TECHNICAL COMMITTEE ON ELECTRONIC SAFETY EQUIPMENT

August 3-4, 2011

Quincy, MA

AGENDA

ROP MEETING FOR NFPA 1982
Standard on Personal Alert Safety Systems (PASS)

Wednesday, August 3 (continuing to close of business on Thursday August 4)

1. **9:00 a.m.**, Call to Order - Chairman Bruce Varner

2. Introduction of Members and Guests

3. NFPA Staff Liaison Report and Procedures - Dave Trebisacci

4. Approval of the Minutes of the January 13-14, 2011 TC meeting, San Diego

5. Chairman's Remarks - Bruce Varner

- NFPA 1801 update
- NFPA 1981 (1802) status and work plan

6. Task group on Alarm Sounds* – Report

7. Task group on Intrinsic Safety* – Report

8. Review and Discussion of Public Proposals received on NFPA 1982

9. Review and Discussion on Committee Proposals for NFPA 1982

10. Future Document(s) Discussion

11. Old Business

12. New Business

- Next TC meeting
- Other

13. Adjourn at close of business on Thursday, August 4.

**** It is estimated that the meeting will fill both days. Task groups that need to meet should plan on early morning, lunch or evening meetings.***

Technical Committee on Electronic Safety Equipment

Minutes of the Meeting

January 13-14, 2011
San Diego, CA

Thursday, January 13, 2011

Agenda Items #1-3: Call to Order, Introduction of Members and Guests, and Committee Procedures

Chairman Bruce Varner called the meeting to order at 9:00 a.m. All committee members and guests introduced themselves.

Members present:

Bruce Varner, Chairman
Chris Spoons, Secretary
Dave Trebisacci, Staff Liaison

Jason Allen
Francine Amon
Robert Athanas – by phone
Craig Gestler
Wayne Haase
Bill Haskell – by phone
Jack Jarboe
Nick Luzie
Mike McKenna
John Morris
Larry Nyberg
Craig Parkulo
Timothy Rehak
Gordon Sletmoe
Steve Townsend
Steven Weinstein

Guests present:

Ravil Agi	K&A Wireless
John Baaker	ISI
Landon Borders	Bullard
Angos Drummond	E2V
Beverly Gulledge	Scott
John Hays	Bullard
Simon Hogg	Draeger
Kate Remley	NIST
Greg Sesny	Draeger
Bernd Spellenberg	Draeger
Jon Turner	E2V

Staff Liaison Dave Trebisacci read the NFPA committee procedures to the committee.

Agenda Item #4: Approval of the Minutes of the June 2010 Portland, ME meeting.

The committee reviewed the minutes of the meeting held June 25-26 in Portland, ME. No changes were proposed

Motion to accept the minutes as amended: Wayne Haase
Second: Tim Rehak

To approve the Minutes of the June 25-26 meeting

Motion carried

Agenda Items #5: Chairman's Remarks

Chairman Varner welcomed all members and guests to San Diego. He then explained that proposal closing date for NFPA 1982 will be May 23, and the TC will need to meet by August 5. The comment period for NFPA 1801 will be open until August 30, and the TC will need to meet before October 7 to review any comments received.

Problematic items from NFPA 1801 have been compiled. Most have been addressed in an errata, which has been released. Some items need to be corrected with a TIA, which is currently being processed. The TIA will need to go to the TCC for a letter ballot, and then to the Standards Council, as the Standards Council has to approve all TIAs. Both the errata and TIA times become proposals for the next revision of the document.

The TC then reviewed the proposed TIA items. They will be open for public comment until Feb. 11.

Agenda Item #6: Task group on Alarm Sounds – Report

Francine Amon gave the task group report on alarm sounds. The sample tones submitted were normalized to account for different recording sound files. The TC listened to all of the sample tones and would like to narrow the samples to 3-4 from which to select the new tone.

Agenda Item #7: Task group on Intrinsic Safety – Report

Wayne Haase gave the task group report on intrinsic safety. The task group reviewed the potential benefits and risks of going from Class I Division 1 to Class I Division 2. They reported that the task group found no real benefit in lowering or removing intrinsic safety with the items tested and recommended no change to IS be made in 1982.

Presentation on Radio Frequency

Dr. Kate Remley presented research related to proposed test methods for RF-Based PASS devices that NIST Boulder has been working on. Chairman Varner appointed a task group for radio frequency. The task group members are: Wayne Haase, Jack Jarboe, Craig Parkulo, Kate Remly, Gordon Sletmoe, and Steve Weinstein.

Agenda Item #8: Review of NFPA process for handling Public and Committee Proposals

Staff Liaison Trebisacci reviewed the process for handling public and committee proposals.

Agenda Item #9: Review and discussion of Proposals received on NFPA 1801

The TC reviewed the proposals received on NFPA 1801.

Agenda Item #10: Review and discussion on Committee Proposals for NFPA 1801

The TC discussed and reviewed committee proposals on NFPA 1801.

Agenda Item #9: Presentation of proposed test methods for radio based PASS; Dr. Kate Remley, Project Leader, Metrology for Wireless Systems; NIST RF Fields Group

Dr. Kate Remley presented research related to proposed test methods for RF-Based PASS devices that NIST Boulder has been working on. Chairman Varner appointed a task group for radio frequency. The task group members are: Wayne Haase, Jack Jarboe, Craig Parkulo, Kate Remly, Gordon Sletmoe, and Steve Weinstein.

Agenda Items #11: Future document(s) discussion

Chairman Varner let the TC know that we have not yet asked Standards Council about a portable radio standard, but that is still forthcoming. He also said we will be seeking permission for NFPA 1800 to enter either the Annual or Fall cycle of 2013 .

Agenda Item #12: Old business

None discussed.

Agenda Item #13: New Business

Tentative dates for the next meeting are Aug 3-5, 2011, at Worchester, MA.

Agenda Item #14: Adjourn at close of business

Having no further business, Chairman Varner sought a motion to adjourn the meeting.

Motion: Mike McKenna

Second: Steve Weinstein

To adjourn the meeting

Motion passed

Chairman Varner adjourned the meeting at 1 p.m.

Task Group on proposed NFPA 1800

The TG on proposed NFPA 1800 met to discuss what is needed for this document. Those in attendance were added to the task group. TG members now include:

Chairman Varner
Kamil Agi
Fran cine Amon
Bob Athanas
Craig Gestler
Jeff Hull
David Little
Andrew Lock

Mike McKenna
John Morris
Larry Nyberg
Tim Rehak
Kate Remley
Chris Spoons
Steve Townsend

Respectfully submitted,

Chris Spoons, Secretary
TC on ESE

Attachments:
Annual 2012 Revision Cycle Calendar
Fall 2012 Revision Cycle Calendar

ANNUAL 2012 REVISION CYCLE

	Process Stage	Process Step	Dates for TC	Dates for TCC
1	Preliminary	1.0 Notification of intent to enter cycle	7/9/10	7/9/10
2	Report on Proposals (ROP)	2.1 Proposal closing date	11/23/10*	11/23/10*
		2.2 Final date for ROP meeting	2/25/11	2/4/11
		2.3 Final date for mailing TC ballots	3/18/11	2/18/11
		2.4 Receipt of (TC) ballots by staff liaison	4/22/11	3/11/11
		2.5 Receipt of TC recirculation ballots	5/6/11	3/18/11
		2.6 Final date for TCC meeting		4/15/11
		2.7 Final date for mailing TCC ballots		4/22/11
		2.8 Receipt of TCC ballots		5/13/11
		2.9 Receipt of TCC recirculation ballots		5/20/11
		2.10 Final copy (w/ ballot statements) to Secretary, Standards Council	5/13/11	5/27/11
		2.11 Completion of Reports	5/20/11	6/3/11
		2.12 ROP Published and Posted	6/24/11	6/24/11
3	Report on Comments (ROC)	3.1 Comment closing date	8/30/11	8/30/11
		3.2 Final date for ROC meeting	11/4/11	10/7/11
		3.3 Final date for mailing TC ballots	11/18/11	10/21/11
		3.4 Receipt of (TC) ballots by staff liaison	12/2/11	11/11/11
		3.5 Receipt of TC recirculation ballots	12/9/11	11/18/11
		3.6 Final date for TCC meeting		12/16/11
		3.7 Final date for mailing TCC ballots		12/23/11
		3.8 Receipt of TCC ballots		1/13/12
		3.9 Receipt of TCC recirculation ballots		1/20/12
		3.10 Final copy (w/ ballot statements) to Secretary, Standards Council	12/23/11	1/27/12
		3.11 Completion of Reports	1/13/12	2/3/12
		3.12 ROC Published and Posted	2/24/12	2/24/12
4	Tech Session Preparation & Issuance of Consent Documents	4.1 Notice of Intent to Make a Motion (NITMAM) Closing Date	4/6/12	4/6/12
		4.2 Posting of Filed NITMAM	5/4/12	5/4/12
		4.3 Council Issuance Date for Consent Documents	5/29/12	5/29/12
		4.4 Appeal Closing Date for Consent Documents	6/13/12	6/13/12
5	Technical Session	5.0 Association Meeting for Documents with Certified Amending Motions	6/4-7/12	6/4-7/12
6	Appeals & Issuance of Documents w/CAMS	6.1 Appeal closing date for Documents with Certified Amending Motions	6/27/12	6/27/12
		6.2 Council issuance for Documents with Certified Amending Motions	8/9/12	8/9/12

* Proposal Closing Dates may vary according to documents and schedules for Revision Cycles may change. Please check the NFPA website (www.nfpa.org) for the most up-to-date information on proposal closing dates and schedules.

FALL 2012 REVISION CYCLE

	Process Stage	Process Step	Dates for TC	Dates for TCC
1	Preliminary	1.0 Notification of intent to enter cycle	1/7/11	1/7/11
2	Report on Proposals (ROP)	2.1 Proposal closing date	5/23/11*	5/23/11*
		2.2 Final date for ROP meeting	8/26/11	8/5/11
		2.3 Final date for mailing TC ballots	9/16/11	8/19/11
		2.4 Receipt of (TC) ballots by staff liaison	10/21/11	9/9/11
		2.5 Receipt of TC recirculation ballots	11/4/11	9/16/11
		2.6 Final date for TCC meeting		10/14/11
		2.7 Final date for mailing TCC ballots		10/21/11
		2.8 Receipt of TCC ballots		11/11/11
		2.9 Receipt of TCC recirculation ballots		11/18/11
		2.10 Final copy (w/ ballot statements) to Secretary, Standards Council	11/11/11	11/25/11
		2.11 Completion of Reports	11/18/11	12/2/11
		2.12 ROP Published and Posted	12/23/11	12/23/11
3	Report on Comments (ROC)	3.1 Comment closing date	3/2/12	3/2/12
		3.2 Final date for ROC meeting	5/4/12	4/6/12
		3.3 Final date for mailing TC ballots	5/18/12	4/20/12
		3.4 Receipt of (TC) ballots by staff liaison	6/1/12	5/11/12
		3.5 Receipt of TC recirculation ballots	6/8/12	5/18/12
		3.6 Final date for TCC meeting		6/15/12
		3.7 Final date for mailing TCC ballots		6/22/12
		3.8 Receipt of TCC ballots		7/13/12
		3.9 Receipt of TCC recirculation ballots		7/20/12
		3.10 Final copy (w/ ballot statements) to Secretary, Standards Council	6/22/12	7/27/12
		3.11 Completion of Reports	7/13/12	8/3/12
		3.12 ROC Published and Posted	8/24/12	8/24/12
4	Tech Session Preparation & Issuance of Consent Documents	4.1 Notice of Intent to Make a Motion (NITMAM) Closing Date	10/5/12	10/5/12
		4.2 Posting of Filed NITMAM	11/2/12	11/2/12
		4.3 Standards Council Issuance Date for Consent Documents	11/27/12	11/27/12
		4.4 Appeal Closing Date for Consent Documents	12/12/12	12/12/12
5	Technical Session	5.0 Association Meeting for Documents with Certified Amending Motions	6/2-6/13	6/2-6/13
6	Appeals & Issuance of Documents w/ CAMS	6.1 Appeal closing date for Documents with Certified Amending Motions	6/26/13	6/26/13
		6.2 Council issuance for Documents with Certified Amending Motions	8/1/13	8/1/13

* Proposal Closing Dates may vary according to documents and schedules for Revision Cycles may change. Please check the NFPA website (www.nfpa.org) for the most up-to-date information on proposal closing dates and schedules.

1982- Log #1 FAE-ELS **Final Action:**
(6.4.3.5, 7.1, and 8.2)

Note: This Proposal appeared as Comment 1982-34 (Log #95) which was held from the F2006 ROC on Proposal 1982-2.
Submitter: John G. Casali, , Jeff A. Lancaster
Recommendation: Casali and Lancaster of Virginia Tech were asked by NFPA TC/ESE to provide a draft of a test protocol for acoustic alarms ONLY under NFPA 1800. This test protocol was presented in draft at the January 2006 meeting. It was not in final form, and is now under study by a Task Group (TG). Our concerns with NFPA 1982, 6.4.3.5 and Section 7.1, center on the sound pressure level (SPL), frequency content, and lack of a comprehensive test protocol (Section 8.2) to verify these parameters, and in addition, to verify the directionality of the alarm that is so critical to providing localization cues needed by rescuers. The alarm and its test specification for 1800 should be accommodated in the 1982 requirements.

In regard to the temperature test on acoustic alarms, we believe that if this type of test is adopted (and we clearly understand the need for it), there also should be a methodology for relating (analytically) the SPI measured in the temperature chamber to that obtained in the umbrella 1800 acoustic test protocol. This "predictive" relationship would likely be quantified via regression equations, and based on a large and diverse test sample of products.
Substantiation: The comment above was meant to convey the complex nature of the issue, and the fact that the TG assigned to the issue has not had time to adequately review and discuss the issue by the time of this standard's comment submission deadline.

1982- Log #2 FAE-ELS **Final Action:**
(6.13.5)

Note: This Proposal appeared as Comment 1982-36 (Log #72) which was held from the F2006 ROC on Proposal 1982-2.
Submitter: David E. Mills,
Recommendation:

Include 1982_L2_R.doc

Substantiation: Adding the Audibility Correlation Test During Heat Stress Test) will eliminate the need to have audibility measuring equipment located inside the variable ambient oven, yet, verify that the samples produce acceptable results.

Add text to read as follows:

6.13.5 Audibility Correlation Test (During Heat Test)

6.13.5.1 Prior to conducting the Heat Test, the sound pressure output for the PASS device shall be positioned on the horizontal plane “x” distance for the acoustic measuring device. The sound measuring device shall have the capability of measuring the A-weighted sound pressure (“x” represents the distance defined by the manufacturer in order to safely conduct the audibility test). Detailed test methods shall be maintained by the manufacturer.

6.13.5.2 The Heat Test shall be conducted.

6.13.5.3 Following 5 minutes of exposure as identified in the Heat Test “paragraph TBD”, the sound pressure of the sample shall be recorded using the same method noted in 6.13.5.1.

