DEVELOPMENT OF CRITERIA  
FOR FIRE SERVICE HAND-HELD RADIOS 

Contract No. EME-97-SA-0500  
Final Report 

Submitted To: 
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Federal Emergency Management Agency  
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INTRODUCTION

This Final Report provides a description of work completed for U.S. Fire Administration Contract No. EME-97-SA-0500, "Fire Service Radio Criteria Development." This contract was intended to result in development of draft performance criteria for hand-held radios used during firefighting and other fire service emergency operations. The approach used in this effort was designed to meet the following objectives:

! To conduct a review of fire service hand-held radio current marketed to and used by the fire service to determine desired features, undesired features, and needs;

! To establish a list of generic performance requirements and criteria for fire service hand-held radios;

! To identify pertinent standards, specifications, and test methods for evaluation of fire service hand-held radio performance;

! To determine performance areas fire service hand-held radios where test method development is required;

! To develop a list of specific performance requirements for fire service hand-held radios; and

! To prepare a comprehensive draft standard providing performance criteria for fire service hand-held radios.

Work in this contract was assisted by a Technical Assistance Group (TAG), consisting of experts with different backgrounds in fire service communications to provide broad perspectives for understanding fire service needs. TAG members included:

! Steve Basnett (Lieutenant, Fairfax County Fire & Rescue)
! Harry Beck (Chief, Phoenix Fire Department)
! Richard M. Duffy (Director, Health and Health, International Association of Fire Fighters)
! Carlos C. Perez (Fire Chief, Dekalb County Fire Department)
! J. Curtis Varone (Battalion Chief, Providence Fire Department)

The TAG was used as a primary resource for input to development of fire service hand-held radio performance criteria. In addition, comments were solicited from other fire service representatives and radio manufacturers to further support development of the performance criteria.

BACKGROUND

In a paper prepared as part of a course requirement at the National Fire Academy (NFA), United States Fire Administration, Battalion Chief Jay Varone (Providence Fire Department) recommended that the U. S. Fire Administration develop an affordable radio for the fire service in his report "Fireground Radio Communications and Firefighter Safety" (Executive Planning,
National Fire Academy, March 1996). The specific recommendation stated that "Additional research is needed to develop a portable radio specifically for the fire service." This recommendation was based on research which showed existing fire service hand-held radios to have a number of limitations:

- "Most hand-held radios are not waterproof or cannot be easily retrofitted to be waterproof requiring that the radio be protected from water especially from extinguishing efforts. Concealment of radios underneath protective clothing makes radios less accessible."

- "Features such as the volume switch, channel selector, and emergency-distress alarm, even when accessible, are difficult to operate with a gloved hand."

The recommendation and observations reflect generally recognized insufficiencies of hand-held radios used on the fireground. A number of fire department officials have echoed the same concerns about portable radios. Chief Varone reviews several incidents where failure of on-scene communications, including portable radios, contributed to firefighter fatalities. Chief Varone also noted in his paper that a nationally recognized fire service professional advised him that radio manufacturers have concluded "that it is not financially worth the cost of researching, developing, and manufacturing a portable radio specifically for the fire service." Instead the majority of manufacturers are intent to market radios developed for general industry to the fire service. Hence, Chief Varone suggested that the U.S. Fire Administration undertake the development if hand-held radios to specifically meet fire service needs.

Although the development of a design for an affordable radio has been suggested, the development of minimum performance criteria is more likely to drive the design of a superior radio for the fire service. Minimum performance criteria establish goals for product performance which can be met by a variety of designs. Minimum performance criteria entail a specific requirement for which the product must demonstrate a certain level of performance to be considered acceptable. Product performance is evaluated by quantitative or pass/fail tests which simulate the conditions of used and desired product characteristics. Thus, the development of performance criteria is the necessary first step to creating change in the marketplace.

Although affordability is of great concern to fire departments, the marketplace usually largely determines what the cost of a radio will be. One factor which positively influences the cost of a product is the development of standards for that product. Standards afford manufacturers the opportunity to develop products that meet minimum performance criteria. The recognition of the such minimum performance criteria as national standards:

- Creates incentives for manufacturers to comply with minimum requirements meeting user needs for fireground hand-held radios;

- Allows end users to compare products on the basis of the same tests and requirements; and

- Documents product performance.
With the development of a national standard, manufacturers have an incentive to continually improve radios based upon a common benchmark and are able to differentiate their products based upon:

- performance beyond the minimum requirements,
- cost,
- design features, and
- service and other forms of customer support.

Such an approach is consistent with the industry improvements observed for both fire service open-circuit, self-contained breathing apparatus (SCBA) and Personal Alarm Safety Systems (PASS), two products used on the fireground which are expensive yet, generally priced competitively.

**Current Portable Radio Technology**

Portable radios are used in several industries for person to person communications in a non-stationary setting. Other than their portability, these radios have a number of characteristics which allow their use in different situations, including:

- size and weight,
- specified operating frequency ranges or channels,
- transmission power and antenna configurations,
- battery life,
- type of microphone and means of microphone keying,
- type of display (including transmit lights and liquid crystal displays),
- controls (such as knobs or keypads) for turning radio on, adjusting volume, selecting channel and accessing advanced radio features,
- emergency activation or "home call" button, and
- accessory connector for headsets, earpieces, remote microphones, and chargers.

As the name implies, hand-held radios are sized to fit into the wearing palm so that these devices can be operated with one hand for transmitting and receiving. For this reason, portable radios have a slender body or housing which measures 2-3 inches across with a 3 to 7 inch height, and 1.3 to 1.8 inch depth. The hand-held radio weight will vary primarily based on the type of battery provided between 14 and 22 ounces. Higher capacity batteries for longer service life result in heavier radios.

A multitude of frequencies are used for portable radios and fire service/public safety applications both in the VHF and UHF bands, set aside for these applications by the Federal Communications Commission (FCC). In addition, many portable radios are part of communications systems which use the 800 Megahertz band in trunking systems.

Transmission power provides some indication of the range for a portable radio, although the local environmental greatly influences communications range. Transmission power generally varies between 2 and 5 watts. Many radios permit setting the transmission power at two or more settings based on transmission needs. Due to concerns for continuous radio frequency (RF)
radiation exposure, some radios now incorporate power down features when the radio is attenuated by being close to the body.

The battery life depends on the amount of transmission time and the transmission power. Battery life is reported for a standard duty cycle. The standard duty cycle relates to the proportion of time that a radio is being operated in the transmission mode, receive mode, and standby (on, but not in use) mode. Typically, a 5-5-90 (transmit, receive, standby) duty cycle is used. Low transmission power radios with high capacity batteries are capable of achieving over 17 hours of battery life, usually through the use of special "battery saving" features. In general, battery life will range between 4 and 12 hours for a 5-5-90 duty cycle and a standard portable radio battery.

Most portable radios are supplied with a push-to-talk microphone switches on the side of the radio. Remote microphones are sometimes used by connection to the accessory adaptor. An especially popular microphone option is the self-contained breathing apparatus (SCBA) microphone in which a microphone and connection jack is built into the SCBA mask by the SCBA manufacturer. Alternative microphones such as bone (conduction) or throat microphones with voice activated transmission are also available, but are less common.

Display indicators can include lights showing that the microphone is being keyed or the battery is charging or is in need of charging. More advanced radios include a liquid crystal display which can show the channel or provide various types of alphanumeric messages associated with the operation of the portable radio.

The principle control for radio operation is the on/off switch, generally a knob which also controls volume. Other controls may be provided for channel selection since automatic squelch is incorporated into most existing portable radios. Keypads are also provided for radio programming. Unfortunately, due to overall desire to lower radio size and weight, most controls are relatively small and are extremely difficult to operate with gloved hands.

Some portable radios include an emergency or "home call" button which can be activated by the user to either automatically key to the base station or dispatcher in the event of an emergency. This is a non-standard feature which can often represent a significant cost of the radio. Furthermore, the overall communications system must be capable of handling emergency communications (through the use of an assigned frequency and responsibility monitoring) for such a feature to be effective.

Most radios include some type of connector or adaptor for charging the radio or adding accessories such as headsets, earpieces, or remote microphones. Unfortunately, the radio industry has not standardized on a common adaptor which can accommodate all accessories. This has been a source of frustration for the fire service where such options as SCBA microphones require working with both the SCBA and the radio manufacturer to provide appropriate connections and satisfactory operation of the two devices.

It is important to realize that the portable or hand-held radio is part of an overall communications system which consists of several elements including the base stations, repeater stations, mobile radios, and hand-held radios. All of these elements have characteristics which
affect the interaction and effectiveness of any one element. The U.S. Fire Administration Fire Department Communications Manual provides a comprehensive overview to communications system concepts and equipment.

**Current Standards Affecting Fire Service Communications**

Several National Fire Protection Association (NFPA) standards address fire service communications, though mostly in a limited way. NFPA 1500, Standard on Fire Department Occupational Safety Health Program (1997 edition) requires the fire department establish and ensure the maintenance of a fire dispatch and incident communication system which meets the requirements of Section 3-6 of NFPA 1561, Standard for Fire Department Incident Management System (1995 edition)." NFPA 1561 provides requirements for fire service communications in Chapters 3 through 6, primarily in the establishment of communications to support incident response activities, but does not address communications hardware.

NFPA 1201, Standard for Developing Fire Protection Services for the Public (1994 edition), provides general requirements for fire service communications. One reference is to NFPA 1221, Standard for Maintenance and Use of Public Fire Service Communication Systems (1994 edition) provides general requirements for the communications center and for dispatching systems, including portable equipment. The specific provisions of Section 3-7 on Radio Dispatching - Portable Equipment are repeated in Table 1. These requirements are relatively general and offer little guidance to departments for specifying hand-held radios.


**STUDY ORGANIZATION**

A multi-task approach was used in this project for developing performance criteria for fire service hand-held radios. Essentially this approach encompassed two major steps:

1. Identifying specific fire service needs for hand-held radios; and

2. Developing the specific radio performance criteria which could form the basis of a proposed National Fire Protection Association (NFPA) standard.

For each step, extensive research was conducted with the results of this research presented to the Technical Advisory Group (TAG) in a meeting. Based on feedback from the TAG, revisions were made in the direction of further research or proposals were modified to reflect the input of the TAG members. The specific details of these two steps are covered in the subsequent report sections.
Table 1. NFPA 1221 Requirements Addressing Hand-Held Radios

3-7.1 This section applies to fire-portable radio devices utilized as a part of a primary dispatch network. The criteria for similar devices used in miscellaneous services, including fireground operations, are found in 3-11.3.

3-7.1.1 Portable radios shall conform to FCC Rules and Regulations.

3-7.1.2 Fire-portable equipment shall be manufactured for the environment in which it will be used with size and construction making it capable of one-handed operation.

3-7.1.3 Fire-portable radio transceivers shall not be placed into transmit mode except by operator action on a mechanically guarded switch.

3-7.1.4 Fire-portable radio transmitters shall have a carrier-controlled timer to disable the transmitter in the event of a malfunction that causes the transmitter to remain inadvertently on the air.

3-7.1.5 Multiple-frequency fire-radio transceivers shall be capable of changing channels while operators are wearing gloves.

3-7.1.6 Single unit chargers for fire-portable radios shall be capable of charging fully while the radio is in the receiving mode.

3-7.1.7 Battery chargers for portable radios shall automatically revert to maintenance charge when the battery is fully charged.

3-7.1.8 Battery chargers shall be capable of charging batteries independently and externally of the portable radio unit.

3-7.1.9 Spare batteries shall be maintained in sufficient quantities to permit reliable operation of fire-portable radios.

NOTE: Rapid-charge batteries and chargers shall be permitted to be utilized to reduce the quantity of spare batteries needed.

3-7.1.10 Fire-portable transceivers shall be capable of multiple-frequency operation to enable a fireground radio network to be organized independently of normal dispatch channels.
Table 1. NFPA 1221 Requirements Addressing Hand-Held Radios

3-7.1.11 Fire-portable radios shall be capable of Continuous Tone Coded Squelch System (CTCSS) or Continuous Digital Coded Squelch System (CDCSS).

NOTE: If operating in standard squelch systems, continuous coded squelch circuitry can be partially or completely disabled.

3-7.1.12 When a data transmission function is utilized from fire-portable transceivers, the radio shall be capable of transmitting data without distortion, and the equipment shall be designed to ensure full data stream transmission at full power.

3-7.1.13 When utilizing fire-portable transceivers in a fire dispatch system, system design shall be such that a portable transceiver will be capable of operating properly within the dispatch area without the use of mobile RF amplifiers.

NOTE: These requirements shall not apply to equipment used for biomedical operations.

3-7.1.14 If scanning devices are used, they shall have an automatic priority feature whereby the radio will revert automatically to its primary channel whenever the channel is being used. Scanning devices shall have a manual lock position to lock the receiver on its primary channel. No other lock position shall be permitted.

3-7.1.15 Radio pocket pagers shall indicate audibly before the battery is incapable of operating the pager for alerting purposes.

