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HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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This selection of abstracts is taken from the Proceedings of the 1999 conference of the United Kingdom Group on Human Response to Vibration. The Conference was held at the Ford Motor Company Ltd, Dunton, Essex, from 22 to 24 September. The Technical Programme was arranged by the ISVR, University of Southampton.

J. L. van Niekerk, P. S. Heyns and M. Heyns. Human vibration levels in the South African mining industry. (14 pages, 5 figures, 3 tables, 19 references) (In English)
Author's Abstract. The research project reported on here represents the first comprehensive attempt to measure the vibration levels of a variety of tools and equipment in the South African mining industry to determine the effect thereof on the health of workers and operators. Both hand-arm and whole body vibration were investigated and measured. More than 700 different sets of vibration data measured on 70 different machines at 15 different mines and workshops were obtained. Data were obtained for at least 24 different types of equipment and machines that were previously judged to have medium to high levels of vibration. All measurements were conducted in accordance with the international standards: ISO 5349, on hand-arm vibration, and ISO 2631-1, for whole-body vibration. The equipment with the highest vibration levels in the hand-arm category was: rock drills, both pneumatic and hydraulic; pavement breakers and jackhammer; hand-held compactors; pneumatic wrenches and electrical hammer drills. Of these the rock drills had averaged weighted vibration levels in excess of 20 m/s^2. As far as whole-body vibration was concerned the highest values were measured on earth-moving equipment. The major conclusion from this study is that the measured vibration levels are sufficiently high to create an enhanced level risk of vibration-induced disorders in a significant proportion of the operators of hand-held equipment. The most notable examples are hand-held rock drills, pavement breakers, jackhammers and certain selected workshop tools. The results of the study indicate that a comprehensive epidemiological study should be undertaken on present and past workers to determine the prevalence of vibration-induced disorders.
Topics: Vibration measurements (whole-body vibration, hand-transmitted vibration).

B. M. Haward. A study to investigate task performance difficulties among the crew of an FPSO vessel. (13 pages, 1 figure, 7 tables, 7 references) (In English)
Author's Abstract. Crew living and working on board floating production and storage offshore vessels (FPSOs) in the North Sea are exposed to the motions of the

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vessel. A field study was carried out to investigate the effects of motions on crew members over a six-month period during the winter months (October 1998–March 1999). The investigation of task performance difficulties experienced whilst working offshore was part of this study. Using a questionnaire-based survey, crew reported their performance difficulties using a 0–5 rating scale for physical and cognitive elements of work tasks. Reported performance problems were correlated with magnitudes of acceleration in the fore-and-aft, lateral and vertical directions. Performance problems were greatest for physical tasks involving balance, moving, lifting and carrying. Cognitive tasks were less affected. The consequences of this are that work tasks become more difficult.
Topics: Performance effects (psychomotor, cognitive).

D.-S. Gong. Effects of narrow-band platform motions on induced postural responses in a standing posture. (10 pages, 5 figures, 1 table, 8 references) (In English)
Author's Abstract. The effects of bandwidth and magnitude of oscillation on induced postural responses in the sagittal plane have been investigated. The input accelerations with three different types of narrow band motion (sinusoidal, 1/3 octave band random, and octave band random) at three different magnitudes were studied with nine male subjects. In contrast to the postural responses induced by wide-band random inputs, there was a significant effect of input magnitude with all three narrow-band motions. The transfer functions between input acceleration and output centre-of-pressure (COP) displacement were dependent on input magnitude. From the phase response, a time advance of the COP displacement with respect to the input acceleration was found at all frequencies, compared with only low frequencies with wide-band motions. This confirms the existence of predictability in the postural control system in response to narrow-band motions. The predictability appears to be dependent on the input magnitude and the input frequency.
Topics: Performance effects (psychomotor)

