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## **POST EXPEDITION REPORT ON THE USE OF SUMMIT OXYGEN PULSE DOSE DELIVERY SYSTEM, ROYAL NAVY EVEREST NORTH RIDGE 2003 (ENR03)**

### **INTRODUCTION**

1. During April and May of 2003, a 13 strong Royal Navy team, with Sherpa support, successfully climbed Mt Everest by the North and North East ridges. Summit Oxygen's new 'Pulse Dose' oxygen system was used throughout and was taken to the summit by WO2 Dave Pearce RM and Chhiring Dorje Sherpa on 22 May 2003.

### **AIM**

2. The aim of this report is to outline how the Summit Oxygen system performed throughout all phases of the expedition and to identify any improvements that could be made to both the system and its composite parts.

### **BACKGROUND**

3. Most high altitude climbers opting for supplementary oxygen use a Russian system called 'Poisk', which has its origins in the aviation world. The system delivers a constant flow of oxygen to the climber, via an insulated face mask. Other companies do produce mountaineering oxygen systems, working on a similar principal, but Poisk is the market leader and is used by most expeditions climbing on Everest. The Poisk system comprises a lightweight, composite cylinder and a mask with an 'exhale bag', which recycles some exhaled oxygen; improving efficiency. Summit Oxygen's new system, however, works on a pulse delivery system and uses a nasal cannula to supply the oxygen, rather than a mask. As the climber breathes in, through either nose or mouth, the pressure difference in the cannula trips a valve in an electronic 'Pulse Dose Meter' (PDM) and a pulse of oxygen is delivered, via the nasal cavity, into the climber's lungs. The main benefit of this system is that oxygen is only delivered as required, on inhalation, making the system roughly 3 times more efficient than a constant flow system. The PDM system is used to conserve oxygen in both medical and aviation roles but, prior to ENR03, had not been used for high altitude mountaineering.

### **OVERVIEW OF OXYGEN USE ON ENR03**

4. Overall the use of Summit Oxygen system on ENR03 was a great success. It was used in both medical and climbing capacities and was an integral part of the successful summit attempt; an attempt carried out in harsh conditions. The system operated as advertised by Summit Oxygen. It continued to operate in very cold conditions and was robust enough to survive the rigours of mountaineering. The efficiency of the system was particularly impressive; as will be discussed in detail later. A measure of the success of the system is how the Sherpa staff, initially very sceptical about the pulse dose idea, and stalwart Poisk users, became great fans. The system was used by two four man summit teams, one of which put a pair on the summit, the other abandoning their summit attempt to carry out a serious, high altitude rescue. The system was also used medically, both during the aforementioned rescue and with Acute Mountain Sickness casualties at various altitudes.

## THE SYSTEM COMPONENTS

5. The system comprises lightweight cylinder (300 bar), cylinder valve, regulator, silicone hose and connectors, PDM (two variants, both supplied with lithium batteries), silicone cannula, silicone facemask (secondary), PDM carrying pouches/vests. A break down of how the components performed is as follows:

- a. Cylinders: The 300 bar cylinders supplied were very reliable and no faults were observed. In addition, all cylinders used were found to be fully pressurised; not all expeditions as Base Camp were so lucky.
- b. Cylinder Valve: The cylinder valves on all cylinders used worked without fault. The design was robust, easy to use and lightweight.
- c. Regulator: The regulators supplied were of a very high quality, easy to use and robust. There was one unfortunate malfunction that caused one of the Sherpas in the 1<sup>st</sup> summit team to abort his summit attempt at 8,400m. The regulator inexplicably stopped delivering oxygen and could not be made to work subsequently, even in warm environments. This is an exception to what was generally an excellent piece of equipment that worked well in the extreme cold above 8,000m.
- d. Silicone Hoses: The hoses which linked the cylinder to the PDM were found to be of a very high quality and no difficulties were encountered with them. They are supple enough so that they do not become brittle or hard to handle at low temperatures. Yet they are robust enough to cope with the wear they receive coming out of a rucksack and over the shoulder, yet not so supple that they can become 'pinched' and oxygen flow disrupted. Likewise the brass 'quick fit' connectors also performed very well and no malfunctions occurred. In summary, this component is ideal and needs no improvements or adjustment.
- e. PDM: Two types of PDM were used, with a total of 4 of each supplied by Summit Oxygen (in retrospect, 6 of each would have given more flexibility/margin for malfunctions).
- f. Silicone Cannula: The silicone cannula were robust, comfortable to wear and continued to operate in harsh and cold conditions. They gave the wearer a real freedom to talk, drink and eat and did not obscure vision, disrupt sleep or cause claustrophobia in the way a mask can. The only weak part of the design was that the piece of tubing immediately above where the cannula attached to the box was very prone to 'kinking' and so reducing the flow of oxygen up the tubing. This was a nuisance rather than a major problem and could probably be rectified by stiffening the tubing for a few inches as it leaves the PDM. Overall an excellent component. However, one member experienced problems with the cannula for the simple reason that he had a cold, but this will be discussed later.
- g. Silicone Face Mask: The face masks were only used in a medical capacity during the expedition. This is the intended use for these masks and so they performed well, inside tents and vehicles. They were carried by the summit parties as a back-up to the nasal cannula but discussion with the Sherpa staff and other expeditions at Base Camp, who had experience of using the Poisk mask, knocked our confidence in the design of the mask. The Poisk mask is designed to take warm, moist exhaled breath away from the oxygen inlet, to avoid it freezing over. Despite this, the Poisk does periodically freeze up. It was felt that, because the exhaled breath had limited egress points from the silicone mask, that it was likely to freeze up very

quickly high up the mountain. This was never tested but is still thought likely. A bespoke, insulated mask would seem preferable.

(h) PDM Carriage: Summit Oxygen supplied both a small pouch for carrying the PDM and a vest, suitable for carrying the PDM, spare batteries and other items such as cameras. Neither of these were used by the 1<sup>st</sup> summit team who preferred just to slip the PDM into a pocket or down the front of the jacket (which worked very well but probably exacerbated problems of kinks at the base of the cannula) and who found the vest too bulky and heavy. One member of the 2<sup>nd</sup> summit team did use the vest and found it comfortable and useful.

### SYSTEM EFFICIENCY

5. The system was remarkably efficient and perhaps too efficient, as strange as that might sound. What is meant by that is when using a setting equivalent to those used on Poisk, say 21pm for climbing, the summit teams found that they had used hardly any oxygen by the end of the day. What is meant is that either the system was not delivering pulses as often as it should or that the setting on the boxes are not quite comparable to the same setting at constant flow. Best guess would be that somewhere between the two is most likely, as delivery by the system was almost always fine. When climbing with the system it seems likely that bouts of very irregular or pure mouth-breathing, mucus from the nose, wind, cold and so on could occasionally disrupt the pulse dose. All the climbers experienced moments where they suddenly realised they had unconsciously blocked off their nose, for instance, and so had missed a couple of pulses. In the same way, it would not be surprising if the flow rates of Poisk and the 'virtual' flow rates of the boxes did not quite match. However, efficiency that is enhanced in such a way can easily be overcome by simply increasing the flow! It is just a matter of experience, knowing what is a good rate to climb on. The two British members of the 1<sup>st</sup> summit team climbed on 31pm and 41pm for the whole of summit day and experienced efficiency that they would have expected (from the provided tables) at 21pm. This does not overshadow the massive benefits of the system however, as the breakdown of the oxygen use of the 1<sup>st</sup> summit team below demonstrates:-

Camp 4 to Camp 5	¼ Cylinder used ( <b>NB:</b> Climbers traditionally start using oxygen at Camp 5)
Overnight at Camp 5	<1/4 Cylinder used
Camp 5 to Camp 6	¼ Cylinder used
Rest at Camp 6	<1/5 Cylinder used (Cylinder changed, still not empty)
Camp 6 to Summit and back to Camp 6	¾ Cylinder used

As laid out above, the 1<sup>st</sup> summit team started on oxygen at Camp 4 and used 1 cylinder to get all the way up to Camp 6 and rest at Camp 6 (7000m to 8,300, over two days). A further cylinder was then used to climb to the summit and return to Camp 6 (15 hrs approx). With Poisk, other teams were using at least 2 bottles for summit day alone. Summit team 1 then still had oxygen left from the 'summit bottle' to descend to Camp 5. However, the team renewed the bottles at Camp 6 and stayed on oxygen down through Camp 5, through Camp 4 and down to the base of the North Col: a descent of 1700m. Teams using constant flow system could not have afforded, logistically, the luxury of starting oxygen at Camp 4 and then breathing most of the way back down to Advance Base Camp: this was only possible with the pulse dose system.

