Identifying Strategies to Improve SCBA Air Management During Fire Division Emergency Operations

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used language, ideas, expressions, or writings of another.

Signed: ________________________________
Abstract

The problem was the Kinston Department of Public Safety (KDPS) Fire Division personnel were not properly managing their air supply and frequently relied on the SCBA low-air alarm activation to indicate when to exit IDLH atmospheres. The purpose of this applied research project (ARP) was to identify strategies to improve air management during emergency operations to increase the probability that KDPS personnel exit IDLH atmospheres prior to SCBA low-air alarm activation. Descriptive research was used to answer the following research questions: a) what effect does remaining in IDLH environments until SCBA low-air alarm activation have on emergency operations?, b) Why are KDPS firefighters remaining in IDLH environments until SCBA low-air alarm activation?, c) What approaches to improve SCBA air management have been identified?, and d) What are other organizations doing to improve SCBA air management? Research was accomplished through questionnaires that were distributed to KDPS Fire Division staff, instructors at three advanced SCBA training programs, and chief officers in other North Carolina fire departments.

Results identified behavioral and situational factors that influence a firefighter’s decision to remain in the hazard environment until low-air alarm as well as complications arising from this practice during emergency operations. Key air management approaches and strategies implemented by other fire agencies to improve SCBA air management were also identified.

Recommendations were developed and included the development and implementation of an SCBA air management training program and standard operating procedure, implementation of an air management system that utilizes work cycles and crew rotation in conjunction with air status radio reports, utilization of guidelines and training to create a heightened awareness and cultural shift with regard to SCBA air management, and development
of a staffing plan for implementation of field technicians to monitor crew work cycles during IDLH operations.
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Air management is the process of keeping track of your supply of fresh air and is an important component of emergency operations when respiratory hazards are present. In the past, the low-pressure alarm activation for the self-contained breathing apparatus (SCBA) was accepted as an indicator of when a firefighter should exit the hazard environment. Today we know that this practice can lead to out of air emergencies if unexpected events delay personnel while they are exiting the hazard environment. Out of air emergencies complicate emergency operations and increase the probability of firefighter injury or death (Zimmerman, 2012).

The problem is the Kinston Department of Public Safety (KDPS) Fire Division personnel are not properly managing their air supply and frequently rely on the self-contained breathing apparatus (SCBA) low-air alarm activation to indicate when to exit immediately dangerous to life and health (IDLH) atmospheres. The purpose of this applied research project (ARP) is to identify strategies to improve air management during emergency operations to increase the probability that KDPS personnel exit IDLH atmospheres prior to SCBA low-air alarm activation. The descriptive research method will be used to answer the following research questions: a) what effect does remaining in IDLH environments until SCBA low-air alarm activation have on emergency operations?, b) Why are KDPS firefighters remaining in IDLH environments until SCBA low-air alarm activation?, c) What approaches to improve SCBA air management have been identified?, and d) What are other organizations doing to improve SCBA air management?

Background and Significance

The KDPS Fire Division protects the citizens of Kinston, North Carolina and covers a response area of approximately 17 square miles. The Fire Division operates out of three fire stations that protect a primarily residential area. The fire division is comprised of 48 career firefighters, staffing five fire suppression units in three fire stations. Services provided by the
division include: aircraft rescue firefighting, fire suppression, technical rescue, hazardous materials response, fire prevention inspection programs, and public education programs. These services are provided to residential, commercial, and industrial occupancies (City of Kinston, n.d.).

According to statistics from the National Fire Incident Reporting System (NFIRS) database, the KDPS Fire Division responds to between 800 and 950 emergency incidents each year. Approximately twelve percent of annual incident responses are structure fires and structure fire operations resulted in ten firefighter injuries in the previous seven year period (United States Fire Administration [USFA], 2013).

It is not uncommon to hear SCBA low-air alarm activations when KDPS Fire Division personnel operate at structure fire incidents. In some cases, KDPS personnel will continue to work into their emergency air reserve before exiting the hazard area at these incidents. Many of the personnel do not properly manage their air supply and rely on the SCBA low-air alarm as an indicator of when to exit the IDLH environment. This practice can be problematic if firefighters encounter unexpected delays or become disoriented while exiting the hazard area. According to Sullivan (2009) rapid changes in fire behavior can be hidden by thick smoke layers above crews and firefighters can become disoriented after advancing deep into complex or large-area structures while conducting search efforts for victims. The SCBA low-air alarm activates when the pressure in the air cylinder reaches approximately one-quarter remaining. By using this alarm as an indicator of when to exit these situations, firefighters are relying on the remnants of their air cylinder to provide enough time to exit the hazard area to a safe zone. Complications or obstacles that often exist in structures with large and complex floor plans can delay a firefighter’s escape resulting in them running out of air before they can self-evacuate. These out
of air emergencies often require deployment of the Rapid Intervention Crew which further complicates and delays mitigation of the emergency incident (Hinton, 2006).

On November 2, 2011, the KDPS Fire Division encountered an out of air emergency while personnel were performing emergency operations at a three alarm structure fire in a textile plant. The 109,000 square foot structure contained a complex internal configuration and the rear portion of the building contained large bales of cotton. These 1,000-pound bales of cotton added to the complexity of the internal configuration of the building. A number of fire personnel were operating to extinguish a fire in the rear portion of the structure when two of the personnel experienced an out of air emergency while attempting to self-evacuate. The two transmitted a Mayday over the radio when they became disoriented and realized that they were nearly out of air and could not quickly locate an egress point. The Rapid Intervention Crew was deployed to locate and assist with their evacuation from the hazard area. Luckily they were quickly located and removed only suffering minor injuries (Lynn, 2011).

This type of fire represents a low frequency event for the KDPS Fire Division as typical structure fire operations for the division occur in 1,500 to 2,000 square foot residential structures. Personnel have become accustomed to relying on the SCBA low-air alarm to indicate when to exit the hazard area in these smaller structures where the travel distance to an egress point is often a short distance. This tactic can be problematic in large commercial structures with longer travel distances to egress points. According to Sullivan (2009) many firefighter fatalities resulting from asphyxiation occur because personnel fail to manage their air supply or treat an incident like a typical residential fire in terms of air management. The near miss suffered by the KDPS Fire Division on November 2, 2011 could have easily resulted in two firefighter fatalities. Avsec (2008) notes the need to change the “SCBA culture” in the fire service to prevent injuries
and fatalities due to out of air emergencies in the hazard area. It is imperative that air
management strategies are identified to increase the probability that KDPS personnel exit IDLH
atmospheres prior to SCBA low-air alarm activation. There is a potential for additional near miss
events if KDPS personnel do not begin to properly manage their air supply during emergency
operations in hazardous environments.

