	25	0.0
JJ*	1	I	118	1985	0	9	0.0

* Single Station Types

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
A	1	Spot	I	29	1090	5152	21.2
A	2	Spot	P	2	26	84	30.2
A	3	Spot	P	5	77	621	12.4
A	4	Spot	P	2	261	165	158.
A	5	Spot	I	2	33	83	39.8
A	6	Spot	P	1	6	17	35.3
A	7	Spot	P	1	1	10	10.0
A	8	Duct	I	11	79	935	8.4
A	9	Spot	P	1	0	10	0.0
A	10	Duct	I	2	7	30	23.3
A	11	Spot	I	1	1	1	100.
A	12	Spot	P	1	1	47	2.1
TOTALS		Spot	I	32	1124	5236	21.5
		Spot	P	13	372	954	40.0
				45	1496	6190	24.2
		Duct	I	13	86	965	8.9
		All	-	58	1582	7155	22.1

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
B	1	Spot	I	29	789	3052	25.9
B	2	Spot	P	13	522	783	66.7
B	3	Spot	I	18	44	1385	3.2
B	4	Spot	P	7	193	1457	13.2
B	5	Spot	I	7	20	514	3.9
B	6	Spot	I	4	49	502	9.8
B	7	Spot	I	2	11	158	7.0
B	8	Duct	I	5	47	260	18.1
B	8	Duct	P	3	2	138	1.4
B	9	Duct	I	8	31	209	14.8
TOTALS		Spot	I	60	913	5611	16.3
		Spot	P	20	715	2240	31.9
				80	1628	7851	20.7
		Duct	I	13	78	469	16.6
		Duct	P	3	2	138	1.4
		All	-	96	1708	8458	20.2

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
C	1	Spot	P	13	20	1520	1.3
C	2	Spot	P	5	105	554	19.0
C	3	Spot	P	3	115	695	16.5
C	4	Spot	P	3	5	207	2.4
C	5	Spot	P	1	1	27	3.7
C	6	Spot	P	1	0	33	0.0
C	7	Spot	I	1	0	15	0.0
TOTALS		Spot	P	26	246	3036	8.1
		Spot	I	1	0	15	0.0
		All	-	27	246	3051	8.1

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
D	1	Spot	P	11	174	1067	16.3
D	2	Spot	P	6	16	211	7.6
D	3	Spot	P	1	0	9	0.0
D	4	Spot	P	4	17	167	10.2
D	5	Spot	P	4	25	110	22.7
D	6	Spot	P	1	1	21	4.8
D	7	Spot	P	5	62	179	34.6
D	8	Duct	P	3	15	160	9.4
TOTALS		Spot	P	32	295	1764	16.7
		Duct	P	3	15	160	9.4
		All	-	35	310	1924	16.1

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
E	1	Spot	I	3	21	458	4.6
E	2	Spot	I	6	75	657	12.0
E	3	Spot	I	8	77	1259	6.1
E	4	Spot	I	3	44	419	10.5
E	5	Spot	P	5	20	370	5.4
E	6	Spot	I	2	104	207	50.2
E	7	Duct	I	2	2	46	4.3
E	8	Spot	P	1	6	7	85.7
E	9	Spot	P	1	0	206	0.0
E	10	Spot	I	1	4	9	44.4
E	11	Duct	I	2	2	119	1.7
TOTALS		Spot	I	23	325	3009	10.8
		Spot	P	7	26	583	4.5
				30	351	3592	7.0
		Duct	I	4	4	165	2.4
		All	-	34	355	3757	9.4

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instl l'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
F	1	Spot	P	1	5	102	4.9
F	2	Spot	I	1	0	23	0.0
F	3	Spot	P	1	1	4	25.0
F	4	Spot	I	1	5	70	7.1
F	5	Spot	I	5	29	433	6.7
F	6	Spot	I	7	105	624	16.8
F	7	Spot	P	2	99	309	32.0
F	8	Spot	I	2	9	149	6.0
F	9	Duct	I	1	0	6	0.0
F	10	Duct	I	5	25	134	18.6
TOTALS		Spot	I	16	148	1299	11.4
		Spot	P	4	105	415	25.3
				20	253	1714	14.8
		Duct	I	6	25	140	17.9
		All	-	26	278	1854	15.0

