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TESTIMONY BY:

LOUIS J. AMABILI, PRESIDENT
INTERNATIONAL SOCIETY OF FIRE SERVICE INSTRUCTORS

PRESENTED TO:

THE NATIONAL INSTITUTE
FOR
OCCUPATIONAL SAFETY AND HEALTH

AND

MINING ENFORCEMENT
AND
SAFETY ADMINISTRATION
IN SUPPORT OF THE
NEW AND IMPROVED PERFORMANCE REQUIREMENTS
FOR

RESPIRATORY PROTECTIVE DEVICES

NOVEMBER 30, 1977

GOOD DAY,

MY NAME IS LOUIS J. AMABILI OF DOVER, DELAWARE, DIRECTOR OF THE DELAWARE STATE FIRE SCHOOL, WHICH PROVIDES FIRE SERVICE TRAINING TO VOLUNTEER, PAID, INDUSTRIAL AND FEDERAL FIRE DEPARTMENTS; AND, FIRE SAFETY TRAINING TO AGENCY, INSTITUTIONAL, AND INDUSTRIAL PERSONNEL. I AM A FORMER MEMBER OF THE NATIONAL COMMISSION OF FIRE PREVENTION AND CONTROL. I APPEAR BEFORE YOU TODAY AS PRESIDENT OF THE INTERNATIONAL SOCIETY OF FIRE SERVICE INSTRUCTORS. OUR SECOND SPEAKER WILL PROVIDE YOU WITH MORE BACKGROUND INFORMATION ON THE SOCIETY, AND SOME PRACTICAL EXAMPLES OF THE NEED FOR THE RECOMMENDATIONS WE INTEND TO MAKE.

I WOULD LIKE TO THANK THE PANEL FOR MAKING TIME AVAILABLE FOR AN ISSUE SO VERY VITAL TO THE SAFETY AND WELFARE OF NOT ONLY THE FIREFIGHTERS OF THIS NATION BUT ALSO A PUBLIC THAT DEPENDS SO MUCH ON THEM.

IT HAS LONG BEEN ACCEPTED THAT FIREFIGHTING IS THE SINGLE, MOST DANGEROUS OCCUPATION IN THIS NATION. IN 1974, THE IAFF DEATH AND INJURY SURVEY SHOWED THAT THERE WERE 47.3 FIREFIGHTER INJURIES PER 100 WORKERS AND 86 DEATHS PER 100,000 WORKERS. THOSE FIGURES REMAINED FAIRLY CONSTANT FROM THE YEARS PREVIOUS TO 1974 AND THERE IS, UNFORTUNATELY, VERY LITTLE REASON TO BELIEVE THAT THE FIGURES HAVE CHANGED APPRECIABLY SINCE 1974. IN THE SIMPLEST TERMS, OUR FIREFIGHTERS HAVE JUST SLIGHTLY BETTER THAN A 50-50 CHANCE OF AVOIDING AN INJURY IN ANY GIVEN YEAR, AND THE GRIMNESS OF THIS STATISTIC IS COMPOUNDED BY THE FACT THAT MANY OF THOSE INJURIES WILL BE PERMANENTLY DISABLING.

THE OPERATIVE WORD IN ALL OF THIS, HOWEVER, IS "ACCEPTED". BOTH THE

PUBLIC IN GENERAL AND THE FIRE SERVICE HAVE "ACCEPTED" DANGER, AND WE CANNOT...AND WILL NOT...CONTINUE TO DO SO. FIREFIGHTERS ARE BEING SERIOUSLY INJURED AND KILLED, IN MANY CASES, UNNECESSARILY. WE CAN NO LONGER "ACCEPT" THIS RISK AS PART OF THE JOB, AND WE CAN NO LONGER "ACCEPT" BEING ASKED TO DO SO.

IT IS OUR BELIEF THAT THERE ARE TWO VERY BASIC REASONS FOR THE CURRENT DEATH AND INJURY RATE.

THE FIRST IS OUR ORGANIZATIONS VERY REASON FOR EXISTANCE. INADEQUATE, IMPROPER, AND POOR TRAINING IS AN UNDERLYING CAUSE IN A NUMBER OF SITUATIONS RESULTING IN DEATHS OR INJURIES. IT IS OUR HOPE, AS A SOCIETY DEDICATED TO THE UPGRADING OF THE FIRE SERVICE INSTRUCTOR, THAT THE FIREFIGHTERS OF THIS NATION WILL BECOME THE BEST TRAINED, MOST KNOWLEDGEABLE MEN FOR THE JOB.