IDENTIFICATION OF SPECIFIC FIRE SERVICE NEEDS

Preliminary research was directed to determining current features, inadequacies, and needed improvements for fire service hand-held radios. This research was conducted using three separate approaches:

1. The first approach entailed conducting a literature survey in the area of portable communications (hand-held radios). The literature survey focused on fire service journals but was expanded into other areas in which similar technology is used (such as the military). Literature surveys were performed by identifying several key words for radios and using the search services in university libraries and the Internet, as well as the U.S. Fire Administration Library. Sample key words included:

   ! Hand-held radio
   ! Portable transceivers
   ! Fireground communications
This literature survey produced a relative few articles and references which dealt with specific radio technology related to the fire service. The majority of literature titles identified dealt with communications procedures as part of the incident command system and not with communications hardware. Two notable exceptions included:


2. The second approach entailed contacting manufacturers of hand-held radios marketing their products to the fire service. A number of manufacturers were identified by looking through the Buyer’s Guides for both the *NFPA Journal* and *Fire Engineering* (see Table 2). Product literature was obtained from these manufacturers and requests were made for specifications for any radios specific to fire service use. Selected manufacturers were later contacted to learn about specific features, testing methods, and performance specifications.

This information was able to establish the current state-of-the-market particularly in terms of radio features and offered performance. A number of testing standards and requirements were also identified in this fashion.

3. The third approach involved collection of information from different fire departments to find out the specific features that fire departments had requested, problems with current radios, and needed improvements.

Most departments contacted were unable to provide detailed specifications for purchased radios using performance requirements. Many of the departments providing information indicated that their specifications were often based on product literature provided by the manufacturer or were selected as part of an overall communications system development for the department. In many cases for large and small cities, this included the consolidation of all city emergency communications (fire service, ambulance service, and police) within a single system.

Each of the departments conducted had experience problems with radio communications which were linked to hand-held radios. The most common complaint was being able to operate radios while wearing fire fighter gloves, insufficient battery life, inability to communication within large structures, and failure due to extensive environmental contact (principally water).
Table 2. Manufacturers of Hand-Held Radios
Advertizing Products for the Fire Service*

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Address</th>
<th>Phone/Fax Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ace Communications</td>
<td>Monitor Division 8030 E. 47th Street Indianapolis, IN 46226</td>
<td>317-543-9769 800-445-7717 Fax: 317-543-9772</td>
</tr>
<tr>
<td>Advanced Video Tech Corporation</td>
<td>1840 County Line Road, Suite 202 Huntington Valley, PA 19006</td>
<td>215-322-4600 800-233-0013 215-322-2812</td>
</tr>
<tr>
<td>Airotron/Repco, Inc.</td>
<td>2400 Sand Lake Road Orlando, FL 32809</td>
<td>407-843-8484 800-950-5633</td>
</tr>
<tr>
<td>BEAR-Com Inc.</td>
<td>11545 Pagemill Road Dallas, TX 75243</td>
<td>214-340-8876 800-527-1670 Fax: 214-349-8950</td>
</tr>
<tr>
<td>CommuniStarr</td>
<td>215 S. Pavilion Avenue Riverside, NJ 08075</td>
<td>609-764-1000 800-952-7129 Fax: 609-764-6519</td>
</tr>
<tr>
<td>E.F. Johnson Company</td>
<td>438 Gateway Blvd. Burnsville, MN 55337</td>
<td>612-882-5500 800-328-3911, x6380 Fax: 612-882-5656</td>
</tr>
<tr>
<td>Ericsson Inc.</td>
<td>Private Radio Systems Mt. View Road Lynchburg, VA 24502</td>
<td>804-528-7000 800-431-2345 Fax: 804-528-7489</td>
</tr>
<tr>
<td>Falcon Direct</td>
<td>#36-20th Avenue NW Birmingham, AL 35215</td>
<td>205-854-2611 800-489-2611 Fax: 205-853-6178</td>
</tr>
<tr>
<td>ICM</td>
<td>10 N. Lee P. O. Box 26330 Oklahoma City, OK 73126</td>
<td>405-236-3741 800-725-1426 Fax: 405-235-1904</td>
</tr>
<tr>
<td>Kenwood U.S.A.</td>
<td>Land Mobile Radio 2201 E. Dominguez St. P. O. Box 22745 Long Beach, CA 90810</td>
<td>213-639-4200 FAX: 213-761-8246</td>
</tr>
<tr>
<td>Maxon America, Inc.</td>
<td>10828 NW Airworld Dr. Kansas City, MO 64153</td>
<td>816-891-6320, x603 Fax: 816-891-8815</td>
</tr>
</tbody>
</table>

* List compiled from manufacturers listed in 1997 Buyers' Guides for NFPA Journal and Fire Engineering. Appearance in list does not constitute U.S. Fire Administration endorsement of any product.
<table>
<thead>
<tr>
<th>Manufacturer</th>
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<th>Phone/Fax Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montana Public Safety Equipment</td>
<td>2526 Yellowstone Ave. Billings, MT 59102</td>
<td>406-655-1232, 800-245-1232</td>
</tr>
<tr>
<td>Motorola Inc.</td>
<td>Motorola C&amp;E Inc. 1301 East Algonquin Road Schaumburg, IL 60196</td>
<td>800-247-2346</td>
</tr>
<tr>
<td>National Radio</td>
<td>321 Century Plaza Drive #100 Houston, TX 77073-6025</td>
<td>713-443-1999, 800-548-2222, Fax: 713-443-1888</td>
</tr>
<tr>
<td>Relm Communications Inc.</td>
<td>Relm Land Mobile 7707 Record Street Indianapolis, IN 46226</td>
<td>317-545-4281, 800-821-2900, Fax 317-545-2170</td>
</tr>
<tr>
<td>Shinwa Comms of America Inc.</td>
<td>3501 Melcat Dr., Suite E P. O. Box 26407 Oklahoma City, OK 73126</td>
<td>405-686-0006, 800-627-4722, Fax: 405-686-0500</td>
</tr>
<tr>
<td>Standard Communications Corp.</td>
<td>Land Mobile Products P. O. Box 92151 Los Angeles, CA 90009-2151</td>
<td>310-532-5300, 800-867-4140, Fax: 800-767-9196</td>
</tr>
<tr>
<td>Uniden Corp. of America</td>
<td>Commercial Communications 4700 Amon Carter Blvd. Fort Worth, TX 76155</td>
<td>817-858-3300, Fax: 817-858-3523</td>
</tr>
<tr>
<td>Vertex Radio Communications</td>
<td>17210 Edwards Road Cerritos, CA 90703</td>
<td>310-404-2700, Fax: 310-404-1210</td>
</tr>
<tr>
<td>Yaesu USA</td>
<td>Vertex Radio Communication 17210 Edwards Road Cerritos, CA 90703-2426</td>
<td>310-404-2700, Fax: 310-404-1210</td>
</tr>
</tbody>
</table>

* List compiled from manufacturers listed in 1997 Buyers' Guides for NFPA Journal and Fire Engineering. Appearance in list does not constitute U.S. Fire Administration endorsement of any product.
Information from each of these approaches was consolidated and reported to the Technical Advisory Group. This information was also reviewed to assist in the development of draft performance guidance for fire service hand-held radios. This guidance took the form of generic performance requirements which qualitatively addressed radio performance. These findings are summarized in Table 3. Table 3 identified generic performance requirements in terms of:

- a critical issue (performance area),
- a description of the performance attribute,
- suggested criteria for measuring the attribute, and
- a suggested test approach for attribute.

The first meeting of the Technical Assistance Group was held on December 18, 1997 at the Headquarters of the International Association of Fire Fighters (IAFF) in Washington, DC. The purpose of this first meeting was to review the draft performance guidance described above.

At this meeting, Issues on hardware versus radio communications procedures were discussed. The group indicated that a number of problems existed for fire ground communications that not only included the portable radio, but the overall system design and proper communications procedures. One suggestion was made for a developing simple, user-friendly primer which addresses proper use of radios. Specific radio problems identified in the meeting included:

- the ineffective use of remote microphones,
- lack of proper training requirements for use,
- an inability to determine which channel the radio is set on,
- control knobs that are too small to operate while wearing gloves,
- microphone push-to-talk switches that are difficult to use,
- some radios which are too heavy,
- the absence of an intercom feature among fireground crew for inter-crew communications,
- the need for integrated PASS and radio systems, and
- problems for communication inside buildings.

Several other issues were discussed at the first TAG meeting. For example, how some cities are getting around communications problems by building repeater systems inside large structures within their jurisdiction. The group recognized that a typical specification for radio performance is 95/95 coverage; this means communications system covers 95 percent of area, 95 percent of the time. This requires optimization of the communications system for a department requires surveying area for possible problems which is usually the task of radio system manufacturer for large departments but may not be available for smaller departments. Some departments get around this problem by using repeaters in vehicles.

A portion of the meeting was devoted to identifying radio design and performance needs. These needs as identified during meeting are categorized below:
<table>
<thead>
<tr>
<th>Critical Issues</th>
<th>Performance Attribute Description</th>
<th>Suggested Criteria for Measuring the Performance Attribute</th>
<th>Suggested Test Method Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mission Performance</td>
<td>Communications Range</td>
<td>Shall operate satisfactorily up to 600 meters (1950 ft) under relatively unimpeded conditions and shall also be capable of reliable performance within a 10 story steel/concrete building structure.</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Three-mode operation</td>
<td>Unit shall operate successfully in each mode with sidetone verification of user voice transmissions in PTT and VOX modes</td>
<td>Recorded observation on survey questionnaire by operating personnel</td>
</tr>
<tr>
<td></td>
<td>Receiver sensitivity</td>
<td>&lt; 1 microvolt at antenna terminal (~ 20 dB quieting)</td>
<td>Laboratory evaluation</td>
</tr>
<tr>
<td></td>
<td>Communications channels</td>
<td>6 frequencies at the 450-470 MHz UHF band</td>
<td>Observation</td>
</tr>
<tr>
<td></td>
<td>Transmission/reception clarity at frequencies within band</td>
<td>Received communications shall be loud and clear under relatively unimpeded conditions, and signal margin/antenna coverage shall be sufficient to provide 95% probability of intelligible reception of any 5 second voice message transmission</td>
<td>Recorded observations by fireground communications aide on communications log</td>
</tr>
<tr>
<td></td>
<td>Communications coverage</td>
<td>Coverage shall be omni-directional for the entire frequency band of operation.</td>
<td>Laboratory evaluation</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>Performance Attribute Description</td>
<td>Suggested Criteria for Measuring the Performance Attribute</td>
<td>Suggested Test Method Approach</td>
</tr>
<tr>
<td>-----------------</td>
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<tr>
<td>2. Human factors, safety, health</td>
<td>Radiation hazard to wearer</td>
<td>Radiated field intensity from the antenna shall meet personnel hazard requirements of USAS C95.1</td>
<td>Instrumented manikin</td>
</tr>
<tr>
<td></td>
<td>Interference with physical motions</td>
<td>Shall not restrict outfitted firefighter's physical motions</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Physical interference with protective equipment</td>
<td>Shall not restrict closure of or bind articles of protective equipment</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Physical interference with breathing apparatus</td>
<td>Shall not impact the mask-to-face seal of breathing apparatus</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Acceptance</td>
<td>Fireground radio shall be acceptable and promote usage</td>
<td>Field evaluation and fireground personnel testimonials</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td>Shall occupy minimum volume under turnout coat or fully encapsulated suit</td>
<td>Tape measurement</td>
</tr>
<tr>
<td></td>
<td>Weight</td>
<td>Weigh less than 0.75 Kg (1.5 lbs.)</td>
<td>Weigh with balance</td>
</tr>
<tr>
<td></td>
<td>Controls placement</td>
<td>Controls shall be placed so that they are operable by hand in common clothing pocket locations</td>
<td>Field evaluation</td>
</tr>
<tr>
<td></td>
<td>Control operability</td>
<td>Volume and push-to-talk operable with protective gloves; no external connections shall be required to operate equipment</td>
<td>Field evaluation</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>Performance Attribute Description</td>
<td>Suggested Criteria for Measuring the Performance Attribute</td>
<td>Suggested Test Method Approach</td>
</tr>
<tr>
<td>---------------------------------</td>
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<td>------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>2. Human factors, safety, health</td>
<td>Mobility</td>
<td>Fully outfitted subject shall be able to climb, reach, twist, crawl using both hands</td>
<td>Field evaluation</td>
</tr>
<tr>
<td>(cont’d)</td>
<td>Fit</td>
<td>Complete system and especially microphone and/or voice pickup technology must fit all sizes</td>
<td>Visual examination and tape measurement</td>
</tr>
<tr>
<td></td>
<td>Body injury</td>
<td>External controls and protrusions shall be designed to preclude personnel injury</td>
<td>Field evaluation</td>
</tr>
<tr>
<td>3. Survivability</td>
<td>Exposure</td>
<td>Protection provided by outer garments</td>
<td>Field evaluation</td>
</tr>
<tr>
<td></td>
<td>Durability</td>
<td>Years of service life to be determined</td>
<td>Field evaluation</td>
</tr>
<tr>
<td></td>
<td>Water resistance</td>
<td>Survives immersion for 5 minutes in 82°C and 1°C water</td>
<td>MIL-STD-810E</td>
</tr>
<tr>
<td></td>
<td>Heat and smoke resistance</td>
<td>Equal to PASS levels</td>
<td>Unit mounted on instrumented manikin and exposed to heat and flame (NFPA 1982)</td>
</tr>
<tr>
<td></td>
<td>Shock and vibration</td>
<td>Survive 12 foot drop to concrete surface</td>
<td>MIL-STD-810E</td>
</tr>
<tr>
<td></td>
<td>Physical abuse resistance</td>
<td>Unit accepts normal fire ground impacts and handling</td>
<td>Field evaluation</td>
</tr>
</tbody>
</table>
### Table 3. Generic Design/Performance Criteria for Fire Service Hand-Held Radios (continued)

