Investigation of issues related to the revision of Iso 10819

Erik Wolf
University of Nevada, Las Vegas

Follow this and additional works at: https://digitalscholarship.unlv.edu/rtds

Repository Citation
INVESTIGATION OF ISSUES RELATED TO THE REVISION OF ISO 10819

by

Erik Wolf

Bachelor of Science in Mechanical Engineering
University of Nevada, Las Vegas
2000

A thesis submitted in partial fulfillment
of the requirements for the

Masters of Science Degree in Mechanical Engineering
Department of Mechanical Engineering
Howard R. Hughes College of Engineering

Graduate College
University of Nevada, Las Vegas
August 2004
INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.
The Thesis prepared by

Erik J. Wolf

Entitled

Investigation of Issues Related to the Revision of ISO 10819.

is approved in partial fulfillment of the requirements for the degree of

Master of Science in Mechanical Engineering

Examination Committee Chair

Dean of the Graduate College
ABSTRACT

Investigation of Issues Related to the Revision of ISO 10819

by

Erik Wolf

Dr. Douglas Reynolds, Examination Committee Chair
Professor, Department of Mechanical Engineering
University of Nevada, Las Vegas

This study has three main goals. The first is to evaluate a proposed change to the input spectra for the ISO 10819 antivibration glove tests. Secondly, this study investigates the effect of palm adapter geometry on linear transmissibility and mean corrected transmissibility values. Finally, the effect of test subject training is discussed and supporting data is shown.

30 rigid acrylic adapters were designed, fabricated, and tested at the University of Nevada, Las Vegas Center for Mechanical and Environmental System Technology laboratory. Linear transmissibility of the bare hand, using 4 test subjects, formed the basis for selecting the adapters to be used. The criterion of acceptability was that the linear transmissibility in each third octave band (averaged over all subjects) must be between 0.95 and 1.05. All adapters fell into one of four categories. Category 1 adapters passed the acceptability criteria. Category 2 adapters failed in the low frequency (16-40
Hz). Category 3 adapters failed in the high frequencies (1000-1600 Hz). Category 4 adapters failed in multiple frequency bands. Four category 1 adapters, one category 3 adapter, and one category 4 adapter were chosen for further testing.

Mean corrected transmissibility tests were performed for these 6 adapters according to the procedure defined in International Standards Organization’s publication, ISO 10819:1996, method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand. 3 test subjects, and 3 different commercially available antivibration gloves were used. A constant velocity (0.01 m/s) third octave band level input spectra from 16-1600 Hz (referred to as F spectrum) was also tested and compared to the M (16 - 400 Hz) and H (100- 1600 Hz) spectra.

The results of this study show that the ISO 10819 adapter is acceptable; however, other configurations give comparable results. In general, adapters length must be 70-80 % of the width of the palm. The adapters must not have too great an upper radius, nor have too small a lower radius. Three alternatives to the standard adapter shapes are given.

The use of the single, F spectrum is recommended. The mathematical separation of the F spectrum into M and H frequency content results in similar mean corrected transmissibility values when compared to those obtained from the M and H standard tests, specified in ISO 10819.

The test subjects to be used for antivibration glove testing must be properly trained and exposed to the test procedure in order to apply proper measurement technique. Mean corrected transmissibility values may be 10 – 20% off the correct value if adequate training is not performed.
# TABLE OF CONTENTS

**ABSTRACT** ....................................................................................................................... iii  
**LIST OF FIGURES** .......................................................................................................... vii  
**LIST OF TABLES** ............................................................................................................. xi  
**LIST OF SYMBOLS** ....................................................................................................... xiii  
**ACKNOWLEDGEMENTS** ............................................................................................. xiv  

**CHAPTER 1  INTRODUCTION** ..................................................................................... 1  
**CHAPTER 2  TEST SETUP** ............................................................................................ 5  
  2.1 Shaker system ........................................................................................................... 5  
  2.1.1 Electro-dynamic shaker ..................................................................................... 6  
  2.1.2 Shaker support structure ................................................................................... 6  
  2.1.3 Electrical power supply .................................................................................... 7  
  2.1.4 Handle design ................................................................................................... 7  
  2.1.5 Mounting plate .................................................................................................. 8  
  2.2 Force measurement system ..................................................................................... 9  
  2.2.1 Push force measurement ................................................................................... 9  
  2.2.2 Grip force measurement ................................................................................... 9  
  2.3 Control and measurement system .......................................................................... 11  
  2.3.1 Vibration control ............................................................................................... 11  
  2.3.2 Data measurement ............................................................................................. 12  
  2.3.2.1 Calibration .................................................................................................. 12  
  2.3.2.2 Displayed functions .................................................................................... 13  
  2.3.2.3 Data recording ............................................................................................ 13  

**CHAPTER 3  TEST PROCEDURES** ............................................................................. 14  
  3.1 Overview of ISO 10819 protocol ............................................................................. 15  
  3.1.1 Test subject requirements ................................................................................. 15  
  3.1.2 Adapter configuration ....................................................................................... 16  
  3.1.3 Input spectra ..................................................................................................... 16  
  3.2 Constant velocity spectra testing procedure ........................................................ 19  
  3.2.1 Calculation of F spectrum data ....................................................................... 21  
  3.3 Adapter evaluation procedure ................................................................................. 22  
  3.3.1 Adapter acceptability criterion ....................................................................... 22  

**CHAPTER 4  ADAPTER DESIGN** .............................................................................. 24  
  4.1 Design dimensions ................................................................................................. 24
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>CMEST lab setup</td>
<td>5</td>
</tr>
<tr>
<td>2.2</td>
<td>Tira shaker with handle (side view)</td>
<td>6</td>
</tr>
<tr>
<td>2.3</td>
<td>Shaker support structure</td>
<td>7</td>
</tr>
<tr>
<td>2.4</td>
<td>Handle</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>Mounting plate (mm)</td>
<td>8</td>
</tr>
<tr>
<td>2.6</td>
<td>Slip plate and strain ring</td>
<td>10</td>
</tr>
<tr>
<td>2.7</td>
<td>Control diagram</td>
<td>11</td>
</tr>
<tr>
<td>3.1</td>
<td>Proper test posture</td>
<td>15</td>
</tr>
<tr>
<td>3.2</td>
<td>Input Spectra F, H, and M</td>
<td>20</td>
</tr>
<tr>
<td>5.1</td>
<td>Category 1 adapters (representative plot)</td>
<td>30</td>
</tr>
<tr>
<td>5.2</td>
<td>Category 2 adapters (representative plot)</td>
<td>31</td>
</tr>
<tr>
<td>5.3</td>
<td>Category 3 adapters (representative plot)</td>
<td>32</td>
</tr>
<tr>
<td>5.4</td>
<td>Category 4 adapters (representative plot)</td>
<td>32</td>
</tr>
<tr>
<td>5.5</td>
<td>F spectrum glove transmissibility plot, glove 1</td>
<td>43</td>
</tr>
<tr>
<td>5.7</td>
<td>F spectrum glove transmissibility plot, glove 3</td>
<td>44</td>
</tr>
<tr>
<td>A1.1</td>
<td>Adapter 02 drawing</td>
<td>51</td>
</tr>
<tr>
<td>A1.2</td>
<td>Adapter 03 drawing</td>
<td>52</td>
</tr>
<tr>
<td>A1.3</td>
<td>Adapter 04 drawing</td>
<td>53</td>
</tr>
<tr>
<td>A1.4</td>
<td>Adapter 06 drawing</td>
<td>54</td>
</tr>
<tr>
<td>A1.5</td>
<td>Adapter 07 drawing</td>
<td>55</td>
</tr>
<tr>
<td>A1.6</td>
<td>Adapter 08 drawing</td>
<td>56</td>
</tr>
<tr>
<td>A1.7</td>
<td>Adapter 09 drawing</td>
<td>57</td>
</tr>
<tr>
<td>A1.8</td>
<td>Adapter 11 drawing</td>
<td>58</td>
</tr>
<tr>
<td>A1.9</td>
<td>Adapter 12 drawing</td>
<td>59</td>
</tr>
<tr>
<td>A1.10</td>
<td>Adapter 13 drawing</td>
<td>60</td>
</tr>
<tr>
<td>A1.11</td>
<td>Adapter 14 drawing</td>
<td>61</td>
</tr>
<tr>
<td>A1.12</td>
<td>Adapter 15 drawing</td>
<td>62</td>
</tr>
<tr>
<td>A1.13</td>
<td>Adapter 17 drawing</td>
<td>63</td>
</tr>
<tr>
<td>A1.14</td>
<td>Adapter 18 drawing</td>
<td>64</td>
</tr>
<tr>
<td>A1.15</td>
<td>Adapter 19 drawing</td>
<td>65</td>
</tr>
<tr>
<td>A1.16</td>
<td>Adapter 20 drawing</td>
<td>66</td>
</tr>
<tr>
<td>A1.17</td>
<td>Adapter 21 drawing</td>
<td>67</td>
</tr>
<tr>
<td>A1.18</td>
<td>Adapter 23 drawing</td>
<td>68</td>
</tr>
<tr>
<td>A1.19</td>
<td>Adapter 24 drawing</td>
<td>69</td>
</tr>
<tr>
<td>A1.20</td>
<td>Adapter 25 drawing</td>
<td>70</td>
</tr>
<tr>
<td>A1.21</td>
<td>Adapter 26 drawing</td>
<td>71</td>
</tr>
<tr>
<td>A1.22</td>
<td>Adapter 27 drawing</td>
<td>72</td>
</tr>
<tr>
<td>A1.23</td>
<td>Adapter 28 drawing</td>
<td>73</td>
</tr>
<tr>
<td>A1.24</td>
<td>Adapter 29 drawing</td>
<td>74</td>
</tr>
</tbody>
</table>
Figure A5.17 F spectra, adapter 29, glove 0 .................................................................147
Figure A5.18 F spectra, adapter 29, glove 1 .................................................................147
Figure A5.19 F spectra, adapter 29, glove 2 .................................................................148
Figure A5.20 F spectra, adapter 29, glove 3 .................................................................148
Figure A5.21 F spectra, adapter 30, glove 0 .................................................................149
Figure A5.22 F spectra, adapter 30, glove 1 .................................................................149
Figure A5.23 F spectra, adapter 30, glove 2 .................................................................150
Figure A5.24 F spectra, adapter 30, glove 3 .................................................................150
Figure A5.25 M spectra, adapter 02, glove 0 .................................................................151
Figure A5.26 M spectra, adapter 02, glove 1 .................................................................151
Figure A5.27 M spectra, adapter 02, glove 2 .................................................................152
Figure A5.28 M spectra, adapter 02, glove 3 .................................................................152
Figure A5.29 M spectra, adapter 03, glove 0 .................................................................153
Figure A5.30 M spectra, adapter 03, glove 1 .................................................................153
Figure A5.31 M spectra, adapter 03, glove 2 .................................................................154
Figure A5.32 M spectra, adapter 03, glove 3 .................................................................154
Figure A5.33 M spectra, adapter 19, glove 0 .................................................................155
Figure A5.34 M spectra, adapter 19, glove 1 .................................................................155
Figure A5.35 M spectra, adapter 19, glove 2 .................................................................156
Figure A5.36 M spectra, adapter 19, glove 3 .................................................................156
Figure A5.37 M spectra, adapter 20, glove 0 .................................................................157
Figure A5.38 M spectra, adapter 20, glove 1 .................................................................157
Figure A5.39 M spectra, adapter 20, glove 2 .................................................................158
Figure A5.40 M spectra, adapter 20, glove 3 .................................................................158
Figure A5.41 M spectra, adapter 29, glove 0 .................................................................159
Figure A5.42 M spectra, adapter 29, glove 1 .................................................................159
Figure A5.43 M spectra, adapter 29, glove 2 .................................................................160
Figure A5.44 M spectra, adapter 29, glove 3 .................................................................160
Figure A5.45 M spectra, adapter 30, glove 0 .................................................................161
Figure A5.46 M spectra, adapter 30, glove 1 .................................................................161
Figure A5.47 M spectra, adapter 30, glove 2 .................................................................162
Figure A5.48 M spectra, adapter 30, glove 3 .................................................................162
Figure A5.49 H spectra, adapter 02, glove 0 .................................................................163
Figure A5.50 H spectra, adapter 02, glove 1 .................................................................163
Figure A5.51 H spectra, adapter 02, glove 2 .................................................................164
Figure A5.52 H spectra, adapter 02, glove 3 .................................................................164
Figure A5.53 H spectra, adapter 03, glove 0 .................................................................165
Figure A5.54 H spectra, adapter 03, glove 1 .................................................................165
Figure A5.55 H spectra, adapter 03, glove 2 .................................................................166
Figure A5.56 H spectra, adapter 03, glove 3 .................................................................166
Figure A5.57 H spectra, adapter 19, glove 0 .................................................................167
Figure A5.58 H spectra, adapter 19, glove 1 .................................................................167
Figure A5.59 H spectra, adapter 19, glove 2 .................................................................168
Figure A5.60 H spectra, adapter 19, glove 3 .................................................................168
Figure A5.61 H spectra, adapter 20, glove 0 .................................................................169
Figure A5.62 H spectra, adapter 20, glove 1 .................................................................169
| Table 3. 2 | ISO 5349 weighting curve | 18 |
| Table 4. 1 | Design dimensions | 24 |
| Table 4. 2 | Adapter geometries | 26 |
| Table Ex. 1 | F spectra raw data | 34 |
| Table Ex. 2 | FM spectra data | 35 |
| Table Ex. 3 | FM data ISO weighted and manipulated | 36 |
| Table Ex. 4 | FH spectra raw data | 37 |
| Table Ex. 5 | FH data ISO weighted and manipulated | 37 |
| Table 5. 1 | Mean corrected transmissibility (passed adapters) | 39 |
| Table 5. 2 | Mean corrected transmissibility (failed adapters) | 40 |
| Table 5. 3 | Mean corrected transmissibility values (6 adapter average) | 41 |
| Table 5. 4 | Test subject training comparison, mean corrected transmissibility | 47 |
| Table A4. 1 | F spectrum bare hand tests | 123 |
| Table A4. 2 | F spectrum, glove 1, uncorrected data | 123 |
| Table A4. 3 | F spectrum, glove 2, uncorrected data | 124 |
| Table A4. 4 | F spectrum, glove 3, uncorrected data | 124 |
| Table A4. 5 | F spectrum, corrected transmissibility | 125 |
| Table A4. 6 | F spectrum, mean corrected transmissibility | 125 |
| Table A4. 7 | FM spectrum, bare hand linear transmissibility | 126 |
| Table A4. 8 | FM spectrum, glove 1, uncorrected data | 126 |
| Table A4. 9 | FM spectrum, glove 2, uncorrected data | 127 |
| Table A4. 10 | FM spectrum, glove 3, uncorrected data | 127 |
| Table A4. 11 | FM spectrum, corrected transmissibility | 128 |
| Table A4. 12 | FM spectrum, mean corrected transmissibility | 128 |
| Table A4. 13 | FH spectrum, bare hand transmissibility | 129 |
| Table A4. 14 | FH spectrum, glove 1, uncorrected data | 129 |
| Table A4. 15 | FH spectrum, glove 2, uncorrected data | 130 |
| Table A4. 16 | FH spectrum, glove 3, uncorrected data | 130 |
| Table A4. 17 | FH spectrum, corrected data | 131 |
| Table A4. 18 | FH spectrum, mean corrected transmissibility | 131 |
| Table A4. 19 | H spectrum, bare hand linear transmissibility | 132 |
| Table A4. 20 | H spectrum, glove 1, uncorrected data | 132 |
| Table A4. 21 | H spectrum, glove 2, uncorrected data | 133 |
| Table A4. 22 | H spectrum, glove 3, uncorrected data | 133 |
| Table A4. 23 | H spectrum, corrected data | 134 |
| Table A4. 24 | H spectrum, mean corrected transmissibility | 134 |
| Table A4. 25 | M spectrum, bare hand transmissibility | 135 |
| Table A4. 26 | M spectrum, glove 1, uncorrected data | 135 |
| Table A4. 27 | M spectrum, glove 2, uncorrected data | 136 |
Table A4. 28  M spectrum, glove 3 uncorrected data.................................................... 136
Table A4. 29  M spectrum, corrected data..................................................................... 137
Table A4. 30  M spectrum, mean corrected transmissibility........................................... 137
LIST OF SYMBOLS

$A_{bl}$ = Third octave band acceleration band level ($m/s^2$)

$A_{sf}$ = Third octave band acceleration spectrum level ($m/(s^2 \sqrt{Hz})$)

$\Delta f$ = Third octave bandwidth (Hz)

$a_w$ = r.m.s frequency weighted acceleration

$a_{ws}$ = r.m.s frequency weighted acceleration for spectrum, $s$

- (F = 0.01 m/s constant velocity band level,
- FM = M spectra generated from F
- FM = H spectra generated from F
- M = M ISO 10819
- H = H ISO 10819

R = subscript to denote measurements taken at handle (reference) accelerometer

P = subscript to denote measurements taken at adapter (palm) accelerometer

b = subscript to denote measurements taken with bare hand

g = subscript to denote measurements taken with bare hand

$TR_{sb}$ = Transmissibility of bare hand

$TR_{sg}$ = Transmissibility of glove

$TR_{sj}$ = Glove transmissibility corrected for bare hand
ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to the following people who have made this study a success. First, I would like to thank Mr. Chris Ransel. Chris rendered and machined all the adapters for this project and several other adapters before I returned to UNLV. His efforts have been greatly appreciated. I would also thank Mr. Trevor Wilcox for his support and instruction on the wonderful world of Perl programming. Without Trevor, I’d still be cutting and pasting data into my grave.

Next, I would like to thank Dr. Douglas Reynolds for his unwavering support throughout my studies, as well as his advice. This project would not have been possible without Dr. Reynolds’ contributions of knowledge, time, and patience.

I would like to thank the members of my committee, all of who have instructed and guided me through my college career, both personally and professionally.

Lastly, I would like to thank my friends and family, especially my wife, Amanda. She has been my sponsor, confidant, and motivator everyday. Thank you from the bottom of my heart.
CHAPTER 1

INTRODUCTION

The methods and practices for measuring the effectiveness of antivibration gloves are constantly being revised and refined. Research is being conducted worldwide defining the relationships between exposure to vibration and the onset of related diseases, such as hand-arm vibration syndrome (HAVS). In order to characterize this vibration exposure, it is necessary to have reliable methods and equipment to measure the level of vibration that enters the hand when gripping vibrating tools. As a point of fact, the interaction between the human hand-arm system and vibrating equipment is complicated both to model mathematically and to measure experimentally. Any method must take into account the effect of the accelerometer-hand dynamic coupling. This is especially applicable to the calculation of the effectiveness of antivibration gloves. Laboratory testing is the current method of choice for evaluating these gloves; however, there are many critical issues when performing antivibration glove tests. Several ongoing studies are investigating the effects of push and grip force on the dynamics of the hand-arm system, or are assessing different frequency weighting curves with regard to the relationship between the frequency of acceleration and HAVS disorders. There is scientific evidence that the effectiveness of antivibration gloves is heavily dependant on frequency, and that the rank ordering of gloves by their transmissibility numbers does
not correlate well with actual working conditions (Pinto et al., 2001). Within the framework of the current test method, the effect of the shape and size of palm adapters on the transmissibility of gloves has not been thoroughly investigated, mainly due to the fact that ISO 10819 (ISO 10819, 1996) defines adapter geometry to be used. A previous study by Cui and Reynolds (Cui, 2001) concluded that smaller adapters than the ISO 10819 adapter could be used, but had little supporting data. When evaluating antivibration gloves, any palm adapter can be a cause for concern. Two of the issues cited by Paddan and Griffin (Paddan et. al.) in their respective studies are difficulty in aligning the adapter when it is placed in the glove and discomfort or inability to properly grip the handle with the adapter inside the glove. All of the available literature stresses the proper alignment of the adapter to reduce inter and intra-subject variability. Another study by Dong (Dong, 2003) investigates in detail the dynamic relationship between the hand, adapter, and handle and suggests redesigning the shaker handle to aid in properly aligning the adapter. Another approach, proposed by W.P. Smutz (Smutz et. al, 2001), suggests that real time 3-axis data be provided to the subject in order to visually aid him/her in correctly performing the test when the adapter cannot be seen.

In this study, a more passive approach to the adapter-hand system is used. Alternative adapter geometries (to the one geometry defined in ISO 10819) were investigated with the goal of addressing the aforementioned issues of alignment and in-glove comfort. The design concept was that a smaller, better fitting palm adapter would alleviate the discomfort, facilitate proper gripping, be somewhat self-aligning in the palm, and not effect the proper fit of the glove over the hand. Several different geometries were designed using Solid Works and produced using a Haas CNC milling machine at the
University of Nevada, Las Vegas CMEST (Center for Mechanical and Environmental Technology) laboratory. Adapters were designed with regards to critical dimensions and overall fit in the hand and then evaluated on an electro-dynamic shaker system. The dynamics of the hand-arm system can be modeled using Newtonian equations (Cui, 2001) or finite-element techniques, but the variability of glove test results shows clearly that there is a great number of unknown influencing factors involved when the hand is coupled with an accelerometer adapter and antivibration glove. It would not be convenient to include all the necessary variables to evaluate adapter performance in a theoretical model. The adapters are to be used in accordance with the standard, so the logical approach was to evaluate the adapter performance within the confines of the standard’s procedures.

A proposed change to the input spectra in the forthcoming revision of ISO 10819 is also investigated in this study. The current standard uses 2 different spectra, named medium (M) and high (H) for their frequency content, as input signals. The new method will be to use a single spectrum of constant velocity bandwidth over the entire third octave frequency band of interest. There are two reasons for making this change. First, the use of one input spectrum, rather than two separate spectra, will cut the required time to evaluate an antivibration glove in half. Secondly, the single spectrum will eliminate a difference of opinion concerning how the ISO 5349 weighting curve should be applied. One argument is that the curve should be applied only to the controlled frequencies, 16 - 400 Hz for the M spectra and 100 – 1600 Hz for the H spectra. The opposing argument is that all the frequencies from 16 - 1600 Hz should be used to calculate the weighted acceleration values whether they are directly controlled or not. When using the constant
velocity spectra as an input, all frequencies within the third octave bands of interest (16-
1600 Hz) are controlled.

The final part of this thesis presents a finding that became apparent as testing
progressed. The effect of the subject familiarizing himself with proper testing technique
is quantified and an explanation for this effect along with supporting data is reported.
CHAPTER 2

TEST SETUP

The equipment used in this project can be divided into three subsets, the shaker system, the force monitoring system, and the control and measurement system.