UNFORTUNATELY, THE SECOND REASON IS OFTENTIMES COUNTERPRODUCTIVE TO OUR GOALS OF SUPERIOR TRAINING. QUITE SIMPLY...THE FIREFIGHTERS OF THIS NATION ARE BEING SERIOUSLY INJURED AND KILLED BECAUSE THEY ARE BEING ASKED TO USE EQUIPMENT THAT IS INADEQUATE FOR THE JOB THEY ARE BEING ASKED TO PERFORM. FIREFIGHTERS ARE DYING BECAUSE THEY ARE FORCED TO "MAKE-DO" WITH EQUIPMENT THAT WAS NEVER INTENDED FOR THEIR USE AND HAS NEVER BEEN GIVEN PROPER CONSIDERATION FOR THEIR NEEDS.

WE BELIEVE THAT THE TIME HAS COME TO STOP TAKING RISKS BY USING INADEQUATE EQUIPMENT AND TO START LESSENING THOSE RISKS BY INSURING THAT THE STANDARDS AND CRITERIA FOR OUR EQUIPMENT IS COMMENSURATE WITH THE TASK THAT MUST BE ACCOMPLISHED....AS IT MUST BE ACCOMPLISHED.

THERE IS NO GETTING AWAY FORM THE FACT THAT FIGHTING FIRES CARRIES MORE INHERENT DANGERS THAN, SAY, DIRECTING TRAFFIC. THE CONDITIONS UNDER WHICH THE FIREFIGHTER MUST PERFORM HIS JOB ARE, AT BEST, ADVERSE; TIME IS OF THE ESSENCE, VISABILITY IS OFTEN NONEXISTENT, AND CAUSES AND CONTRIBUTING FACTORS ARE OFTEN UNKNOWN. THESE FACTORS ARE NOT GOING TO CHANGE...FIRES ARE NOT GOING TO CHANGE, EXCEPT TO BECOME WORSE. WHAT SHOULD CHANGE, AND INDEED MUST CHANGE, ARE THE STANDARDS FOR THE EQUIPMENT TO BECOME REALISTIC TO THOSE UNALTERABLE FACTORS.

RESPIRATORY PROTECTIVE DEVICES ARE ONE OF THE MOST IMPORTANT ITEMS THAT MUST BE UPGRADED. IT IS THE FIREFIGHTERS' LIFELINE ON FREQUENT OCCASIONS, AND IT IS JUST AS FREQUENTLY THE PUBLICS'. HOWEVER, AS THE STANDARDS NOW STAND, THAT LINE IS VERY THIN. WE BELIEVE THAT WITH CERTAIN IMMEDIATE CHANGES IN CRITERIA, AND WITH RESEARCH INTO FUTURE AREAS OF CHANGE, THE RESPIRATORY PROTECTIVE BREATHING DEVICE COULD BECOME THE SINGLE, MOST IMPORTANT FACTOR IN THE EVENTUAL REDUCTION OF FIREFIGHTERS INJURIES AND DEATHS.

IT IS FOR THESE REASONS THAT I, ON BEHALF OF THE INTERNATIONAL SOCIETY OF FIRE SERVICE INSTRUCTORS, RESPECTFULLY SUBMIT THE FOLLOWING RECOMMENDATIONS;

SUGGESTIONS TO THIS COMMITTEE CAN BE EASILY BROKEN INTO TWO CATEGORIES; THOSE FOR IMMEDIATE IMPLEMENTATION THAT REQUIRE NO FURTHER RESEARCH, AND THOSE INTO WHICH RESEARCH SHOULD BE IMMINENT FOR FUTURE CHANGES.

I WOULD LIKE TO DEAL FIRST WITH THOSE AREAS WHERE STANDARDS AND CRITERIA COULD BE QUICKLY IMPLEMENTED.

