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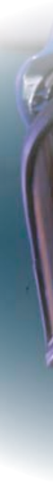

Respirator Selection

Considerations for Worker Protection & Productivity

By Anas A. AlGhamri and Susan L. Murray

In 1994, BLS reported 215 deaths resulting from exposure to harmful substances; 110 of these deaths were from oxygen deficiency (BLS, 2006). Safety awareness regarding respiratory protection has increased in the U.S. in the nearly 20 years since then. For example, a collaborative survey released in 2001 by NIOSH and BLS reported that in the U.S. more than 3.3 million people in 281,776 work establishments used respirators in their daily work. In 2010, 57 deaths resulting from the inhalation of harmful substances were reported (BLS, 2010).

NIOSH (2001) also found that of the work sites where respirators were used in 2001, 50% used respirators voluntarily; 41% provided no respirator training to employees; 53% did not perform medical fitness evaluations; 64% had no written respiratory program; and 76% performed no air sampling to assess hazards in order to select the proper type of respirator. All of these factors could lead to the improper selection or use of respirators (NIOSH).

IN BRIEF

- **Safety professionals must select respirators that are appropriate for various types of hazards, workplaces and tasks.**
- **Respirators with the same protection level are available in different styles. Research has shown that these style differences often affect physical performance, comfort and anxiety.**
- **This article analyzes factors beyond respiratory protection that should be considered when selecting appropriate PPE.**

Although respiratory protection awareness has increased since 2001, respirator-related issues remain a concern. Respiratory protection was the third most cited OSHA violation in 2006 and 2007 (Doney, Greskevitch, Groce, et al., 2009). In 2011, it ranked as the fourth most cited violation (OSHA, 2011).

Protection Factors & Additional Risks

To protect employees from air contamination, employers must establish and implement respiratory protection programs [29 CFR 1910.134(c)], including selecting respirators, performing medical evaluations, training employees and fit testing respirators [29 CFR 1910.134(d)]. Selecting the proper type of respirator should involve evaluating respiratory hazards and identifying workplace and user factors. To indicate a respirator's ability to purify air from contamination, OSHA and NIOSH have assigned protection factors (APFs) for each type of respirator.

APF is a critical consideration when selecting an appropriate respirator. It is a measure of respiratory protection that a respirator or class of respirators is expected to provide to employees when employers implement a continuing and effective respiratory protection program as specified by 29 CFR 1919.134. A higher APF indicates that greater performance can be expected from a respirator.

APF is similar to a workplace protection factor (WPF) in that both factors measure the ratio of concentration of contamination outside the respirator to the concentration inside the respirator. However, WPF is more specific to a certain workplace and respirator type. In this case, the APF for a certain respirator or respirator type is the minimum WPF value that would be experienced by 95% of individuals using this type of respirator. APFs are the result of experiments conducted by NIOSH and unaffiliated investigators. OSHA (2009) extended the research, reviewed all related data and literature, then assigned updated APFs.

Respirators can protect humans. However, they also can impair human senses and decrease performance. To fully realize the benefits and avoid any additional risks that respirator use may introduce, employers must select an appropriate respirator. Understanding the nature of a job and the skills required to perform that job efficiently is as important as understanding the types of hazardous substances present and the types of respirators and their APFs.

OSHA 29 CFR 1910.134(d)(3)(i)(A) recommends using the APF to select a respirator that meets or exceeds the needed protection. During the selection process, one should maximize safety while also considering factors that can affect costs, including costs associated with slow or inaccurate worker performance.

Research has shown that respirators can deteriorate the wearer's performance. They can decrease workers' physical, psychomotor and visual acuity, and increase anxiety (Caretti, Scott, Johnson, et al., 2001; Johnson, Dooly, Blanchard, et al., 1995;

Anas A. AlGhamri, Ph.D., is an assistant professor of industrial engineering at University of Business and Technology, Jeddah, Saudi Arabia. He holds a Ph.D. in engineering management from Missouri University of Science & Technology. He also holds a B.S. in Industrial Engineering from King Abdul Aziz University and an M.S. in Engineering Management from the University of Dayton.

Susan L. Murray, Ph.D., P.E., is a professor of engineering management and systems engineering at Missouri University of Science & Technology. She holds a B.S. in Industrial Engineering from Texas A&M University, an M.S. in Industrial Engineering from the University of Texas at Arlington and a Ph.D. in Industrial Engineering from Texas A&M University. Murray is an associate member of ASSE's St. Louis Chapter.