This ARP is directly related to the Executive Fire Officer Program (EFOP) Executive
Analysis of Fire Service Operations in Emergency Management course, specifically the need to
strengthen preparedness by taking actions to identify and improve “vulnerability points” that
affect emergency operations (USFA, 2012, p. SM 5-28). By identifying strategies to improve air
management, the KDPS Fire Division can take actions to improve the safety and efficiency of
emergency response operations. Additionally, the topic of this ARP supports the USFA strategic
objective of improving the capability of the fire service to respond and recover from all hazards.

Literature Review

According to Brunacini (2008) fire service personnel are effective to the extent that they
can operate and successfully intervene during emergency operations. To be effective they must
manage their work in the hazard zone, ensuring proper work cycles are utilized in conjunction
with rehab of available personnel on scene. For many departments, staffing is a finite resource at
emergency scenes and work cycle management is essential to ensure the availability of personnel
throughout the emergency operation. Firefighters that work in the hazard area until SCBA low-
air alarm activation have chosen a long work cycle and increase their workload on the fire scene.
Standard practices in many fire service organizations and publications encourage a two-cylinder
rotation policy during emergency operations in IDLH atmospheres. Each firefighter that exits the
hazardous environment prior to low-air alarm activation can use two 30-minute SCBA cylinders
consecutively before a visit to the rehabilitation area is required. Firefighters who continue to work into the SCBA low-air alarm must rotate through the rehab area prior to returning to work in the hazard area, which can affect crew rotation and available staffing during the operation (Gagliano, Phillips, Jose, & Bernocco, 2008).

According to Hinton (2006) working into the SCBA low-air alarm at emergency incidents discounts the need for timely relief of crews performing labor-intensive work. This type of work cycle pushes firefighters to close to the edge and can increase the likelihood of out of air emergencies. Numerous firefighter fatalities during emergency operations are attributed to firefighters running out of air and dying of asphyxiation. The air in the SCBA is critically important to the survival of firefighters during structural firefighting operations. Running out of air in a fire increases the chance of being injured or dying exponentially. By remaining in the IDLH environment until low-air alarm activation, firefighters increase the probability that they will cease to be part of the solution to the emergency and become part of the problem. Not only do out of air emergencies compromise firefighter safety, they drastically complicate emergency operations. These events often necessitate deployment of the Rapid Intervention Crew, adding firefighter rescue to the list of strategic priorities for the incident.

Remaining in the IDLH environment until low-air alarm activation can also desensitize the activation of the low-air alarm as an immediate action item during emergency operations. When firefighters continually remain in the IDLH environment until low-air alarm activation, the urgency of the alarm diminishes and in many cases the alarm activation becomes a nuisance to be ignored instead of an emergency alarm. Personnel do not rush to check the status of an individual in low-air alarm because the sound of the alarm has become commonplace during emergency operations. This “false-alarm mentality” can create problems during emergency
operations when a firefighter’s low-air alarm is a true emergency alarm. There are documented cases when the aforementioned “false-alarm mentality” has resulted in the severe injury of fire personnel when they ran out of air as a result of their low-air alarm activation being ignored by other personnel during emergency operations (Gagliano et al., 2008).

According to Sullivan (2010) firefighters have a precarious notion that they can outperform their enemy and many choose to ignore the flaws in this theory. They often refuse to apply sound air management principles and provide unreliable excuses to support the notion that they can operate for extended periods at fire incidents. This work until you run out of air approach creates a powerful attraction that is embedded in fire service tradition (Hinton, 2006). This mentality can be related to a “hero culture” present within the fire service that causes poor risk/gain decision-making. The heroic firefighter is viewed as one who takes chances to save lives and property, often putting the heroic deed ahead of the safe one (Kupietz, 2011; Stehman, 2012). Ego plays into the hero culture and interferes with decision-making and teamwork at emergency incidents. It allows firefighters to develop the attitude that they are the only ones on the fire ground that can get things done and sometimes results in the inability to admit that assigned tasks cannot be completed. This can cause the firefighter to work into their SCBA emergency air reserve because they do not want someone else to finish the job they started (Gagliano et al., 2008).

According to Sullivan (2009) firefighters remain in the IDLH atmosphere until low-air alarm activation due to a misplaced confidence in their air supply. Firefighters are relying on the emergency reserve air remaining after low-air alarm activation to provide enough time to safely exit the hazard area. He contends that this misplaced confidence results in firefighters not taking into consideration unforeseen circumstances that could delay their egress during emergency
operations. Other factors that result in the failure to exit prior to low-air alarm activation include improper training and tunnel vision resulting in a lack of situational awareness. Firefighters that have not been properly trained in air management techniques are more likely to routinely work into their low-air alarm at incidents. A lack of training can result in misplaced assumptions about air supply duration and a failure to routinely monitor air levels during emergency operations. Tunnel vision can impair a firefighter’s judgment and cause their focus to become too narrow. This narrow focus can result in a failure to maintain the situational awareness needed to recognize warning signs or changing conditions in the hazard environment. For example, the desire to push forward with search and rescue becomes more important than exiting due to a diminishing air supply (Gagliano et al., 2008; Sullivan, 2009).

The “single-family dwelling air use mentality” is causing many firefighters to remain in the IDLH environment at commercial structure fires until low-air alarm activation. Fire personnel have become accustomed to working until low-air alarm at single-family dwellings and apartment building fires and in most cases have still been able to exit the structure before their air supply is exhausted. This has given fire personnel a false sense of security in how SCBA air supply is utilized in structure fires. Commercial buildings, unlike single-family dwellings, have limited egress and uncommon layouts. Firefighters are using a mind-set geared toward single-family dwellings, with regard to SCBA air use in commercial buildings, resulting in firefighter injuries and fatalities due to out of air emergencies (Gagliano et al., 2008).