6.13.5.4 The sound pressure correlation measurement recorded in 6.13.5.1 and 6.13.5.3 shall use linear regression calculations consisting of a correlation coefficient confidence level of at least 95 percent and a minimum sound pressure equivalence of “sound pressure dbA TBD”

6.13.5.5 6.13.5.1 through 6.13.5.3 shall be repeated 3 times on 3 separate samples.

Rational:

In this method, linear regression can be used to approximate the best fit between two or more data points (measured data during Heat Test vs. Anachoic Chamber data) and the minimum sound pressure of “TBD” dbA.

Audibility Correlation Calculation Method Using Linear Regression:

Note that the entire polynomial solution has not been displayed, only the end result formulas. Detailed polynomial information can be found in reference material such as Probabilistic Methods of Signal and System Analysis by George R. Cooper and Clare D. McGillem.

General Theory:

Beginning with the equation of a line: y =a + bx

where

y = the minimum sound pressure that must be achieved during the Heat Test.

x = the minimum fixed sound pressure, “TBD”

a = the intercept point for the sound pressure as measured during the Heat Test

$$b = \frac{n\sum_{i=l}^{n} x_i y_i - \sum_{i=l}^{n} x_i \sum_{i=l}^{n} y_i}{n\sum_{i=l}^{n} x_1^2 - \left(\sum_{i=l}^{n} x_i\right)^2}$$

$$a = \frac{n\sum_{i=l}^{n} y_i - b\sum_{i=l}^{n} x_i}{n}$$

INSERT Artwork HERE
Scatter Plot Example

The Correlation Coefficient is a determination of how closely the data correlates to a straight line. The Correlation Coefficient will range from -1 to +1. At 4 = -1, the data lands directly on the line with a negative slope. At r = +1, the data falls directly on the line with a positive slop. If r = 0, the data cannot be approximated at all by the straight line.

Correlation Coefficient (r)

x = a' + b'y

where

$$b' = \frac{n\sum_{i=l}^{n} x_i y_i - \sum_{i=l}^{n} x_i \sum_{i=l}^{n} y_i}{n\sum_{i=l}^{n} y_i^2 - \left(\sum_{i=l}^{n} y_i\right)^2}$$

With *b'* now defined, the correlation coefficient, denoted as r or R, is:

$$r = \sqrt{bb'}$$

With the correlation coefficient now determined, using the Variance Explained or Confidence Factor (r^2), the variance in Y is predicted by the X variable. This mans that we can assign a % relationship to the variance to best determine if the data obtained is sufficient enough to qualify the results.

Variance Explained = $r^2 \times 100$

Example:

A pass device is required to produce a minimum sound pressure of 110 dbA. During testing in the Anachoic Chamber, three different samples were tested with the following results:

Sample 1 – Produced a sound pressure of 115 dbA
Sample 2 – Produced a sound pressure of 110.dbA
Sample 3 – Produced a sound pressure of 112 dbA

The sound pressure is to be recorded before and during the Heat Test. The results recorded before the Heat Test will help identify the correlating minimum value that must be obtained during the Heat Test.

The following sound pressure results were obtained prior to conducting the Heat Test, but while the samples were in the variable ambient chamber.

The following sound pressure results were obtained prior to conducting the Heat Test, but while the samples were in the variable ambient chamber.

Sample 1 – Produced a sound pressure of 87 dbA
Sample 2 – Produced a sound pressure of 82 dbA
Sample 3 – Produced a sound pressure of 84.5 dbA

y = a + bx

x = 110

slope (*b*) = 1.0714

intercept (*a*) = -36.03571

minimum Heat sound pressure reading (*y*) = 81.8 dbA

r = 0.9643

r^2 = 0.93% confidence

Scatter plot points are illustrated in the Audibility Correlation diagram as shown below:

INSERT Artwork HERE
Audibility Correlation

1982- Log #3 FAE-ELS **Final Action:**
(6.13.5)

Note: This Proposal appeared as Comment 1982-37 (Log #112) which was held from the F2006 ROC on Proposal 1982-2.

Submitter: Jeff A. Lancaster,

Recommendation: Add new text to read:

6.13.5 Audibility Correlation Test (During Heat Test).

6.13.5.1 Prior to conducting the Heat Test, the sound pressure output for the PASS device shall be positioned on the horizontal plane "x" distance from the acoustic measuring device. The sound measuring device shall have the capability of measuring the A-weighted sound pressure ("x" represents the distance defined by the manufacturer in order to safely conduct the audibility test). Detailed test methods shall be maintained by the manufacturer.

6.13.5.2 The Heat Test shall be conducted.

6.13.5.3 Following 5 min. of exposures identified in the Heat Test "paragraph TBD", the sound pressure of the sample shall be recorded using the same method noted in 6.13.5.1.

6.13.5.4 The sound pressure correlation measurement recorded in 6.13.5.1 and 6.13.5.3 shall use linear regression calculations consisting of a correlation coefficient confidence level of at least 95 percent and a minimum sound pressure equivalence of "sound pressure dbA TBD".

6.13.5.5 6.13.5.1 through 6.13.5.3 shall be repeated 3 times on 3 separate samples.

Substantiation:

Include 1982_L3_S.doc

1982- Log #4 FAE-ELS **Final Action:**
(7.1.2.2)

Note: This Proposal appeared as Comment 1982-45 (Log #77) which was held from the F2006 ROC on Proposal 1982-2.

Submitter: Jason L. Allen, Intertek Testing Services

Recommendation: Add "at a minimum SPL of 75 dBA..." to 500 Hz requirement.

Substantiation: The committee has decided that 500 Hz is an important frequency for location of signals, and should specify a minimum SPL.

1982- Log #5 FAE-ELS **Final Action:**
(8.16)

Note: This Proposal appeared as Comment 1982-102 (Log #73) which was held from the F2006 ROC on Proposal 1982-2.

Submitter: David Hodson, Draeger Ltd.

Recommendation: Revise text to read as follows;

PASS shall be tested for resistance to vibration as specified in Section

8.16 ~~Tumble – Vibration Resistance Test.~~ Environmental testing Part 2: Tests Test Eb and guidance: Bump BS EN

8.16 ~~Tumble – Vibration Test.~~ Environmental testing Part 2: Tests Test Eb and guidance: Bump BS EN 60068 2-29 1993

~~8.16.5.1 Test in accordance with appendix table 11 40g 6ms 4000 bumps in the as worn direction~~

Substantiation: This a more reliable test method and will stress the electronic components in a controlled and repeatable manner.

Rationale: In this method, linear regression can be used to approximate the best fit between two or more data points (measured data during Heat Test vs. Anachoic Chamber data) and the minimum sound pressure of “TBD” dbA.

Audibility Correlation Calculation Method Using Linear Regression:

Note that the entire polynomial solution process has not been displayed, only the end result formulas. Detailed polynomial information can be found in reference material such as Probabilistic Methods of Signal and System Analysis by George R. Cooper and Clare D. McGillem

General Theory:

Beginning with the equation of a line: $y = a + bx$

Where:

y = the minimum sound pressure that must be achieved during the Heat Test.

x = the minimum <u>fixed</u> sound pressure, “TBD”

a = the intercept point for the sound pressure as measured during the Heat Test

b = the slope of the line

Scatter Plot Example – Illustrates the best fit for the line for a given distribution of data points.

INSERT Scatter Plot Example HERE

$$b = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

$$a = \frac{n\sum_{i=1}^{n} y_i - b\sum_{i=1}^{n} y_i}{n}$$

The Correlation Coefficient is a determination ofhow closely the data correlates to a straight line. The Correlation Coefficient will range from -1 to +1. At r = -1, the data lands directly on the line with a negative slope. At r = +1, the data falls directly on the line with a positive slope. If r = 0, the data cannot be approximated at all by the straight line.

Correlation Coefficient (r)

Calculating the Coefficient b’ is as follows:

$x = a' + b'y$

where

$$b' = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}$$

With b’ now defined, the correlation coefficient, denoted as r or R, is:

$$r \equiv \sqrt{bb'}$$

With the correlation coefficient now determined, using the Variance Explained or Confidence Factor (r^2), the variance in Y is predicted by the X variable. This means that we can assign a % relationship to the variance to best determine if the data obtained is sufficient enough to qualify the results.

Variance Explained = $r^2 \times 100$

Example:

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The sound pressure is to be recorded before and during the Heat Test. The results recorded before the Heat Test will help identify the correlating minimum value that must be obtained during the Heat Test.

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$y = a + bx$

$x = 110$

slope $(b) = 1.0714$

intercept $(a) = -36.03571$

minimum Heat sound pressure reading $(y) = 81.8$ dbA

$r = 0.9643$

$r^2 = 0.93\%$ confidence

Scatter plot points are illustrated in the following Audibility Correlation diagram

INSERT Audibility Correlation Figure HERE

1982- Log #6 FAE-ELS **Final Action:**
(6.4.3, 7.1.2, and Chapter 8)

Submitter: Bruce H. Varner, Santa Rosa Fire Department
Recommendation: Change Sections 6.4.3, 7.1.2 and Chapter 8 to provide that the "Alarm Signal" on all PASS devices meeting the requirements of the standard SHALL provide an identical sound that is clearly identifiable as the "Alarm Signal".
Substantiation: Currently different manufacturers of PASS utilize different sounds that meet the requirements of the standard. This can result in confusion on the fire ground as to the meaning of the sounds and a failure to identify a distress alarm. This is of particular importance when departments are operating in mutual aid scenarios where there may be multiple brands of PASS devices worn by firefighters from different agencies.

1982- Log #7 FAE-ELS **Final Action:**
(6.3)

Submitter: Kevin M. Roche, Phoenix Fire Dept., AZ
Recommendation: Revise text as follows:
6.3.2 PASS shall sound the alarm signal specified in 6.4.3 when the PASS does not sense movement for 30 seconds +5/-0 seconds.
6.3.2.1 PASS shall be permitted to sound the alarm signal specified in 6.4.3 when the PASS does not sense movement for 60 seconds +5/-0 seconds.
6.3.3 The alarm signal shall be preceded by a pre-alarm signal as specified in 6.4.2 that shall sound 10 seconds, +3/-0 seconds before the sounding of the alarm signal.
Substantiation: Most fire service SCBA are purchased with integrated PASS devices. The current standard requires pre-alert activation and alarm activation within 30 seconds when the PASS does not sense movement. This causes numerous pre-alerts and alarm activations when no emergency exists. Firefighters used to hearing inadvertent activations will be less likely to respond to an alarm activation for a firefighter in distress. Extending the time increment to 60 seconds will reduce unnecessary activations and improve firefighter safety. Extension of this time increment will have minimal impact on the time needed to locate and rescue a firefighter in distress.

1982-(6.1) Log #8 FAE-ELS **Final Action:**

Submitter: Jack Jarobe, Grace Industries Inc.

Recommendation: Add new text as follows:

All PASS, shall incorporate, as part of the system:

1. Two way distress/evacuation, individual/team/mass evacuation notification
2. Electronic personnel accountability
3. Person to person local distress notification
4. Automatic electronic PAR checks and Automatic electronic Roll Call

Substantiation: During the development of the 2007 Edition of the PASS Standard, the Technical Committee seriously considered including electronic distress and evacuation signaling as part of the minimum requirements for the Standard. However, in the absence of appropriate test methods to determine the reliability of these features they were placed in the ANNEX of the 2007 Edition.

Recently, NIST made a presentation at the NFPA ESE TC which showed that they have developed the appropriate testing criteria to determine the reach and penetration of RF Signaling. A number of manufacturers currently offer products that meet or exceed the features submitted in this proposal. Having commercial products readily available would allow for these new tests to be validated.

Each year and average of 105 fire fighters die in the line of duty. To address this continuing national occupational fatality problem, NIOSH conducts independent investigations of fire fighter line of duty deaths. These excellent reports are very comprehensive and offer specific recommendations to improve firefighter safety.

I carefully reviewed every LODD report posted for the past 10 years (period of December 22, 1999 through February 19, 2009) and discovered many of the same reoccurring problems we continue to see year after year. Fifty two Firefighters died in the line of duty during the forty incidents selected for this proposal. Had the proposed technology been in place during this period many, if not most, of these deaths could have been avoided. The four features included in this proposal are supported by recommendations made by NIOSH Investigators: The most redundant recommendations germane to this proposal are as follows:

- *Ensure that fire command always maintains close accountability for all personnel at the fire scene*
- *Consider ways to enhance the effectiveness of the personnel accountability system*
- *Ensure personnel accountability reports (PAR) are conducted in an efficient, organized manner and results are reported directly to the IC*
- *Use evacuation signals when command personnel decide that all fire fighters should be evacuated from a burning building or other hazardous area*
- *Instruct and train fire fighters on initiating emergency traffic (Mayday-Mayday) and on the importance of activating their personal alert safety system (PASS) device when they become lost, disoriented, or trapped*

The 40 incidents where these 52 Firefighters perished are included in this proposal review. I did not include the incident at the World Trade Center on September 11, 2001. However, I did speak with Fire Chief Hayden approximately six months following the incident.

He told me that they could not get an Evacuation message to the Firefighters in the second tower because the Aircraft had taken out the repeaters necessary for both “Evac and Mayday” distress signaling. The technology available today for “Distress and Evac signaling” comes with self contained repeaters dedicated solely for that purpose. They would not rely on or interfere with radio systems used by the fire or EMS operations.

Had the Command Staff had the benefit of technology which allowed for pushing one button to initiate a “Mass Evacuation”, all of the Firefighters in that tower had a very good chance of surviving. This technology is readily available today through a number of manufacturers. It has proven track record for the desired performance in “Super High Rise Buildings”

The following incidents were cut and pasted from the official NIOSH Line of Duty Death investigations for the period of December 22, 1999 to February 19, 2009. You can access these reports by going to www.cdc.gov/niosh/fire.

