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# Shock and Vibration Isolation System for Ambulatory and Litter Patients in Ground and Air Medical Transport

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# SHOCK AND VIBRATION ISOLATION SYSTEM FOR AMBULATORY AND LITTER PATIENTS IN GROUND AND AIR MEDICAL TRANSPORT

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# ABSTRACT


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This project explored the effectiveness of seat and litter air bladder technologies in reducing patient exposure to whole body shock and vibration during ground borne and airborne medical transport. Several seat and litter air bladder configurations were examined during field tests in a U.S. Army RG-33 MRAP ambulance and a U.S. Army HH-60M Black Hawk helicopter. The MRAP field tests were conducted at Ft. Detrick, Maryland. The Black Hawk field tests were conducted at Ft. Rucker, Alabama.

During the field tests, tri-axial vibration signals were recorded on a 16-channel CoCo90 Data Logger/Frequency Analyzer and then post processed in the laboratory to obtain three-axis 1/3 octave vibration spectra and vibration transmissibility values and low-pass, band-pass and ISO overall vibration values. Vibration reductions through the seat air bladder of up to 47 percent in the vertical direction were achieved. The vibration reducing characteristics of the litter air bladder were significantly affected by the

flexibility of the litter webbing and were more difficult to evaluate. More testing is necessary on the litter air bladder to more accurately determine its effectiveness in reducing patient exposure to shock and vibration during medical transport.

ACKNOWLEDGEMENTS

I would like to thank all of my family and friends for standing by me and supporting me throughout the various moments of my life, for without them, I would have not achieved my goals nor have I been the individual that I am today. I would also like to extend my gratitude to my advisor, Dr. Douglas Reynolds, whom I respect and admire, for guiding me throughout my post graduate journey.

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# CHAPTER 1

# INDTRODUCTION

## 1.1. Patient Transfer

Patient transport and evacuation is a key element for the survivability of wounded war fighters on the battlefield. Doing so in a timely fashion can be the difference between the life and death of the patient. However, battlefields do not always offer easy routes for evacuation. The types of terrain, battle and weather condition are factors that affect greatly the efficiency of the evacuation and transport. Whether the transport method is ground based or airborne, the patient is often exposed to significant levels of shock and vibration while being transported from the battle field to a field medical facility. Injuries sustained on the battle field, such as spinal or neck injuries, are sometimes made worse by the transport process. This justifies the need to incorporate a shock and vibration mitigation system that will reduce the shock and vibration energy transmitted from a vehicle seat or a litter into the patient during the transport process. Little attention has been given to developing methods of reducing patient exposure to shock and vibration during medical transport, neither in the ambulatory position while sitting on a seat nor in the supine position while lying down on a litter.

Two primary methods can be used to protect wounded war fighters from exposure to shock and vibration during medical transport:

*Method 1*: Develop a shock and vibration isolation system that will isolate the litter or seat support structure, which supports the weight of a patient from the medical transport vehicle (ground-borne or airborne) structure. This method requires individually configured shock and vibration isolation systems for each type of medical transport vehicle.

*Method 2*: Develop a shock and vibration isolation system that can be placed between a patient's body and the seat frame or litter bed that supports his/her body weight. This method required only two individually configured shock and vibration isolation systems that can be used for the medical transport of ambulatory and litter-bound patients.

This project focuses on Method 2. A patented seat air-bladders system was developed as part of a U.S. Army Research Laboratory (USARL)/University of Nevada Las Vegas (UNLV) Co-operative Agreement that can be used to protect military vehicle occupants from the devastating effects of exposure to extreme shocks from mine blasts and IEDs. Technology associated with this seat system was examined for potential use in isolating critically wounded ambulatory and litter-bound war fighters from exposure to shock and vibration during medical transport.

## 1.2. Description of Seat Air Bladder Technology

The air-bladder shock and vibration mitigation system is comprised of two coupled air chambers that are formed by low density open-cell foam panels and that are in fluid communication with each other through inter connecting air vents (Figure 1.1). Bonded to the top and bottom surfaces of the foam panels are impermeable outer coverings that are sealed around their perimeters and in between the foam panels (Figure (1.2). Flexible tubes that are placed within the sealed outer covering between the two air chambers allow air to flow back and forth between the chambers (Figure 1.2). Holes are cut into the foam panels, as shown in Figure 1.3, to facilitate rapid air flow within the open-cell foam matrix. Figure 1.4 shows a picture of the seat air bladder.

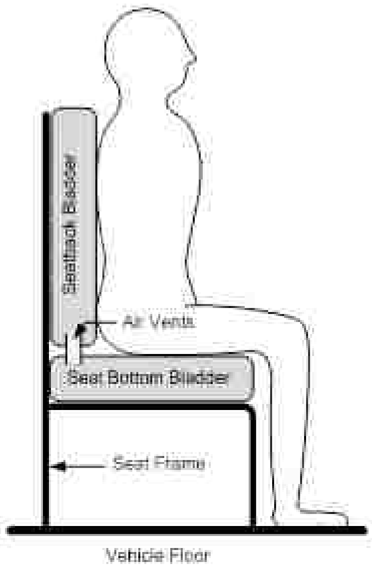


Figure 1.1 Seat Air Bladder

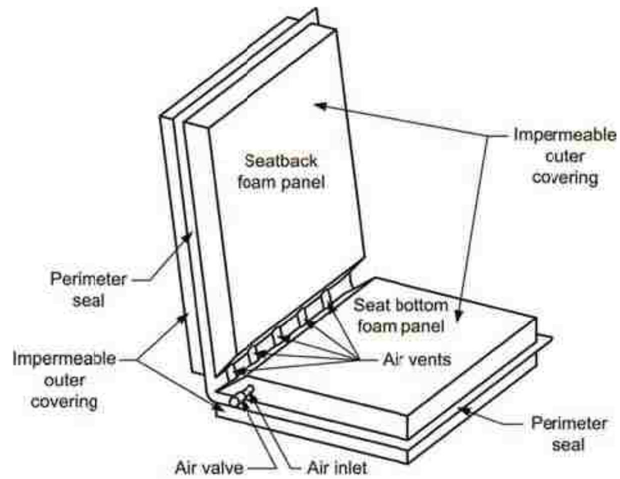


Figure 1.2 Schematic of the Seat Bladder [1]

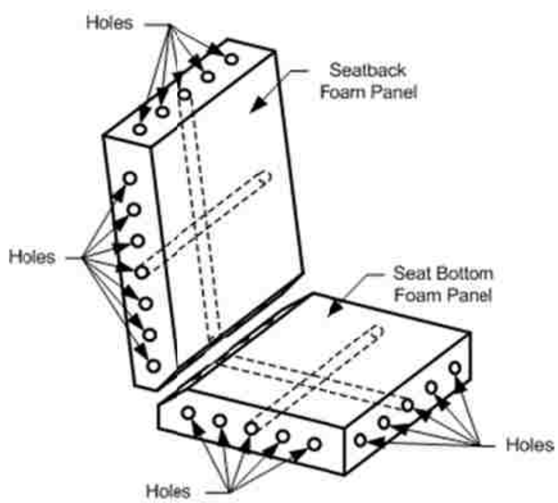


Figure 1.3 Holes that facilitate the airflow within the Foam [1]

The seat air bladder is self-inflatable. To inflate the bladder, an air valve, as shown in Figure 1.5, is open to the atmospheric pressure. The foam panels expand, drawing air into the bladder seat back and seat bottom air chambers.

Figure 1.4 Actual Seat Bladder


Figure 1.5 Seat Air Bladder Air Valve

The seat air bladder was originally designed to attenuate high intensity shock energy that is transmitted from a vehicle's structure and seat frame to the body of the seat occupant when a military vehicle is exposed to a mine blast or IED [1]. The system is designed to replace the seat foam cushions currently used in military vehicle seats. When a vehicle is exposed to significantly high levels of shock energy that is directed through the vehicle's structure and seat frame to a vehicle occupant, the seat air bladder behaves as a non-linear pneumatic (air) spring and damper that, when supporting the weight of a vehicle occupant, will significantly reduce the shock energy that is transmitted to the body of the seat occupant [1].

The combined efforts of U.S. Army Research Laboratory (USARL) and the University of Nevada Las Vegas (UNLV) lead to the development of the seat air bladder system that can be used to protect military vehicle occupants from the devastating effects of exposure to extreme shocks from mine blasts and IEDs. Using a Lansmont Shock System drop tower, tests were conducted at the U.S. Army Research Laboratory to document the effectiveness of the seat air bladder in reducing the transmission of high-intensity shock energy to vehicle occupants. A Thor NT anthropodynamic dummy was used for these tests [1].

Figure 1.6 shows the z-axis (vertical direction) pelvis acceleration results for a 173 g (1,697.1 m/$s^2$) 5 ms shock input to the drop tower plate supporting the seat frame. Figure 1.7 shows the corresponding z-axis spine load results. Tables 1.1 and 1.2 show tabulated results associated with the related measured peak acceleration and spine load values. The maximum allowable z-axis peak acceleration and spine load values to minimize the potential for injury are 23 g's (224.6 m/$s^2$) and 1,500 $lb_f$, respectively.

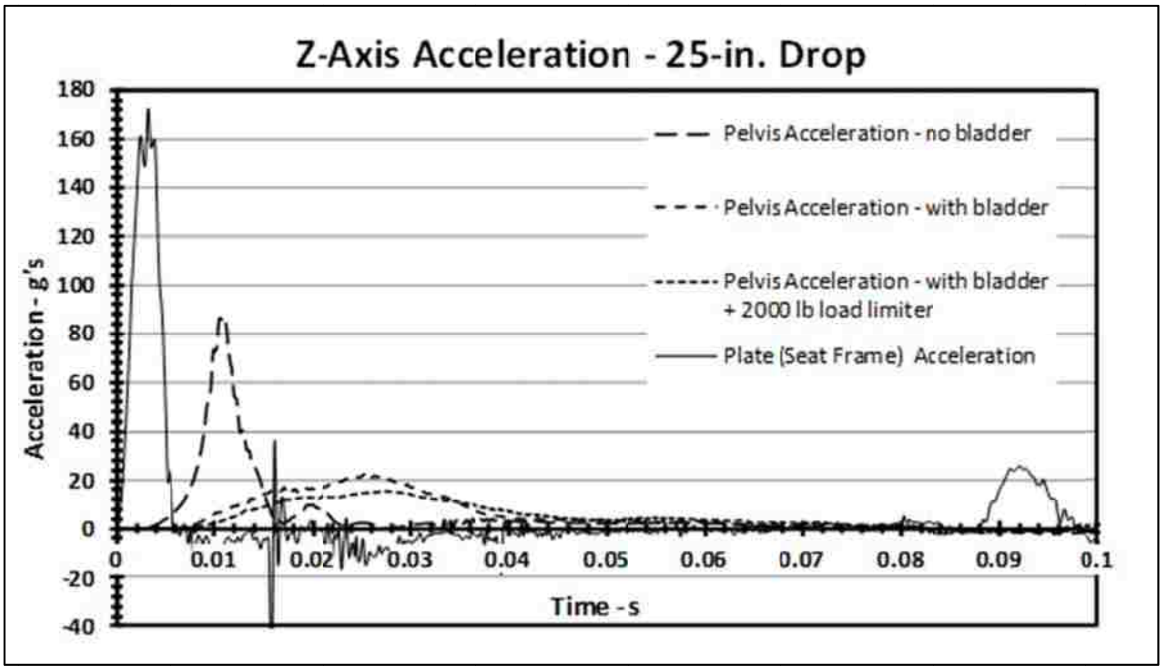


Figure 1.6 Vertical Acceleration [1]

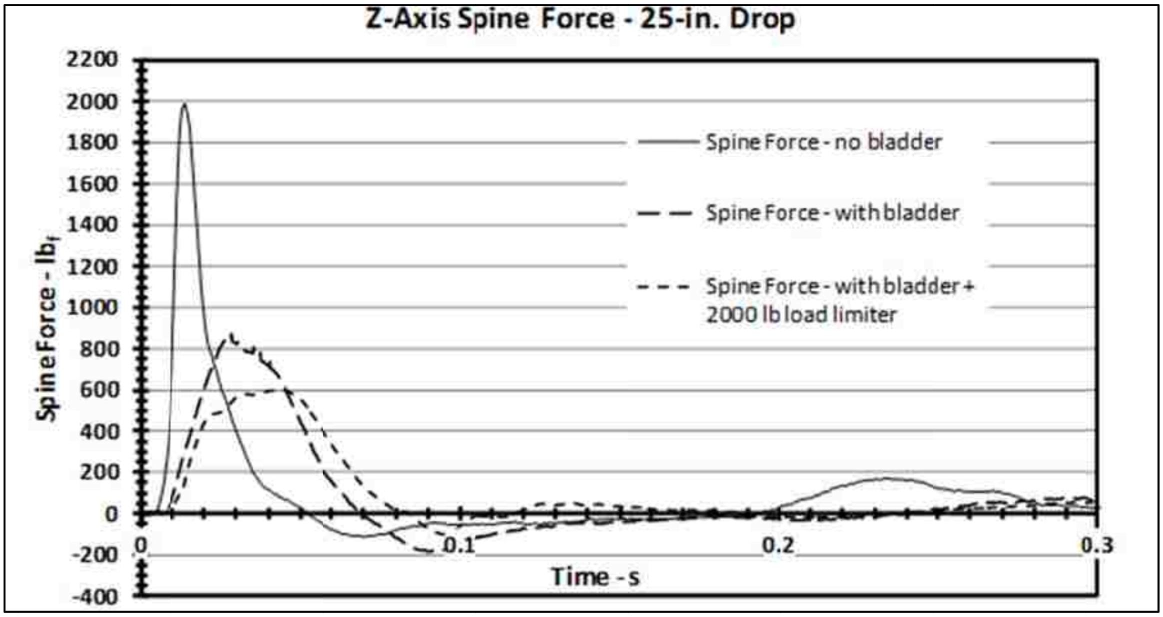

Figure 1.7 Spine Force [1]

Figure 1.8 shows a plot of the percent reduction of peak z-axis pelvis acceleration values for the seat air bladder (relative to no seat bladder) as a function of peak seat frame (plate) input acceleration. Figure 1.9 shows a plot of the percent reduction of peak z-axis spine load values for the seat air bladder (relative to no seat bladder) as a function of peak seat frame (plate) input acceleration.

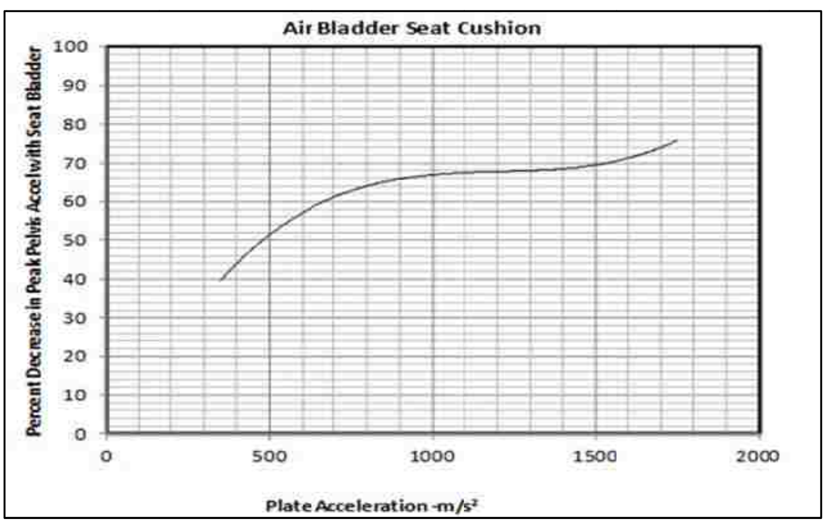

Figure 1.8 Percent Reduction in Peak Pelvis Acceleration with Seat Bladder [1]

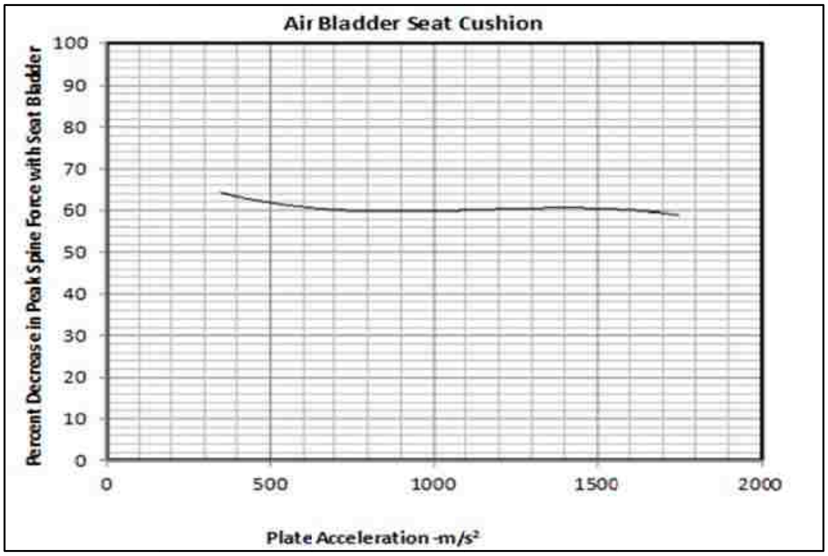

Figure 1.9 Percent Decrease in Peak Pelvis Force with Seat Bladder [1]

Table 1.1 shows the peak acceleration for the seat frame and pelvis with and without the seat bladder and the percent reduction in peak acceleration relative to pelvis acceleration the z-axis (vertical direction). Table 1.2 shows the seat frame peak spine load with the percent reduction relative to the spine load

Table 1.1 Percent Reduction Relative to Plevis [1]

| **z-axis (Vertical Direction) - Peak Acceleration** | **g's** | **$m/s^2$** | **Percent Reduction Relative to Pelvis Accel. - No Bladder** |
|---|---|---|---|
| Plate (Seat Frame) Acceleeration | 173.0 | 1,697.1 | |
| Pelvis Acceleration - No Seat Bladder | 86.7 | 850.5 | |
| Pelvis Acceleration - With Seat Bladder | 21.9 | 214.8 | 74.7 |
| Pelvis Acceleration - With Seat Bladder + 2,000 $lb_f$ Load Limiter with a 2.5 in. Stroke | 15.0 | 147.2 | 82.7 |
| Maximum allowable peak pelvis acceleration value | 23.0 | 225.6 | |

Table 1.2 Percent Reduction Relative to Spine Load [1]

| **z-axi (Vertical Direction) - Peak Spine Load Peak Plate (Seat Frame) Acceleration - 173.0 g's** | **$lb_f$** | **Percent Reduction Relative to Spin Load - No Bladder** |
|---|---|---|
| Spine Load - No Seat Bladder | 1,990 | |
| Spine Load - With Seat Bladder | 856 | 57.0 |
| Spine Load - With Seat Bladder + 2,000 $lb_f$ Load Limiter with a 2.5 in. Stroke | 603 | 69.7 |
| Maximum allowable peak spine load value | 1,500 | |

### 1.2.1. Summary of the Test Results for the USARL/UNLV Project

With respect to a 1,700 $m/s^2$, 5 ms shock input to the seat frame, the seat air bladder reduced the peak pelvis z-axes acceleration from 850 $m/s^2$ with no air bladder seat to 215 $m/s^2$ with the air bladder seat. This was a 57 percent reduction. When a 2,000 $lb_f$ load limiter with a 2.5-in. stroke was used in conjunction with the seat air bladder, the peak spine load was further reduced to 147 $m/s^2$. This was a 83 percent reduction. Over a 5 ms seat frame peak shock input that ranged from 450 to 1,750 $m/s^2$, the percent reduction in peak pelvis z-axis acceleration afforded by the seat air bladder relative to no seat air bladder ranged from 40 (450 $m/s^2$ shock input) percent to 76 percent(1,750 $m/s^2$ shock input) [1].

With respect to a 1,700 $m/s^2$, 5 ms shock input to the seat frame, the air bladder seat reduced the peak z-axes spine load from 1,990 $lb_f$ with no air bladder seat to 856 $lb_f$ with the air bladder seat. This was a 75 percent reduction. When a 2,000 $lb_f$ load limiter with a 2.5-in. stroke was used in conjunction with the seat air bladder, the peak pelvis acceleration was further reduced to 603 $lb_f$. This was a 70 percent reduction. Over a 5 ms seat frame peak shock input that ranged from 450 to 1,750 $m/s^2$, the percent reduction in peak z-axis spine load afforded by the seat air bladder relative to no seat air bladder ranged from 64 (450 $m/s^2$ shock input) percent to 57 percent (1,750) $m/s^2$ shock input) [1].

### 1.2.2. Conclusions from the USARL Project Results

The results from the USARL project indicated that the seat air bladder technology is a viable technology for protecting military vehicle crews from the injurious effects of mine blasts. The air bladder seats can reduce the peak pelvis acceleration from a mine blast by 40 to 80 percent. This reduction increases as peak mine blast shock acceleration amplitude increases. The air bladder seats can also reduce the peak spine load from a mine blast by around 60 percent. This reduction is fairly constant with regard to peak mine blast shock acceleration amplitude. The air bladder seats can be designed to replace existing seat cushions in military vehicles and can be used in conjunction with other vehicle shock energy-reducing systems, such as load-limiting systems, to further reduce mine blast energy transmitted to the human body.

### 1.3. Application of the Seat Air Bladder Technology to Litter Air Bladder

This project explored the application of the seat air bladder technology developed during the USARL/UNLV project for use in litter air bladders that can be used to more effectively isolate litter-bound patients during medical transport. Figure 1.10 shows a drawing a proposed litter air bladder. The litter back bladder is designed to support weight of and stabilized the head, neck, back and buttock. The litter bottom bladder is designed to support the weight of the thighs, lower legs and feet. As with the seat, air will flow between the litter back and litter bottom bladders through vents between the bladders. The structure of the litter air bladder is maintained by open-cell foam panels, which have holes cut into the panels, as shown in Figure 1.3.

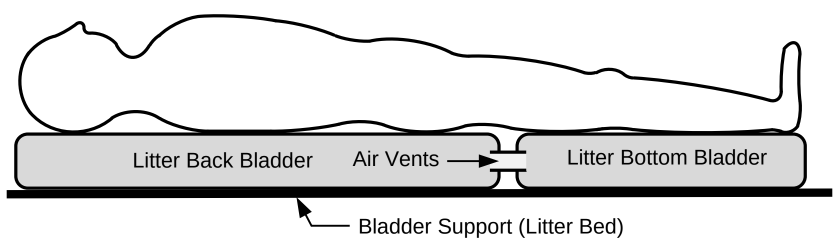


Figure 1.10 Proposed Litter Air Bladder

## 1.4. Goals and Objectives

This thesis has two main objectives:

a. To test the seat and litter air bladder technology and evaluate its effectiveness in attenuating patient exposure to shock and vibration during ground and airborne medical transport. The seat and litter air bladders are installed in an MRAP ambulance and a Black Hawk helicopter and tested using a human subject.

b. To establish a baseline for the acceleration and the transmissibility of vibration and shock energy into the human body during medical transport. The data collected will be used in future studies to recreate the field conditions in the laboratory environment to alleviate the need for expensive and difficult field tests.

## 1.5. Overview and Organization of Thesis

This project is profoundly rooted in the experiments that were conducted in actual field conditions aboard a U.S. Army MRAP ambulance and a Black Hawk medevac helicopter. The field tests were robust and elaborate to depict as closely as possible the conditions in which the previously mentioned vehicles would have to operate on the battlefield. The data that was gathered will be used to characterize the nature of the shock and vibration exposure that wounded war fighters experience during ground borne and airborne medical transport. The results of the field tests will be used to quantify and document effectiveness of the seat and litter air bladder technology in reducing patient exposure to shock and vibration during medical transport.

This thesis describes in detail the experimental protocols and procedures used during the field tests. A thorough analysis of the data obtained in the field is presented and the results are examined and explored. An assessment of the effectiveness of the air bladder technology in reducing patient exposure to shock and vibration during medical transport is presented in the results section and recommendations are made with regard to potential future research.

CHAPTER 2

APPLICATION OF AIR BLADDER TECHNOLOGY FOR AIR BLADDER SEAT AND LITTER SYSTEMS USED FOR PATIENT MEDICAL GROUND AND AIRBORNE TRANSFER

The success of the seat air-bladder laboratory tests at USARL and UNLV indicated the seat air bladder technology could be potentially used to protect ambulatory and litter bound patients during ground borne and airborne medical transport. Therefore, seat air bladders and litter air bladders were designed that could be used in an U.S. Army MRAP ambulance and a U.S. Army Black Hawk helicopter. Figures 2.1 and 2.2 show pictures of the seat air bladders designed for use in the MRAP ambulance and Black Hawk helicopter.


Figure 2.1 MRAP Ambulance Seat Air Bladder


Figure 2.2 Black Hawk Helicopter Seat Air Bladder

The form and structure of the seat air bladders is maintained by specially modified open-cell foam panels that are sandwiched between an upper and lower impervious outer cover. The upper and lower layers of the impervious outer cover are bonded to the upper and lower surfaces of the foam panels. These layers are sealed around their perimeters and in between the seatback and seat bottom foam panels, forming a seatback bladder and a seat bottom bladder. Flexible tubes place between the seatback and seat bottom foam panels are sealed between the upper and lower impervious layers (see Figure 1.1 and 1.2). These tubes facilitate the flow of air between the seatback and seat bottom bladder sections. A series of holes are cut lengthwise and widthwise longitudinally in the seatback and seat bottom foam panes to facilitate the rapid flow of air through the open-cell foam matrix of the panels (Figure 2.3).

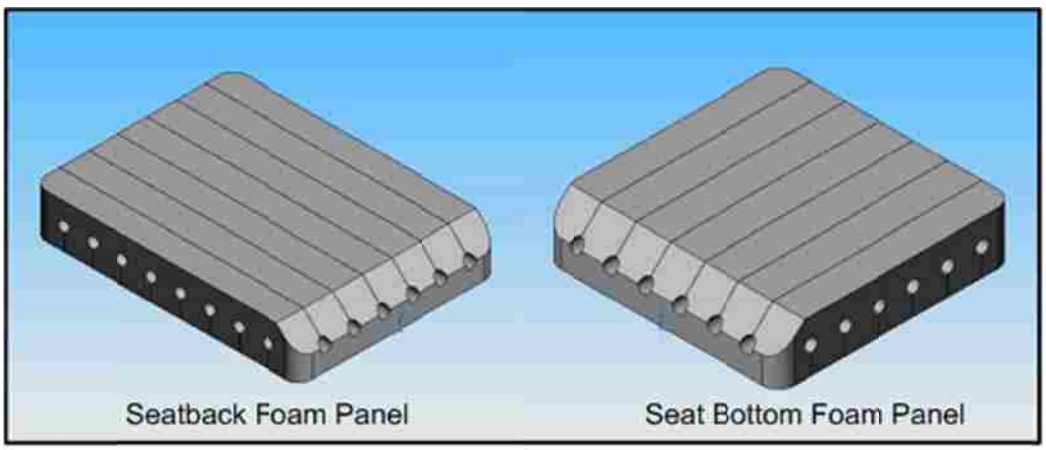


Figure 2.3 Seatback and Seat Bottom Foam Panels with Holes Cut Lengthwise and Widthwise Longitudinally in the panels

The form and structure of the litter air bladder is similar to that of the seat air bladder. The seat air bladder is designed to support the weight of the seat occupant in the area of the buttock, whereas the litter air bladder is designed to primarily support the weight of the litter patient in the area of the head, back and buttock. Referring to Figure 1.9, the litter air bladder is positioned horizontally between the litter patient and the litter bed. Figure 2.4 shows a descriptive drawing of the litter air bladder, and Figure 2.5 shows a picture of the litter air bladder that was used in both the MRAP ambulance and Black Hawk helicopter. The larger air chamber is designed to support the patient's head, back and buttocks. The smaller air chamber is designed to support the thighs, lower legs and feet.

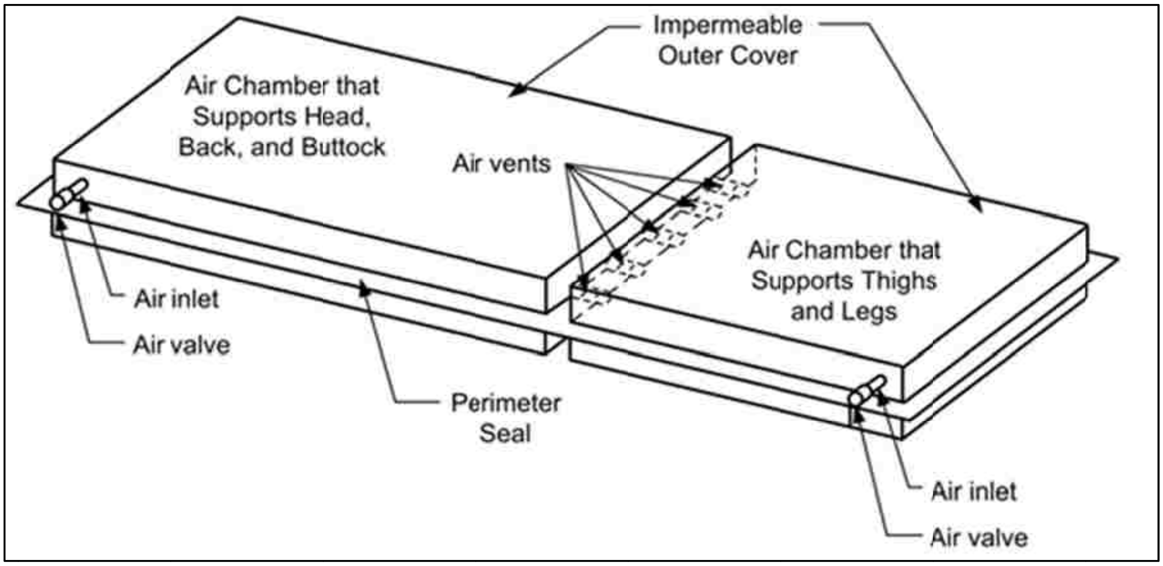


Figure 2.4 Schematic of the Litter Bladder


Figure 2.5 Picture of the Litter with the air bladder

# CHAPTER 3

# WHOLE BODY VIBRATION EXPOSURE

ISO Standard 2631-*Mechanical Vibration and shock Evaluation of Human Exposure to Whole-body Vibration* talk about allowable vehicle occupant shock and vibration exposure amplitudes and provide an approach to analyze human exposure to shock and vibration [2,3].

## 3.1. Coordinate System Used to Describe Whole Body Vibration Exposure

According to the ISO 2631 the biodynamic coordinate system for the ambulatory posture (seated) is different than the one for the supine posture (lying down- face up). Figure 3.1 shows the proper biodynamic coordinates for each posture in terms of the x-, y- and z-axis.

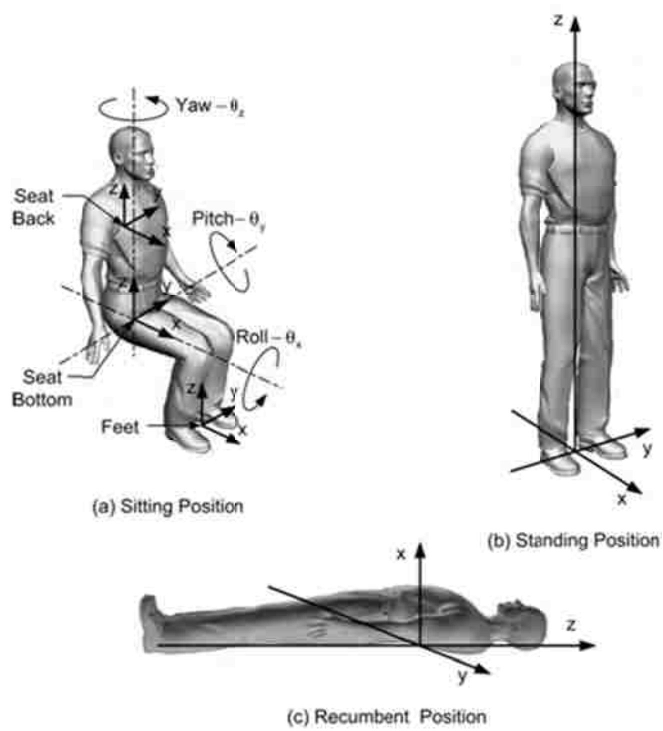


Figure 3.1 Whole Body Biodynamic Coordinate System [3]

## 3.2. Metrics for Assessing Whole Body Vibration Exposure

### 3.2.1. Vibration Transmissibility

Transmissibility is a measure of the acceleration transmitted from one point to another. Transmissibility is the output value divided by the input value. With respect to human exposure to whole body vibration, this quantity reflects the amount of the vibration and shock energy that is released from a source, transmitted through a vibration attenuating element, and then absorbed by the human body. This value is unit-less and given by:

$$TR = \frac{Input\ Acceleration\ Value}{Response\ Acceleration\ Value} \qquad \textbf{equation 3.1}$$

### 3.2.2. Weighted rms Acceleration

If a vibration signal does not contain shock elements, the weighted rms acceleration is expressed in m/s$^2$ and is defined as:

$$a_w = \sqrt{\frac{1}{T}\int_0^T a_w{}^2(t)dt} \qquad \textbf{equation 3.2}$$

$a_w(t)$ is the weighted acceleration as a function of time and is expressed in m/s$^2$.

T represent the measurement duration in seconds.

In the frequency domain:

$$a_w = \sqrt{\sum_{i=1}^{N}(W_i a_i{}^2)} \qquad \textbf{equation 3.3}$$

$a_w$ is the frequency weighted acceleration in m/s$^2$

$W_i$ is the weighting factor fort the i$^{th}$ 1/3 octave frequency

$a_i$ is rms acceleration for the i$^{th}$ for the 1/3 octave

When motion in the x-, y- and z-direction is considered:

$$a_v = [k_x{}^2 a_{wx}{}^2 + k_y{}^2 a_{wy}{}^2 + k_z{}^2 a_{wz}{}^2] \quad \textbf{equation 3.4}$$

$a_v$ is the overall weighted acceleration

$a_{wi}$ is the rms weighted acceleration in each direction

$k_i$ is the multiplying factor for each direction

Table 3.1 Multiplication Factors for the Ambulatory Position

| Weighting Multiplication Factors | | |
|---|---|---|
| $k_x$ | $k_y$ | $k_z$ |
| 1.4 | 1.4 | 1 |

### 3.2.3. Vibration Dose Value

When shock segments are contained in a vibration signal, the rms value often underestimates the exposure of an individual to whole body vibration. To address this situation, the vibration dose value (VDV) is used. The vibration dose value (VDV) is more sensitive to peak values in a shock time signal than the basic rms value. Therefore, with vibration signals that contain repeated shocks, the VDV should be used to assess whole body vibration exposure. The fourth-power vibration dose value (VDV) is in $m/s^{1.75}$ and is defined as:

$$VDV = \left[\int_0^T a_w{}^4(t)dt\right]^{\frac{1}{4}} \quad \textbf{equation 3.5}$$

### 3.2.4. Daily vibration exposure value

The A(8) value is the $a_W$ walue normalized to an 8-hour workday and is defined by:

$$A(8) = a_w\sqrt{T/8} \quad \textbf{equation 3.6}$$

### 3.3. None-Weighting and ISO Weighting Frequency Responses

### 3.4. 1/3 Octave Frequency Responses

The measured acceleration time signal is examined in 1/3 octave frequency bands from 1.25 to 100 Hz. The advantage of using the 1/3 octave bands is that a more detailed description of the frequency content is observed. Acceleration transmissibility as well as percent reduction are displayed in 1/3 octave frequency bands.

#### 3.4.1. Ambulatory Position

For the rms and VDV values in the ambulatory posture all of the 1/3 octave data should be weighted in all directions from 1.25 to 100 Hz as required by the ISO Standard 2631-*Mechanical Vibration and shock Evaluation of Human Exposure to Whole-body Vibration*. Figure 3.2 shows the attenuation curve in all directions x,y and z, where $w_k$ is the attenuating curve for the z-direction (vertical), $w_d$ for the y-direction (side-to-side) and $w_f$ for the x-direction (front-to-back).

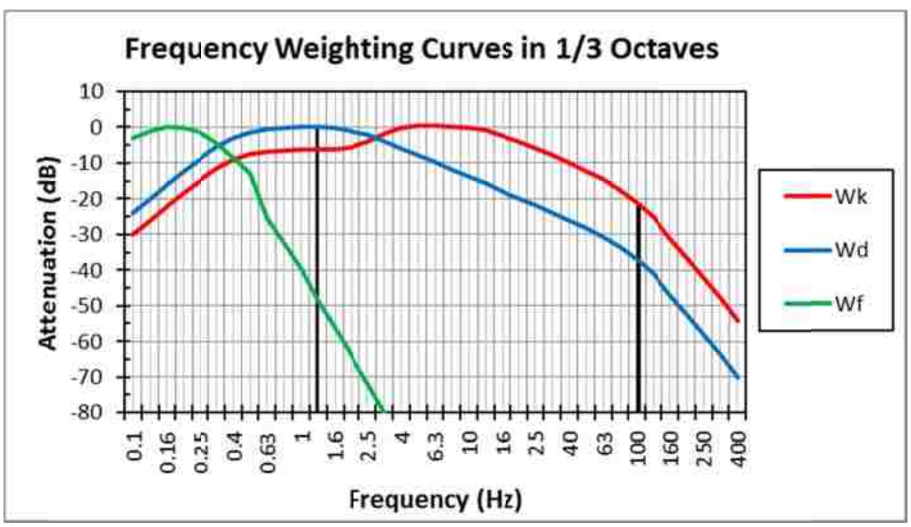


Figure 3.2 ISO 2631 weighting curve for seated whole-body vibration

### 3.4.2. Supine Position

Due to lack of research into whole body vibration exposure in the supine position, ISO weighing of the acceleration time signal is not permissible. Instead of ISO weighting, a low pass Butterworth filter with an upper frequency limit of 100 Hz is used to eliminate high frequencies.

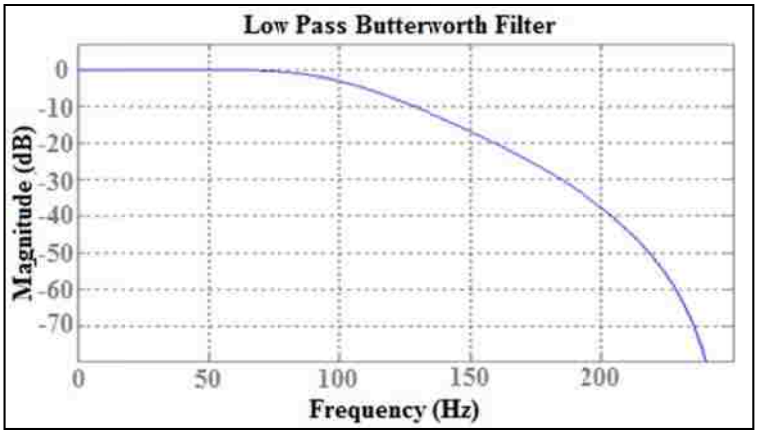

Figure 3.3 Low Pass Butterworth Filter for supine whole-body vibration

### 3.4.3. Other Filters Used

To eliminate unwanted harmonics at the lower frequency bands for the MRAP ambulance tests, a Butterworth band pass filter from 2.5 to 100 Hz was used to address the results.

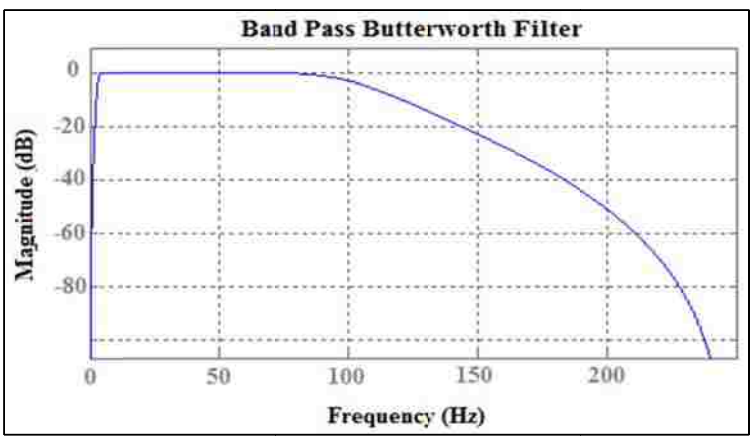

Figure 3.4 Band Pass Butterworth Filter

# CHAPTER 4

# VIBRATION INSTRUMENTATION, CALIBRATION, AND TEST PROTOCOLS

As mentioned in the chapter 1, this thesis focuses primarily on the experimental aspect of the project. With the help of USAARL field experimentations were devised and arranged to test the seat and litter air bladders deployed in the medical response ground-borne and air-borne vehicles. This section will go over the test vehicles, instrumentation, physical tests setup and the different seat and litter air bladder configuration that were tested.

The experiments took place on three separate occasions and two different locations. The MRAP ambulance tests were conducted at Ft. Detrick, Maryland, and the Black Hawk helicopter tests were conducted at Ft. Rucker, Alabama. The MRAP ambulance tests were conducted in July, 2011, and November, 2011. The Black Hawk helicopter tests were conducted in July, 2011, and April, 2012.

## 4.1. Ground and Airborne Test Vehicles

### 4.1.1. RG-33 HAGA MRAP

The MRAP is an armored ambulance designed for mine and IED resistance with a primary mission of medical evacuation [4]. The MRAP has a v-shaped profile that can successfully deflect blast from below the vehicle outward and upward. It is manufactured by BAE and is currently deployed in Iraq and Afghanistan [4]. It is an all-terrain vehicle that can operate in all weather conditions and reach speeds up to 110 km/hr [4]. The MRAP ambulance can hold up to three litter patients, or two on litter and two ambulatory [4]. Figures 4.1 and 4.2 show pictures of the MRAP ambulance from the outside and the inside, respectively.

Figure 4.1 RG-33 HAGA MRAP Ambulance [5]

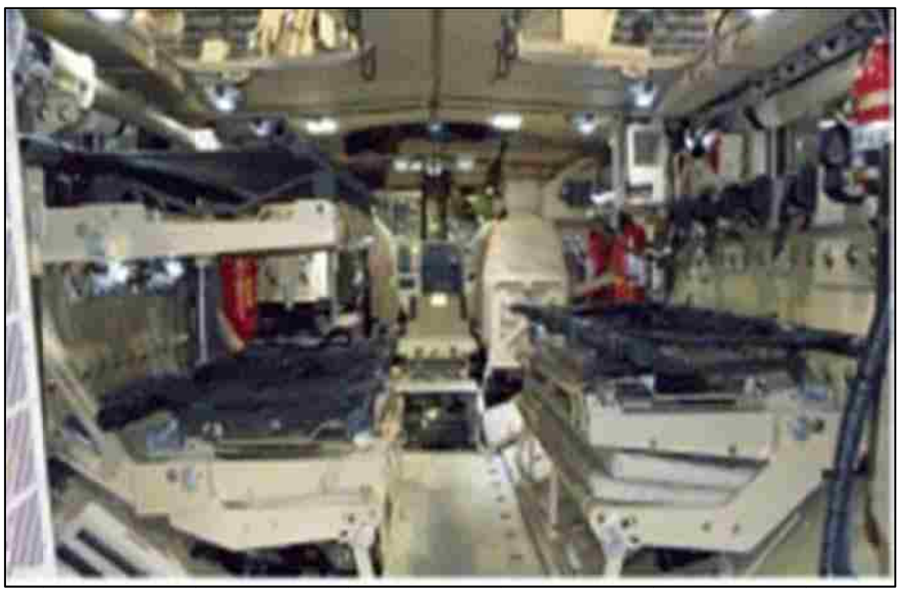

Figure 4.2 Inside of the MRAP Ambulance [6]

### 4.1.2. HH-60M MEDEVAC BLACK HAWK

The Black Hawk HH-60M is an upgraded version of the combat helicopter Black Hawk UH-60 [7]. The helicopter is manufactured by Sikorsky and designed to be a quick and efficient mean of medical transport [7]. It can carry up to six litter or seated patients [7]. Figures 4.3 and 4.4 show pictures of the Black Hawk HH-60M helicopter.

Figure 4.3 Black Hawk HH-60M during training [8]

Figure 4.4 Inside of the Black Hawk Medevac [9]

## 4.2. Instrumentation

### 4.2.1. Data Acquisition System

The data acquisition system that was used to record the data in the field experiments was Crystal Instruments COCO90. Shown in Figure 4.5, the COCO 90 is a 16 input channel and 1 output channel handheld data recorder and dynamic signal analyzer.

Figure 4.5 CI COCO90

4.2.2. Accelerometer Calibrator

To calibrate the accelerometers a PCB Piezotronics Calibrator Handheld Shaker was used as shown in Figure 4.6. The calibrator emits a reference signal of 1 g or 9.81 $m/s^2$ at a frequency of 159.2 Hz.

Figure 4.6 PCB Calibrator

4.2.3. Vibration Transducers

Two Types of accelerometers were used in the field tests. They were adhesively mountable tri-axial IEPE accelerometers and an IEPE seat pad accelerometers. Figure 4.7 shows an IEPE tri-axial accelerometer of the type that was used in the field experiments. Accelerometers with nominal sensitivities of 100 and 10 mV/g were used. Figure 4.8 shows a tri-axial SAE seat pad accelerometer of 100 mV/g nominal sensitivity.


Figure 4.7 IEPE Triaxial Accelerometer

Figure 4.8 Seat Pad Acceleromete

4.2.4. Calibration Procedure

The accelerometer were calibrated before each set of field tests, using the PCB handheld shaker that generates a calibration acceleration signal with value of 1g or 9.81 $m/s^2$ at a frequency of 159.2 Hz. The calibration of each tri-axial accelerometer was checked as follows:

- The accelerometer sensitivity was entered into the C0C0-90 analyzer
- The accelerometer was placed on the vibration calibrator which was then turned on
- The analyzer should read an rms value close 1 g or 9.81 $m/s^2$
- If the analyzer did not read 1 g or 9.81 $m/s^2$, the accelerometer sensitivity in the CoCo-90 analyzer was adjusted accordingly until the correct acceleration value appeared on the analyzer

4.3. Seat and Litter Air Bladder Configurations

Table 4.1 and Table 4.2 summarize the entire seat and litter air bladders tested over the course of this project.

Table 4.1 Seat Air Bladder Configurations

| **Seat Air Bladder Configurations** | | | | |
|---|---|---|---|---|
| **Configuration Number** | **Seat Back Foam Density lb/ft$^3$** | **Seat Bottom Foam Density lb/ft$^3$** | **Foam Hole Diameter inch** | **Orfice Tube Diameter inch** |
| **S1** | 1.5 | 1.5 | 1.0 | 3/8 |
| **S2** | 2.0 | 2.0 | 1.0 | 3/8 |
| **S3** | 1.5 | 2.0 | 1.0 | 3/16 |
| **S4** | 1.5 | 2.0 | 1.0 | 3/8 |

Table 4.2 Litter Air Bladder Configurations

| **Litter Air Bladder Configurations** | | | |
|---|---|---|---|
| **Configuration Number** | **Foam Density lb/ft$^3$** | **Foam Hole Diameter inch** | **Orfice Tube Diameter inch** |
| **L1** | 1.5 | 1.0 | 3/8 |
| **L2** | 2.0 | 1.0 | 3/8 |

### 4.4. Accelerometer Locations and Orientations

The location and orientation of the IEPE tri-axial and IEPE seat pad accelerometers used for the seat air bladder tests differed from those used for the litter air bladder tests. The MRAP seat air bladder tests were different from the Black Hawk seat air bladder tests The MRAP seat was on a solid bench and initially used a soft seat cushion. The Black Hawk seat consisted of a metal frame with attached canvas webbing on no seat cushion.

#### 4.4.1. MRAP and Black Hawk Seat Air Bladder Tests

Figure 4.9 shows the general accelerometer locations for the seat cushion and seat air bladder tests. The figure also shows the biodynamic coordinate system. A tri-axial SAE seat pad accelerometer was located above and below the seat cushion or seat air bladder to measure the acceleration signal before and after it passes through the seat cushion or seat bladder. Reference tri-axial accelerometers were located to the left of the seat and on the vehicle floor. For the MRAP ambulance, the reference accelerometer was located on the seat bench to the left of the seat cushion or seat air bladder. For the Black Hawk helicopter, the reference accelerometers was located on the seat frame (that supported the seat webbing) to the left of where the seat occupant sat.

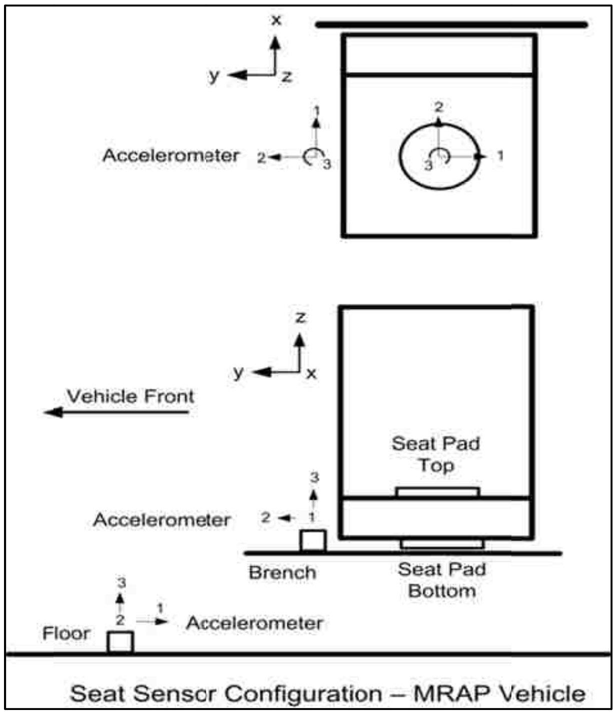


Figure 4.9 Sensor location and orientation - Ambulatory

#### 4.4.2. MRAP and Black Hawk Litter Air Bladder Tests

Figure 4.10 shows the general accelerometer locations for the litter air bladder tests. The figure shows the biodynamic coordinate system for the tests. A tri-axial SAE seat pad accelerometer was located above and below the litter air bladder at the pelvis and the shoulder locations. For the MRAP ambulance tests, reference tri-axial accelerometers were located on the litter rack close to one of the litter stirrups, on the litter stirrup, and on the vehicle floor. For the Black Hawk helicopter tests, reference accelerometers were located on the litter pan close to one of the litter stirrups, on the litter stirrup, and on the vehicle floor.

