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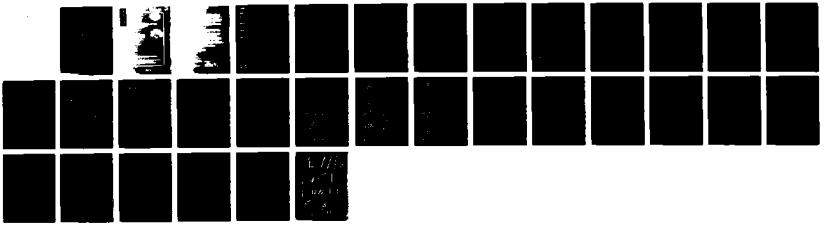

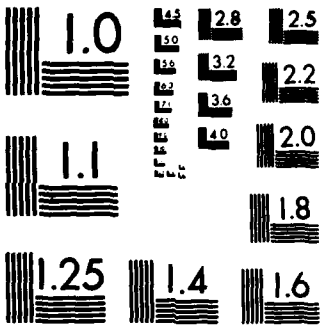

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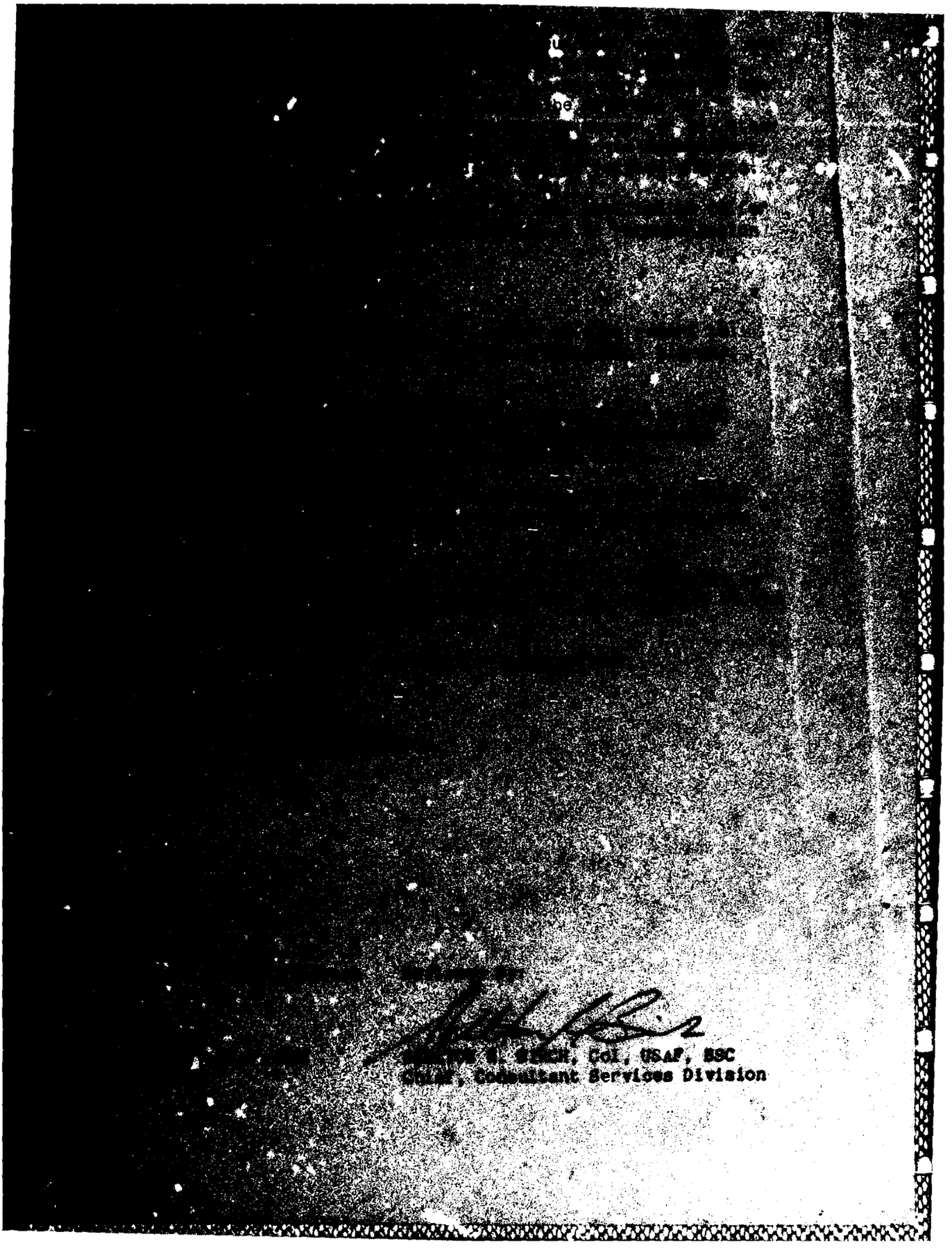