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Johnson, Dooly, Caretti, et al., 1997; Wu, Harber, Yun, et al., 2011). Some studies have indicated that human performance decreases as a respirator's capability increases (James, Dukes-Dobos & Smith, 1994; Zimmerman, Eberts, Salvendy, et al., 1991).

Maximum use concentration (MUC) is another factor to consider. MUC is the upper concentration limit at which a class of respirators is expected to provide protection. It equals the product of the APF and the contaminant exposure limit. When the exposure limit of a certain hazardous substance reaches the MUC, employers may select the next highest level of protection per 29 CFR 1910.134. However, the other risks that this action might impose highlight the importance of assessing the tradeoffs between protection from hazards in the atmosphere and possible impairment of senses.

Respirator Types

OSHA groups respirators into two major categories: air purifying and atmosphere supplying. Each type is further subdivided according to the unit's components and technique for delivering hygienic air to the user. Respirators can also be classified as loose fitting versus tight fitting or powered versus nonpowered.

In general, air-purifying respirators use filters, cartridges and canisters to remove contaminants from breathed air. Atmosphere-supplying respirators provide clean air from an uncontaminated source, such as a high-pressure tank. APF is assigned based on experimentation and the illustrated performance of respirators to prevent contaminants from entering the respiratory system using a filter or face seal. APFs vary from 5 (e.g., the value assigned for a quarter, nonpowered respirator) to 10,000 (e.g., self-contained breathing apparatus). Table 1 outlines OSHA's categorization of respirators and their corresponding APFs.

Military Respirators

U.S. soldiers wear bulky PPE called mission-oriented protective posture (MOPP) gear, which consists of an overgarment, a protective respirator, gloves, overboots and field gear. Not all components are worn every time a threat exists. For example, in less dangerous situations, soldiers might only wear the respirator. As the threat level increases, additional areas of the soldier's body must be protected (U.S. Air Force, 2009). MOPP gear levels vary in terms of their protective components, components readily available and components carried. Levels range from 0 to 4, moving up through the range as the threat increases.

Studies have attempted to clarify the effect of the gear on soldiers' performance. Research shows a definite effect of the suit on human abilities that increases as the level of the gear increases (Adams, Slocum & Keyserling, 1994; Bensel, 1997; Rauch, Witt, Banderet, et al., 1986). These studies have shown that the greater the equipment's encapsulation, the greater the decrement in soldiers' performance. A similar civilian PPE has not been as fully investigated for industrial applications.

Encapsulating Chemical Suits

Another form of chemical protection is the fully encapsulated chemical suit. These suits provide varying levels of HazMat protection (levels A, B,

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Table 1

Assigned Protection Factors

Type of Respirator[1, 2]	Quarter mask	Half mask	Full facepiece	Helmet/Hood	Loose-fitting facepiece
1. Air-Purifying Respirator	5	10[3]	50	—	—
2. Powered Air-Purifying Respirator (PAPR)	—	50	1,000	25/1,000[4]	25
3. Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1,000	25/1,000[4]	25
• Pressure-demand or other positive-pressure mode	—	50	1,000	—	—
4. Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Notes:

[1] Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.

[2] The assigned protection factors in Table I are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit testing, maintenance, and use requirements.

[3] This APF category includes filtering facepieces, and half masks with elastomeric facepieces.

[4] The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. This level of performance can best be demonstrated by performing a WPF or SWPF study or equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.

[5] These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134(d)(2)(ii).

Note. *Reprinted from "Assigned Protection Factors for the Revised Respiratory Protection Standards," (OSHA 3352-02 2009) by OSHA, 2009, p. 14.*

C, D) for firefighters and other first responders. Murray, Simon and Sheng (2011) studied the effect of the Level A chemical suit on gross and fine motor tasks. These suits provide a maximum level of respiratory, eye and skin protection. The wearer is typically fully encapsulated in the protective suit and breathes using a self-contained breathing apparatus (SCBA). The study found that the time required to complete the gross motor task increased 103% while accuracy decreased 34%. The effect of the suit on fine motor tasks was also statistically significant, but to a much smaller degree.