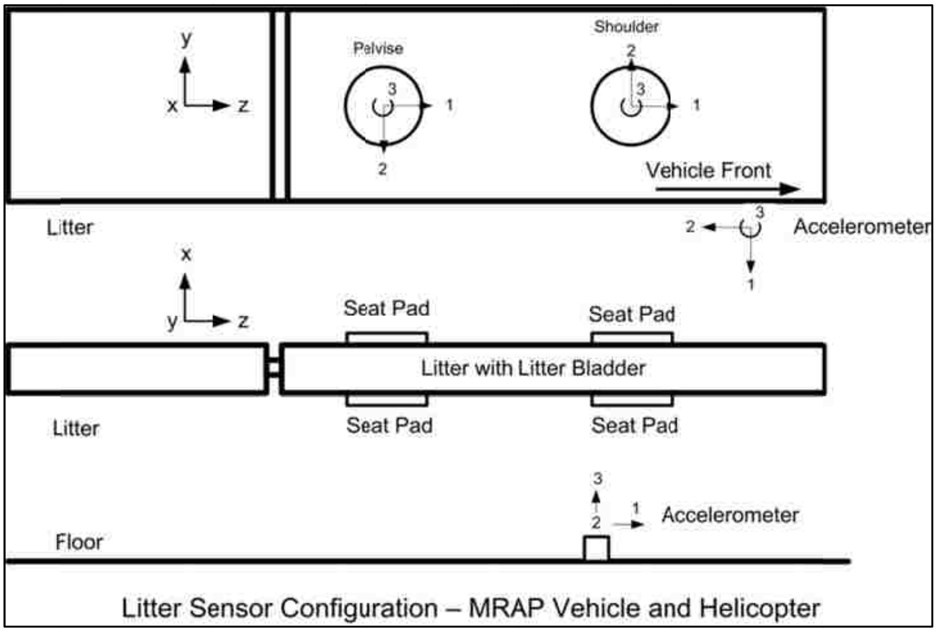

Figure 4.10 Sensor location and orientation – Supine

## 4.5. Test Set-ups

This section describes the instrument set-ups and test conditions for the MRAP ambulance and Black Hawk helicopter tests. The accelerometer locations on the MRAP ambulance and Black Hawk helicopter for the seat and litter air bladder tests are presented. Detailed descriptions for each test series are given. The field test conditions, the test volunteer physical attributes, and seat and litter air bladder configurations are detailed.

### 4.5.1. July 2011 - MRAP Ambulance Tests, Fort Detrick, Site B

Both seat and litter air bladders were examined during each MRAP ambulance field test.

#### 4.5.1.1. Field Test Conditions

The MRAP ambulance test track conditions are listed below (Figure 4.11):

- Gravel road course- 0.5 miles long
- 4-in.x6-in. wood blocks on course, on just driver's side, both sides and just passenger's side
- Potholes at irregular intervals
- Two vehicle speeds: 20 and 30 mph

Figure 4.11 MRAP Road Course

#### 4.5.1.2. Test Subject Physical Attributes

a. Test Subject Attributes - Seat Air Bladder Tests

- Height: 5-ft 6-in.
- Weight: 176 lb.

b. Test Subject Attributes - Litter Air Bladder Tests

- Height: 6-ft 3-in.
- Weight: 210 lb.

#### 4.5.1.3. Air Bladder Configurations

Table 4.3 shows the different seat and litter air bladder configurations that were field tested

Table 4.3 Seat/Litter Air Bladder Configurations

| **Seat and Litter Air Bladder Configurations Tested** | |
|---|---|
| **Seat Configuration** | **Litter Configuration** |
| S1 | L1 |
| S2 | L2 |

### 4.5.2. July 2011 - Black Hawk Helicopter Tests, Ft Rucker, USRAAL Helipad

Only the litter air bladder was examined during this field tests.

#### 4.5.2.1. Field Test Conditions

The weather was partly cloudy with approximately 90 degree Fahrenheit temperatures. Several flight maneuvers were used for the helicopter tests to simulate different flight scenarios that could be experienced during a helicopter ride.. The helicopter flight maneuvers are summarized in Table 4.3.

Table 4.3 Rotary-wing Flight Profiles

| Profile | Flight Maneuver |
|---|---|
| **0** | Ground with Rotors Turning |
| **1** | In Ground Effect Hover (10' above ground hover performance) |
| **2** | Out Ground Effect Hover (70' above ground hover performance) |
| **3** | VMC Approach to Hover (SHUDDER) (high vibration visual approach) |
| **4** | Roll-On Landing (high-speed rolling landing) |
| **5** | Rolling Take Off (high-speed rolling take-off) |
| **6** | 60º Bank (left and right) at 120 Knots (left and right rolls |
| **7** | Flight at Vh (maximum speed for level flight) |
| **8** | Climb to 10,000'MSL (climbing at over 2000 fpm to 10,000' MSL) weather permitting |

#### 4.5.2.2. Test Subject Physical Attributes

- Height: 6-ft 3-in.
- Weight: 210 lb.

#### 4.5.2.3. Litter Air Bladder Configurations

The litter air bladder configurations that were tested are L1 and L2

### 4.5.3. November 2011 - MRAP Ambulance Tests, Fort Detrick, Site B

In this field test both seat and litter air bladders were tested.

#### 4.5.3.1. Field Test Conditions

- Gravel road course, 0.5 miles long
- 4-in.x6-in. blocks on course, at irregular intervals
- Potholes at irregular intervals
- Vehicle speed 30 mph

#### 4.5.3.2. Test Subject Physical Attributes

a. Seat Air Bladder Tests

- Height: 6-ft 1-in.
- Weight: 176 lb.

b. Litter Air Bladder Tests

- Height: 6-ft 1-in.
- Weight: 176 lb.

#### 4.5.3.3. Air Bladder Configurations

Table 4.4 Seat and Litter air Bladder Configurations

| **Seat and Litter Air Bladder Configurations Tested** | |
|---|---|
| **Seat Configuration** | **Litter Configuration** |
| S3 | L1 |
| S4 | L2 |

### 4.5.4. April 2012 - Black Hawk Helicopter Tests, Ft. Rucker, USRAAL Helipad

Both seat and litter air bladders were examined during each MRAP ambulance field test.

#### 4.5.4.1. Field Test Conditions

The weather condition was fair with clear skies and approximately 75 degrees Fahrenheit temperatures. Several flight maneuvers were used for the helicopter tests to simulate different flight scenarios that could be experienced during a helicopter ride.. The helicopter flight maneuvers are summarized in Table 4.2 above.

#### 4.5.4.2. Test Subject Physical Attributes

a. Seat Air Bladder Tests

- Height: 6-ft 3-in.
- Weight: 210 lb.

b. Litter Air Bladder Tests

- Height: 6-ft 3-in.
- Weight: 210 lb.

4.5.4.3. Air Bladder Configurations

Table 4.5 Seat and Litter Bladder Configurations

| **Seat and Litter Air Bladder Configurations Tested** | |
|---|---|
| **Seat Configuration** | **Litter Configuration** |
| S3 | L1 |
| S4 | L2 |

# CHAPTER 5

# SEAT AND LITTER AIR BLADDER FIELD TESTS RESULTS

This chapter presents the results of the MRAP ambulance and Black Hawk helicopter seat and litter air bladder field tests. The 1/3 octave frequency band acceleration and vibration transmissibility plots are presented with the corresponding percent vibration and shock reductions. Also presented are tables that contain the overall rms and VDV shock and vibration values and the corresponding percent shock and vibration reductions in terms of the rms and VDV values.

## 5.1. MRAP Seat Air Bladder Results

Figure 5.1 shows the 1/3 octave band acceleration values that were measured at the indicated location for the S3 seat air bladder configuration in the z-direction (vertical). These values were obtained during the MRAP field test performed in November 2011. Figure 5.2 shows the corresponding 1/3 octave band acceleration transmissibility values through the MRAP seat cushion and the S3 and S4 seat air bladder configurations in the z-direction (vertical). Figure 5.3 is a re-plot of Figure 5.2 in terms of percent vibration reduction. The values in the plots are the averages of four test runs that were performed for each test configuration. The related y- and z-direction 1/3 octave acceleration, vibration transmissibility, and percent vibration reduction are in Appendix A2. The S4 seat air bladder configuration field test results in the z-, y-, and z-directions are in Appendix A2. The corresponding 1/3 frequency band plots for the seat air bladder configurations that were examined in the July 2011 MRAP field tests  are in Appendix A1.

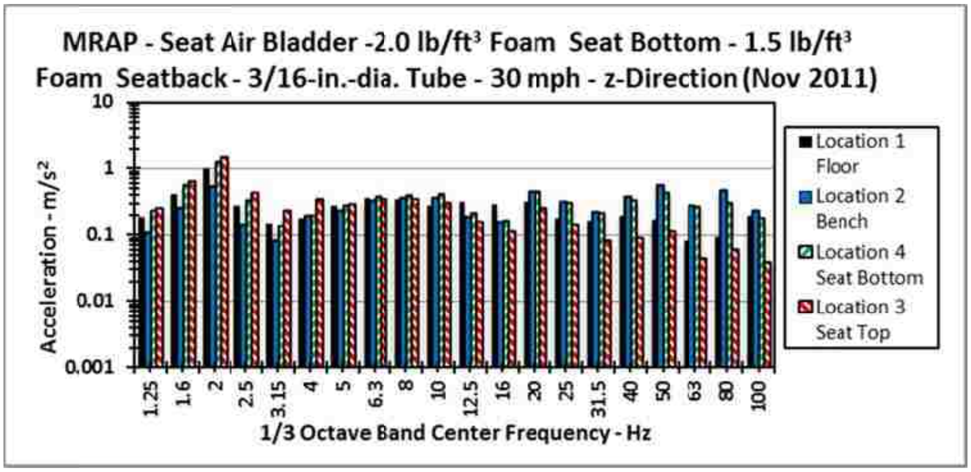

Figure 5.1 Acceleration - MRAP seat air bladder test - S3 - z-direction

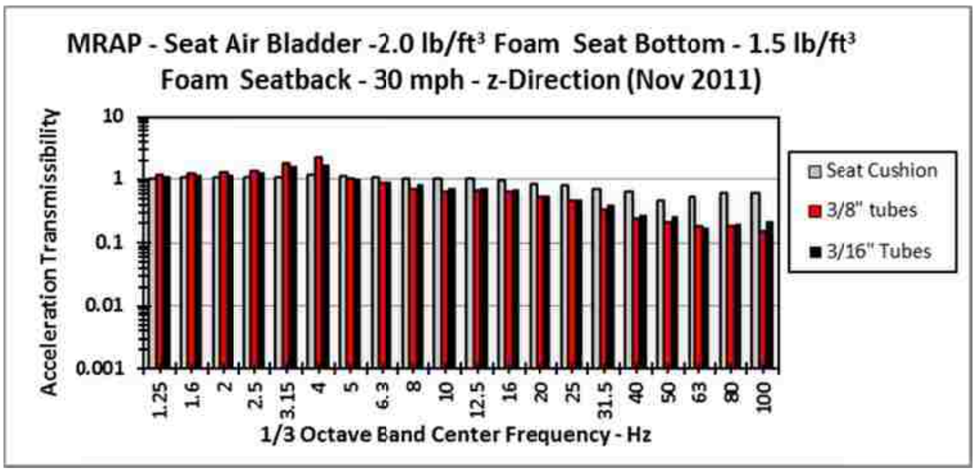

Figure 5.2 Acceleration transmissibility - MRAP seat air bladder test – z-direction- Through seat air bladder/ seat cushion only

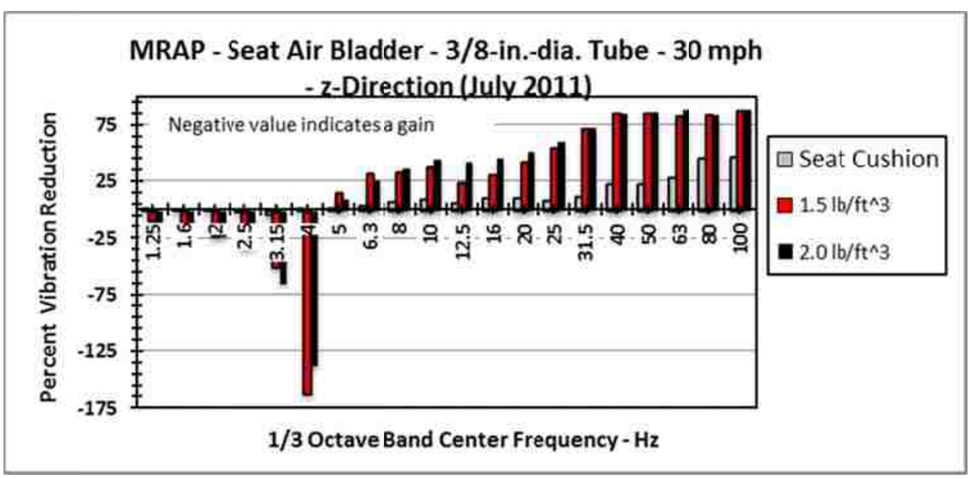

Figure 5.3 Percent vibrationr reduction - MRAP seat air bladder test - z-direction

Table 5.1 shows the overall rms and VDV acceleration values for the July 2011 and the November 2011 MRAP ambulance seat air bladder field tests in the z-direction (vertical). The rms and VDV values shown in this table are taken at the MRAP vehicle floor, between the seat bench and the bottom of the seat cushion or seat air bladder, and between the top of the cushion or seat air bladder and the buttock of the seat occupant. The results displayed were filtered using either a low pass (1-100 Hz), a band pass (2.5-100 Hz) or the ISO 2631 weighting filter. Table 5.2 shows the corresponding percent vibration and shock reduction associated with the rms and VDV values in Table 5.1. The percent reductions were through the seat cushion or seat airbladder and percent reduction through the seat air bladder relative to the percent reduction through seat cushion. The y- and x-direction rms and VDV acceleration values and related percent shock and vibration reductions are in Appendix B1.

Table 5.1 MRAP seat air bladder - overall rms and VDV values – z-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results z-Direction (Vertical) | Frequency Range Hz | Overall rms Value ($m/s^2$) | | | Overall VDV Value ($m/s^{1.75}$) | | |
|---|---|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 1.60 | 2.06 | 1.96 | 7.26 | 9.36 | 8.69 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 1.55 | 1.97 | 1.94 | 7.36 | 9.00 | 8.46 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 1.50 | 1.92 | 1.90 | 6.06 | 7.72 | 8.68 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 1.09 | 1.45 | 1.30 | 6.99 | 7.96 | 7.09 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 1.03 | 1.37 | 0.91 | 6.40 | 7.66 | 4.67 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 0.97 | 1.32 | 0.85 | 5.21 | 7.40 | 4.36 |
| MRAP (Jul 2011) - Seat Cushion | ISO Filter | 1.05 | 1.42 | 1.34 | 5.43 | 6.92 | 6.39 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | ISO Filter | 1.00 | 1.31 | 1.20 | 5.06 | 6.39 | 5.51 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | ISO Filter | 0.98 | 1.27 | 1.17 | 5.21 | 6.44 | 5.71 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 1.60 | 1.94 | 1.97 | 8.25 | 9.54 | 9.83 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 1.47 | 1.88 | 1.96 | 7.94 | 9.56 | 10.67 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 1.50 | 1.88 | 1.91 | 8.19 | 9.52 | 10.14 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 1.06 | 1.22 | 1.15 | 6.87 | 6.84 | 6.41 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 1.00 | 1.32 | 0.94 | 6.69 | 7.72 | 5.02 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 0.97 | 1.24 | 0.92 | 6.73 | 7.69 | 5.31 |
| MRAP (Nov 2011) - Seat Cushion | ISO Filter | 1.11 | 1.25 | 1.31 | 6.61 | 6.36 | 6.61 |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | 1.26 | 1.18 | 1.23 | 6.27 | 6.34 | 6.82 |
| MRAP (Nov 2011) - 3/16-in.Tubes | ISO Filter | 1.02 | 1.17 | 1.20 | 6.51 | 6.29 | 6.65 |

Table 5.2 MRAP seat air bladder - percent reduction in rms and VDV – z-direction

| MRAP Ambulance<br>Summary of Seat Air Bladder Test Results<br>z-Direction (Vertical) | Frequency Range Hz | Percent Reduction in rms values | | Percent Reduction in VDV values | |
|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 4.9 | - | 7.2 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 1.5 | 1.0 | 6.0 | 2.6 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 1.0 | 3.1 | -12.4 | 0.1 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 10.3 | - | 10.9 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 33.6 | 30.0 | 39.0 | 34.1 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 35.6 | 34.6 | 41.1 | 38.5 |
| MRAP (Jul 2011) - Seat Cushion | | 5.6 | - | 7.7 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | ISO Filter | 8.4 | 10.4 | 13.9 | 13.9 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | | 7.9 | 12.7 | 11.5 | 10.8 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | -1.5 | - | -3.0 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | -4.3 | 0.5 | -11.6 | -8.5 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | -1.6 | 3.0 | -6.5 | -3.2 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 5.7 | - | 6.3 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 28.8 | 18.3 | 35.0 | 21.7 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 25.8 | 20.0 | 30.9 | 17.2 |
| MRAP (Nov 2011) - Seat Cushion | | -4.8 | - | -3.9 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | -4.2 | 6.1 | -7.6 | -3.2 |
| MRAP (Nov 2011) - 3/16-in.Tubes | | -2.6 | 8.4 | -5.7 | -0.6 |

## 5.2. Black Hawk Seat Air Bladder Results

Figure 5.3 shows the 1/3 octave band acceleration values measured at the indicated location for the S3 seat air bladder configuration in the z-direction (vertical). These values were obtained during the Black Hawk field test performed in April 2012. Figure 5.4 shows the corresponding 1/3 octave band acceleration transmissibility values through the Black Hawk seat air bladder S3 and S4 configurations in the z-direction (vertical). Figure 5.5 shows the 1/3 octave band acceleration transmissibility values through the Black Hawk S3 and S4 seat air bladder configurations in the z-direction (vertical). Figure 5.6 shows the 1/3 octave band acceleration transmissibility values through the Black Hawk seat frame and the Black Hawk seat frame and the S3 and S4 seat air bladder configurations in the z-direction (vertical). Figure 5.7 is a re-plot of Figure 5.6 in terms of percent vibration reduction. The plots are the averages of the test flight profiles that were performed for each test configuration. The related y- and x-direction 1/3 octave acceleration, vibration transmissibility and percent vibration reduction plots are in Appendix A3. The S4 seat air bladder configuration field test results in the z-, y-, and x-directions are in Appendix A3.

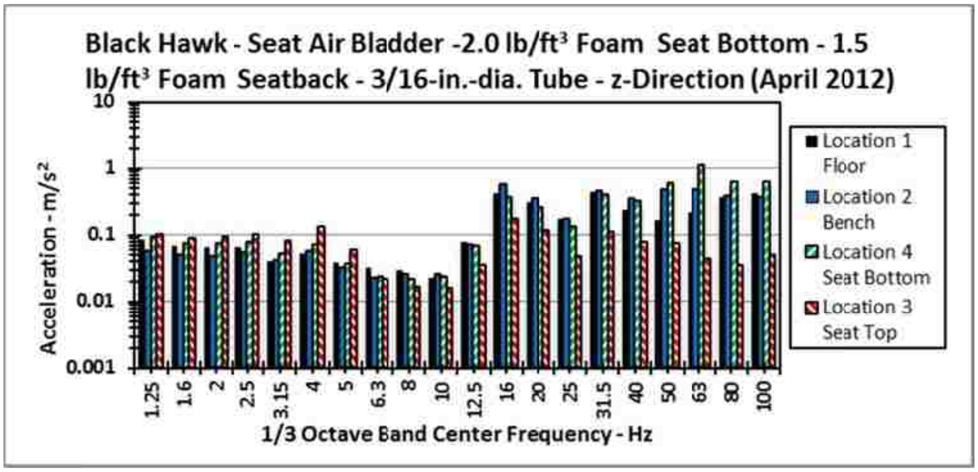

Figure 5.4 Acceleration - Black Hawk seat air bladder test - S3 - z-direction

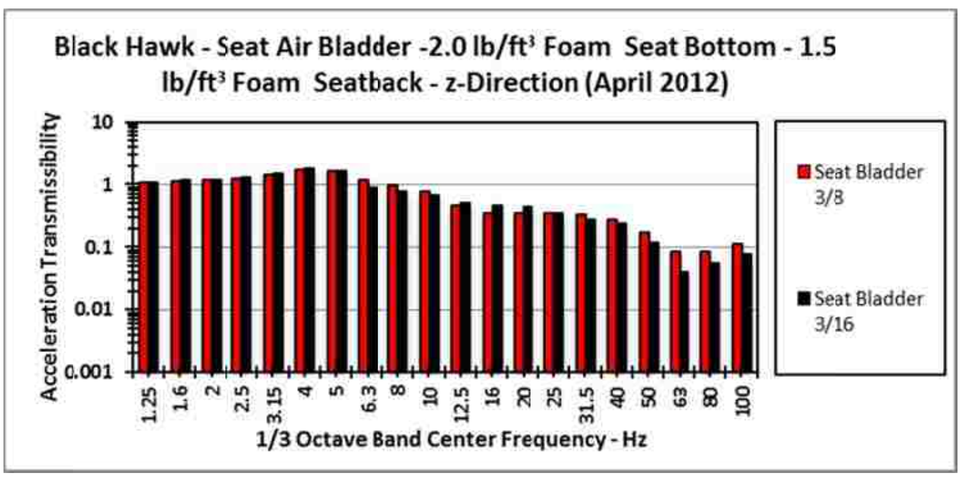

Figure 5.5 Acceleration transmissbility – Black Hawk seat air bladder test – z-direction - through seat air bladder only

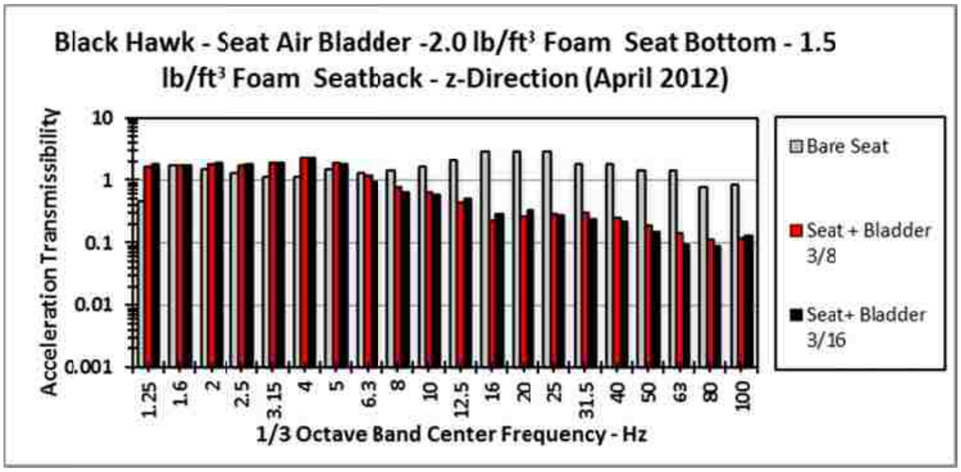


Figure 5.6 Acceleration transmissbility –Black Hawk seat air bladder test – z-direction-through seat frame and/or seat air bladder

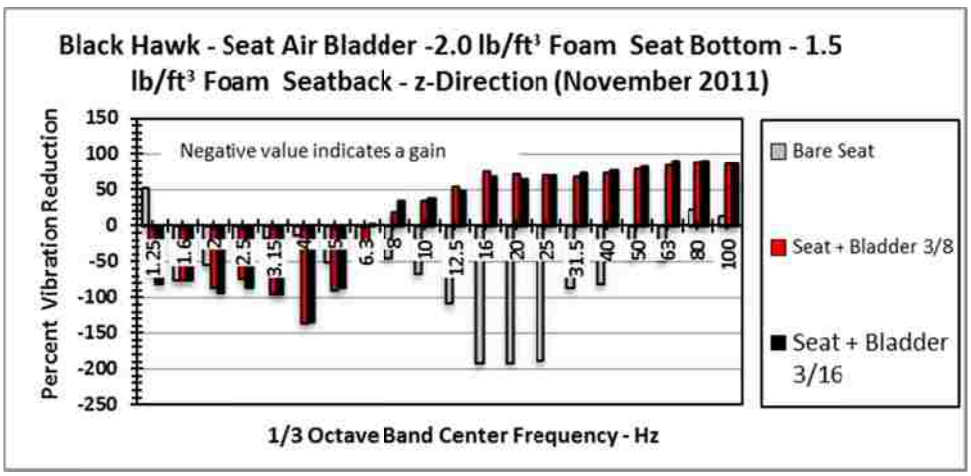


Figure 5.7 Percent Vibration Reduction - Black Hawk seat air bladder test – z-direction

Table 5.3 shows the overall rms acceleration values for the April 2012 Black Hawk seat air bladder field tests in the z-direction (vertical) for all the test flight profiles performed for each test configuration. The rms values shown in this table are taken at the Black Hawk helicopter floor, the seat frame, between the seat bed and the seat occupant's buttock for the bare seat configuration, between the seat bed and the bottom of the seat air bladder and between the top of the seat air bladder and the seat occupant's buttock. The results displayed were filtered using either a low pass (1-100 Hz) or the ISO 2631 weighting filter. Table 5.4 shows the corresponding percent shock and vibration reduction associated with the rms values in Table 5.3. The percent reductions were through the seat air bladder and through the seat air bladder relative to the bare seat. The y- and x-direction rms acceleration values and related percent shock and vibration reductions are in Appendix B2. The S3 and S4 seat air bladder configuration ISO weighted rms acceleration values and the related percent shock and vibration reductions are in AppendixB2.

Table 5.3 Black Hawk seat air bladder - rms values (low pass filter) – z-direction

| **Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Vertical)** | **Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012)** | | | |
|---|---|---|---|---|
| | **Helicopter Floor** | **Helicopter Seat Frame** | **Between Seat Bed and Buttock or Bladder Bottom** | **Between Bladder Top and Buttock** |
| Bare Seat -Flight Profile (0) | 1.31 | 1.92 | 0.91 | |
| Bare Seat -Flight Profile (1) | 1.21 | 1.06 | 0.50 | |
| Bare Seat -Flight Profile (2) | 1.71 | 1.32 | 0.61 | |
| Bare Seat -Flight Profile (3) | 2.45 | 3.06 | 1.04 | |
| Bare Seat -Flight Profile (4) | 1.81 | 2.18 | 0.94 | |
| Bare Seat -Flight Profile (5) | 1.58 | 1.95 | 1.11 | |
| Bare Seat -Flight Profile (7) | 2.78 | 2.67 | 1.08 | |
| Bare Seat -Flight Profile (S&L) | 1.58 | 1.90 | 0.64 | |
| **Average** | **1.80** | **2.01** | **0.85** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 2.00 | 1.87 | 1.55 | 0.42 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 1.39 | 1.11 | 1.27 | 0.26 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 1.68 | 1.35 | 1.33 | 0.23 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 3.49 | 3.04 | 2.65 | 0.52 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 2.07 | 1.86 | 1.51 | 0.53 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 1.95 | 1.70 | 1.49 | 0.57 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 3.73 | 3.08 | 2.05 | 0.69 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 2.16 | 1.73 | 1.70 | 0.40 |
| **Average** | **2.31** | **1.97** | **1.70** | **0.45** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 1.57 | 1.66 | 1.26 | 0.40 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 1.33 | 1.21 | 0.96 | 0.26 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 1.35 | 1.19 | 0.94 | 0.27 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 2.01 | 2.35 | 1.52 | 0.40 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 1.88 | 2.09 | 1.32 | 0.82 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 1.65 | 1.73 | 1.01 | 0.44 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 3.42 | 2.83 | 2.03 | 0.65 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 1.97 | 1.94 | 1.46 | 0.55 |
| **Average** | **1.90** | **1.88** | **1.31** | **0.48** |

Table 5.4 Black Hawk seat air bladder - percent reduction in rms – z-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Vertical) | Percent Reduction in rms Values - (April 2012) | | | |
|---|---|---|---|---|
| | Low Pass Filter (1-100 Hz) | | ISO Filter | |
| | Through Bladder | Bladder Relative to Seat with no Bladder | Through Bladder | Bladder Relative to Seat with no Bladder |
| 3/16-in. Tube Bladder-Flight Profile (0) | 72.8 | 53.4 | 48.7 | 48.6 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 79.3 | 47.6 | 52.9 | 44.9 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 82.9 | 62.8 | 45.3 | 58.3 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 80.2 | 49.8 | 59.4 | 55.5 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 65.2 | 43.8 | 31.6 | 39.4 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 61.9 | 48.7 | 27.2 | 40.8 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 66.1 | 35.9 | 33.8 | 23.7 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 76.7 | 37.6 | 43.6 | 39.8 |
| **Average** | **73.3** | **46.9** | **43.2** | **43.8** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 67.9 | 55.4 | 48.0 | 49.4 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 72.8 | 48.2 | 44.1 | 41.4 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 70.9 | 55.3 | 38.2 | 49.4 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 73.3 | 61.2 | 54.5 | 66.5 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 37.5 | 12.2 | 14.1 | 8.8 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 56.8 | 60.5 | 29.8 | 56.3 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 67.8 | 39.6 | 40.9 | 29.2 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 61.9 | 12.7 | 34.1 | 21.8 |
| **Average** | **63.7** | **44.2** | **37.8** | **41.8** |

## 5.3. MRAP Litter Air Bladder Results

Figure 5.8 shows the 1/3 octave band acceleration values measured at the indicated location for the L1 litter air bladder configuration in the x-direction (vertical). These values were obtained during the MRAP field test performed in November 2011. Figure 5.9 shows the corresponding 1/3 octave band acceleration transmissibility values through the litter air bladder L1 and L2 configurations. Figure 5.10 shows the 1/3 octave band acceleration transmissibility values through the bare litter and through the litter with the L1 and L2 litter air bladder configurations in the x-direction (vertical). Figure 5.11 is a re-plot of Figure 5.10 in terms of percent vibration reduction. The plots are the averages of the four test runs that were performed for each test configuration. The related y- and z-direction 1/3 octave acceleration, vibration transmissibility, and percent vibration reduction are in Appendix A5. The L2 litter air bladder field test results in the x-, y- and z-direction are in Appendix A5. The 1/3 octave frequency band plots for the MRAP litter air bladder configuration L1 and L2 performed in July 2011 are found in Appendix A4.

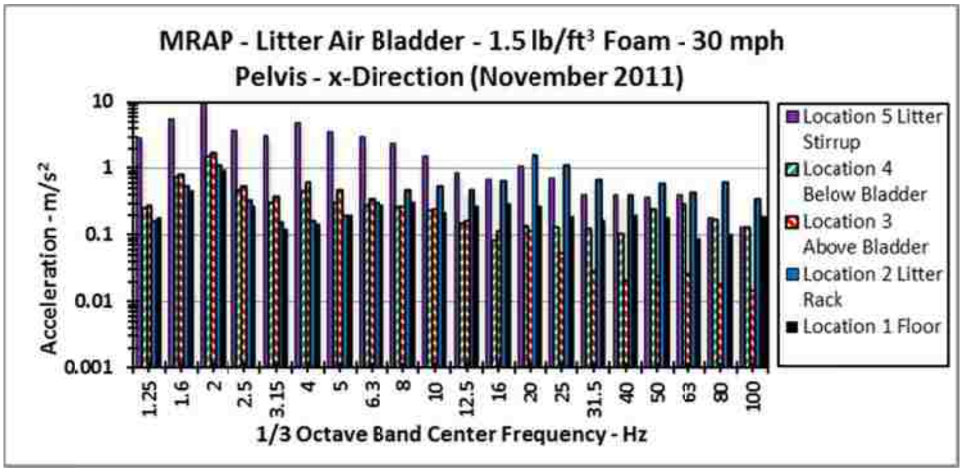


Figure 5.8 Acceleration - MRAP litter air bladder test – L1 - x-direction

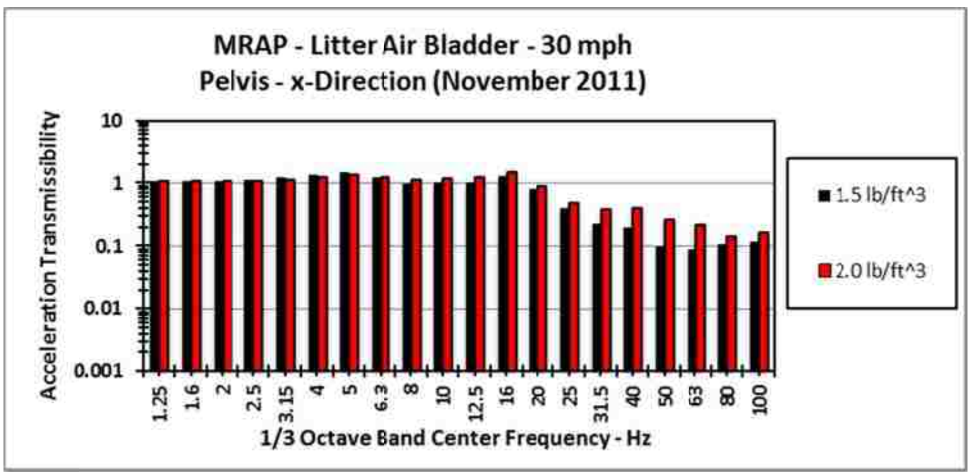


Figure 5.9 Acceleration Transmissibility – MRAP litter air bladder test – x-direction – Through litter air bladder only

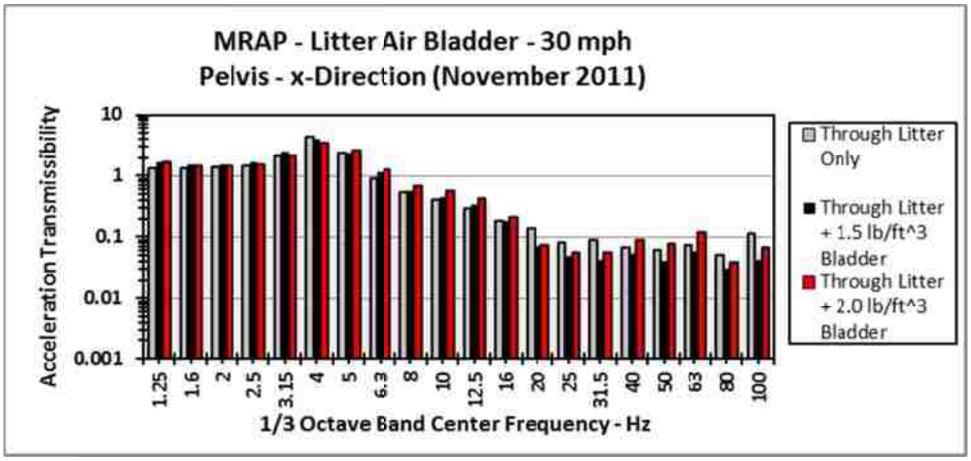


Figure 5.10 Acceleration Transmissibility – MRAP litter air bladder test – x-direction – Through litter and/or litter air bladder

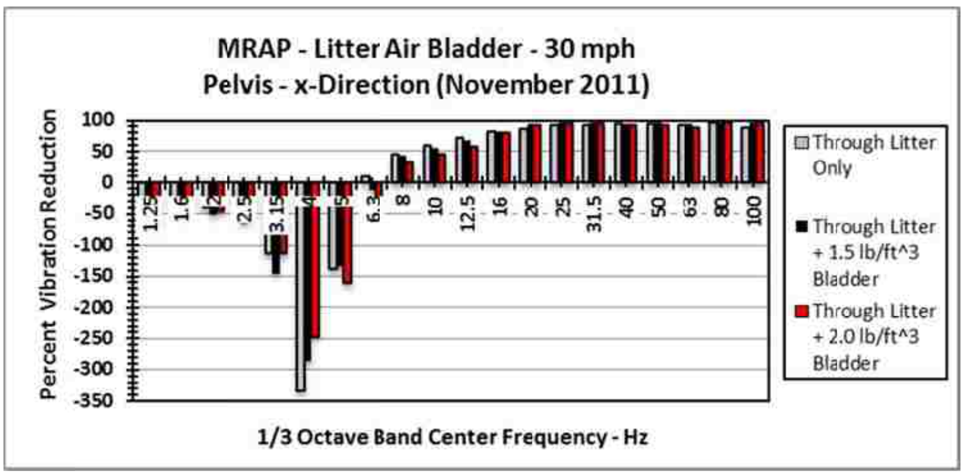


Figure 5.11 Percent Vibration Reduction - MRAP litter air bladder test – x-direction

Tables 5.5 and 5.6 show the overall rms and VDV acceleration values for the July 2011 and November 2011 MRAP ambulance litter air bladder field tests in the x-direction (vertical). The rms and VDV values shown in this table are taken at the MRAP vehicle floor, litter rack, litter stirrup, between litter bed and patient's pelvis in case of bare litter, between litter bed and the bottom of the litter air bladder, and between the top of the litter air bladder and the patient's pelvis. The results displayed were filtered using either a low pass (1-100 Hz) or a band pass (2.5-100 Hz) filter. Tables 5.7 and 5.8 show the corresponding percent shock and vibration reductions associated with the rms and

VDV values in Tables 5.5 and 5.6. The percent reductions were between the litter rack and the stirrup, between the litter rack and the litter webbing, through the bladder, and between the litter rack and the patient's pelvis. The y- and z-direction rms and VDV acceleration values and related percent shock and vibration reductions are in Appendix B3.

Table 5.5 MRAP litter air bladder - overall rms values – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Overall rms ( $m/s^2$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| **3/8-in. Tubes - Pelvice** | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 1.35 | *2.22* | 7.78 | 2.71 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.51 | *2.94* | 9.42 | 1.92 | 1.82 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.45 | *2.69* | 8.36 | 1.87 | 1.97 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 0.87 | *1.92* | 3.91 | 2.44 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.98 | *2.87* | 4.58 | 1.13 | 0.88 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.93 | *2.71* | 3.80 | 0.95 | 0.87 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 1.45 | 2.38 | 17.78 | 2.03 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.46 | 2.84 | 14.85 | 1.98 | 2.20 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.48 | 2.75 | 15.69 | 2.01 | 2.21 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.91 | 2.01 | 9.95 | 0.99 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.87 | 2.55 | 8.32 | 0.95 | 1.05 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.83 | 2.42 | 8.41 | 0.94 | 1.09 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 1.36 | 2.19 | 5.02 | 1.65 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.47 | 2.36 | 4.09 | 1.74 | 1.79 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.48 | 2.29 | 4.25 | 1.77 | 1.90 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.83 | 1.87 | 3.00 | 0.79 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.96 | 2.04 | 2.48 | 1.08 | 0.92 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.89 | 1.94 | 2.50 | 0.97 | 0.89 |

Table 5.6 MRAP litter air bladder - percent reduction – rms Value – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Percent Reductions in rms Values | | | | |
|---|---|---|---|---|---|
| **3/8-in. Tubes - Pelvice** | **Frequency Range Hz** | **Between Litter Rack and Stirrup** | **Between Litter Rack and Litter Bed** | **Through Bladder** | **Between Litter Rack and Bladder Top** |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | -251.0 | -22.2 | - | - |
| **MRAP (Jul 2011) - 1.5 $lb/ft^3$** | **1 - 100** | -220.7 | 34.5 | 5.2 | 37.9 |
| **MRAP (Jul 2011) - 2.0 $lb/ft^3$** | **1 - 100** | -210.4 | 30.7 | -5.7 | 26.7 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | -103.5 | -26.9 | - | - |
| **MRAP (Jul 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | -59.4 | 60.8 | 21.6 | 69.2 |
| **MRAP (Jul 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | -40.1 | 64.9 | 8.3 | 67.8 |
| **3/8-in. Tubes - Pelvice** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -647.1 | 14.7 | - | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **1 - 100** | -422.9 | 30.3 | -11.1 | 22.5 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **1 - 100** | -470.5 | 26.9 | -10.0 | 19.6 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -395.0 | 50.7 | - | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | -226.3 | 62.7 | -10.5 | 58.8 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | -247.5 | 61.2 | -16.0 | 55.0 |
| **3/8-in. Tubes - Shoulder** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -129.2 | 24.7 | - | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **1 - 100** | -73.3 | 26.3 | -2.9 | 24.2 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **1 - 100** | -85.6 | 22.7 | -7.3 | 17.0 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -60.4 | 57.8 | - | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | -21.6 | 47.1 | 14.8 | 54.9 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | -28.9 | 50.0 | 8.2 | 54.1 |

Table 5.7 MRAP litter air bladder - overall VDV values – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Overall Litter VDV ($m/s^{1.75}$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| **3/8-in. Tubes - Pelvice** | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 6.60 | *11.94* | 29.30 | 15.74 | - |
| **MRAP (Jul 2011) - 1.5 $lb/ft^3$** | **1 - 100** | 7.21 | *16.79* | 35.22 | 9.93 | 8.13 |
| **MRAP (Jul 2011) - 2.0 $lb/ft^3$** | **1 - 100** | 6.80 | *14.50* | 31.02 | 8.33 | 8.44 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 5.80 | *11.87* | 21.74 | 15.20 | - |
| **MRAP (Jul 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | 5.92 | *17.31* | 24.03 | 8.10 | 4.55 |
| **MRAP (Jul 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | 5.65 | *16.16* | 20.76 | 5.72 | 4.38 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 7.32 | 13.24 | 78.05 | 9.71 | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **1 - 100** | 7.40 | 17.23 | 66.78 | 9.86 | 10.69 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **1 - 100** | 7.26 | 15.84 | 69.99 | 9.72 | 10.66 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 6.12 | 12.53 | 49.51 | 5.19 | |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | 5.63 | 16.46 | 41.77 | 5.25 | 5.62 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | 5.28 | 15.10 | 4331.00 | 5.19 | 6.23 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 6.52 | 11.25 | 21.41 | 8.05 | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **1 - 100** | 7.75 | 13.38 | 18.17 | 8.49 | 8.91 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **1 - 100** | 7.49 | 12.26 | 18.96 | 8.93 | 9.91 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 4.93 | 10.47 | 13.83 | 4.04 | - |
| **MRAP (Nov 2011) - 1.5 $lb/ft^3$** | **2.5 - 100** | 6.35 | 12.73 | 12.41 | 5.58 | 4.92 |
| **MRAP (Nov 2011) - 2.0 $lb/ft^3$** | **2.5 - 100** | 5.58 | 11.33 | 12.69 | 5.09 | 4.70 |

Table 5.8 MRAP litter air bladder - percent reduction - VDV value –x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Percent Reductions in VDV Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| MRAP (Jul 2011) -Bare Litter | 1 - 100 | -145.4 | -31.8 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -109.8 | 40.8 | 18.2 | 51.6 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -113.9 | 42.5 | -1.3 | 41.8 |
| MRAP (Jul 2011) - Bare Litter | 2.5 - 100 | -83.1 | -28.0 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -38.8 | 53.2 | 43.9 | 73.7 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -28.5 | 64.6 | 23.5 | 72.9 |
| 3/8-in. Tubes - Pelvice | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -489.5 | 26.7 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -287.6 | 42.8 | -8.4 | 38.0 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -341.9 | 38.6 | -9.7 | 32.7 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | -295.1 | 58.6 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -153.8 | 68.1 | -7.0 | 65.9 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -186.8 | 65.6 | -20.0 | 58.7 |
| 3/8-in. Tubes - Shoulder | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -90.3 | 28.4 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -35.8 | 36.5 | -4.9 | 33.4 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -54.6 | 27.2 | -11.0 | 19.2 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | -32.1 | 61.4 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 2.5 | 56.2 | 11.8 | 61.4 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -12.0 | 55.1 | 7.7 | 58.5 |

## 5.4. Black Hawk Litter Air Bladder Results

Figure 5.12 shows the 1/3 octave band acceleration values measured at the indicated location for the L1 litter air bladder configuration in the x-direction (vertical). These values were obtained during the Black Hawk helicopter field test performed in April 2012. Figure 5.13 shows the 1/3 octave band acceleration transmissibility values through the litter air bladder configurations L1 and L2. Figure 5.14 shows the 1/3 octave acceleration band transmissibility values through the bare litter and through the litter with the L1 and L2 litter air bladder configurations in the x-direction (vertical). Figure 5.15 is a re-plot of Figure 5.14 in terms of percent vibration reduction. The plots are the averages of the test flight profiles that were performed for each test configuration. The related y- and z-direction 1/3 octave acceleration, vibration transmissibility, and percent vibration reduction plots are in Appendix A8. The L2 litter air bladder configuration field test results in the x-, y- and z-direction are in Appendix A8. The 1/3 octave frequency band plots for the Black Hawk July 2011 test are in Appendix A7.

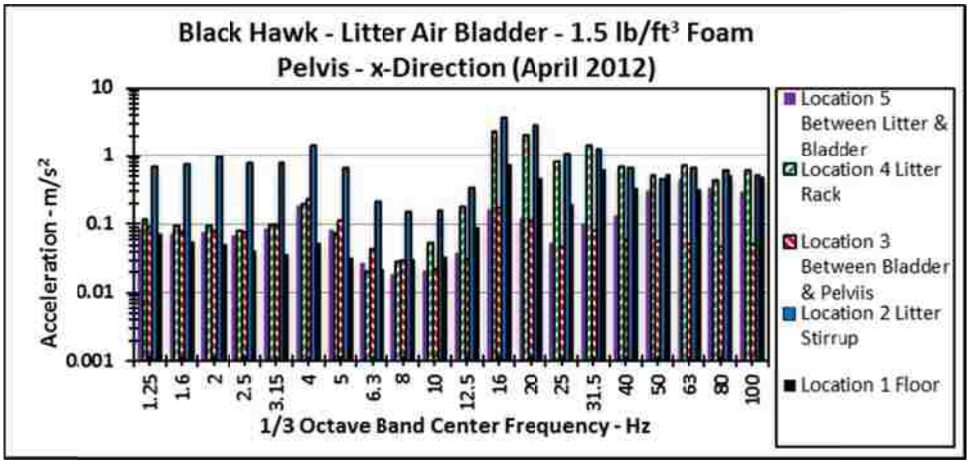


Figure 5.12 Acceleration - Black Hawk litter air bladder test – L1 - x-direction

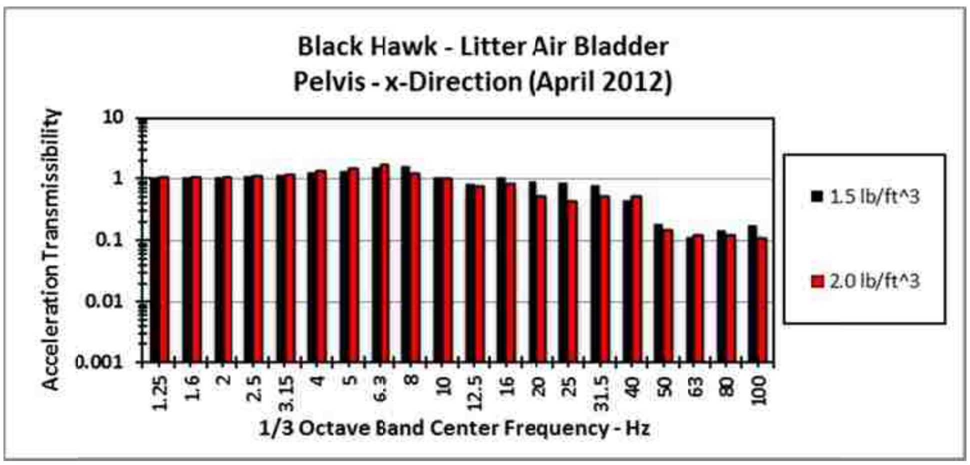


Figure 5.13 Acceleration Transmissibility-Black Hawk litter air bladder test – x-direction– Through litter air bladder only

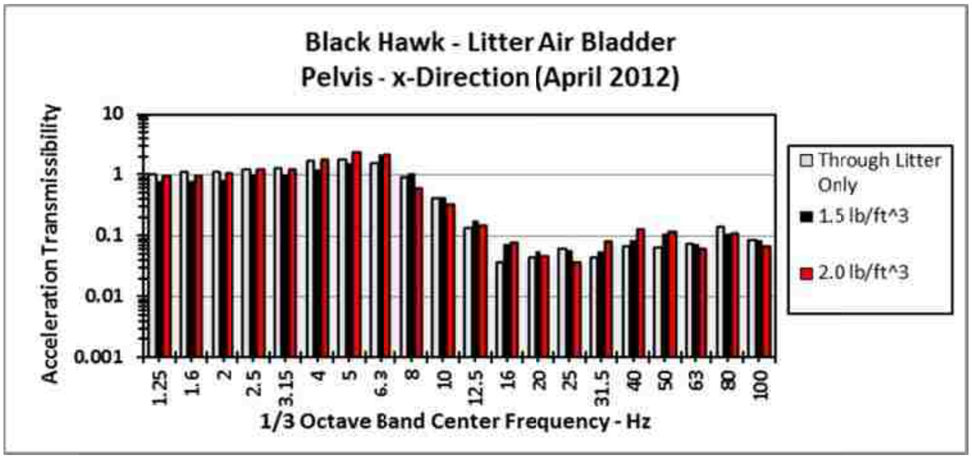


Figure 5.14 Acceleration Transmissibility-Black Hawk litter air bladder test – x-direction–Through litter and/or litter air bladder

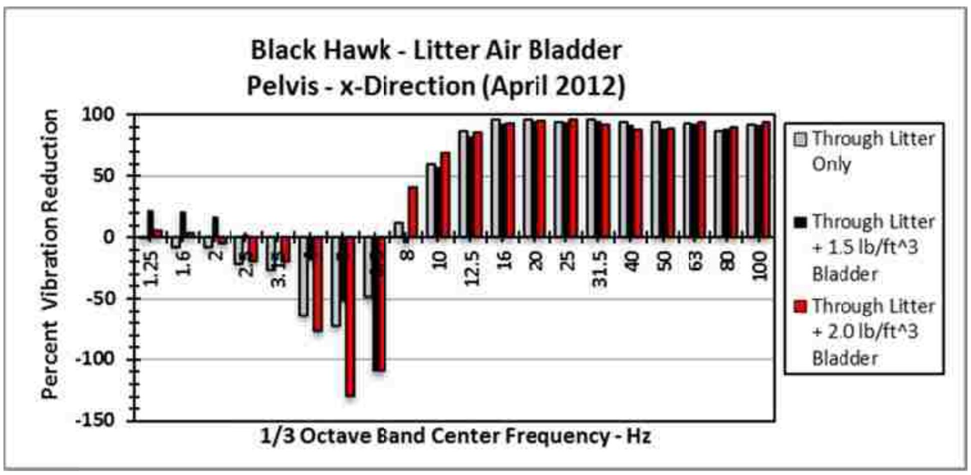


Figure 5.15 Percent Vibration Reduction - Black Hawk litter air bladder test – x-direction

Table 5.9 shows the overall rms acceleration values for the April Black Hawk helicopter litter air bladder field tests in the x-direction (vertical). The rms values shown in this table are taken at the helicopter floor, litter pan, litter stirrup, between litter bed and patient's pelvis in case of bare litter, between litter bed and litter air bladder and between the litter air bladder and the patient's pelvis. The results displayed were filtered using a low pass (1-100 Hz) filter. Table 5.10 shows the corresponding percent vibration and shock reduction associated with the rms values in Table 5.9. The percent reductions were between the litter pan and the stirrup, between the pan and the litter webbing, through the bladder and between the pan and the patient's pelvis. The y- and z-direction rms acceleration values and related percent shock and vibration reductions can be found in Appendix B4.

