Life Support Trials on Submersibles

By

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Background

Nearly 40 years have passed since we carried out these experiments on life support and not surprisingly, some of those who were involved have either shuffled off this mortal coil or moved on to other work or places. I do not have a copy of the original documents or the dive diary we kept during this period but, having being involved with all of the trials, I can say that this is a pretty accurate representation of what we actually did ... which is one of the great advantages of taking so many photos at the time!

However, by coincidence, two of the subjects that undertook these experiments got in contact with me just as I was just finishing this article and that has allowed me to use Richie Head’s own words to describe some of the sensations of undertaking a 24 hr non-stop dive in a JIM suit. It has also required a bit of a re-write as one would expect. After all, while I was sitting at the surface he was the one sitting still for 24 hrs in the suit.

Now, in retrospect, it seems incredible that we were actually given such a job because we did the mechanics, electrics and deployment, not medical research. But we were just expected to get on with it and, of course, come up with the correct conclusions. Who says medical research work cannot be a sharp learning curve for engineers?

An introduction to hypothermia

Anyone can dive, but most divers are aware that it can be a very dangerous profession or hobby and a lot of people have died from various causes, including hypothermia. Historically, it was generally accepted as just another way to die. In fact, many seamen (and aircrew for that matter) stated that if you end up ‘in the drink’, the chances were that you would die before being picked up because the cold would get you first.

This was an issue quickly understood during the Battle of Britain when bailing out over the English Channel resulted in the loss of many pilots just from the cold alone. During WWII the Germans undertook some very questionable ‘research’ on hyporthermia (costing many people their lives) the result of which meant that they became leaders in the field of survival. Operation Paperclip, in which America collected German research documents and scientists, scooped up much information at the end of the war, allowing further experimentation to be undertaken, this time though with the consent of the subjects some of whom also suffered for the sake of science (but not quite to the same extent). Many other nations were also doing their own work in this area for obvious reasons, resulting in improved equipment being developed and subsequently made available to those who face the perils of sea and sky.

Why do it this way?

For those of us who can think back to the1960s, 70s and 80s, the attitude to research was a lot different than it is today. Now health and safety considerations are seen as being the overriding factor, hence the heavy reliance on computer modeling (also known as ‘desktop research’), rather than physical and mental exertion. Do you remember the start of the

North Sea oil boom? It was a time of rich rewards for all, especially if you were prepared to take a risk or two. I used to watch the new oil platforms being towed down the Moray Firth on their way to earning large profits for the Seven Sisters (the major oil companies). ‘If you can weld, we will teach you to dive’ became a common expression and this attitude was responsible for some of the many accidents and injuries as well as quite a few of the deaths that occurred. I do not know if the in-depth reports of the time have been released, but the ones available on the Internet, written by either those involved or made available for general interest, show in graphic detail a litany of mistakes, confusion or just a lack of knowledge. It really did seem to be a time when diving came at a high cost with about 700 deaths in 10 years from various causes. Of course, incidents still occur today because diving remains a dangerous occupation and until divers are made completely redundant by RCVs and ROVs they will continue, albeit at a much lower level than in the past.

An old boy back in town - the atmospheric diving suit

There are two Ministry of Defence (MOD) establishments involved in this story; the Royal Naval Physiological Laboratory (RNPL) and the Experimental Diving Unit (EDU) outstation located at Horsea Island. RNPL was concerned with the effects of diving on the human body, while EDU was responsible for the engineering aspects of manned underwater activity. Another interested party was DHB Construction Ltd (after Dennison, Hibbert and Borrow), supplier of the JIM, SAM, JAM and WASP one-man submersibles to oil companies before Oceaneering took over the market. Then, of course, there was Underwater Marine Equipment Ltd (UMEL) the manufacturer of the above suits. So, there were four main participating groups, with several dozen other submersible companies on the sidelines all eager to see what we were up to and hopefully learn something from the outcomes.

Thus research, on what was then a one-man submersible, needed to cross the boundaries of the two MOD organisations. To solve this problem, and enable a better link with the commercial side of diving, the Atmospheric Diving Group (ADG) was formed to undertake all aspects of the experimental work. This consisted of staff from both organisations, using mainly MOD purchased equipment.