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This report is written in response to a request from HQ USAF/SGPA for assistance in evaluating the Air Force's requirement for quantitative fit testing (QNFT) of respirators and recommendations on specific systems. It includes information to assist in the selection of respirator fit testing equipment based on evaluation of QNFT systems manufactured by Air Techniques Inc., Dynatech Frontier Corporation and TSI Inc.

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I. INTRODUCTION

Purpose. An evaluation of respirator fit-testing systems was conducted in response to a HQ USAF/SGPA request for recommendations on specific systems for Air Force use. This report presents the findings and recommendations which resulted from evaluations conducted on the systems manufactured by three major companies: Dynatech Frontier Corporation (DFC), Air Techniques Inc. (ATI), and TSI Inc.

Problem: The use of respiratory protection devices is required by existing Federal and Air Force occupational safety and health directives in order to prevent unnecessary exposure of workers to airborne concentrations of toxic substances equal to or above the established permissible exposure limit (PEL). An integral part of a respirator protection program is the proper fitting of each individual's respirator to achieve an adequate facepiece-to-face seal. Fit-testing of respirators must be conducted in accordance with current protocols(15,16), and in a manner which ensures the wearer the best fitting and most comfortable respirator. Currently, both qualitative fit-testing (QLFT) and quantitative fit-testing (QNFT) methods are used in the Air Force.

During both qualitative and quantitative fit testing, the respirator wearer should carry out a series of facial movements, head movements, and body movements. These movements are intended to simulate movements the respirator wearer could normally make in the workplace, and may affect the stability of the respirator facepiece-to-face seal.(14)

Qualitative Fit Test: This method exposes the respirator wearer to an atmosphere containing a test agent, e.g., isoamyl acetate or irritant smoke, that can be detected by odor or irritation.(10) The integrity of the respirator facepiece-to-face seal relies on the wearer's subjective response for detection of the test agent inside of the mask. The respirator filters are adapted to the test agent used; organic vapor filters for isoamyl acetate and high efficiency particulate air filters (HEPA) for irritant smoke. There are specific protocols for the procedure, including how the test agent should be administered and the physical exercises performed.(16)

Quantitative Fit Test: This method numerically measures the effectiveness of a respirator facepiece-to-face seal. The wearer is placed in a challenge atmosphere containing an easily measurable and relatively nontoxic gas, vapor, or aerosol. Using a probed respirator facepiece equipped with a HEPA filter, the atmospheres inside and outside the respirator are sampled. The fit factor, or the quality of fit, is the measurement of the effectiveness of the facepiece-to-face seal. The fit factor is defined as the ratio of the concentration of the test agent in the atmosphere surrounding the respirator wearer to the concentration of test agent detected in the air inside the respirator. QNFT instruments with strip chart recorders continuously record the values of penetration of the test agent inside the mask. The mean of the peak values of the penetration should be determined for each type of facial, head, or body exercise carried out by the respirator wearer. The fit factor is calculated using the following equation:

$$FF = 100/(SPP/N)$$

Where 100 = concentration of challenge aerosol in the test chamber
SPP = sum of peak penetrations for exercises in percent

N = number of exercises (14:472)

Computerized QNFT instruments calculate the fit factors automatically and provide results on a computer product, while the respirator wearer performs a series of excerises.

