A Single Platform for Respirator Testing Standards

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NI Product(s) Used:
cDAQ-9171
cDAQ-9174
NI-9481
NI-9403
NI-9205
NI-USB/232
LabVIEW 2012

Category:
Advanced Manufacturing and Control
Advanced Research
Aerospace and Defense

The Challenge
Certify respirator masks by automating leakage tests on multiple human subjects performing physical exercises. The tests system must be adaptable to different challenge agents and their associated concentration measurement devices.

The Solution
Create a LabVIEW application with a modular architecture that can be adapted to different measurement equipment and display formats depending on the challenge agent, and generate test reports using a unified format.

Introduction
Data Science Automation (DSA) is a premier National Instruments (NI) Alliance Partner that specializes in automating and educating the world leading companies. Clients choose DSA because of DSA's deep knowledge of National Instruments products, disciplined process of developing adaptive project solutions, staff of skilled Certified LabVIEW Architects and Certified Professional Instructors, and unique focus on empowerment through education and co-development.

Respirator Testing Standards Include LabVIEW
All Self-Contained Breathing Apparatus (SCBA) – commonly referred to as respirators – manufactured in the United States must adhere to standard testing procedures set forth by the National Institute for Occupational Safety and Health (NIOSH). Respirators must be tested on human subjects wearing the masks while performing a set of physical exercises. Benign "challenge agents" are introduced into the testing area and air is sampled from inside the masks to test for leakage. The standards describe, in detail, the required test procedures, equipment calibration, and pass/fail criteria.

There are several variant standards because of revised test procedures – one example may be found at http://www.cdc.gov/niosh/npptl/stps/pdfs/TEB-CBRN-APR-STP-0352.pdf – but all refer to the "NIOSH Dynamic Fit Software" which is a LabVIEW application designed and developed by DSA for NIOSH. The original specification required the software to collect data for up to six test subjects simultaneously and measuring challenge agent concentrations using laser photometers. Updates to the software have required other measurement hardware for new challenge agents, User Interface (UI) updates, and report format changes.

Automation using LabVIEW

LabVIEW-based software was a natural fit for this application since it would need to be modular enough to be adapted to these changing requirements. In the case of the hardware, the original six laser photometers operated via serial interface, so NI-USB/232 hardware was used to add serial ports to a desktop PC. The driver that was provided with the photometers did not implement full functionality, so a LabVIEW driver was written with an API (Application Programming Interface) that could be used to automate all hardware operations. Since each serial port was a separate resource, re-entrancy was particularly useful here. The application could be scaled to any number of photometers using cloned VI's.

Figure 1 shows the screen the user sees upon startup of the application. The system first prompts for some metadata, then the user can enter information for up to six individual subjects. The system then collects and displays baseline data which is required for the later concentration calculations, as shown in Figure 2. The display allows the user to confirm that the laser hardware is functioning properly.

The software then proceeds to a set of exercises for the human subjects to perform. For each test a countdown in provided before, during, and after. The operator is able to view live data (in terms of "fit factor") and countdowns from the user interface as shown in Figure 3. "Fit factor" is one measure of the quality of a mask's fit based on the measured concentration data. At the end of the test the data are compiled and a final pass/fail rating is provided for each mask/subject, as shown in Figure 4. The data are also saved to a tab-delimited file.

Multiple Applications – One Platform

After testing the application with human subjects the customer requested several changes; some of which can be observed in Figure 5. An additional metric for mask fit called "inward leakage" was added, and a new button allowed the user to bring up a second window showing environmental conditions measured by a separate device as shown in Figure 6. This measurement required the addition of an NI 9205 in a cDAQ chassis. In this version of the software the output files were also upgraded to Excel format to facilitate the formatting of the final report.

In the most recent revision to the application, more extensive automation was needed to monitor a different challenge agent measured by sodium flame photometers (SFP's). Additional cDAQ modules were used for measurement and control. The photometers required several initialization stages with different air flow configurations (for purging, etc.) which were controlled by electronic valves using NI-9481's. On-screen prompts guided the user through the SFP setup which required some manual steps, as demonstrated in Figure 7. The concentration calculations required both digital and analog readings from the photometers, provided by an NI-9403 and NI-9205, respectively. The calculations were updated for the new hardware and the output file format was modified using the same engine as used in the previous version for formatting Excel files.

