

The Role of Closed-Circuit Breathing Apparatus in Structural Firefighting

The editors of the ISRP Journal are reproducing the proceedings of this symposium held at Lawrence Livermore Laboratories in October, 1984. Due to the length, these proceedings will be published throughout several issues of the Journal. Edited by Mr. Jerry Stengel.

- PROCEEDINGS -

Wednesday, October 23, 1984

Thursday, October 24, 1984

BOB GUYETT

Assistant Chief

Long Branch, California.

I really want to talk about some actual incidents that we had where long duration was of benefit to us. In 1980 we purchased thirty six units of closed circuit SCBA. So, we now actually have thirty-five units that are actually in service. There's a real feeling of resentment sometimes about change, and firemen have unique ways of showing that.

Anyway, we bought the units and put them in service in companies that are in our downtown area where we have major high-rise buildings and in our harbor. As you know, Long Beach is a major port on the West Coast, and we do not have ship firefighting problems. Additionally, with the harbor, of course, we have railroad junctions down in the harbor area so we get some significant, hazardous materials type problems.

When we went into it we were fortunate, or unfortunate enough, to have a major high-rise fire within about the first six months. This involved a fourteen-story building; we had a fully involved apartment on the tenth floor. And, typically this is one right off of Ocean Boulevard which butts up on the back side to the beach. There was a single-sided attack and the fire was on the Ocean side. So, we literally had one direction of attack on the fire.

In this case, the first attacking crew, fortunately (or for them, they might have felt unfortunately) had BioPak's. And they were able to effect entry down the hallway, advance their line into the doorway, and then push the fire back into the apartment. From there they advanced and extinguish the fire.

I'm not sure they couldn't have done the same thing with an open-circuit unit. But, the significant thing is that because the attack was in a high-rise, there was a very legitimate possibility that they would have had to stay in an attack position for an extended period of time.

In this particular case, one of our firemen on the first-in line ended up with burns. It was interesting where the burns occurred. He had them on his wrist, just above the glove which when it got wet finally worked its way down between his turnout coat and his gloves. He also had some burns on the back of his neck: first and second degree. He recovered very quickly.

He was outside by the time I got to the fire and I understood he was complaining bitterly about his breathing apparatus. So, I went down and interviewed him. I took a look at the burns to see what the severity was, where they were on him and how he got them.

The crew had advanced their way into the apartment and were knocking the main body of the fire back into the apartment and back into the back wall area. However, the fire had gotten up between the false ceiling and the floor separation above, and they were taking a tremendous amount of heat from above and down the back. His outer case on the BioPak (which was the original case that Bio Marine came out with) had the original type catch deformed because of

the heat, and the outer part of the case popped off. This was a condition that Bio Marine was already aware of and was working on a new type catch and a new material for their case. So I asked the firefighter, "I understand you're upset with it. Were you forced out of there?" No, he wasn't forced out of there: he stayed right in there. He didn't even know that the back had dropped off the case. Literally, that crew stopped that fire single-handedly. We had a lot of people working doing salvage, rescue and checking for things like that. But the condition of the fire was such that the immediate attack and the ability to remain in place were the factors limiting the damage that occurred, and preventing injuries at that fire. The end result was that I asked the firefighter, "Well, what's wrong with the apparatus?" I knew something fell off of it, but I wanted to know if it continued to work. He said, "absolutely!" The bottom line for firefighters is what we know that the units that were out on the market, and are out on the market, are not made specifically for fire service duty. They cannot easily be engineered to withstand the types of conditions into which we put ourselves. Yet it is critical that the unit continues to function even if something goes wrong. We had another incident involving a high-rise building where the fire was limited to the third floor. Sometimes you can take your firefighters into a high-rise fire and get them up close to the fire before they have to put the unit on. But if it's a fifteen-story building and the fire's on the third floor, you're probably going to have smoke down about the first floor when you walk in. In this case they did, so they needed to use breathing apparatus from the time they entered the building, got the fire knocked down, back out and even used breathing

apparatus through cleanup. This is another incident where the need for longer duration existed.

We had a major ship fire in the harbor. It involved a series of three levels of holds in one area of the ship. And, if you've ever worked a ship fire, they're really interesting. On a passenger liner they have stairways and methods of getting down in the lower part of the ship. But on a major carrier or tank type carrier, once they start opening those holds up, your first drop may be about a sixty-foot drop. By the time we've moved material out of the first level of the hold down into the second level and then move the flooring out of that and down into the third level, there is a big hole in the middle of this ship. A significant amount of time is involved in getting your firefighters down into there.

We had both types of units (open and closed circuits) on the scene. And it was an interesting comment about closed-circuit to me in that I deliberately asked the officers and every man that I could talk to at that scene as they took breaks if they had any problems with their breathing apparatus. There was not one complaint at that fire about closed-circuit units. This, to me, is really what it comes down to in the fire service. If there is a need for certain equipment, you need to train your people so they can accept the type of unit they need to satisfy that need. (We're going to have a round table or panel discussion this afternoon about training needs.) But, from my historical standpoint of use, extensive training and familiarity with a new breathing apparatus or any significant piece of equipment is the key to whether or not it will be accepted by the firefighter.

From the Long Beach standpoint, we have approximately 2000 to 3000 structural fires in our city per year.

Because firefighters work various shifts and at various stations we have decided to disperse our closed circuit SCBA rather than concentrating them down in the harbor and the high-rise areas. In order to effectively train all of our people on those units and keep them trained, we have placed one of those units on each apparatus in the city. That enables the captain and the crew to stay trained on it. So no matter where they work, if we get four or five or six or ten units at a fire which calls for long duration, our people are familiar with all units. They know how to use them and know the problems,

in particular (after hearing Mr. Myhre's comments) duration.

There is another interesting story that I wanted to relate. We have an order out that went out when the closed circuit units were placed in service: that the maximum time a man is to be allowed to stay in a working fire situation, while he is working hard, is thirty minutes. At that time if he hasn't left voluntarily, you get him out of there.

One of our officers, who was having a little trouble accepting the unit, came up and complained to me at one of these high-rise incidents that the unit almost killed one of his firefighters and he was really mad about it. So, I asked him to explain what had happened. "Had it malfunctioned or what?" He said, "Oh, no, it worked - worked perfectly, worked perfectly." The problem was that his nozzle man, went into the fire and was working away. Forty minutes later he got weak in the knees and began to collapse. I asked the captain, "Are you aware that we have a policy that after thirty minutes that man be relieved." And he says, "Yeah, but I couldn't get him out of there." Well, how many times did you order him to take relief and go back and rest?" He said, "Three times, but he didn't do it." So I asked, "How many times would you tell him to clean the restroom correctly in the morning?" I was trying to get across the point to him that apparently it was more important to make sure the guy cleaned up around the station - - because he sure as hell wouldn't tell him that three times - - than it was to save his life!

I just told him, "You cannot blame the breathing apparatus when you don't follow the policies that are out there."

Yes, long duration has a need. It gives us a safety factor that we desperately need. But it also gives us a responsibility not to kill somebody because we overwork them. Aggressive firefighters (and they are good ones) will stay in there and work as long as he can physically take it, if he feels that it's vital for him to do it. So, from Long Beach's standpoint that's part of our history.

Now, I would like to introduce another gentleman. Mike is a former assistant fire chief in Decatur, Georgia, and has had extensive experience with closed-circuit. I felt that his experiences

would also benefit us.

Mike: I would just like to take one second and reiterate the things that Bob said about overworking firefighters. The purpose for our long-duration breathing apparatus, originally, was not to work the firefighter longer. It was to enable the firefighter to get through toxic atmosphere and tunnels - to allow him to reach positions in high-rise buildings before they actually began the firefighting process.

We were cast into a role within approximately two years that was totally unfamiliar to any of the firefighters in the Metro-Atlanta area. The city of Decatur is completely surrounded by the city of Atlanta. Our daytime population is almost a quarter of a million people, and when everyone goes home at night, we have about eighteen thousand people.

It's quite lonesome there at night, but nonetheless, when the MARTA system (the Metropolitan-Atlanta Rapid Transit Authority) began, a large number of developers decided, due to the location of Decatur, it was very beneficial to them to build up thirty and forty-story buildings right downtown in an area where the largest exposure that we had prior to this was the county courthouse - it was three stories tall. Within two years we had forty-four buildings (including additions to a college campus) that were over twenty stories tall. You're talking about firefighters that were used to single-family dwellings. At most there was, due to the fire code, a four-unit apartment complex between fire walls. Your talking about guys that never looked down a sewer much less walked through a mile-long tunnel. It was a very traumatic experience. We went through quite a change in a very short period of time.

We have a sixty-member fire department. There was not a single person on board that had the expertise to handle the new situation and we were the first to admit it. The first thing we did was to head to places that had tunnel systems. We went downtown to Atlanta to talk about high-rise and found that a lot of the aerial trucks had one piece of breathing apparatus, and some of the pumps didn't have any. We decided we were talking to the wrong people. We have talked with the people in most of the major fire departments because we didn't consider that we had a small town problem anymore. We had a big city

that time, the Coast Guard thought that an extended duration breathing apparatus would really be beneficial for us. We do a lot of work wearing encapsulated suits. In reality that boils down to about five percent of our work load. The rebreathers, or the closed-circuit type of breathing apparatus, were really bought in 1979 so we could have longer duration times inside these suits. Since then we have found that's not really practical - it's just too long for a person to remain encapsulated.

In our protective equipment requirements, we have two levels which require some sort of breathing air capabilities, a level A and a level B. The level A is a totally encapsulated suit where you have virtually no exposure to any outside or ambient air. (Hopefully) And then level B is just a downgrade from that. You still have your protective clothing and you need some sort of bottled air or rebreather of some sort, but you do have some skin exposure, primarily, just around the neck once the proper taping and everything is done.

The criteria for level A and B entries depends on the chemical. If we know what it is, we may be able to downgrade into a level B. But more likely than not, in a chemical response, we have no idea what type of chemical we're working with. We don't know the concentration, therefore, it is a level A type of entry. Like I said, Level A entries are about five percent of our work, and Level B entries are forty percent.

The design consideration in breathing apparatus that we've looked for are size, weight, maintenance and repair and operational simplicity in the on-sight work that's required. And this is what makes our decision as to what type of system we'll go with. In comparing some of the closed-circuit systems, we know that the CCBA has a lower profile which is really nice, especially in shipboard work. Generally, it has less weight.

Operational characteristics? It does provide longer breathing time. However, it does require a commercial source of breathing oxygen. And some places in the United States that's just not available, some of these out-of-the-way places in Arizona, North Dakota, South Dakota, pure oxygen may not be available.

Also the inhalation temperatures tend to be hot. I was a test subject at ILC Dover. There we were just testing suits, primarily, but we were using both the

closed-circuit and the open-circuit systems. I know from actual experience that these inhalation temperatures are very discomforting.

The maintenance problems? We believe, the closed-circuit requires higher maintenance for us. We like to have things that are sailor-proof and SCBA's are much easier for us.

For the cleaning and inspection in the field, we feel that the SCBA is better for us. It's easier for us to work with. The repair costs seem to be higher for the CCBA's.

One of the big things we found is heat stress. For level A entries, the heat from the scrubber unit goes right into the suit and heats up the air. When you're working in an ambient air of maybe sixty or 50 degrees, this isn't too bad. But we found that we need a cooling tube on this inhalation tube. And we haven't found one that really works.

All of our cooling garments are not operational yet. But, being made by ILC Dover, they use water. Therefore we need a pump to pump this water throughout the suit. This keeps adding weight to the total encapsulated person. And we're now up to approximately seventy pounds of weight, including the suit, the water, the pump, SCBA or CCBA, (either one). This places a lot of fatigue on a person. If we use water, as the cooling medium, we are limited then in how long that water can remain cool. We have to use ice to cool the water. Therefore, we also only get about forty-five minutes of cooling protection for the breathing air and also for the body.

The physical limitations of the wearer? We have found we can work one hour and then we need about two hours rest before they can make another reentry. Most of our units that we have in our inventory are sixty-minute SCBA's and we use Survivair. The Survivair was chosen just because it went out on government contract with the Coast Guard and evidently they were awarded it.

For our Level B entries, (which we do much more of,) we don't have quite the same problems, because the unit is outside the suit. We still get a little bit of that elevated temperature on inhalation. But I'm not so sure if we know exactly what the compatibilities

and the decontamination procedures are for the unit, other than the composite bottle. We don't know exactly how the CCBA's work if there is an accident. All of our work is done in the "what if" mode. What if this happens? What if that happens? What are we going to do? How are we going to take care of the person, and then the equipment? Will he be able to escape or not?

Our other problem we found was user acceptance. There are just people who will not use oxygen. They just flat refuse it, and we can't send them into any environment if they won't wear the protective equipment or the devices available.

The mask designs? We found that it seems as though we can't get masks that are either large or small. They're only one size. That may be valid and it may not be.

Another problem we have found is the breathing tubes themselves tend to be too short. I know from personal experience on the Draeger system using an encapsulated suit that every time the head was turned to the right, it would tend to pull the mask away from the face. Hopefully, we had it on correctly. It was not only me, but the other test subjects involved also.

Our commandant policy for IDLH atmospheres, (immediate dangerous to life and health), requires us to have a certified, pressure-demand type system. As far as I know the CCBA's are not certified at this time.

In conclusion, the self-contained breathing apparatus primarily used by the Pacific Strike Team was chosen because of the cost, the operational simplicity, their lower maintenance and repair requirements and user acceptance.

We do know that there is a need for a longer-duration type system and we are currently (in conjunction with EPA, the U.S. Army and some other organization) looking for a two-and-a-half hour rebreather. This has been out on contract, (to what company I don't know), to develop a two-and-a-half hour closed-circuit type system. We don't feel that it really will work in encapsulated type of environments. The worker just can't stand up to that long duration of time.

One thing that I'm not sure of, and maybe someone in the manufacturing industry can tell me, if contamination does occur with the closed-circuit, is that

contaminant going to be removed by the scrubber? Is it going to react with the scrubber, or is it going to be just passed so you're going to rebreathe it as often as the contaminant exists?

I personally have greater confidence in the quality of air that I'm breathing with an SCBA. I know what type of air is going in there. I can test it. We have two, 5000 psi compressors for our unit. They are checked every month at the lab for air quality. Anytime we're on a job site that we have to use someone else's air, we can test it also.

From what I remember on the Draeger System or any other systems, there is no CO₂ alarm. If that scrubber is not working correctly, (is not taking all that CO₂ out), is there going to be a buildup in there? Is the user going to know it without fainting?

I'm just giving my personal opinions, some of the Coast Guard opinions, and some of the factors that we have found in actual use.

Our biggest reason that we don't use the CCBA's at the present time for encapsulated work is because there is no need for that type of duration. When the sixty-minute bottle alarm goes off, it's time for him to come out. We don't take the chance then that you're overworking him or he doesn't realize how far into a situation he is. He and his buddy can both get out in plenty of time.

With the systems, with pressure gauges, when you're encapsulated, you can't read the pressure gauge very well anyway. You can't extract your arm that easily to turn the pressure gauge around and read it.

Another concern to us is the heat generated with the canister type. There again, I don't like to refer just to the Draeger, but this is the one that we used for our suit testing. The metal pan in the back tended to get very, very warm and the suit that we were wearing was resting right against that. We don't know if that enhances permeation to that suit or penetration from any chemical; we don't know what effect that has on the rubbing of the material against the back of any suit. Each one of the encapsulated suits has to be inflated to help take the weight of the material off the shoulders. With the closed-circuit system, we have no discharge of air into the suit at all, whereas with the open-circuit, just the exhalation of the air tends to keep that

suit inflated.

So, in conclusion, I guess we do realize the need for and we are actively in search of a two-and-a-half hour system, that we feel will be plenty of time as far as duration. It will meet our needs and will meet the EPA's needs. But in the meantime we really like our SCBA's - especially encapsulated.

I personally see a great usage for closed-circuit with our level B entries. Right now, we do work virtually 8 hours a day in a level B type of atmosphere. But it just means that we have to come out and change bottles all the time. And that's our limiting factor, where it would be nice just to remain on site and just continue work in that environment.

JIM JOHNSON

The whole idea is to get all the perspectives we can on the equipment and I think that's another important perspective from a real user. An up and coming problem in the fire service, and emergency response business is taking care of HAZMAT problems with total encapsulating suits.

Our next speaker is Ed Archuleta and he comes from the Federal Mine Safety and Health Administration (MSHA) in San Bernardino, California to bring us the mining experience.

ED ARCHULETA

The CCBA's have been used in mine rescue way back to the 1900's. One of the most commonly used CCBA then was the McKay which was a two-hour apparatus. And right now one of the most commonly used apparatus is the Draeger, of course, the BG-174A. I heard some pros and cons about it, but the majority of the mine rescue teams have the Draeger.

The reason for the CCBA, in the mining field is because of the need for duration and ruggedness. The reason for this is that sometimes we have to get into a confined areas where we have to take the machine off our back, drag it along. We crawl through spaces such as eighteen inches in height - real confined areas; or go down ladders where you have to remove your apparatus to be able to fit through some of these

openings.

I will later on, during the program, give you some experiences that we have and have had. And as a matter of fact, I was just on one last weekend which I will bring up.

I would like to talk about the mine rescue training. What is required for a man to be able to be in a mine rescue team? In the first place, he is a volunteer and he is a miner. MSHA also has a mine rescue team which consists of mine inspectors throughout the nation. Some of the training requirements under Part 49 of the Safety Act requires that a miner be physically able to wear the apparatus. In other words, he's got to have a yearly physical and be in good shape.

And on top of that, he will go through various exercises in mine training, have to go under oxygen for an extensive amount of time (up to twenty hours a year) and be physically able to perform a lot of rugged work that is done underground. He not only has to be able to rescue people, but to prevent them from getting involved in a dangerous condition.