Several approaches to improve air management have been identified. The first approach was developed by a group of firefighters from Seattle, Washington. This approach centers on a behavioral shift in which discipline in the management of air supply is achieved through training and standard operating procedures. The approach involves procedures to ensure that firefighters
exit the hazard area prior to the activation of their SCBA low-air alarm. The approach centers on the Rule of Air Management (ROAM) and the Point of No Return. The ROAM states, “Know how much air you have in your SCBA and manage that air so that you leave the hazardous environment before your SCBA low-air alarm activates” (Gagliano, Phillips, Jose, & Bernocco, 2006, p.11).

According to these Seattle firefighters, it is each individual firefighter’s responsibility to manage their air supply. They contend that the ROAM can be combined with any technological or personnel advancement, but does not rely on these advancements.

The ROAM involves several key components. The first component is a check of the air supply before entry, verifying the amount of available air supply and that nothing has gone wrong with the SCBA prior to smoke exposure in the hazard area. A second critical component of the ROAM is a routine check of the air status by the individual and team leader during the operation. This check serves as a reminder of where the crew stands in regard to air level and increases situational awareness, keeping the team from getting tunnel vision while performing assigned tasks. The final component is the requirement for the team to exit the hazardous atmosphere before the SCBA low-air warning alarm activates. The final 25 percent of the SCBA cylinder is the emergency air reserve and should only be utilized when something has gone wrong for the firefighter or crew (Gagliano et al., 2006).

The Point of No Return is the point at which the remaining operation time of breathing apparatus equals the time necessary to return safely to a nonhazardous atmosphere. It is at this point that a firefighter or team of firefighters stop becoming part of the solution and start to become part of the problem. It is a key concept that is many times overlooked in aggressive interior fire operations. Firefighters often reach the Point of No Return when they fail to properly
manage their air supply, stay in the hazard area too long, and run out of air. Factors that affect the Point of No Return include location of the entry point into the hazard area, the firefighters’ physical condition, firefighter size, and the type of work being performed (Bernocco, Gagliano, Jose, & Phillips, 2005). According to Pindelski (2007) each firefighter is responsible for determining their individual Point of No Return when entering a hazardous atmosphere. Part of proper air management is not relying solely on the SCBA low-air warning device to determine when it is time to exit the hazardous atmosphere.

Bernzweig (2004) advocates a second approach to improve air management. He contends that it is not realistic or fair to expect firefighters assigned to task and tactical level work to monitor their air volumes when engaged in heavy work. He argues that an increase in the firefighter SCBA emergency air reserve is necessary to expand the time available to exit. He offers two options to expand the time to exit for firefighters. First, fire departments can provide more air in the emergency reserve by using larger 45-minute or 60-minute SCBA cylinders instead of 30-minute cylinders. A second option is an increase in emergency reserve air by changing SCBA so that the low-air alarm activates prior to reaching 25 percent of the remaining service life. This would require a change to Federal Regulation 42 CFR part 84. This regulation currently requires the service-life indicator or warning device to give an alarm when the remaining service life of the SCBA is reduced within a range of 20 to 25 percent of its rated service time. Bernzweig suggests a change in the wording of the regulation to state that the service-life indicator or warning device shall give an alarm when the remaining service life of the SCBA is reduced to not less than 25 percent of its rated service time. This would give fire departments the option to increase emergency reserve air supply without increasing SCBA
cylinder capacity. In either case, Bernzweig contends that expanding the amount of air available to exit is the real solution to the air management problem.

Another method to improve air management utilizes time-on-scene radio transmissions from the dispatch center as a cue for fire personnel to check the remaining air levels in their SCBA cylinders. With this method, the emergency dispatch center comes over the radio at five minute intervals during emergency operations and announces the time on scene. This radio report prompts fire personnel in the hazard environment to check their SCBA air level. This method requires training to ensure that personnel faithfully check their air when the dispatch center announces time-on-scene over the radio. The method also requires firefighters to follow the ROAM. Fire personnel check their air levels every five minutes and know that they must exit the IDLH environment before their low-air alarm activates. The time-on-scene method, when coupled with the ROAM, can be an effective method of improving air management (Gagliano et al., 2008).

The Reilly-Emergency Breathing Technique (R-EBT) was developed to help firefighters conserve their air supply during emergency situations. This method is currently recommended only during firefighter emergencies. Firefighters can use the technique to extend their air supply when they become lost, trapped, or entangled in the hazard environment and are low on air. With this method, the firefighter inhales normally and then hums the breath out in a slow, consistent manner while exhaling. The normal breath cycle is approximately four to six seconds, but using the R-EBT can extend the breath cycle to approximately twelve seconds. An evaluation of the R-EBT found that the average firefighter could extend their emergency air reserve by two minutes with utilizing this method (Reilly & Ricci, 2008).
Fire service organizations have implemented a variety of strategies to improve air management. The Phoenix Fire Department has implemented a system that utilizes work cycles and crew rotation along with regular position, air status, conditions, actions, and needs reports (PACAN reports). A field incident technician (FIT) is assigned at emergency incidents to assist the division officers with keeping track of their crew’s work cycles. The system utilizes a three crew rotation system in which one crew is working in the hazard area, a second crew is “on-deck” to relieve the working crew, and a third crew is standing by to relieve the on-deck crew once they rotate into the hazard area. The system also incorporates a training component to teach firefighters to monitor their individual air supply. In conjunction with the individual air management, company officers are required monitor their crew members’ air supplies and provide PACAN reports to incident command at 10 minute intervals during an incident. The system incorporates individual and team based air management with crew rotation to reduce work cycles and get crews out of the hazard area before their low-air alarm activates (Phoenix Fire Department, 2009).

Fire brigades in the United Kingdom work under a national air management system. In this system, firefighters are mandated to report their air supply level to an entry control officer prior to entering a structure fire. Entry control officers are staged at each entry point of the fire building and their job is to track the air status of each firefighter who enters the fire building through a particular entry point. The entry control officers calculate when the low-air alarm will activate for each firefighter wearing SCBA. They keep track of times and advise team leaders to exit the hazard area at a predetermined air pressure reading or time. They are also tasked with keeping track of the location of teams that are operating inside the fire building. The entry control officer’s goal is to have all of the firefighters that they are tracking out of the hazard area
before their low-air alarms activate. At large scale incidents, each entry control officer is assigned an aid to assist with the extra workload and responsibility that accompanies larger fire incidents (Gagliano et al., 2008).