Table 5.9 Black Hawk litter air bladder - overall rms values (low pass) – x-direction

| Black Hawk Helicopter Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | | |
|---|---|---|---|---|---|
| | Helicopter Floor | Helicopter Litter Pan | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| Bare Litter-Flight Profile (0) | 1.58 | 2.61 | 4.45 | 0.35 | |
| Bare Litter-Flight Profile (1) | 0.99 | 1.77 | 4.49 | 0.46 | |
| Bare Litter-Flight Profile (2) | 0.99 | 1.79 | 5.02 | 0.56 | |
| Bare Litter-Flight Profile (3) | 2.01 | 5.45 | 9.12 | 0.32 | |
| Bare Litter-Flight Profile (4) | 1.36 | 2.50 | 5.89 | 0.69 | |
| Bare Litter-Flight Profile (5) | 0.95 | 1.58 | 3.74 | 0.29 | |
| Bare Litter-Flight Profile (7) | 1.53 | 3.02 | 6.34 | 0.72 | |
| Bare Litter-Flight Profile (S&L) | 0.94 | 1.55 | 3.18 | 0.42 | |
| **Average** | **1.29** | **2.53** | **5.28** | **0.48** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 2.07 | 4.47 | 6.67 | 0.70 | 0.34 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 1.20 | 3.06 | 4.50 | 0.61 | 0.43 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 1.89 | 5.59 | 7.80 | 0.94 | 0.58 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 2.05 | 5.64 | 7.90 | 1.08 | 0.39 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (4) | 1.20 | 2.95 | 6.32 | 0.82 | 0.61 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (5) | 1.05 | 2.57 | 4.53 | 0.55 | 0.34 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (7) | 1.48 | 3.66 | 6.61 | 1.09 | 0.66 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 1.20 | 2.69 | 4.75 | 0.88 | 0.50 |
| **Average** | **1.52** | **3.83** | **6.13** | **0.83** | **0.48** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 1.87 | 4.06 | *6.67* | 0.74 | 0.36 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 1.87 | 6.54 | *4.50* | 1.16 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 1.75 | 5.09 | *7.80* | 0.96 | 0.65 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 1.93 | 6.39 | *7.90* | 1.14 | 0.87 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 0.94 | 2.35 | *6.32* | 0.81 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 1.41 | 3.45 | *4.53* | 1.19 | 0.52 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 0.87 | 2.00 | *6.61* | 0.58 | 0.30 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.86 | 1.92 | *4.75* | 0.62 | 0.29 |
| **Average** | **1.44** | **3.98** | ***6.13*** | **0.90** | **0.49** |

Table 5.10 Black Hawk litter air bladder - percent reduction – rms Value – x-direction

| Black Hawk Helicopter Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Percent Redcution in rms Values - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | |
|---|---|---|---|---|
| | Percent Increase Between Litter Stirrup and Pan | Percent Reduction between Litter Pan and Litter Bed | Percent Reduction Through Bladder | Percent Reduction between Litter Pan and Bladder Top |
| Bare Litter-Flight Profile (0) | 70.1 | 86.6 | | |
| Bare Litter-Flight Profile (1) | 153.6 | 73.8 | | |
| Bare Litter-Flight Profile (2) | 180.1 | 69.0 | | |
| Bare Litter-Flight Profile (3) | 67.3 | 94.1 | | |
| Bare Litter-Flight Profile (4) | 135.8 | 72.3 | | |
| Bare Litter-Flight Profile (5) | 136.3 | 81.4 | | |
| Bare Litter-Flight Profile (7) | 109.6 | 76.1 | | |
| Bare Litter-Flight Profile (S&L) | 105.7 | 72.8 | | |
| **Average** | **119.8** | **81.1** | | |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 49.4 | 84.4 | 50.9 | 92.3 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (1) | 47.3 | 80.2 | 28.9 | 85.9 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (2) | 39.6 | 83.1 | 38.3 | 89.6 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 39.9 | 80.9 | 63.3 | 93.0 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (4) | 114.3 | 72.4 | 25.7 | 79.5 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (5) | 75.9 | 78.8 | 37.4 | 86.7 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (7) | 80.5 | 70.2 | 39.2 | 81.9 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (S&L) | 76.5 | 67.3 | 43.1 | 81.4 |
| **Average** | **65.4** | **78.3** | **42.0** | **87.4** |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (0) | 64.4 | *81.9* | 50.6 | 91.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (1) | -31.2 | *82.2* | 60.2 | 92.9 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (2) | 53.1 | *81.2* | 31.5 | 87.2 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (3) | 23.7 | *82.1* | 23.6 | 86.3 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (4) | 168.6 | *65.5* | 43.9 | 80.6 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (5) | 31.4 | *65.4* | 56.6 | 85.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (7) | 230.4 | *71.1* | 47.4 | 84.8 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (S&L) | 146.8 | *67.5* | 54.1 | 85.1 |
| **Average** | **85.9** | ***77.3*** | **45.6** | **87.7** |

CHAPTER 6

DISCUSION AND ANALYSIS OF RESULTS

The results of the analyses of the seat and litter air bladder 1/3 octave acceleration, vibration transmissibility, and percent vibration reduction values and the overall rms and VDV values and related overall percent reduction values that were presented in Chapter 5 are discussed in this chapter. Assessments of the overall performances of the seat and litter air bladders in reducing patient exposure to shock and vibration during medical transport are presented. As a reminder, the seat and litter air bladder configurations that were examined in the MRAP ambulance and the Black Hawk helicopter are shown in Tables 6.1 and 6.2, respectively.

Table 6.1 Seat Air Bladder Configurations

| Seat Air Bladder Configurations | | | | |
|---|---|---|---|---|
| **Configuration Number** | **Seat Back Foam Density lb/ft$^3$** | **Seat Bottom Foam Density lb/ft$^3$** | **Foam Hole Diameter inch** | **Orfice Tube Diameter inch** |
| **S1** | 1.5 | 1.5 | 1.0 | 3/8 |
| **S2** | 2.0 | 2.0 | 1.0 | 3/8 |
| **S3** | 1.5 | 2.0 | 1.0 | 3/16 |
| **S4** | 1.5 | 2.0 | 1.0 | 3/8 |

Table 6.2 Litter Air Bladder Configurations

| Litter Air Bladder Configurations | | | |
|---|---|---|---|
| **Configuration Number** | **Foam Density lb/ft$^3$** | **Foam Hole Diameter inch** | **Orfice Tube Diameter inch** |
| **L1** | 1.5 | 1.0 | 3/8 |
| **L2** | 2.0 | 1.0 | 3/8 |

## 6.1. Discussion of MRAP Seat Air Bladder Results

The acceleration signals associated with the MRAP ambulance field tests contained significant shock events, as well as, continuous vibration. Therefore, both the overall rms and VDV acceleration values were analyzed. The dominant shock and vibration energy was below the 6.3 Hz 1/3 octave frequency band. The field test results indicated the MRAP suspension system had a resonance frequency in the 2 Hz 1/3 octave frequency band. This resonance dominated the overall vibration and shock response of the MRAP ambulance and the overall performance of the seat air bladder in reducing exposure to whole body shock and vibration.

The acceleration transmissibility plots indicated that, for vibration in the z-direction (vertical), the seat air bladder/seat occupant system behaved similar to a one-degree-of-freedom, mass-spring-damper system. The vibration transmissibility plots for vibration in the y and z horizontal directions had transmissibility values close to one, except at the lower and upper 1/3 octave frequency bands.

The acceleration transmissibility plots through the MRAP ambulance seat air bladder indicated the resonance frequency of the seat air bladder/seat occupant system was in the 4 Hz 1/3 octave frequency band. The shock and vibration energy in the frequency bands below 6.3 Hz excited this resonance frequency. As a result, the seat air bladder system amplified the shock and vibration energy below the 5 Hz 1/3 octave frequency band and attenuated the energy above this frequency band.

Tables 6.3 and 6.4 present summaries of the overall rms and VDV acceleration values for the MRAP seat air bladder field tests in the z-, y-, and x-directions. The overall VDV values were obtained because the acceleration signals contained significant shock events. The tables present the overall acceleration amplitude ranges associated with all of the seat air bladder field test configurations (S1 – S4). Because of the prominence of the MRAP ambulance suspension system resonance in the 2 Hz 1/3 octave frequency band, in addition to the low-pass (< 100 Hz) and ISO weighting filters, a band-pass (2.5 – 100 Hz) filter was also used when processing the acceleration signals. Tables 6.5 and 6.6 present summaries of the overall shock and vibration reductions through the MRAP seat cushion and seat air bladder that correspond to the test results reported in Tables 6.3 and 6.4.

Table 6.3 MRAP seat air bladder - overall rms values

| Summary MRAP Seat Air Bladder - rms Values | | | | | | |
|---|---|---|---|---|---|---|
| Direction of Shock and Vibraion | rms Shock and Vibration Values (< 100 Hz) | | rms Shock and Vibration Values (2.5 - 100 Hz) | | rms Shock and Vibration Values (ISO Weighted) | |
| | From MRAP Seat Bottom $m/s^2$ | To MRAP Seat Top $m/s^2$ | From MRAP Seat Bottom $m/s^2$ | To MRAP Seat Top $m/s^2$ | From MRAP Seat Bottom $m/s^2$ | To MRAP Seat Top $m/s^2$ |
| | Seat Air Bladder | | Seat Air Bladder | | Seat Air Bladder | |
| z (Vertical) | 1.88-1.97 | 1.90-1.96 | 1.24-1.37 | 0.85-0.94 | 1.94-2.06 | 1.96-1.97 |
| y (Side-to-Side) | 0.65 - 0.81 | 0.53 - 0.64 | 0.64 - 0.77 | 0.51 - 0.56 | 0.14 - 0.26 | 0.12 - 0.40 |
| x (Front-to-Back) | 0.76 - 0.92 | 0.61 - 0.87 | 0.71 - 0.88 | 0.51 - 0.77 | 0.17 - 0.28 | 0.13 - 0.39 |
| | Seat Cushion | | Seat Cushion | | Seat Cushion | |
| z (Vertical) | 1.94-2.06 | 1.96-1.97 | 1.22-1.45 | 1.15-1.30 | 1.25-1.42 | 1.31-1.34 |
| y (Side-to-Side) | 0.70 - 0.91 | 0.80 - 0.86 | 0.69 - 0.87 | 0.79 - 0.81 | 0.13 - 0.26 | 0.17 - 0.29 |
| x (Front-to-Back) | 0.91 - 0.93 | 0.86 - 1.04 | 0.87 - 0.89 | 0.81 - 0.87 | 0.25 - 0.31 | 0.21 - 0.42 |

Table 6.4 MRAP seat air bladder - overall VDV values

| Summary MRAP Seat Air Bladder -VDV Values | | | | | | |
|---|---|---|---|---|---|---|
| Direction of Shock and Vibraion | VDV Shock and Vibration Values (< 100 Hz) | | VDV Shock and Vibration Values (2.5 - 100 Hz) | | VDV Shock and Vibration Values (ISO Weighted) | |
| | From MRAP Seat Bottom $m/s^{1.75}$ | To MRAP Seat Top $m/s^{1.75}$ | From MRAP Seat Bottom $m/s^{1.75}$ | To MRAP Seat Top $m/s^{1.75}$ | From MRAP Seat Bottom $m/s^{1.75}$ | To MRAP Seat Top $m/s^{1.75}$ |
| | Seat Air Bladder | | Seat Air Bladder | | Seat Air Bladder | |
| z (Vertical) | 7.72 - 9.56 | 8.46 - 10.67 | 7.4 - 7.72 | 4.36 - 5.31 | 6.29 - 6.44 | 5.51 - 6.82 |
| y (Side-to-Side) | 2.82 - 4.96 | 2.49 - 3.82 | 2.77 - 5.02 | 2.44 - 3.75 | 0.61 - 1.25 | 0.55 -1.97 |
| x (Head-to-Toe) | 3.40 - 5.62 | 2.48 - 5.21 | 3.33 - 5.45 | 2.46 - 5.01 | 0.84 - 1.42 | 0.63 - 1.74 |
| | Seat Cushion | | Seat Cushion | | Seat Cushion | |
| z (Vertical) | 9.36 - 9.54 | 8.69 - 9.83 | 6.41 - 7.96 | 6.41 - 7.09 | 6.36 - 6.92 | 6.39 - 6.61 |
| y (Side-to-Side) | 3.00 - 5.36 | 3.39 - 5.16 | 2.95 - 5.29 | 3.36 - 4.92 | 0.58 - 1.21 | 0.67 - 1.38 |
| x (Head-to-Toe) | 3.76 - 5.73 | 3.79 - 6.17 | 3.6 - 5.63 | 3.67 - 6.02 | 1.2 - 1.51 | 0.99 - 1.91 |

Table 6.5 MRAP seat air bladder –Shock and Vibration Reduction - rms values

| Summary MRAP Seat Air Bladder Shock and Vibration Reduction - rms Values | | | | | | |
|---|---|---|---|---|---|---|
| Direction of Shock and Vibraion | Percent Shock and Vibration Reduction (< 100 Hz) | | Percent Shock and Vibration Reduction (2.5 - 100 Hz) | | Percent Shock and Vibration Reduction (ISO Weighted) | |
| | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion |
| z (Vertical) | -4.3 to 1.5 | -1.5 to 4.9 | 25.8 to 35.6 | 5.7 to 10.3 | -4.2 to -1.6 | -4.8 to 5.6 |
| y (Side-to-Side) | 15.8 to 24.7 | -14.3 to 6.9 | 17.6 to 28.6 | -14.5 to 6.9 | -53.8 to 20.0 | -30.8 to -11.5 |
| x (Front-to-Back) | 5.4 to 34.2 | -11.8 to 0.0 | 12.5 to 35.2 | -11.8 to -2.7 | -58.8 to 35.2 | -35.5 to 16.0 |
| Negative sign (-) means amplification | | | | | | |

Table 6.6 MRAP seat air bladder –Shock and Vibration Reduction - VDV values

| Summary MRAP Seat Air Bladder Shock and Vibration Reduction -VDV Values | | | | | | |
|---|---|---|---|---|---|---|
| Direction of Shock and Vibraion | Percent Shock and Vibration Reduction (< 100 Hz) | | Percent Shock and Vibration Reduction (2.5 - 100 Hz) | | Percent Shock and Vibration Reduction (ISO Weighted) | |
| | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion | Through MRAP Seat Air Blafder | Through MRAP Seat Cushion |
| z (Vertical) | -12.4 to 6.0 | -3.0 to 7.2 | 30.9 to 41.1 | 6.3 to 10.8 | -5.7 to 13.9 | -3.5 to 7.7 |
| y (Side-to-Side) | 11.7 to 24.0 | -13.0 to 7.0 | 10.7 to 26.8 | -13.9 to 7.0 | -57.6 to 16.7 | -15.5 to -14.0 |
| x (Front-to-Back) | 7.3 to 27.6 | -7.7 to -0.8 | 8.1 to 26.3 | -6.9 to -1.9 | -61.9 to 27.6 | -26.5 to 17.5 |
| Negative sign (-) means amplification | | | | | | |

Because of the prominence of the MRAP ambulance suspension system resonance, it was necessary to assess the overall effectiveness of the seat air bladder in reduction seat occupant exposure to shock and vibration in the frequency ranges of 1 – 100 Hz and 2.5 – 100 Hz. The effects of the 2 Hz resonance of the MRAP suspension system dominated the overall amplitudes of the acceleration signals used for the performance assessment in the z-direction. Therefore, when using the low-pass filter, the overall performance in the z-direction of the seat cushion and the seat air bladder in reducing seat occupant exposure to whole body shock and vibration were similar. However, for the frequency range of 1 – 100 Hz, the ability of the seat air bladder to reduce exposure to shock and vibration in the y- and x- directions was significantly better than that of the seat cushion. For the frequency range of 2.5 – 100 Hz, the ability of the seat air bladder to reduce exposure to shock and vibration was substantially better than that of the seat cushion. The shock and vibration reduction for the seat air bladder was up to 36 percent for the rms acceleration and 41 percent for the VDV acceleration in the z-direction, up to 29 percent for the rms acceleration and 27 percent for the VDV acceleration in the y-direction, and up to 35 percent for the rms acceleration and 26 percent for the VDV acceleration in the x-direction. There was little observed difference between the performance of the seat air bladder and the seat cushion when using the ISO weighting filter.

The 1/3 octave acceleration transmissibility and percent reduction plots were used to obtain information on the physical vibration characteristics of the four seat air bladder configurations (S1 – S4) that were used in the MRAP ambulance field tests. The resonance frequency of the seat air bladder/seat occupant system remained in the 4 Hz 1/3 octave frequency band for all four seat air bladder configurations. Therefore, the variations in foam density used in the seat air bladders and the variations in the weight of the seat occupants used in the different filed tests did not have any significant effect on value of this resonance frequency. The 2.0 lb/ft$^3$ density foam appeared to have a little more damping associated with it than the 1.5 lb/ft$^3$ density foam. The use of the 3/16-in.-diameter tubes between the seat bottom and seatback air chambers resulted in more damping in the seat air bladder than the 3/8-in.diameter tubes. However, the changes in seat air bladder damping associated with the different foam densities and with the different tube diameters did not have a significant effect on the overall seat air bladder performance in reducing exposure to shock and vibration.

## 6.2. Discussion of Black Hawk Seat Air Bladder Results

The acceleration signals associated with the different flight profiles used during the Black Hawk helicopter field tests did not contain significant shock events. Therefore, only the overall rms acceleration values were analyzed. There were no observed resonances in the helicopter seat structure. The dominant vibration energy was at frequencies above 16 Hz. This was the helicopter's main rotor blade passage frequency.

The vibration transmissibility plots indicated that, for vibration in the z-direction (vertical), the seat air bladder/seat occupant system behaved similar to a one-degree-of-freedom, mass-spring-damper system that had a resonance frequency in the 4 Hz 1/3 octave frequency band. The vibration transmissibility plots for vibration in the y and z horizontal directions had transmissibility values close to one, except at the lower and upper 1/3 octave frequency bands.

The acceleration transmissibility plots through the Black Hawk helicopter seat air bladder indicated the resonance frequency of the seat air bladder/seat occupant system was in the 4 Hz 1/3 octave frequency band. Since there was very little vibration energy below 16 Hz, the 4 Hz resonance associated with the seat air bladder did not affect its overall performance in reducing exposure to whole body vibration in the Black Hawk helicopter.

Tables 6.7 presents a summary of the overall rms acceleration values for the Black Hawk seat air bladder field tests in the z-, y-, and x-directions. The table presents the overall acceleration amplitude ranges associated with the two seat air bladder field test configurations (S3 and S4). Only the low-pass (< 100 Hz) and ISO weighting filters were used when processing the acceleration signals. Table 6.8 presents a summary of the overall vibration reductions through the Black Hawk seat frame and seat frame plus seat air bladder that correspond to the test results reported in Tables 6.7.

Table 6.7 Black Hawk seat air bladder - overall rms values

| Summary Black Hawk Seat Air - rms Values | | | | |
|---|---|---|---|---|
| Direction of Shock and Vibraion | rms Shock and Vibration Values (< 100 Hz) | | rms Shock and Vibration Values (ISO Weighted) | |
| | From Black Hawk Seat Frame $m/s^2$ | To Black Hawk Seat Occupant $m/s^2$ | From Black Hawk Seat Frame $m/s^2$ | To Black Hawk Seat Occupant $m/s^2$ |
| | Seat Frame/Seat Air Bladder | | Seat Frame/Seat Air Bladder | |
| z (Vertical) | 1.88 - 1.97 | 0.45 - 0.48 | 0.57 - 0.57 | 0.28 - 0.29 |
| y (Side-to-Side) | 1.69 - 1.90 | 0.62 - 0.66 | 0.15 - 0.17 | 0.09 - 0.09 |
| x (Front-to-Back) | 0.45 - 0.48 | 0.57 - 0.64 | 0.12 - 0.15 | 0.08 - 0.10 |
| | Seat Frame Only | | Seat Frame Only | |
| z (Vertical) | 2.01 | 0.85 | 0.57 | 0.50 |
| y (Side-to-Side) | 2.49 | 0.61 | 0.14 | 0.08 |
| x (Front-to-Back) | 2.26 | 0.89 | 0.10 | 0.08 |

Table 6.8 Black Hawk seat air bladder – Shock and Vibration Reduction values

| Summary Black Hawk Seat Air Bladder Shock and Vibration Reduction - rms Values | | | | |
|---|---|---|---|---|
| Direction of Shock and Vibraion | Percent Shock and Vibration Reduction (<100 Hz) | | Percent Shock and Vibration Reduction (ISO Weighted) | |
| | Through Black Hawk Seat Frame and Seat Air Bladder | Through Black Hawk Seat only | Through Black Hawk Seat Frame and Seat Air Bladder | Through Black Hawk Seat only |
| z (Vertical) | 61 to 64.4 | 30.8 | 48.8 to 51 | 12.42 |
| y (Side-to-Side) | 12.4 to 16.8 | 17.2 | 43.8 to 48.2 | 46.8 |
| x (Front-to-Back) | 16.6 to 23.3 | -16.8 | 34 to 35.8 | 19.2 |
| Negative sign (-) means amplification | | | | |

There were no significant shock events in the acceleration signals obtained during the Black Hawk helicopter field tests. Also, there were no structural resonances in the helicopter structure or the helicopter seat structure. Therefore, only the overall rms low-pass and ISO weighted acceleration values were analyzed. The use of the seat air bladder in conjunction with the helicopter seat frame resulted in a significant increase vibration energy attenuation through the seat frame and seat air bladder. The vibration reduction for the seat air bladder was up to 64 percent for the low-pass acceleration values and 51 percent for the ISO weighted acceleration values in the z-direction, up to 17 percent for the low-pass acceleration values and 48 percent for the ISO weighted acceleration values in the y-direction, and up to 23 percent for the low-pass acceleration values and 36 percent for the ISO weighted acceleration values in the x-direction

The physical characteristics of the Black Hawk helicopter seat air bladders, in terms of resonance frequency and damper were similar to the MRAP ambulance seat air bladders. The overall performance of the seat air bladder configurations S3 and S4 in reducing exposure to whole body vibration were similar.

## 6.3. Discussion of MRAP Litter Air Bladder Results

The acceleration signals associated with the MRAP ambulance field tests contained significant shock events, as well as, continuous vibration. Therefore, both the overall rms and VDV acceleration values were analyzed. The dominant shock and vibration energy was below the 10 Hz 1/3 octave frequency band. The field test results indicated the MRAP suspension system had a resonance frequency in the 2 Hz 1/3 octave frequency band. This resonance dominated the overall vibration and shock response of the MRAP ambulance and the overall performance of the litter air bladder in reducing exposure to whole body shock and vibration.

For vibration in the x-direction (vertical), the litter webbing plus the litter air bladder with patient behaved similar to a one-degree-of-freedom, mass-spring-damper system. The resonance frequency for both the litter only and the litter and the litter air bladder was in the 4 Hz 1/3 octave frequency band. In the y- and z-directions the litter webbing plus the litter air bladder with patient did not have a defining trend as in the vertical direction. The 1/3 octave acceleration transmissibility plots for the y-direction showed an amplification below the 10 Hz 1/3 octave frequency band that peaked in the 2 Hz 1/3 octave frequency band. The 1/3 octave acceleration transmissibility plots for the z-direction showed an amplification below the 16 Hz 1/3 octave frequency band that peaked in the 4 Hz 1/3 octave frequency band. The vibration transmissibility decreased above the 16 Hz 1/3 octave frequency band.

The shock and vibration energy in the frequency bands below 6.3 Hz excited the 4 Hz resonance frequency associated with the litter only and the litter and the litter air bladder. As a result, the litter and litter air bladder system amplified shock and vibration energy below the 6.3 Hz 1/3 octave frequency band and attenuated the energy above this frequency band.

The MRAP litter rack acceleration was not measure during the July 2011 MRAP field test. Only the stirrup accelerations were measured. Both the litter rack and stirrup accelerations were measured during the November 2011 MRAP field test. To fully compare the July and November 2011 test results, it was necessary to estimate the July litter rack acceleration values. This was done with the following equation:

$$a_{rack-July} = \frac{a_{rack-Nov}}{a_{floor-Nov}} a_{floor-July} \qquad \textbf{equation 6.1}$$

Where $a_{rack-July}$ was the estimated July litter rack acceleration values, $a_{rack-Nov}$ was the measured November litter rack acceleration values, $a_{floor-Nov}$ was the measured November floor acceleration values, and $a_{floor-July}$ was the measured July floor acceleration values.

Table 6.9 and 6.10 summarize the overall rms and VDV acceleration values for the MRAP ambulance litter air bladder field tests in the x-, y-, and z-directions. The overall VDV values were obtained because the acceleration signals contained significant shock events. The tables present the overall acceleration amplitude ranges associated with the two litter air bladder field test configurations (L1 and L2). Because of the prominence of the MRAP ambulance suspension system resonance in the 2 Hz 1/3 octave frequency band, in addition to the low-pass (< 100 Hz) filter, a band-pass (2.5 – 100 Hz) filter was also used when processing the acceleration signals. The ISO weighting filter was not used to process the acceleration signals associated with the litter air bladder tests. Tables 6.11 and 6.12 present summaries of the overall shock and vibration reductions through the

MRAP bare litter and litter with the litter air bladder that correspond to the test results reported in Tables 6.9 and 6.10.

The webbing in the litter structure acted as a resilient element that interacted with the resilient litter air bladder when a patient was lying on the litter air bladder. It was difficult to isolate the effects of these two resilient elements when analyzing the acceleration data. Independent of the litter webbing, the litter air bladder appeared to have a resonance in the 5 Hz 1/3 octave frequency band. The predominant shock and vibration energy for the MRAP ambulance was below the 10 Hz 1/3 octave frequency band. This energy was amplified as it passed through the litter air bladder. The litter air bladder appeared to only attenuate shock and vibration energy above the 16 Hz 1/3 octave frequency band. The litter webbing plus the litter air bladder attenuated shock and vibration energy above the 6.3 Hz 1/3 octave frequency band. Tables 6.11 and 6.12 indicate that the combination of the litter webbing and the litter air bladder resulted in increased reduction of patient exposure to shock and vibration when compared to the bar litter webbing.

Table 6.9 MRAP litter air bladder – VDV values

| Summary MRAP Litter Air Bladder - rms Values | | | | |
|---|---|---|---|---|
| Direction of Shock and Vibraion | rms Shock and Vibration Values (< 100 Hz) | | rms Shock and Vibration Values (2.5 - 100 Hz) | |
| | From MRAP Litter Rack $m/s^2$ | To MRAP Litter Patient $m/s^2$ | From MRAP Litter Rack $m/s^2$ | To MRAP Litter Patient $m/s^2$ |
| | Litter Plus Litter Air Bladder | | Litter Plus Litter Air Bladder | |
| x (Vertical) | 2.29 - 2.94 | 1.79 - 2.21 | 1.94 - 2.87 | 0.88 - 1.09 |
| y (Side-to-Side) | 0.73 - 0.94 | 0.81 - 1.14 | 0.70 - 1.07 | 0.74 - 1.09 |
| z (Head-to-Toe) | 0.55 - 0.91 | 0.66 - 1.36 | 0.46 - 0.87 | 0.56 - 1.23 |
| | Litter Only | | Litter Only | |
| x (Vertical) | 2.19 - 2.38 | 1.65 - 2.71 | 1.87 - 2.01 | 0.79 - 2.44 |
| y (Side-to-Side) | 0.80 - 0.95 | 0.82 - 1.32 | 0.79 - 0.99 | 0.74 - 1.09 |
| z (Head-to-Toe) | 0.54 - 0.87 | 0.82 - 1.69 | 0.49 - 0.83 | 0.76 - 1.66 |

Table 6.10 MRAP litter air bladder – VDV values

| Summary MRAP Litter Air Bladder - VDV Values | | | | |
|---|---|---|---|---|
| Direction of Shock and Vibraion | VDV Shock and Vibration Values (< 100 Hz) | | VDV Shock and Vibration Values (2.5 - 100 Hz) | |
| | From MRAP Litter Rack $m/s^{1.75}$ | To MRAP Litter Patient $m/s^{1.75}$ | From MRAP Litter Rack $m/s^{1.75}$ | To MRAP Litter Patient $m/s^{1.75}$ |
| | Litter Plus Litter Air Bladder | | Litter Plus Litter Air Bladder | |
| x (Vertical) | 12.26 - 17.23 | 8.13 - 10.69 | 11.33 - 17.31 | 4.38 - 6.23 |
| y (Side-to-Side) | 3.99 - 5.39 | 4.23 - 6.02 | 3.91 - 5.44 | 4.04 - 5.77 |
| z (Head-to-Toe) | 4.85 - 9.56 | 3.83 - 7.71 | 4.36 - 6.03 | 3.53 - 7.43 |
| | Litter Only | | Litter Only | |
| x (Vertical) | 11.25 - 13.24 | 8.05 - 15.74 | 10.47 - 12.53 | 4.04 - 15.20 |
| y (Side-to-Side) | 4.33 - 5.01 | 4.31 - 7.02 | 4.28 - 5.23 | 4.09 - 6.95 |
| z (Head-to-Toe) | 4..57 - 9.98 | 4.79 - 8.80 | 4.44 - 5.83 | 4.60 - 8.67 |

Table 6.11 MRAP litter air bladder Shock and Vibration Reduction– VDVvalues

| Summary MRAP Litter Air Bladder Shock and Vibration Reduction - rms Values | | | | |
|---|---|---|---|---|
| Direction of Shock and Vibraion | Percent Shock and Vibration Reduction (< 100 Hz) | | Percent Shock and Vibration Reduction (2.5 - 100 Hz) | |
| | Through MRAP Litter Plus Litter Air Bladder | Through MRAP Litter Only | Through MRAP Litter Plus Litter Air Bladder | Through MRAP Litter Only |
| x (Vertical) | 17 to 37.9 | -22.2 to 24.7 | 55.0 to 69.2 | -26.9 to 50.7 |
| y (Side-to-Side) | -38.7 to -6.6 | -38.2 to -9.3 | -5.7 to 0.8 | -32.2 to 9.2 |
| z (Head-to-Toe) | -145.1 to 25.8 | -213.9 to 5.7 | -166.8 to 34.1 | -236.5 to 8.4 |
| Negative sign (-) means amplification | | | | |

Table 6.12 MRAP litter air bladder Shock and Vibration Reduction– VDVvalues

| Summary MRAP Litter Air Bladder Shock and Vibration Reduction - VDV Values | | | | |
|---|---|---|---|---|
| **Direction of Shock and Vibraion** | **Percent Shock and Vibration Reduction (< 100 Hz)** | | **Percent Shock and Vibration Reduction (2.5 - 100 Hz)** | |
| | **Through MRAP Litter Plus Litter Air Bladder** | **Through MRAP Litter Only** | **Through MRAP Litter Plus Litter Air Bladder** | **Through MRAP Litter Only** |
| **x (Vertical)** | 32.7 to 51.6 | -31.8 to 26.7 | 58.7 to 73.7 | -28.0 to 58.6 |
| **y (Side-to-Side)** | -28.1 to -2.9 | -40.2 to 0.2 | -19.3 to -2.9 | -32.8 to 10.6 |
| **z (Head-to-Toe)** | 6.4 to 34.4 | 11.8 | -50.7 to 33.9 | -48.2 to 14.7 |
| **Negative sign (-) means amplification** | | | | |

The manner in which the test subject was strapped onto the bare litter and the litter with the litter bladder the acceleration values measured on the litter webbing and the top and bottom of the litter air bladder. The large negative rms and VDV acceleration reduction values (meaning amplification) reported in Tables 11 and 12 for the y- and z-directions are associated with the MRAP ambulance field test in July 2011. The test subject was loosely strapped to the bare litter and the litter with the litter air bladders during this test. The corresponding positive rms and VDV acceleration values reported in tables are associated with the MRAP ambulance field test in November 2011. The test subject was firmly strapped to the bare litter and the litter with the litter air bladders during this test.

The acceleration values measured on the litter stirrup during the MRAP field tests were substantially higher than the corresponding acceleration values measured on the litter rack near the litter stirrup. The overall stirrup acceleration values were from 2 to 6 times higher than the corresponding rack acceleration values in the x-direction (vertical), were from 2.5 to 28 times higher in the y-direction (side-to-side), and were from 2.7 to 33 times higher in the z-direction (head-to-toe). These high stirrup acceleration levels were transmitted to the litter bars. However, they appeared to be fully attenuated when transmitted into the litter webbing.

Pins that pass through the litter stirrups secure the litter to the litter racks in the MRAP ambulance. While these pins prevent gross movements of the litter while the patient is being transported, they do allow for relative motion between the litter stirrups and the litter racks. This relative motion that occurs as the MRAP ambulance travels over rough terrain creates chatter that results in the excessively high levels of vibration in the litter stirrups.

Patient shoulders and arms that come into contact with the excessively high levels of vibration in the litter bars during medical transport can result in severe agitation or possible injury to the shoulders or upper torso. This vibration can also be transmitted to the neck and spin. When patients placed on a litter air bladder that is between them and the litter webbing, their arms and shoulders are raised above and, therefore, do not come into contact with the litter bars. This avoids exposure to the excessively high levels of vibration that may be present in the litter bars during medical transport.

### 6.4. Discussion of Black Hawk Litter Air Bladder Results

The acceleration signals associated with the different flight profiles used during the Black Hawk helicopter field tests did not contain significant shock events. Therefore, only the overall rms acceleration values were analyzed. There were no observed resonances in the helicopter seat structure. The dominant vibration energy was at frequencies above 16 Hz. This was the helicopter’s main rotor blade passage frequency.

For vibration in the x-direction (vertical), the litter webbing plus the litter air bladder with patient behaved similar to a one-degree-of-freedom, mass-spring-damper system. The resonance frequency for both the litter only was in the 5 Hz 1/3 octave frequency band. The resonance frequency for the liter and the litter air bladder ranged from the 5 to the 6.3 Hz 1/3 octave frequency bands. In the y- and z-directions the litter webbing plus the litter air bladder with patient did not have a defining trend as in the vertical direction. The 1/3 octave acceleration transmissibility plots for the y-direction showed amplifications at and below the 25 Hz 1/3 octave frequency band and reductions above this frequency band. The 1/3 octave acceleration transmissibility plots for the z-direction showed reductions below the 12.5 Hz 1/3 octave frequency band and amplifications above this band.

There was little vibration energy below the 16 Hz 1/3 octave frequency band. Therefore, the resonances in the x-direction in the 5 to 6.3 1/3 octave frequency bands that were not excited during the Black Hawk helicopter field tests.

The Black Hawk litter pan acceleration was not measure during the July 2011 Black Hawk field test. Only the stirrup accelerations were measured. Both the litter pan and stirrup accelerations were measured during the April 2012 Black Hawk field test. To fully compare the July 2011 and April 2012 test results, it was necessary to estimate the July litter pan acceleration values. This was done with the following equation:

$$a_{pan-July} = \frac{a_{pan-April}}{a_{floor-April}} a_{floor-July} \qquad \textbf{equation 6.2}$$

Where $a_{pan-July}$ was the estimated July litter pan acceleration values, $a_{pan-April}$ was the measured April litter pan acceleration values, $a_{floor-April}$ was the measured April floor acceleration values, and $a_{floor-July}$ was the measured July floor acceleration values.

Tables 6.13 presents a summary of the overall rms acceleration values for the Black Hawk litter air bladder field tests in the z-, y-, and x-directions. The table presents the overall acceleration amplitude ranges associated with the two litter air bladder field test configurations (L1 and L2). Only the low-pass (< 100 Hz) filter was used when processing the acceleration signals. Table 6.14 presents a summary of the overall vibration reductions through the Black Hawk litter and litter plus litter air bladder that correspond to the test results reported in Tables 6.7.

Table 6.13 Black Hawk litter air bladder – rms values

| Summary Black Hawk Litter Air Bladder -rms Values | | |
|---|---|---|
| Direction of Shock and Vibraion | rms Shock and Vibration Values (< 100 Hz) | |
| | From Black Hawk Litter Rack $m/s^2$ | To Black Hawk Patient $m/s^2$ |
| | Litter Plus Litter Air Bladder | |
| x (Vertical) | 2.25 - 3.98 | 0.24 - 0.49 |
| y (Side-to-Side) | 1.22 - 1.87 | 0.45 - 0.84 |
| z (Head-to-Toe) | 1.13 - 1.22 | 0.60 - 1.12 |
| | Litter Only | |
| x (Vertical) | 2.33 - 2.53 | 0.48 - 2.89 |
| y (Side-to-Side) | 1.31 - 1.68 | 0.83 - 1.85 |
| z (Head-to-Toe) | 0.93 - 0.98 | 0.79 - 1.05 |

Table 6.14 Black Hawk litter air bladder Shock and Vibration Reduction– rms values

| Summary Black Hawk Litter Air Bladder Shock and Vibration Reduction -rms Values | | |
|---|---|---|
| Direction of Shock and Vibraion | Percent Shock and Vibration Reduction (< 100 Hz) | |
| | Through Black Hawk Litter Plus Litter Air Bladder | Through Black Hawk Litter Only |
| x (Vertical) | 87.4 to 89.5 | 2.8 to 81.1 |
| y (Side-to-Side) | 53.1 to 64.4 | 16.9 to 50.6 |
| z (Head-to-Toe) | 2.7 to 47.8 | 12.3 to 20 |
| Negative sign (-) means amplification | | |

The webbing in the litter structure acted as a resilient element that interacted with the resilient litter air bladder when a patient was lying on the litter air bladder. It was difficult to isolate the effects of these two resilient elements when analyzing the acceleration data. Independent of the litter webbing, the litter air bladders appeared to have a resonance that ranged between 6.3 Hz and 8 Hz 1/3 octave frequency bands. The predominant shock and vibration energy for the Black Hawk helicopter was at and above the 16 Hz 1/3 octave frequency band. This energy was attenuated as it passed through the litter air bladder. The litter webbing plus the litter air bladder attenuated vibration energy above the 8 Hz 1/3 octave frequency band. Table 6.14 indicates that the combination of the litter webbing and the litter air bladder resulted in increased reduction of patient exposure to shock and vibration when compared to the bar litter webbing.

The acceleration values measured on the litter stirrup during the Black Hawk field tests were substantially higher than the corresponding acceleration values measured on the litter rack near the litter stirrup. The overall stirrup acceleration values were from 2 to 6 times higher than the corresponding rack acceleration values in all three directions.

However, they appeared to be fully attenuated when transmitted into the litter webbing. Patient shoulders and arms that may come into contact with the litter bars during medical transport can possibly be seriously agitated or possibly injured by exposure to this excessive vibration.

The litter stirrups set into indentations in the Black Hawk helicopter litter pan. The litter is secured to the litter pan by the straps that are placed around the patient, litter and litter pan to secure the patient to the litter. While these straps prevent gross movements of the litter while the patient is being transported, they do allow for relative motion between the litter stirrups and the litter pan. This relative motion that occurs as a result of vibration within in the helicopter structure creates chatter that results in the high levels of vibration in the litter stirrups.

Patient shoulders and arms that come into contact with the high levels of vibration in the litter bars during medical transport can result in severe agitation or possible injury to the shoulders or upper torso. This vibration can also be transmitted to the neck and spin. When patients placed on a litter air bladder that is between them and the litter webbing, their arms and shoulders are raised above and, therefore, do not come into contact with the litter bars. This avoids exposure to the high levels of vibration that may be present in the litter bars during medical transport.

# CHAPTER 7

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

The field tests and analysis performed during this project have extended the previous collaborative work completed by USARL and CMEST at UNLV. The seat air bladder technology developed to protect military vehicle occupants from the devastating effects of exposure to extreme shocks from mine blasts and IEDs has been extended to ground born and airborne U.S. Army medical evacuation vehicles to reduce the exposure of wounded war fighters to repeated shocks and vibration during medical ground and airborne transport. The project focused on testing seat and litter air bladder configurations that can be used in a MRAP ambulance and a Black Hawk medevac helicopter.

## 7.1. Field Tests Overview

The seat and litter air bladders were tested in actual military vehicles in configurations similar to those that would be used on the battle field. The seat air bladder replaced the standard seat cushion installed in the MRAP ambulance. It was placed on top of the webbed seat in the Black Hawk helicopter. The litter air bladder was placed on top of the litter webbing, and the litter was placed on the litter racks in the MRAP ambulance and on the litter pan in the Black Hawk helicopter. The MRAP test course was a half mile long gravel road that contained potholes and 4-in. x 6-in. wood blocks that were unnervingly spread out on the road. The course provided both continuous vibration and repeated shocks that simulated a harsh terrain an ambulance would travel over in a battlefield environment. For the Black Hawk helicopter, several flight maneuvers that covered a wide spectrum of fight scenarios used during a battle field medical evacuation were flown during a test series.

Vibration sensors that measure the tri-axial acceleration were mounted on the vehicle floor and the seat bench/litter rack to provide a reference vibration signal. Tri-axial seat pad accelerometers were placed below the seat cushion/bladder and between the seat cushion/bladder and the occupant's buttocks for the seat air bladder tests. For the litter air bladder tests, tri-axial seat pad accelerometers were placed between the litter webbing and the bottom of the liter air bladder and between the top of the litter air bladder and patient's pelvis or shoulders.

The test matrix consisted of four configurations for the seat air bladder and two different configurations for the litter air bladder. The first set of seat air bladder configurations had 1.5 and then 2.0 lb/ft$^3$ density foam panels in the seatback and seat bottom and 3/8-in. diameter tubes between the seatback and the seat bottom air chambers. For the second set of seat air bladder configurations, both configurations had 2.0 lb/ft$^3$ foam panels in the seat bottom and 1.5 lb/ft$^3$ foam panels in the seat back. The first configuration had 3/8-in. diameter tubes between the seatback and seat bottom air chambers, and the second configuration had 3/16-in. diameter tubes between the seatback and seat bottom air chambers. The litter air bladder configurations had 1.5 and then 2.0 lb/ft$^3$ density foam panel in the two litter air bladder air chambers and 3/8-in. diameter tubes between the two air chambers.

## 7.2. Summary of Results

### 7.2.1. MRAP Seat Air Bladder Tests

- The seat air bladder with the seat occupant in the MRAP ambulance behaved similar to a one-degree-of-freedom, mass-spring-damper system. The system had a resonance frequency in the 4 Hz. 1/3 octave frequency band.

- The MRAP field test results indicated the MRAP suspension system had a resonance frequency in the 2 Hz 1/3 octave frequency band that dominated the overall vibration and shock response of the vehicle and of the seat air bladder. With a resonance in the 2 Hz 1/3 octave frequency band, the sear air bladder amplified the vibration and shock energy below 5 Hz and attenuated the energy above 5 Hz.
- In terms of the low-pass (< 100 Hz) rms value, the seat air bladder had shock and vibration energy reductions that ranged from -4.3 to 1.5 percent in the vertical direction vs. -1.6 to 4.6 percent for the seat cushion.
- In terms of the band-pass (2.5-100 Hz) rms value (effects of vehicle suspension system omitted), the seat air bladder had shock and vibration energy reductions that ranged from 25.8 to 35.6 percent in the vertical direction vs. 5.7 to 10.3 percent for the seat cushion.
- In terms of the low-pass (< 100 Hz) VDV value, the seat air bladder had shock and vibration energy reductions that ranged from -12.6 to 6.0 percent in the vertical direction vs. -3.6 to 7.2 percent for the seat cushion.
- In terms of the band-pass (2.51-100 Hz) VDV value (effects of vehicle suspension system omitted), the seat air bladder had shock and vibration energy reductions that ranged from 30.9 to 41.1 percent in the vertical direction vs. 6.3 to 10.9 percent for the seat cushion.

### 7.2.2. Black Hawk Seat Air Bladder Tests

- The seat air bladder with the seat occupant in the Black Hawk helicopter behaved similar to a one-degree-of-freedom, mass-spring-damper system. The system had a resonance frequency in the 4 Hz. 1/3 octave frequency band.

- The Black Hawk helicopter had a main rotor blade passage frequency at 16 Hz, below which little vibration energy was present. Since there is very little vibration energy below 16 Hz, the 4 Hz resonance of the seat air bladder/occupant system had little effect on the seat air bladders ability to reduce the helicopter-related vibration energy.
- Since there are few or no shock events associated with the flight maneuvers of the only the low-pass (< 100 Hz) rms vibration energy is addressed. The seat air bladder had vibration energy reductions that ranged from 65.7 to 73.3 percent in the vertical direction.

#### 7.2.3. MRAP Litter Air Bladder Tests

- The dynamic flexibility of the litter webbing interacted with the dynamic flexibility of the litter air bladder.
- For vibration in the vertical direction, the litter air bladder with patient and the litter webbing plus litter air bladder with patient behaved similar to a one-degree-of-freedom, mass-spring-damper system.
- The litter air bladder with a patient had a resonance frequency that ranged from the 5 to 6.3 Hz 1/3 octave frequency bands.
- The bare litter with a patient and the litter plus litter air bladder had a resonance frequency in the 4 Hz 1/3 octave frequency band.
- In both the MRAP ambulance and the Black Hawk helicopter there vibration amplitude gains of up to a factor of 30 between the litter rack or pan and the litter stirrup (and into the litter poles) in all directions. This is caused by chatter between the litter rack or pan and the litter stirrup. This amplification in vibration energy was attenuated by the litter webbing.

- For the MRAP, the litter air bladder amplified the vibration and shock energy below the 6.3 1/3 octave frequency band and attenuated the energy above this frequency band.
- In terms of the low-pass (< 100 Hz) rms value, for the MRAP ambulance, the litter plus the litter air bladder had shock and vibration energy reductions that ranged from 19.6 to 37.6 percent in the vertical direction vs. -22.2 to 14.7 percent for the bare litter.
- In terms of the band-pass (2.5-100 Hz) rms value (effects of vehicle suspension system omitted), for the MRAP ambulance, the litter plus litter air bladder had shock and vibration energy reductions that ranged from 55.0 to 69.2 percent in the vertical direction vs. 14.7 to 50.7 percent for the bar litter.
- In terms of the low-pass (< 100 Hz) VDV value, for the MRAP ambulance, the litter plus the litter air bladder had shock and vibration energy reductions that ranged from 19.2 to 51.6 percent in the vertical direction vs. -31.8 to 24.1 percent for the bare litter.
- In terms of the band-pass (2.5-100 Hz) rms value (effects of vehicle suspension system omitted), for the MRAP ambulance, the litter plus litter air bladder had shock and vibration energy reductions that ranged from 58.5 to 73.7 percent in the vertical direction vs. -28 to 58.6 percent for the bar litter.

#### 7.2.4. Black Hawk Litter Air Bladder Tests

- There was little vibration energy in the Black Hawk helicopter below the helicopter main rotor blade passage frequency of 16 Hz.

- In terms of the low-pass (< 100 Hz) rms value, for the Black Hawk helicopter, the litter plus the litter air bladder had vibration energy reductions that ranged from 87.4 to 89.5 percent in the vertical direction vs. 33.8 to 81.1 percent for the bear litter.

## 7.3. Conclusion

### 7.3.1. MRAP Ambulance and Black Hawk Seat Air Bladder

- The resonance of the MRAP ambulance suspension system in the 2 Hz 1/3 octave frequency band dominated the overall value of the shock and vibration reduction through the MRAP seat and litter air bladders.
- There were no major identified structural resonances in the structure of the Black Hawk helicopter that would affect the vibration reduction characteristics of the Black Hawk seat and litter air bladders.
- The seat air bladder was more effective in reducing human exposure to vibration in the Black Hawk helicopter than in the MRAP ambulance.
- The seat air bladder is substantially more effective in reducing human exposure to shock and vibration in vehicles with no suspension system where the seat air bladder is the primary system for reducing human exposure to shock and vibration.
- The dominant shock and vibration energy in the MRAP ambulance was below the 6.3 Hz 1/3 octave frequency band. This energy excited the 4 Hz resonance of the seat air bladder/seat occupant system, reducing the overall effectiveness of the MRAP seat air bladder in reducing human exposure to low frequency vibration.
- The dominant vibration energy in the Black Hawk helicopter was above 16 Hz. This resulted in the better performance of the Black Hawk seat air bladder in reducing human exposure to vibration.