Literature was reviewed to identify the benefits and deficiencies of both QLFT and QNFT methods. Persuasive support for the superiority of QNFT protocols includes:

(1) QNFT provides an unambiguous method of selecting the best respirator for each individual.(3)

(2) QNFT provides feedback as to the effectiveness of respirator training and changes in fit over time.(3)

(3) QNFT is reliable for both half-face masks and full-face masks, while QLFT is not as reliable for the full-face mask.(6)

(4) QNFT results are objective, a major advantage since a numerical value, called a fit factor, can be assigned to the quality of fit for a particular respirator-wearer combination.(10)

(5) Strip chart or computerized recordings of fit results produced with QNFT can serve as both training aids when reviewed with the test subjects and legal documentation of the respirator fit.(10)

(6) The National Institute of Occupational Safety and Health (NIOSH) identified that QNFT is the preferred type of fit test to achieve the objective of respirator fitting in the OSHA Lead Standard.(13)

(7) NIOSH states that the additional operating costs, (calibration, maintenance, and training) required for QNFT equipment is compensated for by increasing the likelihood of achieving the intended respiratory protection for the respirator wearer.(13)

(8) Hyatt, et. al., (1971 and 1972) found 24% of respirator wearers had an unsatisfactory fit as demonstrated by QNFT even though all had passed QLFT.(13) NIOSH believes that QNFT methods are intrinsically and empirically superior to QLFT methods. Respiratory protection programs based on QNFT methods are more likely to achieve intended health protection for each respirator wearer. QNFT provides objective, observable, and verifiable measures of actual leakage. QLFT relies on a subjective response to detect leakage. A worker who thinks his job depends on wearing a respirator might disregard the risk to his health and not report the smell or taste of the test agent.(13)

Advantages of QLFT are:

(1) The procedures are relatively fast.(10)

(2) The procedures are relatively easy to perform in the field.10

(3) A study published by Los Alamos National Laboratory showed that at the 95 per cent confidence level the irritant smoke QLFT protocol identified at least 92 per cent of the facepiece fits with inadequate fit factors.(10)

(4) The procedures and materiel are relatively inexpensive.(10)

(5) The procedures do not require complicated equipment.(17)

Although advantages and disadvantages have been documented for both QNFT and QLFT methods, an additional consideration is that the 1986 Occupational Safety and Health Administration (OSHA) standard for asbestos exposure requires QNFT for negative pressure nonpowered air-purifying full facepiece respirators.(15) Similarly, AFOSH Standard 161-16, Occupational Exposure to Inorganic Lead, requires QNFT for employees who are exposed to airborne concentrations of lead greater than 10 X the PEL (>0.5 mg/m^3).(1)

Scope. The contents of this report are applicable to all Air Force, Air Force Reserve and Air National Guard facilities that have industrial activities that require workers to wear respiratory protection. It provides information to assist installation medical authorities in selecting equipment for individual fitting and testing of respiratory protection equipment.

II. DISCUSSION

Methods.

The evaluators traveled TDY to Albuquerque NM, to meet DFC and ATI representatives who gave demonstrations of the equipment and allowed the evaluators "hands on" examinations. The TSI representative brought equipment to the USAFOEHL, Brooks AFB TX, where equipment was demonstrated and examined. One evaluator also attended a respirator fit test course where the QNFT instruments of the three manufactures were demonstrated. Fit factors reported by each system for four respirator wearers were comparable.

The following criteria were developed for evaluating five aspects of quantitative fit testing (QNFT) systems.

(1) Ease of Use: Ease of use encompasses degree of operator involvement from manual testing to fully automated testing, means of data display, requirement for data reduction and interpretation, data storage and retrievability, and hard documentation.

(2) Training: Training is categorized from that which involves demonstration and instruction by the vendor to self instruction using equipment operating manuals.

(3) Maintenance: Maintenance ratings are based on routine preventive care, repair, and calibration needs. The highest scores are given for equipment requiring maintenance which can be accomplished by the user and medical equipment repair and calibration personnel. The lowest scores are assigned to equipment which must be returned to the factory for all maintenance.

(4) Quality of Electronics: Quality of electronics includes both electronic stability and sensitivity of the systems.

(5) Durability: Durability is the subjective evaluation of the general construction and apparent quality of mechanical and electronic components.

The five criteria were rated using a scale of 0 to 9, ranging from "barely acceptable" to "exceptional" (see Appendix A).

Although cost is an important consideration, it was not included as a criterion because of the variability of price between single and dual chamber (two workers can be tested simultaneously) test systems, the capability to use different priced chambers with more than one model of test equipment, significant price differences between computerized and manual models, price variability depending on optional accessories, and whether equipment will be centrally procured through large quantity contracts or local individual buys. The possibility of price negotiation is more likely for sizable quantity purchases. The current price lists for the three companies' products are found at Appendix B.

Equipment was categorized for evaluation as follows:

(1) Computerized, non-portable.