J. Försberg. Effects from lateral and/or roll motion on nausea on test subjects: studies in a moving vehicle simulator. (10 pages, 7 figures, 2 tables, 13 references) (In English).
Authors' Abstract. Introduction: By tilting the car-body in trains, passengers perceive a reduced level of lateral forces in curves. The number of comfort disturbance is possibly reduced and the ride comfort is improved. However, by tilting, some susceptible passengers may experience drowsiness, dizziness or nausea. In order to study the influence from low-frequency lateral accelerations (forces) and simultaneous roll motions on the degree of nausea, a study in a simulator with a moving platform was performed. Methods and materials: from about 150 applicants to the test, about 40 subjects were randomly selected from four groups: gender (male and female) and self-estimated sensitivity to motion sickness (low and medium). Twenty of the subjects participated in all (seven) conditions, others from one up to five conditions. Seven different combinations of lateral motion and roll motions were tested with three possibilities of compression. These were constant lateral acceleration in the horizontal plane with increasing roll motion, constant roll motion with increasing lateral (horizontal) acceleration and constant degree of roll compensation of the lateral (horizontal) acceleration. The typical maximum lateral acceleration that could be achieved was 1·1 m/s^2 during 6 s long run, due to limitation

in the lateral distance (6·5 m) of the simulator track. The roll motions in the test reduced the lateral acceleration perceived by subjects with 0·56, 75 or 100% of acceleration in the horizontal plane. The subjects were seated in a two-seated cabin during the total 31-min-long test ride. Every 5 min they answered questionnaires concerning their degree of nausea and illness. Otherwise they were told to work or read. Main evaluation variables were nausea (NR) and illness ratings (IR), corresponding to the mean of the subjects' ratings of nausea and illness. The subjects also estimated their average ride comfort, ability to work/read and comfort disturbances due to strong lateral forces, high lateral or vertical shakings or uneven roll motion. Results: large variations in NR and IR were found between gender, according to their self-estimated sensitivity to motion sickness and also to successive test runs. The condition with roll motion only had a very low effect on NR and IR and the condition with lateral acceleration only had medium effects. High NR and IR were recorded in the conditions with combined high lateral accelerations in the horizontal plane together with large roll motions. In these conditions ride comfort and ability to work and read decreased and the percentage of comfort disturbances increased. Conclusions: increasing speed in curves (higher lateral acceleration in the horizontal plane) may enhance the risk of discomfort and nausea for sensible persons. This study agrees with earlier train studies, i.e. a lower compensation of the lateral acceleration give less roll and will lower the risk of nausea.
Topics. Motion sickness (causes of).

J. F. Golding, T. Haynes and M. A. Gresty. The effect on motion sickness of head tilts aligned versus misaligned to the acceleration resultant of low-frequency horizontal translational oscillation. (10 pages, 2 figures, 3 tables, 13 references) (In English)
Author's Abstract. Background: Sagawa *et al.* (1997) described a suspension system for ambulance stretchers which tilted to compensate for accelerating and braking and which protected patients against blood pressure variations. Their finding is consistent with Yates' (1996) cat data showing that vestibular-cardiovascular projections arise from the statoliths which transduce accelerations. Hypothesis: our intention was to determine whether compensation for the tilting resultant (gravity + horizontal translational acceleration) would also protect against motion sickness. Method: 12 subjects were exposed to continuous translational oscillation whilst making head tilts which were either aligned or misaligned with respect to the acceleration resultant. The design was a two-period cross-over, counterbalanced for order, with sessions one week apart at the same time of day. Subjects were seated upright and exposed to continuous horizontal translation sinusoidal oscillation through the body x-axis (3·095 m/s^2 peak acceleration, 0·20 Hz frequency). They made head tilts controlled by tracking a moving LED display with a head-mounted laser pointer. Verification of head trajectory was via head-mounted accelerometry. Motion continued until moderate nausea was achieved (motion endpoint) or until a 30 min maximum time cut-off was reached. Results: mean $\pm$ S.D. time to motion endpoint was significantly ($P = 0{\cdot}035$, two-tail) longer for aligned 19·17 $\pm$ 11·9 min than for misaligned 17·75 $\pm$ 12·98. Symptom scores were similar between conditions. Salivary cortisol was higher (marginal $P = 0{\cdot}08$, two-tail) following motion exposure in both conditions, mean $\pm$ S.D. pre-motion 0·94 $\pm$ 0·07 nmol/l, post-motion 1·98 $\pm$ 1·67 nmol/l but there were no significant differences between conditions.