- The 2.0 lb/ft$^3$ density foam seat bottom bladder has a firmer feel and provides a more comfortable ride.
- The seat air bladder with the 3/16-in. diameter tube had higher damping than the seat air bladder with the 3/8 in. diameter tubes. However, this did not result in an overall increase in the shock and vibration reduction through the seat air bladder.

#### 7.3.2. MRAP Ambulance and Black Hawk Litter Air Bladder

- The shock and vibration reducing characteristics of the litter air bladder were significantly affected by the flexibility of the litter webbing and were more difficult to evaluate.
- Even though that was amplification in shock and vibration energy transfer through the MRAP litter air bladder, there was an overall reduction in shock and vibration energy transfer through the flexible litter webbing plus the litter air bladder that was higher than energy reduction through the bare litter webbing.
- The vibration energy reduction through litter webbing with the litter air bladder in the Black Hawk helicopter was in general greater than the vibration energy reduction through the bare litter webbing.
- More testing is necessary on the litter air bladder to more accurately determine its effectiveness in reducing patient exposure to shock and vibration during medical transport.

### 7.4. Recommendations

- Use the measured field acceleration files to conduct more detailed laboratory tests of the seat air bladder configurations that were examined during the MRAP Ambulance and Black Hawk helicopter field tests. The purpose of these tests is to obtain a better understanding of the physical characteristics of the different elements that make up the seat air bladders.

- Use the measured field acceleration files to conduct more detailed laboratory tests of the litter air bladder configurations that were examined during the MRAP Ambulance and Black Hawk helicopter field tests. The purpose of these tests is to obtain a better understanding of the dynamic interaction between the litter webbing in the litter structure and the litter air bladder.
- Once the respective laboratory tests are completed, use the results to better optimize the designs of the seat and litter air bladders to more clearly define how they can be more effectively used in military vehicles to protect patients from exposure to shock and vibration during medical transport.
- Fabricate the newly designed seat and litter air bladders and evaluate their performance in new carefully designed field tests in land borne and airborne medical transport vehicles.

APPENDIX A

A.1. July MRAP seat test

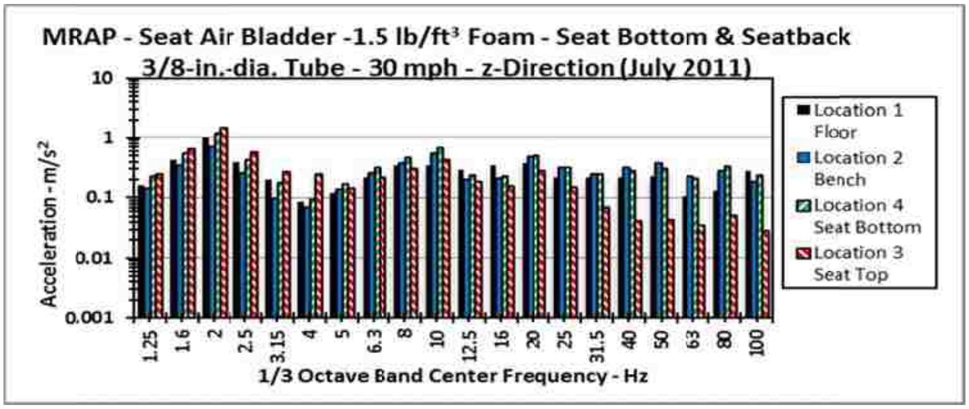


Figure A.1 Acceleration - MRAP seat air bladder test – S1 - z-direction

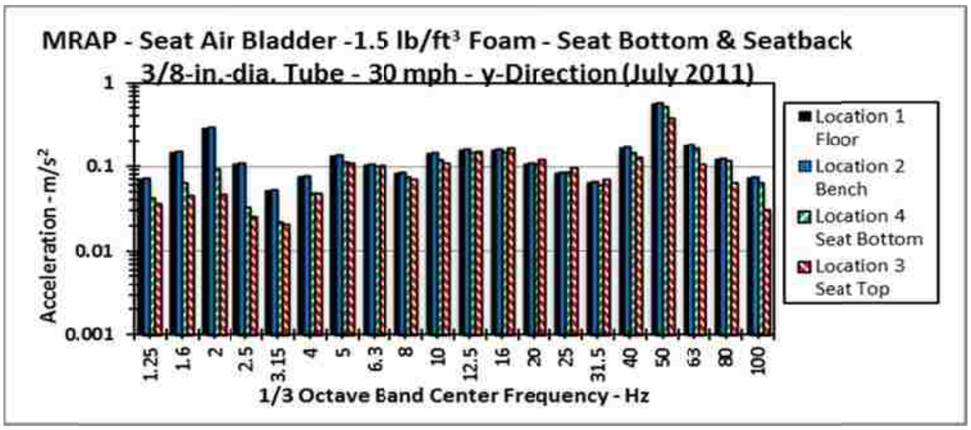


Figure A.2 Acceleration - MRAP seat air bladder test – S1 - y-direction

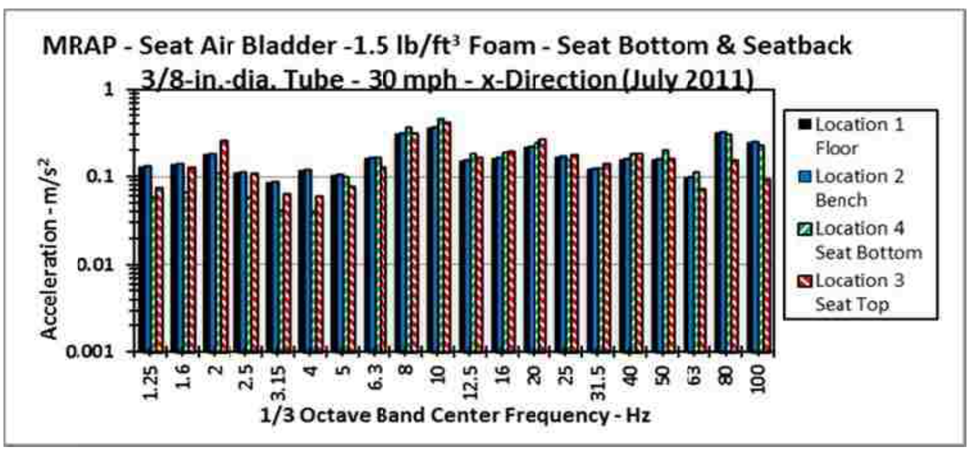


Figure A.3 Acceleration - MRAP seat air bladder test – S1 - x-direction

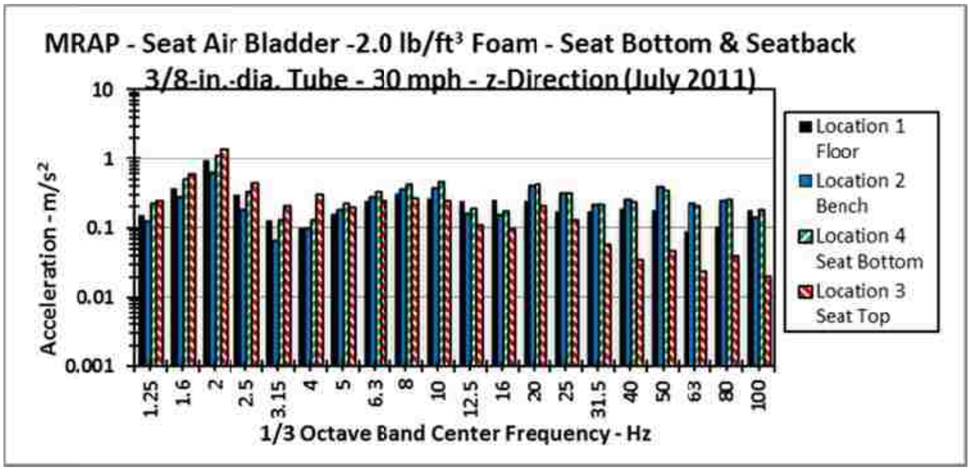


Figure A.4 Acceleration - MRAP seat air bladder test – S2 - z-direction

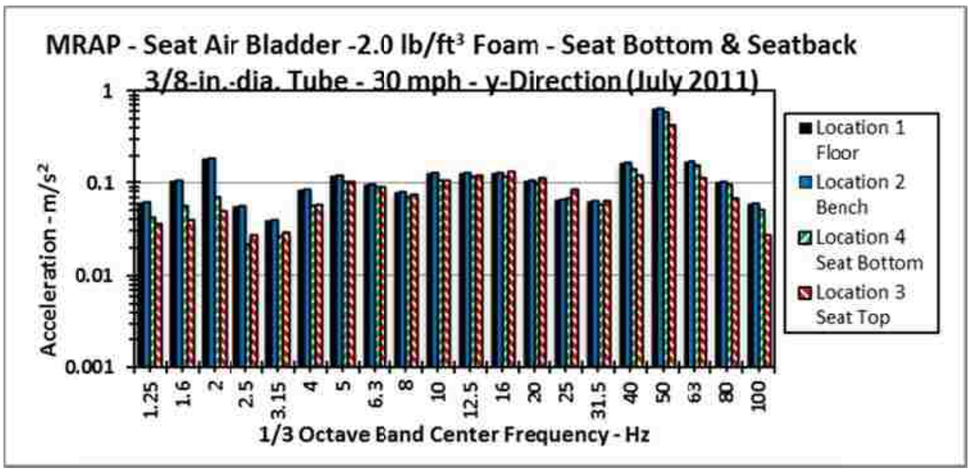


Figure A.5 Acceleration - MRAP seat air bladder test – S2 - y-direction

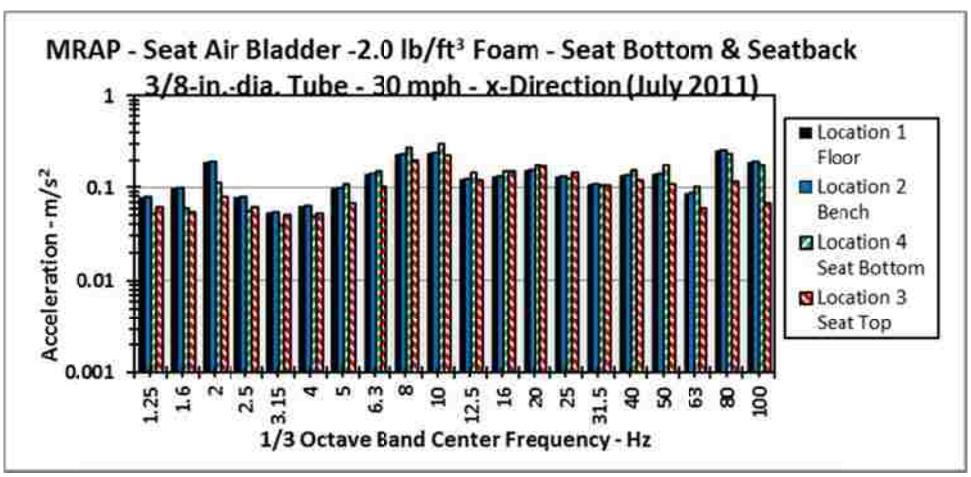


Figure A.6 Acceleration - MRAP seat air bladder test – S2 - x-direction

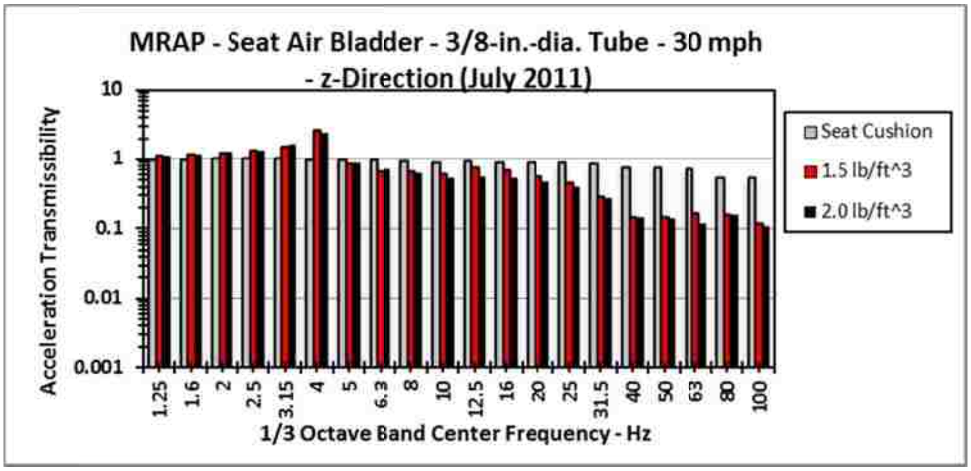


Figure A.7 Acceleration Transmissbility - MRAP seat air bladder test - z-direction – Through seat air bladder/ seat cushion only

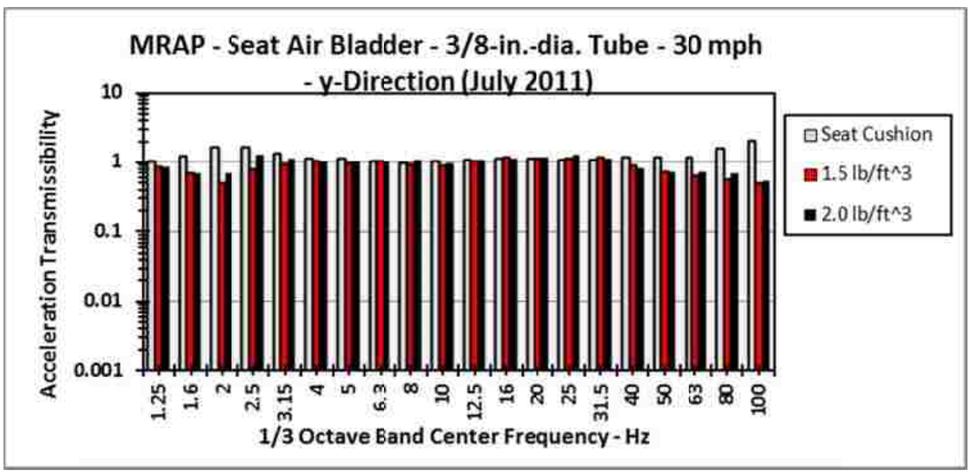


Figure A.8 Acceleration Transmissbility - MRAP seat air bladder test - y-direction – Through seat air bladder/ seat cushion only

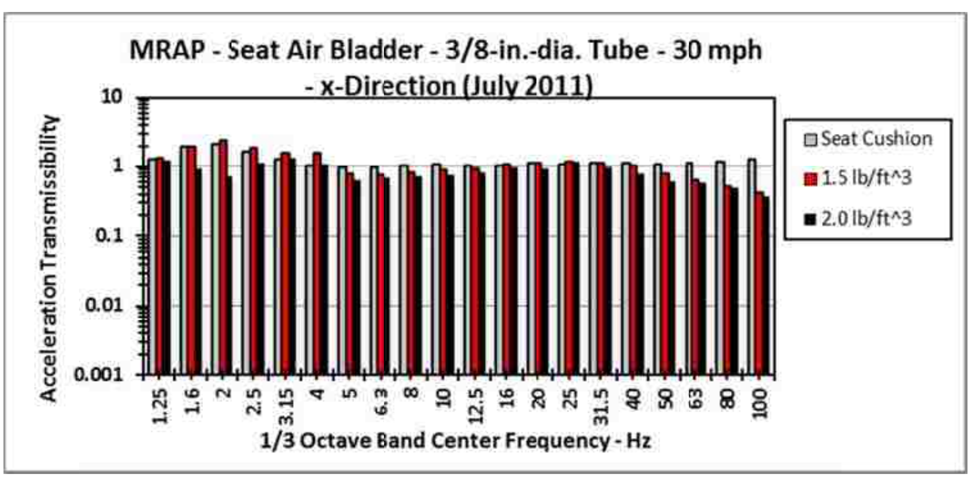


Figure A.9 Acceleration Transmissbility - MRAP seat air bladder test - x-direction– Through seat air bladder/ seat cushion only

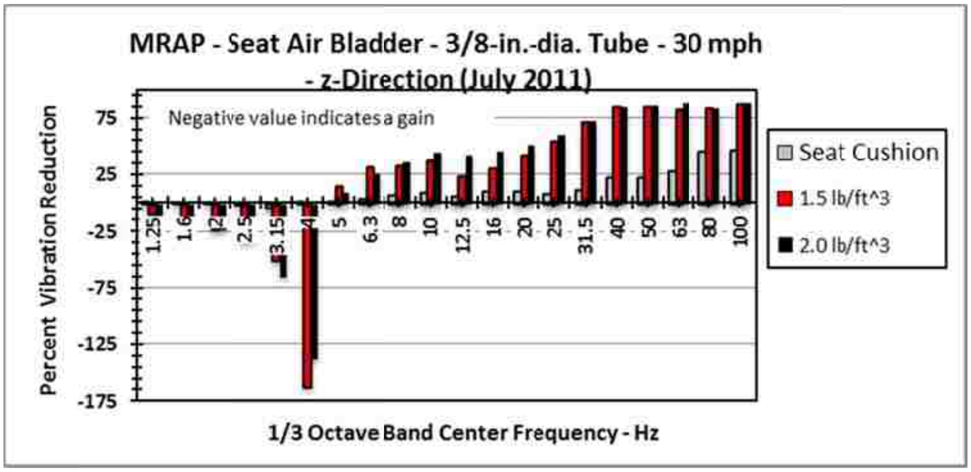


Figure A.10 Percent Vibration Reduction - MRAP seat air bladder test - z-direction

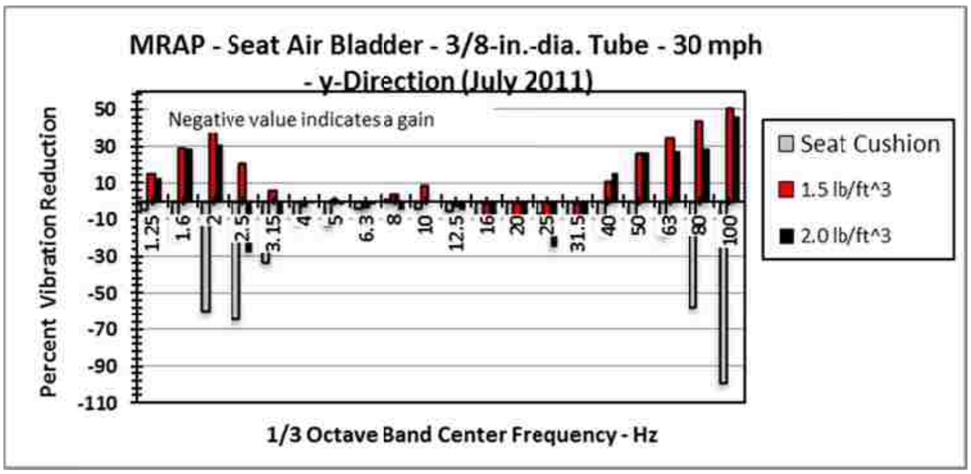


Figure A.11 Percent Vibration Reduction - MRAP seat air bladder test - y-direction

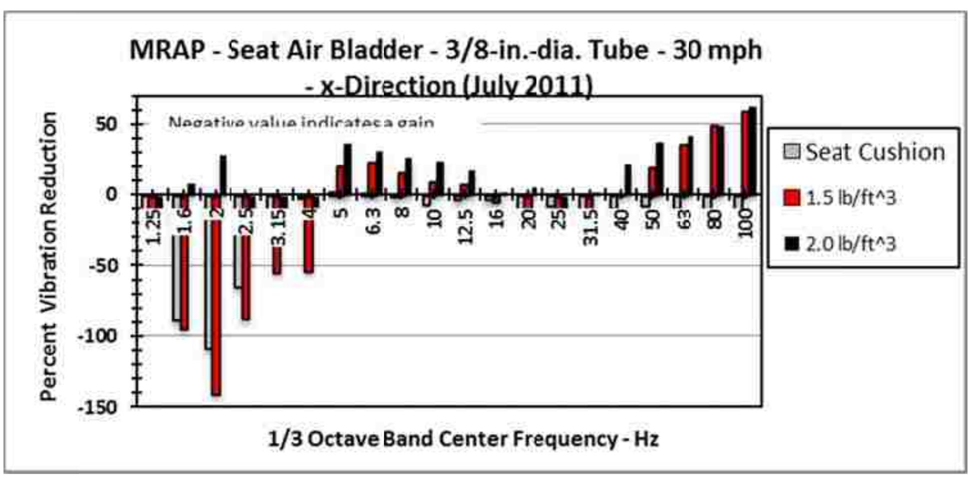


Figure A.12 Percent Vibration Reduction - MRAP seat air bladder test - x-direction

A.2. November MRAP seat test

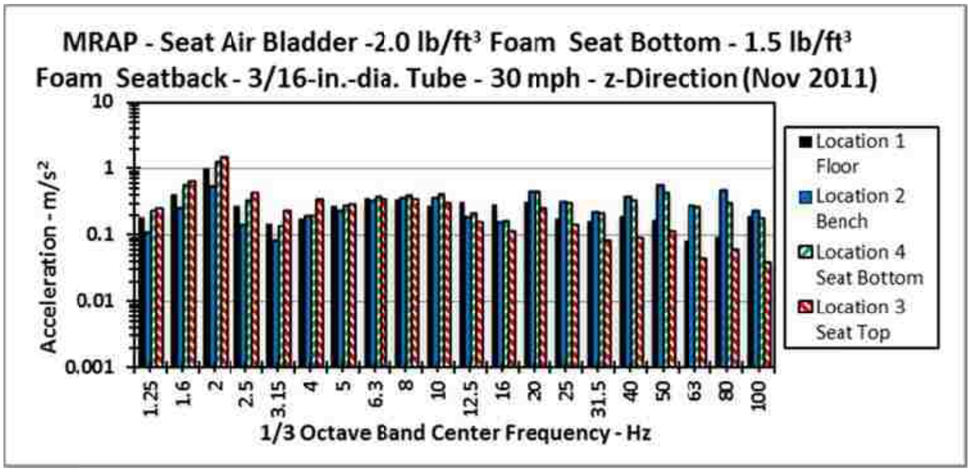


Figure A.13 Acceleration - MRAP seat air bladder test - S3 - z-direction

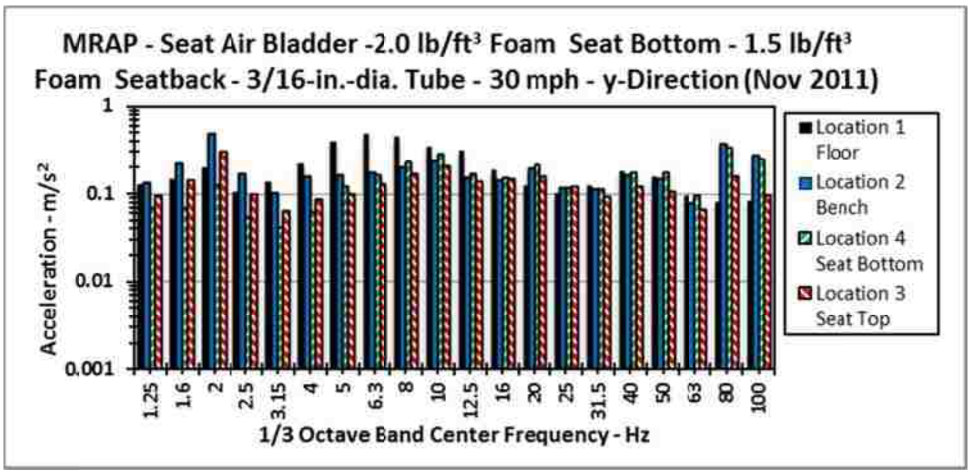


Figure A.14 Acceleration - MRAP seat air bladder test - S3 - y-direction

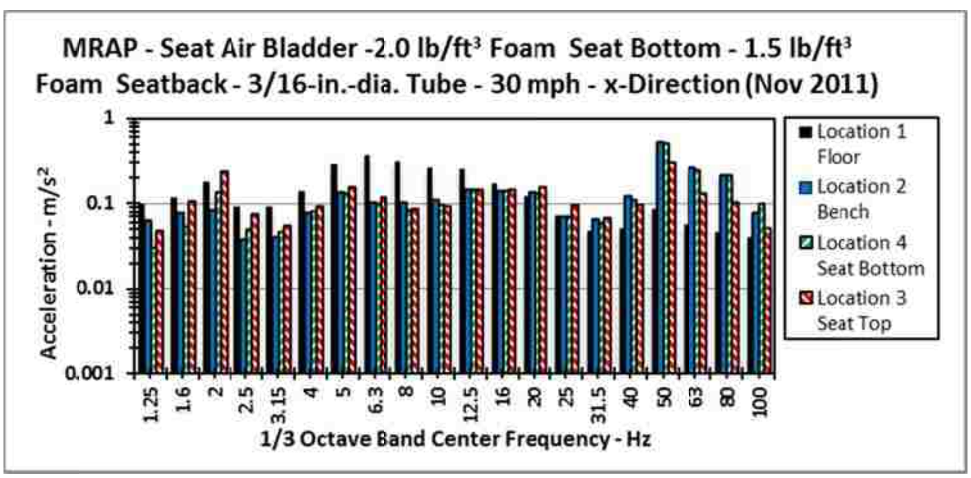


Figure A.15 Acceleration - MRAP seat air bladder test - S3 - x-direction

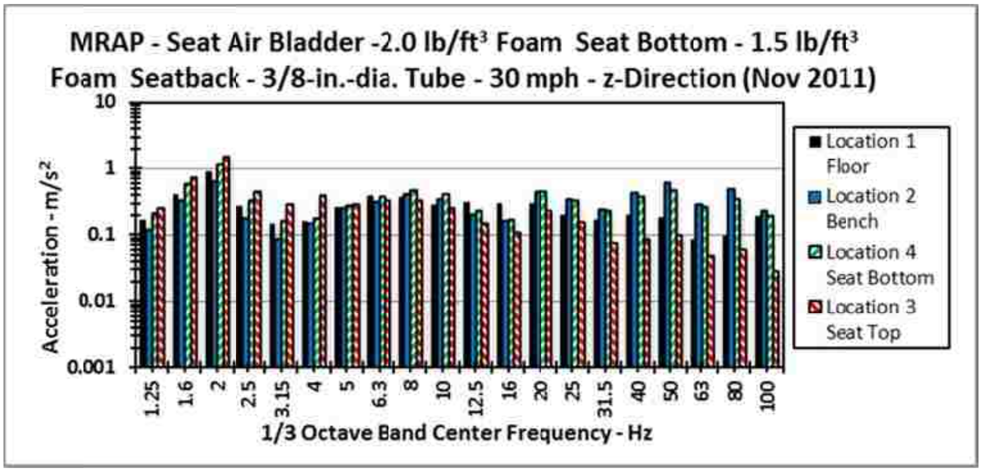


Figure A.16 Acceleration - MRAP seat air bladder test - S3 - z-direction

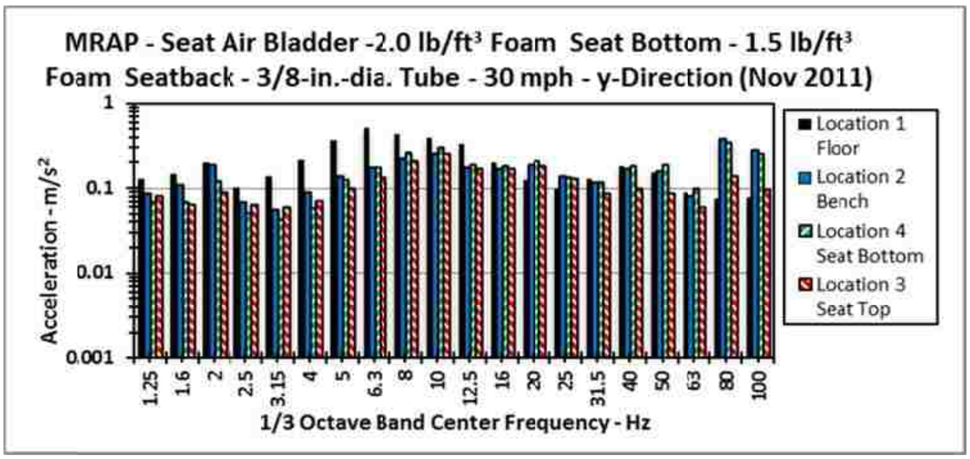


Figure A.17 Acceleration - MRAP seat air bladder test - S4 - y-direction

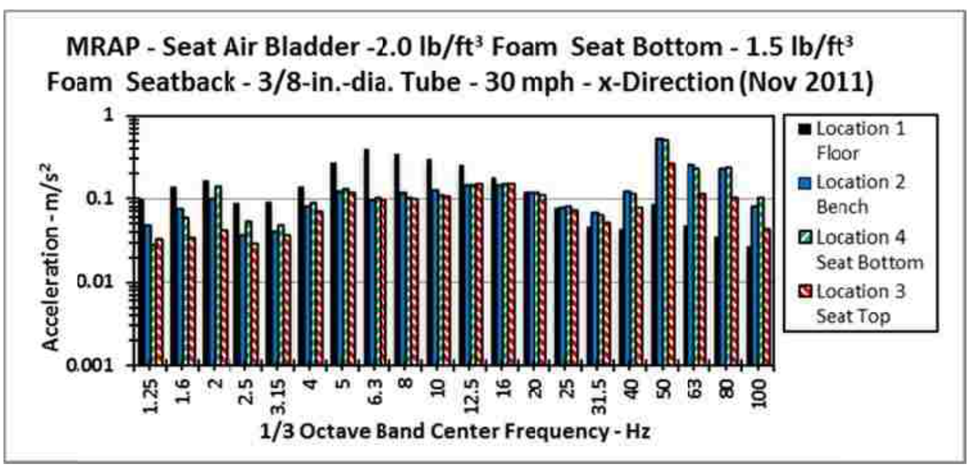


Figure A.18 Acceleration - MRAP seat air bladder test - S4 - x-direction

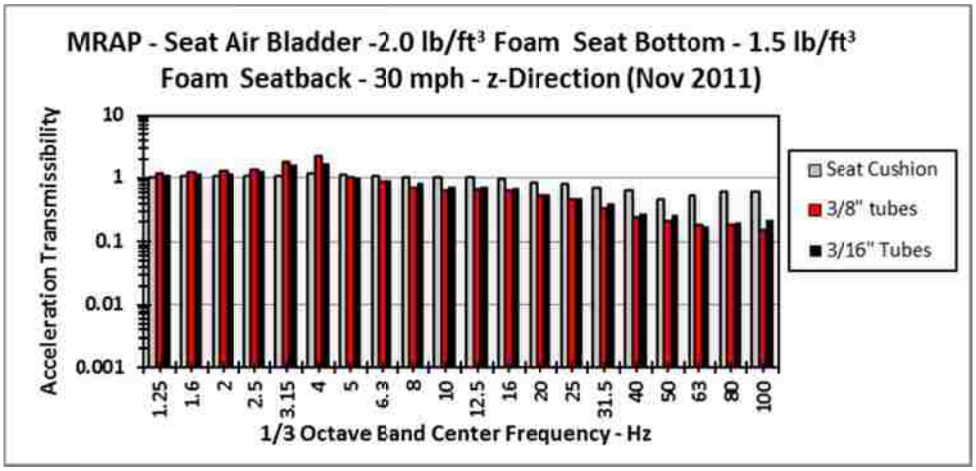


Figure A.19 Acceleration Transmissbility - MRAP seat air bladder test - z-direction – Through seat air bladder/ seat cushion only

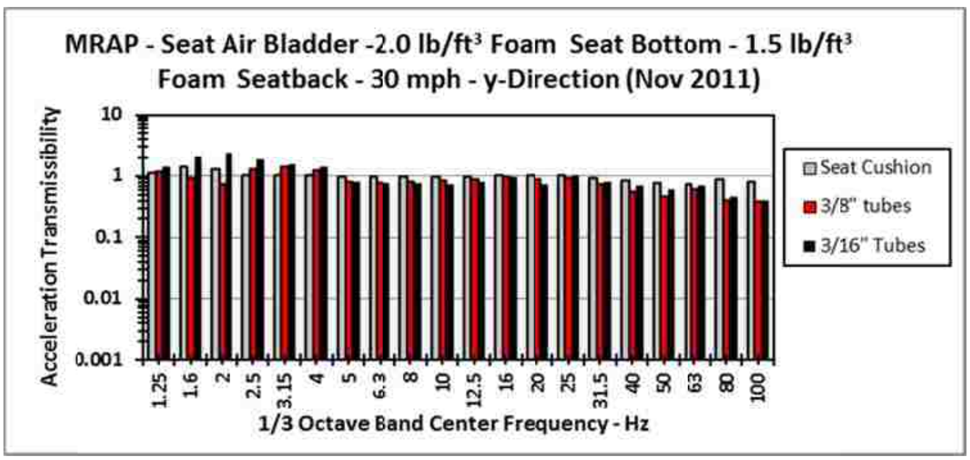


Figure A.20 Acceleration Transmissbility - MRAP seat air bladder test - y-direction – Through seat air bladder/ seat cushion only

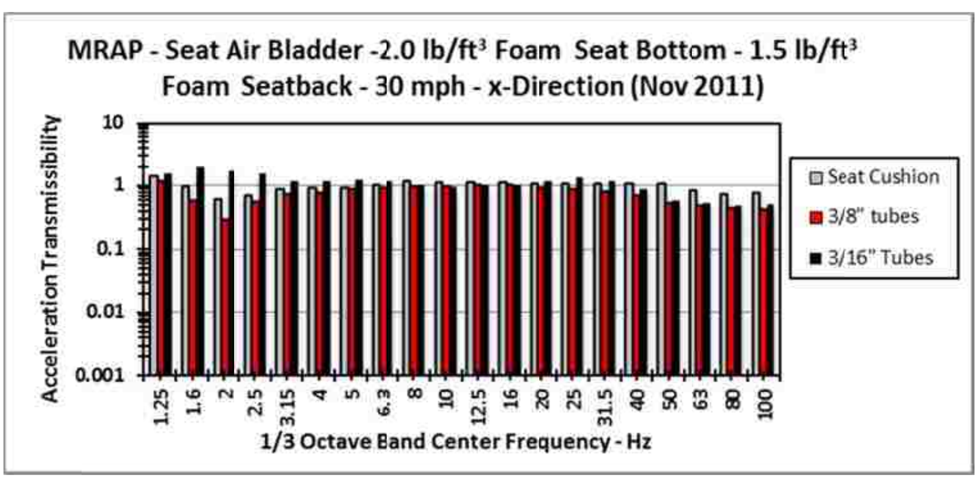


Figure A.21 Acceleration Transmissbility - MRAP seat air bladder test - x-direction – Through seat air bladder/ seat cushion only

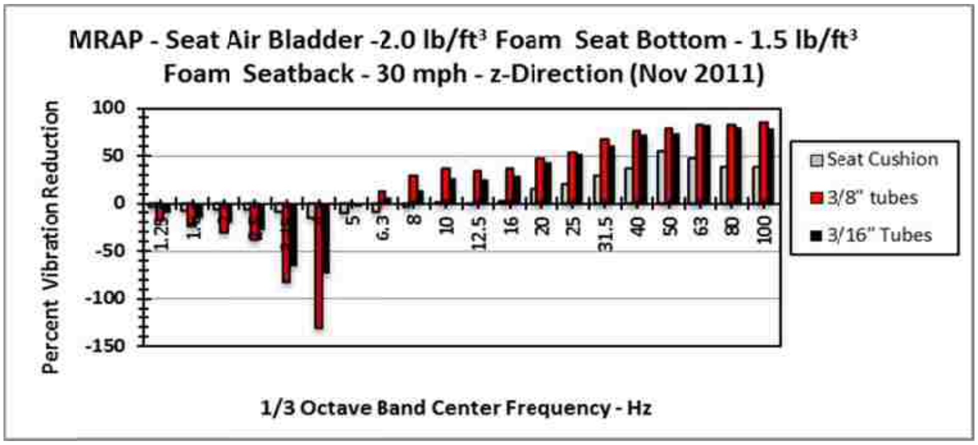


Figure A.22 Percent Vibration Reduction - MRAP seat air bladder test – z-direction

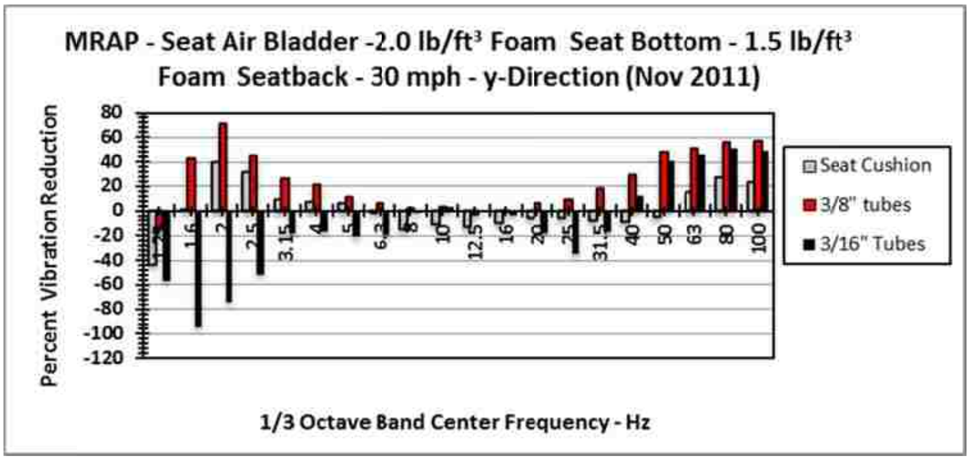


Figure A.23 Percent Vibration Reduction - MRAP seat air bladder test – y-direction

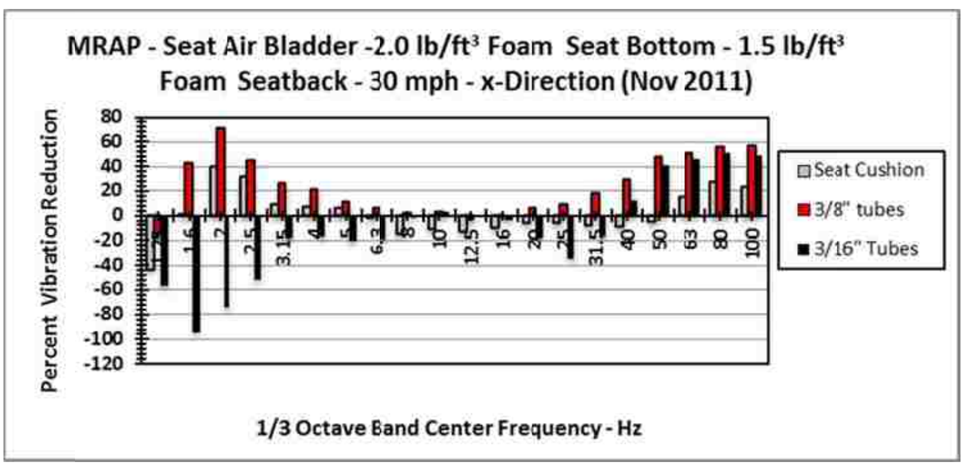


Figure A.24 Percent Vibration Reduction - MRAP seat air bladder test – x-direction

A.3. April Black Hawk seat test

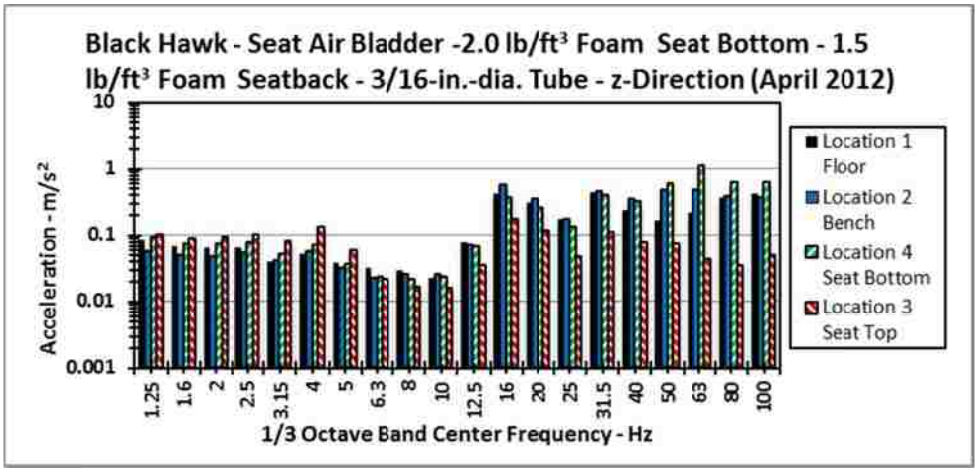


Figure A.25 Acceleration - Black Hawk seat air bladder test - S3 - z-direction

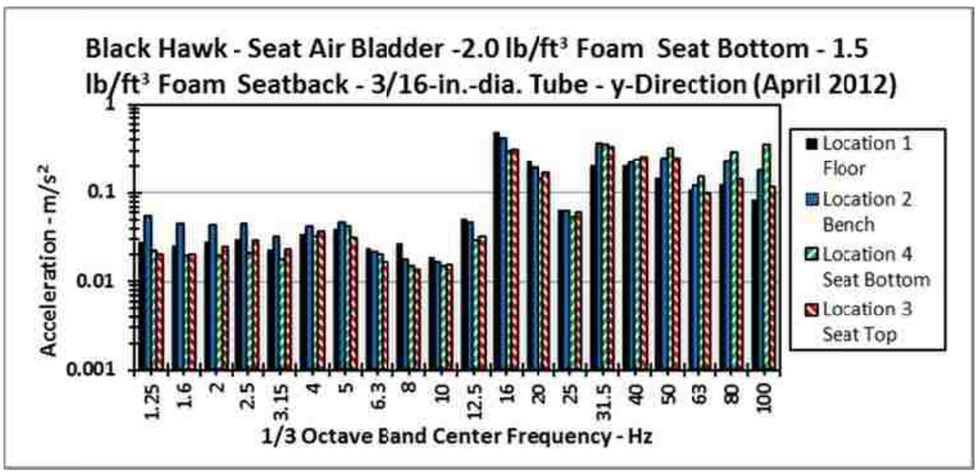


Figure A.26 Acceleration - Black Hawk seat air bladder test - S3 - y-direction

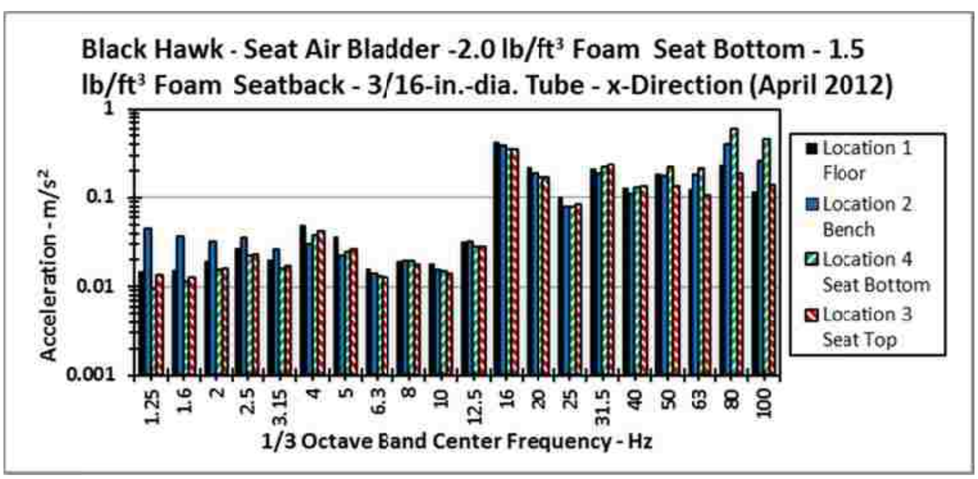


Figure A.27 Acceleration - Black Hawk seat air bladder test - S3 - x-direction

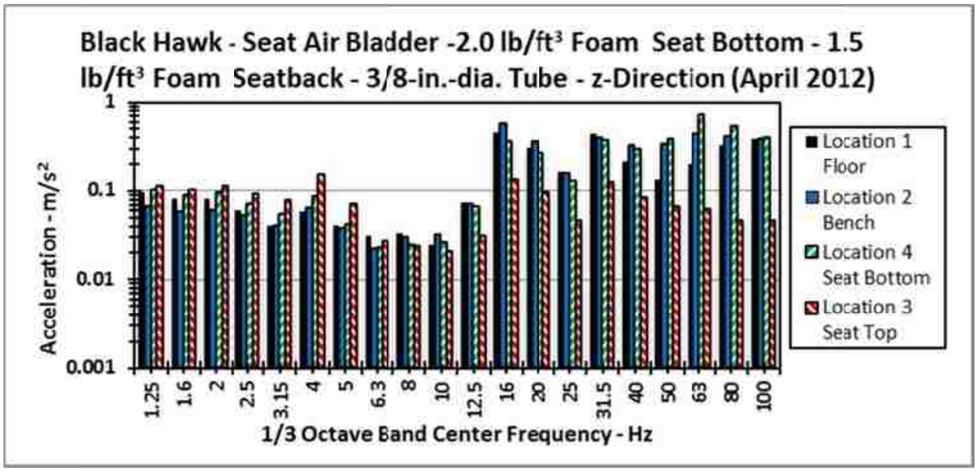


Figure A.28 Acceleration - Black Hawk seat air bladder test - S4 - z-direction

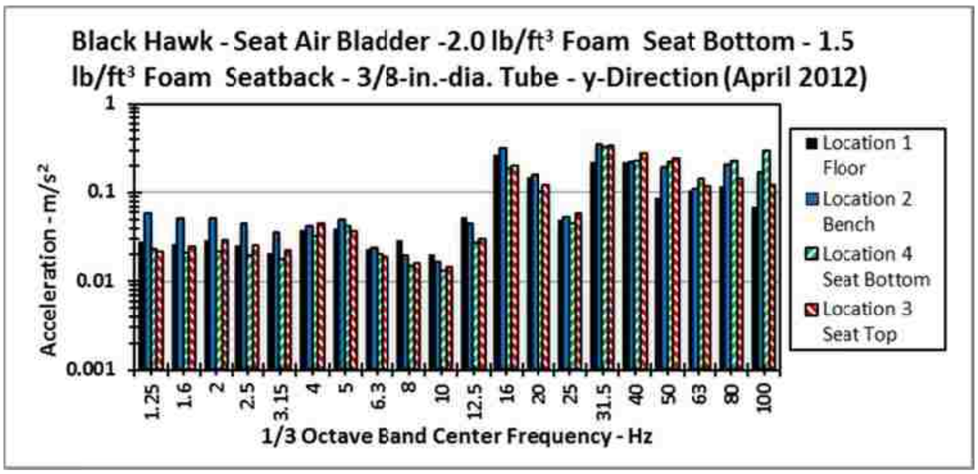


Figure A.29 Acceleration - Black Hawk seat air bladder test - S4 - y-direction

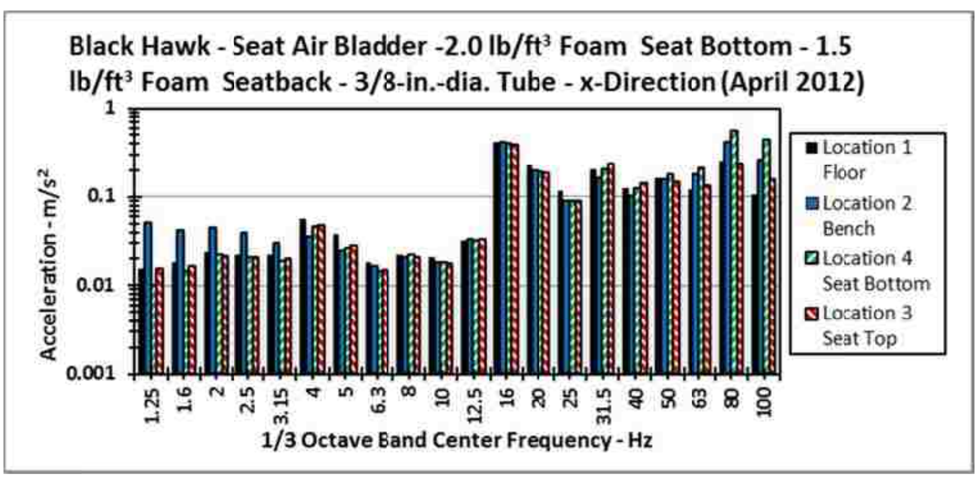


Figure A.30 Acceleration - Black Hawk seat air bladder test - S4 - x-direction

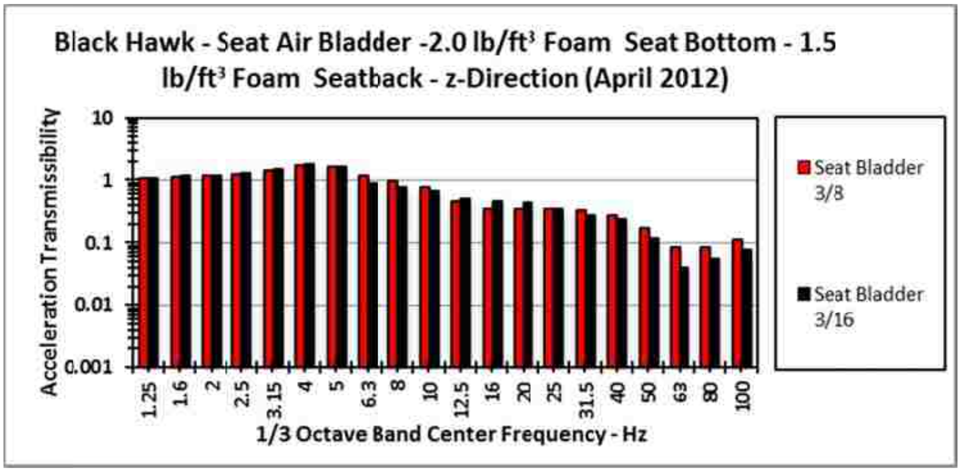


Figure A.31 Acceleration Transmissbility - Black Hawk seat air bladder test - z-direction – Through seat air bladder only