F2009-07 Feb 19, 2009 Volunteer lieutenant and a fire fighter die while combating a mobile home fire - West Virginia

F2008-34 Oct 29, 2008 Volunteer fire fighter dies while lost in residential structure fire - Alabama

F2008-26 Jul 22, 2008 A volunteer mutual aid fire fighter dies in a floor collapse in a residential basement fire - Illinois

F2008-20 May 06, 2007 Volunteer fire fighter dies while performing exterior fire suppression at a large machine shed fire - Illinois

F2008-09 Apr 08, 2008 A career captain and a part-time fire fighter die in a residential floor collapse - Ohio

F2008-08 Mar 05, 2008 Volunteer fire lieutenant killed while fighting a basement fire - Pennsylvania
F2008-07 Mar 07, 2008 Two career fire fighters die and captain is burned when trapped during fire suppression operations at a millwork facility - North Carolina
F2008-06 Feb 29, 2008 Volunteer fire fighter and trapped resident die and a volunteer lieutenant is injured following a duplex fire - Pennsylvania
F2008-03 Feb 22, 2008 Nine fire fighters from a combination department injured in an explosion at a restaurant fire - Colorado
F2007-35 Oct 29, 2007 Four career fire fighters injured while providing interior exposure protection at a row house fire - District of Columbia
F2007-32 Aug 29, 2007 Two career fire fighters die while making initial attack on a restaurant fire - Massachusetts
F2007-29 Aug 03, 2007 A volunteer mutual aid captain and fire fighter die in a remodeled residential structure fire - Texas
F2007-28 Jul 21, 2007 A career captain and an engineer die while conducting a primary search at a residential structure fire - California
F2007-18 Jun 18, 2007 Nine career fire fighters die in rapid fire progression at commercial furniture showroom - South Carolina
F2007-09 Feb 09, 2007 Career probationary fire fighter dies while participating in a live-fire training evolution at an acquired structure - Maryland
F2007-02 Nov 23, 2006 Career fire fighter injured during rapid fire progression in an abandoned structure dies six days later - Georgia
F2006-24 Jun 25, 2006 Volunteer deputy fire chief dies after falling through floor hole in residential structure during fire attack - Indiana
F2005-04 Jan 23, 2005 Career fire fighter dies while exiting residential basement fire - New York
F2005-03 Jan 23, 2005 Career lieutenant and career fire fighter die and four career fire fighters are seriously injured during a three alarm apartment fire - New York
F2005-02 Dec 20, 2004 One probationary career firefighter dies and four career firefighters are injured at a two - alarm residential structure fire - Texas
F2004-37 Apr 08, 2004 Volunteer chief dies and two fire fighters are injured by a collapsing church facade - Tennessee
F2004-17 Mar 13, 2004 Career battalion chief and career master fire fighter die and twenty-nine career fire fighters are injured during a five alarm church fire - Pennsylvania
F2004-10 Feb 18, 2004 Career fire fighter dies searching for fire in a restaurant/lounge - Missouri
F2004-04 Dec 16, 2003 Career fire fighter dies of carbon monoxide poisoning after becoming lost while searching for the seat of a fire in warehouse - New York
F2004-02 Nov 29, 2003 Basement fire claims the life of volunteer fire fighter - Massachusetts
F2002-12 Mar 01, 2002 Volunteer fire fighter killed and career chief injured during residential house fire - Tennessee
F2002-07 Feb 11, 2002 One career fire fighter dies and another is injured after partial structural collapse - Texas
F2002-06 Mar 07, 2002 First-floor collapse during residential basement fire claims the life of two fire fighters (career and volunteer) and injures a career fire fighter captain - New York
F2001-33 Oct 13, 2001 High-rise apartment fire claims the life of one career fire fighter (captain) and injures another career fire fighter (captain) - Texas
F2001-18 May 09, 2001 Career fire fighter dies after becoming trapped by fire in apartment building - New Jersey
F2001-16 Mar 08, 2001 Career fire fighter dies after falling through the floor fighting a structure fire at a local residence - Ohio
F2001-15 Mar 18, 2001 Residential fire claims the lives of two volunteer fire fighters and seriously injures an assistant chief - Missouri
F2001-13 Mar 14, 2001 Supermarket fire claims the life of one career fire fighter and critically injures another career fire fighter - Arizona
F2001-08 Feb 17, 2001 Two volunteer fire fighters die fighting a basement fire - Illinois
F2000-44 Nov 25, 2000 Residential house fire claims the life of one career fire fighter - Florida
F2000-26 Apr 20, 2000 Residential structure fire claims the life of one career fire fighter - Alabama
F2000-23 Mar 31, 2000 Career fire fighter dies and three are injured in a residential garage fire - Utah
F2000-16 Mar 03, 2000 Arson fire claims the life of one volunteer fire fighter and one civilian and severely injures another volunteer fire fighter - Michigan
F2000-13 Feb 14, 2000 Restaurant fire claims the life of two career fire fighters - Texas
F2000-04 Dec 22, 1999 Structure fire claims the lives of three career fire fighters and three children - Iowa

This is not original material; its reference/source is as follows:

Statistical information on Line of Duty Deaths was cut and pasted from the official NIOSH LODD Investigation Web Site at: www.cdc.gov/niosh/fire.

1982- (6.1) Log #9 FAE-ELS **Final Action:**

Submitter: Jack Jarboe, Grace Industries Inc.

Recommendation: New text to read as follows:

All PASS, shall incorporate, as part of the system:

1. Two way distress/evacuation, individual/team/mass evacuation notification
2. Electronic personnel accountability
3. Person to person local distress notification
4. Automatic electronic PAR checks and automatic electronic Roll Call

Substantiation: NFPA Standard 1982 2012 Edition (Numbering for the PASS Standard is being changed to 1882 to conform with the Technical Committee on Electronic Safety Systems Documents)

Chapter 6 Design Requirements

6.1 General Design Requirements for PASS

Insert the following language:

All PASS, shall incorporate, as part of the system:

(1) Two way distress/evacuation, individual/team/mass evacuation notification

(2) Electronic personnel accountability

(3) Person to person local distress notification

(4) Automatic electronic PAR checks and Automatic electronic Roll Call

Substantiation:

During the development of the 2007 Edition of the PASS Standard, the Technical Committee seriously considered including electronic distress and evacuation signaling as part of the minimum requirements for the Standard. However, in the absence of appropriate test methods to determine the reliability of these features they were placed in the ANNEX of the 2007 Edition.

Recently, NIST made a presentation at the NFPA ESE TC which showed that they have developed the appropriate testing criteria to determine the reach and penetration of RF Signaling. A number of manufacturers currently offer products that meet or exceed the features submitted in this proposal. Having commercial products readily available would allow for these new tests to be validated.

Each year and average of 105 fire fighters die in the line of duty. To address this continuing national occupational fatality problem, NIOSH conducts independent investigations of fire fighter line of duty deaths. These excellent reports are very comprehensive and offer specific recommendations to improve firefighter safety.

I carefully reviewed every LODD report posted for the past 10 years (period of December 22, 1999 through February 19, 2009) and discovered many of the same reoccurring problems we continue to see year after year. Fifty two Firefighters died in the line of duty during the forty incidents selected for this proposal. Had the proposed technology been in place during this period many, if not most, of these deaths could have been avoided. The four features included in this proposal are supported by recommendations made by NIOSH Investigators: The most redundant recommendations germane to this proposal are as follows:

- Ensure that fire command always maintains close accountability for all personnel at the fire scene
- Consider ways to enhance the effectiveness of the personnel accountability system
- Ensure personnel accountability reports (PAR) are conducted in an efficient, organized manner and results are reported directly to the IC
- Use evacuation signals when command personnel decide that all fire fighters should be evacuated from a burning building or other hazardous area
- Instruct and train fire fighters on initiating emergency traffic (Mayday-Mayday) and on the importance of activating their personal alert safety system (PASS) device when they become lost, disoriented, or trapped

The 40 incidents where these 52 Firefighters perished are included in this proposal review. I did not include the incident at the World Trade Center on September 11, 2001. However, I did speak with Fire Chief Hayden approximately six months following the incident.

He told me that they could not get an Evacuation message to the Firefighters in the second tower because the Aircraft had taken out the repeaters necessary for both “Evac and Mayday” distress signaling. The technology available today for “Distress and Evac signaling” comes with self contained repeaters dedicated solely for that purpose. They would not rely on or interfere with radio systems used by the fire or EMS operations.

Had the Command Staff had the benefit of technology which allowed for pushing one button to initiate a “Mass Evacuation”, all of the Firefighters in that tower had a very good chance of surviving. This technology is readily available today through a number of manufacturers. It has proven track record for the desired performance in “Super High Rise Buildings”

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F2008-34—Oct 29, 2008—Volunteer fire fighter dies while lost in residential structure fire - Alabama

F2008-26—Jul 22, 2008—A volunteer mutual aid fire fighter dies in a floor collapse in a residential basement fire - Illinois

F2008-20—May 06, 2007—Volunteer fire fighter dies while performing exterior fire suppression at a large machine shed fire - Illinois

F2008-09—Apr 08, 2008—A career captain and a part-time fire fighter die in a residential floor collapse - Ohio

F2008-08—Mar 05, 2008—Volunteer fire lieutenant killed while fighting a basement fire - Pennsylvania

F2008-07—Mar 07, 2008—Two career fire fighters die and captain is burned when trapped during fire suppression operations at a millwork facility - North Carolina

F2008-06—Feb 29, 2008—Volunteer fire fighter and trapped resident die and a volunteer lieutenant is injured following a duplex fire - Pennsylvania

F2008-03—Feb 22, 2008—Nine fire fighters from a combination department injured in an explosion at a restaurant fire - Colorado

F2007-35—Oct 29, 2007—Four career fire fighters injured while providing interior exposure protection at a row house fire - District of Columbia

F2007-32—Aug 29, 2007—Two career fire fighters die while making initial attack on a restaurant fire - Massachusetts

F2007-29—Aug 03, 2007—A volunteer mutual aid captain and fire fighter die in a remodeled residential structure fire - Texas

F2007-28—Jul 21, 2007—A career captain and an engineer die while conducting a primary search at a residential structure fire - California

F2007-18—Jun 18, 2007—Nine career fire fighters die in rapid fire progression at commercial furniture showroom - South Carolina

F2007-09—Feb 09, 2007—Career probationary fire fighter dies while participating in a live-fire training evolution at an acquired structure - Maryland

F2007-02—Nov 23, 2006—Career fire fighter injured during rapid fire progression in an abandoned structure dies six days later - Georgia

F2006-24—Jun 25, 2006—Volunteer deputy fire chief dies after falling through floor hole in residential structure during fire attack - Indiana

F2005-04—Jan 23, 2005—Career fire fighter dies while exiting residential basement fire - New York

F2005-03—Jan 23, 2005—Career lieutenant and career fire fighter die and four career fire fighters are seriously injured during a three alarm apartment fire - New York

F2005-02—Dec 20, 2004—One probationary career firefighter dies and four career firefighters are injured at a two - alarm residential structure fire - Texas

F2004-37—Apr 08, 2004—Volunteer chief dies and two fire fighters are injured by a collapsing church facade - Tennessee

F2004-17—Mar 13, 2004—Career battalion chief and career master fire fighter die and twenty-nine career fire fighters are injured during a five alarm church fire - Pennsylvania

F2004-10—Feb 18, 2004—Career fire fighter dies searching for fire in a restaurant/lounge - Missouri

F2004-04—Dec 16, 2003—Career fire fighter dies of carbon monoxide poisoning after becoming lost while searching for the seat of a fire in warehouse - New York

F2004-02—Nov 29, 2003—Basement fire claims the life of volunteer fire fighter - Massachusetts

F2002-12—Mar 01, 2002—Volunteer fire fighter killed and career chief injured during residential house fire - Tennessee

F2002-07—Feb 11, 2002—One career fire fighter dies and another is injured after partial structural collapse - Texas

F2002-06—Mar 07, 2002—First-floor collapse during residential basement fire claims the life of two fire fighters (career and volunteer) and injures a career fire fighter captain - New York

F2001-33—Oct 13, 2001—High-rise apartment fire claims the life of one career fire fighter (captain) and injures another career fire fighter (captain) - Texas

F2001-18—May 09, 2001—Career fire fighter dies after becoming trapped by fire in apartment building - New Jersey

F2001-16—Mar 08, 2001—Career fire fighter dies after falling through the floor fighting a structure fire at a local residence - Ohio

F2001-15—Mar 18, 2001—Residential fire claims the lives of two volunteer fire fighters and seriously injures an assistant chief - Missouri
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F2001-08—Feb 17, 2001—Two volunteer fire fighters die fighting a basement fire - Illinois
F2000-44—Nov 25, 2000—Residential house fire claims the life of one career fire fighter - Florida
F2000-26—Apr 20, 2000—Residential structure fire claims the life of one career fire fighter - Alabama
F2000-23—Mar 31, 2000—Career fire fighter dies and three are injured in a residential garage fire - Utah
F2000-16—Mar 03, 2000—Arson fire claims the life of one volunteer fire fighter and one civilian and severely injures another volunteer fire fighter - Michigan
F2000-13—Feb 14, 2000—Restaurant fire claims the life of two career fire fighters - Texas
F2000-04—Dec 22, 1999—Structure fire claims the lives of three career fire fighters and three children - Iowa
Respectfully submitted,
Jack Jarboe, Vice President
Grace Industries Inc.
6430 Weems Ave
Tracys Landing, ND 20779
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(w)443-964-8282

This is not original material; its reference/source is as follows:
Statistical information on Line of Duty Deaths was cut and pasted from the official NIOSH LODD Investigation Web Site at: www.cdc.gov/niosh/fire.

1982- Log #CP1 FAE-ELS **Final Action:**
(Entire Document)

Submitter: Technical Committee on Electronic Safety Equipment,
Recommendation: Review entire document to: 1) Update any extracted material by preparing separate proposals to do so, and 2) review and update references to other organizations documents, by preparing proposal(s) as required.
Substantiation: To conform to the NFPA Regulations Governing Committee Projects.

1982- Log #10 FAE-ELS **Final Action:**
(2.3.1)

Submitter: Bob Eugene, Underwriters Laboratories Inc.
Recommendation: Revise text as follows:
2.3.1 ANSI Publications.
American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.
ANSI/UL 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations, ~~Sixth edition,~~ July 31, 2006, Revised August 12, 2008.
ANSI B46.1, Surface Texture, 1978
ANSI S1.13, Methods for Measurement of Sound Pressure Level®, 2005.
ANSI Y1.1, Abbreviations for Use on Drawings and Text, 1972.
ANSI Y14.SM, Dimensioning and Tolerancing, 1982.
Substantiation: The edition published July 31, 2006 is the seventh edition. The differences between the sixth edition and the seventh edition of UL 913 are based on international harmonization efforts. The 2008 revisions to the standard correlate with the acceptable protection techniques defined in Section 506.8 of the NEC.

1982- Log #11 FAE-ELS **Final Action:**
(Chapter 1 through 6)

Submitter: Kate A. Remley, National Institute of Standards and Technology (NIST)
Recommendation: Add text to read as follows:

****Insert include 1982_L11_R.doc here****

Substantiation: RF-based PASS have been recently made available commercially. The 2007 Edition of NFPA does not include methods to test or verify the performance of RF-based PASS. This proposal provides informational background to support the NIST proposal. It is anticipated that this background material would be included as an informational Appendix in NFPA 1982.

1982- Log #12 FAE-ELS **Final Action:**
(Chapter 6 through 8)

Submitter: Kate A. Remley, National Institute of Standards and Technology (NIST)
Recommendation: Add text to read as follows:

****Insert include 1982_L12_R.doc here****

Substantiation: RF-based PASS have been recently made available commercially. The 2007 Edition of NFPA does not include methods to test or verify the performance of RF.-based PASS. The proposal includes proposed language, definitions, performance metrics, and test methods for RF-based PASS for possible inclusion in NFPA standard 1982.

1982- Log #13 FAE-ELS **Final Action:**
(8.11.4.1.3)

Submitter: Michael G. Feely, Boston Fire Department
Recommendation: Add text to read as follows:

A third test shall have the specimen positioned where the annunciator is oriented in a position that will contain the most water.

Substantiation: PASS devices may be found in many positions when a firefighter is down. The current test only reproduces two possible positions. There is a possibility that a PASS annunicator may fill with water and not be able to provide the necessary sound level.

