Hyperbaric Controller

by

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Category
Wellness

Introduction
Hyperbaric Health design, manufacture and distribute hyperbaric chambers sold world-wide. The hyperbaric chambers they build are used for the application of Hyperbaric Oxygen Therapy (HBOT), a practice of breathing 100% oxygen under increased atmospheric pressure to deliver high concentrations of oxygen via the bloodstream for non-invasive medical treatments.

CPE Systems was contracted by Hyperbaric Health to develop a control and monitoring system which would integrate and replace the existing outdated controller. Hyperbaric Health has a vision to take hyperbaric decompression chamber control and monitoring to the next level.

Figure 1 – Hyperbaric Health Decompression Chamber

The key feature of the control system was to regulate the flow of oxygen and control the air pressure within the chamber during treatments. The application of such treatments involved typically three distinct phases:

Compression – where pressure is gently increased linearly over a period of time.

Treatment – where pressure is maintained over a period of time upon reaching the level

Decompression – where pressure in the chamber is linearly decompressed at the end of the treatment phase

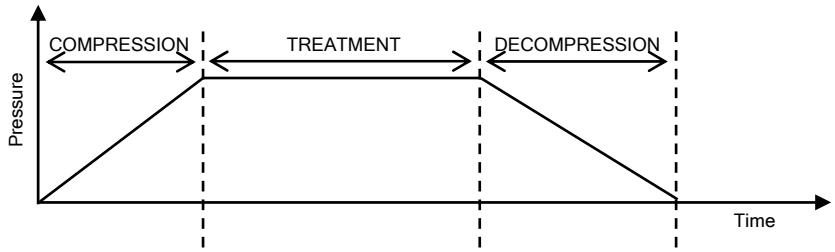

Figure 2 – Example of a Basic Treatment Profile

The system needed to be flexible in order to handle multiple phases such as those illustrated below in

Figure 3.

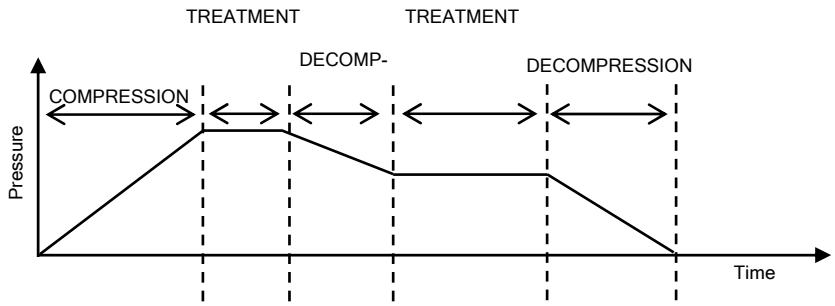

Figure 3 – Example of an Advanced Treatment Profile

During treatment, the interface will present to the operator a graph of the desired treatment profile, along with the actual depth. The system will continually monitor pressure input and control an outlet valve to ensure pressure stays close to the proposed profile.

Other features of the system required:

- Allowing the operator to create and run custom treatment profiles.
- Logging of patient details into a basic report file such as patient name, patient number, number of times treated, operator notes etc.
- Automatic data-logging of treatment data into a basic report file.
- Ability to print report file directly from the user interface
- A configuration screen to allow for PID tuning ensuring a smooth treatment profile response to the selected target profile.

The system as a whole is illustrated in below Figure 4 (courtesy of Hyperbaric Health).