Tony Gisborne (RNPL) was given the responsibility of systematically investigating various types of one-man submersible with Angus McInnes (EDU) taking on a part-time role as support. However, a team of two is rather small for this type of work, so I (from the RNPL Electronics Laboratory) then had the opportunity to join on a full-time basis. Now that the very basic team requirement was met, the workload grew steadily until 1980 when two JIM suits (Nos 18 and 19) were purchased by the MOD from UMEL, ostensibly for training and evaluation purposes.

At this point the JIM suit began to undertake many different roles e.g. diver training, submarine rescue and mine clearance, as well as carrying out numerous life support experiments to ensure that small submersibles would have adequate survival time for the operator to be rescued if something went wrong.

Important JIM facts prior to life support trials

Safe working depth:	1476 ft (450 m)
Life support (estimated):	around 30 hrs
Weight:	1102-1323 lbs (500-600 kg) dependent on configuration

NB: JIM did not require any electronics or electrical power to keep the operator safe since if the diver kept breathing then he remained alive (image 1). Underwater, simplicity rules!


Image 1 – Swanmoor's life support experiments

Now down to experimental work

Being someone who didn't want to go out in the rain, let alone jump in the sea for fun, I wasn't really interested in thermal protection. Even when in the RAF I was never at an altitude to warrant a heated flying suit, although I did wear a survival suit which worked very well thank you. Let's be honest, you can't jump out of a helicopter if it's falling out of the sky as we had no parachutes and rotor blades make wonderful blenders. So, 'what's the problem with these divers?' one might (and did) say.

Then one day, while sitting at my desk at RNPL, I was informed by Tony Gisborne that we were going to carry out a series life support trials on and for one-man submersible craft as this had not been done before. It seems that someone upstairs in the MOD had concerns about the life expectancy of such operators, which may have been due to the research undertaken by Curley MD and Bachrach AJ in Bethesda during 1982 https://europepmc.org/article/med/7135632. Interestingly, their experiments related to working in high water temperatures (20ºC-30ºC) although I am not sure where one would actually come across temperatures that high, especially at the depths JIM would normally dive, unless they were searching for 'lost' heat emitting objects on the seabed.

I should also mention that in 1976 JIM dived under the ice in the Canadian High Arctic at 902 ft (275 m) and, having spoken to one of the divers (Tony Moor at DHBC Ltd), we were aware that it had been a complete success, with a dive of 6 hrs being undertaken on a wellhead. It may not sound much these days, but then it was almost front page news.

All is well and good when there are no problems, but what if you are stuck on the bottom? Now I'm starting to think this might be the inspiration for a story.

With JIM having a life support of about 30 hrs duration and SAM, a closer fitting suit (similar to the Newtsuit) having a maximum life support of only 20 hrs, there needed to be some pretty accurate timings obtained. But why stop there? we also included the effects of temperature, the physical condition of the operator and, in particular, what the outcome would be if an incident happened after, say, a hard working dive of 8 hrs. The best guess of life support for SAM would then only be a maximum of 12 hrs and failure to recover the suit within that time would inevitably result in death. Or would it? no one actually knew. Suddenly, the nature of the job became very important.

NB 1: In 1982 the atmospheric level of CO_2 was 0.033% and equipment was calibrated at this level. It is now 0.04% a rise of 0.07% in approximately 37 yrs.

NB 2: The level of O_2 in the atmosphere was taken as 21% and both internal and external O_2 sensors were calibrated at this level.

NB 3: A measurement of CO_2 could not be read within the suit, so the operator took a cabin pressure reading of O_2 and undertook a quick calculation to get the answer. Occasionally, readings of 19% O_2 and cabin pressure 0 were seen, showing a lack of O_2 and therefore an increased level of CO_2, normally due to an ill fitting mask or even a beard (these were discouraged, by the way). Below 15% O_2 with a cabin pressure of 0 meant you were in serious trouble due to a high level of CO_2. There are many other combinations of readings which assist the operator in understanding the air mixture they are breathing, which is why the training of new operators in keeping a safe cabin environment was (and still is) so important.