NIST Tests of Representative Radio Propagation Environments to Support Development of RF-Based PASS Standards

Executive Summary

The National Institute of Standards and Technology (NIST) has been involved in a multi-year project to support development of performance metrics and test methods for standards for RF-based PASS devices. The work to date has focused on side-by-side tests designed to relate radio-propagation environment characteristics in representative firefighter environments to actual PASS performance in these same environments. Identifying which radio channel characteristics have the most significant effect on PASS performance enables development of lab-based test methods that can be used to evaluate PASS performance in the field.

NIST's work on RF-based PASS standards has been funded by the U.S. Department of Homeland Security's Office of Standards. The NIST Public-Safety Communications Research Lab has funded the measurements of the propagation channel.

In the propagation channel studies, NIST engineers measured path loss and the level of reflectivity (or "multipath," given by the RMS delay spread) in large public structures and environments where radio communications would potentially be difficult. These environments include multi-story buildings; buildings with subterranean floors; buildings with large, deep interior spaces; those with few windows; and outdoor "urban canyons," consisting of city streets surrounded by tall buildings.

To simulate an incident command post in the propagation environment studies, the transmit antenna was located outside each structure at an appropriate location. The receive antenna was placed at various discrete locations within the buildings in positions intended to provide data on locations that could potentially be problematic for radio reception. In each location, the path loss and RMS delay spread were measured using the VNA-based measurement method described in Section 2.

RF-based PASS measurements were conducted in the same locations as the channel characterization measurements by placing the PASS base station unit at the location of the VNA transmit antenna. Portable RF-based PASS devices were then carried to the same locations that the receive antenna had been placed. At each test location, the portable PASS operator sent an alarm from the PASS device, and the base station operator noted whether the alarm was received, not received, or received with a significant delay.

Because the portable RF-based PASS device has a lower transmit power than does the base station, the alarm from the PASS device was typically lost closer to the base station than vice versa. This is why our tests focused on whether or not the alarm from the portable RF-based PASS device was received by the base station.

We conducted tests in several environments, seven of which are described here, in terms of path loss, RMS delay spread, and success or failure of RF-based PASS transmissions. We tested two different commercially available RF-based PASS systems, one that operates on a licensed frequency in the 450 MHz public-safety narrowband frequency allocation, and one that operates in the unlicensed spectrum between 902 MHz and 938 MHz. The latter system was tested alone and with one repeater unit.

From these side-by-side measurements of the radio-propagation channel and RF-based PASS devices, we have been able to draw several important conclusions. First, the data indicate that attenuation, rather than multipath, is the most common cause of a missed alarm from an RF-based PASS device in the representative medium-to-large-structure radio-propagation environments that were studied.

A second conclusion is that there is a range of path-loss values that can be used to roughly classify various structures in terms low-, medium-, and high-attenuation environments. In the low-attenuation environments (defined here as less than 100 dB path loss), RF-based PASS devices could typically be operated successfully without a repeater. In the medium-attenuation environments, RF-based PASS devices could typically be operated with a single repeater. In the high attenuation environments, it is expected that RF-based PASS may face significant obstacles to reliable RF transmission (using current 2010 technology consisting of a base station transceiver and portable, body-worn transceivers).

A third conclusion can be drawn looking at the PASS performance tests conducted at an apartment building that had a cell-phone base station located on its roof. This structure did not present significant attenuation, yet both types of RF-based PASS devices we tested had significant difficulty in reliably communicating with the PASS base station. Radio interference such as this can present a potentially serious obstacle to RF-based PASS transmissions, and should be considered when deploying such systems.

The data and corresponding discussion have been used to develop recommendations for lab-based test methods for RF-based PASS devices. The test methods developed to date focus on inserting a controllable amount of attenuation between the portable PASS device and the PASS base station. The level of attenuation is increased to simulate a given amount of path loss, and the performance of the RF-based PASS system is noted when an alarm is sent from the portable unit to the base station. It is anticipated that additional test methods and standards will be forthcoming in the near future as well.

1.0 Introduction

This document describes NIST tests to characterize the radio propagation channel in representative firefighter environments, along with performance test of RF-based PASS devices in the same environments. In Section 2, we describe the measurement system and data-processing algorithms that we used in the channel characterization measurements, as well as certain assumptions and approximations that were made in analyzing the data. In Section 3, we then summarize the results of our measurements, relating RF-based PASS performance to radio channel characteristics where possible. The final sections present a complete summary of the environments that were studied and the data that were collected.

Because the data presented here were collected during field measurements, in some cases the RF-based PASS performance does not entirely agree with what might be expected theoretically. However, as will be shown, we can generally predict device performance based on the proposed attenuation limits described above.

2.0 Measurements of Path Loss and RMS Delay Spread

The goal of these channel characterization measurements was to provide typical values of path loss and RMS delay spread in representative responder environments for use in the development of technically sound standards and test methods. The work discussed here focuses on RF-Based PASS devices. We measured the wideband frequency response and time-delay characteristics of the outside-to-inside channel using a measurement system based on a vector network analyzer, shown in the figure below. This instrument collects data over a wide frequency range, by stepping through frequencies one at a time. This system, described in more detail in [1, 2], lets us measure the complex transfer function of the radio propagation channel. Using a free-space reference measurement, we can then calculate the path loss without including the effects of the antenna or other instrumentation. By taking the Fourier transform of the measured transfer function, the power delay profile and RMS delay spread of the channel may also be found in post processing.

We made measurements over a “low” frequency band that ranged from 100 MHz to 1.2 GHz, and a “high” frequency band, that ranged from 1 GHz to 18 GHz. The low-band measurements are reported on here because they coincide with the operating frequencies of the PASS devices we tested. We used omnidirectional transmit and receive antennas. The beamwidth of the omnidirectional antennas is approximately 40 ° to 50 ° in the vertical direction.

******Insert Figure 1 here******

Figure 1: Wideband measurement system based on a vector network analyzer. Frequency-domain measurements, synchronized by the optical fiber link, are transformed to the time domain in post-processing. Use of this system enables determination of path loss, time-delay spread, and other figures of merit important in characterizing modulated-signal transmissions.

To make a measurement, the vector network analyzer is first calibrated by use of standard techniques where known impedance standards are measured. The calibration enables us to correct for the response of the fiber-optic system, amplifiers, passive elements, and other electronics used in the measurement. We also high-pass filter our measurements in post processing to suppress the large, low-frequency oscillation that occurs in the optical fiber link.

2.1 Wideband Frequency Response and Path Loss

Our wideband measurements provide a complex channel transfer function $H(f)$, where $H(f)$ typically is derived from the measured transmission parameter $S_{21}(f)$. To find the frequency-dependent path loss between the transmit and receive antennas, we first compute $|H(f)|^2/|H_r(f)|^2$, where $H_r(f)$ is a free-space reference made at a known distance d_r from the transmit antenna. The use of a ratio to find the path loss enables us to calibrate out the antenna response of the system. Because the antenna response is common to both the reference and the measurement, dividing one by the other removes the antenna effects from the measurement. We correct the measurements for the free-space path loss between the transmit antenna and the reference location by dividing $|H_r(f)|^2$ by $(4\pi d_r/\lambda)$□^{2}.

The reference may be acquired either during field tests or from a laboratory measurement. For the measurements discussed in Section 3, the reference measurement distance d_r is specified in each case, and the free-space path loss corresponding to this distance is added to the path loss.

Because the measurements typically involve weak received signals, we use an amplifier in the link. To protect the instrumentation and optical fiber link, we include an attenuator when we are calibrating the VNA. As a result, the value of this attenuator must be added to the overall path loss as well.

Based on the above discussion, we calculate free-space path loss from our VNA measurements as (all quantities expressed in decibels):

Total Path Loss = $10*\log_{10}(|S_{21}(f)|^2/|S_{21r}(f)|^2)$ + calibration attenuator + reference measurement free-space loss.

2.2 RMS Delay Spread

The RMS delay spread is a figure of merit that quantifies the time it takes for reflections in a received signal to die out. We found the RMS delay spread from the measured complex channel transfer function as follows. First, transfer functions were windowed by means of a Hamming window to reduced delay-domain sidelobes. This technique is often employed with VNA measurements. Then the windowed transfer functions were inverse-Fourier-transformed to obtain bandpass channel impulse responses. These bandpass channel impulse responses were then downconverted and low-pass filtered with a fifth-order elliptic filter to suppress the double-frequency components. For a channel impulse response denoted $h(\tau, t_i)$, the corresponding i^{th} ("instantaneous") power delay profile (PDP) was computed as $P_i(\tau)=|h(\tau, t_i)|^2$, where τ denotes the decay time and t denotes the time at which the measurement was taken.

When multiple measurements were available from a particular site, we took the average of the instantaneous power delay profiles to compute the RMS delay spread. When only a single measurement was available, we found the "instantaneous" RMS delay, which provides a rough approximation of the RMS delay spread. RMS delay spread is calculated as the square root of the second central moment of the power-delay profile of a measured signal. The RMS delay spread σ_τ can be defined as

$$\sigma_\tau = \sqrt{\overline{\tau^2} - \left(\overline{\tau}\right)^2}. \qquad (1)$$

In (1), $\overline{\tau}$ is defined as the average value of the power-delay profile in the defined dynamic range window, and $\overline{\tau^2}$ is the variance of the power-delay profile within this window. The figure above shows the power-delay profile for a representative building propagation measurement. The peak level usually occurs when the signal first arrives at the receiving antenna, although in high multipath environments we sometimes see the signal build up over time to a peak value and then fall off.

******Insert Figure 2 here******

Figure 2: Power-delay profile for a building propagation measurement. Important parameters for a measured signal are the peak level, the maximum dynamic range, the mean delay, and the RMS delay spread.

A common rule of thumb is to calculate the RMS delay spread from signals at least 10 dB above the noise floor of the measurement. For the measurements described in the following sections, we used the method described in [2] to determine the useful dynamic range of each measurement. Where insufficient dynamic range existed, no RMS delay spread was calculated.

2.3 Measurement considerations

Several additional factors contributed to the measurement results presented in Section 3. We describe them here so that readers will be aware of the approximations involved in the propagation channel measurements below. These considerations lead to increased uncertainties in the path loss measurements described in Section 3.

2.3.1 Path Loss at 700 MHz

The path loss and RMS delay spread data presented in Sections 3 and 5 were gathered over the frequency band 725 MHz to 800 MHz (unless noted), rather than at the operating frequencies of the RF-based PASS devices. This was done for two reasons: First, both the 450 MHz and 900 MHz bands are typically heavily used. Collecting propagation channel data that is unaffected by external radio interference is difficult, as shown in Figure 3 on the next page.

NIST also had collected a significant amount of propagation channel data in the 700 MHz frequency band as part of a study for emergency response use of the newly allocated band. We were able to leverage the data collected for that project in our study of RF-based PASS performance.

An analysis was conducted of the difference in received power in the 700-800 MHz band compared to 400-500 MHz and 900-1000 MHz. Data from measurements at a high-rise building (Republic Plaza, Denver, CO) were used. For this analysis, four sites were selected: Receive sites 1, 2, 16 and 21 (shown in the diagram in Section 4 of this document). The analysis was conducted by averaging the $|S_{21}|^2$ over the 700-800 MHz band and comparing that number to the average $|S_{21}|^2$ across another band. Between the four sites analyzed, the difference between the band averages ranged from 1.50 dB to 3.10 dB depending on the site. The results are presented in the table below.

Site Number	Average over 700-800 MHz (dB)	Average over 400-500 MHz (dB)	Average over 900-1000 MHz (dB)	Max. Difference (dB), absolute value
1	-20.59	-21.77	-17.49	3.10
2	-40.58	-38.86	-39.58	1.72
16	-57.42	-59.95	-58.96	2.53
21	-60.39	-61.89	-61.75	1.50

It should be emphasized that, due to the potential presence of interferers, the 400 MHz and 900 MHz values may be incorrect. This comparison simply shows that an additional uncertainty in the path loss calculations of around 1 to 3 dB can be expected by using the 700 MHz band.

******Insert Figure 3 here******

Figure 3: The lower red curve in each graph shows the “noise floor” of the VNA measurements made in the Denver urban canyon. The large spikes correspond to interference from radio signals present in the environment. The upper left graph shows the frequency range from 300 MHz to 1 GHz. Interferers can be seen in the mid-400 MHz band and the 900 MHz band. The other graphs show zoomed-in views of these bands, and the 725 MHz to 800 MHz band used in the data presented below. Nine measurements were taken in the 700 MHz band, with the mean and standard deviation indicated.

2.3.2 Use of Field Reference Files vs. Controlled Environment Reference Files

As described above, path loss measurements require the use of a reference file to calibrate out the frequency-dependent loss of the antenna and connecting cables. The reference measurement is made by placing the receive antenna a known distance from the transmit antenna and conducting a VNA measurement. Subsequent measurements made at the field test location are corrected using the reference measurement. Reference measurements made on site at a field test location can include the effects of environmental reflections and interferers. Figure 4 shows two reference measurements covering the frequency range from 100 MHz to 1.2 GHz. The top plot shows a 4 m reference made in the Denver Urban Canyon environment described in the following sections, while the bottom plot shows a 4 m reference made on the NIST open-area test site. The controlled reference measurement is smoother and does not show the dips around 400 MHz, 600 MHz, and 1 GHz that the field reference shows.

******Insert Figure 4 here******

Figure 4: Graphs showing two different 4 m reference files over the frequency range 100 MHz to 1.2 GHz. Top: Denver, CO urban canyon. Bottom: NIST open-area test site.

Based on the graphs in Figure 4 above, it appears to be preferable to use reference measurements made in a controlled environment such as an open-area test site. However, the controlled-environment tests must be made using the same equipment, (antennas, cables, amplifiers, etc.) that were used in the field tests or the calibration will have some errors. It was not possible to perform the controlled-environment reference measurement for all measurements reported in the following sections.

An analysis was conducted of the difference in path loss when two different reference files were used. The data below correspond measurements at five locations on the second floor of the Horizon West apartment building, Boulder, CO. It is clear that even though the reference files may appear to be quite different, the effect on the final path loss result is minimal.

Receiver Location	Field Reference File (dB)	Controlled-environment Reference File (dB)
1	86.13	86.13
2	82.78	82.79
3	77.66	77.67
4	78.34	78.35
5	91.12	91.12

2.4 References

[1] Kate A. Remley, Galen Koepke, Christopher L. Holloway, Chriss Grosvenor, Dennis Camell, John Ladbury, Robert T. Johnk, William F. Young, "Radio Wave Propagation Into Large Building Structures; Part 2, Characterization of Multipath," *IEEE Trans. Antennas Propagat.*, accepted for publication, 2010.

[2] David W. Matolak, Kate A. Remley, Camillo Gentile, Christopher L. Holloway, Qiong Wu, Qian Zhang, "Ground-Based Urban Channel Characteristics for Two Public Safety Frequency Bands**,"** *In review*, 2010.

3.0 Data Analysis

In this section, we discuss the results of NIST measurements of path loss and RMS delay spread from several different environments. The presentation of the data is designed to assist in classifying propagation environments for development of standards for RF-based PASS. The key points that we extract from the data are: (1) Typical levels of attenuation and RMS delay spread for representative firefighter environments (this will allow us to set limits for lab-based RF-PASS testing); (2) The mechanisms that cause the RF-based PASS transmissions to fail, specifically, whether attenuation, multipath, or external radio interference the dominant impairment (this will allow us to develop appropriate lab-based test methods).

