Proceedings of the 11th International Conference on Manufacturing Research (ICMR2013), Cranfield University, UK, 19th – 20th September 2013, pp 101-106

A VIBRATION MEASUREMENT SYSTEM FOR DEAF PEOPLE'S EMERGENCY APPARATUS

A. Abulifa
M. Shafik
T. Wilmshurst
School of Technology
University of Derby
Derby
DE22 2UA, UK
m.shafik@derby.ac.uk

M. Lawday
Deaf Alerter Plc
Derby
DE23 6AG, UK
rml@deaf-alerter.com

ABSTRACT

A vibration measurement system for deaf people's emergency warning equipment is presented in this paper. Deaf alarm devices are among the most supportive products that help to alert deaf people in various emergency circumstances. Applicable British standards recommend that acceptable working parameters for such products are frequency: 25 to 150 Hz, enough vibration strength, intensity and stable performance against lifetime. This paper presents research that has been conducted to test and validate the performance of a variety of alerting devices using the proposed vibration measurement system. It introduces the laboratory arrangements, practical measurements carried out and its compliance with the British standards. The products investigated were the Mk I, Mk II Deaf Alerters, the Deafgard alerting device and the C-TEC 24V Pillow Pad. Measurements were taken using an ADXL335 accelerometer, to determine the vibration strength. Other parameters considered were temperature variation, efficiency and lifetime of the products.

Keywords: emergency, warning equipment, deaf alert.

1 INTRODUCTION

It is estimated that about 8.5 million people in the United Kingdom have some degree of hearing impairment and 250 million people worldwide have disabling hearing loss. Progress in the prevention of harm and death resulting from fire incident and disaster in the past few decades has not yet sufficiently addressed the needs of these people. The common fire safety device is the audible fire alarm, which saves thousands of lives each year. Unfortunately, these devices are of little benefit to deaf people, since the common method to alert deaf people is using vibration devices. These are devices that have a number of vibration elements and can be activated using wire and or wireless interface techniques. There are national and international standards that govern the performance of fire alarm equipment for hearing people. However, there are limited specific standards that can cover fire alarm equipment for deaf people. This disparity in fire safety provision is often caused by the failure to understand the needs of people who are deaf or have impaired hearing. One international Standard being increasingly adopted to control the quality and safety of products in the market is BS EN 14604:2005. It specifies the requirements, test methods and performance criteria for smoke alarms, for those devices that have a vibrating pillow pad, for Deaf and hard of hearing people. It is the main standard that currently addresses the performance of vibrating alert devices, even though it does not cover the performance of portable alerting devices like the Deaf Alerter.

This research work is aimed to validate the testing and measurement method developed and implemented by Deaf Alerter Plc., with a view to produce a vibration measurement standard that can be applied to all alarm systems for Deaf and hard of hearing people. It addresses the validation of vibration measurement versus temperature variation as well as over time. The research has passed through three main phases, first phase focused on integrating the new measurement systems developed by Deaf Alerter Plc. into a mini housing unit with thermo autonomous temperature control system. This was to allow the measurement of various alert device performance versus temperature. The second phase concentrated on testing and measuring the devices performance parameters required by the British standard, for a number of alert devices. The final stage focused on comparing these measurements with the available British standards for fire alarm devices (David. Reeves, Brian. Kokoruwe, Jackie. Dobbins, Valerie. Newton, 2002, TriData Corporation, United States Fire Association, 2012) and provide the necessary recommendation for future use and utilisations.

2 VIBRATING ALERT DEVICES

There are a number of vibration fire alarm warning devices, for Deaf and hard of hearing people, available on the market. They can be classified into two types; the first type is fixed and has been designed to awaken sleeping end-users. This tends to be large and operates from a fixed location. The second one is normally small in size and portable. This is normally carried with the user during the daytime. These portable devices are activated by a wireless radio link, either from a fire alarm or smoke alarm. Four devices have been investigated during this research program and these are:

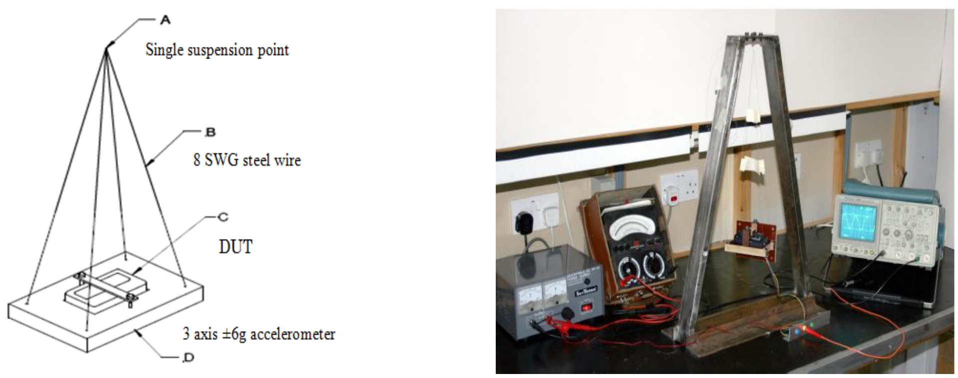
- Deafgard (Http://WWW.Deafgard.Com, 2011): Deafgard is a battery-powered stand-alone product, designed to awake people who are deaf or have hard of hearing from sleep when a nearby audible fire alarm is activated. The presence of continuous, high-volume, sound for more than 10 seconds causes the Deafgard to activate. The primary alerting method of this device is a vibrating pad, placed under the user's pillow or mattress.
- C-TEC BF363 24V Pillow Pad (Http://WWW.Connevans.Co.UK/store/viewProduct.do?id=1975157, 2011): This device is designed to connect into a building's fire alarm system via a wall-plate and provides a warning when the fire alarm is activated. This product is typical of many similar devices supplied by fire alarm manufacturers. The vibrating pad is similar in size to the Deafgard device and is also designed to be placed under a pillow in order to alert a sleeping deaf person.
- Deaf Alerter Mk-I portable Alerter (Http://WWW.Deaf-Alerter.Com, 2011): The Mk-I Alerter is an adaptation of radio-pager, specifically to meet the needs of Deaf and hard of hearing people. It is battery powered, discreet and portable device. It is designed to be clipped to a belt or carried by the users. The end user is normally alerted by a combination of text display, flashing light, audible beep and vibration.
- Deaf Alerter Mk-II portable Alerter (Http://WWW.Deaf-Alerter.Com, 2011): The Mk-II Alerter is a replacement to the Mk-I Alerter. The new design incorporated several improvements, whilst retaining the form factor of the original product. Powered by a larger AA cell batter and it has smaller size and high strength vibration element.

3 EXPERIMENTS ARRANGEMENT, TEST, RESULTS AND DISCUSSIONS

Figure 1 (a) and (b) show the actual and block diagram of the test rig and experimental arrangement used in this investigation. It has been integrated with the necessary measurement units. The Deaf Alerter plc measurement unit was the core unit that has been used to measure the vibration of the above four alert systems. The devices tested were clamped to a SRBP platen, suspended from a welded steel frame by four 8SWG steel wires. This allowed virtually unrestricted vibration in the X and Y axes, with Z axis vibration being constrained by the stiffness of the suspension wires. It also enabled the measurement of a device's vibration performance in all three axes. An accelerometer module was fastened to the underside of the platen. Signal cables were routed from the module to a patch panel mounted at the foot of the A-frame.

