EVALUATION OF THE CAPABILITY OF SEAT SUSPENSION TO REDUCE THE OPERATOR EXPOSURE TO VIBRATION IN TRACK TYPE TRACTORS.

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Introduction

The European Union (EU) completed a new directive 2002/44/EC[1] called the Physical Agents Directive (PAD) that establishes action and limit values for hand-arm and whole body vibrations. The directive specifies that:

"...workers shall not be exposed above the exposure 'limit value'."[1]

and

"...once the exposure action values ... are exceeded, the employer shall establish and implement a programme of technical and/or organisational measures intended to reduce to a minimum exposure to mechanical vibration and the attendant risks..."[1]

The PAD limit value is effective for new machines starting July 6, 2007 and for used machines by at least July 6, 2010. These requirements apply to the users of machines, but machine manufacturers will be challenged to provide machines and information to help the users comply with the directive.

Caterpillar manufactures machines with the goal of enabling our customers to comply with all regulations dealing with health and safety. Caterpillar designs all of our machines to provide a safe, comfortable and productive work environment. This study was to determine if seat suspensions could provide a reduction in the vibration environment experienced by operators of Caterpillar mid sized (<50,000KG) Track Type Tractors

Methods

Seat manufacturers were asked to provide seat suspensions that provide improved isolation over and above current seat suspension. Each supplier was provided with ride profiles and was asked to demonstrate the vibration reduction on a shaker table. Two suppliers provided suspensions that were compared with the current seat suspension in a field study. Three full factorial experiments were conducted. The first experiment was to evaluate overall suspension performance for four operations. The second experiment was to determine the benefit of the adjustable vertical damper at three different levels and the third experiment was to determine the effect of the fore/aft and side/side isolators. Six operators were used for the study. Acceleration was measured at the seat base and at the operator seat pad. Both the transfer function and the ISO 2631 RMS ride values were used to determine the seat suspension's effectiveness of isolating the operator from vibration. A structured questionnaire was used to determine the operators' subjective assessment of the seat suspensions.

Results

There was significant operator-to-operator variability in the vertical direction (>35%), however there was little variability in the fore/aft and side/side direction based on seat base

acceleration. There was significant variation in the vertical vibration levels for all four operations; slot dozing, ripping, cross v-ditch, and roading. Roading showed much lower fore/aft and side/side vibration levels then the other operations. Slot dozing showed lower side/side vibration levels than other operations but was similar to roading. The fore/aft and side/side levels appear to be a function of the ground profile.

The seat suspensions demonstrated reductions in the ISO Ride values for the vertical direction in the shake table test however they did not show any significant reduction during the field operations. The exception was during the roading operations where the advance seat suspensions showed measurable reductions. The damper settings again showed significant differences during the shake test but had little or no effect during the field test. The fore/aft isolator did not provide a statistically significant reduction in the ISO ride values however the Side/Side isolator did provide a 20% reduction.

The seat suspensions did provide an improvement in the operator subjective evaluation of the machine vibration environment. In the vertical directions, the operators felt the advanced suspension provide a slight improvement. The fore/aft isolator provided a significant improvement in the vibration environment. This occurred despite the fact that the isolators provided no statistically significant improvement in the ISO ride values. The side/side isolator did provide a slight improvement in the operator perception of the vibration environment.

Discussion

Seat suspensions tested will not provide a significant reduction in the ISO RMS ride values for the current generation of construction machines however they do provide a significant improvement in the operator subjective opinion of the machine vibration environment. This may imply that the methodology used in the European Union (EU) directive 2002/44/EC may not be appropriate for evaluating operator comfort in construction machines. The basis of the ISO weighting curves are human response testing in a seated position without foot pedals, seat backs, arm rests and control contact. The operator seated position in construction machines may change how the human responds to vibration and perceives vibration. Further work is required to understand the effect of foot pedals, back rests, arm rest and control contact on the operator perception of the vibration environment.

References

[1]EEC, (2002) Directive 2002/44/EC of the European Parliament and of the Council of 25th June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration). (Sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). Official Journal of the European Communities, L177, pp13-20, 6th July 2002.

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