<table>
<thead>
<tr>
<th>Critical Issues</th>
<th>Performance Attribute Description</th>
<th>Suggested Criteria for Measuring the Performance Attribute</th>
<th>Suggested Test Method Approach</th>
</tr>
</thead>
</table>
| 4. Reliability, availability, maintainability | Mean time between failures  
- Battery pack  
- Actuation elements voice-actuation  
Push-to-talk  
Receive-only  
- Antenna  
- Wires  
- Connectors | Meet all performance requirements throughout service life | Field evaluation equipment maintenance log |
<p>|                | Continuous operation from battery power supply | At least 2 hours from full change assuming a 10% transmit 10% receive, 80% standby duty cycle | Laboratory and field evaluation |
|                | Ancillary hardware replacement repair | Basic replacement repairs (e.g., battery, antenna, microphone) can be performed at ground base | Field evaluation |
|                | Retention | Complete system and especially the microphone and/or voice pick up technology must remain in place throughout period of activity on fireground | Field evaluation and observation of non-retention by outfitted test subjects |</p>
<table>
<thead>
<tr>
<th>Critical Issues</th>
<th>Performance Attribute Description</th>
<th>Suggested Criteria for Measuring the Performance Attribute</th>
<th>Suggested Test Method Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Reliability, availability, maintainability (cont’d)</td>
<td>Line-of-communications</td>
<td>Loss of the line-of-communication with personnel on the fireground shall not be due to a failure of the fireground radio equipment with particular emphasis on the voice-pickup technology subsystem, the battery subsystems, the radio controls subsystems, and the antenna subsystem</td>
<td>Fireground command post communications log and post-incident observations recorded on survey questionnaire by fireground entry personnel</td>
</tr>
<tr>
<td></td>
<td>Ease of maintenance</td>
<td>Positive seal on switches and controls</td>
<td>Standard testing methods for sealed switches</td>
</tr>
<tr>
<td>5. Training</td>
<td>-Operator’s manual</td>
<td>A radio operator's manual shall be prepared to accompany the fireground radio set</td>
<td>Observation</td>
</tr>
<tr>
<td></td>
<td>-Training time</td>
<td>Training in the operation of the fireground radio shall be compatible with existing portable radio operation and require a minimum of training</td>
<td>Field evaluation</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>Performance Attribute Description</td>
<td>Suggested Criteria for Measuring the Performance Attribute</td>
<td>Suggested Test Method Approach</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>6. Interoperability</td>
<td>Noninterference with SCBA</td>
<td>Must not interfere or contribute to the breaking of the mask-to-face seal of SCBA</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Noninterference with protective firefighting ensemble</td>
<td>Must not compromise the mobility or function provided by protective firefighting ensemble</td>
<td>Laboratory and field evaluation</td>
</tr>
<tr>
<td></td>
<td>Compatibility</td>
<td>Must be compatible with existing and near term planned systems and subsystems</td>
<td>Observation during field evaluation</td>
</tr>
</tbody>
</table>
General Radio Characteristics and Performance

1. The group was unable to decide whether a weight requirement should be imposed; most thought the market should make this decision.

2. The radio frequency/power/environment should be based on a range which is effective for 95% of location within the operating area for 95% of the time used as related to overall communications system.

3. Radios must work with system within established industry criteria such as the requirements set forth by the Association of Public Safety Communications Officials International, Inc. (APCO) Project 25 addressing public safety organization communication needs.

Testing Criteria

1. Radios must survive the following exposure conditions:
   a. temperature (low/high) with and without battery
   b. shock/vibration/impact
   c. water (driven rain not submersion)
   d. heat/flame resistance (from a safety, but not operational perspective)
   e. corrosion/smoke

2. Radios must possess intrinsic safety for use in potentially hazardous environments.

3. Radios must demonstrate an acceptable level of reliability.

Human Factors

1. The dispatch channel should be located at both ends of the channel selection control to ensure that the user can rapidly acquire this channel.

2. 'Dead' channels should be easily identified on the radio during use.

3. Radio controls should be easy to operate, recognized and be designed to avoid accidental activation.

4. The radio needs to provide an indication that the radio is transmitting through a LED, other means, but two separate means should be provided.

Minimum Controls

1. All hand-held radios should require auto squelch

2. The radio should provide a separate channel selector

3. The radio transmit switch should be easily operated
4. The radio should provide an emergency button which produces a recognizable, distinct transmission either from the radio the dispatcher or over the network to persons responsible for monitoring communications.

5. The radio volume control should be designed so that it cannot be accidental turned off.

6. The radio should include an option for identifying the transmitting station.

Minimum Displays

1. The radio should provide a distinct audible signal and visible or other means to indicate to the user that the battery is at 20% of its charged capacity. One option discussed was the use of a LCD message as an option.

2. If provided on the radio, the LCD should be readable under low light conditions and from an angle of 45 degrees.

3. An indicator should be provide to show that the radio is transmitting.

4. For trunk-based system radios, an audible indication should be provided for 'accept' or 'busy' signals.

5. The radio should provide an indication of the transmission/reception signal strength.

Battery Life

1. The radio should provide a minimum of 8 hours of operation on a 5-5-90 duty cycle.

2. The battery should positively lock into the radio when attached.

3. A period of 2 hours should be required for charging the battery. Manufacturers should provide information to ensure that the battery charging system avoid memory effects by first completely discharging the battery before it is recharged.

4. A milliamp indicator should be provided on the battery charger.

Speaker

1. The audio (volume) control should be limited to a safe level of sound pressure (80 dBA)

2. The radio speaker should provide good sound quality.

Microphone
1. The radio should use a noise cancelling microphone.

2. Remote microphones should be provided as an option with a coiled cord and LED indicator to show that the remote microphone is operating. The remote microphone should have a positive locking feature for its attachment.

3. A standard interface connector should be made available for use with SCBA microphones.

4. Both push-to-talk (PPT) and voice-activated options (VOX) should be provided.

The practicality of addressing these needs through development of specific criteria was investigated in the second step of the project.

**DEVELOPMENT OF SPECIFIC RADIO PERFORMANCE CRITERIA**

Following the first TAG meeting, additional research was conducted to create detailed performance criteria from the recommended generic performance guidance. This research involved three separate approaches to complete this task:

1. A separate literature and industry review was conducted for identifying further literature, manufacturer specifications, and other sources for possible test methods or other means for evaluating different radio performance characteristics. These test methods were then reviewed to determine their application for measuring radio performance in a manner relevant to fire service needs.

These efforts primarily yielded several design and performance specifications prepared by the Telecommunications Industry Association (TIA) and the Electronic Industries Association (EIA). During the initial industry survey, manufacturers had indicated compliance with some of the EIA standards or parts of these standards, including EIA RS-152C and RS-316C. In contacting the Electronic Industries Association, it was discovered that a relatively new standard, Electronic Industries Association TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, had combined and updated earlier recommended standards for communications equipment. This standard has been adopted by the American National Standards Institute (ANSI) and is applicable to land-mobile equipment licensed under FCC Part 90 in the public safety, special emergency, and industrial radio services. TIA/EIA-603 specifically addresses methods of measurement and performance standards for mobile radios, base stations, portable radios, and subaudible signaling devices (pagers).

In addition to telecommunication standards, a review of both NFPA 1981, Standard on Open-Circuit, Self-Contained Breathing Apparatus, and NFPA 1982, Standard on Personal Alert Safety Systems (PASS), provided information on environmental testing and other performance properties which could be applied to radios. This included a review of Military Standard, MIL-STD-810E, Environmental Test Methods and Engineering Guidelines, which is frequently cited
by the radio manufacturing community.

2. When specific performance criteria could not be addressed through existing standards or test methods, alternative techniques were considered. This involved the conceptual development of new test methods or applying design criteria.

The results of this research were combined into a table of performance criteria shown in Table 4 and also prepared as a draft standard. The latter draft included the scope, purposes, definitions, certification, and labeling requirements common with other NFPA protective equipment standards. The draft was prepared using NFPA format and was patterned after NFPA 1982, Standard on Personal Alert Safety Systems (PASS), 1998 Edition.

The second meeting of the Technical Assistance Group (TAG) was held March 14-15, 1998 in Austin, Texas. During this meeting, the draft standard and method for implementing the standard were discussed. The TAG was in agreement with the majority of the standard as prepared. In addition to several suggestions for changing the standard, two principal concerns with the standard raised during the meeting included the following comments:

1. The need exists to address the entire communications system in a like manner as done for hand-held radios. The conformance of hand-held radios to the proposed standard, while improving the portable radio hardware and performance cannot in itself provide a guarantee of reliable communications. The fire service must design the entire system to work with all elements effectively within the given parameters and constraints of the local jurisdiction.

2. The requirements for independent, third-party certification were perceived as adding cost to the radios without commensurate return for the fire service. It was explained that this was a standard practice for protective equipment and that the provisions were intended to ensure conformance with the standard and effective quality control on the part of the manufacturer. Therefore, these requirements were left in the proposed standard.

Identified changes were incorporated into the draft standard and this revised, proposed standard is included with this report as Appendix A. The draft standard as prepared can serve as a suitable basis for submission to the NFPA for soliciting Public Proposals. The U.S. Fire Administration is encouraged to submit this report and the draft to the NFPA for their consideration as a new project. The cover letter submitting the report and draft standard should:

! state the need for a standard for fire service hand-held radios,

! provide a short description of this project and how the draft standard was prepared;
Table 4. Outline of Hand-Held Radio Requirements

**Design Requirements**

1. Maximum weight
2. Noise-cancelling microphone
3. Minimum controls
   a. on/off and volume
   b. channel selector
   c. transmit
   d. emergency transmit
4. Minimum display
   a. battery life
   b. receive/transmit signal
   c. signal strength
5. Battery and charger
6. Accessories

**Performance Requirements**

The majority of the receiver and transmitter requirements are based on ANSI/TIA/EIA-603-1992, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards. This standard applies to land-mobile equipment licensed under FCC Part 90 in the public safety, special emergency, and industrial radio services.

1. Receiver performance
   a. radiated spurious emissions - electromagnetic energy generated or amplified in receiver and radiated from the receiver or by the antenna, or by all control, audio, and power leads
   b. conducted spurious emissions - energy that is generated or amplified in a receiver and appears at the receiver's antenna terminals
   c. power line conducted spurious emissions - energy that is generated or amplified in a receiver and appears between each power line terminal that connects to a public utility line and ground
   d. reference sensitivity - level of receiver input signal at a specified frequency with specified modulation which will result in the standard signal to noise ratio at the output of the receiver
Table 4. Outline of Hand-Held Radio Requirements (continued)

1. Receiver performance (continued)
   e. signal displacement bandwidth - the input signal frequency displacement that reduces the signal to noise ratio by a signal 6 dB in excess of the reference sensitivity, to the standard signal to noise ratio
   f. adjacent channel rejection - the ratio of the level of an unwanted input signal that causes the signal to noise ratio produced by the wanted signal 3 dB in excess of the reference sensitivity to be reduced to the standard signal to noise ratio, to the reference sensitivity
   g. offset channel selectivity - the ratio of the level of an unwanted input signal that causes the signal to noise ratio produced by a signal 3 dB in excess of the reference sensitivity to be degraded to the standard signal to noise ratio, to the reference sensitivity
   h. spurious response rejection - the ability of a receiver to prevent single unwanted signals from causing a degradation to the reception of a desired signal
   i. intermodulation rejection - the ability of a receiver to prevent two unwanted input signals, with a specific frequency relation to the wanted signal frequency, from causing degradation to the reception of the desired signal
   j. audio frequency response - the degree of closeness to which the audio output of a receiver follows a 6 dB per octave de-emphasis curve with constant frequency deviation over a continuous frequency range
   k. hum and noise ratio - the ratio of the rated output power to the residual output power in the absence of modulation, both measured at the standard input signal level
   l. audio distortion - the voltage ratio, usually expressed as a percentage of the rms value of the undesired signal to the rms value of the complete signal at the output of the receiver
   m. audio squelch sensitivity - the minimum signal level from a standard input signal source, which when modulated at standard test modulation, will open the receiver squelch
   n. squelch blocking - the tendency of the receiver squelch to close in the presence of modulation of the input signal
   o. receiver attack time - the time required to produce audio power output after application of a modulated input signal
   p. receiver closing time - the period of time between removal of an input signal and squelch closure
   q. audio sensitivity - the minimum level of modulation, which at maximum volume control setting, will produce rated audio
   r. impulse blanking effectiveness - the ability of the noise blanker to prevent and suppress the effects of short duration steep rise time pulses in the presence of desired signals
**Table 4. Outline of Hand-Held Radio Requirements (continued)**

1. **Receiver performance (continued)**
   - **s.** average radiation sensitivity - the power received by a half wave dipole measure into a 50 \( \Omega \) load when substituted for a receiver that is receiving a signal at the reference sensitivity
   - **t.** acoustic audio output - the level registered on a sound level meter at a distance of 50 cm from the front of the receiver acoustic transducer

