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The fixture and methodologies for evaluating vibration characteristics of hand-held pneumatic impact tools

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TEST FIXTURE & METHODOLOGIES FOR EVALUATING VIBRATION CHARACTERISTICS OF HAND-HELD PNEUMATIC IMPACT TOOLS

by

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ABSTRACT

Test Fixture & Methodologies for Evaluating the Vibration Characteristics of Hand-held Pneumatic Impact Tools

by

Jeffrey G. Markle

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

A test fixture has been designed for the testing of hand held pneumatic impact tools. The test fixture was modeled after a one-degree of freedom mass-spring-damper system. The design of the test fixture allows for a broad range of testing scenarios intended to simulate the methods in which impact tools are used in industry. Sustained use and assembly operations performed by impact tools were simulated on the test fixture. Acceleration measurements at the impact tool's handle and on the test fixture's mass were recorded during the simulations. From the measurements made on the test fixture's mass, the acceleration levels at the tool's working surface were calculated using a force balance model of the impact tool and the test fixture. From the acceleration measurements made at the impact tool's handle, vibration exposure levels were calculated for four and eight hour exposure time periods. Test procedures and methods incorporating the use of the test fixture are discussed. Results obtained during the testing process are provided.

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LIST OF SYMBOLS

Symbol	Description	Unit
$\frac{A(\omega)}{F}$	Accelerance	$\frac{m/s^2}{N}$
$a_{c,j}$	Transmissibility corrected root-mean-square (r.m.s) acceleration measured in the j^{th} third octave band	m/s^2
$a_{h,j}$	See description of $a_{c,j}$	m/s^2
$a_{h,l}$	Linear (un-weighted) r.m.s. acceleration value	m/s^2
$a_{h,w}$	ISO weighted r.m.s. acceleration value	m/s^2
$(a_{h,w})_{eq(Td)}$	Frequency-weighted energy equivalent r.m.s. acceleration for the T_d time period	m/s^2
$a_{m,j}$	Measured r.m.s. acceleration in the j^{th} third octave band	m/s^2
$a_{r,j}$	Measured reference r.m.s. acceleration in the j^{th} third octave band	m/s^2
$a_{(x,y,z),j}$	X,Y,Z r.m.s. acceleration vector component	m/s^2
$(a_{(x,y,z),j})_g$	X,Y,Z r.m.s. acceleration vector component inside the glove	m/s^2
$(a_{(x,y,z),j})_h$	X,Y,Z r.m.s. acceleration vector component at the handle	m/s^2
$a_{(x,y,z),w}$	ISO weighted X,Y,Z r.m.s. acceleration vector component	m/s^2
$a_{x,j}$	Transmissibility corrected x-axis r.m.s. acceleration measured in the j^{th} third octave band	m/s^2
$a_{y,j}$	Transmissibility corrected y-axis r.m.s. acceleration measured in the j^{th} third octave band	m/s^2
$a_{z,j}$	Transmissibility corrected z-axis r.m.s. acceleration measured in the j^{th} third octave band	m/s^2
$(a_{z,j})_g$	Transmissibility corrected z-axis r.m.s. acceleration inside the glove measured in the j^{th} third octave band	m/s^2

Symbol	Description	Unit
$(a_{z,j})_h$	Transmissibility corrected z-axis r.m.s. acceleration at the handle measured in the j^{th} third octave band	m/s^2
C	Viscous damping coefficient	$N \cdot s/m$
F	Excitation force	N
f(t)	Time dependant excitation force	N
f_n	Resonant frequency	Hz
K	Stiffness coefficient	N/m
K_j	ISO weighting factor for the j^{th} third octave band	—
M_{eff}	Effective mass	kg
m_{TF}	Mass of test fixture	kg
m_{chisel}	Mass of impact tool's chisel	kg
m_{tool}	Mass of impact tool	kg
n	Number of third octave bands from 6.3 to 1,250 Hz	—
T_d	Daily exposure time	h
T_e	Calculated exposure time	h
T_4	Daily exposure time of four hours	h
T_8	Daily exposure time of eight hours	h
TR_j	Transmissibility ratio measured in the j^{th} third octave band	—
t_j	Installation time	s
t_{total}	Total installation time of all parts at the station	s
$\frac{V(\omega)}{F}$	Mobility	$\frac{m/s}{N}$
$\frac{Y(\omega)}{F}$	Dynamic compliance	m/N

Symbol	Description	Unit
$\ddot{y}(t)$	Acceleration	m/s^2
$\dot{y}(t)$	Velocity	m/s
$y(t)$	Position	m
ω_n	Resonant frequency	rad/s
ω_1, ω_2	Half power points	rad/s
ξ	Damping ratio	—

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Many were instrumental in the completion of this thesis. I would like to begin by thanking the Lord for all that He provided and for keeping me focused on completing my thesis. Next I wish to express my sincere thanks to my advising professor, Dr. Douglas D. Reynolds. I would not have completed my work without his insight, encouragement, guidance, and willingness to be a test subject throughout the research and experimental phases of my thesis project. I also wish to thank Trevor Wilcox and Eric Wolf, my other eager test subjects who spared their time to assist a fellow student in need of test data. I would like to thank William Bloxsom for the many hours he contributed to the manufacture of the test fixture. The CAD drawings of the test stand were the labor of Richard Silva and I thank him for allowing me to use them.

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Finally, I thank my family. Lena, I love you with all my heart and I appreciate your support and patience through the past two years. Mom and Dad, thank you for always supporting my educational decisions and choices.

CHAPTER 1

INTRODUCTION

For close to a century operators of hand-held vibrating tools have reported of tingling and episodic numbness and blanching of the fingers, a reduction in grip strength and a decrease in finger dexterity. The workers also noted the sensation of pain occurring in response to a decrease in temperature or with the return of circulation to the hands [16]. Over the years the signs and symptoms being reported have been given different names: Raynaud's phenomenon, dead finger, vibration white finger (VWF), vibration syndrome, and traumatic vasospastic disease. Due to the common cause of these signs and symptoms the names have been grouped together and are now referred to as hand-arm vibration syndrome (HAVS). Workers reported an increase in the severity of HAVS as exposure, in the form of intensity and duration, to vibration increased. Studies performed in the past two decades show strong evidence linking high hand-arm vibration exposure to the signs and symptoms of HAVS [17]. In recent years Carpal Tunnel Syndrome (CTS) has also been linked to vibration exposure from hand-held vibrating tools [3]. Chipping hammers, impact wrenches, rock drills, rivet hammers, pneumatic drills, vertical grinders, pneumatic screwdrivers, angle grinders, and scaling hammers are all common hand-held vibration tools that incorporate a reciprocating process powered by air pressure. The reciprocating processes of hand-held vibration tools coupled with harsh repetitive applications produce the high vibration exposure levels that lead to the musculoskeletal disorders HAVS and CTS.

In the United States an estimated two to four million workers are exposed to hand-arm vibration of some degree [11]. U.S. workers are not the only people at risk. Over one million British workers are also at risk from exposure to hand-arm vibration [6]. Workers in other industrialized countries face similar exposure. Hand-held impact tools play an important role in industry. Yet so many workers develop musculoskeletal disorders from exposure to hand-arm vibration. Recommendations have been made and standards developed to identify and reduce musculoskeletal disorders. Hand-held power tool manufacturers now incorporate ergonomics and vibration testing into the design of tools. Current vibration testing performed by manufacturers follows International Organization for Standardization (ISO) standard 8662 [9] for vibration testing of hand-held impact tools. This standard specifies that vibration levels be measured, in the form of acceleration, on the handle or near the working surface of the tool. During the measurement process, the tool is operated on a steel energy ball absorber device. The working surface of the tool rests on top of the balls. Fig. 1 shows a typical steel ball energy absorber.

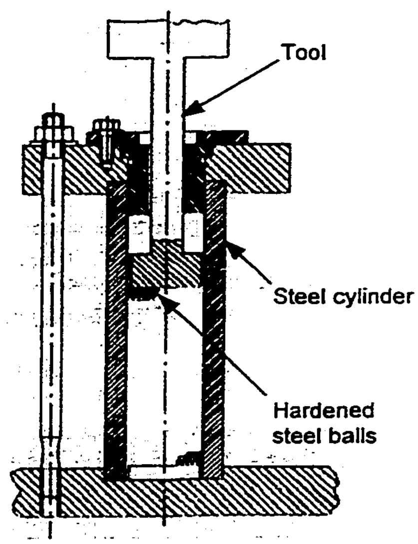


Fig. 1. Steel ball energy absorber

Measuring acceleration values produced by hand held impact tools are often difficult. The high amplitude energy generated by impact tools severely limits the type of transducers capable of measuring acceleration values associated with the impact tools. Accelerometers with the ability to withstand high shock levels are large and/or expensive. The amplitudes near the working surface of the impact tool are so great that even the best accelerometers last only a few seconds before becoming permanently damaged. For acceleration measurements made at the handle of an impact tool, mounting large accelerometers to the handle makes the tool uncomfortable or impossible to operate. Using smaller accelerometers will make tool operation more comfortable, but small accelerometers are delicate. Although acceleration amplitudes at

the handle are not as large as at the working surface of the tool, the amplitudes at the handle are great enough to cause small accelerometers to fail. A common failure occurs when the accelerometer looses connection to ground. Known as D.C. shift, the connection loss is induced by an impact force that exceeds the physical limitations of the transducer. The average impact force may not be that large, but within the average a few peak impact forces are generated by the tool which contain enough energy to cause the transducer's connection to ground to be lost.

To circumvent placing transducers directly on the tool, a test fixture was developed by graduate students and their advising professor at the Center for Mechanical and Environmental Systems Technology (CMEST), located at the University of Nevada, Las Vegas. Fig. 2 pictures this test fixture. With this one-degree of freedom system, acceleration values at the working surface and handle of the tool are determined indirectly. An accelerometer mounted to the test fixture's floating mass measures the acceleration resulting from the excitation caused by the tool impacting the surface of the test fixture's mass. Applying Newton's Third Law, stating that for every action there is an opposite, but equal, reaction, the acceleration of the tool impacting the test mass can be calculated. Thus, eliminating the need to mount an accelerometer directly to the tool.

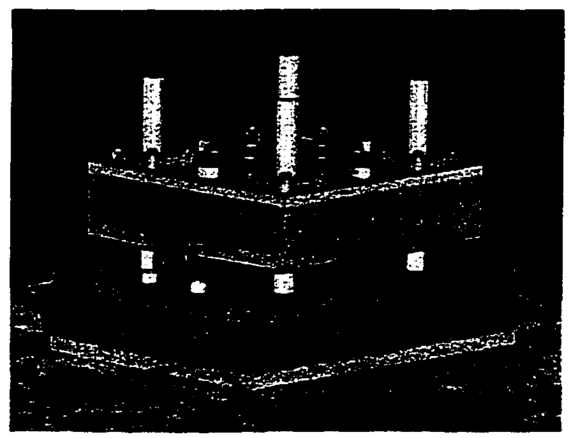


Fig. 2. Test fixture

The test fixture's design leads to a great deal of versatility. Impact tools are used in different applications and on varying materials. Different materials can be attached to the test fixture's surface and testing of an impact tool can occur for continual contact with the material or for a repeated process. Thus, simulations can be developed using the test fixture that range from foundry, quarry, and shipyard-type work performed with chipping hammers, scaling hammers, and hammer drills to automobile and aerospace-type work performed with rivet hammers.

CHAPTER 2

DESIGN AND MANUFACTURE OF TEST FIXTURE

Using experience and information gathered during previous testing performed with hand held impact tools at CMEST, the following guidelines were defined to aid in the development of the test fixture:

- Test fixture must withstand the tremendous forces exerted by impact tools.
- Test fixture must have the versatility to test a variety of hand held impact tools.
- Test fixture's frequency response characteristics cannot influence the frequency response of impact tools tested with the fixture.

To ensure the robustness of the test fixture, thick steel plats were used as the building material. The test fixture consisted of a massive steel base, weighing over 91 kg (200 lbs). Four casehardened steel shafts were mounted into the corners of the steel base. A steel mass weighing 68 kg (150 lbs), with four linear bearings, rode vertically on the shafts. An eight to ten inch wheelbarrow inner tube was placed between the base and the test mass to act as an air spring. Fig. 3 pictures a schematic of the test stand. The top surface of the mass, floating on the inner tube, was drilled and tapped with nine bolt holes. This allowed for mounting various test surfaces to the mass, depending on the type of impact tool being tested.

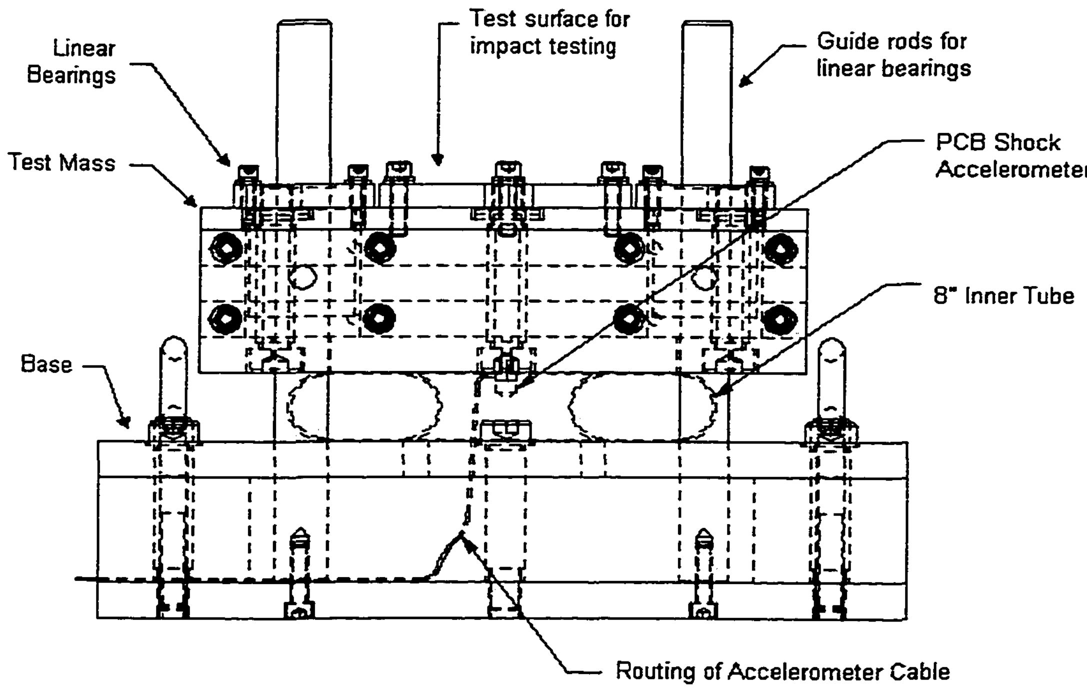


Fig. 3. Schematic of test fixture

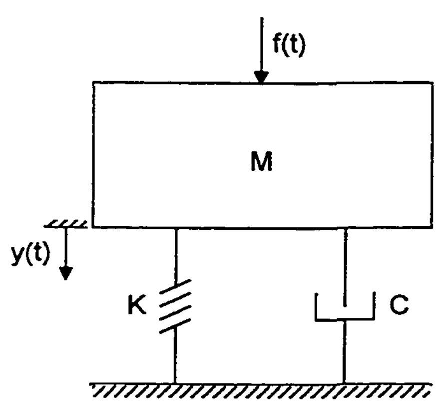


Fig. 4. Mass-spring-damper model

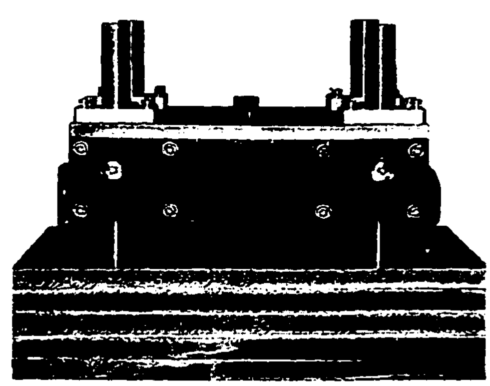


Fig. 5. Side view of test fixture

To achieve the best frequency response characteristics, the test fixture was modeled after a mass-spring-damper system, as shown in Fig. 4. Fig. 5 pictures the actual test fixture. In the mass-spring-damper model, *K* represents the air spring (inner tube) between the mass and the base. Viscous damping, resulting from the greased linear bearings, is represented by *C*. And the large mass into which the impact tools will be tested is represented by *M*. The impact tool supplies excitation force $f(t)$ and an accelerometer measures $\ddot{y}(t)$, from which $y(t)$ can be determined through second order numerical integration. The behavior and characteristics of a simple one-degree of freedom model are easy to analyze. All analytical equations describing the mass-spring-damper are known and performing experimental validation of these equations was not difficult.

The second-order differential equation, defined in equation (2.1), describes the motion of a mass-spring-damper system. Equation (2.2) shows the characteristic form of equation (2.1).

- Equation of motion: $$\mathbf{M}\,\ddot{\mathbf{y}} + \mathbf{C}\,\dot{\mathbf{y}} + \mathbf{K}\,\mathbf{y} = f(\mathbf{t}) \tag{2.1}$$

- Characteristic equation: $$\ddot{y} + (2 \cdot \xi \cdot \omega_n)\dot{y} + (\omega_n^2)y = f(t) \tag{2.2}$$

The constants in equations (2.1) and (2.2) were found by determining the frequency response of the test fixture experimentally. ISO 7626-1 [8] specifies three primary frequency response functions available for describing the response of a vibrating system. The three frequency response functions are dynamic compliance, mobility, and accelerance, as shown in equations (2.3) through (2.5), respectively.

- Dynamic Compliance: $$\frac{\mathbf{Y}(\omega)}{\mathbf{F}} = \frac{1}{\mathbf{K}} \frac{\omega_n^2}{\sqrt{(\omega_n^2 + \omega^2)^2 + (2 \cdot \xi \cdot \omega_n \cdot \omega)^2}} \tag{2.3}$$

- Mobility: $$\frac{\mathbf{V}(\omega)}{\mathbf{F}} = \frac{1}{\mathbf{K}} \frac{\omega \cdot \omega_n^2}{\sqrt{(\omega_n^2 + \omega^2)^2 + (2 \cdot \xi \cdot \omega_n \cdot \omega)^2}} \tag{2.4}$$

- Accelerance:

$$\frac{A(\omega)}{F}=\frac{1}{K}\frac{\omega^2\cdot\omega_n^2}{\sqrt{(\omega_n^2+\omega^2)^2+(2\cdot\xi\cdot\omega_n\cdot\omega)^2}} \tag{2.5}$$

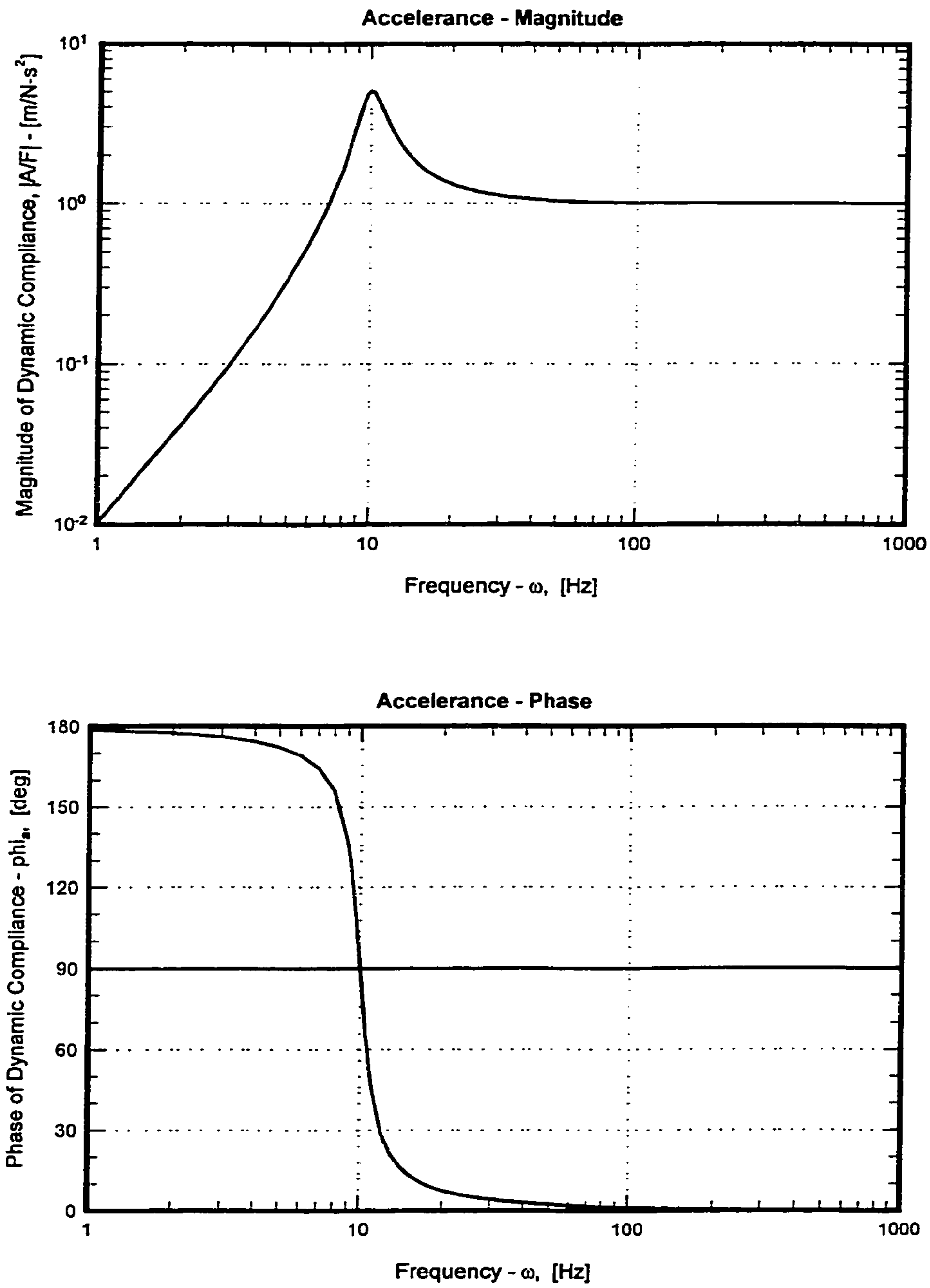


Fig. 6. Magnitude and phase of accelerance

Of the three response functions, accelerance is preferred because the accelerometer is the most common transducer used to measure the response of a vibrating system. Mobility and dynamic compliance are obtained by first and second order integration of accelerance, respectively. The importance of accelerance is best understood when looking at a graphical representation of this function. Fig. 6 shows generic accelerance magnitude and phase plots. The visible peak on the magnitude plot represents the resonance frequency of the test fixture. The units of resonance frequency, when determined graphically, will be hertz. Equation (2.6) converts the resonant frequency value from hertz to radians per second.

- Converting resonant frequency in hertz to radians per second: $$\omega_n = 2 \cdot \pi \cdot f_n \tag{2.6}$$

After the peak, the accelerance magnitude levels off and remains at a constant value as frequency increases. The fact that the accelerance response remains constant within a certain frequency range is extremely important for two reasons. First, the test fixture will have a resonance frequency no matter how it is built. If the vibration frequencies generated by the tool being tested are all greater than the resonance frequency of the test fixture, then the test fixture's characteristics will not bias the test results of the impact tool. Second, the effective mass of the test fixture can be determined using the magnitude values that lie within the constant range. Since the test fixture will be a test bed for many experiments, it is necessary to compare the mass determined experimentally (effective mass) with, mass determined using a scale. Performing this comparison verifies that the test fixture follows the conventions of a one-degree of freedom system. Effective mass is the inverse of accelerance, as shown in equation (2.7).

- Effective Mass: $$M_{eff} = \left(\frac{A(\omega)}{F}\right)^{-1} \tag{2.7}$$

Similar to the test fixture's resonant frequency, the damping ratio, ξ, of the test fixture is determined graphically. To determine the damping ratio the half power points, ω_1 and ω_2, must be determined from the plot of the real part of the dynamic compliance. Fig. 7 shows the graphical determination of half power points.

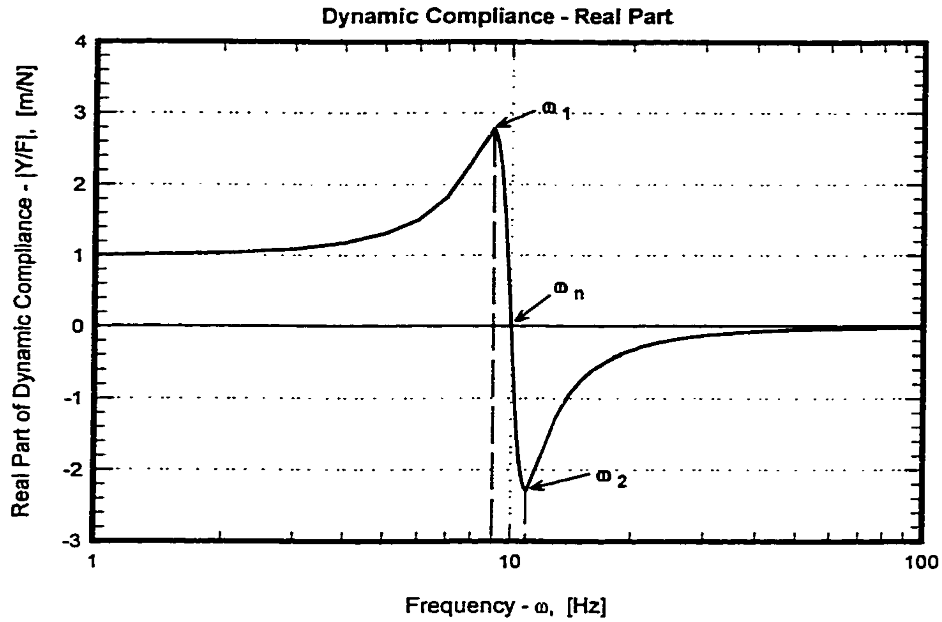


Fig. 7. Real part of dynamic compliance

The graphically determined values of the half power points are then inserted into equation (2.8) to determine the damping ratio.

- Damping ratio

$$\xi = \frac{1}{2} \cdot \frac{\left(\omega_2 / \omega_1\right)^2 - 1}{\left(\omega_2 / \omega_1\right)^2 + 1} \tag{2.8}$$

After determining the resonant frequency, mass, and damping ratio of the test fixture, the stiffness and damping coefficients can be determined. Using the values of the resonant frequency and mass of the system, the stiffness coefficient is determined using equation (2.9). The damping coefficient is determined using equation (2.10).

- Stiffness Coefficient: $\mathbf{K} = \mathbf{M} \cdot \omega_n^2$ (2.9)

- Damping coefficient $\mathbf{C} = 2 \cdot \xi \cdot \omega_n \cdot \mathbf{M}$ (2.10)

CHAPTER 3

TEST PROCEDURES

3.1. Determining the characteristics of the test fixture

Frequency response testing of the test fixture was performed to determine the various characteristics of the system. To determine the frequency response of the test fixture, a PCB Piezotronics modally tuned impact hammer, with imbedded force transducer, was used to excite the test fixture. A computer with a Data Physics FFT analyzer and the software SignalCalc ACE acquired the signal from the force transducer, in the hammer and a PCB Piezotronics shock accelerometer mounted to the floating mass of the test fixture. The software SignalCalc ACE was set up to read in the force transducer and accelerometer signals and to display resulting frequency response plots of the two signals. To obtain the frequency response of the test fixture, SignalCalc Ace divided the accelerometer signal by the force transducer signal. The resulting transfer function produced in SignalCalc ACE represented the accelerance of the test fixture with the impact hammer's force transducer providing the input and the accelerometer providing the output.

The display window of SignalCalc Ace provided space for many different plots to be viewed as the testing of the test fixture was carried out. Fig. 8 show a picture of the display window set up to provide details as the frequency response testing of the test fixture was being performed. The following views were setup in the display: live signals of the accelerometer and force transducer (labeled A and D, respectively), the resulting accelerance of the test fixture in the form of magnitude and phase (labeled C and B, respectively), coherence between the two signals

(labeled F) and the forcing windows of the accelerometer and force transducer (labeled E and G). Although the test fixture's frequency response information was the desired result, the other plot windows displayed played an important role as the test fixture was being analyzed. The view of the live accelerometer and force transducer signals being acquired by the computer provided information on how good the incoming signals were. The forcing windows were set up to ensure that only the desired portions of the signals were used to determine the accelerance of the test fixture. The coherence displayed how well the computer was acquiring and processing the two signals.

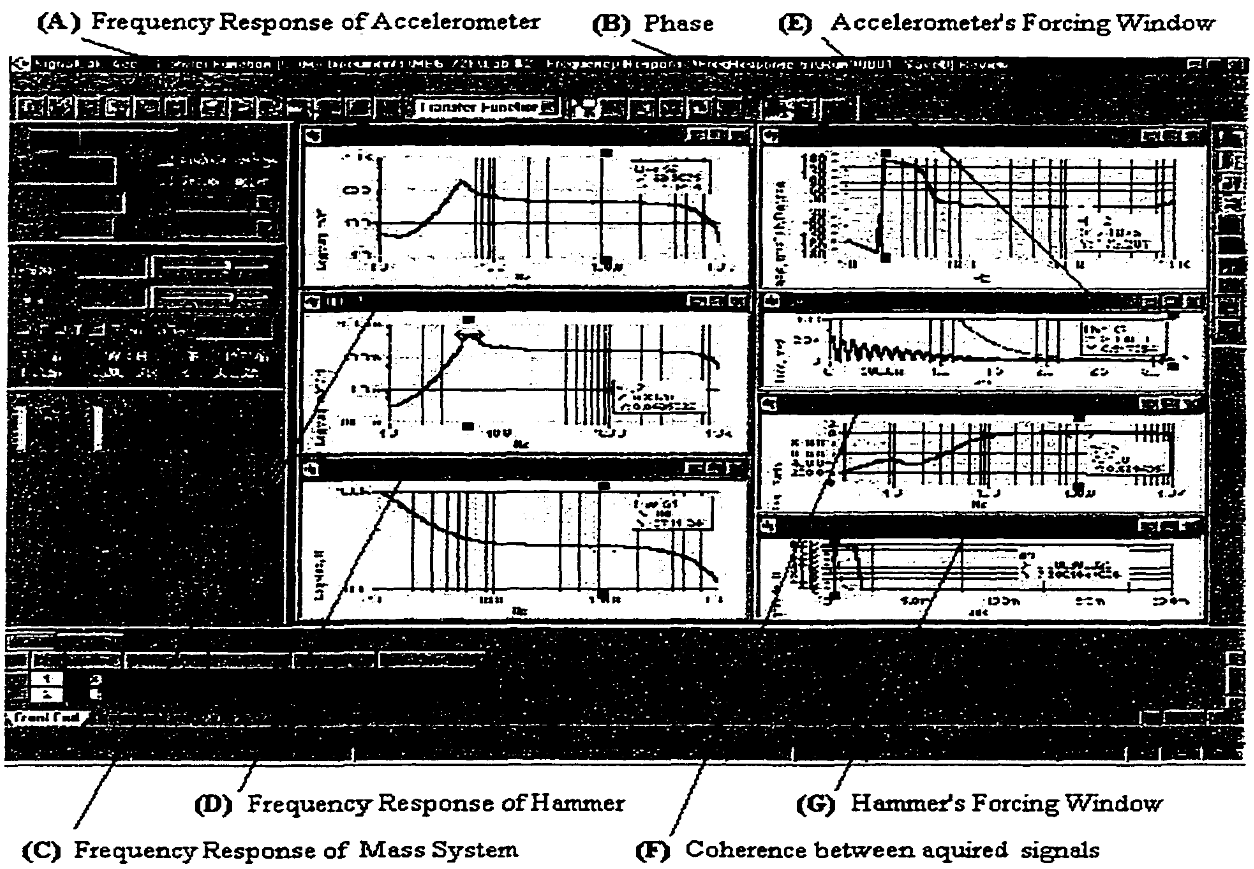


Fig. 8. SignalCalc ACE frequency response program used to test the test fixture

A single test consisted of a series of hammer blows to the test fixture's mass. Fig. 9 provides a picture of the impact hammer impacting the mass of the test fixture. SignalCalc ACE was set to average ten consecutive impacts. Averaging was not limited to ten impacts. A greater number of averages could be used, but after performing several preliminary tests using larger averaging numbers it was found that above ten impacts the resulting accelerance of the test fixture changed very little. After the tenth impact by the hammer, the magnitude and phase plots of the accelerance were ready to be viewed on the computer screen. After viewing the accelerance, magnitude and phase plots of the mobility and dynamic compliance of the test fixture were viewed in SignalCalc ACE by integrating the accelerance once and then twice, respectively. Magnitude and phase plots of accelerance, mobility, and dynamic compliance are shown in Fig. 10 through Fig. 12. After viewing the accelerance, mobility, and dynamic compliance plots the respective data generated by SignalCalc ACE was saved to data files for later use in determining the various characteristics of the test fixture. The resulting accelerance plots generated by SignalCalc ACE are shown.

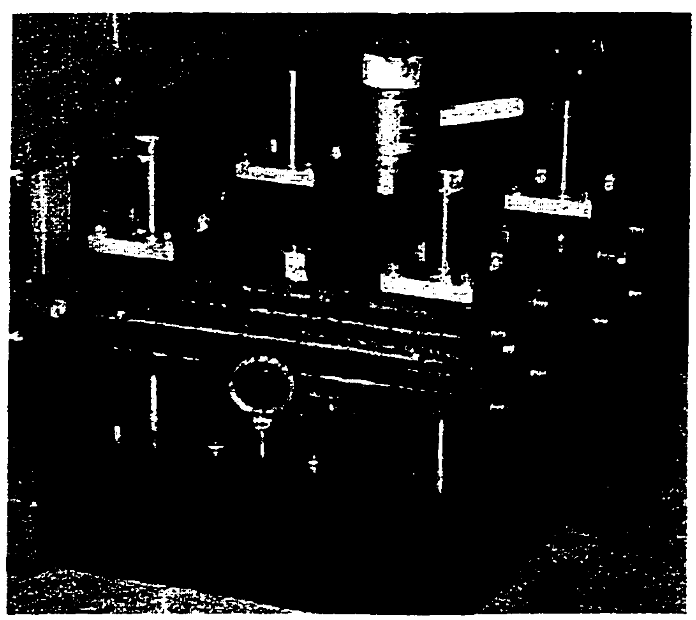
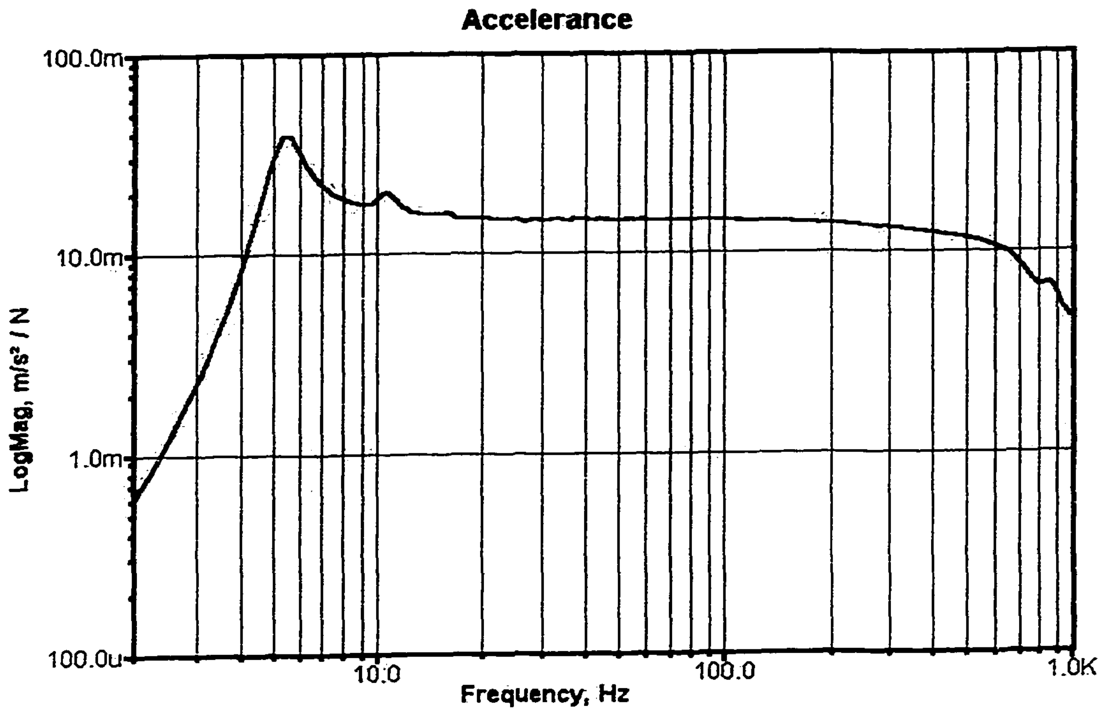


Fig. 9. Exciting test fixture's mass



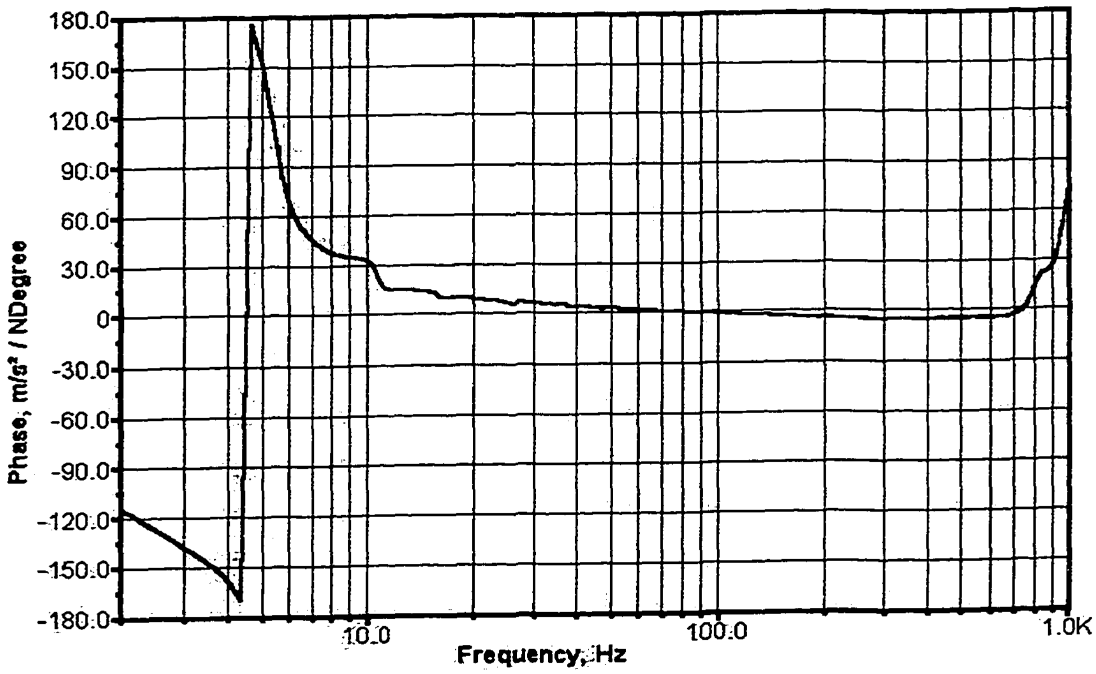


Fig. 10. Magnitude & phase plots of the test fixture's accelerance

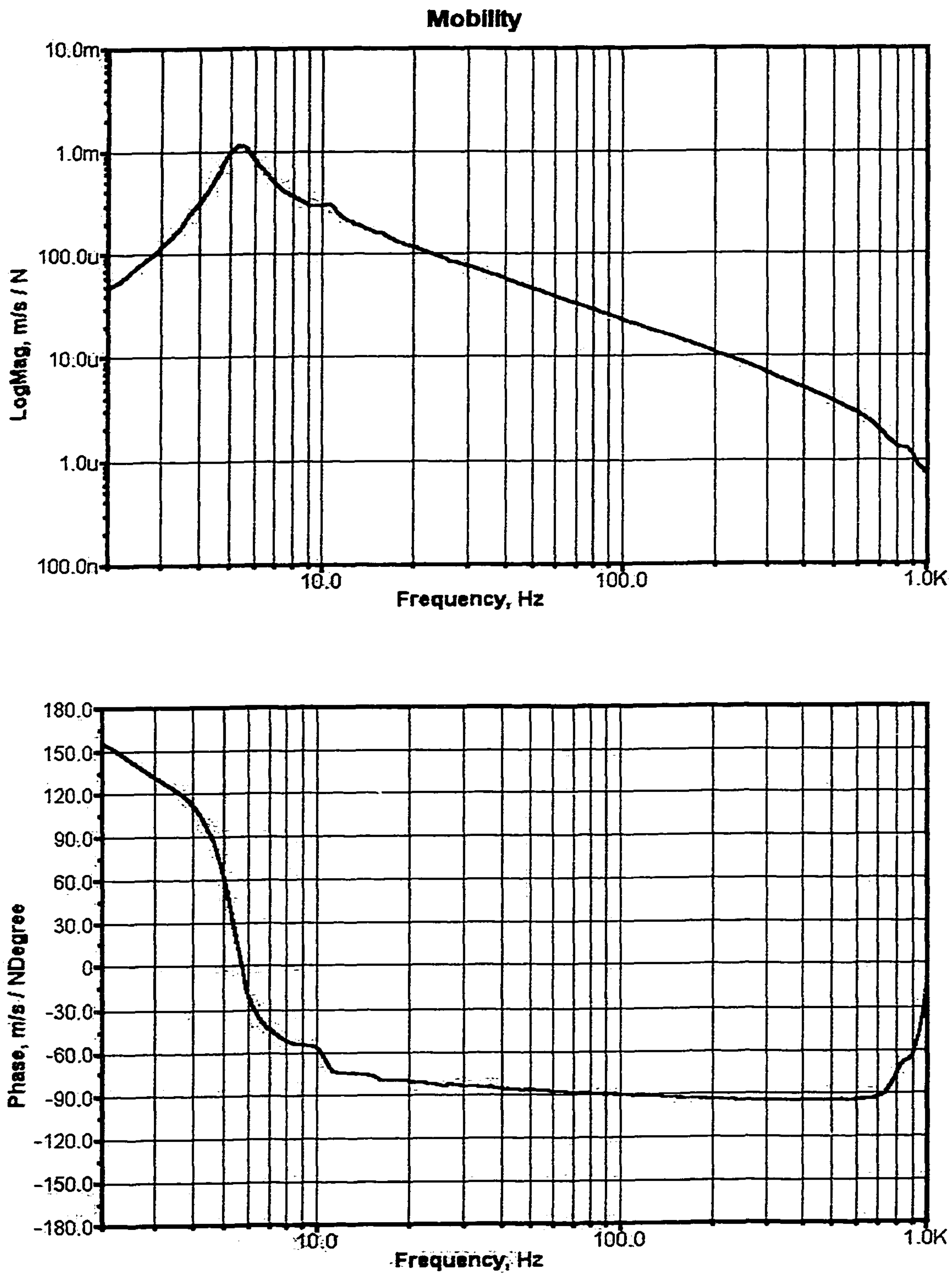


Fig. 11. Magnitude & phase plots of test fixture's mobility

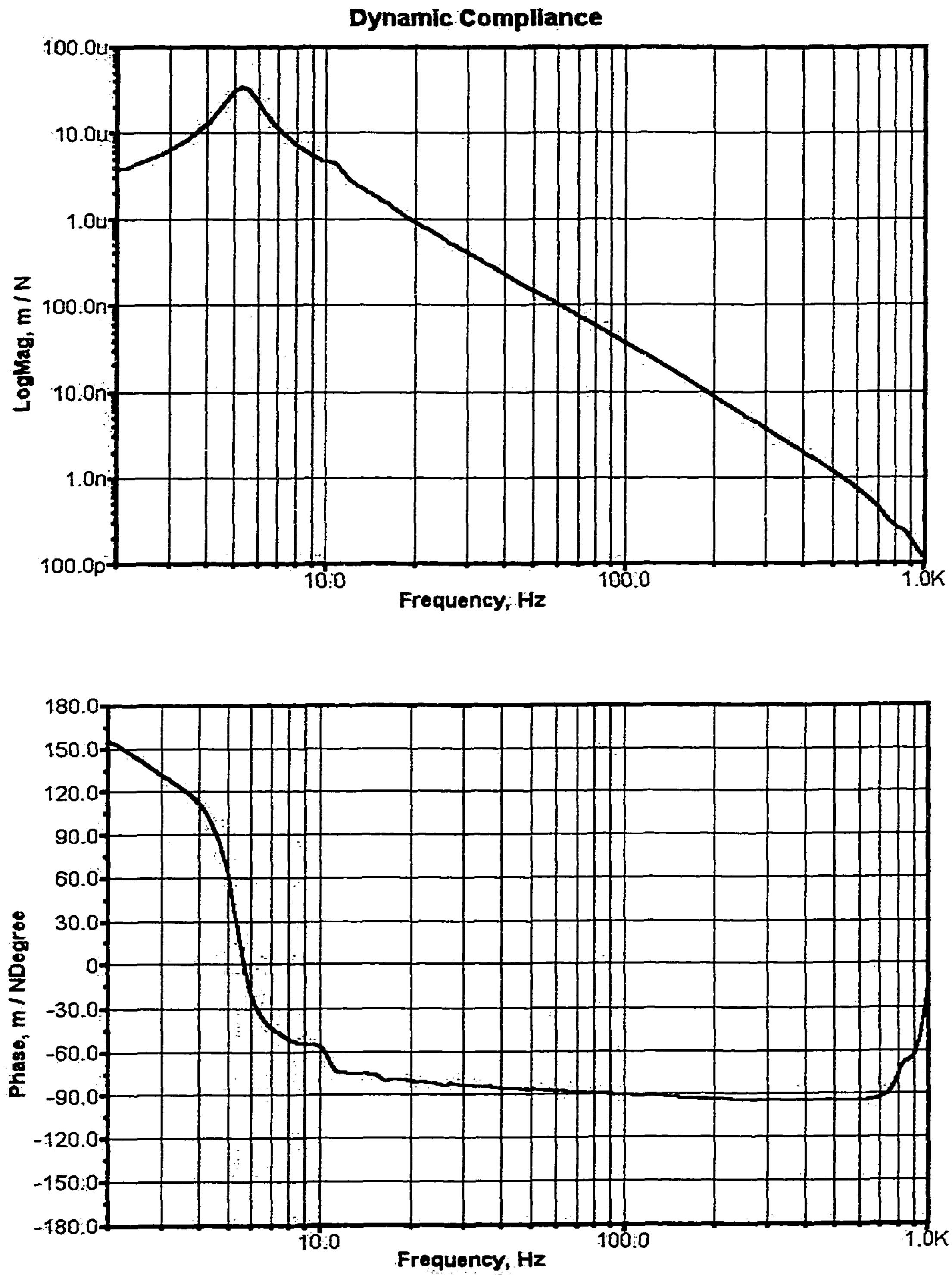


Fig. 12. Magnitude & phase plots of test fixture's dynamic compliance

The accuracy of the data collected during the testing process of the test fixture is subject to some error. Exciting the mass with the hammer requires someone holding and swinging the hammer. The person swinging the hammer must strike the surface of the mass properly and consistently. If this is not done then the accelerance data provided by the computer will not accurately represent the test fixture. A proper hammer blow will strike the mass such that the force vector is perpendicular to the surface of the mass. A good swing, as depicted in Fig. 13, will transfer of the hammer's energy to the mass. An improper hammer swing will strike the mass such that a component of the force vector is broken into parallel and perpendicular components. A bad swing, as depicted in Fig. 14, will only transfer a portion of the hammer's energy to the mass. Knowing if a hammer swing is good or bad while performing a test is not always easy. Monitoring the frequency response of the hammer provides insight into the quality of a hammer strike. The frequency response of the hammer should remain constant over the frequency range of the force transducer. The factory frequency response of the hammer is shown in Fig. 15. A hard rubber tip was used on the impact hammer for all testing performed. The characteristic frequency response for the hammer generated from the force transducer signal by SignalCalc ACE is shown in Fig. 16. Achieving the frequency response shown in Fig. 16 required a great deal of practice.

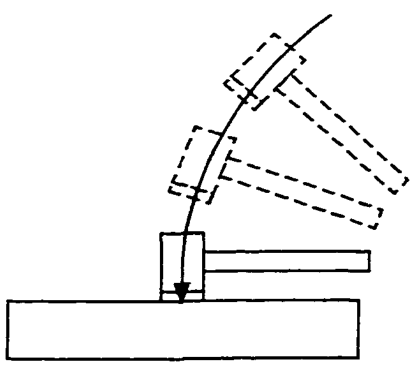


Fig. 13. Good hammer strike

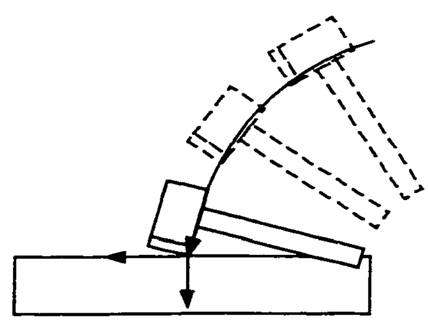


Fig. 14. Poor hammer strike

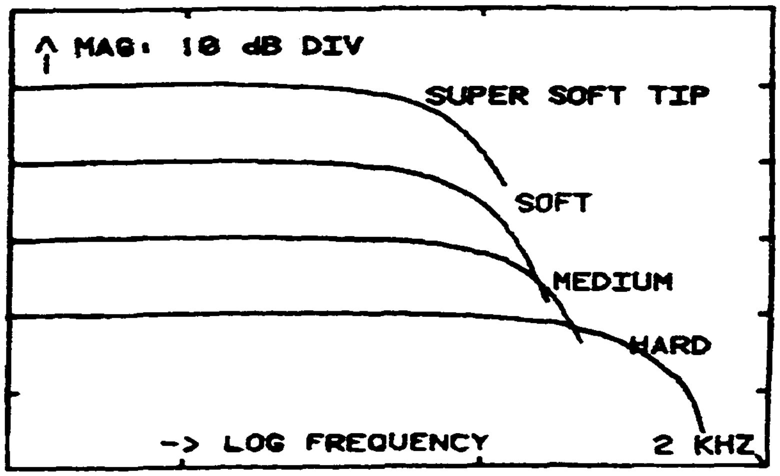


Fig. 15. Ideal hammer frequency response

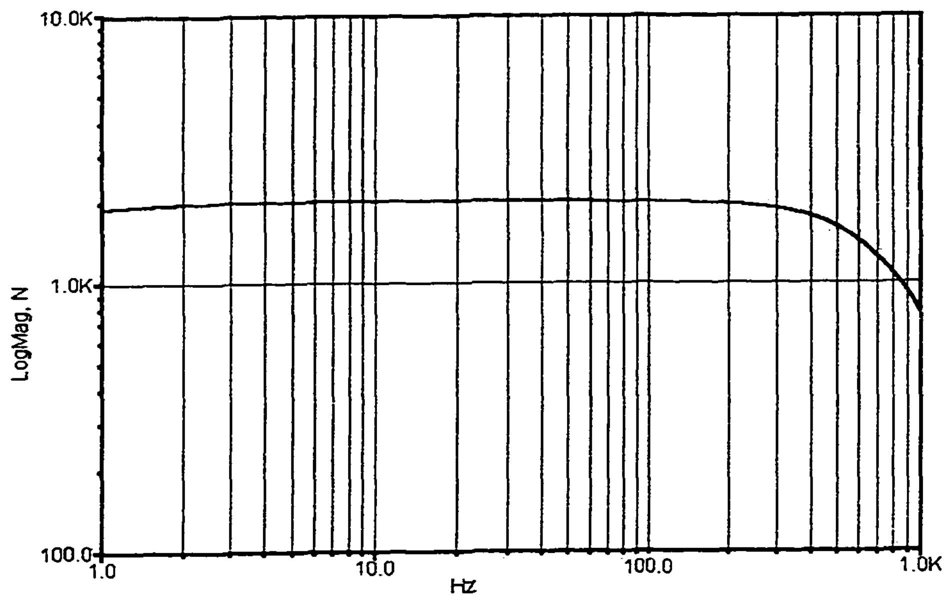


Fig. 16. Experimental hammer frequency

The coherence function was used to assess the validity of the acquired signals used to calculate the accelerance of the test fixture. The coherence should have a value of one. As the relation between the signal of the force transducer in the hammer and the signal of the shock accelerometer degrades, the value of the coherence decreases. At the end of each test

performed with the test fixture, the coherence between the accelerometer and force transducer signals was scrutinized. A typical coherence plot generated by SignalCalc Ace is shown in Fig. 17. Achieving signal coherence close to one for all frequencies was not possible. At upper and lower frequencies, the effectiveness of each transducer is low, which helps decrease coherence. The resonance frequency of the test fixture also influenced the coherence of the signals. The primary concern lies within the frequencies at which impact tool testing will be performed with the test fixture. If the coherence is close to one over this frequency range, then the test data generated will be good

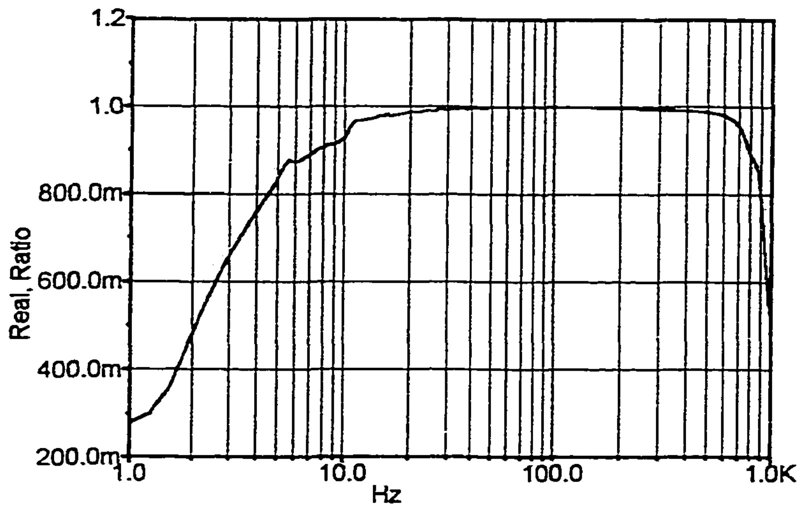


Fig. 17. Coherence during experiment

3.2. Determining the transmissibility corrections of the accelerometer adapters

Before any impact tool testing began, transmissibility correction measurements were made for each accelerometer mounted in the various adapters used to make acceleration measurements at the handle. Transmissibility correction values for each accelerometer mounted in the adapters were needed because the materials from which the various adapters were made altered the vibration signals measured by the accelerometers. Transmissibility correction values are determined using the expression defined in equation (3.1).

- Transmissibility correction ratio: $$TR_j = \frac{a_{m,j}}{a_{r,j}} \quad (3.1)$$

When the adapters are used during impact tools testing, the appropriate transmissibility correction values are applied to the acquired signals of the accelerometers mounted in the adapters. Transmissibility corrected accelerometer measurements made with the various adapters are determined using equation (3.2).

- Transmissibility corrected acceleration: $$a_{h,j} = \frac{a_{m,j}}{TR_j} \quad (3.2)$$

During impact tool testing three different adapters were used; a tri-axial adapter and two single axis adapters. The tri-axial adapter was machined from a small piece of aluminum. A thin piece of rubber was adhered to the bottom surface of the aluminum. Pictured in Fig. 18 are the three PCB Piezotronics Ceramic Shear ICP® accelerometers mounted in the tri-axial adapter. The single axis adapters were made from small pieces of sheet metal. A small amount of curvature was added to the sheet metal so that the complete adapter would follow the contour of a tool handle when used during a test. As in the tri-axial adapter, a thin

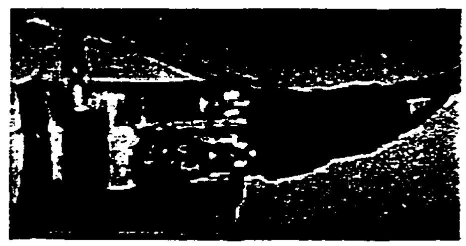


Fig. 18. Tri-axial adapter used on the handle

Fig. 19. Single axis adapter used on the handle

piece of rubber was adhered to the bottom (concave) surface of the sheet metal. Pictured in Fig. 19 and Fig. 20 are the two single axis adapters. A PCB shear accelerometer was mounted to the first adapter (see Fig. 19) and an Endevco Piezoelectric accelerometer was mounted to the second adapter (see Fig. 20).

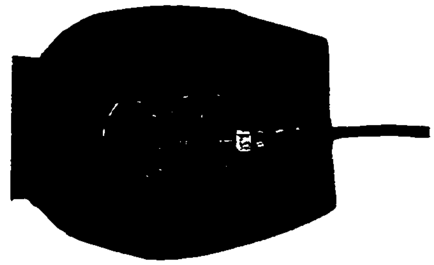


Fig. 20. Single axis adapter used in the glove

A small computer-controlled shaker was used to obtain the transmissibility correction values of the accelerometers mounted in the adapters pictured in Fig. 18 through Fig. 20. The computer-controlled shaker was set up to generated a flat acceleration response over a frequency range of 6.3 to 1,250 Hz. Exciting a broad range of frequencies ensured that the transmissibility correction values would be applicable for each tool tested. To duplicate test conditions, an aluminum handle was attached to the shaker. A PCB shear accelerometer was adhered to the handle to provide a reference acceleration signal. A Brüel & Kjær (B&K) Portable Data Acquisition Unit, attached to a computer loaded with the B&K PULSE™ LabShop software, was used to acquire the adapter axis accelerometer and reference accelerometer signals. The PULSE™ software was set up to use equation (3.1) to calculate the transmissibility of the adapter axis accelerometer at each third octave band from 6.3 to 1,250 Hz.

Transmissibility tests of the tri-axial adapter were performed first. The tri-axial adapter was attached to the handle with double-sided tape. Placement of the adapter on the handle in relation to the reference accelerometer was determined by which adapter axis needed correction values. Pictured in Fig. 22 and Fig. 21 are each axis of measurement and the corresponding accelerometer placement on the tri-axial adapter. The shaker only provided excitation in a single direction. Since each axis of the tri- axial adapter needed correction values, the adapter was repositioned and tested for each accelerometer. The handle was mounted vertically to the shaker for z and y-axis testing and mounted horizontally for x-axis testing. Positions of the tri-axial adapter and handle are shown in Fig. 23 through Fig. 25.

