

mask, he/she shall face forward and hold his/her breath for 10 seconds for test measurement.

- *Second redonning (REDON-2).* The test participant shall remove and redon the respirator mask again; after redonning the mask, he/she shall face forward and hold his/her breath for 10 seconds for test measurement.

As noted earlier, Dr. Crutchfield submitted two peer-reviewed journal articles that provided information on the accuracy and reliability of the proposed CNP REDON fit testing protocol. In the first of these articles, the most important conclusion made by the authors is that the proposed CNP REDON fit testing protocol results in substantially lower respirator fit factors overall than the most commonly used ambient aerosol (AA) fit testing protocol. Accordingly, lower fit factors indicate that the proposed protocol would detect more respirator leaks than the AA protocol, thereby providing employees with an increased margin of safety when they select respirators. The main conclusion reached by the authors in the second article is that the overall fit factors obtained from the three exercises and two redonnings required by the proposed protocol are the same as the overall fit factors found when using the eight-exercise CNP protocol described in the Respiratory Protection Standard. Therefore, compared to the eight-exercise CNP protocol, the same overall fit factors can be obtained in less time using the proposed protocol.

*Peer-reviewed articles.* In the first peer-reviewed article, entitled "Effect of exercise and mask donning on measured respirator fit" and published in *Applied Occupational and Environmental Hygiene*, Dr. Crutchfield and his colleagues tested 14 Air Force personnel who wore elastomeric full facepiece or half mask air purifying respirators while being fit tested using either AA fit testing equipment (the Portacount Plus®, manufactured by TSI, Inc., St. Paul, MN) or CNP fit testing equipment (FitTester 3000®, manufactured by Occupational Health Dynamics, Birmingham, AL) (Ex. 2). The study participants wore their usual respirator mask for half of the tests (mask 1), and a respirator mask that was either a size larger or smaller than their usual mask for the other half of the tests (mask 2). The purpose of using the second mask was to obtain poor respirator fit (*i.e.*, to ensure respirator leakage on some of the tests). Each study participant received three fit tests per day for five consecutive days; they removed and redonned the respirator between fit tests. During a fit test, they engaged in one of two test-exercise procedures. The

first procedure (procedure 1) consisted of the three test exercises described in the proposed protocol (*i.e.*, facing forward, bending over, and head shaking), with no repeated donnings. The second procedure (procedure 2) consisted of the following nine exercises (listed in order of administration): Normal breathing; deep breathing; side-to-side head turning (pausing to inhale at each extreme position); up-and-down head nodding (pausing to inhale at each extreme position); talking loudly (reading a standard passage, counting backward from 100, or reciting a memorized poem or song); grimacing (contracting the facial muscles); bending over (as if touching the toes); jogging in place; and normal breathing. Only the first AA fit test administered each day with each mask (1 and 2) used the second test-exercise procedure; the remaining AA fit tests, and all of the CNP fit tests, used the first test-exercise procedure.

The authors used the AA fit test equipment to compare fit factors for both procedures 1 and 2 under the two mask conditions. This comparison showed that, for mask 1, the log-transformed median overall fit factor obtained under procedure 1 was significantly lower than it was for procedure 2, while no significant difference was found between the procedures for mask 2. Additionally, the authors compared fit factors obtained from the two types of fit test equipment (*i.e.*, CNP and AA) under procedure 1. Accordingly, they found that the log-transformed median fit factors obtained using either type of equipment did not differ significantly among the three test exercises (*i.e.*, facing forward, bending over, and head shaking) for mask 1. However, for mask 2, the data obtained using both types of equipment showed that the bending over test exercise resulted in a significantly lower log-transformed mean fit factor than was obtained using the normal breathing test exercise.

Assessing the fit factors for procedure 2 using the AA fit test equipment, the authors found that the talking exercise resulted in a significantly lower log-transformed mean fit factor than the fit factor determined using the normal breathing exercise for mask 1; for mask 2, the log-transformed mean fit factors for both the talking and bending over exercises were significantly lower than the fit factor obtained for the normal breathing exercise. A subsequent analysis showed that the initial normal breathing exercise, as well as the bending over and the head shaking exercises, accounted for most of the fit testing failures. Finally, after collapsing

the data across mask conditions and exercise procedures, the authors found that the log-transformed median fit factor for the CNP equipment was significantly lower than the log-transformed median fit factor for the AA equipment.

The authors concluded that the results obtained using the AA equipment showed that the three exercises in procedure 1 were as effective in determining poor mask fit as the nine exercises that composed procedure 2. In reaching this conclusion, they specifically discounted the talking exercise, which was assessed in this study using only the AA equipment. In doing so, they asserted that the prolonged exhalation associated with the talking exercise may increase particle migration from the lungs to the sampling probe, which would cause the probe to detect an increase in particle concentration; consequently, the talking exercise likely results in artificially low fit factors. They also concluded that CNP equipment used with the three exercises in procedure 1 detected more poorly fitting masks than AA equipment used with either exercise procedure. The authors noted as well that the study participants took substantially less time to perform the three exercises in procedure 1 than the nine exercises in procedure 2, regardless of the type of equipment used.

The second peer-reviewed article, entitled "A faster, more rigorous protocol for fit testing emergency response respirators" and published in *Semiconductor Safety Association Journal*, describes a study in which 511 firefighters were fit tested for the Scott Model AV-2000 self-contained breathing apparatus using CNP fit testing equipment (Ex. 3). To detect respirator leakage, the authors converted the respirator, which normally operates at positive pressure, to operate in the negative pressure mode. During fit testing, the firefighters performed one of two exercise procedures. The first exercise procedure (procedure 1), administered to 407 firefighters, consisted of the full complement of exercises described in the proposed protocol (*i.e.*, facing forward, bending over, head shaking, and two mask redonnings). The second procedure (procedure 2), administered to 104 of the firefighters, replicated the CNP test exercises listed in Part I.4(b) of Appendix A in the Respiratory Protection Standard, including (listed in order of administration): Normal breathing; deep breathing; side-to-side head turning (pausing to inhale at each extreme position); up-and-down head nodding (pausing to inhale at each