THE INTERCHANGEABILITY OF VARIOUS COMPONENTS ON APPROVED EQUIPMENT IS ONE OF THE MOST IMPORTANT ISSUES. AS SPECIFIED BY THE CURRENT APPROVAL SYSTEM, CERTIFICATES OF APPROVAL WILL ONLY BE ISSUED FOR INDIVIDUAL, COMPLETELY ASSEMBLED RESPIRATORS, AND NOT FOR ANY RESPIRATOR COMPONENT OR SUBASSEMBLY. WE FEEL THAT THIS IS UNNECESSARILY RESTRICTIVE. FIRST OF ALL, MOST DEPARTMENTS ARE NOW WORKING ON A SERIOUSLY REDUCED BUDGET AND THE LIFTING OF THIS RESTRICTION WOULD PROVIDE SAFER, BETTER FITTING EQUIPMENT AT A REDUCED PRICE. IN THE WAY OF EXAMPLE...IT IS UNREALISTIC TO ASSUME THAT ALL PERSONNEL IN ANY GIVEN DEPARTMENT WILL RECEIVE AN ADEQUATE FIT FROM ONE MANUFACTURERS FACE PIECE. RATHER THAN INDULGING IN THE EXPENSE OF MANY COMPLETE RESPIRATORY ASSEMBLIES FROM VARIOUS MANUFACTURERS, IT WOULD BE LESS OF A FINANCIAL STRAIN IF THE DEPARTMENT COULD MERELY PURCHASE VARIOUS APPROVED FACE PIECES. THE SAFETY AFFORDED BY LIFTING THIS RESTRICTION IS ALSO A LARGE CONSIDERATION. SEVERAL STUDIES (THREE ARE LISTED AT THE CONCLUSION OF THIS BRIEF) HAVE BEEN DONE THAT PROVE CONCLUSIVELY THAT THE FIT OF THE FACEPIECE IS A MAJOR CONSIDERATION IN THE RELATIVE SAFETY OF THE EQUIPMENT. IN ORDER TO REDUCE RISKS, WITH TODAY'S ECONOMIC SITUATION, THE ABILITY TO EXCHANGE FACE PIECES WOULD AFFORD THE GREATEST DEGREE AT THE LOWEST POSSIBLE COST.

A SECOND POINT TO BE MADE WOULD BE IN THE ABILITY TO EXCHANGE CYLINDERS, IN COMPARABLE EQUIPMENT, WITHOUT LOSS OF CERTIFICATION. IN A MUTUAL AID OR MULTIPLE ALARMS SITUATION, IT IS HIGHLY PROBABLE THAT THE VARIOUS DEPARTMENTS RESPONDING WOULD NOT BE UTILIZING THE SAME MAKES OF RESPIRATORY DEVICES. IT WOULD BE EXTREMELY ADVANTAGEOUS IN SITUATIONS SUCH AS THESE TO PERMIT THE EXCHANGE OF CYLINDERS. IT IS A FACT OF LIFE THAT THE FIRE FIGHTER WILL USE WHATEVER IS AVAILABLE AT THE FIRE GROUND. HE SIMPLY DOES NOT HAVE TIME TO CONCERN HIMSELF WITH A LOSS OF APPROVAL BY USING A

COMPARABLE CYLINDER FOR REPLACEMENT. HOWEVER, THE RESTRICTIONS NOW IMPOSED PLACE AN UNWARRANTED RESPONSIBILITY ON THE FIREFIGHTER, OFFICER, AND DEPARTMENT BY SUBJECTING THEM TO CIVIL LIABILITIES FOR TAKING ACTIONS FOR WHICH CIRCUMSTANCES OFFER NO CHOICE.

I CAN'T STRESS ENOUGH THAT WE ARE NOT ADVOCATING A HAPHAZARD, DO-IT-YOURSELF RESPIRATORY ASSEMBLY, BUT RATHER ONLY THE EXCHANGE OF APPROVED UNITS AND COMPONENTS WITH OTHER SIMILIARLY RATED AND APPROVED UNITS.

ALONG THE SAME VEIN, WE FEEL THAT ALL AIR LINE HOSES, BOTH AIR SYSTEMS AND SELF CONTAINED BREATHING APPARATUS, SHOULD BE COLOR-CODED AND HAVE MANDATORY STANDARD FITTINGS AND VALVES.

IF WE ARE TO MAKE THE EVENTUAL CHANGE TO PRESSURE DEMAND TYPE DEVICES, SOME MODIFICATION IS NECESSARY TO PROVIDE FOR THE QUICK SHUT-OFF OF AIR SUPPLIES. EITHER A VALVE WITH A 90 DEGREE TURN THAT IS EASILY ACCESSIBLE TO THE FIREFIGHTER WHILE WEARING THE DEVICE, OR SOME TYPE OF SWITCH WHICH WILL PREVENT THE DEVICE FROM TRYING TO MAINTAIN POSITIVE PRESSURE WHEN THE FACEPIECE IS REMOVED, IS NECESSARY TO AVOID AN UNNECESSARY DEPLETION OF THE AIR SUPPLY.