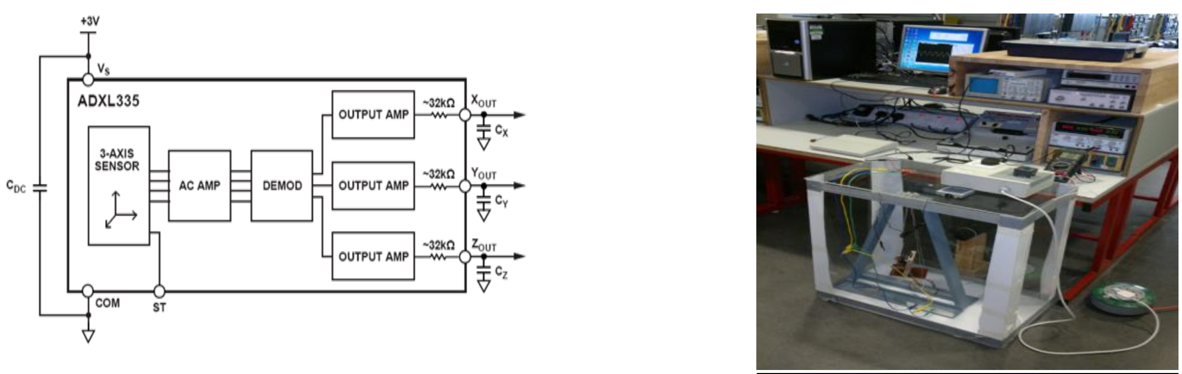
The outputs from the ADXL335 accelerometer were fed directly into a 600MHz 4-beam sampling oscilloscope, from which measurements were taken directly using the screen cursor feature. ADXL335 is a small, low power, 3-axis accelerometer designed for cost-sensitive motion- and tilt-sensing applications. It is capable of measuring both the static acceleration due to gravity and dynamic acceleration due to motion, shock or vibration. It has an internal signal conditioning unit therefore the only external components required are a power supply decoupling capacitor and a bandwidth selection capacitor on each output. The frequency outputs ranges are from 0.5 Hz to 1600Hz in X and Y axes and 0.5 Hz to 550Hz for Z axis. The supply voltage was +3V and this generated output voltage for each axis of 300mV/*g* and at rated output of ±3*g*. The device is provided with a sensor test feature, which enables verification of its performance (http://www.analog.com/static/imported-files/data_sheets/ADXL335.pdf).

The device is available from Sparkfun Electronics, mounted on a small printed circuit board with bandwidth capacitors fitted and all connections routed to a set of 0.1” pitch pads. Figure 2 (a) and (b) show the functional block diagram of ADXL335 module and actual measurement test rig suspension system integrated into the autonomous temperature control system. The actual measurement test arrangement comprised of a plastic enclosure, large enough to house the test rig. A domestic hair drier was used as a heating element. This was controlled by a Tempatron TC4800 to regulate the temperature inside the enclosure between 7 ^{o}C and 70 ^{o}C with approximately 2% accuracy.



(a) (b)

Figure 1: Deaf Alerter plc test rig (a) block diagram of the rig (b) the actual measurement Test rig Suspension System



(a) (b)

Figure 2: (a) ADXL335 Functional Block Diagram (b) Test Rig with a Temperature Control System integrated

Each device under test was fitted with a new battery and mounted securely on to the platen of the Deaf Alerter plc. test rig. A radio message was send from a nearby test transmitter at an interval of 5 seconds.

This caused the device to enter its 50% duty cycle vibration mode. The C-TEC device was activated by connection to a DC voltage source and the Deafgard unit was activated by depressing the 'Test' button on the control panel. Comprehensive tests were carried out at various degrees of ambient temperatures i.e. 6 ^{o}C, 7 ^{o}C, 25 ^{o}C, 40 ^{o}C, 50 ^{o}C and 65 ^{o}C. For each set of tests the peak value, repetition period of the X, Y and Z axis accelerometer output waveforms were recorded. The measurements taken included: Vibration strength, Performance versus temperature, Efficiency versus temperature, Efficiency versus operating time and Battery life time.

Figures 3 and 4 show the variation of operating frequency of the Mk I and Mk II Deaf Alerters versus the temperature. It can be seen that both devices operate most of the time within the frequency range of 25Hz to 150Hz. It also illustrate that both devices have an acceptable vibration strength and performance. These results ratify the suitability of both devises for deaf alert applications since they satisfy the BS EN 14604:2005 standards.