As we had two JIM suits and could borrow GLOBE PROBE, a diving bell owned by the Directorate of Marine Salvage (DMS), we started to pull together a cunning plan which involved the use of commercial operators (initially) and thence DMS divers plus the possibility of Royal Navy (RN) personnel to fulfill the needs of the experiments. Primarily, the focus was on the number of hours one could continue to breathe before dropping off this mortal perch. We looked at it this way, and taking JIM as the benchmark, it was pretty likely that any operator in any other type of submersible (except SAM) would actually be in a more comfortable position during a long sojourn on the bottom because most had more room and less metal pressing against them.

We also realised that heat loss was going to be a big issue, perhaps even bigger than the O_2 uptake and CO_2 output, mainly because of the lack of room in JIM and we had no thermal gear suitable for the purpose. All that the government stores could offer us was; sea boot socks, some ‘woolly bear’ suits that standard divers wore and RN jumpers. Neither aircrew equipment nor neoprene was suitable, as a small incident nicely illustrated when a certain diver, named John Towse, insisted on getting into JIM wearing a wet suit. It stuck fast to the aluminum legs and took us 20 mins to get him out, the result of which was a somewhat painful extraction - for him, mainly. So, in the end, it had to be agreed by all concerned that neoprene and JIM did not make comfortable bedfellows. Well, we did *try* to warn him.

We knew that we needed better kit, but kit that could be worn during heavy workloads and not overheat the operator. It may not be obvious to everyone that because the operator supplied all the power, there were times when it was quite easy to work up a sweat. So it is worthwhile repeating that JIM was made of magnesium with aluminum legs and arms, which meant that heat was not easily dissipated.

Table 1 below shows some examples of other one-man submersibles. It can be seen from the different sizes of submersibles in the photographs and the positioning of the operator inside that there is great difficulty finding a generic solution to hypothermia. Today, one hopes that a significant amount of manufacturer discussion takes place prior to and during the construction of such devices.

Table 1 - Comparison of submersibles

Name	Type	Picture
SAM	Made of aluminium and was an even closer fit when the operator was put inside, so there was also no room to carry spare clothing.	
JAM	Had a fibreglass body and was very slightly smaller than JIM.	
WASP	Was little more than a cylinder made of fibreglass with a fair bit of free space, so few problems in that respect. Actually, WASP could have been lagged internally.	
MANTIS	Made by Offshore Submersible Equipment Ltd (OSEL), MANTIS required the operator to lay face down and had plenty of spare room for insulation.	
SPIDER	The Perry Slingsby Systems Ltd SPIDER, being larger than JIM, had adequate spare room as well as a seat.	

An example of hyperthermia (overheating) was clearly seen when we dived in the, now decommissioned, Submarine Escape Training Tank (SETT) at HMS Dolphin in Gosport, Hants.

The water temperature was around 34ºC to ensure the comfort of the submariners and trainers when they ‘escaped’ and then floated to the surface, but to us the temperature was at least 20ºC too high for a heavy workload and did result in the operators feeling that they had been put into a pressure cooker. Speaking from experience, it was not a pleasant place to be, even for the 20 mins we were actually on the bottom of the tank clearing the escape hatch of wire rope. For once, a little bit of ‘on the job’ training for us to use when training others. So, if you could easily overheat when wearing next to nothing it was pretty obvious you could get very cold indeed standing still with just a set of overalls on when the water was 4ºC.

NB: My memories of hyperthermia in JIM differ considerably from the findings obtained by Curley MD and Bachrach AJ in 1982.

Hurry up and stand still

It was a Friday. Tony, Angus and Janice (my wife who I had stolen from the RNPL Respiratory Physiology department for the weekend) made our way to DHB Construction Ltd at Alton with the firm intention of using a JIM suit to see how long the O_2 and CO_2 absorbent would last (figure 1). We hoped for a dive of 36 hrs duration, a figure that we considered to be acceptable for JIM but, if my memory is correct, a figure of 48 hrs was the target time to improve the viability of saving a life.

As this was our first attempt we did not expect miracles, but the operator from DHB we were going to use felt *very* optimistic and, since he had lots of experience diving 6-8 hrs a day in the oilfields, stated he would only need his overalls and a couple of other items to survive. ‘Are you sure?’ asked Tony and back came the reply ‘YES!’. A rectal probe was inserted. Our monitoring equipment was tested which addressed the recirculation of the cabin air for external CO_2 and O_2 percentage measurement along with ECG electrodes and breath-rate monitoring. Since the tank water temperature was about 16ºC we felt pretty sure that the subject would survive no matter what.