Effects on Human Physiology

The literature is rich with information regarding the physiological effects of respirators. Respirator use can cause changes in heart rate, blood pressure, body temperature, sweat rate and oxygen consumption (James, et al., 1984; Jones, 1991; Zimmerman, et al., 1991). Bansal, Harber, Yun, et al. (2009), measured physiological variables while subjects wore respirators and performed light and moderate exertion tasks. They found that wearing a respirator while performing tasks that require moderate exertion caused increased inspiratory tidal volume, minute ventilation, respiratory rate, heart rate and total breath time.

In another study, Caretti, et al. (2001), found that the resistance to normal breathing imposed by military full-face respirators affects human performance. A strong correlation between treadmill exercise time and a respirator's increasing resistance was found (R = .79). Increasing the respirator's resistance resulted in shorter exercise time as a result of exhaustion.

Wearing a particulate respirator can increase whole body temperature (Nielson, Berglund, Gwosdow, et al., 1987). This effect is magnified if the unit has no mechanism to release heat, which, when allowed to build up inside a respirator, can cause additional physical stress. Most current designs incorporate an exhalation valve that allows hot exhaled air to be released from the respirator. Some studies have shown that exercising with a respirator increases the temperature and humidity inside the respirator, which correspondingly increases body temperature (Guo, Yi, Tokura, et al., 2008; Hayashi & Tokura, 2004; Li, Wong, Chung, et al., 2006).

Effects on Cognitive Ability

The effect of respirators on cognitive ability is a gray area in this field. Two studies conducted by Caretti (1997) and Caretti, et al. (2001), examined this relationship. The first study tested the ability of nine soldiers to perform the California Computerized Assessment Package (CalCap). CalCap tests reaction time, information processing, language skills, rapid visual scanning and form discrimination. In the second study, eight soldiers participated in a treadmill walking exercise. They then were tested in serial addition, serial subtraction, logical reasoning and serial reaction. Both studies found no difference in performance when wearing a military respirator.

However, these studies have limitations. First, the participants were a small number of well-trained military personnel, so the conclusions may not apply to industrial workers. Second, the results of the cognitive tests could be compounded by the mixing of cognitive and visual questions. Finally, the low number and difficulty of questions asked could also compound the results.

Respirators impose a thermal burden on humans (Guo, et al., 2008; Hayashi, et al., 2004; Li, et al., 2006) that could negatively affect cognitive ability due to heat stress. After conducting an extensive review of numerous studies, Hancock and Vasmatzidis (2003) concluded that the physiological response to heat stress is well understood; however, they found that the cognitive response remains unclear. Nevertheless, they found that vigilance is not compromised below 85 °F body temperature, but heat stress negatively affects reaction time and correlates closely with unsafe work behavior. For example, White, Hodous and Vercruyssen (1991) found that wearing an SCBA and performing treadmill exercise in a thermal-neutral environment can increase body temperature to 100.2 °F. James, et al. (1984), found that wearing a full-face respirator under high-heat/high-work conditions increases the body's temperature to 100.6 °F.

Hancock (1987) studied the effect of exposure time on performance and developed a model that measures the correlation between these two factors. After exposing participants to heat for a specific amount of time, the researcher tested the model to determine the decrement coefficient of performance, with specific focus on vigilance, dual tasks, tracking, simple mental tasks and physiological tolerance. The study found that the greater the mental workload imposed, the more vulnerable performance was to heat stress and exposure time.

Effects on Human Psychology

When a breathing obstacle exists, anxiety increases. Wu, et al. (2011), found that respirators increase anxiety, especially among those who are already anxious. As indicators of anxiety, the study measured the heart rate, respiratory volume and State-Trait Anxiety Inventory (STAI) of participants wearing half-face respirators; results indicated an increase in anxiety for those with higher trait anxiety. This finding supports the original finding of Johnson, et al. (1995), who measured the heart rate, blood pressure and maximal oxygen consumption of 20 participants performing treadmill exercise. The study measured the time preceding voluntary stoppage as a result of the participant's exhaustion. Participants with higher anxiety exercised for shorter lengths of time and reported an inability to breathe.

Regardless of any type of airway obstruction, stress can cause breathing difficulties (Rietveld, Van Beest & Everaerd, 1999). A relationship exists between emotions and breathing. Moreover, physicians find it difficult to treat patients with both depression and respiratory illness because difficulty in breathing can be induced by stress (Nouwen, Freeston, Labbe, et al., 1999; Rietveld & Creer, 2003).