2.1 Shaker system

The shaker system consists of several basic elements. They include the shaker, amplifier, cooling blower, the shaker support structure, and the electrical power components. Figure 2.1 is a photograph of shaker system.

Figure 2.01 CMEST lab setup
2.1.1 Electro-dynamic shaker

The first element is the shaker itself, a Tira model TV 5550 LS (see Figure 2.2). This electro dynamic shaker comes with an amplifier tower and blower motor for cooling (not shown). This shaker is capable of 4000 N force output.

![Figure 2.2 Tira shaker with handle (side view)](image)

2.1.2 Shaker support structure

One of the first steps in this project was to install the shaker into the CMEST lab. A support structure had to be fabricated in order to position the horizontal vibration axis off the ground (parallel) at a sufficient height to facilitate most people. A handle height (center to floor) of 46 inches was used. The support system consists of 4 riser legs (refer to Figure 2.3) made from 3” box steel (1/4” thickness) with welded 6” X 6” X 1/2” steel end plates. The bottoms of the air springs are supported by 1” diameter threaded rod (10 threads per inch), which connects the top of the riser leg to an additional steel end plate by means of welded nuts. The threaded rods serve as a leveling mechanism and are held in place by setscrews. The entire system sits on a 4-inch concrete pad (see Figure 2.1).
2.1.3 Electrical power supply

A transformer was installed to step down from the building supply at 480V to three phase 220V, required by the shaker amplifier and cooling fan. Electrical panels and support frames for them (shown in background of Figure 2.1) were constructed. The amplifier and cooling fan control circuitry are connected by means of two 220-volt drop-down receptacle boxes mounted below the electrical panels. 110V receptacles were also installed to power the other measurement devices.

2.1.4 Handle design

A handle was constructed with a single accelerometer channel mounted precisely in the center of the gripping section, and a stout mounting section for attaching to the shaker. Both components were made with the CNC machine from type-6061 aluminum, with the result of an overall handle resonant frequency of 2200-2400 Hz, depending on the tightness of the bolts. Figure 2.4 is a schematic of the handle and mounting bracket.
2.1.5 Mounting plate

It was necessary to construct a mounting plate in order to match the shaker's tabletop, which has metric threads, to the transducers available in the lab. A 3/4" thick, circular mounting plate was CNC machined from type 6061 aluminum plate for this purpose. Figure 2.5 is a scaled rendering of the mounting plate (in millimeters).
2.2 Force measurement system

The push and grip forces applied by the test subject on the handle must be measured and maintained at specific levels throughout the test duration. Two sets of transducers, one for push force and one for grip force, are used to monitor these forces.

2.2.1 Push force measurement

Push force measurement is accomplished by the use of a slip plate (refer to Figure 2.6) that the test subject stands on during the test procedure. 11 matching bearing grooves (1/2” wide, 3” long) were machined into 3/4” tool grade aluminum plates. The plates are kept from over-traveling by 1/2” aluminum angle keepers screwed into the bottom plate at the four corners. Keepers are also mounted on two side sections to prevent lifting of the top plate. Push force is determined by use of a strain ring, which is installed inside a machined groove in the top plate (see cut out Section of Figure 2.6).

Each end of the strain ring is connected to one of the plates by means of a ball joint, which ensures proper alignment of the strain ring axis. The strain gauges on the ring are connected to a strain gauge box in a full bridge configuration. The strain box/strain ring configuration is calibrated by maintaining a desired push force on the shaker handle and then recording the number displayed on the strain box. The level of the calibration push force is set using a hand held Chatillon (model DPP-25) spring-type force meter.

2.2.2 Grip force measurement

The grip force is measured by 4 strain gauges places along the length of a rounded aluminum strip. The strain gauges are wired in a Wheatstone bridge configuration to a strain box with an analog needle display. The aluminum strip is mounted inside the back edge of the handle (see Figure 2.5). The level of grip force is calibrated by pulling on the
center of the strip mounted in the handle with a known force, using a Chatillon model DPP-25 force meter and an aluminum C-bracket to reach around the handle. The gauge factor on the strain box is then adjusted to until the needle reads zero. It was necessary to install rubber o-rings in between the strip and the handle to help dampen some of the high frequency vibration. High frequency vibration was causing the wires connecting the strain gauges to break off during testing. Since the addition of the o-rings, the strain gauges on the strip have not needed further repair.
2.3 Control and measurement system

The data measurement system includes both the computerized control of the input signal to the shaker and the monitoring, measurement, and recording of the acceleration signals from both the handle and the palm. A signal schematic of the systems is pictured in Figure 2.7.

![Figure 2.7 Control diagram](image)

2.3.1 Vibration control

Vibration control is achieved by using a Vibration View controller. This controller is connected to the desktop PC through a specialized DAQ board. The controller software allows the user to define a control signal by inputting an acceleration spectral level for each third octave band that the user wants to control. The program also allows the user to define tolerances for the spectral levels at each third octave band center frequency. The controller is connected directly to the accelerometer (PCB model 352C22) mounted in the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
shaker handle. The Vibration View hardware supplies voltage to this accelerometer and monitors it for closed loop feedback control. The controlled drive signal is output to the shaker amplifier. This system allows the user to quickly change input spectra as needed.

2.3.2 Data measurement

The monitoring, recording, and measurement of the acceleration signals are performed with a Bruel and Kjaer Portable Pulse system. The Portable Pulse hardware front-end contains a type 3032A I/O module and a type 7533 LAN interface module. The LAN interface allows the Pulse system to be connected via an Ethernet hub to a laptop computer. The B&K Pulse Labshop software program controls the front-end and allows for great flexibility in measurement types and details. The Pulse front end is also connected, through the I/O module BNC connections, to the accelerometer in the shaker handle and the palm adapter. The Portable Pulse powers the palm adapter accelerometer, but the connection to the shaker handle is only monitored, because Vibration View supplies the line voltage.

2.3.2.1 Calibration

Accelerometer calibration on both the Pulse and Vibration view systems is performed using a PCB 394C06 accelerometer calibrator, which outputs a 1-G acceleration signal at 159.2 Hz. The Pulse Labshop software program has a built in calibration subroutine, which sets the gain based on measured calibration signal and user inputted manufacturer’s nominal sensitivities. This gain/nominal sensitivity combination is manually transferred to Vibration View.
2.3.2.2 Displayed functions

Pulse Labshop is setup for this project to display the accelerometer signals for both channels (this particular system can monitor up to seven channels at once). The accelerometer output voltages are run though Pulse’s CPB (constant percentage bandwidth) third octave analyzer and displayed as third octave band levels in m/s^2. The Pulse system is able to post-process the data real-time, so a Pulse PL program was written to display the linear transmissibility (palm signal divided handle signal) for each third octave band center frequency as well.

2.3.2.3 Data recording

In order to maximize the number of measurements that can be taken in a given test session, the Pulse recorder module is used to save the time history of the accelerometer voltages. The recorded files can be played back at a later time and any number of analyzers or PL programs applied to the data set, regardless of which ones were initially used. Pulse recordings retain accelerometer serial numbers and associated calibrations and apply this information during playback. The data can be exported to other programs in various ways, including real-time export to programs such as Excel. For this project, the third octave band acceleration power spectrum levels ((m/s^2)^2)) for both channels were manually saved from the CPB analyzer outputs as ASCII text files.
CHAPTER 3

TEST PROCEDURES

There were three different test procedures used in this project. The first test procedure was developed to quantify the performance of different adapter geometries with regards to linear transmissibility between the handle and palm adapter accelerometers. These tests were performed with the subject's bare hand applied to adapter/handle.

The second test procedure used was the ISO 10819 test protocol. Selected adapters were tested to determine differences in measurement of the mean transmissibility values of antivibration gloves (see Section 3.1.4).

The last test procedure was used to investigate a proposed change to the input spectra of the ISO 10819 standard. The protocol is nearly identical to that of the standard, with the exception of a modified input spectrum and corresponding calculations. The goal of these tests was to determine the effect of using a different input spectrum on mean corrected transmissibility values.

The ISO 10819 standard test procedures will be overviewed first for clarity. Next, the new spectrum will be defined and changes to the calculation methods will be given. Finally the adapter geometries and procedures used to evaluate them will be discussed.
3.1 Overview of ISO 10819 protocol

ISO standard 10819 defines the test procedures for measuring the effectiveness of antivibration gloves. The requirements specify proper test subject posture and preparation, the level of push/grip force, the palm adapter geometry, minimum instrumentation requirements, and define the methods for numerical analysis.

3.1.1 Test subject requirements

ISO 10819 requires the use of three test subjects. They must be standing upright, dominant hand on the shaker handle with the palm adapter in between the handle and hand or inside the glove, if one is worn. The angle of the elbow must be $90 \pm 10$ degrees. The wrist angle should be between 0 40 degrees. Proper test posture is illustrated in Figure 3.1.

![Proper test posture](image)

Figure 3.1 Proper test posture
During the 30 second test duration, the test subject is required to maintain 50 ± 8 N of feed force on the handle and 30 ± 5 N of grip force. Between each test, the subject must break his grip on the handle.

3.1.2 Adapter configuration

ISO 10819 specifies the shape of palm adapter to be used. Adapter 02 (see Appendix 1) is designed to meet the specifications laid out in the standard. The basic requirements define the upper and side profile curvature of the adapter, as well as the overall length and width. A maximum weight of 15 grams is also mandated.

3.1.3 Input spectra

The input acceleration spectra to be used for feedback control are denoted medium (M) and high (H) in the standard. Table 3.1 reproduces the acceleration band levels required.

3.1.4 Calculation of mean corrected transmissibility

The calculations of mean corrected transmissibility values are based on 6 tests. Each of three test subjects must perform one bare hand test for each adapter and spectra. In this project, two bare hand tests were taken and then linearly averaged for each adapter and spectra. The subjects must also perform two tests wearing an antivibration glove. Three commercially available antivibration gloves were used in this project. Glove 1 was a gel foam glove, glove 2 was a Nu202 polymer glove, and glove 3 was an air-bladder glove. The bare hand is referred to as glove 0. The r.m.s. acceleration for each accelerometer (handle and palm) is measured for each test. The signals are weighted according to the ISO 5349 weighting curve (refer to Table 3.2)
<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>M</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>31.5</td>
<td>2.36</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>3.18</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3.88</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>4.54</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>5.16</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>5.71</td>
<td>3.77</td>
</tr>
<tr>
<td>125</td>
<td>6.14</td>
<td>6.29</td>
</tr>
<tr>
<td>160</td>
<td>6.28</td>
<td>10.47</td>
</tr>
<tr>
<td>200</td>
<td>5.89</td>
<td>15.24</td>
</tr>
<tr>
<td>250</td>
<td>5.04</td>
<td>20.20</td>
</tr>
<tr>
<td>315</td>
<td>3.94</td>
<td>24.86</td>
</tr>
<tr>
<td>400</td>
<td>2.89</td>
<td>29.07</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>32.48</td>
</tr>
<tr>
<td>630</td>
<td></td>
<td>35.15</td>
</tr>
<tr>
<td>800</td>
<td></td>
<td>35.95</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td>33.79</td>
</tr>
<tr>
<td>1250</td>
<td></td>
<td>28.91</td>
</tr>
<tr>
<td>1600</td>
<td></td>
<td>22.40</td>
</tr>
</tbody>
</table>
Table 3.2 ISO 5349 weighting curve

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>( w_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3</td>
<td>0.727</td>
</tr>
<tr>
<td>8</td>
<td>0.873</td>
</tr>
<tr>
<td>10</td>
<td>0.951</td>
</tr>
<tr>
<td>12.5</td>
<td>0.958</td>
</tr>
<tr>
<td>16</td>
<td>0.896</td>
</tr>
<tr>
<td>20</td>
<td>0.782</td>
</tr>
<tr>
<td>25</td>
<td>0.647</td>
</tr>
<tr>
<td>31.5</td>
<td>0.519</td>
</tr>
<tr>
<td>40</td>
<td>0.411</td>
</tr>
<tr>
<td>50</td>
<td>0.324</td>
</tr>
<tr>
<td>63</td>
<td>0.256</td>
</tr>
<tr>
<td>80</td>
<td>0.202</td>
</tr>
<tr>
<td>100</td>
<td>0.16</td>
</tr>
<tr>
<td>125</td>
<td>0.127</td>
</tr>
<tr>
<td>160</td>
<td>0.101</td>
</tr>
<tr>
<td>200</td>
<td>0.0799</td>
</tr>
<tr>
<td>250</td>
<td>0.0634</td>
</tr>
<tr>
<td>315</td>
<td>0.0503</td>
</tr>
<tr>
<td>400</td>
<td>0.0398</td>
</tr>
<tr>
<td>500</td>
<td>0.0314</td>
</tr>
<tr>
<td>630</td>
<td>0.0245</td>
</tr>
<tr>
<td>800</td>
<td>0.0186</td>
</tr>
<tr>
<td>1,000</td>
<td>0.0135</td>
</tr>
<tr>
<td>1,250</td>
<td>0.00894</td>
</tr>
<tr>
<td>1600</td>
<td>0.00538</td>
</tr>
</tbody>
</table>

The formula used to apply the weighting curve is:

\[
a_w = \sqrt{\sum (a_i \cdot w_i)^2}
\]
a_i is the third octave band acceleration level (m/s^2) and w_i is the weighting value from Table 3.2 in the ith third octave band.

The uncorrected transmissibility for the bare hand tests (TR_sb) and glove tests (TR_sg) for each spectra (s) are defined as:

\[ TR_{sb} = \frac{a_{wsPb}}{a_{wsRb}} \]
\[ TR_{sg} = \frac{a_{wsPg}}{a_{wsRg}} \]

Corrected transmissibility is calculated as follows:

\[ TR_{sj} = \frac{TR_{sg}}{TR_{sb}} \text{ for the jth subject, spectra (s)} \]

Lastly, the mean corrected glove transmissibility is found by averaging over the 3 test subjects (2 tests for each subject) for each spectra (s)

\[ \overline{TR_s} = \frac{1}{3} \sum_{j=1}^{6} TR_{s,j} \]

In order for a glove to be considered an antivibration glove, the mean corrected transmissibility must be <1.0 in the M spectra and <0.6 in the H spectra.

An additional requirement for the test to be considered valid is that the un-weighted transmissibility between the handle (a_{sRb}) and palm (a_{sPb}) signals for the bare hand must be between 0.95 and 1.05.

3.2 Constant velocity spectra testing procedure

For the purposes of this project, a third input spectrum was also used. This spectrum, hereafter referred to as F, is part of a proposed change to ISO 10819. The feasibility of this new spectrum is analyzed. The goal was to compare the F spectra to the current ISO defined spectra and determine what effect the F spectrum would have on the mean corrected transmissibility values for the three antivibration gloves. F spectrum is defined
as a constant velocity third octave band level of 0.01 m/s in the 16 – 1600 Hz frequency range. Figure 3.2 graphs the F spectra in relation to the ISO M and H spectra.

**Input Spectra Comparison**

![Graph showing Input Spectra Comparison](image)

**Figure 3.2 Input Spectra F, H, and M**

Acceleration spectrum levels are calculated from velocity band level by:

\[
A_{sl} = \sqrt{V_{bl}^2 / \Delta f * \omega}
\]

\(V_{bl}\) is the velocity band level (m/s). \(\Delta f\) is the third octave bandwidth about the third octave band center frequency. \(\omega\) is the third octave band center frequency (rad/sec).

The acceleration band level for spectrum F shown in Figure 3.2 is calculated by:

\[
A_{sl} = \sqrt{A_{sl}^2 / \Delta f}
\]
The tolerances for M and H spectra are as defined in ISO 10819 and were (+) 2 Db for the F spectra. There are no procedural differences with regard to performing the test for the F spectrum; however, there are small differences in the method of calculating mean corrected transmissibility.

3.2.1 Calculation of F spectrum data

The calculation of the mean corrected transmissibility of antivibration gloves is as follows:

Step 1: Measure the handle and palm raw third octave band acceleration values for 12 tests, 2 bare hand and 2 gloved hand tests for each of 3 test subjects.

Step 2: Divide the data into two groups, one set will contain the third octave band acceleration values from 16 – 400 Hz (FM spectra) and the other will contain third octave acceleration values from 100 – 1600 Hz (FH spectra). Each of the preceding steps will be repeated for the FM and FH spectra separately. The symbol s is used to denote spectra in the formulas.

Step 3: Calculate the ISO weighted acceleration values by multiplying the third octave band acceleration values by the ISO 5349 weighting curve value at that third octave band, squaring the result, adding the squared values for all third octave bands together, and taking the square root of the sum of the squares. In formula form:

\[
a_w = \sqrt{\sum (a_i * w_i)^2}
\]

\(a_i\) is the third octave band acceleration level (m/s^2) and \(w_i\) is the weighting value from Table 3.2 in the ith third octave band.
Step 4: Calculate the weighted linear transmissibility of the ISO weighted acceleration values for each test (palm acceleration divided by the handle). The formulas for these operations are:

$$TR_{sb} = \frac{a_{wsPb}}{a_{wsRb}}$$

$$TR_{sg} = \frac{a_{wsPg}}{a_{wsRg}}$$

Step 5: Average the two bare hand transmissibility values ($TR_{sb}$) together to obtain $TR_{sbavg}$ for each subject.

Step 6: The corrected transmissibility are calculated as follows:

$$TR_{s,j} = \frac{TR_{sg}}{TR_{sbavg,j}}$$

for the jth subject.

Step 7: The mean corrected glove transmissibility is found by averaging over the 3 test subjects (2 tests for each subject) for each spectra ($s$)

$$\overline{TR}_s = \sum_{j=1}^{6} TR_{s,j}$$

3.3 Adapter evaluation procedure

Various palm adapters for coupling the accelerometer to the hand were constructed to explore the effects of adapter geometry on bare hand tests and antivibration glove tests.

3.3.1 Adapter acceptability criterion

The effect of adapter shape on bare hand linear transmissibility was investigated. The input spectrum used for these tests was the F spectrum. Four test subjects performed two tests each. All other requirements and methods for performing the tests were the same as for performing the ISO standard bare hand tests (see Section 3.1.1). The criterion used to decide if an adapter was acceptable or not was a slightly modified version of the ISO 10819 test validity requirement. The linear transmissibility between the handle and palm
signals in each third octave band from 16-1600 Hz, averaged over the 8 tests (4 subjects, tests each), had to be between 0.95 and 1.05. for an adapter to pass.
CHAPTER 4

ADAPTER DESIGN

Adapters were designed with two main goals. The first was to increase test subject comfort when using the adapter. The second was to more closely fit the adapter to contour of the test subject hand. Several combinations of dimensions were tried, as well as some baseline adapters that met the ISO 10819 recommendations.

4.1 Design dimensions

The critical dimensions that were adjusted to produce the different adapters were the overall length, the radius along the length of the upper profile, the bottom cross-sectional radius, and the thickness measured at the centerline of the adapter. The ranges of the dimensions that were investigated are given in Table 4.1

Table 4.1 Design dimensions

<table>
<thead>
<tr>
<th>Adapter dimensions (millimeters)</th>
<th>Min</th>
<th>Max</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>28</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Bottom radius</td>
<td>19</td>
<td>22</td>
<td>3-flats</td>
</tr>
<tr>
<td>Upper radius</td>
<td>50</td>
<td>93</td>
<td>flat</td>
</tr>
<tr>
<td>Thickness</td>
<td>4.8</td>
<td>9.5</td>
<td></td>
</tr>
</tbody>
</table>
The special cases listed in Table 4.1 were also tried. These cases included completely flat upper profiles and flat bottom sections designed to maintain 2 lines of contact while keeping the accelerometer a short distance above the handle surface in combination with other standard dimensions.

4.2 Adapter geometry

30 adapters were manufactured and tested. Brief descriptions of each adapter’s shape and date of manufacture are given in Table 4.2. Detailed drawings and renderings of the adapters are available in Appendix 1. The adapter numbering system was created as a means of distinguishing the adapters from each other and does not signify any ranking or order.
Table 4. 2 Adapter geometries

<table>
<thead>
<tr>
<th>Adapter number</th>
<th>Upper Profile</th>
<th>Bottom Profile</th>
<th>Accelerometer</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>80 mm radius, Hand-made</td>
<td>Approx 19 mm radius, Hand-made</td>
<td>top</td>
<td>N/A</td>
</tr>
<tr>
<td>02</td>
<td>80 mm radius, 70 mm length</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/24/2004</td>
</tr>
<tr>
<td>03</td>
<td>Flat, 70 mm length</td>
<td>19 mm radius</td>
<td>top</td>
<td>4/2/2004</td>
</tr>
<tr>
<td>04</td>
<td>Flat, 70 mm length</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/30/2004</td>
</tr>
<tr>
<td>05</td>
<td>Flat, 70 mm length thin</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/30/2004</td>
</tr>
<tr>
<td>06</td>
<td>80 mm radius, 70 mm length</td>
<td>22 mm radius</td>
<td>top</td>
<td>N/A</td>
</tr>
<tr>
<td>07</td>
<td>Flat, 50 mm length</td>
<td>3 flats</td>
<td>top</td>
<td>4/9/2004</td>
</tr>
<tr>
<td>08</td>
<td>Flat, 50 mm length</td>
<td>3 flats</td>
<td>top</td>
<td>4/6/2004</td>
</tr>
<tr>
<td>09</td>
<td>Flat, 50 mm length</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/31/2004</td>
</tr>
<tr>
<td>10</td>
<td>Flat, 50 mm length thin</td>
<td>19 mm radius</td>
<td>top</td>
<td>4/2/2004</td>
</tr>
<tr>
<td>11</td>
<td>Flat, 50 mm length</td>
<td>19 mm radius</td>
<td>top</td>
<td>4/2/2004</td>
</tr>
<tr>
<td>12</td>
<td>50 mm radius</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/25/2004</td>
</tr>
<tr>
<td>13</td>
<td>53 mm radius</td>
<td>22 mm radius</td>
<td>top</td>
<td>3/19/2004</td>
</tr>
<tr>
<td>14</td>
<td>53 mm radius, 57.5 mm length</td>
<td>22 mm radius</td>
<td>bottom</td>
<td>3/12/2004</td>
</tr>
<tr>
<td>15</td>
<td>80 mm radius, 70 mm length</td>
<td>22 mm radius</td>
<td>bottom</td>
<td>4/12/2004</td>
</tr>
<tr>
<td>16</td>
<td>80 mm radius, 70 mm length</td>
<td>22 mm radius</td>
<td>bottom</td>
<td>4/12/2004</td>
</tr>
<tr>
<td>17</td>
<td>80 mm radius, 70 mm length</td>
<td>22 mm radius</td>
<td>bottom</td>
<td>N/A</td>
</tr>
<tr>
<td>18</td>
<td>80 mm radius, 66 mm length</td>
<td>22 mm radius</td>
<td>bottom</td>
<td>N/A</td>
</tr>
<tr>
<td>19</td>
<td>80 mm radius, 66 mm length</td>
<td>19 mm radius</td>
<td>bottom</td>
<td>4/12/2004</td>
</tr>
<tr>
<td>20</td>
<td>53 mm radius, 50 mm length</td>
<td>19 mm radius</td>
<td>top</td>
<td>4/14/2004</td>
</tr>
</tbody>
</table>
The 30 adapters listed above were manufactured in the UNLV machine shop. The material used was an acrylic, part number 8560K361 available from McMaster-Carr. This material was easiest to work with and the least expensive. Alternate materials (oak, Lexan, and aluminum) were also considered. The aluminum adapters were too heavy and were discarded for that reason. The oak adapters had the tendency of stripping their mounting threads during machining, and were discontinued for this reason as well as poor durability. The Lexan adapters turned out much the same as Plexiglas, but required higher machining time and raw material costs.