Portland Fire and Rescue has implemented an air management procedure that incorporates individual and team based air management with status reports during emergency operations. Each individual firefighter is responsible for checking their SCBA air pressure prior to entering the IDLH environment. Upon entering the hazard area, the firefighters are responsible for continually monitoring air consumption as an individual and/or team. An automatic air status report must be given to the team leader when the first member of the team reaches 50 percent of their SCBA air supply and teams must request relief to ensure they exit the hazard area prior to low-air alarm activation. Activation of a low-air alarm in the hazard area is an immediate action item requiring the individual/team in low-air alarm to give a status report over the radio to the incident commander. This report must include who is in alarm, their location in the hazard area, and their status. The procedure improves air management through a heightened awareness of individual air supply levels and early notification of low air situations (Bersaas, 2006).

Some fire districts have implemented the half-your-air-and-out system to improve air management and get crews out of the hazard area before their low-air alarm activates. In this system, firefighters work until their SCBA cylinders are half empty and then begin exiting the hazardous environment. Fire departments, such as the Yakima Washington Fire Department, have implemented this system with success. These departments rely on the SCBA heads-up display (HUD) to signal firefighters that their air cylinders are half empty. The HUD is a series of colored indicator lights in the SCBA face piece. When the HUD indicates that a crew member
in the hazard area has reached half their air supply, the team leader must relay this information to command and the crew begins to exit the hazard area (Gagliano et al., 2008).

In summary, this literature review revealed several ways that the failure of firefighters to exit the IDLH environment prior to low-air alarm activation can affect emergency operations at incidents. Increased workloads from longer work cycles, an increased likelihood of out of air emergencies, and a desensitized response to low-air alarm activations in the hazard area can all result from this practice. A variety of behavioral and situational factors can result in firefighters remaining in the hazard area until low-air alarm activation. These include ego resulting in a “can’t quit” or “need to finish the job” mentality, a “hero culture” resulting in poor risk/gain decision-making, a misplaced confidence in their air supply, a failure to maintain situational awareness, and a false sense of security in how SCBA air supply is utilized in structure fires. Methods that have been identified to improve SCBA air management include the ROAM, air status radio reports during emergency operations, an increased exit time created with larger capacity SCBA cylinders and the use of specialized breathing techniques. Strategies such as the use of entry control officers to monitor air pressures of personnel in the hazard area, the ROAM along with pre-entry READY checks, the half-your-air-and-out system, and work cycle/crew rotation systems in conjunction with air status reports have each been utilized by other fire and rescue agencies to improve SCBA air management during emergency incidents.

Information in this literature review has provided the author with a better understanding of behavioral and situational factors that contribute to the failure of firefighters to manage their air supply as well as strategies that could improve SCBA air management and increase the probability that firefighters exit the hazard area prior to low-air alarm activation. The information
influenced this ARP by providing direction for additional research to assist in the development of recommendations to help improve SCBA air management in the KDPS Fire Division.

**Procedures**

The motivation for this research was a need for improved SCBA air management within the KDPS Fire Division. A problem statement, purpose, and research questions were developed. Research began with a review of current literature related to SCBA air management. Three questionnaires were created and distributed to accomplish the research for this ARP. The first questionnaire (Appendix A) was distributed internally to KDPS Fire Division personnel. The questionnaire consisted of six questions and was designed to obtain feedback on why KDPS Fire Division personnel are remaining in the hazard area at emergency incidents until SCBA low-air alarm activation. Some of the questions were designed to solicit either a yes or no response. Other questions provided various choices and included an area for personnel to provide additional information if they felt it was applicable. The questionnaire was distributed to all line personnel in the fire division. Since the KDPS Fire Division consists of less than 50 personnel, sampling was not performed and the questionnaire was distributed to all line personnel in the division. To accomplish questionnaire distribution the Battalion Commander for each shift was utilized. Instructions were included at the beginning of the questionnaire to explain its purpose, the intended use of information obtained through the questionnaire, how to complete the questionnaire, and a desired completion/return date. The questionnaire was distributed on June 24th, 25th, and 26th with an established completion/return date of July 8, 2013.

Two additional questionnaires (Appendix B and Appendix C) were created using SurveyMonkey (2013), a free online survey software. One of these questionnaires (Appendix B) was distributed to instructors for three advanced SCBA training programs. The questionnaire
consisted of six questions designed to obtain feedback on methods to improve SCBA air management and how the failure to properly manage SCBA air supply affects emergency operations. Some of the questions were designed to solicit either a yes or no response. Other questions provided various choices or a text box for respondents to provide a response. Multiple choice questions included an area for the respondent to provide other responses or additional information if they felt it was applicable. The questionnaire was distributed to 15 instructors. The email addresses for the instructors were obtained from the program websites and an email was sent containing an explanation of the purpose of the questionnaire, a completion/close date, and a web link to the online questionnaire created on SurveyMonkey. Emails were sent on June 23, 2013 with a questionnaire completion/close date of July 8, 2013. An additional email was sent out on June 30, 2013 as a reminder of the close date.

The second questionnaire (Appendix C) consisted of six questions designed to obtain feedback on the methods that other fire departments in North Carolina are using to improve SCBA air management. Some of the questions were designed to solicit either a yes or no response. Other questions provided various choices and included an area to provide other responses or additional information if the respondent felt it was applicable. The questionnaire was distributed to officers in 34 North Carolina fire departments. In order to determine the sample population for the questionnaire, a directory of North Carolina fire departments was retrieved from the Internet. Since the KDPS is a career department, only North Carolina fire departments that were career or mostly career were included in the population. The directory was reviewed and a list of 65 fire departments that were categorized as career or mostly career was generated (Fire Department Directory, 2013).
To select a sample from the 65 fire service agencies, the sample size calculator program by Raosoft, Inc. was utilized. This program is a free computer software program available on the Internet. According to the program, the typical margin of error utilized is 5 to 10 percent and the typical confidence level utilized is 90 to 95 percent. The program also recommended using a 50 percent response distribution rate in order to get the largest sample size. Utilizing this program, the appropriate sample size was determined based on a 10 percent margin of error, 90 percent confidence level, population size of 65, and a 50 percent response distribution rate. The recommended sample size was 34 (Raosoft, Inc., 2004).