Conclusions: longer motion exposure times were necessary to elicit sickness when head tilts were aligned with the direction of the acceleration resultant. This indicated reduced nauseogenic potential of translational oscillatory motion with compensatory tilt as compared to misaligned head tilt.
Topics: Motion sickness (causes of).

W. Pielemeier and J. Greenberg. Comparison of SEAT values from transmissibilities versus measurements for 16 seats and 8 subjects. (9 pages, 6 figures, 2 tables, 5 references) (In English)
Authors' Abstract. A comparison is made of SEAT values for purely vertical vibration computed directly from acceleration measurements at the seat top and track to those estimated by computing the seal top vibration using the set track measurement and seat transfer functions. Sixteen seats and six human subjects were involved, for a total of 96 cases. Separate transfer functions were computed using three levels of white noise excitation with each subject on each seat. Seat track and top measurements of the acceleration from an attenuated rough road seat track input were also repeated twice for each subject and seat. All excitations were generated using the Ford Vehicle Vibration Simulator. Results show that the transfer functions computed from different levels of excitation produce significantly different SEAT values. The SEAT values from direct measurements fell among those from the transducer functions. The measured SEAT results correlated (R square of 0·83) with the transfer functions SEAT results from a linear combination of the low- and high-excitation transfer functions. However, the regression coefficients could not be well-approximated *a priori* from the ratios of the r.m.s. levels of the transfer function and road excitations.
Topics: Seating (passive non-suspension seats, transmissibilities).

T. Gunston. The definition of suitable input motions for testing suspension seat end-stop impact performance. (11 pages, 5 figures, 0 tables, 5 references) (In English)
Author's Abstract. The objective of this study was to define standard input motions for the testing of suspension seats in the laboratory. The motions should be representative of the vehicle cab floor motions in situations that might be expected to cause seat suspension end-stop impacts during normal vehicle operation. Data from field trials conducted on three types of off-road vehicle were examined for end-stop impacts. Possible standard input motions are defined based on a half-sine windowed sinusoid. Time histories obtained in the laboratory using these motions produced sinusoid. Time histories obtained in the laboratory using these motions produced waveforms similar to those obtained in the field.
Topics: Seating (suspension seats, transmissibilities).

N. J. Mansfield and R. Lundström. Orthogonal force response of the seated person when exposed to horizontal whole-body vibration. (11 pages, 5 figures, 3 tables, 9 references) (In English)
Authors' Abstract. Fifteen male and 15 female subjects were exposed to five directions of random horizontal vibration at 0·5 m/s^{-2} r.m.s Subjects orientated to the vibration such that it occurred at 0, 22·5, 45, 67·5 and 90° to the mid-sagittal plane. Force and acceleration were both measured in the axis of motion (x direction) and in the orthogonal horizontal direction (y direction). Transfer functions between

the x-acceleration and y-force showed that there was more force generated in the y direction at 45° than at other angles. There was a peak in transfer functions at 2–3 Hz for conditions at 22·5, 45 and 67·5°. The least response was generated at 0 and 90° and did not show a clear peak. Investigation of the horizontal component of the force vector showed that the response of the subjects was generally in the direction of the vibration. At 0 and 90°, the responses were almost entirely in the plane of excitation. The orthogonal component of the force vector increased as the direction of vibration increased to 45°, and then decreased as the direction increased to 90°. These data indicate that the fore-and-aft and lateral modes of the body are distinct, and that both are excited at the intermediate angles of motion.
Topics: Biodynamics (impedance); complex vibration (multiple axis).

L. Wei and M. J. Griffin. Modelling the effect of backrest angle on the vertical apparent mass of seated subjects. (12 pages, 13 figures, 2 tables, 12 references) (In English)
Author's Abstract. The effects of a backrest at various angles on the apparent masses of seated male subjects exposed to random vertical vibration have been measured. The resonance frequency in the apparent mass and the apparent mass around resonance were both affected by backrest contact. It is shown that a two-degree-of-freedom model can provide an apparent mass very similar to that of the human body, but that some parameters require modification according to backrest conditions. The optimum model parameters are tabulated.
Topics: Biodynamics (impedance); Complex vibration (multiple input).

