A Survey of First Responder's Competencies With Four-Gas Air Monitors

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Abstract

The ability to properly use a four-gas air monitor is essential for those who respond to incidents involving hazardous material releases. Typically, the first responder to the scene of a release is from the local fire department. These individuals should be trained at a level to use their tools such as the four-gas monitor to properly characterize the incident and to make informed decisions based upon the best interest for the public. However, it has been questioned if the normal internal protocols for training and instrument familiarity have resulted in an adequate level of competencies for the first responder on the use of a four-gas monitor.

The following paragraphs elucidate the findings of a study involving the survey of a sample of hazardous materials first responders from a selected number of fire departments in the U.S. The survey asked eight germane questions involving the set-up, usage, and interpretation of the values outputted from a common four-gas monitor. One hundred and eighty-five first responders from several municipal and volunteer fire departments were surveyed. While some of the results found were promising, others were somewhat alarming. The findings from the study revealed a need for more detailed training for first responders on the proper set-up and usage of four-gas monitors during an incident field characterization.

Introduction

The four-gas monitor is an essential tool for those professionals who respond initially to an incident involving potential chemical exposures and anoxic or flammable atmospheres. The typical four-gas monitor has a chemical sensor each for percent oxygen, percent lower explosive limit (LEL), concentration (ppm) of carbon monoxide, and concentration (ppm) of hydrogen sulfide. First responders are required to take initial and refresher training on the use of these instruments. However, due to the inherent technical and scientific nature of these instruments, it could be argued that many first responders do not have the necessary background and/or training to make an accurate and timely decision based upon the values measured. The objective of this study was to survey a sample of first responders from both volunteer and non-volunteer fire departments in the U.S. Our objective was to determine whether or not the typical first responder has the knowledge and competency to react as needed based upon their monitor readings**.**

Training and competence are so interrelated that one would find it hard to dissociate the two. Competence comes from acquiring the knowledge and specific training is used to narrow the gap between inconsistency and consistency. Performing task and establishing competency can be as simple as a child practicing their A-B-C's in school until they are able to write complete sentences with meaning as they progress. Emergency responders' competencies are learned much the same way. Through years of education and hands on training, these heroes of our society bring resolution to some of the worst moments experienced by the general public.

During our pre-study conversations with training personnel, industrial hygienist, and instructors of HAZWOPER or Hazardous Material Responder training courses, a clear message became prominent. Many first responders, when asked to perform tasks on a yearly basis, couldn't accurately complete the task or, at a minimum, needed additional refresher training in order to accomplish just the minor monitoring activities and interpretation. The personnel operating these monitors must be able to read the values and make an assessment on whether or not it safe to occupy or enter a particular place after an incident has occurred. In essence, the first responder must be competent enough to make potentially life and death decisions based on the limited information these instruments provide regarding the ambient air conditions in close proximity of an incident.

When addressing potential life and death decisions based on monitoring competencies, this attempt was to identify competencies/inadequacies for responders during the monitoring of hazardous environments using four-gas meters. The intent of this study was not to discredit individuals or their capabilities, but was completed solely to provide a unique perspective of personnel as they monitor potentially hazardous or IDLH atmospheres or environments.

Other professionals have recently addressed this question of competency for emergency responders, and the need for more training on the proper use of equipment and instrumentation (Noll, 2008; Wagner, 2006). These guiding principles are also covered thoroughly in the U.S. federal standards for protecting the environmental and worker (EPA, 2015; OSHA, 2015). Both OSHA HAZWOPER (29 CFR 1910.120) and EPA (Title 40, Part 311) regulations give requirements for competencies of personnel who respond to hazardous materials incidents, including air monitoring. Responders must be able to assess the hazards and take appropriate actions based on the incident facts regardless of their response discipline and as the scope of standards apply.

The need for trained responders during incidents of all types is of vital importance. Organizational standard operating procedures (SOPs) may provide some guidance for responder competencies and, regardless, organizations must train personnel to meet NFPA firefighter standards for certification (NFPA, 2008). Local communities are responsible for protecting their citizens from hazardous materials, which includes identifying the resources necessary for mitigating an emergency. Local officials have the lead role in responding to emergencies involving the release of hazardous materials, with specific responsibility being in the care of the local fire departments (FEMA, 2003). Thus, this reality places the burden upon local governments to supply trained personnel and hazardous materials incident management, capable of properly using the tools available to them for incident characterization, control, and management.