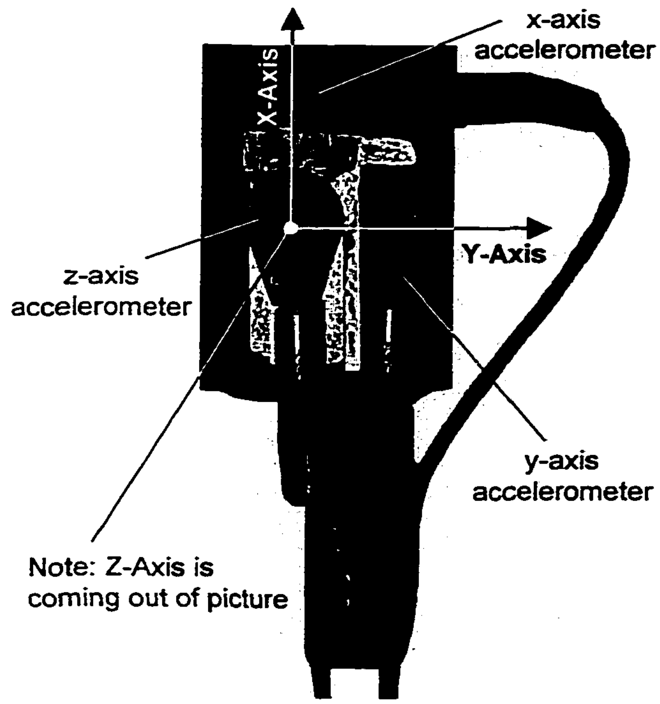


Fig. 21. Axis labels of tri-axial adapter (top view)

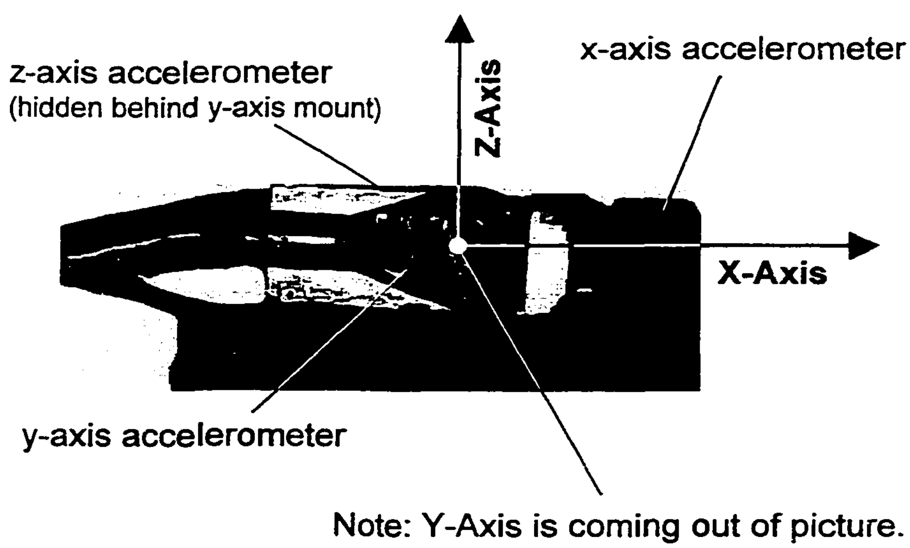


Fig. 22. Axis labels of tri-axial adapter (side view)

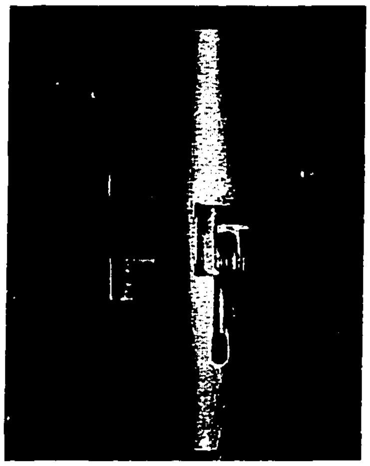


Fig. 23. Position of tri-axial adapter for Z-Axis transmissibility correction

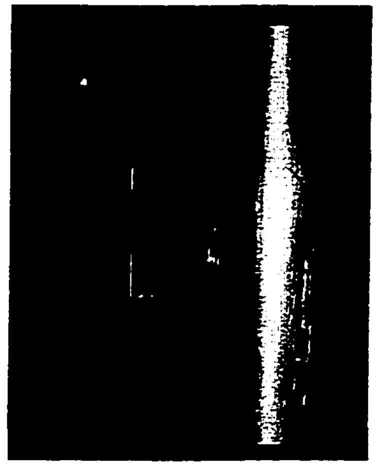


Fig. 24. Position of tri-axial adapter for Y-Axis transmissibility correction

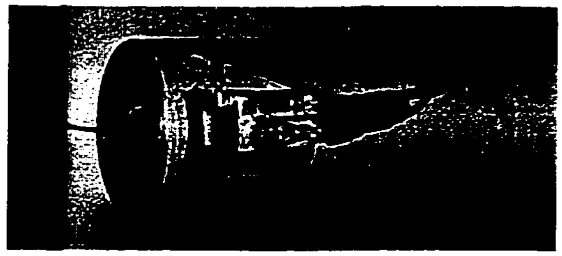


Fig. 25. Position of tri-axial adapter for X-Axis transmissibility correction

After each axis of the tri-axial adapter was tested the appropriate transmissibility data collected by the B&K PULSE™ software was saved to a data file for later use. Once transmissibility correction data for each accelerometer of the tri-axial adapter was collected the single axis adapter used on the handle (see Fig. 19) was placed on the shaker. As with the tri-axial adapter, double-sided tape was used to adhere the single axis adapter to the shaker's handle. The single axis adapter was placed on the handle in the same manner as the z-axis of the tri-axial adapter pictured in Fig. 23. The transmissibility test was performed for the first single axis adapter and the data collected by the B&K PULSE™ software was saved to a data file. After collecting transmissibility data for the first single axis adapter the second single axis adapter (see Fig. 20) was positioned on the shaker handle. The same test process used for the previous two adapters was used with the final single axis adapter.

3.3. Simulating sustained exposure to hand-held impact tools

The first impact tool to be tested with the test fixture was an Atsco No.020 chipping hammer. A picture of this chipping hammer and the accompanying chisel are shown in Fig. 26. The goal of the test was to determine the acceleration values of the chipping hammer's chisel and handle from data collected by the PCB shock accelerometer mounted to the test fixture's mass. A second PCB shock accelerometer was mounted to the handle to provided measured acceleration values at the handle to which the values calculated from the test fixture's shock accelerometer could be compared. The single axis adapter holding the PCB shear accelerometer (see Fig. 19) could not be used to measure the acceleration at the handle because the chipping hammer produced sufficient amounts of high amplitude energy to cause D.C. shift in the PCB shear accelerometer's signal. To mount the shock accelerometer to the handle a modified hose clamp was used. Brazed to the hose clamp was a small piece of brass. The end of the brass was drilled and tapped to allow the threaded stud of the shock accelerometer to be screwed in. Pictured in Fig. 27 are the shock accelerometer and modified hose clamped mounted to the chipping hammer's handle. When using a chipping hammer, the operator normally wears gloves. The gloves being worn during testing of the chipping hammer were antivibration glove. These gloves incorporated air bladder technology developed by ErgoAir. During testing of the chipping hammer the single axis adapter holding the Endevco Piezoelectric accelerometer (see Fig. 20) was placed between the palm and the glove of the gloved hand holding the handle. Pictured in Fig. 28 is a test subjects palm and the placement of the Endevco Piezoelectric accelerometer mounted inside the aluminum/rubber adapter. Placing accelerometers inside the glove and on the handle allowed for the vibration reduction effects of the air bladder to be looked at.

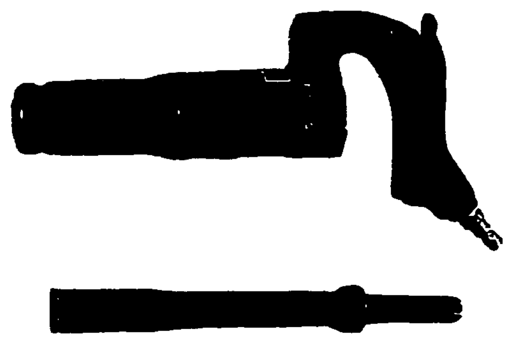


Fig. 26. Atsco No.020 chipping hammer & chisel

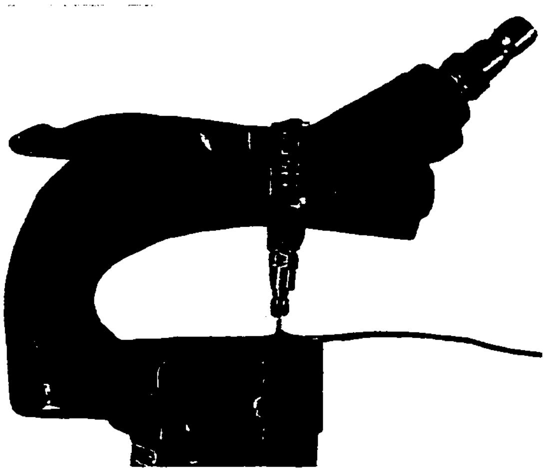


Fig. 27. Placement of accelerometer the chipping hammer's handle

Fig. 28. Placement of accelerometer in the palm of the hand

B&K PULSE™ hardware and software were used to acquire the signals of each accelerometer. The PULSE™ software was setup to provide acceleration time history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values for each acceleration signal acquired. In the process of determining the desired information for the chipping hammer, several calculations were performed to the various accelerometer signals by the PULSE™ software. Transmissibility correction of the single axis acceleration values measured inside the glove was then first calculation. Equation (3.2) was used in the PULSE™ software to perform transmissibility corrections. Next, the PULSE™ software calculated the linear or un-weighted and the ISO weighted acceleration values for the test fixture's mass, the chipping hammer's handle, and inside the glove. Equations (3.3) and (3.4) were used in the PULSE™ software to calculate linear and ISO weighted acceleration.

- Linear (un-weighted) acceleration: $$a_{h,l} = \sqrt{\sum_{j=1}^{n} (a_{h,j})^2} \quad (3.3)$$

- ISO weighted acceleration: $$a_{h,w} = \sqrt{\sum_{j=1}^{n} (K_j \cdot a_{h,j})^2} \tag{3.4}$$

The ISO weighting filter used in the calculation of ISO weighted acceleration applies a two-decibel drop for every third octave band from 16 to 1,250 Hz. as outlined in ISO 5349-1 [7]. Fig. C.1, found in Appendix C, displays the ISO weighting filter used in the PULSE™ software for calculations made with equation (3.4).

The following steps were performed during the collection of the desired chipping hammer acceleration data. Two people were needed to perform each test. One person was the test subject operating the chipping hammer and the other person operated the PULSE™ hardware and software. These steps were performed several times by different test subjects to ensure the repeatability of the test methods and to ensure confidence in the test results.

1. The test subject would grasp the chipping hammer's handle with one hand and insert the chisel into the chipping hammer's barrel with the other hand.

2. The test subject would position the chipping hammer and chisel over the floating mass of the test fixture. Since the chipping hammer's chisel removes large amounts of material quickly, a replaceable steel plate was bolted to the top surface of the test fixture's mass prior to the start of the test.

3. The test subject would check the position of the accelerometer inside the glove. The single axis adapter needed to be positioned in the middle of the palm, as pictured in Fig. 28.

4. The second person opened the valve of the air supply to the chipping hammer. To achieve greatest productivity in industry, the manufacturer of the chipping hammer recommends an air pressure of 90 psi. The air supply regulator was checked to ensure that 90 psi was being supplied.

5. With pre-operation checks complete, the test subject would begin operation of the chipping hammer on the replaceable steel plate. Fig. 29 shows the operation of the chipping hammer by a test subject. The chipping hammer was allowed to operate approximately five before the second person triggered the PULSE™ software start data collection. After an additional ten seconds elapsed, the data collection was stopped and the test subject was given a signal to halt operation of the hammer.

6. The acceleration time history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values determined by the PULSE™ software were viewed on the computer screen. If the displayed data looked acceptable then the acceleration time history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values for each accelerometer were saved to data files for later use.

Fig. 29. Chipping hammer test in progress

To achieve the goal of determining the chipping hammer's chisel acceleration from the measured acceleration of the test fixture's mass, an analysis of the static forces acting between the mass and chisel was performed. Fig. 30 shows the free body diagram of the mass and chisel. Using the free body diagram, a summation of forces equal to zero was performed. The appropriate relationships for each force were substituted into the force summation. Solving the force summation for the chisel acceleration produced the relationship shown in equation (3.5).

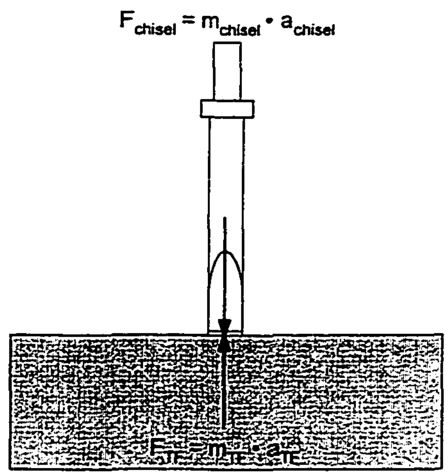


Fig. 30. Reaction between chisel and test fixture

- Acceleration of tool's chisel: $$a_{chisel} = \frac{m_{TF}}{m_{chisel}} a_{TF} \quad (3.5)$$

Analysis similar to that of the chipping hammer's chisel was used to determine the chipping hammer's handle acceleration from the measured acceleration of the test fixture's mass. Fig. 31 shows the free body diagram of the test fixture's mass and the chipping hammer. The chipping hammer and the chisel were modeled as a rigid body, thus the mass of both contributed to m_{tool}. From the summation of forces, equation (3.6) was derived for calculating the chipping hammer's handle acceleration.

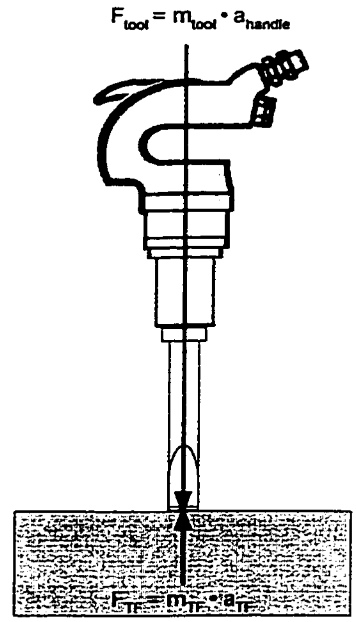


Fig. 31. Reaction between handle and test fixture

- Acceleration of tool's handle: $$a_{handle} = \frac{m_{TF}}{m_{tool}} a_{TF} \quad (3.6)$$

3.4. Simulating assembly operations with hand-held impact tools

The Ford Motor Company, Romeo Engine Plant, requested that CMEST conduct vibration tests on two Atlas Copco RRH series rivet hammers. These tools, pictured in Fig. 32 and Fig. 33, are used at three different workstations during the assembly process of engines to insert different types of dowels, bushings, and bearings into engine blocks. The details of the parts being installed at each station, as provided by the engineers at the Romeo engine plant, are listed in Table D.1 through Table D.3, located in Appendix D. Tests were conducted, that simulated the work process of these tools, to determine if the corresponding vibration exposure values were within the respective limits of 2.5 m/s^2 and 4 m/s^2 as specified by the current European Directive

[5] and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limits Values (TLVS) [1] for exposure to hand-induced vibration.

Fig. 32. Atlas Copco RRH 06P Rivet Hammer

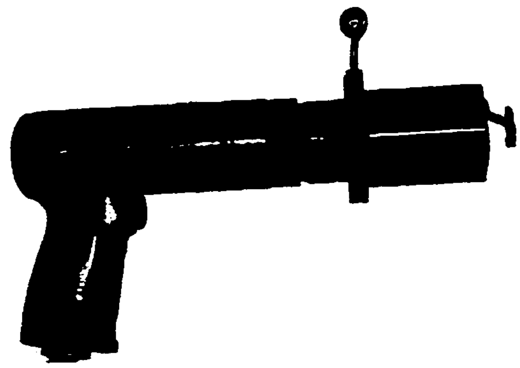


Fig. 33. Atlas Copco RRH 10P Rivet Hammer

Assembly operations performed with the Atlas Copco rivet hammers at the engine plant were simulated at CMEST using the test fixture described in chapter two. Three axis acceleration measurements at the handle and dominant Z-axis measurements between the palm and glove were made for both of the two rivet hammers during the insertion process of the dowels, bushings, and bearings. Three axis measurements were made with the tri-axial adapter pictured in Fig. 18. The tri-axial adapter was mounted to the handle of the rivet hammer between the handle and palm of the hand gripping the handle. Dominant axis measurements inside the glove were made with the single axis adapter pictured in Fig. 20. The transmissibility corrected acceleration vector component was calculated from the individual tri-axial measurements. The three-axis acceleration vector component was then passed through the ISO weighting filter to obtain the ISO weighted vector component value at the rivet hammer's handle. Similar to the three axis measurements, the values of the dominant axis measurement were transmissibility corrected. Next the transmissibility corrected dominant axis values measured inside the glove were passed through the ISO weighting filter to obtain the ISO weighted value inside the glove.

The B&K PULSE™ hardware and software was used to acquire the signals of the accelerometers used during testing of the rivet hammers. The PULSE™ software was setup to provide acceleration time history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values for each acceleration signal acquired. In the process of determining the desired information for the rivet hammer, several calculations were performed to the various accelerometer signals by the PULSE™ software. For the accelerometers used in the tri-axial and single axis adapters at the handle and in the glove, the appropriate transmissibility corrections were applied in the PULSE™ software. Equation (3.2) was used in the PULSE™ software to perform these transmissibility corrections. After correcting the accelerometer signals measured at the handle, the PULSE™ software calculated the X,Y,Z vector component of the transmissibility corrected X, Y, and Z acceleration values measured by the tri-axial adapter. Equation (3.7) was used in the PULSE™ software to calculate the X,Y,Z vector component.

- X,Y,Z acceleration vector component of bare hand tests:

$$a_{(x,y,z),j} = \sqrt{(a_{z,j})^2 + (a_{y,j})^2 + (a_{x,j})^2} \tag{3.7}$$

To determine the X,Y,Z vector component of the gloved hand, the relationship shown in equation (3.8) was used.

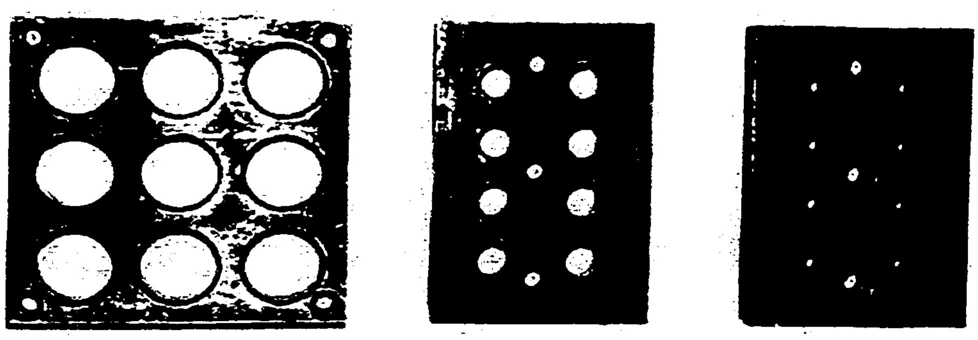
- X,Y,Z acceleration vector component of gloved hand tests:

$$(a_{(x,y,z),j})_g = \frac{(a_{(x,y,z),j})_h}{(a_{z,j})_h} \cdot (a_{z,j})_g \tag{3.8}$$

Next, the PULSE™ software calculated the linear and ISO weighted acceleration value for the test fixture's mass and each axis in the tri-axial adapter. Equations (3.3) and (3.4) were used in the PULSE™ software to calculate the linear and ISO weighted acceleration values of each individual axis and the vector component. The same ISO weighting filter used in the chipping hammer tests was used in the rivet hammer tests. The values of the ISO weighting filter are provided in Fig. C.1, located in Appendix C.

The rivet hammer testing process occurred in two phases. In each phase, a series of tests were performed, inserting the five parts were into the test plates. During the first phase, the rivet hammers were operated with a bare hand. During the second phase, the rivet hammers were operated with a gloved hand. Two people were needed to perform each test. One person was the test subject inserting parts with the rivet hammer and the other person operated the PULSE™ hardware and software. These steps were performed several times by different test subjects to ensure the repeatability of the test methods and to ensure confidence in the test results. For each of the five parts tested the following procedures were used. For ease of describing the testing process, the RRH 06P rivet hammer and the front cover dowel were referred to.

1) The test plate, containing the eight holes into which the front cover dowels were inserted, was attached to the mounting surface of the test fixture's mass. Fig. 34 shows the three different test plates that were attached to the test fixture's mass depending on the part being inserted. The test plates were machined from hardened steel plates. The holes in the test plates were machined to match the holes found in the engine blocks.



Test plate for crank pilot bearings & sleeve crank bushings | Test plate for bell housing dowels | Test plate for front cover & tensioner dowels

Fig. 34. Test plates in which the various parts were inserted during the testing procedure

2) Different accelerometer adapters were attached to the handle of the rivet hammers. Choosing which adapters to attach depended on whether the rivet hammers were operated with a bare or gloved hand.

a) For bare hand operation of the rivet hammer, the tri-axial adapter, pictured in Fig. 18, was attached to the handle of the rivet hammer using double-sided tape. Although two different rivet hammers were used during testing, the attachment of the tri-axial adapter was the same for both. Each axis of measurement was lined up properly so that the accelerometers provide the correct values along the x, y, and z-axis. Fig. 35 and Fig. 36 show the direction of each axis to be measured. A strip of rubber was placed over the top of the tri-axial adapter to provide comfort when the hand gripped the handle.

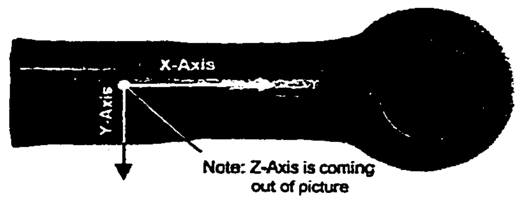


Fig. 35. Measurement direction on handle (top view)

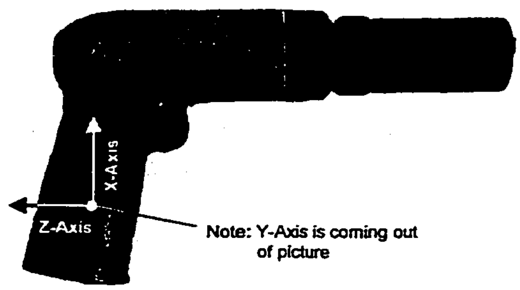


Fig. 36. Measurement direction on handle (side view)

b) For gloved hand operation of the rivet hammer, two single axis adapters were used. The first single axis adapter, pictured in Fig. 19, was attached to the handle of the rivet hammer using double-sided tape. The axis of the first adapter was aligned with the z-axis of the handle. The second single axis adapter, pictured in Fig. 20, was placed between the glove and the palm of the hand. Fig. 28 shows the placement of the second single axis adapter in the palm.

3) The air supply hose was connected to the rivet hammer and then the second person, assisting in the test, opened the supply valve. The second person checked the pressure gage to ensure that the correct air pressure was supplied to the rivet hammer. Depending on the part inserted, air pressure supplied to the rivet hammer was either 30, 60, or 90 psi A box containing unused front cover dowels and the appropriate driver was placed near the test stand. The test subject inserted the front cover dowel driver into the barrel of the rivet hammer and locked the retention spring in place around the driver. Fig. 37 shows each part and the necessary driver used during the testing of the rivet hammers.

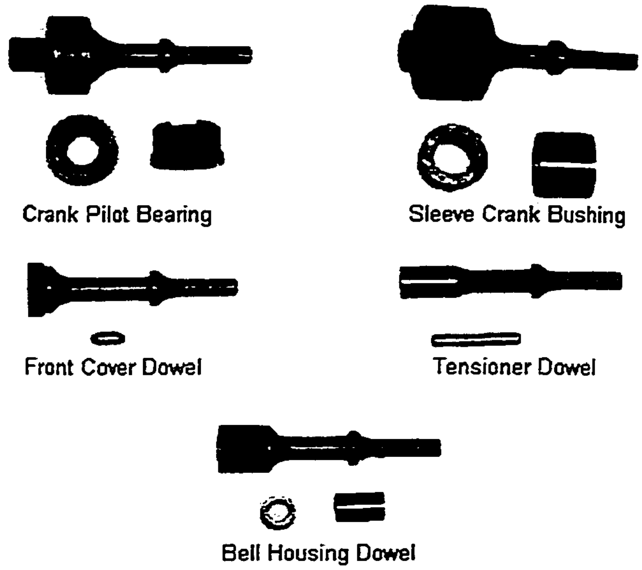


Fig. 37. The five different parts to be inserted and corresponding insertion tool

4) The test subject moved into place next to the test fixture and grasped the handle of the rivet hammer with their dominant hand. Position of the test subject was such that they could opperate the tool with one hand and reach for new front cover dowels from the box with the other hand. The second person triggered the PULSE™ software to start acquiring the signals from the various accelerometers. After triggering the PULSE™ system, the second person signaled the test subject start inserting front cover dowels into each hole of the test plate. Fig. 38 shows the insertion of front cover dowels by a test subject. After inserting dowels into the eight holes, the second person halted the PULSE™ software's data collection.

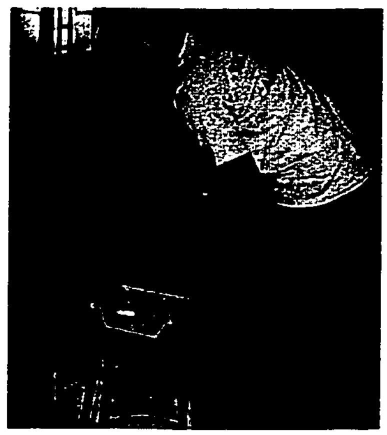


Fig. 38. Rivet hammer test in progress

5) The acceleration time history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values determined by the PULSE™ software were viewed on the computer screen. If the displayed data looked acceptable then the acceleration time

history information, third octave band information, linear (un-weighted), and ISO weighted acceleration values for each accelerometer were saved to data files for later use.

Using the saved ISO weighted X,Y,Z vector component acceleration values, the daily vibration exposure of each workstation was determine. At each station a different combination of the parts were inserted into engine blocks. The amount of vibration exposure resulting from inserting a certain part also differed at each station. Since many parts were inserted at each station, a composite of the vibration exposure levels for all inserted parts was. The method of calculating daily vibration exposure levels is defined in ISO 5349-1 [7]. From this standard equation (3.9) was derived for determining the composite vibration exposure from the ISO weighted acceleration values of different sources.

- Daily ISO weighted acceleration exposure: $$(a_{h,w})_{eq(e)} = \sqrt{\frac{1}{T_e}\sum_{j=1}^{n}(a_{h,w})_{eq(j)}^{2}\left(\frac{t_j}{t_{total}}\cdot T_e\right)} \qquad (3.9)$$

The value calculated with equation (3.9) represents the total vibration exposure level experienced during the measured exposure time. For each station, the measured exposure times ranged from 1.07 to 2.69 hours. The current European Directive [5] and ACGIH TLVS [1] standards focus on eight and four hour exposure times, respectively. To determine the vibration exposure for eight and four-hour exposure times, equations (3.10) and (3.11) were used. Equation (3.10) was defined in ISO 5349 and equation (3.11) is a form of equation (3.10).

- Daily ISO weighted acceleration exposure during four hour period: $$(a_{h,w})_{eq(4)} = \left(\frac{T_e}{T_4}\right)^{1/2}(a_{h,w})_{eq(e)} \qquad (3.10)$$

- Daily ISO weighted acceleration exposure during eight hour period: $$(a_{h,w})_{eq(8)} = \left(\frac{T_e}{T_8}\right)^{1/2}(a_{h,w})_{eq(e)} \qquad (3.11)$$

CHAPTER 4

RESULTS

4.1. Characteristics of the test fixture

The first characteristic of the test fixture determined using the collected was the resonant frequency of the test fixture. As discussed in chapter two, the resonant frequency of the test fixture was determined from the accelerance magnitude plot. The greatest peak on the accelerance magnitude plot, shown in Fig. 39, occurs at a frequency of 5.6 Hz. Converting this frequency with equation (2.6) produces a resonance frequency of 35 rad/s for the test fixture.

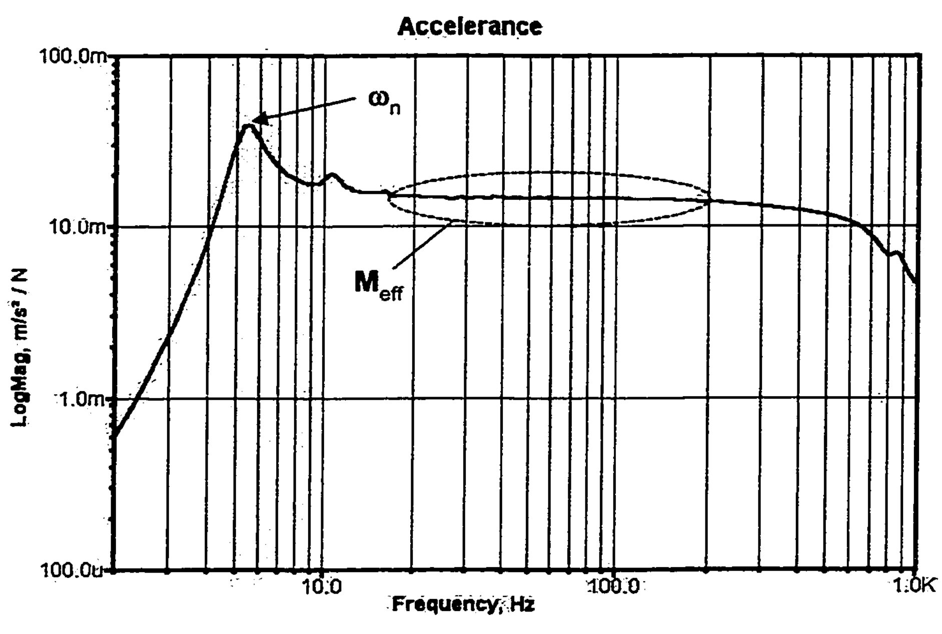


Fig. 39. Determining resonant frequency of test fixture

The effective mass of the test fixture was the second characteristics determined. Equation (2.7) was applied to the accelerance magnitude data collected from the frequency response testing of the test fixture. Only accelerance magnitude values that fell within the frequency range of 15 to 200 Hz were used to calculate the effective mass of the test fixture. This range was chosen because the measured magnitude values are fairly constant within this range, as seen in Fig. 39. The calculated effective mass values at each frequency from 15 to 200 Hz are found in Table 1. Averaging all the effective mass values produced an overall effective mass of 69.4 kg (152.6 lb), which was very close to the value of 68.0 kg (150.0 lb) obtained from a scale.

Table 1. Determining effective mass of the test fixture

Frequency (f) [Hz]	Accelerance (A/F) [m/N•s^2]	Effective Mass $(A/F)^{-1}$ [kg]
15	1.56E-02	6.42E+01
20	1.49E-02	6.72E+01
25	1.47E-02	6.78E+01
30	1.46E-02	6.86E+01
35	1.45E-02	6.89E+01
40	1.47E-02	6.82E+01
45	1.46E-02	6.86E+01
50	1.45E-02	6.89E+01
55	1.46E-02	6.85E+01
60	1.45E-02	6.89E+01
65	1.46E-02	6.87E+01
70	1.45E-02	6.90E+01
75	1.45E-02	6.88E+01
80	1.46E-02	6.87E+01
85	1.44E-02	6.92E+01
90	1.44E-02	6.93E+01
95	1.44E-02	6.94E+01
100	1.44E-02	6.95E+01
110	1.44E-02	6.96E+01
120	1.43E-02	7.01E+01
130	1.42E-02	7.05E+01
140	1.43E-02	7.02E+01
150	1.42E-02	7.04E+01
160	1.41E-02	7.08E+01
170	1.40E-02	7.13E+01
180	1.39E-02	7.18E+01
190	1.39E-02	7.20E+01
200	1.38E-02	7.26E+01
	Average effective mass:	**69.35 [kg]** **152.56 [lb]**
	Percent difference from mass obtained with scale:	**1.7%**

The third characteristic determined was the damping ratio. As explained in chapter two, the damping ratio was calculated using the half power points. The half power points were found using a plot of the real part of the dynamic compliance of the test fixture. Fig. 40 shows the graphical determination of the half power points. From this figure the first half power point occurs at a frequency of 5 Hz. The second half power point occurs at a frequency of 6.4 Hz. The half power points occur just before and after the resonance frequency. The values of the half power points determined from Fig. 40 were inserted into equation (2.8) to calculate the damping ratio of the test fixture. This calculation produced a value of 0.121 for the damping ratio.

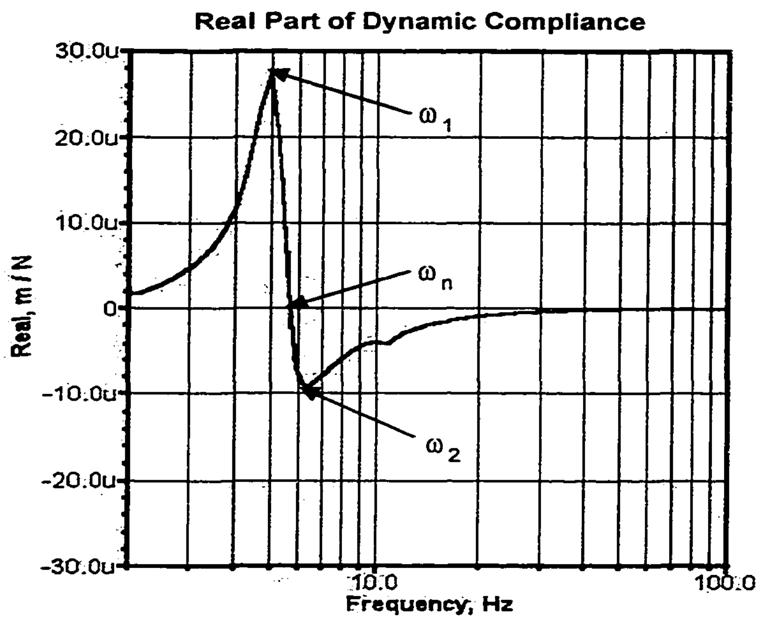


Fig. 40. Determining half power points

With mass, resonance frequency, and damping ratio of the test fixture determined, equations (2.9) and (2.10) were applied to calculate the stiffness and damping coefficients of the test fixture. The calculated value for the stiffness coefficient was 85,024.1 N/m and the calculated value for the damping coefficient was 587.3 N·s/m. All the characteristics determined from the frequency

response testing were grouped together in Table 2. Inserting the appropriate experimentally determined values into equation (2.1) produces the equation of motion shown in equation (4.1).

- Test fixture's equation of motion: $$68\,\ddot{y} + 587\,\dot{y} + 85{,}024\,y = f(t) \qquad (4.1)$$

Table 2. Properties of test fixture

Resonance frequency, ω_n (f_n):	35.0 [rad/s]	(5.6 [Hz])
First half power point, ω_1 (f_1):	31.4 [rad/s]	(5.0 [Hz])
Second half power point, ω_2 (f_2):	40.2 [rad/s]	(6.4 [Hz])
Damping ratio, ξ:	0.121	
Measured mass, M:	68.0 [kg]	(150.0 [lb_f])
Effective mass, M_{eff}:	69.4 [kg]	(152.6 [lb_f])
Damping Coefficient, C	587.3 [N·s/m]	(3.35 [lb_f·s/in])
Stiffness coefficient, K:	85,024.1 [N/m]	(485.50 [lb_f/in])

4.2. Transmissibility correction values of each accelerometer adapter

A total of five transmissibility correction tests were performed. Three tests were performed for the tri-axial adapter and one test was performed for each of the two single axis adapters. The resulting transmissibility correction values for each axis of the tri-axial adapter are displayed in Fig. 41 through Fig. 43. The transmissibility correction values of the two single axis adapters are displayed in Fig. 44 and Fig. 45, respectively.

Frequency [Hz]	Transmissibility along Z-Axis (TR_i)
6.3	0.90
8	0.76
10	1.19
12.5	1.11
16	0.77
20	0.79
25	0.87
31.5	1.03
40	1.48
50	1.64
63	1.36
80	1.13
100	1.03
125	0.98
160	0.97
200	0.98
250	0.98
315	0.98
400	1.00
500	1.03
630	1.05
800	1.12
1,000	1.19
1,250	1.28

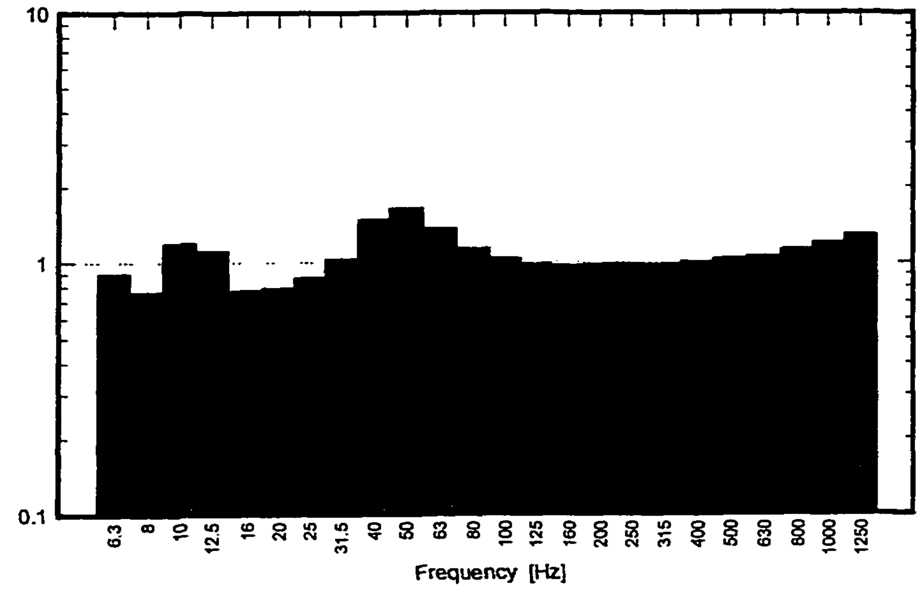


Fig. 41. Transmissibility correction for tri-axial adapter along Z-Axis

Frequency [Hz]	Transmissibility along Y-Axis (TR_i)
6.3	1.13
8	1.17
10	1.09
12.5	1.13
16	1.09
20	1.12
25	1.18
31.5	1.11
40	1.02
50	0.94
63	0.91
80	0.92
100	0.90
125	0.92
160	0.87
200	0.87
250	0.81
315	0.84
400	1.04
500	1.19
630	1.09
800	0.95
1,000	0.72
1,250	0.42

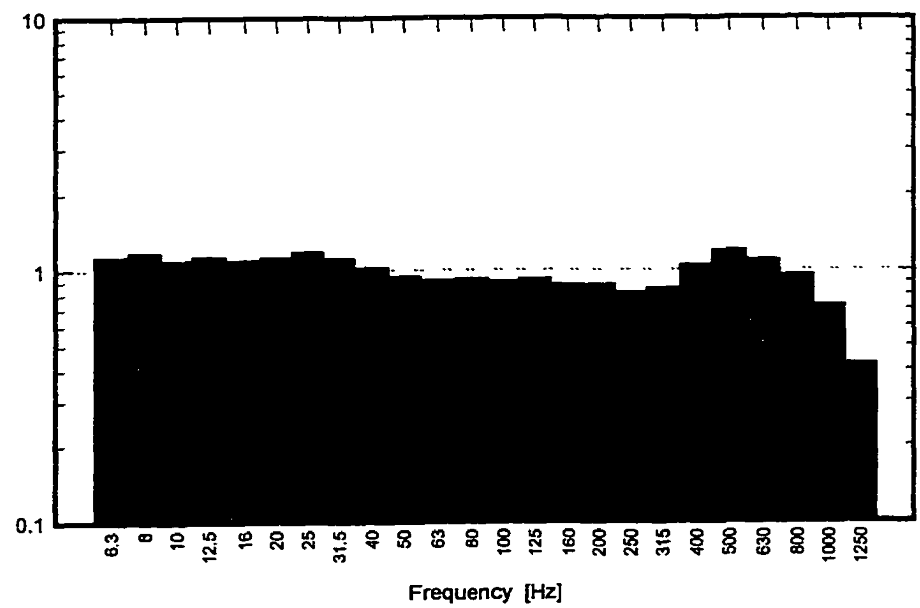


Fig. 42. Transmissibility correction for tri-axial adapter along Y-Axis

Frequency [Hz]	Transmissibility along X-Axis (TRi)
6.3	1.00
8	1.21
10	1.49
12.5	1.40
16	1.15
20	1.07
25	1.02
31.5	1.04
40	0.96
50	0.90
63	0.82
80	0.78
100	0.77
125	0.82
160	0.90
200	0.97
250	0.99
315	1.04
400	1.10
500	1.23
630	1.43
800	1.71
1,000	1.81
1,250	1.30

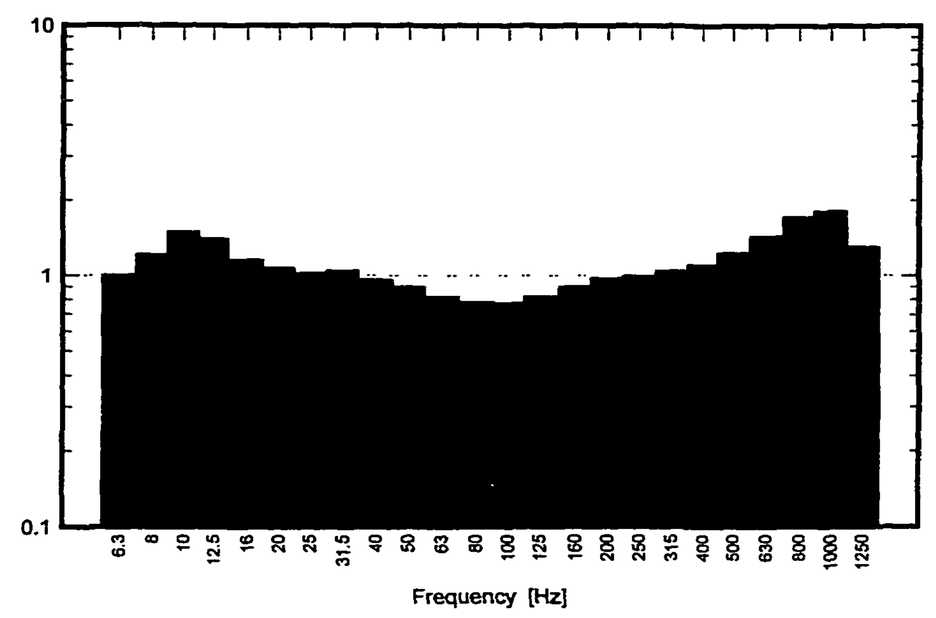


Fig. 43. Transmissibility correction for tri-axial adapter along X-Axis

Frequency [Hz]	Transmissibility along Z-Axis (TRi)
6.3	1.22
8	1.40
10	1.44
12.5	1.33
16	1.18
20	1.21
25	1.17
31.5	1.09
40	0.92
50	0.84
63	0.92
80	1.01
100	1.04
125	1.05
160	0.88
200	0.95
250	1.01
315	0.97
400	1.01
500	1.01
630	0.95
800	0.93
1,000	0.92
1,250	0.91

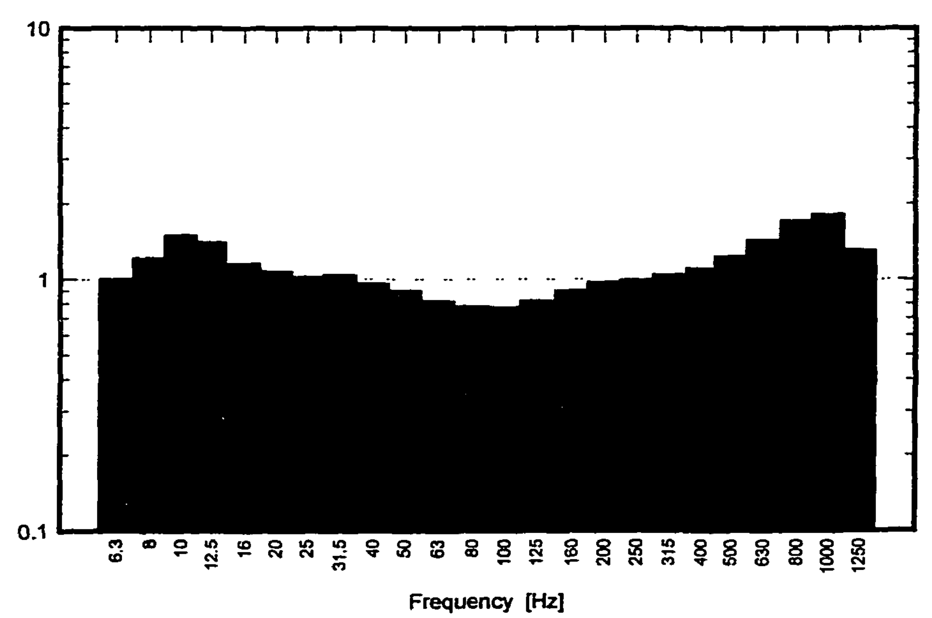


Fig. 44. Transmissibility correction for single axis adapter used on the handle

Frequency [Hz]	Transmissibility along Z-Axis (TR_i)
6.3	1.42
8	1.53
10	1.40
12.5	1.20
16	1.25
20	1.29
25	1.29
31.5	1.28
40	1.21
50	0.99
63	0.87
80	0.84
100	0.90
125	0.96
160	0.97
200	0.97
250	0.98
315	0.98
400	0.97
500	0.96
630	0.99
800	1.01
1,000	0.98
1,250	0.99

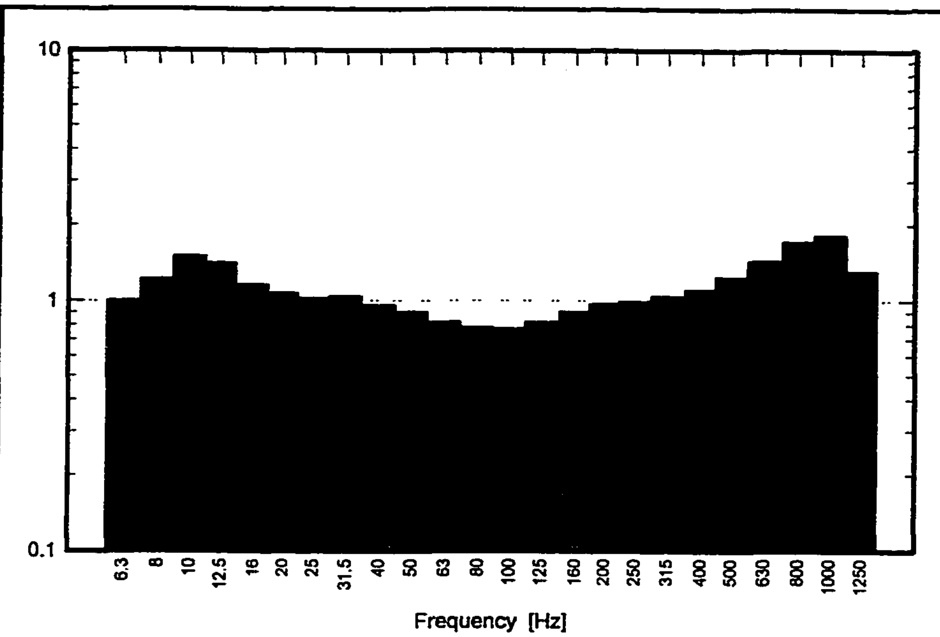


Fig. 45. Transmissibility correction for single axis adapter used in the glove

4.3. Simulation of sustained exposure to hand-held impact tools

A total of twelve tests were performed with the chipping hammer. Three test subjects contributed three tests apiece. The measured value of the chisel's mass was 0.476 kg (1.05 lb) and the measured value of the test fixture's mass was 68 kg (150 lb). Using equations (3.5) and (3.6), the acceleration values of the chipping hammer's chisel and handle were calculated from the collected acceleration values of the test fixture's mass. The measured peak acceleration values of the test fixture's mass ranged from 800 to 1,200 m/s^2. The calculated peak acceleration values of the chisel ranged from 110,000 to 150,000 m/s^2. The calculated peak acceleration values of the handle ranged from 4,000 to 1,500 m/s^2. The measured peak acceleration values of the handle ranged from 1,200 to 1,500 m/s^2. Acceleration time history plots for the test fixture's mass and the chipping hammer's chisel and handle were generated from the respective measured and calculated data. Fig. 46 through Fig. 50 display the acceleration time history plots.

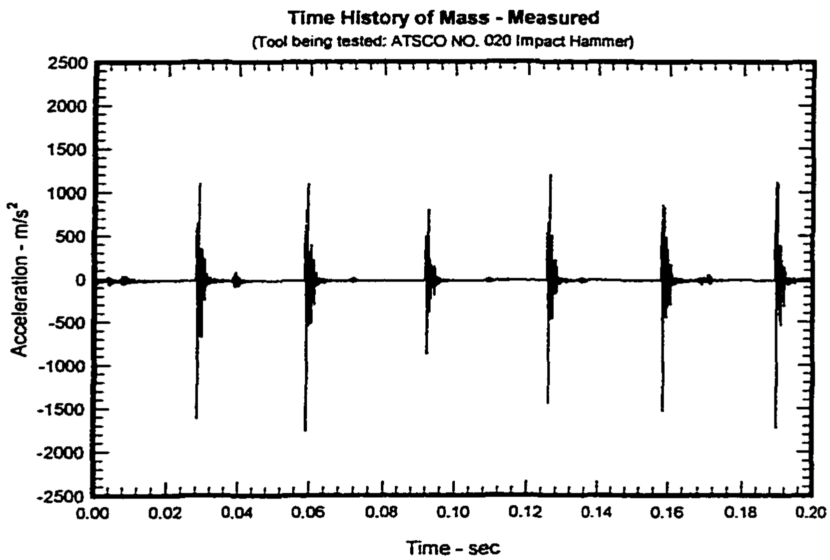


Fig. 46. Measured time history of the test fixture's mass

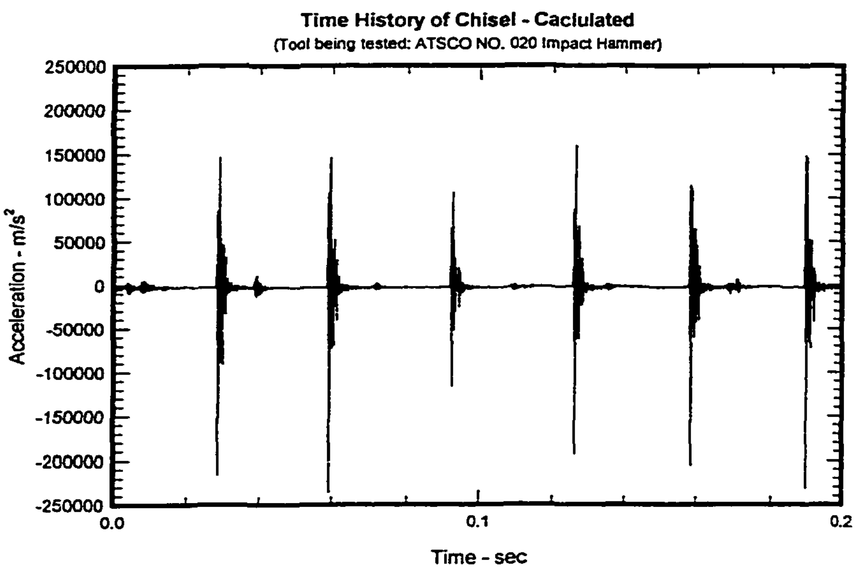


Fig. 47. Calculated time history of the test fixture's mass

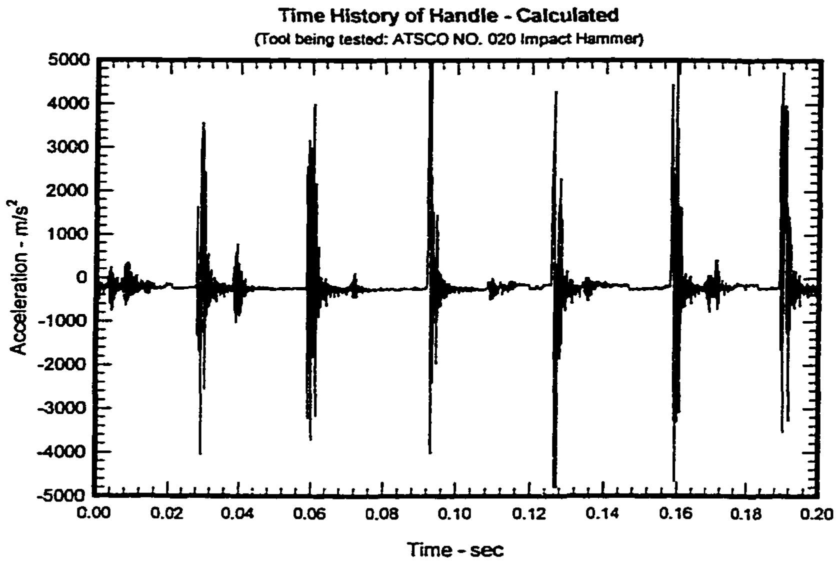


Fig. 48. Calculated time history of the chipping hammer's handle

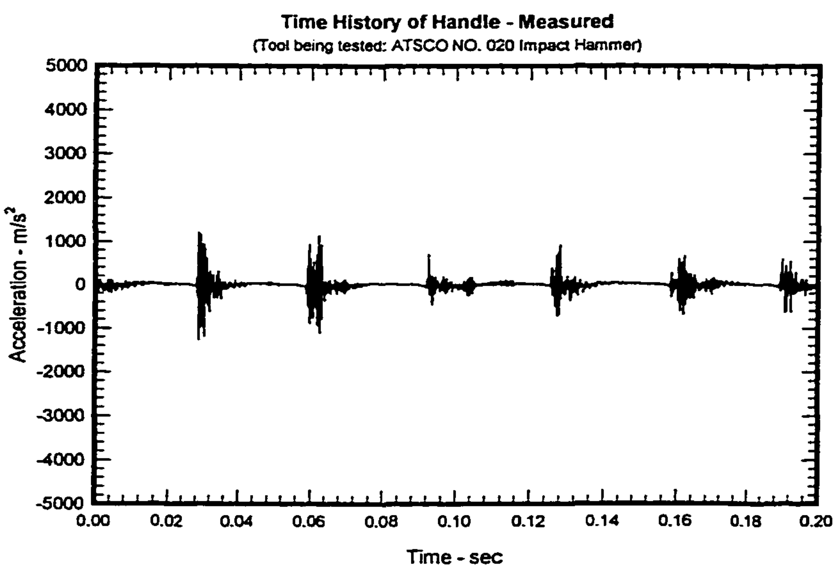


Fig. 49. Measured time history of the chipping hammer's handle

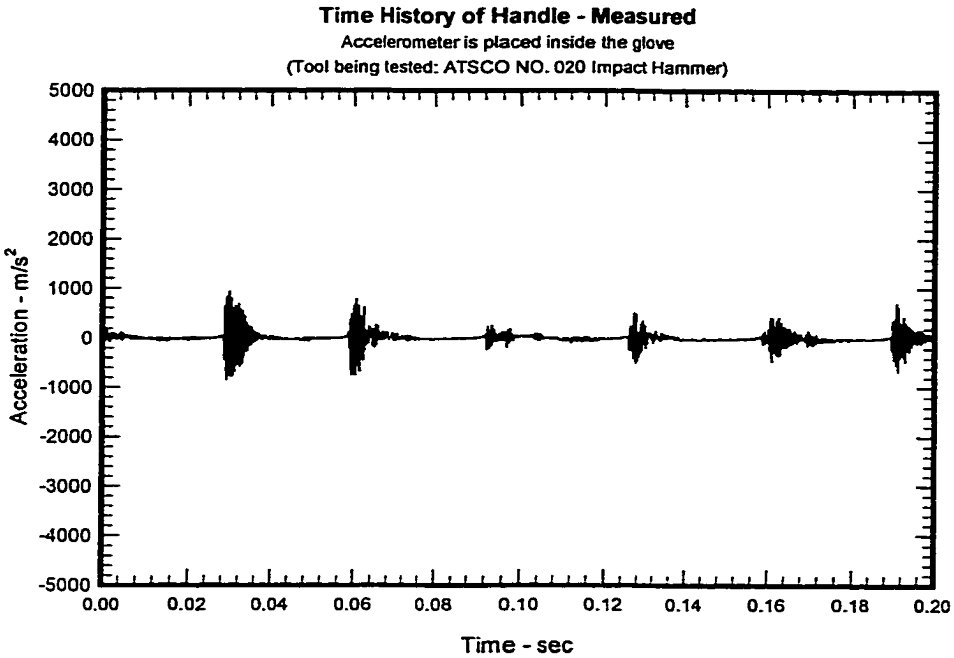
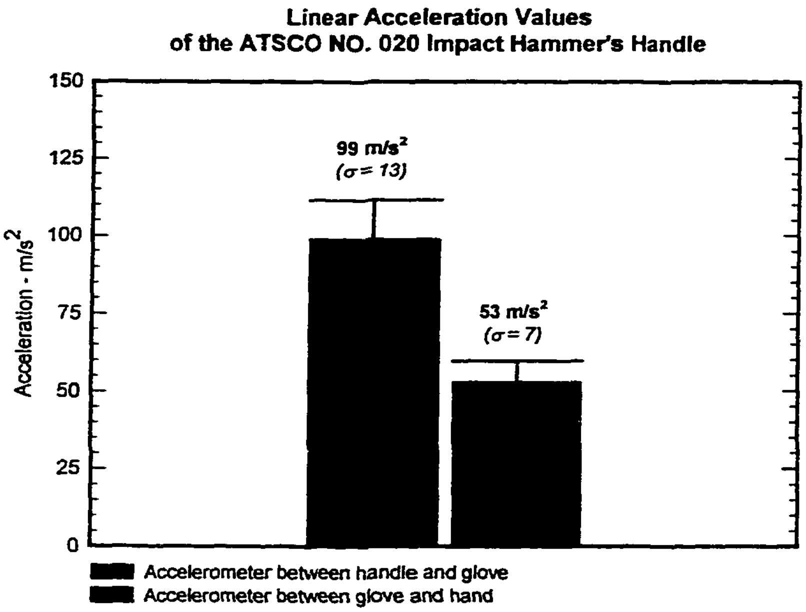


Fig. 50. Measured time history inside the glove at the chipping hammer's handle

The saved third octave band acceleration data for the test fixture's mass, the chipping hammer's handle, and the gloved hand were placed into three tables. Two more tables were created containing the calculated third octave band acceleration values of the chipping hammer's chisel and handle. Equations (3.5) and (3.6) were used to calculate the chisel and handle third octave band acceleration values. In each of the five tables, the measured acceleration values were averaged across each third octave band. In each table, the linear and ISO weighted values were calculated from the third octave band acceleration data. Equations (3.3) and (3.4) were used to determine the respective linear and ISO weighted values. The five tables containing the third octave band acceleration averages of the twelve tests at each third octave band and linear and ISO weighted values can be found in Table E.1 through Table E.5, located in Appendix E

Plots were generated containing the average linear and ISO weighted values determined in the tables containing acceleration data at the handle. The first set of plots pictured in Fig. 51 compare the measured linear and ISO weighted acceleration values at the handle and in the glove. The second set of plots pictured in Fig. 52 compare the measured and calculated linear and ISO weighted vales at the handle.



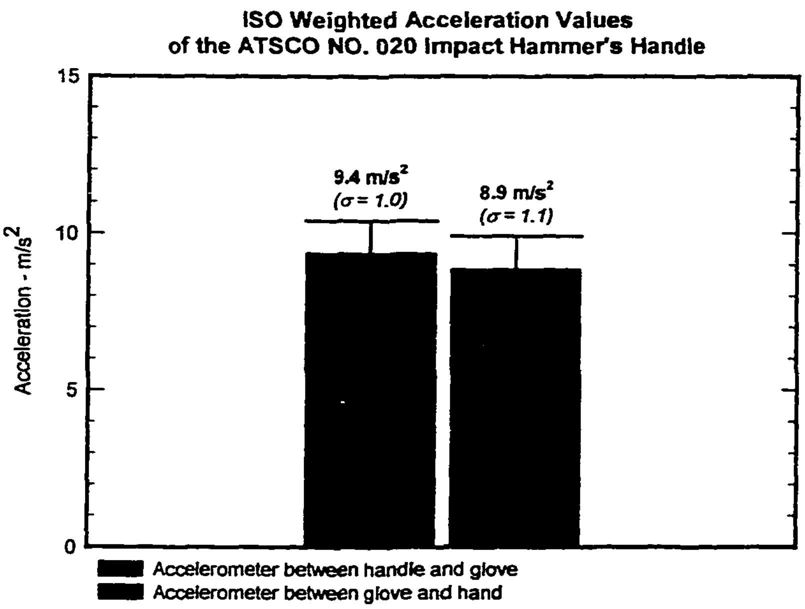
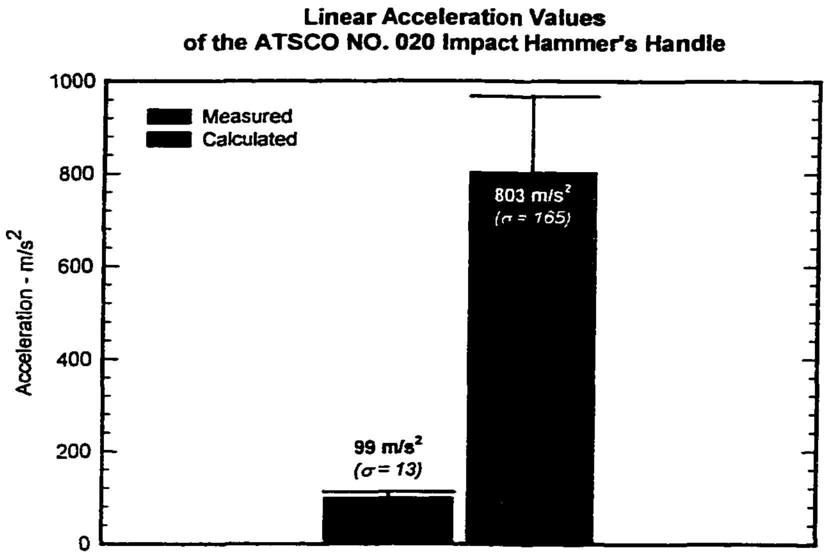


Fig. 51. Measured linear and ISO weighted values at the Atsco No.020 chipping hammer's handle and inside the gloved hand



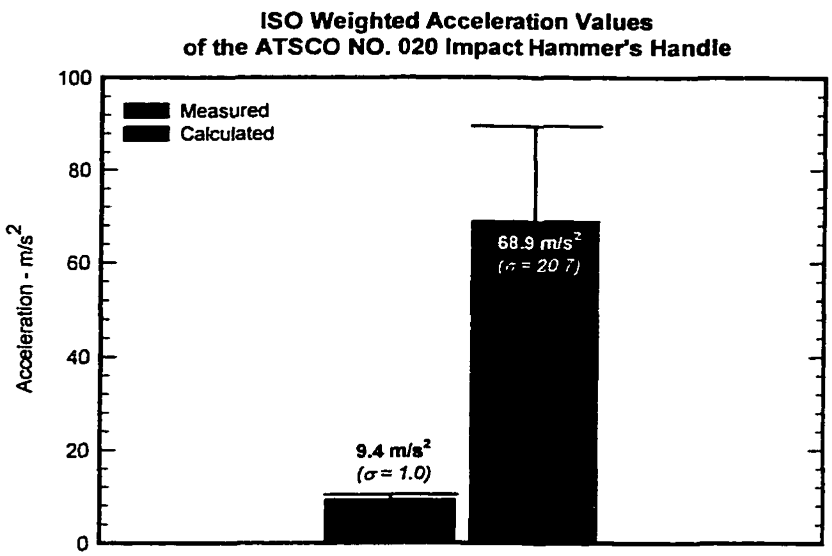


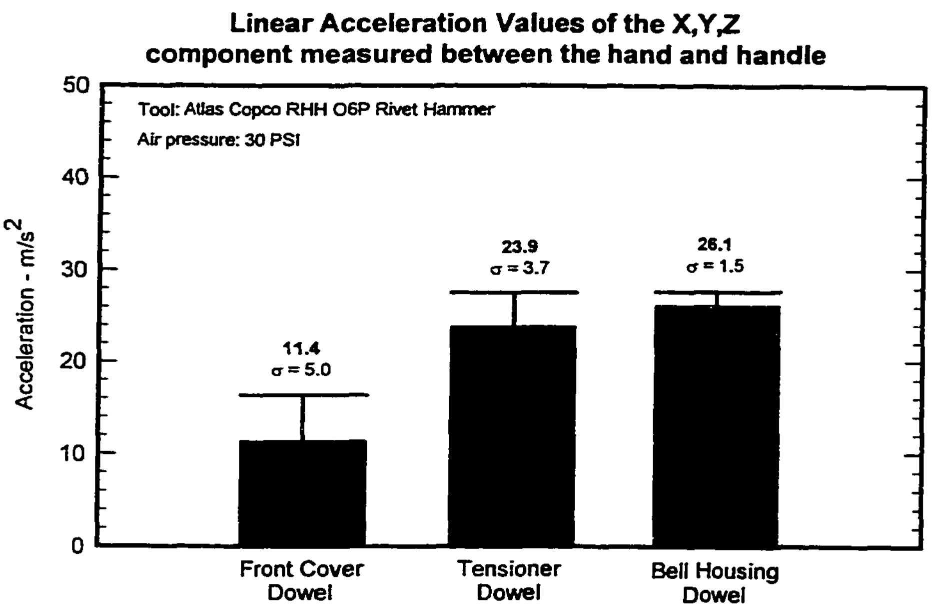
Fig. 52. Measured and calculated linear and ISO weighted values at the Atsco No.020 chipping hammer's handle

4.4. Simulation of assembly operations with hand-held impact tools

A total of seventy-seven tests were performed inserting the dowels, bearings, and bushings into the respective test plates with the rivet hammers. For each part inserted, the air pressure supplied to the rivet hammer was 30, 60, and 90 psi. Each part inserted was done so by at least three test subjects. Test subjects participated in a minimum of two tests for each part being inserted at the respective air pressure. Unless other wise specified in the proceeding results, the Atlas Copco RRH 06P Rivet Hammer was used to insert the parts into the test plates.