Other papers presented were as follows.
V. A. Coveney, G. D. Hunter, S. Jamil and D. E. Johnson. Measurements of accelerations on a pneumatic hand held tool.
R. Deboli, N. Paone and G. L. Rossi. Comparison of laser vibrometers and accelerometers to measure hand-arm transmitted vibration.
M. Morioka. Effect of contact location on vibration perception thresholds in the glabrous skin of the human hand.
N. J. Hansard. Pilot study of the repeatability of finger rewarming times in healthy subjects.
M. H. Pope, M. Magnusson and D. G. Wilder. Degenerative changes in the spines of drivers.
Ö. C. Sezgyn, G. Byrlyk and N. Akkas. A questionnaire study for vibration exposed and non-exposed groups.
S. Maeda, Y. Yonekawa, K. Kanada and Y. Takahashi. Changes of whole-body perception threshold in recumbent subjects.
T. Ishitake and Y. Miyazaki. The effect of whole-body vibration gastric motility in healthy men.
B. Harazin and P. Szlapa. Measurement of coupling forces applied to vibrating tools in industry.
R. Deboli, G. Di Giulio, R. Marsili and G. Miccoli. Static and dynamic characterization of capacitive film sensors for hand-arm vibration evaluation.
J. Venor. Steering wheel impedance and vibration: effect grip, accelerometer mounting mass, steering wheel geometry and engine conditions.

D. D. Reynolds and J. K. Stein. Evaluation of the test procedures in ISO Standard 10819.
D. D. Reynolds and T. C. Jetzer. Use of air bladder technology in antivibration gloves.
C. M. Nelson. The use of multimedia material to provide guidance on the management of occupational exposure to hand-arm vibration.
B. Lobb. Effect of waveform of lateral motion on motion sickness: a comparison of sinusoidal and octave band random motion waveforms.
H. V. C. Howarth. Laboratory study of the effect of frequency of roll motion on motion sickness.
J. F. Golding, A. G. Mueller and M. A. Gresty. Maximum motion sickness is around 0·2 Hz across the 0·1–0·4 Hz range of low frequency horizontal translational oscillation.
B. Kufver and J. Förstberg. A net dose model for development of nausea.
S. Clemes, J. R. R. Stott and K. Reid. Skin pallor as an objective assessment of motion sickness.
S. R. Holmes, S. King, S. Clemes and J. R. R. Stott. Forehead skin colour changes during motion sickness.
H. V. C. Howarth, M. M. Martino and M. J. Griffin. Laboratory study of the effect of visual scene on motion sickness caused by lateral oscillation.
N. A. Webb. Optokinetic motion sickness with and without corrected vision.
P. S. Els. The applicability of ride comfort standards to off-roads vehicles.
G. S. Paddan. Prediction of seat effective amplitude transmissibility (SEAT) values for eight alternative car seats.
N. Harada and T. Sakuri. Occupational exposure limit for hand-arm vibration in Japan.
K. T. Palmer, M. J. Griffin, H. Bednall, B. Pannett and D. Coggon. Occupational exposures to hand-transmitted vibration in Great Britain: a national survey.
B. M. Haward, K. T. Palmer, M. J. Griffin, H. E. Bednall and D. Coggon. The validity of self-reported information on exposures to hand-transmitted vibration.
K. T. Palmer, M. J. Griffin, H. Bednall, B. Pannet and D. Coggon. Raynaud's phenomenon and and hand-transmitted vibration in Great Britain: a national survey.
P. Brereton and C. Nelson. Observations on the progress of EU workplace vibration legislation—originally part of an EC proposal for physical agents directive.
M. A. Ksiazek. Active biomechanical models of a sitting human body.
S. D. Smith. The effects of combined-axis vibration exposures on human body biodynamics.
P. Lemerle and P. Mistrot. A new time model to predict vibration emission of counterbalance trucks.
P. M. Pitts and E. J. Brueck. Experience in assessing instruments against ISO 8041, 'human response to vibration—measuring instrumentation'.

Note. Copies of all papers in this section will be found in the Human Response to Vibration Literature Collection at the Institute of Sound and Vibration Research, University of Southampton. The papers may be used by persons visiting the Institute.

*Contributions to the Literature Collection are invited. They should be sent to Professor M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO*17 1*BJ, England.*