# N95-16755

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**Comparisons of Three Anti-G Suit Configurations During Long Duration, Low Onset, +Gz.** BJ Stecmann*[1], RW Krutz*[1], RR Burton*[2], CF Sawin*[3]. [1]KRUG Life Sciences, San Antonio, TX; [2]Armstrong Laboratory, Brooks AFB, TX; [3]NASA Johnson Space Center, Houston, TX.

INTRODUCTION: Little physiologic data exist on the effects of long duration, low onset, $+G_z$. Space shuttle crewmembers are subjected to low $+G_z$ forces (less than $+\frac{1}{3}$ $G_z$) for upwards of 30 minutes during reentry. A similar reentry profile is predicted for the National Aerospace Plane (NASP). The physiologic effects of this acceleration stress are compounded by the loss of body water experienced during microgravity. Currently, standard 5 bladder anti-G suit is being used during shuttle reentry. There have been complaints of discomfort using this suit, mainly due to the abdominal bladder. This study compared the effectiveness of three anti-G suit configurations in volume-depleted subjects during a simulated space shuttle reentry profile. METHODS: Seven male subjects were given intravenous Lasix in a dose from 20-40 mg to induce a total body weight loss of 3+/- 1.5%. Approximately six hours after the injection, the subjects donned one of three anti-G suits--a standard 5 bladder anti-G suit, an extended coverage anti-G suit (the Advanced Technology Anti-G suit or ATAGS), or an extended coverage anti-G suit without an abdominal bladder (the reentry anti-G suit or REAGS). All subjects were exposed to a simulated space shuttle reentry profile. Non-invasive eye-level blood pressure (ELBP) was monitored throughout the $+G_z$ exposure. When systolic ELBP dropped below 70 mmHg, the anti-G suit was inflated in 0.5 psig increments to the pressure required to maintain 70 mmHg ELBP. Each subject rode with all three suits. Comparisons were made between the final pressure required in each suit to maintain ELBP and subjective reports of comfort. RESULTS: The mean final suit pressure required to maintain ELBP was 1.1 psi in both the ATAGS and REAGS vs. 1.8 psi in the standard suit. In addition, the subjects rated the REAGS suit highest on the comfort scale, citing the absence of the abdominal bladder as the main reason. CONCLUSIONS: Overall, the REAGS suit was the superior anti-G suit during long duration, low onset $+G_z$. This is based on its ability to maintain ELBP and still remain comfortable when inflated for prolonged periods of time.

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PBG EFFECTS ON MUSCLE FATIGUE DURING CENTRIFUGE TESTS. J. Linder*[1)], K. Harms-Ringdahl[2)], S.-A. Johansson[3)], G. Dahlbäck[3)], M. Aldman[1)]. Swedish Air Force, Headquarters, FS/FH3, S-107 84 Stockholm, Sweden[1)], Dept of Rehab/Phys Med, Karolinska Institute, Stockholm[2)], Defence Materiel Administr, Linköping[3)].

INTRODUCTION. The proper anti-G straining manoeuvres (AGSM) required in high-performance flying involve considerable abdominal and leg muscle contraction. Positive pressure breathing during G (PBG) is known to increase G tolerance. The aim was to analyze the electromyographic activity from relevant muscles as part of a study assessing the new Swedish flight combat suit (TFCS), with and without PBG. METHODS. Nine experienced test pilots (mean age 42 yrs, height 1.80 m, and weight 80 kg) participated in a centrifuge test. Gradual onset rate (GOR) 0.1 G/s and rapid onset rate (ROR) 6 G/s, both up to 9 G for max 60 s, were randomized with and without PBG. Using surface electrodes, muscle activity levels were recorded from some chest, abdominal and leg muscles. Signals were preamplified and tape-recorded. RESULTS. With PBG, the G tolerance was significantly increased and muscle activity levels (RMS) were lower. Muscle fatigue, analyzed as the slope of the linear regression line of mean power frequencies per second during the test, was significantly lesser with PBG. It is concluded that the method gives an objective measure of muscle load during AGSM and of the influence of PBG on AGSM. Increased G tolerance with PBG is not due to increased muscle activity, as PBG rather entails a decrease in the muscular load.

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**EFFECT OF SIMULATED AIR COMBAT MANOEUVRING ON MUSCLE GLYCOGEN AND LACTATE.** B. Bain* I. Jacobs and F. Buick* Defence and Civil Institute of Environmental Medicine, North York, Ontario, **CANADA**, M3M 3B9.

