

## Noise Safety Challenge 2016

A Field-Microphone in Real Ear (F-MIRE) multi-subject fit-testing system for earmuffs, earplugs and active noise control systems.

Michael & Associates, Inc.  
2766 W. College Ave, Suite 1  
State College, PA 16801

Hearing protector device (HPD) fit-testing has been recognized as a best practice in industrial hearing conservation by the National Hearing Conservation Association (NHCA). Fit-testing systems were first developed under NIOSH contract in 1974, but none were commercially viable until about 1990 when Michael & Associates began selling the FitCheck system. FitCheck, and all other commercially available fit-testing systems, was designed to measure the attenuation provided by insert-type HPDs only. Fit-testing validates two critical factors: 1) the HPD selected for/by the end user is capable of providing sufficient protection for a given noise exposure, and 2) the end user was trained to properly fit the HPD. Neither of these are a given. Many individuals cannot effectively wear specific insert-type HPDs for various reasons. There may be physiologic factors that prevent a good fit with a specific device and/or dexterity may not be good enough to fit a particular HPD properly.

Problems with existing fit-testing systems include the time it takes to perform the test and the fact that some devices cannot be tested with conventional fit-testing systems. These devices include earmuffs, helmets and active noise control systems. To address these shortcomings, a new system was designed, manufactured and is in the course of being fully evaluated.

A Field-Microphone in Real Ear (F-MIRE) multi-subject fit-testing system for single, double and triple hearing protection systems has been developed under US Army SBIR contract W81XWH-13-C-0054. Double protection is defined as earmuffs (or a helmet) and earplugs in combination. Triple protection is defined as double protection plus active noise control. The new objective measurement system, called FitCheck F-MIRE, is unique as it is capable of testing eight individuals simultaneously. Testing on earplugs-only can be performed using headphones to deliver the test stimulus. Testing on any type of protector or protector combination can be performed by presenting the test stimulus using a self-powered loudspeaker.

The heart of the system is a processor box (Figures 1 and 2) that connects to a laptop or desktop PC via USB cable. The sound card output of the host PC is connected to the processor box via 3.5 mm audio cable. A 1x2x3 mm commercial off-the-shelf MEMS microphone is embedded in an ear dam and is connected to a microphone power supply / signal conditioning module referred to as the mic dongle (Figure 3).

The 2 mil thick cable has been verified to have a negligible effect on hearing protector attenuation (Figure 4). The ear dam / microphone combination is inserted into the ear canal just as it is for an ear canal impression procedure. The purpose of the ear dam is twofold: first, it prevents the microphone

from touching the sensitive ear canal walls, and second, it keeps the microphone placed in a proper measurement position near the center of the canal.



Figure 1. FitCheck F-MIRE processor box.



Figure 2. Rear connection panel of the FitCheck F-MIRE processor box.



Figure 3. FitCheck F-MIRE microphone dongle.

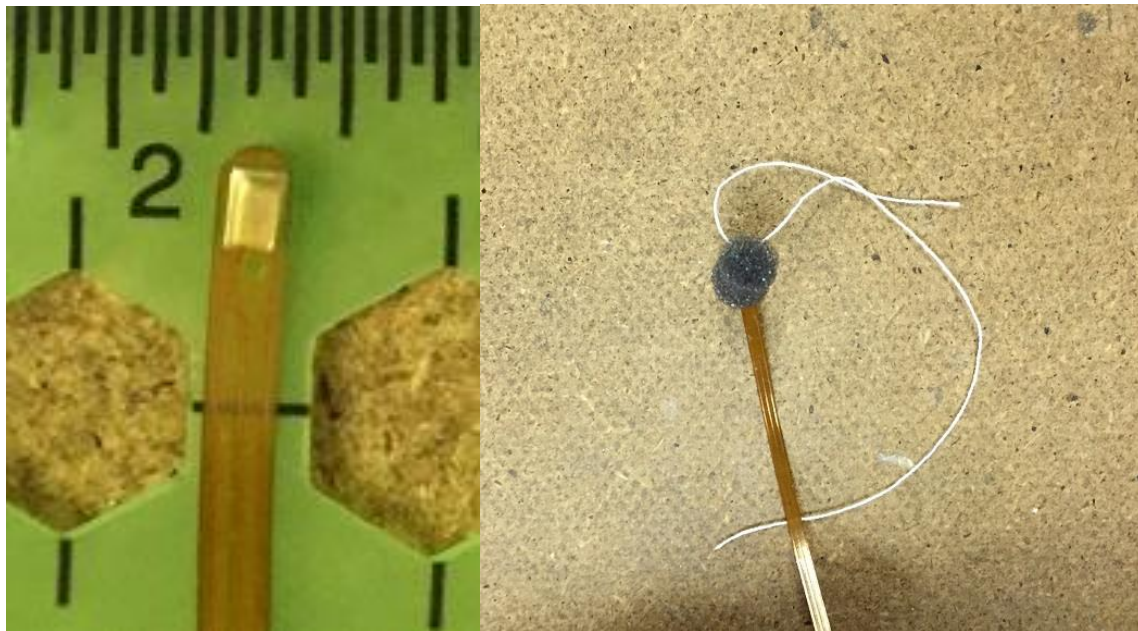


Figure 4. Close up of FitCheck F-MIRE microphone and microphone mounted in ear dam.

