INCORPORATING A FINGER ADAPTER INTO ISO 10819 ASSESSMENTS TO MEASURE THE VIBRATION TRANSMISSIBILITY OF GLOVES AT THE FINGERS

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Introduction

Personal protective equipment (PPE), which is meant to protect workers from unwanted injuries, is widely mandated in nearly every industry around the world. Gloves are one of the most commonly used PPE, especially for the protection of exposure to excessive levels of vibration originating from the use of vibratory equipment. Even though the effects of vibration exposures to the hand-arm system have been extensively studied, the practical effectiveness of vibration-reducing (VR) gloves remains unclear, especially at the fingers, where vibration exposure symptoms occur. ISO 10819[1], which requires glove designs to have no more than a single layer of resilient material less than or equal to 8 mm thick on the palmar side of the hand, provides a standardized approach to testing gloves for their effectiveness in reducing vibration but is limited to only testing transmissibility at the palm. Large reductions in vibration exposures can be obtained in gloves that use thick resilient materials but these gloves are bulky and severely limit finger dexterity. Previous studies[2, 3] have shown that the biodynamic response at the finger pads are significantly different from the palm and suggest that glove test should include finger measurements for accuracy and practicality. In this study, assessments of various VR and non-VR gloves were conducted according to ISO 10819 but with the addition of assessing finger transmissibility using a newly designed and validated finger adapter.

Methods

In accordance with the ISO 10819, an electro-dynamic shaker system with an instrumented handle, having an embedded tri-axial accelerometer and two piezo-electronic grip force sensors, and a push-pull force-plate system was used to conduct glove assessments with data collected via a LabVIEW-based data acquisition system. Both palm and finger adapters (Figure 1) were manufactured from polylactic acid (PLA) using fused deposition modeling (FDM), or 3D printing. As seen in Figure 1, the finger adapter was positioned on the pad of the middle phalange of the third digit, which has been shown to be a common contact point of the fingers when gripping cylindrical style handles[4]. A band-limited random vibration signal from 25 to 1,600 Hz, as defined in ISO 10819, was used for all tests and palmar transmissibility was obtained following the methods outlined in the standard. Finger pad transmissibility was also obtained and was structured to follow the frequency range and calculations used for the palm.

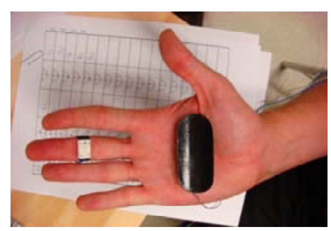

Figure 1. 3D-printed palm and finger adapters

In this study, the transmissibility of nine gloves and the bare hand were evaluated, as seen in Table 1. Here, Gloves 1, 2, 3, 4, and 8 are marketed as anti-vibration (AV), or VR, gloves, while Gloves 5, 6, and 7 are non-VR gloves that are commonly used within manufacturing environments. Glove 9 was a half-finger glove that cannot be categorized as an ISO 10819 AV glove and was used to provide contrast with the full-fingered gloves, especially Glove 8, which is its full-fingered counterpart.

Results

Figure 2 shows the results of the bare adapter test for the FDM palm and finger adapters, while Figures 3 and 4 are the transmissibility response (TR) of the gloves measured at the palm and finger, respectively. Table 1 provides a summary of the total transmissibility values in both M and H frequency ranges at the palm and the finger as well as the pass/fail results of this test for each glove.