In other words, mine rescue is a slow process and very hazardous. So, you need a machine that is going to allow you to work with for an extensive amount of time. This four-hour apparatus is considered to be an excellent piece of equipment I've worn it; I've used it in rescue experiences; I've seen it work, and I am very, very satisfied with four-hour apparatus.

Now, of course, your Draeger weighs a total of about thirty pounds. And the miner usually has a self-rescuer (escape respirator) which might weigh five pounds, a safety belt, and he's got a lamp he has to deal with. So, you can just see how much extra weight he has to carry with him. And usually he has to crawl on his hands and knees, or sometimes lay on his back and pull that machine.

So, to get anything done, you need a machine that is going to last you for quite a while. So you cannot go and hardly do anything in thirty minutes, forty minutes. You have to travel in some mines up to two miles to get to the area where there are miners who need help or there's a fire that you need to put out. You have to work in areas with high concentration sometimes of dangerous gases such as CO, CO₂ and methane. Sometimes you have to work in smoke

where you **can't** even see the palm of your hand if you put it in front of your apparatus.

Some of the other training that we do and encourage is having mine-rescue contests. Like I said, all these miners are volunteers and we want to create interest. We have various mine rescue contests where we simulate a disaster and we have rescue teams that compete and see how they will work a problem. Sometimes it takes them up to two, two and a half hours to work some problems. This gives the miner or the rescuer a chance to wear his apparatus and be comfortable with it and it encourages him to be able to join a mine rescue team.

Usually we have regional contests, every other year we have a national contest in which we invite rescue teams throughout the United States to compete. We issue plaques and scholarships for their efforts. And this really generates interest

Now, a mine rescue team has to work systematically in exploring a mine. Usually a mine rescue team consists of **five** men plus one **officer** or briefing **office** area outside. The mine rescue team will try to explore and find either victims or survivors. And usually what we do is go in, in fives. Sometimes **where** you have restricted areas, you can only work in **two's** or three's, but we always have a back-up team of five people or more that would back us up in case one team got into trouble.

We start at the entrance portal and work our way, trying to establish what we call a fresh air base. We travel for a distance of maybe 1,000 feet and then try to establish fresh air base if we have fresh air. We can then bring in supplies, more apparatus or more men and then proceed. Sometimes we come into areas where we have to fight fires. And sometimes if a fire is uncontrollable, you have to seal up parts of the mine to prevent the fire from spreading. We try to dilute any dangerous gases by using mine ventilation. But our major mission is to try to find survivors.

Usually a mine rescue team will have a total of five men: a captain, a gas man, a map man, stretcher bearers, (we have extra apparatus strapped on to it), and a co-captain, who keeps constant contact with the outside, either by telephone or by using a rope life line.

My maintenance problems have never been actually that great with any type of

closed-circuit apparatus that I've been experienced with, and I've been experienced for twenty years.

We have people that take care of the breathing equipment. **MSHA** requires that a mine with over seventy-five people have a total of two mine rescue teams fully equipped with breathing apparatuses, pumps, parts, gas detectors, **firefighting** equipment, first-aid equipment and whatever is needed for mine rescue operation. For the majority of our mine rescue teams, each man will take care of his own equipment. He'll test it before he puts it on. He wants to make sure that he's got **CO2** absorbent in it, that he's got plenty of air, and he does not rely on somebody else to maintain it. You check that machine yourself before you go under, because you don't know what you're going to encounter. And you want to make sure that you are fully prepared to go **underground**. It's his life and he's got to take care of it. And the captain is responsible for checking the pressure of how much oxygen he's got in his bottle. And everybody will check their own air supply periodically, too, especially going into smoke. When you go into smoke, you frequently check with the people to make sure that they are feeling okay and make sure the apparatus fits him properly. Rescuers might even have to crawl on hands and knees to be able to get to where they might find survivors. A mine rescuer also needs to know ventilation, know ground control, know how to fight fires and have some experience in first aid. He may come across a miner that has either sealed himself behind a barricade, or is unconscious and be able to remove him.

So, he needs a good machine that is going to give him plenty of ventilation. And he needs a spare machine that works in case he does find somebody else. He has to know his equipment real well.

The maintenance checks on the Draeger apparatus are done with test equipment called an **RZ25**. It is a box with gauges to check for leaks, how much air you get, how your relief valves and your admission valves work. So it's a very important piece of equipment to have.

One problem that I have encountered myself, is that whenever there's a

disaster, there are a lot of people that respond. The sheriffs department, the firefighting department (they come in with thirty-minute packs), the state mine safety department, and, of course, the federal mine safety department - **MSHA**. In one situation the sheriffs department was one of the first ones there, and they were going in with thirty-minute packs. Of course, it was a very hazardous condition because they did not know what existed in that mine. Yet they were going to try to go in with a piece of equipment that shouldn't have been used - they could have easily run into problems. And that's the reason **MSHA** has regulations that these mines have mine rescue teams. Mines that have less than twenty people should be affiliated with some mine rescue team within one hour or two hours distance. In case of problems, they can ask for assistance.

Well, I was at a rescue operation in Louisiana, where it took us almost two hours. We were looking for victims, and we had five people underground. When I got there, they had found three people, but we were still lacking two people. It took us almost two hours to get to the point of where the gas ignition occurred. So, what we needed was a machine that gave at least four hours of ventilation. And I was underground for about three hours. And it was hot - let me tell you, it was very hot. And as far as breathing apparatus, we didn't have any problems at all. I had four other men with me and I checked with them periodically. We were mostly just walking, and looking. These passages were maybe eight feet by twenty-two feet high. So, actually, we weren't in a restricted area and we weren't doing any actual work. Although, as I mentioned sometimes you have to buildup bulkheads or use shovels to open up holes. So, after two and a half hours we retreated and another team in and finally we did find the other two people, but they were already dead.

I should mention the Sunshine fire in 1972, where they lost **ninety-one** miners due to a fire. They used the Draeger and the McKay machines to recover bodies and they also found two survivors at that fire.

So, I just want to say, you've got to be comfortable with the machine. That's the main thing - you've got to be comfortable with the **CCBA's**. You have to know how they work. You have to be

comfortable with them, and that's the reason that we encourage that every man that wears a CCBA be thoroughly trained on how it works and how the machine is going to help him out in case he ever runs into trouble. Of course, you've got safety factors on the CCBA's but you shouldn't count on them.

In conclusion, I will say that the mine rescue people who are well-trained people risk their lives in helping out the other miners. They have to have excellent training - every one of them. That is the most important thing. Training.

We (MSHA) and the companies have training where we simulate exercises once a month. Their machines are checked once a month; records are kept of the training, records are kept of the machines; records are kept of any malfunctions; or if you have equipment go out on you, you keep records and send it out for repair, or replace it with another piece of equipment. You take no chances at all!

JIM JOHNSON

We've had firefighter experience, we've had Coast Guard experience with a HAZMAT, now we've had the mine rescue use of the equipment. That we're interested in. Next to round off the major experience base that we need is the Navy. Ron de Marco is going to come up and give us the U.S. Navy's firefighting experience with the closed-circuit breathing apparatus.

RON DE MARCO

I think you'll find the biggest difference with our devices and other people's devices is that we use chemically generated air. We don't use pressurized gas on board ship for fighting fires. I'm trying to relate to many of your land-based firefighting problems - I thought I'd create a hypothetical fire, and then try and make it interesting from the Navy's point of view.

Let's take a structure 50 feet wide by 150 feet long - a small one, when we passed to the 300 feet wide by half a mile long for aircraft carrier problems. Let's get a building that's a few stories, three stories high, up to a building that's maybe seven or eight stories high, and let's get a fire going. Let's have within that structure food, paper products, bedding, anything a small city the size of, let's say, three thousand, five thousand people would

need, including power production, fuel, hydraulic liquids and things of that nature.

I don't think I've yet described a fire that many of you haven't seen. So, we'll make it a little interesting. We'll throw some ordinance into the fire. There is now the potential for ordinance going off.

We're not going to talk about any structure any more. But, we're going to talk about your firehouse because that's what's on fire with the rest of it. The Navy doesn't have firehouses where people run around. We are floating firehouses. To really make it interesting, we don't have firemen either, we have sailors. And that's not meant to be derogatory. We call them damage control assistants. They're usually the people that are directing and trying to coordinate a firefighting effort. The sailors are the people that are on the hoses. The sailors are the people that are using the breathing devices trying to put the fire out. In some cases we lose damage control assistants because they try to get to the fires first.

To give an overall view of the Navy's firefighting device, (I'm sure many of you are familiar with it), it's a Chemox type of closed-circuit breathing device. The Navy, back in the thirties, recognized the need to supply protection to firefighters. More recently, we've decided that we've even got to supply protection to people that are trying to evacuate a fire area, to get to firefighting equipment, or just to save themselves. So, we actually have two devices.

On the Chemox style device we have a facepiece with a nose cup to concentrate exhaled air into the chemical generator. There's a voice box so we can have communication. And an exhalation tube, with the canister sitting inside. There is an earlier version of the MSA device which had a screw on the bottom to drive the canister up. This one has a quick throw bale that puts the canister up in the place very quickly. Right in this area is a spiked part that breaks a protective seal on the chemicals. Then breathing bags on both sides, and an inhalation tube.

It provides a chemically generated atmosphere. Initially, ten liters of oxygen is formed from the decomposition of a sodium chlorate

candle. This provides the sailor with ten liters within about a minute to a minute and a half. He will operate off of that supply until he gets the chemicals activated inside the canister. The iron is used as a method of generating more heat. Some of that oxygen will react with the iron generating heat to continue the reaction so the chlorate candle goes to completion.

The oxygen, the principal gas generated from a reaction between potassium superoxide, and moisture exhaled by the individual. We get caustic and oxygen - produced as carbon dioxide is exhaled by the individual. It is then picked up by the caustics so it's a self-scrubbing system. To give you an idea of what the actual flow is through the device, the candle (located at the base) fills the bags up. The volume of the bags is approximately five liters. There also is an automatic vent valve.

The individual exhales down the nose cup, it goes into the bottom of the canister and then is dispensed over the potassium superoxide. Oxygen is produced to go into the wearer's right lung, when it then transfers by a tube into the left lung and then is inspired back into the device. There is some degree of warmth with it, but sailors have not been too critical about it.

As I mentioned, the device was initially developed in the late thirties. We've have the same device since World War II. We're in our fourth modification of it, but basically we're dealing with the same device. After forty years, you've got to consider that the device has served the Navy well if we're still using it. We haven't found anything that's going to supply us with a better source for firefighting with all the restrictions we have with the Navy's use conditions.

That doesn't mean we haven't had, and still have, some problems. We tend to work very closely with the manufacturer (MSA) to resolve many of these problems, and I think by and large we have been fairly successful.

I'd like to go over some of the recent problems and let you know the status. The tubes inside those breathing bags will sometimes detach and they lay in the bag. Although, not a great concern. Our biggest fear was that we were going to transfer air too quickly; the temperature would not have a chance to go down; the sailor would be breathing hotter gas. We

didn't like that idea. We performed treadmill testing with sailors. The temperature of the gas was insignificantly different with the tube in and the tube out. However, we went after the problem and found it was a crushed grommet that holds that tube in place. Sailors are no different than anybody else. When they get finished, they take these reusable respirators off and throw them around. Sometimes they may step on a bag trying to get away from everything and the grommets get crushed. And as a result, the tube falls out.

MSA now has a stainless steel grommet in there, so they're going to have to step awfully hard. It has a positive seal clamp on that hose so it can't fall off anyway.

Punctured canisters in standby were another problem. When the bail is in the down position, the canister is in place, but the seal has not been punctured. An individual can have the mask behind their head in stand by to walk around or move to different areas until they need it. Then they put the mask on, throw the bail and get the system going.

Well, we had problems where that canister was being punctured before the individual was throwing the bail. And there were two problems associated with this: One's purely maintenance. There is a clearance that must be kept, and the sailors on board ship were not keeping that clearance and checking to make sure the clearance was maintained. So, we cleaned up our maintenance act and that took care of most of the problem.

The other problem, appeared to be that sometimes if they were running, they would jostle that canister up and down, so it would loosen a bit and puncture while it was moving. MSA designed a much tighter seal so that canister will not pop loose. So, we've taken care of that problem.

Another problem is canisters which hung up in the guide. The guide is that box-shaped thing on the wearer's chest. The problem with that occurred when we first go the Navy A4 model apparatus. I think it was just a matter of specifications. We had to open up the distance inside the bail area a little bit more than what it was: A matter of a few mills. But when your canister is hung up and it's very hot, you don't want to reach in there with your hand, you want it to fall out freely when you're done with it.

So that problem has now been taken care of also.

Canister disposal has always been a problem. The first problem is that you seldom ever use these canisters to completion. There is oxidizer remaining in the canister, potassium superoxide. The standard procedure if you're at sea is chop a couple holes in the canister and toss it overboard. It hydrolyzes in the ocean with no problem. If you're in closer to land, then you have to worry about EPS regulations. So you cut the holes in the canister, submerge it in five gallons of water and let it hydrolyze.

Sailors don't always do things the way they're supposed to. Some like to toss used canisters into trash cans, and some of those trash cans have organic materials like latex paint. And we had a three-deck high, flash-explosion and fire because the canister still had oxidizer in it. So, we have to maintain education on that.

The problems of the caustic that's produced when you hydrolyze the KO₂ really is not a great problem. We can neutralize it before we dump it so we're not causing any problems in terms of dumping high pH material into the waterways. But what has turned out to be a much bigger problem is the heavy metals that are being extracted during this hydrolysis. We now have heavy metal levels that can't dump. So, the disposal procedure has changed now. The canisters when they're spent are put into 55-gallon drums and they are sent away to landfill areas where they can be disposed of in the landfill area.

Those first four problems, I think, were more aggravation than problems. They didn't really cause us a lot of grief. It takes away a little bit from the device, but it doesn't hurt that much. The last three problems were things that greatly disturbed us.

Chlorine odor was coming from candles but only during training, not during actual operation. The training canister is different. It doesn't have potassium superoxide. It just has beryllium to pick up CO₂, so an individual gets used to using it. Chlorine will not pass through potassium superoxide without reacting. So, that was the cause of that problem.

Needless to say, people aren't happy about breathing chlorine. And there are

very low permissible exposure limits for it. We went ahead and analyzed some of the canisters to see just what kind of levels we're getting. The levels of chlorine were certainly not anything drastically bad for one-time exposure that somebody might have for a few minutes.

The MSA has now gone ahead and developed a filter to fix that problem. But, after the initial reports, the reports just disappeared. Most of the problem occurred with our old candles, (about eight or nine years old). They should not have been in the system today, and should have been used years before. We don't think this is going to be a problem in the future, and we're not too concerned.

The second problem was the problem of ammonia odor in the firefighter's canister. While he was out fighting a fire, he would smell ammonia, which was disturbing. Our first reports came in from the Coast Guard, but the Navy reports followed relatively rapidly.

We conducted a real-time analysis of the device to find out what was going on. We analyzed over a hundred canisters and the maximum level we ever saw was about 24ppm, with the average about 4ppm - very low levels. I think the Government Industrial Hygienists say 35ppm is a safe level which is lower than the government allowed limit. But we were certainly below even that. As you can see, it occurs very early in the use of the device, within the first two or three minutes the ammonia concentration peaked and disappeared. That agreed with all the reports that we had from the Coast Guard and from the Navy.

Well, it turned out the cause was the copper oxychloride catalyst in the potassium superoxide. The supplier of the catalyst changed its supplier of copper to a reclaimed copper which used ammonia in the process. Some of the ammonia was complexing with the copper when they made their product, and heat treating was inadequate. When the chlorate candle ignites, it burns at very high temperatures that drives off the remaining ammonia. There is now a requirement that reclaimed copper cannot be used and we told the fleet not to use 1976 canisters. But, I'll guarantee you they still have them because it costs them money to replace it. Although there's no shelf life on these canisters, other supplies should be used before

newer ones.

The last problem is one of short life on canisters. This is the one problem that I think disturbs the Navy, and right now we're in the process of putting together a test plan which will involve more testing in actual fires at fire training schools. We will probably use four hundred to six hundred canisters in this test.

We've had reports of durations as short as twenty minutes for one-hour canisters. In the meanwhile, the Navy has put out a message to down rate the time on the canister to forty-five minutes for moderate work, thirty minutes for heavy work. When you consider the sailor needs a certain amount of time to get to and from a fire, that doesn't leave much time for actually fighting the fire. We hope in the next few months to have this resolved.

There are many things that can give the effect of a short-lived canister. A person breathing at about three percent CO₂ will probably double the respiratory rate. He may decide, he's not getting enough air. There may be plenty of air, but he's just breathing a lot more and doesn't realize what's happening. High CO₂ levels can result from the scrubber bed not working or the sailor not working. Don't forget, we're talking about eighteen, nineteen, twenty-year-old people who are not trained firefighters. Often what they'll do is "short breathe" which gives them a relatively large dead space. Then they're rebreathing old air not scrubbed air, and they may be increasing their own CO₂ level.

On the other hand, there may be channeling in the canister, there may be a lot of problem. We have to identify what the problem is that's giving this short life.

The second major breathing apparatus used in the Navy is for escape or evacuation. In our firehouse that was on fire, there are firemen in all areas, but they're not always right around the firefighting equipment. So sailors need to reach the firefighting equipment and others have to just get out to stay alive.

I'll give you a brief background on the device. Shipboard fire in 1960 - a lot of loss of life - a lot of injury, the Navy said, "Something has to be done." The Chief of Naval Operations said, "We're going to have a committee to look into it." Admiral Russel (retired) headed that committee. One of the recommendations that came out was to get some sort of a breathing device that will allow people to

safely evacuate from fire areas. In 1968, the operational characteristics of the device were pretty much set and the call went out to manufacturers for devices. Testing was not really done. And the Lear-Siegler Survival Support Device, the SSD, came into the fleet as an interim, five-minute device, using compressed air in coils. Clearly it was just an interim measure. It will not be the Navy's final choice.