When testing via headphones, each set of phones is connected to the output jacks on the back of the processor box. For testing via self-powered loudspeaker, the speaker is connected to 'headphone output #1' output jack.

The test procedure runs as follows. First, the HPD end user is fitted with the ear dam / microphone in each ear, making sure that the Right / Left convention is followed as labeled on the dongle (Figure 5).

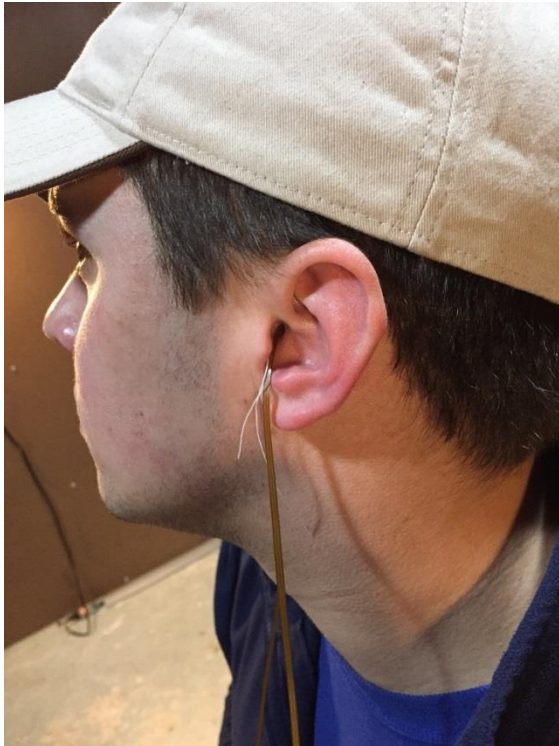


Figure 5. Test subject with microphone mounted in ear canal.

The New Test menu option is selected on the FitCheck F-MIRE software, and demographic information is entered for the test subject (Figure 6). Either occluded (ears blocked with HPD) or unoccluded (ears open) may be tested first. After either test is initiated by clicking the appropriate start button, the noise floor is measured, then the test stimulus is delivered to the subject.