The saved third octave band acceleration data of each handle accelerometer and the calculated acceleration vector component at the handle were placed into tables. In each table, the acceleration values were averaged across each third octave band. In each table, the linear and ISO weighted values were calculated from the third octave band acceleration data. Equations (3.3) and (3.4) were used to determine the respective linear and ISO weighted values. Tables, located in Appendix F, contain the third octave band, linear, and ISO weighted acceleration averages for each part inserted.

From the calculated X,Y,Z vector component values, comparison plots were generated showing the linear and ISO weighted acceleration values. The first set of plots provides comparison of each part tested at the same air pressure. Fig. 53 through Fig. 55 display results for the parts tested at an air pressure of 30, 60, and 90 PSI, respectively. The second set of plots show how each part compared against itself when tested at different air pressures. Fig. 56 through Fig. 60 display the second set of results for each part.



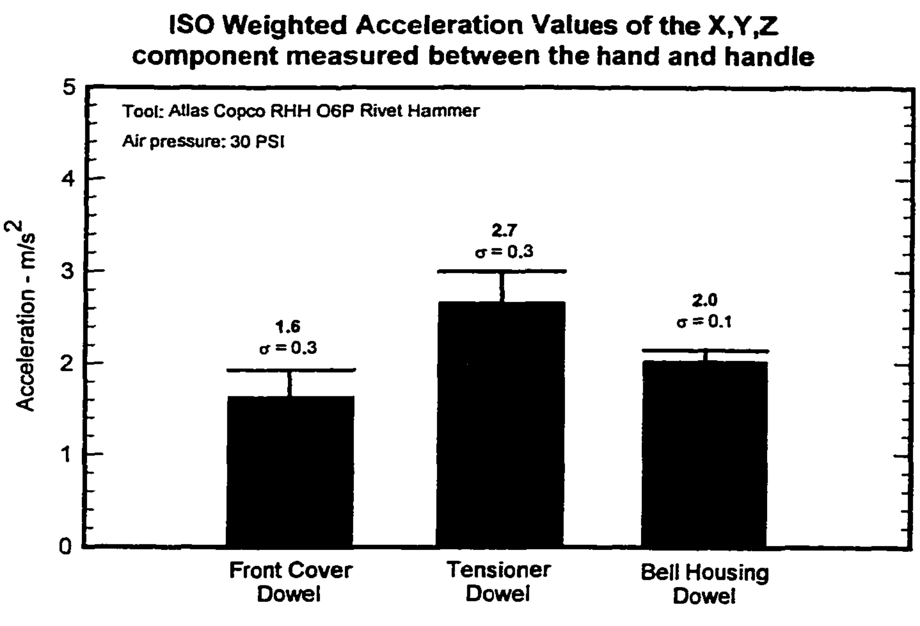
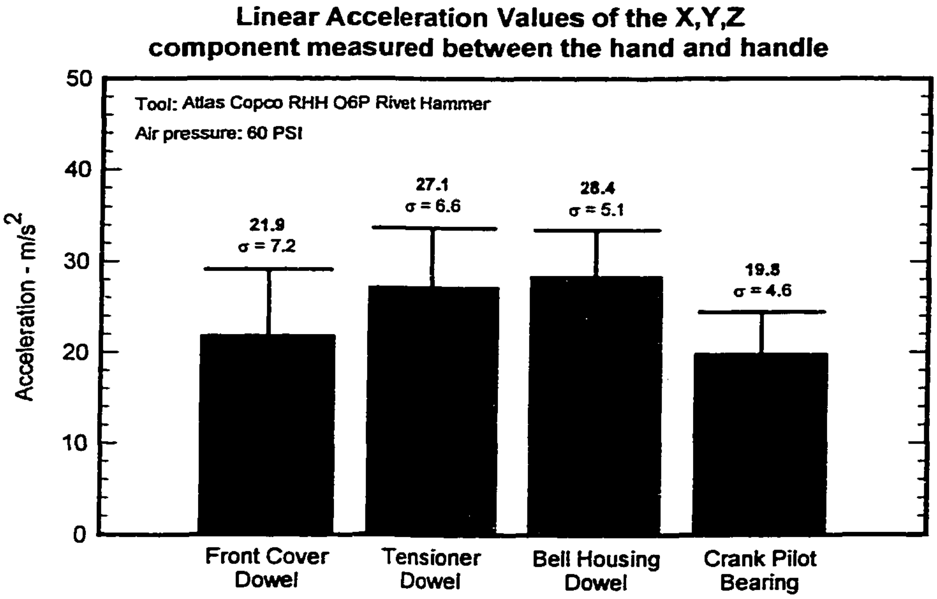


Fig. 53. X,Y,Z Linear and ISO weighted acceleration values at the handle for all parts inserted by rivet hammer supplied with 30 PSI



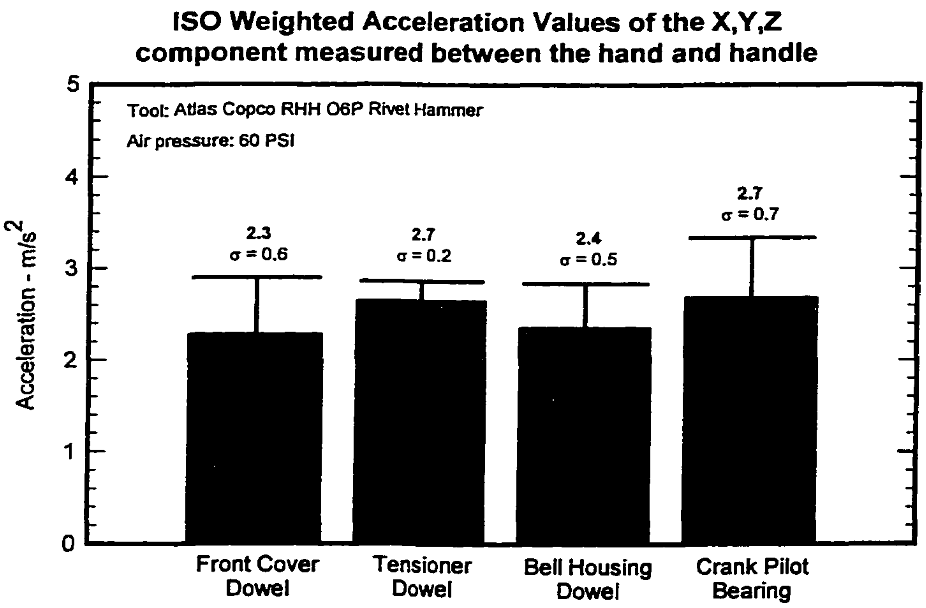
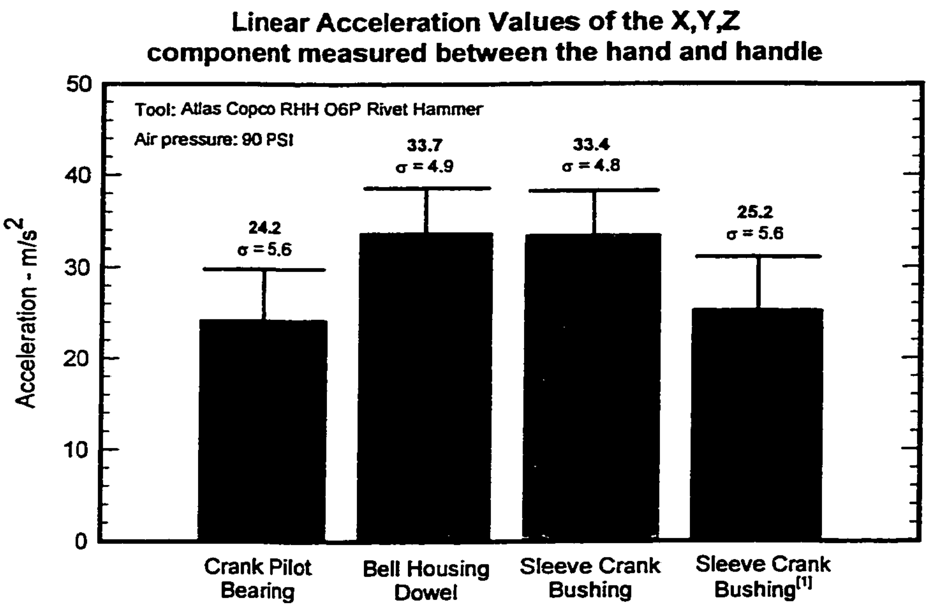
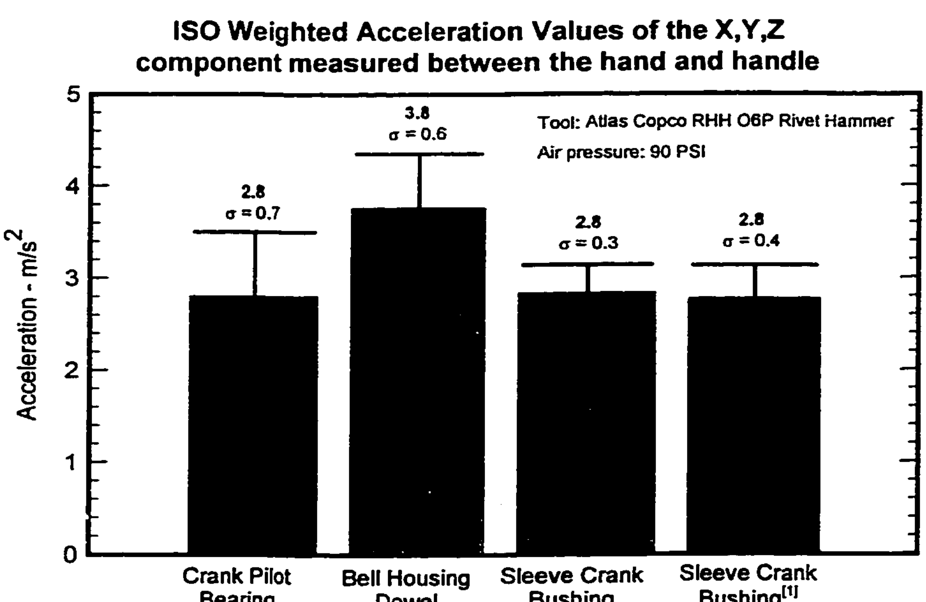


Fig. 54. X,Y,Z Linear and ISO weighted acceleration values at the handle for all parts inserted by rivet hammer supplied with 60 PSI

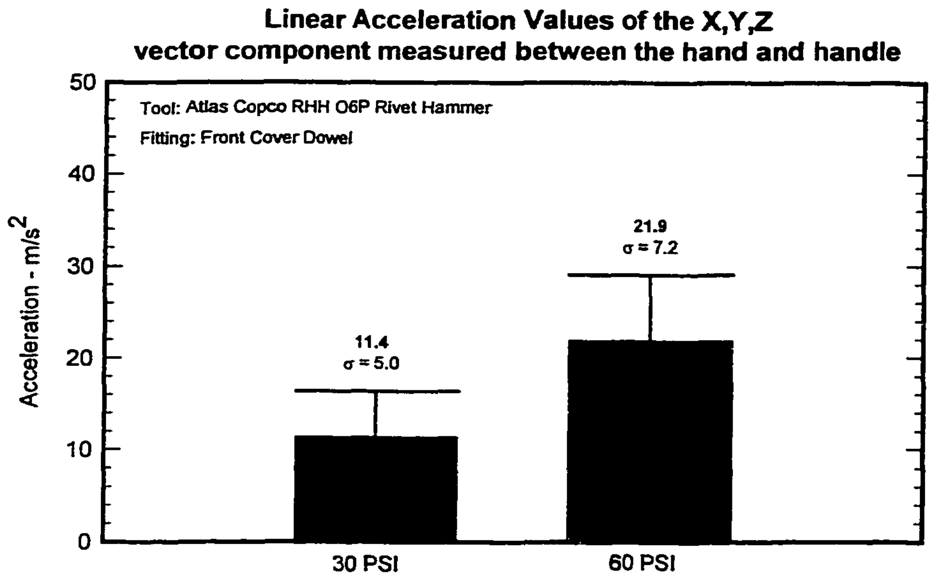


Notes:
1. Test performed with Atlas Copco RRH 10P Rivet Hammer.



Notes:
1. Test performed with Atlas Copco RRH 10P Rivet Hammer.

Fig. 55. X,Y,Z Linear and ISO weighted acceleration values at the handle for all parts inserted by rivet hammer supplied with 90 PSI



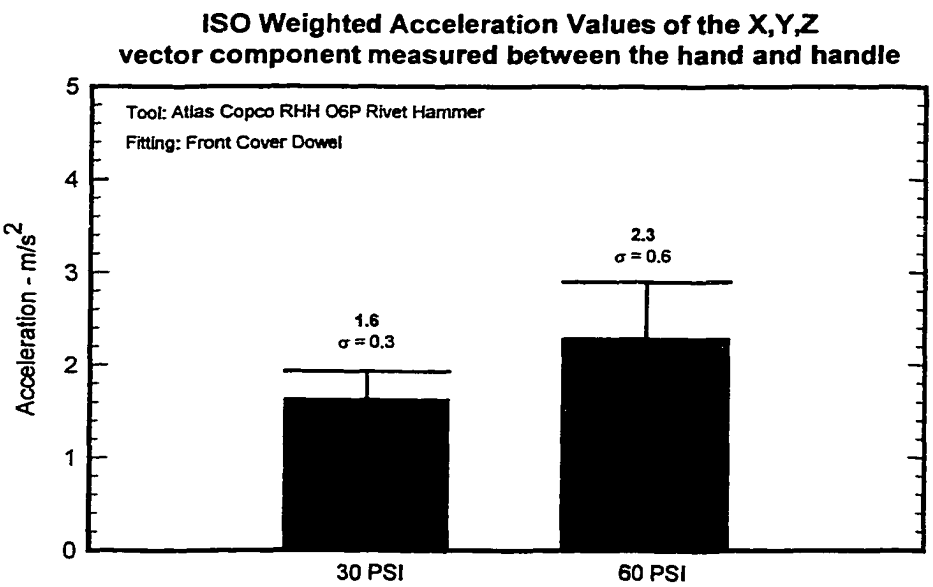
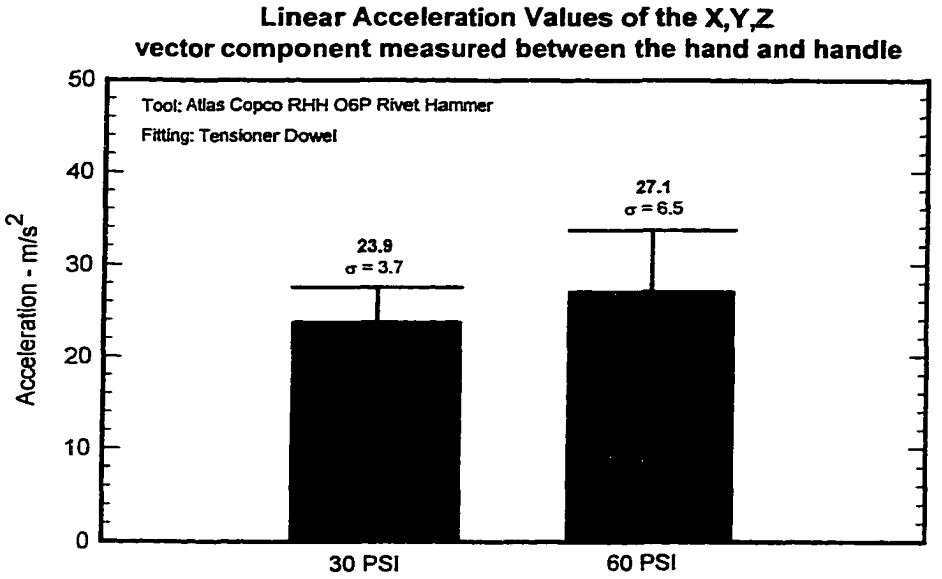


Fig. 56. X,Y,Z Linear and ISO weighted acceleration values at the handle when inserting front cover dowels



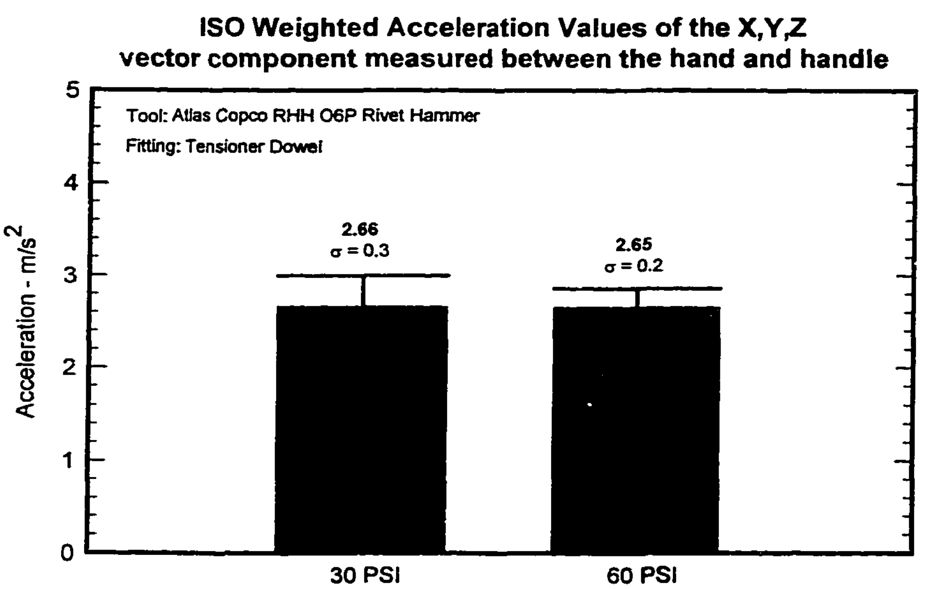
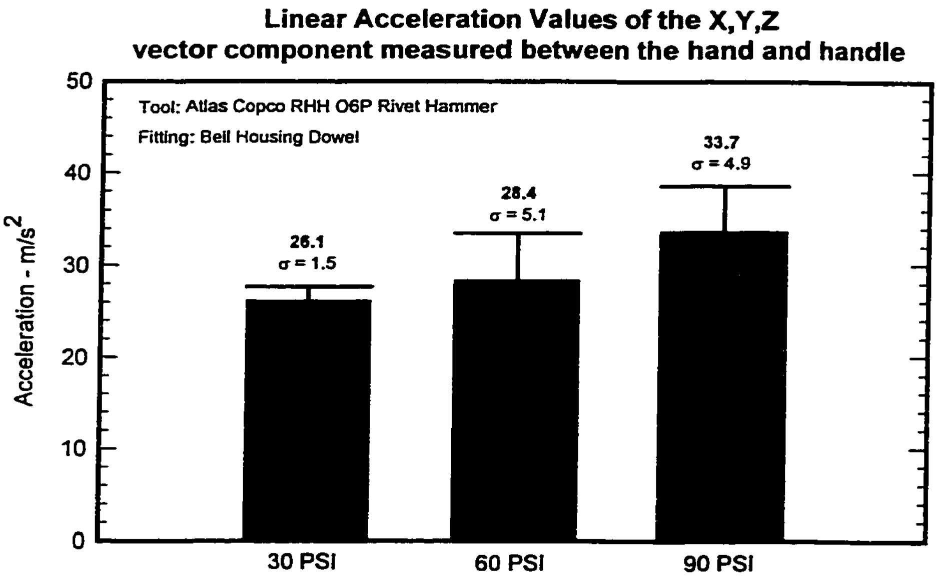


Fig. 57. X,Y,Z Linear and ISO weighted acceleration values at the handle when inserting tensioner dowels



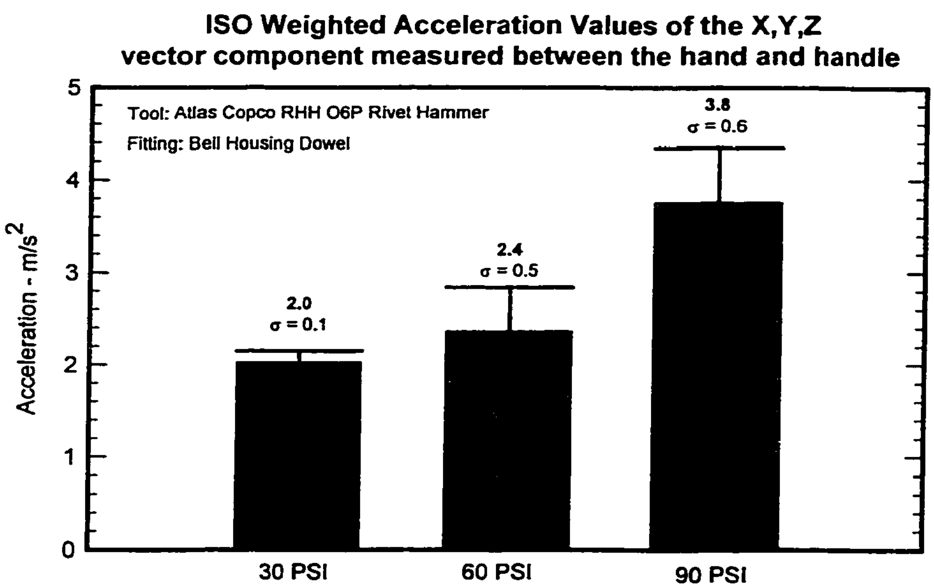
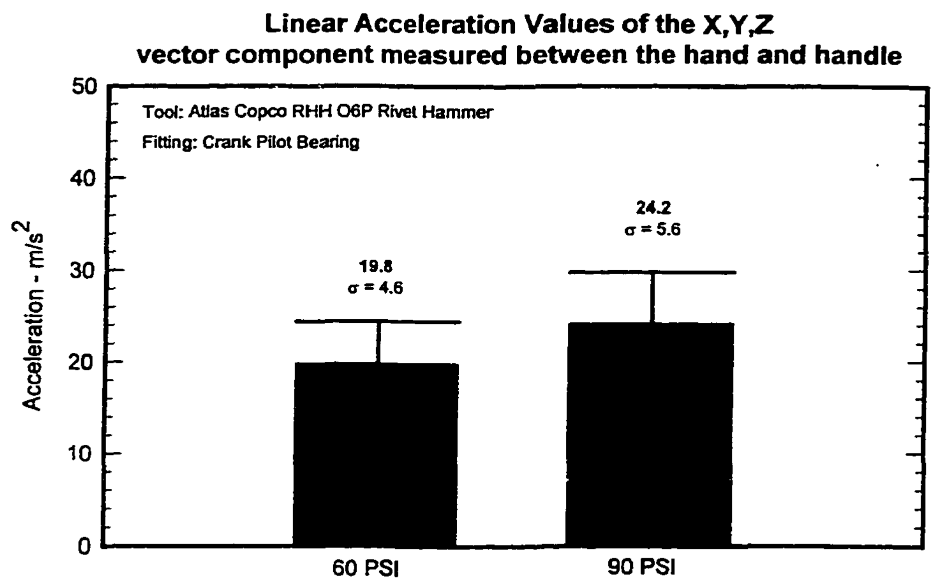


Fig. 58. X,Y,Z Linear and ISO weighted acceleration values at the handle when inserting bell housing dowels



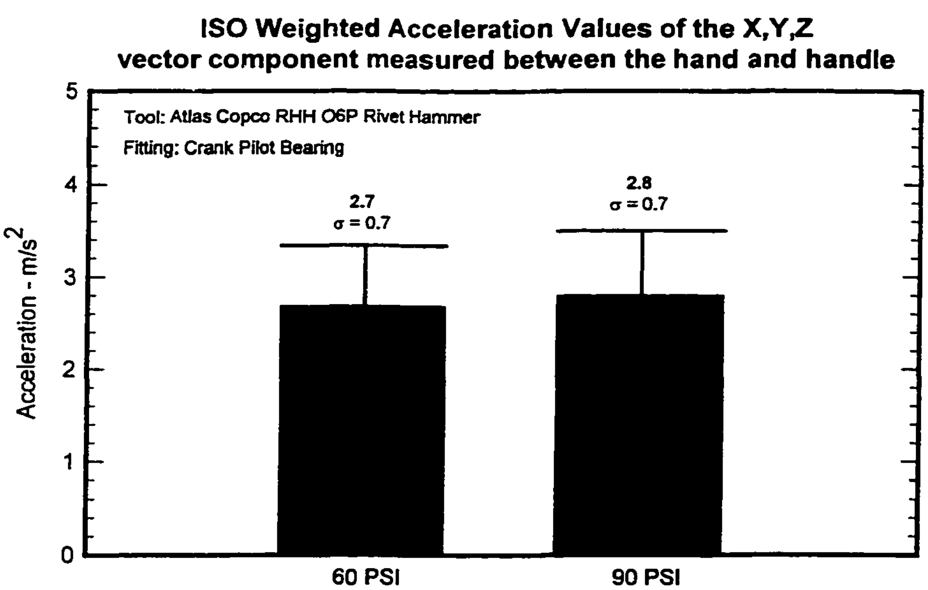
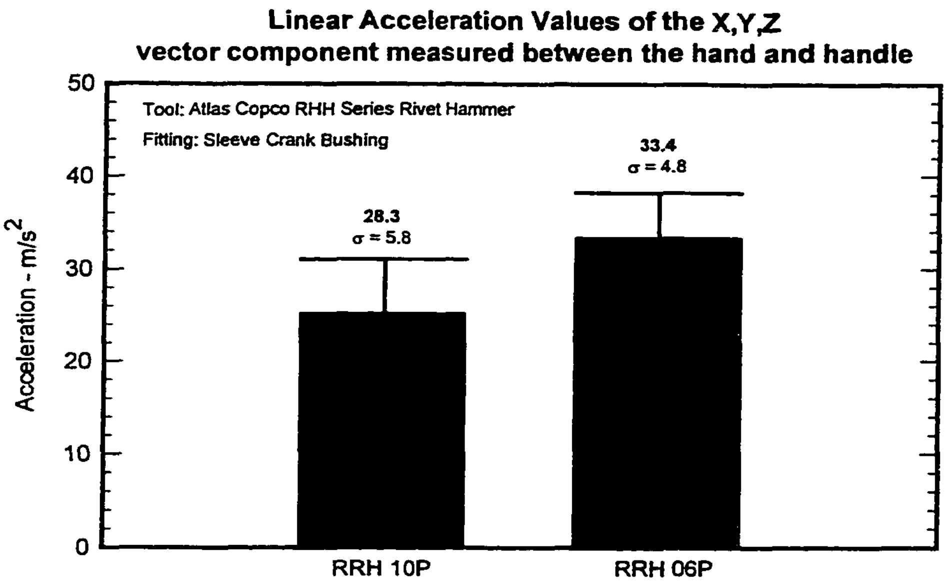


Fig. 59. X,Y,Z Linear and ISO weighted acceleration values at the handle when inserting crank pilot bearings



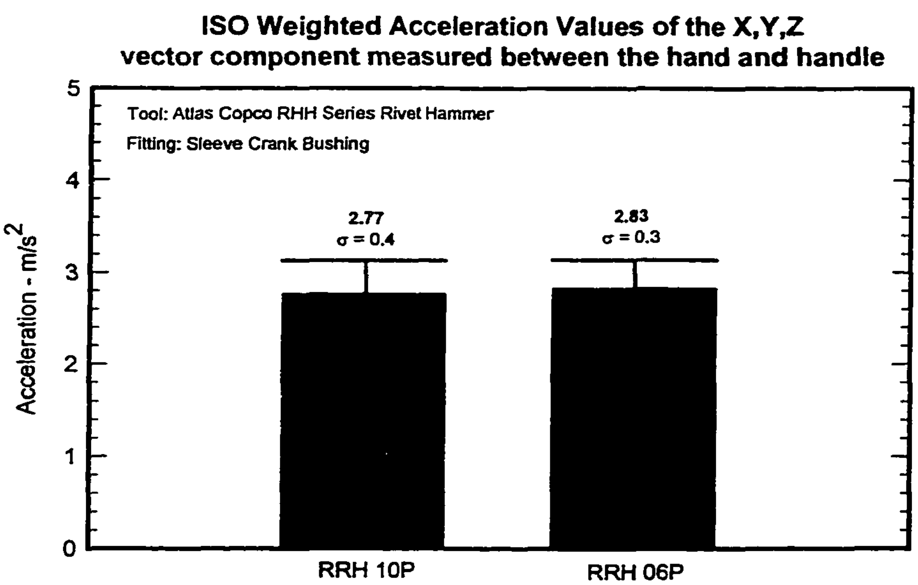


Fig. 60. X,Y,Z Linear and ISO weighted acceleration values at the handle when inserting sleeve crank bushings

For each station, tables were generated listing the installation time and ISO weighted X,Y,Z vector component acceleration value of each part inserted. Using equations (3.9) through (3.11), the actual, four-hour, and eight-hour exposure levels were calculated. These calculated exposure values were placed in the same tables containing the individual installation times and acceleration values. Table G.1 and Table G.2 provide the vibration exposure levels calculated for Station 91R. At station 91R, front cover dowels, water by-pass tubes, and chain tensioner dowels were installed into the engine. Two tables were generated for this station because the rivet hammer was supplied with 30 and 60 PSI when inserting the front cover and chain tensioner dowels. No testing was performed using the water by-pass tube. At the request of the engineers at the Romeo engine plant, the ISO weighted values of the front cover dowel was substituted. Table G.3 through Table G.5 provide the vibration exposure levels calculated for Station 141R. At station 141R, bell housing and rear seal carrier dowels were installed into the engine. The rear seal carrier dowel has the same dimensions as the front cover dowel. Three tables were generated for this station because the rivet hammer was supplied with 30, 60, and 90 PSI when inserting the bell housing dowels and 30 and 60 PSI when inserting the rear seal carrier dowels. Table G.6 through Table G.9 provide the vibration exposure levels calculated for Station 213L. At station 213L, oil slingers and pilot bearing/bushing were installed into the engine. Four tables were generated for this station. The first three tables provide results from the RRH-06P rivet hammer inserting the crank pilot bearing and sleeve crank bushing, when supplied with 60 and 90 PS. The fourth table provides results from the RRH-10P rivet hammer inserting the sleeve crank bushing, when supplied with 90 PS. No testing was performed using the oil slinger part. Values for the front cover dowel were substituted for the oil slinger, as requested by engineers at the Romeo engine plant. All the tables generated for each station are located in Appendix G. Plots of the daily vibration exposure levels calculated on each table were generated. The plots show how calculated vibration exposure levels of each station compared to the European Directive value of 2.5 m/s^2 and the ACGIH TLV value of 4 m/s^2. These plots showing the calculated daily exposure levels for each station are shown in Fig. 61 through Fig. 63.

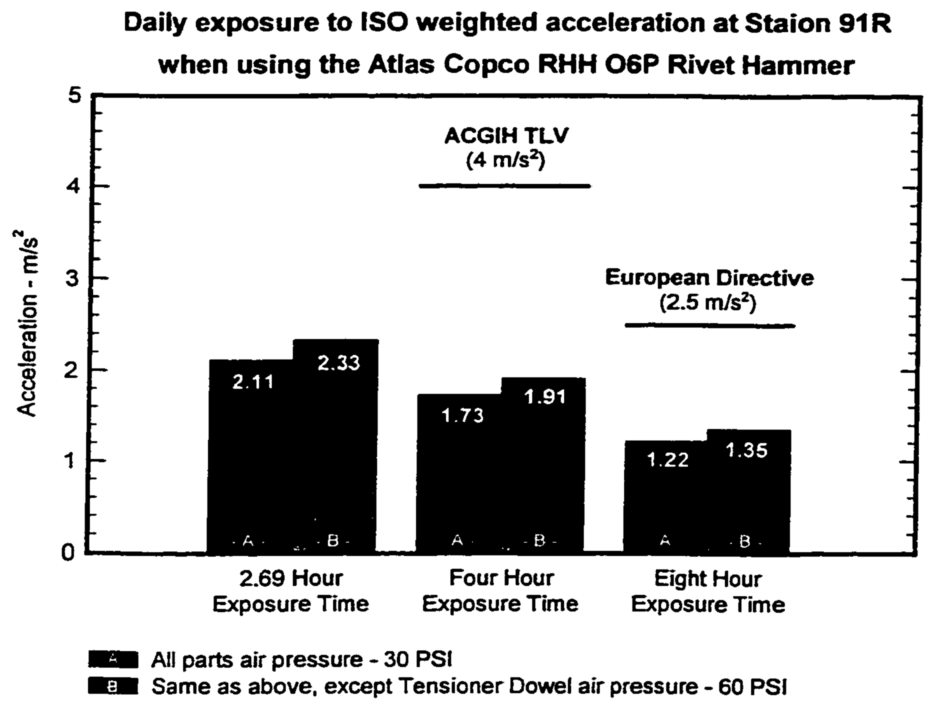


Fig. 61. Daily exposure to ISO weighted acceleration at Station 91R

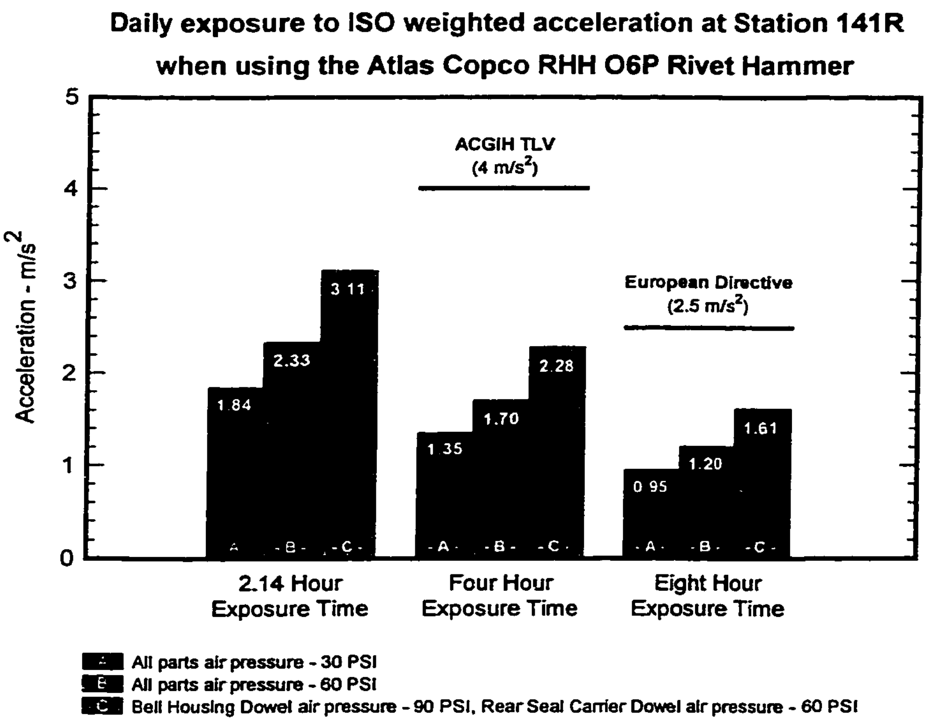


Fig. 62. Daily exposure to ISO weighted acceleration at Station 141R

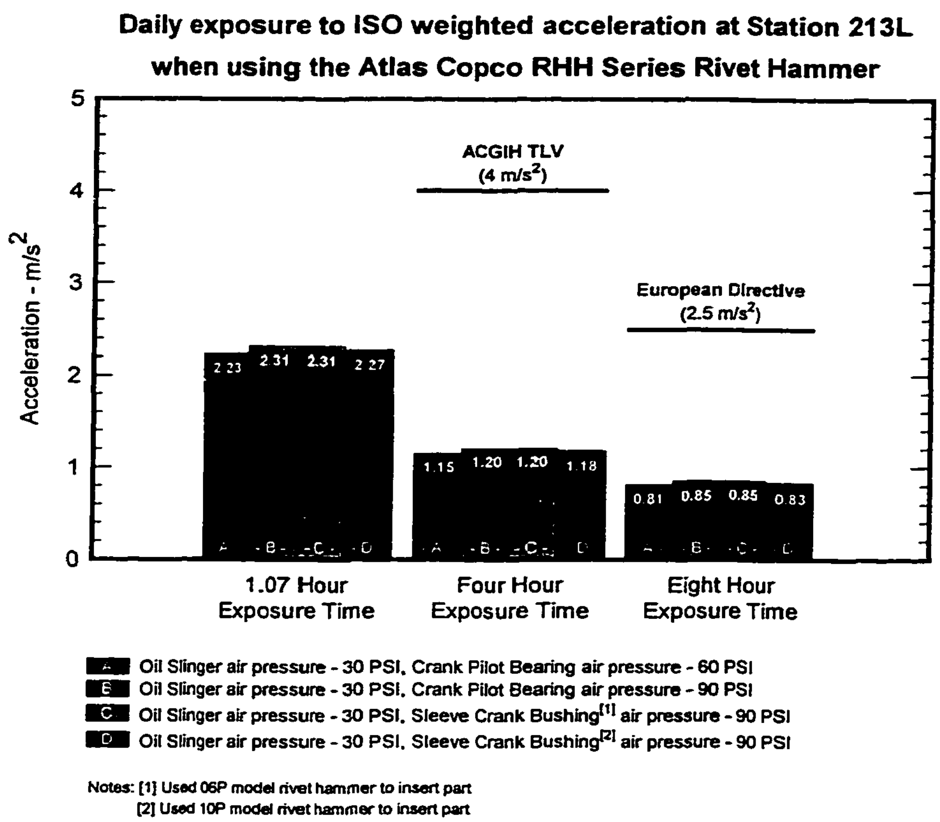
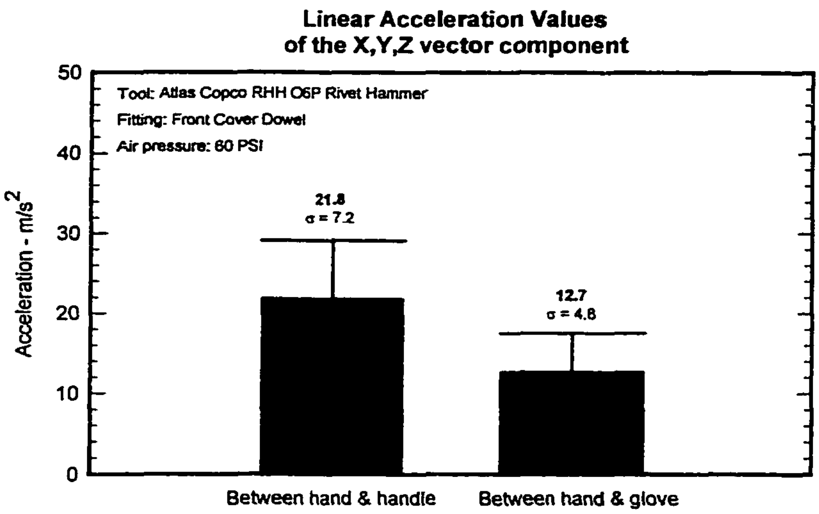


Fig. 63. Daily exposure to ISO weighted acceleration at Station 213L

The engineers at the Romeo engine plant were concerned with the vibration exposure of the Atlas Copco RRH rivet hammers when operated with bare hands. All the results shown thus far were obtained from bare hand testing. Not every autoworker assigned to the assembly line workstations will be able to perform their duties with unprotected hands. Some workers may require antivibration gloves to help reduce the vibration transmission from the rivet hammer. To show the reduction provided antivibration gloves, further testing was done with the rivet hammers. The additional tests followed the same procedures used in the previous tests performed with the rivet hammers. The antivibration gloves used air bladder technology developed by ErgoAir.

A total of thirty-seven tests were performed for the same five parts used in the previous testing. Only a single air pressure setting was supplied to the rivet hammers, which contributed to fewer tests being performed with the antivibration gloves. Each part was tested by at least three test subjects. At least two tests were performed for each part. Unless other wise specified,

the Atlas Copco RRH 06P Rivet Hammer was used to insert the parts into the test plates. The same steps used to analyze the bare hand test data were employed to analyze the gloved hand test data. Again, the data obtained by the PULSE™ software was used to generate a series of comparison plots displaying the linear and ISO weighted acceleration values. Only values associate with the X,Y,Z vector component were used in the creation of the plots. Fig. 64 through Fig. 69 display comparison plots between the bare and gloved hand tests performed for each part.



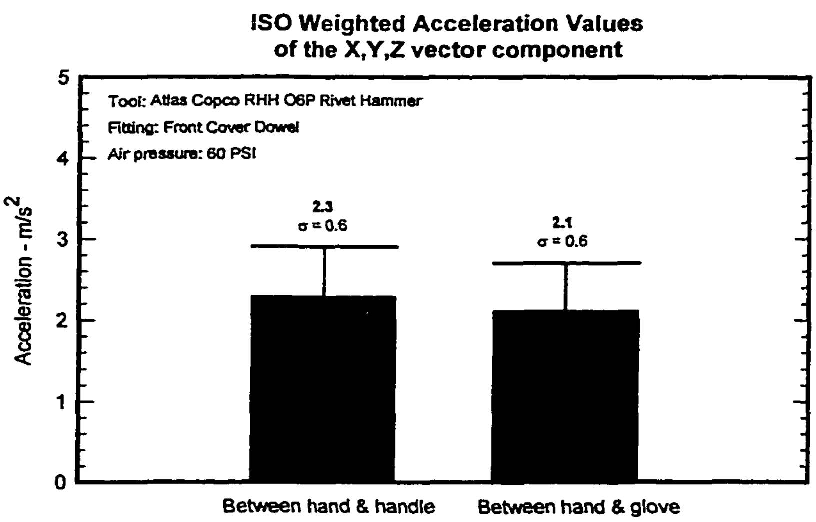
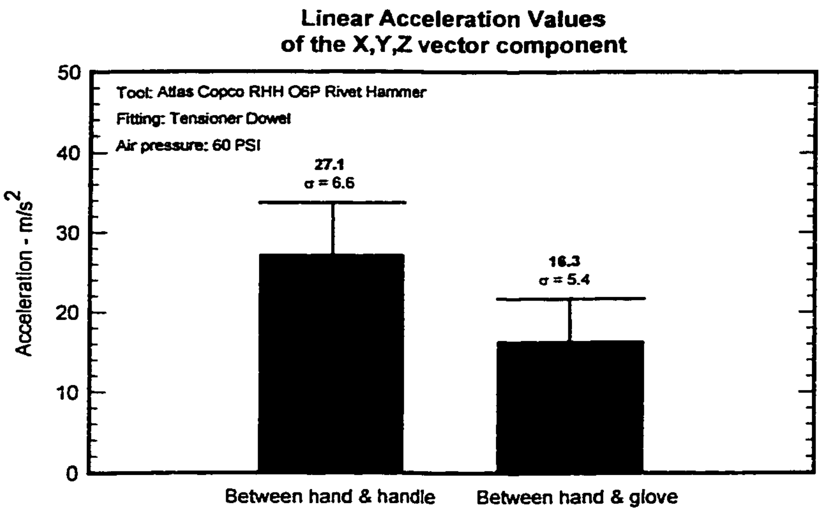


Fig. 64. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting front cover dowels with the model 06P rivet hammer



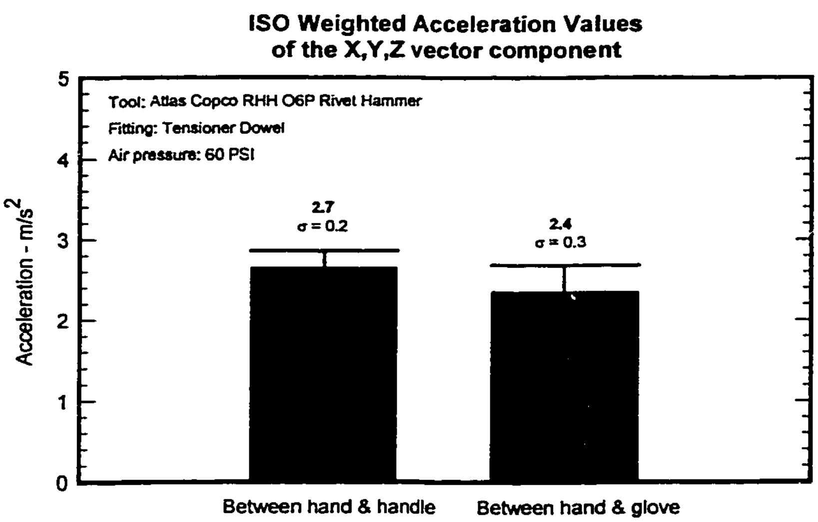
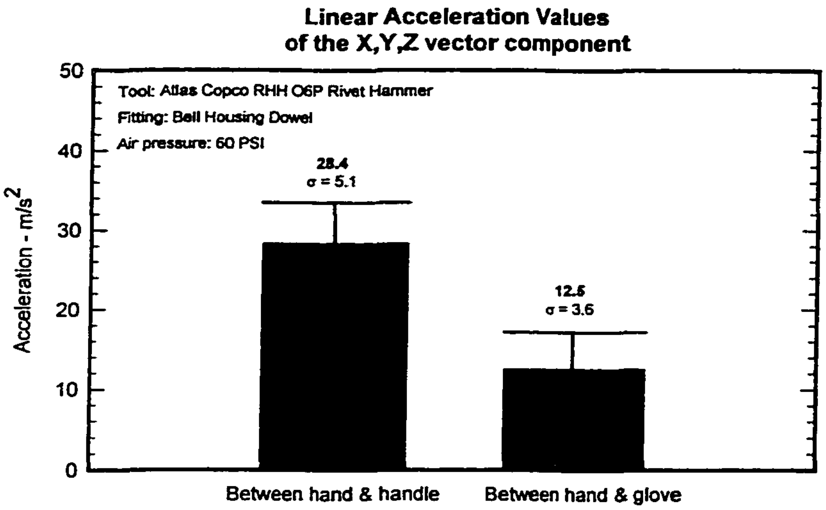


Fig. 65. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting tensioner dowels with the model 06P rivet hammer



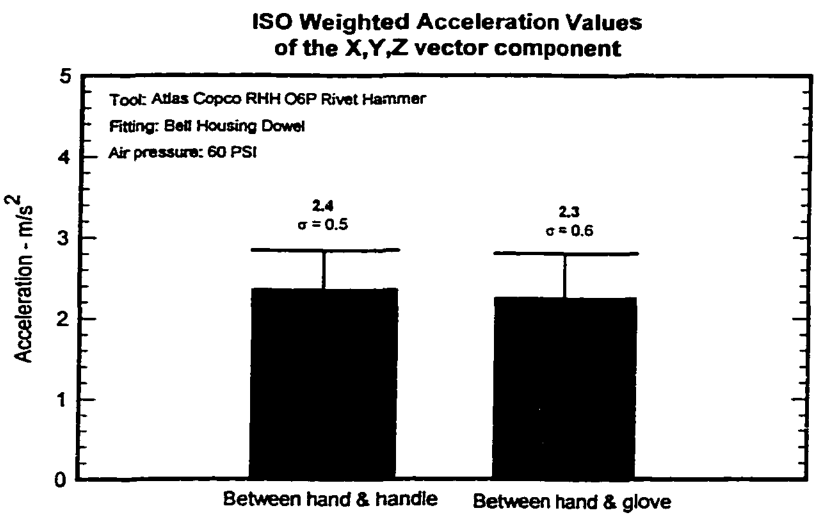
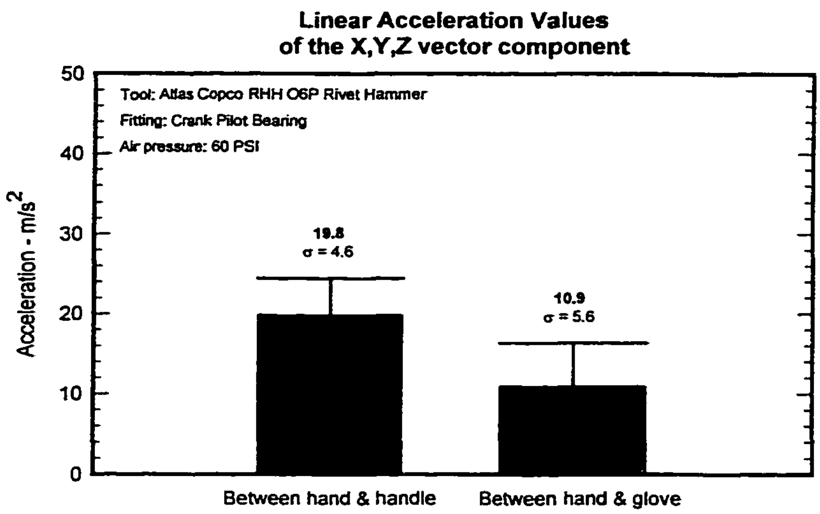


Fig. 66. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting bell housing dowels with the model 06P rivet hammer



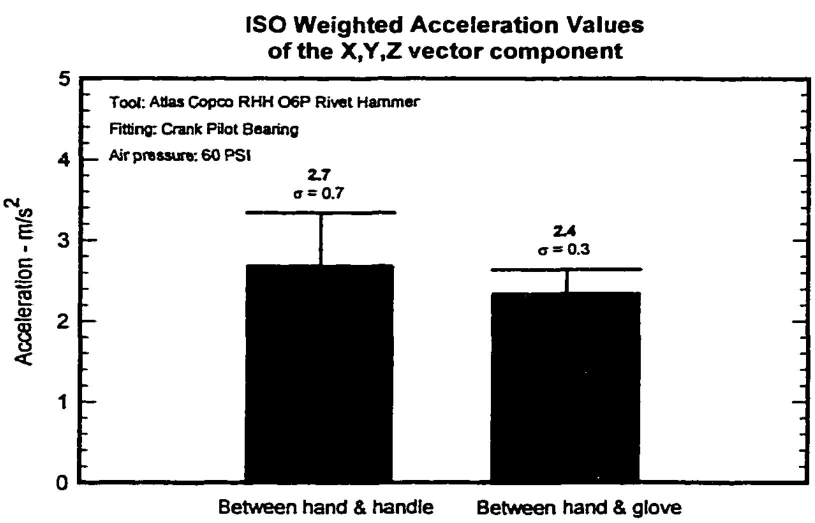
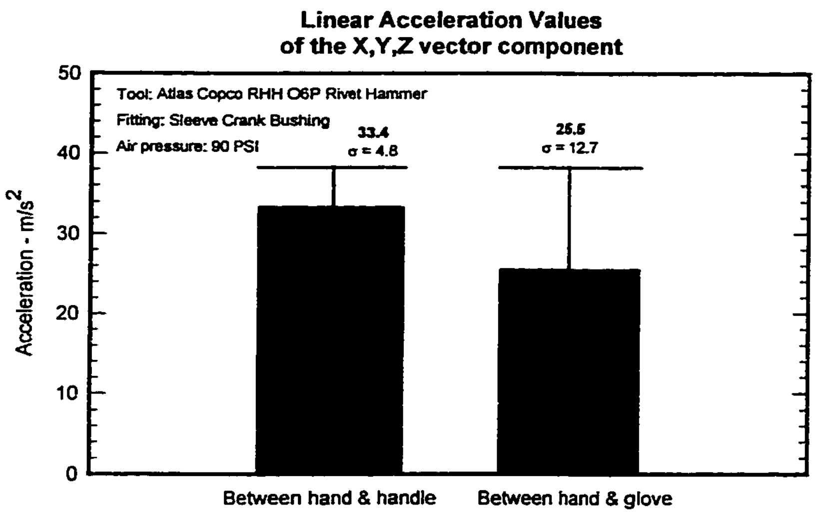


Fig. 67. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting crank pilot bearings with the model 06P rivet hammer



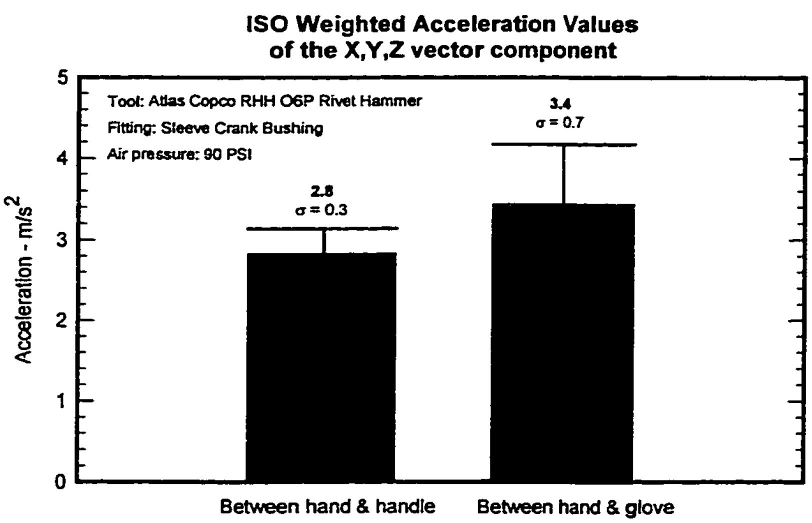
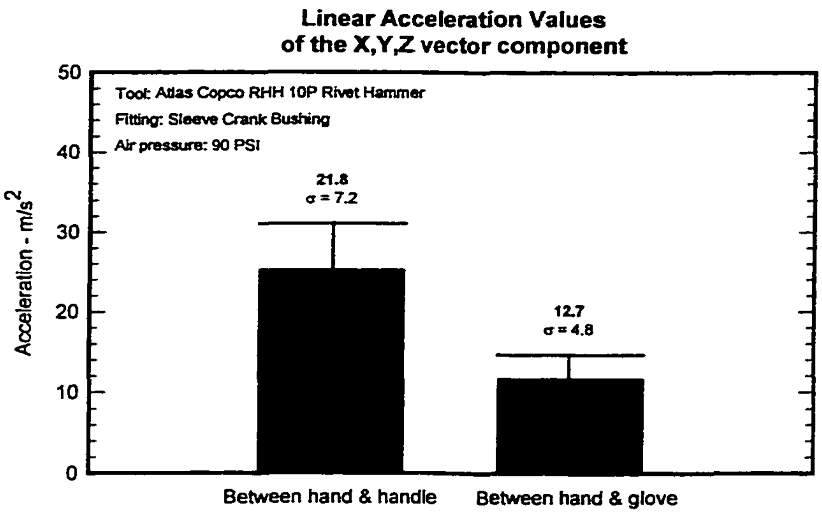


Fig. 68. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting sleeve crank bushings with the model 06P rivet hammer



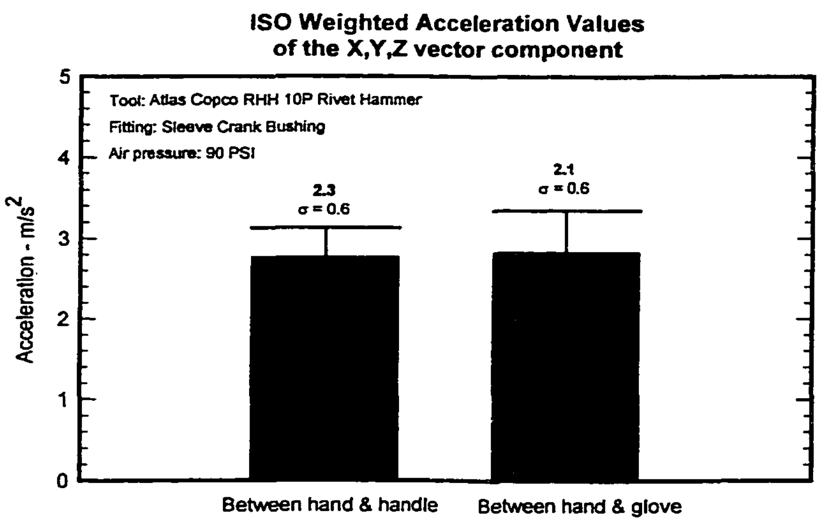


Fig. 69. X,Y,Z Linear and ISO weighted acceleration values at the handle for bare and gloved hands when inserting sleeve crank bushings with the model 10P rivet hammer

To better demonstrate the effectiveness of the antivibration gloves, acceleration time history plots of the dominant z-axis were generated from the saved data collected during testing of the rivet hammers. Fig. 70 and Fig. 71 show the difference between the acceleration levels measured at the rivet hammer's handle by the two single axis adapters when inserting sleeve crank bushings. The measured acceleration time history plots for the other parts inserted are very similar to Fig. 70 and Fig. 71. Fig. H.1 through Fig. H.4, in Appendix H, show the measured acceleration time history plots of the other parts inserted.