(2) Manual, non-portable.

(3) Manual, portable.

III. RESULTS.

The DFC and ATI QNFT systems use corn oil generators to establish a challenge environment of submicron sized aerosols and forward light scattering chambers (FLSCs) to measure aerosol concentrations. Each company uses a different aerosol generation science and the FLSCs differ in design and maintenance. The equipment requires similar start-up procedures and maintenance for both companies. The most significant difference is that the FLSC in the DFC must be blackened with the smoke of camphor after cleaning, the ATI simply needs touch-up painting. The ATI system includes a control to compensate for minor light reflection in the FLSC, the DFC FLSC must be reblackened if light reflection becomes a problem. This difference did not appear to be significant in normal fit testing operations. The DFC and ATI non-portable models require installation. The booth and QNFT equipment must be set-up in about an 8 X 12 foot area with electrical support. The portable models use less floor space and the installation is temporary.

DFC and ATI representatives indicated that two to four hours of system instruction and orientation are necessary to learn respirator fit testing, data reduction, and documentation procedures. It is the conclusion of the evaluators that two to four hours is insufficient for users to become adequately familiar with the equipment for optimal operation and maintenance.

TSI's Portacount uses ambient dust as a challenge environment and a condensation nucleus counter (CNC) to measure dust concentrations. The Portacount needs no installation, fit testing can be done at a table or counter. Like the DFC and ATI equipment, the Portacount measures the amount of challenge agent penetration to determine the fit factor. Probed respirators are needed to perform QNFT with any of the equipment evaluated. The ratings of the equipment according to the criteria are shown on a matrix in Appendix C. Specific comments follow.

Computerized Models:

DFC uses a Wyse PC for their computerized models 1000 and 2000 (1 and 2 chambers, respectively). The operating system and program are stored on a 5 1/4 inch diskette and data storage is also on 5 1/4 inch diskettes. Hard copies of fit testing results are produced on standard paper with a dot matrix printer. The fit testing program is menu driven. The operator can quickly manipulate the fit testing, data storage, data recall, and printing functions. DFC representatives state that a Model 1000 can fit test respirator wearers quicker than the two chamber manual model when comparing data reduction, documentation, and fit testing times. ATI uses a Hewlett Packard computer with a tape drive. The operating system is stored on a tape cassette and data storage is also on tape. Tapes are more expensive than diskettes and hold less data. The program is sequential which compels the operator to do each operation in the sequence established in the program. If any problem is encountered or the operator wishes to do an operation out of sequence, he must reboot the program. Data not stored on tape will be lost. Sequential programs are much less flexible than a menu driven program and operators familiar with menu driven programs will find sequential programs to be an inconvenience. The ATI system uses a thermal printer to produce hard copies of fit test results. The paper will darken with age and light exposure so reproducing the printout with an office copier is necessary for permanent hard documentation. This is a minor inconvenience because stored data can be retrieved and new printouts obtained relatively quickly. The ATI is the only machine that simultaneously samples the challenge environment and the respirator environment, the DFC sequentially samples these environments. Although the ATI system is slower and less convenient than the DFC system, it is easy to use. Pre-screening the respirator-wearer combination with QLFT is not necessary, because both computerized models will auto-abort the fit testing if the fit factor (FF) is less than 10. (There might be regulatory problems with auto-abort and not pre-screening with QLFT. The asbestos Standards, both 29 CFR 1910.1001 and 29 CFR 1926.58, require a worker to successfully pass QLFT before starting QNFT. The lead standard, 29 CFR 1910.1025, describes only QLFT protocols. There are no specific QNFT procedures included; however, QNFT is required for negative pressure respirator wearer.) Fit testing with either of these computerized systems is much faster and easier than fit testing with any of DFC's or ATI's manual or portable systems.

TSI has developed Computer software for the Portacount that will use an IBM PC or compatible computer.

Manual Non-portable Models:

Functionally, there is virtually no difference between DFC and ATI manual models. The test procedures are the same. A strip chart recording of aerosol penetration is produced by each system. The data reduction and documentation are the same. Start-up and maintenance are very similar. The aerosol generation and FLSC differences are as stated above. The only significant difference between the companies' equipment is the fit test booth: DFC uses fiber reinforced plastic components bolted together, ATI uses finished plywood panels and hardware so the booth assembles by sliding the panels into channels. Both booths appeared to be durable.

