EVALUATION OF TRAINING TECHNIQUE AS A MEANS OF INFLUENCING SAFETY KNOWLEDGE, RISK PERCEPTION AND PROPER RESPIRATOR DONNING ABILITY AMONG RESPIRATORY PROTECTION USERS

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Evaluation of Training Technique as a Means of Influencing Safety Knowledge, Risk Perception and Proper Respirator Donning Ability Among Respiratory Protection Users

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(ABSTRACT)

Of all personal protective equipment available for the health and safety of workers, respiratory protection may be the most commonly used. It is also one of the most difficult to administer properly. Improper wearing of respirators can have serious consequences. Of 482,000 reported occupational illnesses in 1996, nearly 22,000 of these were attributed to respiratory conditions as a result of inhalation of toxic agents. Providing effective respiratory safety training has generally proven to be challenging, since the protection a respirator provides is dependent on how well the respirator fits the worker’s face. Improper donning can lead to serious health consequences and may even be fatal. Training methods are effective if they facilitate workers’ progress towards health promoting goals. In this case, proper respirator donning ability is the final exam in determining training method effectiveness. The potential benefit of improving worker health and a review of the OSHA respiratory protection regulations revealed a need for additional investigation about effective respiratory safety training techniques.

This study was conducted to investigate the effectiveness of three different training methods (commercial videotape, manufacturer package instructions and a systematic interactive multimedia method). The experiment was divided into two parts. In part one, each training method was examined for its’ ability to enable subjects to provide safety information and to identify risks associated with respiratory hazards. Each training technique was also evaluated as function of subject education level, age and gender differences.

In terms of safety knowledge and risk perception, results indicated that the systematic interactive multimedia technique was the most effective at training OSHA recommended respiratory safety knowledge, and causing a significant difference between risk perception ratings of worksite conditions determined from a pre- and post-training questionnaire. The systematic interactive multimedia technique incorporated a systematically designed multimedia program with a one-on-one modeled respirator
donning technique. Neither manufacturer provided package instructions nor the commercial videotape was significant for safety knowledge or risk perception.

Part two of the experiment was the final exam in terms of training effectiveness, where subject ability to achieve passing Quantitative Fit Testing (QFT) after donning half- and full-facepiece negative pressure respirators was evaluated. Training methods were assessed in terms of donning instructions. Additional effects evaluated were respirator presentation order, age, education level and gender differences. Evaluation studies inherently have limitations that affect the interpretation of effects. Quantitative fit testing of respirator masks used in this study could only be conducted on 52 of 72 study participants. Eleven females and nine males were eliminated and were scored as missing values in QFT data analysis due to the constraint imposed by the fact that no available half-facepiece or full-facepiece masks could fit/seal their face shapes. Non-parametric testing indicated the commercial videotape and manufacturers’ package instructions were more effective at training subjects to pass half-face respirator quantitative fit testing than full-face respirators. No significant presentation order, age, education level or gender effects were shown. Subjects who could not be tested were petite females and obese males. This finding suggests that a need for additional mask sizes (e.g. extra-small, extra-large) by manufacturers was indicated to reduce the need for custom made to fit masks. In addition, manufacturer’s of negative pressure respirators need to be aware of the large number of QFT failures encountered in this study, as well as their causes to improve design.

Additional information was obtained in the course of analyzing QFT data. First, a large number of subjects failed quantitative fit testing due to their inability to properly tighten headstraps. All training methods were evaluated for effectiveness in ability to properly convey headstrap tightening. Based on QFT pass/fail results, the systematic interactive multimedia training was shown to be more effective at training headstrap tightening for full-facepiece than half-facepiece respirators, as it resulted in the least number of QFT failures due to improper headstrap tightening. No method was superior to the others at training half-facepiece mask headstrap tightening.
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Chapter 1 Introduction

Of all personal protective equipment available for the health and safety of workers, respiratory protection may be the most commonly used. It is also one of the most difficult to administer properly (Krasowska, 1996). Improper respiratory protection training can have serious consequences. Of 482,000 reported occupational illnesses in 1996, nearly 22,000 of these were attributed to respiratory conditions due to toxic agents (National Safety Council, 1998). Providing effective respiratory protection training has generally proven to be challenging. A proper respiratory safety training course provides crucial information that the wearer must be aware of to avoid improper donning or use of respiratory protection devices. Improper use or donning can lead to serious health consequences and may even be fatal.

A review of scientific literature, ANSI Z88.2 (1992) and OSHA 29 CFR 1910.139 (1998) regulations revealed a need for additional investigation about effective training techniques. Analysis of the ANSI standard and OSHA requirements revealed that while minimum training requirements and specific training content are listed by both organizations, no recommendations for media type or “how to present” the minimum requirements were provided.

This study investigated the effectiveness of three different types of training techniques in terms of appropriate presentation of OSHA recommended safety information, ability to cause a change in risk perception of respiratory hazards, and the ability of individuals to properly don half and full facepiece negative pressure respirators following training. Three training techniques were also examined as function of age, education level and gender differences. The three training methods used were: 1) a commercially produced videotape developed without systematic instructional design principles, 2) manufacturers' package instructions, and 3) a systematically designed systematic interactive multimedia training program. Results of this study were expected to be useful for a number of employees at Virginia Polytechnic Institute and State University and for other agencies who have implemented respiratory protection programs. Quantitative fit testing of tight-fitting respiratory protection devices is an important requirement in the process of determining whether a given respirator has been donned correctly for a given employee (Colton, 1996).
Chapter 2 Literature Review

2.1 Respiratory Hazards

Respiratory hazards are a concern in situations when the presence of some form of airborne hazard threatens life and health. This type of hazard exists in the workplace either when a substance is present in the atmosphere at a concentration that, if inhaled, will cause bodily harm, or when there is deficiency of oxygen occurrence in the atmosphere (Harris et al., 1994). Respiratory hazards in the industrial workplace frequently consist of oxygen deficiency or air contaminants (Anton, 1989; Revoir and Bien, 1997). Air contaminants exist in the following forms: 1) particulate contaminants including aerosols, dust, fumes, mists, 2) vapors and gas, and 3) a combination of particulate matter, vapor and gas (Biter, 1992). These hazards are numerous in manufacturing operations, maintenance of plants and equipment, construction and when employees are responding to accidental spills of hazardous substances (Weeks et al., 1991; ANSI Z88.2-1992).

2.1.1 Consequences of Improper Respirator Use

Improper use of a respirator can have serious consequences on a worker’s health (Revoir and Bien, 1997). The Bureau of Labor Statistics reported that over 482,000 occupational illnesses were reported in 1996 (National Safety Council, 1998). Of these, 22,000 illnesses were attributed to respiratory conditions due to toxic agents. The point of this example is to show that the uninformed or improper donning of respirators can have serious consequences. Information about proper respirator donning technique is crucial information that the wearer must be aware. The Occupational Safety and Health Administration (OSHA) of the Department of Labor mandates that employers prepare a written respiratory program if their employees are exposed to respiratory hazards. A respiratory program was a tool used as a guide to train employees if they will be expected to work in conditions that require respiratory protection.
For those with a need to know and understand how and why respirators work, important background issues of general respirator information and the OSHA requirements were examined (Revoir and Bien, 1997). Enactment of the Occupational Safety Health Act in (OSHA) in 1970 has had a significant impact on respiratory protection. An existing consensus standard for respirator protection, ANSI Z88.2-1969, was adopted and enforced by OSHA as its standard on respiratory protection. There have been significant developments in respiratory protection in the past two decades. A brief review of major developments follows.

2.1.2  ANSI Z88.2-1992

The American National Standard for respiratory protection stated acceptable practices for respirator users, provides information and guidance for proper selection and use of respirators, and contains requirements for the establishment of respiratory protection programs. This standard applies to all employees who use some form of respiratory protection against inhalation of harmful air contaminants with the following exceptions: underwater breathing devices, aircraft oxygen systems, respirators used in military combat, and medical inhalators and resuscitators.

2.1.3  29 CFR PART 1910.139

The Occupational Safety and Health respiratory protection standard for general industry is 29 Code of Federal Regulations Part 1910.134. The most recent amendment to this document was enacted April 4, 1998. Included in this text were a number of mandates that stipulate that the employer will provide respiratory protection as necessary to protect the health of employees. The employer shall provide the respirators, which are applicable and suitable for the purpose intended, and were responsible for establishing and maintaining a respiratory protection program.
2.1.4 Respirators

A respirator is defined as a device worn by a person for protection against inhalation of a harmful atmosphere (Weeks et al., 1991). In the workplace it functioned as a face piece designed to prevent contaminated air in a room or breathing area from entering the lungs of the person wearing it to allow a person to breathe and work safely (Koren, 1996). A negative pressure respirator provides protection to the wearer by removing contaminants from the air before the air is inhaled. A respirator which removes contaminants from the ambient air before the air is breathed by the wearer, is called an "air purifying" respirator as air purification is its mode of operation. Air-purifying respirators utilize filters or sorbents that remove harmful contaminant substances from the air prior to breathing (Brief, 1975; Biter, 1992). A limitation of air purifying respirators is an increase both in the resistance of breathing and the physiological dead space in the respiratory tree of the lungs. This limitation prevents some people with respiratory medical disorders from wearing them (Weeks et al., 1991). Several physical attributes also prohibit some people from achieving appropriate respirator facepiece sealing.

2.1.5 Respiratory-Inlet Coverings.

All negative pressure respirators are equipped with respiratory-inlet coverings, which serve as a barrier against harmful atmosphere and provide a way to connect the respirator wearer's respiratory system to an air-purifying device or source of respirable air. The respiratory-inlet covering of a non-powered air-purifying respirator may be a half-facepiece or full facepiece. The type of negative pressure respirators utilized in this study were classified as tight-fitting coverings. See Figures 1 and 2.
2.1.6 Tight-Fitting Respiratory-Inlet Coverings

A tight-fitting respiratory-inlet covering consists of a facepiece that either covers the respirator wearer's nose and mouth (half-facepiece) or the respirator wearer's nose, mouth, and eyes (full facepiece) (NIOSH, 1987). The tight-fitting covering provides a double seal to the device itself. The facepiece covering was designed to make a gas-tight or particle-tight seal on the respirator wearer's face (Siebe-North, 1990).

2.2 Non-Powered Air-Purifying Respirators

This type of respirator was intended for use by trained personnel in accordance with ANSI standard Z88.2 and OSHA regulation 1910.134. Functionally, this type of air-purifying respirator required the wearer to pull air through the filter or cartridge by breathing in order to provide it to the mask. As long as the respirator is in good working order, the only available pathway that
contaminated air can enter an individual's lungs is through a leak in the face-to-facepiece seal.

2.2.1 Negative pressure half-facepiece

This device is an air-purifying respirator consisting of a half-facepiece assembly and a pair of replaceable air-purifying elements/cartridges that provide respiratory protection against hazardous vapors, gases and/or particulate matter, depending upon the type of element/cartridge used (North Safety Equipment, 1990). Functionally, the respirator wearer inhaled air through the air-purifying elements, which removed the airborne hazard from the air before it entered the lungs. During inhalation, inhalation valves in the facepiece opened and the exhalation valve closed to prevent contaminated air from entering the facepiece. During exhalation, the exhalation valve opens and the inhalation valves close to prevent exhaled air from passing back through the air-purifying elements.

2.2.2 Negative pressure full-facepiece

The negative pressure full-facepiece respirator was designed to provide respiratory and eye protection against hazardous vapors, gases and/or particulate matter, depending on the air-purifying elements used, the contaminant concentration and toxicity, and the amount of oxygen present (North Safety Equipment, 1990). Functionally, when the respirator wearer inhaled, the contaminated air was drawn through air-purifying elements that remove the hazardous vapors, gases and/or particulate matter from the air before it entered the lungs. The purified air was passed over the lens in the facepiece to minimize lens fogging. During inhalation, the exhalation valves in the facepiece opened and the exhalation valve closed to prevent contaminated air from entering the facepiece. During exhalation, the exhalation valve opened and the inhalation valves closed to prevent exhaled air from passing back through the air-purifying elements.
2.3 Respirator Fit Testing

In order for a respirator equipped with a tight fitting facepiece to provide adequate respiratory protection to its wearer while in a hazardous atmosphere, the facepiece must form a satisfactory seal to minimize leakage of a hazardous atmosphere into the facepiece where it would be inhaled by the wearer (Revoir and Bien, 1997). Since each individual’s face varies in size and shape, the ability of the facepiece of a respirator to achieve a satisfactory fit on a particular worker’s face must be determined by a fit test. The type of respirator facepiece fitting test used in this study was quantitative.

2.3.1 Quantitative Fit Testing

Quantitative-type respirator Fit Testing (QFT) equipment evaluated the face-to-facepiece fit of a negative pressure respirator. With a perfect respirator and fit, all inhaled air was forced through a filter system, thereby, providing maximum respiratory protection for the individual. If the face-to-facepiece seal leaked, unfiltered air bypassed the filter system and entered the individual’s lungs during inhalation, and reduced respiratory protection. Quantitative test equipment provided a measure in the form of percent of air leakage between the face-to-facepiece seal, and the calculation of the fit factor of the respirator being tested (Colton, 1996).

2.4 Reduction of Hazards

Clearly, more effective injury control techniques were needed to reduce hazards. As outlined by Plog et al., (1996), there are three methods of controlling hazards. The first option was to design respiratory hazards out of the task and equipment by providing an engineering control of emissions or particulates. Engineering controls are workplace-directed approaches that rely on changes in equipment to eliminate or minimize exposure to hazards. However, not all hazards can be practically alleviated by equipment design. Second, when engineering controls are not feasible, the next technique of controlling hazards is requiring individual behavior changes through law or administration. Job rotation, personnel education and training are worker-
directed approaches that attempt to maintain compatibility between the workers capacity and the demands of the job (Anton, 1989). Personnel education and training have been identified as administrative solutions to minimize the exposure of workers to occupational hazards. The purpose of education and training was to ensure that employees are sufficiently informed about the hazards they may be exposed, and therefore be able to apply correct procedures to avoid them (Chissick, and Derricott, 1981). This was accomplished through the presentation of safety information.

2.5 Training

Due to the abundance of safety and hazard avoidance information for respiratory hazards, it was necessary to provide safety information to a wearer through some type of training method. The following sections outlined the current training methods used in the respiratory protection industry, the inadequacies of each approach, reasons why interest in training was increasing, and the ways in which systematic interactive multimedia could improve presentation of respiratory hazards via training methodology.

Training is a process used to present information concerning hazards to individuals. Training and job knowledge are the two most important factors in an accident prevention program. Making a worker fully aware of job hazards, and training the worker to recognize those hazards were the major preventative measures taken. Situations which were not perceived to be very hazardous did not prompt the worker to be cautious. Thus, the workers’ risk perception of hazards should have been made representatively high.

2.5.1 Commercial Videotape Training Program

The Pro-Tech videotape “How to clean, wear and care for your respirator,” was purchased through the Safety Products, Inc. equipment and training materials catalog. This particular videocassette was chosen due to its modest price ($22.00) and its application to both half- and full-facepiece respirator types. It was the investigator’s opinion that this video was likely to be purchased as a training device for compliance with OSHA standard 29 CFR 1910.134 (1998) due to its economic feasibility and practical applicability for companies where multiple types of personal
protective equipment are issued to employees who must receive some type of training. The goal of the commercial videotape was to provide the trainee with comprehensive coverage of “how to” don negative pressure respiratory protection devices and associated maintenance, storage, types of fit testing and hazardous workplace conditions that preclude respiratory use. The script of the commercial videotape produced by Pro Tech, Inc. was shown in Appendix A.

Possible advantages of using this videotape as a form of media instruction were: 1) the training objective was presented to the trainee, 2) instruction may be repeated as needed, 3) training information could be made into a simple step-by-step presentation of sequenced learning, and 4) it may be efficient for training on an individual basis. However, based on its’ contents, it is unlikely that this video tape was developed via a systematic training program instructional design techniques. In particular, the design process did not follow a formal, structured analysis of the trainees, tasks, and information to be presented. Disadvantages associated with use of this videotape as a method of training people about safety have been found using Smith and Berenger’s (1989) criteria. First, trainees were not provided with feedback regarding their performance throughout the training session. Second, trainees received no positive motivation as to their skill performance. Third, trainees were not guided to proper responses to speed up skill acquisition. Therefore, incorrect responses or misunderstanding of a safety concept were not detected before a bad habit is formed by the trainee. Fourth, the video instruction did not present training materials in stages of difficulty ranging from easiest to most difficult. Finally, the video provided no time for skills practice. Trainees were not given a chance to test their newly acquired knowledge/skills before use at an actual workplace.

2.5.2 Manufacturer’s Package Instructions

Manufacturer’s package instructions were presented to the consumer in the form of text. The text served primarily as a source of information in this case. The instructional strategy employed to bring learners into a state of full knowledge was generated by the reader using
text as the method. Further, an instructor was not present to assist in bringing about learning (Dick and Carey, 1996). The advantages and disadvantages associated with the use of text as a form of training were be discussed.

Advantages of text as a form of training technique were: 1) clear objectives of training were provided, 2) specific examples of product use were shown with step-by-step presentation of sequenced learning, 3) the training was learner-paced, 4) materials were repeatable and easily accessible, and 5) it was a form of self-instruction. However, the disadvantages of text as a form of training weighed heavily; 1) no provision for feedback, 2) trainee questions could not be easily answered, and 3) little or no attempt at instilling an increase in trainee risk perception or altering risk perception was made. Half- and full-facepiece respirator text instructions may be seen in Appendix L.

2.5.3 Increased Interest in Training

The interest in training those who use respiratory protection devices has increased; however, factors other than the incidence rates of respiratory illnesses and fatalities are motivating this topic. Economic costs associated with Workman’s Compensation, personal injury litigation and the possibility of paying large sums of money in OSHA fines for non-compliance usually capture a company’s attention for a need to train employees. Further economic loss may occur in terms of lost wages, higher industrial insurance costs, loss of production directly attributable to an unsafe incident, and loss of materials and equipment.

Managerial commitment is a key factor in a training program; there is a direct correlation between good management and a good safety record (Hammer, 1989; Heinrich, 1959). Jackson (1981) stressed that a strong commitment is manifested by active leadership, sustained interest, and total support and participation, and the delegation of responsibility with accountability. A training program backed with strong commitment by management will be successful and will aid in decreasing accident rates (Chissick and Derricott, 1981).
2.5.3.1 Systematic Training Program Design

Training programs based on principles and guidelines of instructional technology, education and human factors are based on a systematic instructional design model (Gordon, 1994). Smith and Berenger (1989) listed principles of an instructional design method that emphasize how to train people about safety. These principles are as follows:

1. Make the training situation similar to actual job conditions to enhance the transfer of training knowledge and skills to actual work situations.

2. Explain the rules to the trainees. Trainees should be provided with a road map of the training process, what they are expected to learn, and how their performance is expected to improve before they start training.

3. Ensure the basics are well learned. Basic materials provide the foundation on which the rest of the training program is built, and ingrained in the trainee before moving on to specific concepts.

4. Provide trainees with feedback regarding their performance frequently throughout the training session. Frequent feedback allows learners to modify their responses to improve the learning process.

5. Motivate trainees on a specific basis. Motivation should always be positive. Punishment should not be used. Specifically, when skills are done incorrectly or questions answered incorrectly, the trainees should receive feedback about their performance. This feedback should identify weaknesses and how to improve performance. It should be straightforward and non-critical so as not to demotivate trainees.

6. Guide trainees to proper responses to speed up skill acquisition. An incorrect response or misunderstanding of a safety concept should be detected quickly before it becomes a bad habit.
7. Present training materials in stages of difficulty ranging from easiest to most difficult. Trainees should be required to study increasingly difficult materials only after they have learned the preceding simpler material that provides the basis for understanding the harder material.

8. Spend the most training time on the most difficult materials, as the amount of training time is limited. This statement carries with it the assumption that the hardest training materials are those of most consequence to hazard control. Because the purpose of training is to control hazards, the most emphasis in the training program should be to that end.

9. Use labels to help trainees identify concepts and skills. These tools will help learners discriminate between materials being taught, should be practiced, feedback and transfer to skilled situations easier.

10. Allow enough time for skills practice. Trainees should be given a chance to test their newly acquired knowledge/skills before use at an actual worksite.

An instructional design model which incorporated these principles is described by Gordon (1994). This was a three-phased model consisting of a front-end analysis, a design and development phase, and an evaluation phase. The front-end analysis included all of the initial work which will be performed before the training program is actually developed. This included a needs assessment (see Appendix B) and a system specification analysis (see Appendix C). The needs assessment included an organizational analysis, a cognitive/task analysis, and a trainee analysis, while the system specification analysis consisted of an outline of constraints, goals, and objectives.

The system design and development phase began after the completion of the front-end analysis. By considering the information generated in the first phase, design concepts were developed for the training system. After analysis of the design
concept and consideration of the system specification analysis, prototypes were developed for user testing. Iterations were completed following the prototyping and user testing. Next, full scale development occurred. Final user testing was done with subject experimentation, and system evaluation was done with experimental procedures and statistical analysis.

2.5.3.2 Systematic Interactive Multimedia Training Instruction

One possibility for bringing together systematic instructional design techniques and safety information was a systematic interactive multimedia training program. Systematic interactive multimedia incorporated a computerized tutorial system which displayed combinations of text, graphics, animation, still video, and motion video, with a one-on-one modeled respirator donning technique formally called a Standardized Behavior Modeled Interaction (SBMI). The SBMI was implemented to provide hands-on exercises to provide trainees the chance to work with half- and full-facepiece respirators. According to OSHA, sole reliance on computer-based training cannot allow trainees to achieve training objectives when personal protective equipment use is involved (OSHA Letter of Interpretation, 1994). The systematic interactive multimedia tutorial text and the SBMI were found in Appendices I and J, respectively. Systematic interactive multimedia best replicated performance conditions at the worksite, as actual digital photography of the representative work groups on campus was incorporated into the screen format. The training designer had the responsibility of selecting and designing the elements which were included in the tutorial. The tutorial was followed by a standardized behavior modeled interaction as a model of proper respiratory protection device donning technique. Constraints to design of the training program did not interfere with selection of an systematic interactive multimedia training medium presentation.
One important factor incorporated into the systematic interactive multimedia training was the user’s interaction which could potentially provide an opportunity to learn by experience. For example, the user was provided with a situation, made a decision, failed or not, received immediate feedback, and then tried again. This concept of allowing failure was supported by Dick and Carey (1996) who stated that after trying to answer a question and failing, the user is confused and is more motivated to learn. Unfortunately, mistakes with manufacturer’s package instruction or videotape technique could result in severe injury or fatality. The use of systematic interactive multimedia training allowed the user to interact with a model, make mistakes, and retry in a safe environment.

Systematic interactive multimedia training also allowed the trainee to see the consequence of a particular hazardous action in the form of animation. Although motion video alone allows the opportunity to see the consequence of a bad decision indirectly (e.g. when a person makes a mistake), a computer based optimized training tutorial allowed the user to make mistakes and observe the consequences as they related to personal harm. Further, a systematic interactive multimedia presentation allowed practice at recognizing potentially hazardous situations and respirator donning with no serious harm if the trainee failed at the task.

An additional advantage of the systematic interactive multimedia training technique was that the ability to program it to accept various text-entered statements. The trainee received information and generated answers which were checked against a database of correct or incorrect answers. Motion video, as previously mentioned, does allow for generative learning if the information is presented in the correct format. However, regular video media (e.g. a video cassette tape) does not require an action by the user, and since the medium is familiar, it may seem dull to the trainee. As systematic interactive multimedia training is
a relatively new technology, its novelty may be found captivating, and therefore motivate the trainee. The ability for interactive, generative learning (as opposed to passive engagement) with training is an advantage when the ability to practice, make errors, and receive feedback in a safe environment is particularly difficult with video media. The systematic interactive multimedia training program was developed in accordance with a three-phased instructional design model by Goldstein (1986) and Dick and Carey, (1986). Figure 3 depicts this process. The steps of each phase was described briefly.

A systems approach to instructional design was conducted in development of the systematic interactive multimedia training program. In this process each component (i.e. instructor, trainee, materials and learning environment) was considered crucial to successful learning and are taken into account. The system was a set of interrelated parts which worked and depended on each other toward a defined goal (Dick and Carey, 1996). Therefore, the instructional process itself was viewed as a system. The purpose of the system was to bring about learning. The instructional design model shown below showed how an instructional systems development process was used in preparation, implementation, evaluation and revision of instruction is an iterative, integrated process. The results were used to determine whether the system should be changed, and if so, how often.
PHASE I: FRONT-END ANALYSIS

Perform Needs Assessment
  Organizational Analysis
Task Analysis
  Trainee Analysis
Write System Specifications
  Requirements (Goals/objectives)
  Constraints
  Learner Characteristics

PHASE II: DESIGN AND DEVELOPMENT

Develop Design Concept
Develop Prototype(s)
Preliminary User Testing
Full Scale Development
Final User Testing

PHASE III: EVALUATION

Identify Evaluation Criteria
Develop Instruments to Measure Performance
Collect and Analyze Data
Evaluate Program

Figure 3: Instructional Design Model
2.5.3.3 Instructional Strategy.

An instructional strategy by Dick and Carey (1986) was utilized to define the instructional materials and procedures to be used in order to elicit learning outcomes from the trainees. The components of instructional strategy were: (1) pre-instructional activities, (2) information presentation, (3) learner participation, and (4) testing.

2.5.3.4 Organizational Analysis.

The first step of the needs assessment consisted of an Organizational Analysis (OA). The OA was concerned with the system-wide components of an organization. It examined organizational goals, resources and environmental constraints. During this analysis, an evaluation was made of the organization in which the trainees will perform their job. In this study, an analysis was performed of ANSI Z88.2 (1986) and 29 CFR 1910.139 standard training requirements and subject matter expert recommendations (see Appendix B). The analysis aided in determining factors which would impact performance after training was complete and in determination of resources available that determine the design of the training program. Analysis of the ANSI standard and OSHA requirements revealed that while minimum training requirements were listed by both organizations, no recommendations for media type or “how to present” the minimum requirements were provided.

2.5.3.5 Job Environment Analysis.

A questionnaire was designed to acquire information about job environment. The completed questionnaire was shown in Appendix B. As the training system was targeted for a specific organization, the goal of the job analysis was to identify the goals and trends of the ANSI and OSHA standards in general, and negative pressure respirator use specifically. The job environment portion was answered by two occupational health compliance
instructors at the Environmental Health and Safety Services (EHSS) office at Virginia Tech. The remainder of this section was a summary of their answers.

2.5.3.6 Training Environment Analysis.

The Training Environment Analysis (TEA) was part of the OA. The TEA explored the resources available for training. NIOSH supplied funding for volunteer subject payment at a rate of $10.00 per hour, as well as a monthly stipend and semester tuition waiver for the student investigator. Available human resources for the research project in addition to the student investigator was one occupational health/industrial hygiene employee from EHSS at VPI & SU who served as an expert quantitative fit tester. Advice and guidance on the project came from experienced respiratory protection instructors, human factors practitioners and training experts. Necessary computer, respiratory protection devices, QFT equipment, video cassette player and other support equipment was made available by the EHSS office. Study participants were trained and tested at the EHSS office.

2.5.3.7 Knowledge Skill Analysis (KSA) and Trainee Analysis

The second step of the needs assessment was the KSA. The KSA was performed to determine what knowledge and skills are needed for successful performance on the job. This step allowed the designer to determine the appropriate contents for the training process. Performing the KSA was a two-part process of acquiring a traditional task analysis and a cognitive task analysis. The traditional task analysis was a complete assessment of the task performed. According to Goldstein (1986), the task statement should include what the person does, how the person does it, to whom or what the task is done (environment), why the task is done (to accomplish what goals), and when, or under what conditions, the task will be performed.
2.5.3.8 Cognitive Task Analysis

The cognitive task analysis dictated the cognitive processes for each task while determining what level of knowledge the program is to teach. The trainee was to acquire declarative (verbalize) knowledge, and the attitude of the trainee was to be altered in terms of opinion about hazard severity. To aid in deciding what type of safety information would be appropriate to include in a safety training program, a cognitive task analysis was performed using an analysis of documents ANSI Z88.2 (1986), 29 CFR 1910.139 (1998), and subject-matter-expert questionnaire results. This evaluation resulted in a substantial amount of information. After this evaluation, the decision was made as to what portions of information would be incorporated into the training program.

Several considerations were involved in determining what information to incorporate into the training program. First, from the organizational analysis, review of the literature, and statistics of occupational respiratory injuries, it became evident that a minimal amount of respiratory hazard information was being used during training sessions. Second, it was noted that the individuals interviewed for the OA, noted attitudes of VT work groups toward training revealed that younger workers are more likely to be more receptive than older workers. Older workers were likely to take the attitude of “I already know how to do this, and don’t need more training.” Further, actual users of respiratory protection were more likely to appreciate training more than first-line supervisors who view training as employee time away from the job. The subject-matter expert suggested thirty to forty minutes as the recommended systematic interactive multimedia training program length. Third, time and monetary resources were limited to design the systematic interactive multimedia training. Finally, because new employees were sometimes placed at the worksites with little training, it was recommended that these workers should have some basic concepts of the safety hazards they might be exposed to increase perception of risk.
2.5.3.9 Trainee Analysis.

The third and final step of the needs assessment was the trainee analysis (See Appendix B). This was conducted to determine the most likely characteristics of the people who would take part in the training program. This step helped in deciding the presentation style of the systematic interactive multimedia training. This step was important in allowing the designer to determine the gap that existed between the knowledge requirements to perform the task (as determined by the task analysis) and the knowledge the trainee already had to bridge the gap between the knowledge requirements of the task and the knowledge of the trainee.

Since trainees for this research were not available until the study was conducted, a first hand trainee analysis was not performed. However, after conducting the organizational analysis and examining the literature regarding respiratory safety and statistics, three assumptions were made concerning trainee characteristics. First, it was assumed that trainees would have little or no concept of how respiratory protection devices are properly donned. Second, it was assumed that subjects would not understand most potential hazards associated with respiratory safety. Third, no knowledge of respiratory terminology was assumed. Therefore, systematic interactive multimedia trainees were supplied with clear definitions of necessary terms.

2.5.3.10 System Specification Document Analysis.

Following the needs assessment, the training system requirements were developed. The system requirements consisted of a document that outlined constraints, goals and objectives determined from the results of the needs assessment (see Appendix B). The constraints discovered included items such as available funding, a limited number of quantitative fit testing protocols imposed by the Dynatech 3,000 fit tester equipment, and time limit of the tutorial. The goals and objectives outlined precisely what the tutorial was to accomplish, specifically,
increasing basic knowledge, risk perception and ability to identify hazards. The system specifications helped the designer focus on what the training program must do, how it would be accomplished, and the constraints of implementing training goals.

2.5.3.11 Design Concept.

The system design and development composed the second phase of the instructional design model. After the front-end analysis was performed, design concepts for the systematic interactive multimedia training tutorial were conceptualized (see Appendix D). The basic interface layout consisted of a window viewing area and a text area. The window viewing area contained a still video, a scanned photo, motion video, or animation with still video. The text window contained the main points conveyed in the window viewing area. In compliance with safety research findings, the text stated the hazard, available statistics regarding the hazard, and the correct hazard avoidance behavior labeled as “precautions.” The window showed the consequences of non-compliance with hazard avoidance behavior. The overall presentation began with “easy” information and progressed toward “more difficult information”, was straightforward and clear, and stated the safety information explicitly without excessive use of technical jargon.

As previously stated, the design of the systematic interactive multimedia training program was divided into three main areas: 1) the respiratory safety equipment necessary for use at a worksite, 2) hazardous locations at worksites, and 3) hazards caused by chemicals or grains at a worksite. Each section had an introduction, presentation of the material, and a concluding screen. The last two sections, devoted to respiratory hazards and hazardous worksites, gave the trainee a pre-information question before the safety information was presented. This method was in agreement with Shank’s (1990) findings which advocated that allowing students to fail (by asking them a question before they
have been given answer) sparked their interest and attention when the information was presented. At the end of all three sets of information, there was a summary screen of the information presented.