INTRODUCTION. Previous investigations have attempted to assess the contribution of anaerobic metabolism to the anti-G straining manoeuvre during simulated air combat manoeuvring (SACM). However, muscle glycogen utilization and lactate production has never been assessed before and after SACM. This study attempted to quantify these variables using the percutaneous muscle biopsy technique. METHODS. The subjects were 6 healthy males, age 25-43 y. Muscle glycogen and lactate were determined from biopsies of m. vastus lateralis and whole blood lactate was analyzed from finger-tip blood samples before and after subjects were exposed to a +4.0/7.0 $G_z$ simulated air combat manoeuvring centrifuge profile. RESULTS. G-tolerance time was 230 ± 37 s (Mean ± SEM). The decrease in glycogen concentration averaged 81 ± 36 $mmol \cdot kg^{-1}$ dry wt. (p=0.07). The rate of glycogen utilization was low, averaging 0.4 ± 0.1 $mmol \cdot kg^{-1} \cdot s^{-1}$. Muscle lactate (LaM) increased significantly from 28 ± 2 $mmol \cdot kg^{-1}$ dry wt pre-SACM to 51 ± 4 $mmol \cdot kg^{-1}$ post-SACM. Post-SACM blood lactate was 4.2 ± 0.3 $mmol \cdot L^{-1}$. Neither final blood nor muscle lactate values nor the difference between pre and post SACM LaM concentrations were related to G-tolerance time.

CONCLUSIONS. Glycogen availability, at least in m. vastus lateralis, is not a limiting factor during exposure to headward acceleration of this type and duration. The lactate values, while high, cannot fully explain the muscular fatigue that appears to be taking place during the centrifuge exposures. The suggestion by others that anaerobic energy metabolism in skeletal muscles is the crucial factor limiting the ability to resist fatigue during exposure SACM is not supported.

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HEAD INJURY PROTECTION FOR PASSENGERS SEATED BEHIND INTERIOR WALLS IN TRANSPORT AIRCRAFT, V. Gowdy, R. DeWeese, FAA Civil Aeromedical Institute, Oklahoma City, OK 73125.

INTRODUCTION. Civil aviation seats in transport aircraft certificated after June, 1988, must provide protection from head injury as defined by the Head Injury Criteria (HIC) with a 50th percentile anthropomorphic test dummy. Passenger seats located behind interior wall structures present problems in demonstrating compliance with this requirement. METHODS. A series of impact tests to investigate the dynamics of head impact with a wall structure replicating a typical installation are presented. The tests were conducted with an impact severity of approximately 16 Gs with a velocity change of 44 ft/sec. Passive energy absorbing (EA) materials placed on the head strike area of the wall were evaluated. The effectiveness of an automotive type air bag system was also investigated. RESULTS. With the configuration tested, the customary installation geometry in transport aircraft interiors resulted in head impact velocities approaching 42 ft/sec. at the vertical plane of a wall structure. Aluminum honeycomb and low density EA foam pads modified to produce a stroking force in the range of 700 pounds were successful in limiting the HIC result below 1000 with a penetration depth of four to six inches. The autotomotive air bag functioned as designed. CONCLUSION. Means of satisfying the HIC requirement for passenger seats aft of interior walls are obtainable. Passive EA materials as well as an air bag system provided acceptable HIC results.

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FACTORS RELATED TO PILOT SURVIVAL IN CRASHES OF COMMUTERS AND AIR TAXIS. S.P. Baker* and G. Li. Johns Hopkins Injury Prevention Center, School of Public Health, Baltimore, MD 21205.

INTRODUCTION. Among civilian workers, pilots are second only to loggers in rates of work-related injury deaths. During 1983-1988, 176 pilots-in-command were killed in crashes of scheduled commuters and nonscheduled air taxis in the U.S. The proportion of crashes in which the pilot was killed was 17% and 20%, respectively, for the two types of operation. METHOD. To identify the factors related to fatal outcome, we used NTSB computer data in logistic regression models. The results are adjusted for pilot age, sex, flight time, airplane versus helicopter, number of engines, type of operation, and other variables. RESULTS. The most important pilot factor influencing survival was non-use of shoulder harnesses, which quadrupled the odds of fatality. Other important factors were aircraft fire (Odds Ratio=7.8), off-airport location of the crash (OR=5.2), and IMC weather (OR=3.8). One crash in six involved postcrash fire. The combination of fire and explosion, although not common, increased the fatality rate from 11% with neither present to 69% with both. CONCLUSION. High priority should be given to increasing shoulder harness use and reducing postcrash fires. The possibility of improving the potential for rescue in off-airport locations and at night should also be explored.