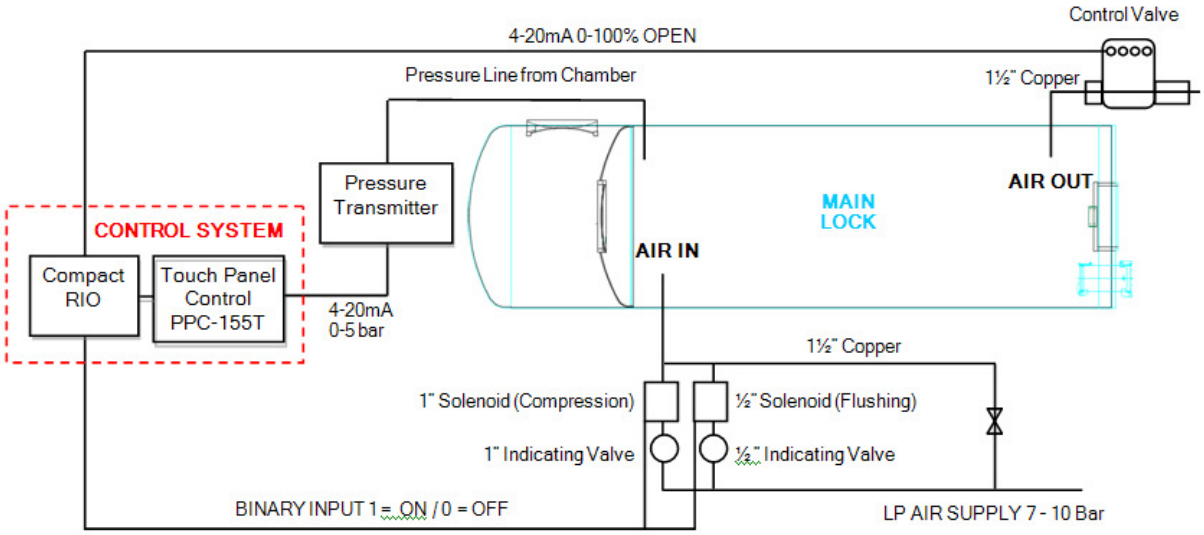

Figure 4 – HDC showing HDC Control System

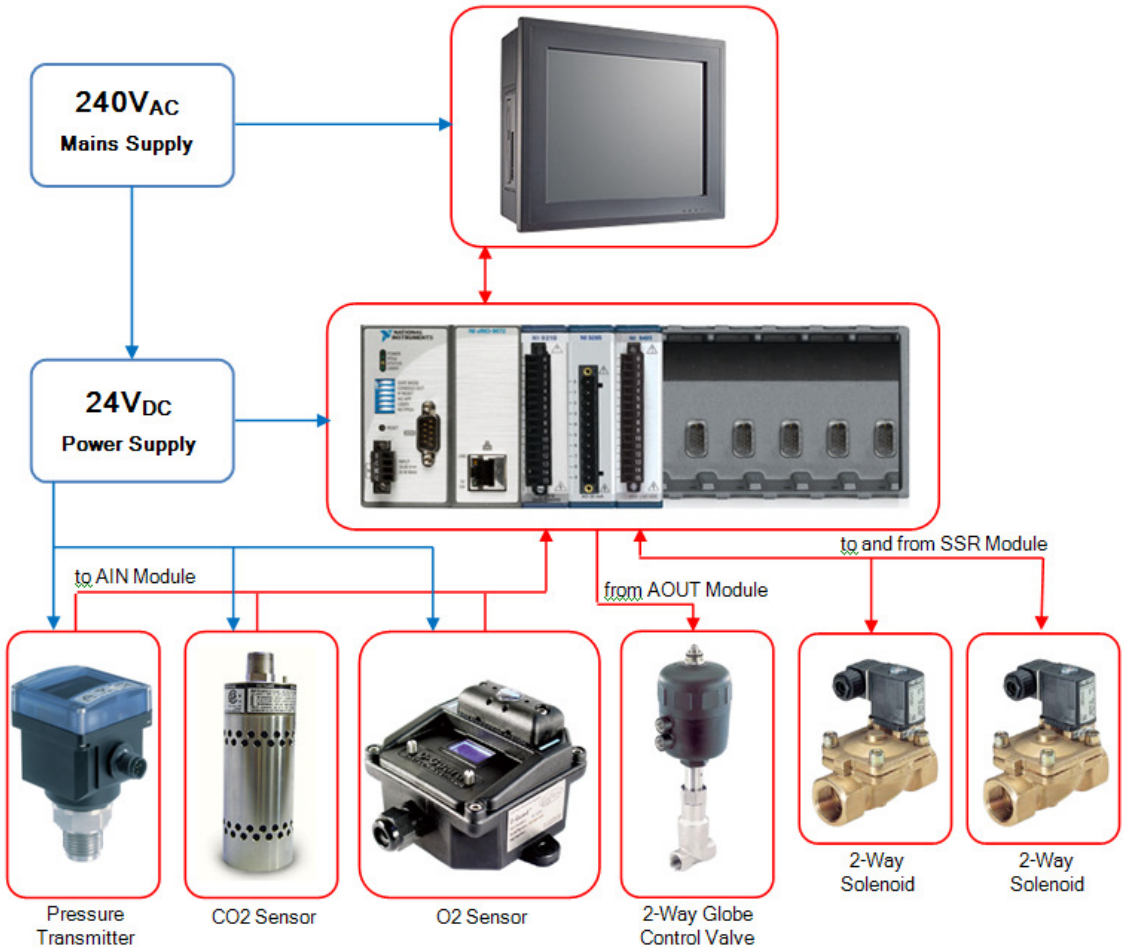

Figure 5 – Control System Architecture

Solution

The fundamental requirement was to have the pressure inside the chamber regulated according to a pre-selected profile chosen by the operator. Although the concept was straight forward, the implementation of the PI controller in software proved to be challenging, as the software had to compensate against the various accumulation of time constants within the plant itself.