Between 1979 and 1982, the Navy undertook an operational and technical evaluation of the devices that were submitted. Initially, three were submitted. One fell out early and two went on to the operational evaluation. One was finally selected. That contract went out to Scott Aviation for their emergency escape breathing device, which is, I think, called Scramfast in the commercial industry.

The Navy evaluation was extensive. Naval research laboratory conducted most of the test procedures and everything: quality of the gas, flow of the gas, and support during sailor testing. Naval Weapons Quality Engineering Center did the shock vibration tests and thermal cycling from minus 20 to plus 140 F. They also did what we call casualty situations: namely, throw the device in the fire and see what happens; and put two rounds of thirty-caliber ammunition through it, see what happens. David Taylor, our Naval Ships R&D Center for materials and materials compatibility, did the analysis on salt corrosion which was carried out at Naval Weapon Quality Center. Once those three groups were done, the Navy Medical Research Institute got the devices, and went through human subjects testing with sailors.

The devices had to provide 1.7 liters of consumable oxygen. Testing was done with sailors on treadmills to insure we were at that rate. The physiologist actually tested them up to two liters a minute consumption rate with no problems. The devices then were sent to the operational test and evaluation force. Their job is to cut all the technical people and all the command people out and look at the device in a real situation: smoke chambers, and fire. What do sailors do with it when they've got it there? So, it was a complete test with a Navy designed testing procedure.

Give you some of the design testing characteristics: Fifteen minutes of protection, five-year shelf life, must go on easy. (We don't have time to sit around and read instructions.) Lightweight and easily stored. It also was a chemically generated oxygen device. It uses the chlorate candle to generate oxygen. Again, the iron is used to generate some more heat. The only addition is lithium hydroxide is put in as a scrubber to take out the CO₂. This is basically what the device looks like. It has a neck seal under a dual hood. The device sold on the commercial market is a single hood and there's a reason for the difference. It had to be hit with a flame and have it survive.

As a result, the initial test we did on the Scott device, it did not pass the flame test. We went back and said, "Sorry, we need a better hood." And they came up with a double hood. The outer hood is a high temperature polymer; the inner hood is a woven glass with Teflon to make it air impermeable. The inner facepiece is a fluoropolymer mixture to make it clear; the outer facepiece is PVC. Now, I know what you're going to say, "If you hit PVC with heat and you get hydrogen chloride." Yes, you do. And in this case we do also, but it doesn't penetrate the inner blood.

To give you an idea of how the device operates, pull the ring and the oxygen candle will start as a Venturi circulates the gas from the hood into the scrubber and back into the hood again. And the recirculation ratio is about nine or ten. So, for every volume of gas that comes out of that can, we're recirculating it nine or ten times. There is a relief valve in case we do get a problem with high pressure. It vents a very small amount of gas up the back.

It weighs about five pounds, if you're going to store it. As you use it, it weighs about three and two thirds pounds. It is small: about two tenths of a cubic foot. Oxygen flow's 4.8 liters per minute from the candle for about seventeen and a half minutes in laboratory tests, but when we went to the operational evaluation, it was about sixty and half minutes. It's a constant flow device, so it is not affected by the user's breathing rate.

Tell them how to put it on and it's going to take them a minute to do it. Don't even tell them how to do it and it's

about a minute. So, telling people how to do things **doesn't** really help very much. You have to go ahead and let them have a device, one that can be used. **I've** put it on in as low as **five** seconds. Now, Scott has one **that's** an especially made lead-weighted training device with big **grommet** holes in it and you breathe the outside air.

In leakage protection, I have to thank, Dick **Ronc** over at **NIOSH** in **Morgantown**, for his assistance in testing, these were the lowest values we came up with. So, Dick said, "You know, these values are probably always plus or minus one hundred percent, so don't hold a lot of weight to them." **But**, it gives you a good feel when unbearded subjects scored protection factors as high as fifteen, 000 and bearded subjects went as high as about 5,000 on laboratory **fit** tests.

That concludes my discussion of the **Navy's** experience with two types of self-contained breathing apparatus.

JIM JOHNSON

Each manufacturer, Clifton Precision, **Draeger**, **MSA**, Rexnord and **Survivair** has about ten minutes to discuss their particular equipment which they will answer questions from the audience.

PAT MCGLOUGHLIN
(*Clifton Precision*)

I think we've all heard a lot about the controversy about oxygen and its potential perils, and I guess I **wouldn't** argue the right or the wrong of them, that's up to the individual. To give you some idea where we came from our division was purchased by Litton approximately two and half years ago from **Benolix**. We started this development approximately five years ago using technology which we have built in Bendix over the past forty years. We have built approximately half a million devices using the basic injector principle which you see in the pressure-demand breathing regulator. We use it in panel regulators to dilute stored gas in an aircraft with ambient air and achieve a long duration.

We've built many, many thousands of them and we know exactly what it will do under certain conditions. **We've** taken that principle and applied it to a closed-circuit breathing device, this case a stored gas design with the area in the **rebreather** bag

basically representing the outside air in an aircraft. Of course, we have the carbon dioxide scrubber like everybody else does. Basically, our system has stored gas which you also have in any open-circuit **device**. there's an on-off valve pressure used for a bypass valve into the positive-pressure demand regulator. And then there is the rebreather section with the scrubber.

We use twenty-eight percent oxygen-enriched air. Your body doesn't need the one hundred percent that you would have in other closed-circuit devices. We maintain it between **twenty-eight** and **thirty percent**, which is more than adequate for the necessary oxygen uptake.

We've built a **half-an-hour** system, and this is the schematic that I am using here today. In principle, the posters that you saw out in the other room are the two-hour system, but principle wise, they are no different. We have two bags in that system to increase the dwell time in the scrubber and maintain better CO2 management. But, it's exactly the same principle.

I'll take you through a circuit to show you. The gas comes out of the pressure reducer or out of the bottle up to the pressure reducer and is delivered to the demand valve on an inhalation cycle. For every liter of gas that travels through we get a minimum of three to five liters of **rebreathed** gas. So, in essence, as your work rate increases, your actual system efficiency will increase because this unit has a variable orifice as opposed to a fixed one. This diagram shows a single tube and in our two-hour system we have a double tube. But on an exhalation cycle, as you exhale, there are two check valves which flows air into the bag filling it. **We'll** say this is set at about two inches of water pressure breathing resistance using current NIOSH requirements. This fills the bag up. Anything in excess of that, gets dumped on every cycle. We dump the last portion of the gas which basically tends to be the more heavily CO2 **laden**. It also helps to manage the CO2 concentration.

Now, on your next inhalation cycle the gas travels through this **Venturi** along with all gas coming out of the storage supply. It lowers the pressure at this point even though the pressure is still positive within the circuit. The

pressure here is lower than any place else in the circuit. So, instead of the individual having to generate enough effort to pull the gas across the bed, it is actually sucked across the scrubber bed because this point is lower in pressure.

We use the bottle as a heat sink because anytime that you open up a valve and draw gas out of a bottle, you get a natural expansion cooling taking place. We actually put the bottles in a sealed chamber and use them to absorb some of the heat that has been given off through the scrubbing action. The gas is now scrubbed, goes back to mix with the next gas coming out of the cycle: and this cycle just continues.

We've tested our thirty-minute units to NIOSH requirements (this is 4500 psi) and it will last, forty-five minutes. We have about an extra fifteen minutes.

We've designed this system for ventilation rates of fifty liters a minute because we don't believe (based on what the users said) that the NIOSH requirements are adequate to take care of firefighters in their normal work situations. We are approximately two to three weeks away from our testing on a two-hour prototype unit, which will be man rated by Dr. **Myhre** at Brooks Air Force Base under the same conditions that you've seen him report on earlier today.

WES KENNIWEG
(*National Draeger*)

Many of you are already familiar with the Draeger closed-circuit breathing apparatus. This is the BG174A, introduced in 1963, which is the American version of the **BG174**. This apparatus was introduced into the United States in the late sixties and probably 95 percent of the mine rescue teams in the United States and Canada are using it as their standard mine rescue and firefighting apparatus. The unit weighs approximately thirty-two pounds. The back cover plate is a stainless steel material, used to enclose the internal parts of the apparatus.

The cover is tapered at the top, as Mr. **Archuletta** mentioned. If you do have to take the unit off in a tight situation, this tapering in the sled-like ridges allows you to either slide or pull the apparatus.

How does air flow through the apparatus? There is an oxygen cylinder

which is pressurized to about 3100 pounds for the four-hour unit. **There's** a constant flow of one and a half liters of oxygen coming into the breathing bag. When you exhale, your exhaled air goes down through the exhalation hose, through a check valve into your scrubber canister where the carbon dioxide is removed. And the oxygen that you exhaled goes back into the breathing bag; it's enriched by the constant dosage from the regulator. From the breathing bag it goes into what's called a lung-demand regulator. That goes through an inhalation check valve, up through your inhalation hose and up to the face mask.

The breathing cylinder has approximately 440 liters of oxygen in it when it's completely full up to 3100 pounds. The regulator or the cylinder valve has a gauge on it. It also has a slip-clutch design you have to pull out to engage the valves so that you don't inadvertently close the unit once you have it opened. The oxygen flows through a two-stage reduction, through the pressure regulator which reduces the cylinder pressure down to 57 psi or 4.2 bars. Then that is fed through a metering orifice, up through the preflushed dosage line and into the breathing bag. The regulator also has several other functions: One is, it preflushes the system as soon as you turn the apparatus on. The apparatus is automatically preflushed, including the breathing bag and the inhalation hose. That way you start out with approximately fifty percent oxygen and avoids any potential hypoxia problems with low oxygen initially.

You also have your constant dosage, or metering device. You have a bypass valve which bypasses the regulator and feeds the oxygen through a line at approximately fifty liters per minute into the breathing bag. There's also a shut-off lever which if you develop a high-pressure leak -- more probably it would be in your chest gauge which is not protected by the cover -- you could reach back and shut off all the high pressure lines in the system so you wouldn't lose any further oxygen.

Above the regulator is the warning whistle which is set to go off when the supply gets down to approximately twenty-five percent of the original oxygen volume in the cylinder. Unlike an open-circuit unit which alarms until you run out of air, this will alarm for twenty to sixty seconds. At that point in time, you

have forty **five** minutes to an hour left

The scrubber canister is a factory packed canister which is approved with the unit. It is factory packed so that the breathing resistance is controlled and also you don't have to be concerned with the user not packing the canister properly. Its function is to scrub out your exhaled carbon dioxide, of course. The breathing bag has a six liter volume. It's a three-ply butyl material, which is fabric reinforced. Next we have the lung-demand regulator assembly with the lung-demand valve.

If you're consuming more than one and a half liters per minute, you'll create a slight negative-pressure of minus two to four millibars, which activates the lung-demand valve that can put up to one hundred twenty liters per minute of oxygen into the system. You also have a pressure release valve, a ventilation valve and the exhalation valve. Breathing hoses are made of a corrugated rubber material. On the bottom inhalation hose there's a saliva or condensation trap. The fitting on the hoses are all hand tightened as are the breathing bag and canister connections.

The face mask is a single connection, **valveless** face mask with a panoramic lens, and a speaking diaphragm built into it. It has two sealing edges and a nose cup which acts as a third sealing edge and cuts down on the dead space inside the mask. It cuts down on fogging because you breathe into the nose cup instead of onto the lens and it also directs your voice to the speaking diaphragm. With a long-duration unit, fogging can be a problem. Most **antifogs** will work good up to a maximum of two hours, if they work that long. If you have a failure of your **antifog**, there's a wiper built in so that you can wipe the inside of the lens. There's a five-piece **headstrap** assembly with a neck strap. These are the basic features. The frame, made of aluminum and the straps are a **travere** material. They are quick adjust straps which most of you are familiar with. There's also a tension strap for breathing hoses.

I'll just briefly give you a demonstration about how to put the unit on. This is the waist belt. Once you get that on, you can reach back, turn the oxygen supply on and you hear the whistle chirp. That indicates it's on. Also, you hear the automatic preflush.

Put your face mask on and then connect the mask to the hoses. Once you get the mask on, the first thing you want to do is check your chest gauge to be sure you have adequate supply pressure. After **that**, everything's automatic within the system.

ELMER BUBAN (MSA)

The MSA four-hour breathing apparatus was developed under a contract with the Bureau of Mines to be used underground and the following were the goals: It was to be lighter than existing four-hour apparatus with a maximum weight of twenty-five pounds without cooking; small in size (nineteen by seventeen by six inches) and it was also to provide cooling.

Units were tested, then we further field tested the units that we made and found that the unit should be redesigned to make it more rugged. Which we did to withstand rough handling, drop tests and vibration tests. A complete redesign was done and this unit now weighs thirty pounds **uncooled**, is twenty and a half by seventeen by six inches in size and it provides cooling by adding either a four-pound or an eight-pound ice packet. It has been approved by **NIOSH-MSHA**. To make the unit light, the oxygen cylinder is a fully wound composite cylinder which contains 491 liters of oxygen at 3,000 psi, weighs three and a half pounds, has a diameter of four and a half inches, is fourteen inches long and has an atmospheric water volume of a 147 cubic inches.

The scrubber contains 2.4 pounds of lithium hydroxide (**LIOH**). The ice cooler is a separate part of the system and can be attached to the apparatus so it can be used either with or without the ice cooler which comes between the device and the wearer's back.

What the oxygen system involves is, a main line valve and a separate bypass valve. You'll note that the bypass valve is completely independent of any malfunction of the main line because it exists prior to the gas coming to the main line. The gas flows from the main line to a pressure regulator which reduces the pressure to approximately 70 psi then goes to an admission valve.

The system is both a constant flow and a demand type. The constant flow is

within the NIOSH regulated requirements of one-and-a-half liters a minute, and the admission valve operates on a demand basis by the volume that exists in the bag.

The plenum is the area of the breathing apparatus that comes in direct contact with the ice packets and provides a cooling for the system. There's a remote gauge, an alarm system which activates at 650 psi somewhat similar to the alarm which exists on our standard open-circuit apparatus.

I'd like to explain why we chose LIOH as the CO₂ scrubber. We need 1.35 kilograms of LIOH to equal the capacity of other types of CO₂ scrubbers that would be necessary in this device. For example, we would need 3.4 kilograms of soda lime or 2.2 of sodium hydroxide. The small volume which this amount of LIOH takes is a definite size advantage. An important aspect of the NIOSH-MSHA approval of this device was that it works at minus 25 F where none of the other systems do partly because of the use of a LIOH scrubber.

The gauge is attached on the waist belt. The breathing tubes come down below the arm and connect to the apparatus. A chest strap which makes for a better harnessing arrangement for the apparatus to the individual. Two holes in the case accomplish two purposes. They're vents which are part of the cooling system and also they enable one to be able to look into the system and see that, indeed, there is a CO₂ scrubber canister attached inside of the system. Connections to the apparatus cannot be misconnected because they're mated with particular size threads. And there is a water trap.

The ice packet is attached to the system so that it comes in intimate contact with the wall of the system which is an aluminum wall. The ice packet is made of an aluminum wall on one side which comes in contact with the wall of the apparatus which is the outside wall of the plenum inside the system. The rest of the ice packet is made of plastic and it contains water which you put into a freezer, freeze and just attach.

We found that putting some shock absorbers in the system, helps tremendously with respect to maintaining the integrity of the system. When it's dropped three foot on each one of the corners of the apparatus onto a concrete surface, it still maintains its integrity. We

found that this particular requirement was necessary for the device that was developed for the Bureau of Mines. This shows the breathing bag, actually the plenum from which is breathed is behind this valve, is behind this breathing bag. So, that again, the intimate contact is maintained between the ice packet and the back of the system.

The cylinder can be swung out to place it in a position for refilling or else remove it from the system. This shows the facepiece and what someone referred to as "the funny-looking lens cleaner." Some fogproofs can last for hours, but it is much safer to put a lens cleaner on the system.

Some of the other features of the MSA system are two types of coolers: an eight pound which is good for four-hour use and a four pound good for two-hour use. With the use of the packets, the system inhalation breathing temperature is ten degrees Fahrenheit lower than what it is without the packets. The inhalation temperature measured during the man test is a maximum of 95 degrees Fahrenheit. The system's inhalation resistance amounts to a half-inch of water, and the exhalation resistance is one-and-a-half inches of water. This means that, depending on where you take your zero point, the system can be made to approximate what would be termed as a positive-pressure system.

Its cold temperature approval is (as I mentioned before) minus 25 degrees Fahrenheit. The CO₂ control is very good. There is no time during the test when the CO₂ gets any higher than one tenth percent. For training, we have a separate canister which is a two-hour canister and it's filled with cardoxide, mostly because it is a much cheaper CO₂ scrubber than LIOH. So, you can get an inexpensive training canister.

For rough handling, the apparatus can be dropped on each one of the corners up to three feet to a concrete surface. We've also run vibration tests on the system, passing the wheeled-vehicle vibration test, which is the Military Standard 810C for vibration. This involves submitting it to a thirty to 500 hertz vibration at 4.2 g's and .033 double amplitude. Again, the last revision to the system has been submitted to the NIOSH for retesting,

but not in production with it at the present time.

JUD MILLS
Rexnord-Biomarine

The BioPak 60P is a positive-pressure, closed-circuit breathing apparatus for use in contaminate and/or oxygen deficient atmospheres. Because of the positive-pressure in the facepiece, the BioPak 60P can be used in atmosphere that contain toxic gases and/or vapors and in atmospheres that are totally oxygen deficient. The BioPak 60P is a closed-circuit breathing apparatus using pure oxygen. The major portion of the user's exhaled gas is scrubbed and recirculated. This, of course, permits the unit to be small in size and light in weight. Properly used, the BioPak 60P will provide its specified duration regardless of the user's size or level of activity.