## PERSONAL ACOCUNTS OF USING THE SYSTEM

7. The two climbers who used the system the most were WO2 Dave Pearce and Capt Rich Cantrill (in charge of Oxygen for the exped). Below are two brief accounts of their experience using the system:

a. Capt Rich Cantrill: “I was in charge of oxygen for the expedition and had been involved in our initial trials and so on, so it was great to get out to Tibet, to see all the equipment in one place and find that Summit Oxygen had packed it all with such care; neatly organised, plenty of spares, extra batteries, etcetera.

When Dave and myself and the two Sherpas headed off on our summit attempt we had the luxury of knowing that the system was working well, the Sherpas having used it to stock Camps 5 and 6 and being very pleased with it; despite their initial scepticism. I was also slightly aware that the system was perhaps more efficient than the endurance tables suggested, having asked one of the team to sleep on the system at Base Camp. After a full night’s sleep his oxygen use was negligible, yet the PDM did not alarm during the night so all had been working correctly. So it was in my mind that we may be able to up the rate from 21pm, which is what we had planned to climb on. My personal concerns were that I would be mouth breathing and gulping air once we got up high and this would lead to problems ‘tripping’ the PDM but this was not the case. I found that I did have to modify slightly the way I was breathing to get the most out of the system, and we all had different ways of doing this, but that was no problem.

The PDM was compact and easy to use but during our 3 days on the system, Dave and I both had occasional trouble with the box getting out of synch with our breathing and had to remove and replace batteries several times. Despite this, the system worked well. However, I had further difficulties due to having a cold. I would clear my nose and for a while the PDM would trip correctly but, over time, the oxygen supply would diminish with less and less powerful pulses, reaching my nose. Interestingly the cannula, to it’s credit, did not seem to be blocking but rather my nose was. At various stages I tried to use the cannula with it held between my teeth. I had no trouble tripping the PDM in this way but I could feel that I was not getting the same benefit. Life was easier at the camps, as I could keep my nose clear more easily and I was surprised about how comfortable it was to sleep with the cannula.

On the summit day itself, due to my blocked nose, I felt perhaps I was getting less oxygen than Dave, although he was the stronger of the two of us anyway and certainly I was having to adjust my cannula more often. This was possibly a contributing factor to my fingers becoming frost bitten and me subsequently having to turn round at 8,500m (but not the only factor). It is difficult to pull a taught cannula away from your face with even thin gloves and often I was having to use my bare hands to adjust it. My overall impression however, of the system, is that it is excellent and the logistic benefits massive. I think the few problems we encountered were teething problems due to the fact we were the first team to take it up on a big mountain. A major bonus to the evolving system would be the inclusion of a bespoke mask that could be used with pulse does; in case you get a cold!

## SUMMIT OXYGEN

8. It is worth of note how helpful Summit Oxygen were during the build up and execution of ENR03. Equipment components were all of the highest quality, the freighting of the equipment was painstakingly organised and advice and support from Neil Greenwood was available throughout; day or night. They are certainly to be recommended as a good company to deal with.

## RECOMMENDATIONS

9. The following is a summary of the recommendations that may improve use of the oxygen system, in priority order:-

- a. Bespoke mask as alternative to cannula (Summit Oxygen already have this in mind)
- b. Investigation into the use of smaller, lighter cylinders is made (given excellent efficiency)
- c. Modifications to prevent kinks forming at the base of the cannula are considered.

## CONCLUSION

10. In summary, ENR03 was very well served by Summit Oxygen and their Pulse Dose system. There are improvements that can be made to the system but this is only to be expected following its first use 'in anger'. The fact that the 1<sup>st</sup> summit team could start using oxygen earlier than other teams and have further extra capacity on the descent, whilst only using 3 bottles per man, is a revolution in mountaineering oxygen.