

CASE STUDY: Zephyr Provides Physiological Monitoring of Chilean Miners During San Jose Mine Rescue Operation

This case study will discuss the application of the Zephyr BioHarness technology as it was applied in assistance to the Rescue Operation of the 33 trapped miners in northern Chile's San Jose mine. After rescue workers identified the need for remote vital sign monitoring (both in the weeks prior to and during the actual extraction operation), Zephyr was very quickly selected for the job as the world leader in the field. There were several options for monitoring presented by Zephyr including full time monitoring for all trapped miners, part time monitoring of all trapped miners, monitoring of miners during exercise periods or during health check-ups, and finally, just an as needed monitoring solution for higher level vital sign monitoring including ECG, Heart Rate, Breathing Rate, Skin Temperature, Posture, Activity, Accelerometry, Blood Pressure, and Pulse Oximetry.



Figure 1. Zephyr Medical Check-up System

Zephyr could log data so the doctors could download it later, and Zephyr could also provide the capability for the doctors to view the data live with data communication capability of radio communication or over a fiber optic link.



Figure 2. Monitoring System for the Rescue

The doctors on site elected to split the group of miners into three groups of 11 and organize their daily routine by periods of rest, work, and exercise. During their exercise period, they would be monitored using the Zephyr BioHarnesses in a logging mode and the data would be downloaded after each session so that the doctors could manage each individual's exercise routine and establish a baseline for each individual based on a stress test as well as other normal parameters such as resting HR/BR, tracking skin temperature, as well as a baseline for blood pressure levels for each individual. All baseline data collected was used to create a profile for each individual, so it would be clear if at any time an individual was going beyond their normal thresholds due to stress, anxiety, fatigue, malnourishment, heat stress, hypothermia, hypoxia, or many other common problems that the miners were susceptible to.



Figure 3. System for remote vital sign monitoring

To transfer the equipment up and down from the mine, it had to pass through a metal pipe with a diameter of 3.5 inches referred to as the “Paloma”. This was the same manner that food, water, medicine, clothing, and supplies were also passed up and down to the mine.



Figure 4. Zephyr BioHarness loaded into “Paloma”

Because items were currently being passed through this means, there was a regular manpower force responsible for the undertaking. These “Palomeros” provided the lifeline for the miners trapped 2000 feet below through this 3.5 inch shaft bored through the earth after the first 17 days of searching for the rest of the 69 days that the miners were trapped underground.



Figure 5. “Palomeros” providing the lifeline.

Chilean medical doctor and athletic trainer, Jean Romagnoli provided the necessary medical expertise to analyze the data and determine the exercise regimen for each individual all for the purpose of ensuring that they were physically capable of handling the stress and rigors that would be required of them during extraction. Zephyr Field Application Engineer, Ben Morris provided the technical expertise and support to ensure the system was effectively employed. Additionally, psychological monitoring and counseling was provided by Chilean psychologist, Alberto Iturra via phone and video call capability that had been established with the miners below.

Once the drilling operation was completed and preparations for the extraction phase were made, vital sign monitoring was provided as each miner ascended in the rescue capsule dubbed “Fenix 2”.



Figure 6. Zephyr monitoring equipment being fitted in the “Fenix 2” capsule during final prep.

Each phase of the rescue operation was tracked on a giant wall-sized white board located inside the triage facility.



Figure 7. Rescue operation command center/triage area

Everyone anxiously awaited the first miner to ascend.



Figure 8. Rescue medical team awaiting first patient



Figure 9. Miner Mario Gomez on his ascent.

As each miner surfaced the lead medical doctor for the rescue operation, Chilean Navy doctor, Andres Llarena check the vital signs, blood pressure, and pulse oximetry from Zephyr's sensors to quickly evaluate any special emergency cases. Then the miner/patient was transferred to the next phase of triage. Where all sensors were removed, data downloaded, and quickly evaluated by the team.



Figure 10. As each miner arrived to the triage facility, Zephyr BioHarness was removed, data downloaded and evaluated.

Further care and evaluation was provided by the team of doctors around the clock for the duration of the rescue operation. Due to extreme organization, careful planning, and amazing teamwork, all miners and rescue workers surfaced without incident.