When the oxygen cylinder valve is opened and oxygen is continuously supplied to the breathing chamber, in addition, a pneumatically activated valve is opened in the exhalation line permitting free breathing. This safety feature prevents operation unless the oxygen bottle is turned on. Additional oxygen is automatically added by the demand of a free-flow valve to compensate for the user's increased work rate. When the user inhales, oxygen flows from the breathing chamber "through the inhalation hose to the facepiece. If the user's inhalation causes the breathing diaphragm to bottom, the demand free-flow valve automatically supplies the additional oxygen requirement. When the user exhales, he exhales breath, it passes through the exhalation hose through the absorber where the carbon dioxide is removed and then into the breathing chamber. Any excess gas is vented out the breathing chamber through the relief valve during exhalation.

The breathing chamber is maintained at a slight positive-pressure with respect to the ambient pressure by means of a compensation spring which exerts a force on the breathing diaphragm. The bypass valve is for emergency use only. The valve bypasses a constant flow restrictor and can be manually operated if the user is not getting enough breathing gas. An audible alarm sounds for approximately one minute when the oxygen cylinder

drops to a approximately 500 psi. The alarm reminds the user that twenty-five percent of the service time remains. When the alarm tone stem opening is covered, a distinct change in sound is produced. This gives a method for any individual within a group using BioPaks to determine if his or her BioPak has sounded the alarm. The BioPak 60P uses factory-sealed coolant tubes which contain a chemical that changes from solid to liquid by absorbing heat from the surrounding gas. After use, it resolidifies for later use.

In summary, the BioPak 60P is a small, lightweight, closed-circuit, positive-pressure rebreather capable of providing an extremely high protection factor. Therefore, the system is ideal for structural firefighting since it offers long duration without the stress of a heavier unit while protecting against toxics found in moderate firefighting scenes.

Now, I'd like to discuss some persistent misconceptions about the BioPak 60P. One is that: "You're not allowed to have an approved positive-pressure, closed-circuit rebreather."

30CFR Part 11, paragraph 11.70 defines both closed-circuit apparatus and open-circuit apparatus. Open-circuit apparatus is further divided into demand and pressure demand. No where does a regulation prohibit a closed-circuit, positive-pressure breathing system. As long as the criteria for maximum inhalation and exhalation restrictions are met, Federal OSHA has, in writing, stated that the BioPak 60 is a positive-pressure device and does meet the requirements of the Fire Brigade Standard for breathing apparatus.

We've had discussion that we need a definition for positive-pressure. I do not deny this. However, there is already a definition in the Fire Brigade Standard. It says that under the conditions set out in 30CFR Part 11, the unit will not go negative. Therefore, there is a definition and in 30CFR 11 it specifies the exhalation resistance. It is required. NIOSH, in a letter from Mr. Moran, has acknowledged that closed-circuit, positive-pressure equipment does exist and has requested input so that this equipment can be properly tested.

Item two: "The BioPak 60P is not positive-pressure." We hear both sides. Almost everyone in this audience is very familiar with its high protection factors.

You're also cognizant that the

protection factors exceeding ten thousand normally have been considered not achievable across a sample panel without positive-pressure devices. Repeated testing has shown that the BioPak 60P achieves a protection factor in excess of ten thousand. I respectfully refer you to the tests conducted by Mr. Hack at Los Alamos National Laboratories and Mr. Dale Drewer at the Army's Edgewood Arsenal.

Number three: "Breathing gas from a BioPak 60P is excessively hot."

Again, NIOSH standards specifies the maximum heat than can be achieved and it's 95 degrees F. Scrubbing of the carbon dioxide from the exhaled gas is an exothermic reaction which does produce heat. Design features such as the cooling tubes minimize this. Basically, all masks opened and closed are hot on the face. Nose cups, which most experts feel greatly adds to the protection factor, further concentrates this heat.

In fire conditions where the ambient temperature is high, tests have been run by Seattle Fire Department, by the Florida State Fire College, by the Philadelphia Fire Department and the Washington, D.C. Fire Department. All these results show no appreciable difference in the inhalation temperature of the breathing gas between open and closed-circuit systems. There is, however, a difference in the humidity which does make the heat more noticeable.

Number four: "Closed-circuit breathing apparatus is dangerous. And closed-circuit, positive-pressure breathing apparatus is more so."

Facts don't bear out these contentions. As you have already heard, thousands of oxygen rebreathers have been used successfully in fighting shipboard fires by the Navy without incident. All KO₂ systems generate more oxygen than can be consumed. Therefore, these systems at one point in time in their cycle are positive-pressure systems. Tests have been conducted by Lawrence Livermore National Laboratory and analyzed by acknowledged experts in the respiratory and firefighting fields. These people have concluded that these closed-circuit devices are safe. Tests were also conducted in San Francisco and Long Beach, California just recently, and in

no case, did we see a great buildup of oxygen in the helmet or around the face or around the unit itself.

Some mannequin tests have been conducted using drastically modified equipment with flow rates beyond human capabilities, with face pressures far in excess of what is allowed by law. And in fact, so excessive that there is a question that they would have prevented exhalation. If these same tests are conducted on a human, the human would have trouble breathing. I believe such tests are ethically wrong because they draw conclusions which would preclude using equipment that a firefighter may need some day to save his life.

In conclusion, we have before us a long-duration, lightweight breathing device with an extremely high protection factor which is safe for use. Because of our high-rise building, underground garages, toxic chemicals, poisons resulting from combustion, the need for a lightweight, long-duration breathing system has become essential. This does not mean that such a system will replace the open-circuit systems in use today, but they will supplement such systems and protect the firefighter under some very difficult conditions which are becoming more and more common. Many suppositions have been made and disseminated as fact. Thank God that NIOSH, OSHA, and Livermore Laboratories are going to conduct tests which will, hopefully, once and for all, get the facts on the table so that the fire community can make their own judgment.

RICH STEIN

Survivair-USD Corp.

The project that we've been working on is called the LP 120. It's a two-hour, (that's where the 120 comes from, 120 minutes), low profile, (LP), self-contained breathing apparatus that is a positive-pressure unit. The lead agency in the funding is the Bureau of Mines. However, FEMA, (the Fire Administration), the Air Force and the Coast Guard have all put money into the project. Which has made it kind of interesting because in many cases there are conflicting design requirements and needs of which we hear about on a weekly basis.

The background as to why we started

on this project was to do with fires in tunnels, high-rises and ships and for rescue and recovery in mines. This is where you need some long-duration apparatus, some specialized needs and specialized equipment.

There are four key requirements: One is duration. It had to be two hours long. Two hours was defined at a work rate of approximately 1.75 liters of oxygen consumption per minute. This is in essence what NIOSH human subject testing for a ninety-five percentile man would require.

Secondly, the profile had to be very narrow. Since the Bureau of Mines took the lead, they were most concerned about mine rescue activities taking place in low seam coal mines. And we've heard from MSHA about the situation where they had to drag units alongside them and work in coal mines which are only twenty-seven to thirty-six inches high as some cases. One of the things we wanted to do was reduce the profile of the apparatus to make it easier to carry on the back.

Third: Weight had to be reduced. At the time that we started the project about two years or so ago, the Draeger BG, for example, was the typical apparatus weighing about thirty-three pounds. We wanted to reduce the weight significantly from that.

And finally, it had to be positive-pressure, mainly because of the additional protection afforded by this design. We later had a major additional requirement to explore the possibility of developing a mixed-gas system because of the concerns over the safety of the oxygen units. We wanted to determine whether we could make a practical device which conceptually could provide twenty-five to thirty percent oxygen to the man. Okay, let's talk about the oxygen unit because that really is the main unit.

The design concept for the oxygen unit is quite simple. Most SCBA have a couple of key elements in common no matter what closed-circuit the design is. They have a face mask, they have some kind of a CO₂ scrubber, they've got some kind of inhalation bag to hold the gas when you exhale and from which you can inhale, they have some sort of source of oxygen. There are many variations on a theme, and we have one more variation which we think gives some advantages.

One is that we've split the bags up. This is a concept which was developed

many, many years ago, actually in the diving industry, and we've adapted it to determine if it will work above surface.

Basically, the system is quite simple. You exhale into the unit. Part of the exhaled gas goes into the positive-pressure side of the bag. When you inhale, you first breathe from the positive side of the bag and then pull through the system through the scrubber and into the facepiece. This split-bag system allows us to change the work phase of the breathing through the scrubber resulting in an overall total reduction in breathing resistance. It also provides a much greater surface area for cooling.

There are two main problems that you have in closed-circuit breathing apparatus. One is the breathing resistance and the second is the heat. In this design, we attempted to try to solve both problems. Since heat is a major problem, we've actually built into the system a phase-change type cooling unit. There isn't anything auxiliary. Although ice is fairly inexpensive, you do have to put it in an ice chest, which means you have to have an ice chest available and wait for it to cool down. Phase change materials work pretty much at room temperature and provide about the same amount of cooling capacity. So, we've chosen that kind of a system. Filament-wound oxygen cylinders which are pretty familiar, are devices to reduce weight. We have a standard, first-stage pressure reducer which goes into a second stage reducer and pushes into the inhalation side of the bag, then up to the mask. This apparatus is designed to meet all the key requirements for NIOSH certification, so it does have a bypass system and an electronic alarm system. The overall apparatus weight, initially, was to be about sixteen, seventeen pounds. The prototype weighs about twenty pounds now including the cooling unit. The cylinder is positioned on the bottom for ease in wearing, and to get air flowing through so that you get a chimney effect to blow the air and help cooling. Breathing bags are located on each side of the unit.

Dimensions are about three-and-a-half inches in profile, about eighteen inches wide and about twenty inches high. As a result of testing, we'll be able to cut down on the size even more, however,

than you see right here. Profile will remain the same. We originally were attempting to get a three-inch profile, but that proved difficult, not so much from a technical point of view, but from manufacturing and from use. It was just too difficult to pull apart for the end user.

The major parts which are the breathing bags, the CO₂ scrubber and the cooler all pull apart very easily. I wanted to show you this because we made it into a modular approach so that you can pull them apart in less than a minute. You can quickly change your scrubber and put it back together again. It also allows ease of maintenance and replacement of parts. All of which count out in the field,

There is a saliva trap or moisture trap which holds about 100 cc's of water. The regulator is an adaption of a current unit that we make in the diving business. There are well over half a million of these out in the fields and that's a fairly reliable piece of equipment.

There really isn't anything spectacular to report in terms of oxygen usage. We have 240 liters, sized out to 1.7 liters per minute and that's more than sufficient to supply the oxygen needed for the kind of testing we do. CO₂ has to be below a half a percent, and we use lithium hydroxide to keep the CO₂ percentage and temperature very low. If this SCBA is going to be used outside, especially in Northern areas like Chicago and Buffalo, we have to think about low operating temperatures. Sometimes, we in Southern California, forget that. The other advantage is efficiency on a weight-to-weight basis, in other words, weight of this lithium hydroxide to weight of the CO₂ absorbed. It's the most efficient of all the scrubbers, but it is extremely expensive. So, the plan usually is to use LION in actual use but then have a training canister of different scrubbing material.

I want to very briefly go through the mixed-gas system to show you what the concept was. This is a little bit more complicated than the schematic I presented before, but basically it's the same system. The only thing we've added now is a small air cylinder. And what we've done is made a decision on terms of strategy to mix on board rather than provide a single cylinder with mixed gas. The feeling was that single cylinders of mixed gas are simpler in terms of apparatus design. But in terms of ability

to find the gas when you need it, that would be very difficult to do. We know you can always get oxygen and we know you can get air, but we prefer to mix on board.

This apparatus is computer controlled. What it does is pick up inputs from the oxygen cell, converts them from analog to digital and decide whether there's enough oxygen. We set the desired level at about thirty percent, so if you drop below or above thirty percent, it turns on the appropriate air or oxygen cylinder to maintain the concentration at thirty percent. Finally, it goes to a driver and into the outputs controlling the system.

This is just a breadboard model of the unit, which should look familiar to you because of the two split breathing bags, oxygen cylinder, the little air cylinder (notice they're both the fully-wrapped filament wound cylinders) and finally just a little onboard computer. The system has been tested and it works.

We are concentrating our efforts at the present time on the oxygen system. We hope to go to NIOSH for testing in the next few months. We have done some testing at Brooks Air Force Base just recently and we have run a similar test in our lab. Again, it's very difficult to say on the basis of two tests, but it appears that even at a work load of 2.8 liters per minute of oxygen Loren Myhre found that it lasted about an hour. When we ran the test we found a little leak in the system and it still lasted about an hour and a half. Which agreed with the oxygen consumption levels in the unit.

The key features of those tests showed the breathing resistance was very low and the temperature was a little bit lower than 90 degrees F which was excellent.

ROBERT DA ROZA

I think I'll call for questions from the audience for people to ask the manufacturers questions so it'll go on the tape better?

Anybody have any questions?

It always takes a while to think of questions and then you really start out.

UNIDENTIFIED SPEAKER

I wanted to ask Wes, on the Draeger unit, where the excess oxygen venting took place.

That's one thing that people are

concerned about is where oxygen venting may catch fire, and I was wondering where that was.

WES KENNIWEG

Any excess oxygen is vented out of a small hole in the diaphragm assembly whenever you build up an overpressure in the system of plus two to four millibars. It will vent through a one-way valve to the outside.

ROBERT DA ROZA

My first talk yesterday indicated that if you're at a low work rate, like just strolling around or sitting around, that you will have excess oxygen and it will be venting then. But, if you're working hard, then you use it all up and you don't have any venting. Is that right?

WES KENNIWEG

Yes. That's correct. If you're using more than one half liters per minute, then your lung-demand valve is going to eventually kick in and give you more oxygen. If you're using less than that, you are going to gradually buildup an overpressure.

ROBERT DA ROZA

And then that oxygen would go out into the case and get mixed?

WES KENAWAY

Yes.

JIM TUNNEL

I would like to address a question to all of the speakers today. I would like to preface it by saying that it's news to some of us that Draeger has also just initiated the evaluation of a new Draeger, positive-pressure, closed-circuit oxygen breathing apparatus.

I was advised yesterday by one of the Draeger reps that that apparatus is not going to be recommended for use for interior structural firefighting.

I wonder if the manufacturers that have just presented new prototype products have that in mind also, or are you going to, in fact, recommend the apparatus be used for interior structural

firefighting?

PAT MCGLOUGHLIN *Clifton-Precision*

Ours will be recommended for structural firefighting. No reason not to.

ROBERT DA ROZA

Now, yours are going to supply about twenty-eight percent oxygen. What about some that have units that are pure oxygen?

RICH STEIN *Survivair*

Quite frankly, I'm not prepared to speak for my company on a question like that. However, when it comes time to produce the apparatus, we will have the information on the testing that's going on right now with Lawrence Livermore, Lile and OSHA, and based on that data, we would make a recommendation.

WES KENNIWEG

I'll just comment for Draeger. The positive-pressure, two-hour unit that we have developed was designed for a specific market area which is known in firefighting. We still feel there is a certain hazard with positive-pressure oxygen in fire.

ELMER BUBAN *MSA*

We have no new unit of a duration which normally we use in firefighting. We do have a four-hour system.

But, the one-hour system, yes, is recommended for structural firefighting. We have seen nothing to say that it should not be used there.

PAT MCGLOUGHLIN *Clifton-Precision*

My own opinion for MSA is I agree with Rexnord's position. And I don't see any restrictions on the device.

JUD MILLS *Rexnord*

I'd like to make one other comment. Among many other products Rexnord

produces, we produce mixed-gas systems. We have for many years. They all happen to be used in diving. They all happen to be military units. They operate as deep as 1500 feet and for as long as eight hours. They are computer controlled and we have an additional problem in that you must vary the oxygen percentage in the mix as you go deeper, and the tolerances get narrower and narrower.

A mixed-gas system, in my opinion, can be produced within a matter of months.

However, a problem is, as Chuck Soros mentioned yesterday, is cost problems.

The present system which is in the United States Navy and used by NATO countries and is beginning to be used commercially costs about \$30,000 each.

The newest version which will be in the fleet shortly is even more expensive for a reason I don't want to go into. But, it can be done. But again, the cost problems to a city that needs a couple of hundred of these things would be pretty horrendous.

ROBERT DA ROZA

It's been very interesting to me to see that a number of manufacturers are working on designing new, closed-circuit breathing apparatus systems. It means that, at least in the manufacturer's eyes, that closed-circuit breathing apparatus certainly have a use somewhere.

Other questions? Jerry?

JERRY STENGEL

For the manufacturers making mixed-gas systems.

There's an implication that twenty-eight percent, or some value in that range, is safe, where as one hundred percent or near one hundred percent pure oxygen systems are not or may not be safe. What's the basis for that?

Is there any technical basis for that 28% number or is it one that's arbitrarily close to twenty-one percent?

RICH STEIN

That's a good question in that is the same thing, as in our last visit to NIOSH that issue was discussed. And I think the answer is that in our discussions with OSHA, previously, there had been discussions that anything under thirty

percent would be considered as safe to operate as compressed air. Anything above that would be considered oxygen.

Quite honestly, we are looking for that data which says that. And to date, we have not been able to find it. Everybody says they've heard the same words but nobody can come up with a piece of paper.

So, quite frankly, it was based on those unsubstantiated words from OSHA at this point.

The other thing, I think, is that the twenty-eight to thirty percent allows you to have enough oxygen in there to satisfy the individual's oxygen uptake plus have a little bit of margin and still stay below the thirty percent limit.

You can probably do it with twenty-six but you'd be running marginal, given that the nineteen and a half percent is what you have to maintain as a minimum.

WES KENNIWEG

National Draeger

To kind of reiterate that, I think what it boils down to is we were concerned about how low can you go and still provide a reasonably safe unit.

And the twenty-eight to thirty percent is a general feeling that's about as low as you want to go and still have a safe unit.

I think Jerry Stengel some time back at the Bureau of Mines, did some work on explosion problems with enriched oxygen, and I believe when you get above thirty percent, the probability of an explosion, I think, doubles.

And I think that's also the concern when you start getting about thirty percent. Although I don't have any hard data, I think those are the two reasons why we are around twenty-eight percent.