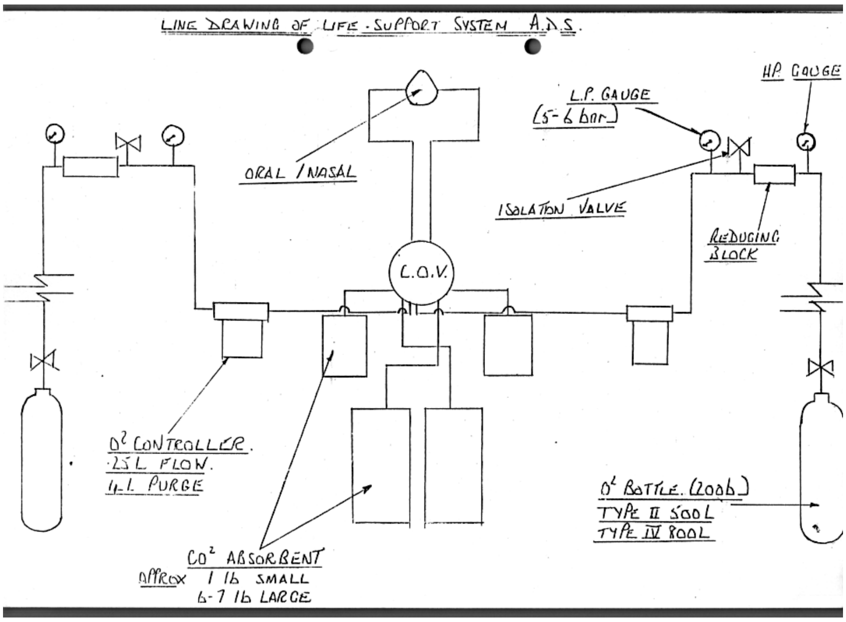

Figure 1 – UMEL’s life support for JIM

We started at 15:00 hrs on the Friday after briefing the subject on the scenario he should be working to:

The diver had taken the suit to a 1000 ft (305 m) and during that dive some heavy equipment had fallen onto him causing the suit to be trapped. It was going to take around

36 hrs to free him and he must take due care not to breathe quickly or move about. In other words 'you must stand still, because you are stuck!'.

At this point, *standing* still actually meant *sitting* still as the crutch of JIM was at the right height to sit on, if you slouched a bit. It was cold though, so a bit of insulation in that area was considered sensible.

Those of us working topside made ourselves as comfortable as possible for at least a 30 hr working day and took turns to take the readings from the operator, writing them down every 15 mins in the diary, along with any comments that were felt to be useful. All went well for a few hours until we were told by the subject that he wanted a pee! Well, we managed to talk him out of it for about an hour, but when you got to go you know that the time is nigh and he didn't want to fill his boots for some reason …

So, we had no choice but to get him out, let him do his thing and wrap him up in some of the clothing we had bought as well as stealing Tony's puffer jacket. Although this experiment was now a write-off, we decided to carry on to see what else was going to go wrong.

We grabbed a few hours kip during the night, but all four of us worked until 23:59 when two would get three hours sleep and then take over from the other pair at 03:00. The JIM operator was permitted to get some sleep as well, but we woke him up every hour, just to make sure nothing was wrong, even though we could count his breathing through the communications link as well as monitor his core temperature, ECG and CO_2 levels.

Inside the suit, O_2 remained at 21% and CO_2 at 0.033% throughout the night whilst his core temperature was always close to 37ºC. We still had complaints from the subject about feeling cold, but that seemed to be just a surface body issue. Remember, the water in the tank was around 18ºC and stayed at that temperature all night.

On Saturday at about 12:00, we called a halt to the experiment as things were generally getting very uncomfortable for the subject so there was little point in continuing. Also the port bank of soda lime had nearly been used up and the CO_2 level was beginning to rise to a point where we needed to consider changing over to the starboard system.