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FACTORS INVOLVED IN EMS HELICOPTER OCCUPANT INJURY. R.S. Dodd*. Johns Hopkins University Injury Prevention Center, Baltimore, MD 21205

INTRODUCTION. Since 1972, 84 helicopters engaged in emergency medical service (EMS) operations have crashed. During 1980-1989, the mean EMS helicopter crash rate was 13.1, roughly 2.5 times that of FAR part 135 helicopter air taxis, a comparable population. The mean fatal crash rate for EMS helicopters of 5.0 was 5 times the mean rate for air taxi helicopters. The National Transportation Safety Board investigated the operational safety of EMS helicopters in 1988 and found, among other things, that the medical modifications to the interior of numerous EMS helicopters may have a negative influence on occupant crash tolerance. METHODS. Survivors of EMS helicopter and air taxi helicopter crashes were surveyed by mail to obtain information on their injuries. Information was requested on age and weight, function in the helicopter, seating position, individual restraint availability and use, damage to their seat, personal protective equipment, damage to the helicopter, crash sequence, their injury status, identification of injury source, and presence or absence of post crash fire. The questionnaire was mailed to all EMS helicopter crash survivors whose address could be determined from the NTSB crash record (n=121) and to a sample of all crash survivors of air taxi helicopter crashes (n=226). RESULTS. 62% of the EMS respondents, and 43% of the air taxi respondents reported injuries. Of the EMS occupants injured, 46% sustained head injuries and 30% sustained back injuries. Of those injured in air taxi crashes, 23% reported head injuries and 50% reported back injures. The modification of the EMS helicopter interior was identified as a factor in 30% of the EMS helicopter occupant injuries. CONCLUSION. The case description of injuries occurring in EMS helicopter crashes provides insight on specific modifications that may increase risk of occupant injury. These factors should be considered during the design or modification of EMS helicopter medical interiors.

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THE EFFECTIVENESS OF AIRBAGS IN REDUCING THE SEVERITY OF HEAD INJURY FROM GUNSIGHT STRIKES IN ATTACK HELICOPTERS. N. M. Alem and D. F. Shanahan*. U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL 36362-5292.

INTRODUCTION. Accident investigation records of U.S. Army helicopter crashes show injuries of pilots due to striking a structure inside the cockpit outnumber those due to excessive accelerations by a five-to-one ratio. This paper presents the results of a study of the effectiveness of airbags in reducing the severity of contact injury to the gunner when striking the gunsight. METHODS. Airbag systems were installed on the gunsights in simulated Cobra and Apache cockpits, then sled tested at 7 and 25 g. RESULTS. The tests indicated airbags reduced head accelerations by 65 percent, head injury criteria by 77 percent, and head angular acceleration by 76 percent in the Cobra tests. In the Apache tests, the airbags reduced those same indicators by 68, 52, and 83 percent. CONCLUSION. The study concludes that an airbag system is likely to prevent severe or fatal head and chest injuries in an Apache or Cobra crash.

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U.S. ARMY HELICOPTER INERTIA REEL LOCKING FAILURES. B. J. McEntire and D. F. Shanahan*. U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL 36362-5292.

INTRODUCTION. The inertia reels utilized in U.S. Army helicopters are regulated by MIL-R-8236E. This performance specification requires the MA-6 and MA-8 inertia reels to lock automatically when the restraint strap is subjected to an acceleration between 1.5 and 3 G and remain locked until manually reset. Inertia reel performance in dynamic environments has become suspect due to increased upper torso injuries received during mishaps. METHOD. A review was conducted of U.S. Army Safety Center mishap data and USAARL dynamic sled test data. Field tests were conducted on 110 inertia reels from Fort Rucker rotary-wing aircraft to determine if calibration settings are greater than 3 G. RESULTS. A number of critical and fatal injuries have occurred in survivable mishaps. Some injuries relate directly to the inertia reel either failing to lock or not locking soon enough. Sled test analysis revealed that the inertia reel locking mechanism, manually locked before testing, can disengage during dynamic tests. Approximately 25% of the inertia reels field tested failed to lock when tested at 3 G. CONCLUSION. Currently fielded inertia reels fail to meet the needs of state-of-the-art crashworthy aircraft. The performance levels of the inertia reels should include dynamic test requirements to ensure proper activation. Maintenance and calibration procedures should be developed to verify fielded inertia reel calibration.

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CRASHWORTHINESS ASSESSMENT OF THE U.S. ARMY UH-60 BLACK HAWK HELICOPTER. D.F. Shanahan.* U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL 36362-5292.