Effects on Visual Ability

Visual acuity and visual range are two notable variables affected by full-face respirators. Zelnick, McKay and Lockey (1994) studied the effect of three types of full-face respirators on 21 participants. The experiment tested the accuracy of detecting a stimulus appearing in different sectors of a visual range (24 sectors within 0° to 360°). The results showed a decrease in performance as well as differences among the three full-face respirators. This indicates that respirators affect visual range and that this effect can vary based on the design of and level of encapsulation provided by different devices.

Johnson, Dooly, Sahota, et al. (1997), supported the findings presented by Zelnick, et al. (1994), by studying the visual range awareness of participants wearing full-face respirators for a period of 10 hours. The study found that among all visual abilities, such as visual concentration tracking and reaction, visual range was affected the most. Respirators were also found to worsen visual acuity by three-quarters of a Snellen chart line. Johnson, et al., tested 10 participants wearing full-face military respirators and performing treadmill exercise. The study used seven levels of respirator lens to alter visual acuity. This study in particular demonstrates the adverse effect of respirators on the wearer's vision.

One reason for the decrease in visual acuity when wearing full-face respirators is lens fogging. One experiment tested the effect of a solution of 3 g of surfactant powder mixed with 100 mL of distilled water in reducing fogging. The solution reduced the fogging effect and improved visual acuity from an average Snellen acuity of 20/254 and 20/261 for the right and left lenses to 20/6 and 20/5, respectively (Coyne, 2010). Employers should keep this in mind when tasks require full-face respirators.

Effects on Psychomotor Ability

Among the lesser-studied effects of respirators is their effect on psychomotor ability. Zimmerman, et al. (1991), conducted a key study in this area that tested physical, cognitive and psychomotor ability among participants wearing three different types of respirators. The study concluded that full-face respirators may decrease movement time by up to 12% and the steadiness of arm-hand movements by 31%.

Style differences among respirators affect physical performance, comfort and anxiety differently.

Table 2

Literature Review Summary

PPE type	Skill(s) studied	Author(s)	Task type	Variable(s) measured	Results
Particulate respirator with and without valve	Physiological	Hayashi (2004)	Stepping exercise	Microclimate temperature and humidity	Higher temperature and humidity with respirator having no valve
Full-face respirator	Physiological	Nielsen (1987)	Bicycle (ergometer) with variable air temperatures	Skin temperatures, heart rates and skin wetness	Body temperature influenced by ambient and respirator air temperatures
Full-face respirator	Peripheral vision	Zelnick (1994)	Goldman projection perimeter	Accuracy in detecting a stimulus	Decreased peripheral vision
Half-face respirator vs. particulate respirator without valve	Physical	Harber (2011)	Simulated fine and gross motor tasks	Time and error	No change in time or error rate
Half-face respirator vs. particulate respirator without valve	Physiological	Bansal (2009)	Simulated fine and gross motor tasks	Total breath and inspiratory time	Greater breathing requirements with half-face respirator
Half-face respirator vs. particulate respirator without valve	Anxiety	Wu (2011)	Simulated fine and gross motor tasks	Time and error, heart rate, state-trait anxiety inventory, respiratory volume	Half-face respirator increased anxiety
Half-face, full-face and PAPR	Physiological	James (1984)	Variable levels of workload and heat	Physiological variables (e.g., oral temperature, heart rate)	Full-face respirator imposed significant physical strain
Particulate respirator without valve, half-face and full-face airline	Physical	Zimmerman (1991)	Bicycle (ergometer)	Time and error	O_2 consumption increased in half-face and full-face
Particulate respirator without valve, half-face and full-face airline	Psychomotor	Zimmerman (1991)	Various	Time and error	Steadiness performance decreased for full-face respirator. Movement time decreased for all three respirators.
Particulate respirator without valve, half-face and full-face airline	Cognitive	Zimmerman (1991)	GRE exam (logical and analytical)	Time and error	No clear cognitive results
Military respirator (M40)	Physical	Caretti (2001)	Treadmill with variable breathing resistance	Time until voluntary stoppage	Stamina decreased with increase in breathing resistance
Military respirator (M40)	Cognitive	Caretti (1999)	Walter Reed Performance Assessment Battery and treadmill	Decision making speed and accuracy, mood and anxiety	No change in cognitive performance
Military respirator (M40)	Cognitive	Caretti (1997)	CalCAP	Reaction, and decision making time and error	No change in cognitive performance
Military respirator (M17)	Peripheral vision	Johnson (1997)	AcuVision	Percentage correct	Decreased peripheral vision
Military respirator (M17)	Visual acuity	Johnson (1997)	Treadmill	Accuracy	Visual acuity worsened by three Snellen lines
Military respirator (M17) with hood, gloves and boots	Anxiety	Johnson (1995)	Treadmill	Heart rate, blood pressure, and oxygen consumption	Participants with higher anxiety had less stamina
Military respirator	Physical	Waugh (1984)	Missile assembly and fault repair	Time required	Increased for fault repair job