Don't think this was easy for the subject. It was a shock for him to realise how quickly cold set in when standing still doing nothing. We, from experience, realised that after only 10 mins of no activity it was possible to feel a bit of a chill around the legs. From our perspective we also realised that travelling to Alton to do this work was not the best idea, mainly because most of us lived in the Portsmouth area and having to drive back some 40 miles with a maximum of 3 hrs sleep in over 36 hrs certainly added another dimension to the experiment.

Our initial findings

We knew 24 hrs was not going to be a problem and on examining the soda lime the colour change indicated that perhaps 48 hrs was possible using both port and starboard canisters to their very limits. The O_2 usage was also satisfactory as we had just used one bottle and that wasn't topped up to the maximum. So, we were right not to focus on the O_2 and CO_2 issues. It was definitely going to be a thermal problem from here on and until we solved that, there was no point in attempting a 36+ hr breathing endurance dive. Deal with the temperature issue first!

Breath-rate (maybe this is just for the technically minded)

Recording the breath-rate of the subject was pretty boring and we started off doing it every 15 mins with a stop watch and counting for a period of 30 secs. As with every repetitive task, mistakes can and do happen and so I had an idea to monitor it continuously. The oral nasal mask used in JIM had an ‘in’ and an ‘out’ hose with mushroom valves fitted to stop unwanted gas returning to the subject.

So the idea was as follows: since there was a long path between ‘in’ and ‘out’ there would be a temperature difference between inhale and exhale so, by using two temperature sensors (one in each hose), the ‘in’ and ‘out’ temperatures would actually produce a sine wave on a chart recorder. Now, if the signal is changed to a square wave, it would be easy to count each breath and thereby display the breath-rate digitally. Remember, this is actually 1982 and these little toys had to be crafted by the designer. It took a couple of weeks to get it working and each ‘in’ and ‘out’ breath could be seen and counted with a reset pulse every minute. Success! (or so it seemed).

As usual, you test your own design and so after building it into the oral nasal mask, I sat in JIM and breathed as normal. All was well for about 5 mins or so and then the readings started to fail. On looking at the temperatures, I could see that within JIM, the inlet and exhaust gas temperatures quickly equalised, indicating that the hoped for cooling effect of the suit in water just did not happen.

I had made a mistake, but at least I didn’t have to worry about making it work at a depth of 1500 ft! Breathing out (hot air) through soda lime would heat the gas and breathing in through soda lime would eventually do the same. It also helped to explain why the humidity in the suit was always close to 99%. Yes the internals were always completely covered in water.

Since *all* experience is useful, it just goes to show that what often appears to work in theory is sometimes very different in practice, something that anyone carrying out simulations should certainly bear in mind.

Hello Swanmoor (DMS base)

We borrowed a small outside tank with about 8 ft depth of water, located next to the lake at Swanmoor (image 2) and, as it was heading towards winter, it was going to be a much more realistic 4ºC when diving.

By that time we also had a bag of clothing similar to that worn by the average JIM operator as well as our other bits and pieces enabling us to see which worked best. It was most noticeable that one’s backside and crotch got the coldest, largely due to contact with the suit, followed by the feet and legs. However, arms and body could be kept away from the magnesium areas of the suit, so less to worry about there. We even tried stuffing newspaper around the legs of the subject to see if it would reduce the chilling effects of the water. Various types of socks were also tried and they were placed either directly on the foot or over the neoprene boots that we normally wore when diving. In fact, anything that could possibly reduce thermal loss was definitely worth a try, but unfortunately JIM could be a rather damp place, even at the best of times. So the newspaper test, which, on the face of it, had great potential since it could be easily stored in the suit, ended up a soggy mess within an hour or so. Do remember we were looking for practical solutions, not a re-build of the suit.

Image 2 - Getting ready to dive at Swanmoor

Also, there was a really very important reason to get this right before the dive, because if we were to open the dome to hand the operator more insulation, we would influence the results of the experiment. This also resurrected the ongoing problem of 'how to have a comfort break' when in the suit. My only experience of how this might be solved was the 'pee tubes' and 'pee bag' in aircraft, so we suggested that the subject did something similar. Take in two bottles of water (no alcohol, of course), drink from one and when it is empty, you have your pee bottle. Just remember which one was which when you were thirsty, particularly at night!