Utilising the cRIO (a National Instruments Process Automation Controller), a touch panel PC and a LabVIEW software application, CPE developed an interface for the operator which would not only monitor and control the pressure, but also highlight the progress of the treatment, provide visual alerts if any sensors were outside their defined limits, provide the operator the ability to add treatment log notes, and provided the ability to pause and extend the duration of the treatment process.

Software Overview

LabVIEW 2010 was chosen due to its powerful graphical capabilities and quick implementation time. This was invaluable for a system that required a complex user interface, communications between two targets (host PC and cRIO) and a real-time monitoring solution.

Treatment Profile Selection Screen

In this screen, the operator can enter or remove patient details by clicking on the "Add Patient Details" or "Remove Patient Details" button. The save button becomes active once the operator completes the mandatory safety checklist. When the save button is active, clicking on it will take the operator to the main treatment screen (Figure 7). The "Edit" button will allow the operator to enter general details about the treatment and the "Cancel" button will prompt the user to confirm their action to cancel and lose changes before returning them to the main menu.

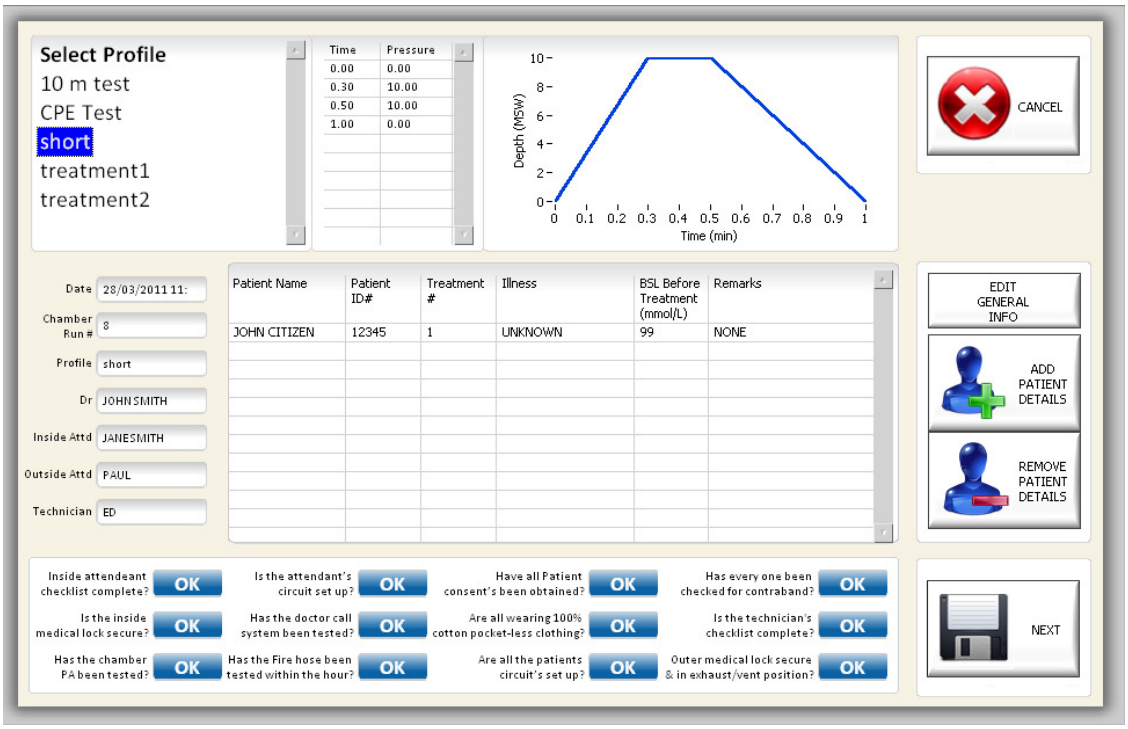

Figure 6 – Treatment Profile Selection Screen

Treatment Monitoring Screen

In the main treatment screen, the start button will commence the selected treatment profile. This button will change to "PAUSE" when the system is in either the compression or decompression phase. When the pause button is pressed during these phases, both solenoids and exhaust valve will be set to their closed positions.