INTRODUCTION. The U.S. Army UH-60A Black Hawk helicopter was the first helicopter designed to crashworthiness standards. The airframe was designed to withstand an 11.6 m/s vertical impact by employing a ruggedized basic structure, energy-attenuating landing gear and seats, a crash-resistant fuel system and other design strategies. This paper will assess these strategies emphasizing what has worked well and suggesting potential improvements. METHODS. Reports of Class A and B accidents involving UH-60 helicopters over the period October 1, 1979 to September 30, 1990 were reviewed. Emphasis was placed on crash kinematics, structural damage and injuries. Information contained in the reports was combined with the personal knowledge of the author who was involved in the investigation of approximately 25 of these crashes. RESULTS. Over the study period, there were 66 Class A and B mishaps of the Black Hawk resulting in 82 fatalities and 146 personnel injured. Crash survivability was excellent for impacts up to 16.8 m/s vertical velocity, well in excess of the design goal. This success is largely attributable to the substantial tie-down strength of high mass items (rotor system, transmission, engines), the performance of the crash resistant fuel system, and the effectiveness of the energy-attenuating landing gear. Problems identified included excessive stiffness of the energy-attenuators on the new crew seats, inadequate design of troop seats and restraint systems, and poor integrity of the roof in high sink rate crashes. CONCLUSIONS. The Black Hawk has proven itself an extremely crash survivable helicopter. This is attributed to the effectiveness of most of the crashworthiness design concepts incorporated into the airframe. However, certain modifications would significantly improve the crash survivability of the Black Hawk.

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A NEW RAPID DEPRESSURISATION AND HYPOXIA TRAINING SIMULATOR FOR AIRCREW. A. G. Dawson* L. J. Thompson*. Air New Zealand Medical Unit, Auckland, New Zealand.

INTRODUCTION: Professional aircrew are trained to react appropriately to rapid depressurisations. Training simulators can promote safety and give crew confidence in equipment and procedures, but they must be safe, realistic and affordable: Hypobaric chambers are used but they involve a significant health risk and considerable financial cost. METHOD: A chamber has been constructed with eight typical airline cabin crew stations. A rapid depressurisation is simulated by releasing a substantial volume of compressed nitrogen into the simulator over 15-30 seconds. RESULTS: This technique produces a fall in temperature, mist, noise, gas movement, and a low oxygen partial pressure (profiles for these will be presented) at ambient pressure. Crew can experience hypoxia, and use the emergency drop-down masks and portable cylinders. There is no risk of DCS, air embolus, or barotrauma and the less stressful learning environment is superior to a hypobaric chamber. CONCLUSION: This simulator replicates the main criteria by which a decompression can be recognised, and offers good prospects for improved quality of aircrew training. The advantages and limitations of this simulator technique will be discussed.

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VARIABILITY OF RESPONSES AND COMPLICATIONS IN HYPOBARIC HYPOXIA. M.Simons*, P.J.L.Valk. Netherlands Aerospace Medical Centre, 3769 ZG Soesterberg.

INTRODUCTION: In hypoxia indoctrination of aircrew, hypoxia is induced by exposure to hypobaric conditions. This study was conducted to assess individual physiological and psychological reactions to hypobaric hypoxia. METHODS: 30 subjects were exposed in 4 identical sessions in a hypobaric chamber at 46.5 kPa (20.000 ft). Ambient air or oxygen was administered (subject-blinded) through a mask. ECG, respiration rate, end-tidal $CO_2$, oxygen saturation, EEG were continuously recorded.Psychological performance was continuously assessed by means of a PC-testbattery. RESULTS: Mean group values of the physiological parameters confirmed earlier results in literature. However, marked inter- and intra-individual differences in the physiological responses were observed. Two cases of asystole were observed. Mean group performance scores showed significant effects of hypoxia. Performance scores also showed marked inter- and intra-individual variability. DISCUSSION: In the assessment of physiological and psychological effects of hypobaric hypoxia marked inter- and intra-individual variability has to be anticipated. This has implications for the hypoxia indoctrination of aircrew. Hypoxia stimulates the vagal reflex arc, which might lead to SA node depression. As hypoxia also depresses AV nodal tissue and impairs conduction in the ventricles, asystole might occur. Implications with respect to medical monitoring during hypobaric chamber demonstrations are discussed.

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TIME COURSE OF CHANGES IN THE ERYTHROPOIETIN ON BLOOD COMPONENTS DURING SUSTAINED EXPOSURE TO HYPOBARIC HYPOXIA. H.Osada*, S.Maruyama, A.Nakamura and S.Yagura. Aeromedical Laboratory,JASDF, Tokyo,190 Japan.

INTRODUCTION. When erythropoietin is adoministered in vivo, erythroid colony forming units(CFU-E) increase accelerated. These phenomena are also induced by hypoxic stimulation; the hypoxic state in the living body enhances to hypobaric hypoxia in rats. METHODS. Fifty male rats were continuosly exposed to a simulated altitude of 18,000 ft for 3 weeks. The animals were divided into a group administered 100 U/kg/day erythropoietin and a group administered the same volume of saline, and exposed to hypoxic stress after 5-day administration. RESULTS. 1) In the erythropoietin group, significant increases were observed in red blood cell(RBC) and $^{125}$I-labeled erythropoietin concentration until 3 days after hypoxia and in hemoglobin(Hb) and hematocrit(Hct) until 7 days after hypoxia. 2) In blood gas analysis, $O_2$ content showed a significant increase in the erythropoietin group but not in the saline groups. CONCLUSION. These results suggest that the administration of erythropoietin before hypoxic stress improves the ability of oxygen transport of the body and increases the resistance to hypoxia. These finding are considered to be important in clarification of the mechanism of adaptation to hypoxia.