A vital part of the first responder's job involves the identification of hazardous materials through the use of container shapes and sizes, identifying markings, interpretation of data from MSDSs, and monitoring of the atmosphere. In most instances, local jurisdictions rely on the fire service to perform this action. Monitoring of the environment ensures citizens as well as responders are protected from hazards. This monitoring includes hazards that are used in industry and are transported. In addition, monitoring activities may include controlled environments, such as homes and products associated with fossil fuel consumption. Furnaces or cooking stoves as well as generators for electrical power, which burn natural gas, propane, gasoline, diesel or charcoal, produce carbon monoxide and other deadly by products that are classified as hazardous materials. Many deaths are attributed to carbon monoxide every year and causes vary from improper use to lackluster maintenance procedures.

First responders must make informed decisions involving life and death situations often in a very chaotic environment. These decisions are based on their abilities to use the assigned equipment correctly, with speed and accuracy. Failure to make the proper decisions may result in a worst case scenario of lives being lost or the evacuation of a facility when it didn't need to be evacuated. The shutting down of major thoroughfares, evacuation of residents, and life safety all cost money, and the inability or ability to make informed decisions will be reflected in those costs.

This study's hypothesis was that most first responders using a four-gas monitor do not understand its basic principles of operation or how to interpret the values measured. This includes confusion, misunderstanding, and misinterpretation associated with monitor outputs, operation, units, alarm settings, and calibration. The following section provides the methodology chosen to test this hypothesis and to address the issue of competency. The methodology section is then followed up with sections that include the data and results realized as well as the conclusions and recommendations from the study.

Methodology

A competency study was conducted involving incident first responders in the fall of 2014 in a large metropolitan are in the Southeast U.S. The competencies that were evaluated involved the operation of a typical four-gas atmospheric monitor and the interpretation of the measurements. The instrument that was used to assess first responder competencies was an eight question questionnaire designed to test these competencies.

The sample of first responders assessed were from a municipal fire department consisting of career first responders, a small-town fire department consisting of both career and volunteer first responders, and an all-volunteer fire department. Since there are many brands and models of four-gas monitors on the market, the eight questions developed for the survey were very generic in nature and were germane to all of the monitors available in the market today. One hundred-eighty subjects in total were survey for this study.

The test subjects were in a controlled classroom environment. No foreknowledge of the survey existed among the participants. Once briefed, participants were then directed to turn over the question sheet and given 2 ½ minutes to complete. No identification markings were made or attempted for each of the surveys because the survey is not to be used for judgment or criticism of the test subjects by their respective administrative staffs. The results of the surveys were not supplied to any of the participating departments.

Some study variables existed and were accounted for with best practice; however, these could not accurately be used as a 100% proof positive guideline. For example, four-gas monitors use different calibration gases for meter calibration in response for flammable/explosive atmospheres. Due to anonymity, we chose to select any of the possibilities that may be used for this calibration procedure. The participant may have produced a correct answer based on this, but may actually have the incorrect answer based on the monitor and gas used by their organization. An attempt was made to minimize the number of these types of data biases.

Data and Results

The following paragraphs begin by providing each of the questions asked and then followed with the results ascertained. Since there are four particular gases monitored by each instrument, questions 2 ,3, and 4 each have four correct answers. The analysis of data was broken down into all four parts and combined as one question. There were 4 potential answers multiplied by 185 test subjects, resulting in 740 possible correct answers. The toxic sensor used by the various fire departments will vary. For example, some departments use H_2S, and others use HCN, still others may use something different; thus, any toxin listed (other than CO) would constitute a correct answer.

Questions 1 and 8 - How long have you been an emergency responder?
This question was explained prior to the start of the survey. Instructions were given to include either career or volunteer or a combination of the two. Any answer was acceptable. The participants knew what the question was before they turned over the survey and did not spend time figuring numbers for their service to the community. This did not hamper their abilities in answering the pertinent questions about the monitor.