In order to randomly select the sample population, each of the 65 fire service agencies was assigned a number from 1 to 65. Research Randomizer (2013) was then utilized to generate a random set of 34 numbers between 1 and 65. Research Randomizer is a free online random sampling tool. Fire agencies from the list with numbers corresponding with the random number set were included in the sample population. The email addresses for officers from each of the agencies in the population were obtained from department websites and an email was sent containing an explanation of the purpose of the questionnaire, a desired completion date, and a web link to the online questionnaire created on SurveyMonkey. Emails were sent on June 23, 2013 with a completion/close date of July 8, 2013. An additional email was sent out on June 30, 2013 as a reminder of the close date.

There were limitations associated with this research project. The population for the questionnaires was limited to a small population of instructors for advanced SCBA training programs. Additionally, only KDPS personnel and other career or mostly career fire departments in North Carolina received questionnaires. Some of the fire department web sites only listed a general department email and it is therefore possible that someone in the department other than
an officer may have accessed the external link and completed the questionnaire. Additionally, the questionnaire could have been completed multiple times by personnel in these departments.

Results

The descriptive research method was utilized to obtain data and successfully answer all four research questions. An external questionnaire (Appendix B) was utilized to answer two of the research questions: a) what effect does remaining in IDLH environments until SCBA low-air alarm activation have on emergency operations? and c) What approaches to improve SCBA air management have been identified? The questionnaire was distributed to 15 instructors at three advanced SCBA training programs. Nine questionnaires were completed. All of the responding instructors indicated that they felt that air management was very important during emergency operations in IDLH environments. When asked what effect remaining in an IDLH atmosphere until SCBA low-air alarm activation has on emergency operations, 89 percent of respondents indicated that this practice desensitizes response to low-air alarm activations during emergency incidents. Additionally, 67 percent of the respondents indicated that the practice increases the likelihood of out of air emergencies and increases firefighter work load due to longer work cycles during an incident. Thirty-three percent of the respondents indicated that remaining in an IDLH atmosphere until SCBA low-air alarm activation complicates crew rotation cycles and five percent indicated that this practice negatively impacts the time available for egress from the hazard area.

When asked about approaches that have been identified to improve SCBA air management, key approaches that were identified included training programs and the ROAM, use of air status reports, systematic monitoring and use of the SCBA air supply, and air management protocol development. Fifty-six percent of the respondents also indicated that they
felt that increasing the SCBA cylinder size was not a valid approach to air management. When asked about air management approaches that were taught during their training program, 67 percent of the responding instructors indicated that their training program focused on the ROAM. Additionally, 33 percent of the respondents indicated that air status reports at designated intervals, the half-your-air-and-out system, and the R-EBT were taught in their training program. Key areas identified for improving air management included strong command and division monitoring, time/air readings after predetermined time intervals, development and enforcement of policy, and training.

An internal questionnaire (Appendix A) was utilized to answer the second research question: b) why are KDPS firefighters remaining in IDLH environments until SCBA low-air alarm activation? The questionnaire was distributed to all KDPS Fire Division line personnel and 39 completed questionnaires were returned. Sixty-four percent of the respondents indicated that they frequently rely on the SCBA low-air alarm activation to indicate when to exit the IDLH environment at incidents. Of these respondents, 40 percent indicated that they felt that this was an acceptable practice. When asked what behavioral factors and attitudes contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation, 72 percent of respondents indicated a need to “finish the job” and a misplaced confidence in their air supply. Additionally, 51 percent of responding personnel indicated that ego or a “can’t quit” mentality was a behavioral factor contributing to firefighters remaining until low-air alarm activation. “Hero culture” resulting in poor risk versus gain decision-making was identified as a behavioral factor by 33 percent of respondents. Some respondents also indicated a feeling that they had to work as long as possible due to the limited staffing to perform fire ground tasks as a behavioral factor.
When asked what situational factors contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation, 56 percent of responding personnel indicated “single-family dwelling air use mentality” resulting in a false sense of security in how SCBA air supply is utilized in structure fires as a factor. Tunnel vision and a lack of situational awareness were also indicated as situational factors by 38 percent of responding KDPS line staff. Minimal staffing to perform fire ground tasks and confidence in the ability to exit quickly due to the proximity to exits were also both identified as situational factors resulting in firefighters remaining in the IDLH environment until SCBA low-air alarm activation. Thirty-nine percent of respondents indicated that they felt that they had not received adequate training in air management principles and practices. Of these respondents, 67 percent indicated that they felt that an air management training program would increase the probability that they would exit IDLH environments prior to low-air alarm activation.

An external questionnaire (Appendix C) was utilized to answer the fourth research question: d) what are other organizations doing to improve SCBA air management? The questionnaire was distributed to officers in 34 North Carolina fire departments and 22 of the questionnaires were completed. When asked about methods that have been implemented to improve SCBA air management within their department, three-quarters of the respondents indicated that work cycles and air status reports had been implemented. Additionally, 40 percent of respondents indicated that periodic air checks and radio reports at specific time intervals had been implemented to improve air management. About one-fifth of the respondents indicated the use of the ROAM, while 10 percent or less indicated the use of entry control officers and the half-your-air-and-out system. One respondent indicated the use of integrated accountability software and 15 percent of the respondents indicated that no air management methods had been
implemented within their department. When asked about the development of an air management standard operating procedure or guideline, 64 percent of the responding officers indicated that their department had not developed a policy or guideline to address SCBA air management. Fifty-two percent of the respondents indicated that they had implemented an SCBA air management training program and of these respondents, 71 percent indicated that the training program had improved air management within their department. Only a small percentage of respondents indicated the use of larger capacity SCBA cylinders and only one-third of those utilizing larger cylinders indicated the intent of using the larger cylinders was related to air management.

**Discussion**

Remaining in the hazard area until SCBA low-air alarm affects emergency operations in several ways. Firefighters that work in the hazard area until SCBA low-air alarm activation have chosen a long work cycle and this increases their workload on the fire scene. Working into the low-air alarm discounts the need for timely relief of fire crews and can affect crew rotation and available staffing during an emergency operation (Gagliano et al., 2008). Hinton (2006) notes that working into the SCBA low-air alarm at emergency incidents pushes firefighters to close to the edge and can increase the likelihood of out of air emergencies. These out of air emergencies compromise firefighter safety and complicate emergency operations often requiring deployment of the Rapid Intervention Crew and adding firefighter rescue as a strategic priority for an incident. Data from the external questionnaire (Appendix B) supports the aforementioned statements concerning working into the SCBA low-air alarm. All of the respondents to the external questionnaire indicated that SCBA air management was important to firefighter safety during emergency operations. Over two-thirds of the respondents indicated that working into the
low-air alarm affects emergency operations by increasing firefighter work load and increasing the likelihood of out of air emergencies. Additionally, one-third of the respondents indicated that the practice complicates crew rotation cycles during emergency incidents.