When in the treatment phase, the extend treatment button will switch from grey-disabled to enabled allowing for operators to extend the treatment phase. When the "extend treatment" button is pressed, an onscreen keyboard will pop up waiting for user to input the time to be extended (in minutes). If there has been an extension already applied, this extend treatment button will have been changed to a "cancel extension" button which when pressed will remove any extension that is currently underway. If the system is in another phase other than treatment, the "extend treatment" button will return to its grey-disabled state.

The "THERAPY RECORD" button will switch from the graph to the report screen (see Figure 8 – Tab 2: Therapy Record Screen) allowing operators to log notes while the treatment continues to run in the background. At all times, the states of the sensors will be visible at the bottom of the screen. Indicators will flash red if there is an error or warning to notify the hyperbaric operator. The settings for these alert limits will be stored in a configuration .ini file.

The "ABORT TREATMENT" button will bring a message prompt awaiting the operator to either choose 'ABORT' or 'CANCEL'. The abort feature will be programmed to relinquish control over the system so that operators can perform a manual control to decompress the chamber in case of emergencies. At the end of the treatment, the "COMPRESS" button will change to a "Return to Main" icon that will return the user back to the main menu.

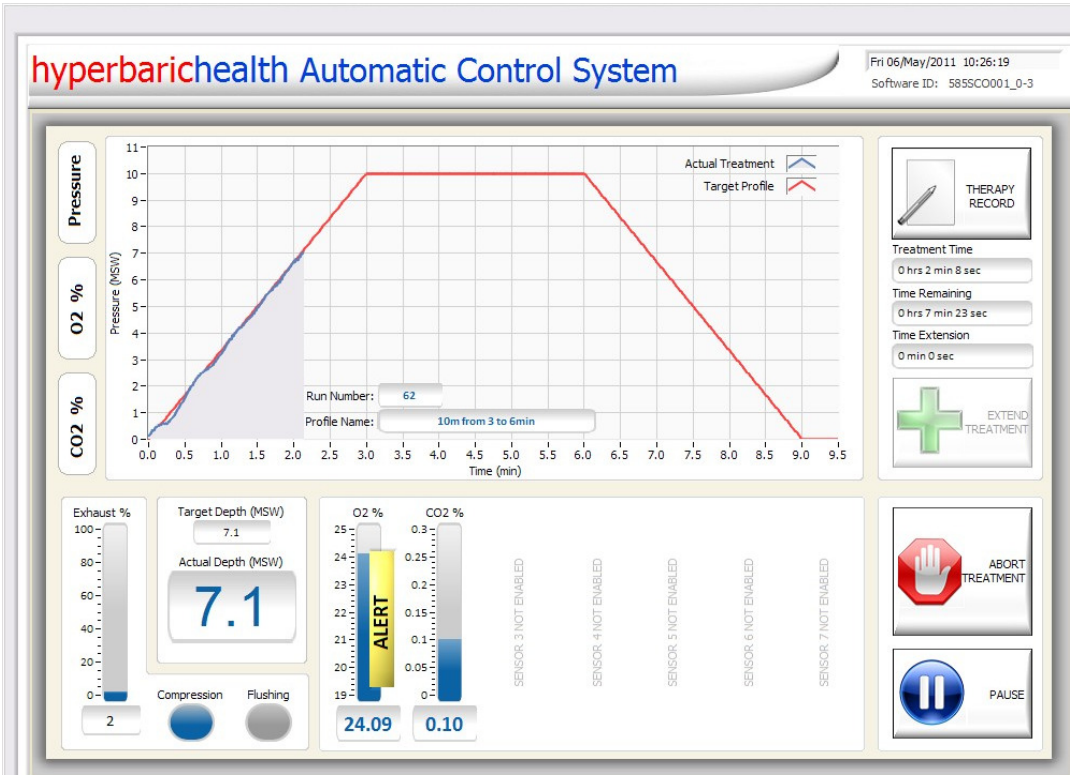

Figure 7 – Main Treatment Screen

Therapy Record Screen

The report screen is an entry screen which allows operators to make notes during the treatment process. When the "add entry" button is pressed, Time, MSW, O2, CO2 and Total Time are filled in automatically by the system and the onscreen keyboard will pop up waiting for the operator to type in their notes. Four pre-defined buttons used throughout all treatment profiles have been loaded with common generic text to reduce the time it takes for operators to enter notes. Pressing the "Return to Treatment" button on the top right hand side will return the user back to the main treatment screen.