Question 2 – What 4 gases does the monitor measure?
A first responder should be able to list these without any difficulties. The gasses were able to be listed in any order the test subject wanted. Some departments use H_2S while others use HCN or another chemical sensor specific to the gas of their concern; thus, any toxin listed, with the exception of carbon monoxide, was counted as a correct answer. Out of 740 possible correct answers, the participants responded correctly 565 times and incorrectly 175 times. This equates to 76.35% correct responses and 23.65% incorrect responses. If you break the data down to each specific sensor, the percentage of correct responses for oxygen was 87.03%, for lower explosive limit was 63.24%, for carbon monoxide was 89.19% and for a specific toxin was 66.95%.

Question 3 – What units (ppm or percent) are used for each of the four gases?
The answers supplied reflected the gases listed in Question 2. The answer should also represented knowledge of the four gases and the interaction with the monitoring device. Out of 740 possible responses, 412 of the questions were answered correctly while 328 were incorrect in their response. Thus, the survey responders answered correctly 55.68% of the time and wrongly 44.32% of the time. The breakdown for each sensor was a follows: Oxygen – 64.32% of respondents supplied the correct answer; LEL – 45.95% of respondents supplied the correct answer; Carbon Monoxide – 65.95% of respondents answer correctly; Toxin – 46.49% answered correctly.

Question 4 – What are the alarm limits for the 4 gases (ppm or percent)?
The answers supplied reflected the gases in question 2 and 3. The answer also represented knowledge of the four gases and the interaction with the monitoring device. This also represents knowledge of the particular hazards associated with each of the four gases and their response levels. Out of the potential 740 results for this question, 175 of the answers were provided correctly, with 565 of the answers being incorrect. The percentage of correct responses was 23.65%, with the percentage of incorrect responses being 76.35%. The breakdown for each sensor was: Oxygen – 10.27% of respondents supplied the correct answer; LEL – 32.43% of respondents supplied the correct answer; Carbon Monoxide – 40.54% of respondents answer correctly; Toxin – 11.35% answered correctly.

Question 5 – What is the calibration gas used to obtain the LEL reading for your monitor?
Four-gas monitors use different calibration gases for calibration in response to flammable/explosive atmospheres. Due to anonymity, the participant may have produced a correct answer for the survey, but may actually have the incorrect answer based on the monitor and gas used by the organization. Several clear failures are: No answer supplied and listing of a particular toxin (e.g., identifying hydrogen cyanide as the calibration gas for explosive/flammable limits). Out of 185 surveys, 68 respondents answered this question correctly. This equates to 36.75% of those surveyed being able to identify a suitable calibration gas for LEL.

Question 6 - How often is your monitor either bump tested and/or calibrated?
The research team could quickly verify with the organizations supplying the test subjects, but due to anonymity and the answer variances, a large selection of criteria was available for the correct answer. Perhaps the most compelling point is that the test subjects realized and understood what the question asked, and therefore, supplied an answer unless a clearly wrong answer was provided. Out of the 185 respondents, 155 answered this question correctly. This equates to 83.78% of those surveyed being able to identify a specific time when the monitor is bump tested and/or calibrated.

Question 7 – When would you do a fresh air calibration?
This answer varies as a large selection of criteria was available for the correct answer. Typical correct answers would include each use, when the numbers start reading negative, daily and before entering an area. Out of the 185 surveyed, 134 respondents answered this question correctly. This equates to 72.43% of those surveyed being able to identify a time or reason when/why a fresh air calibration is to be completed.

The results from questions 2-7 are also provided in the pie charts shown in Figures 1-6.

Conclusions and Recommendations

The following is a list of some of the pertinent conclusions and recommendations from the study:

1. For the identification of oxygen and carbon monoxide as two of the correct gases, the respondents scored 87% and 89%, respectively. Due to the numerous calls regarding potential carbon monoxide releases, these are perhaps the most used in the fire service by first responders. In addition, the respondents faired pretty well on the questions regarding bump/calibrate and fresh air calibration. They were able to answer these questions correctly 83% and 74% of the time.
2. There was a lack of understanding among those surveyed of how the monitor either reads some of the gases in ppm while others as a percentage. This was evidenced by a decrease to an average of 55% correct responses on this question.
3. There was even a more dramatic drop in understanding the aspects regarding instrument alarms. The respondents only answered this question with 23.5% correct response rate.
4. Identifying which gas is used to calibrate the monitor for LEL was correctly responded to by 36% of the survey test subjects. This is a serious issue because the analysis of the data requires the use of correlation charts for conversions, which are based on the calibration gas.
5. It is recommended that a survey be used by each department to assess their capabilities and individual needs regarding training of personnel on the proper use of and the interpretation of the results realized by the four-gas monitor.