PAT MCGLOUGHLIN

Clifton Precision

We've checked with some people at Southwest Research Institute and the Southern Research Institute about the flammability of products in elevated oxygen ambience and high pressures and found that no data exists.

UNIDENTIFIED SPEAKER

Effective voice communication seems

to be a problem in the fire service while they're wearing their breathing apparatus.

I'd like to address all the manufacturers.

What type of research is being performed, presently, considering electronic or other voice communication devices and about what price range are we talking about if there's anything available?

ELMER BUBAN

MSA

Our unit has a speaking diaphragm as do all the units here. The problem with that type of device is that a fire is a noisy place and it does present some problems.

Most of us here are on the NFPA Committee. We are looking seriously at the tests which will, as Mr. Duffy described it this morning, have to have a basis of a test distance of eight feet with a 90 db background and a hundred words of which 90 percent of them have to be audible.

My opinion based on testing we have run is that an electronic device is going to be necessary.

Electronic devices in the fire service give some problems, as the device has shown. Batteries are a problem, and certainly costs are going to be a problem.

As far as how high it will go, I don't know. We'll all have to come up with it, so there will be competition.

We do have an electronic system which is adaptable to all of our devices in which the ultra-view facepiece is used.

We found that the system does work. We've tested it at the 90 db background at three feet and found that it is intelligible and it's operated by a small, 9-volt battery. We're also doing investigative work of adapting this system to radio systems.

UNIDENTIFIED MANUFACTURER

We also have a small receiver and transmitter that can be attached to the mask for connection to a portable radio.

JUD MILLS

Rexnord

We at the present time do have an optional microphone and headset which is available for a BioPak 60 unit.

UNIDENTIFIED SPEAKER

About two years ago, I think it was, OSHA came out with a preliminary report on carbon dioxide. And I believe the recommendation in there was going to be three percent for ten minutes and no more.

Three percent is considered to be an area you don't want to exceed. And I believe the U.S. Divers was the only one who showed CO₂ data in which they mentioned a tenth of a percent most of the way through the device.

Maybe that's a requirement that took the only requirement on the device, but I think this three percent or less is going to be something that will have to be banged up again, so to speak.

Is that going to create any problems?

ROBERT DA ROZA

The question is, will keeping this carbon dioxide concentration below three percent be a problem with any of the devices? Pat.

RICH STEIN

Well, I'm not sure, but in the NIOSH requirement, depending on the duration of the device, you have various CO₂ levels which the device must stay under to meet NIOSH requirements. And I don't know any of them that get up to half a percent.

JUD MILLS

When you test escape apparatus, you're allowed to have a higher concentration, but I think it's only one-and-a-half or two percent.

UNIDENTIFIED SPEAKER

Who said they had three percent, Rob?

BILL JONES

It's Bill Jones. I'm from New York. And I raised an issue yesterday about particulate matter entering the respiratory tract. And I haven't heard it mentioned yet today.

Of course, the panel up there yesterday weren't manufacturers. So, I'd like to address that issue to each of you.

ROBERT DA ROZA

The question had to do with a firefighter in New York City who had a problem with some particulates from the canister getting in his mask. That I believe was referred to as a Draeger unit.

WES KENNIWEG

National Draeger

Sodium hydroxide particles can be present in the exit port on the canister. However, we've done extensive testing and those tests have shown that these particles are not transported to the breathing mask such that they would get into the wearer's lungs or respiratory tract.

These tests have been further supported by the years and years of use of the apparatus in the field. As the representative from MSHA said, each person is training under oxygen approximately twenty hours a year, and you're talking over 100,000 hours per year usage. And we've had no reports of any problems.

UNIDENTIFIED SPEAKER

That sounds like someone had some unfortunate situation take place that doesn't seem to have happened to anyone else.

BILL JONES

As I said yesterday, it had happened several years ago and reportedly was corrected. And we also have the physical presence of the particulate when you shake the canister. Now, I'm reluctant to have somebody put it on just to see if it does in fact happen. I just don't understand, is it just the masks that went into New York? Are they lemons?

You know, it's not funny. As I said yesterday, we put the masks on to keep particulate matter out of your system from the outside, and now we have it coming from the mask itself. I don't think it's funny.

JUD MILLS

I don't think it's funny either.

BILL JONES

And I'd like to know if there are other people who have had this problem.

WES KENNIWEG

As I stated, no one else has reported the problem. We have not been able to duplicate the occurrence that was reported in New York. All the tests we have done have showed that the particles that may be there do not get into the respiratory tract of the user.

PANEL MEMBER

It looks like it's not something that we can solve here.

UNIDENTIFIED SPEAKER

The current apparatus on the market is regulated and certified as a rebreather. My question to the new manufacturers of the new apparatus is: Are you seeking certification of your apparatus as a rebreather or do you have something else in mind?

WES KENNIWEG

As far as the apparatus that Draeger is going to submit, yes, it is going to be submitted as a closed-circuit rebreather.

PAT MCGLOUGHLIN

I think the question answers itself. A rebreather is a closed-circuit device.

RICH STEIN

In our (USD) experience and our discussions with NIOSH, once you introduce any type of recirculation or scrubbing it automatically falls into the category of rebreather. It's not like you have a choice.

LOREN MYHRE
USAF

I really do appreciate the chance to share with you a few other things that we are doing that I feel are pertinent to the discussion that we've been going through so far. We have talked about the breathing apparatus and what it can do. But what we haven't really gotten into deeply enough is what the people can do who are going to be wearing this apparatus. Chief Sharry (LLNL)

mentioned the fact yesterday that management needs to know the limits of the personnel and the equipment and I fully concur. Chief Guyett (Long Beach, Calif.) has indicated that the fear of warm air that's encountered when people first breathe through a breathing apparatus is a problem. And this, of course, is where physiology can be very exciting because physiologically we can assure them that breathing warm air is not life threatening, it's just a little bit new and uncomfortable perhaps. Mr. Seymore, (OSHA) mentioned that the fire department goes in to get a job done as fast as it can and then usually gets out of there. That is very critical. That's what I want to talk about now: going in and getting the job done.

Now, I mentioned in a previous talk that we had determined the energy requirements for various tasks involved in air force firefighting. One of those tasks had to do with rescuing flight personnel from a B52 aircraft. That's rather unique to the air force. But another task, which is not unique at all, is a structural search and rescue effort. In fact, it might be a task that is much more easily performed by air force firefighters than by big city firefighters. I say that because on air force bases we seldom have buildings that are more than three stories high, and it's much easier to climb three stories than to go up twenty stories, of course.

We know what the energy requirement is for firefighters in a typical structural exercise. Imagine the scenario now, where the firefighter is going into a building carrying his protective equipment or wearing it and carrying the hoses that I showed you earlier. The total burden is somewhere about a hundred fifty pounds of equipment he's carrying, and he's climbing up three flights of stairs.

We need to know what the energy requirement is for just climbing up the flights, because by the time he gets to the third floor, he maybe so worn out he can't rescue anyone. And that is absolutely true in some cases.

Then once he gets to the third floor, as he searches we have a scenario where he does find a victim - in fact, he finds two. He must bring them safely to the stairwell where he has help getting them out of the building.

The hallway where the rescue is occurring in our scenario is about seventy to eighty feet long.

In the scenario, the firefighter must

remember that the victim is lying unconscious on the floor and the room might be full of smoke and toxic fumes. If there is any good air, it's down near the floor, so victims will be moved in a very low crouch. The firefighters that I have worked with have been instructed to bring a victim back dragging him on the floor with his head down as near the floor as possible.

Now, this is where the business end comes in then. Using the words that Mr. Seymore did, "getting in there and getting the job done as fast as he can", effectively is a firefighter who is doing the job. If he is removing that victim as quickly as possible, he is consuming about three liters of oxygen per minute.

Well, that might not mean so much to all of you, but let's just say that three liters per minute is a pretty high level oxygen consumption.

In fact, probably half of the firefighters that are assigned to firefighting cannot consume that much. And if one cannot consume three liters a minute, but the job requires three liters a minute, there are two possibilities:

One, is that you begin working at that rate and become exhausted within a minute or two and it's all over. Or the other is that you just slow down and pace yourself and bring the victim out as fast as you can but somewhat slower than is really hoped by the fire department.

You must look at the fitness level of the firefighter to see if he can do the task. If we say three liters a minute is the requirement and a person has a maximal capacity of four liters per minute, then he's working at seventy-five percent of his capacity in doing that job. We know from physiological research that has been going on for fifty years, that one can work at seventy-five percent of his capacity for well over twenty or thirty minutes. A trained person can even work at seventy-five percent of his capacity for two hours or more. But we also know that if that firefighter who has a capacity of three liters per minute is doing a job that requires three liters per minute, then he is working at one hundred percent of his capacity. He can only work for two or three minutes and he is done: is fatigued and has to rest. There is a great variability among firefighters as to whether or not they are able to handle

such a task. Now, what we're finding with air force firefighters can be related to the civilian force as well - that is that the average air force firefighter is below average. And when I say below average, he is below average in physical fitness in our normal population of American people. He is above average in body weight; his is above average in body fat; he is above average in risk factors for cardiovascular disease. He is above average in the incidence of smoking; he's way above average in the incidence of drinking coffee. He lives a very sedentary life, because our firefighters spend less than three percent of their time fighting fires. And, he enters the firefighting profession and stays in it for twenty years or longer,

Now, you can imagine what happens to a person that doesn't fight fires and sits there for twenty years and smokes and drinks coffee and gets overweight, and then all of a sudden the siren goes off and he has to climb into a building and rescue someone? It doesn't work - it just doesn't work. Of course there are some very fit firefighters. But for every fit firefighter, we have two or three that are very unfit.

Now, what does this mean in terms of getting the job done?

One way you can look at this is to ask how long it takes a person to enter a building, go down and find the victim and bring him safely out. We've done this and found that for the scenario that I mentioned, it can be done as quickly as four minutes: entering the door, climbing three flights of stairs, going down the hall, finding the victim and bringing him back. Four minutes is a good performance and so we can even do it in about three minutes. But there are some who require as much as fourteen minutes to do it.

Now, I think you can see the difference this might make in a burning building. Do you have the luxury of spending ten more minutes, taking your time? In other words, you pull the victim a little bit and then you rest, and you pull him a little bit and you rest. You might not have that luxury. There's a great variability among firefighters. There are some firefighters who can't pull them out even in fifteen minutes. I've watched them try. What happens is, they get so far down the hall and then they stop and they are told, "If you can't go any farther, then

save yourself." And that's what happens.

Now, that alarms me. If that is my son or (laughter down there and this firefighter who was paid for twenty years to fight fires and then comes the one time that he really has to do it, and he walks out and leaves my son or daughter down there, that bothers me terrifically! That's his profession and he can't do it. The real alarming thing is that this is the average. This isn't unusual, this is the average firefighter.

Now, this data is for us air force firefighters. However, there have been at least two similar studies done on civilian firefighters, (one was by Charles Dodson, the author) and they are probably not as good in terms of fitness, fatness and incidence of cardiovascular disease.

These are alarming things that also have an important bearing on the breathing apparatus. First of all, a highly fit individual can do a given job with a greater conservation of breathing air than can an unfit individual. For a job which requires three liters of oxygen per minute, to move a person from a hallway to a safe area, a very fit individual can do that with the ventilation requirement or an air use of around 70 liters per minute. The very unfit is going to require 100 liters of air per minute and he's not going to get the job done. So, the efficiency of the use of the air in breathing apparatus is very closely related to the percent of the maximal capacity of the firefighter to do that job. The closer he is working at his maximal capacity, the less efficient he is going to be in breathing that air.

So, if you have two people, one fit and one unfit, doing the same job, the unfit person is going to use more air per minute than is the fit person. And I could give you lots of experimental data to show that. It does work out. And as I observed this in firefighting, I wondered why something isn't done about it. And now we are starting to do something about it.

The Air Force Fire Protection Center at Tindel Air Force Base is concerned with this and they are working with us to develop a program to improve the conditions in the air force. What I wanted to tell you about today, is that we want to determine the fitness level of air force firefighters. We know now what the requirement is in terms of energy expenditure and now we want to see how closely the firefighters that we have are

able to meet that requirement.

We determine their fitness level by standard physiological techniques, and that is determining their work capacity or their aerobic capacity. You might have heard the work "aerobics" used in training. Where we find that their fitness is below what is considered to be acceptable for doing an efficient job, then it's necessary to do something about that and something can be done about it. There are training programs that are very effective if they are followed. The firefighter who needs help can improve his fitness, decrease his fatness and can become a better firefighter. It doesn't take years to do so.

Right now, we're testing this conditioning program. We want to see if the program that we have developed is going to work. So we are going to four different air bases and doing the initial measurement of every firefighter to see where he stands today on physical fitness. Then we're putting him through a year-long fitness training program. Not just twelve weeks, which is what you usually see in the literature, but a full year. Periodically during that year, we are going back and testing his progress to make sure that it's working. If it isn't, we want to know why and we want to improve it so that it does. At the end of that year, we are going to recommend a training program that we, hope to have shown will improve each firefighter's fitness. Following a successful demonstration we expect the whole air force will adopt it for all one hundred and fifty-three air bases.

The opportunity is fantastic and it's exciting because there are few professions in the world where you have the luxury of spending twenty-four hours on duty and not really being very busy all twenty-four hours - that's where we are in the air force. The opportunity to develop a conditioning program that people can enter into while they're on duty is tremendous. We don't have to say, "Now when you go home, try to go jogging tonight." Now, in the air force, we can say, "Look, you're here twenty-four hours" - "we've got a gymnasium in the station, we have a program that we not only want you to follow, but you will follow. You'll do it. That's part of your job."

And it should be part of their job, to maintain a readiness capability. It will

work wherever it is followed, if it is followed. And that, of course, is the key.

In the air force we have both military and civilian firefighters. Now the military can be told, you will do this training, this exercise every day and they just have to do it.

The civilians argue a little bit because they have unions and they have reasons to say that, "Well, maybe we don't have to do it that way." Fortunately, or unfortunately, the air force can be a little more dogmatic in saying, yes, you're going to do it anyway because it's part of your work duty.

And it is being done. And I have done testing through the ninth month of this experimental program so far at Grand Forks Air Force Base. Randolph Air Force Base and Elsworth Air Force Base located in San Antonio and Rapid City, respectively, we'll be going through their four-month progress check within the next several weeks. I can tell you from what we're finding at Grand Forks that it is working and it is working very well. Yet it is not completely acceptable to the firefighters either. There are many that really don't like the idea of being told they will do this as part of your duty.

Now, what is that duty? Is it really so hard and so irritating that one doesn't like to do it? I don't think so. The exercise is not exhausting. It is designed for each individual. Based on his initial test, we then assign an exercise program that has been determined through research to be effective. In other words, everyone has a different conditioning program based on his fitness level. So, he's not competing with anyone but himself. He's starting at an initial level and he's improving from there. It means that he will do an aerobic form of exercise for twenty-five minutes every day that he's on duty. That means only three times a week. Now that is absolutely minimal. We are trying to motivate them to work four times a week eventually. That's twenty-five minutes of aerobic exercise and it happens to be on a stationary cycle odometer which can be kept in the station so he's always ready to go to work if called upon. Another ten minutes is spent in weight training on a universal gym. Not muscle building, just basic conditioning and maintenance of muscular strength to handle the kind of duties that a firefighter is involved in.

We expect fifteen percent improvement over about a six-month period and we

have seen more than thirty in some cases. It's exciting. More than thirty percent. That's more than one would expect. We also find that some people aren't improving very much at all and it is directly related as to whether or not they are doing the program. You might say, if it is mandatory, "Then why aren't some doing it?" Well, there are some that still will find a way not to. You know how that is. But at the end of the year, those who have participated in this program are going to improve tremendously. That's going to mean that they have the capability to do a firefighting task, and they are able to do it with less expenditure of air because of their fitness improvement.

One other thing that is very important is that we are concerned with what we find is an alarming state of health of air force firefighters. Those of you who are in the firefighting profession probably know that firefighters like just as much junk food as anyone else, but they have more opportunity to use it. It is amazing the things that they will eat and drink on duty. Because they are smokers and heavy coffee drinkers and so on, when we look at blood parameters, we find that air force firefighters have a higher than normal risk of cardiovascular disease based just on blood cholesterol, blood lipids and triglycerides. Blood cholesterol is a problem that is often times related to diet, that is, the intake of high cholesterol foods, animal fats. But it also somewhat related to a person's genetic characteristics. But, if one can encourage the firefighter to reduce his cholesterol intake, then you can do something about this killer of coronary artery disease which is instigated by blood cholesterol.

Now, if you're up to date on the literature, you know that low density lipoprotein is the substance that collects in the blood vessel and plugs it. High-density lipoprotein comes behind and sweeps it out, prevents it from collecting. So, what you want optimally is to have a lower level of low-density lipoprotein and a high level of high-density lipoprotein. The low-density lipoprotein is a response due to the diet, but the high-density lipoprotein is independent of the diet. It is a response due to exercise. And people that participate in regular training activities build up high-density lipoprotein to the point where it is a protection against

cardiovascular disease.

Thank you for giving me this time to tell you about what we're doing in the air force.

The main emphasis of this panel will be on discussing the training needs of the fire service on the use of closed-circuit breathing apparatus. We'll start first in here with Capt. Jerry Grey. And I'd like each person to introduce themselves, their name and who they're with and then give their short presentation, somewhere between five and ten minutes.

JERRY GREY

My name is Jerry Grey. I'm with the San Francisco Fire Department, been with them since 1970.

January 17, 1979, eight Oakland firefighters suffered severe respiratory exposure and unfortunately one fire lieutenant died. A second firefighter was pronounced dead, yet is on the job today due to very valiant rescue efforts. Their oxygen supply ran out. This incident in the San Francisco-Oakland BART (Bay Area Rapid Transit) tube was a shot heard round the world and a spark from which the San Francisco Fire Department began investigating long-duration breathing apparatus for fire ground and other emergency use.