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
G	1	Spot	I	1	0	7	0.0
G	2	Spot	I	10	265	454	58.4
G	3	Spot	I	8	25	589	4.2
G	4	Spot	I	11	29	672	4.3
G	5	Spot	P	3	17	25	68.0
G	6	Spot	P	1	4	13	30.8
G	7	Duct	I	1	1	9	11.1
G	8	Spot	I	2	0	43	0.0
G	9	Spot	I	1	2	135	1.5
G	10	Spot	I	1	2	12	16.7
G	11	Spot	I	1	1	12	8.3
G	12	Spot	I	1	9	91	9.9
G	13	Duct	I	1	4	35	11.4
G	14	Duct	I	1	0	46	0.0
G	15	Spot	I	1	26	48	38.2
G	15	Duct	I	1	2	18	11.1
G	16	Duct	I	1	3	14	21.4
G	17	Duct	I	7	6	46	13.0
G	18	Duct	I	4	4	23	17.4
G	19	Duct	I	3	28	102	27.5
G	20	Duct	I	4	0	49	0.0
G	21	Duct	I	2	3	7	42.9

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
TOTALS		Spot	I	37	363	2078	17.5
		Spot	P	3	17	25	68.0
				40	380	2103	18.1
		Duct	I	25	51	349	14.6
		All	-	65	431	2452	17.6

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
H	1	Spot	I	10	98	458	21.4
H	2	Spot	I	5	32	325	9.8
H	3	Spot	P	4	20	93	21.5
H	4	Spot	P	1	0	59	0.0
H	5	Spot	P	1	3	37	8.1
H	6	Spot	P	2	1	95	1.1
TOTALS		Spot	I	17	131	878	14.9
		Spot	P	6	23	189	12.2
		All	-	23	154	967	15.9

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
J	1	Spot	I	5	35	252	13.9
J	2	Duct	I	3	0	29	0.0
J	3	Spot	I	1	3	35	8.6
J	4	Spot	I	1	0	2	0.0
J	5	Duct	I	2	3	49	6.1
J	6	Spot	I	4	20	85	23.5
J	7	Spot	I	1	2	25	8.0
J	8	Spot	I	1	5	13	38.5
J	9	Spot	I	2	3	70	4.3
J	10	Spot	I	1	47	187	25.1
TOTALS		Spot	I	16	115	669	17.2
		Duct	I	5	3	78	3.8
		All	-	21	118	747	15.8

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
K	1	Spot	I	1	11	137	8.0
K	2	Spot	I	3	4	256	1.6
K	3	Spot	I	1	30	384	7.8
K	4	Spot	I	1	53	220	24.0
K	5	Spot	P	4	15	163	9.2
K	6	Duct	I	2	3	128	2.3
K	7	Spot	I	3	27	234	11.5
K	8	Spot	P	1	0	16	0.0
K	9	Duct	I	1	0	101	0.0
K	10	Spot	P	1	0	3	0.0
TOTALS		Spot	I	9	125	1231	10.2
		Spot	P	6	15	182	8.2
				15	140	1413	9.9
		Duct	I	3	3	229	1.3
		All	-	18	143	1642	8.7

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector[a] Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
L	1	DHC	P	1	0	83	0.0
L	1	DHC	I	3	28	40	70.0
L	2	DHC	P	1	34	27	126
L	3	DHC	I	4	125	224	55.8
L	4	DHC	I	3	22	87	25.3
L	5	DHC	I	3	38	173	22.0
L	6	DHC	I	1	2	20	10.0
L	7	DHC	P	1	6	18	33.3
L	8	Spot	I	1	5	26	19.2
L	9	DHC	I	1	2	36	5.6
L	10	DHC	I	1	125	70	176
L	11	DHC	P	1	4	58	6.9
L	12	Spot	I	1	0	4	0.0
L	13	Spot	I	1	0	3	0.0
TOTALS		DHC	I	16	342	650	52.6
		DHC	P	4	44	186	23.7
				20	386	836	46.2
		Spot	I	3	5	33	15.2
		All	-	23	391	869	45.0