Manual Portable Models:

DFC and ATI portable models are as functionally similar as their manual non-portable models. Both use tents for the challenge environment. The tents are plastic and fabric reinforced plastic supported by aluminum poles. ATI uses a three position valve to switch among the zero mode, which uses room air pulled through a HEPA filter to purge the FLSC; the calibrate mode, which samples the concentration of the test aerosol in the booth or test chamber; and the test mode, which samples the aerosol concentration inside the respirator. The operator of the DFC system must change modes by disconnecting and connecting tubing. The tubing connectors appear more prone to failure than the valve if subjected to use or abuse - a minor difference. The DFC portable is smaller and easier to transport than the very bulky ATI system.

Portacount:

The TSI Portacount is different in all respects from the functionally similar, if not identical, DFC and ATI equipment. It is a small, hand held, battery operated device which employs condensation nucleus counting technology and uses ambient dust as a challenge agent. There is sufficient dust in a normally air conditioned office to accomplish fit testing. It is the easiest to use of all the systems evaluated. In fact, one evaluator was able to perform fit testing without assistance or referring to instructions after having observed a demonstration only once and working the Portacount for less than three minutes. The portable printer is also small and prints out fit factors for permanent documentation. The print out is a permanent paper strip unlike the ATI computer thermal print out. A portable 3 1/2 inch diskette data logger is available for electronic storage. The Portacount has an RS232 output port for computerizing the test data. The Portacount system consists of the basic Portacount unit, the strip recorder, the electronic data logger, and computer. Currently, there is no model that includes these functional components in one case. However, the basic Portacount instrument fits an attache case sized carrying case for easy transport and storage.

There are several features of the Portacount which currently may present difficulties for compliance with requirements of regulations and recommendations of standards for quantitative fit testing. In the fit test mode, Portacount continually repeats a 30-second test sequence. It purges 5 seconds, samples the ambient air 5 seconds, purges 5 seconds, samples inside

the mask 10 seconds, and purges 5 seconds. Consultations with several members of the American National Standard Institute, Inc. Committee (ANSI) for the proposed fit test standard, Z88.10, revealed that there may be a future requirement for a longer mask sampling period. It is anticipated that this standard will not be completed before the end of 1987, and conclusive information about recommended mask sampling time will not be available until the standard is published.

There is also a question concerning the Portacount and the suitability of the "test atmosphere." In 29 CFR 1910.134 (3)(5), a "test atmosphere" is called for when conducting QNFT. Also in 29 CFR 1910.1001, Appendix C, a "challenge agent in a test chamber" is called for. Additionally, 29 CFR 1910.1001, Appendix C, states that the sampling instrument shall be selected so that a strip chart record may be made of the test which records the rise and fall of challenge agent concentration with each inspiration and expiration. Neither the computerized models manufactured by DFC and ATI, nor the Portacount provide a strip chart record of the penetration of the challenge agent into the mask. The newly applied technology of Portacount, however, was not considered when these regulations were promulgated.

The Occupational Safety and Health Administration (OSHA) was queried about the acceptance of the use of the TSI Portacount related to the requirements stated in 29 CFR 1910.134 (3) (5) and 29 CFR 1910.1001, Appendix C. OSHA replied that they did not know whether the Portacount determines fit factors as accurately as does the aerosol generation, dilution, and measurement systems. OSHA further stated that if an employer (1) establishes that the Portacount determines fit factors as accurately as the aerosol generation systems; (2) uses it for fit testing of respirators for use in asbestos, tremolite, anthophyllite, or actinolite contaminated environments; (3) is inspected by OSHA and OSHA does not find flaws in the employer's evaluation of the accuracy of the instrument, then OSHA will treat the employer's act as a de minimis violation of a requirement of a standard.

OSHA defines De minimis violations as violations which have no direct or immediate relationship to employee safety or health. When such violations are found during an OSHA inspection, they are documented in the same manner as any other violation but are not included on the citation.

OSHA has stated that the mandatory protocol in 29 CFR 1919.1001 Appendix C for quantitative fit testing of respirators does not apply to other contaminated environments. Their stated position is that if employers know the accuracy of fit factors measured with the TSI Portacount, and correctly account for the errors of the measurements, there are no restrictions for use of the instrument for quantitative fit testing of respirators for use in other environments.