The method of manufacture began with cutting the raw stock into 2” X 4” blocks, and hand or CNC machine milling their edges square. Next, the stock was mounted in a vice inside the CNC machine, which was zeroed off the bottom corner of the material/vice.
The bottom profile, two fixture/mounting holes, and a small hole (1/16") for releasing the accelerometer, were machined into the stock. The two mounting holes were hand-tapped with 10-24 threads. If the accelerometer was to be bottom mounted, the accelerometer track was machined next. The stock was then turned over and bolted to a fixture with a top profile that was the mirror image of the bottom adapter surface. The upper profile of the adapter (and accelerometer track if top mounted) was then machined. Hand sanding of the outer edge was usually necessary to smooth the transition between upper and lower surface and to reduce any sharp edges on the accelerometer track.

4.3.1 Exceptions

Adapters 01, 05, 10, 16, 22, and 28, are not included in Appendix 1. Adapter 01 was hand made by a shop technician and irregularities in its shape cannot be accurately represented. Adapter 05 was machined too thin, and replaced by adapter 04. Adapter 10 was a too thin version of 11. Adapter 16 was made too thick. Adapter 22 was machined with a flat section over the accelerometer track. Adapter 28 was a 3-flat bottom profile that did not make contact between the handle and the side flats. As a consequence of the errors mentioned above, adapter 05 was only tested for linear transmissibility using 2 test subjects. Adapters 16 and 22 were tested with three test subjects. Adapter 28 was never tested and discarded. Linear transmissibility data was collected for these adapters as a curiosity, but since their geometries are not reproducible, they were discarded from final evaluations.
5.1 Adapter testing results

The adapters were evaluated in two stages. The first stage determined whether or not the adapters were acceptable, according to the criterion outlined in Section 3.3.1. The second evaluation investigated the effect of the adapter shape on the mean transmissibility values, calculated for the M and H spectra.

5.1.1 Bare hand transmissibility

The results of the bare hand linear transmissibility tests are plotted in Appendix 2. The graphs depict the third octave band linear transmissibility values averaged over 8 tests (4 subjects, 2 tests each). Exceptions to the number of tests used to generate the plot have been previously identified in Section 4.3.1. The error bars are ± one standard deviation. All of this data was gathered after export from the Pulse system using Perl script 1 (see Appendix 3). The calculations and plots were done with Excel.

5.1.1.1 Category 1 passed adapters

The results of the bare hand tests can be divided into 4 groups. The first group is adapters that passed the acceptability criteria, which was that the linear transmissibility between the palm and handle in each third octave band (averaged over 4 test subjects)
was between 0.95 and 1.05. Adapters 01, 02, 03, 15, 25, 29, and 30 fall into this category. Figure 5.1 is a representative plot of these adapters.

![Figure 5.1 Category 1 adapters (representative plot)](image)

The standard deviations of these adapters often fall outside of the acceptable range in the upper and lower third octave frequency bands. This is usually due to one test subject’s results, but not the same subject consistently. Variability in test results is a common difficulty in this type of testing. The averaging of the tests is an attempt to compensate for this effect.

In general, adapters that passed had some common traits. Their overall length covered roughly 70-80% of the width of the palm. The upper profile of the category 1 adapters had no more curvature than ISO 10819 recommends, in fact adapter 03 was flat-topped. The exception is adapter 29, which has a flat section cut into the larger radius. The majority of category 1 adapters also had a 22 mm bottom radius. The exception is again adapter 03 which had a 19mm bottom radius. Adapters that were exactly similar to adapter 03, but had the 22 mm radius did not pass.
5.1.1.2 Category 2 low frequency fail adapters

The second grouping consists of adapters that failed in the lower third octave frequency bands. Adapters 04, 05, 09, 12, 14, 16, and 17 belong to this category. A representative plot is shown in Figure 5.2.

![Adaptor 04](image)

Figure 5.2 Category 2 adapters (representative plot)

As can be seen in Figure 5.2, these adapters register significant amplification in the 16-31.5 Hz third octave bands, but are usually passable in the other octave bands.

5.1.1.3 Category 3 high frequency fail adapters

The third subset contains adapters that exhibit amplification in the upper third octave band frequencies. The amplification is normally present above 1000 Hz. Adapters 07, 10, 11, 20, 22, 23, 24, 26, and 27 are in this category. Figure 5.3 is a typical plot of this type of adapter.
5.1.1.4 Category 4 combination frequency fail adapters

The final category contains the rest of the adapters, namely 06, 08, 13, 18, 19, and 21. These adapters amplified the accelerometer signal in more than one frequency range. Often the 31.5 – 50 Hz range was amplified as well as bands above 1000 Hz. In some cases, there was significant reduction above 1250 Hz, as is the case for adapter 13 (see Appendix 2). Figure 5.4 is a decent representation of the overall trend of this category.

![Figure 5.3 Category 3 adapters (representative plot)](image)

![Figure 5.4 Category 4 adapters (representative plot)](image)
5.2 Mean corrected transmissibility tests.

The next set of tests performed were standard ISO 10819 glove transmissibility tests, according to the protocols specified in Section 3.1. The data gathering and calculation was done with Perl script 2 for the M and H spectra and Perl script 3 for the F, FH, and FM spectra.

5.2.1 Example of calculation of FM and FH spectra data

For purposes of clarity, a numerical example of how to calculate the corrected transmissibility for one subject, one adapter is shown for both the FM and FH spectra. The starting data set is shown in Table EX.1. The first column in Table Ex.1 is the third octave band center frequency. The next column represents the ISO 5349 weighting curve. The bare hand columns (p1, h1, p2, and h2) represent the measured third octave band acceleration levels for the bare hand palm adapters (p1, p2) and the handle (h1, h2) for the two tests. The corresponding data set to be used for the FM spectrum is given in Table EX.2
<table>
<thead>
<tr>
<th>Freq</th>
<th>ISO 5349</th>
<th>Bare hand p1</th>
<th>Bare hand h1</th>
<th>Bare hand p2</th>
<th>Bare hand h2</th>
<th>Gloved hand p1</th>
<th>Gloved hand h1</th>
<th>Gloved hand p2</th>
<th>Gloved hand h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hz</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
</tr>
<tr>
<td>16</td>
<td>0.896</td>
<td>0.97</td>
<td>0.94</td>
<td>0.95</td>
<td>0.94</td>
<td>0.89</td>
<td>0.87</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>20</td>
<td>0.782</td>
<td>1.36</td>
<td>1.31</td>
<td>1.28</td>
<td>1.24</td>
<td>1.31</td>
<td>1.28</td>
<td>1.29</td>
<td>1.27</td>
</tr>
<tr>
<td>25</td>
<td>0.647</td>
<td>1.69</td>
<td>1.61</td>
<td>1.73</td>
<td>1.64</td>
<td>1.68</td>
<td>1.66</td>
<td>1.66</td>
<td>1.63</td>
</tr>
<tr>
<td>31.5</td>
<td>0.519</td>
<td>2.02</td>
<td>1.93</td>
<td>2.14</td>
<td>2.00</td>
<td>2.06</td>
<td>2.12</td>
<td>1.87</td>
<td>1.94</td>
</tr>
<tr>
<td>40</td>
<td>0.411</td>
<td>2.54</td>
<td>2.46</td>
<td>2.60</td>
<td>2.48</td>
<td>2.07</td>
<td>2.38</td>
<td>2.01</td>
<td>2.35</td>
</tr>
<tr>
<td>50</td>
<td>0.324</td>
<td>3.15</td>
<td>3.11</td>
<td>3.10</td>
<td>3.02</td>
<td>2.68</td>
<td>3.23</td>
<td>2.62</td>
<td>3.18</td>
</tr>
<tr>
<td>63</td>
<td>0.256</td>
<td>4.15</td>
<td>4.13</td>
<td>3.93</td>
<td>3.87</td>
<td>3.44</td>
<td>4.16</td>
<td>3.21</td>
<td>4.09</td>
</tr>
<tr>
<td>80</td>
<td>0.202</td>
<td>4.98</td>
<td>5.01</td>
<td>5.13</td>
<td>5.16</td>
<td>3.78</td>
<td>4.99</td>
<td>3.90</td>
<td>5.16</td>
</tr>
<tr>
<td>100</td>
<td>0.16</td>
<td>6.34</td>
<td>6.38</td>
<td>6.27</td>
<td>6.32</td>
<td>4.87</td>
<td>6.17</td>
<td>5.27</td>
<td>6.55</td>
</tr>
<tr>
<td>125</td>
<td>0.127</td>
<td>7.82</td>
<td>7.84</td>
<td>8.04</td>
<td>8.09</td>
<td>6.52</td>
<td>7.88</td>
<td>6.60</td>
<td>8.06</td>
</tr>
<tr>
<td>160</td>
<td>0.101</td>
<td>10.35</td>
<td>10.36</td>
<td>10.02</td>
<td>10.06</td>
<td>8.72</td>
<td>10.01</td>
<td>8.53</td>
<td>10.07</td>
</tr>
<tr>
<td>200</td>
<td>0.0799</td>
<td>12.58</td>
<td>12.55</td>
<td>12.68</td>
<td>12.66</td>
<td>10.99</td>
<td>12.35</td>
<td>10.70</td>
<td>12.61</td>
</tr>
<tr>
<td>250</td>
<td>0.0634</td>
<td>15.83</td>
<td>15.73</td>
<td>16.17</td>
<td>16.06</td>
<td>14.05</td>
<td>15.92</td>
<td>14.01</td>
<td>16.07</td>
</tr>
<tr>
<td>315</td>
<td>0.0503</td>
<td>20.29</td>
<td>20.09</td>
<td>20.15</td>
<td>19.92</td>
<td>18.04</td>
<td>20.09</td>
<td>17.60</td>
<td>19.91</td>
</tr>
<tr>
<td>400</td>
<td>0.0398</td>
<td>25.60</td>
<td>25.31</td>
<td>25.39</td>
<td>25.10</td>
<td>21.72</td>
<td>25.11</td>
<td>20.95</td>
<td>25.14</td>
</tr>
<tr>
<td>500</td>
<td>0.0314</td>
<td>32.47</td>
<td>32.10</td>
<td>32.10</td>
<td>31.80</td>
<td>22.21</td>
<td>31.73</td>
<td>21.01</td>
<td>31.66</td>
</tr>
<tr>
<td>630</td>
<td>0.0245</td>
<td>40.67</td>
<td>40.00</td>
<td>40.40</td>
<td>39.84</td>
<td>20.12</td>
<td>39.76</td>
<td>20.72</td>
<td>39.85</td>
</tr>
<tr>
<td>800</td>
<td>0.0186</td>
<td>51.49</td>
<td>50.22</td>
<td>50.46</td>
<td>50.29</td>
<td>22.51</td>
<td>50.06</td>
<td>23.16</td>
<td>49.95</td>
</tr>
<tr>
<td>1000</td>
<td>0.0135</td>
<td>64.88</td>
<td>63.43</td>
<td>59.70</td>
<td>62.86</td>
<td>28.40</td>
<td>62.63</td>
<td>28.35</td>
<td>63.56</td>
</tr>
<tr>
<td>1250</td>
<td>0.00894</td>
<td>79.60</td>
<td>79.76</td>
<td>72.72</td>
<td>78.72</td>
<td>30.18</td>
<td>78.61</td>
<td>28.98</td>
<td>79.11</td>
</tr>
<tr>
<td>1600</td>
<td>0.00538</td>
<td>70.43</td>
<td>72.12</td>
<td>67.94</td>
<td>72.49</td>
<td>21.91</td>
<td>72.26</td>
<td>21.14</td>
<td>71.43</td>
</tr>
</tbody>
</table>
Table Ex. 2 FM spectra data

<table>
<thead>
<tr>
<th>Freq (Hz)</th>
<th>ISO 5349</th>
<th>Bare hand p1</th>
<th>Bare hand h1</th>
<th>Bare hand p2</th>
<th>Bare hand h2</th>
<th>Gloved hand p1</th>
<th>Gloved hand h1</th>
<th>Gloved hand p2</th>
<th>Gloved hand h2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
<td>m/s²</td>
</tr>
<tr>
<td>16</td>
<td>0.896</td>
<td>0.97</td>
<td>0.94</td>
<td>0.95</td>
<td>0.94</td>
<td>0.89</td>
<td>0.87</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>20</td>
<td>0.782</td>
<td>1.36</td>
<td>1.31</td>
<td>1.28</td>
<td>1.24</td>
<td>1.31</td>
<td>1.28</td>
<td>1.29</td>
<td>1.27</td>
</tr>
<tr>
<td>25</td>
<td>0.647</td>
<td>1.69</td>
<td>1.61</td>
<td>1.73</td>
<td>1.64</td>
<td>1.68</td>
<td>1.66</td>
<td>1.66</td>
<td>1.63</td>
</tr>
<tr>
<td>31.5</td>
<td>0.519</td>
<td>2.02</td>
<td>1.93</td>
<td>2.14</td>
<td>2.00</td>
<td>2.06</td>
<td>2.12</td>
<td>1.87</td>
<td>1.94</td>
</tr>
<tr>
<td>40</td>
<td>0.411</td>
<td>2.54</td>
<td>2.46</td>
<td>2.60</td>
<td>2.48</td>
<td>2.07</td>
<td>2.38</td>
<td>2.01</td>
<td>2.35</td>
</tr>
<tr>
<td>50</td>
<td>0.324</td>
<td>3.15</td>
<td>3.11</td>
<td>3.10</td>
<td>3.02</td>
<td>2.68</td>
<td>3.23</td>
<td>2.62</td>
<td>3.18</td>
</tr>
<tr>
<td>63</td>
<td>0.256</td>
<td>4.15</td>
<td>4.13</td>
<td>3.93</td>
<td>3.87</td>
<td>3.44</td>
<td>4.16</td>
<td>3.21</td>
<td>4.09</td>
</tr>
<tr>
<td>80</td>
<td>0.202</td>
<td>4.98</td>
<td>5.01</td>
<td>5.13</td>
<td>5.16</td>
<td>3.78</td>
<td>4.99</td>
<td>3.90</td>
<td>5.16</td>
</tr>
<tr>
<td>100</td>
<td>0.16</td>
<td>6.34</td>
<td>6.38</td>
<td>6.27</td>
<td>6.32</td>
<td>4.87</td>
<td>6.17</td>
<td>5.27</td>
<td>6.55</td>
</tr>
<tr>
<td>125</td>
<td>0.127</td>
<td>7.82</td>
<td>7.84</td>
<td>8.04</td>
<td>8.09</td>
<td>6.52</td>
<td>7.88</td>
<td>6.60</td>
<td>8.06</td>
</tr>
<tr>
<td>160</td>
<td>0.101</td>
<td>10.35</td>
<td>10.36</td>
<td>10.02</td>
<td>10.06</td>
<td>8.72</td>
<td>10.01</td>
<td>8.53</td>
<td>10.07</td>
</tr>
<tr>
<td>200</td>
<td>0.0799</td>
<td>12.58</td>
<td>12.55</td>
<td>12.68</td>
<td>12.66</td>
<td>10.99</td>
<td>12.35</td>
<td>12.70</td>
<td>12.61</td>
</tr>
<tr>
<td>250</td>
<td>0.0634</td>
<td>15.83</td>
<td>15.73</td>
<td>16.17</td>
<td>16.06</td>
<td>14.05</td>
<td>15.92</td>
<td>14.01</td>
<td>16.07</td>
</tr>
<tr>
<td>315</td>
<td>0.0503</td>
<td>20.29</td>
<td>20.09</td>
<td>20.15</td>
<td>19.92</td>
<td>18.04</td>
<td>20.09</td>
<td>17.60</td>
<td>19.91</td>
</tr>
<tr>
<td>400</td>
<td>0.0398</td>
<td>25.60</td>
<td>25.31</td>
<td>25.39</td>
<td>25.10</td>
<td>21.72</td>
<td>25.11</td>
<td>20.95</td>
<td>25.14</td>
</tr>
</tbody>
</table>

The ISO 5349 weighting curve is applied to each column of acceleration data and that number is squared. The result is shown in Table Ex.3. The values below the data represent several operations. The first row (ISO) is the square root of the sum of the column above it. This represents the ISO weighted acceleration values for each signal. (TRsb) and (TRsg) are bare hand and glove transmissibility values, obtained by dividing the TR value their respective columns by that in the following column. The bare hand (TRsb) values are then averaged (TRsb avg). (TRs,j) is the ISO weighted glove transmissibility for each test, found by dividing (TRsg) by (TRsb avg). The final step

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
(TRs,j avg) is to average all the (TRs,j) values together. The exercise is repeated for the
FH spectra in tables EX.4 and EX.5.

Table Ex. 3 FM data ISO weighted and manipulated

<table>
<thead>
<tr>
<th>Freq</th>
<th>Bare hand p1</th>
<th>Bare hand h1</th>
<th>Bare hand p2</th>
<th>Bare hand h2</th>
<th>Gloved hand p1</th>
<th>Gloved hand h1</th>
<th>Gloved hand p2</th>
<th>Gloved hand h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hz</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
<td>(m/s^2)</td>
</tr>
<tr>
<td>16</td>
<td>0.75</td>
<td>0.71</td>
<td>0.72</td>
<td>0.71</td>
<td>0.63</td>
<td>0.61</td>
<td>0.58</td>
<td>0.58</td>
</tr>
<tr>
<td>20</td>
<td>1.13</td>
<td>1.04</td>
<td>1.00</td>
<td>0.94</td>
<td>1.05</td>
<td>1.01</td>
<td>1.01</td>
<td>0.98</td>
</tr>
<tr>
<td>25</td>
<td>1.20</td>
<td>1.09</td>
<td>1.26</td>
<td>1.12</td>
<td>1.18</td>
<td>1.15</td>
<td>1.15</td>
<td>1.11</td>
</tr>
<tr>
<td>32</td>
<td>1.10</td>
<td>1.00</td>
<td>1.23</td>
<td>1.08</td>
<td>1.15</td>
<td>1.21</td>
<td>0.94</td>
<td>1.01</td>
</tr>
<tr>
<td>40</td>
<td>1.09</td>
<td>1.02</td>
<td>1.14</td>
<td>1.04</td>
<td>0.72</td>
<td>0.96</td>
<td>0.69</td>
<td>0.93</td>
</tr>
<tr>
<td>50</td>
<td>1.04</td>
<td>1.02</td>
<td>1.01</td>
<td>0.96</td>
<td>0.76</td>
<td>1.09</td>
<td>0.72</td>
<td>1.06</td>
</tr>
<tr>
<td>63</td>
<td>1.13</td>
<td>1.12</td>
<td>1.01</td>
<td>0.98</td>
<td>0.78</td>
<td>1.13</td>
<td>0.67</td>
<td>1.09</td>
</tr>
<tr>
<td>80</td>
<td>1.01</td>
<td>1.03</td>
<td>1.07</td>
<td>1.09</td>
<td>0.58</td>
<td>1.02</td>
<td>0.62</td>
<td>1.08</td>
</tr>
<tr>
<td>100</td>
<td>1.03</td>
<td>1.04</td>
<td>1.01</td>
<td>1.02</td>
<td>0.61</td>
<td>0.98</td>
<td>0.71</td>
<td>1.10</td>
</tr>
<tr>
<td>125</td>
<td>0.99</td>
<td>0.99</td>
<td>1.04</td>
<td>1.06</td>
<td>0.69</td>
<td>1.00</td>
<td>0.70</td>
<td>1.05</td>
</tr>
<tr>
<td>160</td>
<td>1.09</td>
<td>1.09</td>
<td>1.02</td>
<td>1.03</td>
<td>0.78</td>
<td>1.02</td>
<td>0.74</td>
<td>1.03</td>
</tr>
<tr>
<td>200</td>
<td>1.01</td>
<td>1.01</td>
<td>1.03</td>
<td>1.02</td>
<td>0.77</td>
<td>0.97</td>
<td>0.73</td>
<td>1.02</td>
</tr>
<tr>
<td>250</td>
<td>1.01</td>
<td>0.99</td>
<td>1.05</td>
<td>1.04</td>
<td>0.79</td>
<td>1.02</td>
<td>0.79</td>
<td>1.04</td>
</tr>
<tr>
<td>315</td>
<td>1.04</td>
<td>1.02</td>
<td>1.03</td>
<td>1.00</td>
<td>0.82</td>
<td>1.02</td>
<td>0.78</td>
<td>1.00</td>
</tr>
<tr>
<td>400</td>
<td>1.04</td>
<td>1.01</td>
<td>1.02</td>
<td>1.00</td>
<td>0.75</td>
<td>1.00</td>
<td>0.70</td>
<td>1.00</td>
</tr>
<tr>
<td>ISO</td>
<td>3.96</td>
<td>3.90</td>
<td>3.96</td>
<td>3.88</td>
<td>3.47</td>
<td>3.90</td>
<td>3.40</td>
<td>3.88</td>
</tr>
<tr>
<td>TRsb</td>
<td>1.01</td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRsg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.89</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRsb avg</td>
<td>1.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRs,j</td>
<td>0.88</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRs,j avg</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
### Table Ex. 4 FH spectra raw data