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THE ROLE OF PULMONARY SURFACTANT IN EXTREME ALTITUDE EXPOSURES. MA Garber*, B Stegmann*, A Pilmanis, RA Blystone. High Altitude Protection Facility (HAPF), Armstrong Laboratories, Brooks AFB, TX 78235 and Dept. of Biology, Trinity University, San Antonio, TX, 78212.

INTRODUCTION. A guinea pig model is being used at the HAPF to test the efficacy of various treatment modalities for unprotected exposure to near vacuum. The incidence of respiratory arrest and the difficulty of pulmonary resuscitation have led to the hypothesis that normal lung surfactant function is disrupted in extreme altitude exposure. METHODS. Scanning and transmission electron microscopy (with special stains for surfactant) have been used to compare the lung ultrastructure between altitude-exposed and control animals. Low pressure vascular perfusion fixation has been utilized to minimize disruption of the alveolar surface lining layer. RESULTS. Preliminary analysis indicates that, in comparison to controls, the lungs of exposed animals demonstrate a reduced thickness of surfactant lining alveolar spaces. Animals which survive the exposure demonstrate a marked increase in surfactant production 48 hours later. Otherwise, no significant ultrastructural disruption of normal morphology is noted. CONCLUSIONS. Pulmonary surfactant is reduced by altitude exposure in this model. Artificial surfactant may have a role in the clinical treatment of ebullism.

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COMPARISON OF TOLERANCE TO PRESSURE BREATHING BETWEEN TWO SCHEMES OF COUNTERPRESSURE D.Y.He, C.G.Cai Institute of Aviation Medicine Beijing 100036 P.R.China

INTRODUCTION.In order to improve compatibility to positive pressure breathing(PPB),two counterpressure schemes were compared.METHODS.12 healthy young men underwent PPB with a pressure differential 650mm$H_2O$ 100% $O_2$ and 10.7% $O_2$ air for 5 min each with counterpressure scheme A,a capstan vest protecting thorax and abdomen,and on another day,scheme B,a capstan anti-G suit protecting only abdomen and lower extremities,while the subjects being monitored.RESULTS.The responses in scheme A and B were: HR increased 33% and 17.6% respectively;stroke volume lowered 40.1% and 38.6%;T wave in ECG lowered to 0.13mV and 0.04mV,electrical axis deviated to +75° and +62.1°;BP 156.2/110.8mmHg and 154.8/111.6mmHg. The subjects all reported that respiration in scheme B was much easier.When low $O_2$ air was breathed in PPB, the responses were similar to those with pure $O_2$,only oximeter readings were 82% and 84.8% respectively.Though both schemes provided safety in 5 min PPB,responses to scheme B was milder due to better venous return and more stablized was the diaphragm. CONCLUSION.Counterpressure with an anti-Gsuit might be of choice.With cruising altitude of 16 km and utilizing an $O_2$ assembly of 120mmHg differential,anti-G suit not only protects equally well,also is simpler,causes less heat stres and one piece of gear can serve two purposes.

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VARIATION OF TIMES-TO-INCAPACITATION ($t_i$s) AND CARBOXYHEMOGLOBIN (COHb) LEVELS FOR RATS EXPOSED TO TWO CARBON MONOXIDE (CO) CONCENTRATIONS. D. C. Sanders, B. R. Endecott and A. K. Chaturvedi*. FAA Civil Aeromedical Institute, Oklahoma City, OK 73125.

INTRODUCTION. It has been proposed that passenger protective breathing equipment protect the wearer from smoke and toxic gases for 5-min during an evacuation phase and for 35-min during an in-flight-plus-evacuation phase. Although CO is considered the primary toxic smoke component and incapacitation is an end-point related to escape from a fire environment, the $t_i$ variation at specific CO concentrations has not been statistically documented. Therefore, studies were conducted to determine (i) the CO concentrations that produce 5- and 35-min $t_i$s in the rat, (ii) the variance in $t_i$ at each CO concentration and (iii) the blood COHb level at $t_i$. METHODS. Fifty male Sprague-Dawley rats were individually exposed to each CO concentration in a chamber containing a rotating cage, and $t_i$s were determined. At $t_i$, rats were quickly removed and killed; blood samples were collected and analyzed for COHb. Also, COHb levels were determined for rats exposed to CO for stepwise intervals less than $t_i$. RESULTS. Values (mean±SD) for measured parameters were: For 5-min $t_i$ level, $t_i$=5.0±0.4 min, CO=5706±178 ppm, COHb=80.8±1.3%; for 35-min $t_i$ level, $t_i$=34.8±6.8 min, CO=1902±32 ppm, COHb=71.2±1.0%. COHb levels tended to plateau prior to incapacitation; these maximal levels increased with increasing CO concentration. CONCLUSION. Coefficients of variation for $t_i$ were 7.2% for the 5-min and 19.3% for the 35-min studies. The significant difference in the two COHb levels and the approach of COHb to a maximal level before incapacitation suggest that blood COHb levels may not necessarily be indicative of incapacitation.