The data also provide a qualitative comparison of RF-based PASS performance with and without repeaters, and at two different frequencies of operation. Note that the PASS results are purely qualitative: during testing, the position of the device was slightly different from the VNA measurements, the device battery charge was not monitored, and numerous other small differences between the tests mean that direct comparison is not possible.

The data presented below are ordered with the environments providing the lowest path loss first. We plot the RMS delay spread vs. path loss at each location within a structure. The success of a PASS transmission is indicated by a blue circle, the failure of a transmission by a red x and a significant delay (over 1 minute) by a green diamond. This representation allows us to investigate which mechanisms have the most impact on PASS performance. The complete set of graphs follows the discussion in Sections 3.1 – 3.3.

3.1 Notes on measurement results

Here we provide additional information on the measurement data collected in various radio-propagation environments. Consult the graphs that follow for more information.

- **Denver urban canyon – down street, around one corner**: This was the only outdoor-to-outdoor environment studied. The path loss was between 45 dB and 90 dB, but the RMS delay spread is as high as 220 ns, one of the larger values measured. With few exceptions, the PASS devices operated successfully in this environment.
- **Horizon West – 12-story apartment building, floors 2 and 7**: The path loss was not high, between 75 dB and 100 dB, and the RMS delay spread was less than 55 ns on floor two, and 80 ns on floor seven. Still, the RF-based PASS transmissions were not successfully received by the base station. A cell-phone base station located on the roof of the apartment building may have caused interference.
- **Republic Plaza – 60 story office building, floors 1-10 including stairwell**: Based on measurements at other locations and in the NIST lab, it is evident that the path loss values reported in the graph (~70 dB to 115 dB) are too small to be realistic for this large structure. In the NIST lab, the RF-based PASS devices failed to successfully transmit an alarm at an attenuation level between approximately 120 dB and 135 dB, depending on the device. Thus, we expect that there was a problem with the measurement of the path loss data shown here, perhaps because the PASS base station antennas were not reoriented to align with the remote units on the higher floors. The base station antennas likely have a null in the vertical direction. We estimate actual path loss to be 20 to 30 dB higher than the calculated values. The RMS delay spread values ranged from 50 ns to 400 ns.
- **NIST Building 27 – small main building connected by long subterranean tunnel to small back room**: Attenuation values ranged from around 85 dB to 100 dB, and RMS delay spread was generally low, but in one case it jumped to 250 ns, probably because of multipath in the front building before the signal propagated down the hall to the receiver. PASS measurements were not made in this structure.
- **NIST Building 24 – office/lab building with basement**: Measured attenuation values ranged from 95 dB to 115 dB, although the attenuation in the basement was actually higher but we were unable to measure it due to limited dynamic

range of the VNA test set-up. The RMS delay spread values were low, only up to 50 ns for the locations we measured. Where there was not enough dynamic range to calculate the RMS delay spread, it is plotted as zero.

- **NIST Building 1- office/lab building with long, partly subterranean hallway**: Measured attenuation values in this structure ranged from 100 dB to 140 dB and the RMS delay spread values were up to 100 ns. We were only able to measure locations nearest the transmitter because there was insufficient dynamic range to acquire path loss and RMS delay spread data. It is expected that the path loss is significantly higher deeper into the building. Where there was not enough dynamic range to calculate the RMS delay spread, it is plotted as zero.
- **Colorado Convention Center - main entry, one corridor, and downstairs**: The measured attenuation in this large structure was between 80 dB and 150 dB, and the RMS delay spread up to 200 ns. However, our measurement instruments had insufficient dynamic range far into the building, so it is anticipated that the path loss was much higher than this. Where there was not enough dynamic range to calculate the RMS delay spread, it is plotted as zero.

3.2 Typical levels of attenuation

Most of the environments we tested provided at least 50 dB of attenuation, created by the penetration of signals from outside-to-inside a structure (or vice versa), or the distance between transmitter and receiver. Only the outdoor urban canyon environment and the shallow apartment building had maximum attenuation less than 100 dB, which we classify as “low attenuation.” It is expected that typical house structures, small commercial buildings (such as small stores in strip malls and office buildings with exterior-facing offices) and small-to-moderate sized apartment buildings (all apartments with an exterior wall) would provide an environment where the total signal attenuation is less than 100 dB. With current technology, it appears that an individual RF-based PASS unit (no repeater) can operate successfully in these environments, unless external radio interference is experienced, as it was in the Horizon West apartment building measurements.

Some of the environments we studied had maximum attenuation values between 100 dB and 150 dB, which we classify as “medium attenuation.” We expect that the Republic Plaza building attenuation values were on this order, and the NIST Building 27. It is expected that moderate-sized structures such as small hospitals, moderate-sized and tall commercial, office, and apartment buildings would provide an environment with attenuation between 100 dB and 150 dB. With current RF-based PASS technology, the use of a repeater can often overcome this level of attenuation.

Very large structures and those with subterranean floors can be expected to provide attenuation greater than 150 dB, which we classify as “high attenuation.” NIST Buildings 24 and 1, and the convention center had these high levels of attenuation. It is expected that multiple repeaters would need to be used in such environments, using current RF-based PASS technology. A summary is provided in the table below.

Classification	Attenuation (dB)	Typical structures	Current PASS
Low	Less than 100	Houses, small buildings with exterior-facing rooms	Single unit
Medium	100 to 150	Moderate-sized and tall structures with some interior rooms	With repeater
High	Over 150	Very large structures and those with subterranean floors	Multiple repeaters

3.3 Mechanisms that cause the RF-based PASS transmissions to fail (attenuation, multipath, and external radio interference)

For the environments we studied, it is clear that attenuation (path loss) is the dominant failure mechanism. In almost every case, there is a direct correlation between an increasing path loss and the failure of the RF-based PASS device transmission. Conversely, there seems to be little correlation between RMS delay spread and success or failure of the RF-based PASS. However, most of the environments we studied had relatively short RMS delay spread values of 200 ns or less.

We conclude that lab-based tests providing methods for testing RF-based PASS in a controlled attenuation environment would predict device performance in the majority of real-world firefighter environments. Tests utilizing various values of attenuation could be used to verify device performance in environments having the attenuation classifications listed in the table above.

Additional field tests and analysis should be conducted to determine the level of multipath in highly reflective environments such as factories, utility installations, and other manufacturing environments, and lab-based tests should be developed if it is found that these environments affect RF-based PASS performance.

The complete set of graphs described above appear on the next few pages, followed by the descriptions of the environments and data in Sections 4 and 5.

Denver Urban Canyon: Transmit site 1

******Insert Denver Urban Canyon: Transmit site 1, Figure 1 here******
******Insert Denver Urban Canyon: Transmit site 1, Figure 2 here******
******Insert Denver Urban Canyon: Transmit site 1, Figure 3 here******

Denver Urban Canyon: Transmit site 2

******Insert Denver Urban Canyon: Transmit site 2, Figure 1 here******
******Insert Denver Urban Canyon: Transmit site 2, Figure 2 here******
******Insert Denver Urban Canyon: Transmit site 2, Figure 3 here******

Horizon West 12-story apartment building: Floor 2

******Insert Horizon West 12-story apartment building: Floor 2, Figure 1 here******
******Insert Horizon West 12-story apartment building: Floor 2, Figure 2 here******
******Insert Horizon West 12-story apartment building: Floor 2, Figure 3 here******

Horizon West – 12-story apartment building: Floor 7

******Insert Horizon West – 12-story apartment building: Floor 7, Figure 1 here******
******Insert Horizon West – 12-story apartment building: Floor 7, Figure 2 here******
******Insert Horizon West – 12-story apartment building: Floor 7, Figure 3 here******

Republic Plaza – 60 story office building, floors 1-10 including stairwell.

******Insert Republic Plaza – 60 story office building, floors 1-10 including stairwell, Figure 1 here******
******Insert Republic Plaza – 60 story office building, floors 1-10 including stairwell, Figure 2 here******
******Insert Republic Plaza – 60 story office building, floors 1-10 including stairwell, Figure 3 here******

NIST Building 27: Small main building connected by long subterranean tunnel to small back room.
No PASS tests conducted, channel characterization only

********Insert No PASS tests conducted, channel characterization only Figure Here********

NIST Building 24: office/lab building with basement

******Insert NIST Building 24: office/lab building with basement, Figure 1 here******
******Insert NIST Building 24: office/lab building with basement, Figure 2 here******
******Insert NIST Building 24: office/lab building with basement, Figure 3 here******

NIST Building 1: office/lab building with long, partly subterranean hallway

******Insert NIST Building 1: office/lab building with long, partly subterranean hallway, Figure 1 here******
******Insert NIST Building 1: office/lab building with long, partly subterranean hallway, Figure 2 here******

******Insert NIST Building 1: office/lab building with long, partly subterranean hallway, Figure 3 here******

Colorado Convention Center: main entry, one corridor, and downstairs
450 MHz PASS only

******Insert Colorado Convention Center: main entry, one corridor, and downstairs 450 MHz PASS only Figure here******

4.0 Test Environments

4.1 Denver Urban Canyon

Measurements were taken outdoors in the financial district of downtown Denver on Saturday, June 20, 2009. This area contains many large (over 20 story) buildings.

The figure below left shows an illustration of the test area constructed from a Google map view.[1] Street widths were on the order of 20 m. Three transmitter (TX) locations and eleven receiver (RX) locations were used. Results here are presented for TX1 and TX2. The figure below right shows a photograph of the two receiver antennas located at position R5 on the corner of Welton and 17th Streets. The diagram below shows LOS distances ranged from 10 m to 80 m, with NLOS distances placed every 10 m past R5.

******Insert 4.1 Denver Urban Canyon, Figure 1 here******
******Insert 4.1 Denver Urban Canyon, Figure 2 here******
******Insert 4.1 Denver Urban Canyon, Figure 3 here******

4.2 Horizon West Apartment Building, Boulder, Colorado

This building was the 12-story Horizon West apartment building in Boulder, Colorado. The building is constructed of reinforced concrete, steel, and brick with standard interior finish materials. The building was fully furnished and occupied during the experiments. Measurements were performed during daytime hours and, as a result, people were moving throughout the building during the experiments.

The base station site was located on the east side of the apartment building, approximately 60 m from the building. The locations of the tests are shown in the sketch. These measurements were acquired approximately every 5 m down the main hallways, as indicated in the figure, on floors 2 and 7 of the building.

******Insert 4.2 Horizon West Apartment Building, Boulder, Colorado, Figure 1 here******
******Insert 4.2 Horizon West Apartment Building, Boulder, Colorado, Figure 2 here******
******Insert 4.2 Horizon West Apartment Building, Boulder, Colorado, Figure 3 here******
******Insert 4.2 Horizon West Apartment Building, Boulder, Colorado, Figure 4 here******

[1] © 2009 Google, Map Data © 2009 Tele Atlas.

4.3 Republic Plaza, Denver, Colorado

The Republic Plaza is a 57-story office building in downtown Denver. The construction materials are a typical combination of concrete and steel. The interior building materials are a combination of metal framing, drywall, and trim, with stone finishes in lobby. The exterior is a combination of glass and metal. The photographs below illustrate the exterior and interior of the building.

The receive site, depicted in the sketch, was located on the 17th Street side, approximately 10 m from the building. This location was intended to simulate the location of a command vehicle in an emergency response scenario.

Pink numbers on the sketch show the locations within the building where testing was conducted. The vertically stacked numbers indicate testing conducted in a stairwell. The highest floor tested, the tenth floor, had been gutted in preparation for remodeling, as shown in the photographs.

******Insert 4.3 Republic Plaza, Denver, Colorado, Figure 1 here******

******Insert 4.3 Republic Plaza, Denver, Colorado, Figure 2 here******

******Insert 4.3 Republic Plaza, Denver, Colorado, Figure 3 here******

******Insert 4.3 Republic Plaza, Denver, Colorado, Figure 4 here******

Republic Plaza Building, tenth floor level, and ground floor lobby.

4.4 NIST Building 27

The entry to this small concrete building is above ground and consists of a room approximately 5.5 m (18.0 ft) wide and 7.1 m (23.3 ft) deep, shown in the photograph, below left. There are two small windows in the main room. The room is used for storage and contains many boxes of electronics equipment, as shown in the photograph, below right. The room is connected to a much smaller room by a 24.5 m (80.4 ft) long corridor, as shown in the photograph, bottom left. The corridor and small room at the end, which is 3 m x 3 m (9.8 ft x 9.8 ft), are below ground and used to access the NIST open-area test site. The diagram at the bottom of the page shows the dimensions of the building.

******Insert 4.4 NIST Building 27, Figure 1 here******
******Insert 4.4 NIST Building 27, Figure 2 here******
******Insert 4.4 NIST Building 27, Figure 3 here******
******Insert 4.4 NIST Building 27, Figure 4 here******

4.5 NIST Building 24

This building consists of offices and laboratories, including a large semi-anechoic antenna test chamber approximately 25 m x 6 m. The building footprint is approximately 30 m x 30 m. The building is constructed of cinder block, concrete, and steel. There are few windows except in the offices and storage spaces. There are two levels of offices/lab space and a large, open, unfinished basement.

The base station was set up immediately outside the building due to construction behind the building. Tests were conducted by entering the building on the south side, turning west and going down the stairs to the basement, walking to various sites throughout the basement, including into an elevator at the end of a hallway, ascending the stairs on the north side, and walking down a corridor to the original entry position.

******Insert 4.5 NIST Building 24, Figure 1 here******
******Insert 4.5 NIST Building 24, Figure 2 here******
******Insert 4.5 NIST Building 24, Figure 3 here******

NIST Building 24: Left side: View from N. Right side: View from W. PASS basestation was set up on the picnic table.

4.6 NIST Building 1

This building is the main building (referred to as the Radio Building) at the NIST laboratories in Boulder, CO. The building is constructed of reinforced concrete and is basically a four-story building. However, the building is built on a hillside, and consequently, some locations in the building are below ground level. Measurements were made on the 3rd floor hallway called “Wing 4”, continuing in to “Wing 3” on the 3rd floor, around the corner on the “main spine.” The measurements were performed during daytime hours and, as a result, people were moving throughout the building during the experiments.

Two fixed transmit sites were assembled on the south side of the laboratory building (see Figure below). The receive site at Wing 4 was located on the loading dock, while the receive site at Wing 6 was approximately 10 m from the building. Channel measurements were performed with the receiving antennas polarized in the vertical direction.

******Insert 4.6 NIST Building 1, Figure 1 here******
******Insert 4.6 NIST Building 1, Figure 2 here******
******Insert 4.6 NIST Building 1, Figure 3 here******

NIST Building 1 Corridor. Left side: Wing 4 hallway. Right side: Base station outside Wing 6.

4.7 Colorado Convention Center

This massive three-level structure is constructed of reinforced concrete, steel, and standard interior finish materials. The exterior of the building is a combination of glass, metal, and concrete. As shown in the sketch, the convention has a basement and two above-ground levels.

The base station was located approximately 10 m from the entrance on the Speer Boulevard side. A large lobby area and auditorium were located inside this entrance. Testing was conducted only at the points marked by a number in a white square. Only one of the PASS devices was tested at the convention center location.