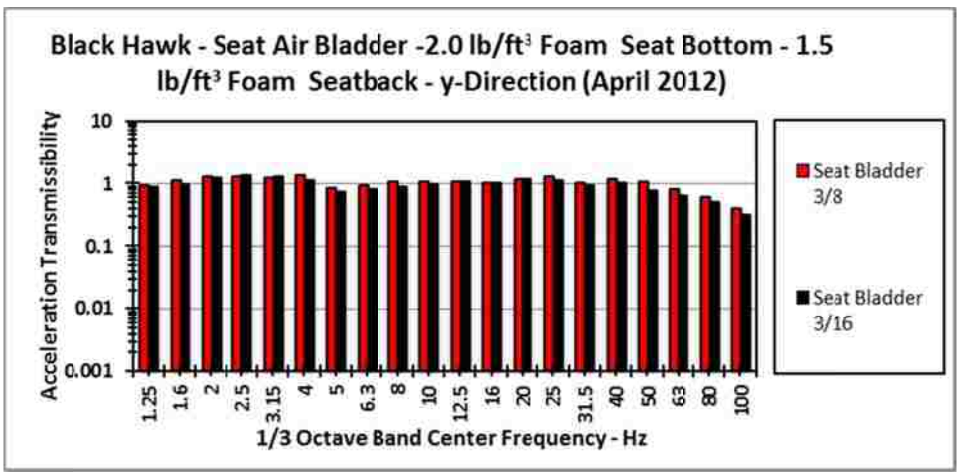


Figure A.32 Acceleration Transmissbility - Black Hawk seat air bladder test - y-direction– Through seat air bladder only

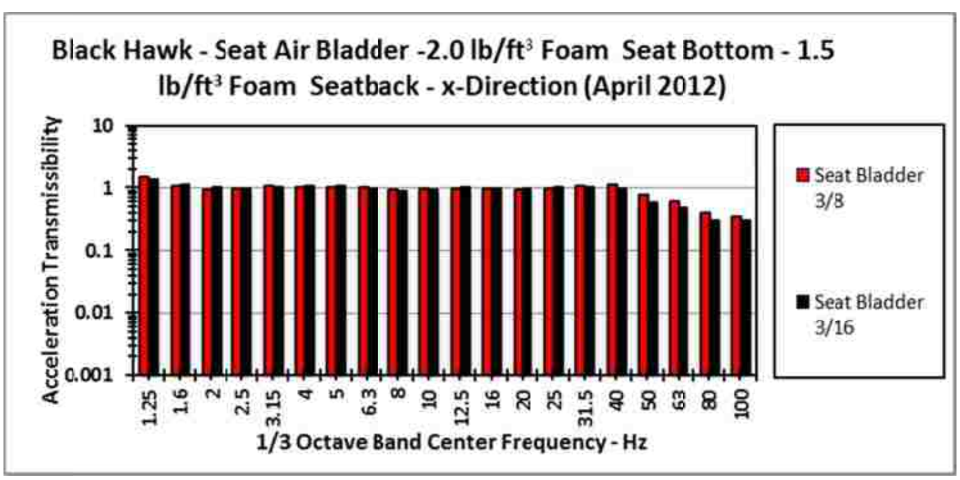


Figure A.33 Acceleration Transmissbility - Black Hawk seat air bladder test - x-direction– Through seat air bladder only

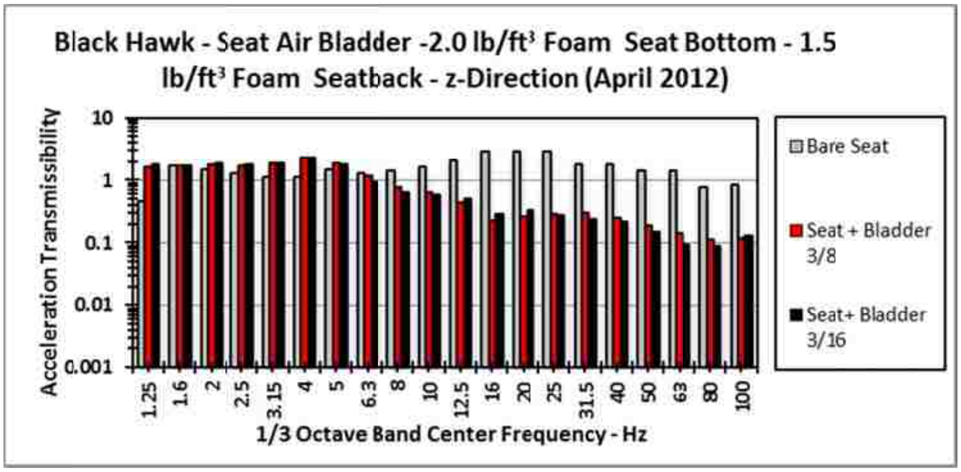


Figure A.34 Acceleration Transmissbility - Black Hawk seat air bladder test – z-direction– Through seat frame and/or seat air bladder

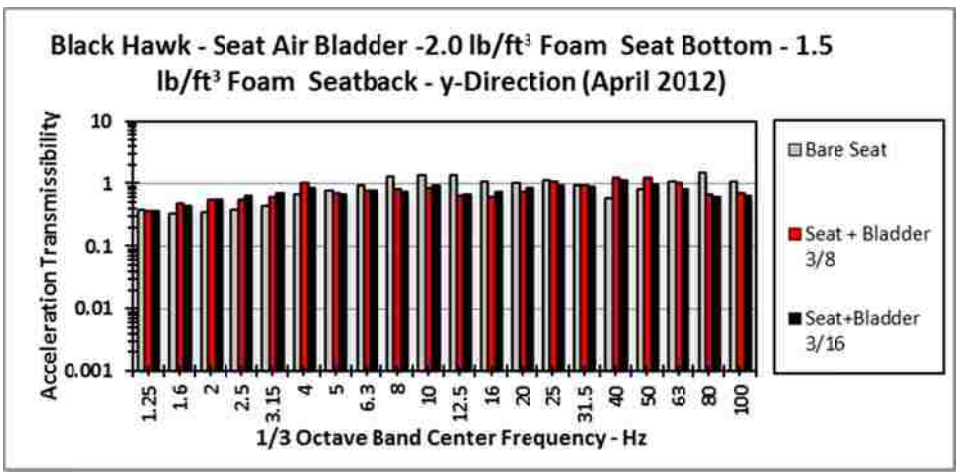


Figure A.35 Acceleration Transmissbility - Black Hawk seat air bladder test - y-direction– Through seat frame and/or seat air bladder

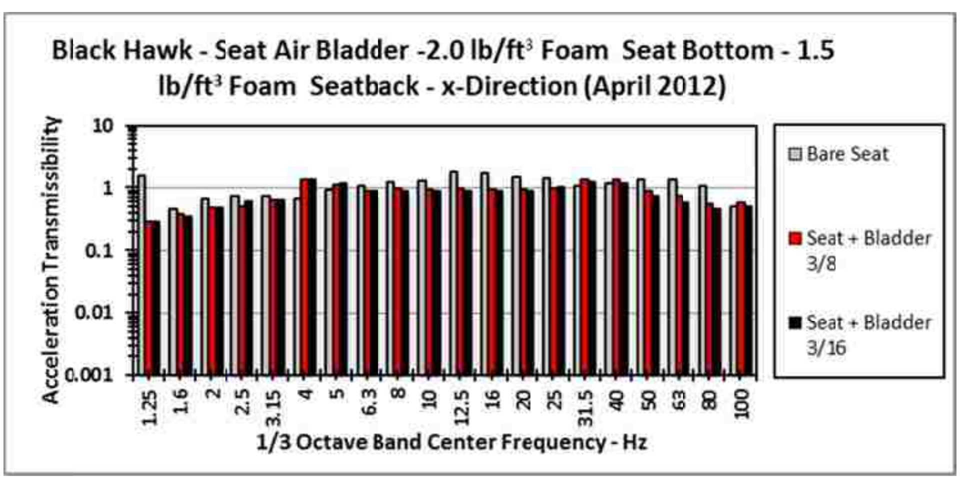


Figure A.36 Acceleration Transmissbility - Black Hawk seat air bladder test - x-direction– Through seat frame and/or seat air bladder

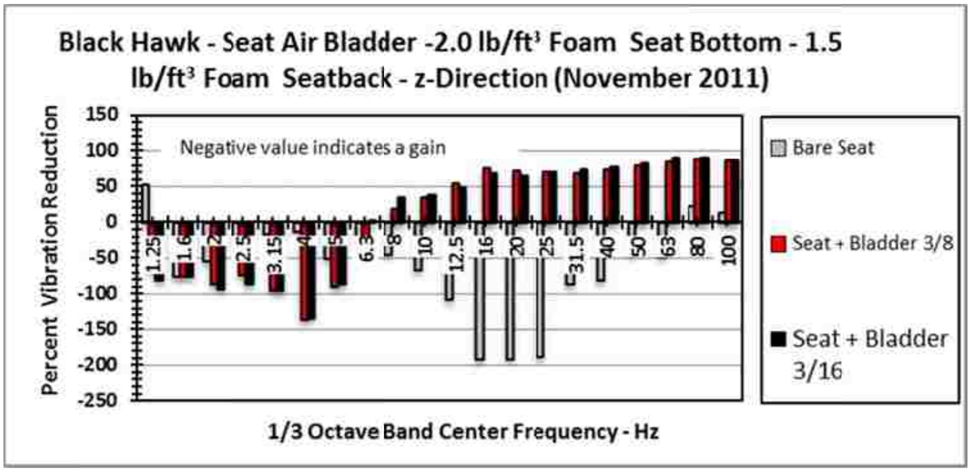

Figure A.37 Percent Vibration Reduction - Black Hawk seat air bladder test – z-direction

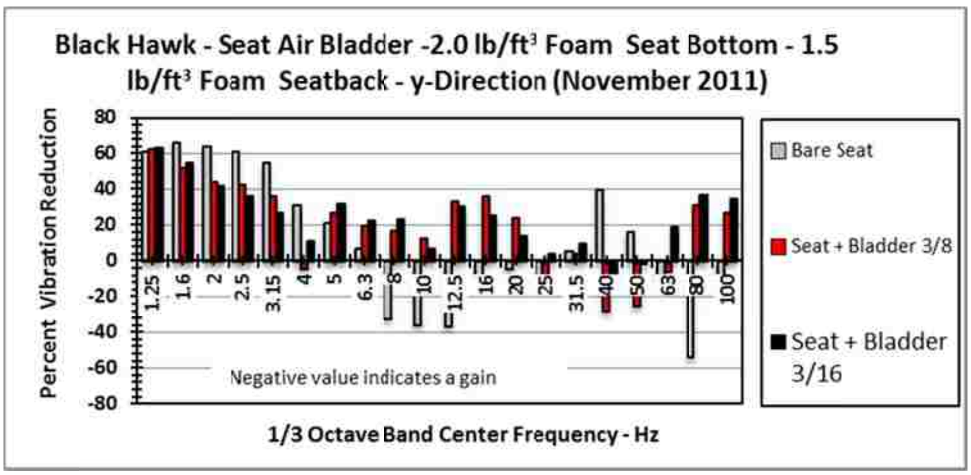

Figure A.38 Percent Vibration Reduction - Black Hawk seat air bladder test – y-direction

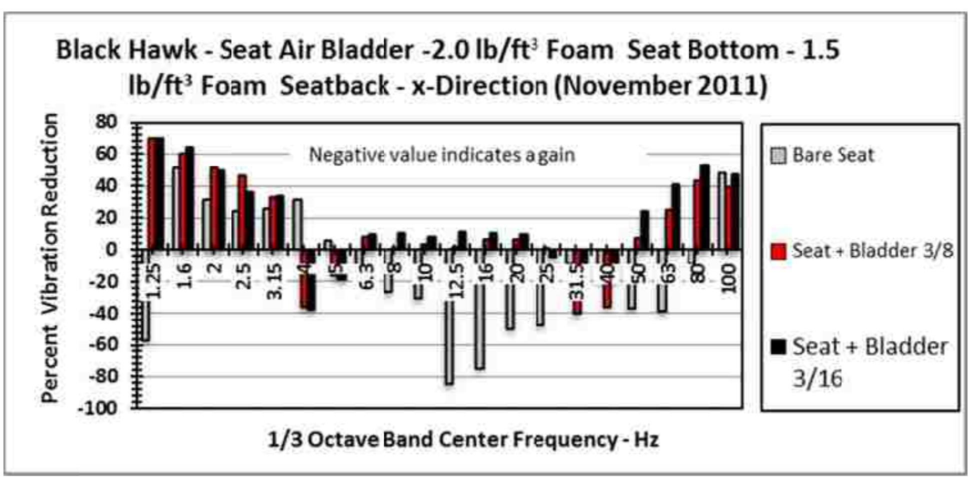

Figure A.39 Percent Vibration Reduction - Black Hawk seat air bladder test – x-direction

A.4. July MRAP Litter Test

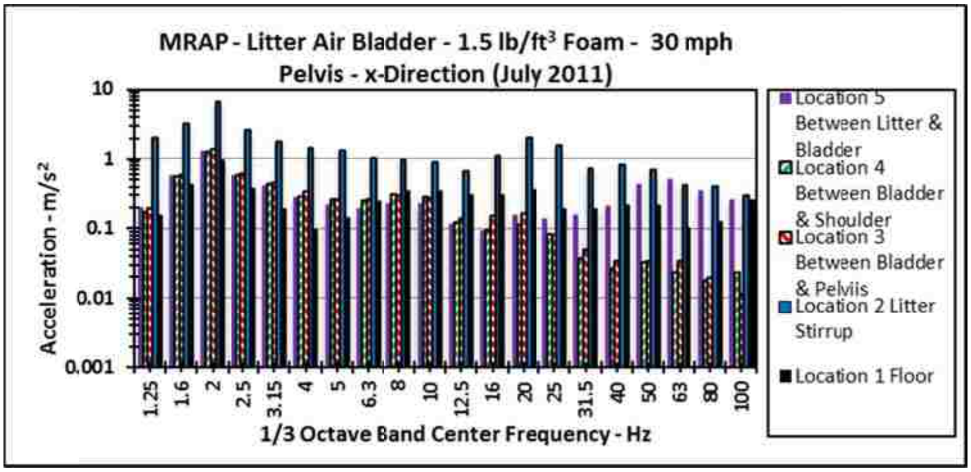


Figure A.40 Acceleration - MRAP litter air bladder test – L1 - x-direction

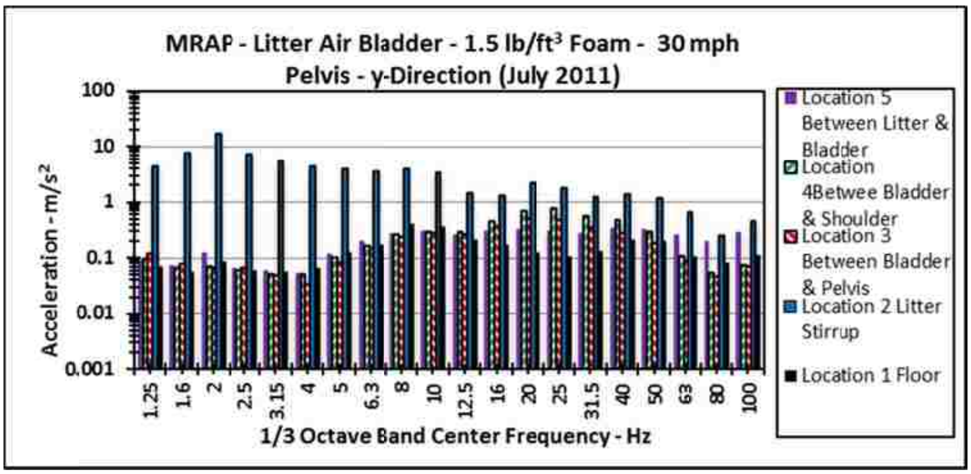


Figure A.41 Acceleration - MRAP litter air bladder test – L1 – y-direction

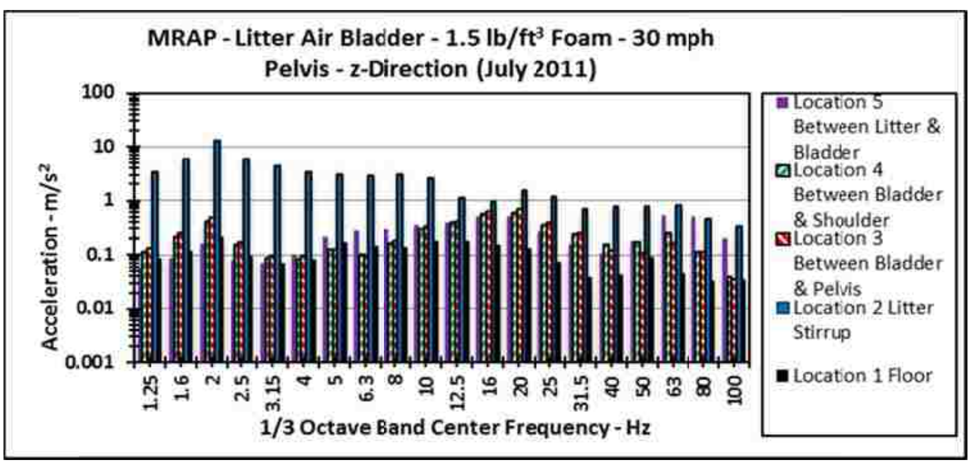


Figure A.42 Acceleration - MRAP litter air bladder test – L1 – z-direction

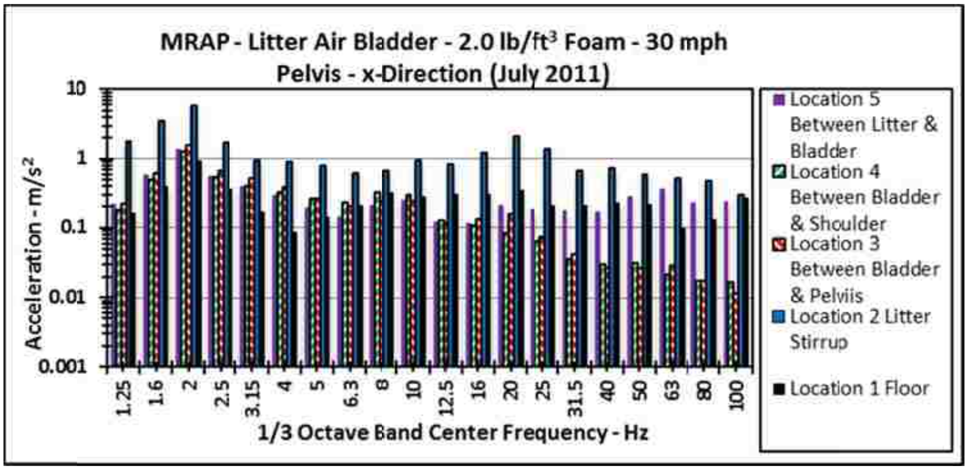


Figure A.43 Acceleration - MRAP litter air bladder test – L2 - x-direction

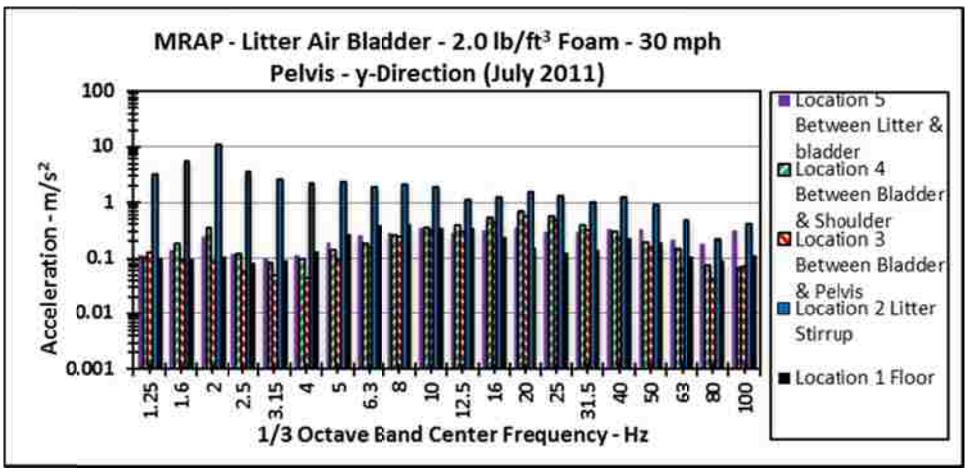


Figure A.44 Acceleration - MRAP litter air bladder test – L2 – y-direction

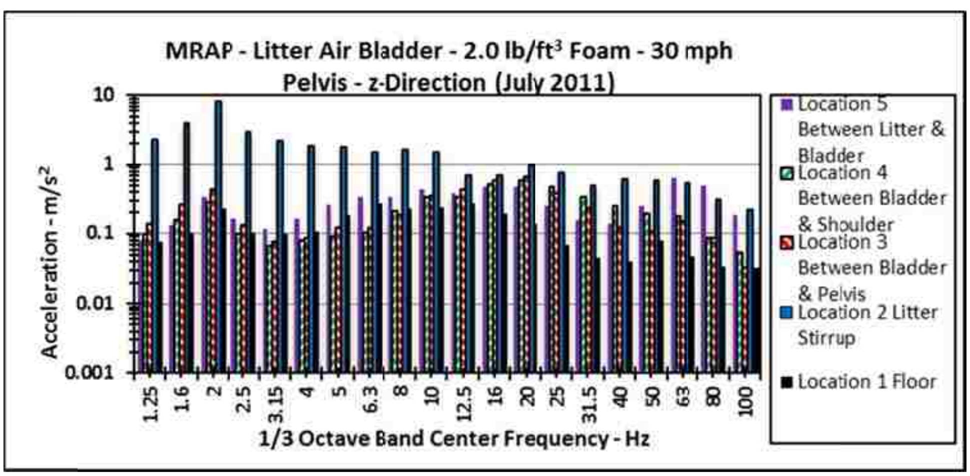


Figure A.45 Acceleration - MRAP litter air bladder test – L2 – z-direction

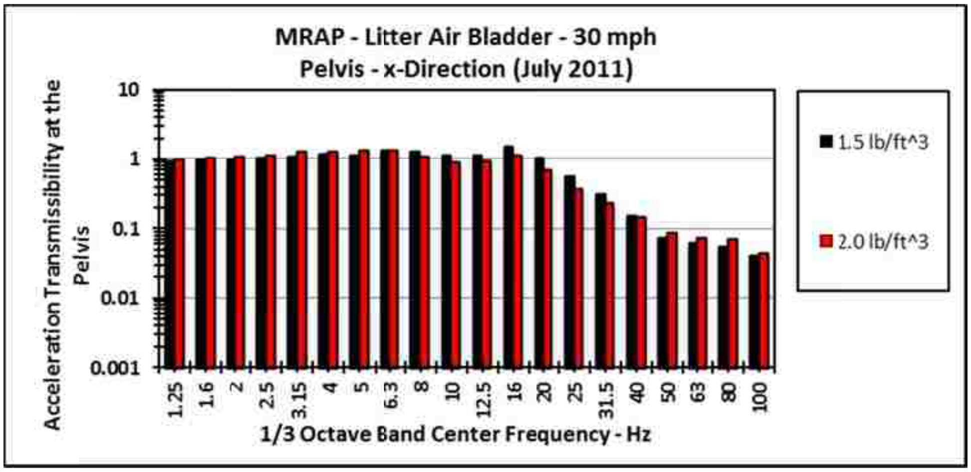


Figure A.46 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter air bladder only

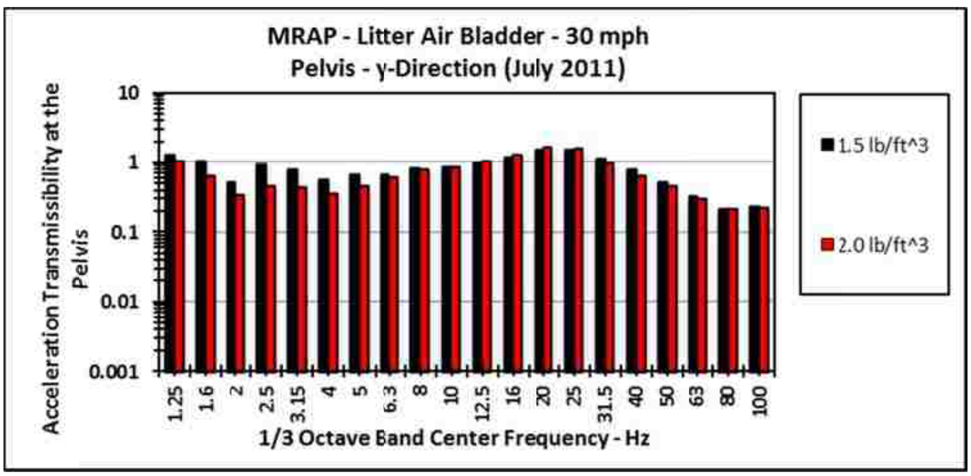


Figure A.47 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter air bladder only

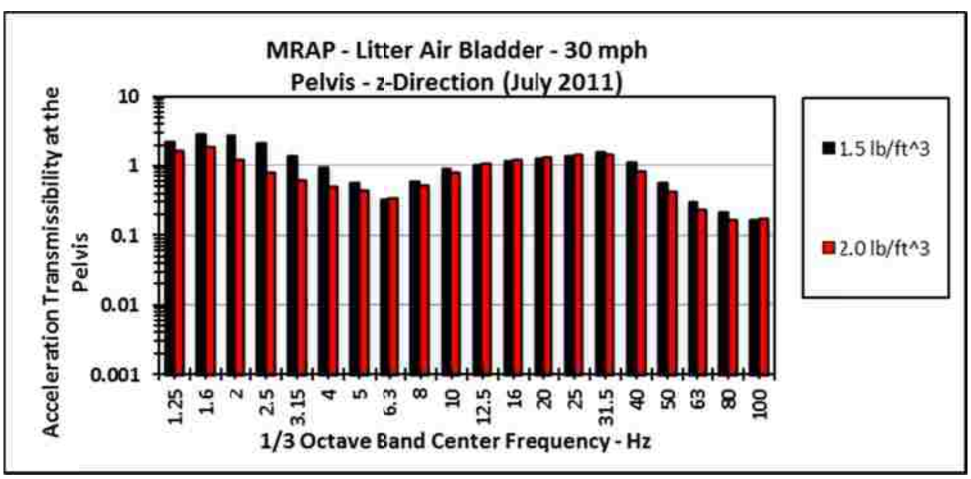


Figure A.48 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter air bladder only

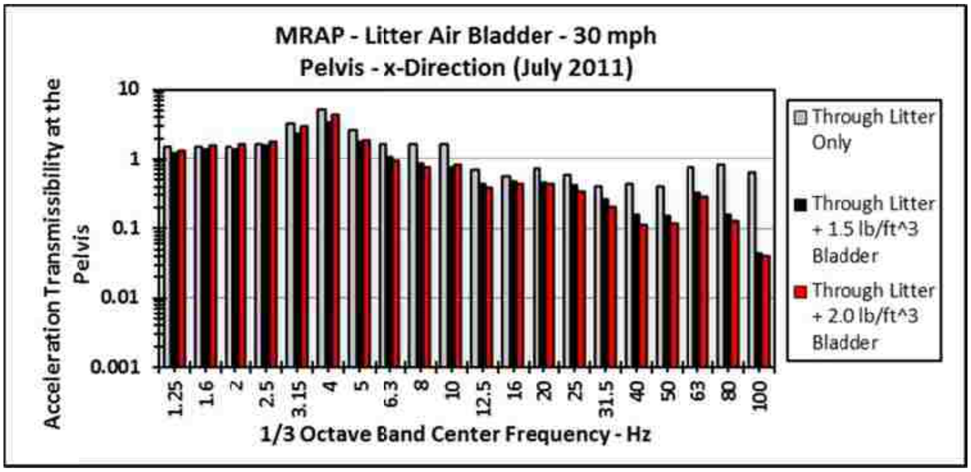

Figure A.49 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter and/or litter air bladder

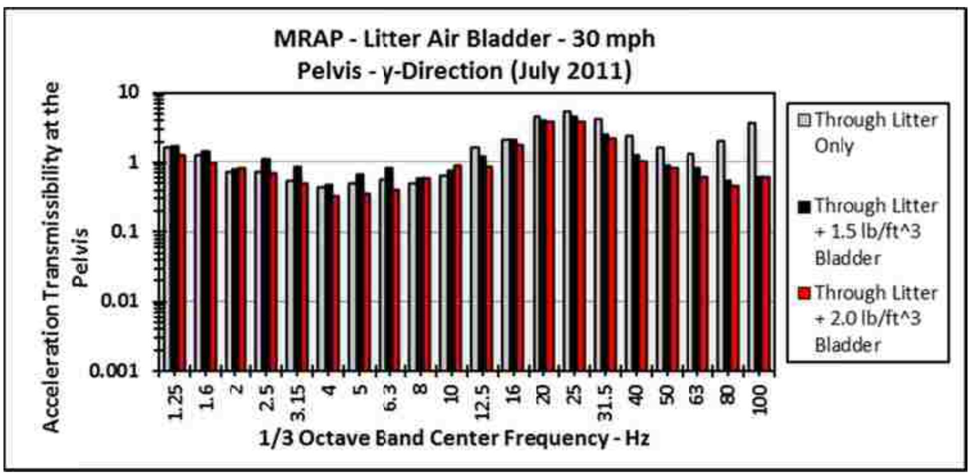

Figure A.50 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter and/or litter air bladder

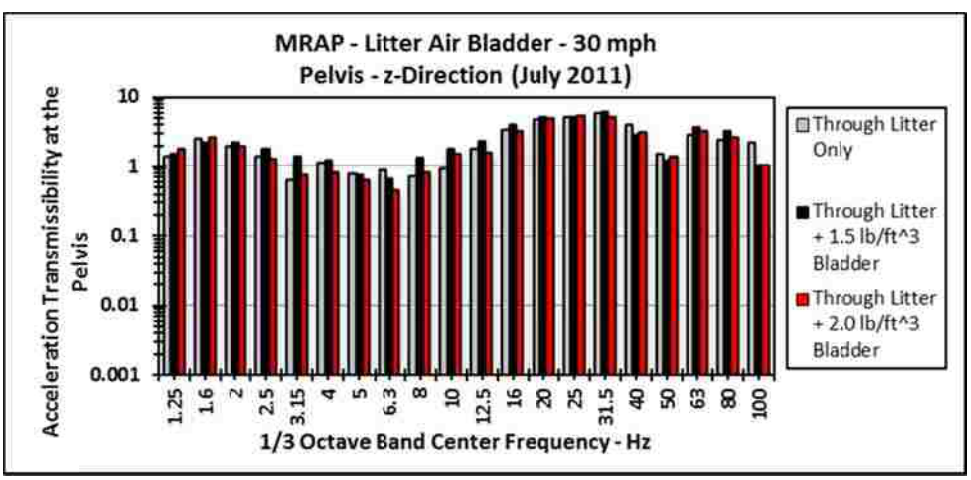

Figure A.51 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter and/or litter air bladder

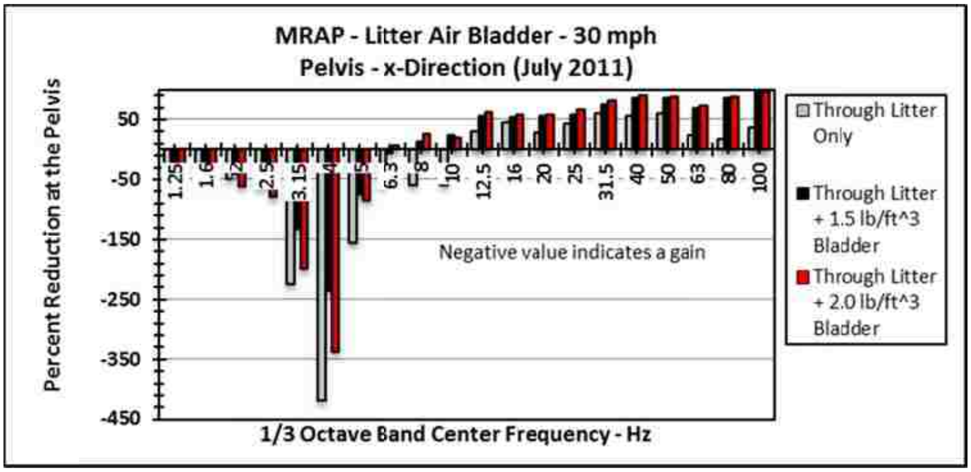


Figure A.52 Percent Vibration Reduction - MRAP litter air bladder test– x-direction

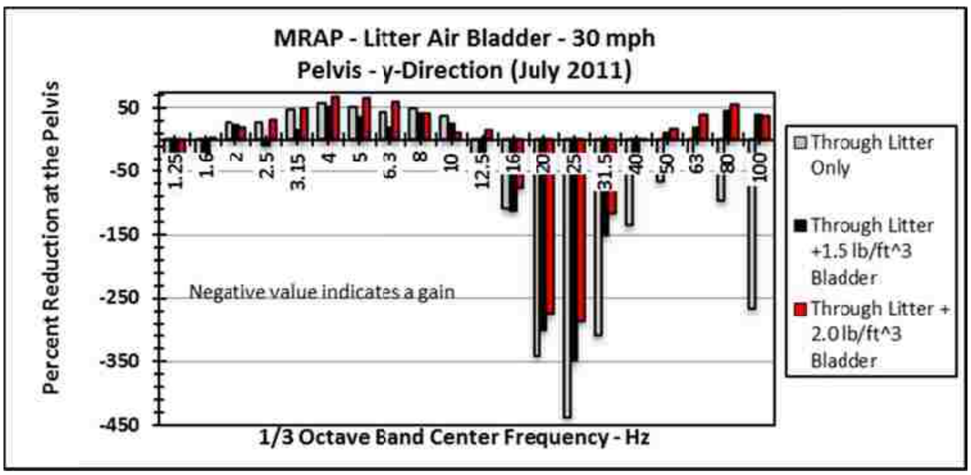


Figure A.53 Percent Vibration Reduction - MRAP litter air bladder test – y-direction

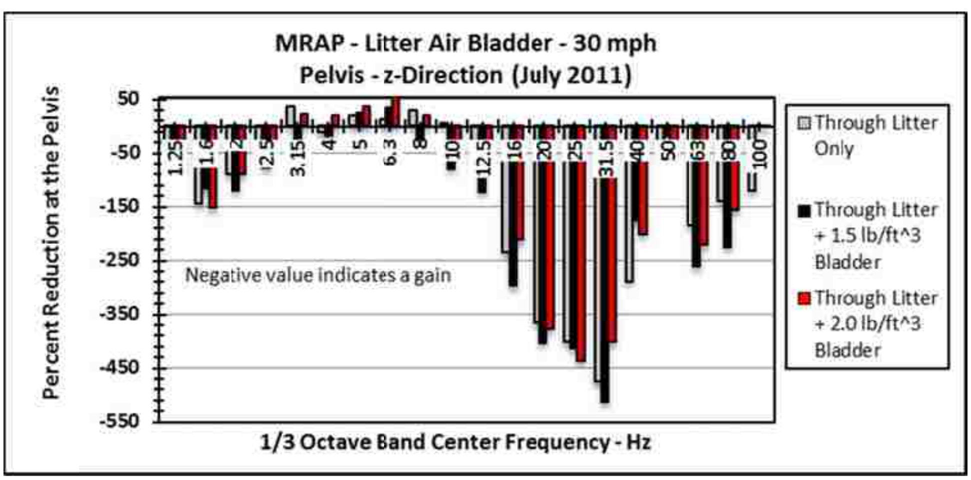


Figure A.54 Percent Vibration Reduction - MRAP litter air bladder test – z-direction

A.5. November MRAP Litter Test - Pelvis

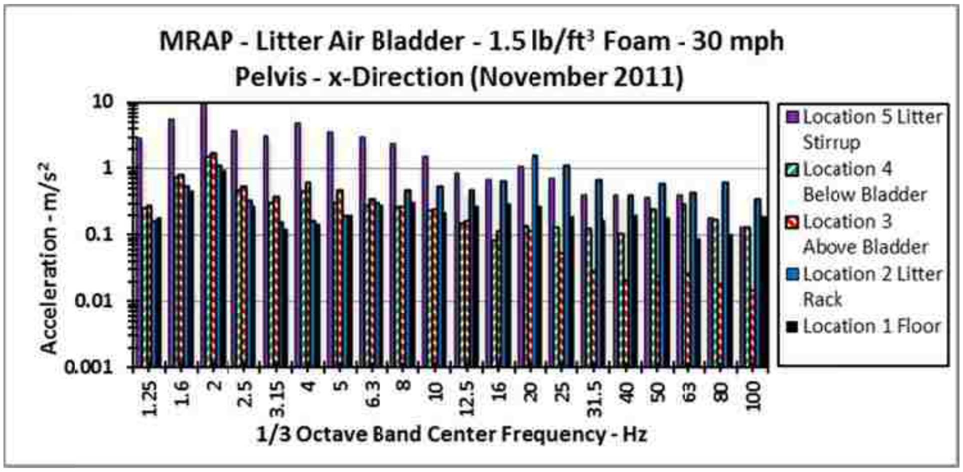


Figure A.55 Acceleration - MRAP litter air bladder test – L1 - x-direction

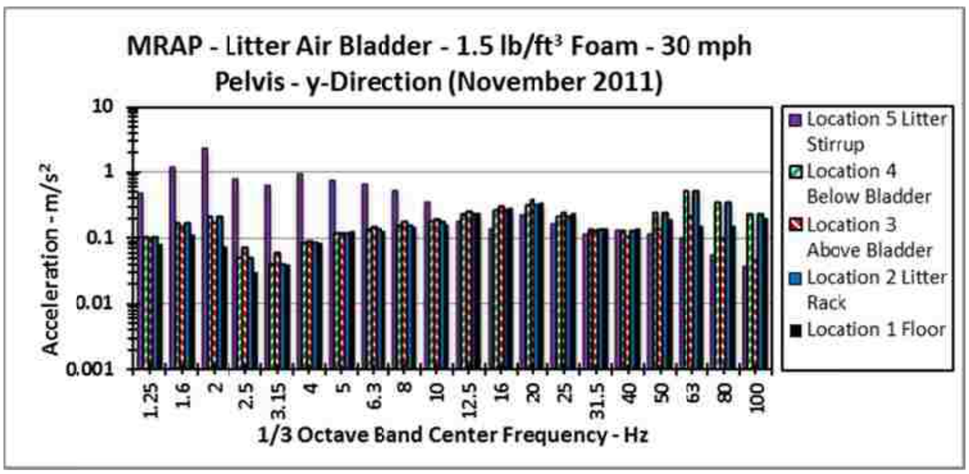


Figure A.56 Acceleration - MRAP litter air bladder test – L1 – y-direction

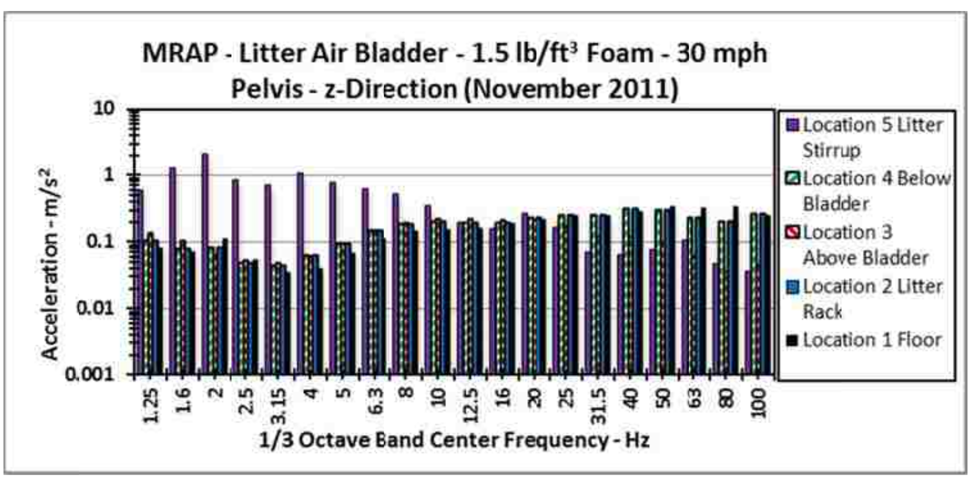


Figure A.57 Acceleration - MRAP litter air bladder test – L1 – z-direction

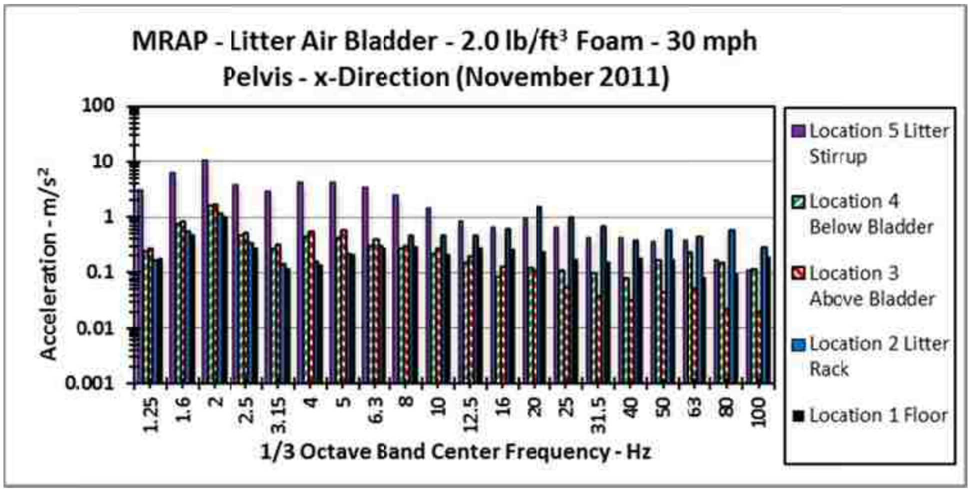


Figure A.58 Acceleration - MRAP litter air bladder test – L2 – x-direction

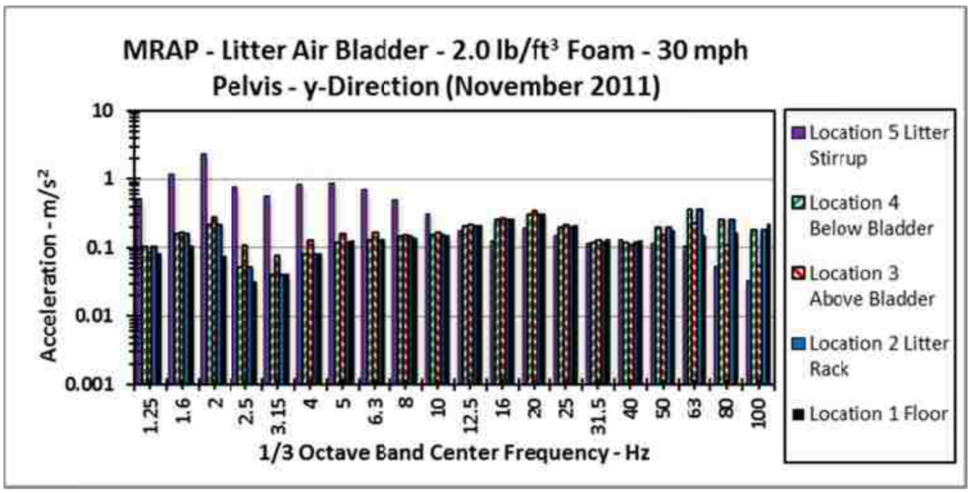


Figure A.59 Acceleration - MRAP litter air bladder test – L2 – y-direction

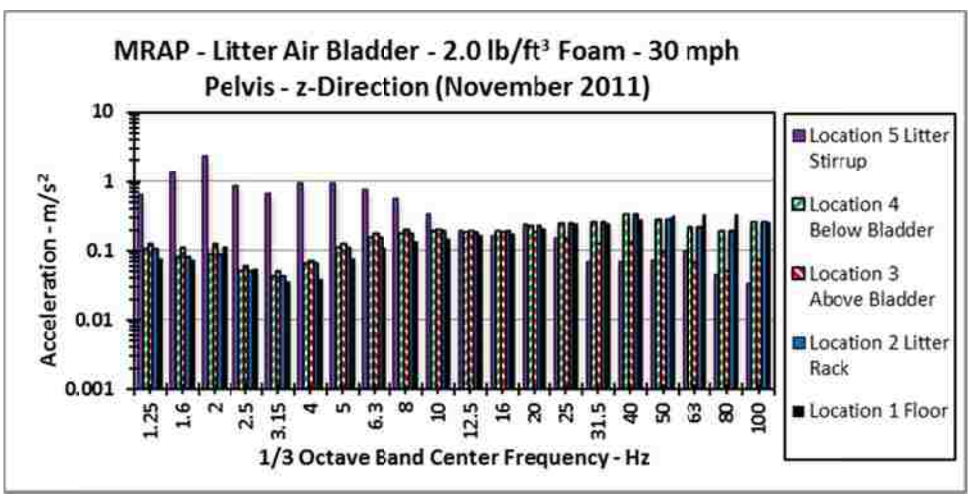


Figure A.60 Acceleration - MRAP litter air bladder test – L2 – z-direction

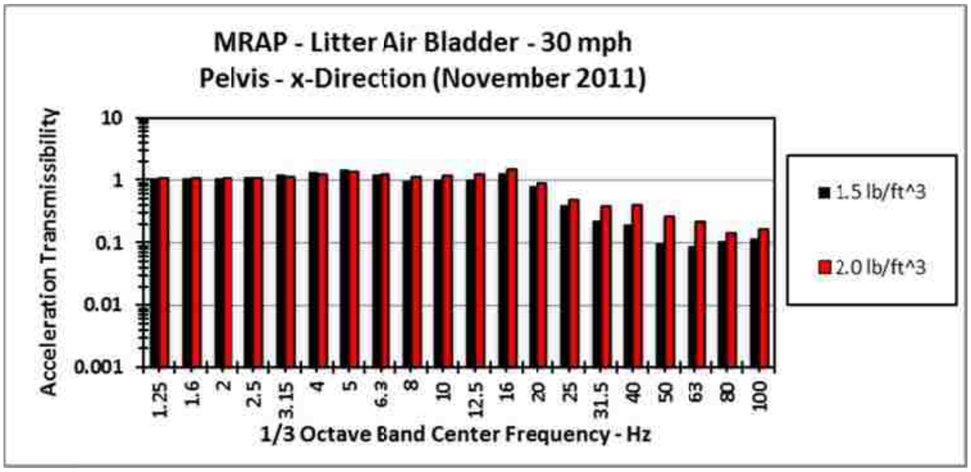


Figure A.61 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter air bladder only

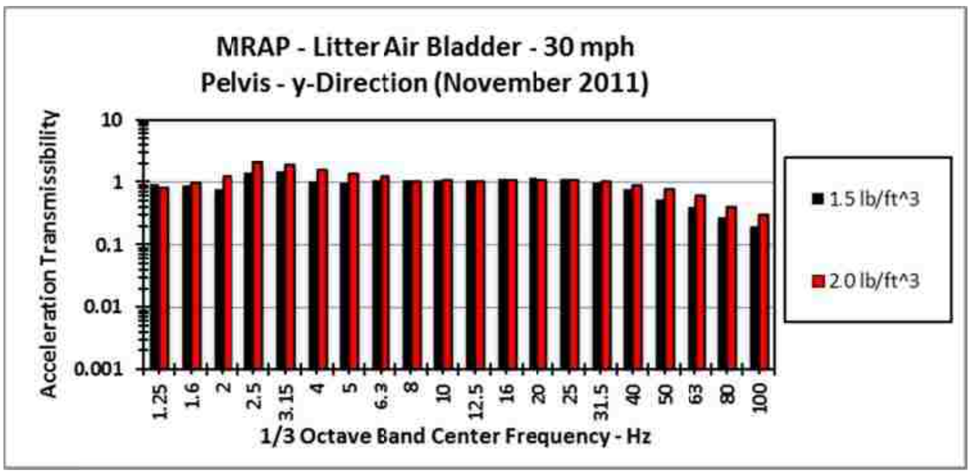


Figure A.62 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter air bladder only

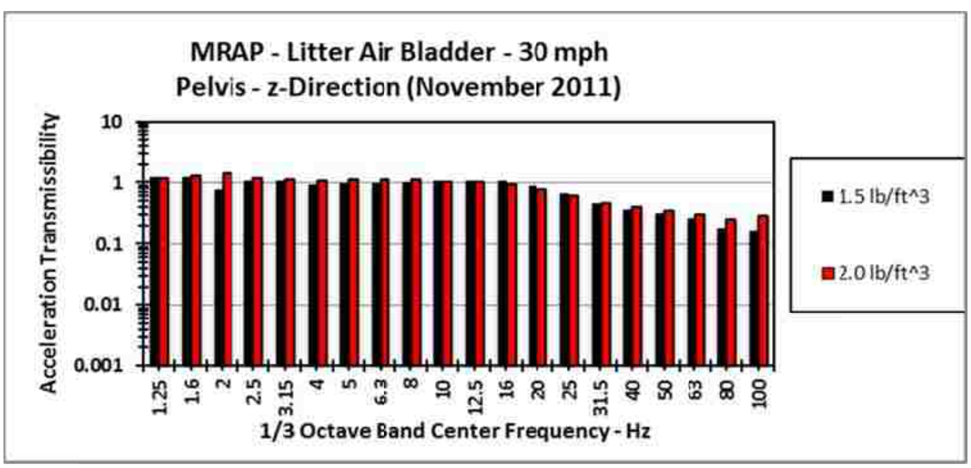


Figure A.63 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter air bladder only