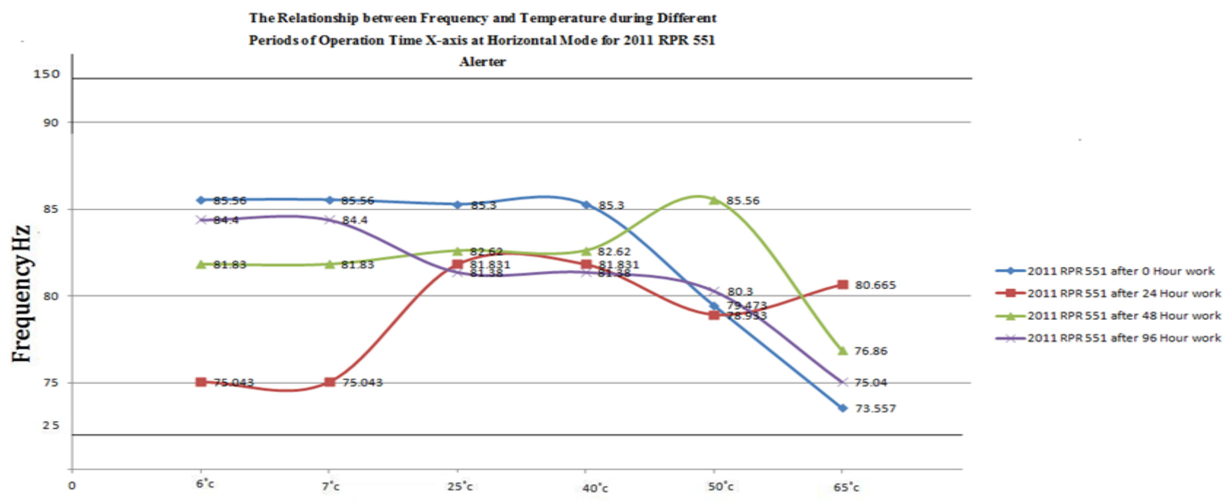


Figure 3: Frequency vs. Temperatures for Mk I Alerter performance in X-axis, Mounted Horizontally

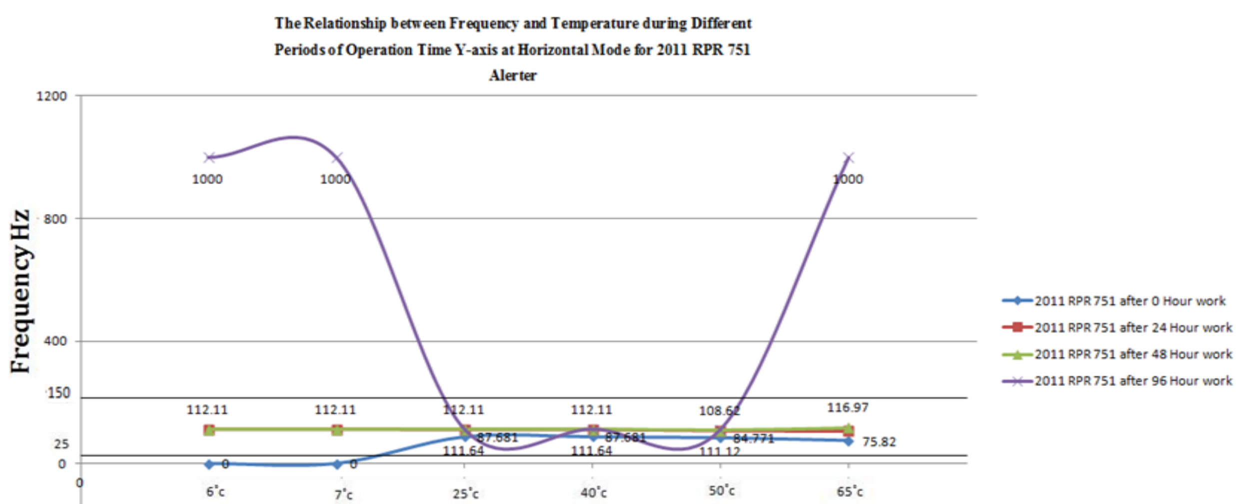


Figure 4: Frequency vs. Temperatures for Mk II Alerter performance in Y-axis, Mounted Horizontally

Figures 5 and 6 show the variation of operating frequency of the Deafgard and the frequency of C-TEC 24V Pad Pillow. It can be seen that the frequency of Deafgard and the frequency of C-TEC 24V Pad Pillow are hardly meeting the Standard's frequency range at certain temperature ranges and specific continuous working hours. However, it can be observed that they meet the standard at temperature range 25 to 50 ^{0}C degree and the performance dramatically changes after 48 hours of continuous working. This suggests that they are not fully working up to the standards at all the temperature ranges. However for such applications we are mainly focused in room temperature.