******Insert 4.7 Colorado Convention Center, Figure 1 here******
******Insert 4.7 Colorado Convention Center, Figure 2 here******
******Insert 4.7 Colorado Convention Center, Figure 3 here******
******Insert 4.7 Colorado Convention Center, Figure 4 here******

5.0: Measured Data

5.1 Denver Urban Canyon

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (mean of 9) (dB)	RMS Delay Spread @700 MHz (mean of 9) (ns)	908 MHz PASS Unit 1	908 MHz PASS Unit 2	450 MHz PASS
Denver Urban Canyon TX1	1	17.25	58.63	51.70	O	O	O
	2	5.15	46.53	20.55	O	O	O
	5	21.01	62.39	107.30	O	O	O
	7	34.24	75.62	146.11	O	O	O
	9	36.54	77.92	134.68	O	X	O
	10	43.48	84.86	210.97	O	O	O
TX2	1	36.84	78.22	114.26	O	O	O
	2	17.06	58.44	32.49	D	O	O
	5	27.65	69.03	81.57	O	X	O
	7	40.13	81.51	108.45	O	O	O
	9	42.34	83.72	94.84	O	X	O
	10	49.71	91.09	NaN	O	O	O

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

Measurement details

Calibration Attenuator: 40 dB for the high bands, 20 dB for the low bands

Note: Denver Urban Canyon data: attenuator in place during measurements. No path loss correction for atten needed.

Reference measurement distance: 4 m (ref. from OATS => 20 dB atten)

Formula: VNA data + free-space loss = Path Loss

5.2 Horizon West Apartments:

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (dB)	RMS Delay Spread @700 MHz	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS

				(ns)			
Horizon West Floor 2 Notes: - System 1 repeater at test point 2.	1	21.41	86.13	24.97	D	X	X
	2	16.29	82.79	16.09	D	X	X
	3	16.97	77.67	32.14	D	D	X
	4	29.74	78.35	18.34	D	X	X
	5	35.44	91.12	54.28	D	X	X
	6	26.29	96.82	37.48	X	X	X
	7	26.34	87.67	48.52	D	X	X
	8	24.05	87.72	19.72	X	X	X
	9	24.25	85.43	46.78	D	X	X
	10	22.38	85.63	31.23	X	X	X
	11	20.68	83.76	20.06	X	X	X
	12	25.77	82.06	34.75	D	X	X
	13	23.47	87.15	46.46	X	X	X
Horizon West Floor 7	1	28.22	89.60	33.94	D	X	O
	2	18.68	80.06	24.43	D	X	O
	3	17.16	78.54	29.79	D	X	O
	4	35.12	96.50	51.40	D	X	O
	5	37.71	99.09	52.43	D	X	O
	6	33.78	95.16	77.07	D	X	X
	7	34.08	95.46	46.22	D	X	O
	8	30.62	92.00	41.53	O	X	X
	9	28.92	90.30	51.29	D	X	O
	10	31.09	92.47	56.53	D	X	X
	11	33.51	94.89	47.39	D	X	X
	12	36.38	97.76	69.66	D	X	O
	13	28.50	89.88	28.24	D	X	O

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

Measurement Details

Calibration Attenuator: 30 dB for the high bands, 30 dB for the low bands (Chriss doesn't know, but 30dB is in the file name)

Reference measurement distance: 4 m (OATS, so use 20 dB atten)

Note: 2m ref file (collected at Horizon West) gives 10 dB lower PL than OATS ref.

Formula: VNA data + atten + free-space loss = Path Loss

5.3 Republic Plaza Building:

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (dB)	RMS Delay Spread @700 MHz (ns)	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS
Republic Plaza Notes: - System 1 repeater at test point 2.	1	7.23	68.61	44.99	O	O	O
	2	27.06	88.44	39.52	D	O	O
	3	38.15	99.53	52.30	X	X	O
	4	37.60	98.98	133.41	X	X	O
	5	37.18	98.56	81.25	X	O	O
	6	42.26	103.64	102.78	X	O	O
	7	46.04	107.42	138.29	X	X	O
	8	44.88	106.26	104.69	X	O	O
	9	48.30	109.68	376.10	X	X	O
	10	45.34	106.72	338.17	X	O	O
	11	50.25	111.63	167.91	X	O	O
	12	50.48	111.86	231.57	X	O	O
	13	50.98	112.36	209.07	X	O	O
	14	51.82	113.20	192.25	X	O	O
	15	49.60	110.98	240.20	X	O	O
	16	44.64	106.02	377.45	X	X	O
	17	29.28	90.66	296.87	O	O	O
	18	30.45	91.83	161.75	O	O	O
	19	42.24	103.62	429.90	O	O	O
	20	39.30	100.68	333.25	O	O	O
	21	47.07	108.45	453.47	O	O	O

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

Measurement Details

Calibration attenuator (atten): 30 dB for the high bands, 10 dB for the low bands

Reference measurement distance (free-space loss): 4 m (OATS => 20 dB atten used)

Formula: VNA data + atten + free-space loss = Path Loss

5.4 NIST Building 27

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (dB)	RMS Delay Spread @700 MHz (ns)	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS
Building 27 Notes: - No PASS tests yet.	1LOS	47.26	108.65	228.20	–	–	–
	2LOS	30.18	91.56	18.40	–	–	–
	3LOS	22.89	84.27	13.36	–	–	–
	1NLOS	48.43	109.82	–	–	–	–
	2NLOS	35.61	97.00	15.88	–	–	–
	3NLOS	21.17	89.55	11.71	–	–	–

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

Measurement details

Calibration Attenuator: 40 dB for the high bands, 20 dB for the low bands

Reference measurement distance: 4 m (ref. from OATS => 20 dB atten)

Formula: VNA data + atten + free-space loss = Path Loss

5.5 NIST Building 24 Outside-to-Inside:

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (mean of 9) (dB)	RMS Delay Spread @700 MHz (mean of 9) (ns)	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS
NIST Bldg	1	37.65	99.03	39.46	O	O	O

24 Notes: - Path Loss and RMS Delay calculated with TX outdoors. - System 1 repeater at test point 2.	2	46.55	107.93	NaN	O	O	O
	3	53.16	114.54	NaN	O	O	O
	4	–	–	NaN	X	O	O
	5	–	–	NaN	X	D	X
	6	–	–	NaN	X	D	X
	7	–	–	NaN	X	O	X
	8	52.81	114.19	NaN	D	D	X
	9	51.90	113.28	NaN	X	D	X
	10	–	–	NaN	X	O	X

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

NIST Building 24 Inside-to-Inside:

Location and Notes	Test Point	VNA Loss Data (mean of 9) (dB)	Path Loss @700 MHz (mean of 9) (dB)	RMS Delay Spread @700 MHz (mean of 9) (ns)	908 MHz PASS (Data from TX outdoors)	908 MHz PASS w/ repeater (Data from TX outdoors)	450 MHz PASS (Data from TX outdoors)
NIST Bldg 24 Notes: - Path Loss and RMS Delay calculated with TX indoors. - System 1 repeater at test point 2.	1	56.29	77.67	41.25	O	O	O
	2	42.72	64.10	33.88	O	O	O
	3	48.47	69.85	35.44	O	O	O
	4	55.50	76.88	35.44	X	O	O
	5	63.36	84.74	NaN	X	D	X
	6	–	–	–	X	D	X
	7	–	–	–	X	O	X
	8	49.16	70.54	41.44	D	D	X
	9	55.05	76.43	25.89	X	D	X
	10	62.02	83.40	NaN	X	O	X

Measurement details

Calibration attenuator: 40 dB for the high bands, 20 dB for the low bands

Ref measurement distance: 4 m (OATS => 20 dB atten): free-space loss=41.38 dB

Formula: VNA data + atten + free-space loss = Path Loss

5.6 NIST Building 1 Corridor:

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @700 MHz (dB)	RMS Delay Spread @700 MHz (ns)	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS
NIST Bldg 1 Corridor: Outside-Inside Notes: - TX inside in “Wing 4” - 908 MHz repeater at test point 8.	1	49.70	105.06	55.86	O	O	O
	2	56.21	111.57	53.76	O	O	O
	3	60.33	115.70	34.10	O	O	O
	4	70.06	125.70	95.05	O	O	O
	5	72.33	127.69	88.12	O	O	O
	6	75.10	133.17	84.00	O	O	D
	7	73.93	129.29	79.10	O	O	D
	8	77.80	133.17	72.41	O	O	X
	9	74.11	129.47	36.93	X	D	X
	10	84.21	139.57	–	X	D	X
	11	86.41	141.77	–	X	X	X
	12	85.15	140.51	–	X	D	X
	13	87.90	143.26	–	X	D	X
	14	86.47	141.83	–	X	D	X
	15				X	O	X
	16				O	O	X
	17				X	O	X
	18				X	O	X

O = Alarm receive

D = Alarm received with Delay

X = Alarm not received

Measurement Details

Calibration attenuator: 40 dB for the high bands, 20 dB for the low bands

Reference measurement distance: 2 m => free-space loss @ 700 MHz = 35.36 dB

Formula: VNA data + atten + free-space loss = Path Loss

5.7 Colorado Convention Center

Location and Notes	Test Point	VNA Loss Data (dB)	Path Loss @1 GHz (dB)	RMS Delay Spread @ 1 GHz (ns)	908 MHz PASS	908 MHz PASS w/ repeater	450 MHz PASS
Colorado Convention Center Notes: - 450 MHz system tested only.	1	24.65	97.57	85.56	–	–	O
	2	26.92	103.65	68.19	–	–	X/O
	3	37.47	113.03	79.60	–	–	O
	4	55.00	123.16	159.31	–	–	O
	5	73.05	137.04	180.61	–	–	D
	6	82.61	137.07	128.77	–	–	X
	7	91.11	137.51	0	–	–	X
	8	91.35	137.58	0	–	–	X
	9	91.74	137.31	0	–	–	X
	10	92.29	137.47	0	–	–	X
	11	91.81	137.52	0	–	–	X

O = Alarm received

D = Alarm received with Delay

X = Alarm not received

Measurement details

Note: Data shown is for 1 to 1.2 GHz band, horn antenna to omnidirectional antenna

Calibration attenuator: 30 dB for the high bands, 10 dB for the low bands

Reference measurement distance: 3 m

Formula: VNA data + atten + free-space loss = Path Loss

6.0 Path Loss

Free space path loss:

$$PL = 10 * \log_{10}\left[\left(\lambda / 4\pi d\right)^2\right](dB),$$

where

$\lambda = c/f$,

f=carrier frequency (Hz)

c= speed of light, 3e8 m/s

At 700 MHz:

2 m: PL = 35.36 dB

3 m: PL = 38.89 dB

4 m: PL = 41.38 dB

Chapter 6: Design Requirements

6.1.2.5 PASS that, in addition to emitting audible alarms, transmit and receive alarm signals through the use of a modulated radio-frequency carrier shall be designated as *RF-based PASS*. The *RF-based PASS* designation may be used in conjunction with any of the designators given in 6.1.2.2 through 6.1.2.4.

6.1.2.5.1 The RF-based PASS shall consist of a wireless transceiver contained within the user-worn PASS unit and a base station transceiver that may be self-contained or designed to operate in conjunction with a portable computer. The base station unit must be capable of battery operation for up to one hour under alarm conditions. The use of repeaters is not precluded as long as their use does not introduce undue latency (delay in transmission or reception) into the system.

6.1.2.5.2 The base station shall be designed to emit an audible alarm when the *alarm signal* described in 6.4.3 is activated by the user-worn RF-based PASS unit.

6.1.2.5.3 Both user-worn PASS unit and base station must comply with FCC regulations for radio-frequency transmissions for the frequency of operation and transmission format chosen by the manufacturer.

6.1.2.5.4 Antennas and/or other peripheral electronic components designed for use with RF-based PASS shall not interfere with or impede firefighting operations.

6.1.2.5.5 Software used in conjunction with RF-based PASS units shall be updated as necessary within six months by the manufacturer for newly released versions of the computer operating system for which the software was designed.

6.2.1.5.6 Data logging may be carried out via the RF-based PASS system base station based on RF transmissions from the body-worn RF PASS.

Chapter 7: Performance Requirements

7.1.2.1.1 The RF-based PASS base station shall be tested for sound pressure level of *alarm signal* as specified in Section 8.2, Sound Pressure Level Tests, and shall not have the alarm signal, once activated, be deactivated unless the PASS is reset.

7.15 RF-based PASS shall be tested for reliable wireless transmission and reception of alarm signals as specified in Section 8.18, Radio System Tests for RF-Based PASS.

7.15.1 RF-based PASS base station shall automatically emit an alarm signal in response to an alarm signal received from the user-worn RF-based PASS within 30 seconds of alarm activation under the radio channel conditions specified in Section 8.18. The user-worn RF-based PASS shall automatically emit an audible alarm within 30 seconds of alarm activation by the base station under the radio channel conditions specified in Section 8.18.

7.15.2 RF-based PASS shall be tested in conjunction with the model of base station with which it is intended to be deployed.

7.15.3 The **Attenuation Test** is conducted to determine whether the user-worn PASS will operate in an RF propagation channel having a specified level of attenuation. The level of attenuation shall be chosen to replicate that expected in certain firefighting conditions, as determined in the informational Appendix "NIST Tests of Representative Radio Propagation Environments to Support Development of Standards for RF-Based PASS."

7.15.3.1 The attenuation test is conducted with the base station acting as the receiver and the user-worn PASS acting as the transmitter. This configuration is tested because the user-worn PASS generally transmits at a lower power level than the base station to conserve batteries and thus represents the weaker RF link in the system.

7.15.3.2 The attenuation classifications to be used for the attenuation test shall correspond to a total path loss (free space path loss + external attenuation + cable and connector loss) as specified in the table below.

Table 7.15.3.2: Classification of environments for attenuation test.

Classification	Attenuation (dB)	Typical structures
Low	Less than 100	Houses, small buildings with exterior-facing rooms
Medium	100 to 150	Moderate-sized and tall structures with some interior rooms
High	Over 150	Very large structures and those with subterranean floors

Chapter 8: Test Methods

Section 8.18 Radio System Tests for RF-Based PASS – Attenuation Test

8.18.1 Application. This test method shall apply to all RF-based PASS systems.

8.18.2 Samples.

8.18.2.1 Samples shall be complete PASS.

8.18.2.2 Samples shall be conditioned as specified in 8.1.2.

8.18.3 Specimens

8.18.3.1 Specimens for testing shall be complete PASS systems

8.18.3.2 A single RF-based PASS and a single base station are used in each test. Three different units shall be tested, for a total of nine tests.

8.18.3.3 The repeaters for RF-based PASS that use repeaters, shall additionally be tested as described in future revisions of this standard.

8.18.4 Test Apparatus

8.18.4.1 The attenuation test is conducted with the base station placed in a shielded test chamber. The shielded chamber shall have a minimum of 110 dB of isolation below 1 GHz and 100 dB above 1 GHz. Manufacturer's certification of shielding is satisfactory. The test chamber may be reflective or anechoic because conducted tests are to be carried out in the test chamber.