Voilà some success

Swanmoor provided us with the most successful trial of the series and that was 34 hrs survival with a core temperature of 36ºC recorded by us at the surface. An actual drop of slightly more than 0.8ºC over 34 hrs was not too serious. In fact, well within the 48 hr survival time. The CO_2 level reached just over 5.5% with no serious complaints from the subject, except that his breathing was becoming laboured which we could hear as well as see on our equipment. I really do take my hat off to Jim Conway for his ability to withstand such a long stint in JIM and do it with extreme patience and fortitude.

Lithium - the American alternative

Then came the directive from 'on-high' to try lithium. For once I felt some research was needed on 'what the hell we were getting involved with' since we were going to breathe through it. I won't go into the details we found, but neither Tony nor I considered it to be a 'friendly' substance, especially the way we had to use it in the JIM suit. NASA specified it on the Apollo missions because it was more efficient at removing CO_2 and lasted longer, so the question was (I suppose) relevant.

If my memory is correct, we found out that getting lithium dust into our lungs was not an advisable thing to do. So we started off our tests by feeding CO_2 from a gas bottle at a measured rate into one of the JIM's 1 lb SODASORB® canisters mounted in the suit and measured the length of time it took before the CO_2 started to rise. Then we would do the same for lithium and carry out a bit of arithmetic to determine the efficiency of each. Unfortunately, this attempt failed due to the freezing of the CO_2 gas line. This problem could be cured, but we would have turned a simple one-day test into a detailed experiment, tying the suit up for a much longer period of time than we actually had available. So, we simply had to try it out for real.

As I have said, neither Tony nor I fancied breathing lithium straight from the canister or through the mask for that matter, so we reverted to the old fashioned method of placing a couple of inches of activated carbon on the top of the lithium in the small 1 lb canister to give us a buffer. We also added a piece of cloth on the bottom of the canister to assist filtering.

Tony undertook the first dive. The lithium worked well enough and actually got quite hot as the CO2 was being removed. Of course, the only way we would get a useful measurement was to undertake a long duration dive and then see what happened. The outcome was as expected, except for the amount of grit that was picked up on the filter cloth. He actually complained that it could be tasted as well, so that (we thought) was enough of lithium, since soda lime was safer for all concerned.

Remember, there was only a need to balance the O_2 supply against the CO_2 absorbent. If all of the O_2 supply had been used up, what was the point of having lots of absorbent left and do remember we still knew that hypothermia was the biggest problem.

Operator comfort

After a few long duration experiments we took pity on the subjects and fed audio into the suit so that they could pass away the hours listening to the radio. This was a success and enabled us to increase the length of time the subject remained in the suit. We then placed a portable TV outside on a shelf so the operator had another form of entertainment.

Let’s be honest, you can only push a subject so far, but as most stations closed down not long after midnight in those days, it was really only a choice of Radio 2 or Radio Victory (the local radio station). In the end most opted for silence. Richie (Head) found that a book was the best solution to pass away the time, but sitting on a magnesium crutch for 24 hrs was certainly quite uncomfortable for particular parts of the male anatomy.

These various forms of ‘relaxation’ worked well for the subjects, allowing us to run through half a dozen dives until we were told to undertake a couple of long duration dives at Falmouth. This was done (mainly) because the RN wished to undertake FLYING JIM trials out in the English Channel. So, JIM was given a real-life dip, in about 40 ft of salt water, in one of the dry docks without an all-inclusive amusement package, whilst the Soviet ‘fishing fleet’ looked on (image 3).

We were short staffed at Falmouth and only managed to get a couple of 1 day dives done because we borrowed someone from EDU. Having set up the equipment and checked out our new helper, I could then relax until someone wanted me.

And, somewhat inevitably, they did.

So I found myself being called out to the RMAS Ilchester (image 4), where the FLYING JIM was being used by the RN and (believe it or not) the superintendant of EDU, Phillip Christopher. Unfortunately, as Ilchester was about 10 miles offshore it resulted in me having to take a 45 min journey on an inflatable to carry out a minor repair to the electrical system - actually, to simply reset the mains generator and circuit breaker.