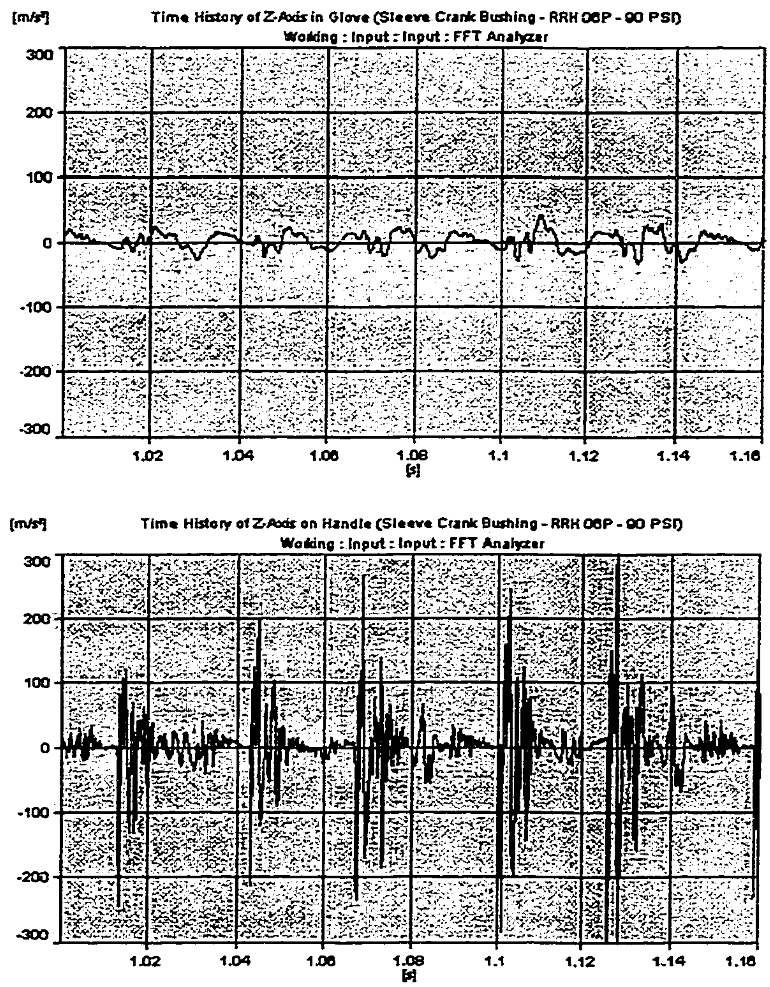


Fig. 70. Time history plots of Z-Axis measurements made while inserting Sleeve Crank Bushing with Atlas Copco RRH 06P Rivet Hammer

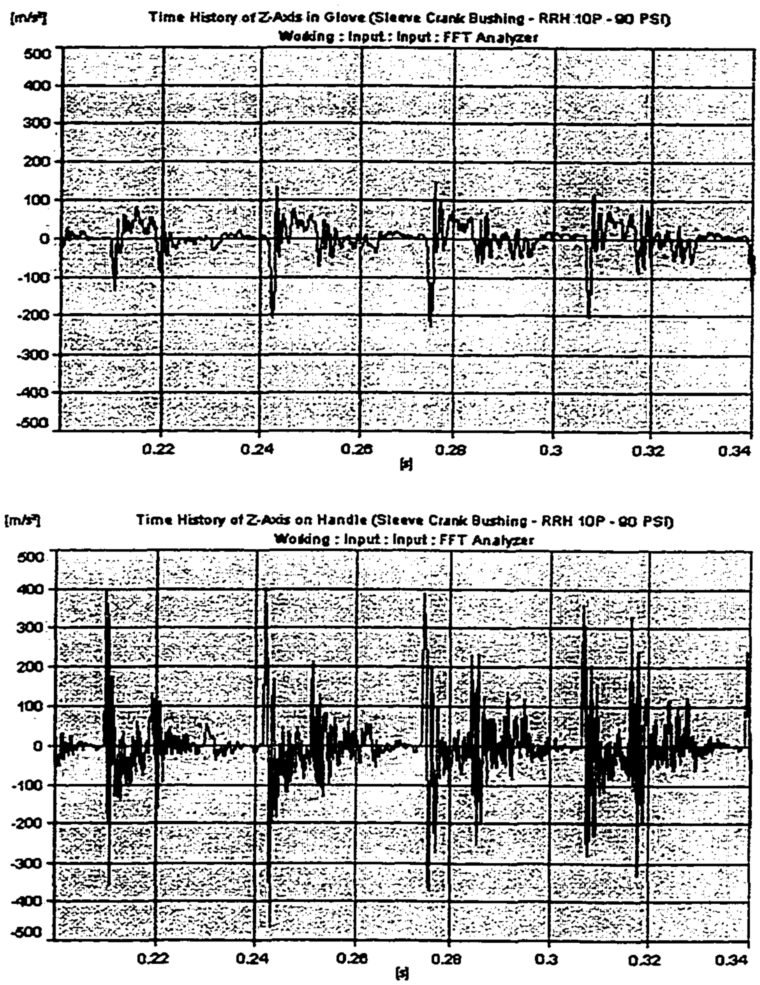


Fig. 71. Time history plots of Z-Axis measurements made while inserting Sleeve Crank Bushing with Atlas Copco RRH 10P Rivet Hammer

Using equations (3.5) and (3.6), the z-axis third octave band acceleration values of the rivet hammer's insertion tool and handle were calculated from the third octave band acceleration values measured by the shock accelerometer attached to the test fixture's mass. It was acceptable to use equations (3.5) and (3.6) with the data collected from the rivet hammer tests because of the similarities between chipping hammers and rivet hammers. The masses of the different insertion tools and the two rivet hammers were determined and recorded on a table. The masses of the insertion plates and parts inserted were also determined and recorded. Table I.1, in Appendix I, lists the measured masses used in the calculation of the insertion tool and handle acceleration values.

For the five parts inserted by the rivet hammers, five tables were generated containing the measured and calculated third octave band, linear, and ISO weighted acceleration values. Table J.1 through Table J.11, in Appendix I, list the measured and calculated third octave band, linear, and ISO weighted acceleration values. Plots were generated using the linear and ISO weighted acceleration values determined in the tables. Fig. 72 through Fig. 74 show the plots comparing the measured and calculated linear and ISO weighted acceleration values at the rivet hammer's handle when the rivet hammer is supplied with 30, 60, and 90 psi.

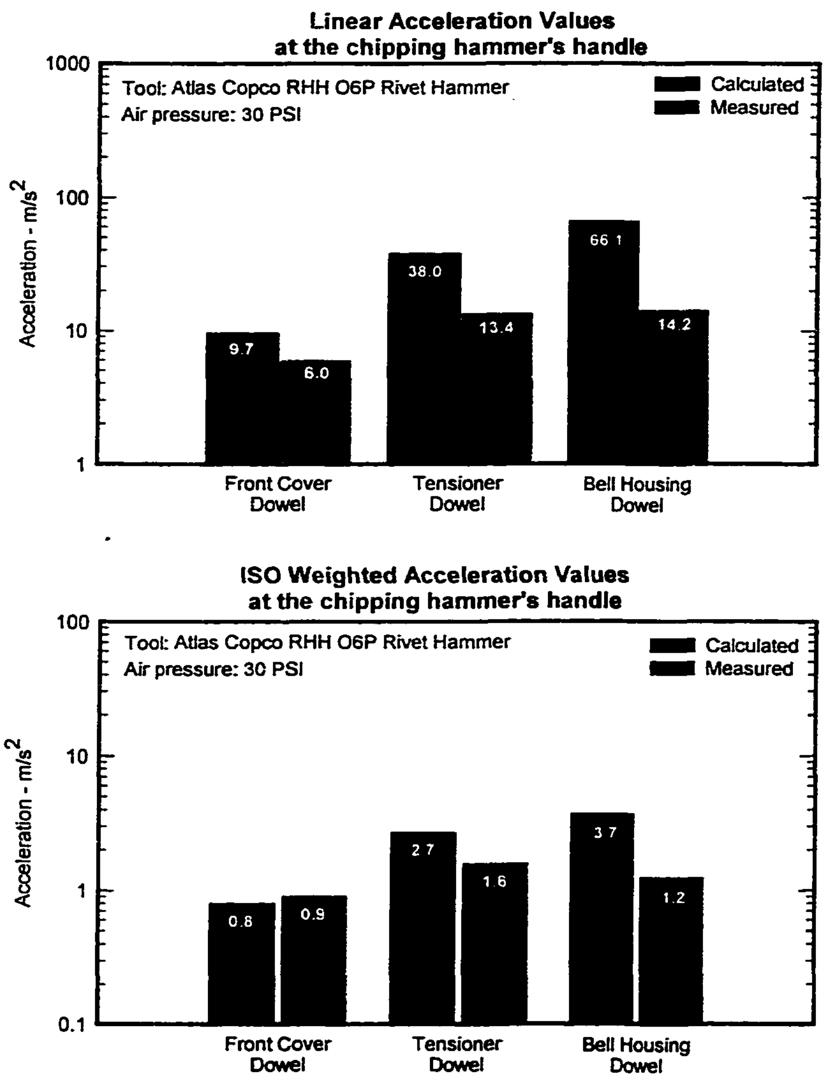
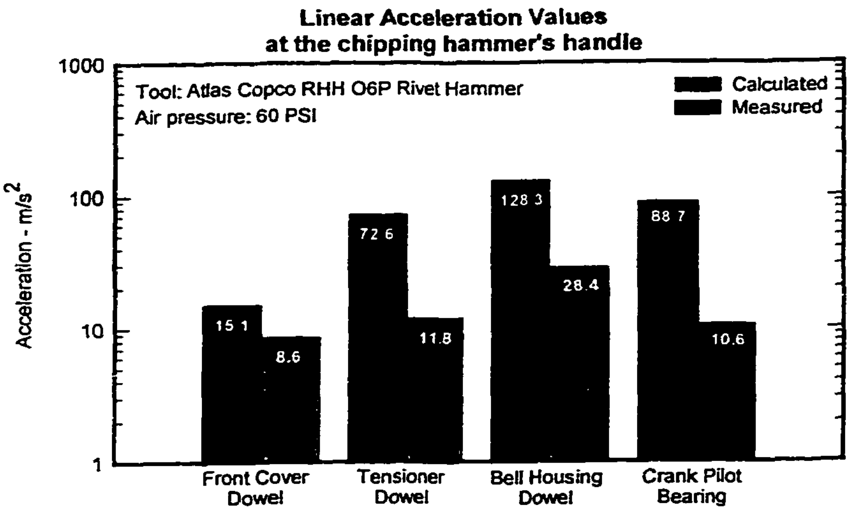


Fig. 72. Measured and calculated z-axis linear and ISO weighted acceleration values for the rivet hammer's handle when the air supply to the rivet hammer is 30 psi



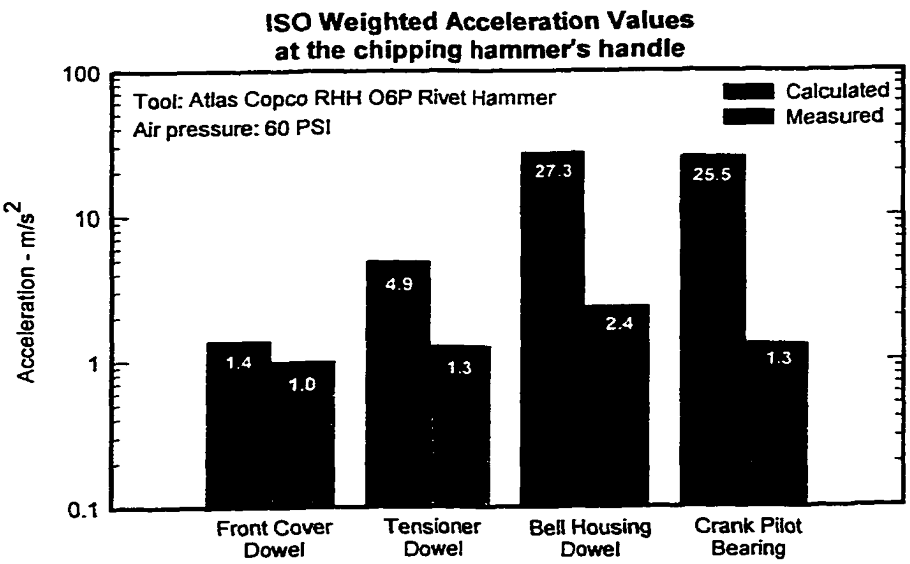
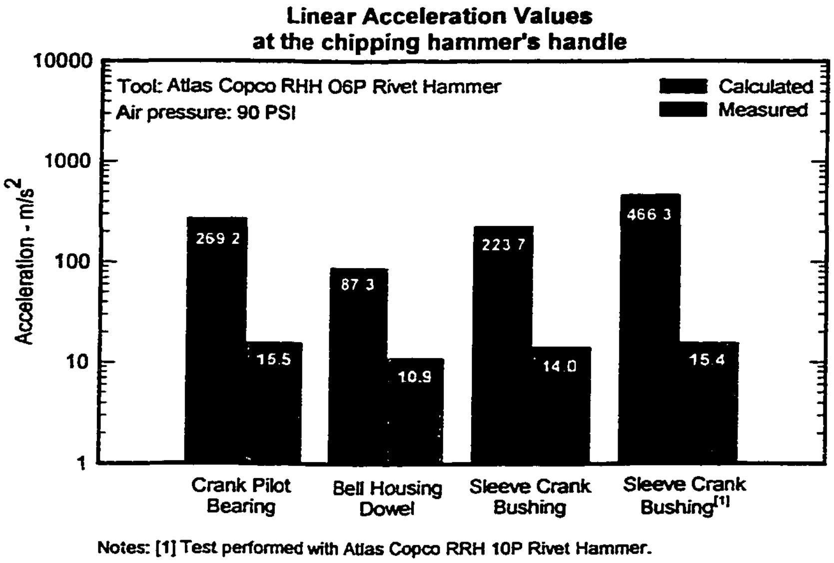


Fig. 73. Measured and calculated z-axis linear and ISO weighted acceleration values for the rivet hammer's handle when the air supply to the rivet hammer is 60 psi



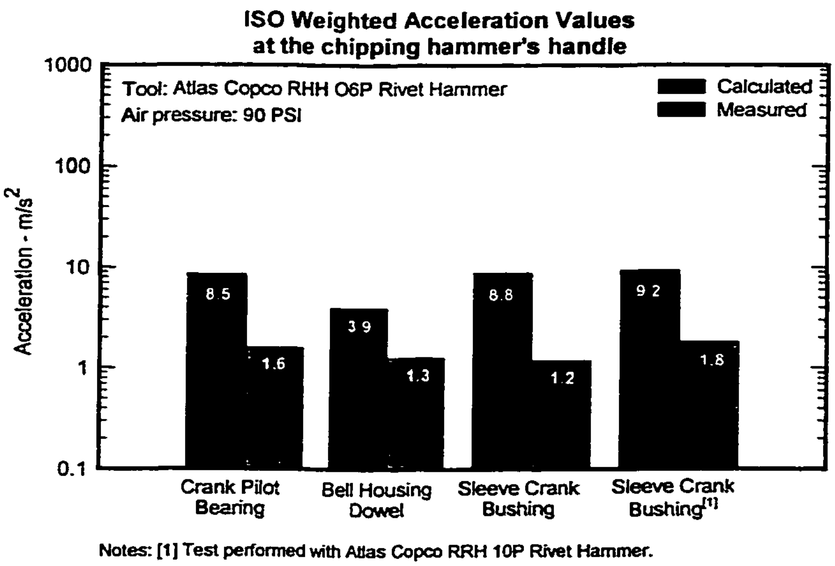


Fig. 74. Measured and calculated z-axis linear and ISO weighted acceleration values for the rivet hammer's handle when the air supply to the rivet hammer is 90 psi

CHAPTER 5

CONCLUSIONS

From the results obtained during the frequency response testing of the test fixture, the following conclusions can be made:

- The test fixture follows the conventions of a mass-spring-damper model, allowing for the determination of the test fixture's characteristics.
- Modeling the test fixture as a mass-spring-damper system provides an effective test bed for the testing of impact tools.
- The resonant frequency of the test fixture will not bias test results of impact tools tested with the test fixture.
- The accelerance of the test fixture remains constant through the desired frequency range in which vibration testing of impact tools is performed.

From the results obtained from vibration testing of the Atsco No.020 chipping hammer on the test fixture, the following conclusions can be made:

- The test fixture can be used for sustained vibration testing of hand held impact tools.
- Acceleration levels at a chipping hammer's working surface can effectively be calculated from acceleration levels measured on the test fixture's mass.
- Acceleration levels at the handle of hand held chipping hammers cannot effectively be calculated from acceleration levels measured on the test fixture's mass using the method shown in Fig. 31 and equation (3.6), derived from this figure. The chipping hammer cannot be modeled as a rigid body.
- Air bladder antivibration gloves reduce the level of acceleration exposure experienced at the handle of chipping hammers

From the results obtained simulating assembly operations using the Atlas Copco RHH series rivet hammers, the following conclusions can be made:

- Composite vibration exposure levels at the rivet hammer's handle can be determined from contributing individual acceleration levels measured at the rivet hammer's handle during testing performed with the test fixture.
- The eight-hour average ISO vector acceleration values at each of the three workstations, for the examined conditions, were well below the recommended value of 2.5 m/s^2, as stated in the current European Directive [5].
- The four-hour average ISO vector acceleration values at each of the three workstations, for the examined conditions, were well below the recommended value of 4 m/s^2 for the dominant axis acceleration as specified by the ACGIH TLVs [1].
- Air bladder antivibration gloves reduce the vibration exposure experienced at the handle of rivet hammers.
- The difference between the bare and gloved hand ISO vector acceleration values is minimal while the difference between the bare and gloved hand Linear (un-weighted) vector acceleration values is large. Because the ISO weighting filter (see Fig. C.1 in Appendix C) severely limits the amount of upper frequency energy contributing to the ISO vector acceleration value the antivibration effects of the glove's air bladder are not shown. The un-weighted acceleration value provides a better look at the antivibration properties of the air bladder because it does not reduce any of the upper frequency energy.
- A worker exhibiting sensitivity to vibration will benefit from using an air bladder antivibration glove to reduce the vibration exposure of rivet hammers being used at workstations along the assembly line.

From the results obtained from vibration testing of the Atlas Copco RHH series rivet hammers on the test fixture, the following conclusions can be made:

- The test fixture can be used for vibration testing of assembly operations performed with hand held impact tools.
- Acceleration levels at a chipping hammer's working surface can effectively be calculated from acceleration levels measured on the test fixture's mass.
- Acceleration levels at the handle of hand held chipping hammers cannot effectively be calculated from acceleration levels measured on the test fixture's mass. Just as in the chipping hammer, the rivet hammer cannot be modeled as a rigid body.

CHAPTER 6

RECOMENDATIONS

The test fixture provides an effective test bed for performing vibration testing of hand held impact tools. Vibration exposure levels at the handle can be determined from acceleration values measured at the handle when testing on the test fixture. During tests of impact tools where the handle was grasped with bare and gloved hands, the air bladder antivibration glove was found to noticeably reduce vibration exposure. When comparing the ISO weighted acceleration values at the handle and in the glove, the calculated amount of reduction is not as great as that physically noted. Determining ISO weighted acceleration values is the recognized method used when reporting on the vibration exposure of a tool. Air bladder antivibration gloves attenuate high frequency vibration exposure. The ISO weighting filter (see Fig. C.1 in Appendix C) allows all vibration energy, from 6.3 to 16 Hz, to pass through and severely limits vibration energy above 200 Hz. Thus, using the ISO weighted acceleration value for the air bladder antivibration glove will not show the true benefits of the glove. The following analytical methods would provide better results, showing the true benefits of the glove.

- Use the linear (un-weighted) acceleration values at the handle and in the glove. Linear acceleration calculations due not filter any of the vibration energy. So high frequency energy contributes the same as low frequency energy in the determination of the linear acceleration value. Many linear acceleration comparison plots were generated from the results of the rivet hammer tests. These comparison plots (see Fig. 64 through Fig. 69) show the amount of attenuation the air bladder antivibration glove provides.

- Use an alternate method of calculating the ISO weighted acceleration value. This method, outlined in ISO 10819 [10], splits the ISO weighting filter into three parts. There is a low, middle, and high filter. The low filter is comprised of the ISO 5349 filter values ranging from 8 to 31.5 Hz. The middle filter is comprised of the ISO 5349 filter values ranging from 31.5 to 200 HZ. The high filter is comprised of the ISO 5349 filter values ranging from 200 to 1000 HZ. By breaking the ISO 5349 filter into three smaller filters, the vibration energy within the low, middle, and high frequency range can be examined. So in the case of the air bladder glove, only the high frequency vibration energy above 200 Hz would be passed through the ISO 10819 high filter. The resulting weighted value would provide a better comparison to show the attenuation effects of the air bladder glove at high frequencies.

From the measured acceleration of the test fixture's mass, the acceleration at the working surface of the tool can effectively be calculated but the acceleration at the handle of the tool cannot be effectively calculated. The method of calculating the handle acceleration from the measured mass acceleration is based on a rigid body model of the tool. Using a rigid body model does not appear to accurately describe the vibration characteristics of the tool. To better represent the tool, the model needs takes into account the internal working components and the outer body of the tool. A better mathematical model of the tool will allow for calculated acceleration values that are closer to the measured acceleration values of the hand-held tool's handle.

APPENDICES

Appendix A. Equipment used for the various tests

Table A.1. Equipment used for frequency response testing of test fixture

1. PCB Piezotronics Quartz Compression ICP® Accelerometer – Model 305 A02 ▪ Serial Number: 5134 ▪ Voltage Sensitivity: 10 mV/g ▪ Frequency Range: 1 – 5,000 Hz ▪ Mass: 4.25 gm	2. PCB Piezotronics Signal Power Unit – Model 480D06 ▪ Serial Numbers: 6071 & 6073 ▪ DC Voltage: 27 V (3 x 9V Battery) ▪ Excitation Current: 2 MA (Constant) ▪ Selectable Gain: 1, 10 & 100
3. PCB Piezotronics Modally Tuned Hammer – Model 086C20 ▪ Serial Number: 7996 ▪ Voltage Sensitivity: 1 mV/lbf [0.23 mV/N] ▪ Frequency Range: 1 – 1,000 Hz ▪ Mass: 3 lb [1.4 kg]	4. Data Physics Corp. DP104 FFT Analyzer – Model ACE ▪ Serial Number: 6310 ▪ Dynamic Range 100 dB ▪ Real-time Rate: 20 kHz ▪ Miscellaneous Info: 2/2 Input/Output 32-bit 50 MHz floating point DSP, PCMCIA Type III
5. Desktop Computer w/PCMCIA Slot ▪ Processor: AMD K6-2 450 MHz ▪ Memory: 128 MB	6. Data Physics Corp. SignalCalc ACE ▪ Version: 2.0.23
7. Test Fixture - one-degree of freedom mass, spring, damper system ▪ Mass: 68.04 kg [150 lb] ▪ Damping Coefficient: 586.96 N·s/m [3.35 lb_f ·s/in] ▪ Stiffness Coefficient: 85,041.51 N/m [485.60 lb_f/in] ▪ Resonance Frequency: 35.03 rad/s [5.58 Hz]	

Table A.2. Equipment used to test chipping hammer

1. PCB Piezotronics Shock Accelerometer – Model 350B04
   - Serial Numbers: 5085 & 5086
   - Voltage Sensitivity: 1 mV/g
   - Frequency Range: 1 – 10,000 Hz
   - Mass: 4.25 gm

2. ENDEVCO Piezoelectric Accelerometer – Model 2222C
   - Serial Number: 21240
   - Charge Sensitivity: 1 pC/g
   - Frequency Range: 1 – 8,000 Hz
   - Mass: 0.5 gm

3. PCB Piezotronics Signal Power Unit – Model 480D06
   - Serial Numbers: 6071, 6073, 6074 & 6076
   - DC Voltage: 27 V (3 x 9V Battery)
   - Excitation Current: 2 MA (Constant)
   - Selectable Gain: 1, 10 & 100

4. PCB Piezotronics Handheld Accelerometer Calibrator – Model 394C06
   - Serial Number: 1566
   - Acceleration: 9.8 m/s^2
   - Frequency: 159.2 Hz
   - Max Load: 210 grams

5. Brüel & Kjær Charge to DeltaTron® Converter – Type 2647 B
   - Serial Number: 2207299
   - Fixed Sensitivity: 10 mV/pC

6. Atsco No.020 Chipping Hammer
   - Serial Number: 2665

7. Gateway SOLO Pro 9300 Notebook Computer
   - Serial Number: 0018443317
   - Processor: Intel Pentium III 600 MHz
   - Memory: 128 MB

8. Brüel & Kjær Portable Data Acquisition Unit – Type 2827
   - Serial Number: 2241801
   - Installed Modules: LAN Interface Module, Type 7533; 4/2-ch. Input/Output Module, Type 3109

9. TEAC Portable DAT Recorder – Model RD 130T
   - Serial Number: 512946
   - Inputs/Outputs: 8

10. Brüel & Kjær PULSE™ LabShop
    - Version: 5.0.45.4 – 2000-01-28

11. Test Fixture - one-degree of freedom mass, spring, damper system
    - Mass: 68.04 kg [150 lb]
    - Damping Coefficient: 586.96 N·s/m [3.35 lb_f ·s/in]
    - Stiffness Coefficient: 85,041.51 N/m [485.60 lb_f/in]
    - Resonance Frequency: 35.03 rad/s [5.58 Hz]

Table A.3. Equipment used to test rivet hammers

12. PCB Piezotronics Ceramic Shear ICP® Accelerometer – Model 352B22 ▪ Serial Number: 141410 ▪ Voltage Sensitivity: 10 mV/g ▪ Frequency Range: 1 – 8,000 Hz ▪ Mass: 0.5 gm	13. PCB Piezotronics Ceramic Shear ICP® Accelerometer – Model 352C22 ▪ Serial Numbers: 19520, 19521, 19522 & 19523 ▪ Voltage Sensitivity: 10 mV/g ▪ Frequency Range: 1 – 8,000 Hz ▪ Mass: 0.5 gm
14. PCB Piezotronics Shock Accelerometer – Model 350B04 ▪ Serial Number: 5086 ▪ Voltage Sensitivity: 1 mV/g ▪ Frequency Range: 1 – 10,000 Hz ▪ Mass: 4.25 gm	15. ENDEVCO Piezoelectric Accelerometer – Model 2222C ▪ Serial Number: 21240 ▪ Charge Sensitivity: 1 pC/g ▪ Frequency Range: 1 – 8,000 Hz ▪ Mass: 0.5 gm
16. PCB Piezotronics Signal Power Unit – Model 480D06 ▪ Serial Numbers: 6071, 6073, 6074 & 6076 ▪ DC Voltage: 27 V (3 x 9V Battery) ▪ Excitation Current: 2 MA (Constant) ▪ Selectable Gain: 1, 10 & 100	17. PCB Piezotronics Handheld Accelerometer Calibrator – Model 394C06 ▪ Serial Number: 1566 ▪ Acceleration: 9.8 m/s^2 ▪ Frequency: 159.2 Hz ▪ Max Load: 210 grams
18. Brüel & Kjær Charge to DeltaTron® Converter – Type 2647 B ▪ Serial Number: 2207299 ▪ Fixed Sensitivity: 10 mV/pC	19. MB Dynamics Shaker – Model Modal 50 w/computer control ▪ Serial Number: 13487
20. Vibration Research Corporation Vibration View Computer Controller for Shakers ▪ Serial Number: 35852842	21. Tri-axial adapter ▪ Materials: Aluminum and rubber
22. Gateway SOLO Pro 9300 Notebook Computer ▪ Serial Number: 0018443317 ▪ Processor: Intel Pentium III 600 MHz ▪ Memory: 128 MB	23. Brüel & Kjær Portable Data Acquisition Unit – Type 2827 ▪ Serial Number: 2241801 ▪ Installed Modules: LAN Interface Module, Type 7533; 4/2-ch. Input/Output Module, Type 3109
24. TEAC Portable DAT Recorder – Model RD 130T ▪ Serial Number: 512946 ▪ Inputs/Outputs: 8	25. Brüel & Kjær PULSE™ LabShop ▪ Version: 5.0.45.4 – 2000-01-28

Table A.3. Equipment used to test rivet hammers (continued)

26. Atlas Copco RRH 06P Rivet Hammers • Serial Number: A066032	27. Atlas Copco RRH 10P Rivet Hammers • Serial Number: A243002
28. Test Fixture - one-degree of freedom mass, spring, damper system • Mass: 68.04 kg [150 lb] • Damping Coefficient: 586.96 N·s/m [3.35 lb_f ·s/in] • Stiffness Coefficient: 85,041.51 N/m [485.60 lb_f/in] • Resonance Frequency: 35.03 rad/s [5.58 Hz]	

Appendix B. CAD drawings of the test fixture

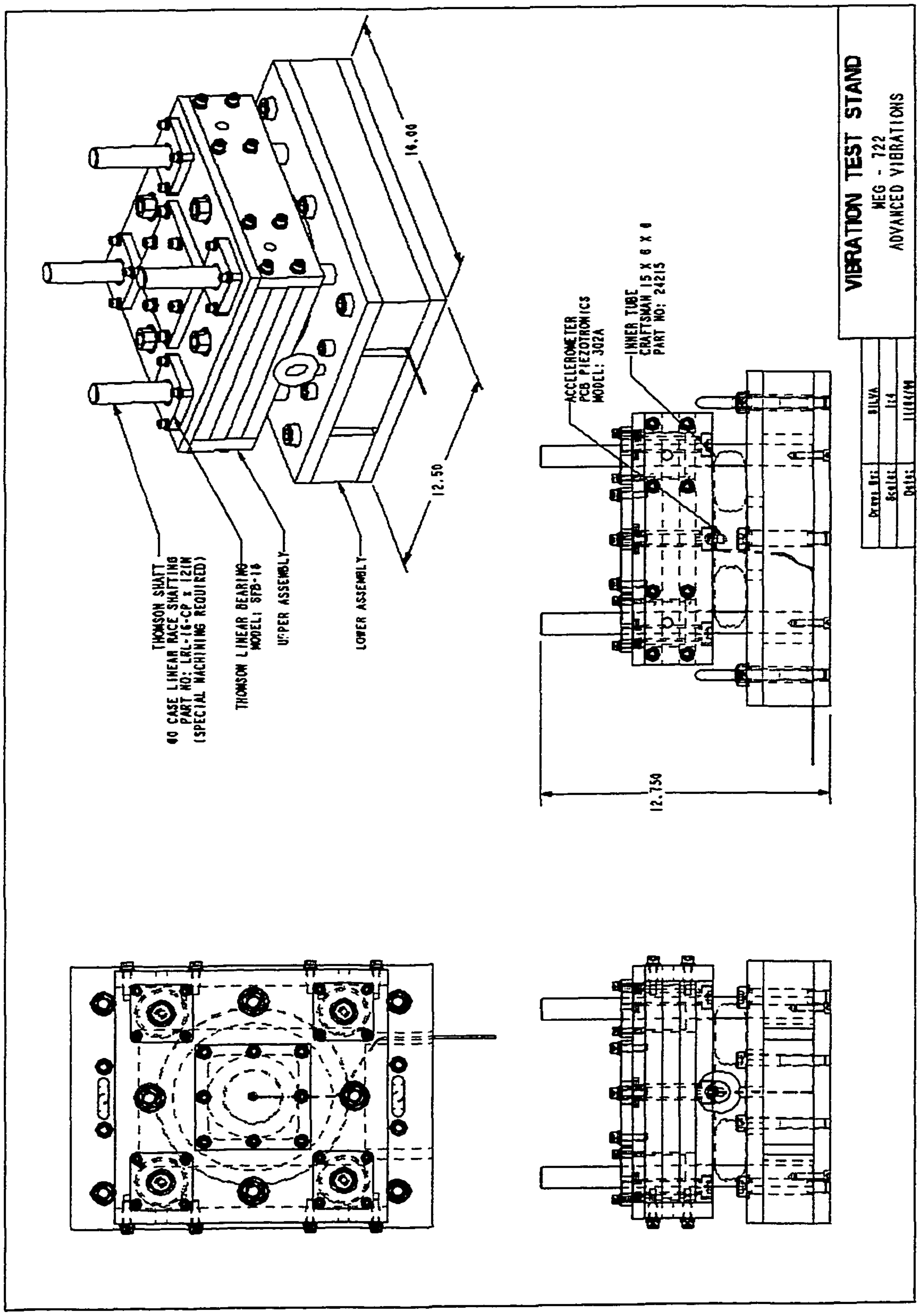


Fig. B.1. CAD drawing of test fixture

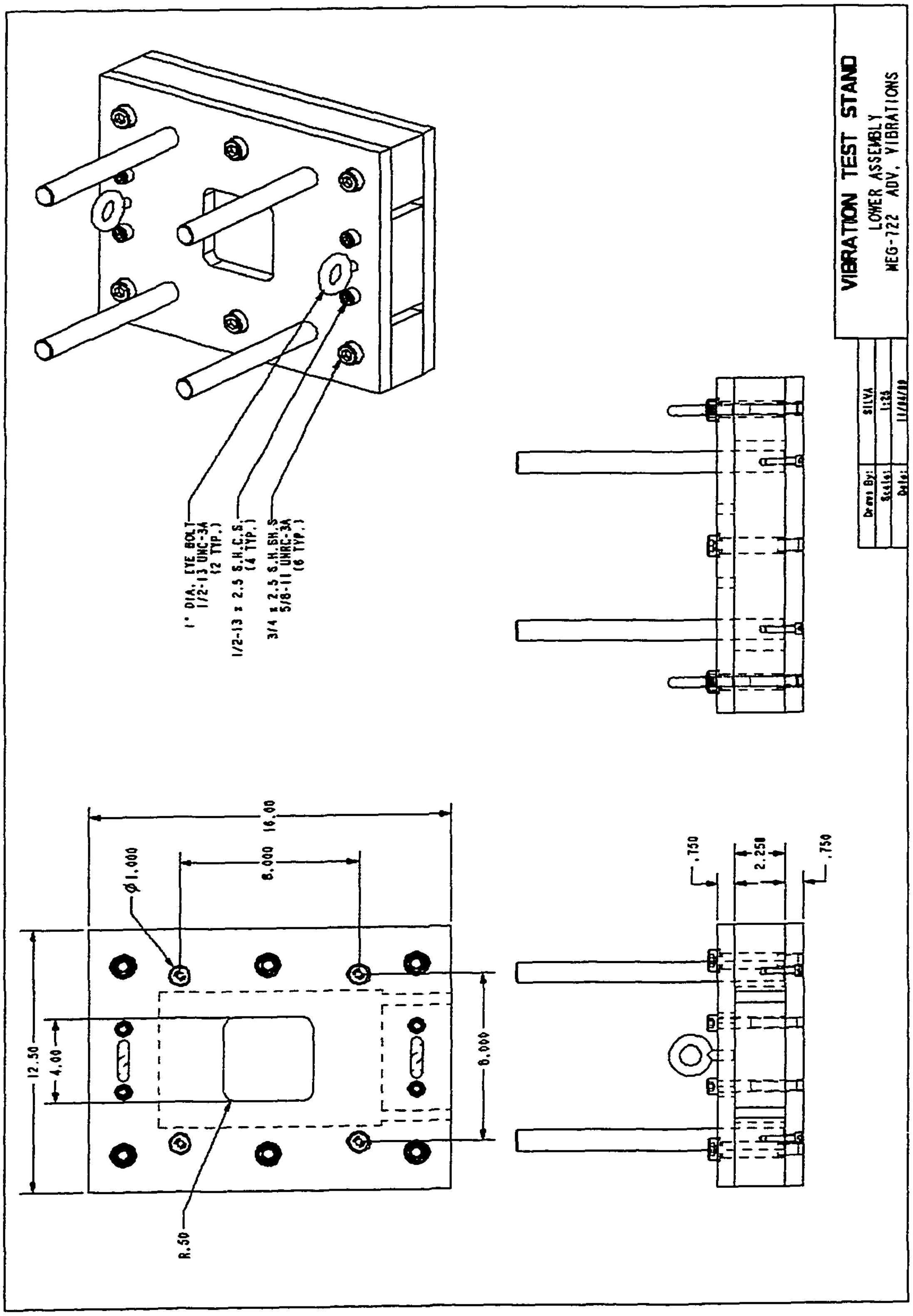


Fig. B.2. CAD drawing of the base of the test fixture

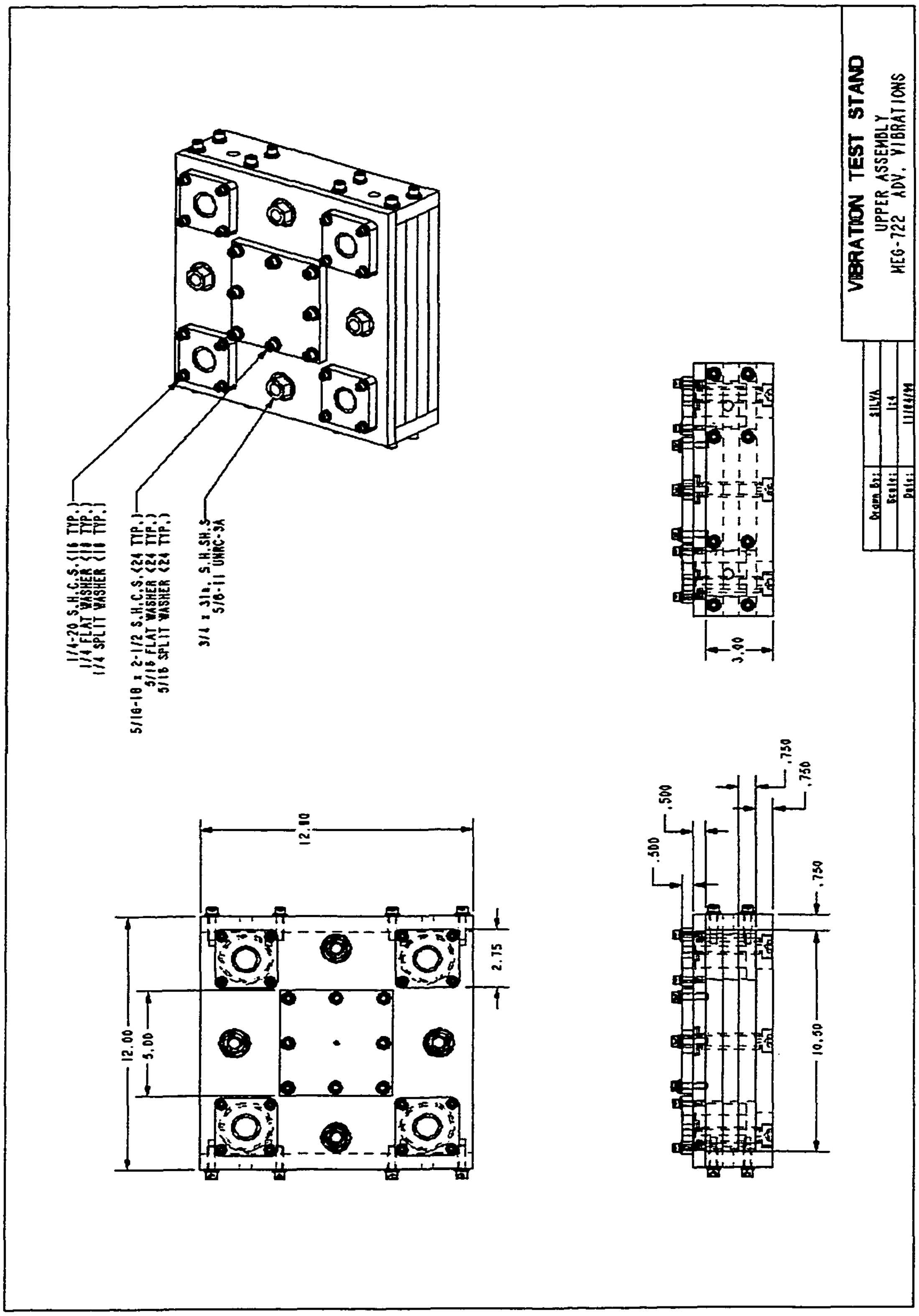


Fig. B.3. CAD drawing of floating mass of the test fixture

Appendix C. ISO 5349-1 weighting filter

Frequency [Hz]	Weighting Factor (K_j)
6.3	1.0
8	1.0
10	1.0
12.5	1.0
16	1.0
20	0.8
25	0.63
31.5	0.5
40	0.4
50	0.3
63	0.25
80	0.2
100	0.16
125	0.126
160	0.1
200	0.08
250	0.063
315	0.05
400	0.04
500	0.03
630	0.025
800	0.02
1,000	0.016
1,250	0.0126

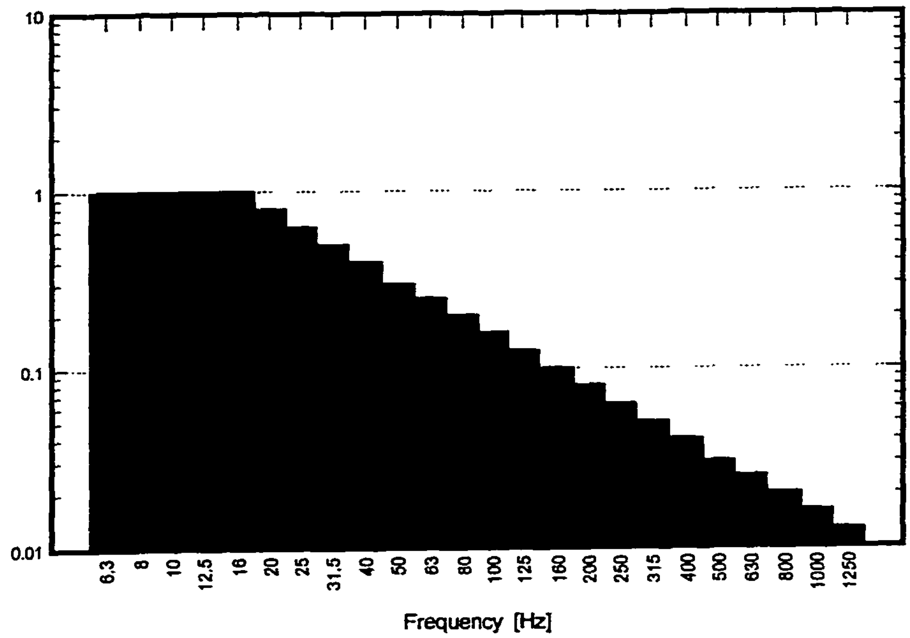


Fig. C.1. ISO Weighting Factors (K_j) for conversion of third octave band measurements

Appendix D. Details of parts installed with the Atlas Copco RRH rivet hammers

Table D.1. Summary of parts and installation times for Section B: Station 91R

Parts Installed	Quantity	Installation Time Per Part [sec]	Total Installation Time [sec]
Font Cover Dowel	2	3	6
Water By-Pass Tube[1]	1	3	3
Chain Tensioner Dowel	2	3	6

Comments:
- Total of 5 parts with a total of 15 seconds of running the rivet hammer
- Exposure time per day is 9664.2 seconds (2.69 hours)

Notes:
1. Substitute front cover dowel results for water by-pass tube

Table D.2. Summary of parts and installation times for Section B: Station 141R

Parts Installed	Quantity	Installation Time Per Part [sec]	Total Installation Time [sec]
Bell Housing Dowel	2	3	6
Rear Seal Carrier Dowel[1]	2	3	6

Comments:
- Total of 4 parts with a total of 12seconds of running the rivet hammer
- Exposure time per day is 7734.1 seconds (2.14 hours)

Notes:
1. Rear seal carrier dowel and front cover dowel are the same part

Table D.3. Summary of parts and installation times for Section C: Station 213L

Parts Installed	Quantity	Installation Time Per Part [sec]	Total Installation Time [sec]
Oil Slinger[1]	1	3	1
Pilot Bearing/Bushing	1	3	3

Comments:

- Total of 2 parts with a total of 6 seconds of running the rivet hammer
- Exposure time per day is 3865.7 seconds (1.07 hours)

Notes:

1. Substitute front cover dowel results for oil slinger

Appendix E. Third octave band acceleration measured during the Atsco No.020 chipping hammer tests

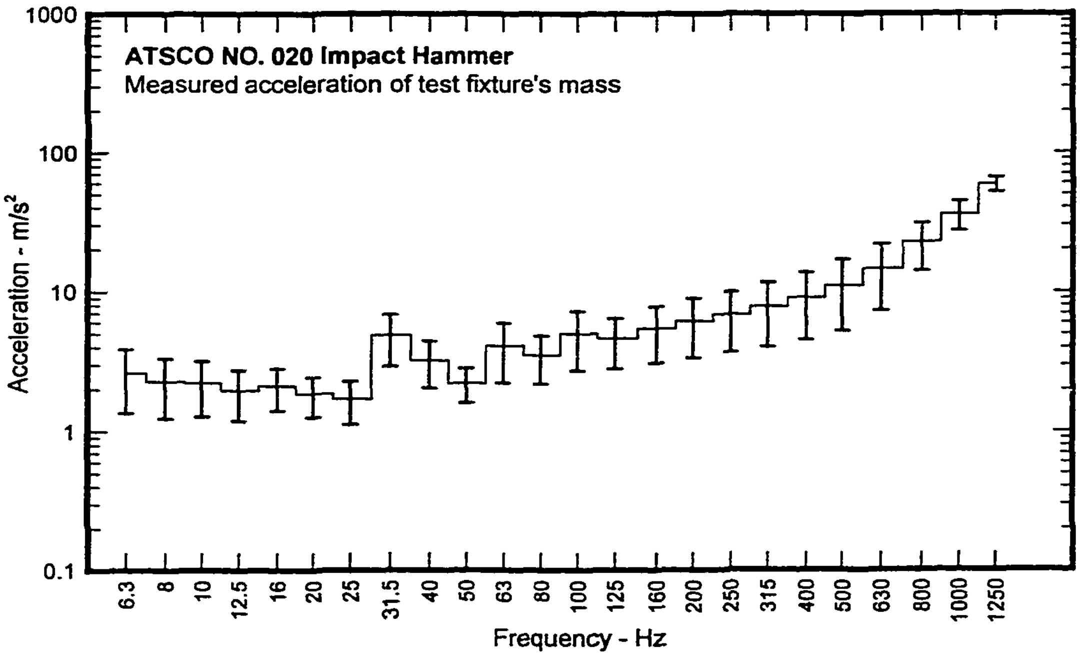


Fig. E.1. Measured third octave band acceleration of the test fixture's mass

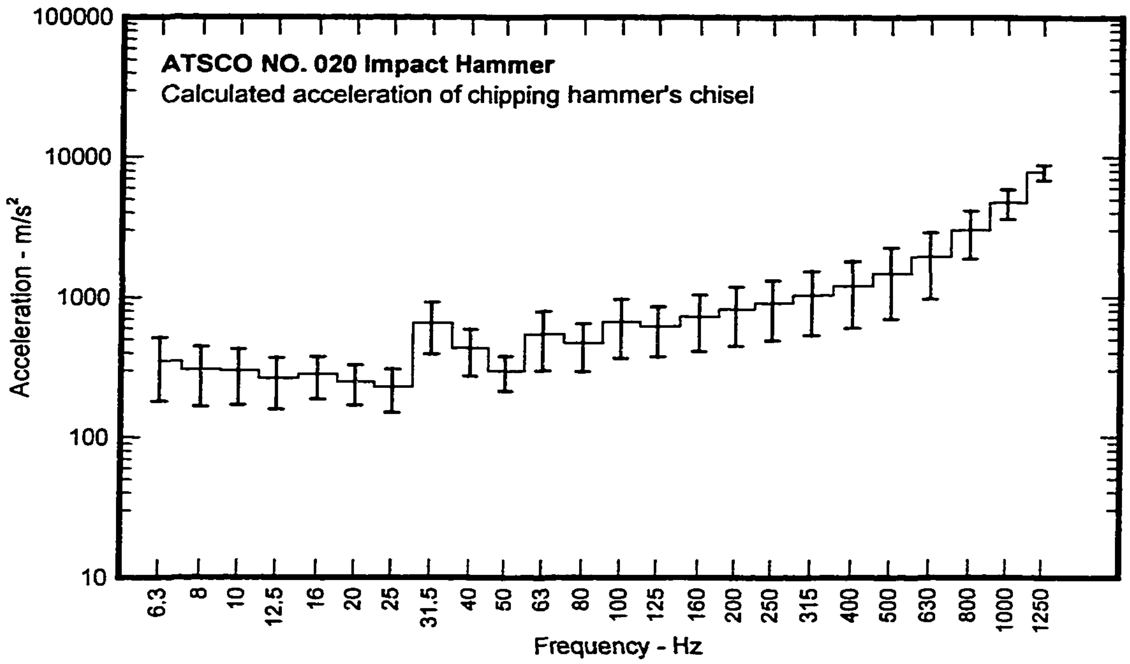


Fig. E.2. Calculated third octave band acceleration of the chipping hammer's chisel

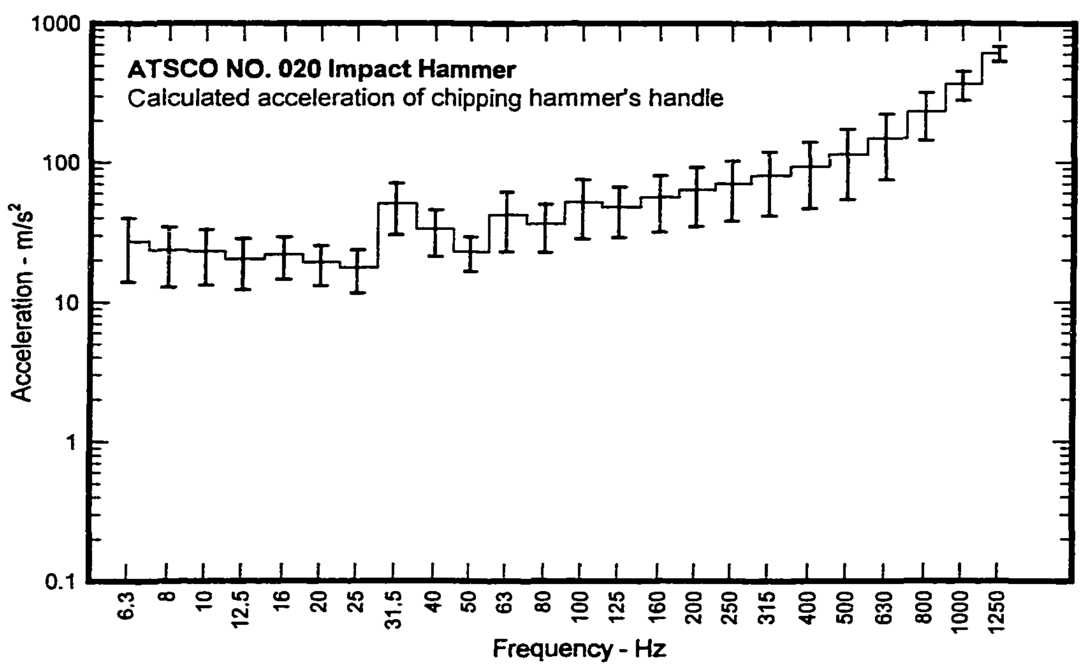


Fig. E.3. Calculated third octave band acceleration of the chipping hammer's handle

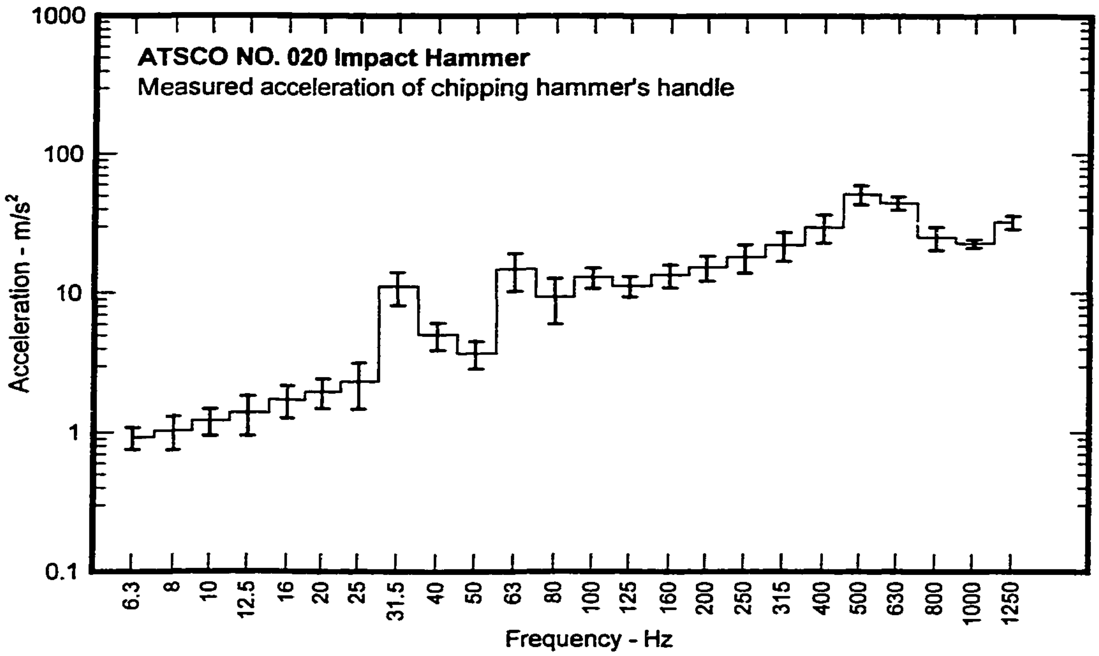


Fig. E.4. Measured third octave band acceleration of the chipping hammer's handle

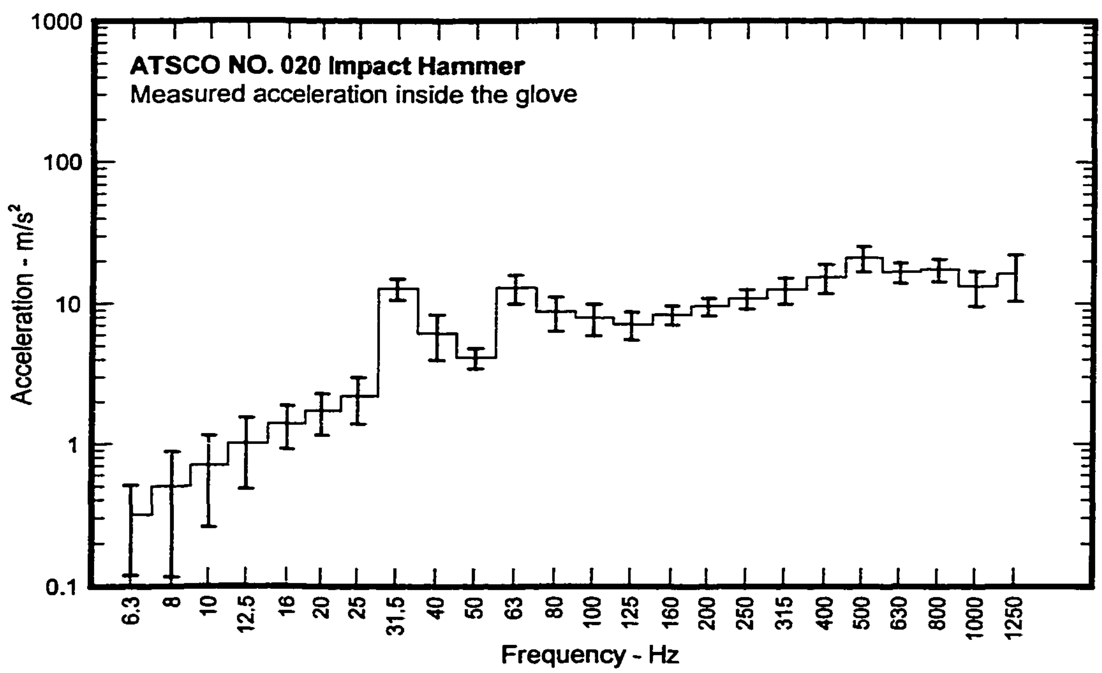


Fig. E.5. Measured third octave band acceleration inside the gloved hand grasping the chipping hammer's handle

Table E.1. Measured third octave band acceleration of test fixture's mass excited by chipping hammer's chisel

Frequency [Hz]	Measured Acceleration [m/s^2]									Average Acceleration [m/s^2]	Standard Deviation
6.3	4.57	3.80	3.89	1.90	2.04	0.62	1.67	2.38	2.71	2.62	1.26
8	2.81	3.21	4.10	1.70	1.78	0.70	1.48	1.92	2.85	2.28	1.04
10	3.47	2.87	3.10	1.65	1.48	0.78	1.40	2.20	3.17	2.24	0.95
12.5	2.94	2.66	2.81	1.48	1.71	0.63	1.29	1.80	2.41	1.97	0.78
16	2.85	2.75	2.94	2.01	2.27	0.79	1.37	2.10	1.96	2.11	0.71
20	2.47	2.08	2.78	1.62	1.70	0.90	1.20	2.15	1.87	1.86	0.59
25	2.33	2.30	2.62	1.24	1.32	0.92	1.30	1.70	1.67	1.71	0.58
31.5	4.30	4.09	6.70	8.60	6.83	3.03	3.14	3.86	3.58	4.90	1.97
40	2.47	2.82	3.45	4.79	5.48	1.87	2.42	3.21	2.60	3.23	1.18
50	2.60	2.58	3.14	1.79	2.32	1.31	1.44	2.74	2.11	2.23	0.62
63	3.75	3.52	5.41	7.51	6.13	2.05	2.84	3.22	2.35	4.09	1.86
80	2.86	3.29	3.97	5.08	5.96	1.72	2.66	3.59	2.57	3.52	1.32
100	3.87	4.05	5.80	9.11	8.29	3.27	3.63	4.21	2.79	5.00	2.26
125	3.97	4.23	5.81	8.07	6.52	2.91	2.96	4.22	2.94	4.63	1.81
160	4.21	4.55	6.31	9.70	8.79	3.42	3.64	4.97	3.37	5.44	2.35
200	4.59	5.08	6.85	10.93	10.48	3.77	4.00	5.73	3.81	6.14	2.77
250	5.09	5.56	7.74	12.62	11.11	4.41	4.05	6.35	4.33	6.81	3.11
315	5.46	6.03	8.28	14.69	13.32	5.40	4.27	7.41	5.14	7.78	3.75
400	6.01	6.67	9.05	17.22	15.78	6.90	4.33	8.89	6.33	9.02	4.49
500	6.81	7.58	9.82	21.56	19.70	9.58	4.61	11.24	8.38	11.03	5.78
630	8.97	9.66	11.33	27.25	25.08	13.82	6.58	15.31	11.91	14.44	7.15
800	16.59	16.56	16.91	37.13	35.13	22.34	13.81	23.79	19.30	22.40	8.39
1000	31.50	29.63	27.92	50.51	48.23	34.84	27.65	37.33	31.58	35.47	8.49
1250	57.45	54.28	49.93	71.28	69.23	57.53	54.36	61.27	53.54	58.76	7.25
Linear	70.56	67.48	65.82	107.02	101.96	73.98	64.24	80.17	68.21	77.71 (77.10)	15.95 {0.99}
ISO	8.56	3.80	9.26	7.36	6.98	2.98	4.26	6.02	6.75	6.67 (6.75)	2.01 {1.01}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table E.2. Third octave band acceleration of the chipping hammer's chisel calculated using measured test fixture's mass acceleration values

Frequency [Hz]	Calculated Acceleration [m/s²]									Average Acceleration [m/s²]	Standard Deviation
6.3	608.8	506.6	519.2	253.6	271.4	82.6	222.9	317.6	360.7	349.3	167.5
8	375.2	428.4	546.1	226.1	237.1	94.0	197.0	255.8	380.6	304.5	138.5
10	462.8	382.0	413.4	220.4	197.6	104.4	186.3	293.7	422.7	298.1	127.1
12.5	391.7	355.0	374.9	197.0	228.1	84.5	172.3	240.0	321.2	262.7	104.4
16	380.2	366.6	391.5	268.4	302.1	105.3	182.9	280.1	260.7	282.0	94.1
20	329.9	277.5	370.4	215.7	227.3	119.9	160.4	286.2	249.7	248.6	78.7
25	311.3	306.7	349.2	165.2	176.1	122.7	173.8	226.4	222.2	228.2	77.9
31.5	573.7	545.1	892.8	1146.2	910.6	404.3	419.3	514.6	477.5	653.8	262.5
40	329.5	375.7	459.5	639.0	730.5	249.6	322.5	428.1	347.1	431.3	157.7
50	346.1	344.0	418.9	238.2	309.3	174.2	192.6	365.2	281.7	296.7	82.1
63	499.6	469.1	721.4	1001.0	817.9	273.7	378.5	428.9	313.4	544.8	247.4
80	381.8	438.7	529.8	676.7	794.6	228.9	354.6	478.1	342.4	469.5	176.1
100	515.8	539.4	773.1	1214.7	1105.6	435.6	484.1	562.0	372.0	666.9	301.6
125	529.5	564.2	775.1	1076.5	868.8	388.4	395.1	562.9	391.6	616.9	241.1
160	560.8	607.0	841.6	1293.1	1171.4	455.6	484.7	662.9	448.7	725.1	313.6
200	612.6	677.5	913.8	1457.5	1397.6	502.6	534.0	763.4	508.4	818.6	370.0
250	679.0	741.3	1031.4	1682.4	1481.8	588.4	540.5	846.8	577.3	907.7	414.5
315	727.5	804.1	1104.4	1959.3	1776.0	719.5	568.8	988.4	685.7	1037.1	499.6
400	800.8	889.8	1206.2	2296.5	2103.7	920.7	577.7	1185.0	843.7	1202.7	598.6
500	907.5	1010.8	1309.9	2874.2	2627.0	1276.9	614.4	1499.2	1117.7	1470.8	771.2
630	1195.3	1287.6	1511.0	3633.7	3344.6	1842.6	877.8	2041.5	1588.6	1924.7	953.6
800	2212.6	2207.3	2254.7	4950.7	4684.5	2979.2	1841.1	3172.5	2572.8	2986.2	1118.1
1000	4200.1	3951.1	3722.5	6734.1	6431.1	4644.9	3686.8	4977.7	4210.7	4728.8	1131.3
1250	7660.1	7236.7	6656.9	9503.6	9230.1	7670.9	7248.4	8169.9	7138.2	7835.0	966.7
Linear	9408.3	8996.9	8775.5	14269.0	13594.7	9863.5	8564.9	10689.9	9095.2	10362.0 (10280.3)	2127.07 {0.99}
ISO	1141.2	1050.3	1234.9	981.6	930.5	396.8	567.4	802.9	900.1	889.5 (900.1)	267.57 {1.01}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table E.3. Third octave band acceleration at handle calculated using measured test fixture's mass acceleration values