After the summary, the trainees were given scenarios to test their learning. Video and still frame photos were presented on the screen, with questions about safety hazards. If the trainee answered correctly, feedback was given stating that the answer was correct, and explained why the answer was correct with a restatement of the safety message. The trainee was then advanced on to the next scenario. If the trainee responded incorrectly, feedback was given stating that the answer was incorrect, and explained why it was incorrect, followed by a review of the information screens again. After receiving remediation, the trainee moved on to the next question. Although it would have been optimal to keep presenting scenarios until the trainee answered all the questions correctly, this procedure would have significantly increased the time necessary to complete the program and the hardware requirements necessary for the program. After the scenarios were completed, each trainee read a screen which thanked them for participating.

2.5.3.12 Evaluation Phase

The final phase of training development was the system evaluation. This was done using usability study results. This method of developing an instructional design program was highly iterative. Although the phases were performed in sequential order as much as possible, information from later phases often gave insight to a previous phase.

2.6 Safety Information

The development of a safety training program should include research findings regarding effective presentation of safety information (Roland and Moriarty, 1990). In searching for the best method to increase compliance with
safety information and risk perception, researchers have focused primarily on the presentation of hazard information. Hazard information has been presented by exhibiting severity of injury by accident scenarios by stating the consequences of non-compliance in order to lead to increased risk perception (Martin and Wogalter, 1989; Godfrey, 1987).

2.6.1 Risk Perception

The perceived risk or hazard associated with a situation influences worker behavior and the degree that he/she takes precautionary actions to prevent injuries (Sanders and McCormick, 1993; Laughery and Brelsford, 1991). Perceived risk is based upon an individual's past experience, the perceived potential for an unsafe incident, and an individuals' assessment of his/her own ability to cope physically and mentally with a hazardous situation (Wilde, 1982). The principle component of risk perception is injury severity (Wogalter et al., 1987a; Wogalter et al., 1991; Young et al., 1992). With regard to behavior modification, attitude has been shown to influence behaviors which are relevant to the effectiveness of a training program. Attitude is the worker’s feeling of “favorableness or unfavorableness” toward performing a behavior (Gordon, 1994). Changing a person’s attitude can effectively be accomplished by making a change in his/her belief system. Therefore, a worker’s beliefs about respiratory safety hazards determines his/her attitude about using respirators to protect themselves. Significant variations in risk perception have been shown between gender and age group demographics (Goldhaber and deTurck 1988a, 1988b; Leonard et al., 1989).

2.6.1.1 Age Characteristics.

Risk perception subject characteristics have been studied as a function of age (Young et al., 1999; Smith and Watzke, 1990). When considering age, older people tend to be more reluctant to take risks, while younger people appear inclined to take greater risks. Cautiousness is a personality trait found in older people, and studies indicate this cautiousness usually begins in the middle years of life. The perception of
risk plays an important role in safety behavior and hazard avoidance as people age. Therefore, age related information may be useful for predicting and intervening with workers who are at high risk for unsafe incidents.

2.6.1.2 Gender Characteristics.

Subject characteristics have been shown to affect the way people perceive products and their risks (Young, 1996). Where gender differences are found in the literature, females are more likely to act safely, intentionally look for and read warning messages on labels of potentially hazardous products, and have been shown to rate products as significantly more hazardous than males (Young et. al, 1989; Godfrey and Laughery, 1983; Young et al., 1999). Therefore, gender effects may be an important safety-related variable toward reducing consumer hazards.

2.6.2 Hazard Avoidance

It has been suggested that a statement of the hazard and proper avoidance techniques may be the most important determinant for increased warning compliance in an effective safety training program. In addition, providing a statement of the consequences of non-compliance may lead to increased risk perception and warning compliance (Lehto and Salvendy, 1995; Laughery and Stanush, 1989; Martin and Wogalter, 1989). Similarly, Eagly and Chaiken (1984) reported that people are influenced by the presence of statistics in support of an argument. Therefore, an effective safety training program should contain specific information about possible consequences in terms of injury and disease as a result of an improper action. Results of a study by Braun et al. (1995) revealed that safety hazards were better understood by the user when consequence information was a component. With regard to relaying safety information to users, it is important to note not only the hazard and its consequences, but specifically what actions should be pursued by the trainee to avoid the consequences of the hazard. In summary, certain underlying principles relating to the presentation of
safety information in training about personal protective equipment have been stated: 1) state the hazard explicitly, 2) state the correct hazard avoidance behavior, 3) state information regarding the consequences of non-compliance, 4) support the position with statistics, and 5) keep the presentation of information clear and simple.

2.6.3 Cost/Benefit Tradeoff

Once the hazard is understood, it is necessary to convince the respiratory protection user to comply with safety procedures. Besides behavioral compliance, cost of compliance must also be considered (Anton, 1989). The cost of compliance was defined as the degree of difficulty or expense that must be incurred while adhering to the persuasion control technique (Hammer, 1989). “Cost” must be thought of in the broadest terms possible and can include monetary cost, additional procedural steps, procedural step difficulty, violation of social norms, personal discomfort, or a change in previously established behavior (Anton, 1989). Studies have shown that a lower cost of compliance results in a higher persuasion control compliance rate (Dingus et al., 1993; Hathaway and Dingus, 1992; Hunn and Dingus, 1992; Wogalter et al., 1988). Further, training designers must provide trainees with information about possible future consequences that may result if recommendations are not followed (e.g. the worker must be informed that exposure to respiratory hazards is not likely to result in physical symptoms until decades of time has passed). The benefit of complying with warnings in the form of training is non-injury. The perception the workers have of the severity of a potential accident, and of the probability that an accident will occur, affects their evaluation of the benefit. Dejoy (1989) reported that strong and consistent data exist to show that people who feel threatened by potential serious injury will be more likely to comply with warning information.

Perceived compliance benefit and cost, as influenced by prior knowledge and experience, are weighed by trainees to decide compliance or non-compliance (Rey and Bousquet, 1995). The purpose of using statistics to state failure to comply information is to relay safety
information to help the respiratory protection wearer perceive that the probability of an unsafe incident occurring is much greater than previously expected. This will help the worker accurately weigh the probability of the benefit occurring, which has been shown to lead to compliance. An effective presentation of respiratory protection information would aid him/her in cognitively forming an accurate cost/benefit trade-off.

2.6.4 Social Influence

Social influence and modeling have been established in the areas of social and psychological behavior as affecting levels of conformity. The use of a confederate or an “accomplice” in terms of modeling appropriate or inappropriate behavior has been shown to affect whether or not a person chooses to comply with warnings of hazardous situations. For example, in an investigation by Wogalter et al. (1987), an accomplice was utilized who did or did not comply with warnings to use protective equipment. Study participants tended to follow the lead of the accomplice even in a high cost situation, which suggested that peer pressure may override the high cost of compliance. Relaying safety information may therefore be enhanced if appropriate behavior modeling is included.

2.6.5 Familiarity

Familiarity has also been shown to be a factor in risk perception (Wogalter et al., 1991b, Godfrey et al., 1983). Previous experience with a product or task tends to cause a decrease in perception of potential hazards (e.g., McCarthy et al., 1995; LaRue and Cohen, 1987; Wogalter, 1987), especially when unsafe behavior is reinforced. Slovic et al., (1978) stated that risk will be more acceptable, and the product or task is perceived as less hazardous if the situation is familiar to the user. However, analyzing fear following air raids in Britain during World War II, Janis (1982) reported that there is a powerful reinforcement of fear among people who experience near misses, or who barely escape from an accident or fatality. Thus, familiarity, especially regarding personal injury, must be controlled in risk perception studies so as not to confound the results.
2.6.6 Summary of Safety Information Literature

In summary, there are several key research findings regarding the presentation of safety information which may influence its effectiveness. First, it is advisable to utilize the theories of social influence by modeling appropriate behavior. Second, it is also desirable to give examples of inappropriate behavior. Finally, it is necessary to determine the user’s previous level of experience and familiarity with the hazard. Those trainees who are more familiar with respiratory protection and hazards require a different approach to safety information than those with no familiarity.

2.7 Research Statement

Given that improved training showed potential as a feasible solution to respiratory-related injuries as a result of exposure to respiratory hazards, an systematic interactive multimedia training program was developed. This training program incorporated systematic training design techniques which provided trainees with: 1) frequent feedback regarding their performance throughout the training session, 2) positive motivation, 3) guidance on proper responses to speed up skill acquisition, 4) use of labels to help improve their skills, 5) time allowed for skills practice, and 6) provision for a standardized modeled respirator donning interaction to provide a one-on-one respirator donning technique. Specifically, the research objective was to develop and evaluate a type of systematic interactive multimedia training method utilizing systematic training design techniques. Next, comparisons were made with 1) a manufacturer’s package instructions training method, and 2) a commercial video training session that was developed without using systematic instructional design techniques. It was hypothesized that presentation of respiratory safety and hazard information via a systematic interactive multimedia program, developed using a systematic instructional design approach, would result in significantly higher knowledge of safety information pertaining to respiratory protective device usage, a higher occurrence of risk perception of respiratory hazards as compared with both the manufacturers’ package instructions and the video training session that was developed without using current instructional design techniques. It was also hypothesized that the standardized behavior modeled interaction portion of the systematic interactive multimedia would result in a higher QFT pass rate than manufacturers’ package instructions or the commercial videotape.
Five primary questions were investigated regarding the effectiveness of three training techniques: (1) Was a systematic interactive multimedia type of instruction more effective for use in training proper respirator safety issues such as safety knowledge, risk perception and proper donning technique than a commercial videotape or manufacturers’ package instructions?, (2) Did a significant difference exist between male and female study participants in risk perception tasks post training?, (3) Did a significant difference in risk perception tasks exist between older and younger study participants following training?, (4) Did younger study participants respond differently than their older counterparts to the different instruction methods?, and (5) Did males respond differently than females to the different instruction methods?
Chapter 3 Method

Three training techniques (commercial videotape, manufacturer provided package instructions, and systematic interactive multimedia training) were evaluated for their effectiveness in influencing risk perception, safety knowledge and respirator donning technique between study participants.

3.1 Participants

Seventy-two volunteer participants equally divided into age groups, education levels and gender were utilized in the study. Participants consisted of 36 males divided into two age groups (18 younger [age 18 – 25], 18 older [age 45 – 60]) separated into three education levels (education level 1 [high school education or less], education level 2 [some college or completed bachelor’s degree] and education level 3 [some graduate school or completed a graduate degree]) and 36 (18 younger, 18 older) females who were also separated into three education levels who responded to an advertisement for this experiment. The first segment of the study involved use of a telephone screening questionnaire (see Appendix N).

3.2 Screening Questionnaire

All potential participants were screened for possible exclusion from the study. Special respirator wearing conditions, previous respiratory safety training, experience with negative pressure respiratory protection devices, or familiarity with respiratory safety protection were reasons for exclusion (see Appendix N). Special respirator wearing problems/conditions included current respiratory illness, missing teeth, and/or the presence of facial hair or facial deformity. Specifically, any potential participant who answered “yes” to questions 10 – 14, or rated his/her familiarity with respirator fitting/safety as 4 or higher on questions 15 or 16 were eliminated as study participants. Volunteers were paid $10.00 per hour for participation in the study.

3.3 Procedure

The experimenter reviewed answers to the screening query and invited qualifying persons to participate in the study. Each participant proceeded
through the research session individually. All research was completed at the office of Environmental Health and Safety Services (EHSS) located on the Virginia Tech campus in one session. After the potential participant was seated, s/he completed an informed consent form relevant to the training group in which he/she was placed (see Appendices F, G, and H). After the informed consent form was signed, the experimenter gave each participant a one-page description of the training process (see Appendix E).

After reading the one-page description, the trainee proceeded by answering the pre-test questionnaire, followed by exposure to either a commercial videotape, manufacturer’s package instructions or the systematic interactive multimedia training technique which was assigned to him/her via randomization (see Figure 3). A ten-minute question and answer period was offered to each trainee following completion of training. Trainees completed their respective tutorials, which was followed by the post-test questionnaire. The pre- and post-training questionnaire focused on assessment of knowledge of safety information and risk perception. See Appendix O. Once all data was collected, the experimenter graded and/or calculated means based on questionnaire answers in a systematic fashion. Differences (pre-training questionnaire mean – post-training questionnaire mean per subject) were obtained and used in statistical analysis. Here, the term “mean” refers to percent correct of multiple choice questions and mean occupation and worksite condition ratings.

### 3.3.1 Data Analysis

An explanation of the data analysis used in the course of this study is provided. All scoring of the trainee responses was completed by the experimenter. A total of 31 items were scored or averaged on the pre- and post-training questionnaire. Safety knowledge items counted 15 points, while risk perception items composed 15 points, plus one essay question. Each section was scored for all subjects before the next section to promote consistency in grading. Questions regarding knowledge of safety information were scored first, followed by questions pertaining to risk perception. Question 16b of the questionnaire was scored at the same time for all participants to provide consistency in grading. The questionnaire is shown in Appendix O. Data analysis was
completed using Minitab™, Statistical Analysis Systems™ (SAS), and Microsoft Office Excel™ software. The pre- and post-training questionnaire was identical and divided into four subsections for analysis purposes: 1) safety knowledge, 2) subjective opinion essay, 3) occupational ratings, and 4) worksite condition ratings.

**Safety knowledge section (questions 1-15):**

Subject knowledge of OSHA recommended safety information was assessed by scoring answers to 15 multiple choice questions. Next, differences between pre- and post-training questionnaire answers were calculated. The resulting differences were grouped into means according to training type and used to compare means between training groups.

**Subjective opinion essay section (question 16b):**

First, the experimenter scored each participants’ subjective pre- and post-training essay answer to question 16b as to presence or absence of risk perception in their content. Answers were graded by the experimenter and placed in discrete (“yes” risk perception or/“no” risk perception present) categories. When a subject’s attitude was altered via his/her essay answer from a “yes” risk perception pre-training, to a “no” risk perception post-training, or from a “no” risk perception pre-training, to a “yes” risk perception present post-training, evidence of a change in risk perception change was considered to have occurred. Non-parametric McNemar test for significance of change of related samples and binomial tests were used in this evaluation (Siegel, 1956).

**Occupational ratings section (question 17 a-h):**

The occupational ratings task was composed of eight items. Each subject was asked to rate a set of given occupations against occupations that require respiratory protection be used. Mean occupational ratings were calculated for both pre- and post-training questionnaires per subject. Item 17c was excluded from mean calculation, as it was included in the ratings as a distractor. Next, differences between pre- and post-training means were obtained. The resulting differences were used to compare means between training groups.
Worksite conditions ratings section (question 18 a-i):

The worksite conditions ratings task was composed of nine items. Mean worksite condition ratings were calculated for both pre- and post-training questionnaires. Item 18d was excluded from mean calculation, as it was included in the ratings as a distractor. Second, the differences between pre- and post-training means for individual subjects were obtained. The resulting data was used to compare means between training groups.

Post-training questionnaire completion was followed by a second training session which focused on respirator donning technique. All respirator donning training was followed by quantitative fit testing of each respirator individually, and in the order training occurred. For example, if the training using the half-facepiece occurred first, the subject underwent QFT of the half-facepiece respirator immediately. Each participant then underwent training for the second respirator type using a different set of manufacturers package instructions for a full facepiece respirator if a half-facepiece was previously trained, or a replay of the same videotape (since both types of respirators were explained on the same tape), or the Standardized Behavior Modeled Interaction (SBMI). The training was followed again by a ten minute question and answer period, and a QFT.

3.4 Experimental Design

A two part experimental design was utilized. In part one, randomization of training type and education level were used to assign treatments to subjects. Inferences were made based on comparison among means. Comparisons were made on an a priori basis, to determine whether or not the test results were related to the structure of the obtained data (Winer, 1991). In part two, respirator presentation order was superimposed (see Figure 4), on top of a part one randomization plot of training treatments. The experimental plan called for collection of 144 QFT data points (where 72 x 2 = 144). Instead, a large proportion of subjects could not be fit tested (28%) as facial physical characteristics barred them from obtaining adequate respirator face seals. Therefore, only 52 of 72 subjects could be fit tested, which resulted in 104 data points.
3.4.1 Part One:

Part one was composed of a 2 X 2 X 3 X 3 between subjects’ design. The experimental design for part one was a pre- and post-training evaluation which resulted in mean differences per training technique. First, mean differences among the three respiratory safety training techniques were analyzed in terms of percent correct items regarding OSHA recommended safety knowledge. Subject risk perception attitudes were analyzed via occupational and worksite condition ratings, and experimenter graded “yes or no” (risk perception presence or absence) subjective opinion essay question results. Training methods were randomly assigned to subjects (see Figure 4). Results were analyzed to obtain information about the effectiveness of individual training techniques. Of particular interest was whether the systematic interactive multimedia training method was superior in teaching OSHA recommended respiratory safety knowledge as compared to the commercial videotape and manufacturer provided instruction training methods, and whether perception of risk was altered in study participants following exposure to one of the training methods.

In this aim, several statistical techniques were employed. First, standard parametric ANalysis Of VAriance (ANOVA) test results were used to determine if the main effect training or interactions were significantly different. Next, Tukey’s studentized range testing was employed to compare the effectiveness of individual training techniques in terms of safety knowledge and worksite condition rating means. Finally, McNemar significance of change for related samples and binomial tests were used to analyze the experimenter graded subjective opinion essay discrete results. See Table 1 for standard parametric ANOVA table. The variables utilized in part one are provided below.
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<td>T3</td>
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<td>T2</td>
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<td>S53</td>
<td>S54</td>
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<td>S 70</td>
<td>S71</td>
<td>S72</td>
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<tr>
<td></td>
<td>EL 2</td>
<td>EL 3</td>
<td>EL 1</td>
<td></td>
<td>EL 1</td>
<td>EL 3</td>
<td>EL 1</td>
</tr>
</tbody>
</table>
Figure 4. Part 1: 2 X 2 X 3 X 3 Between Subjects’ Design

Legend:
T 1 = Manufacturer's package instructions as training technique
T 2 = Commercial videotape as training technique
T 3 = Systematic interactive multimedia as training technique
EL 1 = high school diploma or less was highest level of education achieved
EL 2 = some college or bachelor’s degree was highest level achieved
EL 3 = some graduate school or graduate degree was highest level achieved
Young = 18 to 25 year old age group
Older = 45 to 60 year old age group
Table 1. Standard Parametric ANOVA Table for Part One.

<table>
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<tr>
<th>Source</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
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</tr>
<tr>
<td>Age</td>
<td>1</td>
</tr>
<tr>
<td>Education Level</td>
<td>2</td>
</tr>
<tr>
<td>Training (SIM, CV, MPI)</td>
<td>2</td>
</tr>
<tr>
<td>Gender X Age</td>
<td>1</td>
</tr>
<tr>
<td>Gender X Education Level</td>
<td>2</td>
</tr>
<tr>
<td>Gender X Training</td>
<td>2</td>
</tr>
<tr>
<td>Age X Education Level</td>
<td>2</td>
</tr>
<tr>
<td>Age X Training</td>
<td>2</td>
</tr>
<tr>
<td>Education Level X Training</td>
<td>4</td>
</tr>
<tr>
<td>Gender X Age X Education Level</td>
<td>2</td>
</tr>
<tr>
<td>Gender X Age X Training</td>
<td>2</td>
</tr>
<tr>
<td>Gender X Education Level X Training</td>
<td>4</td>
</tr>
<tr>
<td>Age X Education Level X Training</td>
<td>4</td>
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<tr>
<td>Gender X Age X Education Level X Training</td>
<td>4</td>
</tr>
<tr>
<td>Error Subjects (Gender X Age X Education Level X Training)</td>
<td>36</td>
</tr>
</tbody>
</table>

(where n=6)

Total 71
3.4.1.1 Part One: Independent variables

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Levels</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender:</td>
<td>Male</td>
<td>2</td>
<td>between subject</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age:</td>
<td>Younger (18 – 25)</td>
<td>2</td>
<td>between subject</td>
</tr>
<tr>
<td></td>
<td>Older (45 – 60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Education Level</td>
<td>H.S. Diploma or less highest level achieved</td>
<td>3</td>
<td>between subject</td>
</tr>
<tr>
<td></td>
<td>Some college or bachelor’s degree highest level achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some graduate school or graduate degree highest level achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Training techniques:</td>
<td>Commercial videotape</td>
<td>3</td>
<td>between-subject</td>
</tr>
<tr>
<td></td>
<td>Manufacturers packing instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Systematic interactive multimedia training</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subjects: n = 6 per block

3.4.1.2 Dependent variables

1. Risk perception ratings between training groups
2. Ability to correctly identify respiratory safety knowledge information via multiple choice questions
3. Subjective essay answers to risk perception essay question

3.4.2 Part Two:

The experimental design for part two QFT data collection/analysis was a 2 X 2 X 2 X 2 X 3 X 3 mixed factor design. Part two was an analysis of respirator donning training technique effectiveness for half and full facepiece respirator types as evidenced by QFT results (discrete pass or fail) for each type of respirator. Each participant individually received a continuation of systematic interactive multimedia, commercial videotape or manufacturer’s package instructions, (the same training technique pursued in part one) for both the half and full facepiece negative pressure
respirators in a pre-determined order (see Figure 5). Therefore, thirty-six subjects received half-facepiece respirator donning training first, while the other 36 subjects received full-facepiece donning first. Following training, each subject was quantitatively fit tested consistently as to the type of respirator training they received first, followed by a second QFT of the second type of respirator they received training. For 20 subjects (28%), no available respirators could properly fit their face shapes. Therefore, QFT could only be collected on 52 of the total 72 subjects, which was a constraint to QFT data. All part two evaluations were analyzed in terms of subject ability to achieve passing QFT results. First, training method effectiveness was evaluated via chi-square independence and Fisher exact testing. Fisher exact testing was used when the expected frequency count assumption for chi-square test of independence was violated (Siegel, 1956). Second, chi-square tests of independence were utilized in evaluation of presentation order, age, gender and education level effects. Third, half- and full- facepiece respirators were compared for ease of fit using McNemar significance of change for related samples, and binomial tests. Binomial testing was used when the McNemar test expected frequency count assumption was violated. Finally, headstrap tightening ability was evaluated by chi-square independence or Fisher exact testing. All the significant differences for each variable analyzed are discussed in the following sections. Alpha at the 0.05 level was used in all measures of significance. The variables for part two were:
### 3.4.2.1 Part two: Independent variables

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Levels</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Order</td>
<td>2</td>
<td>between-subject</td>
</tr>
<tr>
<td></td>
<td>O1 = Presentation order first</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O2 = Presentation order second</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Respirator types:</td>
<td>2</td>
<td>within-subject</td>
</tr>
<tr>
<td></td>
<td>HF = Negative pressure half facepiece</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FF = Negative pressure full facepiece</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Age:</td>
<td>2</td>
<td>between subject</td>
</tr>
<tr>
<td></td>
<td>Younger (18 – 25)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Older (45 – 60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Gender:</td>
<td>2</td>
<td>between subject</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Education level:</td>
<td>3</td>
<td>between subject</td>
</tr>
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<td></td>
<td>H.S. diploma or less highest level achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some college or bachelor’s degree highest level achieved</td>
<td></td>
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<tr>
<td></td>
<td>Some graduate school or graduate degree highest level achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Training techniques:</td>
<td>3</td>
<td>between-subject</td>
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<tr>
<td></td>
<td>Commercial videotape</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer package instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Systematic interactive multimedia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subjects: n = 6

### 3.4.2.2 Dependent variable:

- Percentage of air leakage (fit factor) to interpret the degree of compliance (calculated by QFT) (discrete: pass/fail)
- 1% half-facepiece
- 5% full-facepiece
<table>
<thead>
<tr>
<th>Young</th>
<th>Male</th>
<th>Female</th>
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</thead>
<tbody>
<tr>
<td>T1</td>
<td>O1→O2</td>
<td>O1→O2</td>
</tr>
<tr>
<td>S 1</td>
<td>FF→HF</td>
<td>S 19</td>
</tr>
<tr>
<td>S 4</td>
<td>HF→FF</td>
<td>S 22</td>
</tr>
<tr>
<td>S 7</td>
<td>FF→HF</td>
<td>S 25</td>
</tr>
<tr>
<td>S 10</td>
<td>HF→FF</td>
<td>S 28</td>
</tr>
<tr>
<td>S 13</td>
<td>FF→HF</td>
<td>S 31</td>
</tr>
<tr>
<td>S 16</td>
<td>HF→FF</td>
<td>S 34</td>
</tr>
<tr>
<td>T2</td>
<td>O1→O2</td>
<td>O1→O2</td>
</tr>
<tr>
<td>S 2</td>
<td>HF→FF</td>
<td>S 20</td>
</tr>
<tr>
<td>S 5</td>
<td>FF→HF</td>
<td>S 23</td>
</tr>
<tr>
<td>S 8</td>
<td>HF→FF</td>
<td>S 26</td>
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<tr>
<td>S 11</td>
<td>HF→FF</td>
<td>S 29</td>
</tr>
<tr>
<td>S 14</td>
<td>FF→HF</td>
<td>S 30</td>
</tr>
<tr>
<td>S 17</td>
<td>HF→FF</td>
<td>S 32</td>
</tr>
<tr>
<td>T3</td>
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<td>O1→O2</td>
</tr>
<tr>
<td>S 3</td>
<td>FF→HF</td>
<td>S 21</td>
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<td>S 12</td>
<td>HF→FF</td>
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<td>FF→HF</td>
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<td>S 19</td>
<td>FF→HF</td>
<td>S 36</td>
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<td>O1→O2</td>
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<td>S 43</td>
<td>FF→HF</td>
<td>S 61</td>
</tr>
<tr>
<td>T2</td>
<td>O1→O2</td>
<td>O1→O2</td>
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<td>S 38</td>
<td>HF→FF</td>
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<td>T3</td>
<td>O1→O2</td>
<td>O1→O2</td>
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<td>FF→HF</td>
<td>S 57</td>
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<td>S 46</td>
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<td>O1→O2</td>
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<td>T2</td>
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</tr>
<tr>
<td>S 54</td>
<td>HF→FF</td>
<td>S 72</td>
</tr>
</tbody>
</table>

**Figure 5. Part Two: 2 X 2 X 2 X 2 X 3 X 3 Mixed Factor Design**

**Legend:**

T 1 = manufacturer’s package instructions as training technique  
T 2 = commercial videotape as training technique  
T 3 = systematic interactive multimedia training as training technique  
Young = 18 to 25 year old age group
Older = 45 to 60 year old age group
HF = Half -Facepiece respirator
FF = Full - Facepiece respirator
01 = presentation order first
02 = presentation order second
4.1 Part One:

The experimental design for part one was a pre- and post-training evaluation which resulted in differences per training technique. Differences among the three respiratory safety training techniques were analyzed in terms of percent correct items regarding OSHA recommended safety knowledge. Mean differences were analyzed via standard parametric ANOVA. When significant interactions and main effects were present, simple effects tests were conducted to determine the main effects of one factor that were limited to a particular level of other factors (Winer, 1991). When significant main effects were found, a Tukey studentized range post hoc test was used to determine which level(s) were significantly different.

Subject risk perception attitudes were analyzed via occupational and worksite condition ratings, and experimenter graded “yes or no” discrete subjective opinion essay results. Discrete risk perception attitudes were analyzed using non parametric McNemar significance of change for related samples, and binomial tests. Binomial testing was used when the McNemar test expected frequency count assumption was violated (Siegel, 1956). Alpha at the 0.05 level was used in all measures of significance. All significant effects and interactions for each variable analyzed are discussed in the following sections.

4.1.1 Safety knowledge results

To investigate whether or not a significant difference in safety knowledge existed pre-training among age and gender subject groups, a two-way ANOVA using pre-training percent correct scores was conducted. A two-way ANOVA evaluation of age x gender as to percent correct on pre-training safety knowledge multiple choice questions revealed a significant difference between subjects age and gender (p = 0.030). See Table 2. Therefore, group differences in safety knowledge existed before any training was conducted. Despite the difference, safety knowledge was evaluated via ANOVA. ANOVA evaluation of safety knowledge revealed the following interactions and main effect significant statistically: 1) gender x age x training (p = 0.032), 2) age x training (p = 0.012,
and 3) training \((p = 0.001)\). See Table 3. The three way interaction is shown in Figure 6. This graph illustrates the superiority of systematic interactive multimedia over the commercial videotape and manufacturer provided instructions, as well as a different response to systematic interactive multimedia training among young males, when compared to older males, and females of both young and old age groups.