The practice of remaining in an IDLH environment until low-air alarm activation can desensitize the activation of the low-air alarm as an immediate action item and creates a “false-alarm mentality.” In some cases this “false-alarm mentality” results in firefighter injuries during emergency operations when a firefighter’s low-air alarm is a true emergency and immediate action is not taken (Gagliano et al., 2008). Data from the external questionnaire (Appendix B) supports this “desensitization” as an issue during emergency operations. Eighty-nine percent of respondents indicated a desensitized response to SCBA low-air alarm activations during emergency operations as a problem created by firefighters remaining in the hazard area until low-air alarm.

Several behavioral factors motivate firefighters to remain in the IDLH atmosphere until SCBA low-air alarm activation. According to Sullivan (2009) firefighters remain in the hazard area until low-air alarm due to a misplaced confidence in their air supply and reliance on the emergency air reserve to provide adequate time for egress. Ego, a “hero culture” in the fire service, and a need to outperform the enemy result in the refusal to utilize sound air management principles and poor risk/gain decision making during fire operations (Sullivan, 2010; Kupietz, 2011; Stehman, 2012). Firefighters often develop the attitude that they are the only ones on the fire ground that can get things done and this sometimes results in the inability to admit that assigned tasks cannot be completed. This can cause the firefighter to work into their SCBA emergency air reserve because they do not want someone else to finish the job they started (Gagliano et al., 2008). Data from the internal questionnaire of KDPS personnel (Appendix A)
indicates that the aforementioned motivators are also an issue in the KDPS Fire Division. Seventy-two percent of responding KDPS personnel indicated a need to finish the job they started and a misplaced confidence in SCBA air supply as a behavioral factor contributing to firefighters remaining in the IDLH environment until low-air alarm activation. Additionally, 51 percent of respondents indicated that ego and a “can’t quit” mentality was a behavioral factor. “Hero culture” was identified as a factor contributing to firefighters remaining in the hazard area until low-air alarm by 33 percent of the respondents. Other KDPS respondents indicated that they felt they must work as long as possible during emergency operations to complete firefighting tasks.

Situational factors such as improper training, tunnel vision and a lack of situational awareness can also result in the failure of firefighters to exit the hazard area prior to low-air alarm activation. These factors can result in misplaced assumptions about air supply duration, a failure to monitor air levels, and a failure to maintain the situational awareness needed to recognize changing conditions during emergency operations (Gagliano et al., 2008; Sullivan, 2009). The “single-family dwelling air use mentality” is also a contributing factor. Fire personnel have become accustomed to working until low-air alarm in fires at single-family dwellings and in most cases have been able to exit these structures before their air supply is exhausted. This practice has resulted in a false sense of security in how SCBA air supply is utilized and increases the likelihood of firefighter injuries and fatalities due to out of air emergencies in commercial type structure fires (Gagliano et al., 2008).

The “single-family dwelling air use mentality” was identified as a factor contributing to firefighters remaining in the hazard environment until low-air alarm by 56 percent of KDPS personnel responding to the internal questionnaire. Additionally, some KDPS personnel
indicated a confidence in the ability to exit quickly due to the proximity to exits as a situational factor. This correlates with the “single-family dwelling air use mentality” as multiple exits are typically accessible in residential type structures. Additionally, 38 percent of responding KDPS personnel identified tunnel vision and a lack of situational awareness as factors contributing to firefighters remaining in the IDLH environment until SCBA low-air alarm activation.

Various approaches to improve SCBA air management have been identified. One approach centers on a behavioral shift and belief that it is each individual firefighter’s responsibility to manage their air supply during IDLH operations. The approach incorporates the Rule of Air Management (ROAM) and the Point of No Return. This approach involves discipline in the management of air supply and requires firefighters to perform constant air supply checks and maintain situational awareness during IDLH operations (Gagliano et al., 2006). Bernzweig (2004) advocates an approach that increases the SCBA emergency reserve thus expanding the time available to exit the IDLH environment. This is accomplished by utilizing larger capacity SCBA cylinders or by changing SCBA so that the low-air alarm activates prior to reaching 25 percent of the remaining service life. In either case, Bernzweig contends that expanding the amount of air available to exit is the real solution to the air management problem. Time-on-scene radio transmissions from the dispatch center at designated time intervals have also been identified as a method to improve air management (Gagliano et al., 2008). Additionally, the Reilly-Emergency Breathing Technique (R-EBT) has been identified as an approach to control breathing during IDLH operations and to extend the SCBA air supply (Reilly & Ricci, 2008).

Research during this ARP also identified many of the aforementioned air management approaches. Advanced SCBA instructors responding to the external survey (Appendix B) indicated training programs and the ROAM, use of air status reports, systematic monitoring and
use of the SCBA air supply, and air management protocol development as key approaches to improve air management. Sixty-seven percent of the respondents indicated that their training program focused on the ROAM, while 33 percent of the respondents indicated that air status reports at designated intervals and the R-EBT were taught in their SCBA training program. Contrary to Bernzweig (2004), 56 percent of the respondents indicated that they felt that increasing the SCBA cylinder size was not a valid approach to air management. It is important to note that some fire departments are opposed to the use of larger capacity SCBA cylinders as they result in firefighters working longer in the hazard area which can result in greater work stress and greater potential for injury and overexertion. Increasing the capacity of SCBA cylinders is not a viable option for the KDPS as the department recently purchased Scott 30-minute SCBA to replace existing SCBA within the Fire Division.

Fire service agencies have implemented a variety of strategies to improve SCBA air management. Some utilize the half-your-air-and-out system, working until half the air supply is exhausted and then exiting the hazard area. Others, such as fire agencies in the United Kingdom, utilize entry control officers to track the air status and location of teams that are operating inside the fire building and to notify team leaders when to exit the hazard area (Gagliano et al., 2008). The Phoenix Fire Department has implemented a strategy that utilizes work cycles and crew rotation in conjunction with radio status reports and field technicians assigned to track each crew’s work cycles at incidents (Phoenix Fire Department, 2009). Other fire departments have implemented air management procedures that incorporate individual and team based air management with status reports during emergency operations (Bersaas, 2006).

