Journal of Sound and Vibration (1997) **200**(5), 767–771

HUMAN RESPONSE TO VIBRATION

ABSTRACTS

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This selection of abstracts is taken from the 1996 meeting of the United Kingdom Informal Group on Human Response to Vibration, held at MIRA (Motor Industry Research Association), Watling Street, Nuneaton, Warwickshire, on 18–20 September.

G. S. Paddan. Effect of grip force and arm posture on the transmission of vibration through gloves.
(13 pages, 4 figures, 2 tables, 8 references) (In English)
Author's Abstract. An experiment has been conducted to determine the effect of arm posture and applied grip force on the transmission of vibration from a vibrating handle through gloves to an accelerometer in the palm of the hand. Ten gloves were tested in four conditions: a combination of two arm postures (forearm parallel with the axis of vibration (0°) and forearm at an angle of 45° to the axis of vibration) and two grip conditions (no grip and a grip force of 30 N). Eight male subjects took part in the study. The subjects held a horizontally vibrating handle with a push force of 50 N. Vibration was measured at two locations: at the vibrating handle and at the glove–palm interface using a palm adapter. Transmissibilities between the handle and the palm adapter are presented for all gloves. Changes in arm posture (from 0° to 45°) had no effects on the transmission of vibration through the gloves. Grip force (from 0 N to 30 N) had only a marginal effect on transmissibility for some gloves and at different frequencies. A very large variability in transmissibility was seen between the subjects and between gloves.
Topics: Anti-vibration devices (gloves); Biodynamics; Hand-transmitted vibration

Y. Matsumoto. *The influence of posture on the apparent mass of standing subjects exposed to vertical vibration*. (12 pages, 7 figures, 1 table, 6 references) (In English)
Author's Abstract. The apparent mass of the standing human body has been measured with random vertical vibration in the frequency range from 1 to 50 Hz. Twelve male subjects were used to investigate the difference between sitting and standing positions as well as the effects of postural changes when standing. With a normal standing posture, a main resonance of the apparent mass in each subject appeared at about 5 Hz, as in the sitting position, while larger inter-subject variability was found in the standing position. Postural changes of the upper body were found to have an effect that may have been caused by changes in the angle between the upper body, or pelvis, and the legs. A decrease of the main resonance frequency from 5·25 Hz to 2·75 Hz was found with the legs bent. The magnitude of the apparent mass with this posture was remarkably small in the frequency region of 6 Hz.
Topics: Biodynamics (impedance); Body posture (standing)

P. Boulanger, G. Lovat and P. Donati. Development of a low frequency suspension cab for fork lift truck. (21 pages, 10 figures, 4 tables, 15 references) (In English).
Authors' Abstract. Industrial truck drivers may be exposed to high values of whole-body vibration with frequencies below 10 Hz due to the surface irregularities and the lack of

0022–460X/97/100767 + 05 $25.00/0/sv960850

suspension system of these vehicles. The aim of this paper is to report the methodology which was used to develop a low frequency suspension cab for fork lift trucks. A 1·5 ton counterbalance truck was modelled using a software package for simulating the dynamic behaviour of multi-body systems excited by known forces. This work involved firstly the determination for truck physical characteristics (dimensions, masses and inertia of different solid parts), the modelling of the dynamic vertical behaviour of the tyres when they are travelling over obstacles and the validation of the model of truck and tyres by comparison with vibration measurements during tests. The second part of the study was to build a model of a four point suspension cab with three degrees of freedom (vertical, pitch and roll) and a 3 cm stroke. The prediction of emission values by numerical simulation allows one to optimize the suspension parameters in order to get the best reduction of whole-body vibration transmitted to the driver while avoiding bump-stop contacts when travelling over standardized obstacles. The counterbalance truck used for the model was equipped with prototype of the suspension cab. This shows the possibility as predicted to reduce the vibration by half when the truck is used under normal conditions. Tests need to be carried out to check the acceptability of such a truck by drivers.
Topics: Ride (forklift trucks), Mathematical simulation

J. B. Morrison, S. H. Martin, D. G. Robinson, G. Roddan, J. J. Nicol, M. J.-N. Springer, B. J. Cameron and J. P. Albano. Development of a comprehensive method of health hazard assessment for exposure to repeated mechanical shocks. (11 pages, 5 figures, 0 tables, 32 references) (In English)
Authors' Abstract. This study describes a Health Hazard Assessment (HHA) method for evaluating exposures to repeated shocks in tactical ground vehicles (TGV). This method will predict the risk of injury to the crew of a TGV given its acceleration signature. The HHA will identify both acute and chronic health risks resulting from either a single shock, or prolonged exposure due to travel over rough terrain. The HHA is based partly on existing models, humans response and injury data, as well as partly on experimental data obtained from volunteers exposed to a range of shock profiles and to prolonged repeated shock exposures. The HHA consists of three components: dynamic response models which predict seat-to-spine transmission of acceleration; a dose–recovery model for exposure to repeated shocks based on fatigue failure theory and subjective tolerance data; and an injury model based on the cumulative probability of failure. A biomehcanical model was also developed which analyses spinal compression in response to shock. This model does not form part of the HHA model, but will provide an independent evaluation of the HHA using the experimental data from this study. The components of the HHA are outlined and some test results presented.
Topics: Criteria and limits; Injury and disease