**Table 2. Pre-Training Safety Knowledge: Two-Way ANOVA Results**

<table>
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<tr>
<th>Source</th>
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<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
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<td>0.108</td>
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</tr>
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<td>0.128</td>
<td>0.128</td>
<td>4.424</td>
<td>0.039*</td>
</tr>
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<td>2.992</td>
<td>0.088</td>
</tr>
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<td>0.466</td>
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<tr>
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<td>71</td>
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</tbody>
</table>

*significant

**Table 3. Safety Knowledge: ANOVA Results**

<table>
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<tr>
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<th>DF</th>
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<th>MS</th>
<th>F</th>
<th>P</th>
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<tbody>
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<td>0.01580</td>
<td>0.01580</td>
<td>1.20</td>
<td>0.281</td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>0.00618</td>
<td>0.00618</td>
<td>0.47</td>
<td>0.499</td>
</tr>
<tr>
<td>Ed Level</td>
<td>2</td>
<td>0.00531</td>
<td>0.00266</td>
<td>0.20</td>
<td>0.819</td>
</tr>
<tr>
<td>Training</td>
<td>2</td>
<td>1.10084</td>
<td>0.55042</td>
<td>41.67</td>
<td>0.001*</td>
</tr>
<tr>
<td>Gender*Age</td>
<td>1</td>
<td>0.01579</td>
<td>0.01579</td>
<td>1.20</td>
<td>0.281</td>
</tr>
<tr>
<td>Gender*Ed Level</td>
<td>2</td>
<td>0.07270</td>
<td>0.03635</td>
<td>2.75</td>
<td>0.077</td>
</tr>
<tr>
<td>Gender*Training</td>
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<td>0.00530</td>
<td>0.00265</td>
<td>0.20</td>
<td>0.819</td>
</tr>
<tr>
<td>Age*Ed Level</td>
<td>2</td>
<td>0.04233</td>
<td>0.02117</td>
<td>1.60</td>
<td>0.215</td>
</tr>
<tr>
<td>Age*Training</td>
<td>2</td>
<td>0.13197</td>
<td>0.06598</td>
<td>5.00</td>
<td>0.012*</td>
</tr>
<tr>
<td>Ed Level*Training</td>
<td>4</td>
<td>0.02543</td>
<td>0.00636</td>
<td>0.48</td>
<td>0.749</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level</td>
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<td>0.02969</td>
<td>2.25</td>
<td>0.120</td>
</tr>
<tr>
<td>Gender<em>Age</em>Training</td>
<td>2</td>
<td>0.10013</td>
<td>0.05007</td>
<td>3.79</td>
<td>0.032*</td>
</tr>
<tr>
<td>Gender<em>Ed Level</em>Training</td>
<td>4</td>
<td>0.01950</td>
<td>0.00488</td>
<td>0.37</td>
<td>0.829</td>
</tr>
<tr>
<td>Age<em>Ed Level</em>Training</td>
<td>4</td>
<td>0.07061</td>
<td>0.01765</td>
<td>1.34</td>
<td>0.275</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level*Training</td>
<td>4</td>
<td>0.12248</td>
<td>0.03062</td>
<td>2.32</td>
<td>0.076</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>0.47551</td>
<td>0.01321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>2.26928</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant
To further interpret the nature of the significant interactions, simple effects ANOVA testing was conducted (Winer, 1991). No significant difference among training method means existed for young males among the training methods ($p = 0.1391$), which is illustrated by the relatively flat response shown by young males across all training methods shown in Figure 6 and Table 4. However, results for older males, young and older female data were significantly different from young males. See Table 5. Simple effects testing was also conducted for females of both age groups. Young females ($p = 0.0042$) and older females ($p = 0.0015$), respectively, were significantly different. See Tables 6 and 7. The systematic interactive multimedia training technique had a larger impact on older males and females of both age groups as compared to younger males. Although minimal improvement was shown for young males across training types, females of both age groups and older males showed a marked improvement between those exposed to commercial videotape and systematic interactive multimedia. Commercial videotape caused the least amount of change, with systematic interactive multimedia showing the largest change in percent correct answers to multiple choice questions.
Figure 6. Gender X Age X Training Interaction
### Table 4. Young x Male x Training Interaction: Simple Effects Results

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>0.06122617</td>
<td>0.03061309</td>
<td>2.25</td>
<td>0.1393</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>.20372742</td>
<td>.01358183</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>17</td>
<td>0.26495359</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R-Square</th>
<th>C.V.</th>
<th>Root MSE</th>
<th>SK Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.231083</td>
<td>37.02329</td>
<td>0.11654110</td>
<td>0.31477778</td>
</tr>
</tbody>
</table>

Source:

<table>
<thead>
<tr>
<th>DF</th>
<th>Anova SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAINING</td>
<td>2</td>
<td>0.06122617</td>
<td>0.03061309</td>
<td>2.25</td>
</tr>
</tbody>
</table>

### Table 5. Old x Male x Training Interaction: Simple Effects Results

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>0.72048247</td>
<td>0.36024124</td>
<td>22.38</td>
<td>0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>0.24145186</td>
<td>0.01609679</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>17</td>
<td>0.96193433</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R-Square</th>
<th>C.V.</th>
<th>Root MSE</th>
<th>SK Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.748993</td>
<td>34.95877</td>
<td>0.12687313</td>
<td>0.36292222</td>
</tr>
</tbody>
</table>

Source:

<table>
<thead>
<tr>
<th>DF</th>
<th>Anova SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAINING</td>
<td>2</td>
<td>0.72048247</td>
<td>0.36024124</td>
<td>22.38</td>
</tr>
</tbody>
</table>

* significant
Table 6. Young x Female x Training Interaction: Simple Effects Results

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>0.21533284</td>
<td>0.10766642</td>
<td>8.05</td>
<td>0.0042</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>0.20070593</td>
<td>0.01338040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>17</td>
<td>0.41603878</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.517579  
C.V.: 36.74837  
Root MSE: 0.11567366  
SK Mean: 0.31477222

Source       | DF  | Anova SS | Mean Square | F Value | Pr > F |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAINING</td>
<td>2</td>
<td>0.21533284</td>
<td>0.10766642</td>
<td>8.05</td>
<td>0.0042</td>
</tr>
</tbody>
</table>

*significant

Table 7. Old x Female x Training Interaction: Simple Effects Results

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>0.34120025</td>
<td>0.17060012</td>
<td>10.34</td>
<td>0.0015</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>0.24738149</td>
<td>0.01649210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>17</td>
<td>0.58858174</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-Square: 0.579699  
C.V.: 42.28953  
Root MSE: 0.12842157  
SK Mean: 0.30367222

Source       | DF  | Anova SS | Mean Square | F Value | Pr > F |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAINING</td>
<td>2</td>
<td>0.34120025</td>
<td>0.17060012</td>
<td>10.34</td>
<td>0.0015</td>
</tr>
</tbody>
</table>

*significant
To investigate difference in effectiveness among training types for safety knowledge, post-hoc Tukey studentized range testing was conducted. Results indicate that the systematic interactive multimedia technique was most effective, followed by manufacturers’ package instructions and commercial videotape. Tukey results for safety knowledge are shown in Figure 7:

4.1.2 Occupational ratings results

ANOVA results for occupational rating means are shown in Table 8. No significant main effects or interactions were found.
Figure 7. Safety Knowledge Results: Tukey Studentized Range Testing
Table 8. Occupational Rating ANOVA Results

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.00</td>
<td>0.986</td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>0.5609</td>
<td>0.5609</td>
<td>1.35</td>
<td>0.253</td>
</tr>
<tr>
<td>Ed Level</td>
<td>2</td>
<td>0.8339</td>
<td>0.4169</td>
<td>1.00</td>
<td>0.376</td>
</tr>
<tr>
<td>Training</td>
<td>2</td>
<td>0.8861</td>
<td>0.4431</td>
<td>1.07</td>
<td>0.354</td>
</tr>
<tr>
<td>Gender*Age</td>
<td>0.3037</td>
<td>0.3037</td>
<td>0.73</td>
<td>0.398</td>
<td></td>
</tr>
<tr>
<td>Gender*Ed Level</td>
<td>2</td>
<td>0.6003</td>
<td>0.3001</td>
<td>0.72</td>
<td>0.492</td>
</tr>
<tr>
<td>Gender*Training</td>
<td>2</td>
<td>1.8328</td>
<td>0.9164</td>
<td>2.21</td>
<td>0.124</td>
</tr>
<tr>
<td>Age*Ed Level</td>
<td>2</td>
<td>0.3907</td>
<td>0.1953</td>
<td>0.47</td>
<td>0.628</td>
</tr>
<tr>
<td>Age*Training</td>
<td>2</td>
<td>0.5051</td>
<td>0.2525</td>
<td>0.61</td>
<td>0.550</td>
</tr>
<tr>
<td>Ed Level*Training</td>
<td>4</td>
<td>0.7056</td>
<td>0.1764</td>
<td>0.43</td>
<td>0.789</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level</td>
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<td>0.5084</td>
<td>0.2542</td>
<td>0.61</td>
<td>0.547</td>
</tr>
<tr>
<td>Gender<em>Age</em>Training</td>
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<td>0.8513</td>
<td>0.4256</td>
<td>1.03</td>
<td>0.369</td>
</tr>
<tr>
<td>Gender<em>Ed Level</em>Training</td>
<td>4</td>
<td>0.6225</td>
<td>0.1556</td>
<td>0.38</td>
<td>0.825</td>
</tr>
<tr>
<td>Age<em>Ed Level</em>Training</td>
<td>4</td>
<td>3.0367</td>
<td>0.7592</td>
<td>1.83</td>
<td>0.144</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level*Training</td>
<td>4</td>
<td>0.7403</td>
<td>0.1851</td>
<td>0.45</td>
<td>0.774</td>
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<tr>
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<td>36</td>
<td>14.9357</td>
<td>0.4149</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>27.3141</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1.3 Worksite conditions ratings results

ANOVA evaluation of mean worksite condition ratings revealed the main effect training as significant (p = 0.001). No significant difference was shown between gender, age or educational level means. ANOVA worksite condition rating results are shown below in Table 9.
Table 9. Worksite Condition Rating Results: ANOVA

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>1</td>
<td>1.730</td>
<td>1.730</td>
<td>1.30</td>
<td>0.261</td>
</tr>
<tr>
<td>Age</td>
<td>1</td>
<td>1.888</td>
<td>1.888</td>
<td>1.42</td>
<td>0.241</td>
</tr>
<tr>
<td>Ed Level</td>
<td>2</td>
<td>2.339</td>
<td>1.169</td>
<td>0.88</td>
<td>0.423</td>
</tr>
<tr>
<td>Training</td>
<td>2</td>
<td>51.212</td>
<td>25.606</td>
<td>19.29</td>
<td>0.001*</td>
</tr>
<tr>
<td>Gender*Age</td>
<td>1</td>
<td>0.000</td>
<td>0.000</td>
<td>0.00</td>
<td>0.999</td>
</tr>
<tr>
<td>Gender*Ed Level</td>
<td>2</td>
<td>4.245</td>
<td>2.123</td>
<td>1.60</td>
<td>0.216</td>
</tr>
<tr>
<td>Gender*Training</td>
<td>2</td>
<td>0.433</td>
<td>0.216</td>
<td>0.16</td>
<td>0.850</td>
</tr>
<tr>
<td>Age*Ed Level</td>
<td>2</td>
<td>7.571</td>
<td>3.786</td>
<td>2.85</td>
<td>0.071</td>
</tr>
<tr>
<td>Age*Training</td>
<td>2</td>
<td>0.5051</td>
<td>0.2525</td>
<td>0.61</td>
<td>0.550</td>
</tr>
<tr>
<td>Ed Level*Training</td>
<td>4</td>
<td>2.300</td>
<td>0.575</td>
<td>0.43</td>
<td>0.784</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level</td>
<td>2</td>
<td>4.070</td>
<td>2.035</td>
<td>1.53</td>
<td>0.230</td>
</tr>
<tr>
<td>Gender<em>Age</em>Training</td>
<td>2</td>
<td>1.998</td>
<td>0.999</td>
<td>0.75</td>
<td>0.478</td>
</tr>
<tr>
<td>Gender<em>Ed Level</em>Training</td>
<td>4</td>
<td>13.756</td>
<td>3.439</td>
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<td>0.063</td>
</tr>
<tr>
<td>Age<em>Ed Level</em>Training</td>
<td>4</td>
<td>0.868</td>
<td>0.217</td>
<td>0.16</td>
<td>0.956</td>
</tr>
<tr>
<td>Gender<em>Age</em>Ed Level*Training</td>
<td>4</td>
<td>1.392</td>
<td>0.348</td>
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<td>0.900</td>
</tr>
<tr>
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<td>1.327</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>141.697</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant

As expected, a Tukey grouping analysis of worksite condition means revealed the systematic interactive multimedia method as being more effective than manufacturers’ package instructions and commercial videotape at changing attitudes about respiratory safety hazards at a worksite. As illustrated in Figure 8, manufacturers’ package instructions and the commercial videotape were grouped equally, indicating no significant difference between the two. The superiority of systematic interactive multimedia was accounted for by use of a systematic instructional design method.
4.1.4 Subjective opinion scenario results

McNemar significance of changes for related samples and binomial tests were utilized to evaluate subject attitudinal change in risk perception from question 16b of the pre- and post-training questionnaires. See Appendix O for questionnaire. Individual training methods were evaluated for change in subject risk perception. Binomial testing revealed insignificant values of (p = .059) for systematic interactive multimedia, (p = 0.8652) for commercial videotape, and (p = 1.0) for manufacturer package instructions. Binomial testing resulted in insignificant values of (p = 0.427) for males and (p = 0.4222) for females. See Tables 13 and 14. McNemar testing of age differences revealed an insignificant (p = 0.3414) for youth. Binomial testing resulted in a (p = 0.9015) value for older subjects, which was also insignificant. See Tables 15 and 16. Finally, education levels were tested. McNemar results for education level one were insignificant (p = 0.4152). Obtained binomial values of (p = 0.4152 and 0.6473) resulted for education levels two and three, respectively, which were also insignificant (Siegel, 1956). See Tables 17, 18 and 19.
Figure 8. Worksite Condition Rating Results: Tukey Studentized Range Testing
Table 10. Systematic Interactive Multimedia X Risk Perception Change

Results: Binomial Test

<table>
<thead>
<tr>
<th></th>
<th>Pre-Training</th>
<th>Post-Training</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.</td>
<td>R.P. Present</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
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<td>6</td>
<td>13</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.P.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
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<td>Absent</td>
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<td>16</td>
<td>24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Expected Frequency

= 1.666

Binomial: \( p = 0.059 \)

Insignificant

Legend:

Cell A = R.P. Present Pre-Training, Absent Post-Training
Cell B = R.P. Present Pre- and Post- Training
Cell C = R.P. Absent Pre- and Post- Training
Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 11. Commercial Videotape X Risk Perception Change Results: Binomial Test

<table>
<thead>
<tr>
<th></th>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R.P. Present</td>
<td>R.P. Present</td>
</tr>
<tr>
<td>R.P. Absent</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>R.P. Absent</td>
<td>6</td>
<td>18</td>
</tr>
</tbody>
</table>

Expected Frequency = 1.75

Binomial: (p = 0.8652)
Insignificant

Legend:
Cell A = R.P. Present Pre-Training, Absent Post-Training
Cell B = R.P. Present Pre- and Post- Training
Cell C = R.P. Absent Pre- and Post- Training
Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 12. Manufacturer Package Instructions X Risk Perception Change
Results: McNemar Significance of Changes for Related Samples Test

<table>
<thead>
<tr>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Present</td>
<td>R.P. Present</td>
</tr>
<tr>
<td>Absent</td>
<td>10</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>8</td>
</tr>
<tr>
<td>Absent</td>
<td>3</td>
</tr>
</tbody>
</table>

Expected Frequency = 5.0416

McNemar: \( p = 1.0 \)
Insignificant

Legend:
- Cell A = R.P. Present Pre-Training, Absent Post-Training
- Cell B = R.P. Present Pre- and Post- Training
- Cell C = R.P. Absent Pre- and Post- Training
- Cell D = R.P. Absent Pre-Training, Present Post-Training
<table>
<thead>
<tr>
<th></th>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Absent</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>R.P. Absent</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Expected Frequency

\[= 4.3333\]

Binomial: \(p = 0.427\)

Insignificant

Legend:

Cell A = R.P. Present Pre-Training, Absent Post-Training
Cell B = R.P. Present Pre- and Post- Training
Cell C = R.P. Absent Pre- and Post- Training
Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 14. Female X Risk Perception Change Results: Binomial Test

<table>
<thead>
<tr>
<th></th>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Absent</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>R.P. Absent</td>
<td>24</td>
<td>5</td>
</tr>
</tbody>
</table>

Expected Frequency

\[ = 3.666 \]

Binomial: \( (p = 0.4222) \)
Insignificant

Legend:
- Cell A = R.P. Present Pre-Training, Absent Post-Training
- Cell B = R.P. Present Pre- and Post- Training
- Cell C = R.P. Absent Pre- and Post- Training
- Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 15. Young X Risk Perception Change Results: McNemar Significance of Changes for Related Samples Test

<table>
<thead>
<tr>
<th>Pre-Training</th>
<th>Post-Training</th>
<th>R.P. Absent</th>
<th>R.P. Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Absent</td>
<td>7</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>9</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

Expected Frequency = 5.3333

McNemar: (p = 0.3414)
Insignificant

Legend:
Cell A = R.P. Present Pre-Training, Absent Post-Training
Cell B = R.P. Present Pre- and Post- Training
Cell C = R.P. Absent Pre- and Post- Training
Cell D = R.P. Absent Pre-Training, Present Post-Training
### Table 16. Old X Risk Perception Change Results: Binomial Test

<table>
<thead>
<tr>
<th>Pre-Training</th>
<th>R.P. Absent</th>
<th>R.P. Present</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Absent</td>
<td>9</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>4</td>
<td>21</td>
<td>25</td>
</tr>
</tbody>
</table>

**Expected Frequency**

= 2.75

**Binomial: (p = 0.9015)**

Insignificant

**Legend:**

- **Cell A** = R.P. Present Pre-Training, Absent Post-Training
- **Cell B** = R.P. Present Pre- and Post- Training
- **Cell C** = R.P. Absent Pre- and Post- Training
- **Cell D** = R.P. Absent Pre-Training, Present Post-Training
Table 17. Education Level 1 X Risk Perception Change Results: McNemar Significance of Changes for Related Samples Test

<table>
<thead>
<tr>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P. Absent</td>
<td>R.P. Absent</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>R.P. Present</td>
<td>R.P. Present</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Expected Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= 5.5</td>
</tr>
</tbody>
</table>

McNemar: (p = 0.4152)  
Insignificant

Legend:
Cell A = R.P. Present Pre-Training, Absent Post-Training
Cell B = R.P. Present Pre- and Post- Training
Cell C = R.P. Absent Pre- and Post- Training
Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 18. Education Level 2 X Risk Perception Change Results: Binomial Test

<table>
<thead>
<tr>
<th></th>
<th>Post-Training</th>
<th>Expected Frequency</th>
<th>Binomial: (p =0.4152)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R.P. Present</td>
<td></td>
<td>Insignificant</td>
</tr>
<tr>
<td>R.P. Absent</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>R.P. Present</td>
<td>13</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Cell A = R.P. Present Pre-Training, Absent Post-Training
- Cell B = R.P. Present Pre- and Post- Training
- Cell C = R.P. Absent Pre- and Post- Training
- Cell D = R.P. Absent Pre-Training, Present Post-Training
Table 19. Education Level 3 X Risk Perception Change Results: Binomial Test

<table>
<thead>
<tr>
<th></th>
<th>Pre-Training</th>
<th>Post-Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.</td>
<td>R.P. Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Absent</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Expected Frequency = 1.0416

Binomial: (p = 0.6473)
Insignificant

Legend:
- Cell A = R.P. Present Pre-Training, Absent Post-Training
- Cell B = R.P. Present Pre- and Post- Training
- Cell C = R.P. Absent Pre- and Post- Training
- Cell D = R.P. Absent Pre-Training, Present Post-Training

4.2 Part Two: Donning ability results

Part two of the experiment was composed of an evaluation of the effectiveness of training technique donning instructions, as well as an investigation of respirator presentation order, age, gender and education level effects. Following donning training, each subject was quantitatively fit tested consistently as to the type of respirator training they received first, followed by a second QFT of the second type of respirator they received training. For 20 subjects (11 males, 9 females), no available respirators could properly fit their face shapes. Therefore, QFT could only be collected on 52 of the total 72 subjects. Non-parametric statistics were used in evaluating part two data.
4.2.1 Training:

First, a chi-square test of independence was used to evaluate the effectiveness of all three training methods on subject ability to pass half-facepiece respirator quantitative fit testing. A chi-square result ($p = 0.1692$) was insignificant (Siegel, 1956). See Table 20. Next, chi-square independence testing was used to determine if one individual training method was particularly better than another method in obtaining QFT results. See Tables 21, 22, and 23. No significant difference was shown based on chi-square results of ($p = 0.0578, 0.2269$ and $0.8875$).

Table 20. Overall Training Methods X HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>CV</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>MPI</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>

Chi-square ($p = 0.1692$)
Insignificant

Table 21. MPI X CV for HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPI</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>CV</td>
<td>17</td>
<td>7</td>
</tr>
</tbody>
</table>

Chi-square ($p = 0.0578$)
Insignificant
Table 22. SIM X CV for HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>CV</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>

17 16 33

Chi-square (p = 0.2269)
Insignificant

Table 23. SIM X MPI for HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>MPI</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>

14 20 34

Chi-square (p = 0.8875)
Insignificant

Second, evaluation of the effectiveness of all three training methods on subject ability to pass full-facepiece respirator quantitative fit testing was conducted. As the expected frequency count assumption of chi-square test of independence was violated, Fisher exact testing was used. However, the Fisher exact test is feasible only for 2 X 2 contingency tables. Therefore, evaluation of overall training methods was not possible using one contingency table. See Table 24 for observed frequency counts for all training methods for full-facepiece masks.
### Table 24. Overall Training Methods X FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>9</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>CV</td>
<td>16</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>MPI</td>
<td>14</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>27</td>
<td>52</td>
</tr>
</tbody>
</table>

Expected Frequency = 3.75

In light of this testing requirement, training methods were separated out into 2 X 2 contingency tables and evaluated using Fisher exact testing (Siegel, 1956). Fisher exact testing was used to examine if one individual training method was better than another method in obtaining passing QFT results for full-facepiece masks. See Tables 25, 26, and 27. No significant difference was shown among training methods based on Fisher exact results ($p = 0.1728, 0.0551$ and $0.2034$). Although systematic interactive multimedia was not significantly different than the commercial videotape for full-facepiece masks at the alpha of 0.05 level ($p = 0.0551$), a noticeable difference is shown between the two methods. Using systematic interactive multimedia, nine subjects failed, while six passed QFT, vs. sixteen failures and two subjects passed QFT resulted using the commercial videotape.

### Table 25. MPI X CV for FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPI</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>CV</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

Fishers Exact: ($p = 0.1728$)
Insignificant
Table 26. SIM X CV for FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>CV</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>8</td>
</tr>
</tbody>
</table>

Fisher Exact: (p = 0.0551)
Insignificant

Table 27. SIM X MPI for FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>MPI</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>11</td>
</tr>
</tbody>
</table>

Fisher Exact: (p = 0.2034)
Insignificant

Third, an investigation of whether training method(s) were effective at training subjects to don half- or full-facepiece respirators was conducted via binomial and McNemar significance of change for related samples testing. Binomial testing was insignificant for the effect of systematic interactive multimedia on mask type (p = 0.0903). See Table 28. However, the commercial videotape and manufacturers’ package instructions were significantly different based on binomial and McNemar testing. Binomial testing revealed (p = 0.0066) for the effect of commercial videotape, while a McNemar p-value of 0.0433 was significantly different and exhibited by manufacturer package instructions as a training method. See Tables 29 and 30. Small expected frequencies were shown for those subjects exposed to systematic interactive multimedia and the commercial videotape. The sample size of
subjects exposed to systematic interactive multimedia was low due to three people passing the QFT while wearing a full-facepiece respirator, and failing QFT while using a half-facepiece mask. The sample size of commercial videotape was small since only one subject passed the QFT using a full-facepiece respirator, and failed QFT with the half-facepiece respirator mask. These results indicate that manufacturers’ package instructions and the commercial videotape were significantly better at training subjects to properly don half-face respirators than full-facepiece respirators. Out of 52 subjects, 40 passed half-facepiece QFT, while only 12 passed full-facepiece QFT. At the same time, a trend was seen for systematic interactive multimedia training. A noticeable, yet insignificant difference in ability to pass QFT was shown between mask type (p = 0.0903) for full-face mask users exposed to systematic interactive multimedia was shown. Likewise, a noticeable yet insignificant difference was also shown for full-facepiece users when systematic interactive multimedia was compared with the commercial videotape (p = 0.0551) in Table 26.

<table>
<thead>
<tr>
<th>Mask Type</th>
<th>Pass</th>
<th>Fail</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

Binomial test: (p = 0.0903)
Insignificant

Legend:
Cell A = Failed FF, Passed HF
Cell B = Passed both FF and HF
Cell C = Failed both
Cell D = Passed FF, Failed HF
Table 29. Commercial Videotape X Mask Type

<table>
<thead>
<tr>
<th></th>
<th>FF</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>HF</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>2</td>
<td>18</td>
</tr>
</tbody>
</table>

Binomial test: (p = 0.0066)
Significant

Legend:
Cell A = Failed FF, Passed HF
Cell B = Passed both FF and HF
Cell C = Failed both
Cell D = Passed FF, Failed HF
### Table 30. Manufacturer Package Instructions X Mask Type

<table>
<thead>
<tr>
<th></th>
<th>FF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail</td>
<td>Pass</td>
</tr>
<tr>
<td>Pass</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Fail</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>

McNemar: \(p = 0.0433\)

Significant

Legend:
- Cell A = Failed FF, Passed HF
- Cell B = Passed both FF and HF
- Cell C = Failed both
- Cell D = Passed FF, Failed HF

#### 4.2.1.2 Presentation Order:

Chi-square tests of independence were conducted to investigate whether one treatment order (e.g. FF → HF mask, or HF → FF) was more effective than another treatment order in training subjects to pass QFT. In this study, each subject served as his/her own control, by being exposed to both respirator types at different times. Chi-square test results of \(p = 0.5541\) and \(0.6315\) for the HF → FF presentation order and FF → HF presentation order, respectively, were insignificant. See Tables 31 and 32. Based on these results, it appears that a learning effect did not occur as a result of respirator presentation order. The presence of a learning effect was a concern, in that if a learning effect was present, training method effectiveness results of the second mask type would have been confounded.
### Table 31. Presentation Order X HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF first</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>HF second</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

Chi-square (p = 0.5541)  
Insignificant

### Table 32. Presentation Order X FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF first</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>FF second</td>
<td>21</td>
<td>8</td>
</tr>
</tbody>
</table>

Chi-square (p = 0.6315)  
Insignificant

4.2.1.3 Age Effects

Chi-square tests of independence were used to determine the effect of age on subjects’ ability to properly don half- and full-facepiece masks. See Tables 33 and 34. Chi-square test results (p = 0.4166, 0.0522) were not significantly different between young and old, respectively. Therefore, no significant difference existed between young and older subjects in likelihood to pass QFT based on respirator type.
Table 33. Age X HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Old</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

25 27 52

Chi-square (p = 0.4166)
Insignificant

Table 34. Age X FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Old</td>
<td>22</td>
<td>6</td>
</tr>
</tbody>
</table>

39 13 52

Chi-square (p = 0.0522)
Insignificant

4.2.1.4 Gender Effects

No significant difference was shown between male and female subjects in likelihood to pass QFT based on respirator type. Chi-square test of independence results (p = 0.0937 and 0.4237) for half- and full-facepiece masks, respectively, were obtained. See Tables 35 and 36 below.
### Table 35. Gender X HF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Females</td>
<td>9</td>
<td>16</td>
</tr>
</tbody>
</table>

25 27 52

Chi-square (p = .0937)
Insignificant

### Table 36. Gender X FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>Females</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

39 13 52

Chi-square (p = .4237)
Insignificant

4.2.1.5 Education Level

No significant difference existed between subjects of different education levels in ability to properly don half- or full-facepiece respirators. Chi-square independence test results of (p = 0.2794, 0.6101), for half- and full-facepiece masks, respectively, were insignificant. See Tables 37 and 38. Subjects were categorized into three education levels, by highest level of education achieved. Education level one was comprised of subjects with a high school education or less, education level two
equaled some college or a bachelor’s degree, while education level three consisted of subjects with some graduate school or completion of a graduate degree. For analysis purposes, education levels two and three were combined to determine if a need existed for education level one subjects to be trained differently.

**Table 37. Education Level X HF Masks**

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School (Ed Lev 1)</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>College (Ed Lev 2 + Ed Lev 3)</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>27</td>
</tr>
</tbody>
</table>

Chi-square (p = 0.2794) Insignificant

**Table 38. Education Level X FF Masks**

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School (Ed Lev 1)</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>College (Ed Lev 2 + Ed Lev 3)</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>13</td>
</tr>
</tbody>
</table>

Chi-square (p = 0.6101) Insignificant
4.2.1.6  Mask Comparison

Half-face masks were compared with full-face masks in terms of QFT pass and fail results. A McNemar related samples test result (p = 0.089) revealed no significant differences between half- and full-facepiece masks. Results indicated that no significant difference existed between the half-facepiece and full-facepiece masks as to ease of fit, or whether QFT failure or success was likely to result. See Table 39 below.

<table>
<thead>
<tr>
<th></th>
<th>FF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pass QFT</td>
</tr>
<tr>
<td>Fail</td>
<td>9</td>
</tr>
<tr>
<td>Pass</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

McNemar: (p = 0.089)
Insignificant

Legend:
Cell A = Subject failed HF QFT, passed FF QFT
Cell B = Subject failed both HF and FF QFT
Cell C = Subject passed both HF and FF QFT
Cell D = Subject passed HF QFT, failed FF QFT

4.2.1.7  Headstrap Tightening

Additional information was obtained in the course of analyzing QFT data. The expert fit tester made detailed notes of why quantitative fit test failures occurred. For failure ranged from
“inability to properly tighten headstraps,” to “no available mask could fit subjects’ face shape.” A large number of subjects failed QFT due to their inability to properly tighten respirator headstraps. QFT failure charts of training techniques and respirator types as a function of frequency/causality are shown in Figures 9 through 16. Evaluation of these QFT failures was conducted to determine training method effectiveness at teaching proper headstrap tightening ability among subjects. Comparisons were made by training method of subjects who failed QFT with those who passed QFT. See Table 40 for exhibit of expected and observed frequency counts for all training methods for full-facepiece masks. As the expected frequency count assumption of chi-square test of independence was violated, Fisher exact testing was used. However, the Fisher exact test is feasible only for 2 X 2 contingency tables. Therefore, evaluation of overall training methods for full-facepiece masks was not possible using one 2 X 3 contingency table. In light of this testing requirement, training methods were separated out into 2 X 2 contingency tables for evaluation using Fisher exact testing.

First, full-facepiece masks were evaluated using Fisher exact testing. See Tables 41, 42 and 43. Fisher testing was used in order to separate QFT pass/fail results out by training technique to make a direct comparison among the three training methods, since chi-square testing was not feasible due to small expected frequency cell counts. Significant differences were shown between subjects in their ability to properly tighten respirator headstraps based on type of training received. Full-facepiece results revealed systematic interactive multimedia as more effective than the commercial videotape, where \( p = 0.0241 \). Results indicated that systematic interactive multimedia was more successful than commercial videotape at training subjects to properly don full-facepiece masks. The crux of the matter is shown in Table 42, where 50% of subjects exposed to systematic interactive multimedia passed QFT, while only 2 of 18 subjects
exposed to the commercial videotape passed QFT. Systematic interactive multimedia was better in this particular case compared to the commercial videotape. Table 42 exhibits significantly different results due to the difference between systematic interactive multimedia and the commercial videotape. Although not significant, the trend was repeated where manufacturers’ package instructions was the least effective training method. Five of 18 exposed to manufacturers’ package instructions passed QFT, while 13 of 18 failed QFT due to improper headstrap tightening ability.

### Table 40. Headstrap Tightening Ability X Training Method for FF Masks

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>CV</td>
<td>15</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>MPI</td>
<td>13</td>
<td>5</td>
<td>18</td>
</tr>
</tbody>
</table>

Expected frequency = 3.25

### Table 41. MPI X CV for FF Headstrap Tightening Ability

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPI</td>
<td>13</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>CV</td>
<td>15</td>
<td>2</td>
<td>17</td>
</tr>
</tbody>
</table>

Fisher exact (p = 0.2249) Insignificant
Next, chi-square independence testing was used to evaluate the effect of training methods on subject ability to properly tighten headstraps of half-facepiece respirators. Chi-square values of (p = 0.8875, 0.6428 and 0.5902) were all insignificant for systematic interactive multimedia, commercial videotape and manufacturers’ provided instructions, respectively. As no significant difference was shown, one training method was not superior to the others at teaching proper headstrap tightening procedures for half-facepiece masks. See Tables 44, 45, and 46.
### Table 44. SIM X CV for HF Headstrap Tightening Ability

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>CV</td>
<td>10</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>18</td>
<td>35</td>
</tr>
</tbody>
</table>

Chi-Square ($p = 0.8875$)
Insignificant

### Table 45. CV X MPI for HF Headstrap Tightening Ability

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>10</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>MPI</td>
<td>6</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>20</td>
<td>36</td>
</tr>
</tbody>
</table>

Chi-Square ($p = 0.6468$)
Insignificant
Table 46. SIM X MPI for HF Headstrap Tightening Ability

<table>
<thead>
<tr>
<th></th>
<th>Fail QFT</th>
<th>Pass QFT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIM</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>MPI</td>
<td>6</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>16</td>
<td>29</td>
</tr>
</tbody>
</table>

Chi-Square ($p = 0.5902$) Insignificant
Figure 9. Overall Full-Face QFT Failure Results by Causality & Frequency
Figure 10. Systematic Interactive Multimedia Full-Face QFT Failure Results by Causality & Frequency
Figure 11. Commercial Videotape Full-Face QFT Failure Results by Causality & Frequency
Figure 12. MPI Full-Face QFT Failure Results by Causality & Frequency
Figure 13. Overall Half-Face QFT Failure Results by Causality & Frequency
Figure 14. Systematic Interactive Multimedia Half-Face QFT Failure Results by Causality & Frequency
Figure 15. Commercial Videotape Half-Face QFT Failure Results by Causality & Frequency

- Headstraps not tight enough
- Headstraps positioned improperly
- Available masks could not fit/seal face shape
- Oral/nasal cup placed incorrectly over nose and chin area
- Headstraps twisted
- Hair "bunched up" under headstraps
Figure 16. Manufacturer Package Instructions Half-Face QFT Failure Results by Causality & Frequency
Chapter 5 Discussion

5.1 Part One:

The purpose of the present study was to explore the effectiveness of three training methods in terms of safety knowledge and risk perception. It was hypothesized that a systematic interactive form of training would be more effective than manufacturers’ package instructions or a commercial videotape in terms of teaching OSHA recommended safety knowledge, that a difference would be shown between individual pre- and post-training questionnaires, that females would exhibit more risk perception than males post-training, that older participants would demonstrate more risk perception than their younger counterparts post-training, and a gender difference in response to the different training methods would exist.