Frequency [Hz]	Calculated Acceleration [m/s²]									Average Acceleration [m/s²]		Standard Deviation	
6.3	47.15	39.24	40.21	19.64	21.02	6.40	17.27	24.60	27.94	27.05		12.97	
8	29.06	33.18	42.29	17.51	18.36	7.28	15.26	19.81	29.48	23.58		10.73	
10	35.84	29.59	32.02	17.07	15.30	8.08	14.43	22.75	32.74	23.09		9.84	
12.5	30.34	27.49	29.04	15.26	17.67	6.54	13.34	18.59	24.88	20.35		8.08	
16	29.45	28.39	30.32	20.79	23.40	8.15	14.17	21.69	20.19	21.84		7.29	
20	25.55	21.49	28.69	16.71	17.60	9.29	12.43	22.16	19.34	19.25		6.10	
25	24.11	23.75	27.05	12.80	13.64	9.50	13.46	17.53	17.21	17.67		6.03	
31.5	44.44	42.22	69.15	88.78	70.53	31.32	32.48	39.86	36.98	50.64		20.34	
40	25.52	29.10	35.59	49.49	56.58	19.33	24.98	33.16	26.89	33.40		12.21	
50	26.81	26.65	32.44	18.45	23.95	13.49	14.92	28.29	21.82	22.98		6.36	
63	38.70	36.33	55.88	77.53	63.35	21.20	29.32	33.22	24.27	42.20		19.17	
80	29.57	33.98	41.04	52.41	61.55	17.73	27.47	37.03	26.52	36.36		13.64	
100	39.95	41.78	59.88	94.08	85.63	33.74	37.49	43.53	28.82	51.65		23.36	
125	41.01	43.70	60.04	83.37	67.29	30.08	30.60	43.60	30.33	47.78		18.68	
160	43.43	47.01	65.18	100.15	90.73	35.29	37.54	51.34	34.75	56.16		24.29	
200	47.45	52.47	70.77	112.89	108.25	38.93	41.36	59.13	39.38	63.40		28.65	
250	52.59	57.42	79.89	130.31	114.77	45.57	41.86	65.59	44.72	70.30		32.11	
315	56.35	62.28	85.54	151.75	137.55	55.73	44.06	76.55	53.11	80.32		38.70	
400	62.03	68.92	93.43	177.87	162.94	71.31	44.74	91.78	65.35	93.15		46.37	
500	70.29	78.29	101.45	222.62	203.47	98.90	47.59	116.12	86.57	113.92		59.73	
630	92.58	99.73	117.03	281.44	259.05	142.72	67.99	158.12	123.04	149.08		73.86	
800	171.37	170.96	174.63	383.45	362.83	230.75	142.60	245.72	199.27	231.29		86.60	
1000	325.31	306.02	288.31	521.58	498.10	359.76	285.55	385.54	326.13	366.26		87.62	
1250	593.30	560.50	515.59	736.08	714.90	594.13	561.40	632.78	552.87	606.84		74.87	
Linear	728.70	696.83	679.69	1105.17	1052.95	763.96	663.37	827.96	704.45	802.56	(796.24)	164.75	{0.99}
ISO	88.39	81.35	95.64	76.03	72.07	30.73	43.95	62.18	69.71	68.90	(69.71)	20.72	{1.01}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table E.4. Measured third octave band acceleration at chipping hammer's handle - accelerometer placed between handle and glove

Frequency [Hz]	Measured Acceleration [m/s^2]									Average Acceleration [m/s^2]	Standard Deviation
6.3	1.00	1.05	1.04	0.81	1.17	0.94	0.90	0.66	0.72	0.92	0.16
8	1.17	1.33	1.57	0.95	0.87	0.99	0.86	0.73	0.76	1.03	0.28
10	1.24	1.51	1.73	1.09	1.14	0.91	1.05	1.26	0.97	1.21	0.26
12.5	1.92	1.99	1.74	0.91	1.13	0.76	1.34	1.53	1.14	1.38	0.44
16	2.02	2.44	2.16	1.05	1.21	1.62	1.85	1.58	1.49	1.71	0.45
20	2.56	2.19	2.41	1.21	1.33	1.77	2.33	1.93	1.91	1.96	0.47
25	3.07	3.36	3.25	1.44	1.43	1.32	2.45	1.73	2.77	2.31	0.84
31.5	15.42	14.18	14.50	8.28	7.86	10.34	9.16	8.43	11.28	11.05	2.95
40	3.85	3.58	3.77	4.88	5.88	5.50	6.66	6.29	4.96	5.04	1.13
50	4.32	4.38	4.50	2.75	2.94	4.80	3.24	2.68	3.70	3.70	0.82
63	12.54	12.55	11.97	18.73	14.21	25.10	12.94	11.27	13.09	14.71	4.46
80	5.52	5.99	5.97	11.92	11.54	14.96	11.29	9.57	7.39	9.35	3.31
100	10.29	10.03	10.54	15.24	13.95	15.65	13.98	13.86	12.64	12.91	2.15
125	10.40	10.70	10.76	9.84	12.03	15.65	10.15	9.60	11.63	11.20	1.85
160	11.20	10.14	11.48	13.83	14.46	18.88	13.86	13.22	13.44	13.39	2.52
200	12.19	11.42	12.11	15.89	15.77	21.69	16.24	16.11	15.67	15.23	3.12
250	14.39	12.95	13.73	18.39	19.01	26.72	18.94	18.26	19.56	17.99	4.14
315	16.46	15.12	16.31	22.40	22.99	31.15	24.58	23.93	24.63	21.95	5.15
400	22.62	20.41	21.36	30.43	31.63	41.01	33.78	31.38	33.42	29.56	6.81
500	46.52	38.95	42.88	50.15	53.67	62.78	59.56	49.40	59.06	51.44	8.04
630	44.46	40.52	41.64	37.10	41.40	46.25	50.16	46.15	51.65	44.37	4.71
800	20.82	22.04	20.96	22.55	22.98	29.73	22.80	33.58	30.51	25.10	4.79
1000	22.06	23.12	21.33	20.10	21.35	24.05	24.47	23.91	23.71	22.68	1.52
1250	28.99	30.96	31.28	30.50	31.26	38.28	38.24	29.53	31.92	32.33	3.48
Linear	88.69	82.80	85.53	94.21	98.45	121.30	109.34	100.50	109.10	98.88 (98.33)	12.66 {0.99}
ISO	10.36	9.97	10.10	8.64	8.22	11.03	8.89	8.12	9.02	9.37 (9.02)	1.02 {0.96}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table E.5. Measured third octave band acceleration at chipping hammer's handle - accelerometer placed between palm and glove

Frequency [Hz]	Measured Acceleration [m/s²]									Average Acceleration [m/s²]	Standard Deviation
6.3	0.74	0.57	0.41	0.08	0.15	0.09	0.24	0.33	0.22	0.31	0.22
8	1.01	0.98	0.98	0.13	0.18	0.13	0.26	0.37	0.48	0.50	0.38
10	1.22	1.26	1.24	0.20	0.25	0.25	0.58	0.52	0.80	0.70	0.45
12.5	1.69	1.67	1.36	0.27	0.46	0.42	1.00	1.11	1.11	1.01	0.53
16	1.78	2.04	1.50	0.51	0.85	1.25	1.66	1.65	1.32	1.40	0.48
20	2.17	2.09	1.68	0.68	0.97	1.46	2.17	2.17	2.06	1.72	0.57
25	2.54	3.35	2.70	1.08	1.33	1.30	2.74	1.97	2.67	2.19	0.80
31.5	13.88	15.73	12.00	10.88	11.46	16.25	10.31	10.98	13.52	12.78	2.18
40	3.48	3.51	3.47	6.16	8.20	8.57	7.71	8.25	5.91	6.14	2.19
50	4.25	4.15	4.76	3.37	3.38	5.06	4.42	3.16	4.53	4.12	0.67
63	11.52	10.31	10.51	14.48	8.86	18.17	14.54	12.57	15.33	12.92	2.95
80	5.78	7.20	6.44	9.01	6.94	10.39	12.78	10.98	8.62	8.68	2.34
100	9.21	8.51	8.05	6.38	4.21	5.74	9.42	9.11	10.16	7.87	1.99
125	9.12	8.25	8.30	4.68	5.75	8.18	6.92	5.05	7.35	7.07	1.58
160	9.06	8.01	8.94	6.93	7.77	10.42	9.42	6.23	7.94	8.30	1.30
200	9.95	8.63	9.62	8.13	9.22	11.63	11.56	7.70	9.40	9.54	1.37
250	10.94	9.72	10.45	10.12	10.63	14.04	12.49	8.00	10.98	10.82	1.70
315	11.79	9.99	10.75	12.87	12.71	17.86	14.72	9.28	12.39	12.48	2.60
400	14.31	12.17	12.69	16.32	14.45	23.36	17.82	12.08	14.69	15.32	3.56
500	22.89	17.84	17.01	22.95	16.97	29.62	23.52	16.89	21.42	21.01	4.29
630	20.12	16.43	17.56	15.31	10.59	17.21	18.01	16.30	18.93	16.72	2.71
800	18.12	14.70	22.53	15.90	13.30	13.93	19.77	20.03	19.17	17.49	3.18
1000	14.84	14.03	11.46	11.36	7.66	9.39	20.07	15.45	14.94	13.25	3.71
1250	19.56	17.50	14.85	14.40	8.71	7.90	27.44	18.44	16.91	16.19	5.86
Linear	55.51	48.88	49.97	50.22	41.61	61.08	63.64	50.24	55.27	52.94 (52.11)	6.72 {0.98}
ISO	9.14	9.86	8.14	7.67	7.60	10.81	8.70	8.40	9.35	8.85 (9.35)	1.05 {1.06}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Appendix F. Third octave band acceleration measured at the Atlas Copco RRH rivet hammer's handle

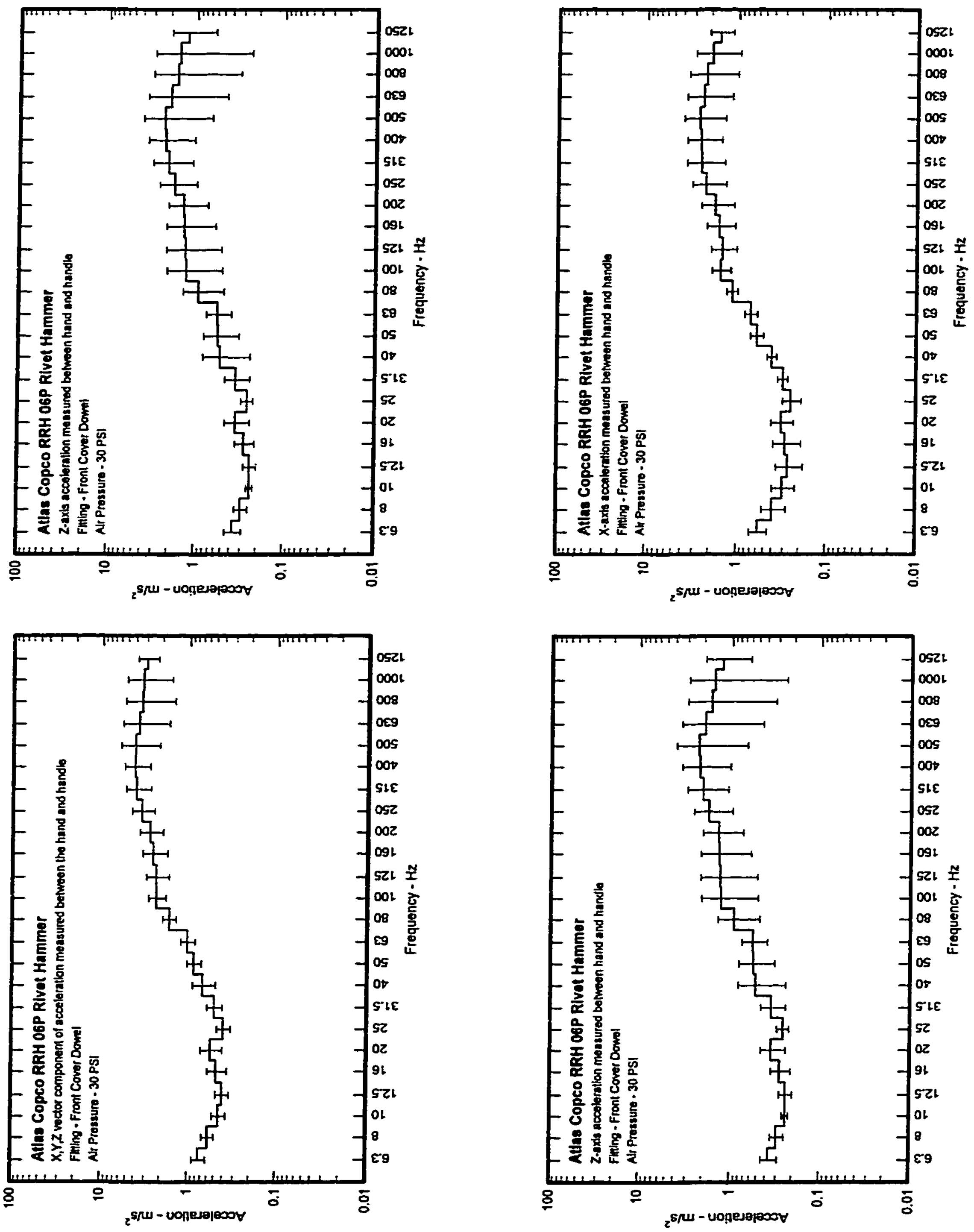


Fig. F.1. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 30 psi.

Table F.1. X,Y,Z vector third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]						Average Acceleration [m/s^2]	Standard Deviation
6.3	0.92	0.82	0.57	0.83	0.64	0.75	0.75	0.13
8	0.73	0.63	0.51	0.63	0.50	0.57	0.59	0.09
10	0.53	0.54	0.43	0.48	0.34	0.37	0.45	0.08
12.5	0.48	0.49	0.43	0.42	0.32	0.34	0.41	0.07
16	0.58	0.61	0.51	0.52	0.33	0.35	0.48	0.12
20	0.69	0.75	0.60	0.51	0.38	0.41	0.56	0.15
25	0.45	0.50	0.41	0.35	0.32	0.37	0.40	0.07
31.5	0.60	0.65	0.49	0.50	0.39	0.44	0.51	0.10
40	0.88	0.99	0.61	0.58	0.53	0.54	0.69	0.20
50	0.93	1.06	0.91	0.97	0.68	0.69	0.87	0.16
63	0.88	1.01	1.08	1.34	0.81	1.03	1.03	0.19
80	1.63	1.82	1.87	1.91	1.20	1.44	1.65	0.28
100	2.53	2.76	2.76	2.33	1.59	1.77	2.29	0.50
125	2.75	2.82	2.94	2.24	1.47	1.58	2.30	0.64
160	3.15	3.16	3.16	2.40	1.51	1.67	2.51	0.77
200	3.32	3.48	3.40	2.58	1.71	1.92	2.73	0.79
250	3.98	4.22	4.50	3.20	2.17	2.34	3.40	0.99
315	4.81	5.18	5.03	3.38	2.55	2.56	3.92	1.24
400	5.20	5.85	4.83	3.19	2.76	2.70	4.09	1.37
500	5.57	6.95	4.45	2.73	2.24	2.38	4.06	1.93
630	5.39	6.55	4.06	2.40	1.68	2.01	3.68	1.99
800	4.97	6.26	3.60	2.16	1.61	1.69	3.38	1.91
1000	4.17	6.31	3.28	2.41	1.76	1.89	3.30	1.73
1250	3.58	4.06	3.34	2.79	2.16	2.16	3.02	0.78
Linear	15.10	17.70	13.60	9.97	7.16	4.61	11.36 (11.69)	4.99 {1.03}
ISO	1.94	1.95	1.62	1.69	1.24	1.39	1.64 (1.63)	0.29 {0.99}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.2. Z-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.43	0.39	0.25	0.29	0.42	0.45	0.37	0.08
8	0.30	0.32	0.28	0.25	0.28	0.37	0.30	0.05
10	0.25	0.27	0.24	0.23	0.20	0.25	0.24	0.02
12.5	0.26	0.29	0.25	0.21	0.20	0.21	0.24	0.04
16	0.34	0.36	0.32	0.28	0.19	0.21	0.28	0.07
20	0.46	0.48	0.39	0.29	0.23	0.26	0.35	0.11
25	0.28	0.32	0.27	0.22	0.20	0.24	0.26	0.04
31.5	0.47	0.49	0.37	0.28	0.23	0.26	0.35	0.11
40	0.87	0.91	0.50	0.35	0.28	0.27	0.53	0.29
50	0.78	0.84	0.64	0.49	0.31	0.28	0.56	0.24
63	0.74	0.79	0.55	0.60	0.33	0.41	0.57	0.18
80	1.42	1.47	0.97	0.82	0.44	0.45	0.93	0.45
100	2.20	2.21	1.44	0.97	0.48	0.46	1.29	0.79
125	2.27	2.15	1.59	0.98	0.47	0.46	1.32	0.81
160	2.26	2.05	1.71	1.05	0.54	0.53	1.36	0.76
200	1.99	2.05	1.82	1.06	0.65	0.73	1.38	0.64
250	2.45	2.60	2.31	1.27	0.89	1.04	1.76	0.78
315	3.03	3.19	2.42	1.57	1.00	1.11	2.05	0.96
400	3.36	3.90	2.33	1.54	1.07	1.17	2.23	1.19
500	3.70	4.77	2.10	1.15	0.90	1.04	2.28	1.61
630	3.30	4.32	1.51	1.00	0.69	0.86	1.95	1.50
800	2.76	3.84	1.33	0.76	0.62	0.67	1.66	1.34
1000	2.27	3.92	1.30	0.70	0.60	0.58	1.56	1.32
1250	1.56	2.40	1.36	0.80	0.77	0.75	1.27	0.65
Linear	10.20	12.60	6.70	4.16	2.91	3.21	6.63 (6.14)	4.00 {4.00}
ISO	1.23	1.26	0.97	0.82	0.77	0.89	0.99 (0.91)	0.21 {0.21}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.3. Y-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.37	0.32	0.19	0.23	0.26	0.20	0.26	0.07
8	0.26	0.26	0.18	0.17	0.19	0.16	0.20	0.04
10	0.21	0.24	0.16	0.13	0.16	0.14	0.17	0.04
12.5	0.17	0.18	0.14	0.13	0.18	0.18	0.16	0.02
16	0.17	0.19	0.15	0.16	0.17	0.16	0.16	0.02
20	0.19	0.24	0.16	0.15	0.18	0.17	0.18	0.03
25	0.12	0.13	0.15	0.14	0.15	0.14	0.14	0.01
31.5	0.17	0.22	0.18	0.27	0.19	0.21	0.20	0.04
40	0.29	0.44	0.29	0.33	0.28	0.30	0.32	0.06
50	0.30	0.36	0.49	0.72	0.36	0.39	0.44	0.15
63	0.28	0.36	0.74	0.94	0.46	0.48	0.54	0.25
80	0.34	0.42	1.07	1.27	0.73	0.81	0.77	0.36
100	0.51	0.59	1.50	1.51	1.10	1.23	1.07	0.44
125	0.73	0.72	1.58	1.50	1.02	1.23	1.13	0.37
160	1.15	1.02	1.77	1.65	1.01	1.21	1.30	0.33
200	1.21	1.12	1.77	1.90	1.18	1.40	1.43	0.33
250	1.10	1.14	2.30	2.46	1.53	1.51	1.67	0.58
315	1.15	1.26	2.82	2.53	1.88	1.63	1.88	0.68
400	1.41	1.64	2.89	2.17	2.00	1.71	1.97	0.52
500	1.23	1.52	2.12	1.70	1.49	1.39	1.57	0.31
630	1.36	1.65	1.88	1.45	1.01	1.10	1.41	0.33
800	1.37	1.55	1.76	1.30	1.00	1.01	1.33	0.30
1000	1.66	2.07	1.96	1.73	1.25	1.39	1.68	0.32
1250	2.45	2.56	2.42	2.19	1.71	1.70	2.17	0.38
Linear	4.83	5.29	7.46	6.77	4.49	4.97	5.64 (5.62)	1.19 {1.00}
ISO	0.66	0.69	0.70	0.75	0.62	0.60	0.67 (0.65)	0.06 {0.97}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.4. X-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.70	0.64	0.47	0.73	0.39	0.54	0.58	0.13
8	0.57	0.40	0.34	0.52	0.30	0.28	0.40	0.12
10	0.40	0.38	0.30	0.38	0.21	0.19	0.31	0.09
12.5	0.34	0.32	0.30	0.33	0.14	0.17	0.27	0.09
16	0.37	0.38	0.29	0.36	0.18	0.18	0.29	0.10
20	0.39	0.43	0.35	0.34	0.20	0.22	0.32	0.09
25	0.31	0.33	0.24	0.22	0.18	0.23	0.25	0.06
31.5	0.34	0.36	0.27	0.32	0.26	0.30	0.31	0.04
40	0.45	0.51	0.36	0.38	0.39	0.40	0.41	0.05
50	0.67	0.78	0.60	0.54	0.53	0.53	0.61	0.10
63	0.60	0.71	0.67	0.83	0.61	0.86	0.71	0.11
80	1.06	1.28	1.31	1.26	0.88	1.13	1.15	0.16
100	1.59	1.90	1.95	1.57	1.07	1.21	1.55	0.35
125	1.67	1.90	2.01	1.41	0.97	0.91	1.48	0.46
160	1.96	2.25	2.03	1.42	1.00	1.03	1.61	0.54
200	2.37	2.59	2.26	1.40	1.05	1.08	1.79	0.69
250	2.92	3.12	3.09	1.61	1.25	1.46	2.24	0.89
315	3.48	3.80	3.33	1.55	1.38	1.61	2.52	1.12
400	3.56	3.85	3.00	1.68	1.54	1.70	2.55	1.04
500	3.64	4.34	3.17	1.74	1.35	1.57	2.63	1.25
630	3.51	3.84	3.14	1.52	1.07	1.34	2.40	1.23
800	3.34	3.78	2.68	1.44	1.01	1.07	2.22	1.21
1000	2.60	3.48	2.09	1.43	0.99	1.06	1.94	0.98
1250	2.08	2.03	1.85	1.52	1.08	1.10	1.61	0.45
Linear	10.10	11.20	9.23	5.67	4.27	4.80	7.55 (7.47)	2.98 {0.99}
ISO	1.36	1.31	1.10	1.27	0.76	0.89	1.11 (1.10)	0.25 {0.99}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

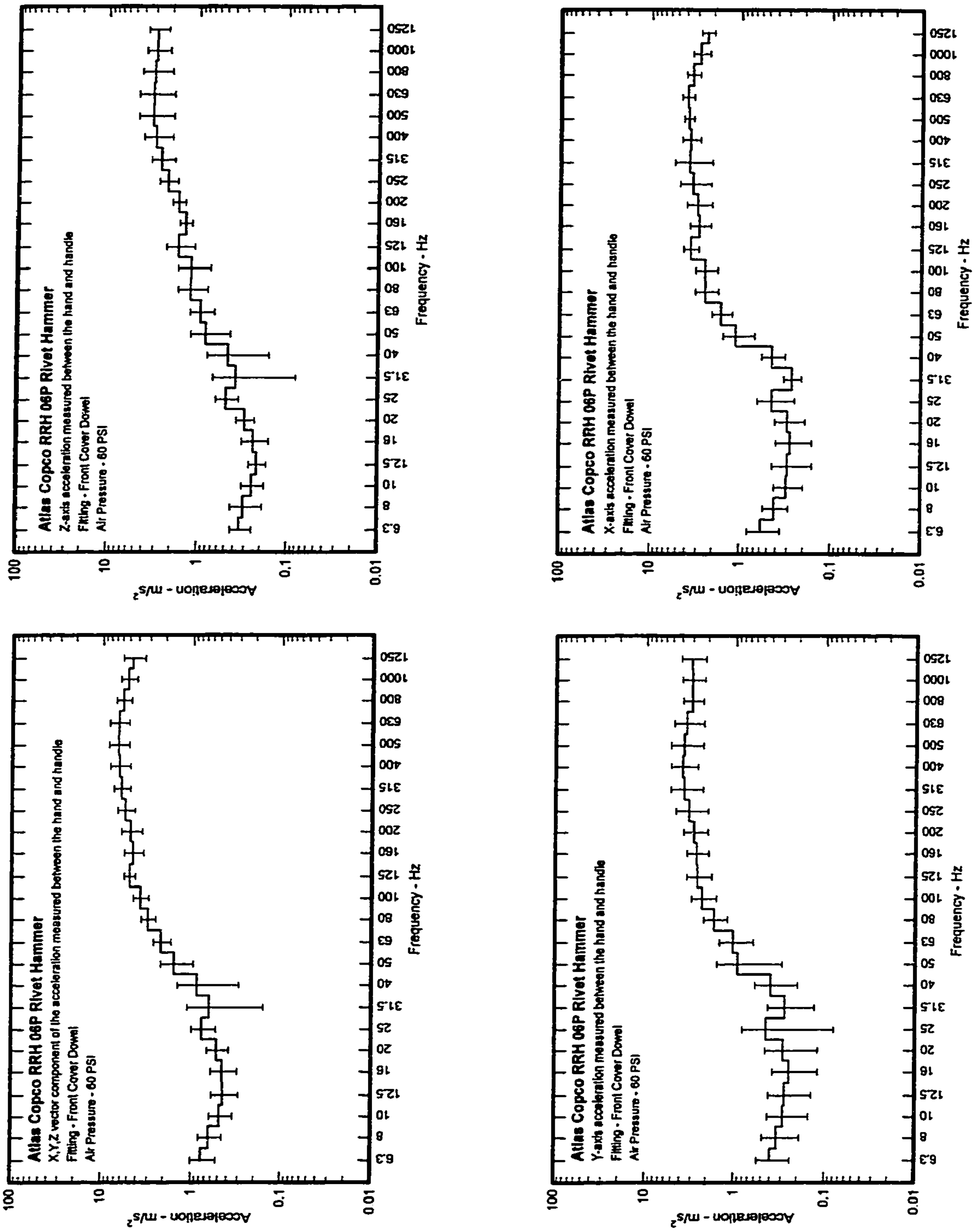


Fig. F.2. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Table F.5. X,Y,Z vector third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]	Standard Deviation
6.3	0.43	0.97	0.61	0.62	1.15	0.99	0.73	0.64	0.79	0.23
8	0.42	0.97	0.53	0.52	0.83	0.69	0.58	0.55	0.62	0.12
10	0.48	0.69	0.36	0.33	0.67	0.59	0.41	0.43	0.46	0.13
12.5	0.45	0.50	0.30	0.28	0.72	0.60	0.41	0.36	0.44	0.17
16	0.58	0.51	0.33	0.26	0.70	0.59	0.38	0.35	0.44	0.17
20	0.63	0.68	0.38	0.33	0.71	0.61	0.46	0.43	0.49	0.14
25	0.58	0.95	0.54	0.55	1.07	1.01	0.86	0.58	0.77	0.24
31.5	1.78	0.56	0.33	0.28	0.72	0.54	0.41	0.47	0.46	0.16
40	2.17	0.94	0.53	0.33	0.92	0.73	0.53	0.79	0.64	0.21
50	2.80	2.10	1.28	0.83	1.53	1.42	1.25	1.38	1.28	0.24
63	2.51	2.88	2.14	1.26	2.29	2.16	1.86	2.33	2.01	0.40
80	3.65	4.17	2.89	2.56	3.04	2.63	2.86	2.77	2.79	0.18
100	4.07	4.52	3.99	2.27	4.28	3.38	3.37	3.74	3.51	0.70
125	5.66	5.83	4.49	4.35	5.56	4.45	4.71	3.99	4.59	0.53
160	6.98	4.33	4.15	3.56	4.81	4.28	4.09	3.76	4.11	0.44
200	7.54	4.73	4.12	3.71	5.40	4.83	3.92	4.01	4.33	0.65
250	7.94	4.66	4.77	4.82	6.40	6.05	4.68	4.52	5.21	0.80
315	8.77	4.97	5.59	5.14	7.11	6.58	5.34	5.40	5.86	0.79
400	10.18	5.92	5.58	5.40	6.99	6.59	5.33	5.58	5.91	0.70
500	10.63	6.91	6.34	5.99	6.59	6.57	4.96	5.43	5.98	0.66
630	9.86	7.16	6.47	6.98	6.16	6.28	4.31	5.58	5.96	0.93
800	6.95	7.04	6.18	6.72	5.12	5.37	3.66	5.90	5.49	1.06
1000	4.16	6.68	5.16	5.28	4.83	5.14	3.63	6.71	5.12	0.99
1250	2.59	6.97	4.59	4.45	4.46	4.94	3.70	5.45	4.60	0.58
Linear	29.90	36.20	17.80	17.50	20.40	19.40	15.60	18.10	18.13 (18.19)	1.65 {1.00}
ISO	3.24	2.93	1.78	1.56	2.69	2.33	1.93	1.88	2.03 (2.02)	0.41 {1.00}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.6. Z-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]		Standard Deviation	
6.3	0.23	0.54	0.30	0.32	0.31	0.30	0.37	0.37	0.33		0.03	
8	0.24	0.60	0.26	0.27	0.30	0.27	0.28	0.29	0.28		0.02	
10	0.32	0.38	0.18	0.20	0.25	0.26	0.21	0.24	0.22		0.03	
12.5	0.28	0.29	0.16	0.15	0.22	0.27	0.21	0.20	0.20		0.05	
16	0.37	0.32	0.15	0.15	0.26	0.29	0.21	0.21	0.21		0.06	
20	0.41	0.35	0.21	0.19	0.31	0.34	0.31	0.29	0.28		0.06	
25	0.39	0.57	0.35	0.34	0.53	0.63	0.71	0.42	0.50		0.15	
31.5	1.09	0.28	0.20	0.16	0.32	0.40	0.29	0.33	0.28		0.09	
40	1.19	0.40	0.26	0.20	0.46	0.49	0.35	0.43	0.36		0.12	
50	1.69	0.93	0.56	0.43	0.76	0.84	0.78	0.62	0.66		0.16	
63	1.50	0.99	0.89	0.56	1.04	1.02	0.76	0.73	0.83		0.19	
80	2.13	1.26	1.06	0.93	1.13	1.15	1.48	0.65	1.07		0.27	
100	2.28	1.40	1.03	0.95	1.17	0.98	0.99	0.76	0.98		0.13	
125	2.52	2.02	1.10	1.32	1.56	1.83	2.24	0.81	1.48		0.51	
160	1.53	1.62	1.25	1.19	1.42	1.59	1.51	0.99	1.33		0.22	
200	1.65	1.91	1.98	1.79	1.73	1.61	1.55	1.10	1.63		0.30	
250	2.95	2.07	2.62	2.68	1.99	2.06	1.70	1.56	2.10		0.46	
315	4.04	2.38	3.06	3.13	2.19	2.20	1.91	1.89	2.40		0.56	
400	5.20	3.05	3.31	3.43	2.49	2.36	1.84	2.37	2.63		0.62	
500	6.12	3.51	3.91	3.59	2.45	2.26	1.85	2.48	2.76		0.81	
630	5.86	3.60	3.79	3.88	2.22	2.27	1.65	2.57	2.73		0.91	
800	4.39	4.27	3.61	3.94	2.01	2.14	1.47	3.01	2.70		0.98	
1000	3.31	4.12	3.08	3.34	2.07	2.33	1.70	3.77	2.71		0.80	
1250	2.23	3.97	3.30	3.31	2.24	2.70	2.03	3.64	2.87		0.65	
Linear	19.20	10.40	10.40	11.10	7.65	7.95	6.56	9.09	8.79	(8.11)	1.73	{0.92}
ISO	2.00	1.29	0.81	0.81	1.01	1.07	1.04	0.90	0.94	(0.89)	0.12	{0.95}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.7. Y-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]	Standard Deviation
6.3	0.70	0.60	0.32	0.28	0.42	0.24	0.35	0.29	0.32	0.06
8	0.55	0.58	0.25	0.21	0.36	0.20	0.27	0.29	0.26	0.06
10	0.52	0.43	0.19	0.16	0.41	0.18	0.24	0.24	0.24	0.09
12.5	0.51	0.33	0.15	0.14	0.44	0.17	0.26	0.21	0.23	0.11
16	0.41	0.34	0.13	0.10	0.44	0.19	0.18	0.18	0.20	0.12
20	0.57	0.50	0.13	0.13	0.39	0.21	0.19	0.20	0.21	0.09
25	1.29	0.62	0.21	0.25	0.42	0.27	0.27	0.24	0.28	0.07
31.5	0.42	0.34	0.14	0.13	0.56	0.23	0.19	0.23	0.25	0.16
40	0.51	0.53	0.20	0.16	0.72	0.50	0.23	0.38	0.37	0.22
50	2.23	1.04	0.37	0.33	1.17	1.05	0.54	0.60	0.68	0.35
63	0.89	1.32	0.91	0.37	1.49	1.57	0.67	1.10	1.02	0.47
80	2.35	1.82	1.45	0.77	2.16	1.85	1.41	1.72	1.56	0.48
100	1.78	1.96	2.57	1.00	3.39	2.61	2.35	2.70	2.44	0.79
125	1.76	2.51	2.57	1.47	4.20	2.92	2.73	2.82	2.78	0.87
160	2.06	1.99	2.47	1.80	3.90	3.28	3.20	2.76	2.90	0.73
200	2.68	2.24	2.09	1.83	4.37	3.84	2.76	3.13	3.00	0.99
250	2.10	2.15	2.57	2.18	5.35	4.98	3.38	3.47	3.66	1.27
315	2.57	2.09	3.35	2.25	6.12	5.44	3.96	4.04	4.19	1.40
400	4.85	2.94	2.71	2.42	5.82	5.30	3.73	3.29	3.88	1.39
500	6.26	3.42	2.46	2.31	4.90	5.11	2.82	2.65	3.38	1.28
630	5.72	3.77	2.49	2.68	4.44	4.44	2.27	2.28	3.10	1.05
800	4.23	3.84	2.42	2.35	3.46	3.48	2.08	2.58	2.73	0.60
1000	3.71	4.29	2.14	1.77	3.39	3.36	2.29	3.50	2.74	0.76
1250	3.20	4.98	2.15	1.97	3.26	3.43	2.47	3.28	2.76	0.64
Linear	13.50	11.10	8.91	7.06	15.90	14.60	10.20	10.90	11.26 (11.19)	3.38 {0.99}
ISO	1.89	1.45	0.92	0.64	1.67	1.22	1.04	1.09	1.10 (1.08)	0.34 {0.99}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.8. X-axis third octave band acceleration of the handle while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]	Standard Deviation
6.3	0.49	0.54	0.42	0.43	1.02	0.91	0.52	0.41	0.62	0.27
8	0.31	0.49	0.34	0.34	0.64	0.56	0.38	0.30	0.43	0.14
10	0.26	0.39	0.23	0.19	0.45	0.48	0.24	0.23	0.30	0.13
12.5	0.37	0.24	0.19	0.17	0.50	0.48	0.22	0.19	0.29	0.16
16	0.33	0.21	0.24	0.16	0.45	0.44	0.21	0.17	0.28	0.13
20	0.34	0.28	0.27	0.21	0.47	0.41	0.21	0.17	0.29	0.12
25	0.48	0.45	0.32	0.32	0.79	0.69	0.27	0.26	0.44	0.24
31.5	0.36	0.35	0.23	0.19	0.32	0.27	0.22	0.26	0.25	0.05
40	0.51	0.67	0.44	0.24	0.42	0.37	0.39	0.60	0.41	0.12
50	1.86	1.57	1.16	0.69	0.82	0.72	0.97	1.15	0.92	0.21
63	1.34	2.36	1.80	1.12	1.55	1.25	1.63	1.97	1.55	0.32
80	3.45	3.53	2.34	2.32	1.92	1.60	2.16	2.10	2.07	0.28
100	1.81	3.82	2.92	1.87	2.41	1.97	2.25	2.50	2.32	0.38
125	4.07	4.87	3.55	3.91	3.35	2.92	3.26	2.73	3.29	0.43
160	4.35	3.48	3.11	2.84	2.47	2.28	2.09	2.37	2.53	0.38
200	5.08	3.70	2.96	2.69	2.66	2.45	2.31	2.25	2.55	0.27
250	6.48	3.57	3.03	3.35	2.88	2.75	2.75	2.44	2.87	0.31
315	7.77	3.83	3.18	3.31	2.82	2.91	3.00	3.01	3.04	0.18
400	5.50	4.13	3.42	3.21	2.85	3.01	3.28	3.76	3.26	0.32
500	3.60	4.88	3.99	3.90	3.50	3.32	3.54	3.89	3.69	0.27
630	3.75	4.91	4.01	4.57	3.38	3.56	3.11	4.12	3.79	0.54
800	3.82	4.08	3.52	3.99	2.84	3.11	2.40	3.77	3.27	0.60
1000	3.88	3.05	2.76	2.78	2.31	2.61	1.88	3.33	2.61	0.49
1250	3.04	2.82	2.32	2.19	2.05	2.28	1.85	2.35	2.17	0.19
Linear	16.80	14.30	11.41	11.60	10.30	10.10	9.84	11.30	10.76 (10.78)	0.76 {1.00}
ISO	1.71	1.77	1.30	1.16	1.85	1.67	1.25	1.23	1.41 (1.38)	0.28 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

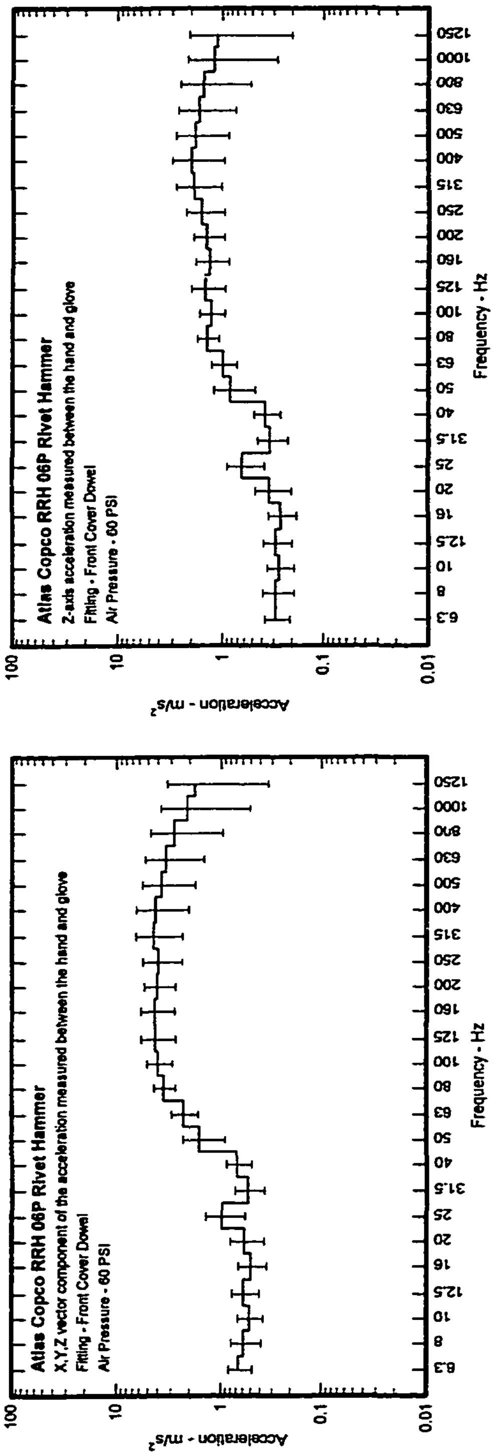


Fig. F.3. X,Y,Z vector and Z-axis third octave band acceleration values measured in the glove while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Table F.9. X,Y,Z vector third octave band acceleration measured in the glove while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.60	0.84	1.00	0.80	0.74	0.55	0.45	0.73	0.20
8	0.67	0.81	1.03	0.61	0.61	0.42	0.39	0.65	0.24
10	0.58	0.59	0.84	0.64	0.51	0.42	0.34	0.56	0.18
12.5	0.63	0.63	0.96	0.76	0.61	0.53	0.33	0.64	0.21
16	0.55	0.52	0.76	0.67	0.63	0.39	0.26	0.54	0.19
20	0.59	0.56	0.77	0.86	0.72	0.28	0.31	0.58	0.24
25	1.36	0.92	1.38	1.21	1.04	0.48	0.38	0.90	0.40
31.5	0.63	0.52	0.61	0.69	0.66	0.37	0.22	0.51	0.18
40	0.72	0.51	0.70	0.85	0.82	0.69	0.32	0.65	0.20
50	2.29	1.31	1.83	2.67	1.59	1.04	0.63	1.51	0.70
63	1.98	1.56	2.14	3.48	3.02	2.69	1.92	2.47	0.72
80	3.95	2.81	3.68	5.24	3.97	3.31	2.77	3.63	0.92
100	5.26	4.32	4.77	6.43	5.41	3.34	2.79	4.51	1.34
125	5.25	4.71	5.67	6.55	4.83	2.51	2.10	4.40	1.75
160	3.96	5.15	5.55	5.08	4.97	2.35	1.89	4.17	1.60
200	3.70	4.86	4.80	4.18	4.88	2.42	1.78	3.82	1.37
250	4.02	5.89	5.63	3.41	4.76	2.37	1.65	3.95	1.75
315	5.04	6.68	7.69	2.63	5.15	2.85	2.14	4.52	2.33
400	5.35	6.59	7.65	2.11	4.87	2.53	1.88	4.27	2.47
500	5.33	5.87	6.05	1.59	4.97	2.30	1.47	3.71	2.16
630	5.35	5.69	5.33	1.27	4.57	1.96	1.18	3.33	2.09
800	4.76	5.01	4.70	0.89	4.11	1.23	0.66	2.77	2.04
1000	3.43	3.67	4.48	0.67	2.99	0.51	0.28	2.10	1.83
1250	2.97	3.08	3.48	0.45	2.35	0.23	0.14	1.62	1.53
Linear	14.79	16.29	17.68	10.87	14.27	7.12	5.38	11.94 (13.81)	4.99 {1.16}
ISO	2.44	2.20	2.91	2.78	2.37	1.59	1.21	2.18 (2.24)	0.67 {1.03}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.10. Z-axis third octave band acceleration measured in the glove while inserting front cover dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.25	0.35	0.42	0.33	0.31	0.23	0.18	0.30	0.08
8	0.30	0.36	0.46	0.27	0.27	0.19	0.17	0.29	0.11
10	0.28	0.28	0.41	0.31	0.24	0.20	0.17	0.27	0.09
12.5	0.29	0.29	0.44	0.35	0.28	0.24	0.15	0.29	0.10
16	0.27	0.25	0.37	0.32	0.31	0.19	0.12	0.26	0.09
20	0.33	0.32	0.43	0.49	0.41	0.16	0.17	0.33	0.14
25	0.88	0.60	0.90	0.78	0.67	0.31	0.25	0.58	0.26
31.5	0.39	0.32	0.37	0.43	0.41	0.23	0.14	0.31	0.11
40	0.41	0.29	0.40	0.48	0.47	0.39	0.18	0.37	0.11
50	1.19	0.68	0.95	1.38	0.83	0.54	0.33	0.78	0.36
63	0.82	0.65	0.89	1.44	1.25	1.12	0.80	1.02	0.30
80	1.51	1.07	1.41	2.00	1.52	1.27	1.06	1.39	0.35
100	1.47	1.21	1.33	1.80	1.51	0.93	0.78	1.26	0.37
125	1.69	1.51	1.82	2.10	1.55	0.81	0.68	1.41	0.56
160	1.28	1.66	1.79	1.64	1.61	0.76	0.61	1.35	0.52
200	1.39	1.82	1.80	1.57	1.83	0.91	0.67	1.43	0.52
250	1.62	2.38	2.27	1.38	1.92	0.96	0.67	1.59	0.71
315	2.06	2.73	3.15	1.08	2.11	1.17	0.87	1.85	0.95
400	2.39	2.94	3.41	0.94	2.17	1.13	0.84	1.90	1.10
500	2.46	2.70	2.79	0.73	2.29	1.06	0.68	1.71	0.99
630	2.45	2.61	2.44	0.58	2.10	0.90	0.54	1.53	0.96
800	2.34	2.46	2.31	0.44	2.02	0.61	0.32	1.36	1.00
1000	1.81	1.94	2.37	0.35	1.58	0.27	0.15	1.11	0.97
1250	1.85	1.93	2.17	0.28	1.47	0.14	0.09	1.01	0.95
Linear	7.17	7.90	8.57	5.27	6.92	3.45	2.61	5.79 (5.57)	2.42 {0.96}
ISO	1.13	1.02	1.35	1.29	1.10	0.74	0.56	1.01 (0.99)	0.31 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

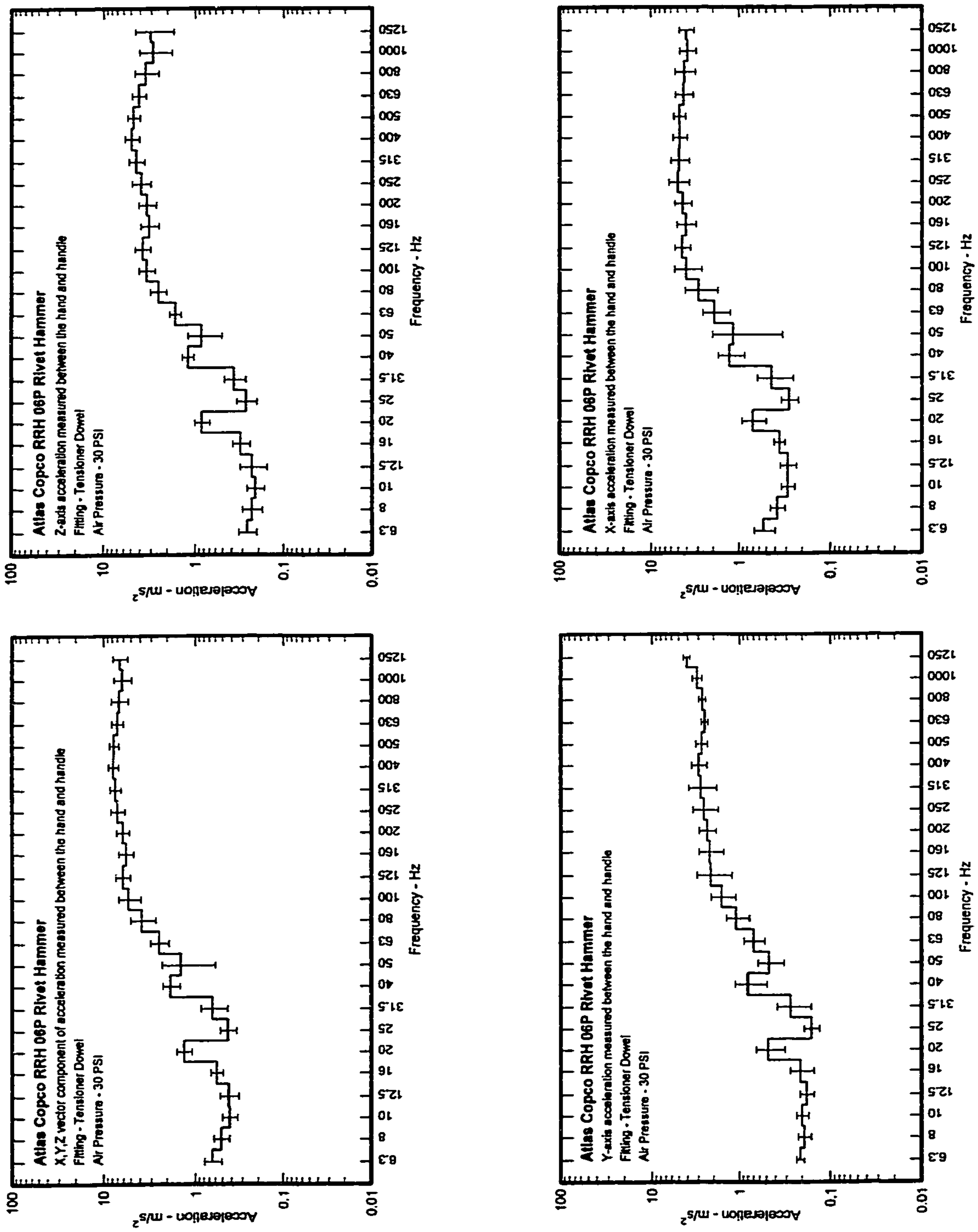


Fig. F.4. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 30 psi.

Table F.11. X,Y,Z vector third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.65	0.89	0.51	0.71	0.61	0.53	0.65	0.14
8	0.51	0.69	0.40	0.50	0.57	0.47	0.52	0.10
10	0.43	0.52	0.31	0.39	0.50	0.39	0.42	0.08
12.5	0.50	0.57	0.29	0.42	0.46	0.36	0.43	0.10
16	0.59	0.71	0.44	0.57	0.51	0.62	0.58	0.09
20	1.08	1.35	1.77	1.40	1.19	1.22	1.33	0.24
25	0.45	0.58	0.31	0.45	0.48	0.39	0.44	0.09
31.5	0.63	0.75	0.37	0.54	0.60	0.98	0.65	0.21
40	1.61	2.19	1.69	1.41	1.75	2.45	1.85	0.39
50	1.09	1.24	0.87	1.07	1.24	3.14	1.44	0.84
63	2.29	3.29	2.01	1.91	2.32	3.08	2.48	0.57
80	3.23	3.84	3.65	2.83	3.45	6.09	3.85	1.15
100	4.66	4.91	5.45	3.93	5.02	8.00	5.33	1.40
125	6.20	5.81	7.66	4.43	5.77	7.00	6.15	1.12
160	5.99	5.13	6.33	4.50	4.92	7.25	5.69	1.03
200	7.14	5.63	6.41	4.94	5.46	7.37	6.16	0.97
250	8.40	6.69	6.51	5.74	6.17	8.67	7.03	1.21
315	8.31	6.78	7.17	6.43	6.62	8.95	7.38	1.02
400	8.39	7.71	7.82	6.45	6.93	9.22	7.75	0.99
500	8.36	7.50	7.81	6.33	6.97	8.79	7.63	0.90
630	7.93	7.15	6.57	5.46	6.82	8.29	7.04	1.01
800	7.13	7.17	5.98	4.58	6.83	8.77	6.74	1.39
1000	6.89	6.68	5.41	4.28	5.96	8.19	6.24	1.34
1250	6.45	7.26	5.86	5.06	6.42	8.59	6.61	1.21
Linear	25.50	23.60	23.50	18.70	22.00	29.80	23.85 (23.80)	3.69 {1.00}
ISO	2.49	2.84	2.65	2.28	2.45	3.24	2.66 (2.62)	0.34 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.12. Z-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.28	0.37	0.22	0.25	0.32	0.21	0.27	0.06
8	0.23	0.34	0.18	0.22	0.27	0.20	0.24	0.06
10	0.22	0.31	0.16	0.19	0.24	0.18	0.22	0.05
12.5	0.27	0.36	0.15	0.22	0.25	0.18	0.24	0.08
16	0.34	0.45	0.23	0.30	0.29	0.33	0.32	0.07
20	0.71	1.04	1.08	0.76	0.79	0.74	0.85	0.16
25	0.29	0.38	0.18	0.28	0.29	0.23	0.28	0.07
31.5	0.36	0.41	0.23	0.36	0.39	0.53	0.38	0.10
40	1.04	1.36	1.20	0.99	1.30	1.38	1.21	0.17
50	0.71	0.70	0.66	0.76	0.74	1.56	0.86	0.35
63	1.47	2.06	1.71	1.47	1.51	1.68	1.65	0.23
80	2.22	2.66	2.80	1.91	2.30	3.37	2.54	0.52
100	3.26	3.27	3.47	2.55	3.30	4.62	3.41	0.67
125	4.31	3.42	4.47	2.52	3.68	4.14	3.76	0.72
160	3.80	2.80	3.46	2.20	2.88	4.10	3.21	0.71
200	4.37	3.27	3.57	2.35	2.93	3.98	3.41	0.73
250	5.14	3.93	3.82	2.64	3.40	4.73	3.94	0.90
315	5.33	4.02	4.14	3.40	4.08	5.59	4.43	0.85
400	5.99	5.00	4.55	3.68	4.66	5.90	4.96	0.88
500	5.61	4.69	4.20	3.80	4.62	5.43	4.73	0.70
630	5.01	4.49	3.27	3.33	4.23	4.57	4.15	0.70
800	3.98	4.08	2.32	2.22	3.92	4.60	3.52	1.00
1000	3.20	3.54	1.76	1.40	3.18	4.39	2.91	1.13
1250	2.57	3.80	1.83	1.66	3.32	5.35	3.09	1.38
Linear	16.70	14.80	12.90	10.30	14.00	18.00	14.45 (13.79)	2.74 {0.95}
ISO	1.54	1.80	1.62	1.29	1.50	1.70	1.58 (1.58)	0.18 {1.00}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.13. Y-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.20	0.21	0.17	0.20	0.24	0.21	0.21	0.02
8	0.21	0.19	0.13	0.17	0.22	0.20	0.19	0.03
10	0.19	0.20	0.14	0.21	0.24	0.19	0.20	0.03
12.5	0.20	0.17	0.15	0.21	0.19	0.15	0.18	0.03
16	0.18	0.15	0.18	0.31	0.19	0.26	0.21	0.06
20	0.33	0.25	0.58	0.71	0.45	0.56	0.48	0.17
25	0.15	0.16	0.14	0.22	0.18	0.13	0.16	0.03
31.5	0.18	0.20	0.19	0.31	0.28	0.46	0.27	0.11
40	0.51	0.40	0.82	0.87	0.97	1.24	0.80	0.31
50	0.30	0.36	0.51	0.64	0.36	0.64	0.47	0.15
63	0.51	0.63	0.93	0.92	0.63	0.61	0.70	0.18
80	0.81	1.06	1.58	1.30	0.73	1.03	1.09	0.32
100	1.27	1.34	2.49	1.85	1.07	1.72	1.62	0.52
125	1.83	1.57	3.99	2.38	1.39	1.84	2.17	0.95
160	1.89	1.88	3.40	2.84	1.61	1.83	2.24	0.71
200	2.32	2.07	3.07	3.08	1.89	1.99	2.40	0.54
250	2.85	2.30	3.22	3.83	1.58	1.88	2.61	0.85
315	2.47	2.58	3.86	4.30	1.69	2.19	2.85	1.01
400	3.11	2.99	3.59	3.60	2.06	2.57	2.99	0.59
500	2.79	2.68	3.49	2.83	2.19	2.67	2.78	0.42
630	2.62	2.30	2.95	2.61	2.36	2.45	2.55	0.23
800	2.85	2.53	3.11	2.65	2.44	2.74	2.72	0.24
1000	3.78	3.02	3.14	2.83	2.73	3.25	3.12	0.38
1250	4.52	4.48	3.84	3.74	3.84	4.04	4.08	0.34
Linear	9.84	9.12	11.90	11.00	7.74	8.95	9.76 (9.64)	1.50 {0.99}
ISO	0.79	0.75	1.16	1.16	0.87	1.03	0.96 (0.94)	0.18 {0.98}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.14. X-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.54	0.77	0.42	0.63	0.44	0.43	0.54	0.14
8	0.36	0.50	0.30	0.38	0.41	0.34	0.38	0.07
10	0.30	0.33	0.20	0.26	0.35	0.27	0.29	0.05
12.5	0.35	0.36	0.19	0.28	0.30	0.27	0.29	0.06
16	0.39	0.42	0.28	0.32	0.33	0.40	0.36	0.05
20	0.60	0.53	1.10	0.81	0.59	0.64	0.71	0.21
25	0.29	0.37	0.19	0.25	0.32	0.27	0.28	0.06
31.5	0.48	0.60	0.23	0.26	0.37	0.69	0.44	0.19
40	1.27	1.86	1.12	0.76	1.01	1.80	1.30	0.44
50	0.91	1.07	0.51	0.65	1.05	2.85	1.18	0.85
63	1.92	2.80	1.20	1.22	1.90	2.71	1.96	0.69
80	2.53	2.95	2.32	1.94	2.78	5.30	2.97	1.20
100	3.48	3.78	3.81	2.68	3.99	6.71	4.08	1.37
125	4.44	4.65	5.12	2.96	4.49	5.61	4.54	0.90
160	4.35	3.93	4.18	2.77	3.72	5.60	4.13	0.99
200	5.16	4.11	4.36	3.07	4.21	5.89	4.47	0.96
250	5.99	4.89	4.15	3.36	4.89	7.01	5.05	1.30
315	5.73	4.71	4.29	3.25	4.82	6.49	4.88	1.13
400	4.60	4.79	5.04	3.72	4.45	6.34	4.83	0.87
500	4.95	4.77	5.26	3.85	4.28	5.92	4.84	0.73
630	4.68	4.28	4.46	2.81	4.07	5.85	4.36	0.98
800	4.31	4.43	4.23	2.54	4.16	6.09	4.29	1.12
1000	4.19	4.05	3.83	2.71	3.56	5.21	3.93	0.82
1250	3.81	4.24	4.03	2.97	3.90	5.33	4.05	0.76
Linear	16.70	16.00	15.60	11.00	15.10	22.10	16.08 (16.02)	3.57 {1.00}
ISO	1.80	2.07	1.74	1.48	1.73	2.56	1.90 (1.85)	0.38 {0.97}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