J. Förstberg, E. Andersson and T. Ledin. Influence of different alternatives of tilt compensation on motion-related discomfort in tilting trains. (12 pages, 3 figures, 4 tables, 35 references) (In English)
Authors' Abstract. Train speed may be increased by constructing new railways with improved curve geometry or by using tilting trains. The tilting system compensates the lateral acceleration in curves by tilting the car body, thus allowing trains to run 23–35% faster on existing curved tracks. Although motion sickness in tilting trains seems to be a small problem for most passengers, it can be a problem to those prone to nausea. To investigate the frequency of motion sickness and how different tilt compensation strategies influence the occurrence of such symptoms, a full-scale test ride was conducted on a curved

track. 200 healthy volunteers were employed, selected for high subjective sensitivity to nausea in three different experiments. Altogether, six alternatives were tested. Four times per test ride the subject answered a questionnaire concerning vegetative symptoms, fatigue, sleepiness and nausea. The test persons' overall estimation of average ride comfort was good in all alternatives: however, some persons reported symptoms of motion sickness. A 55% degree of tilt compensation instead of the normal 70%, reduced the number of test persons reporting dizziness and nausea by about 30–50%. There are also indications that limited tilt speed and/or tilt acceleration can reduce symptoms. The ride comfort was also estimated as slightly better in these alternatives.
Topics: Ride (rail vehicles); Combined stress (vibration and acceleration); Motion sickness

S. D. Smith. The effects of prototype helicopter seat cushion concepts on human body vibration response. (16 pages, 6 figures, 0 tables, 9 references) (In English)
Author's Abstract. The driving-point impedance and transmissibility techniques were used to evaluate the effects of military helicopter seat cushions on human body vibration response. Small females (5th percentile or less for body weight) and large males (95th percentile or greater) were exposed to vibration in the frequency range of 3 to 21 Hz at $0{\cdot}59\ \mathrm{m/s^2}$ r.m.s. Transmissibilities were calculated between the acceleration measured at selected anatomical sites, including the chest, head, spine (C_7), and thigh, and the input at the seat. Seating configurations included the rigid seat, a current inventory seat cushion, and a prototype cushion with an inflatable thigh support in both the deflated and inflated positions. Rigid mass tests showed that the single resonance frequency and associated magnitude peaks were significantly lower for the two prototypes. The most dramatic effects in the humans were observed in the magnitudes of the peak head and spine transmissibilities located between 4 and 6 Hz with the use of the prototype cushions. Both the deflated and inflated cushions significantly increased the peak head and spine transmissibilities in the females, while decreasing or attenuating the transmissibilities in the males as compared to the rigid seat and the current inventory cushion.
Topics: Seating (transmissibility)

S. Perremans, J. M. Randall, L. Allegaert, M. A. Stiles and R. Geers. Influence of vibration on piglets' heart rate during vertical motion. (12 pages, 2 figures, 8 tables, 11 references) (In English)
Authors' Abstract. Pigs having a body weight of 15–20 kg were vibrated in the vertical direction during one hour at 2, 8 and 18 Hz, in combination with root mean square (r.m.s.) acceleration magnitudes of 1 or $3\ \mathrm{m/s^2}$. Welfare and stress were quantified by comparing heart rate parameters during a control period (10 p.m. to 6 a.m.) before vibration exposure and during vibration (10 a.m. to 11 a.m.). The level of maximum heart rate and number of ventricular ectopic beats (VEB) during vibration at 2 and 8 Hz in combination with r.m.s. acceleration of $3\ \mathrm{m/s^2}$ indicated a larger fear response to these treatments. Isocomfort contours based on mean heart rate during vibration showed the greatest specific sensitivity of the piglets during vibration at a frequency of 8 and 18 Hz, especially in combination with a r.m.s. acceleration change up to $3\ \mathrm{m/s^2}$. Hence, during transport r.m.s. acceleration should be lower than $3\ \mathrm{m/s^2}$ to protect pigs' welfare, being more sensitive to acceleration than to frequencies within the treatments investigated. However, due to interactions with body weight, the results may not be representative for effects on slaughter pigs, although the response of the piglets fit within the model concept for humans and for domestic fowl.
Topics: Non-human subjects (pigs); subjective response