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COMPARISON OF MOLECULAR SIEVE OXYGEN CONCENTRATORS (MSOC) FOR POTENTIAL MEDICAL USE ABOARD COMMERCIAL AIRCRAFT. H.M. England, Jr., B.C.Wilcox, Jr., & G.A. McLean*. FAA Civil Aeromedical Institute, Oklahoma City, Oklahoma, 73125-5066.

INTRODUCTION. Medically impaired air travelers requiring supplemental oxygen must depend on airlines to provide oxygen cylinders. Performance, space and cost hinder this service. Tests were conducted in an altitude chamber to assess the viability of MSOC as an alternative. METHODS. Five different MSOC were placed in the altitude chamber, and connected to a mass spectrometer outside. Analog gas concentration data were digitized at one sample-per-second and stored online via a microcomputer. RESULTS. Tests at ground level showed 4 of the 5 MSOC produced oxygen of 95% purity at 2 liters per minute flow, which was maintained until 13,000 ft. Increasing altitude resulted in graded reductions of oxygen levels. At 25,000 ft., only two MSOC produced acceptable levels of oxygen. Only these two MSOC withstood sudden decompression. CONCLUSIONS. Results of this study indicate that some MSOC have the potential to provide oxygen for medically impaired air travelers.

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COMPARISON OF PORTABLE CREWMEMBER PROTECTIVE BREATHING EQUIPMENT (CPBE) DESIGNS. B.C.Wilcox, Jr., G.A.McLean*, H.M.England, Jr. FAA Civil Aeromedical Institute (CAMI) Oklahoma City, Oklahoma, 73125-5066.

INTRODUCTION. CPBE presently certified for transport category aircraft employ three types of oxygen production systems: chlorate candle, potassium superoxide, and compressed oxygen. CPBE performance was evaluated to expose significant differences based on this distinction. METHODS. CPBE tests employing humans were conducted in accordance with FAA Technical Standard Order C-116. All CPBE were tested for oxygen production, carbon dioxide concentration, internal temperature, moisture and breathing resistance for 15 minutes at ground level (1,300 ft) and cabin altitude (8,000 ft), while subjects exercised. RESULTS. All CPBE produced a mean oxygen level of at least 59% and maintained carbon dioxide level below 5% at ground level. Differences in internal temperature and humidity were found. Performance at altitude generally paralleled these findings. CONCLUSIONS. Oxygen and carbon dioxide levels provide little discrimination about the relative merits of particular CPBE. However, differences in the wearability of CPBE, based on internal temperature, humidity and weight, were dependent on the type of CPBE oxygen production system.

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SOUND ATTENUATION AND SPEECH INTELLIGIBILITY EVALUATIONS OF A HELMET-INTEGRATED ACTIVE NOISE REDUCTION (ANR) SYSTEM. C. E. Williams*, D. W. Maxwell, G. B. Thomas, and A. H. McCardie. Naval Aerospace Medical Research Laboratory, Pensacola, FL 32508-5700.

**INTRODUCTION**. Current Navy flight helmets do not provide sufficient sound attenuation of the high-intensity, low-frequency noise present in some naval aircraft. As part of a program to provide improved hearing protection and speech intelligibility for aircrew in MH-53E helicopters, we conducted sound attenuation and speech intelligibility evaluations of a helmet-integrated active noise reduction (ANR) system. **METHODS**. Objective real-ear sound attenuation measurements (utilizing a miniature microphone placed at the entrance to the subject's ear canal) and speech intelligibility measurements (utilizing the NAMRL-developed Tri-Word Modified Rhyme Test) were obtained on ten male ensigns in the Naval Aviation Flight Training Program. **RESULTS**. A comparison of the sound attenuation values obtained in the ANR "on" mode (combined active/passive attenuation) to attenuation values obtained in the ANR "off" mode (passive attenuation) revealed 10-15 dB greater attenuation at 125, 250, and 500 Hz and 1-3 dB less attenuation at 2000, 3150, and 4000 Hz. A comparison of the mean percent correct speech intelligibility scores obtained in the ANR "on/off" modes under four noise level conditions (75, 95, 105, and 115 dB SPL) revealed equivalent intelligibility scores except at the highest noise level where slightly reduced intelligibility scores were obtained in the ANR "on" mode. A 3-5 dB decrease in signal level when the ANR system was changed from "off" to "on" undoubtedly accounted for the reduced intelligibility. **CONCLUSION**. Active noise reduction technology can be utilized to improve the hearing protection of aircrew performing in high-intensity, low-frequency noise environments.