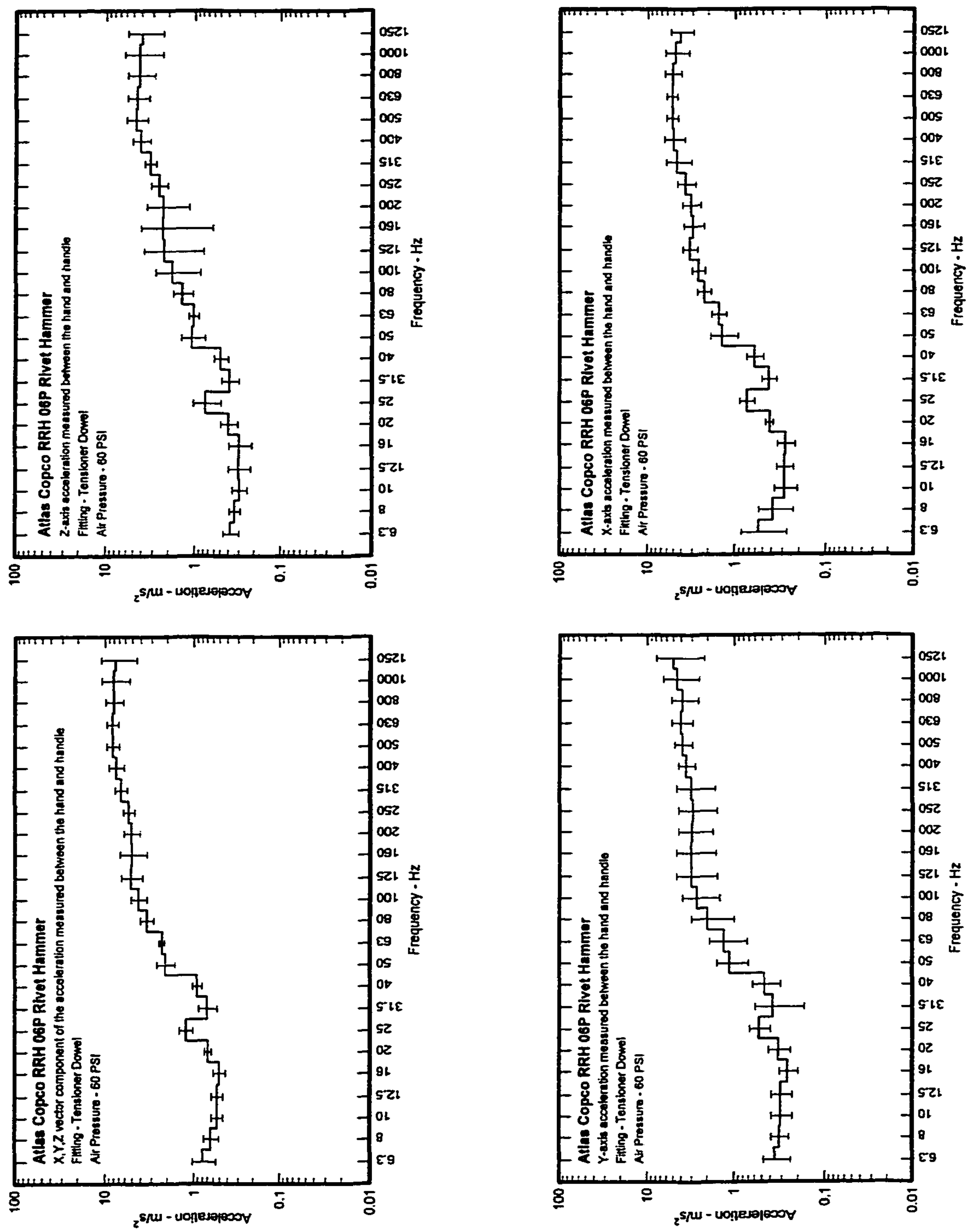


Fig. F.5. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Table F.15. X,Y,Z vector third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]								Average Acceleration [m/s^2]	Standard Deviation
6.3	0.48	0.80	0.62	0.52	0.90	0.89	1.15	1.02	0.85	0.24
8	0.48	0.59	0.58	0.49	0.73	0.75	0.84	0.69	0.68	0.13
10	0.52	0.55	0.52	0.36	0.58	0.69	0.53	0.56	0.54	0.11
12.5	0.60	0.56	0.53	0.36	0.63	0.65	0.47	0.52	0.53	0.11
16	0.56	0.50	0.49	0.34	0.60	0.61	0.49	0.49	0.50	0.10
20	0.74	0.69	0.64	0.67	0.68	0.80	0.68	0.61	0.68	0.07
25	1.72	1.34	1.29	1.07	1.04	1.11	1.17	1.16	1.14	0.09
31.5	0.70	0.61	0.51	0.67	0.85	1.03	0.73	0.58	0.73	0.19
40	0.99	0.81	0.83	1.03	0.96	1.08	0.87	0.81	0.93	0.11
50	2.95	2.25	2.61	1.55	1.68	1.77	1.83	2.26	1.95	0.40
63	2.24	2.03	2.24	2.14	2.47	2.35	2.43	2.47	2.35	0.13
80	3.28	3.01	3.70	2.42	2.97	3.88	3.97	4.06	3.50	0.66
100	3.98	3.66	6.13	3.32	3.81	4.65	4.60	3.88	4.40	0.99
125	4.89	4.89	7.98	3.48	4.80	5.41	6.18	3.81	5.28	1.66
160	5.22	4.29	8.88	3.48	3.77	5.09	5.84	4.25	5.22	1.99
200	5.33	4.43	7.39	4.61	3.93	4.99	5.74	4.71	5.23	1.21
250	5.57	4.70	6.66	4.83	4.50	5.77	6.33	5.70	5.63	0.84
315	6.34	6.36	8.69	5.68	5.73	7.27	7.21	6.05	6.77	1.18
400	7.65	7.96	10.72	6.46	6.84	7.72	7.00	6.15	7.48	1.68
500	9.16	8.56	10.84	7.16	7.78	7.79	7.52	6.92	8.00	1.43
630	8.93	8.21	10.92	7.43	8.20	7.64	7.90	7.07	8.19	1.39
800	9.93	7.96	11.52	7.13	7.13	6.75	7.47	6.48	7.75	1.88
1000	10.89	6.93	13.85	6.83	6.39	6.37	7.25	6.38	7.84	2.96
1250	8.73	5.14	15.32	7.89	5.59	5.91	6.97	6.33	8.00	3.68
Linear	27.70	22.40	36.20	36.20	21.0	22.80	24.00	20.70	27.98 (24.06)	7.60 {0.86}
ISO	2.64	2.38	2.93	2.93	2.42	2.68	2.72	2.48	2.69 (2.48)	0.22 {0.92}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.16. Z-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]	Standard Deviation
6.3	0.34	0.43	0.42	0.31	0.55	0.35	0.37	0.28	0.38	0.09
8	0.35	0.37	0.38	0.33	0.39	0.34	0.31	0.24	0.33	0.05
10	0.37	0.33	0.34	0.22	0.34	0.35	0.25	0.21	0.28	0.06
12.5	0.44	0.40	0.37	0.21	0.35	0.30	0.23	0.20	0.28	0.07
16	0.44	0.38	0.34	0.17	0.31	0.30	0.23	0.23	0.26	0.06
20	0.58	0.46	0.39	0.35	0.38	0.38	0.36	0.29	0.36	0.04
25	1.39	0.84	0.79	0.59	0.53	0.60	0.74	0.63	0.65	0.10
31.5	0.51	0.33	0.30	0.30	0.47	0.49	0.39	0.32	0.38	0.09
40	0.67	0.46	0.44	0.46	0.56	0.60	0.46	0.37	0.48	0.09
50	1.70	1.26	1.37	0.76	0.97	0.97	0.84	0.81	0.95	0.22
63	1.03	1.18	1.29	0.89	0.94	1.01	1.02	1.00	1.02	0.14
80	1.61	1.68	2.02	0.89	1.06	1.44	1.23	1.36	1.34	0.39
100	2.57	2.31	3.66	1.11	1.02	1.24	1.43	1.16	1.60	1.02
125	3.31	3.12	5.13	1.23	1.12	1.29	1.56	1.21	1.92	1.58
160	3.62	2.74	5.91	1.30	1.03	1.40	1.48	1.11	2.04	1.90
200	3.50	2.43	4.64	1.67	1.30	1.84	1.82	1.41	2.11	1.26
250	3.67	2.48	3.02	2.28	2.00	2.72	2.47	2.04	2.42	0.40
315	3.78	3.49	3.04	2.93	3.11	3.75	3.40	2.37	3.10	0.46
400	4.19	5.35	5.60	3.35	4.02	4.23	3.76	2.72	3.95	0.97
500	5.60	6.19	6.51	3.86	4.58	4.22	3.82	2.91	4.32	1.21
630	5.64	5.62	6.38	3.92	4.61	3.95	3.57	2.63	4.18	1.26
800	5.64	5.35	6.55	4.20	3.98	3.22	3.09	2.24	3.88	1.48
1000	6.69	4.59	7.67	3.85	3.62	2.88	2.78	2.12	3.82	1.98
1250	5.13	3.08	7.79	4.16	3.38	2.89	3.09	2.56	3.98	1.94
Linear	16.90	14.60	20.10	10.80	12.20	11.60	10.89	8.23	12.29 (11.52)	4.06 {0.94}
ISO	1.81	1.46	1.77	0.96	1.29	1.22	1.14	0.96	1.22 (1.16)	0.30 {0.94}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.17. Y-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]								Average Acceleration [m/s^2]	Standard Deviation
6.3	0.23	0.56	0.28	0.26	0.37	0.50	0.35	0.32	0.35	0.08
8	0.25	0.37	0.30	0.27	0.36	0.47	0.28	0.28	0.33	0.08
10	0.27	0.38	0.30	0.22	0.32	0.46	0.24	0.30	0.31	0.08
12.5	0.27	0.34	0.30	0.22	0.37	0.43	0.21	0.34	0.31	0.09
16	0.19	0.24	0.30	0.18	0.32	0.34	0.21	0.27	0.27	0.06
20	0.18	0.31	0.37	0.36	0.33	0.50	0.26	0.31	0.35	0.08
25	0.34	0.47	0.76	0.43	0.58	0.70	0.47	0.52	0.58	0.13
31.5	0.17	0.17	0.28	0.25	0.58	0.76	0.45	0.35	0.44	0.19
40	0.24	0.28	0.40	0.40	0.54	0.66	0.64	0.80	0.54	0.12
50	0.86	0.77	1.22	0.69	1.00	1.03	1.45	1.95	1.22	0.44
63	0.71	0.45	1.33	0.86	1.57	1.45	1.98	2.05	1.54	0.44
80	1.20	0.74	2.37	1.04	1.72	2.18	3.28	3.46	2.34	0.92
100	1.36	1.16	4.13	1.30	3.03	3.11	3.67	3.26	3.08	0.97
125	1.60	1.50	4.90	1.26	3.19	3.59	5.08	3.14	3.53	1.39
160	1.78	1.40	5.04	1.44	2.72	3.57	4.95	3.73	3.58	1.37
200	1.79	1.24	4.10	2.06	2.70	3.32	4.86	4.01	3.51	1.02
250	1.59	1.04	2.57	2.46	2.78	3.39	4.95	4.67	3.47	1.09
315	1.78	1.11	1.93	2.78	3.12	3.91	5.07	4.71	3.59	1.20
400	3.31	1.97	4.28	3.78	2.96	3.44	4.04	4.12	3.77	0.49
500	4.60	2.91	5.12	4.33	2.55	3.10	3.84	4.37	3.88	0.93
630	4.89	3.17	5.79	4.81	2.52	2.94	3.90	4.41	4.06	1.21
800	5.54	2.05	5.78	4.44	2.52	2.96	3.78	3.87	3.89	1.15
1000	6.42	2.09	8.36	4.66	2.92	3.43	4.18	3.97	4.59	1.95
1250	5.33	2.03	11.30	5.92	3.32	3.80	4.20	4.05	5.43	3.01
Linear	13.60	6.86	20.30	12.60	10.30	12.20	15.90	14.80	14.35 (13.94)	3.52 {0.97}
ISO	0.91	1.08	1.66	0.92	1.38	1.66	1.69	1.65	1.49 (1.45)	0.30 {0.97}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.18. X-axis third octave band acceleration of the handle while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]								Average Acceleration [m/s²]	Standard Deviation
6.3	0.25	0.37	0.36	0.31	0.58	0.64	1.02	0.93	0.64	0.29
8	0.21	0.29	0.32	0.24	0.41	0.39	0.69	0.55	0.43	0.16
10	0.26	0.22	0.26	0.18	0.29	0.35	0.38	0.41	0.31	0.09
12.5	0.32	0.20	0.24	0.20	0.32	0.35	0.33	0.33	0.29	0.06
16	0.28	0.22	0.20	0.23	0.35	0.35	0.34	0.30	0.30	0.07
20	0.42	0.41	0.34	0.44	0.40	0.45	0.47	0.40	0.42	0.05
25	0.95	0.92	0.68	0.79	0.63	0.56	0.70	0.77	0.69	0.09
31.5	0.45	0.48	0.30	0.54	0.41	0.49	0.43	0.33	0.42	0.09
40	0.69	0.61	0.58	0.84	0.65	0.71	0.46	0.46	0.62	0.15
50	2.25	1.70	1.85	1.16	1.13	1.24	0.93	0.97	1.21	0.33
63	1.86	1.59	1.26	1.75	1.76	1.68	1.18	1.13	1.46	0.30
80	2.59	2.39	2.00	2.00	2.25	2.98	1.98	1.80	2.17	0.43
100	2.71	2.60	2.68	2.84	2.15	3.28	2.48	1.85	2.55	0.51
125	3.22	3.45	3.66	3.00	3.44	3.88	3.22	1.86	3.18	0.72
160	3.31	2.99	4.29	2.89	2.42	3.36	2.74	1.73	2.90	0.87
200	3.59	3.49	4.03	3.78	2.55	3.23	2.46	2.02	3.01	0.80
250	3.88	3.85	5.35	3.47	2.91	3.90	3.07	2.54	3.52	1.00
315	4.78	5.20	7.90	3.99	3.59	4.76	3.73	2.90	4.48	1.78
400	5.48	5.56	8.08	4.03	4.50	5.30	4.13	3.56	4.93	1.65
500	5.61	5.15	6.99	4.20	5.39	5.46	4.94	4.33	5.22	1.01
630	4.90	5.09	6.71	4.09	5.65	5.33	5.46	4.59	5.30	0.91
800	6.01	5.52	7.50	3.68	4.50	4.58	5.19	4.40	4.97	1.33
1000	5.71	4.75	7.94	3.19	3.51	4.03	4.82	4.24	4.62	1.72
1250	4.63	3.58	6.81	3.14	2.93	3.47	4.60	4.12	4.18	1.43
Linear	17.10	15.60	22.30	12.80	13.60	15.40	14.30	12.00	15.07 (14.84)	3.73 {0.98}
ISO	1.69	1.53	1.64	1.40	1.51	1.71	1.80	1.59	1.61 (1.55)	0.14 {0.96}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

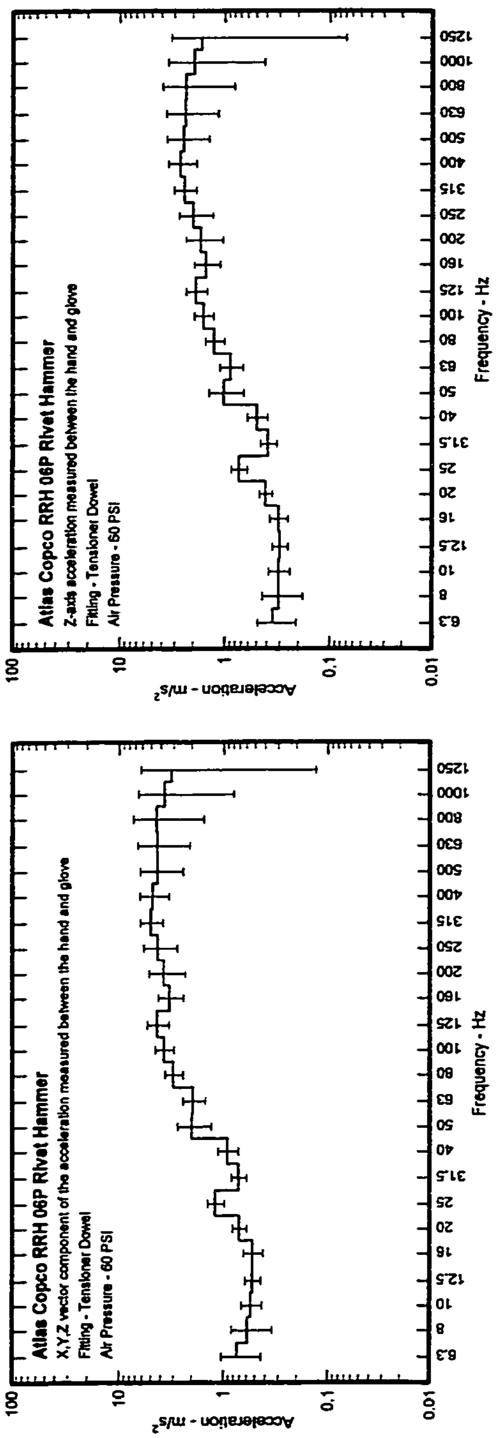


Fig. F.6. X,Y,Z and Z-axis vector third octave band acceleration values measured in the glove while inserting tensioner dowels with the RRH 06P rivet hammer supplied with of 60 psi.

Table F.19. X,Y,Z vector third octave band acceleration measured in the glove while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.42	0.49	0.84	1.30	0.94	0.73	0.79	0.32
8	0.38	0.35	0.79	1.07	0.57	0.66	0.64	0.27
10	0.46	0.47	0.58	0.78	0.51	0.68	0.58	0.13
12.5	0.46	0.55	0.51	0.65	0.62	0.71	0.58	0.09
16	0.47	0.56	0.45	0.64	0.76	0.68	0.59	0.12
20	0.66	0.79	0.68	0.98	0.85	0.70	0.78	0.12
25	1.41	1.72	1.24	1.20	1.10	1.13	1.30	0.23
31.5	0.53	0.71	0.84	0.91	0.81	0.74	0.76	0.13
40	0.64	1.12	1.14	1.17	0.81	0.90	0.96	0.21
50	2.05	3.63	1.75	1.76	1.71	1.78	2.11	0.75
63	1.43	2.94	1.86	1.84	2.08	2.09	2.04	0.50
80	2.87	4.20	3.54	3.26	3.62	2.31	3.30	0.65
100	3.14	4.59	5.30	5.29	4.48	3.47	4.38	0.90
125	3.07	4.76	6.13	6.13	6.12	4.97	5.20	1.22
160	2.69	2.93	4.36	4.29	5.49	3.49	3.88	1.04
200	2.36	2.72	6.18	5.59	5.07	3.32	4.21	1.61
250	3.38	2.93	6.79	6.69	4.52	3.75	4.68	1.68
315	5.62	5.09	6.96	6.61	3.82	3.96	5.34	1.31
400	5.31	4.93	7.19	6.10	2.83	3.88	5.04	1.55
500	4.38	3.63	7.04	6.89	1.78	4.02	4.62	2.02
630	4.38	3.32	6.84	7.84	1.07	4.67	4.69	2.43
800	4.10	2.82	6.88	9.43	0.59	4.48	4.71	3.10
1000	3.06	1.97	6.10	9.16	0.51	3.16	3.99	3.13
1250	1.98	1.12	5.22	8.87	0.40	2.29	3.31	3.18
Linear	14.53	14.64	23.91	27.10	12.86	14.69	17.95 (16.51)	5.97 {0.92}
ISO	1.99	2.77	2.64	3.10	2.60	2.44	2.59 (2.44)	0.37 {0.94}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.20. Z-axis third octave band acceleration measured in the glove while inserting tensioner dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.19	0.22	0.37	0.58	0.42	0.33	0.35	0.14
8	0.19	0.17	0.39	0.52	0.28	0.32	0.31	0.13
10	0.24	0.25	0.31	0.41	0.27	0.36	0.31	0.07
12.5	0.24	0.29	0.27	0.34	0.32	0.37	0.30	0.05
16	0.25	0.29	0.24	0.33	0.40	0.35	0.31	0.06
20	0.35	0.42	0.36	0.52	0.45	0.37	0.41	0.06
25	0.80	0.98	0.70	0.68	0.62	0.64	0.74	0.13
31.5	0.28	0.37	0.43	0.47	0.42	0.39	0.39	0.07
40	0.33	0.58	0.59	0.60	0.42	0.47	0.50	0.11
50	1.00	1.78	0.85	0.86	0.84	0.87	1.03	0.37
63	0.63	1.28	0.81	0.80	0.90	0.91	0.89	0.22
80	1.09	1.60	1.35	1.24	1.38	0.88	1.26	0.25
100	1.14	1.67	1.93	1.93	1.63	1.27	1.60	0.33
125	1.12	1.74	2.24	2.24	2.23	1.81	1.89	0.44
160	1.05	1.14	1.71	1.68	2.15	1.37	1.52	0.41
200	0.95	1.10	2.50	2.26	2.05	1.34	1.70	0.65
250	1.45	1.26	2.92	2.88	1.94	1.62	2.01	0.72
315	2.58	2.33	3.19	3.03	1.75	1.81	2.45	0.60
400	2.80	2.60	3.79	3.22	1.49	2.04	2.66	0.82
500	2.36	1.96	3.80	3.72	0.96	2.17	2.49	1.09
630	2.23	1.69	3.49	4.00	0.55	2.38	2.39	1.24
800	2.06	1.41	3.45	4.72	0.30	2.24	2.36	1.55
1000	1.49	0.96	2.97	4.46	0.25	1.54	1.94	1.52
1250	0.99	0.56	2.60	4.41	0.20	1.14	1.65	1.58
Linear	6.38	6.43	10.50	11.90	5.65	6.45	7.89 (7.58)	2.62 {0.96}
ISO	0.91	1.26	1.20	1.41	1.18	1.11	1.18 (1.16)	0.17 {0.98}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

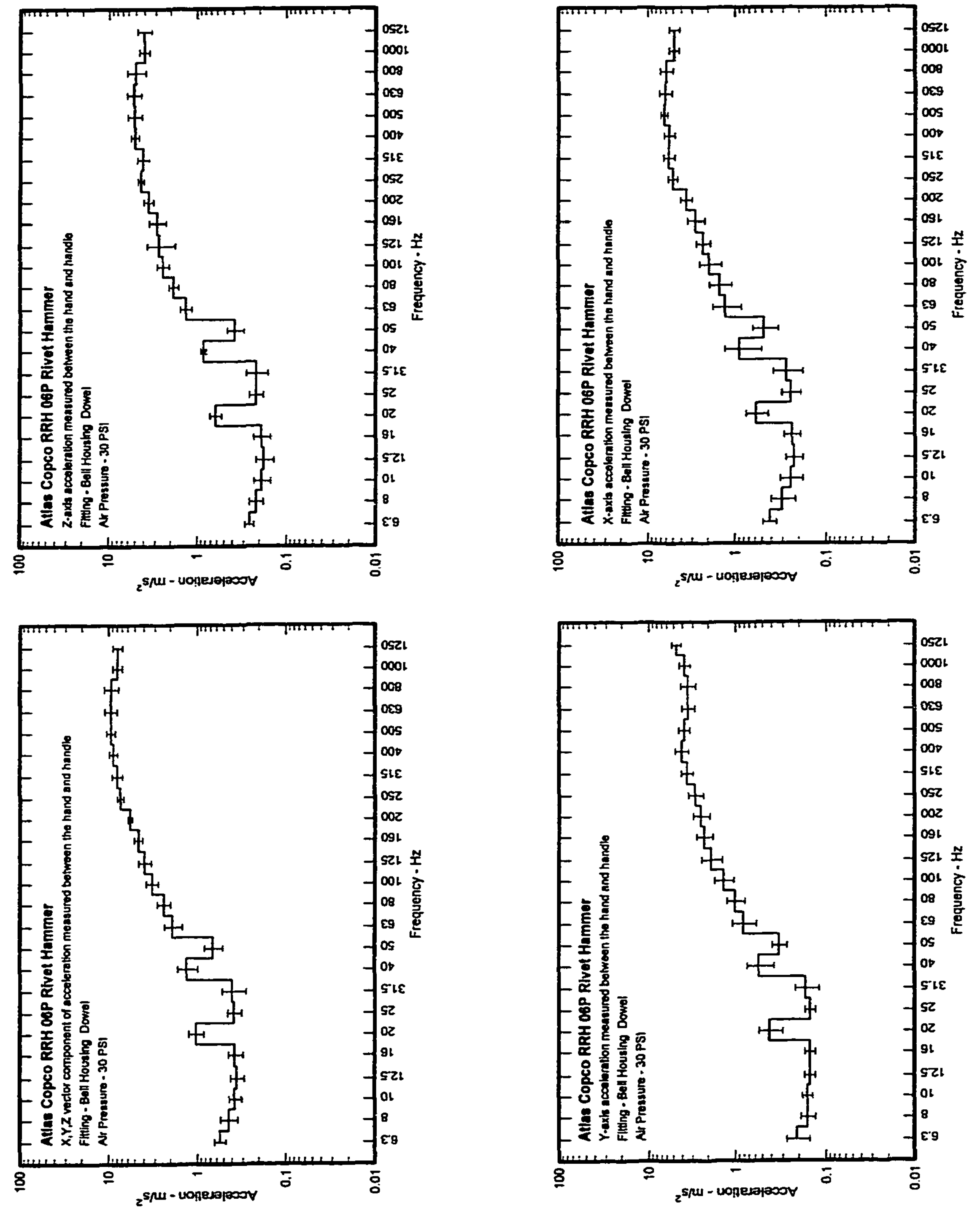


Fig. F.7. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 30 psi.

Table F.21. X,Y,Z vector third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.55	0.51	0.46	0.53	0.70	0.54	0.55	0.08
8	0.45	0.42	0.35	0.35	0.62	0.47	0.44	0.10
10	0.39	0.33	0.33	0.30	0.47	0.38	0.37	0.06
12.5	0.39	0.34	0.32	0.27	0.43	0.33	0.35	0.06
16	0.43	0.37	0.32	0.28	0.46	0.32	0.37	0.07
20	0.98	0.98	1.28	1.25	0.87	0.80	1.03	0.20
25	0.41	0.35	0.35	0.33	0.52	0.33	0.38	0.07
31.5	0.41	0.42	0.29	0.27	0.60	0.38	0.40	0.12
40	1.39	1.78	1.20	1.49	1.01	0.90	1.30	0.33
50	0.68	0.64	0.51	0.54	0.83	0.55	0.66	0.15
63	2.11	2.50	1.76	2.15	1.42	1.40	1.89	0.44
80	2.55	3.08	2.27	2.49	1.94	2.08	2.40	0.41
100	3.40	4.07	2.86	3.32	2.68	3.07	3.23	0.49
125	4.03	4.49	3.29	3.34	3.57	4.85	3.93	0.64
160	4.55	4.88	4.47	4.81	3.73	4.99	4.57	0.46
200	5.80	5.68	5.62	5.99	4.97	5.76	5.64	0.35
250	7.35	7.76	7.38	8.03	6.41	6.79	7.29	0.60
315	7.65	8.43	8.05	9.63	6.62	7.09	7.91	1.06
400	8.93	9.70	8.59	9.87	8.06	7.48	8.77	0.93
500	9.83	10.08	8.85	8.30	10.97	8.29	9.39	1.08
630	11.21	9.99	10.48	7.12	9.62	8.34	9.46	1.49
800	11.55	9.26	10.48	6.73	9.72	8.14	9.31	1.71
1000	7.82	8.25	8.77	6.01	8.36	8.26	7.91	0.98
1250	7.44	8.33	9.11	6.35	7.65	8.48	7.89	0.97
Linear	27.60	27.60	27.10	24.40	25.60	24.40	26.12 (25.96)	1.52 {0.99}
ISO	2.07	2.19	1.98	2.08	1.99	1.85	2.03 (2.01)	0.12 {0.99}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.22. Z-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.30	0.25	0.23	0.23	0.30	0.25	0.26	0.03
8	0.25	0.24	0.17	0.17	0.26	0.20	0.22	0.04
10	0.24	0.20	0.15	0.15	0.21	0.18	0.19	0.04
12.5	0.23	0.22	0.14	0.13	0.20	0.17	0.18	0.04
16	0.25	0.21	0.16	0.14	0.22	0.17	0.19	0.04
20	0.64	0.67	0.72	0.67	0.50	0.50	0.62	0.09
25	0.25	0.21	0.19	0.19	0.27	0.20	0.22	0.04
31.5	0.25	0.21	0.16	0.16	0.32	0.23	0.22	0.06
40	0.88	0.95	0.83	0.77	0.83	0.86	0.85	0.06
50	0.38	0.42	0.30	0.29	0.51	0.39	0.38	0.08
63	1.40	1.70	1.34	1.35	1.11	1.22	1.35	0.20
80	1.77	2.30	1.64	1.84	1.67	1.95	1.86	0.24
100	2.37	2.96	1.87	2.43	2.34	2.87	2.48	0.40
125	2.34	2.91	1.75	1.98	3.00	4.41	2.73	0.96
160	2.55	2.69	2.57	2.57	2.75	4.13	2.88	0.62
200	3.29	3.28	3.34	3.58	3.64	4.44	3.60	0.44
250	4.13	4.50	4.04	4.86	4.09	4.62	4.37	0.33
315	3.76	4.49	3.77	5.27	3.57	4.20	4.18	0.63
400	5.27	5.45	4.56	5.74	5.21	4.52	5.12	0.49
500	5.49	5.38	4.26	4.73	6.85	4.67	5.23	0.92
630	6.93	5.43	5.56	4.21	5.16	4.57	5.31	0.95
800	6.93	4.85	5.40	3.62	5.11	4.19	5.02	1.14
1000	3.84	4.35	4.46	3.07	4.29	4.08	4.01	0.51
1250	3.61	4.42	5.04	2.98	3.97	4.37	4.07	0.72
Linear	17.40	16.50	15.70	14.70	16.50	15.80	16.10 (14.76)	0.92 {0.92}
ISO	1.29	1.34	1.16	1.19	1.23	1.29	1.25 (1.24)	0.07 {0.99}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.23. Y-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.19	0.19	0.18	0.13	0.28	0.28	0.21	0.06
8	0.18	0.16	0.13	0.12	0.21	0.18	0.16	0.03
10	0.17	0.17	0.14	0.14	0.18	0.15	0.16	0.02
12.5	0.17	0.15	0.15	0.13	0.17	0.14	0.15	0.02
16	0.17	0.14	0.15	0.14	0.20	0.14	0.15	0.02
20	0.39	0.34	0.60	0.54	0.37	0.30	0.42	0.12
25	0.15	0.14	0.16	0.15	0.19	0.11	0.15	0.02
31.5	0.18	0.15	0.15	0.15	0.26	0.14	0.17	0.05
40	0.54	0.45	0.71	0.82	0.46	0.33	0.55	0.18
50	0.31	0.31	0.32	0.33	0.45	0.26	0.33	0.06
63	0.85	0.67	0.98	1.22	0.61	0.60	0.82	0.24
80	1.29	1.04	1.19	1.07	0.71	0.78	1.01	0.23
100	1.88	1.38	1.51	1.33	0.97	1.06	1.36	0.33
125	2.73	2.02	1.89	1.52	1.36	1.69	1.87	0.48
160	2.99	2.44	2.31	2.04	1.68	1.91	2.23	0.46
200	3.34	2.28	2.71	2.29	1.95	2.00	2.43	0.52
250	3.72	2.71	3.09	2.93	2.24	2.24	2.82	0.56
315	3.94	3.75	3.71	3.99	2.58	3.05	3.50	0.56
400	4.82	4.75	4.35	3.92	3.13	3.32	4.05	0.71
500	4.55	4.24	3.96	3.09	3.80	3.26	3.82	0.56
630	4.27	3.57	3.39	2.45	3.58	3.40	3.45	0.59
800	4.59	3.43	3.38	2.43	3.37	3.48	3.44	0.69
1000	4.17	4.14	3.90	2.67	3.83	3.92	3.77	0.55
1250	4.98	5.20	5.17	3.71	4.44	4.46	4.66	0.57
Linear	13.70	12.20	12.00	9.97	10.30	10.40	11.43 (11.38)	1.45 {1.00}
ISO	0.99	0.82	0.96	0.90	0.80	0.73	0.87 (0.85)	0.10 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.24. X-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 30 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.40	0.40	0.35	0.45	0.56	0.38	0.42	0.07
8	0.26	0.24	0.25	0.25	0.48	0.35	0.31	0.09
10	0.23	0.17	0.25	0.20	0.36	0.29	0.25	0.07
12.5	0.23	0.18	0.23	0.19	0.32	0.23	0.23	0.05
16	0.26	0.23	0.21	0.18	0.32	0.21	0.24	0.05
20	0.49	0.49	0.76	0.81	0.52	0.45	0.59	0.16
25	0.26	0.23	0.23	0.21	0.38	0.22	0.25	0.06
31.5	0.28	0.33	0.19	0.17	0.44	0.27	0.28	0.10
40	1.07	1.54	0.71	1.08	0.59	0.47	0.91	0.40
50	0.54	0.72	0.33	0.37	0.59	0.40	0.49	0.15
63	1.60	2.01	1.03	1.43	0.94	0.84	1.31	0.45
80	1.63	2.18	1.37	1.64	1.15	1.03	1.50	0.41
100	1.95	2.85	1.81	2.19	1.46	1.45	1.95	0.53
125	2.06	3.01	2.16	2.37	1.84	2.14	2.26	0.40
160	2.39	3.34	2.92	3.59	2.01	2.33	2.76	0.62
200	3.44	4.05	3.63	4.24	2.78	3.10	3.54	0.56
250	4.79	5.70	5.33	5.67	4.38	4.43	5.05	0.60
315	5.30	5.97	6.00	6.88	4.86	4.71	5.62	0.82
400	5.10	6.23	5.66	6.76	5.03	4.73	5.59	0.79
500	6.32	7.01	6.40	5.72	7.07	5.67	6.37	0.60
630	6.47	6.84	7.49	4.53	6.58	5.43	6.23	1.07
800	6.23	6.17	7.34	4.40	6.58	5.23	5.99	1.03
1000	4.60	4.70	5.61	3.82	5.22	5.25	4.87	0.63
1250	4.16	4.74	5.53	4.19	4.77	5.71	4.85	0.65
Linear	16.40	18.50	18.50	16.70	16.60	15.40	17.02 (16.90)	1.24 {0.99}
ISO	1.29	1.53	1.29	1.44	1.35	1.11	1.34 (1.31)	0.14 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

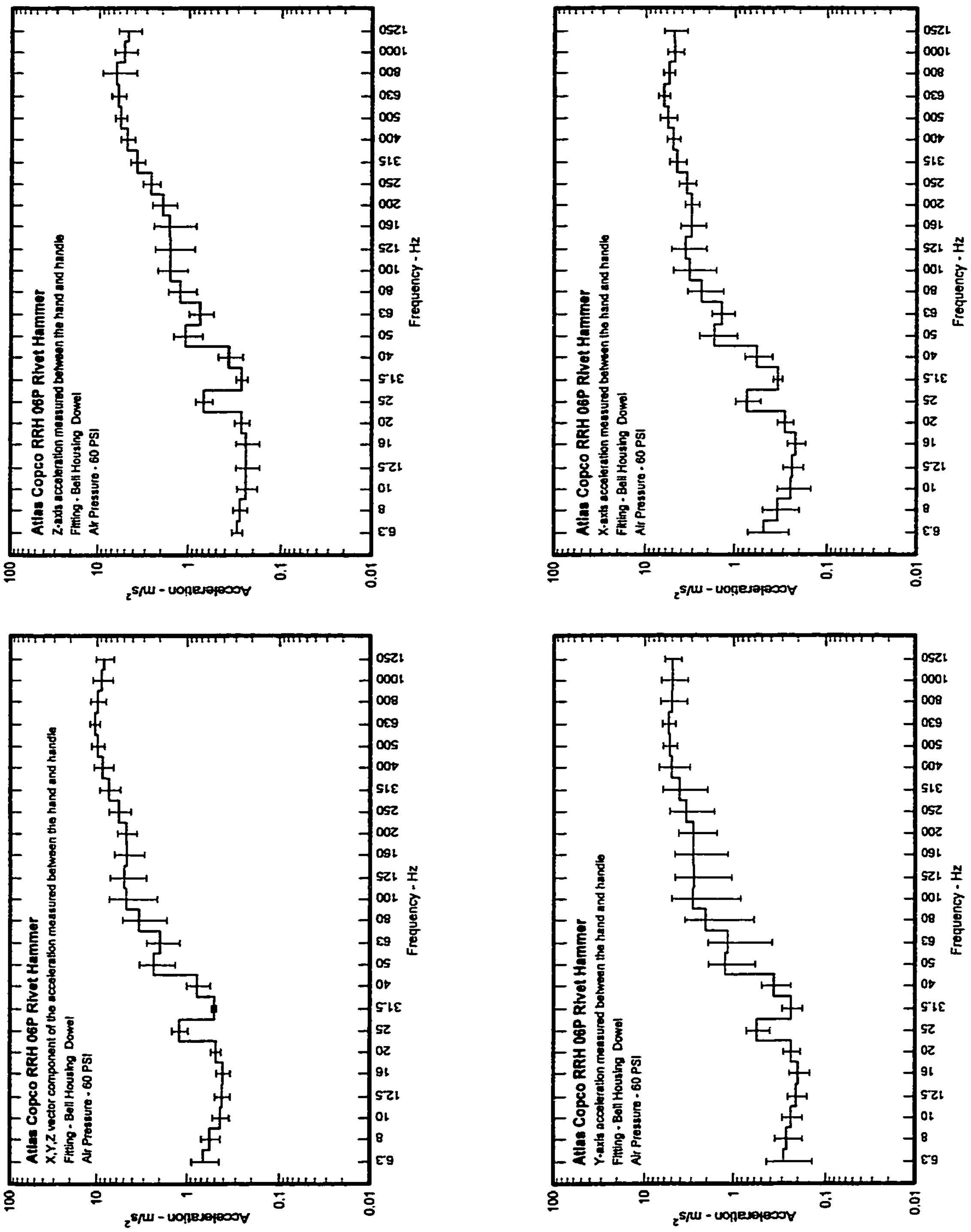


Fig. F.8. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Table F.25. X,Y,Z vector third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]										Average Acceleration [m/s²]		Standard Deviation	
6.3	0.42	1.11	0.60	0.52	0.60	0.51	0.78	0.80	0.63	0.66	0.66		0.11	
8	0.41	0.80	0.66	0.48	0.59	0.44	0.56	0.59	0.63	0.44	0.54		0.08	
10	0.38	0.60	0.51	0.51	0.39	0.31	0.41	0.44	0.51	0.31	0.40		0.08	
12.5	0.44	0.55	0.45	0.49	0.34	0.28	0.43	0.36	0.43	0.24	0.35		0.08	
16	0.41	0.53	0.43	0.43	0.37	0.31	0.47	0.36	0.48	0.25	0.37		0.09	
20	0.41	0.58	0.48	0.52	0.43	0.42	0.50	0.54	0.54	0.35	0.46		0.08	
25	0.92	1.13	1.20	1.11	0.96	1.33	1.34	1.67	1.18	1.02	1.25		0.26	
31.5	0.49	0.53	0.50	0.51	0.53	0.54	0.53	0.44	0.59	0.38	0.50		0.08	
40	0.57	0.66	0.76	0.65	0.95	1.26	0.68	0.71	0.66	0.69	0.82		0.24	
50	1.58	1.77	2.64	1.35	2.70	4.47	1.87	2.25	2.14	2.60	2.67		0.93	
63	1.23	1.26	1.70	1.37	2.54	3.38	1.74	2.71	1.31	2.16	2.31		0.74	
80	1.58	1.90	3.68	1.47	4.00	6.69	3.96	4.03	2.42	4.07	4.19		1.38	
100	1.82	2.25	4.39	1.86	6.01	8.96	6.01	6.25	3.05	5.07	5.89		1.91	
125	2.70	3.03	5.43	2.11	5.62	7.92	7.21	5.64	4.01	4.89	5.88		1.45	
160	3.18	3.37	5.50	2.08	4.92	7.24	6.32	4.79	3.98	4.35	5.26		1.25	
200	3.90	3.92	5.47	2.82	5.09	6.60	4.97	5.11	3.91	4.99	5.11		0.86	
250	4.50	4.38	5.57	3.55	6.33	8.45	6.49	6.58	4.62	6.68	6.52		1.22	
315	5.53	5.07	7.52	5.25	8.78	10.17	8.20	8.34	6.15	8.38	8.34		1.29	
400	8.20	5.84	7.79	5.99	9.64	11.45	9.57	10.92	8.33	9.46	9.90		1.12	
500	11.45	8.98	9.35	6.95	9.30	11.83	11.21	10.01	10.03	10.33	10.45		0.92	
630	11.16	11.42	11.13	8.73	9.63	12.51	11.32	8.73	13.41	11.38	11.16		1.74	
800	12.40	8.05	12.05	7.66	8.78	11.62	9.76	8.44	22.23	11.14	11.99		5.17	
1000	12.06	6.64	9.98	5.91	8.40	11.64	8.66	7.81	11.99	10.44	9.82		1.78	
1250	8.91	6.76	7.95	5.90	8.65	12.26	8.95	7.67	7.72	10.43	9.28		1.77	
Linear	28.70	22.30	28.20	18.90	27.60	36.60	29.70	27.10	34.30	30.10	30.90	(30.45)	3.78	{0.99}
ISO	1.72	2.26	2.45	1.71	2.47	3.36	2.59	2.63	2.16	2.29	2.58	(2.54)	0.42	{0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.26. Z-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]										Average Acceleration [m/s²]	Standard Deviation
6.3	0.25	0.36	0.27	0.32	0.38	0.31	0.30	0.28	0.33	0.23	0.30	0.05
8	0.27	0.31	0.36	0.31	0.32	0.27	0.28	0.24	0.29	0.17	0.26	0.05
10	0.28	0.31	0.28	0.33	0.23	0.19	0.22	0.19	0.26	0.13	0.20	0.04
12.5	0.31	0.36	0.24	0.30	0.20	0.18	0.23	0.18	0.25	0.11	0.19	0.05
16	0.32	0.35	0.25	0.27	0.20	0.17	0.28	0.19	0.28	0.11	0.21	0.07
20	0.31	0.35	0.26	0.28	0.22	0.24	0.29	0.27	0.30	0.18	0.25	0.05
25	0.65	0.56	0.67	0.48	0.60	0.96	0.74	0.87	0.68	0.75	0.77	0.13
31.5	0.33	0.28	0.24	0.26	0.26	0.29	0.33	0.24	0.31	0.20	0.27	0.05
40	0.34	0.35	0.33	0.31	0.38	0.67	0.34	0.31	0.38	0.30	0.40	0.14
50	0.94	0.81	1.18	0.63	1.04	1.89	0.77	0.85	1.33	1.33	1.20	0.41
63	0.45	0.62	0.80	0.53	0.96	1.14	0.81	1.00	0.73	0.60	0.87	0.20
80	0.68	0.87	1.70	0.55	1.28	1.80	1.62	1.40	1.26	1.22	1.43	0.23
100	0.90	1.05	2.16	0.61	1.55	2.10	2.06	1.93	2.23	1.45	1.89	0.31
125	1.64	1.30	2.76	0.62	0.84	1.23	1.69	1.69	2.89	1.29	1.61	0.71
160	2.10	1.60	3.06	0.72	0.86	1.08	1.35	1.44	2.85	1.27	1.47	0.70
200	2.64	2.18	2.87	1.17	1.41	1.67	1.47	1.45	2.50	2.01	1.75	0.43
250	3.26	2.81	3.13	1.79	2.63	2.93	2.21	1.72	2.59	3.45	2.59	0.59
315	4.22	3.39	3.67	2.82	4.28	4.50	3.84	3.07	2.99	4.78	3.91	0.75
400	5.62	3.46	4.01	3.45	5.01	5.78	5.07	5.24	5.25	5.47	5.30	0.28
500	7.06	6.05	5.61	4.20	4.94	6.37	6.14	4.83	6.59	5.94	5.80	0.74
630	6.13	7.42	6.31	5.12	5.22	6.84	5.89	4.13	8.03	6.22	6.06	1.34
800	7.74	4.91	7.44	4.79	4.91	6.25	5.06	4.17	13.24	6.15	6.63	3.33
1000	7.85	3.65	5.77	3.70	4.55	6.15	4.30	3.70	6.97	5.91	5.26	1.27
1250	4.36	2.95	4.56	3.44	4.96	7.32	4.71	3.84	4.64	6.58	5.34	1.32
Linear	18.10	13.50	15.90	10.90	14.90	19.10	15.60	12.80	24.00	18.20	17.43 (15.41)	3.94 {0.88}
ISO	1.09	1.10	1.26	0.91	1.07	1.28	1.15	1.07	1.30	1.00	1.15 (1.11)	0.12 {0.97}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.27. Y-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]										Average Acceleration [m/s²]	Standard Deviation
6.3	0.19	0.61	0.37	0.29	0.32	0.17	0.19	0.18	0.20	0.23	0.22	0.05
8	0.21	0.35	0.41	0.29	0.35	0.17	0.20	0.19	0.21	0.14	0.21	0.07
10	0.19	0.27	0.28	0.33	0.24	0.17	0.22	0.18	0.16	0.14	0.19	0.04
12.5	0.20	0.24	0.26	0.30	0.17	0.14	0.23	0.17	0.15	0.11	0.16	0.04
16	0.17	0.21	0.28	0.27	0.17	0.15	0.23	0.16	0.16	0.10	0.16	0.04
20	0.17	0.24	0.31	0.32	0.22	0.19	0.23	0.28	0.17	0.14	0.20	0.05
25	0.36	0.41	0.70	0.46	0.56	0.59	0.61	0.86	0.32	0.35	0.55	0.20
31.5	0.29	0.14	0.28	0.29	0.30	0.25	0.25	0.20	0.23	0.18	0.24	0.04
40	0.24	0.19	0.36	0.32	0.57	0.52	0.35	0.42	0.25	0.43	0.42	0.11
50	0.57	0.62	1.25	0.63	1.79	2.45	1.11	1.62	0.59	1.54	1.52	0.63
63	0.36	0.32	0.90	0.71	1.78	2.46	0.98	1.87	0.43	1.58	1.52	0.71
80	0.51	0.56	2.14	0.83	2.70	4.93	2.22	2.84	0.72	2.69	2.68	1.35
100	0.64	0.81	2.83	0.90	3.72	6.59	3.39	4.55	0.93	3.04	3.70	1.86
125	0.75	1.24	3.30	0.75	3.15	5.79	3.58	4.04	1.32	3.01	3.48	1.46
160	0.96	1.60	3.52	0.75	3.33	6.01	3.77	3.29	1.48	3.05	3.49	1.46
200	1.37	1.93	3.35	1.11	3.60	5.07	3.29	3.41	1.52	3.21	3.35	1.13
250	1.90	1.56	3.07	1.41	4.31	6.51	4.20	4.99	1.69	3.87	4.26	1.57
315	2.17	1.55	3.51	1.90	5.91	7.39	4.97	5.69	2.27	5.02	5.21	1.69
400	4.06	2.96	4.31	2.63	5.93	7.63	5.56	7.41	2.70	4.84	5.68	1.81
500	5.53	5.03	5.64	3.43	5.06	6.26	5.31	6.52	3.24	4.04	5.07	1.26
630	5.96	6.50	6.92	4.61	4.39	5.41	5.41	4.64	4.39	4.36	4.77	0.51
800	7.37	4.26	7.75	3.85	3.56	5.10	4.39	3.91	7.21	4.28	4.74	1.32
1000	7.48	3.38	6.96	3.44	4.15	5.93	4.22	3.93	4.63	4.75	4.60	0.72
1250	5.54	3.52	5.60	4.03	5.29	6.80	4.57	4.30	3.73	5.66	5.06	1.10
Linear	14.70	11.60	17.50	9.70	15.90	22.50	15.70	17.10	11.90	14.90	16.33 (16.03)	3.49 {0.98}
ISO	0.75	1.01	1.45	0.92	1.53	2.22	1.33	1.60	0.69	1.28	1.44 (1.42)	0.50 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.28. X-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]										Average Acceleration [m/s^2]		Standard Deviation	
6.3	0.28	0.86	0.39	0.29	0.32	0.34	0.69	0.73	0.49	0.57	0.52		0.17	
8	0.23	0.65	0.37	0.23	0.26	0.21	0.39	0.48	0.48	0.36	0.36		0.11	
10	0.18	0.43	0.31	0.21	0.18	0.14	0.24	0.34	0.39	0.24	0.25		0.09	
12.5	0.23	0.34	0.28	0.25	0.19	0.14	0.25	0.25	0.28	0.17	0.21		0.06	
16	0.19	0.34	0.22	0.19	0.22	0.17	0.22	0.23	0.30	0.19	0.22		0.04	
20	0.22	0.39	0.25	0.30	0.27	0.25	0.28	0.35	0.38	0.24	0.29		0.05	
25	0.55	0.89	0.71	0.89	0.44	0.58	0.88	1.08	0.86	0.51	0.73		0.25	
31.5	0.30	0.43	0.33	0.33	0.36	0.37	0.34	0.31	0.44	0.27	0.35		0.06	
40	0.39	0.52	0.57	0.47	0.70	1.01	0.52	0.52	0.52	0.48	0.62		0.21	
50	1.14	1.45	2.01	1.02	1.87	3.47	1.40	1.43	1.81	1.85	1.97		0.77	
63	1.09	1.05	1.20	1.04	1.66	2.14	1.30	1.80	1.10	1.40	1.57		0.38	
80	1.33	1.59	2.46	1.08	2.75	4.28	2.99	2.60	2.06	2.88	2.93		0.74	
100	1.45	1.82	2.56	1.52	4.53	5.79	4.64	3.94	2.18	3.86	4.16		1.19	
125	2.01	2.43	3.32	1.87	4.59	5.30	6.07	3.63	2.72	3.66	4.33		1.23	
160	2.18	2.50	2.93	1.80	3.52	3.90	4.90	3.19	2.47	2.85	3.47		0.86	
200	2.52	2.62	3.24	2.31	3.31	3.89	3.44	3.52	2.60	3.26	3.34		0.42	
250	2.45	2.97	3.44	2.72	3.81	4.51	4.43	3.93	3.43	4.19	4.05		0.41	
315	2.85	3.43	5.56	4.00	4.76	5.24	5.17	5.21	4.82	4.57	4.96		0.28	
400	4.37	3.66	5.09	4.13	5.49	6.01	5.68	5.85	5.64	5.77	5.74		0.18	
500	7.12	4.33	4.91	4.34	5.64	7.24	7.25	5.45	6.19	6.94	6.45		0.80	
630	7.18	5.75	6.02	5.37	6.02	7.95	7.18	5.61	8.53	7.59	7.15		1.13	
800	6.28	4.75	5.47	4.58	5.26	7.03	6.06	5.42	13.21	6.93	7.32		2.98	
1000	5.27	4.40	4.24	3.07	4.67	6.53	5.39	4.97	6.94	5.77	5.71		0.89	
1250	5.45	4.96	3.33	2.60	4.68	7.05	6.06	5.03	4.89	5.73	5.57		0.89	
Linear	15.90	13.50	15.30	12.00	16.90	21.70	19.80	16.60	21.50	18.80	19.22	(18.96)	2.20	{0.99}
ISO	1.10	1.70	1.26	1.12	1.62	2.17	1.91	1.79	1.58	1.61	1.78	(1.74)	0.23	{0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

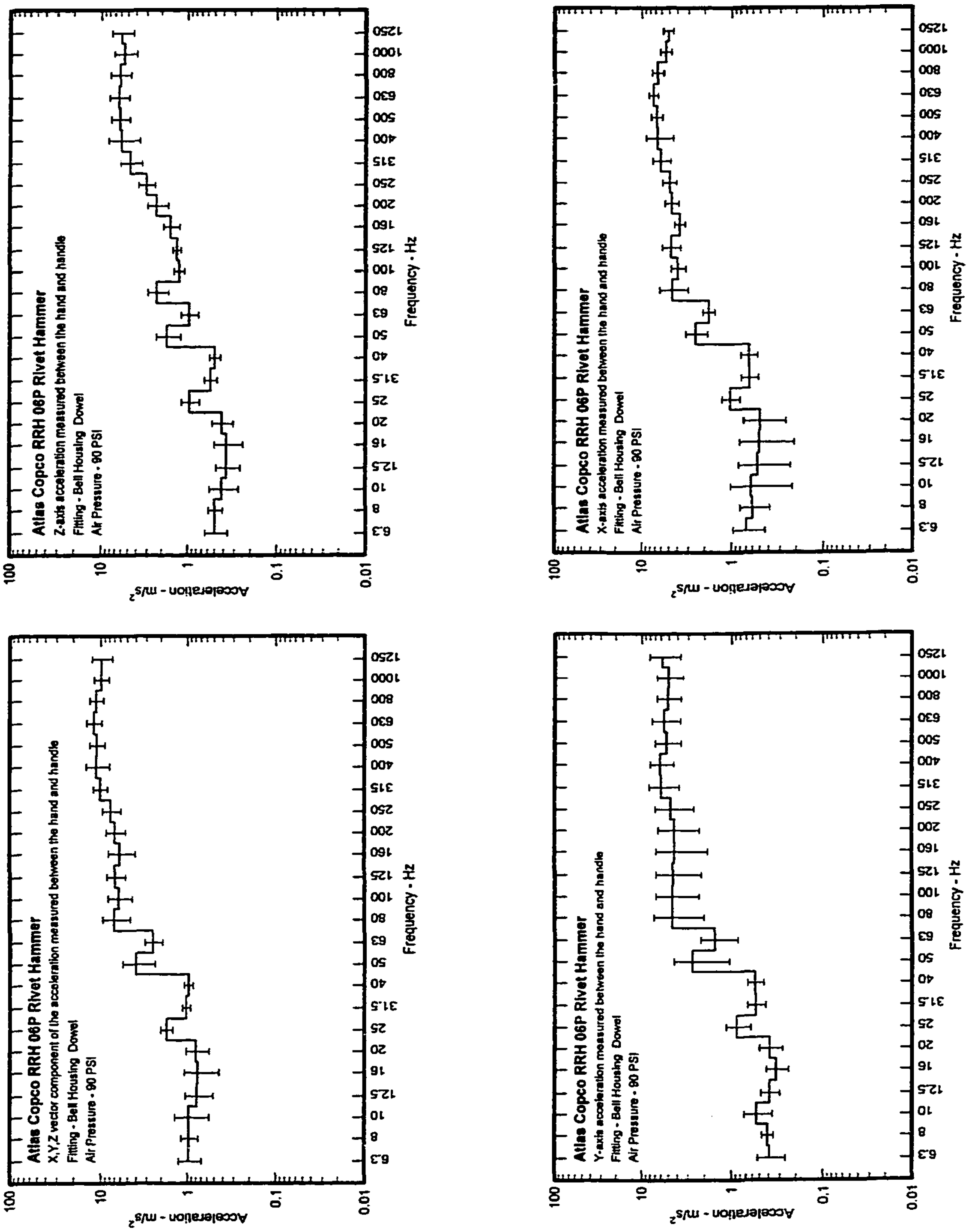


Fig. F.9. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 90 psi.

Table F.29. X,Y,Z vector third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.38	0.99	0.96	1.22	0.98	1.09	1.16	1.07	0.11
8	0.62	1.03	0.80	1.10	0.87	1.21	1.13	1.02	0.16
10	1.02	0.77	0.64	1.10	0.67	1.79	0.75	0.96	0.44
12.5	0.89	0.52	0.56	0.80	0.66	1.34	0.72	0.77	0.30
16	0.63	0.56	0.52	0.81	0.58	1.45	0.76	0.78	0.35
20	0.94	0.69	0.55	0.73	0.64	1.24	0.83	0.78	0.24
25	1.40	1.96	1.72	2.03	2.03	1.60	1.42	1.79	0.25
31.5	1.12	1.03	0.85	1.13	0.99	1.15	0.91	1.01	0.12
40	1.08	1.13	0.95	0.99	0.80	1.00	0.85	0.95	0.11
50	2.30	5.47	3.61	6.28	5.23	2.20	2.97	4.29	1.60
63	2.38	2.75	2.47	3.33	3.15	1.61	2.04	2.56	0.66
80	2.95	8.55	8.67	9.18	8.88	4.94	5.96	7.70	1.78
100	3.32	7.10	6.69	8.53	8.24	4.59	5.72	6.81	1.59
125	3.89	7.35	7.94	7.92	8.83	5.73	6.63	7.40	1.10
160	3.77	6.00	6.32	8.64	8.97	4.38	4.55	6.48	1.96
200	5.16	7.33	7.46	8.78	9.22	4.92	5.65	7.23	1.69
250	6.21	7.76	8.93	9.53	9.76	5.17	6.50	7.94	1.82
315	12.37	9.46	10.70	10.91	11.28	7.46	8.24	9.68	1.56
400	18.08	9.80	10.69	10.58	10.84	8.72	8.96	9.93	0.92
500	15.16	9.95	11.37	10.52	10.99	10.28	8.83	10.32	0.89
630	16.18	11.68	11.86	12.12	12.00	9.06	10.33	11.17	1.22
800	14.47	11.01	11.39	11.84	11.22	8.26	9.96	10.61	1.31
1000	13.52	9.66	9.80	10.06	9.69	7.36	9.05	9.27	0.99
1250	15.25	9.54	9.46	9.12	9.13	7.28	9.14	8.94	0.84
Linear	40.00	33.20	34.60	36.60	36.70	25.80	28.70	32.60 (32.48)	4.44 {1.00}
ISO	2.75	3.95	3.59	4.57	4.14	3.97	3.32	3.92 (3.83)	0.43 {0.98}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.30. Z-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.23	0.63	0.58	0.45	0.45	0.54	0.63	0.55	0.08
8	0.42	0.66	0.43	0.51	0.43	0.54	0.54	0.52	0.09
10	0.70	0.38	0.30	0.37	0.29	0.57	0.35	0.38	0.10
12.5	0.58	0.27	0.29	0.34	0.31	0.46	0.30	0.33	0.07
16	0.41	0.30	0.27	0.32	0.29	0.65	0.35	0.36	0.14
20	0.59	0.39	0.32	0.36	0.31	0.56	0.38	0.39	0.09
25	0.72	1.34	1.14	1.00	0.85	0.87	0.78	1.00	0.21
31.5	0.68	0.60	0.50	0.53	0.45	0.65	0.48	0.53	0.08
40	0.55	0.59	0.48	0.45	0.38	0.57	0.45	0.49	0.08
50	1.05	2.50	1.85	2.03	2.21	1.24	1.40	1.87	0.48
63	0.81	1.05	1.04	1.19	1.28	0.75	0.74	1.01	0.22
80	1.18	3.10	2.94	1.98	2.35	2.37	2.11	2.47	0.45
100	1.22	1.23	1.15	1.43	1.32	1.54	1.02	1.28	0.19
125	1.28	1.26	1.55	1.43	1.41	1.19	1.21	1.34	0.15
160	1.74	1.36	2.03	1.74	1.77	1.18	1.20	1.55	0.35
200	2.50	1.97	3.25	2.53	2.71	1.27	1.91	2.27	0.70
250	3.41	2.59	4.05	3.17	3.40	1.88	2.94	3.00	0.74
315	7.47	4.03	5.14	4.18	4.41	3.43	4.47	4.28	0.56
400	11.14	4.83	5.83	5.09	5.09	4.57	5.12	5.09	0.42
500	9.45	5.43	6.62	5.57	5.66	5.87	5.29	5.74	0.47
630	9.88	6.35	6.58	5.89	5.92	4.83	5.78	5.89	0.60
800	9.59	5.89	6.34	5.63	5.54	4.56	5.68	5.60	0.59
1000	8.94	4.97	5.47	4.85	4.85	4.09	5.23	4.91	0.47
1250	9.35	5.26	5.91	5.03	5.02	4.68	6.12	5.34	0.56
Linear	24.60	16.80	19.10	16.50	16.70	14.40	16.80	16.72 (15.14)	1.49 {0.91}
ISO	1.58	1.89	1.66	1.59	1.49	1.84	1.55	1.67 (1.59)	0.16 {0.95}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.31. Y-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.22	0.28	0.46	0.48	0.31	0.39	0.58	0.42	0.11
8	0.36	0.33	0.39	0.43	0.39	0.51	0.46	0.42	0.06
10	0.64	0.43	0.42	0.79	0.35	0.76	0.38	0.52	0.20
12.5	0.55	0.29	0.35	0.38	0.34	0.44	0.37	0.36	0.05
16	0.38	0.23	0.25	0.46	0.28	0.43	0.31	0.33	0.10
20	0.63	0.33	0.30	0.41	0.32	0.37	0.34	0.35	0.04
25	0.67	1.07	0.88	1.21	1.11	0.56	0.66	0.92	0.26
31.5	0.62	0.61	0.51	0.72	0.57	0.38	0.44	0.54	0.12
40	0.48	0.64	0.61	0.72	0.59	0.41	0.47	0.57	0.12
50	0.87	4.13	1.88	5.13	3.95	1.36	1.64	3.02	1.58
63	0.81	1.79	1.41	2.53	2.21	0.76	1.16	1.64	0.66
80	1.40	5.06	4.54	8.13	7.61	2.45	2.85	5.11	2.36
100	1.32	5.48	4.76	7.22	7.21	2.98	2.93	5.10	1.92
125	1.28	5.05	4.87	6.96	7.68	2.97	2.69	5.04	2.02
160	1.56	4.53	3.91	7.45	7.79	2.62	2.34	4.77	2.35
200	2.43	4.10	3.80	7.29	7.13	3.00	2.57	4.65	2.06
250	2.58	4.52	5.00	7.97	7.30	2.88	3.07	5.12	2.12
315	4.60	5.94	6.29	8.95	8.65	3.64	3.71	6.20	2.30
400	8.30	5.96	5.85	7.62	7.53	3.96	3.89	5.80	1.63
500	8.07	4.91	4.80	6.10	6.27	3.61	3.29	4.83	1.23
630	9.46	4.72	4.54	6.30	6.10	3.93	4.16	4.96	1.00
800	8.01	4.61	4.31	5.93	5.44	3.66	3.96	4.65	0.88
1000	8.38	4.86	4.42	5.24	4.78	3.59	3.95	4.47	0.61
1250	10.67	5.62	5.41	5.33	5.27	3.97	4.76	5.06	0.61
Linear	21.80	18.90	17.70	26.10	25.40	12.30	12.70	18.85 (18.69)	5.96 {0.99}
ISO	1.44	2.42	2.00	3.40	3.03	1.65	1.58	2.35 (2.29)	0.75 {0.98}

Comments:

1. *Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.*
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.32. X-axis third octave band acceleration of the handle while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6,3	0,20	0,69	0,57	1,02	0,80	0,84	0,76	0,78	0,15
8	0,28	0,50	0,44	0,78	0,57	0,86	0,77	0,65	0,17
10	0,38	0,48	0,35	0,65	0,47	1,49	0,51	0,66	0,42
12,5	0,38	0,30	0,29	0,60	0,45	1,15	0,51	0,55	0,32
16	0,29	0,36	0,32	0,54	0,37	1,14	0,55	0,55	0,31
20	0,36	0,40	0,28	0,44	0,42	0,99	0,62	0,52	0,25
25	1,00	0,78	0,80	1,22	1,42	1,16	0,92	1,05	0,26
31,5	0,64	0,58	0,45	0,69	0,67	0,87	0,65	0,65	0,14
40	0,79	0,80	0,62	0,57	0,45	0,79	0,61	0,64	0,13
50	1,85	3,07	2,76	3,29	3,01	1,47	2,26	2,64	0,67
63	2,08	1,92	1,86	1,96	2,00	1,29	1,57	1,77	0,28
80	2,31	6,40	6,97	3,94	4,13	3,81	4,93	5,03	1,35
100	2,79	4,38	4,58	4,38	3,82	3,23	4,84	4,20	0,58
125	3,45	5,22	6,12	3,56	4,17	4,77	5,96	4,97	1,00
160	2,96	3,71	4,57	4,04	4,11	3,33	3,73	3,92	0,43
200	3,81	5,75	5,54	4,20	5,18	3,69	4,66	4,84	0,80
250	4,50	5,75	6,18	4,14	5,50	3,86	4,91	5,05	0,92
315	8,73	6,08	6,86	4,50	5,64	5,47	5,74	5,71	0,77
400	11,56	5,90	6,52	5,04	5,68	6,11	6,03	5,88	0,50
500	8,68	6,30	7,35	6,05	6,57	7,18	5,81	6,54	0,62
630	8,64	7,67	7,80	7,73	7,69	5,91	6,63	7,24	0,79
800	7,30	6,86	7,06	7,53	7,03	4,81	5,85	6,52	1,00
1000	5,72	5,67	5,56	6,16	5,92	3,98	4,96	5,38	0,79
1250	5,60	5,60	4,97	5,39	5,49	3,87	4,78	5,01	0,65
Linear	22,70	21,50	22,80	19,60	20,50	17,60	19,60	20,27 (20,13)	1,79 {0,99}
ISO	1,73	2,48	2,48	2,60	2,40	3,12	2,47	2,59 (2,50)	0,27 {0,96}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

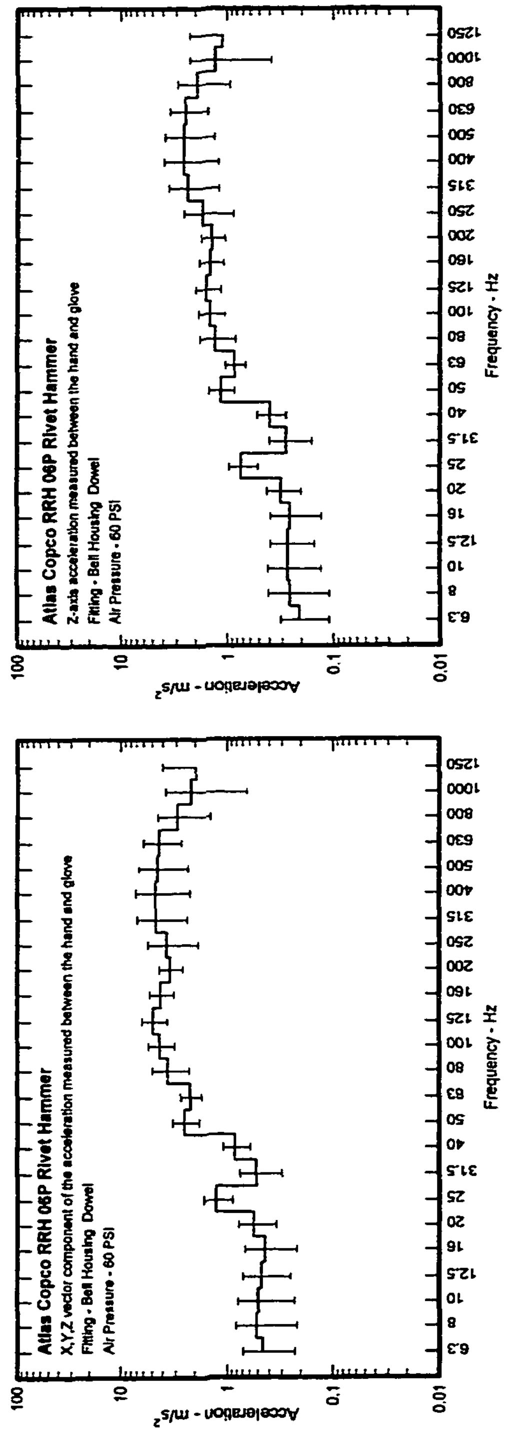


Fig. F.10. X,Y,Z and Z-axis vector third octave band acceleration values measured in the glove while inserting bell housing dowels with the RRH 06P rivet hammer supplied with of 60 psi.