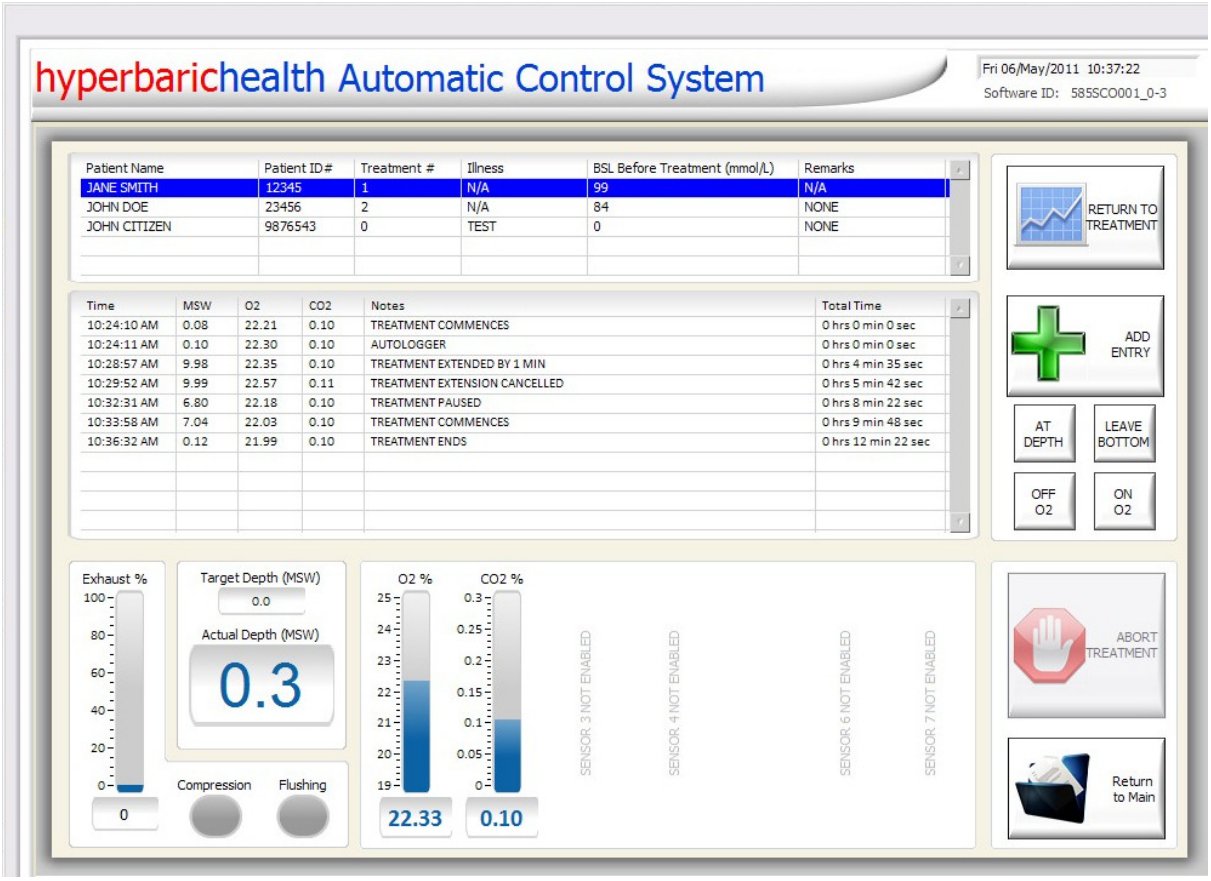

Figure 8 - Tab 2: Therapy Record Screen

Outcomes

Users of the HyperbaricHealth system will benefit from:

- An integrated control and monitoring system
- Autologging which reduces the time the operator spends noting manual measurements from CO2 and O2 sensors. This feature will automatically populate those values from the sensors removing the need to handwrite notes on paper.
- Remote monitoring capability (via Remote Desktop or equivalent)
- Operator alerts which provide a visual and audible alerts when sensors move outside of their pre-defined limits.
- Operator activity monitoring.
- The flexibility to create treatment profiles and use them with the software.
- The scalability to add and scale additional current sensors to the system.
- The ability to automatically switch over to manual controls if needed.

The first system has just been deployed to a hospital in Saudi Arabia for initial trials.