5.1.2 Safety knowledge and risk perception

In this study, the exact nature and cause of significant age x training differences for safety knowledge were unclear due to significant age x gender differences in pre-training safety knowledge. However, significant differences between young and older males, as well as between young males and females of both age groups who received systematic interactive multimedia training was illustrated via simple effects testing. It is possible that the observed age related differences occurred due to underlying risk perception considerations associated with gender and advanced age such as the likelihood of paying attention to and complying with safety-related information, and familiarity with safety hazards (Smith and Watzke, 1990). Therefore, it may be necessary to include more risk perception content in training techniques which target younger males by providing safety information to them based on examples using actors and safety scenarios pertaining to their own age group and gender. Inclusion of these additional techniques would not be detrimental to females or older male trainees, and would probably be beneficial towards training both genders and age groups most effectively.
In the present study, gender and age effects were formal variables under study as they were nested with the other experimental variables. Analysis was conducted to determine how age and gender interacted with, or influenced risk perception subjective opinion scenarios or mean rating findings. Previous studies of gender effects a priori have shown mixed results (Goldhaber and deTurck, 1988a, 1988b; Young et. al, 1989; Young et. al, 1990, and Karnes and Leonard, 1986). Some evidence suggests that females act more safely than their male counterparts with regard to warnings. However, it is unclear whether gender is the true source of observed differences (Young et. al, 1999). It is possible that significant gender differences have been shown due to more basic confounding considerations (e.g. knowledge of the hazards, or familiarity or frequency of use).

Systematic interactive multimedia was more effective at training OSHA recommended safety knowledge and causing significantly different ratings of worksite condition ratings than commercial videotape or manufacturers’ package instructions. Why was the systematic interactive multimedia method more effective than manufacturers’ package instructions or the commercial videotape? It is hypothesized that the superiority of systematic interactive multimedia was due to the use of a systematic instructional design method which included the use of persuasion techniques, hazard avoidance explanations and unsafe incident statistics associated with respiratory safety. In addition, systematic interactive multimedia provoked trainee decision-making, as the training program was designed specifically and explicitly so that all of the trainees would perform each step successfully and would receive continuous feedback. Inclusion of these techniques required the trainees to interact with the instructions and to take very small steps between instructional units using the mastery process. The mastery process requires learning small pieces of information before the trainee can move on to new information (Janicak, 1999). In contrast, commercial videotape and manufacturers’ package instructions both used one-way communication. That is, neither was interactive or adaptive.

In terms of safety knowledge and risk perception, this study brought several points to the forefront of discussion. First, a systematic training program
design should be utilized by training developers. It should be thought of as “the first line of defense” in terms of training OSHA recommended safety knowledge and alteration of risk perception delivery modes. Second, employers need to be aware of the presence of training design flaws before purchasing training programs for use with their employees. It is unacceptable for employers to dispense any available form of training to employees without considering whether or not training contents follow OSHA recommendations, or without considering the consequences of providing flawed training techniques. Employers must provide materials that include safety knowledge and risk perception persuasion techniques in a systematic manner for maximum effectiveness. Third, misuse of respirators can expose employees to serious respiratory hazards and result in costly government fines. Use of a systematically designed training program could provide maximum effectiveness while simultaneously limiting liability (Gordon, 1994). If systematic interactive multimedia training is not feasible, a branching type of instruction should be considered as it can cater to individual learner responses and is adaptable to all learners as to their familiarity with the training topic. Branching is thought to be a reasonable adaptive approach as it caters to learner responses, but is in general more time consuming, and places the learner in a more passive role than the computer-aided systematic interactive multimedia instruction used in the present study.

5.2 Part Two:

Part two of the study was conducted to further investigate the effect of presentation order and training method on user ability to achieve “passing” quantitative fit test results. It was hypothesized that the Standardized Behavior Modeled Interaction (SBMI) component of systematic interactive multimedia training would be superior to the commercial videotape and manufacturers’ provided instructions in teaching subjects to properly don half- and full-facepiece negative pressure respirators. Evaluation studies inherently have limitations that affect the interpretation of effects. In this case, a high failure rate on quantitative fit testing occurred due to study participants’ inability to properly tighten headstraps, and quantitative fit testing of respirator masks used in this study could only be conducted on 52 of the total 72 study participants. Eleven females
and nine males were eliminated and were scored as missing values in QFT data analysis due to the constraint imposed by the fact that no available half-facepiece or full-facepiece masks could fit/seal their face shapes. It should be noted that respirator mask presentation order was evaluated in part two, not transfer of training. Evaluating treatment (presentation) order dictated that both treatments be conducted in the same session, and a short time span between conditions occurred.

5.2.1 Training Effect

Training method effectiveness results were mixed in part two of the experiment. It was hypothesized that several reasons were responsible for these results. First, a larger proportion of subjects who were counted as missing values were exposed to systematic interactive multimedia than the commercial videotape or manufacturers’ package instructions. Of the 52 total subjects analyzed in part two, the number of individuals per training method were unequal. Nineteen subjects were exposed to manufacturers’ package instructions, 18 to commercial videotape and 15 to systematic interactive multimedia. With regard to the commercial videotape and manufacturers’ package instructions being superior to systematic interactive multimedia in training subjects to properly don HF respirators, superiority may have occurred due to unequal sample size bias.

Unequal sample sizes may have been responsible for non-parametric results which were “close” to being significantly different at the 0.05 alpha level of significance. In particular, results associated with most effective training type for half-face and full-face masks, presentation order, age, gender and ease of fit results fit this category. Donning training methods could not be completely evaluated with unequal cell frequencies, as frequency count numbers were used. Bias may have occurred in favor of the parameter with the largest number of cell frequencies (Moore, 1991, p. 21). Equivalent groups were not evaluated. Therefore, it is unknown whether differences between training and demographic groups were due to the effect of the training methods. The true effect may be unknown.
5.2.2 Suggested Systematic Interactive Multimedia Training Changes

Towards the goals teaching OSHA recommended safety knowledge and instilling perception of respiratory hazard risks, systematic interactive multimedia training should be modified in several ways. First, it is hypothesized that personal testimonies of injuries or “near misses” should be included to help trainees develop a mental image of themselves or family members in a particular risk situation (Geller and Clarke, 1999). A second hypothesis is that placing emphasis on the dangers associated with respiratory hazards using young male actors in workplace scenarios should be included in systematic interactive multimedia to target a young male audience. A third hypothesis was made about emphasizing proper headstrap tightening procedure. More emphasis needs placed on proper headstrap tightening. Towards the goal of improving headstrap tightening ability, adding this specific item to the new needs assessment could further emphasize this component of training.

5.2.3 Suggestions for Future Research

Further research is needed to determine whether the systematic interactive multimedia training program does indeed reduce risk taking behaviors on the job. One approach to this evaluation would be to examine long term medical surveillance records of those who received systematic interactive multimedia training, by comparing their respiratory disease rates to other respiratory protection users who had not been so trained. Ultimately this would be the real test of effectiveness of the training. Unfortunately, long term medical surveillance would be very expensive, time consuming and would provide little information that could improve respiratory hazard safety training until long after the training program has been in place.

What amount of input does the comfort factor play in the decision making process of trainees learning to tighten headstraps? Qualitative ratings using Likert scales followed by quantitative fit testing could aid training designers in describing proper technique to trainees.

How many commercially available brands should safety professionals have available for half- and full- facepiece mask fittings? Three brands used in
this study were inadequate to properly fit 28% of subjects. It is hypothesized that to decrease the need for custom made-to-fit masks and to increase likelihood that commercially produced respirators will fit, it seems that at least five brands should be on hand for respiratory protection program administrators until a broader range of sizing is available.

5.2.4 Suggestions for Government Agencies and Safety Professionals

Several recommendations for safety professionals and government agencies were made based on the outcome of this study. First, it is hypothesized that more public awareness concerning the importance of using systematically designed training programs in the development of all types of personal protective equipment and consumer training products is needed. Awareness could be increased through continuing education efforts promoted by nationally recognized organizations whose members train, use and/or supervise workers who use personal protective equipment. National and international organizations with members from industries such as engineering, human resources, industrial hygiene, public health and occupational medicine to name a few need to be aware of the importance of providing systematic training.

Second, it is hypothesized that governmental organizations such as the Occupational Safety and Health Administration could improve its “how to” train respiratory safety hazards recommendation by mandating the use of systematically designed training programs to provide effective training in a regulatory manner.

Third, it appears that many health and safety professionals who perform fit testing assume that the objective of a fit test is facepiece sizing, i.e. finding out if a particular worker should use a small, medium or large respirator. While this view identifies an important element of fit testing, it is not the only component, or even the most important element. The primary reason to fit test a worker is to verify that he or she has been trained to wear a respirator properly, has decided to take personal responsibility for learning how to protect themselves to prevent injury, and has learned how to don the facepiece correctly. If a worker does not know how to use the equipment, or fails to understand why proper use of the
equipment is important to eliminate safety hazards, the protection level afforded will be compromised regardless of whether or not the facepiece is the right size. A fit test should be considered as the final examination for respiratory safety trainees.

5.2.5 Suggestions for the Respiratory Protection Industry

Several recommendations for the respiratory protection industry were made based on the outcome of this study. First, the inadequacy of the commercial videotape and manufacturer provided instructions were highlighted for their failure to provide OSHA recommended safety knowledge to trainees in this study. Both forms of instruction should be modified or replaced in some way (e.g. interactive cd rom) to provide OSHA recommended respiratory safety instruction to trainees based on systematically designed instruction techniques, or should be used as forms of branched instruction.

Second, based on the high incidence of participants who were unable to be fit tested (28%), a need is indicated for improvement in respirator mask design/s to provide better mask fit scenarios for tight-fitting respiratory protection wearers. Manufacturers of tight-fitting respiratory protection devices need to be aware of the cause of quantitative fit testing failures to lessen the need for custom made to fit masks. The seal of a respirator to a worker’s face can be influenced by the worker’s facial dimensions (Brazile et al., 1998). The implication of these findings is that additional mask sizes need to be designed to provide proper fit for workers.

A constraint to QFT data was imposed by the fact that no available half-facepiece or full-facepiece respirator masks could fit/seal the face shapes of 20 subjects. The two facial dimensions used in respirator approval for half-masks by manufacturers are face length and lip length (Aerospace Medical Research Laboratory, 1967; Clauser et al., 1971). These parameters were derived from men and women in the U.S. military. The shortcomings of using anthropometric data from military personnel to characterize the general population were stated by Kroemer et al. in 1994. Results from the present study were not in agreement with previous researchers. In the present study, the majority of males who could
not be fitted properly were obese, while petite and obese females comprised the female exclusions. Three brands of negative pressure respirators were used: Glenaire®, Mine Safety Appliances® and North Safety Equipment®. Gross and Horstman (1990) assessed the fit of respirators for Caucasian males and females. They concluded that when any two commercially available brands of respirators were made available to test subjects, 95 percent of women and men were adequately protected as indicated by ANSI standards for minimum fit factor. Moreover, Oestenstad and Perkins (1992) investigated the prediction of fit factors based on facial dimension measurements. These researchers found that the facial dimensions of 68 subjects did not differ significantly from the distribution of facial dimension measurements from the military. Based on the results of this study it is hypothesized that a broader range of sizing is needed (XS, XL, XXL). Manufacturers could engineer additional mask sizes to accommodate workers who are petite, obese with wide noses and cheeks by including nose and cheek width in face seal calculations.

Third, manufacturers of tight-fitting respiratory protection devices need to be aware of the frequency and cause of QFT failures. A large number of subjects failed quantitative fit testing due to their inability to properly tighten headstraps. Results indicate that a fine line existed between proper headstrap tightening and “over-tightening.” Over-tightening of headstraps also caused some incidence of QFT failure. Based on this finding, it would be interesting to investigate how much input the comfort factor played in the decision making process regarding tightening, through the use of qualitative rating scales. How tight is tight enough? This type of qualitative information could aid respiratory safety training designers in providing better instructions about proper headstrap tightening to trainees.
REFERENCES


Appendix A

Video Transcript
Video Transcript

How to Clean, Wear and Care for Your Respirator

<table>
<thead>
<tr>
<th>Narrative</th>
<th>Time &amp; On screen text</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you think about it, there are safety precautions all around you – most of which you take for granted. Some things you do often as a matter of habit to protect yourself and your family from potential dangers. But what about hazards in the workplace? Some work related dangers are obvious and you wouldn’t think of questioning the need for personal protective equipment. But there are many work environments that expose you to dusts, mists, fumes, hazardous gases or vapors. These are sometimes unseen or un-noticed dangers that damage delicate lungs and other organs. For many of these toxic air contaminants an air purifying respirator by Pro-Tech is your best assurance of safety with the proper cartridge and filter combinations. A Pro-Tech respirator provides protection against thousands of different airborne hazards many of which are listed in our respirator</td>
<td>Pro-Tech Respirators, Inc. Presents How to Clean, Wear and Care for Your Respirator 0:00:10 – 0:00:27</td>
</tr>
</tbody>
</table>
selection guide, along with the recommended filter, cartridge, or combination of each. However, some work environments require air supply respirators to provide adequate protection, and Pro-Tech manufactures a complete line of these too. OSHA demands that respirators be provided to protect the health of employees exposed to hazardous atmospheres. Your employer has demonstrated his commitment to your safety by providing respirators for your protection. But don’t wear a respirator for OSHA or your employer. Do it for yourself. Taking the time to remember your respirator may seem a little inconvenient at first. But that's not a good excuse for jeopardizing your health. Of course to protect your health, your respirator has to make an airtight seal to your face so the cartridge and the filter can do their job. Six different Pro-Tech half mask and a full face model - all designed for maximum wearer comfort assure that virtually all workers can be properly fitted. As with any piece of equipment, there is a right way and a wrong way to use your respirator.

<table>
<thead>
<tr>
<th>How to wear your respirator. Caution!</th>
<th>Caution!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respirators will only work if the wearers’ face is clean shaven. Facial hair between the mask and skin will prevent an airtight seal. If you are using a full face model,</td>
<td>0:02:27 – 0:03:02</td>
</tr>
</tbody>
</table>
Check the exhalation and inhalation flaps to be sure they are securely in place. Then place your chin into the chin cup and pull the head harness over the top of your head. The lower strap should be below the ears, and the upper strap above the ears. The triangular section of the harness should be on the back of the head in a secure position. To adjust the headband tension, pull the free ends of the straps to tighten, or move the buckle bar towards the lens to loosen. With the Pro-Tech half mask models - be sure the cartridge receptacle is firmly attached to the facepiece and that the exhale valve flap and the inhale valve flap are secure to the button in the center of the valve seat before you don the respirator. Then put the narrow part of the respirator over your nose. Hook the upper headband over the crown of your head, and the lower headband behind your neck. The respirator should sit just below your safety glasses. Finally, adjust the headband tensions as recommended in the instruction booklet. The cradle headband should snug up to the face comfortably, or the straight headband should be stretched about two inches between unhooked ends. Avoid over-tightening headbands, as this interferes with proper fit.
How to test your Pro-Tech respirator for proper fit: Your respirator can't protect you if it doesn't fit right. Improper fit is most obvious when you can smell the contaminant, or you experience irritation of the nose or throat. Depending on your specific environment, OSHA requirements and your employers' preference, there are several fit tests you can perform to make sure your respirator will do its job.

<table>
<thead>
<tr>
<th>Test for fit</th>
<th>Odor or Irritation of Nose or Throat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor or Irritation of Nose or Throat</td>
<td></td>
</tr>
</tbody>
</table>

These include the banana oil test, the irritant smoke test, the quantitative test and the positive pressure check.

<table>
<thead>
<tr>
<th>Test for fit</th>
<th>Banana Oil Test</th>
<th>Irritant Smoke Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana Oil Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irritant Smoke Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The quickest and easiest test is the positive pressure CHECK. First, block the exhale valve completely with the heel of your hand. Exhale gently. Slight pressure should build up inside the facepiece before any escaping air is felt, proving that the respirator is making an airtight seal to the face. If no pressure builds up, there is a leak. Adjust the facepiece and headbands, and recheck the seal. This test should be done when you put the respirator on at the beginning of your shift and again at frequent intervals throughout the workday.

<table>
<thead>
<tr>
<th>Positive Pressure CHECK</th>
<th>0:04:33 – 0:05:03</th>
</tr>
</thead>
</table>

When qualitative fit testing required, Pro-

<table>
<thead>
<tr>
<th>Irritant Smoke Test</th>
<th>0:03:94 – 0:04:14</th>
</tr>
</thead>
</table>

Irritant Smoke Test
Tech recommends the irritant smoke procedure. We also supply materials for the banana oil procedure. Qualitative testing is used to insure the proper size facepiece has been provided, and that the facepiece makes an airtight seal with the face of the wearer being tested. To test with irritant smoke, first successfully perform the positive pressure fit test. Then make sure the respirator half or full face style, is equipped with the G108 HEPA filters. Select a location that is free from wind currents, or ventilation fan blasts. Next the test administrator breaks the ends off the glass irritant smoke tube and inserts the tube into the squeeze bulb. The test subject must keep his eyes closed for the duration of this test. The administrator then squeezes out a cloud of irritant smoke. The subject is instructed to perform the following four exercises: 1) move the head from side to side, 2) move the head up and down, 3) take several deep breaths, and 4) state name, address and phone number. If at any time the seal is broken, the test subject will breathe a little of the irritant smoke, which will make him cough or sneeze for a moment. The smoke is not dangerous and there are no permanent effects from it. Too much smoke can be unpleasant, so care must be taken not to overexpose either the test.
subject or the test administrator. When the four exercises are successfully completed without the irritating effect of the smoke being noticed, the test has been passed. Both the subject and the administrator should sign the test form upon completion of the test.

<table>
<thead>
<tr>
<th>The banana oil procedure is identical, except that the respirator must be equipped with the G100 organic vapor cartridges. It is best to ensure that the subject can actually smell the banana oil before donning the respirator and beginning the test. Some people cannot detect its odor at all. The banana oil, actually known as isoamylacitate is not an irritant but has a very distinctive sweet odor of bananas. The ampoule is broken and gently waved around the respirator during the same four exercises as for the irritant smoke test. If at any time the subject notices the odor of bananas, the test has been failed. Another attempt must be made after repositioning the facepiece, or selecting a different size. OSHA regulations state that respirators must be routinely inspected for worn or deteriorated parts which should be promptly replaced as needed.</th>
</tr>
</thead>
</table>
| **Banana Oil Test**
0:06:29 – 0:07:19 |
| Respirators issued to one individual must “Respirators must be routinely inspected” |
Respirators issued to an individual must be cleaned regularly.

Respirators must be stored in a convenient, clean, sanitary place.

So how you clean and inspect your respirator is very important to proper use and care. As you can see, the Pro-Tech respirator consists of only a few parts to be checked and cleaned or replaced. While disassembling for cleaning, be sure to inspect these parts. Check the headband for frayed areas, loose strands, tears or loss of elasticity. Carefully remove the cartridges, filters and valve flaps. Now you need to decide whether or not the cartridges or filters need to be replaced. To do this, consider a filter element works by trapping solid or liquid contaminant particles like dusts, mists or the fumes resulting from metal welding or smelting. After a period of use, the filter will load up for worn or deteriorated parts which should be promptly replaced as needed."
with particles and breathing will become more difficult. When this happens, the filters must be replaced. Pro-Tech respirator cartridges are not for use against dusts, mists or fumes, all solid or liquid particulates.

| A cartridge containing a chemical sorbent does protect you from gases or vapors that might be in the air you breathe. | Gases
Vapors
0:09:03 – 0:09:05 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>If you notice contaminant odor or irritation, the cartridges are spent and should be replaced.</td>
<td>If you notice contaminant odor or irritation, the cartridges should be replaced. 0:09:06 – 0:09:10</td>
</tr>
<tr>
<td>If the contaminant has poor warning properties, that is, no odor at a toxic level, the cartridge should be replaced on a calculated, regular basis.</td>
<td>If the contaminant has poor warning properties, that is, no odor at a toxic level, the cartridges should be replaced on a calculated, regular basis. 0:09:11 – 0:09:22</td>
</tr>
</tbody>
</table>

Next, check the valve flaps. If they are deformed, replace them. If they appear to have no cracks or are not misshapen, wash them with Pro-Tech lemon disinfectant or other bactericidal detergent. Then rinse them with clear water and let them air dry on a flat surface. Examine the facepiece for cuts and replace the facepiece. Always use genuine Pro-Tech replacement filters, cartridges and parts.

Pro-Tech Respirators, Inc.
0:09:23 – 0:10:16
Never modify the respirator in any way. Doing so voids the NIOSH approval and can interfere with the correct functioning of the respirator. The last step is to wash and disinfect the facepiece. Do not clean the facepiece with alcohol or other organic solvents. Instead, immerse it in warm water with a solution of Pro-Tech lemon disinfectant cleanser, a commercial disinfectant, household chlorine bleach or iodine. Scrub with a soft brush or cloth. Your instruction manual contains more details.

On the full face respirator, the lens only may be cleaned with momentary exposure to solvents if necessary. Caution! Any more than a momentary exposure to solvents can ruin the lens. Don’t leave the solvent on the lens more than a few seconds. Next, rinse the facepiece with clear water and air or towel-dry. When the mask is dry, re-install the cradle headband assembly, the exhale valve flap, the inhale valve flaps and new air purification elements as required. Install the cartridges by threading them into the receptacle from which the spent cartridges were taken. Place a new, fresh filter in the retainer, with no wrinkles around the edges. Then snap the filter retainer back on. Pro-Tech provides respirator storage bags to keep respirators clean and fresh. The mask
should then be stored in a cool, dry place. Your employer has taken steps to protect your health by providing respirators. But they won’t help if you don’t wear them. This full color poster will tell you how to wear, care for, clean and wear your Pro-Tech respirator. Pro-Tech will provide it at no cost. Study it. Learn it and remember that the ultimate responsibility is yours. This video produced with your health in mind by Pro-Tech respirators and brought to you by your employer.

| Pro-Tech Respirators, Inc. | 0:11:25 – 0:12:11 |
Appendix B

Organizational Analysis
Organizational Analysis

Interview Questionnaire: Organizational Analysis/Job Environment

Chosen interviewees: Two experienced respiratory protection instructors from the Virginia Tech Environmental Health and Safety Services.

Are there certain tasks that by law have to be trained? Yes. ANSI Z88.2 (1992) states that:

- each respirator wearer shall be given training (and re-training), which includes explanations and discussions of: the need for respiratory protection;
- the nature, extent, and effects of respiratory hazards in the workplace; the need to inform their supervisor of any problems experienced by them or their co-workers;
- an explanation of why engineering controls are not being applied or are not adequate and what effort is being made to reduce or eliminate the need for respirators;
- an explanation of why a particular type of respirator has been selected for a specific respiratory hazard;
- an explanation of the function, capabilities, and limitations of the respirator selected; instruction for inspecting and donning the respirator. This includes a requirement that a fit check shall be done each time the respirator is donned or adjusted;
- an explanation of how to maintain, inspect and store the respirator; regulations concerning respirator use; recognizing and handling emergency situations.

In addition, the OSHA respiratory protection standard 29 CFR 1910.139, Subpart I (1997) states that an employer must ensure that for each employee wearing negative pressure respirators:

- Every respiratory wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, adjusted and to determine if it fits properly;
• the respirator issued to the employee exhibits the least possible facepiece leakage and that the respirator is fitted properly; respirators cannot be worn when conditions prevent a good face seal (i.e. beard growth, sideburns, a skull cap that projects under the facepiece, or temple pieces on eyeglasses).
• A qualitative or quantitative face fit test must be performed at the time of initial fitting and at least every six months thereafter.
• Appropriate personal protection will be provided to the employee at no cost. The employer is responsible for seeing that the employee uses the provided clothing and equipment.
• The hazard communication standard must be applied in the workplace.

Job Environment Analysis

What types of work groups work with respiratory protection?
• Carpenters and electricians due to drilling in building materials
• Chemical waste handlers
• Painters/Pesticide applicators
• Coal/fire power plant employees
• Rock quarry workers
• Ventilation maintenance workers

Note: EHSS is not responsible for providing respiratory protection for contract employees.

What types of respirators are used at Virginia Tech? Both negative pressure and purified air powered respirators.

If the results of this research show that systematic interactive multimedia instruction is effective for training, are current training methods likely to be altered? Yes.

How large are the work groups? Work groups are usually composed of two people for safety.
Do you foresee changes in the composition or number of these work groups? No, all workers report to the same supervisor.

Do you foresee changes in the composition or number of these work groups (are the number of independent groups growing in number, etc.)? No changes are foreseen. However, monitoring results will dictate if a given work group will be added to the Occupational Health Assurance Program.

What are the trends in respirator training techniques? No trends are currently discussed in respiratory protection literature.

Are there ways for an independent person to be trained through the state of Virginia? The Virginia Department of Labor and Industry provides some information about respiratory protection.

What are the goals of large companies concerning training and education of respiratory protection users? Their motivation is probably to avoid OSHA fines/citations.

How does respirator training fit into these goals? By helping to keep costs down.

What do you think are the attitudes of these groups toward an systematic interactive multimedia training form of training? Who will be supportive and who will see the training program as a problem? Why? Younger workers are more likely to be more receptive than older workers. Older workers are likely to take the attitude of “I already know how to do this, and don’t need more training on how to do this.” Further, actual users of respiratory protection appreciate training more than supervisors who view training as employee time away from the job.

What are the initial expectations of workers required to use respirators, either implicit or hidden, regarding skills they need to properly use them? Or, what skills should they have? Initially upon hire, no previous experience or training with respiratory protection devices is expected of employees.
If the systematic interactive multimedia training is shown to be effective, who will have access to it? What limitations do you foresee? Systematic interactive multimedia training information will be available to the public domain. No limitations of its use are foreseen.

Are there negative issues you foresee in using a systematic interactive multimedia training program? No.

As a user of respiratory protection, what trends do you see? In the university setting, a trend toward use of a purified air powered respirators is predicted due to an aging workforce. Aging employees tend to smoke which causes airway obstruction.

What problems do you foresee in bringing the training facilities and workers exposed to respiratory hazards together? No problems are foreseen. Employee training is done concurrently with medical surveillance. Ideally, it is a prerequisite for hire than respiratory protection will be used on the job, and training will accompany respirator use. Currently respiratory ailment/disease is one of the most common occupational ailments in the United States.

If the employee knew how to correctly don and use respirators safely, what incentives do the employees have to perform the task safely? Few incentives exist on the surface, as respiratory ailments/diseases usually occur after long term exposure. For example, it is common for an employee to feel fine after a day of exposure to chemicals or particulates. The effects of exposure are usually invisible for many years. Incentives may be continued employment and health improvement.

What factors lead to poor or unsafe respirator use?

Social: machismo
Psychological: fatigue, discomfort, boredom with the job.
Workload: Supervisors may push employees to do things unsafely or work overtime
Monetary: The university may not have funds to purchase cartridges for employees. Therefore, cartridges may be used too long.
Lack of rewards: Lack of supervisor compliance: Although strongly recommended by EHSS, some supervisors aren’t encouraging workers to use respiratory protection.

Lack of education: Some workers use cartridges incorrectly. For example, the wrong cartridge is sometimes used for a given chemical exposure. Employees are sometimes unaware that cartridges are not all-purpose.

What do you think respiratory protection users should know about respiratory hazards when they go out to the worksite? Be specific. Employees need to be made aware of when breakthrough happens, and proper use of filter cartridges.

Concerning the current state of training in the respiratory protection industry, what changes do you think are warranted? It is recommended that every entry level person go through an initial donning and skills training, a practice period, evaluation, followed by periodic and remedial training as necessary.

What training techniques have been done in the past? A behavioral role modeling type of fit training.

What changes in training techniques do you see happening in the future? Nothing is seen on the horizon.

Right now, where can the biggest improvements be made? More information is needed about how to train, not just a listing of what should be trained from ANSI and OSHA.

What time length is optimal for use in training respiratory hazards and proper donning technique? Thirty to forty five minutes.

Personnel Analysis:

The tasks and Knowledge Skill Analysis (KSA) provide most of the information needed for this analysis. The personnel analysis addresses two major questions: (1) Who within the organization needs training?, and (2) What kind of instruction is needed? The analysis provides the instruction designer with the number of employees that require training and an analysis of the target population. This training program is being developed to specifically train employees.
Measures of criteria were developed and used to assess and determine the capabilities of the trainees. The following criteria were used:

- No prior experience with respiratory protection devices is expected of new trainees,
- No prior knowledge or familiarity with respiratory hazards and the health and physical hazards associated with them is expected of new trainees,
- Safety motivation

**Limitations:**

- Trainees do not have prior experience of respiratory protection device usage or of respiratory hazards,
- Training needs to take place within the university environment,
- Employee attitudes toward respiratory protection

**Constraints:**

Set by OSHA 1910.139 and ANSI Z88.2:

1. An explanation of why engineering controls are not being applied or are not adequate for a worksite;
2. An explanation as to why a particular type of respirator has been selected for a specific respiratory hazard;
3. An explanation of the function, capabilities, and limitations of the respirator selected for their use; instruction for inspecting and donning the respirator;
4. An explanation of how to maintain, inspect and store the respirator;
5. Every respiratory wearer shall receive fitting instructions including demonstration and practice in how the device shall be worn, adjusted and to determine if it fits properly;
6. A qualitative or quantitative face fit test must be performed at the initial fitting.
7. The hazard communication standard must already be in place at each worksite;
Task Analysis:

- **Job Description**: Any employee at the university assigned by a departmental director to ensure a work group or unit’s compliance with the requirements of the respiratory program.

- **Taxonomy of Tasks**: A number of specific tasks have been identified by OSHA 29 CFR 1910.139, which are as follows:

  - each respirator wearer shall be given training (and re-training), which includes explanations and discussions of: the need for respiratory protection;
  - the nature, extent, and effects of respiratory hazards in the workplace; the need to inform their supervisor of any problems experienced by them or their co-workers;
  - an explanation of why engineering controls are not being applied or are not adequate and what effort is being made to reduce or eliminate the need for respirators;
  - an explanation of why a particular type of respirator has been selected for a specific respiratory hazard;
  - an explanation of the function, capabilities, and limitations of the respirator selected; instruction for inspecting and donning the respirator. This includes a requirement that a fit check shall be done each time the respirator is donned or adjusted;
  - an explanation of how to maintain, inspect and store the respirator; regulations concerning respirator use; recognizing and handling emergency situations.
  - Every respiratory wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, adjusted and to determine if it fits properly;
  - the respirator issued to the employee exhibits the least possible facepiece leakage and that the respirator is fitted properly; respirators cannot be worn when conditions prevent a good face seal (i.e. beard growth, sideburns, a skull cap that projects under the facepiece, or temple pieces on eyeglasses).
  - A qualitative or quantitative face fit test must be performed at the time of initial fitting and at least every six months thereafter.
  - Appropriate personal protection will be provided to the employee at no cost. The employer is responsible for seeing that the employee uses the provided clothing and equipment.
  - The hazard communication standard must be applied in the workplace.
  - **Critical Knowledge**: Identification of respiratory hazards, proper respirator donning technique.
• **Critical Skills**: Motor skills required for undergoing systematic interactive multimedia training program, proper donning technique. Verbal skills required for completing pre-training questionnaire and post-training surveys/tests.
Appendix C

System Specification Document
System Specification Document

I. PROGRAM GOAL

What is the overall goal of the training program? The goal of the training program is to train respiratory protection donning technique and associated safety hazards involved with their use.

What is the context for the training program? This training program is being conducted to investigate the effectiveness of an systematic interactive multimedia training technique which will include concerns of general respiratory safety awareness, and safe use of negative pressure respiratory protection devices. For these subject areas a training program is being developed on respiratory protection donning and safety practices. A training system is being developed which will provide for both classroom as well as one-to-one instruction basis.

II. POST - TRAINING GOALS AND OBJECTIVES

What are the goals and specific behavioral objectives with regard to trainee performance after training?