<table>
<thead>
<tr>
<th>Freq (Hz)</th>
<th>ISO 5349</th>
<th>Bare hand p1</th>
<th>Bare hand h1</th>
<th>Bare hand p2</th>
<th>Bare hand h2</th>
<th>Gloved hand p1</th>
<th>Gloved hand h1</th>
<th>Gloved hand p2</th>
<th>Gloved hand h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.16</td>
<td>6.34</td>
<td>6.38</td>
<td>6.27</td>
<td>6.32</td>
<td>4.87</td>
<td>6.17</td>
<td>5.27</td>
<td>6.55</td>
</tr>
<tr>
<td>125</td>
<td>0.13</td>
<td>7.82</td>
<td>7.84</td>
<td>8.04</td>
<td>8.09</td>
<td>6.52</td>
<td>7.88</td>
<td>6.60</td>
<td>8.06</td>
</tr>
<tr>
<td>160</td>
<td>0.10</td>
<td>10.35</td>
<td>10.36</td>
<td>10.02</td>
<td>10.06</td>
<td>8.72</td>
<td>10.01</td>
<td>8.53</td>
<td>10.07</td>
</tr>
<tr>
<td>200</td>
<td>0.08</td>
<td>12.58</td>
<td>12.55</td>
<td>12.68</td>
<td>12.66</td>
<td>10.99</td>
<td>12.35</td>
<td>10.70</td>
<td>12.61</td>
</tr>
<tr>
<td>250</td>
<td>0.06</td>
<td>15.83</td>
<td>15.73</td>
<td>16.17</td>
<td>16.06</td>
<td>14.05</td>
<td>15.92</td>
<td>14.01</td>
<td>16.07</td>
</tr>
<tr>
<td>315</td>
<td>0.05</td>
<td>20.29</td>
<td>20.09</td>
<td>20.15</td>
<td>19.92</td>
<td>18.04</td>
<td>20.09</td>
<td>17.60</td>
<td>19.91</td>
</tr>
<tr>
<td>400</td>
<td>0.04</td>
<td>25.60</td>
<td>25.31</td>
<td>25.39</td>
<td>25.10</td>
<td>21.72</td>
<td>25.11</td>
<td>20.95</td>
<td>25.14</td>
</tr>
<tr>
<td>500</td>
<td>0.03</td>
<td>32.47</td>
<td>32.10</td>
<td>32.10</td>
<td>31.80</td>
<td>22.21</td>
<td>31.73</td>
<td>21.01</td>
<td>31.66</td>
</tr>
<tr>
<td>630</td>
<td>0.02</td>
<td>40.67</td>
<td>40.00</td>
<td>40.40</td>
<td>39.84</td>
<td>20.12</td>
<td>39.76</td>
<td>20.72</td>
<td>39.85</td>
</tr>
<tr>
<td>800</td>
<td>0.02</td>
<td>51.49</td>
<td>50.22</td>
<td>50.46</td>
<td>50.29</td>
<td>22.51</td>
<td>50.06</td>
<td>23.16</td>
<td>49.95</td>
</tr>
<tr>
<td>1000</td>
<td>0.01</td>
<td>64.88</td>
<td>63.43</td>
<td>59.70</td>
<td>62.86</td>
<td>28.40</td>
<td>62.63</td>
<td>28.35</td>
<td>63.56</td>
</tr>
<tr>
<td>1250</td>
<td>0.01</td>
<td>79.60</td>
<td>79.76</td>
<td>72.72</td>
<td>78.72</td>
<td>30.18</td>
<td>78.61</td>
<td>28.98</td>
<td>79.11</td>
</tr>
<tr>
<td>1600</td>
<td>0.01</td>
<td>70.43</td>
<td>72.12</td>
<td>67.94</td>
<td>72.49</td>
<td>21.91</td>
<td>72.26</td>
<td>21.14</td>
<td>71.43</td>
</tr>
</tbody>
</table>

### Table Ex. 5 FH data ISO weighted and manipulated

<table>
<thead>
<tr>
<th>Freq (Hz)</th>
<th>Bare hand p1</th>
<th>Bare hand h1</th>
<th>Bare hand p2</th>
<th>Bare hand h2</th>
<th>Gloved hand p1</th>
<th>Gloved hand h1</th>
<th>Gloved hand p2</th>
<th>Gloved hand h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.03</td>
<td>1.04</td>
<td>1.01</td>
<td>1.02</td>
<td>0.61</td>
<td>0.98</td>
<td>0.71</td>
<td>1.10</td>
</tr>
<tr>
<td>125</td>
<td>0.99</td>
<td>0.99</td>
<td>1.04</td>
<td>1.06</td>
<td>0.69</td>
<td>1.00</td>
<td>0.70</td>
<td>1.05</td>
</tr>
<tr>
<td>160</td>
<td>1.09</td>
<td>1.09</td>
<td>1.02</td>
<td>1.03</td>
<td>0.78</td>
<td>1.02</td>
<td>0.74</td>
<td>1.03</td>
</tr>
<tr>
<td>200</td>
<td>1.01</td>
<td>1.01</td>
<td>1.03</td>
<td>1.02</td>
<td>0.77</td>
<td>0.97</td>
<td>0.73</td>
<td>1.02</td>
</tr>
<tr>
<td>250</td>
<td>1.01</td>
<td>0.99</td>
<td>1.05</td>
<td>1.04</td>
<td>0.79</td>
<td>1.02</td>
<td>0.79</td>
<td>1.04</td>
</tr>
<tr>
<td>315</td>
<td>1.04</td>
<td>1.02</td>
<td>1.03</td>
<td>1.00</td>
<td>0.82</td>
<td>1.02</td>
<td>0.78</td>
<td>1.00</td>
</tr>
<tr>
<td>400</td>
<td>1.04</td>
<td>1.01</td>
<td>1.02</td>
<td>1.00</td>
<td>0.75</td>
<td>1.00</td>
<td>0.70</td>
<td>1.00</td>
</tr>
<tr>
<td>500</td>
<td>1.04</td>
<td>1.02</td>
<td>1.02</td>
<td>1.00</td>
<td>0.49</td>
<td>0.99</td>
<td>0.44</td>
<td>0.99</td>
</tr>
<tr>
<td>630</td>
<td>0.99</td>
<td>0.96</td>
<td>0.98</td>
<td>0.95</td>
<td>0.24</td>
<td>0.95</td>
<td>0.26</td>
<td>0.95</td>
</tr>
<tr>
<td>800</td>
<td>0.92</td>
<td>0.87</td>
<td>0.88</td>
<td>0.88</td>
<td>0.18</td>
<td>0.87</td>
<td>0.19</td>
<td>0.86</td>
</tr>
<tr>
<td>1000</td>
<td>0.77</td>
<td>0.73</td>
<td>0.65</td>
<td>0.72</td>
<td>0.15</td>
<td>0.71</td>
<td>0.15</td>
<td>0.74</td>
</tr>
</tbody>
</table>
5.2.2 Accepted adapter comparison

Four “good” adapters were chosen from category 1, adapters 02, 03, 29, and 30. These adapters were tested for all spectra, using ISO 10819 procedure. Table 5.1 shows a comparison between the mean transmissibility values calculated for each adapter/glove combination. Complete tables for each interim transmissibility value used to calculate the mean transmissibility values are given in Appendix 4. Table 5.1 is organized by input spectra.

The results show that for all gloves and input spectra, the mean corrected transmissibility values do not vary greatly between the category 1 adapters. The largest variation is found in the H spectra for glove 3, which ranges from 0.59 to 0.51. A range of 0.08 in this type of measurement is somewhat significant, but it is isolated to one adapter in one particular spectrum. Variations like the one present in the H spectrum data are common in this type of measurement. However, closer inspection of the H spectrum corrected glove data for subject 2 (see Appendix 4) reveals that the adapter 02 data is uncharacteristic of the other tests for this subject, and therefore can be discounted. If this...
number is ignored, the range of variation in mean transmissibility values is closer to 0.02, which is an acceptable level of error.

Table 5.1 Mean corrected transmissibility (passed adapters)

<table>
<thead>
<tr>
<th>H spectra</th>
<th></th>
<th></th>
<th>FH spectra</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>glove 1</td>
<td>glove 2</td>
<td>glove 3</td>
<td>glove 1</td>
<td>glove 2</td>
<td>glove 3</td>
<td></td>
</tr>
<tr>
<td>A02</td>
<td>0.80</td>
<td>0.73</td>
<td>0.59</td>
<td>A02</td>
<td>0.75</td>
<td>0.64</td>
</tr>
<tr>
<td>A03</td>
<td>0.81</td>
<td>0.67</td>
<td>0.51</td>
<td>A03</td>
<td>0.72</td>
<td>0.63</td>
</tr>
<tr>
<td>A29</td>
<td>0.83</td>
<td>0.67</td>
<td>0.51</td>
<td>A29</td>
<td>0.73</td>
<td>0.60</td>
</tr>
<tr>
<td>A30</td>
<td>0.80</td>
<td>0.70</td>
<td>0.53</td>
<td>A30</td>
<td>0.75</td>
<td>0.64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M spectra</th>
<th></th>
<th></th>
<th>FM spectra</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>glove 1</td>
<td>glove 2</td>
<td>glove 3</td>
<td>glove 1</td>
<td>glove 2</td>
<td>glove 3</td>
<td></td>
</tr>
<tr>
<td>A02</td>
<td>0.86</td>
<td>0.80</td>
<td>0.64</td>
<td>A02</td>
<td>0.87</td>
<td>0.82</td>
</tr>
<tr>
<td>A03</td>
<td>0.87</td>
<td>0.79</td>
<td>0.63</td>
<td>A03</td>
<td>0.85</td>
<td>0.80</td>
</tr>
<tr>
<td>A29</td>
<td>0.86</td>
<td>0.80</td>
<td>0.66</td>
<td>A29</td>
<td>0.87</td>
<td>0.79</td>
</tr>
<tr>
<td>A30</td>
<td>0.87</td>
<td>0.79</td>
<td>0.64</td>
<td>A30</td>
<td>0.88</td>
<td>0.81</td>
</tr>
</tbody>
</table>

There is no one adapter that measures the highest or lowest values consistently for all spectra. The small variation of the mean transmissibility numbers appears to be well disbursed amongst the adapters. The data suggest that if an adapter is category 1, there will be negligible variation in the mean corrected transmissibility value. The mean corrected transmissibility number is used to determine the acceptability of an antivibration glove, so it can be said that a properly selected adapter will not affect the outcome of the evaluation.
5.2.3 Failed adapter comparison

Two adapters that failed the acceptability criterion were also tested. Adapter 19 failed in the 40Hz third octave band and in the 1600 Hz third octave band. Adapter 20 failed in the 1250 and 1600 Hz third octave bands. The mean corrected transmissibility values are also reported in Appendix 4 and repeated in Table 5.2.

Table 5.2 Mean corrected transmissibility (failed adapters)

<table>
<thead>
<tr>
<th>H spectra</th>
<th>Glove 1</th>
<th>glove2</th>
<th>glove3</th>
<th>FH spectra</th>
<th>Glove 1</th>
<th>glove2</th>
<th>glove3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A19</td>
<td>0.83</td>
<td>0.70</td>
<td>0.55</td>
<td>A19</td>
<td>0.75</td>
<td>0.66</td>
<td>0.51</td>
</tr>
<tr>
<td>A20</td>
<td>0.81</td>
<td>0.67</td>
<td>0.54</td>
<td>A20</td>
<td>0.75</td>
<td>0.61</td>
<td>0.52</td>
</tr>
<tr>
<td>M spectra</td>
<td>Glove 1</td>
<td>glove2</td>
<td>glove3</td>
<td>FM spectra</td>
<td>Glove 1</td>
<td>glove2</td>
<td>glove3</td>
</tr>
<tr>
<td>A19</td>
<td>0.86</td>
<td>0.79</td>
<td>0.62</td>
<td>A19</td>
<td>0.88</td>
<td>0.83</td>
<td>0.71</td>
</tr>
<tr>
<td>A20</td>
<td>0.84</td>
<td>0.76</td>
<td>0.66</td>
<td>A20</td>
<td>0.86</td>
<td>0.78</td>
<td>0.72</td>
</tr>
</tbody>
</table>

The calculated values lie within the range of the other adapters for all input spectra. The data confirm that even though the adapters amplify the bare hand acceleration signal in the palm adapter, the effect is negligible when the glove transmissibility values are corrected for the bare hand. This is likely due to the fact that the adapters did not resoundingly fail the acceptability requirement, mostly the failing values were in higher frequency third octave band. The higher frequency third octave bands are increasingly weighted out by the ISO 5349 curve, thus their effect is greatly diminished. More testing is required to fully define the limit of bare hand transmissibility amplification that will not significantly affect mean corrected transmissibility values.
5.3 Input spectra comparisons

Table 5.1 can be analyzed with respect to input spectra. Specifically, a comparison can be made between the H and FH spectra data and the M and FM spectra data. The data are not as clearly similar as was the case looking at adapters with respect to each other.

5.3.1 FH and H spectra results

When comparing the H and FH data the mean transmissibility number, as a trend, is reported somewhat lower for all gloves when the FH spectrum input is used than when H spectrum input is used. The range of these differences varies glove to glove. Glove 1 has measured values that range from 0.05-0.10 lower using FH rather than H input, glove 2 has a range of 0.04-0.09 lower, and glove 3 comes in 0.02-0.06 lower. These are not insignificant numbers on the high end, but if an average is taken over the six adapters (Table 5.3), the differences between the spectra shrink to 0.07 for glove 1, 0.06 for glove 2, and 0.03 for glove 3.

Table 5.3 Mean corrected transmissibility values (6 adapter average)

<table>
<thead>
<tr>
<th>H spectra</th>
<th></th>
<th></th>
<th>FH spectra</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>glove 1</td>
<td>Glove2</td>
<td>glove3</td>
<td>glove 1</td>
<td>glove2</td>
</tr>
<tr>
<td>AVG</td>
<td>0.81</td>
<td>0.69</td>
<td>0.54</td>
<td>AVG</td>
<td>0.74</td>
</tr>
<tr>
<td>M spectra</td>
<td></td>
<td></td>
<td>FM spectra</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>glove 1</td>
<td>Glove2</td>
<td>glove3</td>
<td>glove 1</td>
<td>glove2</td>
</tr>
<tr>
<td>AVG</td>
<td>0.86</td>
<td>0.79</td>
<td>0.64</td>
<td>AVG</td>
<td>0.87</td>
</tr>
</tbody>
</table>

This range of variation is much more acceptable. The variations in test data between the spectra are to be expected, achieving measurement repeatability even using the same
input spectrum is difficult in this type of test. Generally speaking, it can be said that using the FH spectra is less strict than the current H spectra, and would be more likely to pass a glove with borderline performance in the 1000-1600 Hz third octave bands. Using either spectral input, the only glove that meets the ISO 10819 standard for antivibration gloves in this frequency range is glove 3. Glove 2 fails marginally using FH and more so using H. Glove 1 does not pass at all.

5.3.2 FM and M spectra results

When comparing the FM and M spectra, the ranges of values are much smaller on average than was the case with higher frequencies. The range of variation was 0.01-0.02 for glove 1, 0.01-0.02 for glove 2, and 0.05-0.09 for glove 3. Averaging values over the adapters reduces these ranges to 0.01, 0.01, and 0.07 for gloves 1, 2, and 3 respectively. All of the values correspond to a passing value for every glove according to ISO 10819, and the rank order of the gloves does not change using FM or M as an input spectrum. The only appreciable difference is that using the FM input results in glove 3 registering as slightly less effective than if the M input is used.

5.4 Gloved hand linear transmissibility tests

The graphs in Appendix 5 represent an average over the three test subjects (+ one standard deviation) of the linear transmissibility of the handle and palm adapter accelerometer when each glove was worn. Bare hand data is also included. The plots are organized by input spectra, the F, M, and H spectra are represented. For some gloves/adapter combinations, the average value of linear transmissibility in the low frequency third octave bands (16-40 Hz) showed that the glove amplified the level of
vibration coming from the handle. Some researchers believe that no glove should be labeled an antivibration glove if any amplification occurs, regardless of the mean transmissibility value. All glove/adapters that were tested exhibited this behavior in the F and M spectra, except for adapter 03, which only amplified the handle signal in the M spectra. Typical plots of the amplification effect are shown in Figures 5.5, 5.6, and 5.7 for gloves 1, 2 and 3 respectively.

"F" spectra glove test - Glove 1

![Figure 5.5 F spectrum glove transmissibility plot, glove 1](image)

Figure 5.5 F spectrum glove transmissibility plot, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
"F" spectra glove test - Glove 2

Figure 5. 6 F spectrum glove transmissibility plot, glove 2

"F" spectra glove test - Glove 3

Figure 5. 7 F spectrum glove transmissibility plot, glove 3
The amplification does not vary greatly from adapter to adapter. The amplification is slightly greater in the M spectrum data than in the F data in several cases, but the difference is small. Antivibration gloves are not effective in reducing the vibration levels below 200 Hz, in most cases. The overall effect of wearing the gloves has been proven to be beneficial, but the amplification of lower frequency signal is present for a variety of gloves and may be unavoidable.

Close inspection of the bare hand tests (glove 00) reveals some variation from the bare hand data originally reported for the adapter tests. Adapter 29, F spectra data would not pass the acceptability requirement in the 1250 and 1600 Hz third octave bands. It has been explained in the previous section that the high frequency data does not affect the mean corrected transmissibility value. Adapter 19 had worse failure values in the same third octave frequency bands, but passed (with high standard deviation) in the middle and lower bands. Adapter 20 also failed more completely in the 1250 and 1600 Hz third octave bands. The difference between the bare hand tests for all the adapters can be attributed to test subject variability, and the fact that only 3 test subjects were used to produce the bare hand date in Appendix 5, where 4 subjects were used for the initial bare hand tests.

5.5 Test subject training

In the course of performing these tests, a general numerical trend was found to exist for each subject, test to test. All measurement equipment, calibrations, adapters, and gloves were the same for every test. With each round of repetitions, the ISO transmissibility data for all individual test subjects lowered significantly, until the values
approached expected levels. Expected levels were those that were measured for each glove by round robin testing at other labs. The effect was not immediately present, but appeared when same test condition data from subsequent days was cross-examined. Regardless of how many times a test was repeated over the course of a single day, the values did not show appreciable variation. The differences appeared on a day-to-day or week-to-week basis. This is attributed to a process of “familiarization” of the test subjects to the correct feel of the adapter inside the glove. There was little variation in the bare hand tests, because it is easier to align the adapter the same way every time when it can be seen. Table 5.2 is a compilation of mean corrected transmissibility values for each glove and spectra over two test runs. The effect is less pronounced in the H spectra data because those tests were run at the end of round 1. Only adapters 02 and 29 are presented, most adapters tested in round 1 were not the same as those tested in round 2.

By examining these results, it becomes clear that each subject became more experienced in proper glove testing methods as testing progressed, or by the daily exposure. As a consequence, their ability to correctly perform the test was increased. This effect was present for all test subjects. These results suggest that it would be improper to use a test subject for antivibration glove testing without proper training and exposure to the test procedure. It is necessary to “calibrate” the subject in order to get correct results. The easiest method to gauge proper subject performance is to test a glove with reasonably well-known mean corrected transmissibility values. Considering the high degree of variability introduced by the test subject’s physical nature, having a clear picture of what a mean corrected transmissibility value for a specific test subject should be is no easy task. It is necessary to look at average values, and then determine a proper
confidence interval. Further study on the matter is needed to define a complete procedure for preparing a test subject, and is beyond the scope of this project.

Table 5. 4 Test subject training comparison, mean corrected transmissibility

| Round 1 |  | Round 2 |  |
|---------|  |---------|  |
| **F Spectra** |  | **F Spectra** |  |
| glove1 glove2 glove3 | glove1 glove2 glove3 |  |
| A02 0.77 0.73 0.72 A02 0.81 0.74 0.65 |
| A29 0.77 0.70 0.71 A29 0.80 0.71 0.64 |
| **FM Spectra** |  | **FM Spectra** |  |
| glove1 glove2 glove3 | glove1 glove2 glove3 |  |
| A02 0.85 0.83 0.81 A02 0.87 0.82 0.73 |
| A29 0.87 0.81 0.81 A29 0.87 0.79 0.71 |
| **FH Spectra** |  | **FH Spectra** |  |
| glove1 glove2 glove3 | glove1 glove2 glove3 |  |
| A02 0.70 0.65 0.64 A02 0.75 0.64 0.53 |
| A29 0.69 0.60 0.61 A29 0.73 0.60 0.49 |
| **H Spectra** |  | **H Spectra** |  |
| glove1 glove2 glove3 | glove1 glove2 glove3 |  |
| A02 0.88 0.80 0.72 A02 0.80 0.73 0.59 |
| A29 0.84 0.77 0.71 A29 0.83 0.67 0.51 |
| **M Spectra** |  | **M Spectra** |  |
| glove1 glove2 glove3 | glove1 glove2 glove3 |  |
| A02 0.83 0.71 0.65 A02 0.86 0.80 0.64 |
| A29 0.79 0.68 0.63 A29 0.86 0.80 0.66 |
CHAPTER 6

CONCLUSIONS

Adapter geometry can significantly affect the outcomes of bare hand linear transmissibility tests. The performance of an adapter is heavily influenced by the curvature of the upper profile and the fit of the adapter to the handle. A curved bottom surface that is exactly matched to the diameter of the handle is recommended. An adapter's length must span at least 70-80% of the width of the palm.

The geometry of the palm adapter does not effect the mean corrected transmissibility value for an antivibration glove if the average linear transmissibility value for the bare hand falls in the range of 0.95 to 1.05 in each third octave band from 16-1600 Hz. Several adapter geometries that were tested meet this requirement, including the ISO 10819 defined adapter.

Some adapters that do not meet the linear transmissibility requirement will also give accurate mean corrected transmissibility values after the glove test results are adjusted for the bare hand transmissibility. This is due to the fact that most adapters that fail do so in higher, low weighted frequency bands.

It is possible to replace the M and H spectra currently defined as inputs in ISO 10819 with a single, F spectra that consists of a 0.01 m/s constant velocity band level from 16-1600 Hz.
The mean corrected transmissibility values obtained using the F spectra are nearly identical to the those obtained using the ISO 10819 spectra when the F spectra is mathematically split into the M and H frequency contents.