Without a thorough statistical analysis of the data, it cannot be proved (or disproved) that the first responders lacked all of the competencies required to properly use a four-gas monitor in the field. However, even without a mathematical analysis, it can be argued that the hypothesis of the study was proven for some aspects studied regarding first responder competencies and the use of a four-gas monitor. As evidence, one significant finding from the study involved the number of individuals that scored a perfect score on the survey – this was only five respondents out of the one hundred eight-five surveyed.

In conclusion, from the data gathered in this study, there appears a lack of general competence by first responders when it comes to air monitoring with a typical four-gas monitor or when being questioned about its proper use. A lack of knowledge could prove devastating in a courtroom environment or compromise public health and safety as well as the safety of the first responders. Based on information garnered in this study, training should occur with more detail and frequency for first responders with regards to the atmospheric monitoring of the ambient air near an incident for first responders, with competence levels verified to minimize the potential for future serious injuries or death occurring during a response to a hazardous materials incident.

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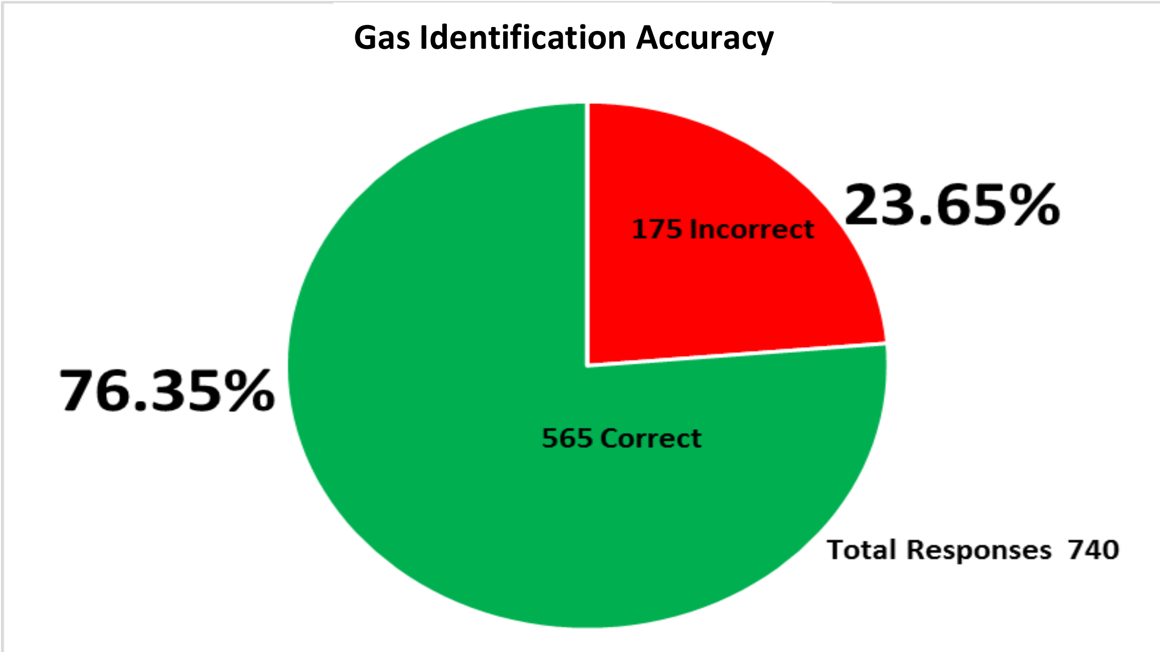