Image 3 - The USSR fishing fleet

Image 4 - RMAS Ilchester & FLYING JIM

A warm dive at Horsea Island

Most operators did feel the cold during their dives so they brought with them a mixture of clothing based upon their personal experiences, with various levels of success. Aircraft had used electrically heated suits during the war, so there was a track record of success with these systems. Unfortunately for us, JIM did not have large powerful petrol engines fitted to it (capable of delivering many amps of current to a rear gunner) so the possibility of using that kit was actually a bit of a dry hole.

However, we did manage to get hold of a prototype heated diver suit from EDU (image 5) which was actually the only electrical one controlled by a ‘switch mode power supply’ the latest electronic gizmo at that time. Several tests were undertaken over a period of months to see how well it functioned and it seemed to do the job quite well. Had we cracked the problem? As can be seen from image 5 it had the immediate advantage of reducing the amount of clothing worn by the subject as well as allowing us to adjust the amount of heat being fed to different areas of the suit.

Altogether it was a success, or would have been with a little more work, but it did raise a few issues:

- We needed to get quite a few amps through the umbilical cable, but unfortunately it would be 1500 ft long in real life and, at this time, we only had a 24 volt supply at the surface, so this was really going to limit the heat delivered if used for real.

- If you are stuck on the bottom following an accident, what is the likelihood of the umbilical cable remaining intact? If it didn't, the operator was going to be in trouble much quicker than if they were wearing thicker clothing.

- We would be making JIM reliant on electricity and that was not a good idea either. As I have already said, if the operator remained capable of breathing then life would be maintained.

- Adjusting the various areas of the heated suit to ensure the subject remained comfortable was, to say the least, no easy i.e. the 'goldilocks zone' was difficult to hit and might have needed significant modification to be undertaken.

At that point, we had proof of concept, but had to think again when it came to suggesting this as a solution for an operator's heating needs.

Image 5 - Jim Conway in heated diving suit

A subject's perspective

Richie Head stated: *'I was a Marine Services diver/supervisor back in the day involved with JIM from the ages 24-32, and now I'm Diving Superintendent for Serco Ltd. The overall experience was exciting at the time as this was a major distraction from air diving and our normal role of salvage divers. I loved diving the suit and latterly the Newtsuit for the challenge of accomplishing tasks that had previously only been carried out by a diver.*

I was involved in the 24 hr test dives at Horsea Island and felt cold during some of the shorter trials when not using the heated suit.

However, I don't remember suffering from CO_2 build-up to any significant level. I remember doing the heated suit trials at Horsea Island with Angus (McInnes) and yourself (Richard Castle) in attendance, a better and more comfortable experience. You had to learn to switch off and go into yourself during the long static trials, I also remember taking in a book to pass the time!'

Now try something different

GLOBE PROBE (image 6) was a doddle compared to JIM when it came to thermal issues and physical comfort, so we approached this part of the trial from a very straightforward direction; that of life support.

Image 6 - GLOBE PROBE

We wanted at least 36 hrs for this series and there was no reason why we wouldn't get it. We could put loads of clothing and extra CO_2 absorbent canisters inside the bell with no penalty whatsoever. However, it had electrically controlled fans for CO_2 removal and thereby hangs a tale - a *total* reliance on electricity.

Question: Would you prefer to wear an oral nasal mask or use electrical scrubber fans and an internal battery pack? It is not a simple decision, so the sensible answer is to enable both to be used at all times.

If lead-acid batteries are mounted within the diving compartment they have the potential to either gas off when being charged or produce chlorine gas if saltwater gets to them (image 7). They could even short out if the insulation was not up to specification, so there is a great advantage to mounting them externally as was done in the case of most submersibles.

Also, at this time, the CO_2 absorbent being used had a fine grain size much favoured by the RN, which tended to create a lot of dust as well as cutting down the airflow. This we changed, after carrying out one comparison test to a larger grained version, which enabled a better throughput of gas and thereby improved efficiency.