Test subjects must be trained in order to achieve repeatability of glove test results. It is important for the test subject to perform many tests to become accustomed to the feel of the adapter in the glove. It is necessary to repeat tests several days apart from each other to validate test results before judgment is passed on a glove.
APPENDIX 1

ADAPTER DIAGRAMS AND RENDERINGS
Figure A1. 1 Adapter 02 drawing
Figure A1.2 Adapter 03 drawing
Figure A1. 3 Adapter 04 drawing
Figure A1. 4 Adapter 06 drawing
Figure A1. 5 Adapter 07 drawing
Figure A1.7 Adapter 09 drawing
Figure A1. 8 Adapter 11 drawing
Figure A1. 9 Adapter 12 drawing
Figure A1. 10 Adapter 13 drawing
Figure A1. 11 Adapter 14 drawing

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A1. 12 Adapter 15 drawing
Figure A1. 13 Adapter 17 drawing
Figure A1. 14 Adapter 18 drawing
Figure A1.15 Adapter 19 drawing
Figure A1. 16 Adapter 20 drawing
Figure A1. 17 Adapter 21 drawing
Figure A1. 18 Adapter 23 drawing
Figure A1. 19 Adapter 24 drawing
Figure A1. 20 Adapter 25 drawing
Figure A1. 21 Adapter 26 drawing
Figure A1. 22 Adapter 27 drawing
Figure A1. 23 Adapter 28 drawing
Figure A1. 24 Adapter 29 drawing
Figure A1. 25 Adapter 30 drawing
APPENDIX 2

BARE HAND LINEAR TRANSMISSIBILITY TEST RESULTS
Figure A2. 1 Adapter 01 bare hand average linear transmissibility data

Figure A2. 2 Adapter 02 bare hand average linear transmissibility data
Figure A2. 3 Adaptor 03 bare hand average linear transmissibility data

Figure A2. 4 Adaptor 04 bare hand average linear transmissibility data
Figure A2. 5 Adapter 05 bare hand average linear transmissibility data

Figure A2. 6 Adapter 06 bare hand average linear transmissibility data
Figure A2. 7 Adaptor 07 bare hand average linear transmissibility data

Figure A2. 8 Adaptor 08 bare hand average linear transmissibility data
Figure A2. 9 Adapter 09 bare hand average linear transmissibility data

Figure A2. 10 Adapter 10 bare hand average linear transmissibility data
Figure A2. 11 Adapter 11 bare hand average linear transmissibility data

Figure A2. 12 Adapter 12 bare hand average linear transmissibility data
Figure A2. 13 Adapter 13 bare hand average linear transmissibility data

Figure A2. 14 Adapter 14 bare hand average linear transmissibility data
Figure A2. 15 Adapter 15 bare hand average linear transmissibility data

Figure A2. 16 Adapter 16 bare hand average linear transmissibility data
Figure A2. 17 Adapter 17 bare hand average linear transmissibility data

Figure A2. 18 Adapter 18 bare hand average linear transmissibility data
Figure A2. 19 Adapter 19 bare hand average linear transmissibility data

Figure A2. 20 Adapter 20 bare hand average linear transmissibility data
Figure A2. 21 Adapter 21 bare hand average linear transmissibility data

Figure A2. 22 Adapter 22 bare hand average linear transmissibility data
Figure A2. 23 Adapter 23 bare hand average linear transmissibility data

Figure A2. 24 Adapter 24 bare hand average linear transmissibility data
Figure A2. 25 Adapter 25 bare hand average linear transmissibility data

Figure A2. 26 Adapter 26 bare hand average linear transmissibility data
Figure A2. 27 Adapter 27 bare hand average linear transmissibility data

Figure A2. 28 Adapter 29 bare hand average linear transmissibility data
Figure A2. 29 Adapter 30 bare hand average linear transmissibility data
APPENDIX 3

PERL SCRIPTS

Perl script 1 - Linear transmissibility data collection

#!/usr/bin/perl

# Script purpose: Open multiple "Pulse" data files, pull out acceleration data column, write to new file
#
# Author: Trevor Wilcox + Erik Wolf
#
# Copyright 2002 Wilcox & Offutt Consulting, LLC
# All rights reserved.
#
# Creation Date: 3/25/2004
#
# Last Rev. Date: 3/26/2004
# Last Rev. by: Erik Wolf
#
# Version: 1.0
#
# File:
#
$dir = $ARGV[0];
undef @ARGV;

print "Frequency range will be 16-1600 Hz\n";
$minfreq = 16;
$maxfreq = 1600;

print "$minfreq\n";
print "$maxfreq\n";

if ( $dir ne "){
    opendir DIR,$dir;
else {
    print "You have to give me the dir name\n";
    print "where the data files are.\n";
    exit;
}
$i=0;
$j=0;
while ($file=readdir(DIR)) {

    if ( $file =~ m!(\w+).txt! ) {
        $filename = $1 . ".txt";
        print "processing file: $filename\n";
        open (FH, "<$dir\$filename") or die "can't find file\n";
        $myarray[0][$j] = $1;
        $i=l;

        while (<FH>) {
            chomp;
            if (m!^d+s+(d+).e\+(d+).s+(d+).e(W)(d+)!){

                $mag="$4.$5e$6$7";
                $myarray[$i][$j] = $mag;

                $i++;

            } # End if

        } # End while

    } # End if

} # End while

close(FH);
} # End while

open (data, ">$dir\output.csv");

for ($m=0; $m<$i; $m++) {
    for ($n=0; $n<$j; $n++) {
        print data "$myarray[$m][$n],";
    }
    print data "\n";
}
Perl Script 2 – M and H ISO 10819 data collection and calculation

#!/usr/bin/perl

# #
# Author: Erik Wolf
#
# Creation Date: 5/24/2004
#
# Last Rev. Date: 5/24/2004
# Last Rev. by: Erik Wolf

# note: there is a bug in this build of Perl that rewrites an array
# if the clone of that array (@array2=@array1) is modified.
# The only fix I found was to manually clone the array, element
# by element, and then operate on the new array

# Define the number of subjects, adaptors, and gloves
$numsub=3;
$numadp=6;
$numglove=3;

$numglv=$numglove+1;
# Use the following (erase the comment #) if user input is desired
#print "Enter number of subject: ";
#$numsub = <STDIN>;
#print "\n";
#print "Enter number of adaptors: ";
#$numadp = <STDIN>;
#print "\n";
#print "Enter number of gloves: ";
#$numglv = <STDIN>;
#print "\n";

$dir = $ARGV[0];
undef @ARGV;

if ( $dir ne ""){
    opendir DIR,$dir;
} else {
    print "You have to input the dir name\n";
    print "where the data files are in the command line.\n";
    exit;
}
while ($file=readdir(DIR)) {
    if ( $file =~ m!(\w+).txt! ) {
        $filename = $1 . "text";
        $filehash{$filename} = $filename;
    }  # end if
}  # end while

foreach $key (sort keys %filehash) {
    print "processing file: $filehash{$key}\n";
    open (FH, "<$dir\$filehash{$key}") or die "can't find file\n";
    print "$dir\$filehash{$key}\n";

    $rawdata2[0][$j] = $filehash{$key};
    $i=1;
    $rawdata2[0][0]="Frequency(Hz)";

    # Extract power unit acceleration data (m/s^2)^2 from
    # ASCII files

    while (<FH>) {
        chomp;
        if (m!d+\(d+\)e\(d+\)s+(d+\)e\(d+\)s+(d+\)e\(d+\)!){
            $mag = "$5.6e7$8";
            $freq="1.2e3$4";
            $rawdata2[$i][$j] = $mag;
            $rawdata2[$i][0] = $freq;

            $i++;
        }  # end if
    }  # end while

    $j++;

    close(FH);
}  # end foreach
# Calculate the actual acceleration values in m/(s^2)

# clone the array (retain filenames and frequency data)

for ($m = 0; $m < $i; $m++) {
    for ($n = 0; $n < $j + 1; $n++) {
        $rawdata[$m][$n] = $rawdata2[$m][$n];
    }
}

for ($m = 1; $m < $i; $m++) {
    for ($n = 1; $n < $j; $n++) {
        $rawdata[$m][$n] = sqrt($rawdata2[$m][$n]);
    }
}

# Calculate linear transmissibilities

# clone the array (retain filenames and frequency data)

for ($m = 0; $m < $i; $m++) {
    for ($n = 0; $n < $j + 1; $n++) {
        $tbl[$m][$n] = $rawdata[$m][$n];
    }
}

for ($m = 1; $m < $i; $m++) {
    for ($n = 1; $n < $j; $n++) {
        $tbl[$m][$n] = $rawdata[$m][$n] / $rawdata[$m][$n + 1];
        $n = $n + 2;
    }
}

for ($m = 1; $m < $i; $m++) {
    for ($n = 2; $n < $j; $n++) {
        $tbl[$m][$n] = " ";
        $n = $n + 2;
    }
}

# Select appropriate ISO weighting curve

if ($rawdata[1][0] == 16) {
    $iso[0] = "ISO";
    $iso[1] = 0.896;
    $iso[2] = 0.782;
}
$iso[3]=0.647;
$iso[4]=0.519;
$iso[5]=0.411;
$iso[6]=0.324;
$iso[7]=0.256;
$iso[8]=0.202;
$iso[9]=0.160;
$iso[10]=0.127;
$iso[11]=0.101;
$iso[12]=0.0799;
$iso[13]=0.0634;
$iso[14]=0.0503;
$iso[15]=0.0398;
$iso[16]=0.0314;
$iso[17]=0.0245;
$iso[18]=0.0186;
$iso[19]=0.0135;
$iso[20]=0.00894;
$iso[21]=0.00538;
} #end if
else {
$iso[0]="ISO";
$iso[1]=0.160;
$iso[2]=0.127;
$iso[3]=0.101;
$iso[4]=0.0799;
$iso[5]=0.0634;
$iso[6]=0.0503;
$iso[7]=0.0398;
$iso[8]=0.0314;
$iso[9]=0.0245;
$iso[10]=0.0186;
$iso[11]=0.0135;
$iso[12]=0.00894;
$iso[13]=0.00538;
} #end else

# ISO weight the data
# clone the array (retain filenames and frequency data)

for ($m=0; $m<$i; $m++) {
  for ($n=0; $n<$j+1; $n++) {
    $wiso[$m][$n]=$rawdata[$m][$n];
  } # end for
} # end for

97

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
$ \text{@sum}=0; \\
for ($m=1; m<i; m++) { \\
for ($n=1; n<j; n++) { \\
\text{\$wiso}[m][n]=$rawdata[m][n]*\text{\$iso}[m]; \\
\text{\$wiso}_2[m][n]=$wiso[m][n]*\text{\$wiso}[m][n]; \\
\text{\$sum}[n]=\text{\$sum}[n]+\text{\$wiso}_2[m][n]; \\
} # end for \\
} # end for \\

$\text{\$iso}[0][0]="\text{ISO Weighted acceleration}"; \\

for ($n=1; n<j; n++) { \\
\text{\$iso}[0][n]= $rawdata[0][n]; \\
} # end for \\

for ($n=1; n<j; n++) { \\
\text{\$iso}[1][n]= \text{sqrt} $\text{\$sum}[n]; \\
} # end for \\

# calculate the weighted transmissibilities \\

$\text{\$raw}[0][0]="\text{ISO Weighted tranmissibility}"; \\

for ($n=1; n<j; ) { \\
\text{\$raw}[0][n]=\text{\$iso}[0][n]; \\
\text{\$raw}[1][n]=\text{\$iso}[1][n]/\text{\$iso}[1][n+1]; \\
\text{n}$=n+2; \\
} # end for \\

# collect and average bare hand transmissibility values \\

$\text{\$asum}=1; \\
for ($s=1; s<\text{\$numsub}+1; s++) { \\
for ($a=1; a<\text{\$numadp}+1; a++) { \\
\text{\$trsb}[s][1][a]=(\text{\$raw}[1][\text{\$asum}]+\text{\$raw}[1][\text{\$asum}+2])/2; \\
\text{\$asum}=$\text{\$asum}+\text{\$numglv}*4; \\
} # end for \\
} # end for \\

# collect glove transmissibilities \\

$\text{\$bsum}=5; \\
for ($s=1; s<\text{\$numsub}+1; s++) { \\
for ($a=1; a<\text{\$numadp}+1; a++) { \\

for ($g=1; $g<$numglv; $g++) {
    $trsg[$s][$g][$a]=($traw[l][$bsum]);
    $trsg2[$s][$g][$a]=($traw[1][$bsum+2]);
    $bsum=$bsum+4;
}  # end for
$bsum=$bsum+4
} # end for
} # end for

# calculate overall transmissibilities

for ($s=1; $s<$numsub+1; $s++) {
for ($a=1; $a<$numadp+1; $a++) {
    for ($g=1; $g<$numglv; $g++) {
        $trs1[$s][$g][$a]=$trsg[$s][$g][$a]/$trsb[$s][1][$a];
        $trs2[$s][$g][$a]=$trsg2[$s][$g][$a]/$trsb[$s][1][$a];
    } # end for
} # end for
} # end for

# calculate average tranmissibility for each glove over the number subjects

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($s=1; $s<$numsub+1; $s++) {
            $trsum[$g][$a]=$trsum[$g][$a]+$trs1[$s][$g][$a]+$trs2[$s][$g][$a];
        } # end for
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $travg[$g][$a]=$trsum[$g][$a]/($numsub*2);
    } # end for
} # end for

# OUTPUT DATA FILES

# print power unit acceleration

#open (data, ">$dir\output.csv");
#for ($m=0; $m<$i; $m++) {
    # for ($n=0; $n<$j+1; $n++) {
        # print data "$rawdata2[$m][sn].";
    # } } # print data "un";
# print acceleration data
$j3=(j+1)/3;
$j23=(j+1)*2/3;
open (rawdata, ">${dir}\raw_data.csv");
for ($m=0; $m<$i; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}

for ($m=0; $m<$i; $m++) {
    print rawdata "$rawdata[$m][0],";
    for ($n=$j3+1; $n<$j23; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}

for ($m=0; $m<$i; $m++) {
    print rawdata "$rawdata[$m][0],";
    for ($n=$j23; $n<$j+l; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}

# print linear transmissibilities

open (lintr, ">${dir}\lin_trans.csv");
print lintr "Linear tranmissibility values bare and glove\n";
for ($m=0; $m<$i; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "\n";
}

for ($m=0; $m<$i; $m++) {
    print lintr "$tbl[$m][0],";
    for ($n=$j3+1; $n<$j23; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "\n";
}

# print linear transmissibilities

open (lintr, ">${dir}\lin_trans.csv");
print lintr "Linear tranmissibility values bare and glove\n";
for ($m=0; $m<$i; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "\n";
}

for ($m=0; $m<$i; $m++) {
    print lintr "$tbl[$m][0],";
    for ($n=$j3+1; $n<$j23; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "\n";
}
print lintr "$tbl[$m][$n],";
}
print lintr "\n";
}
print lintr "\n";

for ($m=0; $m<$i; $m++) {
    print lintr "$tbl[$m][0],";
    for ($n=$j23; $n<$j+1; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "\n";
}
close (lintr);

# print ISO weighting curve

for ($m=0; $m<$i; $m++) {
    print rawdata "$iso[$m],";
    print rawdata "\n";
}
close (rawdata);
# print iso curve applied acceleration values

# for ($m=0; $m<$i; $m++) {
    # for ($n=0; $n<$j+1; $n++) {
        # print data "$wiso[$m][$n], " ;
    }
    # print data "\n";
#}
#print data "\n";

# print iso weighted acceleration numbers

# for ($m=0; $m<2; $m++) {
    # for ($n=0; $n<$j+1; $n++) {
        # print data "$aiso[$m][$n], " ;
    }
    # print data "\n";
#}
#print data "\n";

# print ISO transmissibilities

#open (tiso,">$dir\ISO_temp.csv");
#print tiso "ISO weighted transmissibilities bare hand and glove";
# print tiso "\n";

#for ($m=0; $m<2; $m++) {
# for ($n=0; $n<$j3; $n++) {
# print tiso "$traw[$m][$n],";
# }
# print tiso "\n";
#}
# print tiso "\n";

#for ($m=0; $m<2; $m++) {
# for ($n=$j3+1; $n<$j23; $n++) {
# print tiso "$traw[$m][$n],";
# }
# print tiso "\n";
#}
# print tiso "\n";

#for ($m=0; $m<$i; $m++) {
# for ($n=$j23; $n<$j+1; $n++) {
# print tiso "$traw[$m][$n],";
# }
# print tiso "\n";
#}
#close (tiso);

# print organized and labeled bare hand weighted transmissibility values

open (trans, ">$dir\ISO_trans.csv");

# print bare hand transmissibility (TRsb) values individually

#print trans "TRsb bare hand transmissibility (average)\n";
#for ($s=0; $s<$numsub+1; $s++) {
# for ($a=0; $a<$numadp+1; $a++) {
# if ($trsb[$s][0][$a] !0) {
# print trans "s = $s a= $a \n";
# print trans "$trsb[$s][1][$a]";
# print trans "\n";
# } # end if
# } # end for
#} # end for
#print trans "\n";

102

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
print trans "TRsb = bare hand transmissibility (2 test average)\n";
for ($a=1; $a<=$numadp+1; $a++) {
    print trans ",s1,s2,s3\n";
    print trans "a$a,$trsb[1][1][$a],$trsb[2][1][$a],$trsb[3][1][$a]\n";
}

# print glove transmissibilities individually

# print data "TRsg glove transmissibilities\n";
#for ($s=1; $s<=$numsub+1; $s++) {
#    for ($a=1; $a<=$numadp+1; $a++) {
#        for ($g=1; $g<=$numglv; $g++) {
#            print data "s=$s g=$g a=$a\n";
#            print data "$trsg[1][$g][s][a] $trsg2[1][$g][s][a] $trsg[2][1][s][a] $trsg2[2][1][s][a] $trsg[3][1][s][a]\n";
#        }
#    }
#}
# print data \n";

# print glove transmissibilities

print trans "TRsg = glove transmissibility\n";
for ($g=1; $g<=$numglv; $g++) {
    print trans "glove $g\n";
    for ($a=1; $a<=$numadp+1; $a++) {
        print trans ",s-1 t-1,s-1 t-2,s-2 t-1,s-2 t-2,s-3 t-1,s-3 t-2\n";
        print trans "a=$a,$trsg[1][1][s][a] $trsg2[1][1][s][a] $trsg[2][1][s][a] $trsg2[2][1][s][a] $trsg[3][1][s][a] $trsg2[3][1][s][a]\n";
    }
}

# print overall transmissibilities (individual)

# print data "TRs corrected glove transmissibilities\n";
#for ($s=1; $s<=$numsub+1; $s++) {
#    for ($g=1; $g<=$numglv; $g++) {
#        for ($a=1; $a<=$numadp+1; $a++) {
#            print data "s=$s g=$g a=$a\n";
#            print data "$trsg[1][s][g][a] $trsg2[1][s][g][a] $trsg[2][s][g][a] $trsg2[2][s][g][a] $trsg[3][s][g][a]\n";
#        }
#    }
#}

103

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
# print overall transmissibilities

print trans "TRs = glove transmissibility corrected for bare hand\n";
for ($g=1; $g<$numglv; $g++) {
    print trans "glove $g\n";
    print trans ",s-1 t-1,s-1 t-2,s-2 t-1,s-2 t-2,s-3 t-1,s-3 t-2\n";
    for ($a=1; $a<$numadp+1; $a++) {
        print trans "a=$a,";
        print trans "$trsl[l][g][a],$trs2[l][g][a],$trsl[2][g][a],$trs2[2][g][a],$trsl[3][g][a],$trs2[3][g][a],";
        print trans "\n";
    }  # end for
}  # end for
print trans \n;

# print the TRs average values individually

# print data "TRs average transmissibilities\n";
# for ($g=1; $g<$numglv; $g++) {
#    print data "Glove $g\n";
#    for ($a=1; $a<$numadp+1; $a++) {
#        print data "a=$a,$travg[g][a]\n";
#    }  # end for
#}  # end for

print trans "TRs = glove transmissibility averaged over subjects\n";
print trans ",glove 1,glove 2,glove 3\n";
for ($a=1; $a<$numadp+1; $a++) {
    print trans "a=$a,$travg[1][a],$travg[2][a],$travg[3][a]\n";
}  # end for

close(trans);
Perl Script 3 –F spectrum data gathering, calculation, and manipulation

#!/usr/bin/perl

# #
# Author: Erik Wolf
#
# Creation Date: 5/24/2004
#
# Last Rev. Date: 5/24/2004
# Last Rev. by: Erik Wolf

# note: there is a bug in this build of Perl that rewrites an array
# if the clone of that array (@array2=@array 1) is modified.
# The only fix I found was to manually clone the array, element
# by element, and then operate on the new array

# Define the number of subjects, adaptors, and gloves
$numsub=3;
$numadp=6;
$numglove=3;

$numglv=$numglove+1;
# Use the following (erase the comment #) if user input is desired
#print "Enter number of subject: ";
#$numsub = <STDIN>;
#print "\n";
#print "Enter number of adaptors: ";
#$numadp = <STDIN>;
#print "\n";
#print "Enter number of gloves: ";
#$numglv = <STDIN>;
#print "\n";

$dir = $ARGV[0];
undef @ARGV;

if ( $dir ne ){
  opendir DIR,$dir;
}
else {
  print "You have to input the dir name\n";
  print "where the data files are in the command line.\n";
  exit;
}
$i=0;
$j=1;

# Sort the filenames in a directory and then open the files in order

while ($file=readdir(DIR)) {
    if ( $file =~ m!(\w+).txt! ) {
        $filename = $1 . "_.txt";
        $filehash{$filename}=$filename;
    }  # end if
}  # end while

foreach $key (sort keys %filehash) {
    print "processing file: $filehash{$key}\n";
    open (FH, "<$dir\$filehash{$key}" ) or die "can't find file\n";
    print "$dir\$filehash{$key}\n";
    $rawdata2[0][$j] = $filehash{$key};
    $i=1;
    $rawdata2[0][0]="Frequency(Hz)";

    # Extract power unit acceleration data (m/s^2)^2 from
    # pulse ASCII files

    while (<FH>) {
        chomp;
        if (m!\d+\s+(\d+).\d+e(\W)(\d+).\d+e(\W)(\d+)!{ 

            $mag = "$5.$6e$7$8";
            $freq="$1.$2e$3$4";
            $rawdata2[$i][$j] = $mag;
            $rawdata2[$i][0]=$freq;

            $i++;
        }  # end if
    }  # end while
    $j++;
    close(FH);
}  # end foreach
# Calculate the actual acceleration values in m/(s^2)

# clone the array (retain filenames and frequency data)

for ($m=0; $m<$i; $m++) {
for ($n=0; $n<$j+l; $n++) {
$rawdata[$m][$n] = $rawdata2[$m][$n];
} # end for
} # end for

for ($m=1; $m<$i; $m++) {
for ($n=1; $n<$j; $n++) {
$rawdata[$m][$n] = sqrt $rawdata2[$m][$n];
} # end for
} # end for

# Calculate linear transmissibilities

# clone the array (retain filenames and frequency data)

for ($m=0; $m<$i; $m++) {
for ($n=0; $n<$j+l; $n++) {
$thl[$m][$n] = $rawdata[$m][$n];
} # end for
} # end for

for (Sm-1; $m<$i; $m++) {
for ($n=1; $n<$j; $n++) {
$tbl[$m][$n] = $rawdata[$m][$n] / $rawdata[$m][$n+1];
$n=$n+2;
} #end for
} # end for

for ($m=1; $m<$i; $m++) {
for ($n=2; $n<$j; $n++) {
$thl[$m][$n] = " ";
$n=$n+2;
} #end for
} # end for