Figure 1 – Gas Identification Accuracy

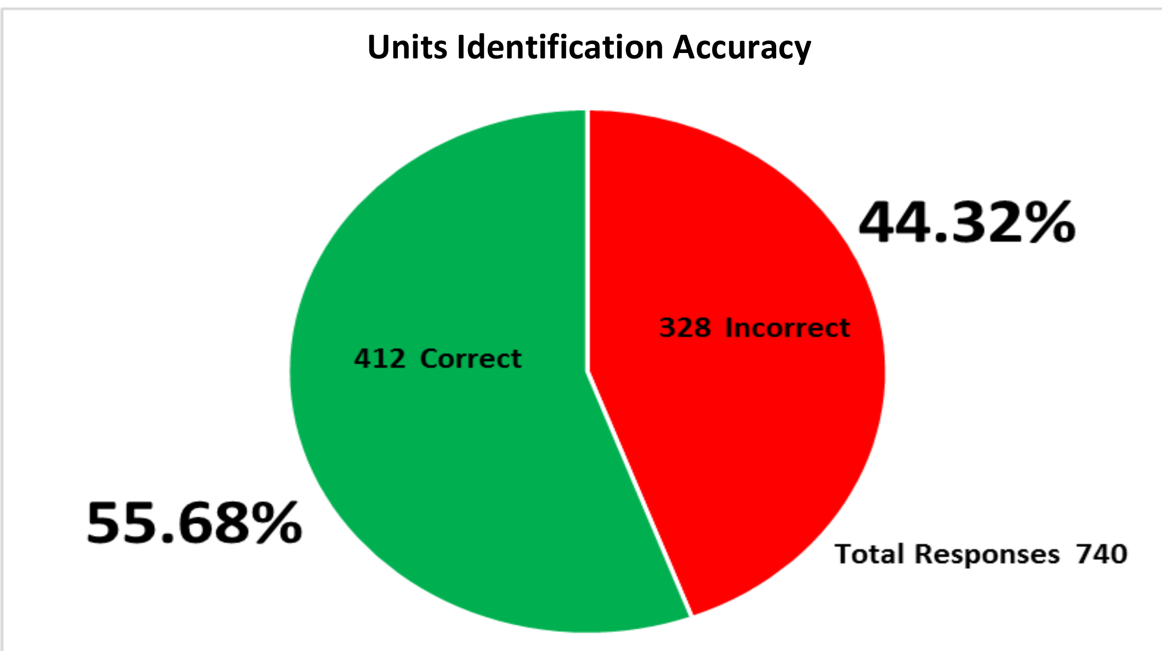

Figure 2 – Units Identification Accuracy

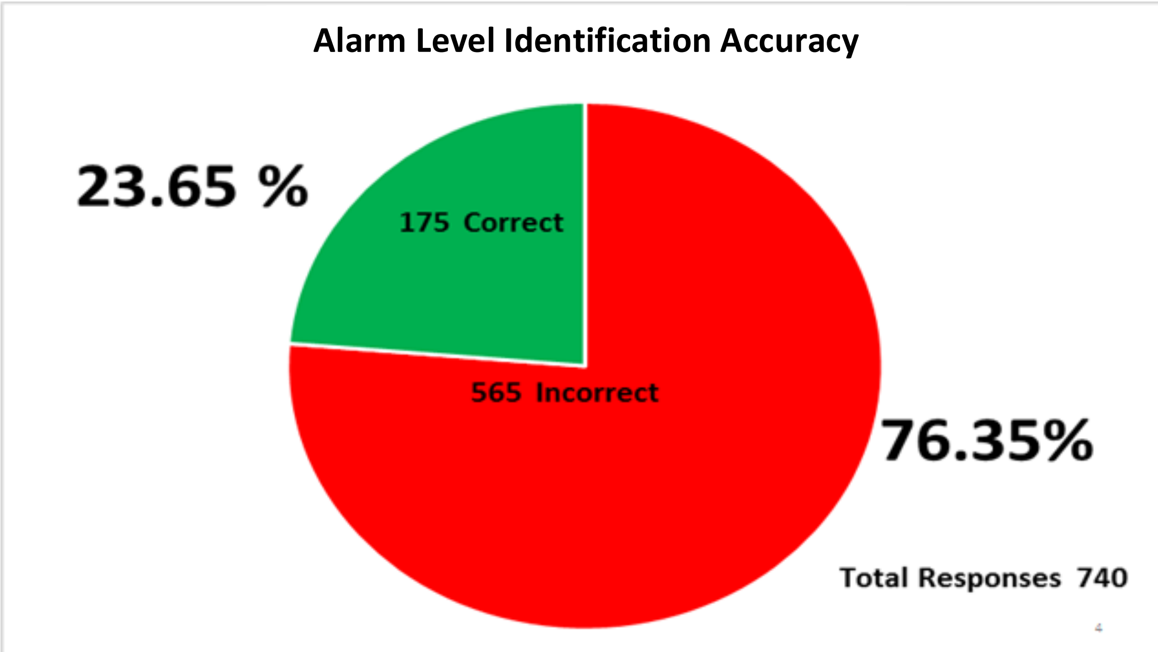