Data collected from the external survey (Appendix C) indicates that North Carolina fire departments are utilizing similar strategies. The largest percentage of respondents indicated that
work cycles and air status reports had been implemented to improve air management within their department. Forty percent of respondents indicated that periodic air checks and radio reports at specific time intervals had been implemented while 20 percent of respondents indicated the use of the ROAM and pre-entry READY checks. Less than 10 percent of the respondents indicated that entry control officers or the half-your-air-and-out system had been implemented and 15 percent of the respondents indicated that no air management methods had been implemented within their department.

Protocol development and training programs focused on air management have been identified as key areas of focus in efforts to improve air management within the fire service (Gagliano et al., 2008). About one-third of the officers responding to the external survey (Appendix C) indicated that their department had implemented an SCBA air management policy or guideline. Additionally, 52 percent of the respondents indicated that their department had implemented an SCBA air management training program. Furthermore, 71 percent of the respondents with implemented training programs indicated that the training program had improved individual air management within their department.

Recommendations

The results of this ARP have identified a variety of strategies that can improve SCBA air management during emergency operations and increase the probability that personnel exit the hazard area prior to low-air alarm activation. The KDPS Fire Division should consider the following recommendations. First, it is recommended that the KDPS Fire Division develop and implement an SCBA air management training program for department personnel. The program should focus on the ROAM and Point of No Return as well as emergency breathing techniques such as the R-EBT. The program should also address factors that affect individual air
consumption rates and incorporate a training component to teach firefighters to monitor their individual air supply. Behavioral and situational factors that contribute to firefighters working until SCBA low-air alarm should also be addressed in the program.

It is recommended that the fire division implements an air management system during IDLH operations that utilizes work cycles and crew rotation in conjunction with air status radio reports. The system should incorporate individual and team based air management with crew rotation to reduce work cycles and get crews out of the IDLH environment prior to low-air alarm activation. Time intervals for operating crews to transmit air status radio reports during IDLH operations should also be established.

Additionally, it is recommended that the KDPS Fire Division develops and implements an air management standard operating procedure that outlines air management training requirements and air management procedures for IDLH operations at emergency incidents.

It is recommended that the fire division utilizes guidelines and training to create a heightened awareness and cultural shift with regard to SCBA air management making it unacceptable to remain in any IDLH environment until low-air alarm activation and emphasizing that any low-air activation in the hazard area is an immediate action item for operating personnel.

Lastly, it is recommended that the KDPS Fire Division develops a staffing plan for implementation of field technicians to monitor crew work cycles during IDLH operations.
References


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Appendix A

KDPS Air Management Questionnaire

The purpose of this questionnaire is to gain information on air management practices in the KDPS Fire Division. Information obtained from the questionnaire will be utilized to complete an applied research project (ARP) for the Executive Fire Officer Program through the National Fire Academy. The questionnaire is designed to gain insight on human and situational factors that are contributing to firefighters remaining in IDLH atmospheres until low-air alarm before exiting the hazard area. Please complete and return the questionnaire by July 8, 2013.

Please mark the appropriate box or write in your response.

1. Do you frequently rely on the SCBA low-air alarm activation to indicate when it is time to exit the IDLH atmosphere at structure fires?
   
   Yes   No

2. If you answered yes to the previous question, do you feel that it is an acceptable practice to remain in the hazard area until low-air alarm activation?
   
   Yes   No

3. What behavioral factors and attitudes do you think contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation? Mark all that apply.

   A need to “finish the job” they started
   “Hero culture” resulting in poor risk vs. gain decision-making
   Misplaced confidence in their air supply
   Ego/ “can’t quit” mentality
   Other

   [Blank space for other comments]
4. What situational factors do you think contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation? Mark all that apply.

☐ Tunnel vision

☐ A lack of “situational awareness”

☐ “Single-family dwelling air use mentality” resulting in a false sense of security in how SCBA air supply is utilized in structure fires

☐ Other

5. Do you feel that you have received adequate training in SCBA air management principles and techniques?

☐ Yes  ☐ No

6. If you answered no to the previous question, do you feel that an air management training program would increase the probability that you would exit IDLH environments prior to low-air alarm activation?

☐ Yes  ☐ No
Appendix B

I am a Captain with the Kinston Department of Public Safety - Fire Division and I am currently enrolled in the Executive Fire Officer Program at the National Fire Academy. I am working on an applied research project (ARP) as part of the program. My ARP is on SCBA air management. I would appreciate if you would go to the link below and complete the short questionnaire, which is part of my research for the project. Information obtained through the questionnaire will be used to complete my ARP. You have been selected to complete the questionnaire due to your role as an instructor in an advanced SCBA training program. If possible, please complete the questionnaire by July 8, 2013. Thank you for your assistance with completion of this ARP. Feel free to reply to this email with any questions regarding the questionnaire.

http://www.surveymonkey.com/s/GYHXPN

Scott Justice, Fire Captain

Kinston Department of Public Safety - Fire Division

Kinston, N.C.
Air Management and Emergency Operations Questionnaire

1. With regard to firefighter safety during emergency operations in IDLH environments, how important is individual SCBA air management?

☐ Not that important
☐ Somewhat important
☐ Important
☐ Very important

2. Do you feel that increased SCBA cylinder size, resulting in a larger emergency reserve and longer escape time for firefighters, is a valid approach to air management?

● Yes
● No

3. What effect does remaining in an IDLH atmosphere until SCBA low-air alarm activation have on emergency operations?

☐ Increases firefighter work load due to longer work cycles
☐ Complicates crew rotation cycles throughout the incident
☐ Increases likelihood of out of air emergencies
☐ Desensitizes response to SCBA low-air alarm activations

Other (please specify)
4. What approaches to improve SCBA air management have been identified?