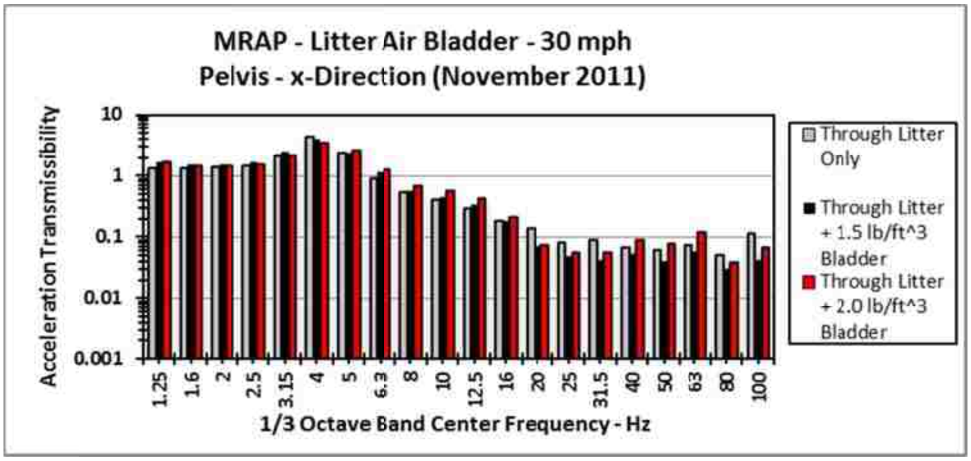

Figure A.64 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter and/or litter air bladder

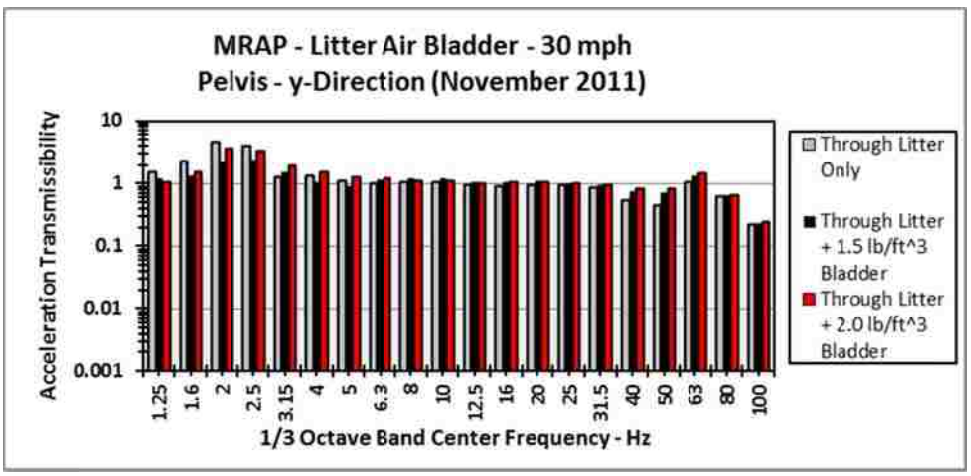

Figure A.65 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter and/or litter air bladder

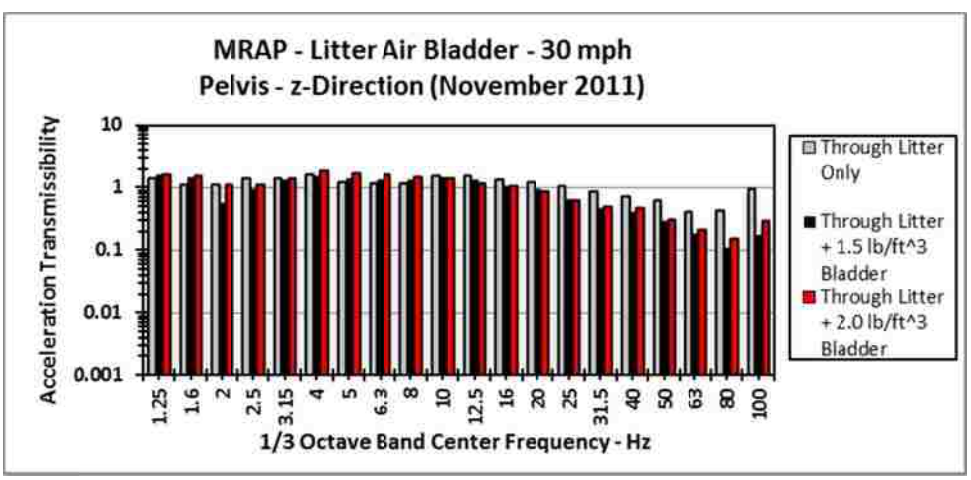

Figure A.66 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter and/or litter air bladder

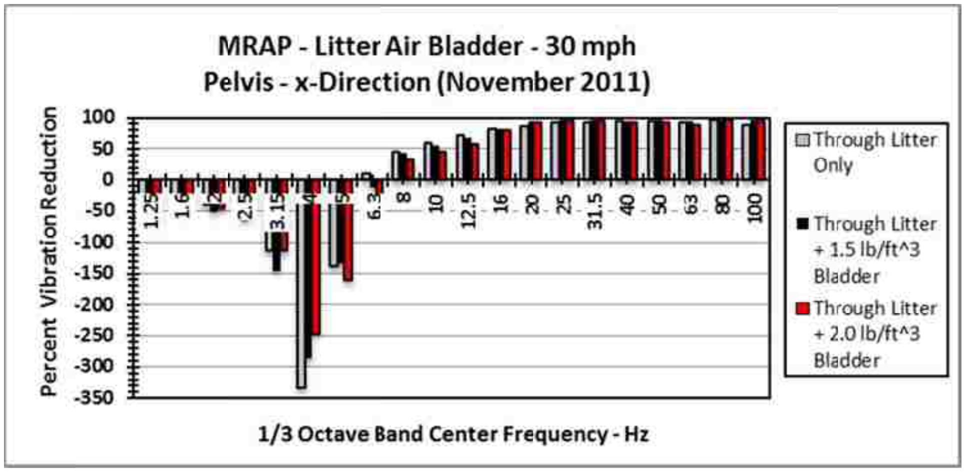


Figure A.67 Percent Vibration Reduction - MRAP litter air bladder test – x-direction

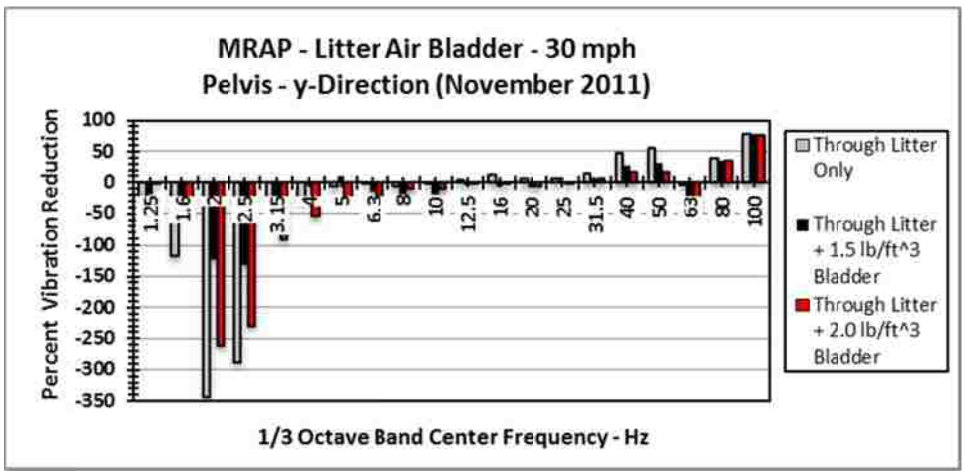


Figure A.68 Percent Vibration Reduction - MRAP litter air bladder test – y-direction

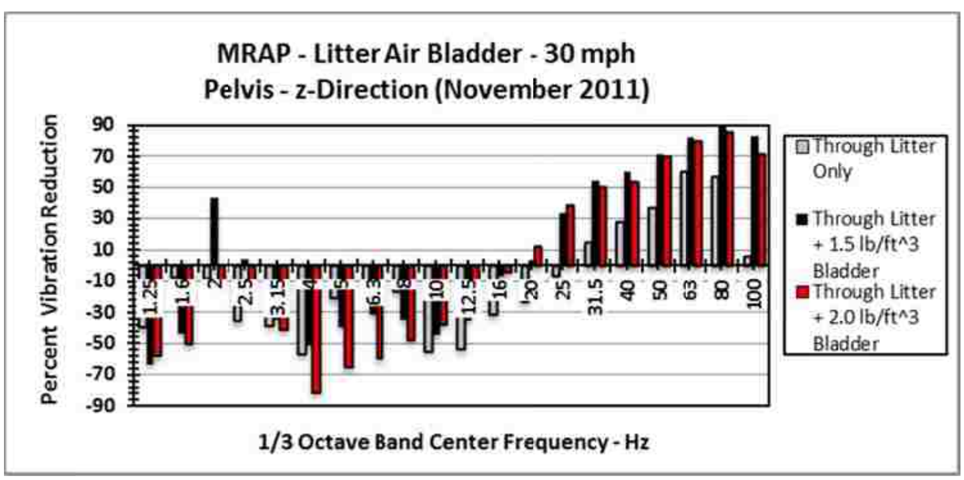


Figure A.69 Percent Vibration Reduction - MRAP litter air bladder test – z-direction

A.6. November MRAP litter test - Shoulder

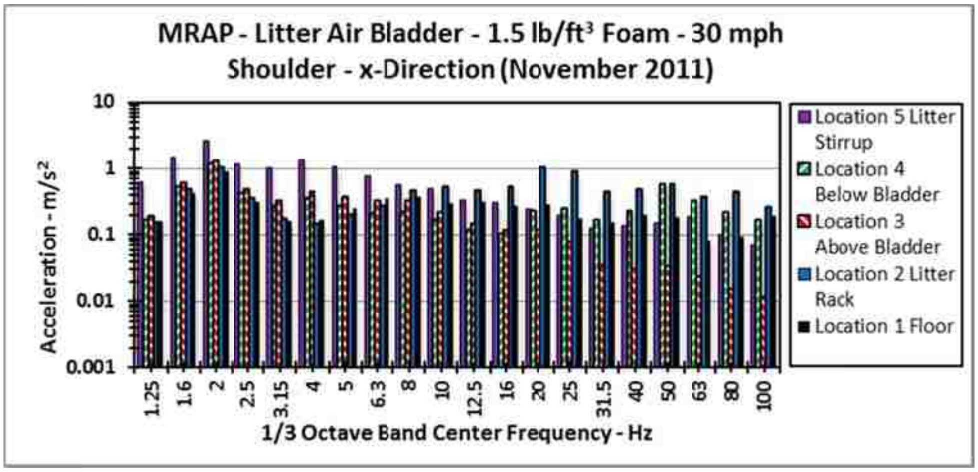


Figure A.70 Acceleration - MRAP litter air bladder test – L1 - x-direction

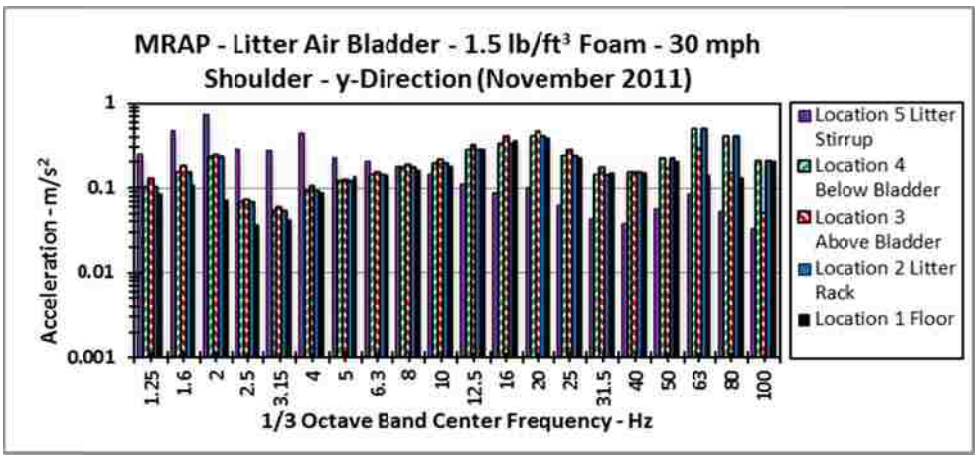


Figure A.71 Acceleration - MRAP litter air bladder test – L1 – y-direction

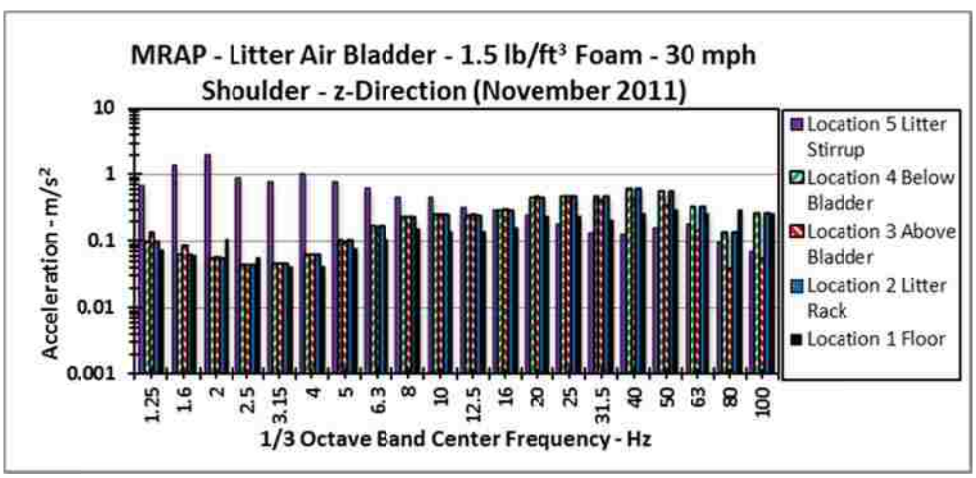


Figure A.72 Acceleration - MRAP litter air bladder test – L1 – z-direction

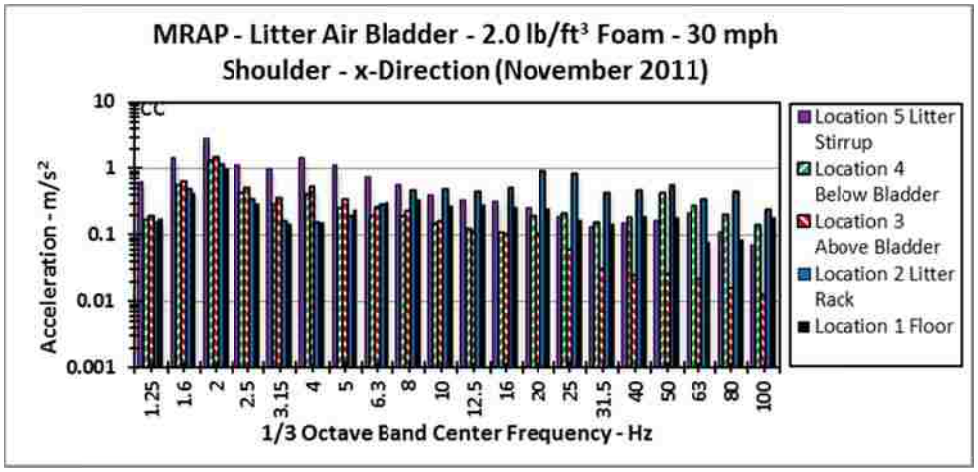

Figure A.73 Acceleration - MRAP litter air bladder test – L2 - x-direction

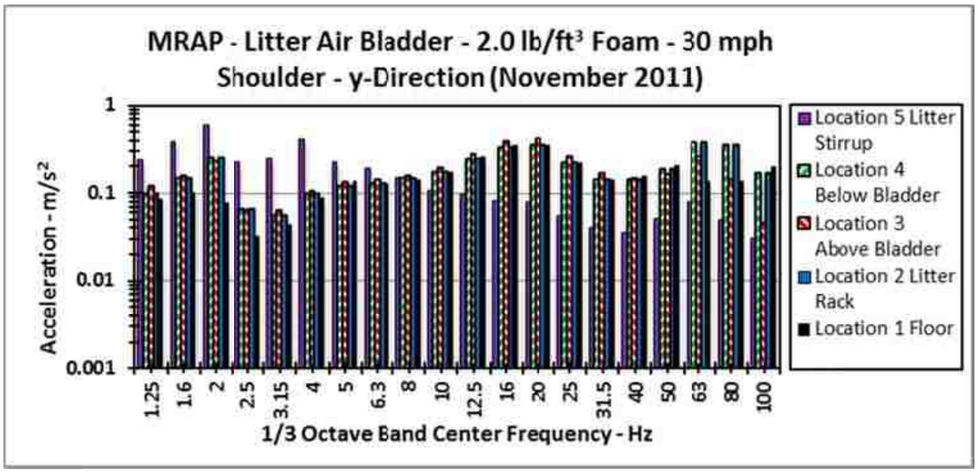

Figure A.74 Acceleration - MRAP litter air bladder test – L2 – y-direction

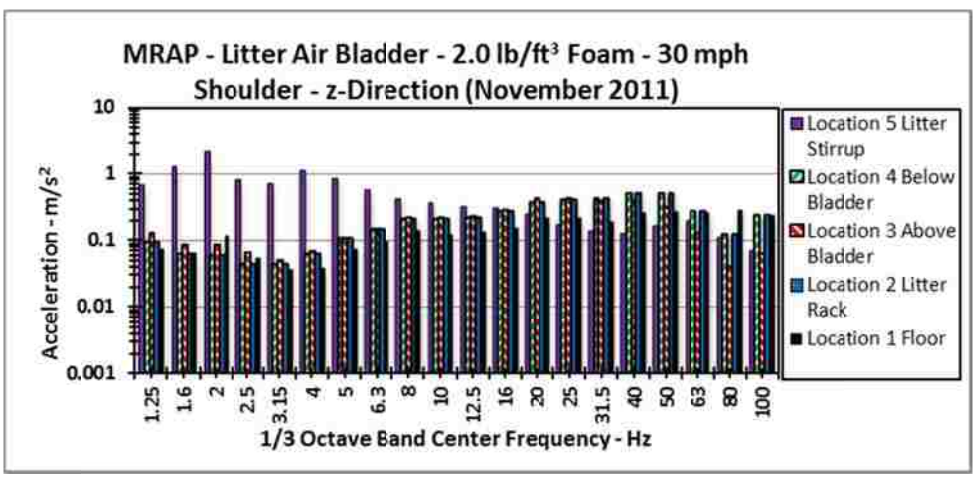

Figure A.75 Acceleration - MRAP litter air bladder test – L2 – z-direction

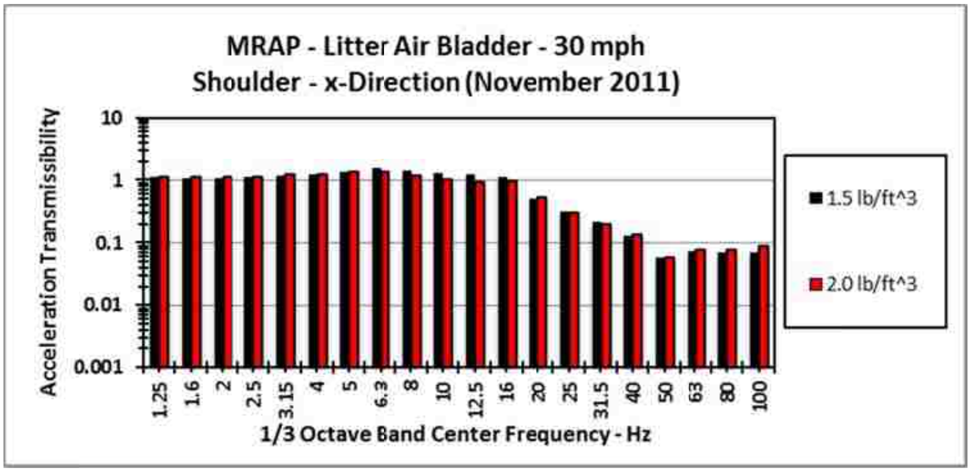


Figure A.76 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter air bladder only

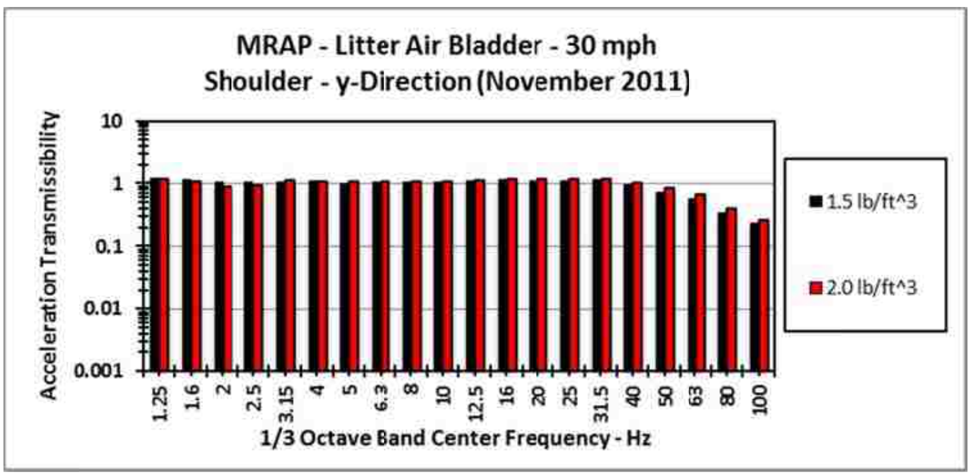


Figure A.77 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter air bladder only

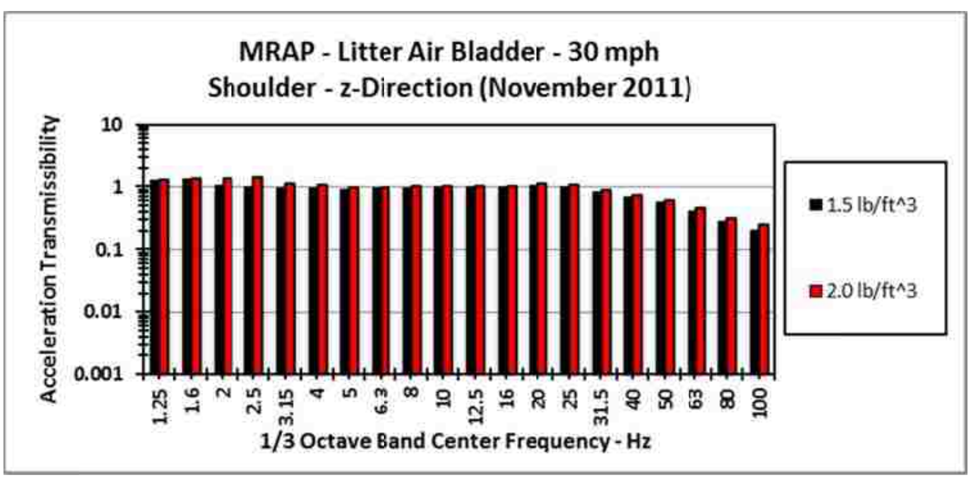


Figure A.78 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter air bladder only

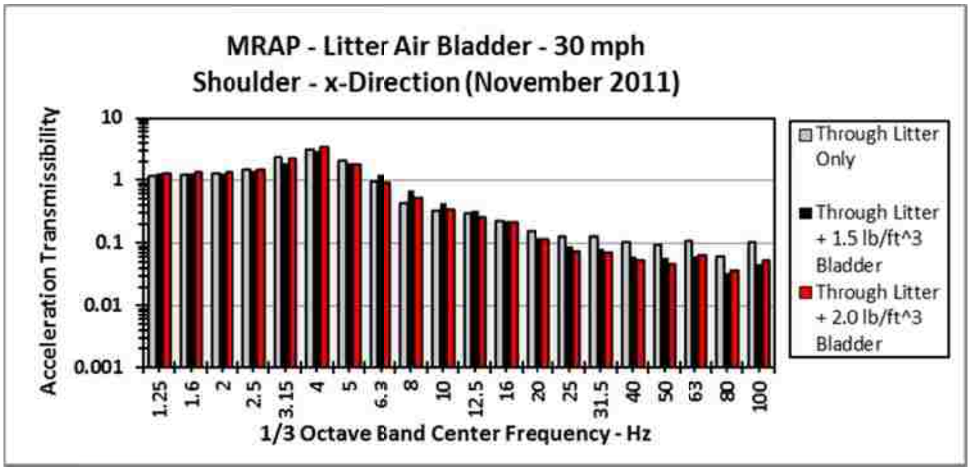


Figure A.79 Acceleration Transmissbility - MRAP litter air bladder test – x-direction– Through litter and/or litter air bladder

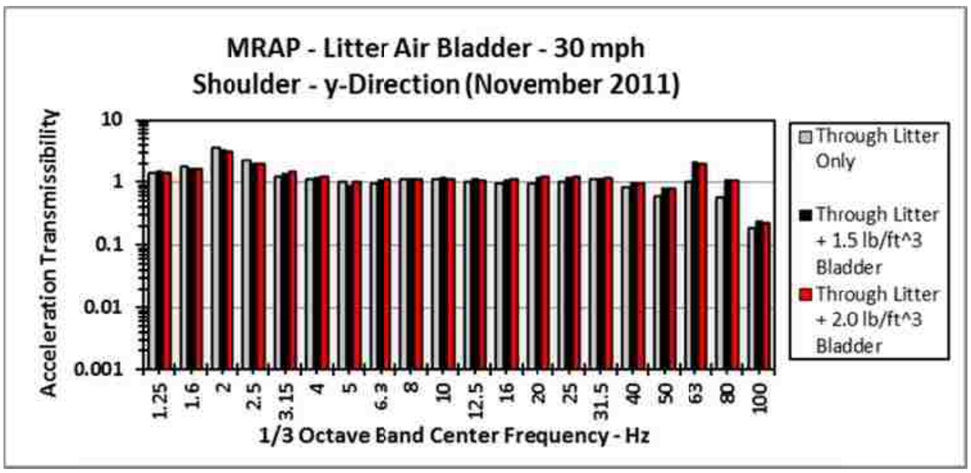


Figure A.80 Acceleration Transmissbility - MRAP litter air bladder test – y-direction– Through litter and/or litter air bladder

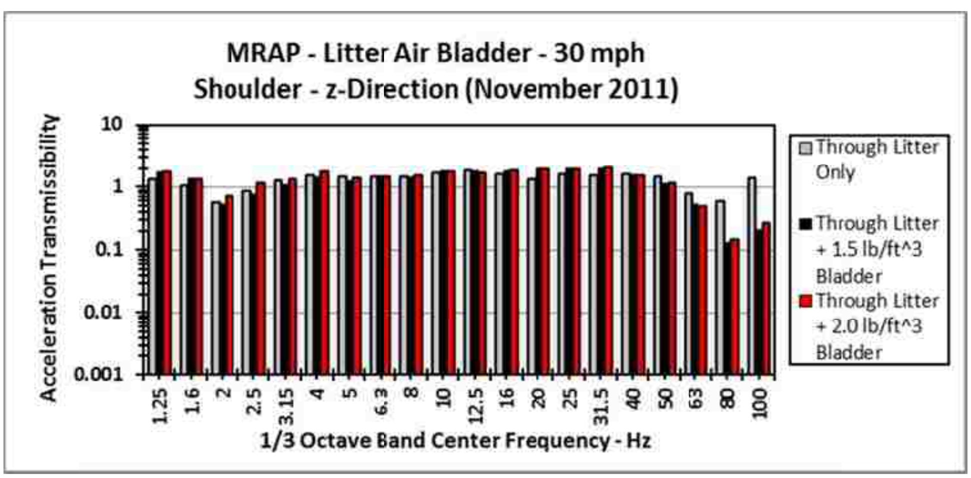


Figure A.81 Acceleration Transmissbility - MRAP litter air bladder test – z-direction– Through litter and/or litter air bladder

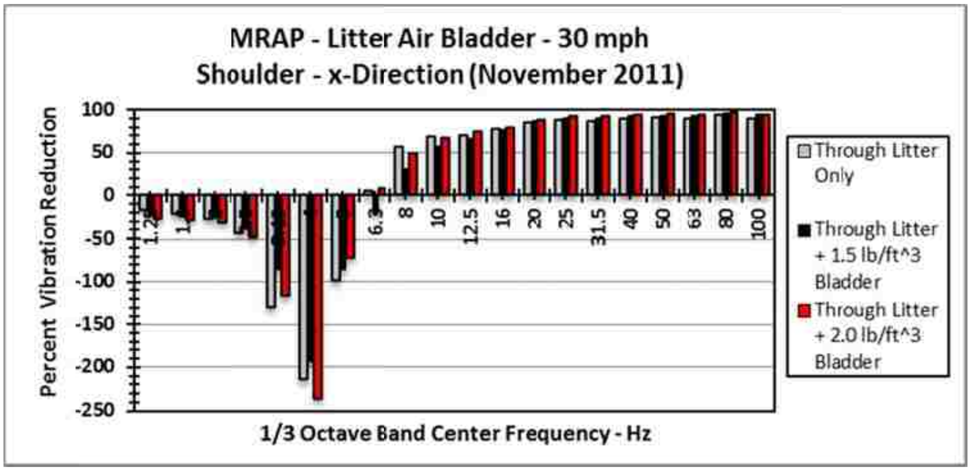


Figure A.82 Percent Vibration Reduction - MRAP litter air bladder test –x-direction

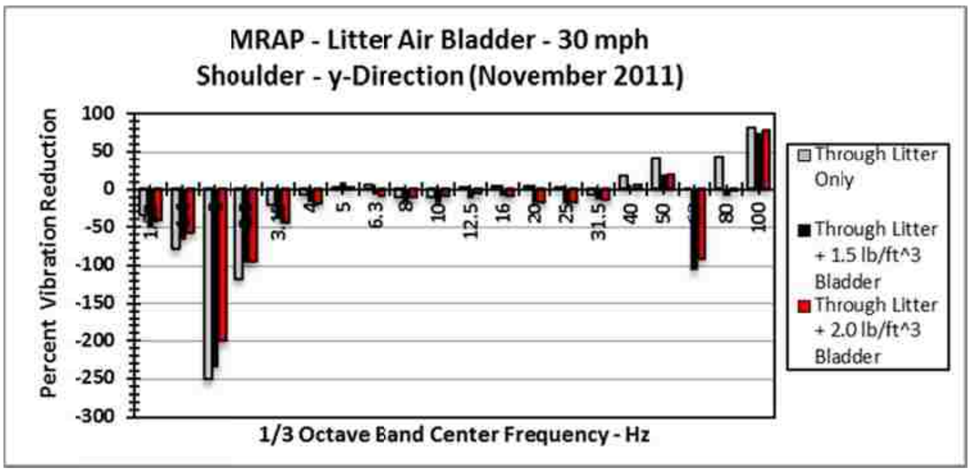


Figure A.83 Percent Vibration Reduction - MRAP litter air bladder test – y-direction

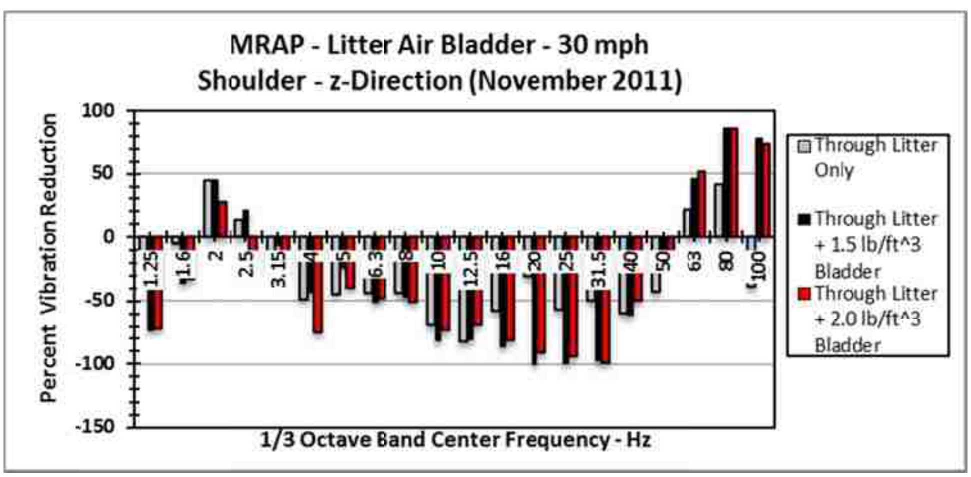


Figure A.84 Percent Vibration Reduction - MRAP litter air bladder test – z-direction

A.7. July Black Hawk litter test

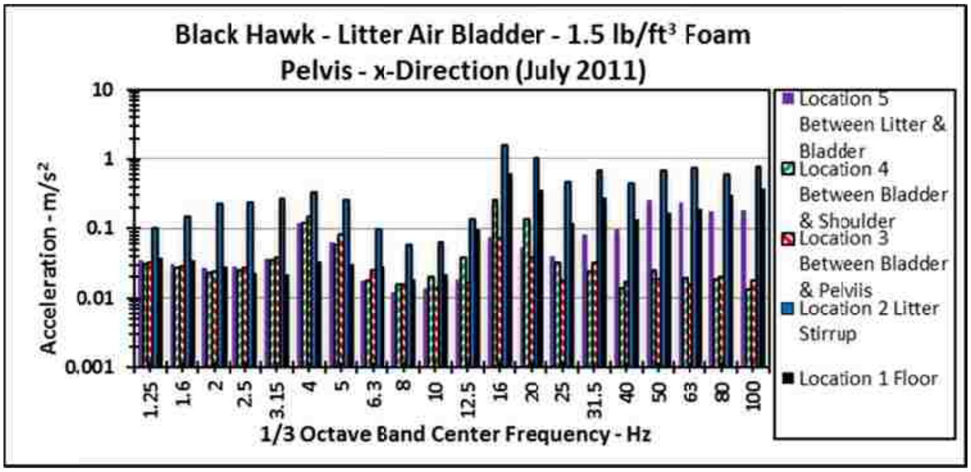


Figure A.85 Acceleration - Black Hawk litter air bladder test – L1 – x-direction

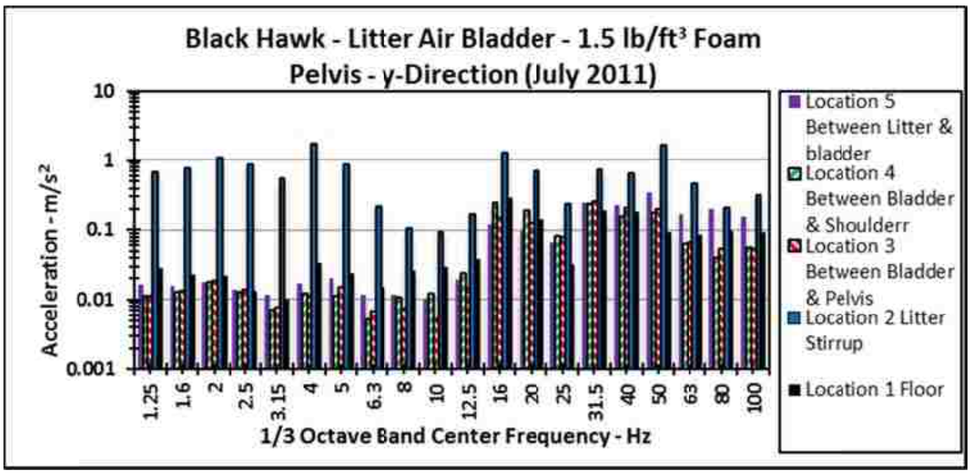


Figure A.86 Acceleration - Black Hawk litter air bladder test – L1 – y-direction

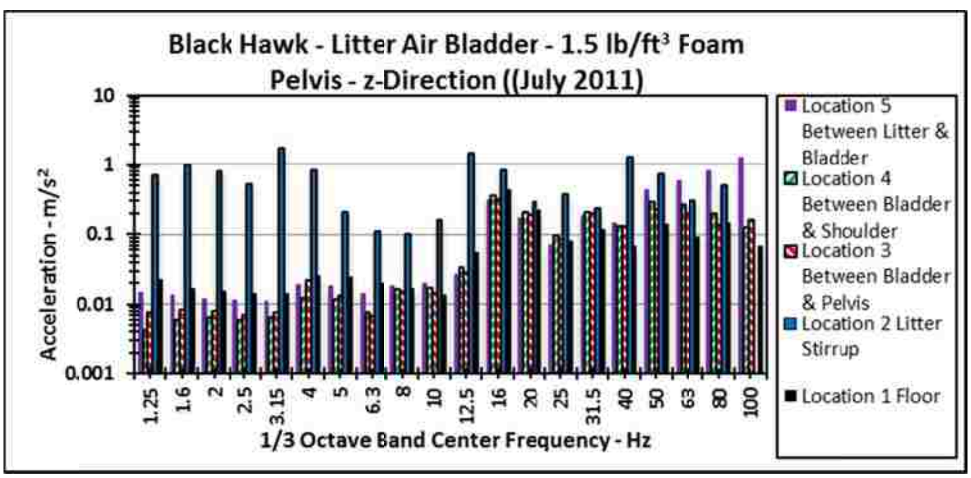


Figure A.87 Acceleration - Black Hawk litter air bladder test – L1 – z-direction

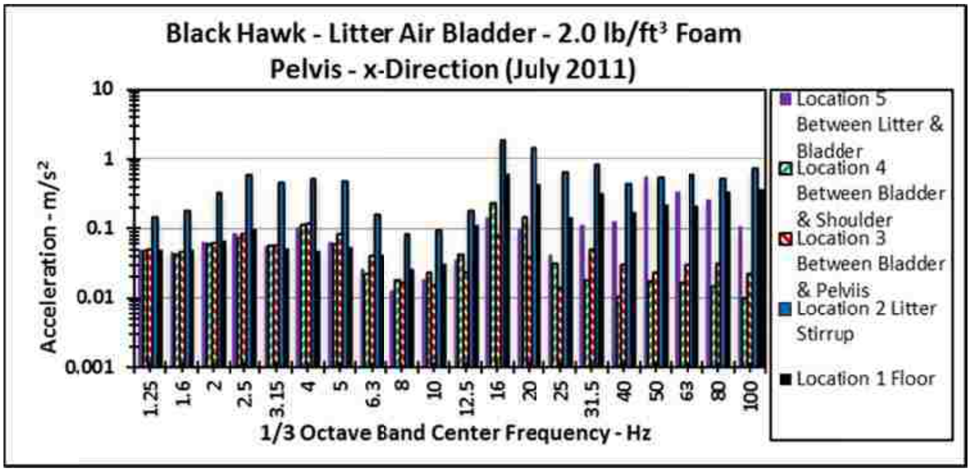


Figure A.88 Acceleration - Black Hawk litter air bladder test – L2 – x-direction

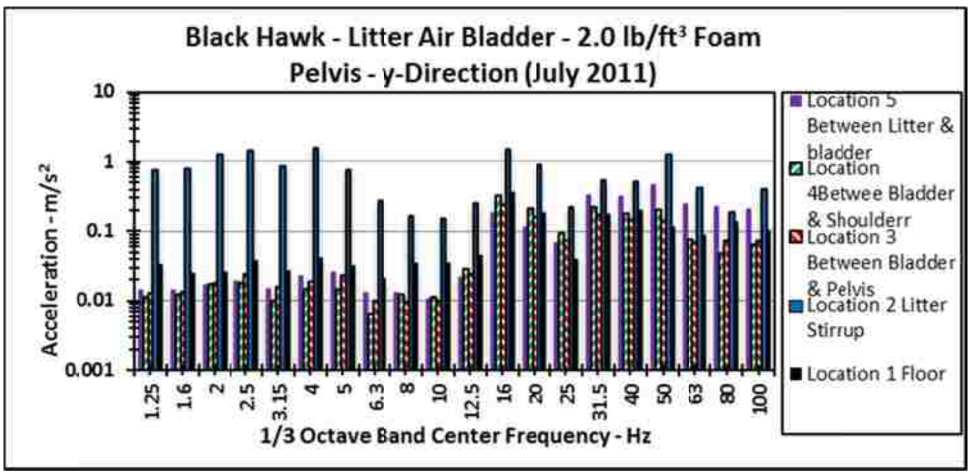


Figure A.89 Acceleration - Black Hawk litter air bladder test – L2 – y-direction

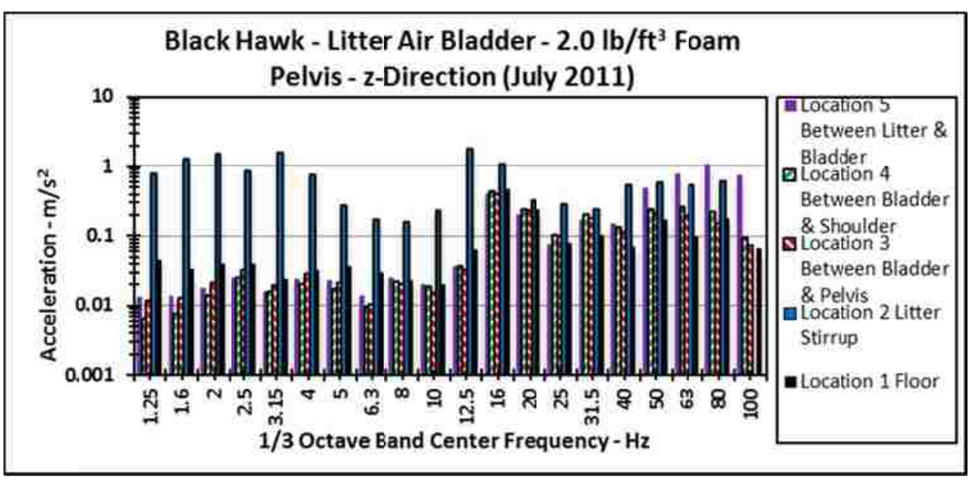


Figure A.90 Acceleration - Black Hawk litter air bladder test – L2 – z-direction

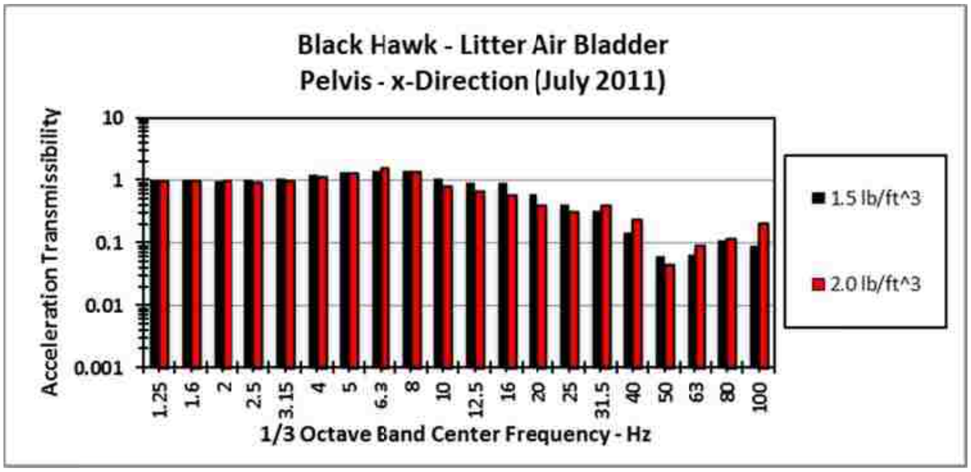


Figure A.91 Acceleration Transmissbility -Black Hawk litter air bladder test – x-direction– Through litter air bladder only

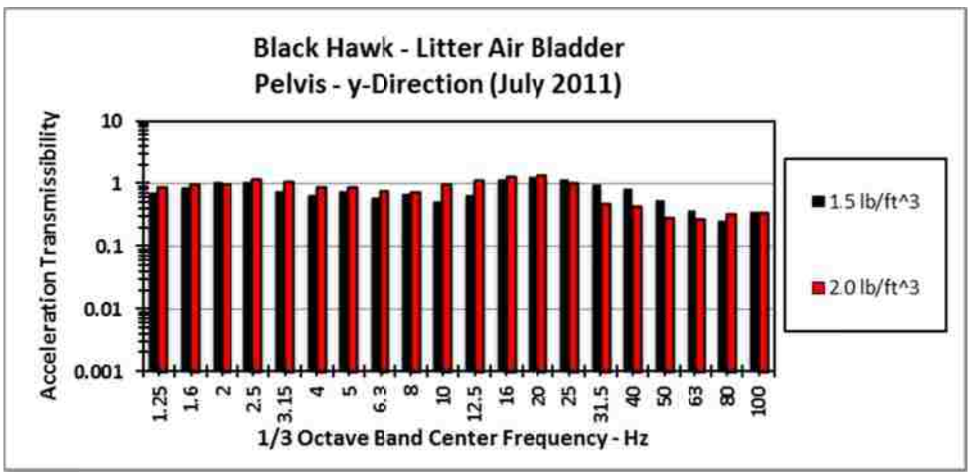


Figure A.92 Acceleration Transmissbility - Black Hawk litter air bladder test – y-direction– Through litter air bladder only

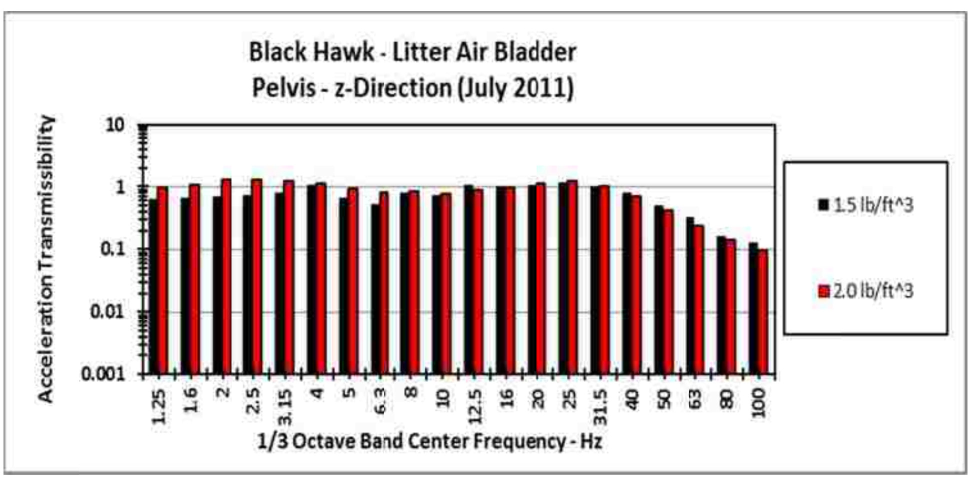


Figure A.93 Acceleration Transmissbility - Black Hawk litter air bladder test – z-direction– Through litter air bladder only

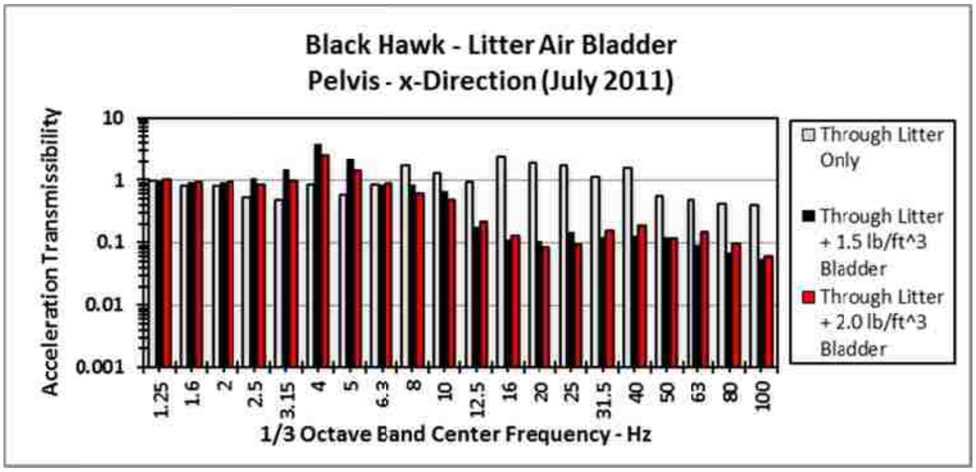


Figure A.94 Acceleration Transmissbility -Black Hawk litter air bladder test – x-direction– Through litter and/or litter air bladder

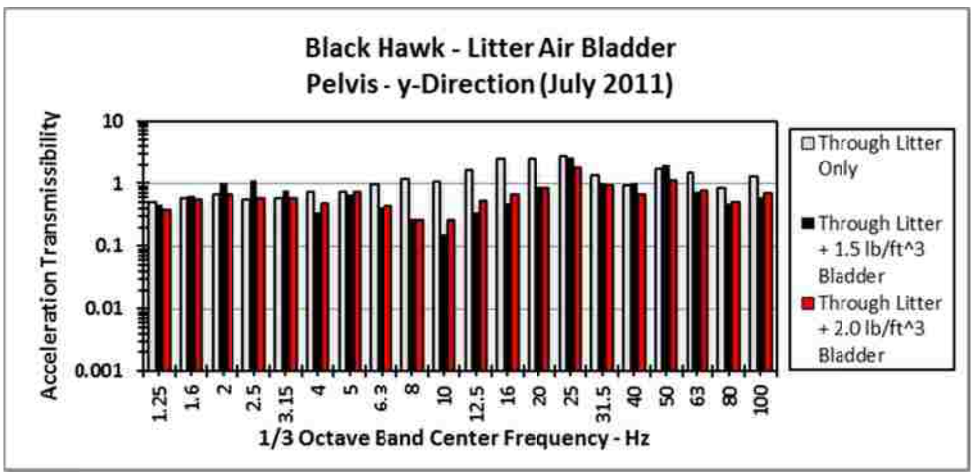


Figure A.95 Acceleration Transmissbility -Black Hawk litter air bladder test – y-direction– Through litter and/or litter air bladder