2. **Transmitter performance**
   - **a.** carrier output power rating - the power available at the output terminals of the transmitter when the output terminals are connected to the standard transmitter load
   - **b.** carrier frequency stability - the ability of the transmitter to maintain an assigned carrier frequency
   - **c.** modulation limiting - the transmitter circuit’s ability to limit the transmitter from producing deviations due to modulation in excess of a rated system deviation
   - **d.** carrier attack time - the time required to produce 50% of the steady-state carrier output power after changing the state of the transmitter from standby to transmit
   - **e.** audio sensitivity - the input rms voltage level that must be applied to the input terminals of the dummy microphone circuit to produce the standard test modulation
   - **f.** audio frequency response - the degree of closeness to which the frequency deviation of the transmitter follows a prescribed characteristic
   - **g.** audio distortion - the voltage ratio, usually expressed as a percentage of the rms value of the undesired signal of the transmitter’s demodulated output to the rms value of the complete signal at the output of the transmitter’s demodulator
   - **h.** FM hum and noise ratio - the ratio of the standard test modulation to the residual frequency modulation measured by the test receiver
   - **i.** AM hum and noise ratio - the ratio of the dc voltage detected from an unmodulated carrier to the detected peak ac voltage
   - **j.** acoustic microphone sensitivity - the acoustic sound pressure level which will produce 60% modulation of the transmitter
   - **k.** sideband spectrum - the sideband energy produced at a discrete frequency separation from the carrier up to the test bandwidth due to all sources of unwanted noise within the transmitter in a modulated condition
   - **l.** radiated spurious emissions - emissions from the equipment when transmitting into a non-radiating load on a frequency or frequencies which are outside an occupied band sufficient to ensure transmission of information of required quality for the class of communications desired
Table 4. Outline of Hand-Held Radio Requirements (continued)

2. Transmitter performance (continued)
   m. conducted spurious emissions - emissions at the antenna terminals on a frequency or frequencies which are outside an occupied band sufficient to ensure transmission of information of required quality for the class of communications desired
   n. adjacent channel power ratio - that part of the total output power of a transmitter under defined conditions and modulation, which falls within a specified passband centered on the nominal frequency of either of the adjacent channels
   o. audio low pass filter response - the frequency response of the post limiter pass filter circuit above 3000 Hz
   p. average radiated power output - the equivalent power required, when delivered to a half-wave dipole antenna, to produce at a distant point the same average received power as produced by a licensed device
   q. transmitter stability into VSWR - the ability of a transmitter not to produce any spurious greater than allowed for the conducted spurious emissions when operated in a load different from the standard load
   r. transient frequency behavior - a measure of the difference, as a function in time, of the actual transmitter frequency to the assigned transmitter frequency when the transmitted RF output power is switched on and off

3. Overall radio functional performance
   a. power supply voltage range - the range of power supply voltages over which the equipment will operate with no more than a specified amount of degradation in overall performance
   b. temperature range - the range of ambient temperature over which the transceiver will operate with no more than a specified amount of degradation in overall performance
   c. high humidity - the relative humidity at which the transceiver will operate with no more than a specified amount of degradation in overall performance
   d. salt spray exposure stability - the amount of salt spray during and after which the equipment will operate with no more than a specified amount of degradation in overall performance
   e. particulate exposure stability - the amount of particulate after which the equipment will operate with no more than a specified amount of degradation in overall performance
   f. vibration stability - the amount of mechanical vibration during and after which the equipment will operate with no more than a specified amount of degradation in overall performance
Table 4. Outline of Hand-Held Radio Requirements (continued)

3. Overall radio functional performance (continued)
   g. shock stability - the amount of mechanical shock after which the equipment does not sustain physical damage, and no more than a specified amount of degradation in overall performance
   h. battery life - the number of hours that the equipment will operate under the standard duty cycle on a single complement of batteries before the battery end point is reached

4. Other radio performance
   a. heat resistance - the resistance to melting and dripping of the equipment when exposed to a 5 minute oven exposure
   b. heat and flame resistance - the resistance to melting and afterflame of the equipment when placed in a pocket of turnout clothing and subjected to sustained heat and flame representing a flashover condition
   c. control operability - the ability of an end user wearing gloves to operate controls
   d. product label durability - the ability of the product label to remain legible following various conditions

I recommend that the project be undertaken by the NFPA Technical Correlating Committee for Fire and Emergency Services Protective Clothing and Equipment because of the similarity of requirements with SCBA and PASS and for the reason that radios can easily be considered items of personal protective equipment when used on the fireground; and

I encourage NFPA to set up the new project.

The following is a recommended project description which could be incorporated in the cover letter to NFPA:

“The U.S. Fire Administration sponsored a work effort to develop draft performance criteria for hand-held radios used during firefighting. The intent of this project was to provide the basis of a recognized standard which can encourage improvements in hand-held radio technology, especially in the areas of survivability under fireground conditions and ease of operation.

This project included the involvement of a Technical Advisory Group (TAG), consisting of experts with different backgrounds in the fire service to provide broad perspectives and experience for determining fire service needs and the adequacy of proposed requirements.
The enclosed project report and proposed draft standard represent a comprehensive review of fire service needs and radio communications technology. The proposed draft standard has been prepared in a format consistent with similar NFPA standards such as NFPA 1981 for SCBA and NFPA 1982 for PASS devices.

This submission should be sent to:

Secretary, Standards Council
National Fire Protection Association
1 Batterymarch Park
P. O. Box 9101
Quincy, MA 02269-9101

RECOMMENDATIONS FOR FURTHER RESEARCH

Through this project several related needs for additional research or activities were identified by the Technical Assistance Group, including the following comments:

1. Portable radios need to be considered as a separate item of personal protective equipment when used on the fireground. This philosophy justifies work on the standard within the NFPA Technical Correlating Committee for Fire and Emergency Services Protective Clothing and Equipment. It also defines the hand-held radio as an essential part of safety practices which can be addressed in fire department safety and health programs.

2. Each firefighter on the fireground should be provided a radio. Several industries exist where personnel are each provided radios, yet the fire service is perceived as lagging behind in providing this level of equipment to its members. The recommendation was made to submit a Public Proposal to NFPA 1500 which requires that each firefighter on the fireground be provided a hand-held radio. This recommendation in addition to heightening the safety of firefighters was considered to be a possible factor for increasing radio manufacturer interest in fire service needs.

3. The proposed standard should receive an extensive review by the radio manufacturing community. Though this review could be considered biased, the input from portable radio manufacturers could be valuable in identifying the practicality of requirements and the possible consideration of alternative criteria. The industry could also comment on new technology which could become available to the fire service.

4. Other NFPA standards need to be updated with information which assists the fire service in specifying communications equipment and designing an appropriate communications system for meeting fire service needs. Specifically, the following actions are recommended:

NFPA 297, Guide on Principles and Practices for Communications
Systems, should be supplemented with guidance for system design and evaluation. The current (1995) edition provides only a basic understanding of communications principles but does not offer technical advice to fire departments.

NFPA 1221, Standard for the Installation, Maintenance, and Use of Public Fire Service Communications Systems, should include more extensive requirements for the specification of communications system components. The current requirements are relative weak and do not provide any basis for product specifications. If the proposed project is undertaken by NFPA, this standard could reference the new standard on hand-held radios, but additional criteria should be developed for other system components, e.g., base stations. In addition, NFPA 1221 should specify criteria for minimum design of fire department communications systems in more detail than currently provided.
APPENDIX A

PROPOSED DRAFT STANDARD ON
FIRE SERVICE HAND-HELD RADIOS
NFPA 19XX

Standard on

Fire Service Hand-Held Radios

XXXX Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 7.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard shall specify the minimum design, performance, certification requirements, and test methods for all hand-held radios to be used by fire fighters and other emergency services personnel who engage in rescue, fire fighting, emergency medical operations, and other hazardous duties.

1-1.2 This standard shall apply to the design, manufacturing, and certification of new hand-held radios.

1-1.3 The requirements of this standard shall not apply to other types of communications equipment unless specifically addressed herein.

1-1.4 Nothing herein shall restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

1-2 Purpose.

1-2.1 The purpose of this standard shall be to provide minimum requirements for the design, construction, evaluation, and certification of all hand-held radios that are intended to be utilized by fire fighters and other emergency services personnel.

1-2.2* Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed as establishing performance levels for all situations to which personnel may be exposed.

1-2.3 This standard is not intended to be utilized as a detailed manufacturing or purchase specification, but can be referenced in purchase specifications as minimum requirements.

1-3 Definitions.
Accessories. Those items that are attached to a hand-held radio element but designed in such a manner to be removable from the hand-held radio and that are not necessary to meet the requirements of this standard. Such accessories include, but are not limited to, remote microphones, headsets, earpieces, and battery chargers.

Amplitude Modulation (AM). Modulation in which the amplitude of the carrier-frequency current is varied above and below its normal value in accordance with the audio, picture, or other intelligence signal to be transmitted. The magnitude of the radio wave is varied in accordance with the information to be transmitted or exchanged.

Antenna. A system of wires or electrical conductors employed for reception or transmission of radio waves. Specifically, a radiator that couples the transmission line or lead-in to space, for transmission or reception of electromagnetic radio waves. (Also known as aerial.)

Approved.* Acceptable to the "authority having jurisdiction."

Attenuation. The decrease in amplitude of a signal during its transmission from one point to another. It can be expressed as a ratio or, by extension of the term, in decibels.

Audio. The voice component of the transmitted signal. The normal ear responses to audio frequencies.

Authority Having Jurisdiction.* The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

Carrier. Radio wave radiated without modulation by a transmitter. Also, an electromagnetic wave at a specific frequency.

Carrier Frequency. The frequency of an unmodulated electromagnetic wave.

Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of the standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine compliance with the requirements of this standard.

Certification Organization. An independent, third party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program.

Channel. Sometimes used synonymously with "frequency." It is the electronic signal path through which radio frequency flows.

Channel, Radio. An assigned frequency of sufficient width to permit its use for radio communication. The necessary width of a channel depends on the type of transmission and the
tolerance for the frequency of emission.

**Compliance/Compliant.** Meeting or exceeding all applicable requirements of this standard.

**Component.** Any material, part, or subassembly used in the construction of the hand-held radio that provides the required performance.

**Drip.** To run or fall in drops or blobs.

**Duplex Operation.** A method of operation in which communication between stations takes place in two directions simultaneously. A separate channel is necessary for each direction of transmission.

**Follow-Up Program.** The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

**Frequency.** The number of cycles per second; the reciprocal of period. Usually refers to the assigned channel. Literally means the time taken by a signal to complete one cycle.

**Frequency Modulation (FM).** A method of modulating a carrier-frequency signal by causing the frequency to vary above and below the unmodulated value in accordance with the intelligence signal to be transmitted. The amount of deviation in frequency above and below the resting frequency is at each instant proportional to the amplitude of the intelligence signal being transmitted. The number of complete deviations per second above and below the rest frequency corresponds at each instant to the frequency of the intelligence signal being transmitted.

**Hand-held Radio.** A completely self-contained radio that can be moved from one position to another.

**Helmet.** An element of a protective ensemble designed to provide minimum protection to the head.

**Labeled.** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

**Listed.*** Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

**Melt.** A response to heat by a material resulting in evidence of flowing or dripping.
Model. The collective term used to identify a group of items of the same basic design and components from a single manufacturer produced by the same manufacturing and quality assurance procedures that are covered by the same certification.

Modulation. The process of modifying some characteristic of an electromagnetic wave (called a carrier) so that it varies in step with the instantaneous value of another wave (called a modulating wave or signal). The carrier can be a direct current, an alternating current (provided its frequency is above the highest frequency component in the modulating wave), or a series of regularly repeating, uniform pulses called a pulse chain (provided their repetition rate is at least twice that of the highest frequency to be transmitted). Also the strength of a voice applied to the microphone.

Noise-Cancelling. This term is applied to microphones that blank out bothersome background noises and permit communication in high noise areas.

Product. The compliant hand-held radio.

Product Label. A label or marking affixed to each compliant hand-held radio by the manufacturer. Such labels contain compliance statements, certification statements, general information, care, maintenance, or similar data. The product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark can be attached to or be part of the product label. (See also Labeled.)

Radio Receiver. An instrument that amplifies radio frequency (RF) signals, separates the intelligence signal from the RF carrier, amplifies the intelligence signal in most cases, and then converts the intelligence signal back into its original form.

Radio Transmitter. A radio-frequency power source that generates radio waves for transmission through space.

Sample. Hand-held radios taken from a manufacturer's current production lot. (See also Specimen.)

Sensitivity. The minimum input signal needed by a radio receiver to produce a specified output.

Shall. This term indicates a mandatory requirement.

Should. This term, as used in the Appendix, indicates a recommendation or that which is advised but not required.

Simplex Operation. A method of operation in which communication between two stations takes place in only one direction at a time.

Specimen. The item that undergoes testing. In some cases, the specimen is also the sample.
Squelch. A system for removing objectionable background noise by desensitizing the receiver.

Transceiver. Combined transmitter and receiving unit.

1-4 Units.

1-4.1* In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement. Equivalent values in parentheses shall not be considered as the requirement as these values might be approximate.

Chapter 2 Certification

2-1 General.

2-1.1 All individual hand-held radios that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certifications shall be performed by a certification organization that meets at least the requirements specified in Section 2-2, and that is accredited for personal protective equipment by the American National Standards Institute (ANSI) in accordance with ANSI Z34.1, American National Standard for Third-Party Certification Program for Products, Processes, and Services.

2-1.3 All individual compliant hand-held radios shall be labeled and listed. All individual compliant hand-held radios shall also have a product label. The product label shall meet the requirements in 3-1.

2-1.4* The certification organization's label, symbol, or identifying mark shall be attached to the product label, be part of the product label, or immediately adjacent to the product label.

2-2 Certification Program.