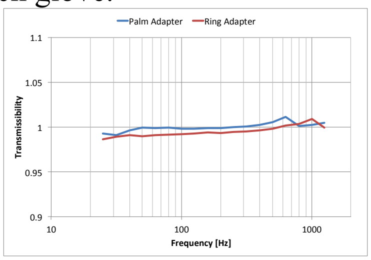

Figure 2. Typical Palm and Finger Adapter Transmissibility

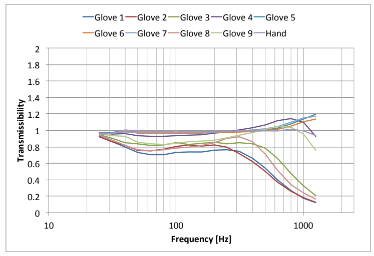

Figure 3. Glove TR at the Palm

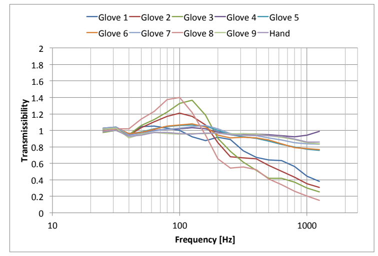

Figure 4. Glove TR at the Finger

Table 1. Summary of Tested Vibration Attenuation Gloves and Results

Glove	Glove Material(S)	Glove Type	Palm		Finger	
			M Spectrum (Pass: < 0.90)	H Spectrum (Pass: < 0.60)	M Spectrum	H Spectrum
1	Air bladder, Pearl leather palm, Lycra back	Full finger	0.764	0.664	0.982	0.775
2	Air bladder, Leather	Full finger	0.810	0.670	1.070	0.673
3	Chloroprene rubber coated, Nylon/cotton knitted liner	Full finger	0.851	0.797	1.136	0.653
4	Eva foam padded, Synthetic leather palm, Spandex back,	Full finger	0.947	1.028	1.006	0.955
5	Nitrile foam coated, Kevlar liner	Full finger	0.977	1.004	1.025	0.918
6	Nitrile foam coated, Kevlar liner	Full finger	0.971	0.993	1.020	0.897
7	Polyurethane coated, Dyneema and Lycra liner	Full finger	0.976	1.012	1.015	0.945
8	Nu2O2 polymer padded, Pigskin leather	Full finger	0.813	0.805	1.131	0.526
9	Visco-elastic gel polymer padded, Pigskin leather	Half finger	0.876	0.954	0.967	0.947
Bare Hand	Reference		0.984	0.992	0.966	0.943

Discussion

The novel 3D-printed PLA adapters exhibited exceptional performance within the required ISO frequency range and demonstrated that 3D printing can be used in human vibration research, especially in ISO 10819 glove testing.

Although Gloves 1, 2, 3, and 8 are marketed as AV gloves, their effectiveness was only confirmed within M spectrum and not within the H spectrum. Air bladder gloves (Gloves 1 and 2) were very close to the standard's threshold value of 0.6 for the H spectrum but were observed to not quite meet this requirement, which is in agreement with other previously reported glove studies[5, 6, 7]. Finger transmissibility for all gloves varied from that of the palm, where the transmissibility at the M spectrum for the palm indicated appropriate attenuation in some gloves but for none of the gloves at the finger, where amplification was observed (Figure 4). These results suggest that glove transmissibility measurements taken only at the palm can incorrectly characterize the ability of a glove to attenuate vibration and mitigate exposures to the entire hand. These results also suggest that ISO 10819 transmissibility measurements taken at the finger are feasible and should be strongly considered in a future revision of this standard.

References

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Forward – Welcome Address

On behalf of my conference co-chairs, I am pleased to welcome you to Guelph, Ontario, Canada for the 5th American Conference on Human Vibration. The 5th ACHV is being co-hosted by the University of Guelph, Laurentian University, Western University and the University of Toronto. We are honored to be hosting this biennial conference on the University of Guelph campus. As the premier North American conference for human exposure to vibration, the conference provides a unique and convenient opportunity for researchers, engineers, medical professionals and industry representatives to exchange information on all aspects of vibration control and human responses to hand-transmitted vibration and whole-body vibration. The theme for this year's meeting is "Human Vibration - From Theory to Industrial and Clinical Applications".

Founded in 1827, Guelph was named after the British Monarch King George IV, who was from the House of Hanover. Selected as the headquarters of a British development firm called "The Canada Company", Guelph was designed by John Galt, who was a Scottish Novelist. The town was designed to resemble a European city center comprised of squares, wide main streets and narrow side streets. Guelph was home to Lieutenant Colonel John McCrae, the author of "In Flanders Fields". Its references to the red poppies that grew over the graves of fallen soldiers resulted in the remembrance poppy becoming one of the world's most recognized memorial symbols for fallen soldiers. Guelph was also the home of North America's first cable TV system. Fredrick T. Metcalf created MacLean Hunter Television (now part of Rogers Communications) and their first broadcast was of current monarch Queen Elizabeth II's Coronation in 1953. With a population of over 120,000, Guelph is part of a technology triangle which is comprised of the cities of Guelph, Kitchener, Cambridge and Waterloo. Guelph is consistently rated as one of Canada's best places to live because of its low crime rate, clean environment, high standard of living and low unemployment rate. Almost one quarter of Guelph employment is provided through the manufacturing sector with over 10% provided through Educational services. The City of Guelph has identified life science, agri-food and biotechnology, environmental management and technology companies as industries on which to focus future economic development activities.

Many thanks to Elyse Dubé from Conference Services at the University of Guelph for all of her hard work in helping to plan and sort through the conference logistics. We'd also like to thank Guelph Engineering students Gregor Scott and Dan Leto as well as School of Engineering technician Carly Fennell for their help in setting up the laboratory tours. We hope that your visit to the 5th ACHV and Guelph will be both educational and enjoyable.

Sincerely,

Michele Oliver, Jim Dickey, Tammy Eger and Aaron Thompson