- Participants will be able to identify respiratory safety hazards at a worksite.
- Participants will be able to identify that improper donning of a respirator can result in serious health consequences.
- Participants will be able to identify proper use of a half-facepiece negative pressure respiratory protection device.
- Participants will be able to identify proper use of a full-facepiece negative pressure respiratory protection device.
- Participants will be able to identify properly functioning filter cartridges.
- Participants will be able to identify physical problems that affect adequate face-seal abilities of a respiratory protection device.
• Participants will be able to identify appropriate accompanying personal protective equipment for use with respiratory protection at a worksite.
• Participants will be able to identify long term effects of exposure to respiratory hazards.
• Participants will express a higher risk perception on a 7 point rating scale than participants who do not receive training via a method based on systematic training principles.
• Participants will be able to identify/explain why working with a “buddy” coworker is important.

What are the performance criteria for evaluating training program effectiveness?
The training program will be considered successful if a statistically significant difference is shown between the systematic interactive multimedia training application, the videotape developed without state-of-the-art instructional design principles, and workers who received manufacturer’s package instruction training.

III. SYSTEM PERFORMANCE REQUIREMENTS

What performance characteristics are essential for the training program?
• It is essential that the strategies to gain attention of the trainee are implemented.
• It is essential that the trainee find the material relevant.
• It is essential to use strategies that cause the trainee to believe they are capable of success at the task without taking away the challenge of the task.
• It is essential to use concrete language that the trainees understand.
• It is essential to use as many criteria of good instructional design methods as feasible.
• In design of the systematic interactive multimedia training program based on training principles, it is essential to provide immediate feedback for correct choices.
• It is essential that cognitive resources of the trainee are not overloaded.

What performance characteristics would be desirable for the training program?
• It is desirable to give many non-instance as well as instance examples of hazardous respiratory situations to give the trainee more practice at making safe decisions.
• It is desirable to give the trainee opportunities to practice donning each respiratory protection device until proper fit is achieved.

IV. SYSTEM CONSTRAINTS

With respect to the training program development:
What financial resources are available? NIOSH is supplying funding for volunteer subject payment at a rate of $10.00 per hour.

What human resources are available (in person hours)? The training program developer and two occupational health and industrial hygiene employees from Environmental Health and Safety Services at VPI&SU. Advice and guidance on the project is coming from experienced respiratory protection instructors, human factors practitioners, and training experts.

What equipment and other tools are available? Necessary computer, respiratory protection devices, quantitative fit testing equipment, video cassette player and other support equipment is available.

What are the time limits? All materials must be developed by June 30 so that participants can be trained and evaluated by August 30.

With respect to the training program delivery:
When do the trainees need to be trained? All participants need to be trained and evaluated by August 30.

How many trainees need to be trained? For the purposes of this research project, 24 participants will undergo training with the systematic interactive multimedia training program, 24 will undergo training with the videotape not based on training principles, and 24 will undergo training based on manufacturer’s package instructions.
Where do trainees need to be trained? For the purposes of this research project, participants will be trained and tested at the EHSS office at VPI&SU.

What is the frequency of the tasks being trained? The donning tasks being trained occurs on a daily basis at the EHSS office. The respiratory hazard identification aspects being trained are common and basic situational awareness tasks that occur on a worksite.

What is the time span from training to actual job performance? It is not possible to foresee at this time. However, the EHSS manager interviewed in the organizational analysis stated that if the systematic interactive multimedia training is found to be significantly better than the current training system, it will be implemented.

Any other constraints on method of delivery? The media equipment that is being used for the purposes in this experiment is being borrowed from EHSS. Coordinating the particular times of use may be slightly difficult but is by no means impossible.

Will instructional content change over time or is it stable? The instructional content is unlikely to change over time unless OSHA or new experimental findings indicate a need for content change.

What is the estimated life span of the training program? That is unforeseen at this time. Success of the training program and future funding to support training efforts are controlling variables.

What financial resources are available for delivery? NIOSH is providing funding for paid volunteer participation, payment of an experienced trained quantitative fit tester.

What human resources are available for delivery? The instructional designer and two occupational health and industrial hygiene employees from Environmental Health and Safety Services at VPI&SU.
What equipment is available for delivery (including video cassette player, quantitative fit tester, actual job equipment)? Necessary computer, respiratory protection devices, quantitative fit testing equipment, video cassette player and other support equipment is available at EHSS.

What are the needs or biases of management or other personnel involved? Funding and time are the main concerns with regard to making the project work. All parties involved desire very polished and professional work and are working under moderate budget constraints. The need is to have a finished report under these constraints.

With respect to trainees: Who are the trainees and what are their characteristics? Participants are males and females from the age groups of 18 - 25 and 45 -60.

Anything in trainee background or attitudes that would constrain the training program? All accepted participants will have no previous experience or training with respiratory protection devices.

What is the relevant knowledge and skills of the trainees? All participants will have no previous experience or training with respiratory protection devices.
Appendix D

Design Concept for Systematic Interactive Multimedia Training Program
How to Use This Training Program

To move through this training program, use your left mouse button to click on the < Back left or Continue > right arrows. Clicking on the left arrow will take you back one screen, while clicking on the right arrow will take you forward one screen.

Take a moment now to explore this page. We hope you enjoy this training course, and good luck.

Screen 1
Identifying Hazardous Situations

Did you know that work sites with respiratory safety hazards are rated among the most hazardous work sites in the United States? If we only count employers with 11 or more employees, in 1996 alone:

- Every day, one employee died from either a work-related respiratory illness or from an electrocution!

- Over 24,000 job-related respiratory conditions occurred due to inhaled toxic agents.

The most important route and greatest risk potential at work sites is inhalation of airborne contaminants through the respiratory system.

Statistics scroll onto screen

Screen 2
Workers exposed to respiratory hazards on our campus are:

- Ventilation systems maintenance workers
- Coal/fire power plant workers
- Rock quarry workers
- Chemical waste handlers
- Carpenters and electricians (due to drilling in building materials)
- Painters/pesticide applicators
- Dairy farm workers
- Agriculture workers

Note: Environmental Health and Safety Services (EHSS) continues to monitor campus work sites regularly for respiratory hazards.
Health Hazards in the Workplace

Health hazards in the workplace are a major concern for both employers and employees. Because many substances that are health hazards can become airborne, specific regulations for controlling and protecting you from airborne contaminants have been established by the Federal Government (OSHA regulation 29 CFR 1910.134).

The purpose of this course is to examine the permissible practices for respiratory protection and for you to acquire the skills and information that will allow you to work safely in situations where airborne contaminants are present.

Screen 4
This tutorial will discuss three categories of information concerning your work site here on campus.

1. The safety equipment you need to wear to protect yourself on the job.
2. Hazardous work site locations on campus.
3. Hazardous work sites that are non-obvious.

As you go through this program you will be asked to answer some questions by typing in the answer. So do not be concerned if you don’t know the answer. Just try your best.

Your goal in this program is to learn about respiratory safety hazards and to identify these hazards before they become a problem. We will start with some basic information you need to know about respiratory hazards.

Screen 5
Routes of Entry

It is important to remember that hazardous materials present a health hazard only when they come into contact with the body. Hazardous materials can enter your body in 3 ways:

1. **Ingestion** (eating)
2. **Skin Absorption**
3. **Inhalation** (breathing)

Screen 6

---

**Routes of Entry:**

**INGESTION**

It is possible to eat and swallow hazardous materials. To avoid eating any of the hazardous materials you may work with:

1. Never eat food in areas where hazardous materials are used.  
2. Never smoke in areas where hazardous materials are used.  
3. Wash your hands and face with soap and water after working with hazardous materials and before you eat, drink, or smoke.

Screen 7
Routes of Entry:

SKIN ABSORPTION

Some materials that are health hazards are absorbed into the body through skin contact. “Skin absorption” means the chemical or particle you are working with is a health hazard that can be easily absorbed into the skin.

- Chemicals can be splashed into your eyes if you don’t wear safety glasses.

- Chemicals can be absorbed into your hands (like skin cream or rubbing alcohol is) if you don’t wear gloves while handling chemicals.

Digital photo of worker handling chemical without safety glasses or gloves

Each bullet scrolls onto the screen

Display of irritated hand scrolled onto screen in conjunction with second bullet

Screen 8

Routes of Entry:

INHALATION

Inhalation is the most common route of exposure for most materials that are health hazards. This includes breathing in dust, fumes, oil, mists and vapors from solvents and various gases.

Display of breathing organs

Screen 9
QUICK QUIZ

The most common route of exposure for most health hazards is:

1. Ingestion
2. Skin Absorption
3. Inhalation

Enter 1, 2, or 3, then press Return. _____

When correct, then “That’s right! Inhalation is the most common route of exposure for most health hazards” appears.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 10
Occupational Respiratory Diseases

Diseases that result from exposure to poisonous chemicals, dusts, vapors, gases, smokes and other hazards of the workplace are classed as occupational diseases. Together, they are a major cause of illness and death in modern industrial countries.

Remember: Every day in 1996 at least one person died from an occupational respiratory illness or from electrocution!

Screen 11

Chemical Hazards

Thousands of chemical substances are in commercial use, and almost all of them present some hazard. Perhaps one out of every ten chemicals causes cancer. Those chemicals used in pesticides, industrial solvents, refrigerants and plastics are known to cause damage to the liver, nervous system, skin, and sometimes other organs; many of them cause cancer. Generally, workers are exposed to much, much higher concentrations than the general public and are therefore much more at risk.

Screen 12
Dust Hazards

DANGER! Diseases due to inhalation of certain dusts on our campus are DEADLY.

- Inhalation of silica causes *silicosis*.
- Inhalation of coal dust causes *black lung disease*.
- Inhalation of asbestos fibers causes *asbestosis*.

Silica, coal and asbestos dusts directly injure the tissues of the lungs and often result in pulmonary fibrosis (scar formation); this results in impaired lung function and will result in progressive disability of the lungs to function.

When asbestos workers carry asbestos dust home on their clothing and shoes, their families are also put at risk.

Screen 13
The Breathing Process

To better understand how health hazards can enter your body by inhalation, let’s take a closer look at the breathing process.

Whenever you take a breath, oxygen rich air is taken into your body through your mouth and nose, and travels down your windpipe and into your lungs. In your lungs, there are tiny air sacs called alveoli. These delicate air sacs then transfer the oxygen that is in the air into your blood. At the same time the oxygen is being absorbed into your bloodstream, carbon dioxide is being transferred from your bloodstream into the air sacs. When you breathe out, you are ridding your body of gaseous wastes.

Screen 14
Your Body’s Limitations

Although your body has some natural defenses against hazardous materials, there will be times when you must work in an environment that contains airborne contaminants that your body cannot protect itself from. If you try to work in such an environment, airborne contaminants can inhibit your lungs’ ability to exchange oxygen, or can cause other adverse health effects.

Screen 15

Spirometry Testing

Because of the dangers involved in working with respiratory hazards, you must be in good health to use a respirator.

Environmental Health and Safety Services (EHSS) personnel will do some spirometry testing to determine what kind of respirator you need and your ability to wear one. **Spirometry** is the measurement of lung volume (how much air the lungs can take in) and relating it to time.

To safeguard your health as a respirator user, you will be re-evaluated yearly by EHSS to monitor your fitness to use a respirator.

Screen 16
Acute Reactions

Some airborne contaminants will cause your body to react immediately. You may cough, sneeze or choke. Your stomach may become upset or you may feel dizzy. **Acute reactions to airborne contaminants are short term or IMMEDIATE.**

For example, you begin to work with a paint solvent in a closed area, and the vapors make you feel dizzy.

Screen 17

Chronic Reactions

There are airborne contaminants, that **after many repeated exposures, take years to affect your body.**

For example, the dangerous effects for people who have been overexposed to asbestos take years to appear and have been linked to a number of fatal lung diseases. Respiratory hazards are very DANGEROUS and DEADLY.

Screen 18
QUICK QUIZ

Acute reactions to airborne contaminants take years to appear.

1. True  
2. False

Enter 1 or 2, then press Return. ______

If correct, “Correct! acute reactions to airborne contaminants can appear immediately or within a short time,” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 19
Controlling Your Exposure to Air Contaminants

There are **4 ways** to control your exposure to airborne contaminants. These are:

1. **Engineering controls**;
2. **Administrative controls**;
3. **Product substitution**; and
4. Establishing and maintaining an ongoing **respiratory protection program**.

### ENGINEERING CONTROLS

Well designed work areas minimize exposure to airborne contaminants. Examples of engineering controls include:

- Exhaust systems
- Ventilation systems
- Wetting systems

Display of fume hood absorbing chemical emissions
Controlling Your Exposure to Air Contaminants:

**ADMINISTRATIVE CONTROLS**

*Administrative controls are any changes in your work schedule or operation that reduce your exposure to airborne contaminants.*

Common examples of administrative controls include:

1. Scheduling operations and processes that produce airborne contaminants when fewer people are exposed;  

2. Moving you to another job or area once your daily exposure level has been reached.

Screen 22
Controlling Your Exposure to Air Contaminants:

PRODUCT ELIMINATION AND SUBSTITUTION

Sometimes the use of a hazardous material can be discontinued. Or, a less toxic material can be substituted that does the same job.

Display of product skull/crossbones over poisonous container.

Product substitute shown with green tree on container.

What is a respiratory program, and why does VT have one?

Respiratory Protection Program

There will be times and situations where engineering controls, administrative controls and product substitution will not provide adequate protection. In these situations, a Respiratory Protection Program has been implemented by VT EHSS to safeguard your health.

The purpose of the respiratory protection program is to establish requirements for employer occupational health programs for the use of respirators.

Both the employer and the employee must accept some responsibilities as part of the program.

Screen 23
Employer Responsibilities

*Employers are responsible for:*

- Providing appropriate respirators, replacement cartridges/filters and any necessary safety equipment for employees,
- Correcting malfunctions of respirators,
- Providing training for employees,
- Having the hazard communication standard in place.

Screen 25

Employer Responsibilities

THE HAZARD COMMUNICATION STANDARD

In 1987, OSHA implemented the hazard communication standard. *This standard requires employers to inform employees* involved in any type of manufacturing of the nature of the *hazardous chemicals used in their workplaces.* Employees must also be trained in safe ways to deal with the hazardous chemicals they will encounter.

Screen 26
Employee Responsibilities

Employees are responsible for:

- Reporting to the worksite with a clean-shaven face
- Changing the air-purifying elements or other respirator components as needed
- Leaving hazardous work areas for any respirator-related causes such as: respirator failure, if an air leakage into the respirator is found, or if he/she experiences severe discomfort while wearing the respirator.
- Washing his/her face and the respirator facepiece to minimize skin irritation.

Screen 27
QUICK QUIZ

The four ways to control your exposure to airborne contaminants are engineering controls, administrative controls, product substitution and establishing and maintaining an ongoing respiratory protection program.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, then “Yes! You are well on your way towards being an effective respiratory protection user” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.
SAFETY EQUIPMENT FOR
RESPIRATORY HAZARDS

Student Question…
Why isn’t this worker ready for the job?

1. Worker is not wearing safety equipment.
2. I don’t know.

Enter 1 or 2, then press Return. _____

If correct, then “That’s right! Properly using your safety equipment is the single best thing you can do to protect yourself against respiratory hazards.”

If incorrect, then “Notice this worker isn’t wearing her safety equipment. Wearing proper safety equipment is the single best thing you can do to protect yourself.”

Screen 29
Safety Equipment

RESPIRATORS

Inhaling airborne contaminants caused approximately 1,777 injuries in 1996 in Virginia. The piece of safety equipment that could have prevented these injuries is a respirator. The folks at EHSS and your supervisor will recommend the proper respirator for your use.

Screen 30

WORK BOOTS

A good pair of work boots is another important piece of safety equipment. Work boots are recommended for foot protection, and they help eliminate slips and falls.

Screen 31
WORK GLOVES

Exposure to harmful chemicals caused approximately 2,006 chemical burns in Virginia in 1996. A good pair of work gloves will protect your hands from absorbing “caustic” chemicals you are working with. The word “caustic” means “irritates, burns, corrodes, or burns through living tissue” like your skin.

Screen 32

EYE PROTECTION

Approximately 1,666 eye injuries occurred in Virginia in 1996. Protecting your eyes is an important safety precaution.

For eye protection, a number of different items are available; for example, the plastic shield on a full-facepiece respirator and safety glasses.

Screen 33
Safety Precautions

Being visible to your “buddy” or co-workers is extremely important. Work sites that involve respiratory hazards are known to be DEADLY.

- Humans can survive for weeks without food, and for days without water, but only for a few minutes without air.

- If you should pass out, your co-worker should be easily alerted to the situation if he/she is keeping an eye on you.

- Remember that you always want your co-worker to know where you are.

Screen 34

Now you have on your safety equipment: your respirator, work boots, gloves and safety glasses.

Wearing safety equipment is the most basic way to prepare yourself for respiratory hazards on the job.

Screen 35
How Respirators Work

Respirators are designed to provide you with clean air. The air that is provided to you by a respirator may be:

- **Filtered** – the air you breathe is passed through a mechanical filter that removes harmful airborne particles.

- **Purified** – cartridges or canisters are used to remove toxic chemicals and purify the air.

- **Supplied** – clean air contained in a cylinder is pumped into the breathing zone of the wearer.

Digital photo of a filter cartridge

Each bullet scrolls onto screen along with type of respirator

Screen 36
How Respirators Work (continued)

Respirators also rely upon negative or positive air pressure in order to work.

*What do we mean by negative or positive pressure?*

- **Negative Pressure Respirators** require your lungs to “pull in” air through the respirator.

- **Positive Pressure Respirators**, on the other hand, use a mechanical pump or air under pressure to “push” air through the respirator.
QUICK QUIZ

Which of the following is NOT a method used by respirators for providing the user with clean air?

1. Negative Pressure
2. Positive Pressure
3. Discernable Pressure

Enter 1, 2, or 3, then press Return. ______

If correct, then “Nice job!” appears on screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 38
Oxygen Deficient and IDLH Atmospheres

*DANGER! Never* use a respirator which uses filters, cartridges, or canisters in atmospheres that are oxygen deficient or in atmospheres that are *Immediately Dangerous to your Life or Health (IDLH).*

Never use a respirator that uses filters, cartridges, or canisters for protection against exposure to contaminants that cannot be easily detected by odor or irritation, or when you don't know the amounts or identity of the contaminant.

Screen 39
QUICK QUIZ

You can safely use a respirator that uses filters, cartridges, or canisters in oxygen deficient or IDLH atmospheres.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, then “That’s right!” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 40
Types of Respirators

There are two types of respirators used on the VT campus:

1. Air purifying/filtered respirators, and
2. Supplied air respirators.

Screen 41

Air Purifying Half-Mask Respirators

Air purifying half mask respirators use replaceable chemical cartridges/filters.

Air purifying respirators are not for use in air spaces containing less than 19.5% oxygen.

These negative pressure masks are designed to protect you against dusts, mists, gases and vapors.

Since the chemical cartridges and filters are replaceable, you do not throw away the respirator's entire unit once the chemical cartridges/filters are exhausted.

Screen 42
Air Purifying Full Mask Respirators

Air purifying full face mask respirators also use replaceable chemical cartridges/filters.

These are also called *negative pressure* masks and are designed to protect you against dusts, mists, gases and vapors.

Similar in design to half mask units, these masks provide full face protection against airborne materials. When working in environments where contaminant concentrations are irritating to the eyes, a full face air purifying respirator must be used. As with the half mask respirators, you replace the filters and cartridges once they are exhausted.

Screen 43
Powered Air Purifying Respirators

*Powered air purifying respirators*

These types of units feature a *positive pressure*, because air is “pumped” into the mask. The pressure in the mask is *positive* compared to the pressure outside of the mask.

Battery powered blower units are usually located on the mask or on a waist belt.

These masks are designed to protect you against dusts, mists, gases and vapors.

No cartridges or filters are used with this type of respirator.

Screen 44
Air Purifying Respirators:

CARTRIDGES AND FILTERS

There are a wide variety of cartridges and filters available for respirators. Each is designed to protect you against different types of dusts, fumes, vapors and mists.

Because no one filter or cartridge is suitable for every type of work environment, always check with your supervisor or EHSS to make sure you are using the right filter or cartridge for the environment that you will be working in.

In some situations, you may have to use more than one cartridge to insure your safety (like when you may be exposed to more than one chemical at a time).

Screen 45
QUICK QUIZ

You may use any type of filter or cartridge to work in any type of environment.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, then “That’s right! Every filter is made for use only with a certain chemical and may not be used in any type of environment.”

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 46
Selecting the Correct Respirator

The first step in selecting the correct respirator is to determine what the level of hazard is in the environment you will be working in.

For example, since asbestos exposure in the workplace has been found to cause cancer, employees are no longer allowed to be exposed to it without wearing an extremely high level of protective equipment, including a hooded chemical resistant suit.

So, safety professionals have investigated how to protect workers against inhaling asbestos fibers to safeguard their health. To do this, 4 basic questions must be answered before you enter the workplace:

1. What type of contaminant is present?
2. What is the form of the contaminant?
3. How poisonous is the contaminant?
4. What is the concentration of the contaminant?

Because you probably are not able to answer these questions on your own, always work with your supervisor and EHSS to determine the correct answers to these questions. YOUR LIFE DEPENDS ON IT!

Screen 47
Proper Safety Equipment to Wear at a Hazardous Worksite.

- Safety equipment to be worn at the work site is determined by a hazard assessment. EHSS and your supervisor will perform the hazard assessment before you, the worker, enter.

Screen 48

Selecting the Correct Respirator

To select the correct respirator, your individual requirements must be determined. Keep in mind that in order for a respirator to work properly, there must be a proper seal between the respirator and your face.

Facial features that will interfere with achieving a proper face seal are:

- **Facial hair** such as a beard, mustache, sideburns or slight stubble growth;

- **Missing teeth** or dentures;

- **Facial injury/deformity**;

- Skin disorders or **contact allergies**.

*Any of these facial features are not allowed* because they can prevent a proper seal.

Screen 49
Selecting the Correct Respirator

IF YOU WEAR GLASSES, you cannot wear glasses when using a full face respirator, because the template bars will prevent a proper seal. To provide good vision while using a respirator, your respirator will be equipped with corrective lenses mounted inside of your facepiece.

EHSS will make arrangements for equipping corrective lenses inside your facepiece.

You can wear glasses with a half mask respirator if you put the glasses on after donning the respirator.

Screen 50
Selecting the Correct Respirator

IF YOU HAVE FACIAL HAIR . . . Display of beard/facial hair

*Beards, sideburns and even facial stubble will prevent a proper seal* between your face and the respirator. For this reason, beards, sideburns and other facial hair are not allowed when you must use a respirator.

Screen 51

Selecting the Correct Respirator

IF YOU WEAR DENTURES . . . Display of dentures

You must wear your dentures whenever you wear a respirator. *If you do not wear your dentures*, both lower and upper plates, the shape of your face will change, and *a proper seal cannot be made*.

Screen 52
Other Protective Equipment

Other protective equipment such as a hood or head band that projects under the facepiece cannot be worn because it will interfere with a proper seal.

Instead, wear a hood that fits over the outside of your mask if you must wear a hood.

Screen 53
QUICK QUIZ

It is okay to have facial hair stubble when using a respirator.

1. True
2. False

Enter 1 or 2, then press Return. ______

If correct, "Yes! beards, sideburns and even facial hair stubble will prevent a proper seal between the respirator and your face."

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 54
Respirator Parts

In these pictures, we have labeled the major parts of a full-face respirator.

Screen 55

Respirator Parts:

INSPECTION BEFORE USE

Every time you use your respirator, you must first inspect it. To properly inspect a respirator before using it, you should look for:

- Cracks or chips in the faceplate;
- Cracks or holes in the breathing tube;
- Worn or frayed straps;
- Worn or damaged fittings;
- Bent or corroded buckles;
- Dirty or improperly seated valves.

If you find anything wrong with your respirator, do not use it. Have it repaired or replaced immediately by EHSS.

Screen 56

Display of labeled:
- head harness
- oral/nasal cup
- facepiece
- inhalation valve
- cartridge connector
- exhalation valve
- exhalation valve seat
- exhalation valve cover

Display of:
- frayed headstrap
- bent buckles

Each bullet scrolls onto screen, with accompanying graphic where applicable.
QUICK QUIZ

You should always inspect your respirator before using it.

1. True
2. False

Enter 1 or 2, then press Return. ______

If correct, “Nice job! Always inspecting your respirator before you use it may save your life” appears.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen  57
Donning and Fitting the Respirator

1. With one hand over the faceplate, hold the respirator to your face.

2. While holding the respirator in place, slip the head harness over your head.

3. Adjust and tighten the head harness straps until the respirator fits snugly to your face. The best way to tighten a respirator is to tighten the straps from the bottom up.

NOTE: Always check the guidelines provided by the manufacturer before donning, fitting, and using your respirator.

Screen 58

Each number scrolls onto screen

Video plays once student allowed time to read text.

Video display of each step. Student allowed to replay video as desired.
Fit Testing the Respirator

Because you want an airtight seal between your face and the respirator, you will need to fit test the respirator each time you wear it to make sure no contaminant gets inside the facepiece and into your lungs.

*Positive Pressure Test*

closing the respirator’s exhalation valve by covering it with your hand, then breathe out slowly. The facepiece will bulge out slightly. Hold your breath for about 10 seconds. If during this time no air leaks from around the facepiece, you know you have a good fit. If you do not have a good fit, re-adjust the head harness straps, and repeat the pressure test.

Screen 59
Fit Testing the Respirator (continued)

Another way to test the seal formed by your respirator around your face is to perform a negative pressure test.

**Negative Pressure Test**

Begin by closing the respirator’s inhalation valves with your hands, then breathe in slowly. The facepiece will collapse slightly. Hold your breath for about 10 seconds, and if during this time no air leaks in from around the facepiece, you know you have a good fit. If you do not have a good fit, re-adjust the head harness straps, and repeat the pressure test.

**NOTE:** Perform both positive and negative pressure tests on your respirator every time before you use it.
Fit Testing the Respirator:

**Quantitative Fit Testing**

At least once a year, you and your respirator must be tested by EHSS.

**Quantitative Fit Test**

In a quantitative fit test, special instruments are attached to your respirator, and any air leaks are detected electronically.

The Importance of Fit Testing

DANGER! Never use a respirator that will not form an airtight seal between your face and the respirator.

Take time to learn what it feels like NOT to have a proper seal. While you are working, you should continually monitor the seal; if you lose the seal around your face, exit the contaminated area as quickly as possible.
QUICK QUIZ

You should always fit test your respirator before using it.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, “Yes! Fit testing your respirator before using it is a great habit to start” appears.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 63
Monitoring Your Respirator

As you work, you must monitor the seal around your face; and how well your respirator is working.

You will know that your respirator is not working when:

- Breathing becomes difficult;
- You become dizzy or feel sick;
- The manufacturer’s recommended service life of the filters or cartridges expires;
- The respirator is damaged.

**DANGER! Never use or continue to use a respirator that is not working perfectly.**

Screen 64
QUICK QUIZ

Once you have fit tested your respirator, monitoring it while you work is optional.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, then “Nice job!” appears.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 65
Inspecting and Cleaning Your Respirator
After Use.

After using your respirator, you should clean and inspect it. Use a disposable brush for cleaning. As you clean, be sure to look for:

- Cracks or chips in the faceplate;
- Cracks or holes in the breathing tube;
- Worn or frayed straps;
- Worn or damaged fittings;
- Bent or corroded buckles;
- Improperly seated valves.

If you find anything wrong with your respirator, have it repaired or replaced immediately by EHSS.

Screen 66
Respirator Inspection, Cleaning, Maintenance and Storage:

A strong commitment to respirator maintenance must be included in the respiratory protection program.

All respiratory programs must include instruction regarding:

- How to clean the respirator;
- How to do repairs if allowable;
- How to properly store the respirator.
Respirator Inspection, Cleaning, Maintenance and Storage:

CLEANING AND DISINFECTING RESPIRATOR

To clean and disinfect your respirator, you must first disassemble it. Carefully remove the:

- Cartridge and filters
- Exhalation valve cover
- Exhalation valve
- Exhalation valve seat
- Cartridge connector
- Inhalation valve
- Oral/nasal cup
- Head harness
- Any breathing tubes or hoses

WARNING: If a respirator part does not disconnect easily, DO NOT FORCE IT. Consult your supervisor or EHSS on how to disconnect the respirator.

Screen 68
Cautions and Limitations of Filter Cartridge Use:

- Ask your supervisor or EHSS personnel for further information about instructions on use or maintenance of respirators or accessories.

- Use only exact replacement parts in the respirator or cartridge filters as specified by the EHSS personnel.

- Never substitute, modify, add, or omit parts.

- Follow the manufacturer’s instructions for changing cartridges and/or filters, and look for signs of “breakthrough” in a filter cartridge (see next screen).

Remember…failure to properly use and maintain a filter cartridge could result in injury or death.

Screen 69
Inspecting Your Filter/Cartridge for “Breakthrough.”

“Breakthrough” occurs when a filter cartridge is “maxed out or used up”; the filter can no longer absorb the chemical, gas or vapor it is protecting the respirator wearer from inhaling.

In this case, the service life of the filter/cartridge is expired, and it is no longer usable.

When “breakthrough” has occurred in your filter cartridge, you will be able to smell the odor of the chemical (or contaminant) the filter is supposed to be protecting you from while breathing through your respirator.

So, you will not always be able to see breakthrough in your filter. Also, keep an eye on the “end of service life” date that is printed on the side of each filter to avoid using ineffective filters.

Screen 70
What is a “Loaded” Filter?

A filter becomes “loaded” when dirt or other particles clog or become built up in the filter.

Loaded filters become obvious when:

- you inspect your respirator;
- you try to perform positive and negative checks as you use your respirator; and
- you and your buddy at a work site can visibly see build up in the filter.

Screen 71
**End of Service Life Indicator**

Every filter cartridge has a “service life.” This means that a filter cartridge can be expected to absorb a chemical or air contaminant for only a limited amount of time once it has been activated.

Shelf life is also a part of “end of service life.” Filters cannot be expected to work forever, even if they are not opened or activated.

End of service life information is located on the side of most filters. However, not all cartridges/filters are equipped with ESL information. In those cases, you must follow a “change-out” schedule. If you have any questions, contact EHSS.

Screen 72
Cleaning and Disinfecting Your Respirator

Once you have disassembled your respirator, make up a cleaning solution of $\frac{1}{2}$ cup mild dish detergent with a gallon of hot water ($110^\circ - 120^\circ$ Fahrenheit). Check the water temperature if a thermometer is available.

Using a soft sponge, you can wash the plastic rubber and nylon parts of the respirator. Do not wash the filters or cartridges; they must be completely replaced when they are exhausted (“used up”) or when breakthrough occurs.

Screen 73

Cleaning and Disinfecting (continued)

Once you have washed your respirator, rinse the parts you have washed under hot running water to remove all of the soap.

Screen 74
Cleaning and Disinfecting (continued)

To sanitize the respirator, use a disinfectant spray made for respirators. Make sure you cover all of the respirator’s parts with disinfectant. Set the disinfected parts aside for about 2 minutes, then rinse them again under hot running water. Set the disinfected parts aside on clean paper or cloth towels to dry.

Screen 75
QUICK QUIZ

The recommended cleaning solution for washing respirator parts consists of mixing ½ cup of mild detergent with 1 gallon of hot water at a temperature of 110° - 120° Fahrenheit. After washing your respirator, you should always disinfect it.

1. True
2. False

Enter 1 or 2, then press Enter. _____

If correct, then “Yes! Always disinfect your respirator after washing it” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 76
Re-assemble the Respirator

Once the respirator is completely dry, carefully re-assemble it.

WARNING: If a respirator part does not re-assemble easily, DO NOT FORCE IT. Consult your supervisor or EHSS on how to re-assemble the respirator.

Screen 77

Respirator Repair

If, during the inspection and cleaning process, you find any worn, frayed, or damaged parts, have them replaced by an experienced person.