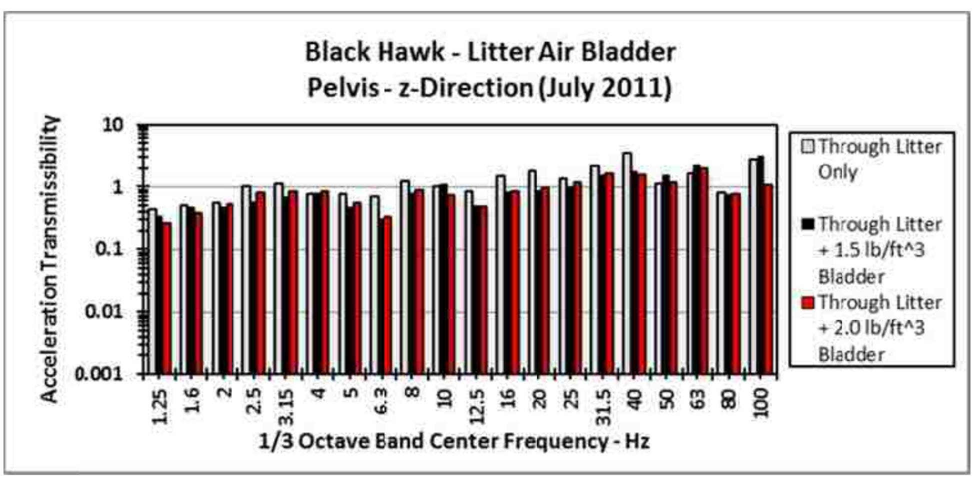


Figure A.96 Acceleration Transmissbility -Black Hawk litter air bladder test – z-direction– Through litter and/or litter air bladder

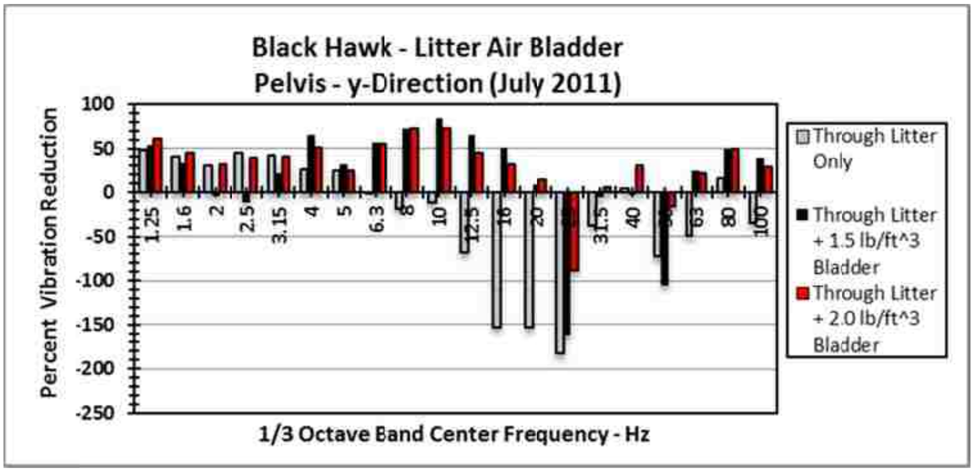


Figure A.97 Percent Vibration Reduction -Black Hawk litter air bladder test – x-direction

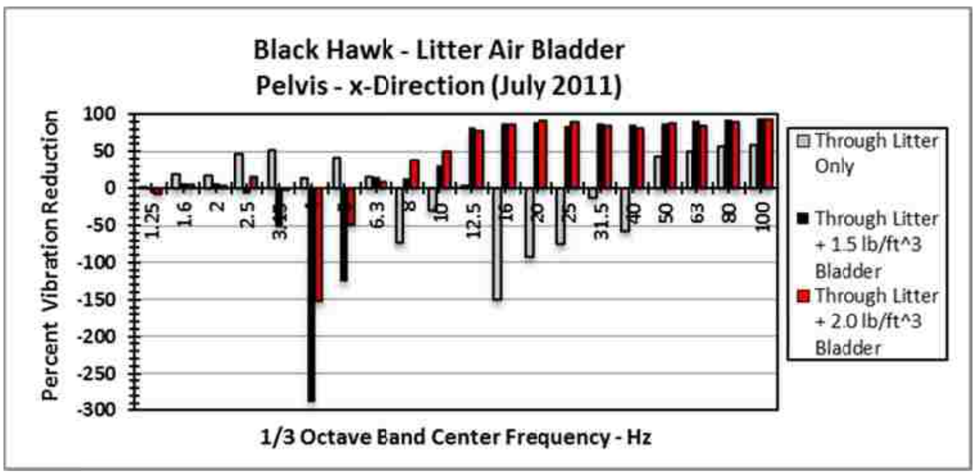


Figure A.98 Percent Vibration Reduction -Black Hawk litter air bladder test – y-direction

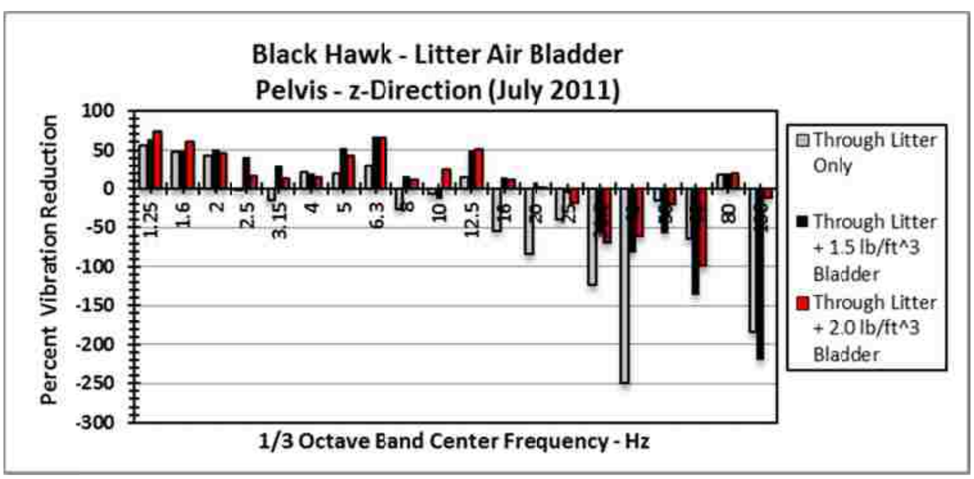


Figure A.99 Percent Vibration Reduction -Black Hawk litter air bladder test – z- direction

A.8. April Black Hawk Litter Test

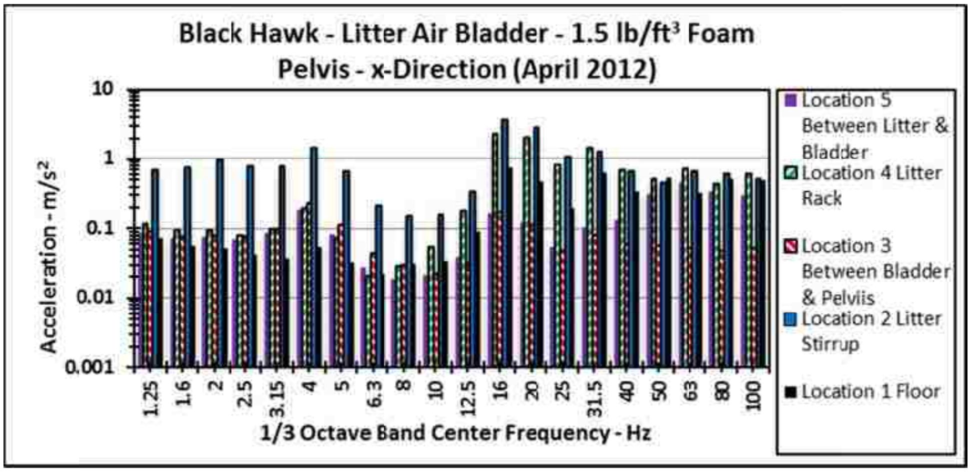


Figure A.100 Acceleration - Black Hawk litter air bladder test – L1 - x-direction

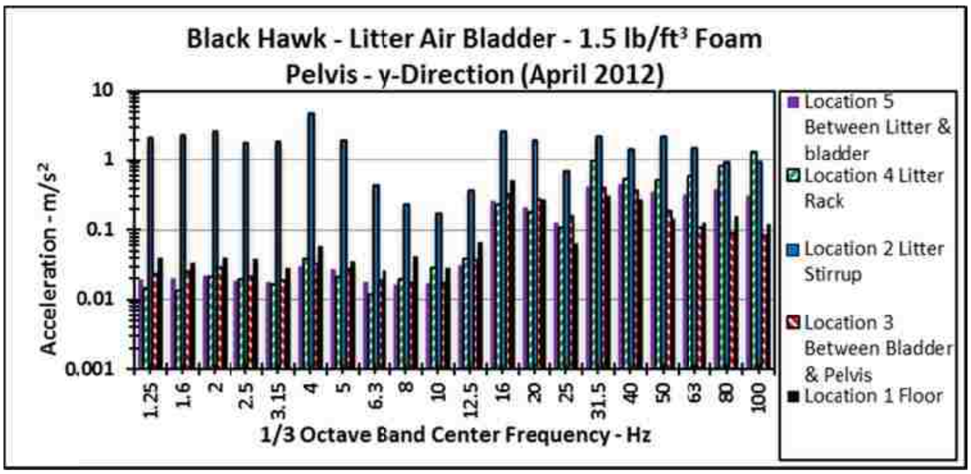


Figure A.101 Acceleration - Black Hawk litter air bladder test – L1 – y-direction

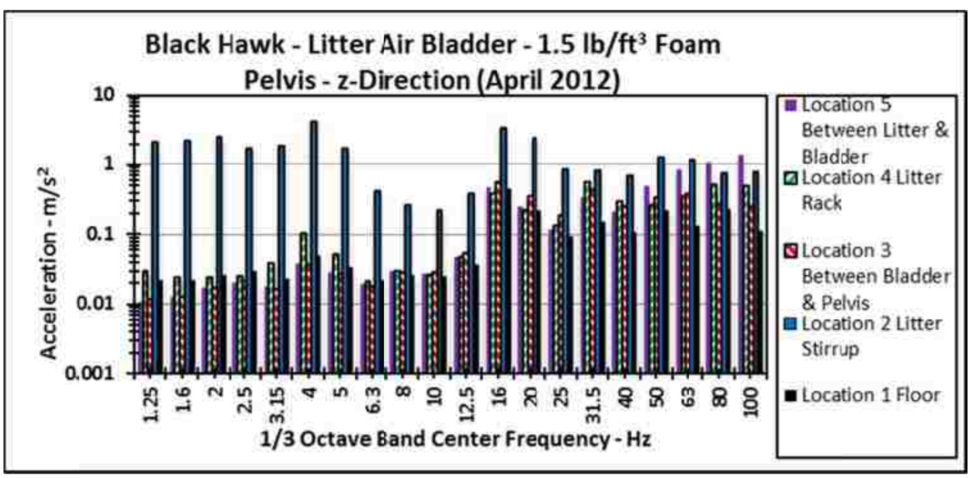


Figure A.102 Acceleration - Black Hawk litter air bladder test – L1 – z-direction

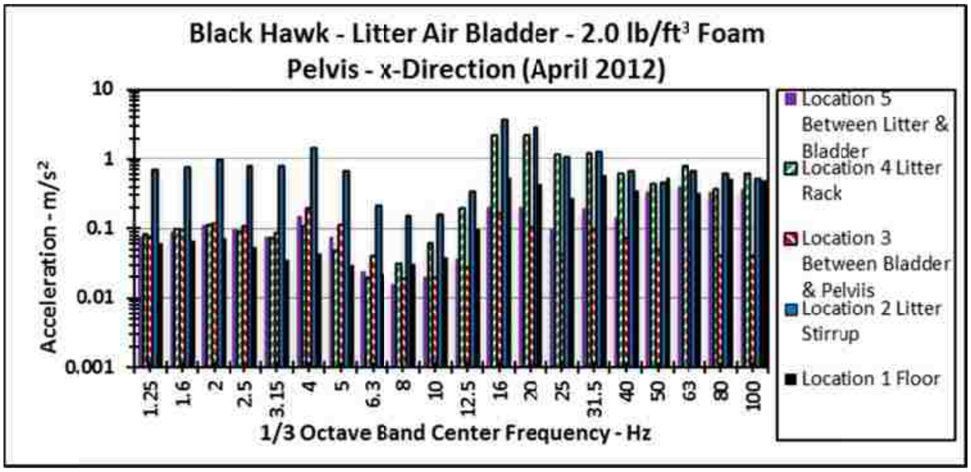


Figure A.103 Acceleration - Black Hawk litter air bladder test – L2 – x-direction

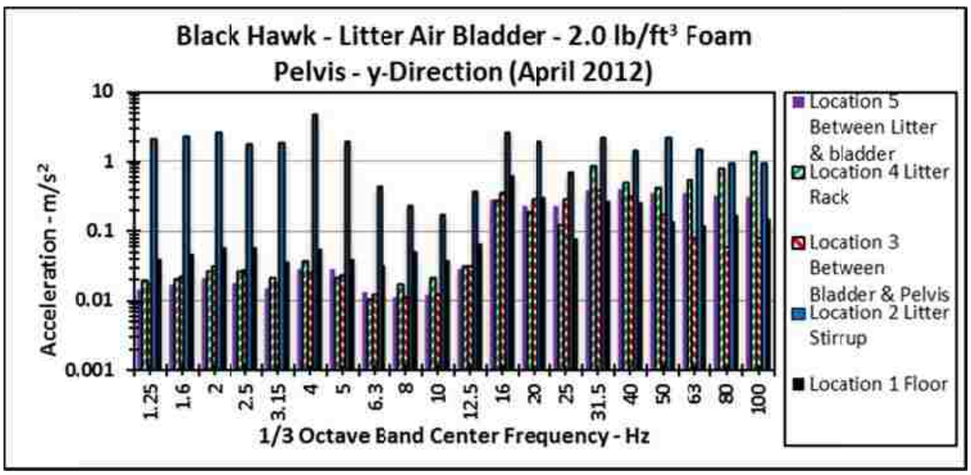


Figure A.104 Acceleration - Black Hawk litter air bladder test – L2 – y-direction

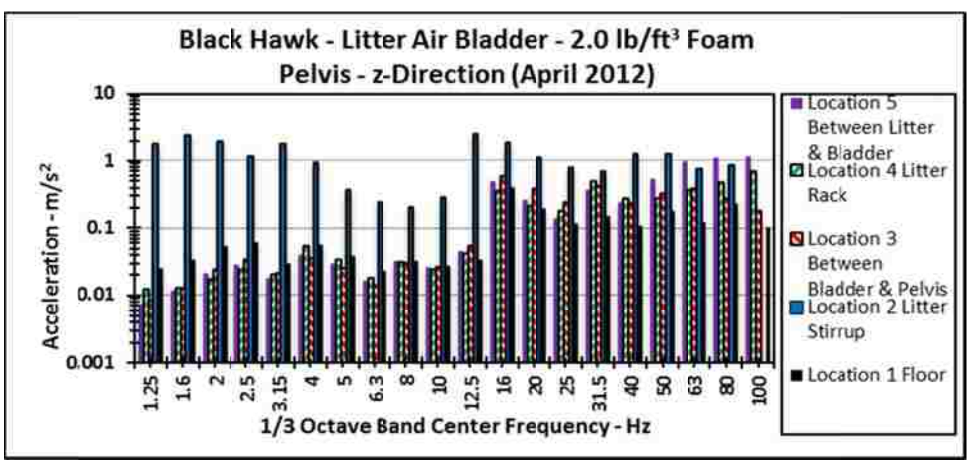


Figure A.105 Acceleration - Black Hawk litter air bladder test – L2 – z-direction

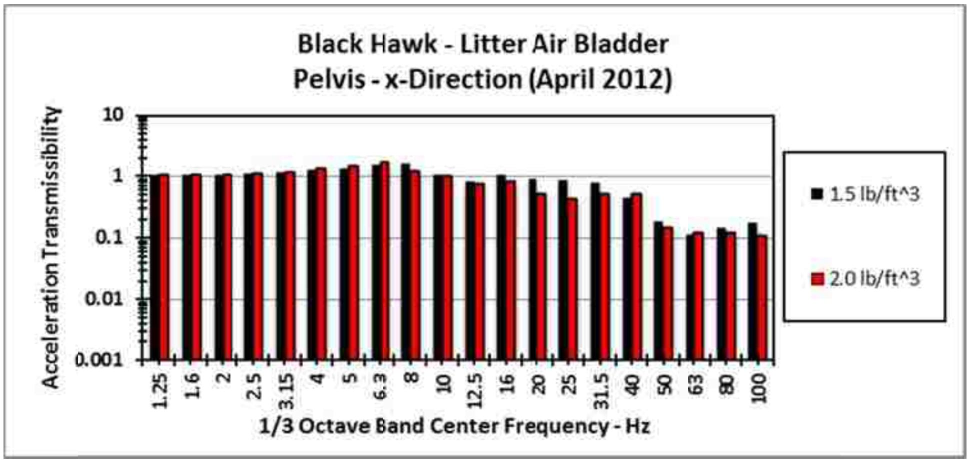


Figure A.106 Acceleration Transmissbility-Black Hawk litter air bladder test– x-direction– Through litter air bladder only

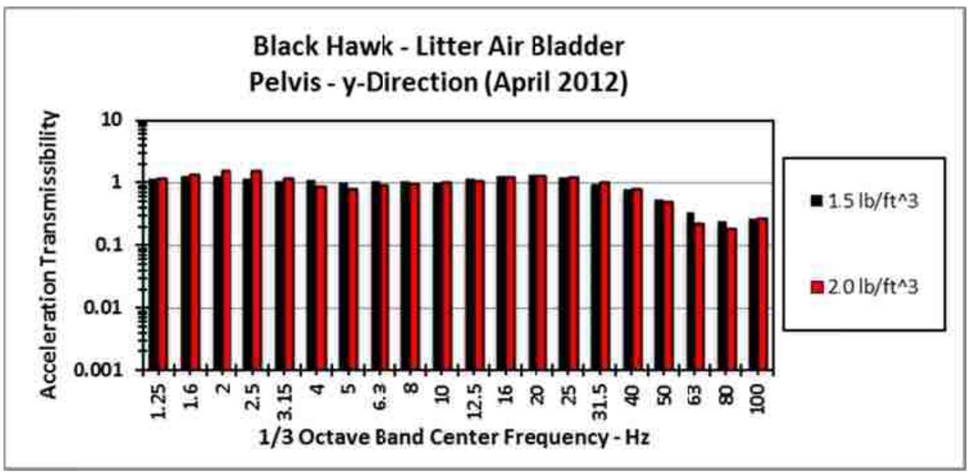


Figure A.107 Acceleration Transmissbility-Black Hawk litter air bladder test– y-direction– Through litter air bladder only

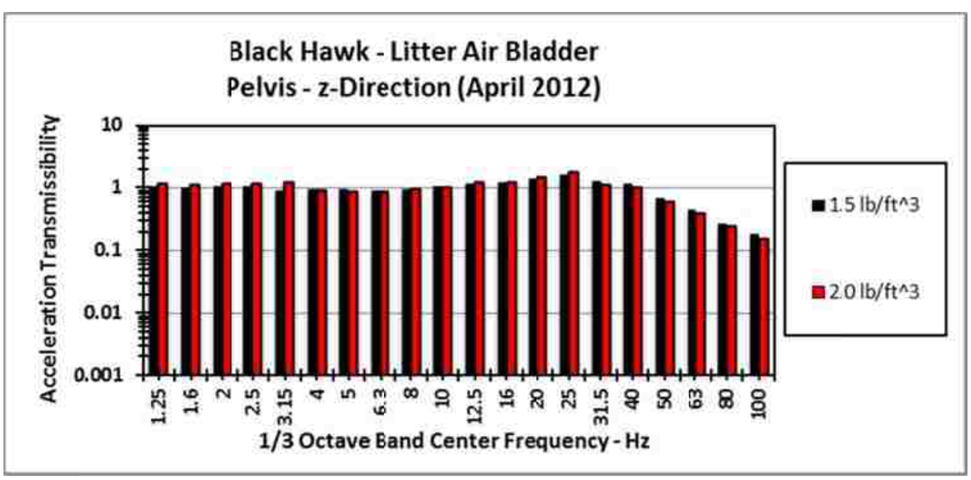


Figure A.108 Acceleration Transmissbility-Black Hawk litter air bladder test– z-direction– Through litter air bladder only

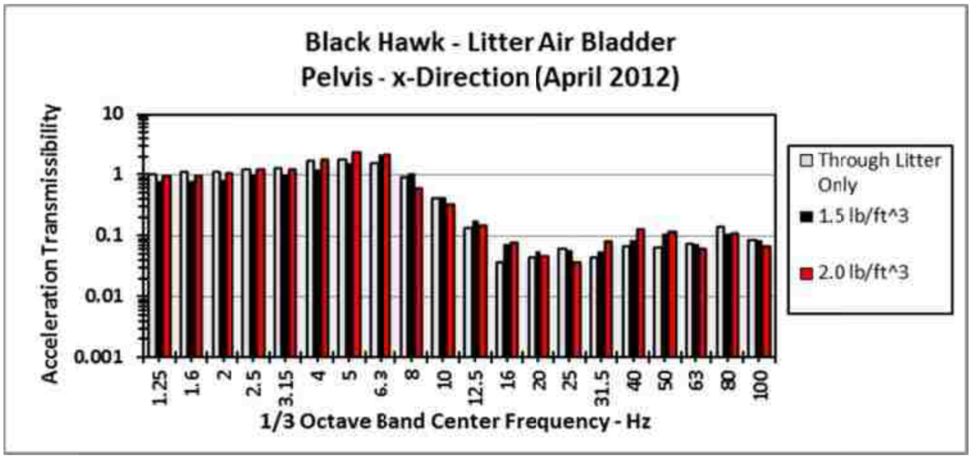


Figure A.109 Acceleration Transmissbility-Black Hawk litter air bladder test– x-direction– Through litter and/or litter air bladder

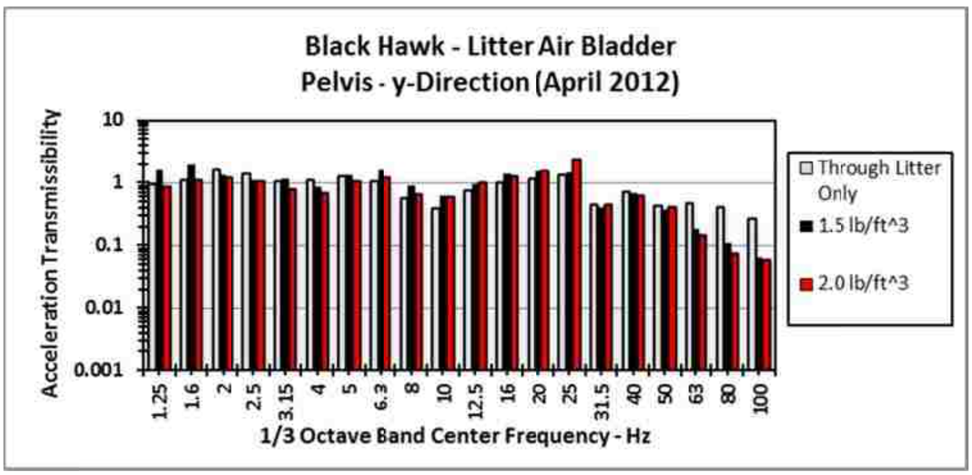


Figure A.110 Acceleration Transmissbility-Black Hawk litter air bladder test– y-direction– Through litter and/or litter air bladder

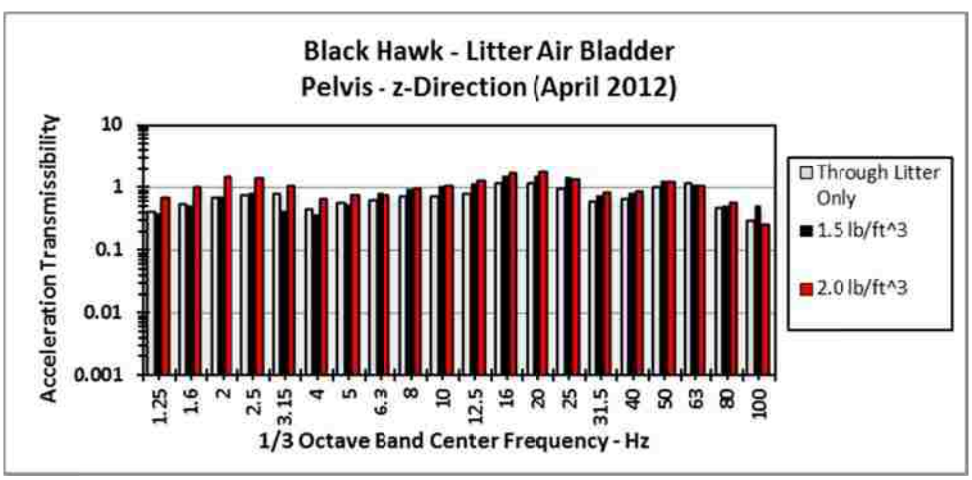


Figure A.111 Acceleration Transmissbility-Black Hawk litter air bladder test– z-direction– Through litter and/or litter air bladder

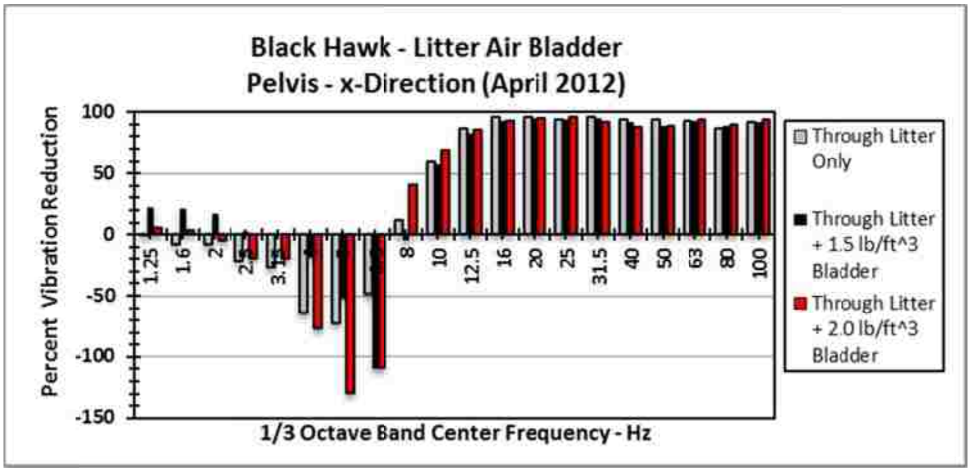


Figure A.112 Percent Vibration Reduction -Black Hawk litter air bladder test – x-direction

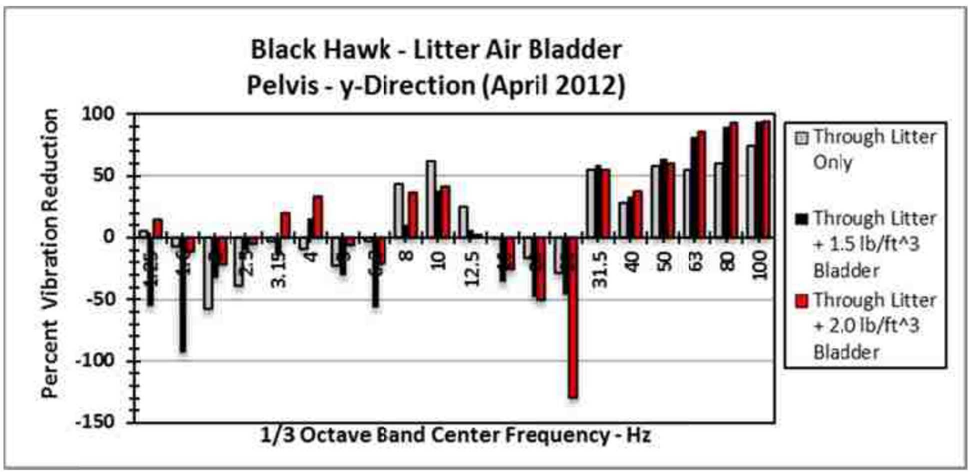


Figure A.113 Percent Vibration Reduction -Black Hawk litter air bladder test – y-direction

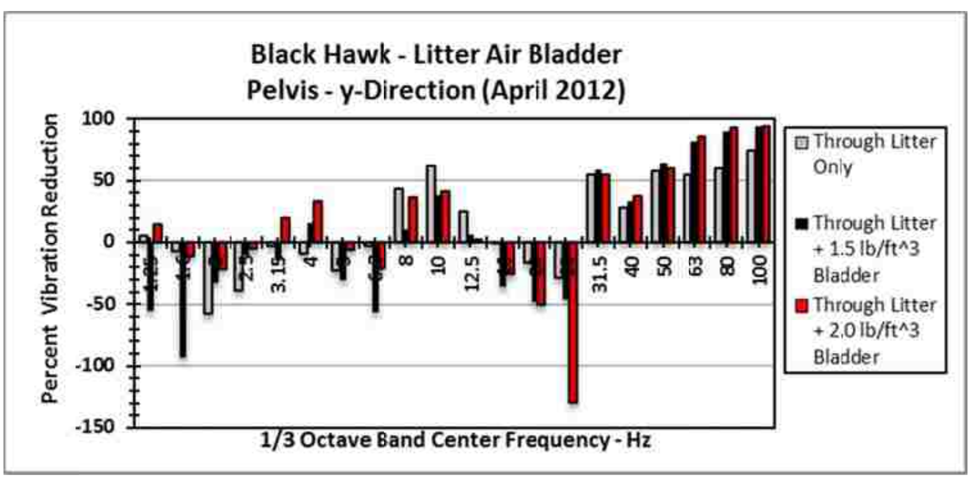


Figure A.114 Percent Vibration Reduction -Black Hawk litter air bladder test – z-direction

# APPENDIX B

## B.1. MRAP seat test

Table B.1 MRAP seat air bladder - overall rms and VDV values – z-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results z-Direction (Vertical) | Frequency Range Hz | Overall rms Value (m/s$^2$) | | | Overall VDV Value (m/s$^{1.75}$) | | |
|---|---|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 1.60 | 2.06 | 1.96 | 7.26 | 9.36 | 8.69 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 1.55 | 1.97 | 1.94 | 7.36 | 9.00 | 8.46 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 1.50 | 1.92 | 1.90 | 6.06 | 7.72 | 8.68 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 1.09 | 1.45 | 1.30 | 6.99 | 7.96 | 7.09 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 1.03 | 1.37 | 0.91 | 6.40 | 7.66 | 4.67 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 0.97 | 1.32 | 0.85 | 5.21 | 7.40 | 4.36 |
| MRAP (Jul 2011) - Seat Cushion | | 1.05 | 1.42 | 1.34 | 5.43 | 6.92 | 6.39 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | ISO Filter | 1.00 | 1.31 | 1.20 | 5.06 | 6.39 | 5.51 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | | 0.98 | 1.27 | 1.17 | 5.21 | 6.44 | 5.71 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 1.60 | 1.94 | 1.97 | 8.25 | 9.54 | 9.83 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 1.47 | 1.88 | 1.96 | 7.94 | 9.56 | 10.67 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 1.50 | 1.88 | 1.91 | 8.19 | 9.52 | 10.14 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 1.06 | 1.22 | 1.15 | 6.87 | 6.84 | 6.41 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 1.00 | 1.32 | 0.94 | 6.69 | 7.72 | 5.02 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 0.97 | 1.24 | 0.92 | 6.73 | 7.69 | 5.31 |
| MRAP (Nov 2011) - Seat Cushion | | 1.11 | 1.25 | 1.31 | 6.61 | 6.36 | 6.61 |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | 1.26 | 1.18 | 1.23 | 6.27 | 6.34 | 6.82 |
| MRAP (Nov 2011) - 3/16-in.Tubes | | 1.02 | 1.17 | 1.20 | 6.51 | 6.29 | 6.65 |

Table B.2 MRAP seat air bladder - overall rms and VDV values – y-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results y-Direction (Side-to-Side) | Frequency Range Hz | Overall rms Value (m/s$^2$) | | | Overall VDV Value (m/s$^{1.75}$) | | |
|---|---|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 0.62 | 0.70 | 0.80 | 3.35 | 3.00 | 3.39 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 0.60 | 0.69 | 0.57 | 3.22 | 2.94 | 2.59 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 0.57 | 0.65 | 0.53 | 3.44 | 2.82 | 2.49 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 0.50 | 0.69 | 0.79 | 2.80 | 2.95 | 3.36 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 0.47 | 0.68 | 0.56 | 2.67 | 2.91 | 2.60 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 0.45 | 0.64 | 0.52 | 2.68 | 2.77 | 2.44 |
| MRAP (Jul 2011) - Seat Cushion | | 0.36 | 0.13 | 0.17 | 1.78 | 0.58 | 0.67 |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | ISO Filter | 0.36 | 0.15 | 0.12 | 1.76 | 0.66 | 0.55 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | | 0.35 | 0.14 | 0.13 | 1.86 | 0.61 | 0.62 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 1.19 | 0.91 | 0.86 | 8.00 | 5.36 | 5.16 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 1.12 | 0.81 | 0.61 | 7.80 | 4.96 | 3.77 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 1.09 | 0.76 | 0.64 | 8.76 | 4.88 | 3.82 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 1.12 | 0.87 | 0.81 | 7.40 | 5.29 | 4.92 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 1.05 | 0.77 | 0.55 | 7.06 | 5.02 | 3.75 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 1.02 | 0.71 | 0.51 | 7.67 | 4.77 | 3.49 |
| MRAP (Nov 2011) - Seat Cushion | | 0.50 | 0.26 | 0.29 | 2.86 | 1.21 | 1.38 |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | 0.47 | 0.26 | 0.27 | 2.80 | 1.25 | 1.29 |
| MRAP (Nov 2011) - 3/16-in.Tubes | | 0.41 | 0.26 | 0.40 | 2.94 | 1.25 | 1.97 |

Table B.3 MRAP seat air bladder - overall rms and VDV values – x-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results x-Direction (Front-to-Back) | Frequency Range Hz | Overall rms Value ($m/s^2$) | | | Overall VDV Value ($m/s^{1.75}$) | | |
|---|---|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock | MRAP Floor | between Bench and Cushion or Bladder Bottom | between Cushion or Bladder Top and Buttock |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 0.92 | 0.93 | 1.04 | 5.86 | 5.73 | 6.17 |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | 1 - 100 | 0.83 | 0.92 | 0.87 | 5.53 | 5.62 | 5.21 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | 1 - 100 | 0.57 | 0.84 | 0.67 | 4.76 | 4.78 | 3.85 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 0.86 | 0.89 | 0.96 | 5.69 | 5.63 | 6.02 |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | 2.5 - 100 | 0.82 | 0.88 | 0.77 | 5.39 | 5.45 | 5.01 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | 2.5 - 100 | 0.71 | 0.79 | 0.61 | 4.39 | 4.68 | 3.68 |
| MRAP (Jul 2011) - Seat Cushion | ISO Filter | 0.35 | 0.31 | 0.42 | 1.69 | 1.51 | 1.91 |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | ISO Filter | 0.32 | 0.28 | 0.39 | 1.52 | 1.36 | 1.75 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | ISO Filter | 0.31 | 0.28 | 0.29 | 1.47 | 1.42 | 1.41 |
| 2.0 $lb/ft^3$ Seat Bottom; 1.5 $lb/ft^3$ Seat Back | | | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 0.94 | 0.91 | 0.86 | 6.11 | 3.76 | 3.79 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 0.88 | 0.81 | 0.61 | 5.94 | 3.41 | 2.48 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 0.89 | 0.76 | 0.64 | 6.12 | 3.40 | 3.01 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 0.83 | 0.87 | 0.81 | 5..45 | 3.60 | 3.67 |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 0.78 | 0.77 | 0.55 | 5.22 | 3.34 | 2.46 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 0.79 | 0.71 | 0.51 | 5.55 | 3.33 | 2.77 |
| MRAP (Nov 2011) - Seat Cushion | ISO Filter | 0.46 | 0.25 | 0.21 | 2.38 | 1.20 | 0.99 |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | 0.42 | 0.18 | 0.13 | 2.35 | 0.87 | 0.63 |
| MRAP (Nov 2011) - 3/16-in.Tubes | ISO Filter | 0.40 | 0.17 | 0.27 | 2.37 | 0.84 | 1.36 |

Table B.4 MRAP seat air bladder - percent reduction in rms and VDV – z-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results z-Direction (Vertical) | Frequency Range Hz | Percent Reduction in rms values | | Percent Reduction in VDV values | |
|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | 4.9 | - | 7.2 | - |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | 1 - 100 | 1.5 | 1.0 | 6.0 | 2.6 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | 1 - 100 | 1.0 | 3.1 | -12.4 | 0.1 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | 10.3 | - | 10.9 | - |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | 2.5 - 100 | 33.6 | 30.0 | 39.0 | 34.1 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | 2.5 - 100 | 35.6 | 34.6 | 41.1 | 38.5 |
| MRAP (Jul 2011) - Seat Cushion | ISO Filter | 5.6 | - | 7.7 | - |
| MRAP (Jul 2011) - 1.5 $lb/ft^3$ | ISO Filter | 8.4 | 10.4 | 13.9 | 13.9 |
| MRAP (Jul 2011) - 2.0 $lb/ft^3$ | ISO Filter | 7.9 | 12.7 | 11.5 | 10.8 |
| 2.0 $lb/ft^3$ Seat Bottom; 1.5 $lb/ft^3$ Seat Back | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | -1.5 | - | -3.0 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | -4.3 | 0.5 | -11.6 | -8.5 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | -1.6 | 3.0 | -6.5 | -3.2 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 5.7 | - | 6.3 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 28.8 | 18.3 | 35.0 | 21.7 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 25.8 | 20.0 | 30.9 | 17.2 |
| MRAP (Nov 2011) - Seat Cushion | ISO Filter | -4.8 | - | -3.9 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | ISO Filter | -4.2 | 6.1 | -7.6 | -3.2 |
| MRAP (Nov 2011) - 3/16-in.Tubes | ISO Filter | -2.6 | 8.4 | -5.7 | -0.6 |

Table B.5 MRAP seat air bladder - percent reduction in rms and VDV – y-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results y-Direction (Side-to-Side) | Frequency Range Hz | Percent Reduction in rms values | | Percent Reduction in VDV values | |
|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | -14.3 | - | -13.0 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 17.4 | 28.8 | 11.9 | 23.6 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 18.5 | 33.8 | 11.7 | 26.5 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | -14.5 | - | -13.9 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 17.6 | 29.1 | 10.7 | 22.6 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 18.8 | 34.2 | 11.9 | 27.4 |
| MRAP (Jul 2011) - Seat Cushion | ISO Filter | -30.8 | - | -15.5 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | | 20.0 | 29.4 | 16.7 | 17.9 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | | 7.1 | 23.5 | -1.6 | 7.5 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 5.5 | - | 3.7 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 24.7 | 29.1 | 24.0 | 26.9 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 15.8 | 25.6 | 21.7 | 26.0 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | 6.9 | - | 7.0 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 28.6 | 32.1 | 25.3 | 23.8 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 28.2 | 37.0 | 26.8 | 29.1 |
| MRAP (Nov 2011) - Seat Cushion | ISO Filter | -11.5 | - | -14.0 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | | -3.8 | 6.9 | -3.2 | 6.5 |
| MRAP (Nov 2011) - 3/16-in.Tubes | | -53.8 | -37.9 | -57.6 | -42.8 |

Table B.6 MRAP seat air bladder - percent reduction in rms and VDV – x-direction

| MRAP Ambulance Summary of Seat Air Bladder Test Results x-Direction (Front-to-Back) | Frequency Range Hz | Percent Reduction in rms values | | Percent Reduction in VDV values | |
|---|---|---|---|---|---|
| 3/8-in. Tubes Between Seat Bottom and Seat Back | | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion | Through Seat Cushion or Seat Bladder | Relative to Seat Cushion |
| MRAP (Jul 2011) - Seat Cushion | 1 - 100 | -11.8 | - | -7.7 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | 5.4 | 16.3 | 7.3 | 15.6 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | 20.2 | 35.6 | 19.5 | 37.6 |
| MRAP (Jul 2011) - Seat Cushion | 2.5 - 100 | -7.9 | - | -6.9 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 12.5 | 19.8 | 8.1 | 16.8 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 22.8 | 36.5 | 21.0 | 38.9 |
| MRAP (Jul 2011) - Seat Cushion | ISO Filter | -35.5 | - | -26.5 | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | | -39.3 | 7.1 | -28.7 | 8.4 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | | -3.6 | 31.0 | 0.7 | 26.2 |
| 2.0 lb/ft$^3$ Seat Bottom; 1.5 lb/ft$^3$ Seat Back | | | | | |
| MRAP (Nov 2011) - Seat Cushion | 1 - 100 | 0.0 | - | -0.8 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 1 - 100 | 34.2 | 39.2 | 27.3 | 34.6 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 1 - 100 | 18.1 | 25.3 | 11.5 | 20.6 |
| MRAP (Nov 2011) - Seat Cushion | 2.5 - 100 | -2.7 | - | -1.9 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | 2.5 - 100 | 35.2 | 40.3 | 26.3 | 33.0 |
| MRAP (Nov 2011) - 3/16-in.Tubes | 2.5 - 100 | 25.7 | 32.5 | 16.8 | 24.5 |
| MRAP (Nov 2011) - Seat Cushion | ISO Filter | 16.0 | - | 17.5 | - |
| MRAP (Nov 2011) - 3/8-in.Tubes | | 27.8 | 38.1 | 27.6 | 36.4 |
| MRAP (Nov 2011) - 3/16-in.Tubes | | -58.8 | -28.6 | -61.9 | -37.4 |

## B.2. Black Hawk seat test

Table B.7 Black Hawk seat air bladder - rms values (low pass filter) – z-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Vertical) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 1.31 | 1.92 | 0.91 | |
| Bare Seat -Flight Profile (1) | 1.21 | 1.06 | 0.50 | |
| Bare Seat -Flight Profile (2) | 1.71 | 1.32 | 0.61 | |
| Bare Seat -Flight Profile (3) | 2.45 | 3.06 | 1.04 | |
| Bare Seat -Flight Profile (4) | 1.81 | 2.18 | 0.94 | |
| Bare Seat -Flight Profile (5) | 1.58 | 1.95 | 1.11 | |
| Bare Seat -Flight Profile (7) | 2.78 | 2.67 | 1.08 | |
| Bare Seat -Flight Profile (S&L) | 1.58 | 1.90 | 0.64 | |
| **Average** | **1.80** | **2.01** | **0.85** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 2.00 | 1.87 | 1.55 | 0.42 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 1.39 | 1.11 | 1.27 | 0.26 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 1.68 | 1.35 | 1.33 | 0.23 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 3.49 | 3.04 | 2.65 | 0.52 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 2.07 | 1.86 | 1.51 | 0.53 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 1.95 | 1.70 | 1.49 | 0.57 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 3.73 | 3.08 | 2.05 | 0.69 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 2.16 | 1.73 | 1.70 | 0.40 |
| **Average** | **2.31** | **1.97** | **1.70** | **0.45** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 1.57 | 1.66 | 1.26 | 0.40 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 1.33 | 1.21 | 0.96 | 0.26 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 1.35 | 1.19 | 0.94 | 0.27 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 2.01 | 2.35 | 1.52 | 0.40 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 1.88 | 2.09 | 1.32 | 0.82 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 1.65 | 1.73 | 1.01 | 0.44 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 3.42 | 2.83 | 2.03 | 0.65 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 1.97 | 1.94 | 1.46 | 0.55 |
| **Average** | **1.90** | **1.88** | **1.31** | **0.48** |

Table B.8 Black Hawk seat air bladder - rms values (low pass filter) – y-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - y-Direction (Side-to-Side) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 2.17 | 1.65 | 0.45 | |
| Bare Seat -Flight Profile (1) | 1.88 | 1.82 | 0.41 | |
| Bare Seat -Flight Profile (2) | 2.34 | 2.44 | 0.59 | |
| Bare Seat -Flight Profile (3) | 2.39 | 2.76 | 0.86 | |
| Bare Seat -Flight Profile (4) | 2.44 | 2.35 | 0.50 | |
| Bare Seat -Flight Profile (5) | 2.91 | 2.85 | 0.48 | |
| Bare Seat -Flight Profile (7) | 4.03 | 3.18 | 1.03 | |
| Bare Seat -Flight Profile (S&L) | 2.81 | 2.89 | 0.56 | |
| **Average** | **2.62** | **2.49** | **0.61** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 2.02 | 1.46 | 0.69 | 0.64 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 1.76 | 0.97 | 0.48 | 0.38 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 1.96 | 0.98 | 0.56 | 0.45 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 3.14 | 2.31 | 1.23 | 1.05 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 2.62 | 1.62 | 0.62 | 0.55 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 2.71 | 1.71 | 0.58 | 0.51 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 4.10 | 2.58 | 1.36 | 1.11 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 3.53 | 1.87 | 0.74 | 0.59 |
| **Average** | **2.73** | **1.69** | **0.78** | **0.66** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 1.98 | 1.70 | 0.53 | 0.56 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 1.66 | 1.14 | 0.45 | 0.41 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 1.88 | 1.16 | 0.47 | 0.41 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 2.52 | 2.35 | 0.71 | 0.84 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 2.67 | 2.03 | 0.57 | 0.60 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 2.95 | 2.15 | 0.49 | 0.46 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 3.76 | 2.43 | 1.27 | 1.04 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 3.81 | 2.24 | 0.67 | 0.66 |
| **Average** | **2.65** | **1.90** | **0.64** | **0.62** |

Table B.9 Black Hawk seat air bladder - rms values (low pass filter) – x-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - x-Direction (Front-to-Back) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 0.91 | 2.23 | 0.76 | |
| Bare Seat -Flight Profile (1) | 0.50 | 1.94 | 0.68 | |
| Bare Seat -Flight Profile (2) | 0.61 | 2.46 | 0.82 | |
| Bare Seat -Flight Profile (3) | 1.04 | 2.80 | 0.82 | |
| Bare Seat -Flight Profile (4) | 0.94 | 2.05 | 0.71 | |
| Bare Seat -Flight Profile (5) | 1.11 | 2.35 | 0.91 | |
| Bare Seat -Flight Profile (7) | 1.08 | 2.77 | 1.43 | |
| Bare Seat -Flight Profile (S&L) | 0.64 | 1.45 | 1.01 | |
| **Average** | **0.85** | **2.26** | **0.89** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 1.55 | 0.42 | 0.70 | 0.51 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 1.27 | 0.26 | 0.61 | 0.33 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 1.33 | 0.23 | 0.66 | 0.33 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 2.65 | 0.52 | 1.09 | 0.83 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 1.51 | 0.53 | 0.79 | 0.48 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 1.49 | 0.57 | 0.81 | 0.51 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 2.05 | 0.69 | 1.44 | 0.91 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 1.70 | 0.40 | 1.24 | 0.66 |
| **Average** | **1.70** | **0.45** | **0.92** | **0.57** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 1.26 | 0.40 | 0.67 | 0.57 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 0.96 | 0.26 | 0.57 | 0.39 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 0.94 | 0.27 | 0.65 | 0.39 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 1.52 | 0.40 | 0.91 | 0.84 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 1.32 | 0.82 | 0.83 | 0.63 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 1.01 | 0.44 | 0.89 | 0.64 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 2.03 | 0.65 | 1.31 | 0.85 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 1.46 | 0.55 | 1.35 | 0.79 |
| **Average** | **1.31** | **0.48** | **0.90** | **0.64** |

Table B.10 Black Hawk seat air bladder - rms values (ISO filter) – z-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Vertical) | Average rms values ($m/s^2$) - ISO Filter Results (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 0.65 | 0.64 | 0.60 | |
| Bare Seat -Flight Profile (1) | 0.28 | 0.35 | 0.32 | |
| Bare Seat -Flight Profile (2) | 0.32 | 0.51 | 0.40 | |
| Bare Seat -Flight Profile (3) | 0.47 | 0.92 | 0.64 | |
| Bare Seat -Flight Profile (4) | 0.48 | 0.58 | 0.53 | |
| Bare Seat -Flight Profile (5) | 0.46 | 0.62 | 0.61 | |
| Bare Seat -Flight Profile (7) | 0.48 | 0.46 | 0.53 | |
| Bare Seat -Flight Profile (S&L) | 0.30 | 0.51 | 0.40 | |
| **Average** | **0.43** | **0.57** | **0.50** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 0.76 | 0.70 | 0.60 | 0.31 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 0.39 | 0.41 | 0.37 | 0.18 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 0.24 | 0.32 | 0.30 | 0.17 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 0.63 | 0.94 | 0.70 | 0.28 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 0.42 | 0.57 | 0.47 | 0.32 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 0.46 | 0.57 | 0.50 | 0.36 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 0.54 | 0.58 | 0.61 | 0.41 |
| 3/16-in. Tube Bladder-Flight Profile (S&L | 0.33 | 0.46 | 0.43 | 0.24 |
| **Average** | **0.47** | **0.57** | **0.50** | **0.28** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 0.77 | 0.76 | 0.59 | 0.30 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 0.35 | 0.39 | 0.33 | 0.19 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 0.36 | 0.39 | 0.32 | 0.20 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 0.46 | 0.84 | 0.47 | 0.21 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 0.59 | 0.64 | 0.56 | 0.48 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 0.39 | 0.48 | 0.38 | 0.27 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 0.54 | 0.61 | 0.64 | 0.38 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 0.44 | 0.45 | 0.47 | 0.31 |
| **Average** | **0.49** | **0.57** | **0.47** | **0.29** |