2-2.1* The certification organization shall not be owned or controlled by manufacturers or vendors of the product being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

2-2.2 The certification organization shall refuse to certify products to this standard that do not comply with all applicable requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications. Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.
2-2.4* The certification laboratory shall have laboratory facilities and equipment available for conducting proper tests, a program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.5 The certification organization shall require the manufacturer to establish and maintain a program of production inspection and testing that at least meets the requirements of Section 2-5 or 2-6. The certification organization shall ensure that the audit assurance program provides continued product compliance with this standard.

2-2.6 The certification organization and the manufacturer shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continued certification to this standard.

2-2.7* The certification organization an shall have a follow-up inspection program of the manufacturing facilities of the certified product, with at least 2 random and unannounced visits per 12-month period. As part of the follow-up inspection program, the certification organization shall select sample product at random from the manufacturer's production line, from the manufacturer's in-house stock, or from the open market. Sample product shall be inspected and tested by the certification organization to verify the product's continued compliance.

2-2.8 The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

2-2.9* The certification organization shall require the manufacturer to have a product recall system as part of the manufacturer's quality assurance program.

2-2.10 The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

2-2.11 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

2-3 Inspection and Testing.

2-3.1 For both initial certification and recertification of hand-held radios, the certification organization shall conduct both inspection and testing as specified in this section.

2-3.2 Sampling levels for inspection to determine compliance with this standard shall be established by the certification organization and the manufacturer to ensure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant.
2-3.3 Inspection by the certification organization shall include a review of all product labels to ensure that all required label attachment, compliance statements, certification statements, and other product information are at least as specified in Section 3-1.

2-3.4 Inspection by the certification organization shall include a review of any graphic representations used on product labels, as permitted by Section 3-1 to ensure that the systems are consistent with the worded statements, readily understood, and clearly communicate the intended message.

2-3.5 Inspection by the certification organization shall include a review of the user information required by Section 3-2 to ensure that the information has been developed and is available.

2-3.6 Inspection by the certification organization for determining compliance with the design requirements specified in Chapter 4 shall be performed on whole and complete hand-held radios.

2-3.7* Testing conducted by the certification organization in accordance with the testing requirements of Chapter 6, for determining product compliance with the applicable requirements specified in Chapter 5, shall be performed on whole and complete hand-held radios. Where hand-held radios are an integral part of another item of protective clothing or protective equipment, that item with the hand-held radio incorporated shall be tested as a whole, unless otherwise specified herein.

2-3.8 Hand-held radios shall be tested for initial certification to this edition of NFPA 19XX, Standard on Fire Service Hand-Held Radios, and shall meet the performance requirements of the test series specified in the test matrix in Table 2-3.8.

2-3.8.1 Where there is more than one test for a single test specimen required by Table 2-3.8, the order of testing shall be from top to bottom of the test specimen column as shown in the table.

2-3.9 After initial certification to this edition of NFPA 19XX compliant hand-held radios shall be tested annually for recertification within 12 months from the previous certification or recertification.

2-3.9.1 Recertification shall occur each year of the 4 years following initial certification. If there is no revision to this edition of NFPA 19XX by the fifth year following initial certification, compliant hand-held radios shall be required to undergo full certification testing as specified in 2-3.7 in the fifth year.

2-3.9.2 Only one test specimen shall be required for each test specified in either Table 2-3.8.

2-3.9.3 Where there is more than one test for a single test specimen hand-held radios required by Table 2-3.8, the order of testing shall be from top to bottom of the test specimen column as shown in the table.

2-3.10 Where the hand-held radios is equipped with an accessory or accessories certification testing shall include accessories and each accessory shall be certified as complying with Section
2-3.11 Any change in the design, construction, or material of a compliant hand-held radio shall necessitate new inspection and testing to verify compliance to all applicable requirements of this standard that the certification organization determines can be affected by such change. This recertification shall be conducted before labeling the modified hand-held radio as being compliant with this standard.

2-3.12 The certification organization shall not allow any modifications, pretreatment, conditioning, or other such special processes of the hand-held radio or any hand-held radio component prior to the product’s submission for evaluation and testing by the certification organization. The certification organization shall accept, from the manufacturer for evaluation and testing for certification, only hand-held radios or hand-held radio components that are the same in every respect to the actual final product or product component. The certification organization shall not allow the substitution, repair, or modification, other than as specifically permitted herein, of any hand-held radio or any hand-held radio component during testing.

2-4 Recertification.

2-4.1 All hand-held radios that are labeled as being compliant with this standard shall undergo recertification on an annual basis. This recertification shall include inspection and evaluation to all design requirements and testing to all performance requirements as required by this standard on all manufacturer models and components.

2-4.1.1 Any change that affects the hand-held radio's performance under design or performance requirements of this standard shall constitute a different model.

2-4.1.2 For the purpose of this standard, models shall include each unique design of the individual hand-held radio.

2-4.2 Samples of manufacturer models and components for recertification shall be acquired from the manufacturer or component supplier during random and unannounced visits as part of the follow-up inspection program.

2-4.3 The manufacturer shall maintain all design and performance inspection and test data from the certification organization used in the recertification of manufacturer models and components. The manufacturer shall provide such data, upon request, to the purchaser or authority having jurisdiction.

2-5 Manufacturer’s Quality Assurance Program.

2-5.1 The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

2-5.2 The manufacturer shall maintain written inspection and testing instructions. The instructions
shall prescribe inspection and test of materials, work in process, and completed articles. Criteria for acceptance and rejection of materials, processes, and final product shall be part of the instructions.

2-5.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

2-5.4 The manufacturer’s inspection system shall provide for procedures that assure the latest applicable drawings, specifications, and instructions are used for fabrication, inspection, and testing.

2-5.5 The manufacturer shall, as part of the quality assurance program, maintain a calibration program of all instruments used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

2-5.6 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

2-5.7 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material. All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

2-5.8 The manufacturer’s quality assurance program shall be audited by the third party certification organization to determine that the program is sufficient to ensure continued product compliance with this standard.

2-6* ISO Registration for Manufacturers.

2-6.1 The manufacturer shall provide and operate a quality assurance program that meets the requirements of this Section and that includes a product recall system as specified in 2-2.9.

2-6.2 The manufacturer shall be registered to ISO 9001.

2-6.3 All elements of the protective ensemble shall be required to be assembled in a facility that is registered at least to ISO 9002.

2-6.4 The ISO registration requirements shall have an effective date of August 1, 2004.

2-6.5 Until August 1, 2004, or until the date the manufacturer becomes ISO registered, whichever date occurs first, the manufacturer shall comply with Section 2-5.

Chapter 3 Labeling and Information
3-1 Product Labeling Requirements.

3-1.1 Each hand-held radio shall have a product label(s) permanently and conspicuously attached.

3-1.2 Multiple label pieces shall be permitted in order to carry all statements and information required to be on the product label.

3-1.3 All worded portions of the required product label shall be printed at least in English.

3-1.4 Symbols and other pictorial graphic representations shall be permitted to be used to supplement worded statements on the product label(s). Such graphic representations shall be consistent clearly communicate the intended message.

3-1.5* The certification organization's label, symbol, or identifying mark shall be permanently attached to the product label or shall be part of the product label.

3-1.6 The following statement shall be printed legibly on the product label. All letters shall be at least 1.5 mm (1/16 in.) high.

"THIS HAND-HELD RADIO MEETS THE REQUIREMENTS OF NFPA 19XX, STANDARD ON FIRE SERVICE HAND-HELD RADIOS, XXXX EDITION."

3-1.7 The following information shall also be printed legibly on the product label. All letters shall be at least 1.5 mm (1/16 in.) high:

(a) Manufacturer's name, identification, or designation
(b) Country of manufacture
(c) Model name, number, or design
(d) Identification/lot/serial number;
(e) Month and year of manufacture, not coded

3-1.8 Hand-held radios shall also meet the labeling requirements for Class I, Division 1 hazardous locations of ANSI/UL 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1 Hazardous Locations.

3-1.9 All product labels shall also meet the requirements specified in Section 5-4.4.

3-2 User Information.

3-2.1 The hand-held radio manufacturer shall provide user information including, but not limited to, warnings, information, and instructions with each garment element.

3-2.2 The hand-held radio manufacturer shall attach the required user information, or packaging containing the user information, to the hand-held radio in such a manner that it is not possible to use the hand-held radio without being aware of the availability of the information.
3-2.3 The required user information, or packaging containing the user information, shall be attached to the hand-held radio so that a deliberate action is necessary to remove it. The hand-held radio manufacturer shall provide notice that the user information is to be removed ONLY by the end user.

3-2.4 The hand-held radio manufacturer shall provide at least the following instructions and information with each hand-held radio:

(a) Pre-use information:
   - Safety considerations
   - Limitations of the hand-held radio
   - Marking recommendations and restrictions
   - A statement that most performance properties of the hand-held radio cannot be tested by the user in the field
   - Warranty information

(b) Preparation for use:
   - Preferred wearing position for optimal performance
   - Training instructions
   - Recommended storage practices

(c) Inspection frequency and details.

(d) Maintenance and Cleaning:
   - Cleaning instructions and precautions
   - Decontamination procedures
   - Battery testing and replacement
   - Maintenance criteria

(e) Retirement and disposal criteria and considerations

Chapter 4 Design Requirements

4-1 General Design Requirements

4-1.1 Hand-held radios shall be capable of multiple-frequency operation to enable a fireground radio network to be organized independently of normal dispatch channels.

4-1.2 Hand-held radios shall be capable of Continuous Tone Coded Squelch System (CTCSS) or Continuous Digital Coded Squelch System (CDCSS) operation.

4-1.2.1 If the hand-held radio is operating in standard squelch systems, the continuous coded squelch circuitry shall be permitted to be partially or completely disabled.
4-1.3 Hand-held radio transmitters shall have a carrier-controlled timer to disable the transmitter in the event of a malfunction that causes the transmitter to remain inadvertently on the air.

4-1.4 Hand-held radios shall have a noise cancelling microphone.

4-1.5 Hand-held radios shall have universal device connector or jack for radio accessories, including but not limited to remote microphones, headsets, earpieces, and battery chargers.

4-1.6 If, hand-held radios or components of hand-held radios which are incorporated into helmets, shall meet the helmet accessory requirements of NFPA 1971, Standard on Protective Ensemble for Structural Fire Fighting.

4-1.7 If hand-held radios or components of hand-held radios which are incorporated into self-contained breathing apparatus, shall meet the accessory requirements in NFPA 1981, Standard on Open-Circuit, Self-Contained Breathing Apparatus.

4-2 Minimum Controls

4-2.1 Hand-held radios shall have the following minimum controls:
   (a) On/off and volume
   (b) Channel selector
   (c) Transmit or push-to-talk button
   (d) Emergency transmit button

4-2.2 The on/off and volume control shall have a positive indication when placed in the "on" position.

4-2.3 The channel selector control shall be a multi-position switch or other control which has discrete positions for each channel.

4-2.4 The channel selector control shall have a shape which is unique and easily differentiated by the user from the on/off and volume control.

4-2.5 The transmit or push-to-talk button shall be a mechanically guarded switch or other means of protecting the switch from accidental keying.

4-2.6 The emergency transmit button shall be a distinctly different shaped, mechanically guarded switch from the transmit or push-to-talk switch.

4-3 Minimum Display

4.3.1 The hand-held radio shall have the minimum following displays:
   (a) Battery life
   (b) Receive/transmit signal
   (c) Signal strength
4-3.2 The display for battery life shall be continuous when the radio is turned on.

4-3.3 The hand-held radio shall provide two different means for alerting the radio user of battery life of less than 30 minutes based on the standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby). Audible means shall have a minimum sound pressure level of 90 dBA.

4-3.4 The display for receive and transmit shall be different for distinctly indicating the mode of operation (receiving or transmitting).

4-3.5 Signal strength shall be displayed by an alphanumeric or geometrical rating during each reception.

4-4 Battery and Battery Charger.

4-4.1 Single unit chargers for hand-held radios shall be capable of charging fully while the radio is in the receiving mode.

4-4.2 Battery chargers for hand-held radios shall automatically revert to maintenance charge when the battery is fully charged.

4-4.3 Battery chargers shall be capable of charging batteries independently and externally of the portable radio unit.

4-5 Accessories.

4-5.1 Any accessories attached to or part of any hand-held radio shall not interfere with the function(s) of the hand-held radio or with the function(s) of any of the hand-held radio component parts as required by this standard.

4-5.2 Any accessories attached to or part of any hand-held radio shall degrade the designed protection or performance of the hand-held radio below the requirements of this standard.