Manufacturer-supplied parts designed exactly for the respirator must be used.

Screen 78
Proper Respirator Storage

If you are not going to use your respirator immediately, you need to store it. To store your respirator, place it in a re-sealable plastic bag.

Be sure to store your respirator somewhere that is convenient for you, but the respirator should be stored away from:

- Dust;
- Sunlight;
- Heat;
- Extreme Cold;
- Moisture; and
- Damaging Chemicals

Screen 79

Video of worker placing clean respirator in a storage bag and placing it in a locker
QUICK QUIZ

You should always have your respirator repaired by an experienced person, using only exact parts specified by the manufacturer.

1. True
2. False

Enter 1 or 2, then press Return. ______

If correct, then “Very good! You should only use manufacturer supplied parts to repair your respirator,” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 80
HAZARDOUS WORKSITES

Workers exposed to respiratory hazards on our campus include:

- Agricultural workers
- Ventilation systems maintenance workers
- Coal/fire power plant workers
- Rock quarry workers
- Chemical waste handlers
- Carpenters and electricians (due to drilling in building materials)
- Painters/pesticide applicators
- Dairy farm workers

Note: EHSS continues to monitor campus worksites regularly for hazards.
Identifying Hazardous Work Sites

Forms of Airborne Contaminants

Airborne contaminants include:

- Dusts
- Vapors
- Fogs
- Mists
- Gases
- Fumes
- Smokes

Let’s take a moment to look more closely at each of these forms of airborne contaminants.

Screen 82
DUSTS

Dusts are formed whenever solid material is broken down into tiny particles. Dusts are often produced during sanding and grinding operations.

Screen 83

VAPORS

Vapors are substances that are created when a solid or liquid material evaporates. Materials that evaporate easily at room temperature include paint thinner, solvents and gasoline.

Screen 84
Forms of Airborne Contaminants (continued)

FOGS

Fogs are vapors that have condensed into tiny airborne particles or droplets. An example of a hazardous fog would be an insect fogger used to rid industrial and residential areas of fleas and ticks.

Screen 85

MISTS & SPRAYS

Mists and sprays are very small droplets of liquid material that hang in the air. They are often produced by spraying and coating operations.

Screen 86
### Gases

Gases are materials that become airborne at room temperature. Gases may have an odor, but many do not. Some gases can be seen, but again, others cannot. Gases can be heavier than air, or lighter than air, but in either case, gases can travel great distances undetected.

Screen 87

### Fumes

Fumes can occur whenever a metal, plastic or polymer is subjected to high heat during such processes as welding and soldering operations.

Screen 88
Forms of Airborne Contaminants (continued)

SMOKE

Smoke is made up of small particles by incomplete combustion of any material that has carbon in it. Smoke is often produced during processes that require high heat or burning as part of the manufacturing process.

Display of fire with smoke rising from the process.
QUICK QUIZ

Which of the following is NOT a form of an airborne contaminant?

1. Dusts
2. Mists & Sprays
3. Vapors
4. Silt

Enter 1, 2, 3 or 4, then press Return. _____

If correct, then “That’s right! Dusts, mists, sprays and vapors are forms of airborne contaminants” appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 90
Every cell in the body requires a constant supply of oxygen rich air. Some require more oxygen than others. Some cells in the brain and nervous system can be injured or die within 4 – 6 minutes without oxygen.

The air we normally breathe contains, by volume, no less than 19.5% oxygen. Air that contains less than 19.5% oxygen is called oxygen deficient. Breathing oxygen deficient air can be DEADLY.

Symptoms of breathing oxygen deficient air include lightheadedness, disorientation, giddiness and drowsiness. These symptoms cause the exposed worker to believe he/she is not in danger, when in fact, the situation is EXTREMELY DANGEROUS.
QUICK QUIZ

The air we normally breathe contains, by volume, no less than _____% oxygen.

1. 12.9
2. 19.5
3. 22.4
4. 98.6

Enter 1, 2, 3, or 4, then press Return. _____

If correct, then "Yes!" appears on the screen.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.

Screen 92
An Immediately Dangerous to Life or Health (IDLH) atmosphere is one where the concentration of airborne contaminants poses an immediate danger to your life or health. An example of an IDLH atmosphere is a storage tank filled with poisonous gas.

DANGER! Never enter an oxygen deficient or IDLH area without first consulting with your supervisor and EHSS.
QUICK QUIZ

It is okay to enter oxygen deficient or IDLH areas without first consulting with your supervisor or EHSS.

1. True
2. False

Enter 1 or 2, then press Return. _____

If correct, “Correct! NEVER enter oxygen deficient or IDLH areas without first consulting your supervisor or EHSS,” appears.

If incorrect, then the tutorial automatically goes back to the information screen, replays it, and proceeds to quick quiz screen until the correct answer is entered.
Introduction to Non-Obvious Hazards

Now that you have learned about potentially hazardous conditions on a work site, you should know about non-obvious respiratory hazards that are present on campus.

Screen 95
Non-Obvious Hazards

CONFINED SPACE ENTRY

Confined spaces are DEADLY.

- **Oxygen deficiency is known to occur in worksites called “confined spaces”**. This is because residual chemicals left in confined spaces combine with each other through chemical reactions and result in gases forming like argon, nitrogen and carbon dioxide.

- These gases use up oxygen already present in the space. These gases are very dangerous if inhaled. So **you can see the importance of using appropriate respiratory protection devices in confined spaces**.

- In confined spaces, the breathing air must be measured by the EHSS Office before any employee is allowed to enter them.

- **Oxygen deficient conditions can occur in tanks, silos, tunnels, and air ducts to name a few**. Repair or maintenance of systems for storing or transporting fluids must not be overlooked as hazardous. Basically, any work area where the breathing air is diluted or contaminated by dangerous levels of gases or vapors, or where oxygen has been consumed by chemical reactions, is extremely dangerous.

- Danger! Even if a tank is empty, it may have been closed for some time and may have developed an oxygen deficiency through a chemical reaction of residues left in the tank.
Confined Space Entry (continued)

Look at this worker. Notice he is entering a confined space area without his buddy.

When you work in a confined space, look ahead. **PREDICT** airborne contaminant exposure before it happens! Make that extra effort to create a work site that is safer for yourself and your co-workers. By considering safety equipment hazardous situations at work sites, you can prevent respiratory illness and deaths.

Remember, accidents don't exist. Illnesses and deaths can be prevented by foresight, planning, and a commitment to safety first!

Screen 96
Introduction to Practice

Now is your chance to practice finding the hazard before it becomes a problem. A picture of the work environment will be presented. Your job is to find the possible hazard and use the mouse to click and select the hazardous object.

Screen 97

SCENARIO 1: Bearded worker shown.

Click on the object in this picture that is a potential hazard.

Student input: Correct! Facial hair is never allowed on workers who wear respirators.

Student input: Incorrect response. Facial hair of any kind is not allowed to be worn by workers who wear respirators. Remember...facial hair is a physical feature that will cause your respirator not to seal properly on your face, allowing toxic contaminants to enter your breathing zone.
SCENARIO 2:

Why is this worker in a potentially dangerous situation?

A. Things look okay. The worker is wearing proper safety equipment to shield her from inhaling toxic fumes.

B. Worker is working alone without her buddy.

C. I don’t know.

Student input: A.

A. Let’s take another look at the situation. Notice that the worker is working alone. Although the worker is wearing the proper safety equipment to enter a confined work space, she and her buddy are not looking out for the welfare of each other. Remember…never work without your buddy.

Student input: B.

B. That’s right! The worker is entering a confined workspace without her buddy. You remembered that it is never okay to work alone without your buddy.

Student input C.

C. Let’s take another look at the situation. Notice that the worker is working alone. Although she is wearing the proper safety equipment to enter a confined work space, she and her buddy are not looking out for the welfare of each other. Remember…never work without your buddy.
SCENARIO 3:

Click on the object that is a hazard on this work site.

Student input: Selects oral/nasal cup.
Correct! The worker is not using her respirator properly. Her chin is not placed properly in the oral/nasal cup. Failure to wear a respirator properly will result in little or no protection.

Student input: Incorrect response.
Look at how the worker is wearing her respirator. It is not donned properly on her face. Her chin is not placed properly in the oral/nasal cup. Failure to wear a respirator properly will result in little or no protection.

Worker shown wearing her respirator with her chin out of the oral/nasal cup.
SCENARIO 4:

What potential hazard exists in this picture?
Type in the correct answer: A, B or C.

A. The worker failed to wash her respirator before placing it in the storage bag.

B. Things look O.K., the worker is finished working for the day and has stored her respirator properly.

C. I don’t know.

Student input: A.

A. Correct! Failure to clean a dirty respirator will result in a respirator’s failure to work properly.

Student input B.

B. Let’s look again. The worker failed to wash her respirator before placing it in the storage bag. Failure to clean a dirty respirator will result in a respirator’s failure to work properly.

Student input C.

C. Let’s look again. The worker failed to wash her respirator before placing it in the storage bag. Failure to clean a dirty respirator will result in a respirator’s failure to work properly.
SCENARIO 5:

Worker shown wearing a headband underneath her respirator.

What respiratory safety hazard is shown in this picture? Type in the correct answer: A, B or C.

A. Things look O.K., since the worker is having no difficulty breathing.

B. The worker is wearing a headband underneath her respirator. Wearing the headband underneath the respirator will allow air to leak into the mask. A proper seal to insure a good fit to the face is lost.

C. I don't know.

Student input: A

A. Take another look. The worker is wearing a headband underneath her respirator. Wearing the headband underneath the respirator will allow air to leak into the mask. A proper seal to insure a good fit to the face is lost.

Student input: B

B. Right! Wearing a headband underneath a respirator will allow air to leak into the mask. Wearing a faulty respirator for several hours with exposure to hazardous contaminants.

Student input: C

C. Take another look. The worker is wearing a headband underneath her respirator. Wearing the headband underneath the respirator will allow air to leak into the mask. A proper seal to insure a good fit to the face is lost.
SCENARIO 6:

Digital picture of worker shown who replaced a broken headstrap with a large, thick rubber band and a paper clip.

Select the object that is a hazard to this worker. Click on the hazard.

Student input: Selects rubber band or paper clip. Good job! Replacing broken respirator parts with non-approved objects/parts is never a good idea. Only manufacturer-approved parts should be used for replacement.

Student input: Incorrect response.

The problem is that the worker replaced the broken headstrap with a non-approved object (rubber band and paper clip) to hold the respirator in place. Replacing broken respirator parts with non-approved objects/parts is never a good idea. Only manufacturer-approved parts should be used for replacement.
SCENARIO 7:

Select one of the body parts that are at risk in the Picture.

Student input: Correct response
That’s right! Failure to wear safety glasses and gloves could result in severe chemical burns to the skin and eyes.

Student input: Incorrect response
Take another look. The worker’s eyes and hands/arms are not protected against a chemical spill. Failure to wear safety glasses and gloves could result in severe chemical burns to the skin and eyes.

Worker shown wearing a half-facepiece mask while pouring a liquid chemical from one bottle to another without wearing gloves or safety glasses.
SCENARIO 8:

Worker surrounded by grain dust.

Click on the potential airborne hazard that exists in this picture.

Student input: Selects grain.
That’s right! The grain dust is an airborne contaminant if inhaled.

Student input: Incorrect response.
The problem is not obvious. The worker is surrounded by grain dust. The grain dust is an airborne contaminant if inhaled by the worker.

Summary:

Great Job! Your goal was to learn to identify a hazard before it becomes a problem, and you have found quite a few workday hazards. However, even though you have completed this computer tutorial with flying colors, don’t be lulled into a false sense of security. Your job on campus is hazardous and requires you to be at 100% every day. Take all precautions that have been discussed in this program and go to your work site with the proper safety equipment and your “buddy.” Remember, you can stop an injury by careful care and maintenance of your personal protective equipment and by being aware of what’s going on at all times.

THANKS FOR PARTICIPATING!
Acknowledgements Screen

Traci Thomas, multimedia program submitted as part of masters’ thesis
Mike McGee, multimedia development
Tom Dingus, thesis committee chairman
Maury Nussbaum, thesis committee
Deborah Young, thesis committee
Catherine Bond, pictures
Kathy Warwick, pictures
Phil Fincher, pictures
Theresa Conti, pictures
Frank Imperatore, pictures
Vicki Neale, concept development

Disclaimer Screen:
This training program is funded by NIOSH and is to be used for the purposes of research only. It does not necessarily reflect the views of NIOSH, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.
Statistics cited in this program were obtained from the following sources:


No video portion on this screen, text only.
Appendix E

Training Process Description Written Instructions
TRAINING PROCESS DESCRIPTION

Thank you for participating in this experiment. The purpose of the experiment is to evaluate the effectiveness of training methods on the ability of people to identify respiratory safety hazards and to don respiratory protection devices. The experiment will take about 1 to 2 hours to complete. The first segment will be an initial screening session. It will consist of a pre-training questionnaire/interview with the experimenter concerning your past experiences with respiratory protection devices. The second segment will require your attention to a training method. In the third session the examiner will ask you to answer a post-training questionnaire. The fourth segment will require you to don two types of respirators and proceed with quantitative respirator fit testing. No foreseen risk is posed by the experimenter. Please sign below to indicate you have read and understand the instructions.

_____________________________________
Participant’s Signature
Appendix F

Manufacturer’s Package Instructions Informed Consent Form
In the experiment, you will be asked to answer a pre-training questionnaire, to complete a training program regarding placement of two respiratory protection devices on your face, a quantitative fit test with each device, and a post-training questionnaire. No previous experience with respirator use is required. The experiment is expected to take 90 minutes or less.

Please note that only the training system is under study. You are not.

You have certain rights as a volunteer participant in this study. This form will list those rights and obtain your written consent to voluntarily participate in the study. Your rights as a participant are: You have the right to withdraw from this study at any time and for any reason by simply informing the experimenter. You have the right to inspect your data and withdraw them from the experiment if you feel that you should for any reason. Data are processed and analyzed after a participant has completed the study. At that time, these data will be treated with anonymity since all identifying information will be removed from the data. No one else will have access to your data. You have the right to be informed of the overall results of this study. To avoid biasing other potential subjects, you are requested not to discuss this study with anyone until six months from now. If you wish to receive an overview of the results, include your address with your signature in the below box.
If you have any questions prior to data collection please feel free to ask. The experimenter will provide answers to your questions unless the outcome of the study will be influenced. Answers which may influence the study will be delayed until after data collection, at which time full and complete answers will be given. There is minimal risk to you as a participant in this study. You will be using experimenter provided paper training materials. You will be paid at the rate of $10.00 per hour for your time. If you have further comments or questions about your rights as a participant, please contact H. T. Hurd, the chairman of the Institutional Review Board for the Use of Human Subjects in Research at:

Research Division  
396 Burruss Hall  
Virginia Polytechnic Institute and State University  
Blacksburg, VA 24061  
(540) 231-5281

The experimenter for the study will be Traci Thomas, a graduate student in Industrial and Systems Engineering. She may be contacted at:

Industrial and Systems Engineering  
242 New Engineering Building  
Virginia Polytechnic Institute and State University  
Blacksburg, VA 24061  
(540) 231-5586

The faculty advisor for the study will be Dr. Thomas A. Dingus, a professor of Human Factors and Safety in Industrial and Systems Engineering. He may be contacted at:

Center for Transportation Research  
1700 Kraft Drive, Suite 2,000  
Virginia Polytechnic Institute and State University  
Blacksburg, VA 24061  
(540) 231-8831
Your signature on the next page indicates that you have read this document in its entirety, and understand your rights as a participant as listed above, and that you consent to participate. Thank you for your participation. (PLEASE TEAR OFF AND KEEP THIS PAGE FOR FUTURE REFERENCE)
I have read a description of this study, understand the nature of the research and my rights as a participant. I hereby consent to participate, with the understanding that I may discontinue participation at any time if I so choose.

________________________________________  __________________________
Participant’s Signature                        Date

________________________________________
Printed Name
Appendix G

Commercial Videotape Informed Consent Form
Videotape Informed Consent Form

In the experiment, you will be asked to answer a pre-training questionnaire, to complete a training program regarding placement of two respiratory protection devices on your face, a quantitative fit test with each device, and a post-training questionnaire. No previous experience with respirator use is required. The experiment is expected to take 90 minutes or less.

Please note that only the training system is under study. You are not.

You have certain rights as a volunteer participant in this study. This form will list those rights and obtain your written consent to voluntarily participate in the study. Your rights as a participant are: You have the right to withdraw from this study at any time and for any reason by simply informing the experimenter. You have the right to inspect your data and withdraw them from the experiment if you feel that you should for any reason. Data are processed and analyzed after a participant has completed the study. At that time, these data will be treated with anonymity since all identifying information will be removed from the data. No one else will have access to your data. You have the right to be informed of the overall results of this study. To avoid biasing other potential subjects, you are requested not to discuss this study with anyone until six months from now. If you wish to receive an overview of the results, include your address with your signature below in the box.
If you have any questions prior to data collection please feel free to ask. The experimenter will provide answers to your questions unless the outcome of the study will be influenced. Answers which may influence the study will be delayed until after data collection, at which time full and complete answers will be given. There is minimal risk to you as a participant in this study.

You will be using experimenter provided videotaped training materials. You will be paid at the rate of $10.00 per hour for your time. If you have further comments or questions about your rights as a participant, please contact H.T. Hurd, the chairman of the Institutional Review Board for the Use of Human Subjects in Research at:

Research Division
396 Burruss Hall
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-5281

The experimenter for the study will be Traci Thomas, a graduate student in Industrial and Systems Engineering. She may be contacted at:

Industrial and Systems Engineering
242 New Engineering Building
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-5586

The faculty advisor for the study will be Dr. Thomas A. Dingus, a professor of Human Factors and Safety in Industrial and Systems Engineering. He may be contacted at:

Center for Transportation Research
1700 Kraft Drive, Suite 2,000
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-8831
Your signature on the next page indicates that you have read this document in its entirety, and understand your rights as a participant as listed above, and that you consent to participate. Thank you for your participation. (PLEASE TEAR OFF AND KEEP THIS PAGE FOR FUTURE REFERENCE)
I have read a description of this study, understand the nature of the research and my rights as a participant. I hereby consent to participate, with the understanding that I may discontinue participation at any time if I so choose.

___________________________  _____________________
Participant’s Signature       Date

___________________________
Printed Name
Appendix H

Systematic Interactive Multimedia Informed Consent Form
Systematic Interactive Multimedia Training Informed Consent Form

In the experiment, you will be asked to answer a pre-training questionnaire, to complete a training program regarding placement of two respiratory protection devices on your face, a quantitative fit test with each device, and a post-training questionnaire. No previous experience with respirator use is required. The experiment is expected to take 2-1/2 hours or less.

Please note that only the training system is under study. You are not.

You have certain rights as a volunteer participant in this experiment. This form will list those rights and obtain your written consent to voluntarily participate in the study. Your rights as a participant are: You have the right to withdraw from this study at any time and for any reason by simply informing the experimenter. You have the right to inspect your data and withdraw them from the experiment if you feel that you should for any reason. Data are processed and analyzed after a participant has completed the study. At that time, these data will be treated with anonymity since all identifying information will be removed from the data. No one else will have access to your data. You have the right to be informed of the overall results of this study. To avoid biasing other potential subjects, you are requested not to discuss this study with anyone until six months from now. If you wish to receive an overview of the results, include your address with your signature below in the box.

If you have any questions prior to data collection please feel free to ask. The experimenter will provide answers to your questions unless the outcome of the study will be influenced. Answers which may influence the study will be delayed until after data collection, at which time full and complete answers will be given. There is minimal risk to you as a participant in this study.
You will be using experimenter provided computerized and one-on-one training materials. You
will be paid at the rate of $10.00 per hour for your time. If you have further comments or
questions about your rights as a participant, please contact H.T. Hurd, the chairman of the
Institutional Review Board for the Use of Human Subjects in Research at:

Research Division
396 Burruss Hall
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-5281

The experimenter for the study will be Traci Thomas, a graduate student in Industrial and
Systems Engineering. She may be contacted at:

Industrial and Systems Engineering
242 New Engineering Building
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Blacksburg, VA 24061
(540) 231-5586

The faculty advisor for the study will be Dr. Thomas A. Dingus, a professor of Human Factors
and Safety in Industrial and Systems Engineering. He may be contacted at:

Center for Transportation Research
1700 Kraft Drive, Suite 2,000
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-8831
Your signature on the next page indicates that you have read this document in its entirety, and understand your rights as a participant as listed above, and that you consent to participate. Thank you for your participation. (PLEASE TEAR OFF AND KEEP THIS PAGE FOR FUTURE REFERENCE)
I have read a description of this study, understand the nature of the research and my rights as a participant. I hereby consent to participate, with the understanding that I may discontinue participation at any time if I so choose.

________________________________________  __________________________
Participant’s Signature                     Date

________________________________________
Printed Name
Appendix I

Standardized Behavior Modeled Donning Instructions
Standardized Behavior Modeling Donning Instructions

“During this session I will give you a half-facepiece and a full facepiece respirator (depending on pre-determined order). I will show you a step-by-step procedure for correctly placing or what we call “donning” the respirator on your face and head. As the placement procedure is performed, you should carefully observe my technique while listening to any instructions I tell you. You may ask me questions about the respirator donning technique. Then you will place the respirator on your own face and head to the best of your ability, following the step-by-step procedure I showed you closely. I will be repeating the instructions as you place the respirator on your face.

Respirator Donning Steps:
1. The instructor will point to and describe all the components of the respirator.
2. The instructor and trainee will adjust the upper headstraps of the respirator by shortening them.
3. The instructor will hold the mask over his/her own mouth, nose and chin to show the trainee how the mask should appear for the trainee, and ask the trainee to do the same task.
4. The instructor will further demonstrate proper fit by sliding lower headstraps behind the head at his/her neck.
5. The instructor will further demonstrate how to slide upper headstraps over his/her face while aiming towards final placement near crown of the head.
6. The instructor will adjust the mask again starting with the facepiece. Hold facepiece in desired place while double-checking the fit of both upper and lower headstraps. “Adjust these if needed. Take as much time as you need. Tell me when you think the facepiece is providing you with a proper air-tight seal. Good. Tell me when you think the respirator is properly placed on your face. Are you ready to begin the quantitative fit test?”

Systematic Interactive Multimedia Donning Instructions
During this session the instructor will give you a half facepiece respirator (or full facepiece depending on order). A step-by-step procedure for correctly placing or donning the respirator on your face and head will be provided. As the placement procedure is performed, you should
carefully watch the technique while listening to instructions. You may ask the instructor questions about the donning technique at any time. Then you will don the respirator on your own face and head to the best of your ability, following the step-by-step procedure showed to you. You will be provided with instructions as you don the respirator on your face.

Respirator Donning Steps:
The instructor will point to and describe all the components of the respirator. The instructor and you will adjust the upper headstraps of the respirator by tightening/shortening them. The instructor will hold the facepiece over his/her own mouth, nose and chin to show you how the mask should appear, and will then ask you to do the same task. The instructor will further demonstrate proper fit by sliding lower headstraps behind the head at his/her neck. The instructor will demonstrate sliding upper headstraps over his/her face while aiming toward final placement near crown of head. The instructor will adjust the device again starting with the facepiece. The facepiece will be held in the desired place while double-checking the fit of both upper and lower headstraps. Adjust these if needed. Take as much time as you need. Tell me when you think the facepiece is providing you with a proper seal.” A ten minute question and answer period is now made available to you. The experimenter will say “Tell me when you think the respirator is properly placed on your face,” followed by “Tell me when you are ready to begin the QFT.”
Checklist for Systematic Interactive Multimedia Training

1. What is a respiratory protection program?
2. Why does Virginia Tech have a respiratory protection program?
3. OSHA, who are they and what is the purpose of compliance?
4. NIOSH and MSHA, who are they and what is the purpose of compliance?
5. What proper respiratory safety equipment should be worn?
6. Which worksites at VT contain known respiratory hazards?
7. What are non-obvious respiratory hazards?
8. What are the main organs included in respiratory system anatomy?
9. What are oxygen deficient atmospheres?
10. What are the special problems which render employees to be unable to use respiratory protection devices?
11. What is a respirator and what does it do?
12. What types of respirators are used on the VT campus?
13. What are the procedures for proper respirator inspection, cleaning, maintenance and storage?
14. What are the cautions and limitations of respirator cartridge/filter use?
15. What is “breakthrough” in a respirator filter?
16. What is a “loaded” respirator filter?
Important Terms
These are important terms to know before you begin the systematic interactive multimedia training session (Grolier, 1995; Koren, 1996):

Air contaminant: any smoke, soot, fly ash, dust, dirt, fume, non-naturally occurring gas, odor, toxin, or radioactive substance occurring in an environment.

Carcinogen: a cancer-causing substance.

Concentration: a large amount or volume of substance present in a gas, liquid or solid.

Combustion: is usually caused by the combination of oxygen with a gas, liquid or solid fuel through a chemical reaction.

Contaminant: a chemical substance used in manufacturing that is toxic. These substances are known to cause birth defects and cancer in people who are exposed to them.

Corrosion: Corrosion is the natural deterioration or destruction of a material that occurs as a result of its interaction with its environment.

Dis-assemble: to take apart.

Exhausted: to be “used up.” A filter or cartridge is exhausted when it has absorbed as much of the chemical or dust as it possibly can, or “breakthrough” has occurred.

Exposure: Diseases that result from exposure to poisonous chemicals and other hazards in the workplace are called occupational diseases.

Ingestion: Disease may be caused by ingestion (swallowing) of toxins that are inhaled through the respiratory system. Gastrointestinal diseases such as pneumonia and staphylococcus (“staph”) infections may be ingested.

Inhibit: A substance that interferes with a chemical reaction inhibits it. An inhibitor works by preventing or retarding rust or corrosion from occurring.

Physician: a medical doctor.

Solvent: A solvent is a chemical compound that is used for dissolving other compounds.

Toxic: Relates to the poisonous or deadly effects on the body that occur through inhalation, ingestion, absorption, or contact with a toxin.

Toxin: Any poisonous substance of vegetable, animal or man-made chemical origin that reacts with certain body cells to kill cells, alter growth or development, or to kill the living organism.
Appendix J

Systematic Interactive Multimedia Training Instructional Strategy
Systematic Interactive Multimedia Training Instructional Strategy

The components of the systematic interactive multimedia training program are summarized below in their chronological sequence (Dick and Carey, 1986). These components serve as the organizing structure for the design.

**Pre-instructional activities consist of four components:** Motivating learners. Four attributes to be included are attention, relevance, confidence and satisfaction. Students must attend to the training task in order to learn to perform it. Initial attention will be gained by using emotional information and providing human interest examples. For learners to be highly motivated, they must be confident they can master the objectives for the instruction. Informing trainees of objectives they will learn is information to be included. Trainees need to be informed of why the instruction is relevant to them, and the relationship between training and their job. Learners should not feel responsible for knowing everything, but should be able to do certain specific things. Information about objectives helps learners use more efficient study strategies and to determine the relevance of the instruction. Informing the trainees of prerequisite skills. The purpose of this activity is to prepare the learners for instruction that is to follow. Trainees must have little or no concept of how respiratory protection devices are properly donned or knowledge of potential hazards associated with respiratory safety. Information presentation is determination of what information, concepts, rules and principles need to be presented to the learner. It is important to define new concepts and to explain their inter-relationship with other concepts. Examples should be included in the instructional strategy.

**Instructional sequence:** Information Verbal information techniques are recommended for use as learners must rapidly retrieve information from memory. The application context must be adequately represented in the learning context. As information is entirely new and unrelated to prior learning, a job aid in the form of a poster will be utilized. Use of the poster while performing the donning task will be employed to reduce the need to memorize a large amount of information and could possibly reduce the length of instruction. Finally, a list of possible problems the learner may encounter and how these can be overcome should be included.
Examples Learner participation: One of the most powerful components in the learning process is practice with feedback. The learning process can be greatly enhanced by providing the student with activities that are directly relevant to the objectives.

Practice: Each trainee will practice donning each both half and full facepiece device before quantitative fit testing and post-test questionnaires is to be completed.

Feedback: Feedback is knowledge of the results. Feedback about the accuracy of verbal information recalled should be provided in the form of reinforcement. The feedback will include the correct response and information about why a given response is incorrect.

Testing: Two basic criterion-referenced tests will be utilized: Pretest consists of a test of entry behavior skills. Attitude questions will be embedded in the pre-test. Post-test items should be composed items that students should know as a result of the training. Appropriate cues for recalling the information will be provided. Verbal information will be sequenced near related intellectual skill, motor skills and attitudes to provide relevant context for recalling information. This sequencing strategy for testing negates placing all items related to definitions and facts in a separate section at the beginning or end of the test. The QFT and post-test are included for learners to do the information they have been trained. Therefore, the motivation of the learner and adequacy of practice are critical.

RATIONALE FOR TRAINING DESIGN

During the development of a training program, the training system designer is most concerned with the elements of the learning environment. These elements include the (1) instructional environment, (2) design of the training environment, (3) issues in learning and instruction, and (4) conditions of transfer (Goldstein, 1993). The level of integration and cohesiveness of these elements determine the potency of the training environment. When evaluating the instructional environment, factors such as trainee readiness, preconditions of learning and trainee motivation must be considered. It is during this process that the training system designers must determine the following: (1) background or exposure of the average trainee, (2) the trainee’s motivation for success, (3) the types of tasks to be learned are either
verbal, cognitive, motor or intellectual, and (4) the training best suited for each type of learning and each stage of learning. The training system designer must also pay careful attention to the conditions of transfer by incorporating design principles that maximize transfer from the training environment to the task environment, and be aware of the climate of transfer. This is an environmental factor that can have negative effects on the success of training but can be counteracted in the training system design if the trainee is given the coping skills to be properly prepared.

Respiratory Protection Training Program (RPTP)

An iterative approach was used to develop the RPTP for employees at Virginia Tech. The training designer considered elements of the learning environment when developing and optimizing the training program. The program was specifically developed for employees exposed to respiratory hazards at the university. Therefore, many examples have been tailored to meet the needs of this specific function.

Instructional Environment

Trainees will enter the training program usually with the same level of experience. It is anticipated that some trainees will have had some previous exposure to respiratory hazards and protection, but few will have had any formal training. All participants in the program will have been assigned job tasks that require exposure to respiratory hazards which require the use of respiratory protection as part of their job description, and must complete formal training as a job requirement. The training program is designed for trainees with a medium-high level of readiness and a medium level of motivation.

Design of the Training Environment

Criteria and conditions in the performance objective as well as training media selection in the RPTP were carefully aligned to the motivation for learning that exists in trainees. Several motivation theories were taken into account in the development of the training program. They include social learning theory which focuses on modeling and reinforcement of appropriate behaviors; appropriate media for this type of motivation includes demonstration of appropriate behaviors by modeling or videotape. When considering goal setting theory, the designer incorporated a check list into the training program's design to allow trainees easy access as to
how well the training practices meet OSHA and ANSI requirements. This type of technique allows the trainee to quickly set goals that are aligned with their progress through the training program. Aspects of reinforcement theory were also addressed throughout the programs’ design. Trainees are informed of the consequences of non-compliance and given statistics about respiratory protection safety in the work environment.