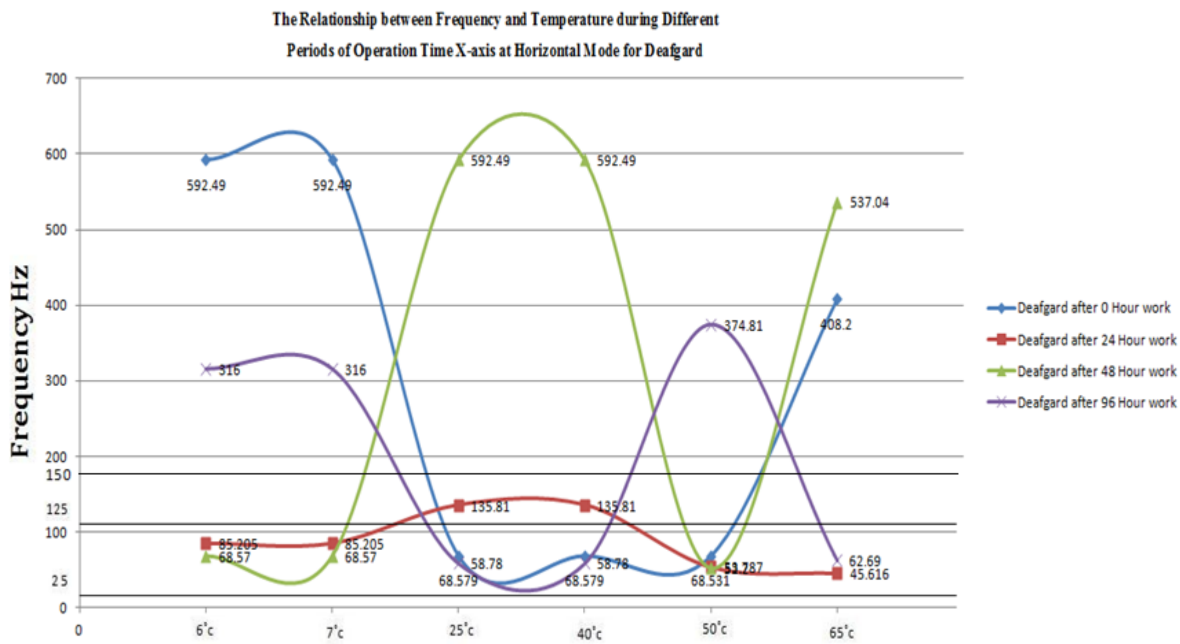


Figure 5: Frequency vs. Temperatures for Deafgard performance in X-axis, Mounted Horizontally