A May 1987 report published by the Product Assurance Directorate Assessment Branch, Aberdeen Proving Ground MD presents results of testing to determine acceptable accuracy, precision, and reliabilty of the Army version of the condensation nucleus counter technology used in the Portacount. They concluded that the equipment is equal to or better than that of other aerosol generation reference testers evaluated in the report.

IV. CONCLUSIONS

Except when QNFT is specifically required by federal regulations (such as 29 CFR 1910.1025, Appendix D and 29 CFR 1910.1001, Appendix C) QLFT, done with strict adherence to acceptable protocols, eg., DuPont Protocol, may be used. The ability to objectively determine the quality of respirator fit and the requirements of specific federal regulations stated above are the most compelling reasons for selecting QNFT over QLFT methods. It is often optional to weigh the desirable features of QNFT systems against their high cost, required maintenance, and training of personnel. When exposures exist which require mandatory QNFT by federal law, there is no longer a choice for the method of fit test used.

Permanent documentation, which is more readily available from QNFT systems, is a convenient feature; however, documentation is required for administrative and legal purposes for both QLFT and QNFT methods. The difference being whether results are hand recorded or recorded by strip chart or computer product.

A numerical value for the fit test result, the ability to determine fit variability over time, and results which can be used as training aids are all advantages of QNFT that contribute to a good respiratory protection program in which medical authorities can have confidence.

THE DFC and ATI systems evaluated can be used to implement a good respiratory protection program. The total of the criteria scores for each system shows which systems perform best. As previously noted, one very important factor, cost, was not considered as a criterion. Buyers of QNFT systems will probably include cost in their purchase decision making.

Using our criteria, the Portacount system scored highest of all the systems evaluated. It did everything well and appeared to be durable. Its small size makes it easy to transport. The fact that it is a component system may present advantages and disadvantages.

The computerized models were only slightly less desirable than the Portacount. They are more complex, need more maintenance (corn oil must be replenished and system cleaned periodically), and operators must be trained. They are quick and documentation of fit test results is virtually instantaneous.

The manual and portable systems scored lowest and are the most difficult to use. The strip chart recording must be annotated for future data reduction. The data must be reduced and fit factors recorded on a separate form. Portable models are advantageous if one system is to be used to test respirator wearers at different locations. The Portacount is the easiest to transport. The DFC is somewhat heavier and bulkier, and the ATI system is the bulkiest and most difficult to transport.

At this time, the DFC and ATI systems are not compatible with existing Environmental Health computers. The Portacount is compatible with the Z248 as of Oct 1987.

V. RECOMMENDATIONS

One specific manufacturer's equipment or particular model may not be suitable for every respiratory protection program. A dual chamber computerized model may be a justifiable investment for a respiratory protection program for 1000 workers, but not for a program with 200 workers.

Factors relevant to a choice of fit testing methods and QNFT equipment include: the training and manpower required to conduct a respiratory protection program; cost and size of the program; degree of toxicity of agents to which workers are exposed; and the content of respiratory protection regulations and standards.

Considerations could be given to sharing portable QNFT units among bases where portable equipment is appropriate for the size and complexity of the respiratory protection program, and base geographic location makes sharing feasible.

The Portacount holds promise in that it is small and easy to use, portable, compatible with computers currently on the Air Force small computer contract, and does not require any special installation or floor space.

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APPENDIX A

Ratings

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EASE OF USE
(INCLUDES DATA INTERPRETATION AND STORAGE)

0 1	2 3	4 5	6 7	8 9
BARELY ACCEPTABLE	BELOW AVERAGE	ABOVE AVERAGE	AVERAGE	EXCEPTIONAL
COMPLETELY MANUAL OPERATOR MUST COLLECT DATA, CALCULATE FIT FACTORS AND COMPLETE ALL DOCUMENTATION MANUALLY	MOSTLY MANUAL MACHINE COLLECTS DATA. OPERATOR MUST DETERMINE FIT FACTOR AND COMPLETE MOST DOCUMENTS MANUALLY.	SEMI-AUTOMATIC MACHINE COLLECTS DATA, OPERATOR MUST DETERMINE FIT FACTOR AND COMPLETE SOME DOCUMENTS MANUALLY.	MOSTLY AUTOMATIC MACHINE COLLECTS DATA AND DETERMINES FIT FACTOR. OPERATOR MUST COMPLETE SOME DOCUMENTATION.	FULLY AUTOMATIC MACHINE COLLECTS ALL DATA, DETERMINES FIT FACTOR, AND COMPLETES ALL DOCUMENTATION.