8.18.4.2 The room in which the shielded chamber is located shall be constructed of standard building materials rather than highly reflective metal walls. Its suitability will be determined in Section 8.18.5.3.

8.18.4.3 The base station and PASS unit shall be configured as shown in Figure 8.18.4.3. The base station, rather than the user-worn PASS, is placed in the shielded chamber to minimize the effect of reflections on the radiation pattern of the user-worn PASS antenna.

8.18.4.4 Separate tests shall be conducted for every RF-based PASS antenna set-up and amplifier configuration, if applicable.

8.18.4.5 Unused bulkhead connectors on the shielded chamber shall be terminated in short circuits.

8.18.4.6 RF connectors shall be tightened using a appropriate torque wrench.

******Insert Artwork here******
(a)

******Insert Artwork here******
(b)

Figure 8.18.4.3: Test apparatus set up for the Attenuation Test method.

8.18.4.5 Test set-up within the shielded chamber

8.18.4.5.1 The base station and control computer, if applicable, shall operate on batteries to eliminate coupling of RF signals into the shielded chamber on the power lines.

8.18.4.5.2 For RF-based PASS systems with separate transmit and receive antenna ports, the base station transmit antenna shall be left intact (that is, not terminated in a non-radiating load) in case coupling of RF energy occurs through that antenna port. This represents the most realistic use case.

8.18.4.5.3 The base station receive antenna shall be connected through a shielded 50 Ω coaxial cable to a 50 Ω fixed attenuator of a minimum of 30 dB. The fixed attenuator shall be connected to a 50 Ω variable RF attenuator that operates in 1 dB steps over a minimum 10 dB range, and the variable attenuator shall be connected to a feedthrough bulkhead connector on the shielded test chamber using a shielded 50 Ω coaxial cable. Type N, SMA, or higher-frequency connectors shall be used for all connections. An RF adapter may be used at the antenna port of the base station only.

The value of 30 dB for the fixed attenuator was chosen to protect the variable attenuator from damage for PASS base stations that have a single transmit/receive antenna port, but small enough that the majority of the external attenuation remains outside the test chamber, limiting the received RF energy inside. The operator shall ensure that the power rating on the 30 dB attenuator is sufficient to prevent damage of the attenuator when the RF-PASS base station is operated. The same cables shall be used in each of the nine tests of the PASS system.

8.18.4.5.4 For the case of RF-based PASS systems that utilize multiple receive antennas, each antenna port shall be connected to the shielded chamber's bulkhead connectors as described above using identical set-ups: The cables shall be made by the same manufacturer, of the same model, length, and connector type (N, SMA, or higher-frequency). The variable attenuators shall be of the same model.

8.18.4.6 Test set-up for the receive antennas outside the shielded chamber

8.18.4.6.1 A metallic ground plane fixture containing a sufficient number of chassis-mount connectors to accommodate the receive antennas from the base station shall be fabricated. The receive antennas to be used with the base station unit shall be connected to the chassis-mount RF connector on the top side of the metallic ground plane. The ground plane shall have a surface area within 120% of the top surface area of the base station unit for antennas mounted directly to the base station unit, and no larger than 1 m square for antennas intended to magnetically mount on a vehicle. Magnetically mounted antennas shall be attached to the metallic ground plane and the RF cables shall be attached to the chassis-mount connectors described above. Pole mounted or other self-contained antennas shall not be attached to the metallic ground plane.

8.18.4.6.2 The receive antennas, including the metallic ground plane fixture, if applicable, shall be mounted to a dielectric tripod or other stable base made of non-metallic, non-conducting parts. The height of the base shall be 1.5 meters to approximate the height of a firefighter. The tripod or other base shall be placed at least 1 meter from the shielded chamber to minimize chamber/antenna interactions.

8.18.4.6.3 The chassis-mount connectors on the base of the metallic ground plane shall be connected to fixed attenuators having type N or SMA connectors. One RF adapter may be used between the chassis-mount connector and the attenuator. Multiple attenuators may be used to obtain the specified level of attenuation. The fixed attenuators shall be placed outside the test chamber in order to reduce the RF signal level in the test chamber.

8.18.4.6.4 The fixed attenuators shall be connected to the shielded test chamber's bulkhead connectors by a shielded 50 Ω coaxial cable having type N, SMA, or higher-frequency connectors.

8.18.4.6.5 For the case of PASS systems using multiple receive antennas, each antenna/attenuator assembly shall be connected to the shielded chamber's bulkheads as described above using identical set-ups: The cables shall be made by the same manufacturer, of the same model, length, and connector type. The attenuators shall be from the same manufacturer, have the same value, and be of the same model.

8.18.4.7 Test set-up for the user-worn RF-based PASS outside the shielded chamber

8.18.4.7.1 The RF-based PASS shall be mounted to a non-metallic, dielectric tripod or other stable base placed 3 meters from the receive antenna. The 3 m distance shall be measured from the base of the receive antenna to the base of the RF-based PASS.

8.18.4.7.2 The antenna on the user-worn RF-based PASS shall be oriented in the same direction as the receive antenna(s).

8.18.5 Procedure.

8.18.5.1 Repeatability. A minimum of three repeat measurements shall be conducted. For each repeat, the tripod or other base that supports the RF-based PASS device shall be moved and repositioned to the same location. The base station shall be powered down and restarted.

8.18.5.1.1 The base station and RF-based PASS shall establish wireless communication, by, for example, leaving the door of the chamber open or reducing the level of the variable attenuator within the chamber. The door or covering of the chamber shall then be closed and sealed.

8.18.5.1.2 The RF-based PASS shall be mounted on the transmit test base and alarm condition initiated. If the base station receives the alarm, the test chamber shall be opened, the base station alarm reset, the attenuation increased. The test procedure shall be repeated until the alarm is not received by the base station. This value of attenuation shall be noted.

8.18.5.2.3 If the level of attenuation required to cause the base station to fail to receive the alarm signal differs by more than 2 dB from one repeat test to another, the operator shall determine why. The repeatability may be improved, for example, by reducing the level of reflectivity in the room containing the test chamber or by improving the shielding of the test chamber.

8.18.5.2 Attenuation Test. A minimum of three repeat attenuation tests shall be conducted for each RF-based PASS unit.

8.18.5.2.1 A total attenuation corresponding to the classification for which the RF-based PASS is to be certified, as specified in Table 7.15.3.2, shall be inserted between the user-worn RF-based PASS and the RF-based PASS base station. The total attenuation consists of a summation of the cable and connector losses in the test set-up (to be measured and noted by the operator), the summation of all external attenuators inserted, and the free space path loss calculated for a 3 m distance at the frequency of operation. The free-space path loss (PL) is given by:

Free space path loss:
$PL = 10*\log_{10}[(\lambda/4\pi d)^2]$ (dB),
where
$\lambda = c/f$,
f=carrier frequency (Hz)
c= speed of light, 3e8 m/s

Typical values of free space path loss at 700 MHz are:
2 m: PL = 35.36 dB
3 m: PL = 38.89 dB
4 m: PL = 41.38 dB

In summary:
Total attenuation = Cable Loss + Connector Loss + Free-space Path Loss at 3 m + External Attenuators

8.18.5.2.2 The base station and RF-based PASS shall establish wireless communication, by, for example, leaving the door of the chamber open or reducing the level of the variable attenuator within the chamber. The door or covering of the chamber shall then be closed and sealed.

8.18.5.2.3 The RF-based PASS shall be mounted on the transmit test base and alarm condition initiated. The operator shall note whether the alarm was received by the RF-based PASS base station.

8.18.6 Report.

8.18.6.1 All quantities shall be reported to the nearest decibel.

8.18.6.2 The operator shall note the results of the three repeatability tests specified in 8.18.5.1.

8.18.6.3. The operator shall note the results of the three attenuation tests, including the values of (1) Cable loss + connector loss, (2) Free-space path loss at 3 m for the frequency of operation (3)

Value of external attenuators used (4) Frequency of operation (the minimum and maximum operating frequencies utilized).

8.18.7 Interpretation.

8.18.7.1 Pass or fail performance shall be determined for each specimen.

8.18.7.2 One or more specimens failing this test shall constitute failing performance.

1982- Log #14 FAE-ELS **Final Action:**
(5.1.8)

Submitter: Craig Gestler, Mine Safety Appliances Company
Recommendation: Delete 5.1.8 and replace with:
5.1.8 PASS also shall be labeled as certified at least to the requirements for Class I, Groups C and D; and Class II, Groups E, F and G, Division II hazardous locations specified in ANSI/ISA-12.12.01, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*,
Substantiation: A change to the Division to which a PASS device is certified to in section 7.6 would require a change to the applicable labeling requirements. This proposal is valid only if section 7.6 is changed from requiring a Div. 1 approval to requiring a Div. 2 approval.

1982- Log #15 FAE-ELS **Final Action:**
(7.6)

Submitter: Craig Gestler, Mine Safety Appliances Company
Recommendation: Delete 7.6 and replace with:
7.6 Nonincendive. PASS shall be tested as being nonincendive as specified in ANSI/ISA-12.12.01, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*, and shall meet the requirements for Class I, Groups C and D, and Class II, Groups E,F,G, Division 2 hazardous locations.
Substantiation: A Class I and II , Division 1 approval severely limits the amount of power available to a PASS device. This limited power results in quieter PASS alarms and shortened run times. If PASS telemetry is being considered, a Div 1 approval will limit transmitted power to under 500mW, severely limiting the range and penetration of the telemetry signal. In addition, the fire service operates in an environment that is better described by Division 2 where known explosive environments are not typical but can be expected to be encountered occasionally.

1982- Log #16 FAE-ELS **Final Action:**
(3.3.2 Annunciator)

Submitter: Glossary of Terms Technical Advisory Committee,
Recommendation: The Glossary of Terms Committee requests that the term "Annunciator" used in NFPA 1982 be changed to "Pass Annunciator" or "Audible Alert Component" .
~~Annunciator~~. Pass annunciator. The component designed to emit audible signals.
or ~~Annunciator~~. Audible Alert Component. The component designed to emit audible signals.

Substantiation: NFPA 72, 730, and 731 all use the term Annunciator for a different application and changing the term in 1982 would eliminate confusion.
Your technical committee has the following options:
a) Adopt the preferred definition
b) Modify the term to make it unique
c) Request that the Standards Council reassign responsibility for the term
d) Request that the standards council authorize a second *preferred* definition

1982- Log #17 FAE-ELS **Final Action:**
(2.3.1)

Submitter: John F. Bender, Underwriters Laboratories Inc.
Recommendation: Revised text as follows:

2.3.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036. ANSI/UL 913, *Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations*, 2006, Revised 2010.

ANSI B46.1, Surface Texture, 1978

ANSI S1.13, Methods for Measurement of Sound Pressure Level®, 2005.

ANSI Y1.1, Abbreviations for Use on Drawings and Text, 1972.

ANSI Y14.SM, Dimensioning and Tolerancing, 1982.

Substantiation: Reason: Update referenced standard to most recent revision.

1982- Log #18 FAE-ELS **Final Action:**
(Entire Document)

Submitter: Gordon R. Sletmoe, Medford Fire-Rescue
Recommendation: This proposal adds RF PASS as optional equipment associated with PASS, and the methods to test and/or verify the performance of RF PASS. Extensive additions, deletions, and revisions are indicated throughout the document. These changes are indicated by underscore or strike-through.

INCLUDE 1982_L18_R.DOCX HERE

Substantiation:

INCLUDE 1982_L18_S.DOCX HERE

Add text to read as follows:

6.13.5 Audibility Correlation Test (During Heat Test)

6.13.5.1 Prior to conducting the Heat Test, the sound pressure output for the PASS device shall be positioned on the horizontal plane “x” distance for the acoustic measuring device. The sound measuring device shall have the capability of measuring the A-weighted sound pressure (“x” represents the distance defined by the manufacturer in order to safely conduct the audibility test). Detailed test methods shall be maintained by the manufacturer.

6.13.5.2 The Heat Test shall be conducted.

6.13.5.3 Following 5 minutes of exposure as identified in the Heat Test “paragraph TBD”, the sound pressure of the sample shall be recorded using the same method noted in 6.13.5.1.

6.13.5.4 The sound pressure correlation measurement recorded in 6.13.5.1 and 6.13.5.3 shall use linear regression calculations consisting of a correlation coefficient confidence level of at least 95 percent and a minimum sound pressure equivalence of “sound pressure dbA TBD”

6.13.5.5 6.13.5.1 through 6.13.5.3 shall be repeated 3 times on 3 separate samples.

Rational:

In this method, linear regression can be used to approximate the best fit between two or more data points (measured data during Heat Test vs. Anachoic Chamber data) and the minimum sound pressure of “TBD” dbA.

Audibility Correlation Calculation Method Using Linear Regression:

Note that the entire polynomial solution has not been displayed, only the end result formulas. Detailed polynomial information can be found in reference material such as Probabilistic Methods of Signal and System Analysis by George R. Cooper and Clare D. McGillem.

General Theory:

Beginning with the equation of a line: y =a + bx

where

y = the minimum sound pressure that must be achieved during the Heat Test.

x = the minimum fixed sound pressure, “TBD”

a = the intercept point for the sound pressure as measured during the Heat Test

$$b = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_1^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

$$a = \frac{n\sum_{i=1}^{n} y_i - b\sum_{i=1}^{n} x_i}{n}$$

INSERT Artwork HERE

Scatter Plot Example

The Correlation Coefficient is a determination of how closely the data correlates to a straight line. The Correlation Coefficient will range from -1 to +1. At 4 = -1, the data lands directly on the line with a negative slope. At r = +1, the data falls directly on the line with a positive slop. If r = 0, the data cannot be approximated at all by the straight line.

Correlation Coefficient (r)

$$\boldsymbol{P_k^i}(\boldsymbol{dB})_{\boldsymbol{relative}} = \mathbf{20} \times \log_{10}\left(\frac{\boldsymbol{E_k^i}}{\text{minimum}(\boldsymbol{E_{total}^i})}\right)$$

1982/L18/Eq1/R/F2012/ROP

$x = a' + b'y$

where

$$b' = \frac{n\sum_{i=l}^{n} x_i y_i - \sum_{i=l}^{n} x_i \sum_{i=l}^{n} y_i}{n\sum_{i=l}^{n} y_i^2 - \left(\sum_{i=l}^{n} y_i\right)^2}$$

With *b'* now defined, the correlation coefficient, denoted as r or R, is:

$$r = \sqrt{bb'}$$

With the correlation coefficient now determined, using the Variance Explained or Confidence Factor (r^2), the variance in Y is predicted by the X variable. This mans that we can assign a % relationship to the variance to best determine if the data obtained is sufficient enough to qualify the results.

Variance Explained = $r^2 \times 100$

Example:

A pass device is required to produce a minimum sound pressure of 110 dbA. During testing in the Anachoic Chamber, three different samples were tested with the following results:

Sample 1 – Produced a sound pressure of 115 dbA
Sample 2 – Produced a sound pressure of 110.dbA
Sample 3 – Produced a sound pressure of 112 dbA

The sound pressure is to be recorded before and during the Heat Test. The results recorded before the Heat Test will help identify the correlating minimum value that must be obtained during the Heat Test.