Figure 3 – Alarm Level Identification Accuracy

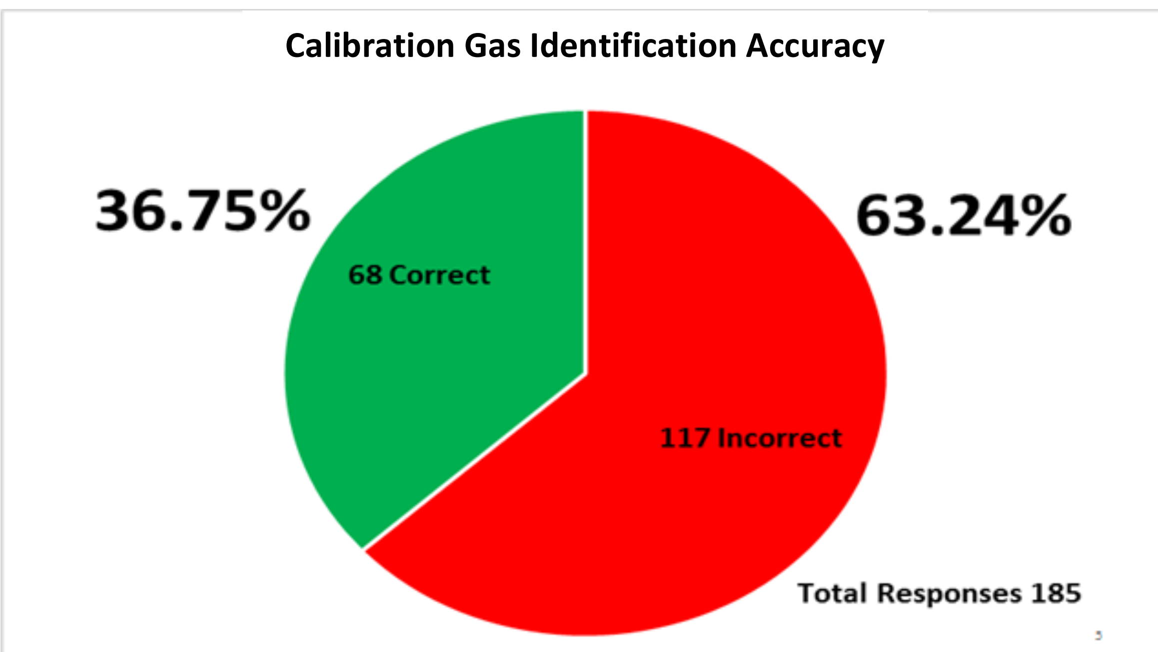

Figure 4 – Calibration Gas Identification Accuracy

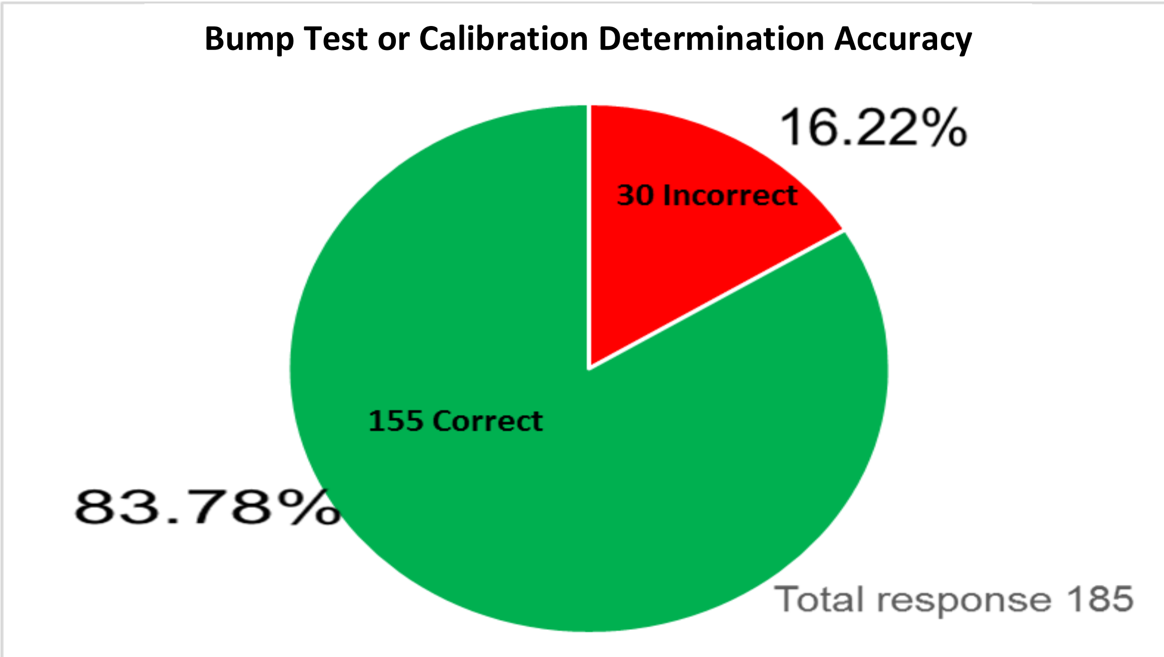

Figure 5 – Bump Test or