# Select appropriate ISO weighting curve

if ($rawdata[1][0] == 16) {
$iso[0] = "ISO";
$iso[1] = 0.896;
$iso[2] = 0.782;
}
$iso[3]=0.647;
$iso[4]=0.519;
$iso[5]=0.411;
$iso[6]=0.324;
$iso[7]=0.256;
$iso[8]=0.202;
$iso[9]=0.160;
$iso[10]=0.127;
$iso[11]=0.101;
$iso[12]=0.0799;
$iso[13]=0.0634;
$iso[14]=0.0503;
$iso[15]=0.0398;
$iso[16]=0.0314;
$iso[17]=0.0245;
$iso[18]=0.0186;
$iso[19]=0.0135;
$iso[20]=0.00894;
$iso[21]=0.00538;

} #end if
else {
$iso[0]="ISO";
$iso[1]=0.160;
$iso[2]=0.127;
$iso[3]=0.101;
$iso[4]=0.0799;
$iso[5]=0.0634;
$iso[6]=0.0503;
$iso[7]=0.0398;
$iso[8]=0.0314;
$iso[9]=0.0245;
$iso[10]=0.0186;
$iso[11]=0.0135;
$iso[12]=0.00894;
$iso[13]=0.00538;
}

} #end else

# ISO weight the data

# clone the array (retain filenames and frequency data)

for ($m=0; $m<$i; $m++) {
  for ($n=0; $n<$j+1; $n++) {
    $wiso[$m][$n]=$rawdata[$m][$n];
  } # end for
\@sum=0;
for ($m=1; $m<i; $m++) {
    for ($n=1; $n<j; $n++) {
        $wiso[$m][$n] = $rawdata[$m][$n] * $iso[$m];
        $wiso2[$m][$n] = $wiso[$m][$n] * $wiso[$m][$n];
        $sum[$n] = $sum[$n] + $wiso2[$m][$n];
    }  # end for
}  # end for

$msum=0;
for ($m=1; $m<16; $m++) {
    for ($n=1; $n<j; $n++) {
        $mwiso[$m][$n] = $rawdata[$m][$n] * $iso[$m];
        $mwiso2[$m][$n] = $mwiso[$m][$n] * $mwiso[$m][$n];
        $msum[$n] = $msum[$n] + $mwiso2[$m][$n];
    }  # end for
}  # end for

$hsum=0;
for ($m=9; $m<i; $m++) {
    for ($n=1; $n<j; $n++) {
        $hwiso[$m][$n] = $rawdata[$m][$n] * $iso[$m];
        $hwiso2[$m][$n] = $hwiso[$m][$n] * $hwiso[$m][$n];
        $hsum[$n] = $hsum[$n] + $hwiso2[$m][$n];
    }  # end for
}  # end for

$aiso[0][0] = "ISO Weighted acceleration";

for ($n=1; $n<j; $n++) {
    $aiso[0][$n] = $rawdata[0][$n];
}  # end for

for ($n=1; $n<j; $n++) {
    $maiso[0][$n] = $rawdata[0][$n];
}  # end for

for ($n=1; $n<j; $n++) {
    $haiso[0][$n] = $rawdata[0][$n];
}  # end for

for ($n=1; $n<j; $n++) {
    $aiso[1][$n] = sqrt $sum[$n];
}  # end for

109

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
for ($n=1; $n<$j; $n++) {
    $maiso[1][$n] = sqrt $msum[$n];
}  # end for

for ($n=1; $n<$j; $n++) {
    $haiso[1][$n] = sqrt $hsun[$n];
}  # end for

# calculate the weighted transmissibilities
$straw[0][0]="ISO Weighted tranmissibility";

for ($n=1; $n<$j; ) {
    $straw[0][$n] =$aiso[0][$n];
    $straw[1][$n] =$aiso[1][$n]/$aiso[1][$n+1];
    $n=$n+2;
}  # end for

$mtraw[0][0]="ISO Weighted tranmissibility";

for ($n=1; $n<$j; ) {
    $mtraw[0][$n] =$maiso[0][$n];
    $mtraw[1][$n] =$maiso[1][$n]/$maiso[1][$n+1];
    $n=$n+2;
}  # end for

$htraw[0][0]="ISO Weighted tranmissibility";

for ($n=1; $n<$j; ) {
    $htraw[0][$n] =$haiso[0][$n];
    $htraw[1][$n] =$haiso[1][$n]/$haiso[1][$n+1];
    $n=$n+2;
}  # end for

# collect and average bare hand transmissibility values

$asum=1;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $strsb[$s][1][$a] = ($straw[1][$asum]+$straw[1][$asum+2])/2;
        $asum=$asum+$numglv*4;
    }
}
$masum=1;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $mtrsb[$s][1][$a]=(\$mtraw[1][$masum]+\$mtraw[1][$masum+2])/2;
        $masum=$masum+$numglv*4;
    } # end for
} # end for

$hasum=1;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $htrsb[$s][1][$a]=(\$htraw[1][$hasum]+\$htraw[1][$hasum+2])/2;
        $hasum=$hasum+$numglv*4;
    } # end for
} # end for

# collect glove transmissibilities

$bsum=5;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $trsg[$s][$g][$a]=($traw[1][$bsum]);
            $trsg2[$s][$g][$a]=($traw[1][$bsum+2]);
            $bsum=$bsum+4;
        } # end for
    } # end for
} # end for

$mbsum=5;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $mtrsg[$s][$g][$a]=($mtraw[1][$mbsum]);
            $mtrsg2[$s][$g][$a]=($mtraw[1][$mbsum+2]);
            $mbsum=$mbsum+4;
        } # end for
    } # end for
} # end for

111
$hbsum=5;
for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $htrsg[$s][$g][$a]=$htraw[1][$hbsum];
            $htrsg2[$s][$g][$a]=$htraw[1][$hbsum+2];
            $hbsum=$hbsum+4;
        }  # end for
    }  # end for
}  # end for

# calculate overall transmissibilities

for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $trs1[$s][$g][$a]=$trsg[$s][$g][$a]/$trsb[$s][1][$a];
            $trs2[$s][$g][$a]=$trsg2[$s][$g][$a]/$trsb[$s][1][$a];
        }  # end for
    }  # end for
}  # end for

for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $mtrs1[$s][$g][$a]=$mtrsg[$s][$g][$a]/$mtrsb[$s][1][$a];
            $mtrs2[$s][$g][$a]=$mtrsg2[$s][$g][$a]/$mtrsb[$s][1][$a];
        }  # end for
    }  # end for
}  # end for

for ($s=1; $s<$numsub+1; $s++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($g=1; $g<$numglv; $g++) {
            $htrs1[$s][$g][$a]=$htrsg[$s][$g][$a]/$htrsb[$s][1][$a];
            $htrs2[$s][$g][$a]=$htrsg2[$s][$g][$a]/$htrsb[$s][1][$a];
        }  # end for
    }  # end for
}  # end for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
# calculate average tranmissibility for each glove over the number subjects

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($s=1; $s<$numsub+1; $s++) {
            $trsum[$g][$a]=$trsum[$g][$a]+$trs1[$s][$g][$a]+$trs2[$s][$g][$a];
        } # end for
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $travg[$g][$a]=$trsum[$g][$a]/($numsub*2);
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($s=1; $s<$numsub+1; $s++) {
            $mtrsum[$g][$a]=$mtrsum[$g][$a]+$mtrsl[$s][$g][$a]+$mtrs2[$s][$g][$a];
        } # end for
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $mtravg[$g][$a]=$mtrsum[$g][$a]/($numsub*2);
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        for ($s=1; $s<$numsub+1; $s++) {
            $htrsum[$g][$a]=$htrsum[$g][$a]+$htrs1[$s][$g][$a]+$htrs2[$s][$g][$a];
        } # end for
    } # end for
} # end for

for ($g=1; $g<$numglv; $g++) {
    for ($a=1; $a<$numadp+1; $a++) {
        $htravg[$g][$a]=$htrsum[$g][$a]/($numsub*2);
    } # end for
} # end for
# OUTPUT DATA FILES

# print acceleration data
$j3=(\$j+1)/3;
$j23=(\$j+1)*2/3;
open (rawdata, ">$dir\f_rawdata.csv");
for ($m=0; $m<=$i; $m++) {
    for ($n=0; $n<=$j3; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}
for ($m=0; $m<=$i; $m++) {
    print rawdata "$rawdata[$m][0],";
    for ($n=$j3+$l; $n<=$j23; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}
for ($m=0; $m<=$i; $m++) {
    print rawdata "$rawdata[$m][0],";
    for ($n=$j23; $n<=$j+$l; $n++) {
        print rawdata "$rawdata[$m][$n],";
    }
    print rawdata "\n";
}
close (rawdata);

open (mrawdata, ">$dir\m_rawdata.csv");
for ($m=0; $m<16; $m++) {
    for ($n=0; $n<=$j3; $n++) {
        print mrawdata "$rawdata[$m][$n],";
    }
    print mrawdata "\n";
}
for ($m=0; $m<16; $m++) {
    print mrawdata "$rawdata[$m][0],";
    for ($n=$j3+$l; $n<=$j23; $n++) {
        print mrawdata "$rawdata[$m][$n],";
    }
    print mrawdata "\n";
}
```perl
print mrawdata "\n";
print mrawdata "\n";
for ($m=0; $m<16; $m++) {
    print mrawdata "$rawdata[$m][0],";
    for ($n=$j23; $n<=$j+l; $n++) {
        print mrawdata "$rawdata[$m][$n],";
    }
    print mrawdata "\n";
}
close (mrawdata);

open (hrawdata, ">$dir\h_rawdata.csv");
for ($n=0; $n<=$j3; $n++) {
    print hrawdata "$rawdata[0][$n],";
} # end for
print hrawdata "\n";
for ($m=9; $m<=$i; $m++) {
    for ($n=0; $n<=$j3; $n++) {
        print hrawdata "$rawdata[$m][$n],";
    }
    print hrawdata "\n";
}
print hrawdata "\n";
print hrawdata "Frequency,";
for ($n=$j3+1; $n<=$j23; $n++) {
    print hrawdata "$rawdata[0][$n],";
} # end for
print hrawdata "\n";
for ($m=9; $m<=$i; $m++) {
    print hrawdata "$rawdata[$m][0],";
    for ($n=$j3+1; $n<=$j23; $n++) {
        print hrawdata "$rawdata[$m][$n],";
    }
    print hrawdata "\n";
}
print hrawdata "\n";
print hrawdata "Frequency,";
```

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
for ($n=$j23; $n<$j+l; $n++) {
    print hrawdata "$rawdata[0][$n],";
} # end for

print hrawdata "$n";

for ($m=9; $m<$i; $m++) {
    print hrawdata "$rawdata[$m][0],";
    for ($n=$j23; $n<$j+l; $n++) {
        print hrawdata "$rawdata[$m][$n],";
    }
    print hrawdata "$n";
}

close (hrawdata);

# print linear transmissibilities

open (lintr, "$dir\_f_lin_trans.csv");
print lintr "Linear transmissibility values bare and glove\n";
for ($m=0; $m<$i; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "$n";
}
print lintr "$n";

for ($m=0; $m<$i; $m++) {
    print lintr "$tbl[$m][0],";
    for ($n=$j3+1; $n<$j23; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "$n";
}
print lintr "$n";

for ($m=0; $m<$i; $m++) {
    print lintr "$tbl[$m][0],";
    for ($n=$j23; $n<$j+l; $n++) {
        print lintr "$tbl[$m][$n],";
    }
    print lintr "$n";
}
close (lintr);

open (mlintr, "$dir\m_lin_trans.csv");
print mlintr "Linear tranmissibility values bare and glove\n"
for ($m=0; $m<16; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print mlintr "$tbl[$m][$n],";
    }
    print mlintr "\n";
}

for ($m=0; $m<16; $m++) {
    print mlintr "$tbl[$m][0],";
    for ($n=$j3+1; $n<$j23; $n++) {
        print mlintr "$tbl[$m][$n],";
    }
    print mlintr "\n";
}

close (mlintr);

open (hlintr, "$dir\h_lin_trans.csv");
print hlintr "Linear tranmissibility values bare and glove\nFrequency"
for ($n=0; $n<$j3; $n++) {
    print hlintr "$rawdata[0][$n],";
}  # end for
print hlintr "\n";

for ($m=9; $m<$i; $m++) {
    for ($n=0; $n<$j3; $n++) {
        print hlintr "$tbl[$m][$n],";
    }
    print hlintr "\n";
}  
print hlintr "\nFrequency,";

117
for ($n=$i3+1; $n<=$i23; $n++) {
    print hlintr "$rawdata[0][$n],";
} # end for
print hlintr "n";

for ($m=9; $m<=$i; $m++) {
    print hlintr "$tbl[$m][0],";
    for ($n=$i3+1; $n<=$i23; $n++) {
        print hlintr "$tbl[$m][$n],";
    }
    print hlintr "n";
}
print hlintr "nFrequency,";

for ($n=$i23; $n<=$i+1; $n++) {
    print hlintr "$rawdata[0][$n],";
} # end for
print hlintr "n";

for ($m=9; $m<=$i; $m++) {
    print hlintr "$tbl[$m][0],";
    for ($n=$i23; $n<=$i+1; $n++) {
        print hlintr "$tbl[$m][$n],";
    }
    print hlintr "n";
}
close (hlintr);

# print organized and labeled bare hand weighted transmissibility values

open (trans, "$dir\f_ISO_transmissibility.csv");
open (mtrans, "$dir\m_ISO_transmissibility.csv");
open (htrans, "$dir\h_ISO_transmissibility.csv");

# print bare hand transmissibility (TRsb) values

print trans "TRsb = bare hand transmissibility (2 test average)\n"
for ($a=1; $a<=$numadp+1; $a++) {
    print trans ",s1,s2,s3\n"
    print trans "a$a,$trsb[1][1][$a],$trsb[2][1][$a],$trsb[3][1][$a]";
    print trans "\n"
} # end for
print trans "\n";

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
print mtrans "TRsb = bare hand transmissibility (2 test average)\n";
for ($a=1; $a<$numadp+1; $a++) {
    print mtrans ",s1,s2,s3\n";
    print mtrans "a$a,$mtrsb[1][1][$a],$mtrsb[2][1][$a],$mtrsb[3][1][$a]\n";
    print mtrans "\n";
}  # end for
print mtrans "\n";

print htrans "TRsb = bare hand transmissibility (2 test average)\n";
for (Sa=1; $a<$numadp+1; $a++) {
    print htrans ",s1,s2,s3\n";
    print htrans "a$a,$htrsb[1][1][$a],$htrsb[2][1][$a],$htrsb[3][1][$a]\n";
    print htrans "\n";
}  # end for
print htrans "\n";

# print glove transmissibilities

print trans "TRsg = glove transmissibility\n";
for ($g=1; $g<$numglv; $g++) {
    print trans "glove $g\n";
    for ($a=1; $a<$numadp+1; $a++) {
        print trans ",s-1 t-1,s-1 t-2,s-2 t-1,s-2 t-2,s-3 t-1,s-3 t-2\n";
        print trans "a=$a,$trsg[1][$g][$a],$trsg2[1][$g][$a],$trsg[2][$g][$a],$trsg2[2][$g][$a],$trsg[3][$g][$a],$trsg2[3][$g][$a],\n";
    }  # end for
}  # end for
print trans "\n";

print mtrans "TRsg = glove transmissibility\n";
for ($g=1; $g<$numglv; $g++) {
    print mtrans "glove $g\n";
    for ($a=1; $a<$numadp+1; $a++) {
        print mtrans ",s-1 t-1,s-1 t-2,s-2 t-1,s-2 t-2,s-3 t-1,s-3 t-2\n";
        print mtrans "a=$a,$mtrsg[1][$g][$a],$mtrsg2[1][$g][$a],$mtrsg[2][$g][$a],$mtrsg2[2][$g][$a],$mtrsg[3][$g][$a],$mtrsg2[3][$g][$a],\n";
    }  # end for
}  # end for
print mtrans "\n";
print mtrans "\n";

print htrans "TRsg = glove transmissibility\n";
for ($g=l; $g<$numglv; $g++) {
    print htrans "glove $g\n";
    for ($a=l; $a<$numadp+l; $a++) {
        print htrans "a=$a,$htrsg[ 1 ][ 1 ][ $g ][ $a ],$htrsg2[ 1 ][ 1 ][ $g ][ $a ],$htrsg[ 2 ][ 1 ][ $g ][ $a ],$htrsg2[ 2 ][ 1 ][ $g ][ $a ],$htrsg[ 3 ][ 1 ][ $g ][ $a ],$htrsg2[ 3 ][ 1 ][ $g ][ $a ],\n";
    }
}
# end for
} # end for
print htrans "\n";

# print overall transmissibilities

print trans "TRs = glove transmissibility corrected for bare hand\n";
for ($g=l; $g<$numglv; $g++) {
    print trans "glove $g\n";
    for ($a=l; $a<$numadp+l; $a++) {
        print trans "a=$a,\n";
        print trans "$trsl[l][ 1 ][ $g ][ $a ],$trs2[l][ 1 ][ $g ][ $a ],$trsl[ 2 ][ 1 ][ $g ][ $a ],$trs2[ 2 ][ 1 ][ $g ][ $a ],$trsl[ 3 ][ 1 ][ $g ][ $a ],$trs2[ 3 ][ 1 ][ $g ][ $a ],\n";
    }
}
# end for
} # end for
print trans "\n";

print mtrans "TRs = glove transmissibility corrected for bare hand\n";
for ($g=l; $g<$numglv; $g++) {
    print mtrans "glove $g\n";
    for ($a=l; $a<$numadp+l; $a++) {
        print mtrans "a=$a,\n";
        print mtrans "$mtrsl[l][ 1 ][ $g ][ $a ],$mtrs2[l][ 1 ][ $g ][ $a ],$mtrsl[ 2 ][ 1 ][ $g ][ $a ],$mtrs2[ 2 ][ 1 ][ $g ][ $a ],$mtrsl[ 3 ][ 1 ][ $g ][ $a ],$mtrs2[ 3 ][ 1 ][ $g ][ $a ],\n";
    }
}
# end for
} # end for
print mtrans "\n";

120

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
print htrans "TRs = glove transmissibility corrected for bare hand\n";
for ($g=1; $g<$numglv; $g++) {
  print htrans "glove $g\n";
  print htrans "s-1 t-1,s-1 t-2,s-2 t-1,s-2 t-2,s-3 t-1,s-3 t-2\n";
  for ($a=1; $a<$numadp+1; $a++) {
    print htrans "a=$a,\n";
    print htrans "$htrs1[1][$g][a],$htrs1[2][$g][a],$htrs2[1][$g][a],$htrs2[2][$g][a],$htrs1[3][$g][a],$htrs2[3][$g][a],\n";
    print htrans "\n";
  }  # end for
}  # end for
print htrans "\n";

# print Averaged transmissibilities

print trans "TRs = glove transmissibility averaged over subjects\n";
print trans ",glove 1,glove2,glove3\n";
for ($a=1; $a<$numadp+1; $a++) {
  print trans "a=$a,$travg[1][$a],$travg[2][$a],$travg[3][$a]\n";
} #end for

print mtrans "TRs = glove transmissibility averaged over subjects\n";
print mtrans ",glove 1,glove2,glove3\n";
for ($a=1; $a<$numadp+1; $a++) {
  print mtrans "a=$a,$mtravg[1][$a],$mtravg[2][$a],$mtravg[3][$a]\n";
} #end for

print htrans "TRs = glove transmissibility averaged over subjects\n";
print htrans ",glove 1,glove2,glove3\n";
for ($a=1; $a<$numadp+1; $a++) {
  print htrans "a=$a,$htravg[1][$a],$htravg[2][$a],$htravg[3][$a]\n";
} #end for

close(trans);
close(mtrans);
close(htrans);
APPENDIX 4

MEAN CORRECTED TRANMISSIBILITY RESULTS
Table A4. 1 F spectrum bare hand tests

<table>
<thead>
<tr>
<th></th>
<th>s1</th>
<th>s2</th>
<th>s3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>1.013158</td>
<td>1.000131</td>
<td>1.008193</td>
</tr>
<tr>
<td>A03</td>
<td>0.986033</td>
<td>0.989971</td>
<td>0.991354</td>
</tr>
<tr>
<td>A19</td>
<td>1.008838</td>
<td>0.965151</td>
<td>0.997496</td>
</tr>
<tr>
<td>A20</td>
<td>1.002822</td>
<td>0.991989</td>
<td>0.994237</td>
</tr>
<tr>
<td>A29</td>
<td>1.00175</td>
<td>0.986599</td>
<td>0.996957</td>
</tr>
<tr>
<td>A30</td>
<td>0.995186</td>
<td>0.994842</td>
<td>0.994192</td>
</tr>
</tbody>
</table>

Table A4. 2 F spectrum, glove 1, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.82553</td>
<td>0.81019</td>
<td>0.86217</td>
<td>0.85321</td>
<td>0.77835</td>
<td>0.75871</td>
</tr>
<tr>
<td>A03</td>
<td>0.76669</td>
<td>0.75083</td>
<td>0.80265</td>
<td>0.78212</td>
<td>0.7762</td>
<td>0.7759</td>
</tr>
<tr>
<td>A19</td>
<td>0.81708</td>
<td>0.80473</td>
<td>0.83594</td>
<td>0.81417</td>
<td>0.78426</td>
<td>0.75926</td>
</tr>
<tr>
<td>A20</td>
<td>0.78321</td>
<td>0.75338</td>
<td>0.85972</td>
<td>0.84706</td>
<td>0.78627</td>
<td>0.77905</td>
</tr>
<tr>
<td>A29</td>
<td>0.76514</td>
<td>0.74096</td>
<td>0.85475</td>
<td>0.87038</td>
<td>0.77784</td>
<td>0.76884</td>
</tr>
<tr>
<td>A30</td>
<td>0.78069</td>
<td>0.77847</td>
<td>0.83325</td>
<td>0.82153</td>
<td>0.83103</td>
<td>0.81078</td>
</tr>
</tbody>
</table>
Table A4. 3 F spectrum, glove 2, uncorrected data

| TR_{FG} = glove transmissibility | glove 2 | | | | |
|---|---|---|---|---|---|---|
| | s-1 t-1 | s-1 t-2 | s-2 t-1 | s-2 t-2 | s-3 t-1 | s-3 t-2 |
| A02 | 0.74725 | 0.72301 | 0.76685 | 0.7704 | 0.72014 | 0.73151 |
| A03 | 0.68298 | 0.69941 | 0.73363 | 0.7304 | 0.71636 | 0.71032 |
| A19 | 0.72458 | 0.73733 | 0.7509 | 0.77475 | 0.7204 | 0.72439 |
| A20 | 0.68126 | 0.69752 | 0.76335 | 0.77093 | 0.64769 | 0.66858 |
| A29 | 0.7039 | 0.68546 | 0.73981 | 0.73453 | 0.68918 | 0.68112 |
| A30 | 0.70897 | 0.71758 | 0.77887 | 0.78706 | 0.63238 | 0.71621 |