**Issues of Learning and Instruction**

The skills required with respiratory protection and safety were considered in the training program development. The requirements to achieve a high level of transfer for each skill form the basis for selection for the media trade-off analysis. The issues of whole vs. part learning and over-learning were both considered during the RPTP program development. The program design emphasizes part learning such that tasks have been divided into logical subtasks with little repetition of the material learned in subsequent sections. To ensure the program allows for cohesive integration of the subtasks, regular feedback is provided to the trainee.
Table 47. Advantages and Disadvantages of Chosen Media Specific to the Training of Respiratory Hazards and Respiratory Protection Devices

<table>
<thead>
<tr>
<th>Media Chosen:</th>
<th>Advantages:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior Modeled Interaction</td>
<td>personal contact</td>
<td>may not be efficient if only training one person</td>
</tr>
<tr>
<td>Presentation Method</td>
<td>immediate feedback to questions and performance</td>
<td>trainee may leave the session with a false sense of knowledge</td>
</tr>
<tr>
<td></td>
<td>repeatability of instruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>can rearrange sequence of material</td>
<td></td>
</tr>
<tr>
<td>Audiovisual Media include:</td>
<td>presents objective of training</td>
<td>no feedback</td>
</tr>
<tr>
<td></td>
<td>repeatability of instruction</td>
<td>questions cannot be answered</td>
</tr>
<tr>
<td></td>
<td>constant reference</td>
<td>fixed sequence learning</td>
</tr>
<tr>
<td></td>
<td>can be made into a very simple step-by-step presentation of sequenced learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>efficient for individual training</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text</td>
<td>presents objective of training</td>
<td>no feedback</td>
</tr>
<tr>
<td></td>
<td>provide specific examples with step-by-step presentation of sequenced learning</td>
<td>questions cannot be answered</td>
</tr>
<tr>
<td></td>
<td>flexible sequence of learning between sections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>learner paced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>materials are repeatable and accessible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>self-instruction</td>
<td></td>
</tr>
<tr>
<td>Computer Augmented Training</td>
<td>can provide a relatively flexible sequence of learning</td>
<td>trainee may be technophobic</td>
</tr>
<tr>
<td></td>
<td>materials can be repeatable and accessible</td>
<td>if too many options, training sequence may be confusing to trainee</td>
</tr>
<tr>
<td></td>
<td>can provide feedback for specific, concrete tasks</td>
<td>may not work for training of medium - to large-sized groups</td>
</tr>
<tr>
<td></td>
<td>can provide feedback for programmed tasks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>can be learner paced for self-instruction</td>
<td></td>
</tr>
</tbody>
</table>

- Digital photos
- Motion pictures
- Videotapes
- Videodisks

- Brochure
- Handbook
- Any form of written reading material

- Can provide feedback for specific, concrete tasks
- Can provide feedback for programmed tasks
- Can be learner paced for self-instruction
Conditions of Transfer

Data gathered during the needs analysis phase suggest a moderately difficult transfer climate for trainees in the RPTP. The designer proposed the usage of reinforcement theory to counteract the negative effects of the task environment. The development of a thorough understanding of the consequences of non-compliance as well as the related effects on safety should provide the trainee with enough information to cope with the challenges of his/her working environment.
DETAILED CONTENT

This section will provide the details of the training program’s content. Using the outline of the training program, specifics for each task will be presented.

Task 1  What is a respiratory protection program?
Task 2  Why does Virginia Tech have a respiratory protection program?
Task 3  OSHA, who are they and what is the purpose of compliance?
Task 4  ANSI, who are they and what is the purpose of compliance?
Task 5  What proper respiratory safety equipment should be worn at hazardous worksites?
Task 6  Which worksites at VT contain known respiratory hazards?
Task 7  What are non-obvious respiratory hazards?
Task 8  What are the main organs included in respiratory system anatomy?
Task 9  What are oxygen deficient atmospheres?
Task 10 What are occupational respiratory diseases?
Task 11 What are the special problems which render employees to be unable to use respiratory protection devices?
Task 12 What is a respirator and what does it do?
Task 13 What types of respirators are used on the VT campus?
Task 14 What are the procedures for proper respirator inspection, cleaning, maintenance and storage?
Task 15 What are the cautions and limitations of respirator cartridge/filter use?
TRAINING MEDIA DESCRIPTION

Work-related education and training occupies a curious intellectual space in adult learning (Dirkx, 1996). According to a recent report, 33% of employed adults in the U.S. receive some form of job-related training (U.S. Dept. of Education, 1994); and, work related goals are the most common reason given for adults participating in some form of education (Courtney, 1992). A complete, systematic needs assessment procedure includes a set of learning objectives that determines the “what to teach” to achieve goals (Goldstein, 1993). With that information now determined, instructional designers must answer the question of “how to teach it?” Instructional strategy refers to the aspects of organization and sequencing of the information and deciding how to deliver it (Dick and Carey, 1996; Wentling, 1993). What media should be used to deliver the instruction? Media selection must be based on what theory of learning needs to be addressed, the type of skills to be taught in training, the learning context, and the practicality for the situation. Designers must examine available media and techniques in choosing the method(s) most appropriate for the behaviors being considered. Listed below are learning context, skills to be taught, and domains of learning to better define what type of training is needed in order to achieve each objective. Anderson’s (1983) media selection process to define basic requirements needed for the execution of the RPTP was utilized. The learning domains and a trade-off analysis (Wentling, 1993; Simpson and Weiner, 1986; Microsoft, 1993-1994; Goldstein, 1993) follows.

For the purposes of this project, two domains of learning were utilized to characterize lesson objectives and content:

1. Verbal - requires trainee to declare information; and,
2. Attitude - requires trainee to develop opinions.
Checklist for Systematic Interactive Multimedia Training

1. What is a respiratory protection program?
2. Why does Virginia Tech have a respiratory protection program?
3. OSHA, who are they and what is the purpose of compliance?
4. NIOSH and MSHA, who are they and what is the purpose of compliance?
5. What proper respiratory safety equipment should be worn?
6. Which worksites at VT contain known respiratory hazards?
7. What are non-obvious respiratory hazards?
8. What are the main organs included in respiratory system anatomy?
9. What are oxygen deficient atmospheres?
10. What are the special problems which render employees to be unable to use respiratory protection devices?
11. What is a respirator and what does it do?
12. What types of respirators are used on the VT campus?
13. What are the procedures for proper respirator inspection, cleaning, maintenance and storage?
14. What are the cautions and limitations of respirator cartridge/filter use?
15. What is “breakthrough” in a respirator filter?
16. What is a “loaded” respirator filter?
Appendix K

Protocol for QFT
Protocol for QFT

The following was the procedure used when preparing each participant for a QFT. First, the experimenter assembled the following equipment:

1. Dynatech 3,000 QFT fit test machine,
2. Two lines of clear tubing,
3. Cartridges for half and full facepiece masks, and
4. A line of tubing with squeeze bulb at end.

Second, the Dynatech 3,000 was pre-calibrated before use.

1. The Dynatech 3,000 QFT was turned to “on” on the back panel, followed by the printer on its front side.
2. Dual tubes were connected to empty porter holes, so that both ends of tubes were running into the Dynatech 3,000.
3. Once they Dynatech 3,000 was turned on, a category entitled **SYSTEM** along with other categories was shown.
4. Under **SYSTEM**, the expert fit tester scrolled down with arrow keys to dual tube calibration (press enter).
5. The Dynatech 3,000 instructs user to press enter again.
6. The Dynatech 3,000 produced a series of graphs until it was finished calibrating.
7. Once finished the calibration sequence, the expert fit tester printed, signed and dated the copy of the graph stating the calibration was successful.

Third, the participant was prepared for the QFT. Note: it was of foremost importance to ensure that the test subject had no beard. If so, the participant was asked to shave before the QFT. The experimenter provided materials as necessary. The expert fit tester chose the face piece for the participants’ use. Facepiece selection was contingent upon face shape and size. There were three mask sizes and manufacturers used: North, Glenaire, and MSA. Once the proper face piece size was selected and inhalation valves removed, it was time to Pre-test:

1. The expert fit tester attached cartridges (according to the type of facepiece being tested) as labeled on cartridge bags. It was not essential as to what side (left or right) the cartridges were placed on the facepiece.
2. On one cartridge there one prong was located. On the other cartridge there were two 
prongs. The fit tester connected the dual tubing to the dual prong, with the single line of 
tubing with squeeze bulb at end to the single prong.

3. With arrow keys, the fit tester proceeded to the category entitled TEST (1st column)

4. With arrow keys, she scrolled down to category below entitled PRETEST (press enter).

5. The display instructed the fit tester to “Press any key to continue.”

6. The study participant was instructed to take a deep breath, then to squeeze bulb at the end 
of the tubing. This action was proceeded by experimenter pressing the start button.

7. The study participant was instructed to hold his/her breath an average of eight seconds 
while the graphing occurred; then to release his/her breath.

The fourth step was the actual QFT:

It was now time for testing to begin if the pre-test fit factor was at least 95% to 
100%. It was not always possible to obtain a perfect 100% fit.

1. The study participant was asked to face the machine.

2. The fit tester pressed ESC button (to go back to menu). This was the first of a series of five 
tests.

3. The fit tester went to the column entitled TEST. This test was exactly like the pre-test just 
completed above.

4. The fit tester scrolled down to PROTOCOL 1 (press enter).

5. The fit tester pressed F1 for TEST.

The display instructed the fit tester to “Press any key to continue.”
Appendix L

Manufacturer's Package Donning Instructions
Manufacturer's Package Donning Instructions

During this session you will be given a half-facepiece respirator inside its package. Carefully read the directions in the package completely one time for correct donning (placement) of the respirator. After reading the instructions, please fit the respirator to your face and head to the best of your ability. Notify the examiner when you are ready to begin the test.

Manufacturer’s Package Instructions for a Half-Facepiece
Non-Powered Air Purifying Respirator (North Safety Equipment, 1990)
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1 INTRODUCTION

North Air-Purifying respirators are intended to be used for respiratory protection against hazardous vapors, gases and/or particulate matter, depending on the air-purifying elements used and the contaminant concentration and/or toxicity; but only if there is sufficient oxygen present in the contaminated atmosphere to support life. These respirators are approved by the National Institute of Occupational Safety and Health (NIOSH) and are suitable for use in workplaces regulated by the Occupational Safety and Health Administration (OSHA).

1.1 IMPORTANT INFORMATION

This Operating and Maintenance Instruction Manual contains important information and must be completely read and understood by all persons who may use or maintain this respirator.

This Respirator should be used or maintained only by persons who understand the instructions contained within this manual.

1.1.1 TERMINOLOGY

Warnings, cautions and notes used in this manual have the following significance:

**NOTE**

Procedures and techniques that are considered important enough to emphasize.

**CAUTION**

Procedures and techniques which, if not carefully followed, will result in damage to the equipment.

**WARNING**

Procedures and techniques which, if not carefully followed, will expose the user to the risk of serious injury, illness or death.
1.1.2 GENERAL WARNINGS

1. Failure to properly select the appropriate respirator for all the contaminants and their concentrations against which protection is required, or a failure to follow North’s instructions and warnings, may result in exposure to the hazardous materials, exposing the user to the risk of serious injury, illness or death.

2. Do not use this respirator for protection against air contaminants other than those listed on the air-purifying elements and on the NIOSH Approval Label which is supplied with each respirator and/or replacement air-purifying element.

3. Do not use this respirator under any of the following conditions:
   • While performing or observing abrasive blasting (sandblasting) operations.
   • For fire fighting.
   • In oxygen-deficient atmospheres (any atmosphere having less than 19.5 % oxygen by volume at sea level).
   • In atmospheres where the concentrations of toxic contaminants are unknown, or are Immediately Dangerous to Life or Health (IDLH). An IDLH atmosphere is any atmosphere which has a concentration of any toxic, corrosive or asphyxiating substance that poses an immediate threat to life, which would cause irreversible debilitating effects on health, or which would interfere with the ability to escape from a dangerous atmosphere.
   • In atmospheres where the concentration of the contaminant exceeds the respirator’s Maximum Use Concentration. That is, where the concentration of the contaminant exceeds:
     i. 10 times the contaminant’s permissible exposure limit (the maximum permissible 8-hour time weighted average (TWA) concentration) established by applicable OSHA or other government regulations, or by NIOSH or ACGIH publications; or
     ii. any lower Maximum Use Concentration for that contaminant (when using a half mask air purifying respirator) established by such OSHA or other government regulations (as in the case of asbestos) or NIOSH or ACGIH publications, or shown in the contaminant’s Material Safety Data Sheet (MSDS), in a pesticide label, or in the current edition of the North Respirator Selection Guide.
   • In poorly ventilated areas, or confined spaces such as tanks, small rooms, tunnels or vessels, unless the confined space is well ventilated and the concentration of toxic contaminants is known to be, and will continue to be, below the Maximum Use Concentration recommended for the respirator.
**WARNINGs (CONTINUED)**

- For protection against gas or vapor contaminants with poor warning properties (irritation, odor or taste) at or below their permissible exposure limit or those which are sensory desensitizers, unless the air-purifying elements are equipped with End-of-Service-Life Indicators; or a cartridge change schedule is implemented based on service data which includes:
  i. desorption studies (unless the cartridges are changed daily),
  ii. expected concentration,
  iii. pattern of use, and
  iv. duration of exposure;

and the contaminant does not have a ceiling limit.

- For protection against gases or vapors which generate high heats of reaction with the sorbent material in the cartridge.

- For protection against gases or vapors which are not adsorbed by the sorbent material in the cartridge (e.g. Methanol).

4. Do **not** use any air purifying respirator when conditions prevent a good facepiece-to-face seal. Examples of such conditions are:
   i. the growth of beards, mustaches or sideburns which will pass between the facepiece sealing area and the face;
   ii. the use of spectacles, goggles or other devices which interfere with the respirator;
   iii. the use of head or face coverings which contain materials which will pass between the facepiece sealing area and the face; and
   iv. missing teeth or dentures, facial deformities or deep scars.

5. Immediately leave the contaminated area if:
   i. breathing becomes difficult;
   ii. dizziness or other distress occurs;
   iii. you smell, taste or sense irritation from the contaminants;
   iv. the air purifying element is equipped with an End-of-Service-Life Indicator which has changed color to indicate expiration, or
   v. the respirator becomes damaged.
6. Any air purifying respirator, when properly selected and fitted, will significantly reduce, but will not completely eliminate, the breathing of contaminant(s) by the respirator wearer. When working in atmospheres containing substances which are reported to cause cancer in amounts below their permissible exposure limit, you will obtain better protection from a continuous flow or positive pressure air supplied respirator or self-contained breathing apparatus (an SCBA).

7. This respirator does not provide protection to exposed areas of the body. If the contaminated atmosphere contains vapors, gases or airborne particulate matter which may either irritate or burn the eyes or the skin, or can be absorbed by the body through penetration of the skin, the use of specialized eye, hand and/or body coverings may be required for protection.

1.1.3 USER REQUIREMENTS

To use this respirator you must know:

1) The contaminants and their concentrations. (Ask your Safety Director or Industrial Hygienist, or follow the hazard determination steps as outlined in paragraph 7.2.2.1 of American National Standards Institute (ANSI) Standard Z88.2-1992, American National Standard for Respiratory Protection.)

2) That this is the respirator approved for use against those contaminants and at those concentrations. (Carefully read the NIOSH Approval Label Summary booklet included with this facepiece. Make sure the part numbers on the respirator components match the component numbers on the NIOSH Approval Label or on the configuration chart. If you have any doubts, prior to using the respirator consult an Industrial Hygienist, or North Safety Products Customer Service in the United States at 1-800-581-0444 or 1-401-946-0444.)

3) That the contaminated atmosphere is not Immediately Dangerous to Life or Health (IDLH). For the definition of IDLH see Warning #3 of the preceding list of General Warnings.

4) That this respirator fits you properly. (See Warning #4 of the preceding list of General Warnings.)
5) That you do not have any physical limitations or illness which would preclude you from using this respirator or be aggravated by an increase in breathing resistance. (Ask your Safety Director or physician.)

You should not enter any potentially contaminated atmosphere unless you have confirmed all of these factors.

1.1.4 TRAINING PROGRAM

These brief written instructions cannot substitute for a formal Respirator Training Program. Such training should include an opportunity for you to handle the respirator, learn how to inspect it, have it properly fitted, test its facepiece-to-face seal, wear it in normal air for a long familiarity period, and finally, to wear it in a test atmosphere. The Training Program should be based on ANSI Z88.2-1992, and should familiarize you with OSHA Regulation 29CFR Section 1910.134 and other regulations promulgated by various Regulatory Authorities.

1.1.5 FIT TESTING

A respirator should not be assigned to a person unless the person is given a qualitative or quantitative respirator fit test and the results of the test indicate that the facepiece of the respirator fits properly.

This respirator is available in three sizes; large, medium and small. Most faces can be fit with the medium, however person with small faces may get a better fit with the small size, and person with large faces may get a better fit with the large size.

Fit tests should be conducted at least annually and more frequently if there are factors such as weight change or dental surgery which may affect the fit of the respirator.

A fit test adapter is available for conducting quantitative fit tests. (See Accessories.)

Instructions for carrying out qualitative and quantitative respirator fit tests are given in publications such as ANSI Z88.2-1992, and respirator manuals published by government agencies such as NIOSH, ERDA, and NRC.
1.1.6 PERIODIC FIT CHECKS

Each time that the respirator is put on, before entering an area containing hazardous atmospheres, and periodically while wearing the respirator in the contaminated area, the respirator wearer should check the effectiveness of the seal of the facepiece to the wearer's face by carrying out a negative or positive pressure fit check. Instructions for carrying out fit checks on this respirator are given in Section 3 of this manual.

1.2 RESPIRATOR DESCRIPTION

This device is an air-purifying respirator consisting of a half mask facepiece assembly and a pair of replaceable air-purifying elements which provide respiratory protection against hazardous vapors, gases and/or particulate matter, depending upon the type of air-purifying element used.

When the respirator wearer inhales, the contaminated air is drawn through the air-purifying elements, which, depending upon their type, remove the hazardous vapors, gases and/or particulate matter from the air before it enters the lungs. During inhalation, the inhalation valves in the facepiece open and the exhalation valve closes to prevent contaminated air from entering the facepiece. During exhalation, the exhalation valve opens, and the inhalation valves close to prevent exhaled air from passing back through the air-purifying elements.

This respirator is approved by NIOSH to protect against, and reduce exposure to the type of air contaminants specified on the air-purifying elements and in the approval label supplied with the respirator or the air-purifying elements. When assembled with a pre-filter, this respirator is also approved to protect against, and reduce exposure to, additional air contaminants specified in the approval label on the pre-filter package.
2 PRE-USE INSTRUCTIONS

WARNING

The respirator facepiece and air-purifying elements may be sold separately. Do not use this respirator unless the proper air-purifying elements are attached. See the NIOSH Approval label on the back cover of this manual for a list of the approved components, or check with your Safety Director or Industrial Hygienist or North Safety Products Customer Service in the United States at 1-800-581-0444 or 1-401-946-0444.

2.1 FACEPIECE

Remove the facepiece assembly from its container and visually check the facepiece to make sure that the sealing flange is not distorted, and that all components including the exhalation valve flap are in place, in good condition and secure.

2.2 PRE-FILTERS

If replaceable pre-filters are required, they should be assembled to the cartridges or filter holders before the cartridges or filter holders are attached to the facepiece. Follow the directions on the pre-filter for proper orientation. Place the pre-filters in the appropriate filter covers so that the entire outer edges of the pre-filters are seated evenly and securely against the inner wall of the filter covers. (See Figure 1.)
Snap the filter covers, with the pre-filters seated evenly and securely, to the cartridge or filter holders. (See Figure 2.)

2.3 ASSEMBLING THE RESPIRATOR

Assemble the respirator by screwing the two appropriate air-purifying elements onto the inhalation connectors mounted on the facepiece. Check to be sure that each air-purifying element is effectively sealed against the facepiece. (See Figure 3.)

After assembling the respirator facepiece and air-purifying elements, inspect the respirator to make certain that the respirator has not been damaged.

CAUTION

A respirator must be inspected by the wearer before and after each use to insure that it is in good working condition.
3 TO PUT ON THE RESPIRATOR

The following should be performed in an area with uncontaminated air.

1) Remove your eyewear (if worn), then grasp the front of the respirator with one hand and the upper headband with your other hand. Then place the portion of the facepiece containing the exhalation valve under your chin. (See Figure 4.)

![Figure 4]

**FIGURE 4**
Putting on the Respirator

2) Position the narrow portion of the respirator on your nose bridge and place the cradle suspension system on your head so that the top headband rests across the top of your head and the bottom headband rests above your ears, on the back of your head. Then hook the bottom headband behind your neck, below your ears, and adjust the position of the facepiece on your face for best fit and comfort. (See Figure 5.)

![Figure 5]

**FIGURE 5**
Hooking the Bottom Headband
3) The length of the headbands are adjustable; tighten or loosen by holding the respirator body or headband yoke with one hand and pulling on the elastic material in the appropriate direction with your other hand. (See Figure 6.)

NOTE
For a comfortable fit, the headbands must be adjusted equally on both sides of the respirator.

FIGURE 6
Adjusting the Facepiece

4) Position the facepiece so that the nose section rests as low on the bridge of your nose as is comfortable, and tighten the upper headband on both sides just tight enough so that the respirator doesn’t slide down on your nose. Do not over tighten. If the respirator pinches your nose, loosen the upper headband slightly. (See Figure 7.)

FIGURE 7
Adjusting the Upper Headband
5) Then, tighten the lower headband on both sides just tight enough to secure the respirator under your chin. (See Figure 8.)

![Figure 8](image)

**FIGURE 8**
Adjusting the Lower Headband

**NOTE**
For proper positioning and comfort, the upper headband must be adjusted first, then the lower headband must be adjusted.

6) If you previously removed your eyewear, put it back on at this time.

7) Conduct a positive or negative fit check as follows:

   To conduct a negative pressure fit check, place the palms of your hands over the openings in the cartridges or fit check/filter covers (if so equipped) or, unscrew the air-purifying elements from the respirator and place the palms of your hands over the inhalation connectors, inhale and hold your breath for about 5 seconds. If the facepiece collapses slightly and no air leaks between the facepiece and your face are detected, an effective fit has been obtained. If air leaks are detected, reposition the facepiece on your face and/or readjust the tension of the headbands and repeat the negative pressure check until an effective seal is obtained. If the air-purifying elements were removed, once an effective facepiece-to-face seal is obtained, a co-worker or a representative of the Safety or Industrial Hygiene Department must assist you by screwing the air-purifying elements onto the inhalation con-
nectors mounted on the facepiece. (This must be done without removing the facepiece from your face.) Check to be sure that each air-purifying element is effectively sealed against the facepiece. (See Figure 9.)

FIGURE 9
Negative Pressure Fit Check

To conduct a positive pressure fit check, block the openings in the exhalation valve guard using the palm of your hand and simultaneously exhale. If the facepiece bulges slightly and no air leaks between the facepiece and your face are detected, an effective fit has been obtained. If air is detected to be leaking out between the facepiece and your face, reposition the facepiece on your face and/or readjust the tension of the headbands to eliminate the leakage. This check must be repeated until an effective seal of the facepiece to your face is obtained. (See Figure 10.)

FIGURE 10
Positive Pressure Fit Check
4 USE

⚠️ WARNING

If the air-purifying elements have End-Of-Service-Life Indicators, you must be able to see the End-of-Service-Life Indicators while wearing the respirator.

If you cannot see the indicators, do not use the respirator because you will not know when the cartridge has expired. Should this occur, and you remain in the contaminated work area, you risk exposure to hazardous quantities of the air contaminant which can result in serious injury, illness or death.

You are now ready to enter the use environment for which the respirator is intended.

⚠️ WARNING

Immediately leave the work area and replace the respirator if:

i. breathing becomes difficult;
ii. dizziness or other distress occurs,
iii. you smell, taste or sense irritation from the contaminants in the work area,
iv. the air purifying element is equipped with an End-of-Service-Life Indicator which has changed color to indicate expiration, or
v. the respirator becomes damaged.

Should any of these occur, and you remain in the contaminated work area, you risk exposure to hazardous quantities of the air contaminant which can result in serious injury, illness or death.

4.1 SERVICE LIFE

The service life of this respirator will vary depending on the work environment.
4.1.1 CÁRTRIDGES

When you are using a gas or vapor cartridge respirator which does not have End-Of-Service-Life Indicators, you will know the service life is ending when you smell, taste, or sense irritation from the contaminants while wearing the respirator.

If the respirator has End-Of-Service-Life Indicators, the cartridges must be changed when the color of either one of the indicators match the color standard indicated on the cartridge.

4.1.2 PARTICULATE FILTERS

When you are using a particulate filter respirator, or a gas or vapor respirator with pre-filters, the filters or pre-filters should be replaced when breathing becomes difficult.

5 TO TAKE OFF THE RESPIRATOR

1) Go to an area with uncontaminated breathable air.

2) Loosen headbands and remove the facepiece.
6 TURNAROUND MAINTENANCE

After each use, the respirator should be examined by trained personnel:

**NOTE**

It is good hygiene practice to replace the air-purifying elements after a single day of use even if the service life of the air-purifying elements have not expired.

**WARNING**

Always replace air-purifying elements after water spray decontamination. Excessive moisture can damage the air-purifying elements and expose the user to the risk of serious injury, illness or death.

6.1 AIR-PURIFYING ELEMENT REPLACEMENT

**NOTE**

The replacement of air-purifying elements must be done in a safe area containing uncontaminated breathable air.

6.1.1 PRE-FILTERS

To replace pre-filters, detach the filter cover from the cartridge or filter holder, discard old pre-filters and replace them with new ones. Follow the directions printed on the pre-filter for proper orientation. Check to ensure that the entire outer edge of the pre-filters are seated evenly and securely against the inner wall of the filter covers. Snap the filter covers with the pre-filters to the cartridges or filter holders. (See Figures 1 and 2.)
6.1.2 CARTRIDGES

To replace gas, particulate or combination cartridges, unscrew them from the inhalation connectors, which are mounted on the facepiece, and discard them. Screw on new cartridges tightly to insure an effective seal between each cartridge and the facepiece. (See Figure 3.)

6.2 INSPECTION

Visually inspect all components for damage or wear, especially rubber parts. Replace parts where needed.

If needed, clean and sanitize the facepiece assembly (see Section 8: Periodic Maintenance).

7 STORAGE

Store in a clean dry area in the respirator storage bag provided with the facepiece.

---

CAUTION

Rubber and elastomeric parts must be stored in a manner which will prevent them from taking an abnormal set. Do not expose this device, during storage, to excessive heat (above 140°F/60°C), moisture, contaminating gaseous substances or airborne particulates. Excessive heat may distort the facepiece resulting in the inability to achieve a proper fit. Moisture and contaminated air can damage the air purifying elements. Either of these conditions will expose the wearer to the risk of serious injury, illness or death.

---

8 PERIODIC MAINTENANCE

As needed, remove, inspect and clean the facepiece assembly.
8.1 CLEANING AND SANITIZING

⚠️ WARNING

Never allow air-purifying elements to come in contact with water or cleaning and sanitizing solutions. Excessive moisture can damage the air-purifying elements and expose the user to the risk of serious injury, illness or death.

1) Remove filters and/or cartridges from connectors and discard them.

2) Inspect headbands for wear. Check all elastomer and rubber parts for pliability and signs of deterioration.

3) Remove the facepiece inhalation connectors, headband assembly, exhalation valve guard, valve and seat from the facepiece.

4) Remove the inhalation valves from inhalation connectors.

5) Prepare a solution of cleaner/sanitizer (North Catalog Number 80992) according to the cleaner/sanitizer instructions.

6) Wash the facepiece and components in the cleaning solution.

7) Rinse components completely in clean warm water, then air dry in a clean area.

8) Visually inspect the exhalation valve for damage. If damage or wear is evident, replace.

9) Reassemble the facepiece. Follow steps 2 through 4 above, in reverse order.
8.2 PREPARE FOR USE

1) Install a new pair of air-purifying elements.

2) Perform a fit check to make sure that components are functioning properly.

9. REPLACEMENT PARTS

<table>
<thead>
<tr>
<th>COMPLETE ASSEMBLIES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CATALOG NUMBER</strong></td>
<td><strong>DESCRIPTION</strong></td>
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<td>7700-30S</td>
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<tr>
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<table>
<thead>
<tr>
<th>COMPONENTS (See Figure 11.)</th>
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<tr>
<td><strong>ITEM</strong></td>
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<td><strong>5500 SERIES</strong></td>
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10 ACCESSORIES

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<tr>
<td>7002</td>
<td>Fit Check Ampule</td>
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<tr>
<td>7700-21</td>
<td>Fit Test Adapter</td>
</tr>
<tr>
<td>N7500-27</td>
<td>Fit Check / Filter Cover</td>
</tr>
<tr>
<td>80992</td>
<td>Cleaner/Sanitizer Powder</td>
</tr>
</tbody>
</table>

11 KEY TO CAUTIONS AND LIMITATIONS CONTAINED IN NIOSH APPROVAL LABELS

A – Not for use in atmospheres containing less than 19.5 percent Oxygen.
B – Not for use in atmospheres immediately dangerous to life or health.
C – Do not exceed maximum use concentrations established by regulatory standards.
H – Do not wear for protection against organic vapors with poor warning properties or those which generate high heats of reaction with sorbent.
J – Failure to properly use and maintain this product could result in injury or death.
K – The Occupational Safety and Health Administration regulations require gas-proof goggles to be worn with this respirator when used against formaldehyde.
M – All approved respirators shall be selected, fitted, used and maintained in accordance with MSHA, OSHA, and other applicable regulations.
N – Never substitute, modify, add, or omit parts. Use only exact replacement parts in the configuration as specified by the manufacturer.
O – Refer to user instructions, and/or maintenance manuals for information on use and maintenance of these respirators.
S – Special or critical user's instructions and/or specific use limitations apply. Refer to instruction manual before donning.
11.1 SPECIAL USER'S INSTRUCTIONS

⚠️ WARNING

If the air purifying elements have End-of-Service-Life Indicators, you must be able to see the End-of-Service-Life Indicators while wearing the respirator.

If you cannot see the indicators, do not use the respirator because you will not know when the cartridge has expired. Should this occur, and you remain in the contaminated work area, you risk exposure to hazardous quantities of the air contaminant which can result in serious injury, illness or death.
Manufacturer's Package Instructions for a Full-Facepiece Non-Powered Air-Purifying Respirator (Mine Safety Appliances, 1994).

During this session you will be given a full-facepiece respirator inside its package. Carefully read the directions in the package completely one time for correct donning (placement) of the respirator. After reading the instructions, please fit the respirator to your face and head to the best of your ability. Notify the examiner when you are ready to begin the test.
INSTRUCTIONS FOR USE AND CARE BY PROPERLY TRAINED AND QUALIFIED PERSONNEL

FULL FACEPIECE RESPIRATOR DESCRIPTION
The Advantage 1000 is an air purifying respirator which includes a Full Facepiece assembly and a pair of Advantage 100 air purifying elements to provide respiratory protection against hazardous vapors, gases and/or particulate matter. When the wearer inhales, the contaminated air is drawn through the air-purifying elements and depending on the elements used, removes the hazardous vapors, gases and/or particulate matter. The inhalation valves open and the exhalation valve remains closed to prevent contaminated air from entering the facepiece. During exhalation, the exhalation valve opens, and the inhalation valve closes to prevent exhaled air from passing back through the air purifying elements. The exhalation valve permits exhaled air to exit from the respirator.

WARNING
1. This device does NOT supply oxygen, and must only be used in adequately ventilated areas containing at least 19.5 percent oxygen.

2. This respirator must be used in conjunction with the proper chemical or particulate cartridges for protection against specific contaminants.

3. Do not use when concentrations of contaminants are unknown or immediately dangerous to life or health (IDLH).

4. Do not use when appropriate exposure limit (OSHA PEL, NIOSH REL, ACGIH TLV, etc.) is not known or when it is below the odor threshold or any other established warning level for the contaminant.

5. Leave area immediately if: A. Breathing becomes difficult. B. Dizziness or other distress occurs. C. You taste or smell contaminant. D. You experience eye, nose or throat irritation.

6. Use strictly in accordance with instructions, labels and limitations pertaining to this device.

7. This respirator may not provide a satisfactory seal with certain facial characteristics, such as beards or large sideburns that prevent direct contact between the skin and the sealing surface of the facepiece. Do not use this facepiece if such conditions exist.

8. Never alter or modify this device.

9. This respirator is for use by trained qualified personnel only.

FAILURE TO FOLLOW THE ABOVE WARNINGS MAY RESULTS IN SERIOUS PERSONAL INJURY OR DEATH.