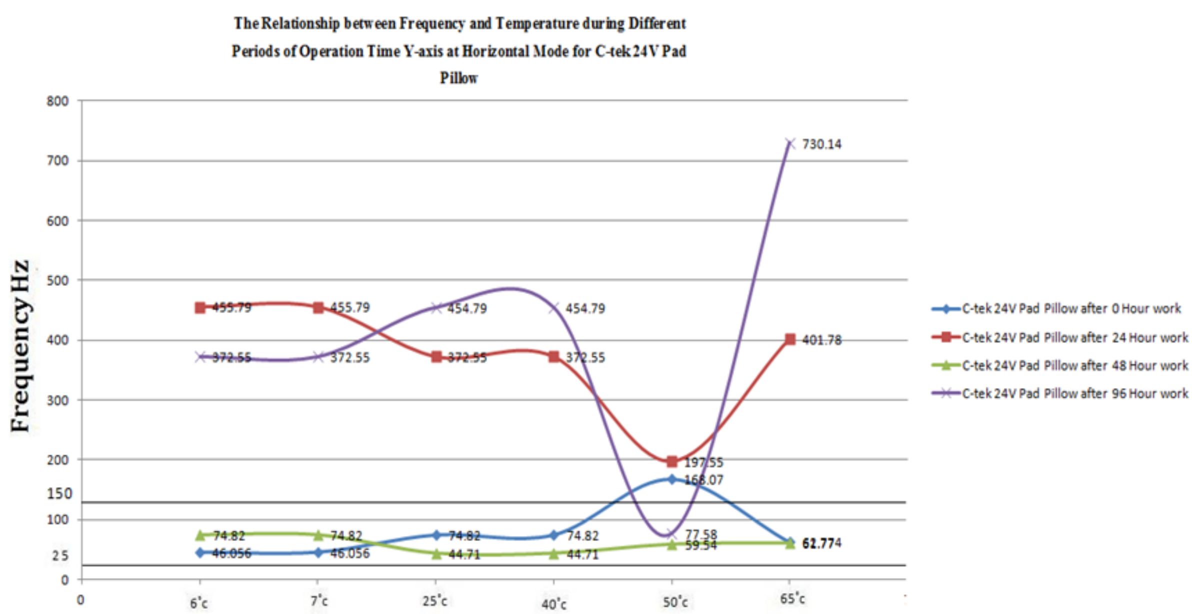


Figure 6: Frequency vs. Temperatures for C-TEC 24V Pillow Pad performance in Y-axis, Mounted Horizontally

4 CONCLUSIONS

A vibration measurement system for deaf people's emergency warning equipment is tested, validated and presented in this paper. This research work carried out showed the potential of the system to be used to measure the necessary parameters required by the British Standard, for a number of available deaf alerting products. The performance measurements of different alarm devices versus temperatures, in both horizontal and vertical orientations, in all 3 axes, were taken. The measurements were repeated at different durations of time. The measurements have been compared to the specifications from a British Standard to determine which of these devices follow the Standard and adopt its specifications.

It has been observed that the Mk I and the Mk II Alerter operate most of the time in frequency range of 25Hz to 150Hz. They also gave acceptable vibration strength versus different temperatures and different operating times. These provide enough evidence that both devices measurements meet the Standard requirement for such applications. However for Deafgard and the C-TEC 2V it has been observed that both devices meet the standard at temperature range 25^0C to 50^0C and the performance dramatically changes after 48 hours of continuous working. This suggests that they are not fully working up to the standards at all the temperature ranges. However for such applications we are mainly focused in room temperature.

REFERENCES

Analog Devices. 2009. ADXL 335: Small, Low Power, 3-Axis ±3g Accelerometer. Available: http://www.analog.com/static/imported-files/data_sheets/ADXL335.pdf. Last accessed 20th August 2012.

British Standards, 2005. Smoke alarm devices. 40 (3), p1-p40.

Datasheet of CTEC 24V Pad Pillow Alarm, UK. 2102.: C-TEC 24V Pad Pillow Alarm. Last accessed 24th August.

David. Reeves, Brian. Kokoruwe, Jackie. Dobbins, Valerie. Newton. 2002. Access to Primary Care and Accident & Emergency Services for Deaf People in the North West, United Kingdom: National Primary Care Research and Development Centre, University of Manchester.

Dennis H. Shreve. 1994. INTRODUCTION TO VIBRATION TECHNOLOGY, Columbus, Ohio 43229: Director of Marketing IRD Misanalysis, Inc.

Http://WWW.Connevans.Co.UK/store/viewProduct.do?id=1975157 (2011).

Http://WWW.Deaf-Alerter.Com (2011). Datasheet of Mk II Alerter, UK, Derby: Mk II Alerter. Last accessed 24th August.

Http://WWW.Deaf-Alerter.Com (2012). Datasheet of Mk I Alerter, UK, Derby: Mk I Alerter. Last accessed 24th August.

Http://WWW.Deafgard.Com. 2011. Datasheet of Deafgard. UK, BRIGHTON: Deafgard. Last accessed 24th August.

Spark Fun Electronics Team. 2012. Triple Axis Accelerometer - ADXL335, Available: http://WWW.Sparkfun.Com/products/9265. Last accessed 24th June.

TriData Corporation, United States Fire Association, "Fire Risks for the Deaf or Hard of Hearing," 1999, http://www.usfa.dhs.gov/downloads/pdf/publications/hearing.pdf, Last accessed 20th August 2012.