ANOTHER ISSUE TO CONSIDER IF THE RESPIRATORY BREATHING DEVICE IS TO TRULY BECOME A "LIFE SUPPORT SYSTEM", IS SOME TYPE OF MODIFICATION TO A DEVICE WHICH WOULD ALLOW "BUDDY-BREATHING". AS THE DEVICES ARE NOW, THE ONLY WAY A FIREFIGHTER MAY SHARE HIS AIR SUPPLY WITH ANOTHER FIREFIGHTER...OR A VICTIM...IS BY REMOVING THE FACEPIECE. THIS IS A DANGEROUS PRACTICE FOR SEVERAL REASONS. THE MOST OBVIOUS IS, OF COURSE, THE INCREASED RISK OF BOTH THE FIREFIGHTER AND VICTIM ACCIDENTLY INHALING THE TOXIC ATMOSPHERE

WHILE NOT ON THE MASK. IT ALSO, HOWEVER, SEVERELY HAMPERS THE FIREFIGHTER FROM REMOVING THE FALLEN INDIVIDUAL FROM THE HAZARDOUS ENVIRONMENT BECAUSE HE NO LONGER HAS HIS HANDS FREE. AND, PSYCHOLOGICALLY SPEAKING, BUDDY-BREATHING CAN BE A VERY TRICKY MATTER WHEN DONE IN THIS MANNER. THE POSSIBILITY ALWAYS EXISTS THAT THE VICTIM WILL PANIC AND REFUSE TO GIVE UP THE FACEPIECE.

IT IS OUR CONTENTION THAT BY ALLOWING MODIFICATIONS, THAT ARE ALREADY ON THE MARKET, AND STANDARDIZING HOSE AND FACEPIECE CONNECTIONS, BUDDY-BREATHING UNDER EMERGENCY CONDITIONS COULD BE A SIMPLE MATTER OF PLUGGING ANOTHER FACEPIECE ASSEMBLY INTO THE WORKING DEVICE.

THERE HAVE BEEN SOME OBJECTIONS RAISED OVER THE ENTIRE THEORY OF BUDDY-BREATHING. HOWEVER, WE FEEL THAT THE FACT REMAINS THAT THERE WILL, AT TIMES, BE EXTREME EMERGENCY CONDITIONS WARRANTING SUCH A PROCEDURE. WHILE IT'S CERTAINLY TRUE THAT IF ONE FIREFIGHTER IS LEFT WITH FIVE MINUTES OF AIR AND IS FORCED TO SHARE, HIS SUPPLY IS SERIOUSLY DEPLETED; IT'S ALSO TRUE THAT WITH PROPER TRAINING, EVEN A SITUATION SUCH AS THIS ONE CAN BE EFFECTIVELY HANDLED. WE BELIEVE VERY STRONGLY THAT IF BUDDY-BREATHING MODIFICATIONS ARE ALLOWED, WE, AS FIRE SERVICE INSTRUCTORS, WILL BE ABLE TO TEACH SAFE, INTELLIGENT METHODS OF UTILIZATION.

A CLARIFICATION IS NEEDED OF PRESENT STORAGE STANDARDS. AT PRESENT, SOME MANUFACTURERS DEMAND THAT THE DEVICES BE STORED IN CASES WHEN NOT IN USE. OTHERS DISCOURAGE ANY OTHER STORAGE METHODS BUT WILL APPROVE ALTERNATE METHODS ONLY IF SUBMITTED FOR APPROVAL. MANY DEPARTMENTS HAVE FOUND THAT BY STORING THE DEVICES ON BRACKETS MOUNTED TO EMERGENCY APPARATUS, IT IS MUCH EASIER TO DON THE EQUIPMENT WHEN NECESSARY, THEREBY SAVING PRECIOUS

TIME. ALONG THIS SAME LINE, STANDARDS MUST BE DEVELOPED SO THAT WRAPPED OR ALUMINUM BOTTLES WILL NOT BE DAMAGED WHEN MOUNTED. THE ADVERSE CONDITIONS ASSOCIATED WITH THE JOB OF FIREFIGHTING WILL NOT ALWAYS ALLOW THE "KID-GLOVE" TREATMENT OF THESE DEVICES AND REALISTIC STANDARDS MUST BE MAINTAINED TO PROTECT BOTH PERSONNEL AND INVESTMENTS.