I have a couple of slides. I would like to show on that BART incident just to give some of you people that may not be totally familiar with the fire aspect of it what we were encountering. We staged our people at Embarcadero Station back a little way from the bay. The Oakland Fire Department had their people staged at the vent shaft, over on the other side of the Bay. There's a large travel problem here. You could consider this a high-rise building laying down on its side, if you want, or just like an elevator shaft.

Our people were sent in on not only a BART train, but we also were using an emergency vehicle. Our crews were loaded up and they had a long trip ahead of them, a couple of miles.

No pun intended, but there's no slide there.

We couldn't get any pictures during the incident for obvious reasons - it was impossible to see anything. After the incident, this is what was encountered:

There was a damaged train off in the distance. You could see a lot of the discoloration that the smoke generated. There are two bores through which the trains travel. They're separated by a safe area - a gallery where people supposedly could go for safety and not encounter smoke. That's where the Oakland firefighter, or the lieutenant, died and the firefighter was pronounced dead.

This is what you see when you open the door looking into the BART tube where the trains are. The trains are kind of elevated up. It's very awkward. Without any visual senses, it's extremely difficult. In the first car you can see that there was discoloration because a lot of smoke was generated and this car was at the front end of the train. The fire was several cars back.

As we walked along the walkway towards the fire-involved cars, you could see some of the damage done. This is the interior of one of the cars with fiberglass falling down. The smoke generated from this contained tarry particles that were so thick that the next day the firefighters that had worked the night before could not get the things off their face. Everybody was one color. Everybody was black. Most of their clothes, had to be thrown away. There was total destruction of these cars.

The eight Oakland firefighters that were sent in were all trapped in that gallery. They could not get out. And for some miscommunication, not on the firefighters' part but, evidently on BART's part, the smoke somehow got down inside that safe haven area, and that's why they were overcome. You can see the damage that was done not only to the car, but also to the tube up above. A lot of cement was broken away.

The Oakland firefighters who were walking in that tube to rescue those initial eight firefighters, had to walk side by side with their arms clasped together walking down the tube because the visibility was zero. Their hand lanterns were no good. But, eventually, they found the firefighters that were in the gallery. Someone was heard beating on the door. When they opened the door, they were able to pull him out into the opposite tube. This is how they were rescued.

The firefighters' need for breathing apparatus is obvious. But until recently, the self-contained units were of too short

a duration for many emergencies. This was realized in this incident. The San Francisco Fire Department has been using rebreathers since the 1930's. It's nothing new to us. The last of the two-hour McCay units were removed from service in 1978 through attrition. They had just suffered a lot of damage over the years. Following this 1979 incident, BART purchased four-hour Draegers for the fire departments of Berkeley, Oakland, Orinda and San Francisco.

Our 7-truck and both rescue squads were issued four Draegers each. A twenty-hour training course was conducted by certified MSHA instructors for fifty firefighters from the squads and 7-truck.

The instruction included: field stripping, minor repairs, oxygen cylinder and cartridge replacement, field testing operations, which is a ten to fifteen-minute operation, and proper donning use. Although our Draegers have never been used during an emergency, we became aware of several potential problems through evaluation and training.

Problems included: fittings loosening up while they're bouncing about on the apparatus. Realize that the vehicles that these were placed on are very high response vehicles. The squads averaged at that time two hundred fifty to three hundred fifty runs a month. Also, a problem with heat and humidity buildup in the breathing air was reported. The training of detailed personnel was an endless task. The people that were just detailed in for one day to be briefed about this apparatus that they possibly had never seen before.

One firefighter passed out during a BART training exercise because his oxygen bottle had been filled by an outside agency with compressed air instead of oxygen. Now, how could that happen? It was very difficult. Someone had to make several adapters, but he did it. At any rate, we immediately purchased the equipment necessary to fill the small, high-pressure bottles ourselves.

Another concern that we have with the Draeger units is the possibility of using them without turning on the oxygen bottle. Just a couple of weeks ago, I put one on (I've used them in the past) and the gentleman that was with me asked me if I felt everything was all right. I said, "Yeah, no problem at all." He said, "I have not turned on your oxygen." There was no way for me to tell that.

Another problem that has been brought to our attention was that the particles of the alkali cartridge material may come out of the canister upon shaking. This has occurred during inspections of canister, but we have not knowingly experienced this problem during use. We also noticed that the ten to fifteen-minute **preoperational** check-out was extremely frustrating to firefighters that were accustomed to immediate entry on arrival at incidents. This frustration could lead to possibly rushing or missing of some very important, preoperational checks.

These problems and concerns coupled with a lack of use under emergency conditions has created a lack of confidence in our Draeger rebreathers. On October 4th, 1984, the four-hour Draegers were removed from service.

Searching the smokey, hot floors above fires with limited air supply has always been a concern for firefighters. In 1980, our breathing apparatus director researched available, long-duration breathing apparatus. We've purchased some of the newly developed BioPak 60 units at that time, in 1980. Twelve of them were placed on our rescue squads again. Six on each one. Also our airport division purchased approximately twenty units. Training for these rebreathers consisted of a one-day program which included light maintenance, donning procedures and operation of the units. The problems encountered during the short time that they were in service, included: whistles not operating, covers falling off, cracked breathing chambers and excessive fogging. The training of personnel detailed into the squads for a day, again, was an endless job. It was a real problem. Some of these people never even heard of a rebreather. Additional concerns include the lengthy operational maintenance time and the cost factor of filling the canisters after short duration usage. All of these things I think have been pointed out earlier in this symposium.

Due to the problems encountered in the confusion as to the certification of the BioPak rebreathers for **firefighting** activities (there was much confusion in past years) they are in storage. They're not in service either.

It's been over five years since the BART tunnel incident, and the San

Francisco Fire Department has researched and field tested several units, each having pros and cons. The availability and operational simplicity of the one-hour open-circuit, self-contained breathing apparatus has temporarily filled the need of the **fire** service for long-duration breathing apparatus, but we are still looking.

JOE MCDONAGH

My name is Joe **McDonagh**. I am currently here representing the International Society of Fire Service Instructors and have been for the last twenty some years involved in statewide **fire** training, seventeen years of which was at the University of Maryland with the Maryland Fire and Rescue Institute. I am currently serving as Director of the South Carolina Fire Academy where I have been for the last four years.

Breathing apparatus training, in general, has been a specialty of mine that I have become very acquainted with over the years. Going back to the old filter type canister mask and the conversion from that to the demand breathing apparatus and thus to the pressure demand, there have been a lot of changes in the **fire** service equipment over the past number of years. But rather than talk about specifics in training, I'd like to talk about maybe some philosophical differences that I have.

Number one: A municipal fire department or career **fire** department has different problems of conducting training than does a county-wide training or **fire** department organization. And the same is true even worse with a statewide fire training program. Whereas in a municipal fire department the chief can pretty much dictate what the training requirements are going to be within the guidelines of personal practices, and so can a county-wide training program, the state training program really has no control over its students per se. It can set some guidelines in hope that the students, within certain reasonable limits, fulfill those requirements.

We've had a lot of discussion here today about physical requirements. And I was very, very pleased to hear the research that's being done by the air force. One concern I think all of us have had in the **fire** service for a number of years is the physical requirements **or** demands

placed upon the firefighters. The training requirements differ depending upon the fire department that's involved. There's a large municipal fire department that has a number of people involved in fire training. And coming in through the recruit schools, they have pretty good programs going on. You take that down to a lower number or a lesser size fire department where you have maybe a combination department with a small paid crew backed up by volunteers. The people who are involved do not have the resources in time, money or experience in order to bring about significant training to the degree we're talking about here today, so training depends a great deal upon the concept, philosophical approach and resources of the individuals involved in it. I think we'd all like to be idealistic. I tend to be that way and it sometimes gets me in trouble.

In the late or mid-sixties with the part-time instructors we had at the university, we initiated what we called at that time a "maze" which was kind of built after the London Fire Brigade maze at the University of Maryland, probably one of the very first in the country.

We found that very, very quickly that we had to change our whole approach of putting experience into the hands of the student. And where we were doing something in six hours or three hours, we had to back up and psychologically condition the student in order for him to participate in the more advanced type of training. This was an **eye-opener** for us and it has been for me all down through the years. We've heard a great deal of discussion today and yesterday about equipment, about standards, about certification, about physical requirements. But one of the areas I personally feel that's very often overlooked and under-studied is the psychological aspect of it. There is very little that has been done in terms of research in the Psyche as it applies to fire department breathing apparatus training.

I had the experience or the pleasure - I don't know whether you'd call it a pleasure or not because it was kind of scary to me - but to participate in a panic exercise in a society fog conference out in Anaheim, California back in the early seventies. And there was a faculty member there from one of the community colleges who conducted the experiment. And even with the knowledge of knowing what was going to happen, and with a room filled with

people and going through that panic exercise, it still made me scared down inside to go through that little bit of an exercise. And I wonder how people are psychologically conditioned in the fire service to react under very extreme and trying circumstances.

In the early seventies, I had the pleasure of participating in one of the very first smoker diver schools in the United States held in Florida under Bill Clark's tutelage. After that, we started our own at Maryland and conducted it for several years and we would only accept a limited number of students in the program. Part of the prerequisites for getting into the program was to pass a stress test. We found out very quickly, that there were a lot of firefighters who weren't really ready for that kind of training. We also found, that the techniques that we used in the training program brought out more and more the fact that the physical requirements were much greater than we had anticipated before and so was the need for psychological conditioning.

Search and rescue patterns, is another subject which a lot of us take for granted. When you talk about buddy-breathing or rescue of another firefighter and you talk about sharing the facepiece, or you talk about sharing or swapping regulators using your own facepiece, there's a great deal of self-discipline that has to be instilled in that student. If he doesn't have that self-discipline and he can't perform under very stressful situations, even in training, he could become hurt. So, it was a learning experience for us as well as for the students. And most of all, and the biggest benefit of the smoke-divers program was the fact that the student had an opportunity to push himself to his limit both psychologically and physiologically. And many of them got to a point of just complete exhaustion. And it was a very, very good experience.

Now, how does that all apply to closed-circuit breathing apparatus. I think it fits right in line with what you're talking about and what was said today about the time expectation and exposure of the firefighter to the job of firefighting in terms of the breathing apparatus that he has to wear. There is a point of no return where you're going to expose yourself physiologically and not

be able to come out. And I think it's imperative that every firefighter that is exposed to either kind of breathing apparatus understand his equipment and his limitations both physically and emotionally. That's what training and education of the firefighter in his specific area is all about.

ROBERT DA ROZA

Our next speaker is Mr. Lane.

MR. LANE

We've all shared a little philosophy today and it's my turn again. A well-known author, (and he's been mentioned already today), has said in one of his strategy and tactics books, if we could resurrect a fire chief that was 100 years old and put him in front of a burning building today, that his strategy and tactics would differ very little with that of the fire chief today. I'm inclined to agree with him in many, many instances. We're finding that the fire service, in general, is putting demands or having demands placed upon them to face new hazards, to face situations, as we discussed here, requiring long-duration breathing apparatus. We in turn are placing demands upon others and they're saying, "Okay, tell us exactly what you want." And we have yet to tell them exactly what we want. We're going right back to the old principle of management by reaction. We're reacting to the need. We're saying, "Hey, we can't stay in here long enough to get down the tunnel and get these people out. Hey, we can't get up to the top of this building in time, What are you going to do about it?" And the guy's been building breathing apparatus for the mining industry for years and he says, "Well, what do you want me to do about it?" And where are our answers?

That's where the fire service has fallen kind of short. When we write specifications, how many of you go and look for a manufacturer that builds something very close to what you'd like to have, Xerox those specifications and send them off? How many of you write your own specifications and say, this is what we want?

In the fire service, if we're going to be taken seriously by these folks that manufacture these products, we're going

to have to say, "If you want to sell it to us, you sell us what we need." Then we can in turn train our people with a product that was designed to do what we want to do with it. That sounds kind of harsh to some folks and probably to the people that are building these products, but it's the truth.

I don't believe in management by reaction. I believe in management by objectivities; I believe in training by objectives. We find ourselves training by reaction too many times. The news media is on the scene. We lay out hose at a large fire and somebody forgets to turn the hydrant on. Five or ten minutes later, the guy's hollering for water and news media picks it up. What do the guys in the field do?

For the next three weeks, they lay out hose. They lay out every day because the chief is training or having his training personnel react, management by reacting. We need to decide once and for all who's going to wag the tail - - if the dog's going to wag the tail or if the tail's going to wag the dog.

As a training officer, it is just as much my responsibility to go back to my department and tell the chief what's going on and the state of affairs because ninety percent of his time is staying at home making sure the political situation's favored so we'll get what we need next year. We were in a situation where, very bluntly, all hell broke loose. We were using a 1967 life-safety code. One day we had a deluge of building permit applications for high-rise buildings, and we found out that the MARTR system is going to buildup four tunnels under the city. We had no idea what to do. So, we sat down and said, "What are we going to do?" And we decided the first thing we would do is go find somebody else that had had the same problem and see what they did and see how well they did it.

We used three primary groups as resources: One, was the people that had written the high-rise and tunnel codes and had refined them. We talked with the people from San Francisco and we talked with the people from New York. We visited these sites and made changes in our codes because of it. When it came down to the bottom line, we felt that our codes were just as good as theirs and we still didn't have a high-rise building. We met the requirement before - didn't wait till the buildings were being built. We tried to get

a year ahead of it.

The next thing we did was use a group of people that are often overlooked. When we went and talked with the people in Baltimore and New York and in Los Angeles, we asked these people, "Would you mind, while we're talking to your administrative staff, if our combat chiefs talked to your combat chiefs?" We had a level of communication between the people that were going to actually be doing the hands-on firefighting.

When this finished, we came back and sat down and said, "Okay, now what do we need?" We need to decide what our objectives are. We sat down and wrote a needs analyses as far as codes; we wrote a needs analyses as far as protective clothing; a needs analyses as far as breathing apparatus. And that's why I'm here today. As a direct result of those needs analyses. Not only were the chief officers involved, the combat firefighters were involved. And if you think that you're going to pull a piece of equipment off a manufacturer's shelf and take it in brand new in today's society and say you are going to wear this or else, it's going to be or else. You'll find out what's going on.

We had our people involved as a part of the decision making process from the beginning. We chose the BioPak Sixty for one reason. I'm not a salesman for Rexnord. We could have ended up with Survivair, we could have ended up with virtually anybody's product, but this is why we ended up with that product. We went to every vendor in the metropolitan area and Atlanta at that time and said, "These are our needs; we must meet these needs within twelve months from today because we have a federal grant to buy this equipment and it has to be in place."

We were told by Draeger that they did not feel that a positive-pressure breathing apparatus, closed-circuit was safe. That's still their position. I can understand their position. Survivair says, "We've almost got it. It won't be long." And that's what the City of Atlanta's using right now. They've gone completely Survivair. They're happy with the product. We use closed-circuit breathing apparatus as a by-product of our initial needs analysis. Initially, it was to use in high-rise and in tunnels. By attrition, our firefighters chose to go

over to the closed-circuit breathing apparatus. We were a hundred percent MSA compressed air, open-circuit fire department up until that time. When we did change over, it was a situation of some very strong resistance on one hand and a welcomed situation on the other hand.

The entire process, the entire attitude change was made in training. That was the place. And with one evening dinner, and I'll explain that to you in just one second.

We initially had a four-day presentation, for the firefighters within the department where we presented the breathing apparatus to them, let them try it on, let them use it, let them pick it to pieces and talk about it. We had four volunteers that decided to use this breathing apparatus in lieu of the regular breathing apparatus. About six months down the road, we had a new recruit school coming through with sixteen new recruits. We decided to do something very radical. Never once in their recruit program did we tell them about open-circuit breathing apparatus. There were two reasons for that. One was a philosophical reason; the other is that our objective was to give every man on the department a piece of breathing apparatus. And it just so happened that our BioPaks were coming in. So, we gave these people each his own, very own piece of breathing apparatus with his name written on it. He was not allowed to put that piece of breathing apparatus on until he could disassemble it, tell you what each part was and reassemble it. In three weeks, every recruit, (the average age was nineteen years old), could be blindfolded, disassemble that piece of equipment and put it back together.

We wanted them to be very intimately familiar with it. That's training. Then they earned the privilege of using it by being able to don it in twenty-five seconds. Once they could do that, we would let them breathe through the piece of breathing apparatus. They earned that. And it became a very stiff competition. About the fourth week of recruit school, we had these guys coming in for the first period every morning, putting on their breathing apparatus and sitting through the first class. The first class was always the worst class of the day. We would have hydraulics or we'd have fire department policies and procedures and

things of this nature. But they had to pay attention because that was the only class of the day that had a written examination at the end of the day. Their attention was not on their breathing apparatus. They were sitting there breathing it in class. Their attention was on the testing material. So, they forgot about wearing a breathing apparatus. At the end of the day, they had to take a test. A written examination.

By the time we went to the drill tower, they had already gone through physical stress testing with their breathing apparatus on. We also used a process that could be consistent year after year regardless of the climate. We went to the local YMCA, we used their swimming pool to traverse back and forth. The guy was in up to his chest for one hour. Every single person had to go for one hour. At fifteen-minute intervals, we took blood pressure readings. We had to run as many vital signs as we could get on these people within thirty seconds because we **didn't** want to have them stopping and resting too long. We had our paramedics there. For one hour, these guys walked chest deep in water back and forth across a swimming pool. Now I realize it's not chopping holes and it's not running up and down stairs. Yet the average time of duration on this breathing apparatus was about **eighty-five** minutes. One thing that we did notice while they were in the swimming pool is, (it was a heated pool), that we still had a problem of what we felt was warm, humid air in the mask. On the **fire** ground, we had the same problem, warm humid air in the mask. We sought a solution. We found the solution and it didn't cost \$50,000.