Calibration Determination Accuracy

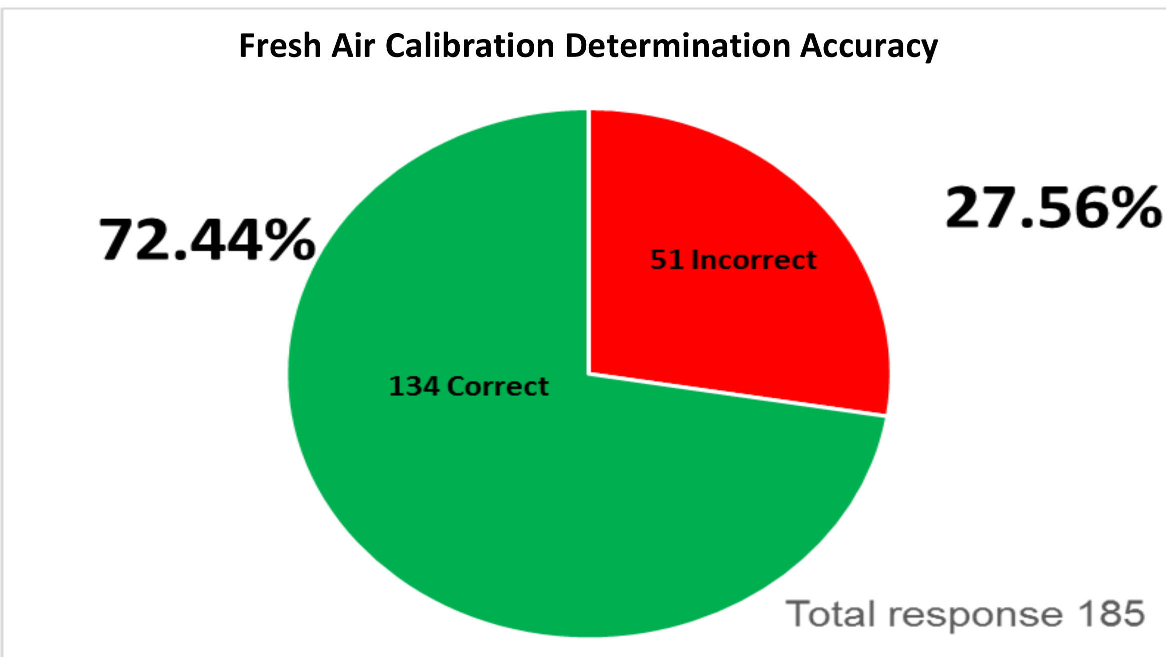

Figure 6 – Fresh Air Calibration Determination Accuracy

BIOS

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