THE FINAL ISSUE UNDER CONSIDERATION FOR IMMEDIATE IMPLEMENTATION WOULD BE A CLARIFICATION OF USER MAINTENANCE. IN MANY DEPARTMENTS, EQUIPMENT IS AT A PREMIUM AND HAVING TO SEND ENTIRE ASSEMBLIES BACK TO THE MANUFACTURER WOULD ALMOST BE CONSIDERED A HARDSHIP. MINOR REPAIRS, SUCH AS A BROKEN HARNESS STRAP OR A BAD WARNING BELL, COULD BE TAKEN CARE OF BY THE DEPARTMENT WITHOUT THE LOSS OF TIME INHERENT IN HAVING TO SHIP SOMETHING BACK TO A MANUFACTURER.

ALONG WITH THIS CLARIFICATION WE WOULD ALSO RECOMMEND THAT EACH MANUFACTURER BE REQUIRED TO KEEP AN ACCURATE RECORD OF THEIR VARIOUS MODELS AND THE REPAIRS THAT WERE PERFORMED ON THOSE MODELS, FOR THE REGULATORY AGENCIES. BY CURRENT PRACTICE, A DEPARTMENT IN NEW HAMPSHIRE COULD RETURN A DEVICE BECAUSE OF A SERIOUS DEFECT, HAVE IT REPAIRED AND RETURNED, AND NO OTHER DEPARTMENT WOULD BE AWARE OF THE PROBLEM UNTIL THEIRS FAILED. WE BELIEVE THAT BY SUBMITTING REPAIR REPORTS TO THE REGULATORY AGENCIES, THOSE AGENCIES COULD THEN REVIEW THE REPORTS AND ISSUE WARNINGS, OR, IN EXTREME SITUATIONS, REMOVE THE DEVICES FROM SERVICE ENTIRELY, IF THEY FELT CONDITIONS WARRANTED SO DOING.

THESE RECOMMENDATIONS, WE BELIEVE, ARE ALL REASONABLE REQUESTS. THEY COULD BE CARRIED OUT IMMEDIATELY, WITH A MINIMUM LOSS OF TIME AND EXPENSE. WE ALSO FEEL THAT IT IS IN THE BEST INTEREST OF FIREFIGHTER SAFETY TO DO SO.

OUR SECOND MAJOR AREA OF CONCERN DEALS WITH THE NEED OF ADDITIONAL, IMMEDIATE RESEARCH. IT IS IN THIS AREA WHERE THE LACK OF UNDERSTANDING REGARDING THE CONDITIONS UNDER WHICH THE FIREFIGHTER MUST PERFORM HIS JOB BECOMES PAINFULLY, AND DANGEROUSLY APPARENT.

BY FAR THE MOST IMPORTANT AREA OF CONCERN SHOULD BE THAT OF TEMPERATURE CRITERIA. PRESENT STANDARDS SHOW NO MINIMUM SPECIFICATIONS OF HIGH OR LOW TEMPERATURE PERFORMANCE STANDARDS, AND BOTH ARE DESPERATELY NEEDED. NO HIGH AIR TEMPERATURE AND RADIANT HEAT TESTING PROCEDURES ARE CURRENTLY INCORPORATED INTO THE REGULATIONS, AND RESEARCH IS NEEDED INTO A HIGH TEMPERATURE PERFORMANCE LEVEL THAT IS REALISTIC FOR THE CONDITIONS OF THE JOB. IN ORDER FOR THE DEVICES TO BE EFFECTIVE, THEY MUST BE ABLE TO WITHSTAND EXPOSURE TO THE KINDS OF HIGH HEAT FOUND IN THE FIRE ENVIRONMENT FOR AT LEAST A MINIMUM OF TIME.