Table A4. 4 F spectrum, glove 3, uncorrected data

| TR_{FG} = glove transmissibility | glove 3 | | | | |
|---|---|---|---|---|---|---|
| | s-1 t-1 | s-1 t-2 | s-2 t-1 | s-2 t-2 | s-3 t-1 | s-3 t-2 |
| A02 | 0.67686 | 0.67273 | 0.67925 | 0.67444 | 0.62822 | 0.62318 |
| A03 | 0.61984 | 0.62574 | 0.63235 | 0.62302 | 0.57933 | 0.61665 |
| A19 | 0.66905 | 0.63773 | | | | |
| A20 | 0.63869 | 0.64793 | 0.64317 | 0.6521 | 0.62591 | 0.61142 |
| A29 | 0.64895 | 0.67005 | 0.6559 | 0.63878 | 0.6021 | 0.57583 |
| A30 | 0.66183 | 0.6676 | 0.66279 | 0.63331 | 0.5882 | 0.55627 |

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table A4. 5 F spectrum, corrected transmissibility

**TR_p** = glove transmissibility corrected for bare hand

<table>
<thead>
<tr>
<th>Glove 1</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.81481</td>
<td>0.79966</td>
<td>0.86206</td>
<td>0.8531</td>
<td>0.77202</td>
<td>0.75254</td>
</tr>
<tr>
<td>A03</td>
<td>0.77755</td>
<td>0.76147</td>
<td>0.81078</td>
<td>0.79004</td>
<td>0.78297</td>
<td>0.78266</td>
</tr>
<tr>
<td>A19</td>
<td>0.80992</td>
<td>0.79768</td>
<td>0.86613</td>
<td>0.84357</td>
<td>0.78623</td>
<td>0.76117</td>
</tr>
<tr>
<td>A20</td>
<td>0.781</td>
<td>0.75126</td>
<td>0.86666</td>
<td>0.8539</td>
<td>0.79083</td>
<td>0.78356</td>
</tr>
<tr>
<td>A29</td>
<td>0.7638</td>
<td>0.73967</td>
<td>0.86636</td>
<td>0.8822</td>
<td>0.78022</td>
<td>0.77118</td>
</tr>
<tr>
<td>A30</td>
<td>0.78447</td>
<td>0.78223</td>
<td>0.83757</td>
<td>0.82578</td>
<td>0.83588</td>
<td>0.81552</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 2</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.73755</td>
<td>0.71362</td>
<td>0.76674</td>
<td>0.77029</td>
<td>0.71429</td>
<td>0.72557</td>
</tr>
<tr>
<td>A03</td>
<td>0.69265</td>
<td>0.70932</td>
<td>0.74106</td>
<td>0.7378</td>
<td>0.72261</td>
<td>0.71651</td>
</tr>
<tr>
<td>A19</td>
<td>0.71823</td>
<td>0.73087</td>
<td>0.77801</td>
<td>0.80272</td>
<td>0.72221</td>
<td>0.72621</td>
</tr>
<tr>
<td>A20</td>
<td>0.67934</td>
<td>0.69556</td>
<td>0.76952</td>
<td>0.77716</td>
<td>0.65144</td>
<td>0.67245</td>
</tr>
<tr>
<td>A29</td>
<td>0.70267</td>
<td>0.68426</td>
<td>0.74986</td>
<td>0.74451</td>
<td>0.69128</td>
<td>0.6832</td>
</tr>
<tr>
<td>A30</td>
<td>0.7124</td>
<td>0.72105</td>
<td>0.78291</td>
<td>0.79114</td>
<td>0.63607</td>
<td>0.72039</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 3</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.66807</td>
<td>0.664</td>
<td>0.67916</td>
<td>0.67435</td>
<td>0.62312</td>
<td>0.61812</td>
</tr>
<tr>
<td>A03</td>
<td>0.62862</td>
<td>0.6346</td>
<td>0.63876</td>
<td>0.62933</td>
<td>0.58439</td>
<td>0.62203</td>
</tr>
<tr>
<td>A19</td>
<td>0.66319</td>
<td>0.63215</td>
<td>0.65768</td>
<td>0.6926</td>
<td>0.5767</td>
<td>0.58323</td>
</tr>
<tr>
<td>A20</td>
<td>0.63689</td>
<td>0.64611</td>
<td>0.64837</td>
<td>0.65736</td>
<td>0.62953</td>
<td>0.61497</td>
</tr>
<tr>
<td>A29</td>
<td>0.64782</td>
<td>0.66888</td>
<td>0.66481</td>
<td>0.64746</td>
<td>0.60394</td>
<td>0.57758</td>
</tr>
<tr>
<td>A30</td>
<td>0.66504</td>
<td>0.67083</td>
<td>0.66622</td>
<td>0.63659</td>
<td>0.59164</td>
<td>0.55952</td>
</tr>
</tbody>
</table>

Table A4. 6 F spectrum, mean corrected transmissibility

**TR_p** = glove transmissibility averaged over subjects

<table>
<thead>
<tr>
<th></th>
<th>Glove 1</th>
<th>Glove 2</th>
<th>Glove 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.80903</td>
<td>0.73801</td>
<td>0.65447</td>
</tr>
<tr>
<td>A03</td>
<td>0.78425</td>
<td>0.71999</td>
<td>0.62295</td>
</tr>
<tr>
<td>A19</td>
<td>0.81078</td>
<td>0.74638</td>
<td>0.63426</td>
</tr>
<tr>
<td>A20</td>
<td>0.80454</td>
<td>0.70758</td>
<td>0.63887</td>
</tr>
<tr>
<td>A29</td>
<td>0.80057</td>
<td>0.7093</td>
<td>0.63508</td>
</tr>
<tr>
<td>A30</td>
<td>0.81358</td>
<td>0.72733</td>
<td>0.63164</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table A4. 7 FM spectrum, bare hand linear transmissibility

<table>
<thead>
<tr>
<th></th>
<th>TRFMb = bare hand transmissibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2 test average)</td>
</tr>
<tr>
<td>s1</td>
<td>s2</td>
</tr>
<tr>
<td>A02</td>
<td>1.016566</td>
</tr>
<tr>
<td>A03</td>
<td>0.979159</td>
</tr>
<tr>
<td>A19</td>
<td>0.998662</td>
</tr>
<tr>
<td>A20</td>
<td>0.99624</td>
</tr>
<tr>
<td>A29</td>
<td>0.993394</td>
</tr>
<tr>
<td>A30</td>
<td>0.988995</td>
</tr>
</tbody>
</table>

Table A4. 8 FM spectrum, glove 1, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>TRFMg = glove transmissibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>glove 1</td>
</tr>
<tr>
<td>s1</td>
<td>s2</td>
</tr>
<tr>
<td>A02</td>
<td>0.890828</td>
</tr>
<tr>
<td>A03</td>
<td>0.826139</td>
</tr>
<tr>
<td>A19</td>
<td>0.879593</td>
</tr>
<tr>
<td>A20</td>
<td>0.842803</td>
</tr>
<tr>
<td>A29</td>
<td>0.832361</td>
</tr>
<tr>
<td>A30</td>
<td>0.850289</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table A4. 9 FM spectrum, glove 2, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.824357</td>
<td>0.800071</td>
<td>0.845726</td>
<td>0.850719</td>
<td>0.799916</td>
<td>0.809312</td>
</tr>
<tr>
<td>A03</td>
<td>0.751412</td>
<td>0.77081</td>
<td>0.804444</td>
<td>0.802442</td>
<td>0.78673</td>
<td>0.780152</td>
</tr>
<tr>
<td>A19</td>
<td>0.800136</td>
<td>0.81451</td>
<td>0.829749</td>
<td>0.85407</td>
<td>0.789912</td>
<td>0.794547</td>
</tr>
<tr>
<td>A20</td>
<td>0.752715</td>
<td>0.77269</td>
<td>0.834864</td>
<td>0.842882</td>
<td>0.710992</td>
<td>0.734976</td>
</tr>
<tr>
<td>A29</td>
<td>0.780357</td>
<td>0.757537</td>
<td>0.813083</td>
<td>0.8073</td>
<td>0.759133</td>
<td>0.750163</td>
</tr>
<tr>
<td>A30</td>
<td>0.784891</td>
<td>0.795049</td>
<td>0.860712</td>
<td>0.862238</td>
<td>0.690947</td>
<td>0.784142</td>
</tr>
</tbody>
</table>

Table A4. 10 FM spectrum, glove 3, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.757876</td>
<td>0.752297</td>
<td>0.758296</td>
<td>0.754738</td>
<td>0.704263</td>
<td>0.697262</td>
</tr>
<tr>
<td>A03</td>
<td>0.69409</td>
<td>0.700583</td>
<td>0.701149</td>
<td>0.692515</td>
<td>0.644586</td>
<td>0.688205</td>
</tr>
<tr>
<td>A19</td>
<td>0.746615</td>
<td>0.713457</td>
<td>0.70868</td>
<td>0.74027</td>
<td>0.641343</td>
<td>0.649505</td>
</tr>
<tr>
<td>A20</td>
<td>0.716037</td>
<td>0.724877</td>
<td>0.712879</td>
<td>0.722535</td>
<td>0.698329</td>
<td>0.68332</td>
</tr>
<tr>
<td>A29</td>
<td>0.725622</td>
<td>0.746768</td>
<td>0.728929</td>
<td>0.709648</td>
<td>0.673032</td>
<td>0.645759</td>
</tr>
<tr>
<td>A30</td>
<td>0.738968</td>
<td>0.744852</td>
<td>0.740823</td>
<td>0.707255</td>
<td>0.660824</td>
<td>0.624365</td>
</tr>
</tbody>
</table>
Table A4. 11 FM spectrum, corrected transmissibility

<table>
<thead>
<tr>
<th>Gloves 1</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.876311</td>
<td>0.86061</td>
<td>0.921297</td>
<td>0.916972</td>
<td>0.842004</td>
<td>0.823735</td>
</tr>
<tr>
<td>A03</td>
<td>0.843723</td>
<td>0.828502</td>
<td>0.866549</td>
<td>0.850184</td>
<td>0.841454</td>
<td>0.84664</td>
</tr>
<tr>
<td>A19</td>
<td>0.880771</td>
<td>0.87875</td>
<td>0.934978</td>
<td>0.911626</td>
<td>0.839552</td>
<td>0.820638</td>
</tr>
<tr>
<td>A20</td>
<td>0.84312</td>
<td>0.816599</td>
<td>0.924166</td>
<td>0.909618</td>
<td>0.84324</td>
<td>0.843664</td>
</tr>
<tr>
<td>A29</td>
<td>0.837896</td>
<td>0.814827</td>
<td>0.919704</td>
<td>0.924047</td>
<td>0.851706</td>
<td>0.843868</td>
</tr>
<tr>
<td>A30</td>
<td>0.859751</td>
<td>0.855519</td>
<td>0.900267</td>
<td>0.895702</td>
<td>0.905038</td>
<td>0.888489</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gloves 2</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.810924</td>
<td>0.787034</td>
<td>0.849295</td>
<td>0.854309</td>
<td>0.798241</td>
<td>0.807617</td>
</tr>
<tr>
<td>A03</td>
<td>0.767406</td>
<td>0.787217</td>
<td>0.817692</td>
<td>0.815657</td>
<td>0.795202</td>
<td>0.788554</td>
</tr>
<tr>
<td>A19</td>
<td>0.801207</td>
<td>0.815601</td>
<td>0.86489</td>
<td>0.890241</td>
<td>0.791917</td>
<td>0.796564</td>
</tr>
<tr>
<td>A20</td>
<td>0.752998</td>
<td>0.772981</td>
<td>0.854176</td>
<td>0.86238</td>
<td>0.721561</td>
<td>0.745901</td>
</tr>
<tr>
<td>A29</td>
<td>0.785547</td>
<td>0.762575</td>
<td>0.82931</td>
<td>0.823412</td>
<td>0.76645</td>
<td>0.757394</td>
</tr>
<tr>
<td>A30</td>
<td>0.793625</td>
<td>0.803896</td>
<td>0.872782</td>
<td>0.87433</td>
<td>0.69874</td>
<td>0.792985</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gloves 3</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.745526</td>
<td>0.740038</td>
<td>0.761496</td>
<td>0.757923</td>
<td>0.702788</td>
<td>0.695802</td>
</tr>
<tr>
<td>A03</td>
<td>0.708864</td>
<td>0.715495</td>
<td>0.712696</td>
<td>0.703919</td>
<td>0.651528</td>
<td>0.695617</td>
</tr>
<tr>
<td>A19</td>
<td>0.747615</td>
<td>0.714413</td>
<td>0.738694</td>
<td>0.771622</td>
<td>0.642971</td>
<td>0.651154</td>
</tr>
<tr>
<td>A20</td>
<td>0.716307</td>
<td>0.725149</td>
<td>0.729369</td>
<td>0.739249</td>
<td>0.708709</td>
<td>0.693477</td>
</tr>
<tr>
<td>A29</td>
<td>0.730447</td>
<td>0.751734</td>
<td>0.743477</td>
<td>0.723811</td>
<td>0.679519</td>
<td>0.651983</td>
</tr>
<tr>
<td>A30</td>
<td>0.747191</td>
<td>0.75314</td>
<td>0.751212</td>
<td>0.717173</td>
<td>0.668277</td>
<td>0.631406</td>
</tr>
</tbody>
</table>

Table A4. 12 FM spectrum, mean corrected transmissibility

<table>
<thead>
<tr>
<th>TRFM = glove transmissibility averaged over subjects</th>
<th>Glove 1</th>
<th>Glove 2</th>
<th>Glove 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.873488</td>
<td>0.817903</td>
<td>0.733929</td>
</tr>
<tr>
<td>A03</td>
<td>0.846175</td>
<td>0.795288</td>
<td>0.69802</td>
</tr>
<tr>
<td>A19</td>
<td>0.877719</td>
<td>0.826737</td>
<td>0.711078</td>
</tr>
<tr>
<td>A20</td>
<td>0.863401</td>
<td>0.784999</td>
<td>0.71871</td>
</tr>
<tr>
<td>A29</td>
<td>0.865341</td>
<td>0.787448</td>
<td>0.713495</td>
</tr>
<tr>
<td>A30</td>
<td>0.884187</td>
<td>0.80606</td>
<td>0.7114</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
### Table A4. 13 FH spectrum, bare hand transmissibility

\( TR_{FHb} = \text{bare hand transmissibility} \)

<table>
<thead>
<tr>
<th></th>
<th>s1</th>
<th>s2</th>
<th>s3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>1.00191</td>
<td>1.00843</td>
<td>1.0118</td>
</tr>
<tr>
<td>A03</td>
<td>0.99741</td>
<td>0.99315</td>
<td>0.98873</td>
</tr>
<tr>
<td>A19</td>
<td>1.01131</td>
<td>0.96745</td>
<td>0.98694</td>
</tr>
<tr>
<td>A20</td>
<td>0.9962</td>
<td>1.00078</td>
<td>1.00018</td>
</tr>
<tr>
<td>A29</td>
<td>1.00425</td>
<td>0.98958</td>
<td>0.9971</td>
</tr>
<tr>
<td>A30</td>
<td>0.99631</td>
<td>0.99728</td>
<td>0.9952</td>
</tr>
</tbody>
</table>

### Table A4. 14 FH spectrum, glove 1, uncorrected data

\( TR_{FHg} = \text{glove transmissibility} \)

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.7533</td>
<td>0.74031</td>
<td>0.82297</td>
<td>0.80854</td>
<td>0.71421</td>
<td>0.69069</td>
</tr>
<tr>
<td>A03</td>
<td>0.72057</td>
<td>0.69645</td>
<td>0.74921</td>
<td>0.72341</td>
<td>0.71324</td>
<td>0.70839</td>
</tr>
<tr>
<td>A19</td>
<td>0.7523</td>
<td>0.71361</td>
<td>0.79682</td>
<td>0.76933</td>
<td>0.72574</td>
<td>0.68983</td>
</tr>
<tr>
<td>A20</td>
<td>0.71119</td>
<td>0.67297</td>
<td>0.82182</td>
<td>0.80152</td>
<td>0.73825</td>
<td>0.73372</td>
</tr>
<tr>
<td>A29</td>
<td>0.6848</td>
<td>0.6532</td>
<td>0.8073</td>
<td>0.84401</td>
<td>0.71318</td>
<td>0.69167</td>
</tr>
<tr>
<td>A30</td>
<td>0.70431</td>
<td>0.69718</td>
<td>0.78913</td>
<td>0.77676</td>
<td>0.76309</td>
<td>0.74375</td>
</tr>
</tbody>
</table>
### Table A4. 15 FH spectrum, glove 2, uncorrected data

\[ TR_{FHg} = \text{glove transmissibility} \]

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.64787</td>
<td>0.60691</td>
<td>0.661</td>
<td>0.66974</td>
<td>0.63457</td>
<td>0.65553</td>
</tr>
<tr>
<td>A03</td>
<td>0.59998</td>
<td>0.60903</td>
<td>0.65365</td>
<td>0.63748</td>
<td>0.63136</td>
<td>0.62709</td>
</tr>
<tr>
<td>A19</td>
<td>0.62053</td>
<td>0.62983</td>
<td>0.65828</td>
<td>0.69313</td>
<td>0.63302</td>
<td>0.64837</td>
</tr>
<tr>
<td>A20</td>
<td>0.55934</td>
<td>0.57399</td>
<td>0.69322</td>
<td>0.68928</td>
<td>0.56797</td>
<td>0.59301</td>
</tr>
<tr>
<td>A29</td>
<td>0.59682</td>
<td>0.54913</td>
<td>0.64508</td>
<td>0.64817</td>
<td>0.57122</td>
<td>0.56214</td>
</tr>
<tr>
<td>A30</td>
<td>0.61847</td>
<td>0.62333</td>
<td>0.6985</td>
<td>0.72218</td>
<td>0.55523</td>
<td>0.62542</td>
</tr>
</tbody>
</table>

### Table A4. 16 FH spectrum, glove 3, uncorrected data

\[ TR_{FHg} = \text{glove transmissibility} \]

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.57181</td>
<td>0.5683</td>
<td>0.53209</td>
<td>0.54206</td>
<td>0.51138</td>
<td>0.50019</td>
</tr>
<tr>
<td>A03</td>
<td>0.49882</td>
<td>0.50322</td>
<td>0.49031</td>
<td>0.46413</td>
<td>0.48285</td>
<td>0.49715</td>
</tr>
<tr>
<td>A19</td>
<td>0.54482</td>
<td>0.498</td>
<td>0.51481</td>
<td>0.55213</td>
<td>0.45658</td>
<td>0.46158</td>
</tr>
<tr>
<td>A20</td>
<td>0.53397</td>
<td>0.52195</td>
<td>0.50389</td>
<td>0.51582</td>
<td>0.51687</td>
<td>0.49827</td>
</tr>
<tr>
<td>A29</td>
<td>0.50797</td>
<td>0.54682</td>
<td>0.52419</td>
<td>0.48822</td>
<td>0.44461</td>
<td>0.39156</td>
</tr>
<tr>
<td>A30</td>
<td>0.56498</td>
<td>0.55812</td>
<td>0.54421</td>
<td>0.50502</td>
<td>0.4133</td>
<td>0.37704</td>
</tr>
</tbody>
</table>
### Table A4. 17 FH spectrum, corrected data

| TRFH = glove transmissibility corrected for bare hand |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Glove 1                          | s-1 t-1                         | s-1 t-2                         | s-2 t-1                         | s-2 t-2                         | s-3 t-1                         | s-3 t-2                         |
| A02                              | 0.75187                         | 0.7389                          | 0.81609                         | 0.80178                         | 0.70589                         | 0.68264                         |
| A03                              | 0.72244                         | 0.69825                         | 0.75437                         | 0.72839                         | 0.72137                         | 0.71647                         |
| A19                              | 0.74388                         | 0.70562                         | 0.82363                         | 0.79521                         | 0.73534                         | 0.69896                         |
| A20                              | 0.71391                         | 0.67554                         | 0.82118                         | 0.80089                         | 0.73811                         | 0.73359                         |
| A29                              | 0.68191                         | 0.65044                         | 0.81581                         | 0.8529                          | 0.71525                         | 0.69368                         |
| A30                              | 0.70692                         | 0.69977                         | 0.79128                         | 0.77889                         | 0.76677                         | 0.74733                         |

| Glove 2                          | s-1 t-1                         | s-1 t-2                         | s-2 t-1                         | s-2 t-2                         | s-3 t-1                         | s-3 t-2                         |
| A02                              | 0.64664                         | 0.60576                         | 0.65547                         | 0.66414                         | 0.62718                         | 0.64789                         |
| A03                              | 0.60154                         | 0.61061                         | 0.65815                         | 0.64187                         | 0.63855                         | 0.63424                         |
| A19                              | 0.61359                         | 0.62278                         | 0.68042                         | 0.71644                         | 0.6414                          | 0.65695                         |
| A20                              | 0.56147                         | 0.57618                         | 0.69268                         | 0.68875                         | 0.56786                         | 0.5929                          |
| A29                              | 0.59429                         | 0.54681                         | 0.65188                         | 0.655                            | 0.57288                         | 0.56378                         |
| A30                              | 0.62076                         | 0.62564                         | 0.7004                          | 0.72416                         | 0.55791                         | 0.62844                         |

| Glove 3                          | s-1 t-1                         | s-1 t-2                         | s-2 t-1                         | s-2 t-2                         | s-3 t-1                         | s-3 t-2                         |
| A02                              | 0.57072                         | 0.56722                         | 0.52764                         | 0.53753                         | 0.50541                         | 0.49436                         |
| A03                              | 0.50012                         | 0.50452                         | 0.49369                         | 0.46733                         | 0.48835                         | 0.50281                         |
| A19                              | 0.53872                         | 0.49243                         | 0.53213                         | 0.5707                          | 0.46262                         | 0.46769                         |
| A20                              | 0.53601                         | 0.52394                         | 0.5035                          | 0.51542                         | 0.51677                         | 0.49818                         |
| A29                              | 0.50582                         | 0.5445                          | 0.52971                         | 0.49336                         | 0.44591                         | 0.3927                          |
| A30                              | 0.56707                         | 0.56019                         | 0.5457                          | 0.5064                          | 0.41529                         | 0.37886                         |