Waugh and Kilduff (1984) tested military respirators on participants performing assembly tasks. Participants were asked to perform two tasks of varying difficulty. The first task, rifle assembly, was considered an easy task requiring less hand-eye coordination. The second task was a more difficult fault repair task. No significant difference was found in the performance of the easy task. However, the time increased by 17% when participants wore respirators and performed the fault repair task that required additional hand-eye coordination.

Effects of Respirator Type With Respect to APFs

In reviewing the literature, it did not appear that the selection of respirators to be studied was uniform or based on consistent criteria. No study was found that compared respirator types with respect to their APFs.

The current investigation examines the effect of the compared respirators and analyzes the results when considering APFs. The objective is to determine whether a respirator's level of protection indicates its effect on performance. Understanding such a relationship would help SH&E professionals choose from respirators with variable or similar APFs. Previous relevant studies were divided into two groups, the first of which compared respirators with similar APFs (Bansal, et al., 2009; Harber, et al., 2011; Wu, et al., 2011); for example, particulate respirators and half-face respirators both have an APF of 10.

Respirators With the Same APF

Bansal, et al. (2009), compared the Comfo-Elite half-mask to 3M's N95 model 8510 particulate respirator. The experiment tested 56 participants on fine and gross motor tasks that included sorting bolts, performing a simulated casting operation, stocking/shelving buckets, packing and delivering boxes to the proper shelves, performing a driving simulation, stocking store shelves and building a Lego tower. The study measured physiological variables such as inspiratory volume, minute ventilation, respiratory rate and heart rate. These four variables, although higher during the moderate exertion tasks, were not affected by the type of respirator.

The experiment also measured inspiratory time, expiratory time and total breath time. The half-face respirator increased the inspiratory time, reduced the expiratory time and increased the total breath time compared to the particulate respirator. The particulate respirator had a major effect on the expiratory time. According to Bansal, et al. (2009), different half-face mask and particulate respirator designs have different physiological loads, including dead space and airflow resistance, which explains the difference in inspiratory and expiratory times.

Wu, et al. (2011), also compared the Comfo-Elite half-mask to 3M's N95 model 8510 particulate mask. The study tested 12 participants on fine and gross motor tasks and measured speed, accuracy, heart rate, work productivity, subjective responses and anxiety via the STAI. Some tests were similar to those used in the previous study. Wu, et al., found no change in speed or accuracy, nor did they report a relationship between trait anxiety and the increment in state anxiety due to the use of the half-face respirator ($r = 0.14$), which appears to have higher encapsulation. No statistically significant correlation existed between trait anxiety and the level of state anxiety during half-face respirator use ($r = 0.38$, $p > 0.10$). However, the half-face respirator contributed to higher anxiety levels than the particulate respirator.

Harber, et al. (2011), conducted a similar study of respirator types and motor skill tests. The study tested 107 participants and focused exclusively on comparing the two respirators in terms of their effect on motor skills, measuring task completion time and accuracy. No statistical significance existed performance differences between the two types of respirators. Although particulate respirators and half-face respirators differ in design and method of operation, experimentation has shown that they have a similar effect on performance. These results support the assumption that two respirators with the same APF would likely have the same effect on human psychomotor performance regardless of respirator design; however, they might produce different effects on physiological and psychological abilities. According to Harber, et al. (2011), the half-face respirator imposes more stress than the particulate respirator.

To compare visual effects, Zelnick, et al. (1994), compared three full-face respirators in terms of their effect on the visual field. Although all three respirators were full-face respirators with APFs of 50, they affected the visual field differently. The researchers concluded that having the same APF might not indicate similar visual field range.

Respirators With Different APFs

The second group of studies compared different types of respirators in terms of their physical, cognitive and psychomotor effects (James, et al., 1984; Zimmerman, et al., 1991). To compare the effects of different types of respirators, James, et al. (1984), put five participants under the stress of three different types of respirators, two levels of heat and two levels of workload. The first respirator was a half-face respirator (Willson model 1200). According to OSHA, it has an APF of 10. The second respirator was a full-face respirator (Willson model 1700) with an APF of 50. The third respirator was a powered air-purifying respirator with an APF of 25.