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
M	1	DHC	I	1	0	35	0.0
M	2	DHC	I	1	15	23	65.2
M	3	DHC	I	1	6	34	17.6
M	4	DHC	I	2	2	29	6.9
M	5	DHC	P	1	5	24	20.8
M	6	DHC	I	1	3	19	15.8
M	7	DHC	I	1	28	24	117
TOTALS			I	7	54	164	32.9
			P	1	5	24	20.8
		All		8	59	188	31.4

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
N	1	Spot	I	7	147	782	18.8
N	2	Spot	I	4	11	36	30.6
N	3	Spot	P	6	54	530	10.2
N	4	Spot	I	1	0	10	0.0
N	5	Spot	P	1	0	14	0.0
N	6	Spot	I	1	3	88	3.4
N	7	Duct	I	5	23	66	34.8
TOTALS		Spot	I	13	161	916	17.6
		Spot	P	7	54	544	9.9
				20	224	1460	15.3
		Duct	I	5	23	66	34.8
		All	-	25	247	1526	16.2

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instl'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
P	1	Spot	I	5	68	646	10.5
P	2	Spot	P	1	4	31	12.9
P	3	Duct	I	1	75	70	107.
P	4	Spot	I	1	15	265	5.7
P	5	Duct	I	2	0	6	0.0
TOTALS		Spot	I	6	83	911	9.1
		Spot	P	1	4	31	12.9
				7	87	942	9.2
		Duct	I	3	75	76	98.7
		All	-	10	162	1018	15.9

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
Q	1	Spot	I	1	6	15	40.0
Q	2	Spot	I	1	0	15	0.0
TOTALS				2	6	30	20.0

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S

By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
R	1	Spot	I	2	3	43	7.0
R	1	Spot	P	1	2	12	16.7
R	2	Duct	I	1	0	109	0.0
R	3	Spot	I	1	5	13	35.4
R	4	Duct	I	1	11	57	19.3
R	5	Spot	I	1	4	14	28.6
R	6	Spot	I	1	28	170	16.5
R	7	Spot	I	1	1	12	8.3
R	8	Duct	I	1	1	5	20.0
TOTALS		Spot	I	6	41	252	16.3
		Spot	P	1	2	12	16.7
				7	43	264	16.3
		Duct	I	3	12	171	7.0
		All	-	10	55	435	12.6

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
S	1	Spot	I	5	18	279	6.5
T	1	Spot	I	1	26	30	86.7
U	1	Spot	P	1	3	34	8.8
V	1	Spot	P	1	3	263	1.1
W	1	Spot	I	1	3	12	25.0
X	1	DHC	I	1	6	150	4.0
Y	1	Spot	I	1	3	50	6.0
Z	1	Spot	P	1	2	16	12.5

TABLE 3 - SUMMARY OF SMOKE DETECTOR FALSE ALARM PERFORMANCE - VAMC'S
By Manufacturer

Detector Mfr.	Detector Model	Type	Operating Principle	Number of Instll'ns	Total No. of False Alarms	Total No. of Detectors	False Alarms Percentage
AA	1	Spot	P	1	0	8	0.0
BB	1	Spot	I	1	0	18	0.0
BB	2	Spot	P	1	2	4	50.0
TOTALS				2	2	22	9.1
CC	1	Spot	I	1	0	10	0.0
CC	2	Spot	P	1	0	5	0.0
TOTALS				2	0	15	0.0
DD	1	Spot	I	1	0	11	0.0
EE	1	Spot	I	1	0	113	0.0
FF	1	Spot	I	1	0	7	0.0
GG	1	Single Station	I	1	0	30	0.0
GG	2	Single Station	I	1	0	28	0.0
TOTALS				2	0	58	0.0
HH	1	Single Station	I	1	0	25	0.0
JJ	1	Single Station	I	1	0	9	0.0