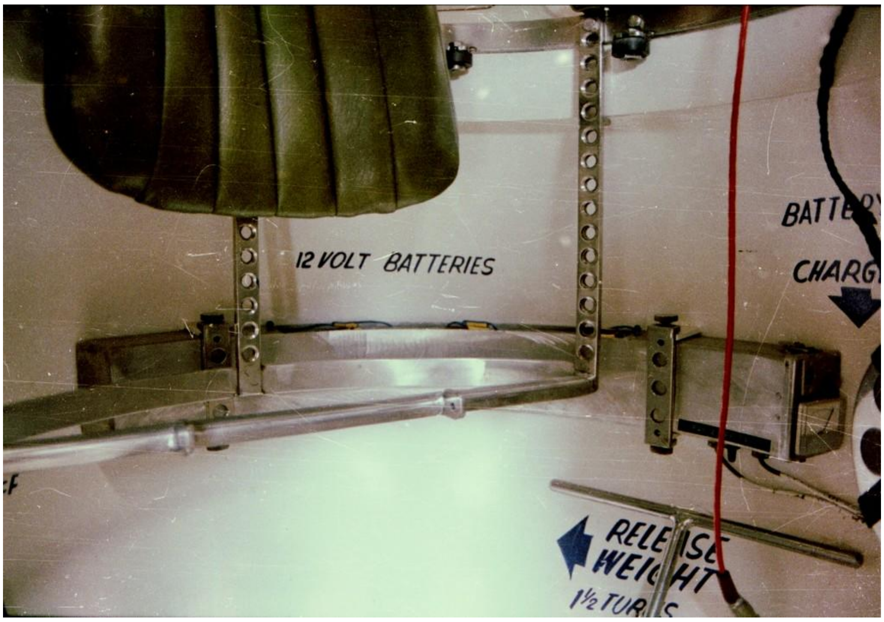

Image 7 - Inside GLOBE PROBE

To be honest, GLOBE PROBE was really a waste of our time as there was so much empty space for bits and pieces to be stored, that a successful test was just about guaranteed. We said we would check it and we did. We also suggested that several issues should be dealt with to improve safety and closed the book.

By 1984, the use of such a diving rig was redundant as cameras were well capable of sending good quality pictures to the surface. I never *did* discover whether GLOBE PROBE was ever used for the purpose intended. We undertook about another six long duration experiments using various operators. Although no one beat Jim Conway's 34 hr stint in the suit, everyone managed at least 24 hrs which certainly provided us with some valuable data.

And now the end

By the end of our trials, we were pretty sure that a JIM operator could survive for 48 hrs with a bit of luck and some warm clothing on their body. However, 36 hrs was far more realistic and if that time was taken from the minute that the operator became stuck, the topside crew could then afford to plan out a rescue attempt knowing the total amount of time they had to succeed in their endeavors. I think it is fair to say that an operator without warm clothing, some high energy food and a small supply of water on board would find that being stuck for more than 36 hrs meant that the cold could get to them before the O_2 and CO_2 absorbent ran out.

However, in the case of SAM, it would be the safest bet to recover as soon as possible, even if it meant taking a chance, because of the effects of cold and a general shortage of life support.

The operator's perspective

It is always difficult to place oneself into the mind of an operator including how they would react in an emergency. But I would suggest, as a general rule, that if you became stuck on the bottom yet were still watertight there would be little panic for the first 6 hrs, on condition that topside were well briefed on how to deal with the situation. After that, there could easily be a build-up of cold, cramp, damp, tiredness and fear, any or all of which may reduce the total time the operator would survive.

Should there be a communications failure, it is quite possible that this would negatively affect the operator quite quickly. To overcome this situation, it was suggested that the best action would be to send the backup suit down in order to make eye contact as quickly as possible (as was already laid down in the JIM operations manual). However, it is open to question as to whether to place another suit into what may be a very precarious situation. The decision is for the person in charge of the recovery and not necessarily the standby diver who would no doubt wish to help his oppo.

Conclusion

Ultimately, we had provided an answer to the question of life support which highlighted the dangers that could be faced by a one-man submersible stuck on the seabed and I am pleased to say that we were never required to assist with such an emergency. Let us hope that companies which currently use this type of equipment undertake regular exercises to ensure that both topside and operators have some experience of what to do if and/or when such an emergency occurs.

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Just one last thought

You might be interested in reading ‘A Story of Survival at 1500 ft’ which is based on this paper. We used part of the scenario to help stimulate the imagination of the divers involved in the experiments, introduce an element of role-play and give them some valuable experience of a situation which could possibly have happened in real-life.