The solution was that after a firefighter had been in a situation fifteen, twenty minutes, his buddy would take an inch and a half for a booster line, and for about **five** seconds just run water over the back of the scrubber cover. This would reduce the air temperature in the mask about **five** degrees.

Now, that's really complicated, but that's what we did to solve our problem. I'm not saying that this is panacea for everybody, I'm saying these are just common sense things.

Watch the firefighter and see what he does. If he likes what he's doing, he's going to find a way to use it.

To finalize our training program, we still had some guys in the department that

were completely against this breathing apparatus because it was new. They were the same guys that didn't like automatic transmissions. So, we decided to go about it two ways: One, when these new men come out of recruit school, these same sixteen people, we put all sixteen of them in ladder companies.

Now, I'll tell you why we did that. Most of our militant firefighters and macho guys are in ladder companies. Now, all the chiefs are sitting in here that came up through ladder companies saying, "Well, you better believe that. That's true. That's true."

When these guys went in, of course, they displaced these other guys. We had to send them into a rescue company or we had to put them into an engine company. In about three weeks, I had a grievance filed on me with the city manager because I had not permitted them to use the new breathing apparatus.

So, we started the training program again and we trained them to use it. And the stipulation was: "If I use this breathing equipment, all right, and if I pass, you got to put me back on the ladder. Well, don't throw me in a briar patch - these guys worked. They got back on the ladders.

The chief and I sat down one evening and decided that we would demonstrate to these people that we do have their health and safety at heart. We did something they thought was very benevolent. We decided to have a supper and honor and give plaques to all the retired firefighters from the City of Decatur. It was a very elaborate occasion -- the mayor and city manager and press and everybody was there. We had twenty-one widows and seven firefighters that had retired from the city. And if that doesn't bring on the fact that we had been doing something wrong for years, I don't know what else would. And we never had to say it. because the guys themselves were looking around, "Well, you know, I thought Fred Marcus would have been here. Well, Fred's dead, you know. No, I didn't know that." And it went right down the line, "Well, I really didn't know that happened." Most of them died from cardiovascular diseases.

But to bring this thing to a head and to give to you my exact position on

this. Maybe we don't have the very perfect piece of breathing apparatus that we need yet. We have a piece of breathing apparatus that has filled our needs. It did have some drawbacks. We got with the manufacturer and worked those out as best as we could. But we're going to have to let them know exactly what we want and quit taking everything that everybody throws at us. And when we get what we want, it's up to us to present it to our people in an organized, positive training method so that they're going to accept and use it.

JOHN PRITCHARD

I'm John Pritchard, and I'm a consultant in respiratory protection, and I'm also a member of a small rural volunteer fire department in Santa Fe, New Mexico. And my remark's are going to be directed from a little bit different direction than what we've heard here as far as closed-circuit, self-contained breathing apparatus is concerned.

I think here we've by and large been making a case for the use of self-contained, and I'm going to kind of make a case for the non-use of self-contained.

Primarily, because of our peculiar situation, which I don't think is that unusual throughout the country, namely the small volunteer departments. When you're determining training needs, what goes into determining what kind of training you're going to give your people?

One is the needs of the department. What is their task? Two would be what is the equipment that you use to accomplish that task? Once you establish that equipment, then that pretty well locks you into a training program. In our case, we have, primarily, single-family dwellings with a lot of wild land. We cover about 40 square miles with a small department about fifteen people, one piece of apparatus. Right now we have eight self-contained breathing apparatuses. Four about to be delivered. They're all open-circuit.

I don't think that I would use a closed-circuit apparatus in our situation for a number of reasons: One is that with the modern blitz attacks that we have available to us, (our pumper tanker does have that capability), we should be able to knock down most any fire in ten to fifteen minutes in a structure. If we can't,

we probably **don't** have any business being in that building anyhow because **it's** likely to fall in on our heads. So, from that standpoint, we **don't** need really any more than a ten to fifteen-minute useful lifetime. Now, with a closed-circuit apparatus, if we were to use one, **we'd** only used up a small portion of the useful lifetime and we have to go through all the bother of cleaning the unit up and replacing the absorbents. That's going to get expensive.

Training on closed-circuit devices is complex. I'm dealing with volunteers and I don't have the string of the paycheck or the string in military discipline to get people to do what I want them to do. What I have to rely on is motivation. This means teaching the firefighter to want to do things right, not doing it because they have to.

If you present any person with a complex piece of apparatus, (that goes for open-circuit too), and all at once just drag it out of its case and say, "Here's how you put it on, and here's how you turn it on", you're going to scare them half to death because they will not have any confidence in their equipment whatsoever. You must start from ground zero and build. I think that **instructogram** which the International Society of Fire Service Instructors is very good from that standpoint

You start from the cylinder. Here's the cylinder, here's the valve, here's how it works, here's how you take it in and out. Then you move to the back pack, you put on the facepiece, then don it, and then, finally, you put it into operation. I take about a two-hour period initially with my people. Then for any training sessions we have, we drag out every SCBA unit that we have and use them. I don't care whether it's land hoses, climbing ladders, whatever exercises we're doing, we do them in SCBAs. As I sit back and watch, I can tell fairly quickly how confident people are on their apparatus. Occasionally I'll yank somebody out and give them a little bit of extra tender loving care on that particular apparatus.

So, in any of the rule making that goes on, standard setting, whatever, I would ask you to consider the needs of the small departments in the United States. They may or may not have all of the resources that are available to big departments. Volunteer departments by and large are great scroungers. We operate our department on a budget of about \$30,000

a year. Out of that, we're supposed to buy \$125,000 fire engines, \$1,000 SCBAs, \$1300 radios and \$600 turnout gear-all on \$30,000 a year! **It's** a very, very difficult task. Any way we can save and still get the job done, we're sure going to do it. The closed-circuit devices are much more expensive than the open-circuit devices.

So, I have nothing against closed-circuit devices per se. I think they have their place. For the situations mentioned here, tunnel fires, high-rise, mine rescue, etc., that type of unit is probably necessary. But in our situation, in a small department, I don't think that it really has that much use.

ROBERT DA ROZA

Thank you, John. Our next speaker is Chuck Soros from the Seattle, Washington Fire Department.

CHUCK SOROS

Seattle, Washington Fire Department

Dr. Myhre's talked about a very touchy nerve - sedentary firefighters. I've been an engine officer my entire career, (I'm not the macho one) and my points of view for training are as I'd like to present. My position for training needs and for closed-circuit, self-contained breathing apparatus. Before I take any training exercises, I would start by asking myself: One, "What is the rationale for such units - where would I use them?" Two, "Will I have a program that is both meaningful and **measureful**, i.e., what do I expect? Three, "What are my controls and timetables for training?" Four, "What are priorities for its use?" Five, "What is the right instructor for the task?" And finally, the sixth point is, "What evaluating process will work for what I want to accomplish?"

Now, with these six points in mind, then I will go ahead and move into my training personnel, closed-circuit breathing apparatus. When it comes to training, one of the most important of the six is making sure I have the right instructor for the task. This is a very important issue in the fire service. I need someone who is accepted by their troops. This individual will sell the program, not only because he believes in it, but because he can show how it

will aid them in doing their jobs. The **fire** service is steeped in tradition and the guys themselves always know who the best firefighters are and they admire these particular guys' feet. And this is one of the people that I would choose.

The attitude I display through my people also greatly affects how the program is going to be accepted. If I, as a chief officer, show the need for such a closed-circuit unit, and then grab an open-circuit, I've just blown all the validity for my program. Additionally, once I put one of these units in service, I got to see that it's going to stay there. If I keep taking these things in and out of service for various problems, I'm going to have a real problem with acceptance - getting others to take the program and the equipment seriously.

Closed-circuit units have a definite role in the fire service, as far as I'm concerned. They're ideally suited for long-duration situations, i.e., hazardous material incidents, tunnel fires, etc., which have all been touched on previously. When you consider the logistics of the numbers of bottles that one would have to use in open-circuit operations, the closed-circuit breathing apparatus here would more than foot the bill. The closed-circuit becomes cost productive over **open-circuit**.

Now comes the question of what do I expect from this equipment? I believe we need to put this in some meaningful and measurable terms. One of the biggest problems was facing the realization closed-circuit, self-contained breathing apparatus is a specialized piece of equipment and as such is not used on a regular basis. Here's where you get into a rub - when you take a piece of equipment that's not used on a regular basis and you ask people to use it periodically. The thing has to be used all the time. They have to understand it. You have to put it on a unit where people are going to use it on a day-to-day basis.

We have them and they're put on marine units; they're put on **HAZMAT** teams, and these people stay with them. They know what's the matter with them. They know what to expect from them, and they know how to use them. Also these units can be dispatched at a later time with trained users to assist in other fire responses to supplement those using open-circuit SCBA.

In selecting controls and timetables for closed-circuit breathing apparatus, I was

really out to do my homework. Here's where I asked other fire departments about the problems they have with closed-circuit breathing apparatus and what their likes and dislikes are. The concern I would have is: How much down time do these units have? How about the availability of parts? How does the company stand behind their units? If I buy them, I don't want a product that I can't get answers to in a reasonable amount of time. I would also want to have my personnel trained in the repairs of such unit. These factors will greatly determine implementations of such a new system as I would have a grip on potential problems.

As far as determining additional priorities of these units, I would have to develop them after my research on the unit. Additionally, I would start the evaluation in just one company before I dispersed them to additional companies. I would take the evaluations that I received from the field and also the shop and I'd put this data together so I could form a basis for my program.

The last item I want to discuss is evaluation. It is the most important, next to the instructor. All the concepts I mentioned are important, but evaluation rates very high on the list. In order to have a good respiratory protection program, be it using either closed-circuit or open-circuit, you must evaluate your actual usage of equipment. If you just establish a program, do good R&D, provide good instruction but do not evaluate your results, you don't really have a program. The evaluation process is your barometer. It implements present as well as future considerations. Evaluation is a tool that helps modify or correct possible mechanical as well as procedural requirements. It is something you can go to the manufacturer with and say these are my findings. You provide them data and reports that substantiate your arguments. I don't know how many times I've heard people say, "I don't know where that came from," when talking about a field problem. That kind of substantiation will aid the fire service in future design consideration for closed-circuit breathing

apparatus.

DON STEVENS

I've been associated with closed-circuit breathing apparatus for over twenty years. The State of California in its continuing effort to promote safety in the State of California, has opened up a new division in their grant from MSHA called Mined Safety Training. Miners are required by law to receive quite a bit of training in several different areas. One of these areas in CFR30 Section 49 is the establishment of the training for mine rescue operations. California's gone into the training pretty heavy but we're brand new. Six months is all the longer our unit's been in operation.

I thought we had very unique problems in California until I started finding out that a lot of other states have unique problems too. We've got over 500,000 abandoned mines and shafts in the State of California. This puts a lot of people out looking in a lot of dangerous places. We've got people making entries into some of these areas without any training at all, looking for people who have gone in and got hurt.

We recently had a very bad incident in Southern California, in a working mine. That comes under MSHA's requirements and State of California, too, has jurisdiction. But all the abandoned mines do not come under MSHA's requirements. There aren't any mine rescue teams to go into these places to get these people out once they get into them.

We have a bunch of sheriffs that are volunteers making these emergency entries into these places now with no training whatsoever at all. They don't have any idea what kind of gases that are in there; they don't know how to work the areas in any way, shape or form.

So, that's the business we're in, to establish training programs for the existing search and rescue teams that are in the state now and bring them up to where they can make these entries and

rescues safely.

Like mine rescue teams, we deal strictly with volunteers and all our training is done with volunteers. They don't have the choice of being brought up to a fire department for training or of going from open-circuit apparatuses to closed-circuit apparatuses. All our training is done strictly on closed-circuit apparatuses. I have used over twenty years of different machines that have come along. We started out with basically the McKay units.

In the types of mine rescue competition that the man from MSHA referred to earlier, there were thirty-three teams in July in Las Vegas. Out of those thirty-three teams, which are the best among the metal-non-metal mines, there were three teams using Aerolux units, two Scott Pak teams and all the rest were Draeger units.

Draegers are the backstay of all our mine rescue operations. We take these units off, put them over the top of our head, drop them down on the inverts, secure them up and down through the invert and treat them very, very badly while we've got them on in bad air. We haven't had any problems with shaking any of the canisters and material that's inside of them loose. We haven't had anybody that has ever had a fatality from in-leakage of bad air, because it's a negative-pressure system. We like the units. We've been trained with them and we know what they are.

And I think that's the secret to our training. I think that's the secret to what you people have got to do too. Your people have got to know their units. They have to know that they can depend on them and they've got to have confidence in them. But that's not all. The commanders have to know too.

In our sheriffs search and rescue training we require training for every person involved, (from the commander and sergeants on down), even though they never have any intention to going underground at all. They have to go through our training program because they've got to know what those people are going to do when they're underground

with these apparatuses on. If they **don't** understand and have confidence in those machinery, how can they expect their people to? The whole program is all designed where the commanders have to have the same confidence as the people that's using it. And **that's** what I see as the biggest problem in going from an open-circuit to a closed-circuit. We train. **That's** our basic thing - we train. There's a lot of data out there on closed-circuit operations from every manufacturer. Training information has also been developed by the Bureau of Mines and by MSHA. It's available to you people to incorporate it into your programs if you want it.

UNIDENTIFIED SPEAKER

I have a question for anyone who's had experience with closed-circuit units and also the manufacturers.

There's been a great deal of concern expressed over a subject that hasn't been brought up yet, and that's what's been called cumulative contamination with the closed-circuit products. This gets into areas about threshold limit values and **time-weighted** averages, and I'd just like to hear a little bit of dialogue since the fire service is considering using these HAZMAT situations.

And the other question is also tied into that is:

What kind of a difficult situation will we have in going through a decontamination of these devices after they're used, if you do in fact have any contamination?

ROBERT DA ROZA

Let me paraphrase those two questions: One, is that how do you view the situation that with a **rebreather** that any leakage into the **facepiece** stays in there. It isn't blown out in the next breath or two but actually stays in the system, and if you've got a little leakage at the start, you're going to have to wear it for two hours. Is that little contamination you got at the start still there after two hours. How do you view that problem?

The second problem is what about in a HAZMAT situation where you're in some material that is so awful **that** it is really difficult to get it off of your \$2,000 rebreather when **you're** through with it. How do you handle that problem?

MIKE LANE

Insofar as getting the foreign toxic matter into the system originally, our policy is that **you're** dispatched to a hazardous material **incident**, to a structure fire or vehicle fire, you leave the fire station with your breathing apparatus on. A man is buckled into his seat, fully clothed for the fire when he gets there. It's not a matter of hanging off the side of the engine, putting turnout gear on and putting breathing apparatus on. When you turn onto the street where there is a working fire, many times it is down in the street. While you're putting the breathing apparatus on in that atmosphere, if you are, indeed, getting foreign **particulate** in the mask. You will recognize that problem.

Insofar as hazardous materials, when you get into a situation where our state EPA people come to the scene and cannot advise us how to decontaminate the equipment, we are required to discard that equipment. It's put in **55-gallon** drums and sent to **Barnwell**, South Carolina. Who picks up the tab for that? **Decatur** picks up the tab for that. But as far a decontamination, we don't have means to do it other than soap and water or some chemical that a chemist would recommend to decontaminate the unit itself.

JERRY GREY

If the material that you're going to be coming in contact with has a high toxicity rating that you're concerned about that, the individual should be in an appropriate level of protective clothing. The people referred to it earlier as **level-A** protection, which is a fully encapsulated chemical suit that would protect the breathing apparatus. And in this particular case, you're going to need a long-duration unit underneath there because if decontamination is necessary, it's going to be decontamination of the encapsulated suit and the person's going to have to stay in the encapsulated suit until decontamination is complete.

Theoretically, the SCBA inside the suit should not be contaminated. Also, any contamination getting inside that suit would have a very low potential for getting inside the mask.

JOHN MCDONAGH

This is one aspect of education and training, where the fire officer **who's** in charge of the scene or the incident has to have enough moxie to take into consideration all of those factors. If he **doesn't**, **he's** exposing his firefighters, or his people, to a very hazardous situation. Unless **there's** a leak in the system itself, there really **shouldn't** be any contamination of the inside of that mask. **You've** got to recognize that to begin with, and if the officer **doesn't** recognize it, then **you're** in trouble.

ALAN HACK

Los Alamos National Laboratory

Just a minor point. I **don't** know if the **TLV** or the **PEL** is an appropriate limit for an exposure during these types of operations because it is not a chronic exposure for your whole working life. So, clearly the fact that **you've** exceeded those values **can't** be of much concern. **I'm** not saying we know what a short-term exposure limit is for every **compound**, but usually the **TLC** refers to an entire working life.

CHUCK SOROS

One of the key things about any hazardous material type incident is the encapsulated suit, where you've got the SCBA unit on underneath.

This requires a lot of training. It's not something that the mask is going to take care of. You've got hot zones, you keep moving them back and you've got another back-up team. This, to me is one of the more pressing reasons why the mask should be positive-pressure, if anything else.

I would not want to wear anything other than positive-pressure if I had to go into one of these **situations**. I can say **we've** done it but hazardous material is something that you just don't rush into. A HAZMAT response is something that should be controlled and it's something that you have a certain degree of control over. To just arbitrarily subject people to these things without prior consideration is asking for trouble.

BARRY MCNEAL*Reynolds, Las Vegas, Nevada*

MSHA prescribes aspects of the training for the mine rescue equipment. I assume that Mr. Duffy's NFPA Committee also prescribed fire and rescue training for their equipment. Is this going to be for **open-circuit**, closed-circuit or long-term future, or is this going to be a fluid situation that will be changing?

CHUCK SOROS*Answering for R. Duffy*

Since I'm the only one **that's** up here under Rich's NFPA Committee, and we **won't** do any of that because we're setting performance criteria for the different conditions that we feel the mask is exposed to.

I have committee **that's** set up by Alan **Brutocchini**, which is the Occupational Safety and Health Committee. And they're charged with the parentage of that type of legislation and they are working on it right now.

