

# HAZARD AND OPERABILITY STUDY (HAZOP) REPORT

## Subject: SCR on/off algorithm.

Site: St.Petersburg, Russia Design Centre  
Date: 17 January 2007, 2d part.  
Time: 10:00 -19:00  
Project: Provision of diver rebreather (RB) and monitoring system NR0006357.  
Participants: Statoil team: Yngve Bergflodt  
Technip team: Jim Holborn , Jon Are Hvalbye , John Nortcliffe, Stein Olberg,  
NUI team: Kare Segadal  
Deep Life team: Alex Deas, Marat Evtuhov, Alexey Bogachev, Alexander Kudyashov, Sergei Maluytin, Vladimir Davidov, Pavel Kamochkin.  
Study leader: Vladimir Komarov .

### General summary:

Terms of reference and scope of the study are SCR on/off algorithm according to the project document Green Book GreenB\_ORTONOR\_070105.pdf and Agenda of HAZOP Study of 17.01.2007. There is a special algorithm of SCR ON/OFF described in above documents with definitions of ON and OFF status:

- Definition: OFF means the unit is not providing breathing gas but in fact the electronics is always on if there is either battery power or umbilical power and if it detects a PPO2 of less than 0.3, will turn on to inject gas to raise the PPO2 in the loop.
- Definition: ON means the unit is fully functional.
- The Technip SCR is OFF when powered up.
- It switches ON if it detects breathing when in the off state, OR is wet determined by a low resistance path between the battery holders. Breathing is detected by a drop in PPO2, either to less than 0.3 or drops by 0.1 in 10 minute. If either of those states occurs, the unit switches ON.
- The unit switches OFF if the PPO2 has not fallen for 15 minutes AND the gas injector is fully closed AND there is a high resistance path between the battery holders.
- When the unit is switched OFF, the voice annunciation in the mouthpiece will announce this and the HUD lights will then go off.
- When the unit is switched ON, the unit will perform its pre-dive checks, the voice annunciation will declare "Ready" and the HUD lights will go on. From the moment of the "Ready" announcement, the unit will be ready for diving, but the diver should also carry out pre-dive positive and negative pressure checks (the unit does all the others automatically). However, if the unit is wet, it skips these checks and goes straight into dive mode and reports an alert.
- The unit can be switched on by USB diagnostics, or in diagnostics mode from the Top Side Unit. It cannot be switched off by the Top Side Unit or the USB port.

The meeting agreed that PPO2 falling below safety level is a Critical Failure and should be carefully dealt with.

### The keywords combinations:

#### Primarily keywords:

Pressure; Corrode; PPO2 level;  
Shutdown; Start-up; Humidity; Wet.

#### Secondary keywords:

No; Under; Over; Reverse;  
Other.

During the HAZOP study sessions all the combinations of primarily and secondary keywords were considered. Action worksheets have been filled out (attached).

### **Observations and Recommendations:**

1. Meeting considers battery low/flat as a critical characteristic for monitoring of PPO2 level. Reliable management of battery low/flat is believed to have been implemented. **Action:** a separate DV report on the battery charging system is required.
2. Operational procedure has to check and eliminate battery flat in pre-dive check. No power – no dive. It's recommended to use colour lights to indicate battery status.
3. PPO2 level of 0.3 should be changed to vary with pressure, using the same algorithm as for the PPO2 set point, with a minimum PPO2 0.19 at 1 atm, to avoid the unit running the battery flat.
4. The operational limits for O2 sensors should be changed from not permitting the unit to enter normal dive mode after pre-dive checks with more than one sensor down per side, to allowing up to two of the four sensors down per side. This still leaves 4 good sensors, and the sensor elimination algorithm should detect the faulty sensors.
5. A case of PPO2/over should be thoroughly investigated as a safety case for 2 one side sensors.
6. Jon Are Hvalbye noted that in ON/OFF algorithm two separate safety systems have to work together: one controlled by diver himself and second is monitoring by supervisor. The software should be modified accordingly.
7. Meeting considers software security as a critical point and underlines necessity to prevent unauthorized intervention. Sergei Malyutin describes security system and several level of authorization of software. **Action:** Pavel Pyankov to describe security arrangements in writing.
8. **Action:** ask Vladimir Vikulin, hardware engineer, to add a special field for SCR serial number to be written into database.
9. Meeting noted and agreed with operational instruction that the sensors be from two different batches. The diver has to be trained to change sensors during maintenance.
10. The meeting noted that the sensor circuit includes a DAC to ensure that only the correct type of sensors are fitted.
11. There should be a requirement in operational procedure to avoid storing of the rebreather in water or in high wet.
12. **Action:** The use of wet contacts should be revisited: they are seen as a source of problems, particularly when the harness is wet.

Enclosure: HAZOP Action worksheets – 2 pages.

HAZOP Study leader:

V. Komarov