TRAINING

0 1	2 3	4 5	6 7	8 9
BARELY ACCEPTABLE	BELOW AVERAGE	ABOVE AVERAGE	AVERAGE	EXCEPTIONAL
TRAINING REQUIRES INSTRUCTION BY TECHNICAL REPRESENTATIVE AND TRAINING TAKES AT LEAST 20 HRS	TRAINING REQUIRES INSTRUCTION BY TECHNICAL REPRESENTATIVE AND TRAINING TAKES AT LEAST 12 HRS BUT NOT MORE THAN 20 HOURS.	TRAINING REQUIRES INSTRUCTION BY TECHNICAL REPRESENTATIVE AND TRAINING TAKES AT LEAST 8 HRS BUT NOT MORE THAN 12 HRS.	EQUIPMENT OPERATION LITERATURE CAN BE USED FOR SELF-INST. BUT WILL LIKELY REQUIRE INSTRUCTION BY TECHNICAL REPRESENTATVIE AND TRAINING WILL TAKE NO MORE THAN 8 HRS.	EQUIPMENT OPERATION LITERATURE IS COMPREHENSIVE, EASY TO INTERPRET, AND CAN BE USED FOR SELF-INST. IN OPERATION OF THE SYSTEM.

MAINTENANCE

0 1	2 3	4 5	6 7	8 9
BARELY ACCEPTABLE	BELOW AVERAGE	ABOVE AVERAGE	AVERAGE	EXCEPTIONAL
ALL REPAIR MAINTENANCE, AND CALIB., MUST BE DONE AT THE FACTORY	SOME REPAIR, MAINTENANCE AND CALIB., CAN BE DONE AT REGIONAL BR., MAJOR WORKS MUST BE DONE AT THE FACTORY.	ROUTINE REPAIR, MAINTENANCE, AND CALIB., CAN BE DONE BY MERC., UNIT MUST GO TO BR. FOR MORE DIFFICULT WORK; AND MAJOR WORK DONE AT THE FACTORY.	ROUTINE REPAIR MAINTENANCE, AND CALIB., DONE BY MERC; MAJOR WORK DONE AT REGIONAL BR.	USER CAN PERFORM ROUTINE REPAIR, MAINTENANCE AND CALIBRATION OF THE UNIT, MERC DOES MAJOR WORK.

QUALITY OF ELECTRONICS
(INCLUDES ELECTRONIC STABILITY AND SENSITIVITY)

0 1	2 3	4 5	6 7	8 9
BARELY ACCEPTABLE	BELOW AVERAGE	ABOVE AVERAGE	AVERAGE	EXCEPTIONAL
RANGE OF MEASUREMENT: 100% - 0.01%. AFTER CHECK/CAL, DRIFT TO LESS THAN 0.05% AND ELECTRONIC NOISE IS LESS THAN 0.02%.	RANGE OF MEASUREMENT: 100% - 0.01%. AFTER CHECK/CAL, DRIFT IS NO MORE THAN 0.01% AND ELECTRONIC NOISE IS NO MORE THAN 0.01%.	RANGE OF MEASUREMENT 100% - 0.01%. AFTER CHECK/CAL, DRIFT IS LESS THAN 0.01% AND ELECTRONIC NOISE IS NO MORE THAN 0.01%.	RANGE OF MEASUREMENT 100% - 0.01%. AFTER CHECK/CAL, DRIFT IS 0 AND ELECTRONIC NOISE IS NO MORE THAN 0.01%.	RANGE OF MEASUREMENT 100% - 0.001%. AFTER CHECK/CAL, DRIFT IS 0 AND ELECTRONIC NOISE IS NO MORE THAN 0.01%.