Table F.33. X,Y,Z vector third octave band acceleration measured in the glove while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.57	0.86	0.33	0.40	0.27	0.31	0.46	0.23
8	0.80	1.06	0.34	0.40	0.33	0.32	0.54	0.31
10	0.88	0.90	0.37	0.36	0.32	0.33	0.53	0.28
12.5	0.62	0.88	0.40	0.36	0.32	0.31	0.48	0.22
16	0.76	0.77	0.37	0.35	0.27	0.26	0.46	0.24
20	0.83	0.79	0.63	0.39	0.37	0.38	0.57	0.21
25	1.22	1.21	1.02	0.80	1.85	1.06	1.19	0.36
31.5	0.64	0.90	0.45	0.36	0.42	0.32	0.52	0.22
40	1.11	1.17	0.74	0.73	0.54	0.70	0.83	0.25
50	3.14	1.89	1.86	2.34	3.69	2.67	2.60	0.72
63	2.94	2.05	1.91	2.74	1.66	2.25	2.26	0.49
80	4.06	2.45	2.54	4.04	6.36	3.60	3.84	1.42
100	6.46	5.24	2.82	3.74	4.46	4.65	4.56	1.25
125	5.31	8.11	3.80	4.81	6.06	6.56	5.77	1.50
160	5.49	7.33	4.45	3.86	4.14	6.12	5.23	1.34
200	5.21	5.43	3.08	3.75	3.14	4.02	4.10	1.01
250	7.15	6.55	2.64	4.05	3.57	1.90	4.31	2.11
315	9.00	6.70	2.51	5.36	3.99	2.85	5.07	2.48
400	9.21	6.47	2.91	4.51	3.44	2.63	4.86	2.55
500	8.62	6.11	3.94	3.85	3.04	2.64	4.70	2.27
630	7.66	5.28	5.12	3.78	2.99	2.98	4.63	1.79
800	6.72	4.10	3.65	2.27	2.34	1.90	3.50	1.80
1000	5.51	3.32	2.20	1.19	1.50	0.93	2.44	1.73
1250	5.58	2.84	1.39	0.74	0.76	0.35	1.94	1.98
Linear	21.09	15.76	9.85	10.69	10.28	8.90	12.76 (16.20)	4.74 {1.27}
ISO	3.05	3.14	1.83	1.91	2.59	1.96	2.41 (2.32)	0.59 {0.96}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.34. Z-axis third octave band acceleration measured in the glove while inserting bell housing dowels with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.26	0.40	0.15	0.18	0.12	0.14	0.21	0.10
8	0.38	0.51	0.16	0.19	0.16	0.15	0.26	0.15
10	0.45	0.46	0.19	0.18	0.16	0.17	0.27	0.14
12.5	0.34	0.49	0.22	0.20	0.17	0.17	0.27	0.12
16	0.42	0.42	0.20	0.19	0.15	0.14	0.26	0.13
20	0.45	0.43	0.34	0.21	0.20	0.21	0.31	0.11
25	0.75	0.74	0.63	0.49	1.14	0.65	0.73	0.22
31.5	0.35	0.49	0.24	0.20	0.23	0.17	0.28	0.12
40	0.53	0.56	0.36	0.35	0.26	0.34	0.40	0.12
50	1.41	0.85	0.83	1.05	1.66	1.20	1.17	0.32
63	1.11	0.77	0.72	1.04	0.63	0.85	0.85	0.19
80	1.38	0.84	0.87	1.38	2.17	1.23	1.31	0.49
100	2.07	1.68	0.90	1.20	1.43	1.49	1.46	0.40
125	1.45	2.21	1.04	1.31	1.65	1.79	1.58	0.41
160	1.54	2.05	1.25	1.08	1.16	1.71	1.47	0.37
200	1.79	1.86	1.06	1.28	1.08	1.38	1.41	0.35
250	2.84	2.60	1.05	1.60	1.42	0.75	1.71	0.84
315	4.22	3.14	1.18	2.52	1.87	1.34	2.38	1.16
400	4.93	3.47	1.56	2.41	1.85	1.41	2.60	1.36
500	4.79	3.39	2.19	2.14	1.69	1.47	2.61	1.26
630	4.15	2.86	2.78	2.05	1.62	1.62	2.51	0.97
800	3.71	2.27	2.02	1.26	1.29	1.05	1.93	0.99
1000	2.95	1.78	1.18	0.64	0.80	0.50	1.31	0.93
1250	3.21	1.63	0.80	0.43	0.44	0.20	1.12	1.14
Linear	11.90	8.89	5.56	6.03	5.80	5.02	7.20 (6.99)	2.67 {0.97}
ISO	1.35	1.39	0.81	0.85	1.15	0.87	1.07 (1.03)	0.26 {0.96}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

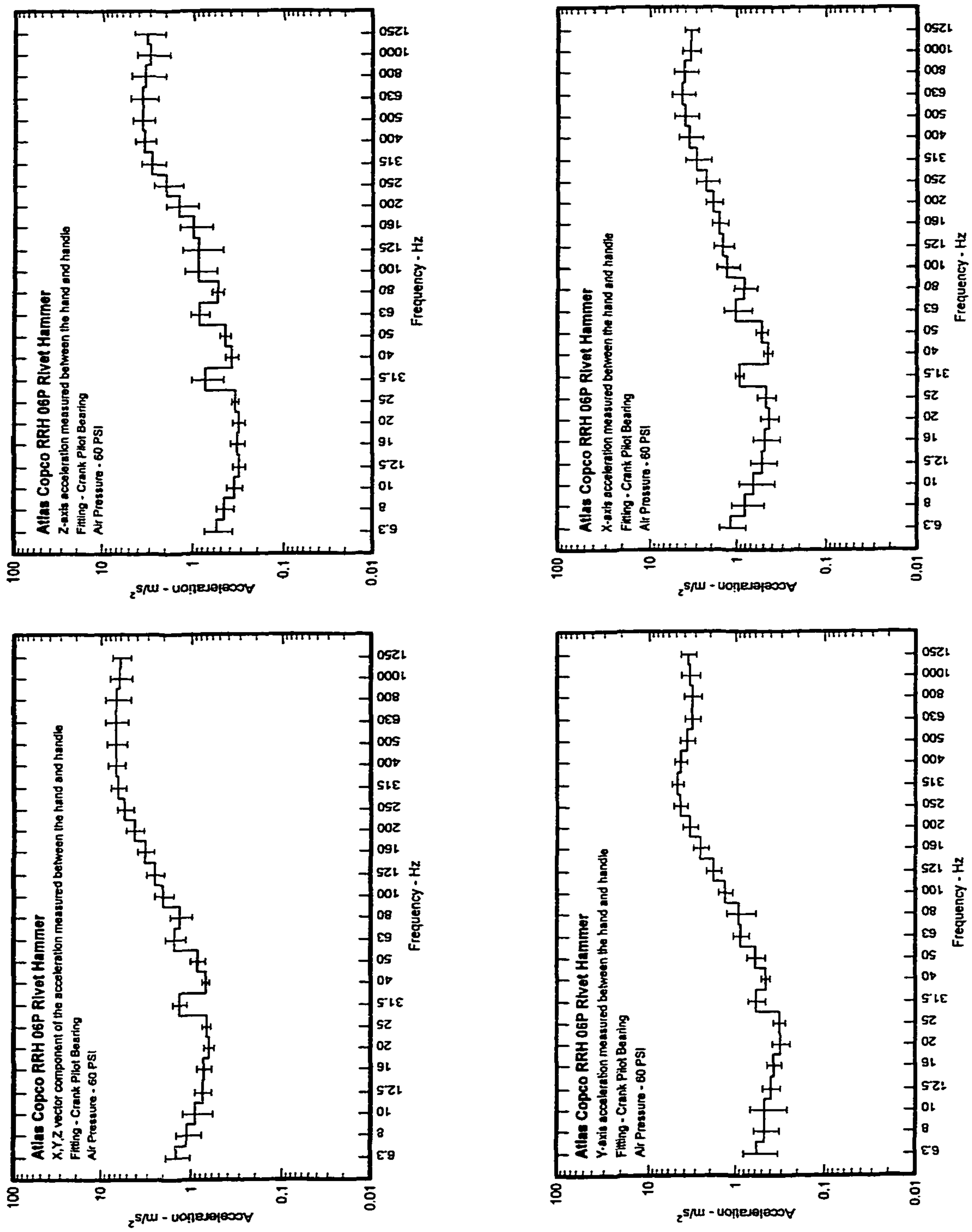


Fig. F.11. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Table F.35. X,Y,Z vector third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]		Standard Deviation	
6.3	2.24	1.28	1.54	1.17	1.02	1.46	1.45		0.43	
8	1.76	0.89	0.97	1.11	0.84	1.11	1.11		0.33	
10	1.33	0.70	0.83	0.76	0.59	1.29	0.91		0.32	
12.5	1.01	0.65	0.71	0.74	0.60	0.86	0.76		0.15	
16	0.91	0.62	0.63	0.76	0.66	0.86	0.74		0.13	
20	0.78	0.62	0.67	0.65	0.55	0.67	0.65		0.08	
25	0.80	0.74	0.64	0.64	0.63	0.71	0.69		0.07	
31.5	1.61	1.20	1.18	1.56	1.04	1.52	1.35		0.24	
40	0.67	0.65	0.80	0.75	0.64	0.74	0.71		0.06	
50	0.77	0.83	1.10	0.98	0.72	0.75	0.86		0.15	
63	1.94	1.57	1.61	1.87	1.04	1.07	1.52		0.38	
80	1.36	1.39	1.88	1.51	1.05	0.85	1.34		0.36	
100	2.67	1.92	2.15	2.47	1.58	1.43	2.04		0.49	
125	3.13	2.49	2.56	3.13	1.94	1.81	2.51		0.56	
160	3.60	3.27	3.38	4.26	2.64	2.37	3.26		0.68	
200	4.32	4.02	4.81	5.74	3.51	3.22	4.27		0.92	
250	5.95	5.20	6.26	7.04	4.03	4.44	5.49		1.14	
315	6.54	6.41	7.61	8.11	4.94	5.09	6.45		1.28	
400	7.56	7.06	7.30	9.05	5.13	5.06	6.86		1.53	
500	8.66	7.46	6.20	9.05	4.76	5.23	6.89		1.78	
630	9.08	8.01	5.95	9.10	4.59	5.14	6.98		2.01	
800	9.23	7.62	5.44	9.07	4.23	5.02	6.77		2.16	
1000	7.30	6.72	5.68	8.80	4.02	4.81	6.22		1.74	
1250	6.91	6.89	5.64	7.89	4.24	4.70	6.05		1.42	
Linear	23.50	20.90	19.50	25.80	14.00	15.20	19.82	(19.72)	4.60	{0.99}
ISO	3.81	2.04	2.67	2.68	2.06	2.86	2.69	(2.73)	0.65	{1.01}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.36. Z-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]						Average Acceleration [m/s^2]	Standard Deviation
6.3	0.84	0.52	0.72	0.50	0.37	0.38	0.56	0.19
8	0.62	0.37	0.44	0.56	0.39	0.39	0.46	0.10
10	0.48	0.28	0.33	0.36	0.31	0.39	0.36	0.07
12.5	0.36	0.24	0.28	0.34	0.32	0.39	0.32	0.05
16	0.38	0.22	0.31	0.36	0.38	0.37	0.33	0.06
20	0.38	0.25	0.35	0.34	0.30	0.31	0.32	0.05
25	0.40	0.31	0.36	0.36	0.32	0.35	0.35	0.03
31.5	1.11	0.54	0.53	1.05	0.47	0.83	0.75	0.28
40	0.36	0.27	0.45	0.43	0.37	0.38	0.38	0.06
50	0.43	0.37	0.52	0.51	0.39	0.45	0.45	0.06
63	1.09	0.78	0.80	1.07	0.59	0.81	0.86	0.19
80	0.63	0.52	0.60	0.63	0.47	0.47	0.55	0.08
100	1.55	0.69	0.76	0.85	0.89	0.78	0.89	0.33
125	1.70	0.75	0.69	0.91	0.69	0.59	0.89	0.41
160	1.53	0.86	0.99	1.41	0.70	0.60	1.01	0.38
200	1.63	1.48	1.78	2.12	0.87	0.74	1.44	0.54
250	2.25	2.04	2.55	2.76	1.30	0.98	1.98	0.70
315	3.19	2.74	3.39	4.04	1.88	1.89	2.86	0.86
400	3.83	3.51	3.55	4.92	2.39	2.66	3.48	0.90
500	4.66	3.77	3.03	4.91	2.69	2.80	3.68	1.01
630	5.32	3.95	2.98	4.76	2.32	2.56	3.65	1.23
800	5.33	3.86	2.48	4.55	1.94	2.20	3.39	1.39
1000	4.28	3.51	2.35	4.34	1.67	1.82	3.00	1.20
1250	4.32	4.19	2.79	4.49	1.96	1.83	3.26	1.22
Linear	14.20	11.40	9.44	14.30	6.74	7.16	10.54 (9.48)	3.33 {0.90}
ISO	1.71	1.06	1.31	1.44	1.07	1.19	1.30 (1.17)	0.25 {0.90}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.37. Y-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.83	0.32	0.81	0.69	0.31	0.47	0.57	0.24
8	0.71	0.27	0.55	0.49	0.39	0.43	0.47	0.15
10	0.50	0.25	0.58	0.41	0.29	0.83	0.47	0.21
12.5	0.43	0.26	0.51	0.38	0.33	0.49	0.40	0.09
16	0.31	0.29	0.41	0.43	0.33	0.47	0.37	0.07
20	0.29	0.20	0.37	0.34	0.29	0.38	0.31	0.07
25	0.28	0.24	0.34	0.34	0.33	0.38	0.32	0.05
31.5	0.72	0.39	0.59	0.68	0.50	0.70	0.59	0.13
40	0.38	0.45	0.49	0.47	0.43	0.53	0.46	0.05
50	0.47	0.54	0.83	0.71	0.52	0.51	0.60	0.14
63	1.05	0.91	1.05	0.94	0.67	0.67	0.88	0.18
80	0.76	0.90	1.56	0.99	0.74	0.61	0.93	0.34
100	1.54	1.30	1.59	1.56	1.09	0.97	1.34	0.26
125	2.03	1.87	2.16	2.19	1.47	1.28	1.83	0.38
160	2.74	2.69	2.92	3.40	2.24	1.86	2.64	0.54
200	3.33	3.23	3.88	4.79	3.08	2.85	3.53	0.71
250	4.67	4.12	5.05	5.79	3.46	4.13	4.54	0.82
315	4.29	4.76	5.90	5.52	4.21	4.34	4.83	0.71
400	4.46	4.58	4.94	5.46	3.90	3.44	4.46	0.72
500	4.22	4.22	3.92	4.53	2.74	2.98	3.77	0.73
630	3.57	4.05	3.14	3.97	2.35	2.75	3.30	0.68
800	3.19	3.86	3.09	4.35	2.17	2.88	3.25	0.76
1000	3.27	3.75	3.73	4.86	2.29	2.99	3.48	0.86
1250	4.00	3.99	3.79	4.60	2.58	2.96	3.65	0.74
Linear	12.50	12.90	13.60	15.50	9.74	10.40	12.44 (12.39)	2.12 {1.00}
ISO	1.59	1.03	1.67	1.52	1.06	1.49	1.39 (1.37)	0.28 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.38. X-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	1.88	1.11	1.05	0.78	0.89	1.32	1.17	0.39
8	1.41	0.71	0.58	0.70	0.57	0.89	0.81	0.32
10	1.11	0.57	0.48	0.49	0.39	0.88	0.65	0.28
12.5	0.82	0.53	0.38	0.51	0.35	0.55	0.52	0.17
16	0.73	0.49	0.30	0.44	0.34	0.57	0.48	0.16
20	0.57	0.51	0.38	0.38	0.31	0.41	0.43	0.10
25	0.62	0.61	0.38	0.38	0.41	0.45	0.47	0.11
31.5	0.92	1.00	0.87	0.94	0.78	1.06	0.93	0.10
40	0.47	0.41	0.52	0.47	0.37	0.41	0.44	0.05
50	0.53	0.57	0.61	0.57	0.42	0.44	0.52	0.08
63	1.40	1.13	1.04	1.38	0.66	0.55	1.03	0.36
80	1.00	0.97	0.92	1.01	0.63	0.43	0.83	0.24
100	1.73	1.28	1.29	1.77	0.97	0.81	1.31	0.39
125	1.81	1.48	1.23	2.07	1.10	1.15	1.47	0.39
160	1.81	1.68	1.43	2.18	1.24	1.36	1.61	0.35
200	2.23	1.88	2.23	2.34	1.46	1.29	1.91	0.44
250	2.92	2.43	2.66	2.89	1.61	1.27	2.30	0.70
315	3.68	3.24	3.29	4.24	1.73	1.82	3.00	1.01
400	4.60	3.93	3.88	5.05	2.19	2.45	3.68	1.15
500	5.39	4.56	3.49	5.71	2.55	3.02	4.12	1.30
630	5.58	5.15	3.67	6.01	2.88	3.15	4.41	1.34
800	5.63	4.50	3.25	5.63	2.73	3.09	4.14	1.30
1000	3.83	3.51	3.15	5.01	2.58	3.01	3.52	0.85
1250	3.59	3.70	3.10	4.54	2.72	3.15	3.47	0.63
Linear	13.80	11.90	10.20	14.90	7.49	8.40	11.12 (11.06)	2.95 {1.00}
ISO	3.02	1.89	1.63	1.67	1.41	2.13	1.96 (1.94)	0.57 {0.99}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

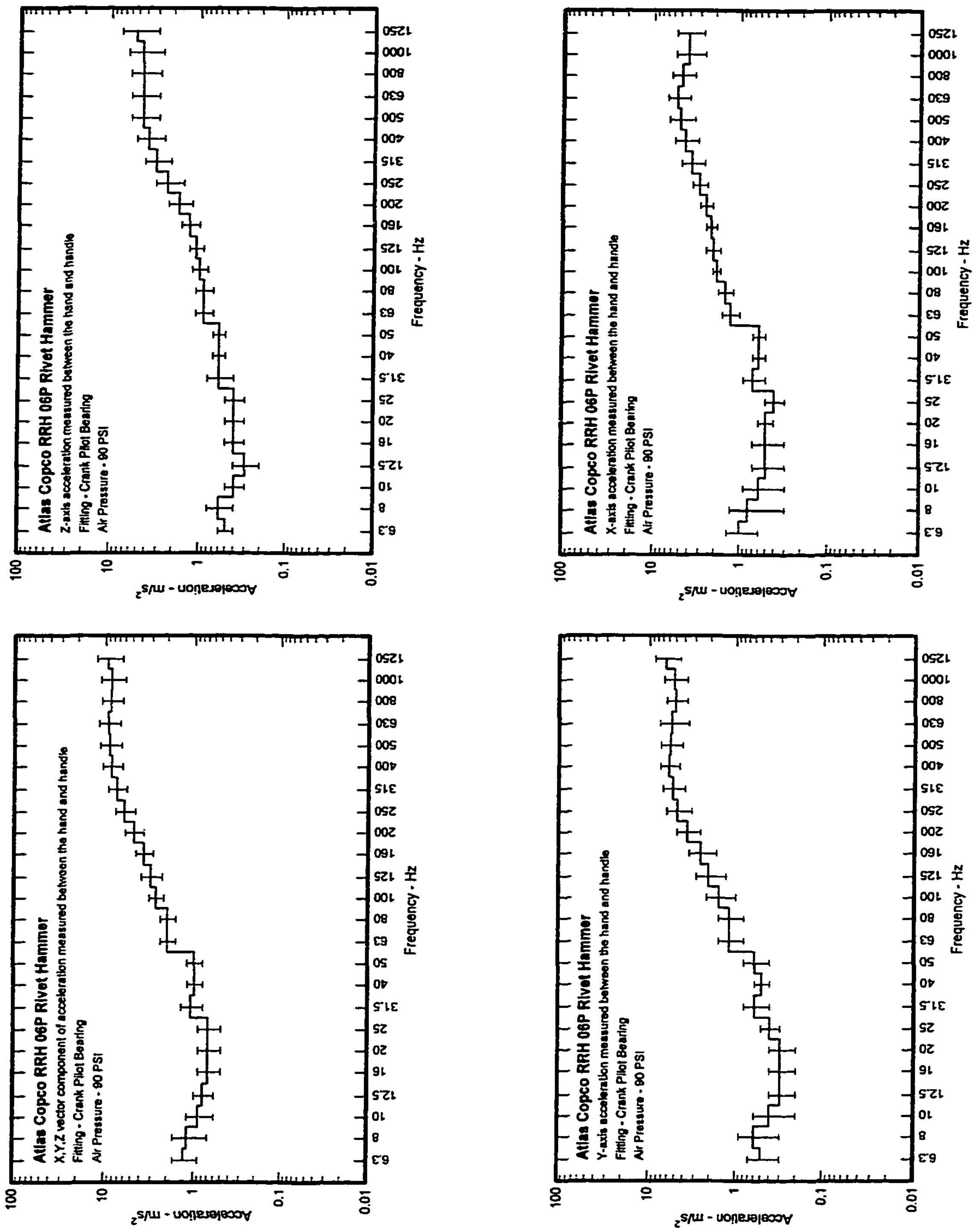


Fig. F.12. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 90 psi.

Table F.39. X,Y,Z vector third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	1.58	0.91	1.03	0.91	1.29	1.99	1.22	1.23	0.40
8	1.84	0.69	0.93	0.67	1.11	2.06	1.21	1.11	0.51
10	1.22	0.54	0.80	0.59	0.77	1.36	1.10	0.86	0.32
12.5	1.02	0.44	0.69	0.57	0.71	1.03	0.85	0.72	0.21
16	0.81	0.39	0.72	0.57	0.73	1.03	0.85	0.72	0.22
20	0.86	0.38	0.63	0.53	0.69	0.83	0.94	0.67	0.20
25	0.89	0.50	0.61	0.50	0.69	0.69	0.93	0.65	0.16
31.5	1.11	0.96	1.45	0.68	1.10	1.12	1.50	1.13	0.31
40	1.15	0.67	0.98	0.96	1.07	0.89	1.13	0.95	0.16
50	1.29	0.84	0.99	1.06	0.90	0.90	1.18	0.98	0.13
63	1.79	2.00	1.84	1.61	2.13	1.63	2.69	1.98	0.40
80	2.06	1.48	2.12	2.60	2.00	1.56	2.53	2.05	0.47
100	2.15	2.06	2.52	3.16	3.37	2.35	3.00	2.74	0.51
125	2.38	2.22	3.14	3.92	4.08	2.46	3.70	3.25	0.78
160	2.55	2.96	3.96	4.04	4.01	3.21	5.06	3.87	0.74
200	3.13	4.27	5.63	4.70	5.33	4.21	6.50	5.11	0.89
250	3.55	5.61	7.34	6.28	6.89	5.37	7.95	6.57	1.00
315	4.76	8.40	8.51	6.02	8.07	6.45	9.38	7.81	1.30
400	6.17	11.31	9.41	6.59	8.70	6.69	10.69	8.90	1.98
500	7.13	11.80	10.03	6.41	9.35	6.50	11.99	9.34	2.46
630	7.99	12.54	10.22	6.71	9.36	6.14	12.29	9.54	2.71
800	7.30	10.02	10.09	6.18	9.41	5.57	11.87	8.86	2.46
1000	7.24	9.97	9.28	5.83	9.86	5.01	12.52	8.75	2.82
1250	8.82	12.55	9.06	5.73	10.24	6.07	13.65	9.55	3.26
Linear	20.60	21.40	27.70	19.70	27.30	18.70	34.10	24.82 (26.15)	5.93 {1.05}
ISO	3.35	2.02	2.56	2.14	2.76	3.80	3.18	2.74 (2.69)	0.67 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.40. Z-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.76	0.41	0.53	0.44	0.44	0.61	0.65	0.51	0.10
8	1.06	0.36	0.50	0.35	0.43	0.58	0.58	0.47	0.10
10	0.59	0.28	0.43	0.37	0.37	0.32	0.43	0.37	0.06
12.5	0.49	0.26	0.33	0.36	0.37	0.26	0.36	0.32	0.05
16	0.45	0.22	0.33	0.35	0.38	0.34	0.43	0.34	0.07
20	0.46	0.20	0.32	0.30	0.33	0.39	0.47	0.34	0.09
25	0.46	0.24	0.34	0.30	0.30	0.35	0.46	0.33	0.07
31.5	0.66	0.45	0.77	0.35	0.50	0.64	0.81	0.59	0.18
40	0.71	0.31	0.65	0.61	0.68	0.53	0.57	0.56	0.13
50	0.79	0.44	0.56	0.55	0.52	0.60	0.65	0.55	0.07
63	0.93	0.72	0.82	0.73	0.85	0.83	1.30	0.87	0.21
80	0.94	0.59	0.92	1.07	0.88	0.85	1.14	0.91	0.19
100	0.96	0.65	0.97	1.23	0.92	1.09	1.34	1.03	0.24
125	1.07	0.71	1.21	1.20	1.13	1.02	1.30	1.10	0.21
160	1.18	0.97	1.70	1.06	1.33	1.04	1.74	1.31	0.34
200	1.32	1.38	2.37	1.04	1.78	1.52	2.48	1.76	0.57
250	1.56	2.01	3.05	1.35	2.29	2.06	3.68	2.41	0.83
315	2.36	3.39	4.01	1.66	3.21	2.25	4.48	3.17	1.06
400	3.06	4.44	4.74	2.28	3.97	2.48	5.89	3.97	1.38
500	3.85	5.02	5.23	2.74	4.41	2.58	6.76	4.46	1.59
630	4.21	5.63	5.35	2.73	4.14	2.57	6.49	4.48	1.61
800	4.31	6.04	5.05	2.33	4.27	2.49	6.30	4.41	1.71
1000	4.48	5.88	4.68	2.06	4.70	2.25	7.31	4.48	2.04
1250	5.16	6.30	5.41	2.30	5.48	2.97	9.37	5.30	2.53
Linear	11.30	10.10	15.40	7.54	13.50	8.25	20.80	12.60 (12.24)	5.03 {0.97}
ISO	1.77	0.89	1.40	1.14	1.26	1.36	1.65	1.28 (1.19)	0.26 {0.92}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.41. Y-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	0.79	0.48	0.37	0.27	0.56	0.59	0.68	0.49	0.15
8	0.86	0.37	0.35	0.17	0.69	0.88	0.71	0.53	0.27
10	0.59	0.29	0.32	0.22	0.44	0.64	0.64	0.43	0.18
12.5	0.45	0.26	0.30	0.20	0.40	0.40	0.40	0.33	0.09
16	0.36	0.22	0.29	0.21	0.35	0.44	0.45	0.33	0.10
20	0.38	0.20	0.25	0.21	0.35	0.38	0.55	0.33	0.13
25	0.34	0.31	0.26	0.22	0.39	0.39	0.59	0.36	0.13
31.5	0.45	0.65	0.74	0.37	0.65	0.63	1.05	0.68	0.22
40	0.48	0.34	0.55	0.56	0.54	0.54	0.72	0.54	0.12
50	0.51	0.46	0.65	0.75	0.66	0.51	0.90	0.65	0.16
63	0.81	1.10	1.17	1.17	1.80	0.99	1.68	1.32	0.34
80	1.06	0.73	1.16	1.89	1.20	0.80	1.26	1.17	0.41
100	1.12	0.98	1.49	2.24	2.45	1.26	1.69	1.69	0.57
125	1.08	1.20	2.08	2.96	2.71	1.67	2.82	2.24	0.71
160	1.30	1.89	2.98	3.01	2.93	2.42	3.92	2.86	0.68
200	1.71	2.97	4.47	3.96	4.39	3.26	5.04	4.01	0.78
250	1.92	3.90	5.70	5.79	5.79	4.17	6.05	5.23	0.94
315	2.43	5.44	6.12	5.43	6.41	5.24	6.97	5.94	0.68
400	3.68	8.51	6.06	5.49	6.21	5.34	6.55	6.36	1.15
500	4.18	9.13	5.45	4.72	6.07	4.89	5.91	6.03	1.61
630	4.77	9.84	4.71	4.43	5.61	4.13	5.54	5.71	2.11
800	3.95	7.10	5.16	4.03	5.47	3.44	5.57	5.13	1.29
1000	4.32	7.65	5.39	4.09	5.96	3.28	5.95	5.39	1.54
1250	6.18	10.40	5.84	4.41	6.56	4.48	7.55	6.54	2.25
Linear	12.30	15.70	17.00	15.20	18.40	13.50	19.40	16.53 (17.54)	2.17 {1.06}
ISO	1.58	1.11	1.29	1.19	1.65	1.65	1.92	1.47 (1.44)	0.32 {0.98}

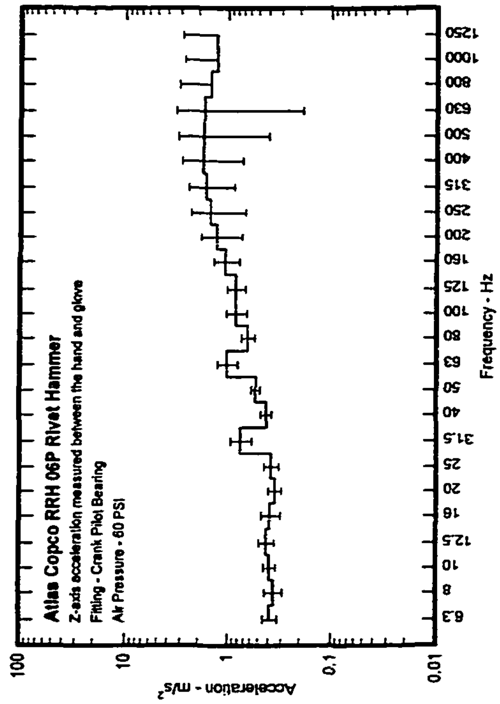
Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.42. X-axis third octave band acceleration of the handle while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]							Average Acceleration [m/s²]	Standard Deviation
6.3	1.13	0.66	0.79	0.73	1.07	1.78	0.75	0.96	0.43
8	1.23	0.46	0.58	0.48	0.67	1.71	0.65	0.76	0.47
10	0.89	0.36	0.55	0.36	0.48	1.15	0.75	0.61	0.30
12.5	0.78	0.25	0.49	0.36	0.40	0.91	0.63	0.51	0.24
16	0.57	0.24	0.52	0.30	0.44	0.84	0.50	0.47	0.21
20	0.62	0.24	0.44	0.34	0.45	0.58	0.52	0.43	0.12
25	0.68	0.32	0.41	0.32	0.47	0.42	0.51	0.41	0.08
31.5	0.78	0.54	0.98	0.45	0.73	0.66	0.70	0.68	0.18
40	0.76	0.49	0.63	0.61	0.74	0.56	0.75	0.63	0.10
50	0.87	0.55	0.62	0.64	0.48	0.59	0.61	0.58	0.06
63	1.30	1.50	1.27	0.94	0.92	1.13	1.84	1.27	0.36
80	1.49	1.14	1.60	1.56	1.42	1.13	1.97	1.47	0.32
100	1.56	1.69	1.86	1.97	2.17	1.74	2.19	1.93	0.21
125	1.83	1.72	2.08	2.32	2.87	1.55	2.08	2.10	0.47
160	1.86	2.06	2.03	2.48	2.42	1.85	2.72	2.26	0.33
200	2.26	2.74	2.48	2.30	2.45	2.19	3.29	2.58	0.39
250	2.55	3.49	3.46	2.03	2.94	2.68	3.60	3.03	0.61
315	3.35	5.42	4.23	1.97	3.64	2.96	4.26	3.75	1.19
400	3.90	5.98	5.21	2.75	4.45	3.07	5.76	4.54	1.37
500	4.29	5.53	6.20	3.14	5.23	3.21	7.37	5.11	1.67
630	4.83	5.36	6.58	3.90	5.73	3.41	7.93	5.48	1.68
800	4.37	3.68	6.03	3.70	5.55	3.13	7.02	4.85	1.56
1000	3.69	2.50	4.88	3.29	5.30	2.58	6.33	4.15	1.58
1250	3.59	3.10	4.28	2.83	5.60	2.80	6.35	4.16	1.52
Linear	12.10	10.30	15.60	9.98	15.00	9.92	18.70	13.25 (13.62)	3.71 {1.03}
ISO	2.36	1.26	1.72	1.37	1.81	3.13	1.92	1.87 (1.83)	0.67 {0.98}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.



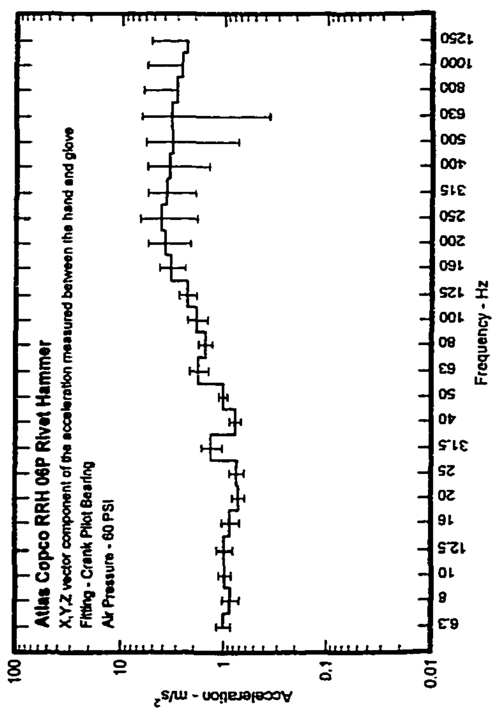


Fig. F.13. X,Y,Z and Z-axis vector third octave band acceleration values measured in the glove while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with of 60 psi.

Table F.43. X,Y,Z vector third octave band acceleration measured in the glove while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.96	1.23	0.89	1.16	0.80	1.02	1.01	0.16
8	0.64	1.10	0.81	0.97	0.82	0.89	0.87	0.16
10	0.85	1.09	0.99	1.21	0.87	0.93	0.99	0.14
12.5	0.80	1.18	1.09	1.13	0.77	0.95	0.99	0.18
16	0.64	1.05	1.00	1.00	0.80	0.71	0.87	0.17
20	0.57	0.81	0.78	0.82	0.65	0.69	0.72	0.10
25	0.59	0.92	0.76	0.83	0.70	0.69	0.75	0.12
31.5	1.11	1.06	1.42	1.57	1.86	1.13	1.36	0.32
40	0.60	0.86	0.84	0.85	0.81	0.75	0.78	0.10
50	0.89	1.17	1.00	1.03	1.06	0.97	1.02	0.10
63	1.37	1.57	1.58	1.91	2.45	2.11	1.83	0.40
80	1.66	1.85	1.52	1.75	1.35	1.18	1.55	0.25
100	1.72	2.00	1.86	2.72	1.73	1.48	1.92	0.43
125	2.15	2.50	2.41	3.13	2.43	1.66	2.38	0.48
160	3.05	3.80	3.19	4.88	3.74	1.98	3.44	0.96
200	3.56	4.93	4.26	6.39	2.77	1.53	3.91	1.70
250	4.10	5.87	5.36	7.19	1.60	1.33	4.25	2.37
315	4.66	5.67	4.41	5.16	1.77	1.23	3.82	1.85
400	5.27	6.11	4.23	4.00	1.12	0.85	3.60	2.16
500	5.96	6.99	3.21	2.51	0.84	0.68	3.36	2.62
630	6.41	7.87	2.86	1.54	0.72	0.95	3.39	3.03
800	6.46	7.52	2.16	0.83	0.49	0.57	3.00	3.16
1000	6.40	6.60	1.97	0.57	0.33	0.29	2.69	3.02
1250	6.23	5.95	1.51	0.43	0.22	0.20	2.42	2.88
Linear	15.96	18.35	9.93	10.75	5.88	4.61	10.91 (11.91)	5.42 {1.09}
ISO	1.95	2.67	2.38	2.69	2.26	2.15	2.35 (2.56)	0.29 {1.09}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.44. Z-axis third octave band acceleration measured in the glove while inserting crank pilot bearings with the RRH 06P rivet hammer supplied with 60 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.37	0.47	0.34	0.44	0.31	0.39	0.39	0.06
8	0.27	0.46	0.33	0.40	0.34	0.37	0.36	0.07
10	0.33	0.43	0.39	0.48	0.34	0.36	0.39	0.05
12.5	0.34	0.50	0.46	0.48	0.32	0.40	0.42	0.07
16	0.29	0.48	0.45	0.45	0.36	0.32	0.39	0.08
20	0.28	0.40	0.39	0.40	0.32	0.34	0.35	0.05
25	0.30	0.46	0.38	0.42	0.35	0.35	0.38	0.06
31.5	0.62	0.59	0.80	0.88	1.04	0.63	0.76	0.18
40	0.32	0.46	0.45	0.46	0.43	0.40	0.42	0.05
50	0.46	0.61	0.52	0.53	0.55	0.50	0.53	0.05
63	0.77	0.89	0.89	1.08	1.38	1.19	1.03	0.23
80	0.69	0.76	0.63	0.72	0.56	0.49	0.64	0.10
100	0.75	0.87	0.81	1.18	0.75	0.65	0.84	0.19
125	0.76	0.89	0.85	1.11	0.86	0.59	0.84	0.17
160	0.95	1.18	0.99	1.52	1.16	0.62	1.07	0.30
200	1.20	1.66	1.43	2.15	0.93	0.52	1.31	0.57
250	1.48	2.12	1.93	2.60	0.58	0.48	1.53	0.85
315	2.06	2.51	1.95	2.28	0.78	0.54	1.69	0.82
400	2.67	3.10	2.14	2.02	0.56	0.43	1.82	1.10
500	3.18	3.73	1.71	1.34	0.45	0.36	1.79	1.39
630	3.35	4.12	1.50	0.81	0.38	0.50	1.77	1.58
800	3.24	3.77	1.08	0.41	0.25	0.28	1.51	1.59
1000	3.08	3.18	0.95	0.28	0.16	0.14	1.30	1.45
1250	3.36	3.21	0.81	0.23	0.12	0.11	1.31	1.56
Linear	8.49	9.76	5.28	5.72	3.13	2.45	5.81 (5.33)	2.88 {0.92}
ISO	0.94	1.29	1.15	1.30	1.09	1.04	1.14 (1.12)	0.14 {0.99}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

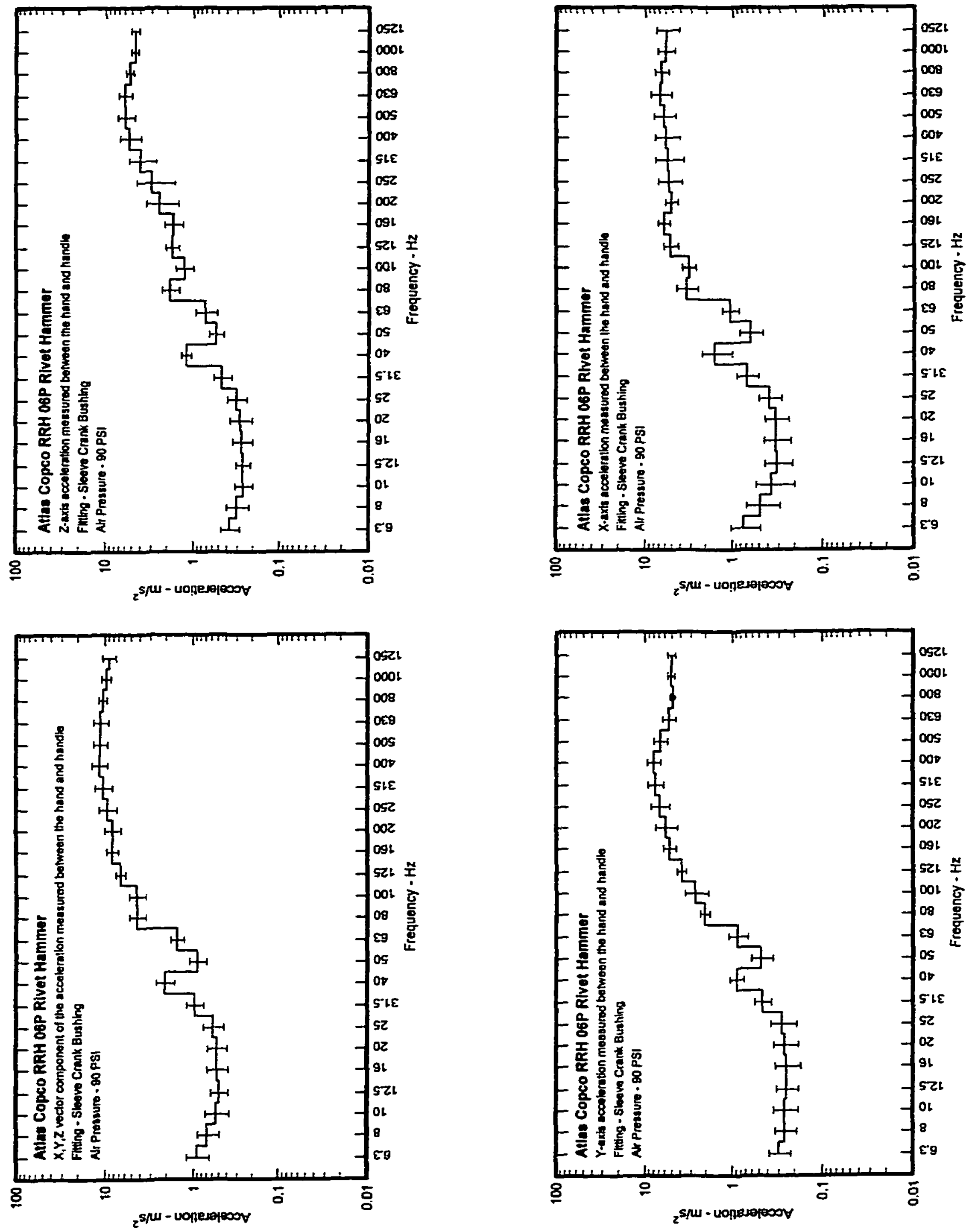


Fig. F.14. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Table F.45. X,Y,Z vector third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	1.08	0.48	0.89	0.75	1.24	1.01	0.91	0.27
8	0.98	0.39	0.70	0.62	0.81	0.62	0.69	0.20
10	0.84	0.31	0.55	0.48	0.57	0.52	0.54	0.17
12.5	0.66	0.30	0.51	0.49	0.49	0.58	0.50	0.12
16	0.72	0.27	0.58	0.47	0.55	0.58	0.53	0.15
20	0.70	0.28	0.62	0.50	0.54	0.55	0.53	0.14
25	0.79	0.33	0.68	0.62	0.55	0.57	0.59	0.16
31.5	1.03	0.55	0.99	0.87	1.14	1.15	0.96	0.22
40	1.76	1.69	1.70	2.95	2.12	2.32	2.09	0.49
50	1.02	0.67	1.10	1.14	0.75	0.72	0.90	0.21
63	1.24	1.48	1.88	1.72	1.27	1.46	1.51	0.25
80	3.44	4.35	4.40	6.03	4.10	3.63	4.32	0.92
100	2.97	4.69	4.74	3.92	4.13	5.77	4.37	0.94
125	5.34	6.37	6.58	7.90	7.04	7.01	6.71	0.85
160	6.30	7.89	8.32	9.94	8.04	9.23	8.29	1.25
200	5.58	7.20	9.78	10.22	7.95	8.51	8.21	1.71
250	6.79	7.06	9.88	11.81	11.30	9.55	9.40	2.09
315	6.96	8.65	10.32	12.64	12.39	12.07	10.51	2.31
400	8.14	9.91	10.84	13.10	13.17	13.97	11.52	2.27
500	9.05	10.09	10.04	11.34	13.60	13.95	11.34	2.02
630	10.07	10.16	9.82	9.57	14.64	13.38	11.28	2.17
800	9.71	10.16	9.91	9.74	12.50	11.06	10.51	1.09
1000	8.24	8.97	9.56	9.49	11.29	10.80	9.72	1.14
1250	7.24	7.83	9.42	8.30	11.25	10.28	9.05	1.54
Linear	26.30	29.60	32.50	35.80	38.60	37.60	33.40 (33.23)	4.82 {0.99}
ISO	2.77	2.26	2.84	3.13	3.01	2.99	2.83 (2.79)	0.31 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.46. Z-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s^2]						Average Acceleration [m/s^2]	Standard Deviation
6.3	0.43	0.22	0.44	0.46	0.37	0.30	0.37	0.09
8	0.39	0.19	0.37	0.40	0.32	0.20	0.31	0.09
10	0.29	0.16	0.34	0.29	0.24	0.20	0.26	0.06
12.5	0.28	0.17	0.31	0.29	0.23	0.26	0.26	0.05
16	0.32	0.14	0.34	0.24	0.27	0.29	0.27	0.07
20	0.34	0.14	0.37	0.23	0.28	0.29	0.28	0.08
25	0.39	0.19	0.39	0.28	0.30	0.31	0.31	0.08
31.5	0.49	0.28	0.56	0.37	0.54	0.52	0.46	0.11
40	1.33	1.24	1.14	1.05	1.05	1.43	1.21	0.16
50	0.58	0.37	0.68	0.58	0.52	0.48	0.54	0.11
63	0.58	0.42	1.01	0.74	0.88	0.74	0.73	0.21
80	1.74	1.52	2.23	2.48	1.66	1.51	1.86	0.40
100	1.31	0.91	1.26	1.08	1.45	1.77	1.29	0.30
125	1.79	1.32	1.56	1.81	2.19	1.77	1.74	0.29
160	1.53	1.00	1.84	1.90	2.05	1.93	1.71	0.39
200	1.26	1.17	3.06	3.20	3.04	2.96	2.45	0.96
250	1.28	1.27	3.61	3.73	4.43	3.71	3.00	1.37
315	2.24	2.51	4.10	4.58	5.51	5.08	4.00	1.35
400	3.62	3.98	5.00	5.77	7.23	6.79	5.40	1.47
500	4.83	4.60	5.16	6.00	7.82	7.03	5.91	1.29
630	5.65	5.69	5.11	5.11	7.66	6.93	6.03	1.04
800	5.32	5.66	4.85	4.60	5.98	5.35	5.29	0.51
1000	4.26	4.70	4.53	4.06	5.23	4.96	4.62	0.44
1250	4.10	4.11	5.02	4.37	5.18	4.91	4.61	0.48
Linear	13.90	14.20	15.50	15.19	20.20	18.50	16.25 (14.71)	2.53 {0.91}
ISO	1.25	0.83	1.36	1.28	1.26	1.20	1.20 (1.17)	0.19 {0.98}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.47. Y-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.39	0.20	0.28	0.22	0.35	0.34	0.30	0.08
8	0.36	0.15	0.27	0.22	0.27	0.28	0.26	0.07
10	0.35	0.14	0.23	0.26	0.34	0.27	0.26	0.08
12.5	0.34	0.12	0.26	0.27	0.28	0.25	0.25	0.07
16	0.32	0.10	0.26	0.24	0.29	0.27	0.25	0.08
20	0.32	0.10	0.29	0.29	0.25	0.29	0.26	0.08
25	0.34	0.11	0.34	0.36	0.25	0.31	0.28	0.09
31.5	0.47	0.27	0.56	0.45	0.49	0.50	0.46	0.10
40	0.82	0.60	0.90	0.98	1.04	0.97	0.89	0.16
50	0.61	0.28	0.54	0.60	0.39	0.48	0.48	0.13
63	0.69	0.94	1.10	0.84	0.58	1.05	0.87	0.21
80	1.78	2.20	2.24	2.26	1.63	2.29	2.07	0.29
100	1.69	3.09	3.26	2.23	2.07	3.89	2.71	0.84
125	3.29	4.06	4.16	3.80	3.57	4.50	3.89	0.44
160	4.10	5.13	5.07	6.50	4.92	6.14	5.31	0.87
200	3.61	5.45	6.71	8.41	5.04	6.03	5.87	1.62
250	5.43	6.00	6.92	9.97	6.74	6.19	6.88	1.61
315	5.71	7.54	7.08	10.01	7.17	8.73	7.71	1.49
400	6.25	8.15	7.00	9.68	7.33	9.39	7.97	1.36
500	5.75	7.70	5.71	6.65	6.33	8.70	6.81	1.18
630	5.03	5.60	4.92	4.36	5.87	6.99	5.46	0.92
800	4.49	4.65	4.59	5.08	5.12	5.17	4.85	0.31
1000	4.48	4.93	5.02	5.83	5.15	5.32	5.12	0.45
1250	4.03	5.05	5.26	5.20	5.52	5.20	5.04	0.52
Linear	16.30	20.20	19.60	24.20	19.50	23.00	20.47 (20.33)	2.81 {0.99}
ISO	1.38	1.38	1.58	1.73	1.45	1.71	1.54 (1.51)	0.16 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.48. X-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.90	0.37	0.71	0.53	1.12	0.89	0.75	0.27
8	0.77	0.27	0.46	0.29	0.65	0.49	0.49	0.20
10	0.69	0.21	0.33	0.23	0.36	0.38	0.37	0.17
12.5	0.47	0.20	0.27	0.25	0.30	0.43	0.32	0.11
16	0.52	0.19	0.31	0.27	0.33	0.37	0.33	0.11
20	0.49	0.19	0.33	0.30	0.34	0.33	0.33	0.10
25	0.58	0.23	0.41	0.41	0.36	0.34	0.39	0.11
31.5	0.78	0.39	0.60	0.65	0.87	0.89	0.70	0.19
40	1.13	1.22	1.11	2.65	1.64	1.77	1.59	0.59
50	0.69	0.55	0.81	0.87	0.52	0.41	0.64	0.18
63	0.93	1.09	1.31	1.39	0.91	0.84	1.08	0.23
80	2.56	3.54	3.30	5.19	3.49	2.52	3.43	0.97
100	2.17	3.43	3.27	3.08	3.34	3.98	3.21	0.59
125	3.89	4.76	4.90	6.73	5.73	5.13	5.19	0.96
160	4.55	5.91	6.35	7.30	6.04	6.63	6.13	0.92
200	4.06	4.56	6.44	4.87	5.35	5.23	5.09	0.81
250	3.86	3.50	6.05	5.09	7.90	6.24	5.44	1.64
315	3.23	3.36	6.22	6.11	8.36	6.48	5.63	1.98
400	3.57	3.79	6.41	6.41	7.89	7.49	5.93	1.84
500	4.57	4.15	6.04	6.43	8.48	7.74	6.23	1.70
630	5.69	5.27	6.06	6.09	10.00	8.04	6.86	1.81
800	5.56	5.73	6.42	6.05	8.69	7.20	6.61	1.17
1000	4.50	4.74	5.91	5.56	7.69	7.14	5.92	1.28
1250	4.37	4.33	5.96	4.74	8.31	7.35	5.84	1.68
Linear	15.20	16.20	20.80	21.00	26.40	23.30	20.48 (20.34)	4.23 {0.99}
ISO	2.05	1.59	1.93	2.27	2.32	2.13	2.05 (1.99)	0.27 {0.97}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

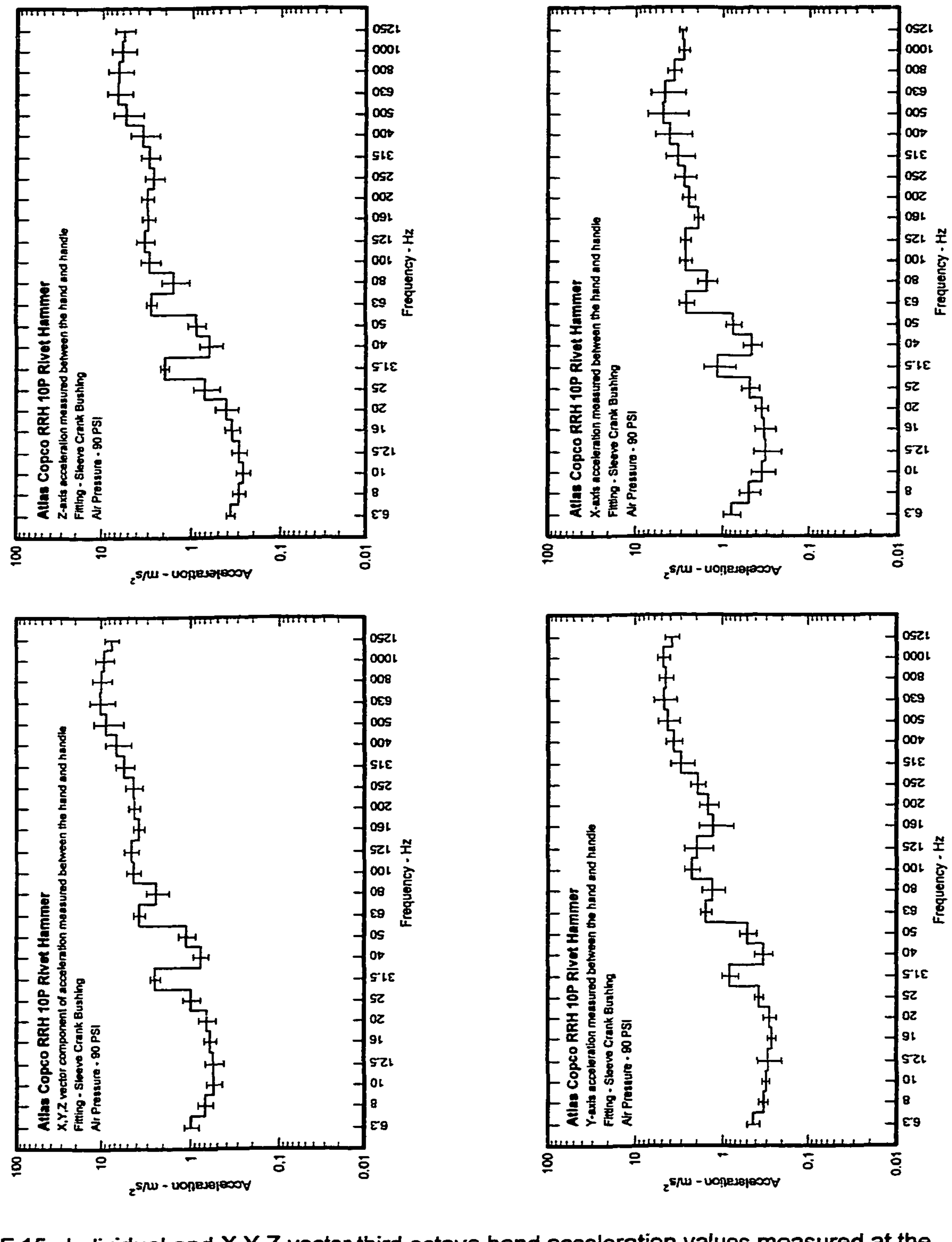


Fig. F.15. Individual and X,Y,Z vector third octave band acceleration values measured at the handle while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Table F.49. X,Y,Z vector third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	1.02	0.95	1.27	1.03	0.70	0.96	0.99	0.18
8	0.68	0.74	0.92	0.75	0.50	0.62	0.70	0.14
10	0.55	0.62	0.74	0.52	0.46	0.48	0.56	0.11
12.5	0.55	0.75	0.69	0.51	0.41	0.46	0.56	0.13
16	0.54	0.72	0.75	0.51	0.55	0.57	0.61	0.10
20	0.63	0.90	0.74	0.46	0.61	0.68	0.67	0.15
25	1.14	1.33	1.02	0.74	0.87	0.90	1.00	0.21
31.5	2.23	2.60	2.93	2.56	2.00	2.60	2.49	0.33
40	0.76	0.97	0.84	0.52	0.74	0.83	0.78	0.15
50	1.18	1.36	0.99	0.72	1.24	1.24	1.12	0.23
63	3.65	3.95	3.97	2.66	4.30	3.96	3.75	0.57
80	3.19	3.22	2.31	1.46	2.10	2.24	2.42	0.68
100	4.58	5.55	4.80	3.32	3.93	4.03	4.37	0.78
125	5.08	5.74	5.07	3.87	3.58	4.16	4.58	0.84
160	4.10	4.49	3.82	3.57	2.89	3.82	3.78	0.54
200	3.98	4.61	5.19	4.27	3.45	4.02	4.25	0.60
250	3.81	4.40	6.12	3.52	3.87	4.44	4.36	0.93
315	4.35	5.20	8.09	4.83	5.38	5.39	5.54	1.31
400	5.93	7.03	10.98	5.32	5.18	6.06	6.75	2.17
500	8.72	9.36	15.26	6.59	6.28	7.24	8.91	3.34
630	11.07	11.23	16.08	7.86	7.15	8.13	10.25	3.33
800	11.95	12.75	11.98	8.56	7.10	7.58	9.99	2.52
1000	10.93	11.62	11.61	7.32	7.10	7.52	9.35	2.25
1250	6.45	7.44	10.04	6.52	6.64	8.45	7.59	1.42
Linear	26.20	28.40	34.90	20.40	19.70	22.10	25.28 (25.08)	5.80 {0.99}
ISO	2.74	3.11	3.27	2.46	2.36	2.67	2.77 (2.75)	0.36 {0.99}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.50. Z-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]		Standard Deviation	
6.3	0.43	0.35	0.41	0.37	0.31	0.36	0.37		0.04	
8	0.32	0.29	0.38	0.31	0.24	0.26	0.30		0.05	
10	0.27	0.29	0.36	0.22	0.25	0.25	0.27		0.05	
12.5	0.27	0.39	0.38	0.23	0.28	0.29	0.30		0.06	
16	0.30	0.47	0.42	0.28	0.34	0.35	0.36		0.07	
20	0.39	0.63	0.43	0.26	0.41	0.42	0.42		0.12	
25	0.90	1.08	0.64	0.45	0.63	0.61	0.72		0.23	
31.5	1.99	2.18	1.90	1.79	1.74	2.26	1.97		0.21	
40	0.66	0.92	0.56	0.39	0.59	0.74	0.64		0.18	
50	0.94	1.02	0.77	0.56	0.94	1.13	0.89		0.20	
63	2.57	3.00	3.03	2.07	2.85	2.91	2.74		0.36	
80	2.22	1.98	1.72	0.79	1.28	1.40	1.57		0.52	
100	3.17	3.49	3.85	2.01	2.41	2.46	2.90		0.72	
125	3.67	4.07	4.25	2.67	2.49	2.84	3.33		0.76	
160	2.96	3.76	2.98	2.92	2.26	3.34	3.04		0.50	
200	2.75	3.32	3.81	3.29	2.39	2.98	3.09		0.50	
250	2.15	2.72	3.74	2.48	1.91	2.85	2.64		0.64	
315	2.52	3.31	4.15	2.88	2.20	2.63	2.95		0.70	
400	3.28	4.42	5.63	2.72	2.16	2.98	3.53		1.27	
500	5.52	6.28	8.99	3.96	3.53	4.57	5.47		2.00	
630	7.29	7.40	10.15	5.07	4.54	5.47	6.64		2.07	
800	8.14	9.12	7.59	5.18	4.22	4.82	6.51		2.03	
1000	7.43	7.95	7.66	4.19	4.17	4.76	6.02		1.83	
1250	4.48	5.25	8.02	4.79	5.12	6.97	5.77		1.40	
Linear	19.60	21.90	24.70	14.20	13.00	15.90	18.22	(16.39)	4.61	{0.90}
ISO	1.84	2.12	1.97	1.27	1.56	1.80	1.76	(1.80)	0.30	{1.02}

Comments:

1. *Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.*
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.51. Y-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.49	0.42	0.44	0.51	0.32	0.41	0.43	0.07
8	0.30	0.35	0.39	0.34	0.27	0.30	0.33	0.04
10	0.31	0.36	0.31	0.31	0.26	0.31	0.31	0.03
12.5	0.31	0.45	0.26	0.29	0.21	0.24	0.29	0.09
16	0.24	0.25	0.28	0.22	0.29	0.27	0.26	0.03
20	0.25	0.32	0.31	0.20	0.27	0.34	0.28	0.05
25	0.32	0.38	0.34	0.35	0.43	0.41	0.37	0.04
31.5	0.64	0.80	0.89	1.19	0.69	0.81	0.83	0.19
40	0.32	0.37	0.28	0.21	0.38	0.41	0.33	0.08
50	0.47	0.63	0.44	0.33	0.56	0.56	0.50	0.11
63	1.34	1.51	1.77	1.28	1.82	1.72	1.57	0.23
80	1.72	1.85	1.17	0.78	1.17	1.29	1.33	0.40
100	2.45	3.18	2.20	1.92	2.04	2.08	2.31	0.46
125	2.85	2.99	1.56	1.49	1.72	1.42	2.00	0.72
160	2.25	1.78	1.01	0.85	1.03	0.92	1.30	0.57
200	1.95	1.92	1.44	1.06	1.27	1.28	1.49	0.37
250	1.97	1.78	2.23	1.31	2.41	2.12	1.97	0.39
315	2.26	2.34	3.81	2.16	4.33	3.49	3.07	0.93
400	3.59	3.28	5.08	2.73	3.91	3.60	3.70	0.79
500	4.51	4.37	6.53	3.38	3.74	3.37	4.32	1.19
630	5.40	5.60	6.76	4.00	3.55	3.21	4.75	1.38
800	5.02	4.61	5.73	4.50	3.88	3.40	4.52	0.82
1000	5.33	5.52	5.71	4.32	4.14	3.97	4.83	0.77
1250	3.78	4.20	5.03	3.32	3.16	3.47	3.83	0.70
Linear	13.00	13.10	15.50	10.20	11.20	10.30	12.22 (12.08)	2.05 {0.99}
ISO	1.22	1.37	1.25	1.18	1.11	1.17	1.22 (1.19)	0.09 {0.98}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.52. X-axis third octave band acceleration of the handle while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.77	0.77	1.11	0.80	0.53	0.78	0.79	0.19
8	0.45	0.53	0.68	0.55	0.30	0.44	0.49	0.13
10	0.35	0.40	0.54	0.33	0.25	0.23	0.35	0.11
12.5	0.33	0.40	0.48	0.33	0.18	0.22	0.32	0.11
16	0.31	0.37	0.47	0.32	0.21	0.27	0.33	0.09
20	0.35	0.40	0.44	0.28	0.28	0.32	0.35	0.06
25	0.49	0.51	0.66	0.44	0.33	0.44	0.48	0.11
31.5	0.78	1.15	2.04	1.40	0.71	1.00	1.18	0.49
40	0.45	0.50	0.65	0.36	0.43	0.39	0.46	0.11
50	0.82	0.94	0.67	0.49	0.87	0.72	0.75	0.16
63	2.75	2.80	2.65	1.68	3.20	2.75	2.64	0.51
80	1.95	2.05	1.39	1.04	1.37	1.41	1.54	0.39
100	2.74	3.40	2.66	2.08	2.63	2.72	2.71	0.42
125	2.55	3.21	2.88	2.61	2.18	2.94	2.73	0.36
160	1.91	1.97	2.30	2.03	1.60	1.85	1.94	0.23
200	2.14	2.56	3.23	2.53	2.14	2.39	2.50	0.40
250	2.44	2.95	4.29	2.13	2.34	2.65	2.80	0.78
315	2.67	3.15	5.70	3.13	2.25	3.08	3.33	1.21
400	3.24	4.13	7.74	3.57	2.52	3.76	4.16	1.84
500	4.39	4.63	9.69	3.66	3.24	4.02	4.94	2.38
630	4.77	4.48	8.51	3.28	3.22	3.87	4.69	1.97
800	4.04	3.78	4.77	3.46	2.84	3.24	3.69	0.67
1000	2.65	2.90	3.59	2.86	2.62	2.52	2.85	0.39
1250	2.63	3.13	3.20	2.87	2.75	3.20	2.96	0.25
Linear	11.50	12.60	19.30	10.40	9.66	11.20	12.44 (12.29)	3.50 {0.99}
ISO	1.62	1.82	2.29	1.59	1.39	1.58	1.72 (1.69)	0.31 {0.99}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

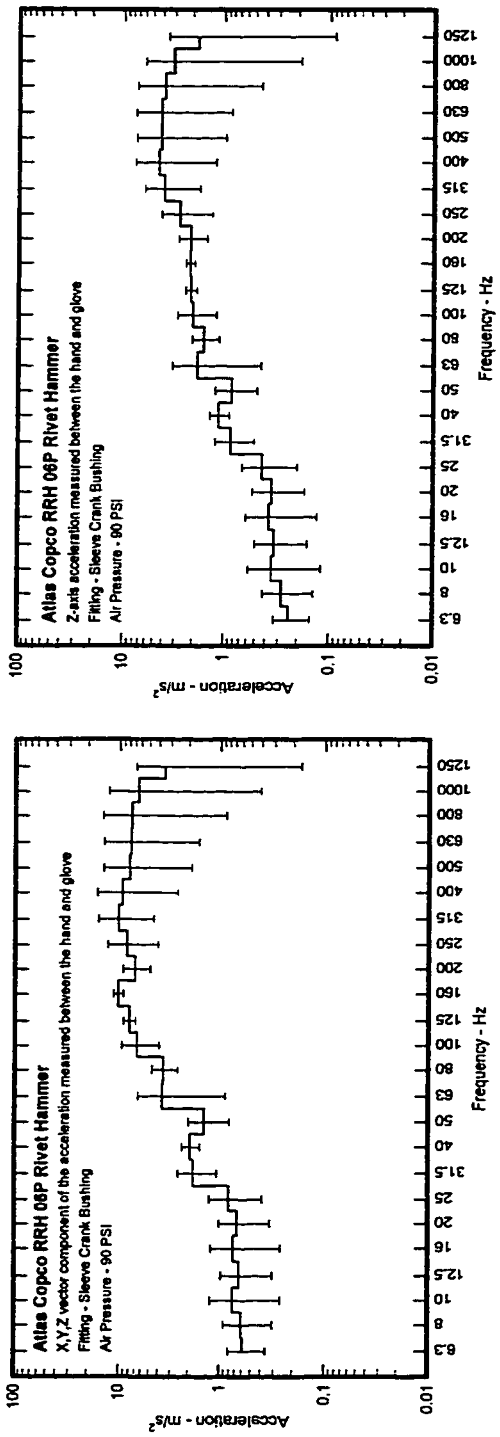


Fig. F.16. X,Y,Z and Z-axis vector third octave band acceleration values measured in the glove while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with of 90 psi.