Chapter 5 Performance Requirements

5-1* Receiver Operational Requirements

5.1.1 Specimen hand-held radios shall be tested for the following properties as specified in 6-1, Receiver Performance Tests, and shall meet the "Required Standard" criteria established in Section 5.1, "Standards for Portable Receivers," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Power line conducted spurious emissions
   (b) Reference sensitivity
(c) Signal displacement bandwidth
(d) Adjacent channel rejection
(e) Offset channel selectivity
(f) Spurious response rejection
(g) Intermodulation rejection
(h) Audio frequency response
(i) Hum and noise ratio
(j) Audio distortion
(k) Audio squelch sensitivity
(l) Squelch blocking
(m) Receiver attack time
(n) Receiver closing time
(o) Audio sensitivity
(p) Impulse blanking effectiveness
(q) Average radiation sensitivity
(r) Acoustic audio output

5.1.2 Specimen hand-held radios shall be tested for the following properties as specified in 6-1, Receiver Performance Tests, and shall meet the "Recommended Standard" criteria established in Section 5.1, "Standards for Portable Receivers," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Radiated spurious emissions
   (b) Conducted spurious emissions

5.2* Transmitter Operational Requirements

5.2.1 Specimen hand-held radios shall be tested for the following properties as specified in 6-2, Transmitter Performance Tests, and shall meet the "Required Standard" criteria established in Section 5.2, "Standards for Portable Transmitters," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Carrier output power rating
   (b) Carrier frequency stability
   (c) Carrier attack time
   (d) Audio sensitivity
   (e) Audio frequency response
   (f) Audio distortion
   (g) FM hum and noise ratio
   (h) AM hum and noise ratio
   (i) Acoustic microphone sensitivity
   (j) Sideband spectrum
   (k) Radiated spurious emissions
   (l) Conducted spurious emissions
   (m) Adjacent channel power ratio
   (n) Audio low pass filter response
Specimen hand-held radios shall be tested for the following properties as specified in 6-2, Transmitter Performance Tests, and shall meet the "Recommended Standard" criteria established in Section 5.2, "Standards for Portable Transmitters," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for Modulation limiting.

5-3 Overall Radio Functional Requirements

5-3.1 Power Supply Voltage Range.

5-3.1.1 Specimen hand-held radios shall be tested for the following properties as specified in Section 6-3, Power Supply Voltage Range Test, and shall meet the criteria established in Section 5.3.1.2, "Standard," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity
(l) Carrier output power rating
(m) Carrier frequency stability
(n) Modulation limiting
(o) Transmit audio distortion
(p) FM hum and noise ratio
(q) AM hum and noise ratio
(r) Transmitter stability into VSWR

5-3.2 Electronic Temperature Stress.

5-3.2.1 Specimen hand-held radios shall be tested for resistance to electronic temperature stress as specified in Section 6-4, Electronic Temperature Stress Test, and shall meet the criteria established in Section 5.3.1.2, "Standard," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
5-3.3 Electronic Humidity Stress

5-3.3.1 Specimen hand-held radios shall be tested for resistance to humidity stress as specified in Section 6-5, Electronic Humidity Stress Test, and shall meet the criteria established in Section 5.3.3.2, “Standard,” of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity
(l) Carrier output power rating
(m) Carrier frequency stability
(n) Modulation limiting
(o) Transmit audio distortion
(p) FM hum and noise ratio
(q) Transmitter stability into VSWR

5-3.4 Salt Spray Exposure Stability

5-3.4.1 Specimen hand-held radios shall be tested for resistance to wet exposures as specified in Section 6-6, Salt Spray Exposure Stability Test, and shall meet the criteria established in Section 5.3.3.2, “Standard,” of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity
(l) Carrier output power rating
(m) Carrier frequency stability
(n) Modulation limiting
(o) Transmit audio distortion
(p) FM hum and noise ratio

5-3.5 Particulate Exposure Stability.

5-3.5.1 Specimen hand-held radios shall be tested for resistance to particulate exposures as specified in Section 6-7, Particulate Exposure Stability Test, and shall meet the criteria established in Section 5.3.3.2, "Standard," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Reference sensitivity
   (b) Signal displacement bandwidth
   (c) Adjacent channel rejection
   (d) Offset channel selectivity
   (e) Spurious response rejection
   (f) Intermodulation rejection
   (g) Hum and noise ratio
   (h) Receive audio distortion
   (i) Audio squelch sensitivity
   (j) Squelch blocking
   (k) Audio sensitivity
   (l) Carrier output power rating
   (m) Carrier frequency stability
   (n) Modulation limiting
   (o) Transmit audio distortion
   (p) FM hum and noise ratio

5-3.6 Vibration Stability

5-3.6.1 Specimen hand-held radios shall be tested for vibration stability as specified in Section 6-8, Vibration Stability Test, and shall meet the criteria established in Section 5.3.4.2, "Standard," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Reference sensitivity
(b) Carrier output power rating
(c) Carrier frequency stability
(d) Modulation limiting
(e) FM hum and noise ratio

5-3.6.2 Specimen hand-held radios shall be tested for vibration stability as specified in Section 6-8, Vibration Stability Test, with no fixed part shall be loosened, adjusted or shifted in position under any test condition of vibration.

5-3.7 Shock Stability

5-3.7.1 Specimen hand-held radios shall be tested for shock stability as specified in Section 6-9, Shock Stability Test, and shall meet the criteria established in Section 5.3.4.2, "Standard," of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for each of the following properties:
   (a) Reference sensitivity
   (b) Carrier output power rating
   (c) Carrier frequency stability
   (d) Modulation limiting
   (e) FM hum and noise ratio

5-3.7.2 Specimen hand-held radios shall be tested for vibration stability as specified in Section 6-8, Vibration Stability Test, and shall suffer no more than superficial mechanical damage.

5-3.8 Battery Life

5-3.8.1 Specimen hand-held radios shall be tested for battery life as specified in Section 6-10, Battery Life Test, and shall provide a minimum battery life of 8 hours.

5-4 General Radio Requirements.

5-4.1 Heat Resistance.

5-4.1.1 Specimen hand-held radios shall be tested to resistance to heat as specified in Section 6-11, Heat Resistance Test, and shall not melt, drip, or ignite.

5-4.2 Heat and Flame Resistance.

5-4.2.1 Specimen hand-held radios shall be tested for resistance to heat and flame as specified in Section 6-12, Heat and Flame Test, and shall not function as follows:

   (a) The afterflame time shall not exceed 2.2 seconds.
   
   (b) Nothing shall fall off the hand-held radio, and the hand-held radio shall not fall from its mounted position.
5-4.3 Control Operability.

5-4.3.1 Specimen hand-held radios shall be tested for control operability as specified in Section 6-13, Control Operability Test, and shall have a percent of bare-hand control not less than 120%.

5-4.4 Intrinsic Safety.

5-4.4.1 Specimen hand-held radios shall be tested for intrinsic safety as specified in ANSI/UL 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1 Hazardous Locations, and shall meet the requirements for Class I, Division 1 hazardous locations.

5-4.5 Product Label Durability.

5-4.5.1 Specimen hand-held radios with product labels shall be tested for durability and legibility as specified in Section 6-14, Product Label Durability Test, and the product labels shall remain attached to the hand-held radio, and shall be legible to the unaided eye.

Chapter 6 Test Methods

6-1 Receiver Performance Tests.

6-1.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.1, Standards for Portable Receivers of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following properties:
   (a) Radiated spurious emissions
   (b) Conducted spurious emissions
   (c) Power line conducted spurious emissions
   (d) Reference sensitivity
   (e) Signal displacement bandwidth
   (f) Adjacent channel rejection
   (g) Offset channel selectivity
   (h) Spurious response rejection
   (i) Intermodulation rejection
   (j) Audio frequency response
   (k) Hum and noise ratio
   (l) Audio distortion
   (m) Audio squelch sensitivity
   (n) Squelch blocking
   (o) Receiver attack time
   (p) Receiver closing time
   (q) Audio sensitivity
   (r) Impulse blanking effectiveness
   (s) Average radiation sensitivity
   (t) Acoustic audio output
6-1.2 Testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:

(a) Temperature: 25°C, + 5°C (77°F, + 9°F)
(b) Relative humidity: 60 percent, ± 15 percent
(c) Atmospheric pressure: 96 kPa, ± 10 kPa (720 mm Hg, ± 75 mm Hg)

6-2 Transmitter Performance Tests.

6-2.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following properties:

(a) Carrier output power rating
(b) Carrier frequency stability
(c) Modulation limiting
(d) Carrier attack time
(e) Audio sensitivity
(f) Audio frequency response
(g) Audio distortion
(h) FM hum and noise ratio
(i) AM hum and noise ratio
(j) Acoustic microphone sensitivity
(k) Sideband spectrum
(l) Radiated spurious emissions
(m) Conducted spurious emissions
(n) Adjacent channel power ratio
(o) Audio low pass filter response
(p) Average radiated power output
(q) Transmitter stability into VSWR
(r) Transient frequency behavior

6-2.2 Testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:

(a) Temperature: 25°C, + 5°C (77°F, + 9°F)
(b) Relative humidity: 60 percent, ± 15 percent
(c) Atmospheric pressure: 96 kPa, ± 10 kPa (720 mm Hg, ± 75 mm Hg)

6-3 Power Supply Voltage Range Test.

6-3.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.1, "Power Supply Voltage Range" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity

6-3.2 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.1, "Power Supply Voltage Range" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating
(b) Carrier frequency stability
(c) Modulation limiting
(d) Transmit audio distortion
(e) FM hum and noise ratio
(f) Transmitter stability into VSWR

6-3.3 Except where otherwise specified in Section 5.3.1, "Power Supply Voltage Range" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:

(a) Temperature: 25°C, +5°C (77°F, +9°F)
(b) Relative humidity: 60 percent, +15 percent
(c) Atmospheric pressure: 96 kPa, +10 kPa (720 mm Hg, +75 mm Hg)

6-4 Electronic Temperature Stress Test.

6-4.1 Specimen hand-held radios shall be subjected to a series of three temperature stress tests identified as Test Procedure 1 for elevated temperature, Test Procedure 2 for low operating temperature, and Test Procedure 3 for temperature shock. Different specimen hand-held radios shall be used for each of the three test series. Each specimen hand-held radio tested shall be complete with power source.

6-4.2 The test chamber or cabinet shall be capable of maintaining the required conditions throughout the envelope of air surrounding the specimen hand-held radio being tested, and these conditions shall be continuous monitored.

6-4.3 For all three tests, different specimen hand-held radio shall be conditioned and used for each of the three test series. The conditioning shall be at the specified temperatures and exposure times. Following each test, the specimen hand-held radio shall be allowed to stabilize at ambient conditions prior to proceeding to the next test.
6-4.4 Except where otherwise specified in Section 5.3.1, "Power Supply Voltage Range" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby).

6-4.5 Test Procedure 1.

6-4.5.1 Specimen hand-held radio shall be placed in the test apparatus that has been stabilized at 49°C (120°F). After 6 hours, the temperature shall be raised within 1 hour to 71°C (160°F) and maintained for 4 hours. The temperature shall then be decreased within 1 hour to 49°C (120°F).

6-4.5.2 This cycle shall be repeated twice.

6-4.5.3 After the second cycle, the temperature shall be raised to 71°C (160°F) for 4 hours.

6-4.5.4 Specimen hand-held radios shall be evaluated in accordance with Section 5.1, "Standards for Portable Receivers" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:
   (a) Reference sensitivity
   (b) Signal displacement bandwidth
   (c) Adjacent channel rejection
   (d) Offset channel selectivity
   (e) Spurious response rejection
   (f) Intermodulation rejection
   (g) Hum and noise ratio
   (h) Receive audio distortion
   (i) Audio squelch sensitivity
   (j) Squelch blocking
   (k) Audio sensitivity

6-4.5.5 Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:
   (a) Carrier output power rating
   (b) Carrier frequency stability
   (c) Modulation limiting
   (d) Transmit audio distortion
   (e) FM hum and noise ratio
   (f) Transmitter stability into VSWR

6-4.6 Test Procedure 2.

6-4.6.1 Specimen hand-held radios shall be placed in the test apparatus that has been stabilized
at -20°C (-4°F) and maintained for a minimum of 4 hours.

**6-4.6.2** Specimen hand-held radios shall be removed following the specified conditioning, and testing shall begin within 30 seconds of removable from conditioning.

**6-4.6.3** Specimen hand-held radios shall be evaluated in accordance with Section 5.1, "Standards for Portable Receivers" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity

**6-4.6.4** Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating
(b) Carrier frequency stability
(c) Modulation limiting
(d) Transmit audio distortion
(e) FM hum and noise ratio
(f) Transmitter stability into VSWR

**6-4.7 Test Procedure 3.**

**6-4.7.1** Specimen hand-held radios shall be placed in the test apparatus that has been stabilized at -20°C (-4°F), cold condition, for 4 hours. Specimen hand-held radios shall be removed from the cold condition and shall be placed within 5 minutes into another test apparatus that has been stabilized at 71°C (160°F) hot condition. After 4 hours, specimen hand-held radios shall be returned to cold condition test apparatus for another 4 hours.

**6-4.7.2** This cycle shall be repeated twice.

**6-4.7.3** Specimen hand-held radios shall then be allowed to stabilize at ambient conditions.

**6-4.7.4** Specimen hand-held radios shall be evaluated in accordance with Section 5.1, "Standards for Portable Receivers" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications
Equipment Measurement and Performance Standards, for the following receiver performance properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity

6-4.7.5 Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating
(b) Carrier frequency stability
(c) Modulation limiting
(d) Transmit audio distortion
(e) FM hum and noise ratio
(f) Transmitter stability into VSWR

6-5 High Humidity Stress Test.

6-5.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.3, "High Humidity" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity

6-5.2 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.3, "High Humidity" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating
6-5.3 Except where otherwise specified in Section 5.3.3, "Power Supply Voltage Range" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby).

6-6 Salt Spray Exposure Test.

6-6.1 A salt fog chamber shall be used for testing and shall meet the requirements of ASTM B 117, Standard Test Method for Salt Spray (Fog) Testing.