J. A. Duggan, J. M. Randall, R. P. White and C. J. Nicol. Frequency weightings for aversion of broiler chickens to whole-body vertical vibration. (15 pages, 7 figures, 2 tables, 10 References) (In English)
Authors' Abstract. The objective of the study was to assess which specific frequencies of vertical vibration, occurring during transport, influence the behaviour of broiler chickens through the derivation of frequency weightings. An operant conditioning, passive avoidance technique was used to assess aversion. In a completely randomized design, each bird was exposed to one frequency (0·5, 1, 2, 5, 10 Hz vertical) at one of three acceleration magnitudes. Four birds were assessed at each of the 15 combinations. Six behavioural responses were significantly affected by vibration ($P < 0{\cdot}05$): suppression of total number of peck responses made during the session; latency to first peck(s) after the first treatment; number of jumps and time to sit(s) during the first treatment; and the number of head movements occurring throughout the session. For each response weighted, non-linear regression analyses were carried out. These regression models were then used to derive frequency weightings for each response measure. Acceptable and unacceptable levels of vibration were proposed and compared with human semantic labels.
Topics: Non-human subjects (chicken)

S. Rakheja, Z. Q. Wang and P.-E. Boileau. Ride performance analysis of a torsio-elastic linkage suspension for log skidders. (14 pages, 5 figures, 4 tables, 11 references) (In English)
Authors' Abstract. The ride performance potentials of a torsio-elastic linkage suspension concept, designed for log skidders, are investigated through development and analysis of a 13-degree-of-freedom vehicle model. The prototype suspension is fitted to the rear axle of a log skidder and field measurements are performed to evaluate its ride dynamics. Field tests are also performed with a conventional unsuspended vehicle and the measured ride dynamic response is analyzed to estimate the effective roughness profile of the terrain using a three-degree-of-freedom vehicle model. A randomly distributed cross-slope profile is further integrated into the average terrain profile to investigate the roll dynamic response of the vehicle. The analytical model is validated using the field measured vertical, pitch, roll, lateral and longitudinal acceleration data. A comprehensive parametric study is undertaken to derive near optimal suspension geometry, and restoring and dissipative properties of the torso-elastic members. The results of the analytical and experimental study revealed that the proposed linkage suspension significantly reduces the vehicle vibration along the longitudinal, lateral, vertical, roll and pitch co-ordinates.
Topics: Ride (off-road vehicle); Modelling

Other papers presented at the meeting were as follows. S. M. Hewitt. Development of a test facility for anti-vibration gloves. T. Ward. Hand–tool vibration emission: correlation between declared and in-use values. Part 1—Grinders. Y. Tominaga. Comparison report for Japanese mailmen who used motorbikes daily. C. H. Lewis. The development of a multi-channel plethysmograph. C. J. Lindsell. Finger systolic blood pressure measurement: effects of thermal provocation of four as opposed to one digit. J. R. Venor. The measurement of the mechanical impedance of steering wheels using the impulse hammer technique. S. Maeda and M. Morioka. Repeatability of vibrotactile threshold measurements on the finger obtained with different equipment. J. Nicol, J. Morrison, G. Roddan and A. Rawicz. An artificial neural network model of the dynamic response of the human spine to repeated mechanical shocks. D. G. Robinson, S. H. Martin, G. Roddan, G. H. Gibbs and J. Dutnall. The application of vibration assessment in mining vehicles to return-to-work protocols. A. V. Vukusic, J. M. Morrison, J. J.-N. Springer, D. G. Robinson and B. J. Cameron. Comparison of subjective response to mechanical shocks with predictive models of human response. R. M. Stayner. European grinder vibration test code: a critical review. P.-E. Boileau, S. Rakheja, X. Yang and I. Stiharu. Comparison of biodynamic response characteristics of various human body models as applied to seated vehicle drivers. N. J. Mansfield. A study of the effect of vibration duration on the apparent mass of the seated human body. L. Richard. A study of the effect of gender on the transmissibility of car seats. J. M. Randall, M. A. Alami and R. P. White. Responses of broiler chickens to whole-body horizontal vibration. P. D. Woodman. The effect of the head-helmet coupling on the relative acceleration between head and helmet. X. Wu, S. Rakheja and P.-E. Boileau. Distribution of human-seat interface pressure under vertical vibration. C. Peng. Experimental measurements of lateral tyre behaviour. J. Whitehead. Suspension and ride and handling development: the integrated approach. P. Schäfer, U. Eichhorn, K. Schebsdat, D. Neidlein and C. Eicker. Objective investigation of shock absorber influence on vehicle ride. M. Demic. A contribution to the optimizing the power train suspension. S. R. Holmes. Heart rate variability as a predictor of individual motion sickness susceptibility on exposure to yaw oscillation. P. R. Payne. Comparative ride comfort studies.

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.

Copies of the proceedings of the 1995 U.K. Informal Group on Human Response to Vibration may be obtained from Mr. John Whitehead, MIRA, Watling Street, Nuneaton, Warwickshire, CV10 0TU, England.

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, SO17 1BJ, England.

Readers may like to know that the 1997 U.K. Informal Group Meeting on Human Response to Vibration will be held at the University of Southampton from 17 to 19 September. This will be preceded by an International Conference on "Whole-body Vibration Injuries". Information on both conferences may be obtained from Professor M. J. Griffin, Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, England (fax (+44) 1703 592927).