Table B.11 Black Hawk seat air bladder - rms values (ISO filter) – y-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - y-Direction (Side-to-Side) | Average rms values ($m/s^2$) - ISO Filter Results (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 0.08 | 0.10 | 0.05 | |
| Bare Seat -Flight Profile (1) | 0.07 | 0.08 | 0.06 | |
| Bare Seat -Flight Profile (2) | 0.07 | 0.08 | 0.06 | |
| Bare Seat -Flight Profile (3) | 0.13 | 0.15 | 0.10 | |
| Bare Seat -Flight Profile (4) | 0.15 | 0.22 | 0.10 | |
| Bare Seat -Flight Profile (5) | 0.10 | 0.14 | 0.09 | |
| Bare Seat -Flight Profile (7) | 0.10 | 0.27 | 0.09 | |
| Bare Seat -Flight Profile (S&L) | 0.08 | 0.11 | 0.07 | |
| **Average** | **0.10** | **0.14** | **0.08** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 0.10 | 0.08 | 0.06 | 0.07 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 0.09 | 0.12 | 0.07 | 0.07 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 0.05 | 0.08 | 0.04 | 0.04 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 0.17 | 0.15 | 0.10 | 0.10 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 0.16 | 0.21 | 0.11 | 0.11 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 0.12 | 0.19 | 0.08 | 0.09 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 0.12 | 0.24 | 0.12 | 0.12 |
| 3/16-in. Tube Bladder-Flight Profile (S&L | 0.10 | 0.16 | 0.08 | 0.08 |
| **Average** | **0.11** | **0.15** | **0.08** | **0.09** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 0.07 | 0.07 | 0.05 | 0.06 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 0.06 | 0.09 | 0.06 | 0.06 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 0.05 | 0.09 | 0.04 | 0.04 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 0.09 | 0.15 | 0.07 | 0.08 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 0.18 | 0.33 | 0.13 | 0.14 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 0.10 | 0.20 | 0.08 | 0.10 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 0.11 | 0.21 | 0.11 | 0.12 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 0.10 | 0.18 | 0.09 | 0.09 |
| **Average** | **0.10** | **0.17** | **0.08** | **0.09** |

Table B.12 Black Hawk seat air bladder - rms values (ISO filter) – x-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - x-Direction (Front-to-Back) | Average rms values ($m/s^2$) - ISO Filter Results (April 2012) | | | |
|---|---|---|---|---|
| | Helicopter Floor | Helicopter Seat Frame | Between Seat Bed and Buttock or Bladder Bottom | Between Bladder Top and Buttock |
| Bare Seat -Flight Profile (0) | 0.05 | 0.06 | 0.05 | |
| Bare Seat -Flight Profile (1) | 0.05 | 0.05 | 0.04 | |
| Bare Seat -Flight Profile (2) | 0.05 | 0.06 | 0.05 | |
| Bare Seat -Flight Profile (3) | 0.09 | 0.10 | 0.09 | |
| Bare Seat -Flight Profile (4) | 0.12 | 0.12 | 0.10 | |
| Bare Seat -Flight Profile (5) | 0.11 | 0.12 | 0.14 | |
| Bare Seat -Flight Profile (7) | 0.10 | 0.19 | 0.10 | |
| Bare Seat -Flight Profile (S&L) | 0.07 | 0.07 | 0.06 | |
| **Average** | **0.08** | **0.10** | **0.08** | |
| 3/16-in. Tube Bladder-Flight Profile (0) | 0.06 | 0.06 | 0.05 | 0.05 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 0.05 | 0.06 | 0.05 | 0.06 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 0.05 | 0.05 | 0.04 | 0.05 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 0.10 | 0.12 | 0.08 | 0.09 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 0.12 | 0.14 | 0.09 | 0.10 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 0.13 | 0.14 | 0.10 | 0.10 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 0.12 | 0.30 | 0.09 | 0.10 |
| 3/16-in. Tube Bladder-Flight Profile (S&L | 0.10 | 0.13 | 0.07 | 0.08 |
| **Average** | **0.09** | **0.12** | **0.07** | **0.08** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 0.06 | 0.06 | 0.06 | 0.06 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 0.05 | 0.06 | 0.04 | 0.07 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 0.06 | 0.06 | 0.05 | 0.05 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 0.07 | 0.11 | 0.08 | 0.10 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 0.17 | 0.27 | 0.17 | 0.17 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 0.09 | 0.16 | 0.08 | 0.13 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 0.11 | 0.24 | 0.09 | 0.09 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 0.11 | 0.21 | 0.09 | 0.09 |
| **Average** | **0.09** | **0.15** | **0.08** | **0.10** |

Table B.13 Black Hawk seat air bladder - percent reduction in rms – z-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Vertical) | Percent Reduction in rms Values - (April 2012) | | | |
|---|---|---|---|---|
| | Low Pass Filter (1-100 Hz) | | ISO Filter | |
| | Through Bladder | Bladder Relative to Seat | Through Bladder | Bladder Relative to Seat with no Bladder |
| 3/16-in. Tube Bladder-Flight Profile (0) | 72.8 | 53.4 | 48.7 | 48.6 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 79.3 | 47.6 | 52.9 | 44.9 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 82.9 | 62.8 | 45.3 | 58.3 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 80.2 | 49.8 | 59.4 | 55.5 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 65.2 | 43.8 | 31.6 | 39.4 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 61.9 | 48.7 | 27.2 | 40.8 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 66.1 | 35.9 | 33.8 | 23.7 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 76.7 | 37.6 | 43.6 | 39.8 |
| **Average** | **73.3** | **46.9** | **43.2** | **43.8** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 67.9 | 55.4 | 48.0 | 49.4 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 72.8 | 48.2 | 44.1 | 41.4 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 70.9 | 55.3 | 38.2 | 49.4 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 73.3 | 61.2 | 54.5 | 66.5 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 37.5 | 12.2 | 14.1 | 8.8 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 56.8 | 60.5 | 29.8 | 56.3 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 67.8 | 39.6 | 40.9 | 29.2 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 61.9 | 12.7 | 34.1 | 21.8 |
| **Average** | **63.7** | **44.2** | **37.8** | **41.8** |

Table B.14 Black Hawk seat air bladder - percent reduction in rms – y-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - y-Direction (Side-to-Side) | Percent Reduction in rms Values - (April 2012) | | | |
|---|---|---|---|---|
| | Low Pass Filter (1-100 Hz) | | ISO Filter | |
| | Through Bladder | Bladder Relative to Seat | Through Bladder | Bladder Relative to Seat with no Bladder |
| 3/16-in. Tube Bladder-Flight Profile (0) | 6.8 | -43.5 | -8.5 | -31.7 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 19.9 | 7.4 | 0.7 | -23.5 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 19.4 | 23.5 | 2.6 | 28.2 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 14.1 | -22.2 | -2.6 | -3.8 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 10.9 | -9.9 | -6.8 | -16.4 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 12.7 | -4.8 | -19.8 | -6.1 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 18.3 | -8.2 | 2.7 | -23.5 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 20.3 | -6.4 | -5.5 | -22.4 |
| **Average** | **15.4** | **-8.4** | **-4.6** | **-12.4** |
| 3/8-in. Tube Bladder-Flight Profile (0) | -6.5 | -25.1 | -17.3 | -7.5 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 9.0 | -0.2 | -10.2 | -7.2 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 12.6 | 30.9 | -2.7 | 23.7 |
| 3/8-in. Tube Bladder-Flight Profile (3) | -18.6 | 2.6 | -15.5 | 18.8 |
| 3/8-in. Tube Bladder-Flight Profile (4) | -6.3 | -19.7 | -12.9 | -44.7 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 5.0 | 4.2 | -29.6 | -10.8 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 18.2 | -1.1 | -3.1 | -21.7 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 1.1 | -19.2 | -10.7 | -37.1 |
| **Average** | **3.1** | **-2.2** | **-12.6** | **-12.3** |

Table B.15 Black Hawk seat air bladder - percent reduction in rms – x-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - x-Direction (Front-to-Back) | Percent Reduction in rms Values - (April 2012) | | | |
|---|---|---|---|---|
| | Low Pass Filter (1-100 Hz) | | ISO Filter | |
| | Through Bladder | Bladder Relative to Seat | Through Bladder | Bladder Relative to Seat with no Bladder |
| 3/16-in. Tube Bladder-Flight Profile (0) | 27.3 | 33.7 | -2.1 | -12.6 |
| 3/16-in. Tube Bladder-Flight Profile (1) | 45.2 | 50.9 | -17.3 | -42.4 |
| 3/16-in. Tube Bladder-Flight Profile (2) | 50.8 | 60.3 | -13.1 | 9.3 |
| 3/16-in. Tube Bladder-Flight Profile (3) | 23.8 | -1.1 | -18.8 | -6.5 |
| 3/16-in. Tube Bladder-Flight Profile (4) | 38.7 | 31.8 | -9.2 | 1.1 |
| 3/16-in. Tube Bladder-Flight Profile (5) | 37.0 | 43.6 | 3.3 | 29.2 |
| 3/16-in. Tube Bladder-Flight Profile (7) | 37.1 | 36.8 | -6.4 | -4.0 |
| 3/16-in. Tube Bladder-Flight Profile (S&L) | 47.0 | 35.4 | -5.2 | -42.3 |
| **Average** | **37.9** | **36.3** | **-7.7** | **-1.6** |
| 3/8-in. Tube Bladder-Flight Profile (0) | 14.2 | 25.3 | -0.1 | -21.1 |
| 3/8-in. Tube Bladder-Flight Profile (1) | 32.2 | 42.6 | -71.5 | -73.3 |
| 3/8-in. Tube Bladder-Flight Profile (2) | 39.5 | 52.1 | -9.6 | -0.1 |
| 3/8-in. Tube Bladder-Flight Profile (3) | 7.8 | -1.3 | -22.8 | -13.8 |
| 3/8-in. Tube Bladder-Flight Profile (4) | 24.6 | 11.5 | 4.0 | -63.8 |
| 3/8-in. Tube Bladder-Flight Profile (5) | 28.8 | 30.0 | -58.8 | 4.5 |
| 3/8-in. Tube Bladder-Flight Profile (7) | 35.4 | 40.9 | 1.1 | 3.1 |
| 3/8-in. Tube Bladder-Flight Profile (S&L) | 41.3 | 22.2 | -5.7 | -69.5 |
| **Average** | **29.1** | **28.9** | **-15.0** | **-23.6** |

## B.3. MRAP litter test

Table B.16 MRAP litter air bladder - overall rms values – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Overall rms ( $m/s^2$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| | Frequency Range Hz | MRAP Floor | Litter Rack | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 1.35 | *2.22* | 7.78 | 2.71 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.51 | *2.94* | 9.42 | 1.92 | 1.82 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.45 | *2.69* | 8.36 | 1.87 | 1.97 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 0.87 | *1.92* | 3.91 | 2.44 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.98 | *2.87* | 4.58 | 1.13 | 0.88 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.93 | *2.71* | 3.80 | 0.95 | 0.87 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 1.45 | 2.38 | 17.78 | 2.03 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.46 | 2.84 | 14.85 | 1.98 | 2.20 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.48 | 2.75 | 15.69 | 2.01 | 2.21 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.91 | 2.01 | 9.95 | 0.99 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.87 | 2.55 | 8.32 | 0.95 | 1.05 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.83 | 2.42 | 8.41 | 0.94 | 1.09 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 1.36 | 2.19 | 5.02 | 1.65 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.47 | 2.36 | 4.09 | 1.74 | 1.79 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.48 | 2.29 | 4.25 | 1.77 | 1.90 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.83 | 1.87 | 3.00 | 0.79 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.96 | 2.04 | 2.48 | 1.08 | 0.92 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.89 | 1.94 | 2.50 | 0.97 | 0.89 |

Table B.17 MRAP litter air bladder - overall rms values – y-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results y-Direction (Side- to-Side) | Overall rms ( $m/s^2$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 0.92 | *0.95* | 15.25 | 1.32 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 0.82 | *0.81* | 23.55 | 1.09 | 1.12 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.00 | *0.94* | 14.85 | 1.13 | 1.14 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 0.87 | *0.98* | 7.76 | 1.30 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.98 | *1.07* | 11.51 | 1.04 | 1.06 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.93 | *0.96* | 6.37 | 1.06 | 1.09 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 0.86 | 0.86 | 3.95 | 0.94 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 0.77 | 0.76 | 3.31 | 0.99 | 0.81 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 0.78 | 0.73 | 3.31 | 0.85 | 0.82 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.77 | 0.87 | 2.17 | 0.79 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.68 | 0.74 | 1.76 | 0.95 | 0.76 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.68 | 0.70 | 1.74 | 0.79 | 0.74 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 0.76 | 0.80 | 0.87 | 0.82 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 0.86 | 0.84 | 1.19 | 1.07 | 1.01 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 0.82 | 0.79 | 1.03 | 0.95 | 0.93 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.64 | 0.79 | 0.56 | 0.72 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.76 | 0.82 | 0.70 | 1.02 | 0.94 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.71 | 0.78 | 0.64 | 0.89 | 0.87 |

Table B.18 MRAP litter air bladder - overall rms values – z-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results z-Direction (Head-to-Toe) | Overall rms ( $m/s^2$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 0.65 | *0.54* | 11.66 | 1.69 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 0.59 | *0.55* | 18.53 | 1.35 | 1.36 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 0.71 | *0.64* | 11.17 | 1.48 | 1.31 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 0.56 | *0.49* | 5.89 | 1.66 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.47 | *0.46* | 9.00 | 1.33 | 1.23 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.64 | *0.61* | 4.86 | 1.41 | 1.19 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 1.05 | 0.87 | 4.10 | 0.82 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 0.97 | 0.91 | 3.29 | 0.88 | 0.68 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 0.98 | 0.89 | 3.49 | 0.86 | 0.66 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.94 | 0.83 | 2.27 | 0.76 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 0.89 | 0.87 | 1.87 | 0.83 | 0.58 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.89 | 0.85 | 1.90 | 0.81 | 0.56 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 0.94 | 0.77 | 3.57 | 1.06 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 1.10 | 0.82 | 3.33 | 1.35 | 1.17 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 1.02 | 0.79 | 3.39 | 1.21 | 1.08 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 0.86 | 0.73 | 2.18 | 1.02 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 1.03 | 0.78 | 1.93 | 1.33 | 1.12 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 0.95 | 0.75 | 1.94 | 1.18 | 1.03 |

Table B.19 MRAP litter air bladder - percent reduction – rms Value – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Percent Reductions in rms Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| MRAP (Jul 2011) -Bare Litter | 1 - 100 | -251.0 | -22.2 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -220.7 | 34.5 | 5.2 | 37.9 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -210.4 | 30.7 | -5.7 | 26.7 |
| MRAP (Jul 2011) - Bare Litter | 2.5 - 100 | -103.5 | -26.9 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -59.4 | 60.8 | 21.6 | 69.2 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -40.1 | 64.9 | 8.3 | 67.8 |
| 3/8-in. Tubes - Pelvice | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -647.1 | 14.7 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -422.9 | 30.3 | -11.1 | 22.5 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -470.5 | 26.9 | -10.0 | 19.6 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | -395.0 | 50.7 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -226.3 | 62.7 | -10.5 | 58.8 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -247.5 | 61.2 | -16.0 | 55.0 |
| 3/8-in. Tubes - Shoulder | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -129.2 | 24.7 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -73.3 | 26.3 | -2.9 | 24.2 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -85.6 | 22.7 | -7.3 | 17.0 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | -60.4 | 57.8 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -21.6 | 47.1 | 14.8 | 54.9 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -28.9 | 50.0 | 8.2 | 54.1 |

Table B.20 MRAP litter air bladder - percent reduction - VDV value – y-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results y-Direction (Side- to-Side) | Percent Reductions in rms Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| MRAP (Jul 2011) -Bare Litter | 1 - 100 | -1501.3 | -38.2 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -2810.1 | -34.3 | -3.3 | -38.7 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -1487.0 | -20.8 | -1.0 | -22.0 |
| MRAP (Jul 2011) - Bare Litter | 2.5 - 100 | -689.4 | -32.2 | - | - |
| MRAP (Jul 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -979.3 | 2.8 | -2.1 | 0.8 |
| MRAP (Jul 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -565.4 | -10.5 | -2.8 | -13.6 |
| 3/8-in. Tubes - Pelvice | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -359.3 | -9.3 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -335.5 | -30.3 | 18.2 | -6.6 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -353.4 | -16.4 | 3.5 | -12.3 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | -149.4 | 9.2 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | -137.8 | -28.4 | 20.0 | -2.7 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | -148.6 | -12.9 | 6.3 | -5.7 |
| 3/8-in. Tubes - Shoulder | | | | | |
| MRAP (Nov 2011) -Bare Litter | 1 - 100 | -8.7 | -2.5 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 1 - 100 | -41.7 | -27.4 | 5.6 | -20.2 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 1 - 100 | -30.4 | -20.3 | 2.1 | -17.7 |
| MRAP (Nov 2011) - Bare Litter | 2.5 - 100 | 29.1 | 8.9 | - | - |
| MRAP (Nov 2011) - 1.5 lb/ft$^3$ | 2.5 - 100 | 14.6 | -24.4 | 7.8 | -14.6 |
| MRAP (Nov 2011) - 2.0 lb/ft$^3$ | 2.5 - 100 | 17.9 | -14.1 | 2.2 | -11.5 |

Table B.21 MRAP litter air bladder - percent reduction –VDV Value – z-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results z-Direction (Head-to-Toe) | Percent Reductions in rms Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | -2064.9 | -213.9 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -3248.4 | -144.1 | -0.4 | -145.1 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -1632.6 | -129.2 | 11.6 | -102.6 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | -1091.2 | -236.5 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -1858.9 | -188.9 | 7.6 | -166.8 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -695.1 | -130.4 | 15.6 | -94.4 |
| **3/8-in. Tubes - Pelvice** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -371.3 | 5.7 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -261.5 | 3.3 | 22.7 | 25.3 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -292.1 | 3.4 | 23.3 | 25.8 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -173.5 | 8.4 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -114.9 | 4.6 | 30.1 | 33.3 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -123.5 | 4.7 | 30.9 | 34.1 |
| **3/8-in. Tubes - Shoulder** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -363.6 | -37.7 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -306.1 | -64.6 | 13.3 | -42.7 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -329.1 | -53.2 | 10.7 | -36.7 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -198.6 | -39.7 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -147.4 | -70.5 | 15.8 | -43.6 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -158.7 | -57.3 | 12.7 | -37.3 |

Table B.22 MRAP litter air bladder - overall VDV values – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Overall Litter VDV (m/s$^{1.75}$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | MRAP Floor | Litter Rack | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 6.60 | *11.94* | 29.30 | 15.74 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 7.21 | *16.79* | 35.22 | 9.93 | 8.13 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 6.80 | *14.50* | 31.02 | 8.33 | 8.44 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 5.80 | *11.87* | 21.74 | 15.20 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 5.92 | *17.31* | 24.03 | 8.10 | 4.55 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 5.65 | *16.16* | 20.76 | 5.72 | 4.38 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 7.32 | 13.24 | 78.05 | 9.71 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 7.40 | 17.23 | 66.78 | 9.86 | 10.69 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 7.26 | 15.84 | 69.99 | 9.72 | 10.66 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 6.12 | 12.53 | 49.51 | 5.19 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 5.63 | 16.46 | 41.77 | 5.25 | 5.62 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 5.28 | 15.10 | 4331.00 | 5.19 | 6.23 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 6.52 | 11.25 | 21.41 | 8.05 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 7.75 | 13.38 | 18.17 | 8.49 | 8.91 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 7.49 | 12.26 | 18.96 | 8.93 | 9.91 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 4.93 | 10.47 | 13.83 | 4.04 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 6.35 | 12.73 | 12.41 | 5.58 | 4.92 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 5.58 | 11.33 | 12.69 | 5.09 | 4.70 |

Table B.23 MRAP litter air bladder - overall VDV values – y-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results y-Direction (Side- to-Side) | Overall Litter VDV ($m/s^{1.75}$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 5.93 | *5.01* | 54.44 | 7.02 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 5.13 | *4.66* | 86.52 | 6.38 | 5.97 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 6.55 | *5.39* | 52.20 | 6.21 | 6.02 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 5.80 | *5.23* | 36.83 | 6.95 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 5.02 | *4.83* | 53.88 | 6.24 | 5.77 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 6.30 | *5.44* | 30.14 | 5.90 | 5.89 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 5.79 | 4.89 | 17.27 | 4.88 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 4.62 | 4.20 | 14.69 | 5.35 | 4.32 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 4.85 | 3.99 | 14.68 | 4.45 | 4.23 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 5.33 | 4.81 | 10.98 | 4.30 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 4.30 | 4.14 | 9.03 | 5.16 | 4.19 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 4.53 | 3.91 | 9.18 | 4.21 | 4.04 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 4.59 | 4.33 | 4.63 | 4.31 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 5.75 | 4.51 | 6.67 | 5.65 | 5.36 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 5.14 | 4.35 | 6.50 | 5.07 | 4.97 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 4.20 | 4.28 | 3.35 | 4.09 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 5.30 | 4.44 | 4.01 | 5.56 | 5.25 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 4.78 | 4.27 | 4.21 | 4.89 | 4.78 |

Table B.24 MRAP litter air bladder - overall VDV values – z-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results z-Direction (Head-to-Toe) | Overall Litter VDV ($m/s^{1.75}$) Vibration Values | | | | | |
|---|---|---|---|---|---|---|
| | **Frequency Range Hz** | **MRAP Floor** | **Litter Rack** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | 4.07 | *9.98* | 41.68 | 8.80 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 3.24 | *7.26* | 67.79 | 7.05 | 6.80 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 4.06 | *9.56* | 39.46 | 7.50 | 6.27 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | 3.53 | *5.83* | 27.62 | 8.67 | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 2.84 | *4.36* | 41.91 | 6.98 | 6.56 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 3.75 | *6.03* | 22.77 | 7.32 | 6.09 |
| **3/8-in. Tubes - Pelvice** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 6.75 | 5.43 | 16.55 | 4.79 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 6.15 | 5.77 | 13.79 | 5.85 | 4.04 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 6.10 | 5.35 | 14.37 | 5.65 | 3.83 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 6.44 | 5.39 | 10.64 | 4.60 | |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 5.84 | 5.66 | 8.96 | 5.70 | 3.74 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 5.77 | 5.26 | 9.28 | 5.49 | 3.53 |
| **3/8-in. Tubes - Shoulder** | | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | 5.87 | 4.57 | 15.62 | 7.48 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | 7.64 | 4.88 | 15.07 | 9.71 | 7.71 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | 6.65 | 4.85 | 15.61 | 8.81 | 7.38 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 5.51 | 4.44 | 9.93 | 7.16 | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 7.24 | 4.78 | 9.53 | 9.55 | 7.43 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 6.33 | 4.76 | 9.66 | 8.63 | 7.08 |

Table B.25 MRAP litter air bladder - percent reduction – VDV Value – x-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Percent Reductions in VDV Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | -145.4 | -31.8 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -109.8 | 40.8 | 18.2 | 51.6 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -113.9 | 42.5 | -1.3 | 41.8 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | -83.1 | -28.0 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -38.8 | 53.2 | 43.9 | 73.7 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -28.5 | 64.6 | 23.5 | 72.9 |
| **3/8-in. Tubes - Pelvice** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -489.5 | 26.7 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -287.6 | 42.8 | -8.4 | 38.0 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -341.9 | 38.6 | -9.7 | 32.7 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -295.1 | 58.6 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -153.8 | 68.1 | -7.0 | 65.9 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -186.8 | 65.6 | -20.0 | 58.7 |
| **3/8-in. Tubes - Shoulder** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -90.3 | 28.4 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -35.8 | 36.5 | -4.9 | 33.4 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -54.6 | 27.2 | -11.0 | 19.2 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -32.1 | 61.4 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 2.5 | 56.2 | 11.8 | 61.4 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -12.0 | 55.1 | 7.7 | 58.5 |

Table B.26 MRAP litter air bladder - percent reduction – VDV Value – y-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results y-Direction (Side- to-Side) | Percent Reductions in VDV Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | -987.0 | -40.2 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -1755.2 | -36.7 | 6.3 | -28.1 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -868.7 | -15.2 | 3.0 | -11.7 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | -603.6 | -32.8 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -1014.8 | -29.2 | 7.6 | -19.3 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -454.3 | -8.4 | 0.1 | -8.3 |
| **3/8-in. Tubes - Pelvice** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -253.2 | 0.2 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -249.8 | -27.4 | 19.3 | -2.9 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -267.9 | -11.5 | 4.9 | -6.0 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -128.3 | 10.6 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -118.1 | -24.6 | 18.8 | -1.2 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -134.8 | -7.7 | 4.0 | -3.3 |
| **3/8-in. Tubes - Shoulder** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -6.9 | 0.5 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -47.9 | -25.3 | 5.1 | -18.8 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -49.4 | -16.6 | 2.0 | -14.3 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 21.7 | 4.4 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 9.7 | -25.2 | 5.6 | -18.2 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 1.4 | -14.5 | 2.2 | -11.9 |

Table B.27 MRAP litter air bladder - percent reduction – VDV value – z-direction

| MRAP Ambulance Summary of Litter Air Bladder Test Results y-Direction (Side- to-Side) | Percent Reductions in VDV Values | | | | |
|---|---|---|---|---|---|
| 3/8-in. Tubes - Pelvice | Frequency Range Hz | Between Litter Rack and Stirrup | Between Litter Rack and Litter Bed | Through Bladder | Between Litter Rack and Bladder Top |
| **MRAP (Jul 2011) -Bare Litter** | **1 - 100** | -987.0 | -40.2 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -1755.2 | -36.7 | 6.3 | -28.1 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -868.7 | -15.2 | 3.0 | -11.7 |
| **MRAP (Jul 2011) - Bare Litter** | **2.5 - 100** | -603.6 | -32.8 | - | - |
| **MRAP (Jul 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -1014.8 | -29.2 | 7.6 | -19.3 |
| **MRAP (Jul 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -454.3 | -8.4 | 0.1 | -8.3 |
| **3/8-in. Tubes - Pelvice** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -253.2 | 0.2 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -249.8 | -27.4 | 19.3 | -2.9 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -267.9 | -11.5 | 4.9 | -6.0 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | -128.3 | 10.6 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | -118.1 | -24.6 | 18.8 | -1.2 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | -134.8 | -7.7 | 4.0 | -3.3 |
| **3/8-in. Tubes - Shoulder** | | | | | |
| **MRAP (Nov 2011) -Bare Litter** | **1 - 100** | -6.9 | 0.5 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **1 - 100** | -47.9 | -25.3 | 5.1 | -18.8 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **1 - 100** | -49.4 | -16.6 | 2.0 | -14.3 |
| **MRAP (Nov 2011) - Bare Litter** | **2.5 - 100** | 21.7 | 4.4 | - | - |
| **MRAP (Nov 2011) - 1.5 lb/ft$^3$** | **2.5 - 100** | 9.7 | -25.2 | 5.6 | -18.2 |
| **MRAP (Nov 2011) - 2.0 lb/ft$^3$** | **2.5 - 100** | 1.4 | -14.5 | 2.2 | -11.9 |

B.4. Black Hawk litter test

Table B.28 Black Hawk litter air bladder - overall rms values (low pass) –x-direction

| **Black Hawk Helicopter Summary of Litter Air Bladder Test Results x-Direction (Vertical)** | **Average rms values (m/s$^2$) - Low Pass Filter Results - Less than 100 Hz (July 2011)** | | | | |
|---|---|---|---|---|---|
| | **Helicopter Floor** | **Helicopter Litter Pan** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| Bare Litter-Flight Profile (0) | 1.60 | 2.64 | 2.29 | 4.20 | |
| Bare Litter-Flight Profile (1) | 0.56 | 1.01 | 1.06 | 1.78 | |
| Bare Litter-Flight Profile (2) | 0.60 | 1.09 | 1.16 | 1.46 | |
| Bare Litter-Flight Profile (3) | 2.40 | 6.49 | 5.30 | 9.64 | |
| Bare Litter-Flight Profile (4) | 1.49 | 2.74 | 3.77 | 1.86 | |
| Bare Litter-Flight Profile (5) | 1.42 | 2.35 | 4.01 | 1.88 | |
| Bare Litter-Flight Profile (8) | 0.69 | 1.09 | 1.45 | 1.25 | |
| Bare Litter-Flight Profile (S&L) | 0.76 | 1.26 | 2.65 | 1.05 | |
| **Average** | **1.19** | **2.33** | **2.71** | **2.89** | |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 1.69 | 3.66 | 3.72 | 0.48 | 0.28 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (1) | 0.62 | 1.39 | 1.98 | 0.38 | 0.13 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (2) | 0.71 | 1.63 | 2.16 | 0.43 | 0.16 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (S&L) | 0.93 | 2.34 | 2.98 | 0.72 | 0.41 |
| **Average** | **0.99** | **2.25** | **2.71** | **0.50** | **0.24** |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (0) | 1.61 | 3.48 | 3.88 | 1.04 | 0.20 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (1) | 0.59 | 1.50 | 1.86 | 0.70 | 0.12 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (2) | 0.88 | 2.61 | 2.54 | 0.96 | 0.18 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (3) | 0.85 | 2.35 | 2.76 | 0.74 | 0.31 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (4) | 1.43 | 3.94 | 4.68 | 0.83 | 0.25 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (5) | 1.21 | 2.96 | 3.90 | 0.90 | 0.58 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (7) | 1.25 | 3.07 | 4.25 | 0.77 | 0.45 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (S&L) | 0.73 | 1.63 | 2.36 | 0.64 | 0.27 |
| **Average** | **1.12** | **2.84** | **3.41** | **0.85** | **0.30** |

Table B.29 Black Hawk litter air bladder - overall rms values (low pass) – y-direction

| Black Hawk Helicopter Summary of Litter Air Bladder Test Results - y-Direction (Side-to-Side) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (July 2011) | | | | |
|---|---|---|---|---|---|
| | Helicopter Floor | Helicopter Litter Pan | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| Bare Litter-Flight Profile (0) | 0.58 | 1.35 | 3.07 | 2.52 | |
| Bare Litter-Flight Profile (1) | 0.45 | 1.02 | 1.51 | 0.87 | |
| Bare Litter-Flight Profile (2) | 0.43 | 0.94 | 1.38 | 0.81 | |
| Bare Litter-Flight Profile (3) | 1.16 | 1.50 | 4.93 | 4.34 | |
| Bare Litter-Flight Profile (4) | 0.79 | 1.57 | 13.03 | 1.42 | |
| Bare Litter-Flight Profile (5) | 0.67 | 1.57 | 10.01 | 1.11 | |
| Bare Litter-Flight Profile (8) | 0.51 | 0.94 | 13.03 | 1.42 | |
| Bare Litter-Flight Profile (S&L) | 0.66 | 1.56 | 6.03 | 1.18 | |
| **Average** | **0.68** | **1.31** | **6.62** | **1.85** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 0.53 | 1.20 | 5.04 | 0.68 | 0.59 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 0.41 | 1.01 | 2.90 | 0.46 | 0.34 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 0.50 | 1.34 | 3.35 | 0.59 | 0.44 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.57 | 1.31 | 5.77 | 0.71 | 0.54 |
| **Average** | **0.50** | **1.22** | **4.26** | **0.61** | **0.48** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 0.61 | 1.65 | 3.99 | 0.94 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 0.50 | 1.28 | 2.37 | 0.64 | 0.29 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 0.59 | 1.41 | 2.95 | 1.01 | 0.43 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 0.57 | 0.95 | 4.48 | 0.75 | 0.40 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 0.85 | 1.43 | 4.32 | 1.09 | 0.62 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 0.58 | 1.27 | 8.79 | 0.78 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 0.52 | 1.22 | 6.23 | 0.69 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.54 | 1.29 | 3.60 | 0.78 | 0.35 |
| **Average** | **0.60** | **1.26** | **4.73** | **0.84** | **0.45** |

Table B.30 Black Hawk litter air bladder - overall rms values (low pass) – z-direction

| Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Head-to-Toe) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (July 2011) | | | | |
|---|---|---|---|---|---|
| | Helicopter Floor | Helicopter Litter Pan | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| Bare Litter-Flight Profile (0) | 0.68 | 1.25 | 2.50 | 1.82 | |
| Bare Litter-Flight Profile (1) | 0.32 | 0.71 | 1.38 | 0.76 | |
| Bare Litter-Flight Profile (2) | 0.37 | 0.76 | 1.36 | 0.69 | |
| Bare Litter-Flight Profile (3) | 0.60 | 0.76 | 2.33 | 1.52 | |
| Bare Litter-Flight Profile (4) | 0.78 | 1.21 | 12.50 | 0.85 | |
| Bare Litter-Flight Profile (5) | 0.63 | 0.94 | 9.89 | 0.88 | |
| Bare Litter-Flight Profile (8) | 0.63 | 0.92 | 5.98 | 0.79 | |
| Bare Litter-Flight Profile (S&L) | 0.61 | 0.88 | 4.44 | 1.73 | |
| **Average** | **0.57** | **0.93** | **5.13** | **1.05** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 0.83 | 1.63 | 4.74 | 1.38 | 0.67 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 0.36 | 0.88 | 2.82 | 1.38 | 0.44 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 0.42 | 0.95 | 3.25 | 1.62 | 0.48 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.80 | 1.08 | 5.55 | 1.73 | 0.82 |
| **Average** | **0.60** | **1.13** | **4.09** | **1.53** | **0.60** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 0.77 | 1.12 | 3.88 | 1.38 | 0.70 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 0.37 | 0.71 | 2.33 | 1.52 | 0.43 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 0.51 | 1.11 | 2.82 | 1.76 | 0.49 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 0.68 | 1.49 | 4.44 | 1.73 | 0.67 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 0.96 | 2.11 | 4.55 | 1.70 | 0.91 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 0.75 | 1.13 | 8.84 | 1.63 | 0.63 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 0.61 | 0.88 | 6.56 | 1.54 | 0.63 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.63 | 0.86 | 3.54 | 1.53 | 0.64 |
| **Average** | **0.66** | **1.22** | **4.77** | **1.61** | **0.64** |

Table B.31 Black Hawk litter air bladder - overall rms values (low pass) – x-direction

| Black Hawk Helicopter Summary of Litter Air Bladder Test Results x-Direction (Vertical) | Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | | |
|---|---|---|---|---|---|
| | Helicopter Floor | Helicopter Litter Pan | Litter Stirrup | Between Litter Bed and Patient or Bladder Bottom | Between Bladder Top and Patient |
| Bare Litter-Flight Profile (0) | 1.58 | 2.61 | 4.45 | 0.35 | |
| Bare Litter-Flight Profile (1) | 0.99 | 1.77 | 4.49 | 0.46 | |
| Bare Litter-Flight Profile (2) | 0.99 | 1.79 | 5.02 | 0.56 | |
| Bare Litter-Flight Profile (3) | 2.01 | 5.45 | 9.12 | 0.32 | |
| Bare Litter-Flight Profile (4) | 1.36 | 2.50 | 5.89 | 0.69 | |
| Bare Litter-Flight Profile (5) | 0.95 | 1.58 | 3.74 | 0.29 | |
| Bare Litter-Flight Profile (7) | 1.53 | 3.02 | 6.34 | 0.72 | |
| Bare Litter-Flight Profile (S&L) | 0.94 | 1.55 | 3.18 | 0.42 | |
| **Average** | **1.29** | **2.53** | **5.28** | **0.48** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 2.07 | 4.47 | 6.67 | 0.70 | 0.34 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 1.20 | 3.06 | 4.50 | 0.61 | 0.43 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 1.89 | 5.59 | 7.80 | 0.94 | 0.58 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 2.05 | 5.64 | 7.90 | 1.08 | 0.39 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (4) | 1.20 | 2.95 | 6.32 | 0.82 | 0.61 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (5) | 1.05 | 2.57 | 4.53 | 0.55 | 0.34 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (7) | 1.48 | 3.66 | 6.61 | 1.09 | 0.66 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 1.20 | 2.69 | 4.75 | 0.88 | 0.50 |
| **Average** | **1.52** | **3.83** | **6.13** | **0.83** | **0.48** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 1.87 | 4.06 | *6.67* | 0.74 | 0.36 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 1.87 | 6.54 | *4.50* | 1.16 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 1.75 | 5.09 | *7.80* | 0.96 | 0.65 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 1.93 | 6.39 | *7.90* | 1.14 | 0.87 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 0.94 | 2.35 | *6.32* | 0.81 | 0.46 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 1.41 | 3.45 | *4.53* | 1.19 | 0.52 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 0.87 | 2.00 | *6.61* | 0.58 | 0.30 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.86 | 1.92 | *4.75* | 0.62 | 0.29 |
| **Average** | **1.44** | **3.98** | ***6.13*** | **0.90** | **0.49** |

Table B.32 Black Hawk litter air bladder - overall rms values (low pass) – y-direction

| **Black Hawk Helicopter Summary of Litter Air Bladder Test Results - y-Direction (Side-to-Side)** | **Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012)** | | | | |
|---|---|---|---|---|---|
| | **Helicopter Floor** | **Helicopter Litter Pan** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| Bare Litter-Flight Profile (0) | 0.65 | 1.51 | 10.42 | 0.66 | |
| Bare Litter-Flight Profile (1) | 0.62 | 1.42 | 9.58 | 0.66 | |
| Bare Litter-Flight Profile (2) | 0.68 | 1.49 | 11.67 | 0.66 | |
| Bare Litter-Flight Profile (3) | 1.81 | 2.34 | 13.63 | 1.37 | |
| Bare Litter-Flight Profile (4) | 0.76 | 1.50 | 17.31 | 0.81 | |
| Bare Litter-Flight Profile (5) | 0.52 | 1.22 | 6.41 | 0.60 | |
| Bare Litter-Flight Profile (7) | 0.97 | 2.51 | 18.38 | 1.14 | |
| Bare Litter-Flight Profile (S&L) | 0.60 | 1.44 | 9.75 | 0.72 | |
| **Average** | **0.83** | **1.68** | **12.14** | **0.83** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 0.62 | 1.68 | 8.38 | 0.90 | 0.72 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 0.59 | 1.51 | 8.27 | 0.87 | 0.68 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 1.14 | 2.72 | 11.34 | 1.56 | 1.26 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 1.38 | 2.30 | 9.19 | 1.23 | 0.98 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (4) | 0.61 | 1.33 | 13.26 | 0.74 | 0.61 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (5) | 0.50 | 1.17 | 7.51 | 0.64 | 0.51 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (7) | 1.00 | 2.37 | 14.26 | 1.05 | 0.79 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.80 | 1.91 | 9.30 | 0.96 | 0.67 |
| **Average** | **0.83** | **1.87** | **10.19** | **0.99** | **0.78** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 0.70 | 1.57 | *8.38* | 0.88 | 0.72 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 0.50 | 1.24 | *8.27* | 0.71 | 0.49 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 0.58 | 1.56 | *11.34* | 0.64 | 0.44 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 1.81 | 2.54 | *9.19* | 1.32 | 1.19 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 1.12 | 1.73 | *13.26* | 1.36 | 1.36 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 0.77 | 1.47 | *7.51* | 1.15 | 1.09 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 1.15 | 2.57 | *14.26* | 1.13 | 0.85 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.71 | 1.63 | *9.30* | 0.89 | 0.56 |
| **Average** | **0.92** | **1.79** | ***10.19*** | **1.01** | **0.84** |

Table B.33 Black Hawk litter air bladder - overall rms values (low pass) – z-direction

| **Black Hawk Helicopter Summary of Seat Air Bladder Test Results - z-Direction (Head-to-Toe)** | **Average rms values ($m/s^2$) - Low Pass Filter Results - Less than 100 Hz (April 2012)** | | | | |
|---|---|---|---|---|---|
| | **Helicopter Floor** | **Helicopter Litter Pan** | **Litter Stirrup** | **Between Litter Bed and Patient or Bladder Bottom** | **Between Bladder Top and Patient** |
| Bare Litter-Flight Profile (0) | 0.51 | 0.95 | 9.60 | 0.73 | |
| Bare Litter-Flight Profile (1) | 0.32 | 0.70 | 9.90 | 0.50 | |
| Bare Litter-Flight Profile (2) | 0.36 | 0.73 | 11.97 | 0.55 | |
| Bare Litter-Flight Profile (3) | 0.91 | 1.58 | 13.44 | 1.47 | |
| Bare Litter-Flight Profile (4) | 0.57 | 0.88 | 15.50 | 0.71 | |
| Bare Litter-Flight Profile (5) | 0.50 | 0.74 | 6.50 | 0.59 | |
| Bare Litter-Flight Profile (7) | 0.94 | 1.39 | 16.52 | 1.10 | |
| Bare Litter-Flight Profile (S&L) | 0.62 | 0.90 | 8.63 | 0.65 | |
| **Average** | **0.59** | **0.98** | **11.51** | **0.79** | |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 0.72 | 1.04 | 7.94 | 1.57 | 1.01 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (1) | 0.40 | 0.77 | 6.98 | 1.59 | 0.70 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (2) | 0.62 | 1.36 | 10.07 | 2.46 | 1.27 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (0) | 0.71 | 1.55 | 8.38 | 2.51 | 1.44 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (4) | 0.55 | 0.83 | 13.23 | 1.47 | 0.80 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (5) | 0.52 | 0.76 | 7.32 | 1.42 | 0.76 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (7) | 0.94 | 1.43 | 13.60 | 1.92 | 1.42 |
| 1.5 $lb/ft^3$ Bladder-Flight Profile (S&L) | 1.02 | 1.40 | 8.89 | 1.83 | 1.26 |
| **Average** | **0.69** | **1.14** | **9.55** | **1.85** | **1.08** |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (0) | 0.52 | 1.02 | *5.67* | 1.69 | 0.87 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (1) | 0.27 | 0.65 | *3.96* | 1.43 | 0.57 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (2) | 0.39 | 0.88 | *4.77* | 1.60 | 0.73 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (3) | 0.83 | 1.61 | *6.81* | 2.28 | 1.58 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (4) | 0.71 | 1.21 | *13.01* | 2.03 | 1.22 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (5) | 0.71 | 1.14 | *10.38* | 2.02 | 1.17 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (7) | 0.88 | 1.51 | *6.30* | 2.61 | 1.62 |
| 2.0 $lb/ft^3$ Bladder-Flight Profile (S&L) | 0.86 | 1.16 | *6.26* | 2.00 | 1.15 |
| **Average** | **0.65** | **1.15** | ***7.15*** | **1.96** | **1.12** |

Table B.34 Black Hawk litter air bladder - percent reduction– rms Value – x-direction

| **Black Hawk Helicopter Summary of Litter Air Bladder Test Results x-Direction (Vertical)** | **Percent Redcution in rms Values - Low Pass Filter Results - Less than 100 Hz (April 2012)** | | | |
| --- | --- | --- | --- | --- |
| | **Percent Increase Between Litter Stirrup and Pan** | **Percent Reduction between Litter Pan and Litter Bed** | **Percent Reduction Through Bladder** | **Percent Reduction between Litter Pan and Bladder Top** |
| Bare Litter-Flight Profile (0) | 70.1 | 86.6 | | |
| Bare Litter-Flight Profile (1) | 153.6 | 73.8 | | |
| Bare Litter-Flight Profile (2) | 180.1 | 69.0 | | |
| Bare Litter-Flight Profile (3) | 67.3 | 94.1 | | |
| Bare Litter-Flight Profile (4) | 135.8 | 72.3 | | |
| Bare Litter-Flight Profile (5) | 136.3 | 81.4 | | |
| Bare Litter-Flight Profile (7) | 109.6 | 76.1 | | |
| Bare Litter-Flight Profile (S&L) | 105.7 | 72.8 | | |
| **Average** | **119.8** | **81.1** | | |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 49.4 | 84.4 | 50.9 | 92.3 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (1) | 47.3 | 80.2 | 28.9 | 85.9 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (2) | 39.6 | 83.1 | 38.3 | 89.6 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 39.9 | 80.9 | 63.3 | 93.0 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (4) | 114.3 | 72.4 | 25.7 | 79.5 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (5) | 75.9 | 78.8 | 37.4 | 86.7 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (7) | 80.5 | 70.2 | 39.2 | 81.9 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (S&L) | 76.5 | 67.3 | 43.1 | 81.4 |
| **Average** | **65.4** | **78.3** | **42.0** | **87.4** |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (0) | 64.4 | *81.9* | 50.6 | 91.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (1) | -31.2 | *82.2* | 60.2 | 92.9 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (2) | 53.1 | *81.2* | 31.5 | 87.2 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (3) | 23.7 | *82.1* | 23.6 | 86.3 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (4) | 168.6 | *65.5* | 43.9 | 80.6 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (5) | 31.4 | *65.4* | 56.6 | 85.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (7) | 230.4 | *71.1* | 47.4 | 84.8 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (S&L) | 146.8 | *67.5* | 54.1 | 85.1 |
| **Average** | **85.9** | ***77.3*** | **45.6** | **87.7** |

Table B.35 Black Hawk litter air bladder - percent reduction – rms Value – y-direction

| **Black Hawk Helicopter Summary of Litter Air Bladder Test Results - y-Direction (Side-to-Side)** | **Percent Redcution in rms Values - Low Pass Filter Results - Less than 100 Hz (April 2012)** | | | |
|---|---|---|---|---|
| | **Percent Increase Between Litter Stirrup and Pan** | **Percent Reduction between Litter Pan and Litter Bed** | **Percent Reduction Through Bladder** | **Percent Reduction between Litter Pan and Bladder Top** |
| Bare Litter-Flight Profile (0) | 590.6 | 56.3 | | |
| Bare Litter-Flight Profile (1) | 573.8 | 53.4 | | |
| Bare Litter-Flight Profile (2) | 684.6 | 55.5 | | |
| Bare Litter-Flight Profile (3) | 483.5 | 41.2 | | |
| Bare Litter-Flight Profile (4) | 1051.1 | 45.9 | | |
| Bare Litter-Flight Profile (5) | 426.7 | 50.8 | | |
| Bare Litter-Flight Profile (7) | 633.0 | 54.5 | | |
| Bare Litter-Flight Profile (S&L) | 577.9 | 50.2 | | |
| **Average** | **627.7** | **50.6** | | |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 399.6 | 46.1 | 20.3 | 57.1 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (1) | 446.5 | 42.5 | 22.2 | 55.3 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (2) | 317.0 | 42.6 | 19.1 | 53.6 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 299.0 | 46.8 | 20.2 | 57.5 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (4) | 897.9 | 44.4 | 17.6 | 54.2 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (5) | 541.6 | 45.4 | 19.7 | 56.1 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (7) | 500.7 | 55.8 | 24.3 | 66.6 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (S&L) | 386.5 | 49.6 | 30.0 | 64.8 |
| **Average** | **473.6** | **47.0** | **21.7** | **58.5** |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (0) | 432.0 | *44.0* | 18.2 | 54.3 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (1) | 568.8 | *42.9* | 30.2 | 60.1 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (2) | 628.9 | *58.6* | 31.9 | 71.8 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (3) | 262.3 | *47.8* | 9.9 | 53.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (4) | 666.1 | *21.7* | -0.7 | 21.1 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (5) | 412.5 | *21.4* | 5.7 | 25.8 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (7) | 454.9 | *56.1* | 24.8 | 67.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (S&L) | 470.1 | *45.4* | 36.9 | 65.5 |
| **Average** | **487.0** | ***43.5*** | **17.0** | **53.1** |

Table B.36 Black Hawk litter air bladder - percent reduction – rms Value – z-direction

| Black Hawk Helicopter Summary of Litter Air Bladder Test Results - x-Direction (Front-to-Back) | Percent Redcution in rms Values - Low Pass Filter Results - Less than 100 Hz (April 2012) | | | |
|---|---|---|---|---|
| | Percent Increase Between Litter Stirrup and Pan | Percent Reduction between Litter Pan and Litter Bed | Percent Reduction Through Bladder | Percent Reduction between Litter Pan and Bladder Top |
| Bare Litter-Flight Profile (0) | 913.5 | 23.4 | | |
| Bare Litter-Flight Profile (1) | 1311.4 | 28.1 | | |
| Bare Litter-Flight Profile (2) | 1541.7 | 24.6 | | |
| Bare Litter-Flight Profile (3) | 749.1 | 7.5 | | |
| Bare Litter-Flight Profile (4) | 1655.6 | 19.3 | | |
| Bare Litter-Flight Profile (5) | 773.4 | 20.7 | | |
| Bare Litter-Flight Profile (7) | 1092.7 | 20.8 | | |
| Bare Litter-Flight Profile (S&L) | 860.5 | 27.1 | | |
| **Average** | **1112.2** | **20.0** | | |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 662.6 | -50.7 | 35.3 | 2.5 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (1) | 810.6 | -108.1 | 55.9 | 8.2 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (2) | 642.3 | -81.7 | 48.5 | 6.4 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (0) | 440.3 | -62.0 | 42.8 | 7.3 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (4) | 1493.4 | -76.8 | 45.7 | 4.1 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (5) | 866.4 | -87.8 | 46.5 | -0.5 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (7) | 850.0 | -34.0 | 26.0 | 0.9 |
| 1.5 lb/ft$^3$ Bladder-Flight Profile (S&L) | 536.0 | -31.1 | 31.1 | 9.7 |
| **Average** | **787.7** | **-61.9** | **41.4** | **5.1** |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (0) | 457.8 | *-65.8* | 48.3 | 14.3 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (1) | 510.3 | *-120.4* | 60.5 | 13.0 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (2) | 443.8 | *-83.0* | 54.7 | 17.1 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (3) | 323.2 | *-42.0* | 30.7 | 1.6 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (4) | 979.4 | *-68.1* | 39.6 | -1.5 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (5) | 814.4 | *-77.9* | 41.9 | -3.4 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (7) | 316.4 | *-72.2* | 37.7 | -7.3 |
| 2.0 lb/ft$^3$ Bladder-Flight Profile (S&L) | 439.0 | *-72.2* | 42.3 | 0.7 |
| **Average** | **535.5** | ***-70.8*** | **43.0** | **2.7** |

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