### Table A4. 18 FH spectrum, mean corrected transmissibility

| TRFH = glove transmissibility averaged over subjects |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Glove 1                          | Glove 2                         | Glove 3                         |
| A02                              | 0.74953                         | 0.64118                         | 0.53381                         |
| A03                              | 0.72355                         | 0.63083                         | 0.49281                         |
| A19                              | 0.75044                         | 0.65526                         | 0.51072                         |
| A20                              | 0.7472                          | 0.61331                         | 0.51564                         |
| A29                              | 0.735                            | 0.59744                         | 0.48533                         |
| A30                              | 0.74849                         | 0.64288                         | 0.49559                         |
Table A4. 19 H spectrum, bare hand linear transmissibility

|   | TR\textsubscript{Nb} = bare hand transmissibility  
(2 test average) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s1</td>
</tr>
<tr>
<td>A02</td>
<td>0.98475</td>
</tr>
<tr>
<td>A03</td>
<td>0.99542</td>
</tr>
<tr>
<td>A19</td>
<td>0.99746</td>
</tr>
<tr>
<td>A20</td>
<td>0.99</td>
</tr>
<tr>
<td>A29</td>
<td>0.99065</td>
</tr>
<tr>
<td>A30</td>
<td>0.98287</td>
</tr>
</tbody>
</table>

Table A4. 20 H spectrum, glove 1, uncorrected data

|   | TR\textsubscript{Ng} = glove transmissibility  
glove 1 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s-1 t-1</td>
</tr>
<tr>
<td>A02</td>
<td>0.76872</td>
</tr>
<tr>
<td>A03</td>
<td>0.78504</td>
</tr>
<tr>
<td>A19</td>
<td>0.84992</td>
</tr>
<tr>
<td>A20</td>
<td>0.77398</td>
</tr>
<tr>
<td>A29</td>
<td>0.78587</td>
</tr>
<tr>
<td>A30</td>
<td>0.75711</td>
</tr>
</tbody>
</table>
### Table A4. 21 H spectrum, glove 2, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>TR&lt;sub&gt;tg&lt;/sub&gt; = glove transmissibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>glove 2</td>
</tr>
<tr>
<td>A&lt;sub&gt;02&lt;/sub&gt;</td>
<td>0.6684</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;03&lt;/sub&gt;</td>
<td>0.60914</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;19&lt;/sub&gt;</td>
<td>0.63359</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;20&lt;/sub&gt;</td>
<td>0.64033</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;29&lt;/sub&gt;</td>
<td>0.62985</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;30&lt;/sub&gt;</td>
<td>0.66587</td>
</tr>
</tbody>
</table>

### Table A4. 22 H spectrum, glove 3, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>TR&lt;sub&gt;tg&lt;/sub&gt; = glove transmissibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>glove 3</td>
</tr>
<tr>
<td>A&lt;sub&gt;02&lt;/sub&gt;</td>
<td>0.61355</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;03&lt;/sub&gt;</td>
<td>0.63767</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;19&lt;/sub&gt;</td>
<td>0.60063</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;20&lt;/sub&gt;</td>
<td>0.59501</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;29&lt;/sub&gt;</td>
<td>0.55155</td>
</tr>
<tr>
<td></td>
<td>s&lt;sup&gt;-1&lt;/sup&gt; t&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
<tr>
<td>A&lt;sub&gt;30&lt;/sub&gt;</td>
<td>0.60901</td>
</tr>
</tbody>
</table>
**Table A4. 23 H spectrum, corrected data**

$\text{TR}_H = \text{glove transmissibility corrected for bare hand}$

<table>
<thead>
<tr>
<th>Glove 1</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.78062</td>
<td>0.74364</td>
<td>0.88689</td>
<td>0.86664</td>
<td>0.76977</td>
<td>0.76653</td>
</tr>
<tr>
<td>A03</td>
<td>0.78865</td>
<td>0.78594</td>
<td>0.85551</td>
<td>0.86006</td>
<td>0.78079</td>
<td>0.76972</td>
</tr>
<tr>
<td>A19</td>
<td>0.85209</td>
<td>0.83634</td>
<td>0.87146</td>
<td>0.85656</td>
<td>0.77665</td>
<td>0.77104</td>
</tr>
<tr>
<td>A20</td>
<td>0.78179</td>
<td>0.72044</td>
<td>0.87541</td>
<td>0.88689</td>
<td>0.80306</td>
<td>0.80105</td>
</tr>
<tr>
<td>A29</td>
<td>0.79328</td>
<td>0.75622</td>
<td>0.88072</td>
<td>0.87421</td>
<td>0.84624</td>
<td>0.81552</td>
</tr>
<tr>
<td>A30</td>
<td>0.7703</td>
<td>0.72936</td>
<td>0.84433</td>
<td>0.84539</td>
<td>0.82017</td>
<td>0.8136</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 2</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.67874</td>
<td>0.67289</td>
<td>0.80014</td>
<td>0.79751</td>
<td>0.7165</td>
<td>0.70989</td>
</tr>
<tr>
<td>A03</td>
<td>0.61195</td>
<td>0.60372</td>
<td>0.73297</td>
<td>0.73607</td>
<td>0.66194</td>
<td>0.65003</td>
</tr>
<tr>
<td>A19</td>
<td>0.63521</td>
<td>0.6227</td>
<td>0.77561</td>
<td>0.77877</td>
<td>0.69264</td>
<td>0.71296</td>
</tr>
<tr>
<td>A20</td>
<td>0.64679</td>
<td>0.58177</td>
<td>0.75128</td>
<td>0.75504</td>
<td>0.63321</td>
<td>0.64347</td>
</tr>
<tr>
<td>A29</td>
<td>0.63579</td>
<td>0.6167</td>
<td>0.73372</td>
<td>0.73304</td>
<td>0.67417</td>
<td>0.63378</td>
</tr>
<tr>
<td>A30</td>
<td>0.67747</td>
<td>0.65782</td>
<td>0.77738</td>
<td>0.78765</td>
<td>0.65439</td>
<td>0.62535</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 3</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.62305</td>
<td>0.62873</td>
<td>0.60663</td>
<td>0.61016</td>
<td>0.55313</td>
<td>0.50392</td>
</tr>
<tr>
<td>A03</td>
<td>0.64061</td>
<td>0.59951</td>
<td>0.52205</td>
<td>0.47396</td>
<td>0.42219</td>
<td>0.38561</td>
</tr>
<tr>
<td>A19</td>
<td>0.60216</td>
<td>0.54569</td>
<td>0.58756</td>
<td>0.60808</td>
<td>0.48115</td>
<td>0.47242</td>
</tr>
<tr>
<td>A20</td>
<td>0.60102</td>
<td>0.614</td>
<td>0.49693</td>
<td>0.51417</td>
<td>0.50471</td>
<td>0.49871</td>
</tr>
<tr>
<td>A29</td>
<td>0.55676</td>
<td>0.53346</td>
<td>0.54301</td>
<td>0.49163</td>
<td>0.45461</td>
<td>0.47109</td>
</tr>
<tr>
<td>A30</td>
<td>0.61962</td>
<td>0.57397</td>
<td>0.54637</td>
<td>0.55029</td>
<td>0.42518</td>
<td>0.44005</td>
</tr>
</tbody>
</table>

**Table A4. 24 H spectrum, mean corrected transmissibility**

$\text{TR}_H = \text{glove transmissibility averaged over subjects}$

<table>
<thead>
<tr>
<th></th>
<th>glove 1</th>
<th>glove 2</th>
<th>glove 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.80235</td>
<td>0.72928</td>
<td>0.5876</td>
</tr>
<tr>
<td>A03</td>
<td>0.80678</td>
<td>0.66611</td>
<td>0.50732</td>
</tr>
<tr>
<td>A19</td>
<td>0.82736</td>
<td>0.70298</td>
<td>0.54951</td>
</tr>
<tr>
<td>A20</td>
<td>0.81144</td>
<td>0.66859</td>
<td>0.53826</td>
</tr>
<tr>
<td>A29</td>
<td>0.8277</td>
<td>0.6712</td>
<td>0.50843</td>
</tr>
<tr>
<td>A30</td>
<td>0.80386</td>
<td>0.69668</td>
<td>0.52591</td>
</tr>
</tbody>
</table>

134

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table A4. 25 M spectrum, bare hand transmissibility

<table>
<thead>
<tr>
<th></th>
<th>s1</th>
<th>s2</th>
<th>s3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.97166</td>
<td>0.9954</td>
<td>0.9742</td>
</tr>
<tr>
<td>A03</td>
<td>0.9686</td>
<td>0.98089</td>
<td>0.99515</td>
</tr>
<tr>
<td>A19</td>
<td>0.9751</td>
<td>0.98258</td>
<td>0.97982</td>
</tr>
<tr>
<td>A20</td>
<td>0.97409</td>
<td>0.97954</td>
<td>0.96791</td>
</tr>
<tr>
<td>A29</td>
<td>0.98298</td>
<td>0.99373</td>
<td>0.95907</td>
</tr>
<tr>
<td>A30</td>
<td>0.97481</td>
<td>0.98901</td>
<td>0.97555</td>
</tr>
</tbody>
</table>

Table A4. 26 M spectrum, glove 1, uncorrected data

<table>
<thead>
<tr>
<th></th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.81303</td>
<td>0.82681</td>
<td>0.87692</td>
<td>0.86123</td>
<td>0.83502</td>
<td>0.82562</td>
</tr>
<tr>
<td>A03</td>
<td>0.84977</td>
<td>0.83572</td>
<td>0.88306</td>
<td>0.87995</td>
<td>0.83919</td>
<td>0.83567</td>
</tr>
<tr>
<td>A19</td>
<td>0.80874</td>
<td>0.82368</td>
<td>0.87974</td>
<td>0.89919</td>
<td>0.83625</td>
<td>0.82669</td>
</tr>
<tr>
<td>A20</td>
<td>0.82017</td>
<td>0.8083</td>
<td>0.83651</td>
<td>0.82674</td>
<td>0.80309</td>
<td>0.79128</td>
</tr>
<tr>
<td>A29</td>
<td>0.86119</td>
<td>0.85487</td>
<td>0.86817</td>
<td>0.87642</td>
<td>0.79722</td>
<td>0.78957</td>
</tr>
<tr>
<td>A30</td>
<td>0.85404</td>
<td>0.88069</td>
<td>0.8768</td>
<td>0.86652</td>
<td>0.8244</td>
<td>0.82408</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table A4. 27 M spectrum, glove 2, uncorrected data

<table>
<thead>
<tr>
<th>Glove Transmissibility</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.76286</td>
<td>0.76669</td>
<td>0.81534</td>
<td>0.82753</td>
<td>0.75286</td>
<td>0.76875</td>
</tr>
<tr>
<td>A03</td>
<td>0.73562</td>
<td>0.77169</td>
<td>0.82069</td>
<td>0.82789</td>
<td>0.74045</td>
<td>0.74667</td>
</tr>
<tr>
<td>A19</td>
<td>0.75464</td>
<td>0.78894</td>
<td>0.80576</td>
<td>0.80171</td>
<td>0.7335</td>
<td>0.73431</td>
</tr>
<tr>
<td>A20</td>
<td>0.69374</td>
<td>0.74361</td>
<td>0.76264</td>
<td>0.7706</td>
<td>0.72335</td>
<td>0.73546</td>
</tr>
<tr>
<td>A29</td>
<td>0.83841</td>
<td>0.83817</td>
<td>0.79946</td>
<td>0.79014</td>
<td>0.7222</td>
<td>0.73681</td>
</tr>
<tr>
<td>A30</td>
<td>0.78801</td>
<td>0.77818</td>
<td>0.79301</td>
<td>0.78922</td>
<td>0.76857</td>
<td>0.71948</td>
</tr>
</tbody>
</table>

Table A4. 28 M spectrum, glove 3, uncorrected data

<table>
<thead>
<tr>
<th>Glove Transmissibility</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.63028</td>
<td>0.62288</td>
<td>0.67582</td>
<td>0.65109</td>
<td>0.60777</td>
<td>0.59651</td>
</tr>
<tr>
<td>A03</td>
<td>0.65441</td>
<td>0.63572</td>
<td>0.58223</td>
<td>0.58678</td>
<td>0.62441</td>
<td>0.61774</td>
</tr>
<tr>
<td>A19</td>
<td>0.66966</td>
<td>0.64349</td>
<td>0.55972</td>
<td>0.55322</td>
<td>0.62583</td>
<td>0.60334</td>
</tr>
<tr>
<td>A20</td>
<td>0.68167</td>
<td>0.67358</td>
<td>0.59763</td>
<td>0.59311</td>
<td>0.66583</td>
<td>0.64675</td>
</tr>
<tr>
<td>A29</td>
<td>0.69712</td>
<td>0.69711</td>
<td>0.64323</td>
<td>0.64375</td>
<td>0.58695</td>
<td>0.59088</td>
</tr>
<tr>
<td>A30</td>
<td>0.7017</td>
<td>0.69377</td>
<td>0.61825</td>
<td>0.57512</td>
<td>0.61327</td>
<td>0.5708</td>
</tr>
</tbody>
</table>
Table A4. 29 M spectrum, corrected data

<table>
<thead>
<tr>
<th>Glove 1</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.83674</td>
<td>0.85092</td>
<td>0.88097</td>
<td>0.86521</td>
<td>0.85713</td>
<td>0.84748</td>
</tr>
<tr>
<td>A03</td>
<td>0.87323</td>
<td>0.86281</td>
<td>0.90026</td>
<td>0.89709</td>
<td>0.84328</td>
<td>0.83975</td>
</tr>
<tr>
<td>A19</td>
<td>0.82939</td>
<td>0.84471</td>
<td>0.89534</td>
<td>0.91513</td>
<td>0.85347</td>
<td>0.84371</td>
</tr>
<tr>
<td>A20</td>
<td>0.84199</td>
<td>0.82981</td>
<td>0.85398</td>
<td>0.84401</td>
<td>0.82972</td>
<td>0.81752</td>
</tr>
<tr>
<td>A29</td>
<td>0.8761</td>
<td>0.86906</td>
<td>0.87365</td>
<td>0.88195</td>
<td>0.83125</td>
<td>0.82327</td>
</tr>
<tr>
<td>A30</td>
<td>0.87611</td>
<td>0.90345</td>
<td>0.88654</td>
<td>0.87615</td>
<td>0.84506</td>
<td>0.84473</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 2</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.78511</td>
<td>0.78905</td>
<td>0.81911</td>
<td>0.83135</td>
<td>0.7728</td>
<td>0.78911</td>
</tr>
<tr>
<td>A03</td>
<td>0.75947</td>
<td>0.79671</td>
<td>0.83668</td>
<td>0.84401</td>
<td>0.74406</td>
<td>0.75031</td>
</tr>
<tr>
<td>A19</td>
<td>0.77391</td>
<td>0.80909</td>
<td>0.82004</td>
<td>0.81592</td>
<td>0.74861</td>
<td>0.74943</td>
</tr>
<tr>
<td>A20</td>
<td>0.7122</td>
<td>0.7634</td>
<td>0.77857</td>
<td>0.78669</td>
<td>0.74734</td>
<td>0.75985</td>
</tr>
<tr>
<td>A29</td>
<td>0.85293</td>
<td>0.85269</td>
<td>0.80451</td>
<td>0.79512</td>
<td>0.75302</td>
<td>0.76826</td>
</tr>
<tr>
<td>A30</td>
<td>0.80837</td>
<td>0.79829</td>
<td>0.80182</td>
<td>0.79798</td>
<td>0.78783</td>
<td>0.73751</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Glove 3</th>
<th>s-1 t-1</th>
<th>s-1 t-2</th>
<th>s-2 t-1</th>
<th>s-2 t-2</th>
<th>s-3 t-1</th>
<th>s-3 t-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>0.64866</td>
<td>0.64105</td>
<td>0.67894</td>
<td>0.6541</td>
<td>0.62387</td>
<td>0.61231</td>
</tr>
<tr>
<td>A03</td>
<td>0.67563</td>
<td>0.65633</td>
<td>0.59357</td>
<td>0.59821</td>
<td>0.62746</td>
<td>0.62075</td>
</tr>
<tr>
<td>A19</td>
<td>0.68676</td>
<td>0.65992</td>
<td>0.56964</td>
<td>0.56302</td>
<td>0.63871</td>
<td>0.61576</td>
</tr>
<tr>
<td>A20</td>
<td>0.6998</td>
<td>0.6915</td>
<td>0.61011</td>
<td>0.60549</td>
<td>0.6879</td>
<td>0.66819</td>
</tr>
<tr>
<td>A29</td>
<td>0.70919</td>
<td>0.70918</td>
<td>0.64728</td>
<td>0.64781</td>
<td>0.612</td>
<td>0.61609</td>
</tr>
<tr>
<td>A30</td>
<td>0.71983</td>
<td>0.7117</td>
<td>0.62512</td>
<td>0.58151</td>
<td>0.62864</td>
<td>0.5851</td>
</tr>
</tbody>
</table>

Table A4. 30 M spectrum, mean corrected transmissibility

| TRM = glove transmissibility averaged over subjects |
|---------------------------------|-----------------|-----------------|
| Glove 1                         | Glove 2         | Glove 3         |
| A02                             | 0.85641         | 0.79775         |
| A03                             | 0.87009         | 0.78854         |
| A19                             | 0.86363         | 0.78617         |
| A20                             | 0.83617         | 0.75801         |
| A29                             | 0.85932         | 0.80442         |
| A30                             | 0.87201         | 0.78863         |

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
APPENDIX 5

LINEAR TRANSMISSIBILITY OF GLOVED HAND PLOTS
Figure A5. 1 F spectra adapter 02 glove 0

Figure A5. 2 F spectra adapter 02 glove 1
Figure A5. 3 F spectra, adapter 02, glove 2

Figure A5. 4 F spectra, adapter 02, glove 3
Figure A5. 5 F spectra, adapter 03, glove 0

Figure A5. 6 F spectra, adapter 03, glove 1
Figure A5. 7 F spectra, adapter 03, glove 2

Figure A5. 8 F spectra, adapter 03, glove 3
Figure A5. 9 F spectra, adapter 19, glove 0

Figure A5. 10 F spectra, adapter 19, glove 1
Figure A5. 11 F spectra, adapter 19, glove 2

Figure A5. 12 F spectra, adapter 19, glove 3
Figure A5. 13 F spectra, adapter 20, glove 0

Figure A5. 14 F spectra, adapter 20, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 15 F spectra, adapter 20, glove 2

Figure A5. 16 F spectra, adapter 20, glove 3
Figure A5. 17 F spectra, adapter 29, glove 0

Figure A5. 18 F spectra, adapter 29, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 19 F spectra, adapter 29, glove 2

Figure A5. 20 F spectra, adapter 29, glove 3

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 21 F spectra, adapter 30, glove 0

Figure A5. 22 F spectra, adapter 30, glove 1
Figure A5. 23 F spectra, adapter 30, glove 2

Figure A5. 24 F spectra, adapter 30, glove 3
Figure A5. 25 M spectra, adapter 02, glove 0

Figure A5. 26 M spectra, adapter 02, glove 1
Figure A5. 27 M spectra, adapter 02, glove 2

Figure A5. 28 M spectra, adapter 02, glove 3
Figure A5. 29 M spectra, adapter 03, glove 0

Figure A5. 30 M spectra, adapter 03, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 31 M spectra, adapter 03, glove 2

Figure A5. 32 M spectra, adapter 03, glove 3
Figure A5. 33 M spectra, adapter 19, glove 0

Figure A5. 34 M spectra, adapter 19, glove 1
Figure A5. 35 M spectra, adapter 19, glove 2

Figure A5. 36 M spectra, adapter 19, glove 3
Figure A5. 37 M spectra, adapter 20, glove 0

Figure A5. 38 M spectra, adapter 20, glove 1
Figure A5. 39 M spectra, adapter 20, glove 2

Figure A5. 40 M spectra, adapter 20, glove 3
Figure A5. 41 M spectra, adapter 29, glove 0

Figure A5. 42 M spectra, adapter 29, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 43 M spectra, adapter 29, glove 2

Figure A5. 44 M spectra, adapter 29, glove 3
Figure A5. 45 M spectra, adapter 30, glove 0

Figure A5. 46 M spectra, adapter 30, glove 1
Figure A5. 47 M spectra, adapter 30, glove 2

Figure A5. 48 M spectra, adapter 30, glove 3

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 49 H spectra, adapter 02, glove 0

Figure A5. 50 H spectra, adapter 02, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 51 H spectra, adapter 02, glove 2

Figure A5. 52 H spectra, adapter 02, glove 3
Figure A5. 53 H spectra, adapter 03, glove 0

Figure A5. 54 H spectra, adapter 03, glove 1
Figure A5. 55 Hz spectra, adapter 03, glove 2

Figure A5. 56 Hz spectra, adapter 03, glove 3
Figure A5. 57 H spectra, adapter 19, glove 0

Figure A5. 58 H spectra, adapter 19, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 59 H spectra, adapter 19, glove 2

Figure A5. 60 H spectra, adapter 19, glove 3

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 61 H spectra, adapter 20, glove 0

Figure A5. 62 H spectra, adapter 20, glove 1
Figure A5. 63 H spectra, adapter 20, glove 2

Figure A5. 64 H spectra, adapter 20, glove 3
Figure A5. 65 H spectra, adapter 29, glove 0

Figure A5. 66 H spectra, adapter 29, glove 1

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 67 H spectra, adapter 29, glove 2

Figure A5. 68 H spectra, adapter 29, glove 3

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Figure A5. 69 H spectra, adapter 30, glove 0

Figure A5. 70 H spectra, adapter 30, glove 1
Figure A5. 71 H spectra, adapter 30, glove 2

Figure A5. 72 H spectra, adapter 30, glove 3


VITA

Graduate College
University of Nevada, Las Vegas

Erik J. Wolf

Local Address:
1350 N. Town Center Dr. #2111
Las Vegas, NV 89144

Home Address:
1350 N. Town Center Dr. #2111
Las Vegas, NV 89144

Degrees:
Bachelor of Science, Mechanical Engineering, 2000
University of Nevada, Las Vegas

Thesis Title: Investigation of Issues Relating to the Revision of ISO 10819

Thesis Examination Committee:
Chairman, Dr. Douglas Reynolds
Committee Member, Dr. William Culbreth
Committee Member, Dr. Woosoon Yim
Graduate Faculty Representative, Dr. Moses Karakouzian

176