ON THE OPPOSITE END OF THE SCALE, MANY DEPARTMENTS ARE NOT ONLY HAMPERED BY THE HIGH HEAT EXTREMES, BUT ALSO BY EXTREME LOW TEMPERATURES. RESEARCH IS NECESSARY TO INSURE RELIABLE PERFORMANCE AT EITHER END OF THE TEMPERATURE SCALE IN A WIDE ENOUGH MARGIN TO ALSO INSURE SAFETY. UNDER THESE EXTREMES CONSIDERATION MUST BE GIVEN TO THE FACT THAT THE DEVICES WILL OFTEN BE REQUIRED TO GO FROM EXTREME LOW TEMPERATURES (WELL BELOW 0 DEGREES F IN SOME PARTS OF THE COUNTRY) TO IMMEDIATE HIGH TEMPERATURES (UPWARDS OF 400 DEGREES F). THE NEED FOR FREQUENT CYLINDER CHANGES MAY NECESSITATE THIS TRIP SEVERAL TIMES, AND THE FIREFIGHTER MUST BE ABLE TO DEPEND ON THE EQUIPMENT, SINCE THE CONDITIONS WILL NOT CHANGE. BY RESEARCHING METHODS OF INSURING SAFE OPERATION OF THE RESPIRATOR UNDER A WIDE RANGE OF TEMPERATURE EXTREMES, THE PROBLEM OF FACEPIECES SHATTERING UNDER LOW TEMPERATURES MIGHT ALSO BE SOLVED.

RESEARCH SHOULD ALSO BE IMMINENT INTO DETERMINING CORROSION LIMITS FOR RESPIRATORY REGULATORS. WE FEEL THAT RESEARCH INTO THE CORROSIBILITY OF ACIDS, SALTS, AND BASES, IS URGENT.

MUCH OF THE FIREFIGHTERS PROTECTIVE GEAR HAS ALREADY BEEN UPGRADED TO PROVIDE SOME FLAMMABILITY PROTECTION. WE FEEL THAT STANDARDS SHOULD BE INVESTIGATED THAT WOULD ALSO UPGRADE THE RELATIVE STRENGTH AND FLAME RETARDANCY OF THE FACEPIECE STRAPS AND HARNESSSES.

FINALLY, WE WOULD LIKE TO SEE RESEARCH INITIATED INTO MINIMUM CRITERIA FOR COMMUNICATIONS WHILE THE DEVICES ARE IN USE. NO FIRE IS STATIC, OR BURNS BY THE BOOK. THE FIREFIGHTER, TO BE BOTH SAFE AND EFFECTIVE, MUST BE IMMEDIATELY AWARE OF ANY AND ALL CHANGES IN HIS WORKING ENVIRONMENT. WITHOUT EFFECTIVE COMMUNICATIONS, HE IS BEING DANGEROUSLY ISOLATED WHILE WEARING CURRENT DEVICES.

IN CONCLUSION, I WOULD LIKE TO REITERATE. WE CAN NO LONGER "ACCEPT" UNNECESSARY RISKS FOR THE FIREFIGHTERS OF THIS NATION. THE SOCIETY IS DEDICATED TO INSURING THAT THE BEST KNOWLEDGE IS AVAILABLE AT THE GRASS-ROOTS LEVEL AND WE ALSO LOOK FORWARD TO THE DAY WHEN THEY ALSO HAVE THE SAFEST EQUIPMENT AVAILABLE. THE INTERNATIONAL SOCIETY OF FIRE SERVICE INSTRUCTORS STANDS READY TO ASSIST BOTH NIOSH AND MESA IN ACCOMPLISHING THIS TASK AND WOULD WELCOME THE OPPORTUNITY TO DO SO.

THANK YOU AGAIN FOR THIS OPPORTUNITY TO EXPRESS OUR OPINIONS, AND FOR TAKING THE FIRST, OF WHAT WE HOPE WILL BE MANY, STEPS TOWARDS REDUCING THE DEATHS AND INJURIES OF THIS NATIONS FIREFIGHTERS.

THE FOLLOWING ARE THREE STUDIES INDICATING THE IMPROVED SAFETY AFFORDED BY A GOOD FIT ON PROTECTIVE BREATHING DEVICE FACEPIECES;

1. IBM, UNDER CONTRACT # 1-35907, FOR THE NATIONAL BUREAU OF STANDARDS APRIL 1972.
2. BRUCE J. HELD AND C.B. RICHARDS, LAWRENCE LIVERMORE LABORATORY, UNDER CONTRACT # W-7405-ENG-48, U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION.
3. WILLIAM A, BURGESS, HARVARD SCHOOL OF PUBLIC HEALTH, UNDER CONTRACT # S-198099-71-2 FOR THE NATIONAL BUREAU OF STANDARDS, JUNE 1972.