TABLE 27 - OBSCURATION - OPTICAL DENSITY CHART

Based on a 5 foot (1.52 m) light beam

Light Transmission (Meter Reading) (microamperes)	Obscuration Percent Per Foot	Obscuration Percent Per Meter	Total Obscuration	Optical Density Per Foot	Optical Density Per Meter	Total Optical Density
100.0	0.000	0.000	0.000	0.0000	0.0000	0.0000
99.5	0.100	0.328	0.500	0.0004	0.0014	0.0022
99.0	0.201	0.657	1.000	0.0009	0.0029	0.0044
98.5	0.302	0.987	1.500	0.0013	0.0043	0.0066
98.0	0.403	1.317	2.000	0.0018	0.0058	0.0088
97.5	0.505	1.648	2.500	0.0022	0.0072	0.0110
97.0	0.607	1.979	3.000	0.0027	0.0087	0.0132
96.5	0.710	2.311	3.500	0.0031	0.0102	0.0155
96.0	0.813	2.643	4.000	0.0036	0.0116	0.0177
95.5	0.917	2.976	4.500	0.0040	0.0131	0.0200
95.0	1.021	3.310	5.000	0.0045	0.0146	0.0223
94.5	1.125	3.644	5.500	0.0049	0.0161	0.0246
94.0	1.230	3.979	6.000	0.0054	0.0176	0.0269
93.5	1.335	4.314	6.500	0.0058	0.0192	0.0292
93.0	1.441	4.650	7.000	0.0063	0.0207	0.0315
92.5	1.547	4.987	7.500	0.0068	0.0222	0.0339
92.0	1.654	5.324	8.000	0.0072	0.0238	0.0362
91.5	1.761	5.662	8.500	0.0077	0.0253	0.0386
91.0	1.869	6.001	9.000	0.0082	0.0269	0.0410
90.5	1.977	6.340	9.500	0.0087	0.0285	0.0434
90.0	2.085	6.680	10.00	0.0092	0.0300	0.0458
89.5	2.194	7.020	10.50	0.0096	0.0316	0.0482
89.0	2.304	7.362	11.00	0.0101	0.0332	0.0506
88.5	2.414	7.703	11.50	0.0106	0.0348	0.0531
88.0	2.524	8.046	12.00	0.0111	0.0364	0.0555
87.5	2.635	8.389	12.50	0.0116	0.0381	0.0580
87.0	2.747	8.733	13.00	0.0121	0.0397	0.0605
86.5	2.859	9.077	13.50	0.0126	0.0413	0.0630
86.0	2.971	9.423	14.00	0.0131	0.0430	0.0655
85.5	3.085	9.768	14.50	0.0136	0.0446	0.0680
85.0	3.198	10.12	15.00	0.0141	0.0463	0.0706
84.5	3.312	10.46	15.50	0.0146	0.0480	0.0732
84.0	3.427	10.81	16.00	0.0152	0.0497	0.0757
83.5	3.542	11.16	16.50	0.0157	0.0514	0.0783
83.0	3.658	11.51	17.00	0.0162	0.0531	0.0809
82.5	3.774	11.86	17.50	0.0167	0.0548	0.0836
82.0	3.891	12.21	18.00	0.0172	0.0566	0.0862
81.5	4.009	12.56	18.50	0.0178	0.0583	0.0889
81.0	4.127	12.91	19.00	0.0183	0.0600	0.0915
80.5	4.246	13.27	19.50	0.0188	0.0618	0.0942
80.0	4.365	13.62	20.00	0.0194	0.0636	0.0969
79.5	4.48	13.48	20.5	0.0199	0.0654	0.0996
79.0	4.61	14.33	21.0	0.0204	0.0672	0.1023
78.5	4.73	14.64	21.5	0.0210	0.0690	0.1051
78.0	4.85	15.04	22.0	0.0215	0.0708	0.1079
77.5	4.97	15.40	22.5	0.0221	0.0726	0.1107
77.0	5.09	15.76	23.0	0.0227	0.0745	0.1135
76.5	5.22	16.12	23.5	0.0232	0.0763	0.1163
76.0	5.34	16.48	24.0	0.0238	0.0782	0.1191
75.5	5.47	16.84	24.5	0.0244	0.0801	0.1220
75.0	5.59	17.20	25.0	0.0249	0.0820	0.1249