5. What air management methods or techniques are taught during your advanced SCBA course?
Mark all that apply.

☐ Rule of Air Management (ROAM)

☐ Air status radio reports at designated time intervals

☐ Half-your-air-and-out system

☐ Reilly Emergency Breathing Technique

☐ None of the above

Other (please specify)

6. What recommendations would you suggest to improve air management and increase the
likelihood that firefighters exit the hazard environment prior to SCBA low-air alarm activation?
Appendix C

I am a Captain with the Kinston Department of Public Safety - Fire Division and I am currently enrolled in the Executive Fire Officer Program at the National Fire Academy. I am working on an applied research project (ARP) as part of the program. My ARP is on SCBA air management. I would appreciate if you would go to the link below and complete the short questionnaire, which is part of my research for the project. Information obtained through the questionnaire will be used to complete my ARP. If possible, please complete the questionnaire by July 8, 2013. Thank you for your assistance with completion of this ARP. Feel free to reply to this email with any questions regarding the questionnaire.

http://www.surveymonkey.com/s/G3CWRHK

Scott Justice, Fire Captain

Kinston Department of Public Safety - Fire Division

Kinston, N.C.
Air Management Practices Questionnaire

1. What methods have been implemented within your department to improve self-contained breathing apparatus (SCBA) air management? Mark all that apply.

☐ Use of an entry control officer to check and monitor air pressures of personnel in the hazard area

☐ Rule of Air Management (ROAM)/READY Checks

☐ Half-your-air-and-out system

☐ Periodic air checks/radio reports at specific intervals during emergency operations

☐ Work cycles/crew rotation system along with air status reports

☐ None

Other (please specify)

☐

2. Does your department currently have an air management SOG/SOP to address individual SCBA air management?

● Yes

● No

3. Has your department implemented an SCBA air management training program?

● Yes

● No
4. If you answered yes to the previous question, has the training program improved individual air management increasing the probability that personnel exit the hazard area prior to low-air alarm activation?

- Yes
- No

5. Which classification of air supply is the self-contained breathing apparatus (SCBA) used by your department personnel?

- 30-minute
- 45-minute
- 60-minute
- Other (please specify)

6. If 45 or 60-minute SCBA cylinders are utilized, instead of 30-minute cylinders, was the intent of purchasing larger volume cylinders to increase escape time/emergency air reserve?

- Yes
- No
Appendix D

KDPS Air Management Questionnaire Analysis

1. Do you frequently rely on the SCBA low-air alarm activation to indicate when it is time to exit the IDLH atmosphere at structure fires?

2. If you answered yes to the previous question, do you feel that it is an acceptable practice to remain in the hazard area until low-air alarm activation?
3. What behavioral factors and attitudes do you think contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation? Mark all that apply.

Other Responses:

- Feeling that you need to work as long as possible to complete fire ground tasks
4. What situational factors do you think contribute to firefighters remaining in the IDLH environment until SCBA low-air alarm activation? Mark all that apply.

- Tunnel vision
- A lack of “situational awareness”
- “Single-family dwelling air use mentality” resulting in a false sense of security in how SCBA air supply is utilized in structure fires
- Other

Other Responses:
- Confident in ability to exit quickly due to proximity to exits
5. Do you feel that you have received adequate training in SCBA air management principles and techniques?

![Bar chart showing the percentage of respondents.]

6. If you answered no to the previous question, do you feel that an air management training program would increase the probability that you would exit IDLH environments prior to low-air alarm activation?

![Bar chart showing the percentage of respondents.]

Appendix E

Air Management and Emergency Operations Questionnaire Analysis

1. With regard to firefighter safety during emergency operations in IDLH environments, how important is individual SCBA air management?

2. Do you feel that increased SCBA cylinder size, resulting in a larger emergency reserve and longer escape time for firefighters, is a valid approach to air management?
3. What effect does remaining in an IDLH atmosphere until SCBA low-air alarm activation have on emergency operations?

Other Responses:
- Reduced time for personnel to exit the hazard area

4. What approaches to improve SCBA air management have been identified?

Responses:
- Increasing situational awareness of personnel (ROAM)
- Going from half-a-cylinder-in/half-a-cylinder-out to one-fourth in, work one-fourth, exit one-fourth, one fourth for emergency reserve
- Training that builds muscle memory for constantly checking and knowing your air status
- The issuance of NFPA 1404, increasing reserve capacity, local protocol development, and development of air tracking requirements
- Air management testing and SCBA training
- Knowing actual working times for an individual firefighter – changes as you get older
- Putting responsibility on the company officer and having dispatch contact you every ten minutes of the incident to improve air management

5. What air management methods or techniques are taught during your advanced SCBA course? Mark all that apply.

![Bar chart showing percentage of respondents for various air management methods and techniques.]

Other Responses:

- Our course is a self-preservation course. We take the individual firefighter to his/her limits with gear and SCBA. We show them how long they can last from a full cylinder to a completely empty cylinder in a controlled setting so they know their individual work time in SCBA.
- Personal accountability and awareness. No your location and air capacity at all times and be out of the structure prior to low-air activation.
- Work load management, skip breathing techniques, and importance of physical conditioning.
- Communication between crew members and emergency breathing procedures.

6. What recommendations would you suggest to improve air management and increase the likelihood that firefighters exit the hazard environment prior to SCBA low-air alarm activation?

Responses:

- Work to make it socially unacceptable to be caught in any IDLH atmosphere with a low-air alarm activation
- Development and enforcement of policy
- Strong command and division monitoring, trying to pair up individuals with like work cycle durations
- Get a time/air reading after a predetermined time interval (ex. 15 minutes)
- Cultural change (will take at least one generation to see the effects). Gain buy in from trainers and organizational leaders and hold the line on a zero tolerance to effect change
- Air consumption training
- Marking time on air and monitor air use
Appendix F

Air Management Practices Questionnaire Analysis

1. What methods have been implemented within your department to improve self-contained breathing apparatus (SCBA) air management? Mark all that apply.

Other Responses:
- SCBA policy with guidelines for air management
- MSA Integrated Accountability Software
- Training that stresses the importance of air management
2. Does your department currently have an air management SOG/SOP to address individual SCBA air management?

3. Has your department implemented an SCBA air management training program?
4. If you answered yes to the previous question, has the training program improved individual air management increasing the probability that personnel exit the hazard area prior to low-air alarm activation?

5. Which classification of air supply is the self-contained breathing apparatus (SCBA) used by your department personnel?
6. If 45 or 60-minute SCBA cylinders are utilized, instead of 30-minute cylinders, was the intent of purchasing larger volume cylinders to increase escape time/emergency air reserve?