DURABILITY

0	1	2	3	4	5	6	7	8	8
BARELY ACCEPTABLE		BELOW AVERAGE		ABOVE AVERAGE		AVERAGE		EXCEPTIONAL	

SUBJECTIVE EVALUATION RESULTING IN A RATING BETWEEN 0 AND 9. (9 BEING THE MOST DURABLE). EVALUATION WILL INCLUDE LOOKING AT HARDWARD, ELECTRONIC EQUIPMENT, MANUFACTURING METHOD (BOLTING VS. SCREWS, RIVETS VS. WELDING, AND SO ON), WEIGHT OF MATERIALS (THICK VS. THIN), SELECTION OF MATERIALS (PLASTIC VS. METAL) AND OVERALL OPERATION OF MECHANICAL COMPONENTS (DOORS, CASTORS, SWITCHES, MOTORS, FANS, PUMPS, AND SO ON). SPECIFIC CRITERIA COULD NOT BE DEVELOPED BECAUSE OF SUBJECTIVENESS OF THIS EVALUATION AND THE LARGE NUMBER OF VARIABLES. IT SHOULD BE REALIZED THAT THE RESULT WILL BE "APPARENT DURABILITY."

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APPENDIX B

Current Price Lists

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Dynatech Frontier Corporation

Classification	Instrument Model	Unit Price	Test Chamber Model (models may be listed for use with more than one instrument)	Unit Price
Non-portable, Computerized	System 2000 dual test	$34,800.00	222-8 dual test	$6,615.00
	System 1000 single test	$28,600.00	222-6 single test or 222-4 single test	$6,065.00 $4,000.00
Non-portable, Manual	260-A with strip chart recorder single test	$15,960.00	222-6 single test or 222-4 single test	$6,065.00 $4,000.00
	260B with strip chart recorder dual test	$25,725.00	222-8 dual test	$6,615.00
Portable, Manual	264 single test	$7,940.00	223 single test or 222-4 single test	$2,060.00 $4,000.00

Air Techniques Incorporated

Non-portable, Computerized	TDA-51 single test	$28,000.00	TDA-71 single test	$4,275.00
	TDA-52 dual test	$32,000.00	TDA-72 dual test	$4,750.00
Non-portable, Manual	**TDA-50 single test	$7,575.00	**TDA-70	$2,080.00
	TDA-50 strip chart recorder	$1,265.00		
Portable, Manual	TDA-80 (includes test chamber)	$6,600.00		

**Equipment listed on GSA Schedule

TSI Inc.

Classification	Instrument Model	Unit Price	Test Chamber Model (models may be listed for use with more than one instrument)	Unit Price
Portable	Portacount Respirator Fit Tester model 8010 115V model 8010-1 230V	$6,000.00	Uses ambient air	N/A
	Portacount Printer includes cable model 8902 115V model 8902-1 220V	$495.00		
	Software for use with IBM-PC or compatibles (includes cables) model 8015-9 model 8015-25	$500.00		
	Data Analysis Center model 8907 115V model 8907-1 220V	$2,375.00		

DFC and ATI charge $550.00 and $480.00 per day respectively plus expenses for travel to the customer's place of business to demonstrate newly purchased equipment. Demonstrations are free when the customer travels to the companies for demonstrations.

Complete price listings for accessories and spare parts for the systems may be obtained from the individual companies.

APPENDIX C

Equipment Ratings

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CRITERIA/ EQUIPMENT	EASE OF USE	TRAIN	QUALITY OF* ELECTRONICS	MAINT. #	DURABILITY	TOTAL SCORE
DFC COMPUTER	9	5	7	5	7	33
DFC MANUAL	3	5	7	4	7	26
DFC PORTABLE	3	5	7	4	5	24
ATI COMPUTER	8	5	7	5	7	32
ATI MANUAL	3	5	7	4	7	26
ATI PORTABLE	3	5	7	4	5	24
TSI PORTACOUNT	9[TM]	9	7.5	6	8	39.5

* With printer or computer

DFC and ATI use forward light scattering chambers; TSI uses a condensation nucleus counter with laser detector.

[TM] Computer versions have diagnostics. All must be returned to factory for repair - no branch offices exist.

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Defense Technical Information Center (DTIC) Cameron Station Alexandria VA 22319	2
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HQ SAC/SGPM Offutt AFB NE 68113-5001	1
HQ SAC/IGBUE Offutt AFB NE 68113-5001	1
HQ AFSPACECOM/SGB Peterson AFB CO 80914-5001	1
HQ AFSPACECOM/SGPM Peterson AFB CO 80914-5001	1
HQ PACAF/SGPB Hickam AFB HI 96853-5001	1
HQ PACAF/SGPM Hickam AFB HI 96853-5001	1
HQ USAFE/SGPA APO New York 09012-5001	1
HQ AFRES/SGPB Robins AFB GA 31098-6001	1
HQ ANGSC/SGB Andrews AFB DC 20331-6008	1

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