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EFFECTS OF SIMULATED HEARING LOSS ON SPEECH PERCEPTION IN NOISE. A. H. McCardie and G. B. Thomas. Naval Acrospace Medical Research Laboratory, Pensacola, FL 32508-5700.

INTRODUCTION. Hearing standards for aviators often permit relatively large pure-tone losses at the higher audiometric frequencies. This study investigated the effects of simulated hearing loss at 2 kHz and 4 kHz on speech perception in cockpit noise. METHODS. Four lists of the Tri-Word Modified Rhyme Test (TMRT), two lists at a +4 dB signal-to-noise (S/N) ratio and two lists at a 0 dB S/N ratio, were administered to 26 student naval aviators. Before testing, standard air-conduction, pure-tone audiograms were administered to each subject. During one list at each S/N ratio, the speech signal was narrow-band attenuated to simulate a 25 dB hearing loss at 2 kHz and a 50-60 dB hearing loss at 4 kHz. The other two lists were presented without attenuation. RESULTS. The results indicated that performance differences due to S/N ratio were significant, $p < .00001$, and that performance differences due to attenuation were significant, $p < .00001$. No interaction effects were noted. Interestingly, there was a tendency for those subjects with the poorer audiograms to be affected less by the simulated loss of hearing. This suggests the possible development of a compensatory perceptual/cognitive mechanism in those subjects. CONCLUSION. Subjects' normal-hearing performance on the TMRT is significantly better than their performance while experiencing simulated hearing loss equivalent to 25 dB at 2 kHz and 50-60 dB at 4 kHz. Subjects with poorer pure-tone thresholds may develop compensatory perceptual/cognitive mechanisms to partially offset their hearing loss.

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DEVELOPMENT OF A NEW COMMUNICATION SYSTEM INTENDED FOR NOISY ENVIRONMENTS. H.Pongratz*, D.-M. Rose*, W. Blank, H.Welsch*, German Air Force Institute of Aerospace Medicine, Division IV -Ergonomics-, Flugplatz, D-8072 Manching

INTRODUCTION. A new 2-way communication system integrated into an ear plug with a piezoelectric accelerometer to pick up the human voice as the direct vibration through bone and tissue in the auditory canal, and an ultra-small electromagnetic speaker for transmission of incoming speech-signals, was investigated for the fitness of communication in loud ambient aircraft noise. METHODS. Monosyllabic word intelligibility tests were carried out via intercom with 24 candidates (12 of them wearing the ear plug in only one ear and 12 wearing it in both) who were concurrently exposed to white noise of 104 dB with and without an extra ear muff. Additionally this system was used in place of the normal hearing protection helmets for ground crews during routine fighter pre-flight-checks. The subjective impressions were validated with a questionnaire. RESULTS. Without additional ear-muffs the rate of error was 70%. With ear-muffs the error-rate decreased by more than 70% to 19.9%. There was no difference whether the ear plug was worn in one or both ears. During the pre-flight checks the comprehensibility of speech was good for both the ground and the cockpit crew. DISCUSSION. The great safety and comfort advantages of this new system are: A) ground crews are able to work unemcumbered, B) the heat and restriction of a helmet are eliminated, C) the visual field is broader and D) breathing noises in microphones that interfere with communication are eliminated. A future option would be the integration of this system into a whole body climated suit for fighter pilots.

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SHORT LATENCY VESTIBULAR EVOKED POTENTIALS. G. Knox*, J. Isaacs, D. Woodard*, L. Johnson. University of Florida Health Science Center, Jacksonville, Florida 32209.

Auditory responses including the well-characterized auditory brainstem response have been used extensively in clinical investigations. Evoked responses have not been adequately developed to investigate the vestibular system. The purpose of this study is to describe a new method for the evaluation of short-latency vestibular evoked potentials in human subjects. Standard ABR equipment is employed using a customized solid-state modification of the triggering mechanism. Signal averaging is used to record responses to multiple accelerations. Normal and vestibular deficient subjects are tested. Results indicate the presence of a short latency wave which is absent in vestibular deficient subjects. The literature is reviewed and illustrative cases are presented. We feel that vestibular evoked potentials are a promising new modality in investigating vestibular physiology and motion sickness.