TABLE 27

OBSCURATION – OPTICAL DENSITY CHART (Cont'd)
Based on a 5 foot (1.52 m) light beam

Light Transmission (Meter Reading) (microamperes)	Obscuration Percent Per Foot	Obscuration Percent Per Meter	Total Obscuration	Optical Density Per Foot	Optical Density Per Meter	Total Optical Density
74.5	5.72	17.56	25.5	0.0255	0.0839	0.1278
74.0	5.84	17.93	26.0	0.0261	0.0858	0.1307
73.5	5.97	18.29	26.5	0.0267	0.0877	0.1337
73.0	6.10	18.66	27.0	0.0273	0.0897	0.1366
72.5	6.23	19.02	27.5	0.0279	0.0916	0.1396
72.0	6.36	19.39	28.0	0.0285	0.0936	0.1426
71.5	6.49	19.76	28.5	0.0291	0.0956	0.1456
71.0	6.62	20.13	29.0	0.0297	0.0976	0.1487
70.5	6.75	20.50	29.5	0.0303	0.0996	0.1518
70.0	6.89	20.87	30.0	0.0309	0.1016	0.1549
69.5	7.02	21.24	30.5	0.0316	0.1037	0.1580
69.0	7.15	21.61	31.0	0.0322	0.1057	0.1611
68.5	7.29	21.98	31.5	0.0328	0.1078	0.1643
68.0	7.42	22.36	32.0	0.0335	0.1099	0.1674
67.5	7.56	22.73	32.5	0.0341	0.1120	0.1707
67.0	7.70	23.11	33.0	0.0347	0.1141	0.1739
66.5	7.84	23.49	33.5	0.0354	0.1163	0.1771
66.0	7.97	23.86	34.0	0.0360	0.1184	0.1804
65.5	8.11	24.24	34.5	0.0367	0.1206	0.1837
65.0	8.25	24.62	35.0	0.0374	0.1228	0.1870
64.5	8.40	25.00	35.5	0.0380	0.1250	0.1904
64.0	8.54	25.39	36.0	0.0387	0.1272	0.1938
63.5	8.68	25.77	36.5	0.0394	0.1294	0.1972
63.0	8.83	26.15	37.0	0.0401	0.1317	0.2006
62.5	8.97	26.54	37.5	0.0408	0.1339	0.2041
62.0	9.12	26.92	38.0	0.0415	0.1362	0.2076
61.5	9.26	27.31	38.5	0.0422	0.1385	0.2111
61.0	9.41	27.70	39.0	0.0429	0.1409	0.2146
60.5	9.56	28.09	39.5	0.0436	0.1432	0.2182
60.0	9.71	28.48	40.0	0.0443	0.1456	0.2218
59.5	9.86	28.87	40.5	0.0451	0.1480	0.2254
59.0	10.01	29.26	41.0	0.0458	0.1504	0.2291

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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)

A study of 133 VA Medical Centers (VAMC), out of a total of 172 throughout the U.S., coupled with visits to 20 facilities, was conducted to gather data on false alarms of smoke detectors.
Data collected included name of the detector manufacturer and model number, control unit manufacturer and model number, number and type of detectors installed, where installed, number of false and real alarms for preceding year, date of installation, and policies on smoking, testing, cleaning, and maintenance. VAMC personnel involved with the installations were requested to indicate the maximum level of false alarms that could be tolerated and to provide any recommendations to reduce their occurrence.

The study included a total of approximately 37,000 system type smoke detectors of which 69 percent were of ionization (ion) type and 31 percent photoelectric, 3000 duct detectors (90 percent ion and 10 percent photo), and 1100 smoke detector modules (80 percent ion and 20 percent photo) integral with door holder closers (DHC). Also, included are approximately 100 single station smoke alarms.

Analysis of data collected from operating facilities through forms, site visits, and staff interviews resulted in a series of recommendations which could result in a substantial reduction in observed false alarms.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

sensitivity, false alarms, ionization principle, photoelectric principle, production window, smoke detectors, smoking, testing, lack of cleaning, dust, misapplication, VA Medical Centers (VAMCs).

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