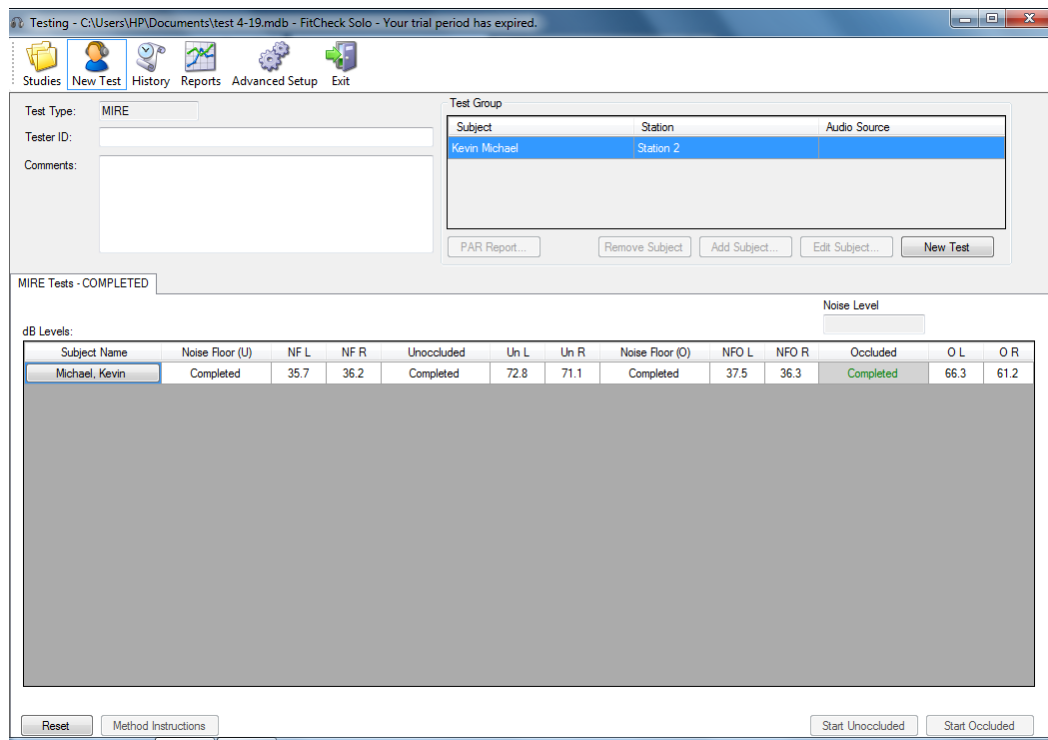


Figure 6. New Test menu screenshot

A single presentation of pink noise at 80 dBA is sufficient for the ears open measurement. With the ears occluded, the system starts at 80 dBA, then rises in 5 dB increments until the measurement at the microphone is 5 dB above the noise floor at each 1/3 octave band between 50 and 10000 Hz. For multi-subject testing, some subjects will complete the test before others, and their stimulus will be turned off while the other subjects finish. The insertion loss attenuation for each subject is then calculated as the difference in dB at each octave (or 1/3 octave) band between the ears open and ears occluded conditions. The system is capable of measuring over 60 dB of attenuation for any type of hearing protection.

All data is stored in a Microsoft Access database, and it is accessible via the History main menu selection. Graphical presentation of the data is presented in Figure 7.



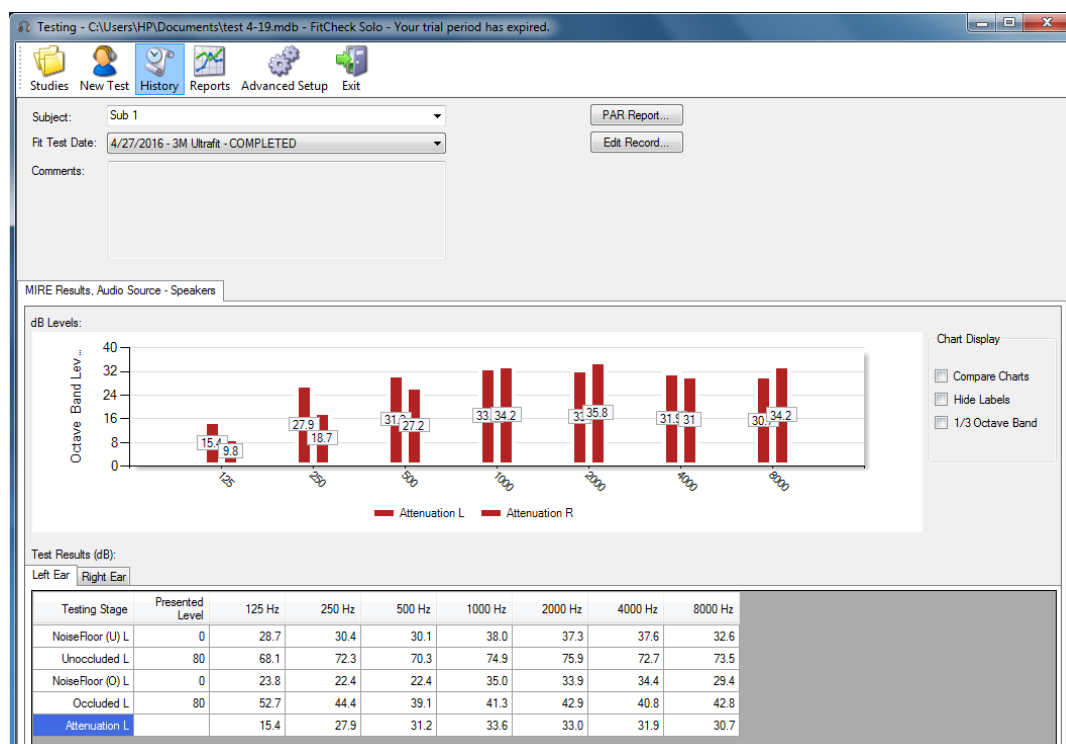


Figure 7. History menu selection screenshot.

The FitCheck F-MIRE system represents a significant advancement in hearing protector fit-testing. First, any type of HPD can be evaluated, including active noise control and combinations of HPD types. Second, it is the first multi-subject fit-testing system. These advancements will make fit-testing more acceptable for industry, reducing the time required for testing a large number of employees using any type(s) of HPDs.

A future enhancement of FitCheck F-MIRE involves integrating the system with FitCheck Solo, which is a Real Ear at Threshold (REAT) HPD fit-testing system that is currently available as a single user system. This would allow the REAT test to be performed on 8 subjects simultaneously using the FitCheck F-MIRE processor box. The advantage of the REAT system would be that no ear canal microphones would be required, thus no requirement for a test administrator that was experienced in placing ear dams in the ear canal. This test protocol would require headphones and therefore be used for insert-type HPDs only. It follows that with precise calibration, this REAT system could be used to perform annual audiometry of noise-exposed employees. Another future enhancement of the FitCheck F-MIRE system is the capability to measure output levels of various communication devices. It is a requirement in Europe to limit output levels of communication and entertainment devices to safe levels. It is likely that a similar requirement will be eventually enacted in the USA.