6-6.2 Specimen hand-held radios shall be subjected to a 5 percent ± 1 percent, salt solution fog at a chamber temperature of 35°C (95°F) for 48 hours in the typical wearing position as if worn by a fire fighter, as specified by the manufacturer. The hand-held radios shall then be stored in an environmental of 22°C ± 3°C (72°F, ± 5°F) at 50 percent, ± 5 percent, relative humidity for a minimum of 48 hours.

6-6.3 Specimen hand-held radios shall be removed following the specified conditioning, and testing shall begin within 30 seconds of removal from conditioning.

6-6.4 Specimen hand-held radios shall be evaluated in accordance with Section 5.1, "Standards for Portable Receivers" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:

(a) Reference sensitivity
(b) Signal displacement bandwidth
(c) Adjacent channel rejection
(d) Offset channel selectivity
(e) Spurious response rejection
(f) Intermodulation rejection
(g) Hum and noise ratio
(h) Receive audio distortion
(i) Audio squelch sensitivity
(j) Squelch blocking
(k) Audio sensitivity

6-6.5 Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:
(a) Carrier output power rating  
(b) Carrier frequency stability  
(c) Modulation limiting  
(d) Transmit audio distortion  
(e) FM hum and noise ratio  
(f) Transmitter stability into VSWR  

6-6.6 Except where otherwise specified in Section 5.3.3, "Humidity" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby).  

6-7 Particulate Exposure Stability Test.  

6-7.1 Specimen hand-held radios shall be subjected to Method 510.3, Sand and Dust, Section II-3, Procedure 1, of MIL-STD-810E, Environmental Test Methods.  

6-7.2 The test conditions as outlined per Method 510.3, Sand and Dust of MIL-STD-810E, Environmental Test Methods., Section I-3d, shall be the following:  
   (a) Air velocity: 1750 m/min, ± 76.2 m/min (1750 ft/min, ± 250 ft/min)  
   (b) Temperature: 22°C, ± 3°C (72°F, ± 5°F)  
   (c) Test item configuration and orientation: specimen upright and rotated 180 degrees midway through the test  
   (d) Dust composition: refer to Section I-3.2d (1)  
   (e) Dust concentration: refer to Section I-3.2e (1)  
   (f) Test duration: 1.0 hour  

6-7.3 Specimen hand-held radios shall be removed following the specified conditioning, and lightly brushed off. Testing shall begin within 1 minute of removal from conditioning.  

6-7.4 Specimen hand-held radios shall be evaluated in accordance with Section 5.1, "Standards for Portable Receivers" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following receiver performance properties:  
   (a) Reference sensitivity  
   (b) Signal displacement bandwidth  
   (c) Adjacent channel rejection  
   (d) Offset channel selectivity  
   (e) Spurious response rejection  
   (f) Intermodulation rejection  
   (g) Hum and noise ratio  
   (h) Receive audio distortion  
   (i) Audio squelch sensitivity  
   (j) Squelch blocking  
   (k) Audio sensitivity
6-7.5 Specimen hand-held radios shall be evaluated in accordance with Section 5.2, "Standards for Portable Transmitters" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating  
(b) Carrier frequency stability  
(c) Modulation limiting  
(d) Transmit audio distortion  
(e) FM hum and noise ratio  
(f) Transmitter stability into VSWR

6-7.6 Except where otherwise specified in Section 5.3.1, "Humidity" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby).

6-8 Vibration Stability Test.

6-8.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.4, "Vibration Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for Reference sensitivity.

6-8.2 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.4, "Vibration Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:

(a) Carrier output power rating  
(b) Carrier frequency stability  
(c) Modulation limiting  
(d) FM hum and noise ratio

6-8.3 Except where otherwise specified in Section 5.3.4, "Vibration Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:

(a) Temperature: 25°C, + 5°C (77°F, + 9°F)  
(b) Relative humidity: 60 percent, + 15 percent  
(c) Atmospheric pressure: 96 kPa, + 10 kPa (720 mm Hg, + 75 mm Hg)

6-8.4 Specimen hand-held radios shall be examined for damage after testing with particular attention to loosened parts.

6-9 Shock Stability Test.

6-9.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.5, "Shock Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:

(a) Temperature: 25°C, + 5°C (77°F, + 9°F)  
(b) Relative humidity: 60 percent, + 15 percent  
(c) Atmospheric pressure: 96 kPa, + 10 kPa (720 mm Hg, + 75 mm Hg)
Measurement and Performance Standards, for Reference sensitivity.

6-9.2 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.5, "Shock Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, for the following transmitter performance properties:
   (a) Carrier output power rating
   (b) Carrier frequency stability
   (c) Modulation limiting
   (d) FM hum and noise ratio

6-9.3 Except where otherwise specified in Section 5.3.5, "Shock Stability" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, testing shall be carried out using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:
   (a) Temperature: 25°C, +5°C (77°F, +9°F)
   (b) Relative humidity: 60 percent, + 15 percent
   (c) Atmospheric pressure: 96 kPa, + 10 kPa (720 mm Hg, + 75 mm Hg)

6-9.4 Specimen hand-held radios shall be examined for damage after testing with particular attention to loosened parts.

6-10 Battery Life Test.

6-10.1 Specimen hand-held radios shall be evaluated in accordance with Section 5.3.7, "Battery Life" of ANSI/TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards, using a standard duty cycle of 10-10-80 (6 seconds receive at radio audio power output, 6 seconds transmit at rated power output, and 48 seconds standby) under the following environmental conditions:
   (a) Temperature: 25°C, +5°C (77°F, +9°F)
   (b) Relative humidity: 60 percent, + 15 percent
   (c) Atmospheric pressure: 96 kPa, + 10 kPa (720 mm Hg, + 75 mm Hg)

6-11 Heat Resistance Test.

6-11.1 The test oven shall be a horizontal flow circulating oven with minimum interior dimensions of 610 x 610 x 610 mm (24 x 24 x 24 in.). The test oven shall have an airflow rate of 38 to 76 linear m/min (125 to 250 linear ft/min) at the standard temperature and pressure of 21°C (70°F) at 1 atmosphere, measured at the center of the oven. A test thermocouple shall be positioned so that it is level with the horizontal centerline of a mounted sample specimen. The thermocouple shall be equidistant between the vertical centerline of a mounted specimen placed in the middle of the oven and the oven wall where the air flow enter the test chamber. The thermocouple shall be an exposed bead, Type J or K, No. 30 AWG thermocouple. The test oven shall be heated and the test thermocouple stabilized at 260°C, + 6/-0°C (500°F, + 10/-0°F) for a period of not less than 30 minutes.
6-11.2 Specimen hand-held radios shall be mounted on a test fixture that includes an aramid belt that is at least 51 mm (2 in.) wide and fastened to a mounting post spaced 305 mm, +25/-0 mm (12 in., +1/-0 in.) apart. The test fixture shall be designed to allow specimen hand-held radios to be attached to the belt.

6-11.3 The test fixture with the specimen hand-held radio shall be placed in the test oven. The specimen hand-held radio shall be turned off. There shall be no obstructions between the specimen hand-held radio and the air flow. The test fixture shall position the specimen hand-held radio equidistant from all interior oven surfaces. The oven test door shall not remain open for more than 15 seconds. The air circulation shall be shut off while the door is open and turned on when the door is closed. The total oven recovery time after door is closed shall not exceed 30 seconds. The thermocouple shall remain at 260°C, +6/-0°C (500°F, +10/-0°F) for the duration of the test.

6-11.4 The specimen hand-held radio, mounted as specified, shall be exposed in the test oven for 5 minutes, +0.15/-0 seconds. The test exposure time shall begin when test thermocouple recovers to a temperature of 260°C, +6/-0°C (500°F, +10/-0°F).

6-11.5 Immediately after the specified exposure, the specimen shall be removed and examined for evidence of ignition, melting, dripping, or separation.

6-12  Heat and Flame Test.

6-12.1 A test mannequin meeting the requirements specified in Figure 6-12.1 shall be provided.

6-12.2 The test mannequin shall have a protective covering. The protective covering shall be designed and constructed as follows:

6-12.2.1 The assembled protective covering composite consisting of an outer shell, moisture barrier, and thermal liner shall have an average thermal protective performance (TPP) of not less than 35.0 when tested in accordance with Section 6-11 of NFPA 1971, Standard on Protective Ensemble for Structural Fire Fighting.

6-12.2.2 The outer shell shall be 40 percent PBI®/60 percent Kevlar® rip stop weave, weighing approximately 7.5 oz/yd², with a water-repellent finish. Color shall be natural, undyed.

6-12.2.3 The thermal liner shall be constructed of a 3 oz/yd² rip stop pajama check Nomex III® batting of approximately 6 oz/yd².

6-12.2.4 The moisture barrier shall be constructed of approximately 2.25 oz/yd² polyester/cotton fabric that is coated with approximately 6.5 oz/yd² of flame-resistant neoprene.

6-12.2.5 The moisture barrier shall be completely sewn to the thermal liner at its perimeter, with the neoprene side facing outward from the thermal liner. All edges shall be sewn together and bound with nonwicking moisture barrier material. The liner/moisture barrier shall be no more than 77 mm (3 in.) from the coat hem.
6-12.2.6  The moisture barrier and thermal liner shall be completely detachable from the outer shell.

6-12.2.7  The protective covering shall be stitched with Kevlar® thread using a minimum of 6 to 8 stitches per 25 mm (1 in.). All major seams shall be double stitched and felled locked, with all inside seams to be finished with Kevlar® thread. All stress points shall be reinforced. No metal shall pass from the outside of the protective covering through the moisture barrier and liner to cause the transfer of heat to the mannequin when the protective covering is completely assembled. The protective covering, including the front closure, shall be constructed in a manner that provides secure and complete moisture and thermal protection. If non-positive fasteners, such as snaps or hook and pile tape are utilized in garment closures, positive locking fasteners, such as hooks and dees or zippers, shall also be utilized. Pockets and fluorescent retroreflective trim shall not be installed.

6-12.2.8  The collar shall be of four-piece construction consisting of outer shell material on both the back, or outside, next to the mannequin neck. The two inner layers shall consist of a thermal liner and moisture barrier. No throat strap shall be attached.

6-12.2.9  Outside sleeve seams shall be felled, while inside seams shall be lock stitched.

6-12.2.10 The protective covering shall measure 890 mm (35 in.) in length measured from the center of the back collar seam to the hem. The protective covering size shall be 11 mm chest by 86 mm sleeve (44 in. by 34 in.).

6-12.2.11 The complete protective covering shall be discarded and shall not be used where the damage to any portion indicates the covering can no longer provide thermal protection for the test mannequin.

6-12.3  The test headform portion of the mannequin shall be fully covered by an undyed, protective hood covering for protection of the headform during testing. The protective hood covering shall meet the performance requirements of Section 5-5 of NFPA 1971, Standard on Protective Ensemble for Structural Fire Fighting.

6-12.4  The heat and flame apparatus shall be as specified in Figures 6-12.4(a) and (b).

6-12.5  The test oven shall be a vertical forced circulating air oven with an internal velocity of 61 linear m (200 linear ft) per minute. The test oven shall have minimum dimensions of 914 mm depth x 914 mm width x 1220 mm height (36 x 36 x 48 in.).

6-12.6  The test oven shall be calibrated using a 30-gauge exposed bead, Type J iron/constantan wire reference thermocouple that has been calibrated to set the 0°C (32°F) reference point with an ice bath containing ice and deionized or distilled water. Boiling water shall be used to set the 100°C (212°F) reference value. The reference temperatures shall be corrected to standard temperatures using a barometric pressure correction.

6-12.7  For calibration prior to the heat and flame test, the calibration mannequin, as specified
in Figure 6-12.7, shall be exposed to direct flame contact for 10 seconds using the heat and flame test apparatus specified in Figure 6-12.4. All peak temperature readings shall be within a temperature range of 815°C to 1150°C (1500°F to 2100°F). The average mean of all peak temperature readings shall be no higher than 950°C (1742°F).

6-12.8 The test oven recovery time, after the door is closed, shall not exceed 1 minute.

6-12.9 Specimen hand-held radios shall be attached to the front or rear of the test mannequin by the retention system, in accordance with manufacturer's instructions, by means of a loop, belt, or other means, that is on the outside of the or over the mannequin protective covering. Specimen hand-held radios shall be attached in such a manner that the hand-held radio is facing a burner array.

6-12.10 Specimen hand-held radios mounted on the test mannequin, shall be first place in the test oven that has been preheated to 95°C, ±2°C (203°F, ±4°F) for 15 minutes. The test exposure time of 15 minutes shall begin after the door is closed and the oven temperature recovers to 95°C (203°F).

6-12.11 At the completion of the 15-minute exposure, the oven door shall be opened and the specimen hand-held radio, mounted on the test mannequin, shall be moved out of the oven and into the center of the burner array.

6-12.12 The specimen hand-held radio, mounted on the test mannequin, shall then be exposed to direct flame contact for 10 seconds, +25/-0 seconds. This exposure shall begin within 20 seconds of removal of the specimen hand-held radio from the test oven.

6-12.13 The specimen hand-held radio shall be observed for any after-flame, and the after-flame duration shall be recorded to determine pass/fail.

6-12.14 Within 20 seconds of completing the direct flame exposure, the specimen hand-held radio mounted on the test mannequin, shall be raised 152 mm, + 6 mm/-0 mm (6 in., + 0.25/-0 in.).

6-13 Control Operability Test.

6-13.1 Gloves meeting the requirements of NFPA 1971, Standard for Protective Ensemble for Structural Fire Fighting, shall be used for control operability testing. Glove pair specimens shall not receive special softening treatments prior to tests. Gloves used for testing shall meet the following requirements.