Table F.53. X,Y,Z vector third octave band acceleration measured in the glove while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

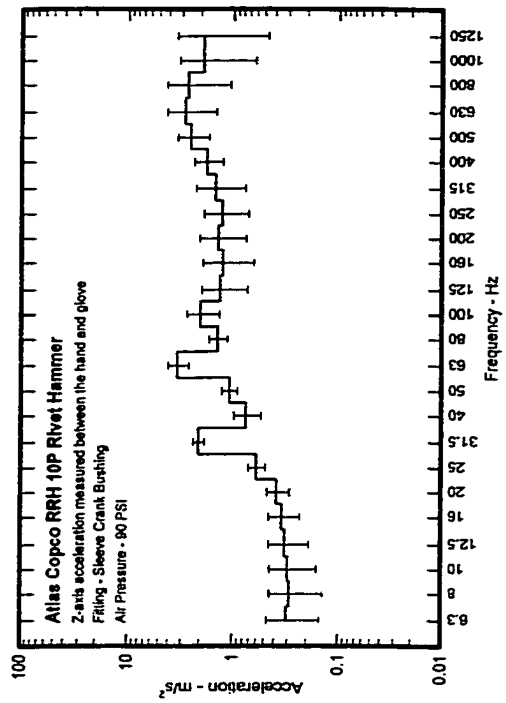
Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]		Standard Deviation	
6.3	0.68	1.01	0.57	0.39	0.46	0.43	0.59		0.23	
8	0.87	1.09	0.55	0.44	0.36	0.35	0.61		0.30	
10	0.97	1.62	0.60	0.54	0.35	0.38	0.74		0.48	
12.5	0.96	1.14	0.57	0.46	0.33	0.40	0.64		0.33	
16	1.19	1.46	0.55	0.48	0.31	0.42	0.73		0.47	
20	0.94	1.24	0.53	0.46	0.42	0.45	0.67		0.34	
25	1.15	1.55	0.53	0.54	0.53	0.61	0.82		0.43	
31.5	1.82	3.05	0.86	1.34	1.82	1.84	1.79		0.73	
40	1.64	1.82	2.59	2.09	1.97	1.48	1.93		0.39	
50	1.46	1.70	0.64	0.73	2.12	1.84	1.41		0.60	
63	1.62	3.13	1.13	1.91	7.57	6.84	3.70		2.81	
80	2.41	3.41	3.34	2.85	5.15	4.60	3.63		1.05	
100	4.07	5.18	4.37	6.66	10.75	9.24	6.71		2.74	
125	6.33	8.44	7.75	9.11	9.19	7.41	8.04		1.10	
160	9.71	9.55	9.66	12.11	11.01	9.53	10.26		1.07	
200	10.14	6.72	7.97	8.18	4.91	4.40	7.05		2.16	
250	16.36	7.89	9.63	8.26	3.97	4.83	8.49		4.42	
315	20.51	10.00	10.31	10.84	3.95	5.85	10.24		5.74	
400	19.83	13.25	9.32	10.35	1.82	2.06	9.44		6.87	
500	17.29	12.07	6.44	9.56	1.48	1.54	8.07		6.19	
630	17.60	12.57	4.73	7.85	1.99	2.16	7.82		6.23	
800	18.42	12.95	4.88	6.41	1.54	1.55	7.63		6.75	
1000	14.67	13.38	4.76	5.00	0.68	0.67	6.53		6.12	
1250	8.88	5.98	3.01	2.38	0.40	0.42	3.51		3.34	
Linear	47.07	33.30	20.12	23.84	14.88	13.90	25.52	(28.45)	12.69	{1.11}
ISO	3.81	4.64	2.84	2.60	3.53	3.24	3.44	(3.18)	0.73	{0.92}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.54. Z-axis third octave band acceleration measured in the glove while inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.28	0.41	0.23	0.16	0.19	0.18	0.24	0.09
8	0.39	0.49	0.25	0.20	0.16	0.16	0.28	0.14
10	0.46	0.76	0.28	0.25	0.16	0.18	0.35	0.23
12.5	0.49	0.58	0.29	0.23	0.17	0.20	0.33	0.17
16	0.60	0.73	0.27	0.24	0.15	0.21	0.37	0.24
20	0.49	0.64	0.27	0.24	0.22	0.23	0.35	0.18
25	0.61	0.82	0.28	0.28	0.28	0.32	0.43	0.23
31.5	0.88	1.47	0.41	0.65	0.88	0.89	0.86	0.35
40	0.95	1.05	1.50	1.21	1.14	0.86	1.12	0.23
50	0.87	1.01	0.38	0.44	1.26	1.09	0.84	0.36
63	0.78	1.51	0.54	0.92	3.66	3.30	1.79	1.35
80	1.03	1.46	1.43	1.22	2.21	1.97	1.56	0.45
100	1.21	1.53	1.29	1.97	3.18	2.74	1.99	0.81
125	1.64	2.19	2.01	2.36	2.38	1.92	2.09	0.28
160	2.00	1.97	1.99	2.50	2.27	1.97	2.12	0.22
200	3.02	2.00	2.37	2.44	1.46	1.31	2.10	0.65
250	5.23	2.52	3.08	2.64	1.27	1.54	2.71	1.41
315	7.82	3.81	3.93	4.13	1.51	2.23	3.90	2.19
400	9.29	6.21	4.37	4.85	0.85	0.96	4.42	3.22
500	9.00	6.29	3.36	4.98	0.77	0.80	4.20	3.23
630	9.41	6.72	2.53	4.20	1.06	1.15	4.18	3.33
800	9.28	6.52	2.46	3.23	0.77	0.78	3.84	3.40
1000	6.98	6.36	2.26	2.38	0.33	0.32	3.10	2.91
1250	4.53	3.04	1.53	1.21	0.20	0.22	1.79	1.70
Linear	22.90	16.20	9.79	11.60	7.24	6.76	12.42 (11.45)	6.17 {0.92}
ISO	1.61	1.96	1.20	1.10	1.49	1.37	1.46 (1.33)	0.31 {0.92}

Comments:
1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.



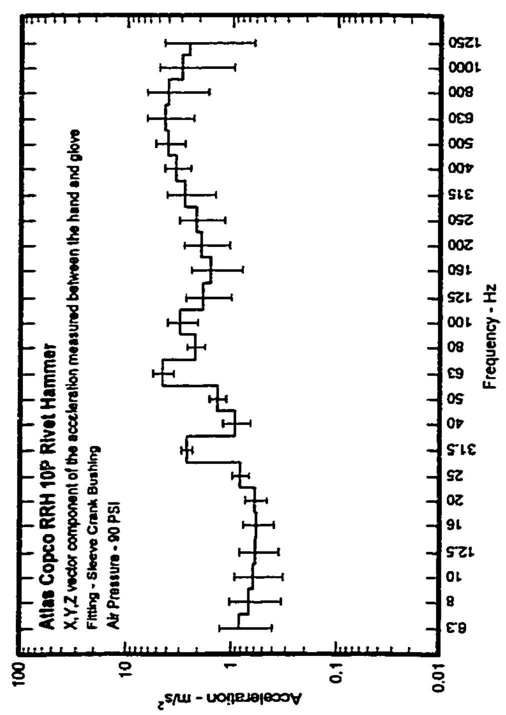


Fig. F.17. X,Y,Z and Z-axis vector third octave band acceleration values measured in the glove while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with of 90 psi.

Table F.55. X,Y,Z vector third octave band acceleration measured in the glove while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6,3	1.04	1.61	0.54	0.50	0.57	0.71	0.83	0.43
8	1.00	1.24	0.53	0.40	0.44	0.46	0.68	0.35
10	0.88	1.09	0.54	0.37	0.38	0.44	0.62	0.30
12,5	0.79	0.97	0.56	0.40	0.39	0.41	0.59	0.24
16	0.72	0.89	0.57	0.43	0.42	0.44	0.58	0.19
20	0.68	0.84	0.58	0.46	0.48	0.58	0.60	0.14
25	0.60	0.74	1.03	0.82	0.94	0.85	0.83	0.15
31,5	2.82	2.96	2.58	2.63	2.07	2.51	2.59	0.31
40	1.21	1.31	0.78	0.81	0.82	0.62	0.93	0.27
50	1.59	1.49	1.10	1.07	1.56	1.37	1.36	0.23
63	3.78	5.49	3.53	3.45	5.36	5.53	4.52	1.03
80	2.82	2.43	2.15	1.89	1.94	1.72	2.16	0.41
100	3.11	4.78	3.35	2.74	2.10	2.14	3.04	0.99
125	2.41	2.59	2.17	2.28	0.82	0.78	1.84	0.82
160	2.08	2.47	1.58	2.08	0.61	0.66	1.58	0.78
200	2.62	2.85	1.84	2.41	0.89	0.89	1.92	0.86
250	2.95	3.14	2.10	2.59	1.23	0.79	2.13	0.95
315	3.24	5.02	2.91	2.55	1.58	1.34	2.77	1.33
400	4.02	4.76	3.34	3.58	2.20	2.39	3.38	0.97
500	4.80	4.90	4.80	5.01	2.04	2.75	4.05	1.30
630	5.79	5.39	5.15	6.31	1.13	2.36	4.35	2.10
800	5.91	4.64	4.61	6.78	0.77	1.55	4.04	2.39
1000	4.79	2.63	3.03	5.61	0.62	1.00	2.95	1.99
1250	3.59	1.24	4.41	4.54	0.52	0.70	2.50	1.88
Linear	13.88	14.02	12.17	14.16	7.68	8.33	11.70 (12.12)	2.96 {1.04}
ISO	3.30	3.65	2.53	2.39	2.47	2.64	2.83 (2.57)	0.52 {0.91}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Table F.56. Z-axis third octave band acceleration measured in the glove while inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with 90 psi.

Frequency [Hz]	Measured Acceleration [m/s²]						Average Acceleration [m/s²]	Standard Deviation
6.3	0.39	0.61	0.20	0.19	0.22	0.27	0.31	0.16
8	0.43	0.53	0.23	0.17	0.19	0.20	0.29	0.15
10	0.43	0.53	0.26	0.18	0.19	0.21	0.30	0.14
12.5	0.43	0.53	0.31	0.22	0.21	0.22	0.32	0.13
16	0.43	0.53	0.34	0.25	0.25	0.26	0.34	0.11
20	0.43	0.53	0.37	0.29	0.30	0.37	0.38	0.09
25	0.43	0.53	0.74	0.59	0.68	0.61	0.60	0.11
31.5	2.24	2.35	2.05	2.08	1.65	1.99	2.06	0.24
40	1.00	1.08	0.65	0.67	0.68	0.51	0.76	0.22
50	1.27	1.19	0.87	0.86	1.25	1.09	1.09	0.18
63	2.76	4.01	2.58	2.52	3.92	4.04	3.30	0.75
80	1.83	1.57	1.39	1.22	1.25	1.11	1.40	0.26
100	2.06	3.17	2.22	1.81	1.39	1.42	2.01	0.66
125	1.75	1.88	1.57	1.66	0.60	0.57	1.34	0.60
160	1.67	1.98	1.27	1.67	0.49	0.53	1.27	0.63
200	1.90	2.07	1.34	1.75	0.65	0.65	1.39	0.63
250	1.79	1.90	1.27	1.57	0.75	0.48	1.29	0.57
315	1.73	2.67	1.55	1.36	0.84	0.71	1.48	0.71
400	2.10	2.49	1.74	1.87	1.15	1.25	1.77	0.51
500	2.95	3.01	2.95	3.08	1.25	1.69	2.49	0.80
630	3.75	3.49	3.34	4.09	0.73	1.53	2.82	1.36
800	3.85	3.03	3.00	4.42	0.50	1.01	2.64	1.58
1000	3.09	1.70	1.96	3.62	0.40	0.64	1.90	1.28
1250	2.73	0.95	3.35	3.45	0.40	0.53	1.90	1.43
Linear	10.00	10.10	8.77	10.20	5.53	6.00	8.43 (8.03)	2.14 {0.95}
ISO	2.10	2.32	1.61	1.52	1.57	1.68	1.80 (1.72)	0.33 {0.96}

Comments:

1. Linear & ISO values inside parenthesis were calculated using averaged third octave band acceleration values.
2. Values in squiggly brackets are ratio between calculated and averaged Linear and ISO values.

Appendix G. Vibration exposure at each station

Table G.1. Vibration Exposure at Section B - Station 91R: Operating RRH-06P rivet hammer with bare hand and air pressure at 30 PSI

Parts Installed	Installation Time t_i	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Front Cover Dowels (Air pressure - 30 PSI)	6 sec.	1.64 m/s²
Water By-Pass Tube[1]	3 sec.	1.64 m/s²
Chain Tensioner Dowel (Air pressure - 30 PSI)	6 sec.	2.66 m/s²

[1] Substituted value of Front Cover Dowel (Air Pressure - 30 PSI)

- Total Time, t_{total}: 15 sec.
- Exposure Time, T_e: 2.69 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{2.69}$	2.11 m/s²
Four Hour, T_4	1.73 m/s²
Eight Hour, T_8	1.22 m/s²

Table G.2. Vibration Exposure at Section B - Station 91R: Operating RRH-06P rivet hammer with bare hand and air pressure at 60 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Front Cover Dowels (Air pressure - 60 PSI)	6 sec.	2.29 m/s²
Water By-Pass Tube[1]	3 sec.	1.64 m/s²
Chain Tensioner Dowel (Air pressure - 60 PSI)	6 sec.	2.65 m/s²

[1] Substituted value of Front Cover Dowel (Air Pressure - 30 PSI)

- Total Time, t_{total}: 15 sec.
- Exposure Time, T_e: 2.69 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{2.69}$	2.33 m/s²
Four Hour, T_4	1.91 m/s²
Eight Hour, T_8	1.35 m/s²

Table G.3. Vibration Exposure at Section B - Station 141R: Operating RRH-06P rivet hammer with bare hand and air pressure at 30 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Bell Housing Dowels (Air pressure - 30 PSI)	6 sec.	2.03 m/s^2
Rear Seal Carrier Dowels (Air pressure - 30 PSI)	6 sec.	1.64 m/s^2

- Total Time, t_{total}: 12 sec.
- Exposure Time, T_e: 2.14 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{2.14}$	1.84 m/s^2
Four Hour, T_4	1.35 m/s^2
Eight Hour, T_8	0.95 m/s^2

Table G.4. Vibration Exposure at Section B - Station 141R: Operating RRH-06P rivet hammer with bare hand and air pressure at 60 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Bell Housing Dowels (Air pressure - 60 PSI)	6 sec.	2.36 m/s²
Rear Seal Carrier Dowels (Air pressure - 60 PSI)	6 sec.	2.29 m/s²
• Total Time, t_{total}: 12 sec. • Exposure Time, T_e: 2.14 hours		

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{2.14}$	2.33 m/s²
Four Hour, T_4	1.70 m/s²
Eight Hour, T_8	1.20 m/s²

Table G.5. Vibration Exposure at Section B - Station 141R: Operating RRH-06P rivet hammer with bare hand and air pressure at 90 & 60 PSI

Parts Installed	Installation Time t_i	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Bell Housing Dowels (Air pressure - 90 PSI)	6 sec.	3.76 m/s²
Rear Seal Carrier Dowels (Air pressure - 60 PSI)	6 sec.	2.29 m/s²

- Total Time, t_{total}: 12 sec.
- Exposure Time, T_e: 2.14 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{2.14}$	3.11 m/s²
Four Hour, T_4	2.28 m/s²
Eight Hour, T_8	1.61 m/s²

Table G.6. Vibration Exposure at Section C - Station 213L: Operating RRH-06P rivet hammer with bare hand and air pressure at 60 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Oil Slinger[1]	3 sec.	1.64 m/s²
Pilot Bearing/Bushing[2] (Air pressure - 60 PSI)	3 sec.	2.69 m/s²

[1] Substituted values of Front Cover Dowel (Air pressure - 30 PSI)
[2] Used value of Crank Pilot Bearing

- Total Time, t_{total}: 6 sec.
- Exposure Time, T_e: 1.07 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{1.07}$	2.23 m/s²
Four Hour, T_4	1.15 m/s²
Eight Hour, T_8	0.81 m/s²

Table G.7. Vibration Exposure at Section C - Station 213L: Operating RRH-06P rivet hammer with bare hand and air pressure at 90 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Oil Slinger[1]	3 sec.	1.64 m/s²
Pilot Bearing/Bushing[2] (Air pressure - 90 PSI)	3 sec.	2.83 m/s²

[1] Substituted values of Front Cover Dowel (Air pressure - 30 PSI)
[2] Used value of Crank Pilot Bearing

- Total Time, t_{total}: 6 sec.
- Exposure Time, T_e: 1.07 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{1.07}$	2.31 m/s²
Four Hour, T_4	1.20 m/s²
Eight Hour, T_8	0.85 m/s²

Table G.8. Vibration Exposure at Section C - Station 213L: Operating RRH-06P rivet hammer with bare hand and air pressure at 90 PSI

Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Oil Slinger[1]	3 sec.	1.64 m/s²
Pilot Bearing/Bushing[2] (Air pressure - 90 PSI)	3 sec.	2.83 m/s²

[1] Substituted values of Front Cover Dowel (Air pressure - 30 PSI)
[2] Used value of Sleeve Crank Bushing inserted with Atlas Copco RRH 06P Rivet Hammer

- Total Time, t_{total}: 6 sec.
- Exposure Time, T_e: 1.07 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{1.07}$	2.31 m/s²
Four Hour, T_4	1.20 m/s²
Eight Hour, T_8	0.85 m/s²

Table G.9. Vibration Exposure at Section C - Station 213L: Operating RRH-10P rivet hammer with bare hand and air pressure at 90 PSI

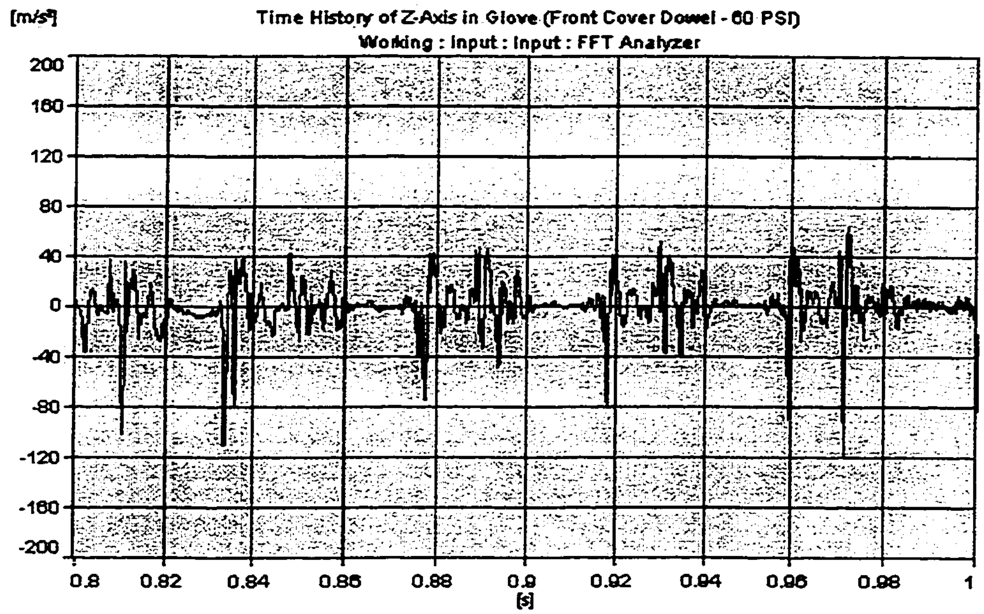
Parts Installed	Installation Time t_j	ISO Weighted Value of X,Y,Z vector component $a_{(x,y,z),w}$
Oil Slinger[1]	3 sec.	1.64 m/s²
Pilot Bearing/Bushing[2] (Air pressure - 90 PSI)	3 sec.	2.77 m/s²

[1] Substituted values of Front Cover Dowel (Air pressure - 30 PSI)
[2] Used value of Sleeve Crank Bushing inserted with Atlas Copco RRH 10P Rivet Hammer

- Total Time, t_{total}: 6 sec.
- Exposure Time, T_e: 1.07 hours

Daily exposure time, T_d	Daily exposure to ISO weighted acceleration $(a_{h,w})_{eq(Td)}$
Exposure Time, $T_{1.07}$	2.27 m/s²
Four Hour, T_4	1.18 m/s²
Eight Hour, T_8	0.83 m/s²

Appendix H. Z-axis acceleration time history plots for the Atlas Copco RRH rivet hammer handle



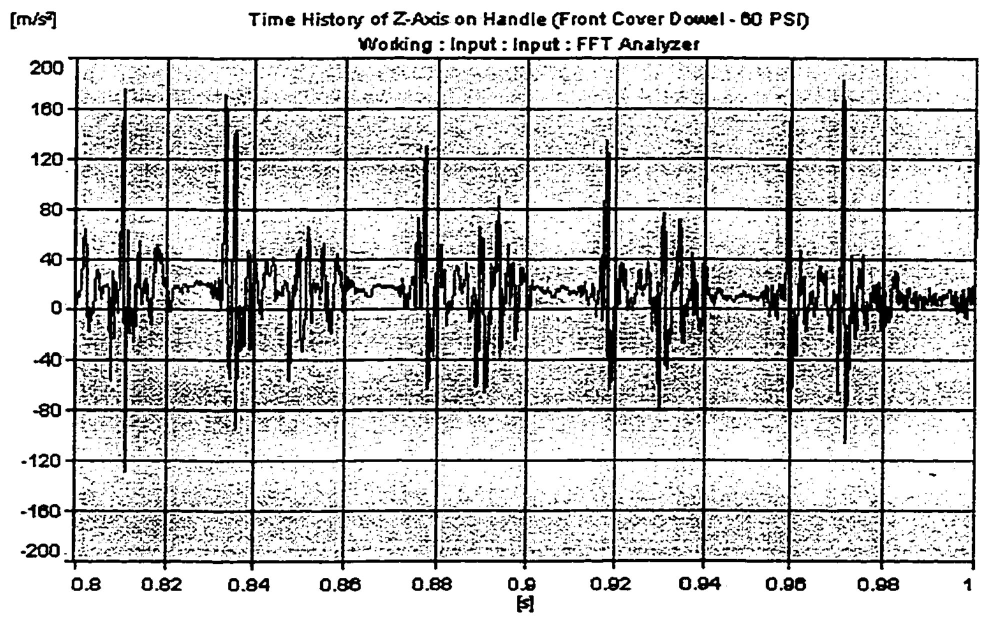
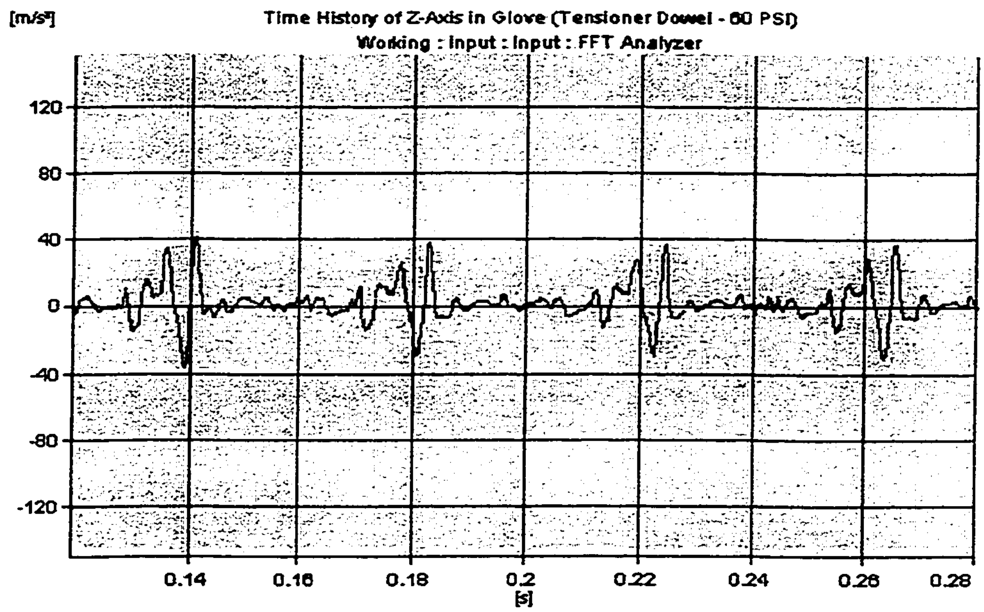


Fig. H.1. Time history plots of Z-Axis measurements made while inserting Front Cover Dowels with Atlas Copco RRH 06P Rivet Hammer



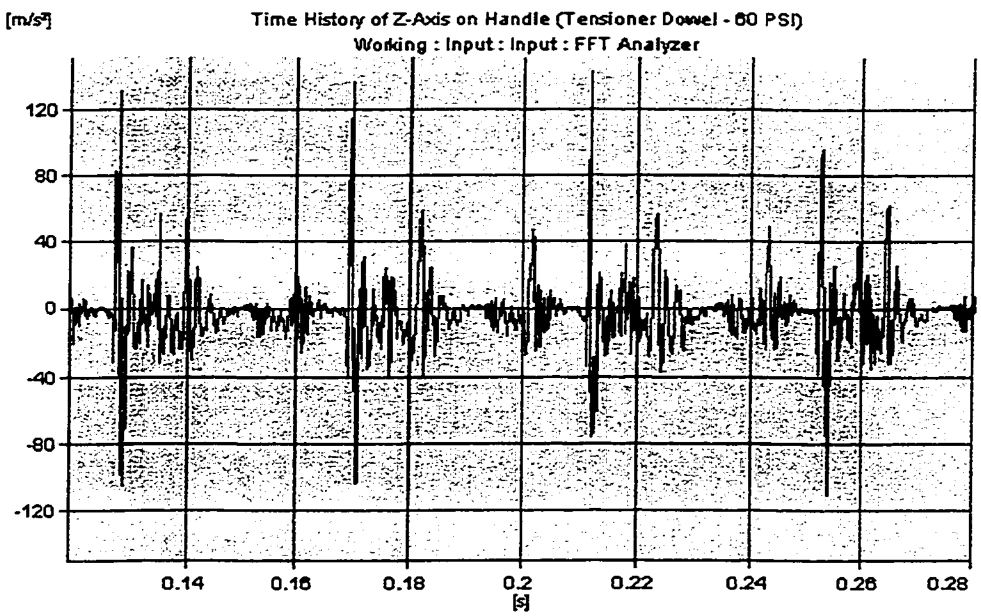
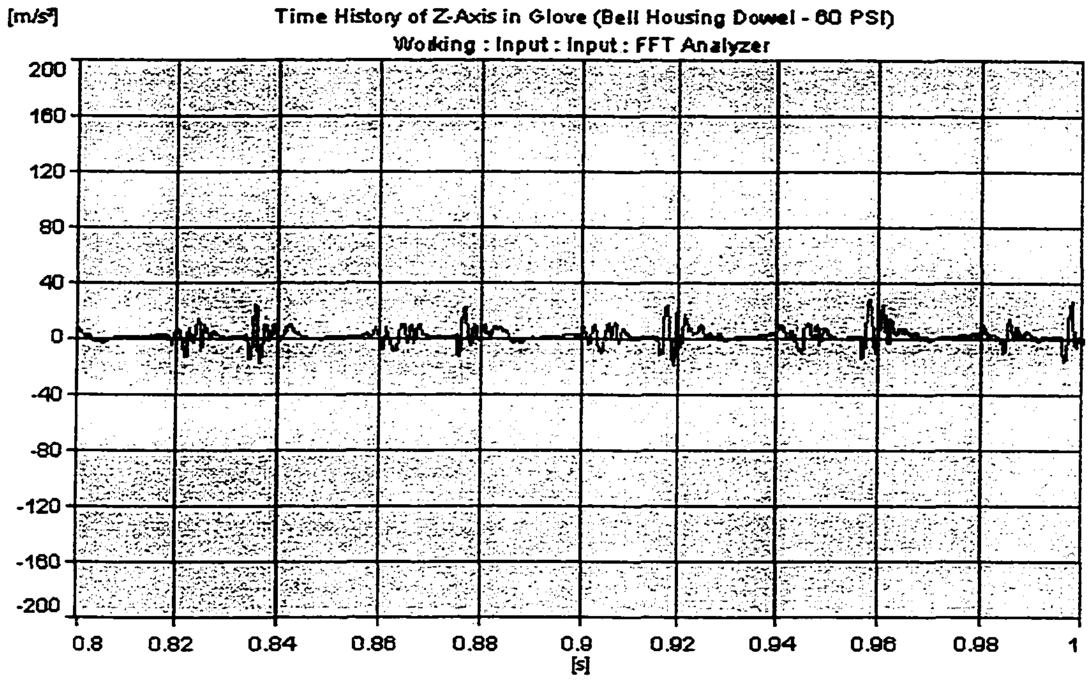


Fig. H.2. Time history plots of Z-Axis measurements made while inserting Tensioner Dowels with Atlas Copco RRH 06P Rivet Hammer



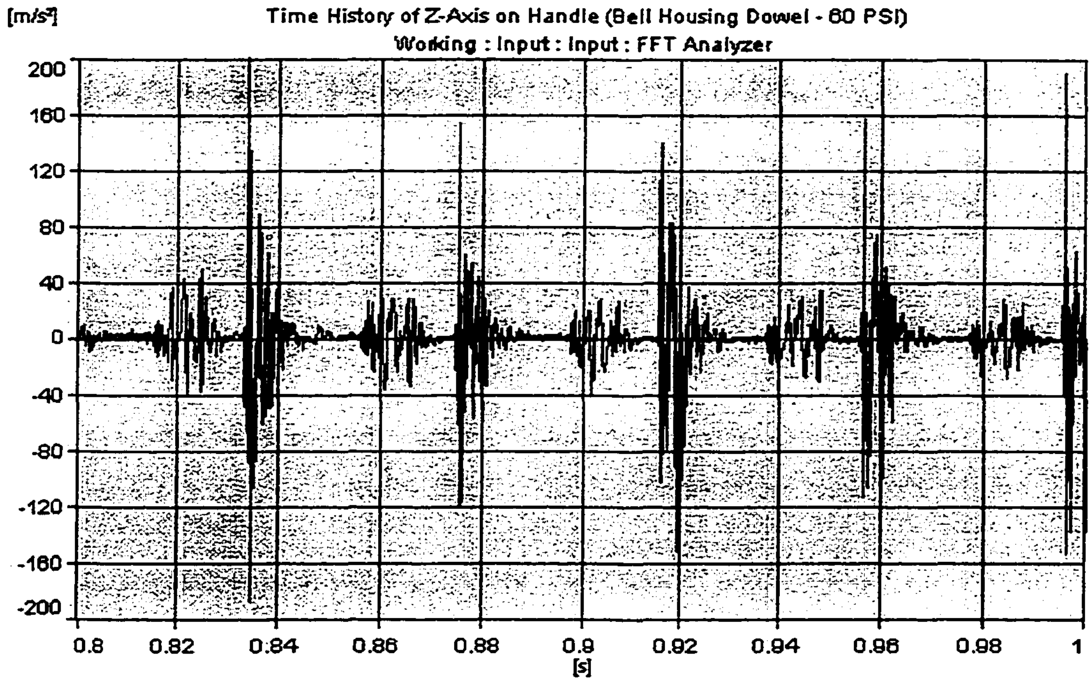
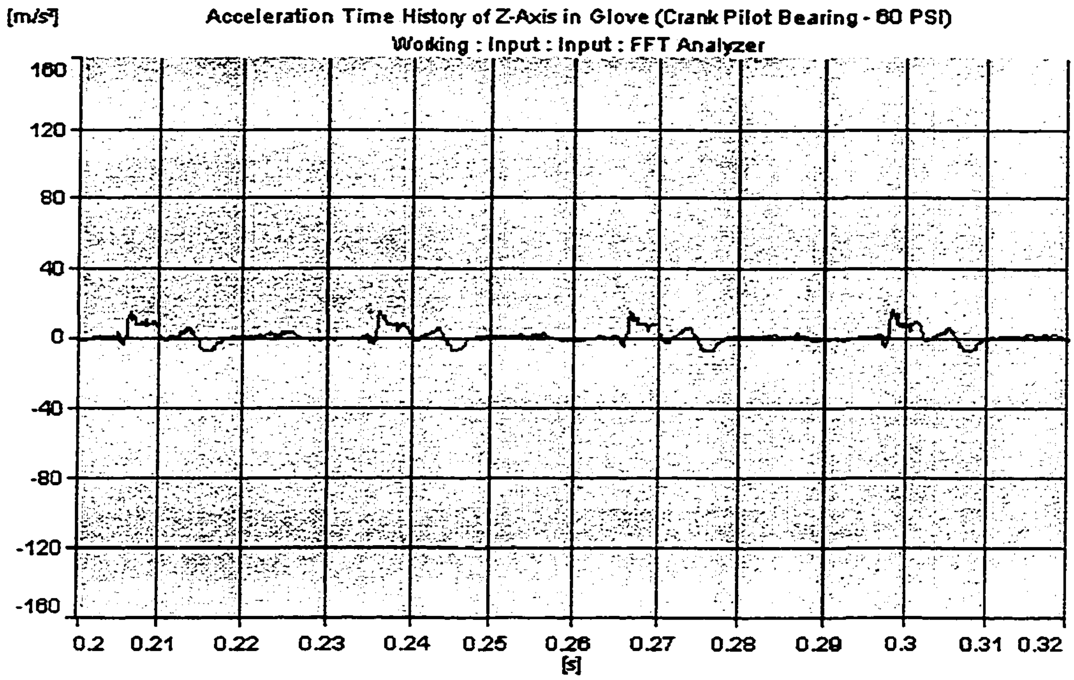


Fig. H.3. Time history plots of Z-Axis measurements made while inserting Bell Housing Dowels with Atlas Copco RRH 06P Rivet Hammer



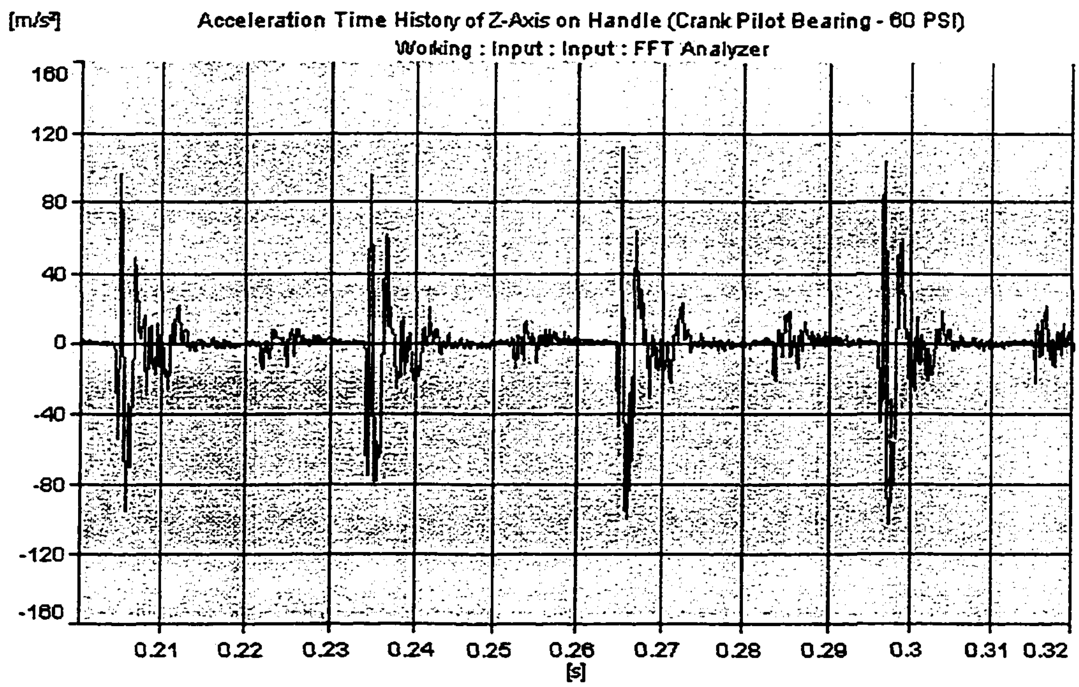


Fig. H.4. Time history plots of Z-Axis measurements made while inserting Crank Pilot Bearing with Atlas Copco RRH 06P Rivet Hammer

Appendix I. Measured masses of the various equipment used during the Atlas Copco RRH rivet hammer testing

Table I.1. Measured masses of the various equipment used during the rivet hammer testing

Item	Measured Mass [kg]	Measured Mass [lb]
Test fixture's mass	68	150
Atlas Copco RRH 06P rivet hammer	1.467	3.2
Atlas Copco RRH 10P rivet hammer	2.571	5.7
Insertion Tools for:		
▪ front cover dowel	0.1307	0.29
▪ tensioner dowel	0.1261	0.28
▪ bell housing dowel – deep	0.1597	0.35
▪ crank pilot bearing	0.3050	0.67
▪ sleeve crank bushing (RRH 06P)	0.5139	1.13
▪ sleeve crank bushing (RRH 10P)	0.6140	1.35
Parts Inserted:		
▪ front cover dowel	0.0057	0.013
▪ tensioner dowel	0.0172	0.038
▪ bell housing dowel	0.0170	0.038
▪ crank pilot bearing	0.0760	0.168
▪ sleeve crank bushing	0.1370	0.302
Insertion Plates for:		
▪ front cover/tensioner dowels	2.8688	6.3
▪ bell housing dowels	2.6304	5.8
▪ crank pilot bearing/sleeve crank bushing*	3.7210	8.2
* three riser bars	2.6139	5.8

Appendix J. Measured and calculated third octave band acceleration of the Atlas Copco RRH rivet hammer's handle

Table J.1. Z-axis acceleration when inserting front cover dowels with the RRH 06P rivet hammer supplied with an air pressure of 30 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.002	1.330	0.118	0.371
8	0.002	0.816	0.073	0.296
10	0.002	0.810	0.072	0.240
12.5	0.001	0.794	0.071	0.235
16	0.006	3.011	0.268	0.282
20	0.015	7.917	0.705	0.352
25	0.002	0.848	0.076	0.255
31.5	0.004	1.962	0.175	0.347
40	0.006	3.355	0.299	0.529
50	0.006	3.023	0.269	0.557
63	0.009	4.971	0.443	0.569
80	0.016	8.690	0.774	0.930
100	0.019	10.145	0.903	1.293
125	0.021	11.328	1.009	1.318
160	0.029	15.515	1.381	1.358
200	0.033	17.917	1.595	1.383
250	0.043	23.329	2.077	1.760
315	0.058	31.267	2.784	2.053
400	0.071	38.484	3.427	2.228
500	0.080	43.338	3.859	2.276
630	0.081	43.575	3.880	1.949
800	0.074	39.758	3.540	1.663
1000	0.091	49.247	4.385	1.562
Linear	0.20	108.53	9.66	6.01
ISO	0.02	9.01	0.80	0.91

Table J.2. Z-axis acceleration when inserting tensioner dowels with the RRH 06P rivet hammer supplied with an air pressure of 30 PSI

Frequency [Hz]	Test Mass (measured) [m/s^2]	Insertion Tool (calculated) [m/s^2]	Handle (calculated) [m/s^2]	Handle (measured) [m/s^2]
6.3	0.002	1.341	0.115	0.273
8	0.001	0.834	0.072	0.241
10	0.001	0.724	0.062	0.217
12.5	0.001	0.737	0.063	0.236
16	0.003	1.905	0.164	0.323
20	0.054	30.110	2.588	0.854
25	0.002	1.089	0.094	0.276
31.5	0.003	1.810	0.156	0.378
40	0.035	19.366	1.664	1.214
50	0.010	5.560	0.478	0.857
63	0.034	18.802	1.616	1.650
80	0.059	33.071	2.842	2.542
100	0.065	36.075	3.100	3.411
125	0.101	56.410	4.848	3.755
160	0.092	51.359	4.414	3.208
200	0.111	61.925	5.322	3.413
250	0.150	83.881	7.209	3.944
315	0.180	100.337	8.623	4.427
400	0.223	124.467	10.697	4.963
500	0.272	151.793	13.045	4.726
630	0.289	161.625	13.890	4.149
800	0.297	165.918	14.259	3.519
1000	0.482	269.074	23.124	2.912
Linear	0.79	442.06	37.99	13.44
ISO	0.06	31.45	2.70	1.58

Table J.3. Z-axis acceleration when inserting bell housing dowels with the RRH 06P rivet hammer supplied with an air pressure of 30 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.001	0.623	0.068	0.261
8	0.001	0.604	0.066	0.215
10	0.001	0.552	0.060	0.188
12.5	0.001	0.525	0.057	0.183
16	0.003	1.182	0.129	0.192
20	0.077	33.851	3.684	0.616
25	0.003	1.155	0.126	0.217
31.5	0.002	1.060	0.115	0.220
40	0.038	16.652	1.812	0.855
50	0.006	2.733	0.297	0.381
63	0.060	26.341	2.867	1.353
80	0.071	31.247	3.401	1.859
100	0.077	33.855	3.685	2.475
125	0.103	45.157	4.915	2.734
160	0.122	53.444	5.817	2.876
200	0.141	61.794	6.726	3.597
250	0.188	82.672	8.998	4.374
315	0.235	103.439	11.258	4.176
400	0.258	113.436	12.346	5.124
500	0.354	155.838	16.961	5.228
630	0.354	155.499	16.924	5.312
800	0.348	152.858	16.637	5.018
1000	1.145	503.514	54.802	4.014
Linear	1.38	607.23	66.09	14.19
ISO	0.08	33.98	3.70	1.24

Table J.4. Z-axis acceleration when inserting front cover dowels with the RRH 06P rivet hammer supplied with an air pressure of 60 PSI

Frequency [Hz]	Test Mass (measured) [m/s^2]	Insertion Tool (calculated) [m/s^2]	Handle (calculated) [m/s^2]	Handle (measured) [m/s^2]
6.3	0.011	5.972	0.532	0.341
8	0.007	3.580	0.319	0.314
10	0.004	2.023	0.180	0.255
12.5	0.005	2.851	0.254	0.224
16	0.003	1.749	0.156	0.244
20	0.005	2.562	0.228	0.302
25	0.028	14.996	1.335	0.492
31.5	0.003	1.633	0.145	0.384
40	0.005	2.564	0.228	0.470
50	0.031	16.891	1.504	0.824
63	0.014	7.704	0.686	0.936
80	0.016	8.570	0.763	1.224
100	0.039	20.770	1.849	1.195
125	0.037	19.788	1.762	1.674
160	0.048	25.724	2.291	1.390
200	0.047	25.447	2.266	1.666
250	0.056	30.277	2.696	2.203
315	0.069	37.263	3.318	2.601
400	0.077	41.275	3.675	3.008
500	0.082	44.103	3.927	3.270
630	0.074	40.096	3.570	3.231
800	0.063	33.755	3.006	3.105
1000	0.242	130.631	11.632	2.964
Linear	0.31	169.17	15.06	8.56
ISO	0.03	15.48	1.38	0.99

Table J.5. Z-axis acceleration when inserting tensioner dowels with the RRH 06P rivet hammer supplied with an air pressure of 60 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.070	39.147	3.364	0.381
8	0.024	13.666	1.174	0.339
10	0.009	4.885	0.420	0.300
12.5	0.003	1.635	0.141	0.311
16	0.003	1.431	0.123	0.300
20	0.007	4.041	0.347	0.399
25	0.069	38.796	3.334	0.765
31.5	0.003	1.679	0.144	0.389
40	0.010	5.751	0.494	0.503
50	0.085	47.645	4.095	1.085
63	0.034	19.100	1.641	1.044
80	0.044	24.538	2.109	1.412
100	0.127	70.907	6.094	1.812
125	0.128	71.745	6.166	2.246
160	0.128	71.451	6.141	2.327
200	0.158	88.243	7.584	2.325
250	0.192	107.160	9.209	2.586
315	0.236	131.831	11.330	3.234
400	0.261	145.612	12.514	4.153
500	0.271	151.645	13.032	4.711
630	0.255	142.701	12.264	4.540
800	0.216	120.863	10.387	4.285
1000	1.359	759.073	65.235	4.274
Linear	1.51	844.89	72.61	11.79
ISO	0.10	57.04	4.90	1.26

Table J.6. Z-axis acceleration when inserting bell housing dowels with the RRH 06P rivet hammer supplied with an air pressure of 60 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.002	0.973	0.106	0.669
8	0.002	0.873	0.095	0.567
10	0.002	0.760	0.083	0.444
12.5	0.002	0.670	0.073	0.417
16	0.002	0.696	0.076	0.413
20	0.015	6.569	0.715	0.486
25	0.096	42.271	4.601	1.208
31.5	0.003	1.137	0.124	0.509
40	0.020	8.903	0.969	0.780
50	0.116	51.139	5.566	2.331
63	0.055	23.987	2.611	1.993
80	0.067	29.271	3.186	3.414
100	0.263	115.733	12.596	4.694
125	0.267	117.545	12.794	4.959
160	0.192	84.534	9.201	4.673
200	0.306	134.411	14.629	4.734
250	0.346	152.266	16.573	5.731
315	0.426	187.345	20.391	7.357
400	0.517	227.429	24.753	8.675
500	0.571	250.855	27.303	9.885
630	0.548	241.016	26.232	10.580
800	0.490	215.301	23.433	9.846
1000	4.212	1851.731	201.541	8.888
Linear	2.68	1178.32	128.25	28.35
ISO	0.57	250.61	27.28	2.36

Table J.7. Z-axis acceleration when inserting crank pilot bearings with the RRH 06P rivet hammer supplied with an air pressure of 60 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.003	0.671	0.139	0.557
8	0.002	0.444	0.092	0.460
10	0.001	0.315	0.065	0.358
12.5	0.001	0.310	0.065	0.321
16	0.002	0.505	0.105	0.335
20	0.001	0.361	0.075	0.322
25	0.011	2.757	0.573	0.351
31.5	0.107	25.925	5.389	0.755
40	0.005	1.125	0.234	0.379
50	0.016	3.975	0.826	0.446
63	0.089	21.530	4.475	0.856
80	0.069	16.686	3.468	0.554
100	0.104	25.271	5.253	0.887
125	0.153	37.140	7.720	0.889
160	0.177	42.980	8.934	1.014
200	0.183	44.388	9.227	1.436
250	0.272	65.864	13.691	1.980
315	0.384	93.152	19.363	2.855
400	0.456	110.564	22.982	3.476
500	0.585	141.709	29.456	3.677
630	0.753	182.500	37.935	3.648
800	1.152	279.137	58.023	3.394
1000	1.711	414.563	86.173	2.996
Linear	1.760	426.555	88.666	10.54
ISO	0.506	122.635	25.491	1.30

Table J.8. Z-axis acceleration when inserting bell housing dowels with the RRH 06P rivet hammer supplied with an air pressure of 90 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.003	1.350	0.147	0.502
8	0.002	0.718	0.078	0.504
10	0.001	0.578	0.063	0.424
12.5	0.001	0.577	0.063	0.366
16	0.002	0.706	0.077	0.369
20	0.002	0.866	0.096	0.416
25	0.134	58.909	6.412	0.957
31.5	0.010	4.225	0.460	0.555
40	0.003	1.305	0.142	0.496
50	0.240	105.592	11.493	1.754
63	0.022	9.853	1.072	0.981
80	0.218	95.632	10.409	2.290
100	0.347	152.503	16.598	1.274
125	0.339	148.911	16.207	1.332
160	0.245	107.859	11.739	1.574
200	0.408	179.279	19.513	2.304
250	0.482	211.909	23.064	3.063
315	0.543	238.687	25.979	4.732
400	0.600	264.001	28.734	5.953
500	0.615	270.463	29.437	6.269
630	0.527	231.695	25.218	6.461
800	0.499	219.423	23.882	6.173
1000	5.411	2379.021	258.931	5.487
Linear	5.63	2473.74	269.24	15.48
ISO	0.18	78.15	8.51	1.58

Table J.9. Z-axis acceleration when inserting crank pilot bearings with the RRH 06P rivet hammer supplied with an air pressure of 90 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.002	0.583	0.121	0.549
8	0.003	0.635	0.132	0.552
10	0.002	0.479	0.100	0.399
12.5	0.002	0.467	0.097	0.348
16	0.003	0.621	0.129	0.357
20	0.003	0.767	0.159	0.354
25	0.003	0.843	0.175	0.351
31.5	0.065	15.654	3.254	0.597
40	0.024	5.809	1.207	0.580
50	0.019	4.644	0.965	0.586
63	0.121	29.367	6.104	0.882
80	0.072	17.476	3.633	0.915
100	0.141	34.267	7.123	1.024
125	0.176	42.558	8.846	1.092
160	0.170	41.163	8.556	1.290
200	0.214	51.758	10.759	1.698
250	0.288	69.901	14.530	2.287
315	0.358	86.693	18.020	3.050
400	0.458	110.885	23.049	3.837
500	0.561	135.883	28.245	4.370
630	0.683	165.473	34.396	4.445
800	0.824	199.805	41.532	4.399
1000	0.987	239.149	49.711	4.479
Linear	1.73	420.10	87.32	10.87
ISO	0.08	18.80	3.91	1.26

Table J.10. Z-axis acceleration when inserting sleeve crank bushings with the RRH 06P rivet hammer supplied with an air pressure of 90 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.002	0.282	0.099	0.370
8	0.002	0.222	0.078	0.311
10	0.002	0.236	0.083	0.256
12.5	0.001	0.198	0.069	0.256
16	0.004	0.624	0.218	0.266
20	0.003	0.390	0.137	0.276
25	0.003	0.417	0.146	0.310
31.5	0.112	16.160	5.660	0.462
40	0.069	9.969	3.492	1.208
50	0.055	7.970	2.791	0.535
63	0.137	19.642	6.879	0.729
80	0.259	37.310	13.067	1.857
100	0.207	29.775	10.428	1.294
125	0.494	71.060	24.888	1.741
160	0.538	77.436	27.121	1.709
200	0.571	82.154	28.773	2.446
250	0.702	100.954	35.358	3.005
315	0.878	126.350	44.252	4.004
400	1.089	156.609	54.850	5.399
500	1.240	178.424	62.490	5.906
630	1.449	208.455	73.008	6.025
800	1.945	279.733	97.972	5.295
1000	2.974	427.743	149.811	4.625
Linear	4.44	638.80	223.73	13.96
ISO	0.17	25.07	8.78	1.17

Table J.11. Z-axis acceleration when inserting sleeve crank bushings with the RRH 10P rivet hammer supplied with an air pressure of 90 PSI

Frequency [Hz]	Test Mass (measured) [m/s²]	Insertion Tool (calculated) [m/s²]	Handle (calculated) [m/s²]	Handle (measured) [m/s²]
6.3	0.010	1.191	0.285	0.371
8	0.005	0.627	0.150	0.300
10	0.005	0.572	0.137	0.273
12.5	0.006	0.721	0.172	0.305
16	0.010	1.148	0.274	0.359
20	0.006	0.723	0.173	0.423
25	0.052	6.201	1.481	0.718
31.5	0.212	25.503	6.090	1.974
40	0.015	1.848	0.441	0.642
50	0.037	4.457	1.064	0.893
63	0.253	30.448	7.271	2.737
80	0.107	12.890	3.078	1.565
100	0.286	34.425	8.221	2.898
125	0.323	38.937	9.298	3.332
160	0.329	39.610	9.459	3.038
200	0.549	66.137	15.794	3.091
250	0.535	64.381	15.375	2.640
315	0.688	82.780	19.769	2.950
400	0.957	115.181	27.506	3.528
500	1.344	161.750	38.627	5.474
630	2.344	282.250	67.404	6.639
800	6.779	816.132	194.899	6.512
1000	14.401	1733.800	414.046	6.025
Linear	16.22	1952.61	466.30	15.34
ISO	0.32	38.71	9.24	1.80

Table J.12. Ratios between the calculate and measured linear and ISO weighted acceleration values at the RRH 06P rivet hammer's handle - air pressure 30 PSI

Part inserted	Linear	ISO
Front Cover Dowel	0.62	1.13
Tensioner Dowel	2.83	1.71
Bell Housing Dowel	4.66	2.99

Table J.13. Ratios between the calculate and measured linear and ISO weighted acceleration values at the RRH 06P rivet hammer's handle - air pressure 60 PSI

Part inserted	Linear	ISO
Front Cover Dowel	0.57	0.72
Tensioner Dowel	0.16	0.26
Bell Housing Dowel	0.22	0.09
Crank Pilot Bearing	0.12	0.05

Table J.14. Ratios between the calculate and measured linear and ISO weighted acceleration values at the RRH 06P rivet hammer's handle - air pressure 90 PSI

Part inserted	Linear	ISO
Bell Housing Dowel	0.06	0.19
Crank Pilot Bearing	0.12	0.32
Sleeve Crank Bushing	0.06	0.13

Table J.15. Ratios between the calculate and measured linear and ISO weighted acceleration values at the RRH 10P rivet hammer's handle - air pressure 90 PSI

Part inserted	Linear	ISO
Sleeve Crank Bushing	0.03	0.19

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