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EVALUATION OF A VOICE-RECOGNITION SYSTEM FOR THE AUTOMATION OF THE VORPET TEST. E.A. Molina*. Naval Aerospace Medical Research Laboratory, Pensacola, FL 32508-5700.

INTRODUCTION. The Vestibulo-Ocular-Reflex Performance Evaluation Test (VORPET), developed at the Naval Aerospace Medical Research Laboratory, gives a measure of left- and right-directed gaze-shift threshold time. This task can be used to assess the type of head/eye coordination relevant to the aviator who routinely makes large shifts in gaze while scaning cockpit instruments and the outside environment. Automation of the VORPET requires the use of a voice-recognition system to collect and score the subject's voice responses. We compared the accuracy of the Votan voice-recognition system to that of the present method that uses a test administrator to listen and record subject's responses when administering the VORPET. METHODS. Thirty-six subjects were administered the VORPET under three different conditions: (a) direct viewing of the stimulus digits presented on the CRT, involving no head movement, (b) VORPET administration using a test operator for subject's voice recognition and manual data entry, and (c) VORPET administration using the automatic voice-recognition system for subject's voice acquisition and recognition. Two, three, and four digits were used as visual stimuli for each method. RESULTS. Analysis of variance of test results indicates significant differences between the thresholds obtained when methods (b) and (c) were used to administer the VORPET. CONCLUSIONS. The Votan automated voice-recognition system cannot be used to automate the VORPET. Present speed and accuracy of automated voice-recognition systems still need additional technological advancement or improvement in order to replace the present "human-based voice-recognition system."

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**ACHILLES TENDON REFLEX (ATR) IN RESPONSE TO SHORT EXPOSURES OF MICROGRAVITY AND HYPERGRAVITY. M. Fujii* and @M. Jaweed. Space Biomedical Research Institute, @Biomedical Operations and Research Branch, NASA Johnson Space Center, Houston, Texas 77058.**

INTRODUCTION: Previous studies indicate that latency and amplitude of the ATR are reduced after exposure to microgravity for 28 days. The objective of this study was to quantitatively measure the latency of ATR during brief (20 second) exposure to microgravity in KC-135 parabolic flights. METHODS: The ATR was elicited in ten men during parabolic flight, with the ankle held neutrally, plantarflexed, and dorsiflexed. During flight, the ATR was elicited during the 0-g and 1.8-g phases. Postflight testing was performed flying back to the airfield. Latencies to onset of the ATR were calculated and analyses of variance were performed to determine the effect of gravity and ankle position on latency. RESULTS: The mean latencies for 0-g, 1.8-g, and postflight with the ankle in the neutral position were 32.7 +/- .5 ms, and 33.1 +/- .7 ms.respectively, which were not significantly different. There was a trend towards prolongation of latencies postflight. The mean latency for those who were motion sick was 32.1 +/-.1 ms compared to 34.0 +/-.3 ms for those who were not sick. CONCLUSIONS: These studies indicate that neither the level of gravity nor ankle position significantly affected the latency of the ATR.

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**PREDICTION OF SPACE SICKNESS IN ASTRONAUTS FROM PREFLIGHT FLUID, ELECTROLYTE, AND CARDIOVASCULAR VARIABLES AND WEIGHTLESS ENVIRONMENTAL TRAINING FACILITY (WETF) TRAINING. K. Simanonok*, E. Mosely, and J. Charles*. Space Biomedical Research Institute, NASA Johnson Space Center, Houston, Texas 77058.**

Nine preflight variables related to fluid, electrolyte, and cardiovascular status from 64 first-time Shuttle crewmembers were differentially weighted by discriminant analysis to predict the incidence and severity of each crewmember's space sickness as rated by NASA flight surgeons. The nine variables are serum uric acid, red cell count, environmental temperature at the launch site, serum phosphate, urine osmolality, serum thyroxine, sitting systolic blood pressure, calculated blood volume, and serum chloride. Using two methods of cross-validation on the original sample (jackknife and a stratified random subsample), these variables enable the prediction of space sickness incidence (NONE or SICK) with 80 percent sickess and space severity (NONE, MILD, MODERATE, or SEVERE) with 59 percent success by one method of cross-validation and 67 percent by another method. Addition of a tenth variable, hours spent in the Weightless Environment Training Facility (WETF), did not improve the prediction of space sickness incidence but did improve the prediction of space sickness severity to 66 percent success by first method of cross-validation of the original sample and to 71 percent by the second method. Results to date suggest the presence of predisposing physiologic factors to space sickness that implicate a fluid shift etiology. The data also suggest that prior exposure to fluid shift during WETF training may produce some circulatory preadaptation to fluid shifts in weightlessness that results in a reduction of space sickness severity.