6-13.1.1 Gloves shall consist of three layers, a leather outer shell, a moisture barrier insert, and a lining material.

6-13.1.2 The leather outer shell shall be cowhide with an unit area weight of 1250 g/m², ± 50 g/m² (36.8 oz/yd², ± 1.5 oz/yd²) and a thickness of 2.5 mm, + 0.2 mm (0.10 in. ± 0.01 in.).

6-13.1.3 The moisture barrier insert shall be a polytetrafluoroethylene (PTFE) material which
has an unit area weight of 150 g/m$^2$, $\pm$ 25 g/m$^2$ (4.4 oz/yd$^2$, $\pm$ 0.8 oz/yd$^2$) and thickness of 1.0 mm, $\pm$ 0.1 mm (0.040 in. $\pm$ 0.005 in.).

6-13.1.4 The liner shall be a monoacrylic fiber fleece material with an unit area weight of 250 g/m$^2$, $\pm$ 50 g/m$^2$ (8.0 oz/yd$^2$, $\pm$ 0.8 oz/yd$^2$) and thickness of 2.0 mm, $\pm$ 0.2 mm (0.080 in. $\pm$ 0.010 in.).

6-13.1.5 All layers of the gloves shall be permanently attached.

6-13.1.6 Gloves shall have a knit wristlet. The wristlet shall be a double layer of Nomex® circular knit with an overall unit area weight of 250 g/m$^2$, $\pm$ 25 g/m$^2$ (8.0 oz/yd$^2$, $\pm$ 0.8 oz/yd$^2$) and thickness of 2.0 mm, $\pm$ 0.2 mm (0.080 in. $\pm$ 0.010 in.).

6-13.2 A total of five different test subject shall be used. Test subjects shall be selected such that their hand dimensions are a close as possible to those specified in the tables in 4-3.5.3 in NFPA 1971, Standard for Protective Ensemble for Structural Fire Fighting.

6-12.3 Starting with the specimen hand-held radio in one hand, each test subject shall practice the following operations:

(a) Turning the specimen hand-held radio on.
(b) Adjusting the volume all the way up, all the way down, and then to a mid-range setting.
(c) Depressing the push-to-talk switch 5 times for a period of 2 seconds separated by 5 a channel between push-to-talk depressions.
(d) Activating the emergency transmit button.

6-13.4 After the test subject has been given an opportunity to practice these operations, the test subject shall perform the series of operations in 6-13.3 with the time required for completing these operations recorded.

6-13.5 Each test subject shall then don gloves, and perform the same operations in 6-13.3 with the time required for completing these operations recorded.

6-13.6 The average barehanded and glove-based test trials shall be calculated for each test subject.

6-13.7 For each test subject, the change in radio manipulation time shall be calculated as follows:

\[
\text{Percent of barehanded control} = \frac{\text{Radio test time (with gloves)}}{\text{Radio test time (without gloves)}} \times 100
\]

6-13.8 The percent of barehand control shall be reported for each glove pair specimen and test subject tested.
6-13.9 The pass/fail performance shall be based on the lowest measured percent of barehanded control.

6-14 Product Label Durability Test.

6-14.1 Specimen hand-held radios with all product labels attached shall be subjected to the tests in 6-3, 6-4, 6-5, 6-6, 6-8, and 6-9.

6-14.2 After each test, specimen product labels shall be examined for legibility to the unaided eye by a person with 20/20 vision, or vision corrected to 20/20, at a nominal distance of 30.5 cm (12 in.) in a well-illuminated area to determine pass/fail.

6-14.3 The product labels shall be permitted to be wiped clean with an untreated clothing prior to being examined.

Chapter 7 Referenced Publications

7-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

7-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P. O. Box 9101, Quincy, MA 02269-9101.


7-1.2 Other Publications.

7-1.2.1 ANSI Publications. American National Standards Institute, 1450 Broadway, New York, NY 10018.


7-1.2.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

7-1.2.3 ISO Publications. ISO Central Secretariat; 1 Rue de Varembé; Case portal 56; CH 1211 GENEVA 201 Switzerland.


7-1.2.4 Navy Publication. Navy Publication and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.


General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plan, Washington, DC 20407.

Appendix A

This Appendix is not a part of the requirements of this NFPA document, but it is included for information purposes only.

A-1-1.1 < General information on use of radios: refer to other standards or practices>

A-1-2 This standard is not designed to be utilized as a purchase specification. It is prepared, as far as practical, with regard to required performance, avoiding restriction of design wherever possible. Purchasers should specify departmental requirements for such items as < provide list >. Tests specified in this standard should not be deemed as defining or establishing performance levels for conditions of use.

A-1-2.2 < limitations of testing: (1) testing does not address all conditions to which radios may be subjected, and (2) radio is only part of a system, entire system must be properly designed to ensure reliable communications>

A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

A-1-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

A-1-4.1 Metric units are used throughout Chapters 5 and 6 with English equivalents provided in parentheses.
A-2-1.4 The National Fire Protection Association (NFPA), from time to time, has received complaints that certain items of fire and emergency services protective clothing or protective equipment might be carrying labels falsely identifying them as compliant with an NFPA standard. The requirement for placing the certification organization’s mark on or next to the product label is to help ensure that the purchaser can readily determine compliance of the respective product through independent third party certification.

A-2-2.1 The certification organization should have sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well-being of the agency.

A-2-2.3 The contractual provisions covering a certification program should contain clauses advising the manufacturer that if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

Without the clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

A-2-2.4 Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the agency before any major testing is undertaken.

A-2-2.7 Such inspections should include, in most instances, witnessing of production tests. With certain products the certification organization inspectors should select samples from the production line and submit them to main laboratory for countercheck testing. With other products, it may be desirable to purchase samples in the open market for test purposes.

A-2-2.9 For further information and guidance on recall programs, see Title 21, Code of Federal Regulations, Part 7, Subpart C (21 CFR 7, Subpart C).

A-2-6 ISO 9000 defines quality terms and concepts. It gives an overview of the content and use of the entire ISO 9000 series. A useful cross-reference to the series’ quality system elements is found in Annex A of ISO 9000.

ISO 9001 is used when the quality system to be assessed covers several stages of one firm’s processes. It prescribes quality system requirements for design, development, production, installation and servicing.

ISO 9002 focuses on quality system requirements for production and installation.

ISO 9003 details quality system requirements for final inspection and testing.

ISO 9004 is used for internal quality assurance purposes. It defines a basic set of elements that a company can use to develop and implement a quality management system. Guidance is provided
on the technical, administrative and human factors that affect the quality of products or services at all stages of operation. This standard may help you determine the extent to which each quality system element applies to your organization.

A-3-1.1 Purchasers might wish to include a requirement in the purchase specifications for an additional label that includes certain information such as the date of manufacture, manufacturer's name, and garment identification number to be located in a protected location on the garment in order to reduce the chance of label degradation and as a backup source of information to aid in garment tracking or during an investigation.

A-3-1.5 See A-2-1.4

A-5-1 Receiver performance is measured using the following properties:

a. radiated spurious emissions - electromagnetic energy generated or amplified in receiver and radiated from the receiver or by the antenna, or by all control, audio, and power leads

b. conducted spurious emissions - energy that is generated or amplified in a receiver and appears at the receiver's antenna terminals

c. power line conducted spurious emissions - energy that is generated or amplified in a receiver and appears between each power line terminal that connects to a public utility line and ground

d. reference sensitivity - level of receiver input signal at a specified frequency with specified modulation which will result in the standard signal to noise ratio at the output of the receiver

e. signal displacement bandwidth - the input signal frequency displacement that reduces the signal to noise ratio by a signal 6 dB in excess of the reference sensitivity, to the standard signal to noise ratio

f. adjacent channel rejection - the ratio of the level of an unwanted input signal that causes the signal to noise ratio produced by the wanted signal 3 dB in excess of the reference sensitivity to be reduced to the standard signal to noise ratio, to the reference sensitivity

g. offset channel selectivity - the ratio of the level of an unwanted input signal that causes the signal to noise ratio produced by a signal 3 dB in excess of the reference sensitivity to be degraded to the standard signal to noise ratio, to the reference sensitivity

h. spurious response rejection - the ability of a receiver to prevent single unwanted signals from causing a degradation to the reception of a desired signal

i. intermodulation rejection - the ability of a receiver to prevent two unwanted input signals, with a specific frequency relation to the wanted signal frequency, from causing degradation to the reception of the desired signal

j. audio frequency response - the degree of closeness to which the audio output of a receiver follows a 6 dB per octave de-emphasis curve with constant frequency deviation over a continuous frequency range

k. hum and noise ratio - the ratio of the rated output power to the residual output power in the absence of modulation, both measured at the standard input signal level
l. audio distortion - the voltage ratio, usually expressed as a percentage of the rms value of the undesired signal to the rms value of the complete signal at the output of the receiver
m. audio squelch sensitivity - the minimum signal level from a standard input signal source, which when modulated at standard test modulation, will open the receiver squelch
n. squelch blocking - the tendency of the receiver squelch to close in the presence of modulation of the input signal
o. receiver attack time - the time required to produce audio power output after application of a modulated input signal
p. receiver closing time - the period of time between removal of an input signal and squelch closure
q. audio sensitivity - the minimum level of modulation, which at maximum volume control setting, will produce rated audio
r. impulse blanking effectiveness - the ability of the noise blanker to prevent and suppress the effects of short duration steep rise time pulses in the presence of desired signals
s. average radiation sensitivity - the power received by a half wave dipole measure into a 50 Ω load when substituted for a receiver that is receiving a signal at the reference sensitivity
t. acoustic audio output - the level registered on a sound level meter at a distance of 50 cm from the front of the receiver acoustic transducer

A-5-2 Transmitter performance is measured using the following properties:

a. carrier output power rating - the power available at the output terminals of the transmitter when the output terminals are connected to the standard transmitter load
b. carrier frequency stability - the ability of the transmitter to maintain an assigned carrier frequency
c. modulation limiting - the transmitter circuit's ability to limit the transmitter from producing deviations due to modulation in excess of a rated system deviation
d. carrier attack time - the time required to produce 50% of the steady-state carrier output power after changing the state of the transmitter from standby to transmit
e. audio sensitivity - the input rms voltage level that must be applied to the input terminals of the dummy microphone circuit to produce the standard test modulation
f. audio frequency response - the degree of closeness to which the frequency deviation of the transmitter follows a prescribed characteristic
g. audio distortion - the voltage ratio, usually expressed as a percentage of the rms value of the undesired signal of the transmitter's demodulated output to the rms value of the complete signal at the output of the transmitter's demodulator
h. FM hum and noise ratio - the ratio of the standard test modulation to the residual frequency modulation measured by the test receiver
i. AM hum and noise ratio - the ratio of the dc voltage detected from an unmodulated carrier to the detected peak ac voltage
j. acoustic microphone sensitivity - the acoustic sound pressure level which will produce 60% modulation of the transmitter
k. sideband spectrum - the sideband energy produced at a discrete frequency
separation from the carrier up to the test bandwidth due to all sources of unwanted noise within the transmitter in a modulated condition

l. radiated spurious emissions - emissions from the equipment when transmitting into a non-radiating load on a frequency or frequencies which are outside an occupied band sufficient to ensure transmission of information of required quality for the class of communications desired

m. conducted spurious emissions - emissions at the antenna terminals on a frequency or frequencies which are outside an occupied band sufficient to ensure transmission of information of required quality for the class of communications desired

n. adjacent channel power ratio - that part of the total output power of a transmitter under defined conditions and modulation, which falls within a specified passband centered on the nominal frequency of either of the adjacent channels

o. audio low pass filter response - the frequency response of the post limiter pass filter circuit above 3000 Hz

p. average radiated power output - the equivalent power required, when delivered to a half-wave dipole antenna, to produce at a distant point the same average received power as produced by a licensed device

q. transmitter stability into VSWR - the ability of a transmitter not to produce any spurious greater than allowed for the conducted spurious emissions when operated in a load different from the standard load

6. transient frequency behavior - a measure of the difference, as a function in time, of the actual transmitter frequency to the assigned transmitter frequency when the transmitted RF output power is switched on and off

A-5-3 Overall radio functional performance is measured using the following properties:

a. power supply voltage range - the range of power supply voltages over which the equipment will operate with no more than a specified amount of degradation in overall performance

b. temperature range - the range of ambient temperature over which the transceiver will operate with no more than a specified amount of degradation in overall performance

c. high humidity - the relative humidity at which the transceiver will operate with no more than a specified amount of degradation in overall performance

d. salt spray exposure stability - the amount of salt water spray during and after which the equipment will operate with no more than a specified amount of degradation in overall performance

e. particulate exposure stability - the amount of particulate exposure after which the equipment will operate with no more than a specified amount of degradation in overall performance

f. vibration stability - the amount of mechanical vibration during and after which the equipment will operate with no more than a specified amount of degradation in overall performance

g. shock stability - the amount of mechanical shock after which the equipment does not sustain physical damage, and no more than a specified amount of degradation in overall performance

h. battery life - the number of hours that the equipment will operate under the
A-5-4 Other radio performance properties measured include:

- heat resistance - the resistance to melting and dripping of the equipment when exposed to a 5 minute oven exposure
- heat and flame resistance - the resistance to melting and afterflame of the equipment when subjected to sustained heat and flame representing a flashover condition
- control operability - the ability of a end user wearing gloves to operate controls
- product label durability - the ability of the product label to remain legible following various conditions