**UNIDENTIFIED
SPEAKER**

Not really. I believe Mr. Grey has already identified part of the problem, but I'd like to hear some other cities address this same problem. I think that we're all aware that this is a training problem. And if it is other than a training problem, I would like to hear somebody give their opinion on it

ROBERT DA ROZA

As I recall, the basic question was: Why have some of the **fire** departments that have used closed-circuit apparatus in the past stopped using them?

Do you want to comment on that more, Jerry?

JERRY GREY

I think it was more than a training problem. Maybe I didn't emphasize it enough. Some of the other problems that come into play are the cost of replacing canisters after short-duration uses or replacing the cartridges. The fact is that after use there is an operational maintenance time that's going to take **anywhere** from about ten to thirty minutes

for cleansing this equipment

It was mentioned tongue in cheek about our people getting back from a two or three-hour fire and even though they had something planned the next day you know they spent ten or fifteen minutes cleaning their mask. That was meant tongue in cheek then and I'm saying it again now, there is a problem with that. There are a lot of priorities, and a lot of equipment to get back in service. For each person to have to spend ten or thirty minutes putting their respiratory equipment back in service is something that, in the real world, isn't always going to be happening unless each man has his own apparatus. For departments that can afford that, that may be an answer, but in most of our departments, we share the apparatus.

One of the other problems that we ran into is having only these units on certain specialized apparatus and having to train these people coming in to work there only for the day. That's a training problem, and it's something that takes time. Sometimes maybe you don't spend a lot of time training because they've worked on it before and they say, "Oh, yeah, I understand that" Because they're thinking of something else. But maybe they're missing some of the important points that should be covered again.

There's more to the **fire** service than breathing apparatus. **There's** a lot of training things that have to be done with the current equipment that we're using in addition to the respiratory equipment. There's inspections to be made and a multitude of other services and things that we do around, inside the house and out as a public service. Many of you people who are not from the fire service may think all the fireman does is sit around and play pinochle - that's a lot of bull, and most of us know that

We have to spend a lot of time cleaning apparatuses each time it's used. If it happens to be near the end of the shift, I don't think it gets done. And **that's** one of the problems that we did encounter.

We were talking yesterday at one of the breaks about the little fuzzy things that have a tendency to want to grow inside if it's not cleaned completely and disinfected and washed. And that's true with the self-contained units, we're talking about washing the mask and

that's all we're worried about, not even disassembling a large unit. Those are some of the problems that we did encounter. They are training problems but maybe also a matter of priority. As I said earlier, the sixty-minute units have temporarily filled our need - not totally - not for the hazardous materials incident. For the BART tunnel situations maybe we don't have an answer yet

MIKE LANE

I suppose the longer you do it, the better you get. In our situation, our turnaround time for cleaning and restoring a piece of breathing apparatus to service is about fifteen minutes. We use three different baths: one's clean water, one's a **betadine** solution, and another clear water, and then we have a warm air blower that connects to each piece of breathing apparatus and the inhalation tube and blows warm air through and dries the unit

At the same time, each man in the **morning** is responsible for having an additional oxygen cylinder and canister available for his position.

In high-rise situations we have what we call "the milkman pack", because all it is is a little six-pack that the milkman uses to carry six bottles of milk filled with six oxygen bottles. With that and an orange knapsack one person can carry six hours of breathing air upstairs in a high-rise building. Normally it would take three or four guys from a ladder company carrying all that up.

If you do it, you do it every day. Then you're going to figure out an easy way to do it and still be able to do it properly.

The Atlanta Fire Department had some sixty-minute closed-circuit breathing apparatus at the airport. Their sole reason for changing was they switched entirely to **Survivair** open-circuits. They weren't especially dissatisfied with the unit. I agree with standardization in many cases. They simply wanted to standardize the entire fire department on one type of breathing apparatus. So, they took the closed circuit units out of service.

The Decab County Fire Department has forty units that are still in the original packing material. They say, "If they ever need them, they'll pull them out and use them." Yet there is not the first guy that knows how to put it on. So, it's just a lot of attitude. We've had

some small rural departments that bought. And their local oxygen vendor was charging them thirty and forty bucks for eight cylinders of oxygen. Being the **scrooge** that I am, I checked with a hospital and found that they were paying \$12.00 for eight cylinders. So, now we have an exchange program. **We'll** put out their fires if **they'll** let us have their oxygen for \$12.00. They were buying individual packets of sodasorb from Rexnord. I'm not trying to take any profits away from anybody, but sodasorb is used in the medical industry and it's the exact same thing that goes in the prepackaged containers for Rexnord made in Atlanta. Now we buy sodasorb by the 55-gallon drums and it costs us about fifty cents per pound. Our turn around cost on a piece of breathing apparatus is about eighty-five cents, not counting the time that it takes to put it in service. I think the national average is about \$3.00 -that's the cost of the oxygen and prepackaged sodasorb. But cost certainly can be one consideration, but consider the cost of a compressor. You can lease a lot of oxygen bottles and buy a lot of sodasorb for \$14,000,440,000.

CHUCK SOROS

The biggest thing we've got in the fire service is rumors - they kill you. Another thing is we get people to sit on panels that ask to have engineering things put into or built into equipment that **shouldn't** be there. They **didn't** want to engineer the training into it - - not engineer training into the man.

I once had a professor who came in one day and just made up a word and stuck it up on the board, and he asked, "What does that say?" They all started breaking the word down by phonetics, when they got done, the college professor says, "Well, that doesn't say anything - there's no such word." The point that he was trying to make is you can't talk about something you know nothing about. That's what happens with the fire service. People will wear one SCBA one time. Even though they don't know anything about it, they tell everybody in the country what the problem is. That's one of the biggest problems that we have - that our own people don't understand SCBA. It's a training function, but if you just killed the rumors, you'd be a thousand miles ahead.

JIM JOHNSON

I would be interested to know if anybody is doing any quantitative fitting of the mask - especially people using the closed-circuit breathing apparatus.

CHUCK SOROS

That's why we want positive pressure.

JIM JOHNSON

Are there any fire departments you're aware of that are doing quantitative fitting on a routine basis for the firefighters for **closed-circuit**?

ALAN HACK

Jim, let's be honest. Los Alamos and **Livermore** do quantitative fitting but don't do it for the fire departments, right?

BILL STOJACK

Clark County Fire Department

We've done it for three years. We set up and developed the quantitative fit testing program for individual air breathing mask. The paper that Dr. Raven offered with me on the initial test program will be the next issue of the **ISRP Journal**. Read all about it in there.

ROBERT DA ROZA

So, there is a county fire department that does quantitative fit testing.

UNIDENTIFIED SPEAKER

Captain Grey mentioned that one-hour, open-circuit SCBA was temporarily filling the need for long duration in this department. After two-day's discussion, I was wondering if there's been any consensus of the members on the panel about the duration in the sense of a working fireman. I think we'll all agree that a working fireman uses far more than forty liters a minute than NIOSH to rate that, so we'll say duration time for a working fireman. Is there a consensus

of what that duration wants to be for "long-duration" apparatus in the fire service? I know this is an individual opinion which is expressed. I wonder if a consensus has started as a result of the two days of talking? Is it twenty-five minutes of **firefighting** or three hours and twenty-five minutes of firefighting?

ROBERT DA ROZA

As I understand the question: Has any consensus been formed as to what the duration of a closed-circuit breathing apparatus really should be? We've seen numbers on what it can be, but what is a practical number? What is a desirable length of time?

CHUCK SOROS

You're not going to go much longer than an hour - believe me. You can't get rid of the heat and you're worn out at the end of an hour. Besides, most of the fires are put out in about six minutes or less. When we need these other ones, it's for longer duration. Like I say, they're a specialized piece of **equipment**. But at the end of thirty to thirty-five minutes, **you're** shot. You want a break. You want to get out. You also want a little bit of reserve to get out. That's why I suggested the figure of sixty minutes. Over **that**, there's probably a need for it in certain cases, but I don't think **there's** that much need for it in the fire service.

ROBERT DA ROZA

Chuck, you're talking about the length of time that the person wears the gear to get the fire out. But even if you get the fire out in six minutes, there are firemen there for hours poking around through the coals. Shouldn't they be wearing breathing apparatus?

CHUCK SOROS

The other day we had a cleanup, and we wore the mask all through the cleanup. The thing is when you first start out at a fire, the anxiety and the rest of it causes you to suck the bottle down pretty quick on open-circuits. When you're doing the cleanup type phase, then anxiety seems to leave and those bottles seem to last a much longer period of time. The same firefighter who will breathe the bottle down in **eight**, nine, ten minutes, will

get about twenty minutes out of it.

But if it says thirty-minutes, I'd like to see thirty-minutes. If it says an hour, I'd like to see an hour. If you've actually been there in a **fire** and in the heat, you know these psychological, physiological problems that go on. But the cleanup is entirely different. That **bottle's** going to last a lot longer. It's a different **ballgame** entirely, and that's why I say the hour.

ALAN HACK

In Europe they rated the open-circuit by the volume of air in the bottle. What we would call a thirty-minute **unit**, they call it a 1200-liter bottle. Now, would that make anyone happier? You see the problem. It's the same thing. The duration will depend on how hard you're working. So it's no one's fault that it's called a thirty-minute unit and it doesn't last thirty minutes. No one made a mistake. There's enough air to pass the thirty minute test at a certain consumption of air. That's all it means. Just like positive pressure is positive under the condition of tests. It's not positive under all conditions, it can't be. It's like a bullet-proof glass will stop a rifle but **won't** stop a machine gun.

If we changed the rules and called it a 1200 liter, or whatever, the forty-five cubic-foot system, would that make anyone happier?

One thing you can do is take the existing system and call it a nominal twenty minutes under heavier **work** instead of thirty minutes. Then if really you need thirty minutes, you have to go to the one-hour system. So, what will serve all of you better?

DON STEVENS

One of the bones of contentions that I've been involved in for probably fifteen or twenty years with NIOSH and the old Bureau of Mines is just that question. They established a test and NASA did the same thing with the 4.5 SCBA design. They took idealistic conditions and set the time limit based upon those idealistic conditions and lab tests. They haven't done anything to change that in twenty years and I think **that's** the bone of contention that the fire service has been expressing for a number of years.

JOHN MCDONAGH

Well, let's be more specific. What do you want? Do you want an apparatus that weighs the same as the existing equipment and lasts through 30 minutes?

DON STEVENS

I don't think that has anything to do with it. I think the test has got to be realistically reflective of what the firefighters require. Base the time duration or the value of the apparatus on that and not some lab test.

UNIDENTIFIED SPEAKER

That's the very issue I tried to avoid in my question. If you'd like, I'll stipulate an average breathing rate of seventy-two liters a minute. But what I'm trying to get an answer to is: "What is a long-duration apparatus as opposed to the basic open-circuit attack apparatus?" Is there a consensus on how long the fire service would like a long-duration apparatus to last while they're working? Aside from the argument about how many liters a minute, let's talk about the amount of man-work minutes you can get out of an apparatus. What is the **fire** service really looking for?

JERRY GREY

We have to evaluate all of the information presented today. The entire envelope. Not just the breathing apparatus, but what the firefighter is wearing, the heat retention, the buildup, his body temperature increases, etc. **All** those things have to go together. I think the information that Dr. Myhre from the air force presented was excellent.

Looking at all of that, my own personal feeling is that **we'd** be rather foolish to expect a firefighter to wear a true sixty-minute unit and stay in there through sixty-minutes, or a true, whatever the amount of time is unit, and stay there that amount of time without taking into consideration these other factors that were brought out today. All that should be put together to come up with a real thirty-minute unit.

It might be one heck of a thing. That seems to be somewhere in the neighborhood of where all of these charts and graphs and all of those wiggly lines seem to come together, and maybe that's just what we'd really like.

I've gone through three bottles in thirty minutes, and my partner went through them sooner than I did. But I personally, after listening today, I really **don't** want to stay in there more than thirty minutes. And I've been there a couple of times where I've literally had to be helped out because - - and I didn't know why except that I was really tired. Now, I'm getting a real good understanding, from what we've done here today, what we listened to today and yesterday, on maybe some of the reasons why some of our guys get a little bit nasty and act a little bit irrational at a fire.

UNIDENTIFIED SPEAKER

I'd like to ask Mike or the department that does have true, sixty-minute units, how long do your firefighters use the units?

MIKE LANE

The units, as we said, are capable of better than 60 minutes. We don't encourage a firefighter to stay in a burning building much longer than fifteen minutes. We have a policy that if we do have a working fire, we have a second alarm. We set up so that the second relief company goes in to relieve the first company in fifteen minutes. They just take the line from them and back them up. And they come out even if they have forty-five minutes of breathing air left. **That's** great, but if we have a collapse and they're trapped in there and can't get out, I'd sure like to have that extra forty-five minutes.

Take a situation where you pull up on a, supposedly, gasoline truck and it ends up being even worse than gasoline. You can't go any place. You can't walk out of it before the alarm bells ring on a thirty-minute piece of breathing apparatus. What we're looking for is a safety factor, and we're not trying to say the firefighter's going to work sixty minutes. If you tell this guy right up front, we're buying you this new breathing that'll last sixty minutes so we can fire half you

guys, they'd all walk out. But that's not our intent, and we had to educate people that that was not our intent. We told them, "Well, this is for your protection. It allows that extra time." Let's give them an hour. It doesn't cost that much more to give him a true hour, but tell them they're not expected to stay in that building for an hour. They're expected to stay in there for fifteen minutes or whenever relieved.

It also encourages firefighters to use breathing apparatus during the overhaul process. It's too easy when that first bell goes off to take it and dump it on the sidewalk and take your bunker gear off and go inside and start shoveling. We've got rules against it, but you can't watch everybody all the time. Once they learn they've got that extra duration of breathing air, they'll wear it during the overhaul process.

I'm not an advocate for keeping the firefighter in there any longer than he's already in there. I am an advocate for giving that extra protection. And that's why we're looking at turnout gear; that's why we're looking at helmets; that's why we're looking at breathing apparatus. And as far as true, thirty-minute piece of breathing apparatus on the market, there's a true, thirty-minute piece of breathing apparatus on the market nobody will buy.

MIKE LANE

Right. The BioPak 30P will last 30 minutes. We didn't buy it because for a little more money we get 30 more minutes. So why not spend the extra money?

UNIDENTIFIED SPEAKER

Do you just pull your men out in fifteen minutes? Do you go back in with the apparatus or do you reservice the apparatus?

MIKE LANE

They go back in with the same apparatus. They cut it off, disconnect their inhalation-exhalation hose, connect those two together so the sodasorb is not exposed to the outside atmosphere.

DICK GRIFFITH

*Division Leader of our
LLNL Special Projects Division*

Well, it's a pleasure for me to take the opportunity to close the meeting. I really

appreciate the attendance that we had and I appreciate the people that have come out here to participate.

One of my very first experiences when I came to Livermore was to go through a rebreather class. It was a week long, and at the end of that week I developed a real enthusiasm for going into management. I'm not closely related to respirator research other than having that function in my division. However, it's been a fascinating two days for me. I've learned some new words, new jargon, I've learned that fire chiefs have opinions and quite a few of them.

One of the things that impressed me initially about this whole meeting was the variety of people, the variety of experience, the variety of backgrounds that are present here. And in my experience in research or standards development we typically sit around in a circle and tell each other how good it is. And we don't often have a lot of input from real life. Sometimes when we do it's frightening and it sends us to the bar thinking about it.

But at this meeting, we've had over a hundred people. We've had representatives from, clearly, the fire services, labor, we had one individual from Sacramento, maybe more, from the legislature, we've had local and Federal OSHA people, NIOSH, the suppliers talked this afternoon, we've had people from the military, researchers, representatives from national laboratories. I can't remember when I've been to a meeting with that kind of diversity and I think it's great. I was struck by the comment yesterday, by the individual who talked from Sacramento, that he didn't understand what all of this emotionalism was about having to do with the bill dealing with this particular issue. And I guess listening to you all talk in the last couple of days, there is a real life-safety issue and I can understand the emotionalism. It just makes sense to me.

Looking at the meeting, the experience of the users was varied. There are a lot of people that seem to like the closed-circuit apparatus for their applications. There are some that have had some negative experiences, and prefer not to use them. There are some problems that were discussed including the complexity of use and maintenance, the potential problems with negative

pressure, the potential problems with positive pressure oxygen systems. Clearly, there's not at this point a definitive answer, but at least we had a forum to get the experiences out on the table and discuss them.

Looking ahead at some of the needs that I heard, and I heard other people discuss, there have been a number of references to the talk by our friend from Brooks Air Force Base having to do with the man aspect, or the person aspect of the use of these systems. The heat stress and what I would paraphrase as oxygen withdrawal. These kinds of things are things that we really haven't thought about. And for some of us it may not be in our purview, but it's still part of the whole system, part of the whole aspect of using these.

The oxygen hazard issue has been discussed and needs a lot more work, a lot more study, apparently. We need to look at our fitting test, we need to look at the variety of facepieces that can be made available.

Practical research, and by practical research I refer to the need for interaction between the people who are doing the work and the people who are doing the using. In Livermore, we have the luxury of having the fire department as part of the safety department. So we have a built-in feedback to be able to do that. And when Chief John Sharry comes to my office and talks to me, I tend to listen.

The question of cost control. Many, if not all of, the fire departments have some moderate to severe cost limitations, and that's an issue that has to be dealt with.

Training. We had a whole session on training this afternoon.

Durability of units. Simplification of units so that they are easier to use.

Finally, getting back to the thing that struck me, I think there's need for continued, if not enhanced, communication between the types of people represented here, between the researchers and the manufacturers and the standard-setting organizations, and particularly between all of these and the fire services so that everybody understands clearly what their particular problems and needs are.

So the solutions that we eventually home in on are solutions that are really appropriate to everyone's needs and particularly the needs of the user.

Thank you all again. It's been a great two-day symposium.