Paint Spray and GMA-H Respirator Users

WARNING
Do not use for urethane paints or other paints containing diisocyanates because of their poor warning properties. Use against such contaminants could result in severe permanent damage to the respiratory system. Use Air Supplied Respirators.

RESPIRATOR USE LIMITATIONS
The wearer must comply with the following MSA respirator use limitations:

1. MAXIMUM USE CONCENTRATION - Do not exceed any of the following:
   a. 100 times the exposure limit for the contaminant present, or lower if the result of the respirator fitting test indicates a protection factor less than 100 (see explanation below).
   b. 1,000 parts per million organic vapors (for organic vapor respirators).
   c. Immediately dangerous to life or health (IDLH) concentration for the contaminant.

2. Do not wear for protection against organic vapors with poor warning properties or those which generate high rates of reaction with sorbent material in the cartridge (organic vapor respirators).

3. Any applicable limitation contained in a standard established by a regulatory
agencies (such as OSHA) with jurisdiction over the wearer.

4. Use only Advantage 100 cartridges.

<table>
<thead>
<tr>
<th>LIMITATIONS AGAINST SPECIFIC GASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following is a partial list of gaseous materials for which chemical cartridge respirators should not be used for respiratory protection regardless of concentration or time of exposure; this far-from-complete list is offered only as a guide to proper evaluation of the many contaminants found in industry. Contact MSA for further information on other specific material.</td>
</tr>
<tr>
<td>Arsine</td>
</tr>
<tr>
<td>Bromine</td>
</tr>
<tr>
<td>Carbon monoxide</td>
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<tr>
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<tr>
<td>Methyl bromide</td>
</tr>
<tr>
<td>Methyl chloride</td>
</tr>
<tr>
<td>Methylene chloride</td>
</tr>
</tbody>
</table>

**RESPIRATOR FIT TEST**
A qualitative or quantitative respirator fit test must be carried out for each wearer of this respirator to determine the amount of protection it will provide.

Respirator fit tests are explained fully in the American National Standard “Practices for Respiratory Protection”, ANSI Z88.2 1992, Published by the American National Standards Institute, 11 West 42nd Street, New York, New York, 10018.

**QUALITATIVE TEST** — If the wearer passes a Qualitative Fit Test, the respirator can be worn in contaminant (gas, vapor, and/or particulate) concentrations up to 100 times the exposure limit for the contaminant.

**QUANTITATIVE TEST** — If the wearer performs a Quantitative Fit Test, the respirator can be worn in contaminant (gas, vapor, and/or particulate) concentrations determined by the results of the test, but not to exceed 100 times the exposure limit for the contaminant.

**EXPOSURE LIMITS**
The exposure limit for the contaminant present should be obtained from the governmental regulatory agency with jurisdiction over the wearer, or from NIOSH.

- OSHA’s permissible exposure limits (PELs) are contained in the Air Contaminants Standard, 29 CFR 1910.1000.
- NIOSH’s recommended exposure limits (RELs) are published in the NIOSH Pocket Guide to Chemical Hazards. If the exposure limit for a contaminant is not obtainable from the above sources, use the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs).

**WARNING**
The user must perform a respirator fit test and follow all warnings and limitations specified. Failure to do so can result in serious personal injury or death.

**PREPARATIONS FOR DONNING**
There are five inspection points, listed, that should be checked before donning the respirator. Under no circumstances should a respirator that fails inspection be used. The respirator should be repaired or replaced.

1. Head Harness: Check to see that the head harness straps still have their elasticity. Inspect for breaks or tears and make sure all adjusters are in place and working properly.
2. Facepiece: Check facepiece for dirt, cracks, tears or holes. Inspect the shape of the facepiece for possible distortion that may occur from improper storage and make sure the rubber is flexible, not stiff. Also check for cracks.
3. Inhalation and exhalation valves: Check for cracks, tears, distortion, dirt or build-up of material between valve and valve seat.
4. Cartridge connectors: Check to make sure connectors are in place and check for cracks and damage.
5. Cartridges and filters: Make sure cartridges and filters are clean. Never try to clean a cartridge or filter by washing it or using compressed air. Inspect cartridges for scratches, cracks or other damage, particularly the sealing bead around the bottom.
CARTRIDGE ATTACHMENT: Carefully attach cartridges to facepiece connectors by first aligning the cutouts on the cartridges with the lugs on the facepiece connectors and then turning the cartridge clockwise by hand until tight. Align the small lug on the connector with the matchmark located on the cartridge body. (See Replacing Cartridges.)

DONNING THE RESPIRATOR
To put on the respirator:

a. Adjust the facepiece headstraps so the end tabs are at the buckles. (see fig. 1)
b. Grip the facepiece between the thumb and fingers with both hands. Insert your chin into the chin cup. (see fig. 2)
c. Pull the facepiece headstraps over your head. Smooth the straps flat against your head.
d. Support the facepiece by holding the speaking diaphragm housing with one hand.
e. To tighten the lower (neck) straps, pull the straps straight back, not out.
f. Tighten the side (temple) straps. (see fig. 3)
g. Adjust the forehead straps if needed to position the lens for best vision.
h. Perform the Air-Tightness Test.

NOTE
A nosecup accessory is available to reduce lens fogging. If the respirator will be used in areas of high humidity, or at temperatures below 32°F, the nosecup accessory may be installed. See page 5.

WARNING
Do not wear conventional eyeglasses with a full facepiece. The temple bars pass through the sealing surface of a full facepiece and prevent a seal. Use the spectacle kit from MSA. Failure to follow this warning may result in serious personal injury or death.

TEST FOR TIGHTNESS

NEGATIVE PRESSURE METHOD  POSITIVE PRESSURE METHOD

Test for Tightness Before Each Use By One of the Following Methods:

• Negative Pressure Method — Place your palms over cartridges lightly. Gently inhale so that the Facepiece collapses slightly and hold breath for ten seconds. The facepiece should remain collapsed while the breath is held, unless there is a leak in the seal.

• Positive Pressure Method — Place your palm over exhalation valve cover lightly. Gently exhale so that a slight positive pressure builds up inside the respirator and hold breath for ten seconds. The positive pressure should remain while the breath is held, unless there is a leak in the seal.

If any leakage is detected around the facial seal, readjust head harness straps and repeat test until there is no leakage. If other than facial seal leakage is detected, the condition must be investigated and corrected before another test is made. The respirator must pass one of the above tightness tests before the respirator is used. The respirator will not furnish protection unless all inhaled air is drawn through suitable cartridges.

WARNING
Do not enter any atmosphere with this respirator unless you know that:
1. You have read, understood and fol-
lowed all instructions and warnings pertaining to the respirator.
2. The respirator and conditions meet the requirements outlined.
3. The cartridges are the proper type for the contaminant or contaminants present.
4. The amount of oxygen is sufficient to support life (that is, at least 19.5 percent oxygen by volume at sea level). Do not use if oxygen concentration sufficient to support life is questionable.
5. Respirator does not leak (see test for tightness)

Failure to follow the above warnings can result in serious personal injury or death.

**REPLACING CARTRIDGES**
The following conditions indicate that the cartridges have served their useful life and should be replaced.

**CHEMICAL CARTRIDGES:** Odor or taste of gases or vapors; eye, nose, or throat irritation.

**FILTER CARTRIDGES:** Excessive breathing resistance when inhaling.

**COMBINATION CARTRIDGES:** Either of the above conditions.

To replace cartridges:

A. Remove the expended cartridges and dispose of properly.
B. Remove the replacement cartridges from storage bags.
C. Place cartridges on connectors carefully. Line up match-mark on cartridge with small lug on connector (on facepiece). Make sure cartridge connector lugs align with the cartridge opening. Push down and tighten cartridge clockwise until the stops are engaged. To ensure a good seal against the facepiece, tighten each cartridge by gripping as much of the circumference of the cartridge as possible and then slowly turning the cartridge until tight.

**CLEANING AND SANITIZING**
If the facepiece is to be cleaned, remove the cartridges. The facepiece should be cleaned and sanitized after every use with MSA® Cleaner-Sanitizer II Part No. 34337. Rinse thoroughly in plain warm water (maximum 120°F to avoid possible overheating and distortion of parts) and then air dry.

**CAUTION**

Cleaning and Sanitizing at the recommended 120°F temperature will avoid possible overheating and distortion of parts which would require replacement.

**MAINTENANCE**
This respirator must be kept in good condition to function properly. When any respirator shows evidence of excessive wear or failure, it should be replaced immediately. This respirator, when not in use, should be stored in a clean dry location, such as its storage bag. Do not distort rubber facepiece during storage.

**INSTALLING THE NOSECUP**
The nosecup assembly is to be placed onto the exhalation valve lugs inside the mask. The larger hole surrounded by 3 smaller holes at the bottom of the nose cup is to be used.

1. Push the exhalation valve/voicemitter area out through the back portion (face seal area) of the mask. Push until this portion of the mask becomes inverted and the wings of the exhalation valve are exposed and can freely accept this nosecup.
2. Bend the intern mask sealing lip away from the exhalation valve for easier installation.
3. Slide the larger lower nosecup hole over one of the wings of the exhalation valve. A mild soap solution can be used to aid
in the installation and alignment process.

4. Stretch the nosecup over the other exhalation valve wing.

5. Orient the nosecup in the facemask by rotating it around the exhalation valve. Use the respirator voicemitter and facemask inter-lip for locating and aligning the nosecup.

6. Return the facemask to its original non-inverted position. Inspect the inter-lip positioning of the facemask to assure that the nosecup is underneath the lip and in the correct location. Now use the facemask in the normal instructed manner.

### INSTALLING THE OUTSIDE LENS

Remove the outside lens from the packaging. Place the two hook lugs at the top of the outside lens over the top of the mask lens edge. Center the outside lens on the mask. Next stretch the elastic retainer band (located at the bottom of the outside lens) over the voicemitter housing and seat it under the voicemitter retainer flange. The respirator can be used in the normal prescribed manner.

### Approval Plates

#### PERMISSIBLE HIGH-EFFICIENCY RESPIRATOR FOR DUSTS, FUMES, MISTS AND ASBESTOS-CONTAINING DUSTS AND MISTS

MINE SAFETY AND HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
APPROVAL NO.
TC-21C-837
MINE SAFETY APPLIANCES COMPANY
Pittsburgh, Pennsylvania, U.S.A.

**LIMITATIONS**

Approved for respiratory protection against dusts, fumes and/or mists having a time-weighted average less than 2 million particles per cubic foot and asbestos-containing dusts and mists.

Not approved for radionuclides.

Not for use in atmospheres containing less than 19.5 percent oxygen.

Not for use in atmospheres immediately dangerous to life or health.

**CAUTION**

In making renewals or repairs, parts identical with those furnished by the manufacturer under the permit approval shall be maintained. Follow the manufacturer's instructions for charging filters.

This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

**NASHA/NIOSH Approval TC-21C-837**

Issued to Mine Safety Appliances Company, July 7, 1983

The approved respirator assembly consists of the following NSHA parts: 7-1292-1, 7-1292-2, or 7-1292-3 facemask and 80-1786 or 80-1787 (TC-21C-837) filters. Approved accessories include: 5-1299-1 outside, 80-1225, 80-1226, 80-1227, 80-1228, 80-1229, or 80-1300 nosecup.

#### PERMISSIBLE RESPIRATOR FOR DUSTS, FUMES, MISTS, ASBESTOS-CONTAINING DUSTS AND MISTS, AND RADIONUCLIDES

MINE SAFETY AND HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
APPROVAL NO.
TC-21C-838
MINE SAFETY APPLIANCES COMPANY
Pittsburgh, Pennsylvania, U.S.A.

**LIMITATIONS**

Approved for respiratory protection against dusts, fumes, and/or mists having a time-weighted average less than 0.05 milligrams per cubic meter, asbestos-containing dusts and mists and radionuclides.

Not for use in atmospheres containing less than 19.5 percent oxygen.

Not for use in atmospheres immediately dangerous to life or health.

**CAUTION**

In making renewals or repairs, parts identical with those furnished by the manufacturer under the permit approval shall be maintained. Follow the manufacturer's instructions for charging filters.

This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

**NASHA/NIOSH Approval TC-21C-836**

Issued to Mine Safety Appliances Company, July 7, 1983

The approved respirator assembly consists of the following NSHA parts: 7-1292-1, 7-1292-2, 7-1292-3, 80-1786 or 80-1787 (TC-21C-836) filters. Approved accessories include: 5-1299-1 outside, 80-1225, 80-1226, 80-1227, 80-1228, 80-1229, or 80-1300 nosecup.

#### PERMISSIBLE CHEMICAL CARTRIDGE RESPIRATOR FOR ORGANIC VAPORS

MINE SAFETY AND HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
APPROVAL NO.
TC-23C-1370
MINE SAFETY APPLIANCES COMPANY
Pittsburgh, Pennsylvania, U.S.A.

**LIMITATIONS**

Approved for respiratory protection against organic vapors. Do not exceed maximum use concentrations established by regulatory standards.

Do not use for protection against organic vapors with low warning properties or those which generate high levels of reaction with certain materials in the cartridge.

Not for use in atmospheres containing less than 19.5 percent oxygen.

Not for use in atmospheres immediately dangerous to life or health.

**CAUTION**

In making renewals or repairs, parts identical with those furnished by the manufacturer under the permit approval shall be maintained. Follow the manufacturer's instructions for charging cartridges.

This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

**NASHA/NIOSH Approval TC-23C-1370**

Issued to Mine Safety Appliances Company, July 7, 1983

The approved respirator assembly consists of the following NSHA parts: 7-1292-1, 7-1292-2, or 7-1292-3 facemask and 80-1771 (TC-23C-1370) cartridges. Approved accessories include: 5-1299-1 outside, 80-1225, 80-1226, 80-1227, 80-1228, 80-1229, or 80-1300 nosecup.

#### PERMISSIBLE CHEMICAL CARTRIDGE RESPIRATOR FOR CHLORINE, HYDROGEN CHLORIDE, AND SULFUR DIOXIDE OR CHLORINE DIOXIDE OR HYDROGEN SULFIDE (ESCAPE ONLY)

MINE SAFETY AND HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
APPROVAL NO.
TC-23C-1371
MINE SAFETY APPLIANCES COMPANY
Pittsburgh, Pennsylvania, U.S.A.

**LIMITATIONS**

Approved for respiratory protection against chlorine, hydrogen chloride, and sulfur dioxide or chlorine dioxide or hydrogen sulfide (escape only). Do not exceed maximum use concentrations established by regulatory standards.

Do not use in concentrations which generate high levels of reaction with certain materials in the cartridge.

Not for use in atmospheres containing less than 19.5 percent oxygen.

Not for use in atmospheres immediately dangerous to life or health.

**CAUTION**

In making renewals or repairs, parts identical with those furnished by the manufacturer under the permit approval shall be maintained. Follow the manufacturer's instructions for charging cartridges.

This respirator shall be selected, fitted, used, and maintained in accordance with the Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

**NASHA/NIOSH Approval TC-23C-1371**

Issued to Mine Safety Appliances Company, July 7, 1983

The approved respirator assembly consists of the following NSHA parts: 7-1292-1, 7-1292-2, or 7-1292-3 facemask and 80-1771 (TC-23C-1371) cartridges. Approved accessories include: 5-1299-1 outside, 80-1225, 80-1226, 80-1227, 80-1228, 80-1229, or 80-1300 nosecup.
Appendix M

QFT Standardized Script
QFT Standardized Script

Standardized Script: “Here is the respirator our expert fit tester thinks will provide the best seal to your face. Put this on based on the training you received and adjust it to your face. When you think the respirator is fitted correctly on your face, tell me. At that time I will have you wear the respirator five minutes before we begin the QFT.” Each trainee wears his/her respirator in the fit testing room in the standing position for at least five minutes before starting the QFT. The five minute acquaintance period is recommended by OSHA to allow the trainee to become acquainted with the test room and the perceptual feel of the respirator on his/her face. Standardized Script: “Step over here so that you are standing in front of the Fit Tester.” The examiner will connect the dual air flow adapters from the Fit Tester 3,000 to open valves on the respirator, and hand the squeeze bulb to the trainee. Pretest: “This is what I need you to do. Face the machine. Now we will begin the fit test. Take a deep breath, then squeeze the bulb. I will tell you when to release the bulb. You will hear two beeps from the fit tester machine before I tell you to release.” The trainee performs the following exercises in the order given (ANSI Z88.2 – 1980). These exercises are chosen because it is assumed that they simulate actual normal work movements, which occur in the workplace.

1. In the normal standing position, without talking, the subject breathes normally for at least one minute while facing the fit test machine. Exercise followed by QFT.
2. Remaining in the normal standing position, the trainee does deep breathing for at least one minute, pausing as necessary so as not to hyperventilate. Exercise followed by face forward QFT.
3. Standing in place, the trainee slowly moves his/her head up and down between the extreme position straight up and the extreme position straight down. Exercise followed by face forward QFT.
4. The head is held at each extreme “up” and “down” position for five seconds and the complete test exercise is performed for at least one minute. Exercise followed by face forward QFT.
5. Standing in place, the trainee slowly turns his/her head from side to side between the extreme left and extreme right position. The head is held at each extreme position for at
least five seconds, and the complete test exercise is performed for one minute. Exercise followed by face forward QFT.

6. Standing in place, the trainee slowly tilts his/her head from left side to right side continually for one minute. Exercise followed by face forward QFT.

7. Standing in place, the trainee will grimace (extreme smile or frown) for 15 seconds. Exercise followed by face forward QFT.

8. The trainee is asked to read the “Rainbow Passage” out slowly and loud, so as to be heard clearly by the test examiner or monitor. Exercise followed by face forward QFT.

9. The test subject shall bend at the waist as if he/she were to touch his/her toes for one minute. Exercise followed by face forward QFT.

10. Finally, the trainee returns to a normal breathing pattern, facing the Fit Tester equipment. Exercise followed by QFT.
Appendix N

Participant Screening Questionnaire
Participant Telephone Screening Questionnaire

1. NAME ____________________________________________________________
   Last, First M. I.
2. TODAY’S DATE: ___ / ___ / 99
3. PHONE # (540)___________
4. DOB: ___ / ___ / ___
5. AGE: _____ years
6. Sex: _____ Male _____ Female
7. Native Language: _____ English _____ Other
8. Marital Status (circle one): Married Single Divorced
9. What is the highest grade you have completed (circle one):
   6  7  8  9  10  11  12  some college
   Bachelor’s Degree some graduate school Graduate Degree
10. Have you ever used a respirator either at home or at work for protection from air
    contaminants? _____ Yes _____ No
11. Have you ever participated in an experiment which included respirator fit
    testing? _____ Yes _____ No
12. Have you ever been formally employed in a job where respiratory protection
    was used? _____ Yes _____ No
    If no, skip to question 13.
12a. Did you receive any training in general respirator donning or safety operations while
    employed? _____ Yes _____ No
12b. Have you ever sustained a respiratory disease, injury or impairment (or impairments)
    while employed? _____ Yes _____ No
    If no, skip to question 13.
12c. If yes, describe the nature of the disease, injury or impairment.
    ___________________________________________________________________
    ___________________________________________________________________
13. Do you have any close friends or family members who regularly use respiratory
    protection? _____ Yes _____ No
14. Have any of your friends or family sustained respiratory disease/injury while employed?
    _____ Yes _____ No
If no, skip to question 15.

14a. If yes, please describe the nature of the disease/injury, for example, asthma, asbestosis, black lung disease?

______________________________________________________________________
______________________________________________________________________

14b. Would you describe the injury as a major or minor injury? _____ Major
       _____ Minor

14c. Was respiratory protection involved? _____ Yes   _____ No

14d. Describe how the incident/disease occurred ______________________________

______________________________________________________________________

15. Overall, how would you rate your familiarity with respirator fitting and safety? Please circle the number which applies.

<table>
<thead>
<tr>
<th>Not Familiar</th>
<th>Somewhat Familiar</th>
<th>Very Familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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16. Overall, how would you rate your familiarity with the risks of respirator fitting and safety? Please circle the number which applies.

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<tr>
<th>Not Familiar</th>
<th>Somewhat Familiar</th>
<th>Very Familiar</th>
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17. Do you have any of the following?

Hyperventilation (over-breathing)? _____ Yes   _____ No
Asthma? _____ Yes   _____ No
Sensation of choking or smothering when using any type of face covering? _____ Yes   _____ No
Facial injury, surgery or deformity? _____ Yes   _____ No
Do you wear dentures? _____ Yes   _____ No
Are you missing teeth? _____ Yes   _____ No
Arthritis of hands or wrists? _____ Yes   _____ No
Loss of fingers or difficulty in using hands or fingers? _____ Yes   _____ No
Skin disorders or contact allergies? _____ Yes   _____ No
Impaired vision requiring eyeglasses? _____ Yes _____ No
Impaired hearing requiring the use of hearing aids? _____ Yes _____ No

18. Do you feel that you have now or have had any medical problems that could interfere with proper and safe respirator fit testing? _____ Yes _____ No
If yes, please state the problem.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

________________________________________________________________________

Participant signature       Date       Experimenter signature       Date
Appendix O

Pre- and Post-Training Questionnaire
Pre- and Post- Training Questionnaire

Select the correct answer to each statement below based on your present level of knowledge (Circle one number).

1. Which of the following statements is true about oxygen deficient atmospheres?
   A. Oxygen deficiency is known to occur in confined workspaces. These workspaces must be evaluated for chemical reactions once employees have performed their duties at the work site.
   B. Oxygen deficiency is known to occur in confined workspaces. Confined workspaces are oxygen deficient atmospheres that may include tanks, tunnels and air ducts.***
   C. Oxygen deficiency is known to occur in confined workspaces. Oxygen deficiency occurs through chemical reactions between residues left in the workspace and outside air introduced to the space when the door is opened, and oxygen enters the airspace.
   D. Oxygen deficiency is known to occur in confined workspaces. Repair or maintenance jobs in confined spaces are usually short term, and the time spent in the dangerous area will probably be minimal.
   E. I don’t know.

2. According to the OSHA regulation, which of the following is the most desirable course of action against respiratory safety hazards?
   A. Personal protective equipment
   B. Administrative controls
   C. Engineering controls***
   D. Enrollment in a respiratory protection program
   E. I don’t know
3. Which of the following is NOT a form of airborne contaminant?
   A. Dust
   B. Hepatitis B***
   C. Solvents
   D. Fumes
   E. I don’t know

4. Respirators for use by employees must be approved and certified by:
   A. AMA and CDC
   B. CDC and EPA
   C. NIOSH and AMA
   D. NIOSH and MSHA***
   E. I don’t know
   AMA = American Medical Association
   CDC = Centers for Disease Control
   EPA = Environmental Protection Agency
   NIOSH = National Institute of Occupational Safety & Health
   MSHA = Mine Safety & Health Administration

5. The most common route of exposure for most health hazards is:
   A. Ingestion
   B. Inhalation***
   C. Inhibition
   D. Skin Absorption
   E. I don’t know

6. The air we breathe normally contains, by volume, no less than ____% oxygen.
   A. 12.9
   B. 19.5***
   C. 56.5
   D. 72.3
   E. I don’t know
7. The OSHA regulation for controlling and protecting workers from airborne contaminants in the workplace is:
   A. 29 CFR 1910.134***
   B. 29 CFR 1910.604
   C. 29 CFR 1910.1050
   D. 29 CFR 1926.581
   E. I don’t know

8. The system used to warn a respirator user of the end of adequate respiratory protection is the:
   A. breakthrough indicator
   B. material safety data sheet
   C. volumetric ending indicator
   D. end of service life indicator***
   E. I don’t know

9. Employers must ensure that employees using negative or positive pressure tight fitting respirators be fit tested at least on a/an _________ basis.
   A. quarterly
   B. every six months
   C. annual***
   D. bi-annual
   E. I don’t know

10. According to OSHA guidelines, a __________________ must be established by all employers who require their employees to wear respiratory protection devices:
    A. non-routine work authorization
    B. respiratory protection program***
    C. pulmonary protective equipment program
    D. threshold limit respiratory value program
    E. I don’t know
11. The term used for a type of reaction to inhalation of airborne contaminants that is immediate and occurs shortly after the exposure is called _________.
   A. acute***
   B. deluge
   C. chronic
   D. brazing
   E. I don’t know

12. Which of the following statements is false about “breakthrough” in a filter cartridge?
   A. “Breakthrough” in a filter cartridge is not always visible.
   B. “Breakthrough” information may be located on the filter cartridge label.***
   C. “Breakthrough” occurs when a filter cartridge can no longer absorb the contaminant it should be protecting the wearer from inhaling.
   D. When “breakthrough” has occurred in a filter cartridge, you might be able to smell the odor of the contaminant the filter is supposed to be protecting you from.
   E. I don’t know.

13. Negative pressure will cause the respirator to ____________________.
   A. allow air to leak into the respirator
   B. re-adjust itself to the wearer’s face
   C. bulge out slightly from the wearer’s face
   D. create a vacuum toward the wearer’s face***
   E. I don’t know

14. In selecting the correct respirator, which of the following is NOT a question to be answered before you enter a workplace?
   A. How poisonous is the contaminant?
   B. What is the form of the contaminant?
   C. What type of contaminant is present?
   D. How discernible is the contaminant?***
   E. I don’t know
15. Which of the following statements is FALSE about Powered Air Purifying Respirators (PAPRs)?

A. Cartridges or filters are used with PAPRs.
B. PAPRs require your lungs to “pull in” air through the respirator.***
C. The pressure inside the PAPR mask is positive compared to the pressure outside of the mask.
D. PAPRs are designed to protect the wearer against fumes, aerosols, and gases.
E. I don’t know.
16. Consider a work site where hazardous chemicals are being utilized by employees, and respiratory protection is required. Rank the following items from “least” to “most” important regarding respiratory safety. Rank the least important item as “1”, and the most important item as number “10”.

_____ wearing safety glasses
_____ wearing steel-toed work boots
_____ being visible to your co-worker
_____ wearing a properly fitted respirator
_____ respirator maintenance and storage
_____ wearing appropriate protective clothing
_____ proper maintenance of filters, cartridges
_____ enrollment in a respiratory protection program
_____ taking a mid-morning and mid-afternoon coffee break
_____ properly functioning ventilation ducts

16 a. Consider the item you ranked as 1. Why did you choose to rank this item as the least important regarding respiratory safety at a work site where hazardous chemicals are being used?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

16 b. Consider the item you ranked as 10. Why did you choose to rank this item as the most important regarding respiratory safety at a work site where hazardous chemicals are being used?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
17. Please rate the following occupations on a scale of “1” being “less dangerous” to “7” being “more dangerous” than occupations that require respiratory protection be used. (Circle one number)

a. Airline Piloting:

<table>
<thead>
<tr>
<th>Less Dangerous</th>
<th>Same Amount of Danger</th>
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b. Security Guard:

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c. Truck Driving: ***DISTRACTOR***

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d. Teaching:

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e. Air Traffic Controller:

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f. Banking:

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g. Animal Training:

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h. **Medical Doctor:**

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18. Consider a work site where employees are exposed to hazardous airborne contaminants, and respiratory protection is required. Rate the following items from “not dangerous” to “very dangerous” regarding respiratory safety (Circle one number):

- **a. Missing teeth**

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<tr>
<th>Not Dangerous</th>
<th>Some Hazard</th>
<th>Very Dangerous</th>
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- **b. Soldering operations**

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- **c. Loaded filter**

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- **d. Use of safe lifting practices ***DISTRACTOR***

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- **e. IDLH atmospheres**

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<td>f. Dust inhalation</td>
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<th>g. Inhalation valve distortion</th>
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<th>h. Facial hair</th>
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<th>i. Sanding operations</th>
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EXPERIENCE:

Virginia Polytechnic Institute and State University, Dept. of Environmental Health and Safety Services, Occupational Health and Industrial Hygiene Department, 459 Tech Center Drive, Blacksburg, VA 24061. Industrial Hygiene Technician. Provided administrative support for a range of industrial hygiene programs including respiratory protection, hearing conservation, laser safety, and regulated medical waste. Exposure to indoor air quality principles. Recorded sound survey data, established standard operating procedures, performed data analysis, and prepared reports regarding the identification of major noise sources for which noise control measures may be implemented via the Occupational Health Assurance Program at VPI&SU. Instrumentation utilized include Quest Model 1900 (Type I) Integrating and Logging sound level meter and Larson-Davis 705 noise logging badges, and quantitative respiratory fit testing. Demonstrated ability to follow protocols, prioritize among multiple tasks, make sound decisions, communicate effectively, and accomplish goals with minimal supervision.
1997-1999 (part- to full-time)

Virginia Polytechnic Institute and State University, Dept. of Industrial & Systems Engineering, Environmental Safety Laboratory, 250 New Engineering Building, Blacksburg, VA 24061. Graduate Research Assistant. Designed and implemented a computer based interactive multimedia respiratory protection training program. Project was funded through a NIOSH grant and is used by Environmental Health and Safety Services at Virginia Tech as of 1999.
1996-1998 (part-time)

Instrumentation utilized includes Quest Model 1900 (Type I) Model M-15 and M-27 (Type II) noise logging dosimeters.

1996 (summer intern)

**Drs. E.W. Stevenson, G.T. Turner, and E.S. Elledge, M.D.,** 840 Montclair Road, Suite 218, Birmingham, AL, 35213. *Clinical Audiologist.* Experience in pediatric, adult and geriatric site-of-lesion testing including pure tone air and bone conduction audiometry, speech audiometry, immittance battery, auditory brainstem response testing, electrocochleography, electronystagmography, and counseling patients regarding the outcomes of these evaluations. Performed industrial serial audiograms for Southern Railroad employees as well as pre-employment hearing evaluations for Energy Absorption, Inc. Provided hearing assessment for the Alabama Division of Disability Determination Office for calculation of percent hearing impairment of applicants. Performed brainstem evoked audiometric hearing screenings on high-risk infants in neonatal intensive care nursery. Hearing aid dispensing including troubleshooting, repair, modification, ear mold impressions, probe tube “real ear” measures, and performed electroacoustic analysis of new and repaired hearing instruments. Supervised masters’ level practicum students from the University of Montevallo, AL.

1992-1995 (full-time)

**Drs. R.A. Willis and B.E. Linden, M.D.** 106 Glenoak Blvd., Suite 105, Hendersonville, TN, 37075. *Clinical Audiologist.* Provided site-of-lesion testing including pure tone air and bone conduction audiometry, speech audiometry, immittance battery, auditory brainstem response testing, electronystagmography, electrocochleography, and counseled pediatric, adult and geriatric patients regarding test outcomes.

1990-1992 (full-time)

**Knoxville Otolaryngology and Facial Surgery Clinic, P.C.,** Drs. R.A. Crawley, R.J. DePersio, and W.D. Horton, 930 Emerald Ave., Suite 713, Knoxville, TN 37917. *Clinical Fellowship Year Audiologist.* Provided site-of-lesion testing including pure tone air and bone conduction audiometry, auditory brainstem response testing, speech audiometry, masking level differences, immittance battery, and counseled patients regarding test outcomes.

1989 -1990 (full-time)
EDUCATION:

Master of Science, Virginia Polytechnic Institute and State University, Blacksburg, VA. 1999
Major: Industrial & Systems Engineering, with emphasis on Human Factors and System Safety Engineering

Master of Arts, University of Tennessee, Knoxville, TN. 1989
Major: Audiology

Bachelor of Science, West Virginia University, Morgantown, WV. 1987
Major: Speech Pathology and Audiology

CERTIFICATION AND LICENSURE:

Certificate of Clinical Competence - Audiology - 1990 - present

PROFESSIONAL ASSOCIATIONS:

American Speech Language Hearing Association - 1990 – present
American Society of Safety Engineers - 1995 - present
President, Virginia Tech Student Chapter of ASSE - 1996
National Hearing Conservation Association - 1996 - present
Human Factors and Ergonomics Society - 1995 - present

AWARDS/SCHOLARSHIPS:

NIOSH Safety Training Program Graduate Scholarship - 1996-1998
Outstanding Industrial Hygiene Technician at VT EHSS - 1997

REFERENCES:

Available upon request.