The study based the comparison on the respirators' dead space volume. The experiment measured participants' heart rate, oral temperature, sweat rate, minute volume, oxygen consumption and energy expenditure. Five out of six physiological variables showed that the full-face respirator imposed additional stress on the participants. The study restated the effect of the larger dead space of the full-face respirator. The authors of this article considered the results of this research in terms of the respirators' APFs. The results support the assumption that a higher APF results in greater physical stress on humans.

To compare different types of respirators in terms of their physical, psychomotor and cognitive effects, Zimmerman, et al. (1991), tested three types of respirators on 12 participants. The first respirator was a 3M disposable particulate respirator (model 8710) with an APF of 10. The second respirator was a half-face respirator (North 7700) also with an APF of 10. The third respirator was a full-face airline respirator with air supply with an APF of 1,000. The full-face respirator resulted in more strain and decline in psychomotor performance. The cognitive effect was not clear because, as Zimmerman, et al. (1991), noted, the test provided to the participants was extremely difficult.

Recommendations

OSHA reports of fatal injuries from 1984 to 1995 indicate that workers wearing respirators were involved in 41 incidents resulting in 45 deaths as a result of asphyxiation or chemical poisoning. Most of these fatalities involved regulatory and procedural violations and could have been prevented through proper training and better compliance with regulations (Suruda, Milliken, Stephenson, et al., 2003).

Therefore, OSHA and others offer several recommendations pertaining to the use of respirators.

•OSHA requires written, work-site-specific procedures under 29 CFR 1910.134(c)(1). According to OSHA, employers must evaluate any respiratory hazards and identify relevant workplace and user factors when selecting respirators. Employers should also consider a set of procedures that highlight the skills related to each specific task and how those skills may be affected by the respirator.

•OSHA 29 CFR 1920.134(c) states, in general terms, that under certain conditions, employers can decide to make respirators use voluntary in order to prevent potential hazards associated with respirator use.

•The current literature review indicates that full-face respirators may cause workers to be less efficient in situations that require high mental activity and quick decision making, or that are hot and have an extended exposure time.

•Based on several studies, particulate respirators that have no exhalation valve increase heat stress. Thus, units with exhalation valves are preferred when considering employee comfort and performance.

•In addition to WPF studies and experiments, employers can perform assessments to ensure a successful match between workers' skills, abilities, job requirements and PPE.

•Selecting a proper respirator is only the beginning of an effective respiratory program. Fit testing, training, continuous medical evaluation and respirator maintenance are needed to ensure worker safety (Smithers, 2012).

A hands-on, interactive workshop is one form of training that can contribute enormously to the effectiveness of proper respirator use (Krasowska, 1996; Thomas, 1999). When engaging in fit testing, employers should consider that some individuals cannot use respirators due their special facial dimensions (Oestenstad & Perkins, et al., 1992; Thomas, 1999).

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Conclusion

Analysis of past studies indicates that respirators with different APF values will affect physiological and psychological performance differently. Respirators with higher APF values can reduce a wearer's physiological and psychological ability, especially if the task involves physical activity. The effect of respirators with different APFs on visual ability is unclear. However, with regard to full-face respirators with similar APFs, the visual ranges may vary. Certain chemical solutions may help to eliminate the lens fogging that commonly occurs in these devices.

No evidence strongly suggests that an increase in APF would decrease psychomotor abilities. This reivew also showed that tasks involving easy-to-moderate motor skills were not affected differently by respirators with similar APFs. However, although particulate respirators and half-face respirators have similar APFs, only the half-face respirator has been found to decrease physiological ability and increase anxiety. Also, respirators with similar APFs seem to have no effect on the cognitive abilities of wearers performing easy tasks.

Furthermore, no evidence strongly suggests that respirator use might decrease cognitive abilities, regardless of the protection level provided. That said, if a task is performed in a high-temperature environment and involves a high level of physical activity or critical mental ability, caution should be taken.

Employers should consider the results of respiratory studies when determining the proper respirators for their workers and tasks. After the proper respirator is selected, employers must continue to diligently ensure that rules and recommendations are followed for the ultimate safety and productivity of their workers. **PS**

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