The following sound pressure results were obtained prior to conducting the Heat Test, but while the samples were in the variable ambient chamber.

The following sound pressure results were obtained prior to conducting the Heat Test, but while the samples were in the variable ambient chamber.

Sample 1 – Produced a sound pressure of 87 dbA
Sample 2 – Produced a sound pressure of 82 dbA
Sample 3 – Produced a sound pressure of 84.5 dbA

$y = a + bx$

$x = 110$

slope (b) = 1.0714

intercept (a) = -36.03571

minimum Heat sound pressure reading (y) = 81.8 dbA

r = 0.9643

r^2 = 0.93% confidence

Scatter plot points are illustrated in the Audibility Correlation diagram as shown below:

INSERT Artwork HERE
Audibility Correlation

$$\boldsymbol{E_{total}^{i}} = \sqrt[2]{(\boldsymbol{E_x^i})^2 + \left(\boldsymbol{E_y^t}\right)^2 + \left(\boldsymbol{E_y^i}\right)^2}$$

Each year an average of 105 fire fighters die in the line of duty. To address this continuing national occupational fatality problem, NIOSH conducts independent investigations of fire fighter line of duty deaths. These excellent reports are very comprehensive and offer specific recommendations to improve firefighter safety. A technical committee task group carefully reviewed every line-of-duty death report posted for the past 10 years (the period of December 22, 1999 through May 22, 2010, exceeding 10 years) and discovered many of the same reoccurring problems we continue to see year after year. Fifty-eight Firefighters died in the line of duty during the forty-three incidents selected for this proposal. Had RF PASS technology been in place during this period many, if not most, of these deaths could have been avoided. The inclusion of RF PASS in this proposal is supported by recommendations made by NIOSH Investigators: The most redundant recommendations germane to this proposal are as follows:

- ***Ensure that fire command always maintains close accountability for all personnel at the fire scene***

- ***Consider ways to enhance the effectiveness of the personnel accountability system***

- ***Ensure personnel accountability reports (PAR) are conducted in an efficient, organized manner and results are reported directly to the IC***

- ***Use evacuation signals when command personnel decide that all fire fighters should be evacuated from a burning building or other hazardous area***
- ***Instruct and train fire fighters on initiating emergency traffic (Mayday-Mayday) and on the importance of activating their personal alert safety system (PASS) device when they become lost, disoriented, or trapped***

In a letter dated April 14, 2011, from the Fire Fighter Fatality Investigation and Prevention Team at CDC/NIOSH/DSR they stated the following "We are in agreement that providing PASS devices that offer two-way Mayday and Evacuation signal capabilities would greatly enhance fire fighter safety at structure fires and other emergency response events"

Substantiation for changes to Section 1: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. In order to include RF PASS as optional equipment associated with PASS, it is necessary to include RF PASS in the Scope and Purpose of the standard.

Substantiation for changes to Section 2: Test methods for RF PASS are detailed in Annex C "Single-Hop RF Attenuation Test." The values for attenuation used in the attenuation test were derived from the NIST Technical Notes references above.

Substantiation for changes to Section 3.3: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. As a result, it is necessary to define RF PASS and the equipment associated with it. Because there are additional alarm capabilities associated with RF PASS, the definitions of the various alarm types have been revised in Section 3.3.1. To clearly differentiate the various types of alarms, the original audible *alarm signal* is now referred to as an *audible distress alarm*. Additionally, to ensure that all alarms are defined within Section 3.3.1, the *Pre-Alarm Signal* in Section 3.3.15 has been moved to Section 3.3.1.2.

Substantiation for changes to Section 4.3: These additions describe the configuration and order (relative to other tests) in which the Single-Hop RF Attenuation Test for RF PASS, Section 8.18.5, shall be conducted. It is anticipated that elevated temperature and rough-duty handling will be the primary sources of failure of RF PASS. Thus, the Single-Hop RF Attenuation Test is conducted after these conditioning tests only. Modifications to Tables 4.3.10(a) and (b) include: (1) Attenuation test conducted after tumble test, Specimens 19-21 (for 4.3.10(a)) or 16-18 (for 4.3.10(b)). This will be 12 measurements.

(2) Attenuation test conducted after high temperature test, Specimen 13. This will be four measurements.

Because the radio-system portion of the RF PASS system is tested by the Single-Hop Attenuation Test, the Out-of-Range Alarm Test is conducted only on Specimens 19-21 (for 4.3.10(a)) or 16-18 (for 4.3.10(b)). This will be 3 measurements.

Substantiation for changes to Section 5.1: These additions describe the labeling that should be included on optional RF PASS. Section 5.1.10 allows users to easily see the maximum number of user-worn units that may be monitored because exceeding this number could jeopardize the safety of firefighters who may inadvertently not be monitored. Section 5.1.11 is required by the FCC for any commercially available radio system technology.

Substantiation for adding Section 5.2.4, part (2)(d): This addition describes the danger of muting the speaker of a portable laptop when operating an RF PASS system.

Substantiation for Section 6.1: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. This section describes the key aspects of system design necessary to ensure reliable performance of RF PASS, including the minimum design requirements for the base station and user-worn devices.

Substantiation for Section 6.2: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. Additions to this section describe the additional mode sensing capabilities of RF PASS and how the RF PASS interfaces with the motion sensing device on the PASS. To clearly differentiate the different types of modes, the original mode designators (1) *off*, (2) *alarm*, and (3) *sensing* have been renamed and reordered to (1) *off*, (2) *motion sensing* and (3) *audible distress alarm*. RF PASS allows for two additional modes: (4) *remote distress alarm* and (5) *evacuation sensing.* These were defined and their interactions spelled out. Note that even when an RF PASS is in alarm mode, it continues to monitor for an evacuation alarm.

Substantiation for Section 6.3: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. Additions to this section describe the additional alarm functions of RF PASS, and how the base station interfaces with the RF PASS in the various alarm modes. To clearly differentiate the various types of alarms, the original audible *alarm signal* is now referred to as an *audible distress alarm*. Language specifying signals transmitted within xx seconds +5/-0 should just be within 30 seconds (quicker would be allowable and even better) .

Substantiation for Section 6.4.1: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate the various modes of operation, it has been necessary to designate the motion sensing operation as “motion sensing” instead of “sensing.”

Substantiation for Section 6.4.2: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate the various modes of operation, it has been necessary to designate the motion sensing operation as “motion sensing” instead of “sensing.” To clearly differentiate the various alarm signals, it has been necessary to designate the signal at the user-worn PASS device as an “audible distress alarm” instead of an “alarm signal.” Language specifying signals transmitted within 10 seconds +3/-0 should just be within 10 seconds (quicker would be allowable and even better) .

Substantiation for Section 6.4.3: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. Additions to this section describe the alarm signals associated with RF PASS. To clearly differentiate the various alarm signals, it has been necessary to designate the signal at the user-worn PASS device as an “audible distress alarm” instead of an “alarm signal.” Note that even when an RF PASS is in alarm mode, it continues to monitor for an evacuation alarm.

Language specifying signals transmitted within xx seconds, +y/-z seconds should just be within xx seconds (quicker would be allowable and even better)

Substantiation for modifying Section 6.4.3.5: This deleted text describes the performance metric *sound pressure level*, which is given in Section 7.1.2.1.

Substantiation for Section 6.4.4: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate the various modes of operation, it has been necessary to designate the motion sensing operation as “motion sensing” instead of “sensing.” To clearly differentiate the various alarm signals, it has been necessary to designate the signal at the user-worn PASS device as an “audible distress alarm” instead of an “alarm signal.”

Substantiation for modifying Section 6.4.4.1: The deleted text describes the performance metric *sound pressure level*, which is given in Section 7.1.2.1.

Substantiation for Section 6.4.5: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. Updates to this section describe the key aspects of RF system design necessary to ensure reliable performance, the additional alarm capabilities of RF PASS, and how the RF PASS interfaces with the motion sensing device on the PASS. The definition and interval of an “out-of-range alarm” has been added to let users know when the RF portion of an RF PASS system is not functional. To clearly differentiate between the audible alarm signal emitted by the traditional PASS, and the RF PASS “remote distress alarm” and “evacuation alarm,” it has been necessary to change the nomenclature from “alarm signal" to "audible distress alarm"

Substantiation for changes to Section 7.1: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate between the audible alarm signal emitted by the traditional PASS, and the RF PASS "remote distress alarm" and "evacuation alarm," it has been necessary to change the nomenclature from "alarm signal" to "audible distress alarm." In Section 7.1, the sound pressure level associated with the "remote distress alarm" and the "out of range alarm" have been added. A sound pressure of 80 dBA is the loudness of a ringing telephone according to the NIOSH web site. Sound levels greater than 85 dBA can cause hearing loss. See http://www.cdc.gov/niosh/topics/noise. The value of 80 dBA was chosen because the remote distress alarm may be heard within closed quarters. The value of 80 dBA was chosen for the out of range alarm so that the user does not become tired of hearing the out of range alarm when it is active for a long duration.

Substantiation for Sections 7.1 to 7.14: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate the various modes of operation, it has been necessary to designate the motion sensing operation as "motion sensing" instead of "sensing." To clearly differentiate the various alarm signals, it has been necessary to designate the signal at the user-worn PASS device as an "audible distress alarm" instead of an "alarm signal."

Substantiation for Section 7.15: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. When RF PASS is included as an option in NFPA 1802, it will be necessary to include test methods to verify the performance of these systems. Extensive NIST research on radiowave penetration into buildings and large structures has confirmed that attenuation (path loss) and interference from other radio systems are the key potential impairments to successful transmission of alarm signals such as those associated with commercially available RF PASS. This research is documented in various NIST Technical Notes, as documented in Annex C. Based on this research, attenuation tests and interference tests have been deemed the highest priorities in the development of radio-system tests for RF PASS. The Single-Hop RF Attenuation Test verifies system performance for a specified path loss.

Substantiation for Section 7.16: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. When RF PASS is included as an option in NFPA 1802, it will be necessary to include test methods to verify the performance of these systems. Because it is a necessity that firefighters and those monitoring the RF PASS signals are aware when a firefighter will no longer have the RF PASS link available, an out-of-range alarm has been designed into RF PASS systems. Section 8.19 specifies how this alarm will be tested repeatably in the laboratory.

Substantiation for additions to Section 8.2: The 2007 Edition of NFPA does not include methods to test or verify the performance of RF PASS. Additions to Section 8.2 describe the sound pressure level tests for the base station associated with RF PASS. These additions are necessary to ensure that those who monitor the RF PASS radio signals are aware of any remote distress alarm conditions. To clearly differentiate between the audible alarm signal emitted by the traditional PASS, and the RF PASS "remote distress alarm" and "evacuation alarm," it has been necessary to change the nomenclature from "alarm signal" to "audible distress alarm"

Substantiation for Sections 8.1 to 8.17: The 2007 Edition of NFPA 1982 does not include methods to test the performance of RF PASS. This edition of the standard will include test methods for RF PASS as optional equipment associated with PASS. To clearly differentiate the various modes of operation, it has been necessary to designate the motion sensing operation as "motion sensing" instead of "sensing." To clearly differentiate the various alarm signals, it has been necessary to designate the signal at the user-worn PASS device as an "audible distress alarm" instead of an "alarm signal."

Substantiation for Section 8.18: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. When RF PASS is included as an option in NFPA 1802, it will be necessary to include test methods to verify the performance of these systems. Extensive NIST research on radiowave penetration into buildings and large structures has confirmed that attenuation (path loss) and interference from other radio systems are key potential impairments to successful transmission of alarm signals such as those associated with commercially available RF PASS. This research is documented in NIST Technical Notes 1540-1542, 1546, 1546, 1550, 1552, and 1557, which are referenced in Annex C. Based on this research, attenuation tests and interference tests have been deemed the highest priorities in the development of radio-system tests for RF PASS.

The "Single-Hop RF Attenuation Test" verifies the performance of RF PASS systems operating under conditions where a significant path loss (or "attenuation") is encountered, such as inside a building or other structure. A combination of two small anechoic chambers, antennas, cables, and an adjustable attenuator are used to create a repeatable RF propagation environment where a specified level of attenuation can be inserted between a user-worn RF PASS and its base station. Successful reception of an alarm signal under this level of attenuation constitutes a pass of the test. Two alarms are tested in the Single-Hop RF Attenuation Test. First, the reception of the remote distress alarm by the base station is tested when the audible distress alarm on the user-worn device is activated. Second, reception of the evacuation alarm by the user-worn device is tested when it is initiated at the base station.

This test method is designed to allow free-field testing of a complete RF PASS system, that is, testing of the system without the use of conducted measurements or removing the antennas. This is important because the antennas on many RF PASS devices are integrated into the user-worn SCBA, which can impact the radiation pattern of the antenna. Free-field testing allows the system to be characterized with any unusual antenna radiation pattern intact.

Substantiation for Section 8.19: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. When RF PASS is included as an option in NFPA 1802, it will be necessary to include test methods to verify the performance of these systems. Because it is a necessity that firefighters and those monitoring the RF PASS signals are aware when a firefighter will no longer have the RF PASS link available, an out-of-range alarm has been designed into RF PASS systems. Section 8.19 specifies how this alarm will be tested in the laboratory.

Substantiation for Annex A and B: With the inclusion of RF-enabled PASS as an option in this Standard a 'great deal of language in Appendix A and B of the 2007 Edition of the Standard is no longer relevant. Irrelevant text has been deleted and new explanatory text has been inserted.

Substantiation for Annex C: The 2007 Edition of NFPA 1982 does not include methods to test or verify the performance of RF PASS. When RF PASS is included as an option in NFPA 1802, it will be necessary to include test methods to verify the performance of these systems. Extensive NIST research on radiowave penetration into buildings and large structures has confirmed that attenuation (path loss) and interference from other radio systems are key potential impairments to successful transmission of alarm signals such as those associated with commercially available RF PASS. This research is documented in NIST Technical Notes 1540-1542, 1546, 1546, 1550, 1552, and 1557, which are referenced below. Based on this research, attenuation tests and interference tests have been deemed the highest priorities in the development of radio-system tests for RF PASS.

The “Single-Hop RF Attenuation Test” verifies the performance of RF PASS systems operating under conditions where a significant path loss (or “attenuation”) is encountered, such as inside a building or other structure. A combination of two small anechoic chambers, antennas, cables, and an adjustable attenuator are used to create a repeatable RF propagation environment where a specified level of attenuation can be inserted between a user-worn RF PASS and its base station. Successful reception of an alarm signal under this level of attenuation constitutes a pass of the test. Two alarms are tested in the Single-Hop RF Attenuation Test. First, the reception of the remote distress alarm by the base station is tested when the audible distress alarm on the user-worn device is activated. Second, reception of the evacuation alarm by the user-worn device is tested when it is initiated at the base station.

This test method is designed to allow free-field testing of a complete RF PASS system, that is, testing of the system without the use of conducted measurements or removing the antennas. This is important because the antennas on many RF PASS devices are integrated into the user-worn SCBA, which can impact the radiation pattern of the antenna. Free-field testing allows the system to be characterized with any unusual antenna radiation pattern intact.