The Future of Respirator Testing Standards

This most recent version of the application has permitted more advanced testing and further updates to the NIOSH test standards. In fact, both versions of the system (using laser photometers and SFP's, and their corresponding challenge agents) are in use at various locations, and further variants can be designed in the future using the same platform. The software that was originally designed for a single type of test has been expanded for multiple types thanks to a LabVIEW application with good modular design. The cDAQ platform has also allowed for easy portability between the applications (both during development and for duplicating systems). As an example, a four-slot cDAQ-9174 chassis that was being used on a system that only utilized one of the four slots was replaced with a one-slot cDAQ-9171 chassis. This permitted the four-slot chassis to be repurposed on a system that had a higher channel count and needed a four slot chassis. This reduced the overall cost of implementing an additional system. We anticipate that this use of a single software and hardware platform will allow for the duplication and modification of the test systems used for respirator standards for many years to come.

Contact Information

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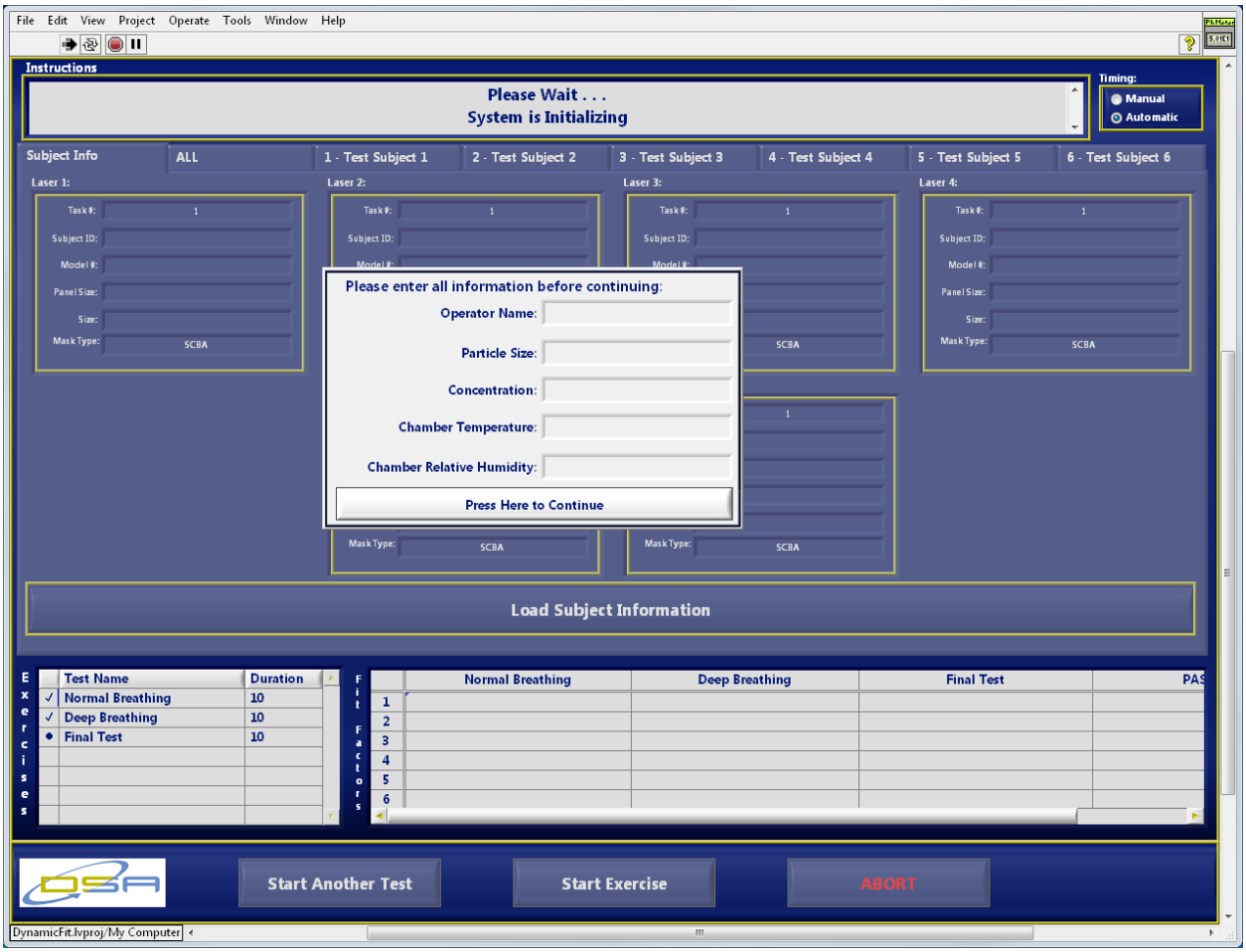

Figure 1: Startup Screen and Metadata Entry

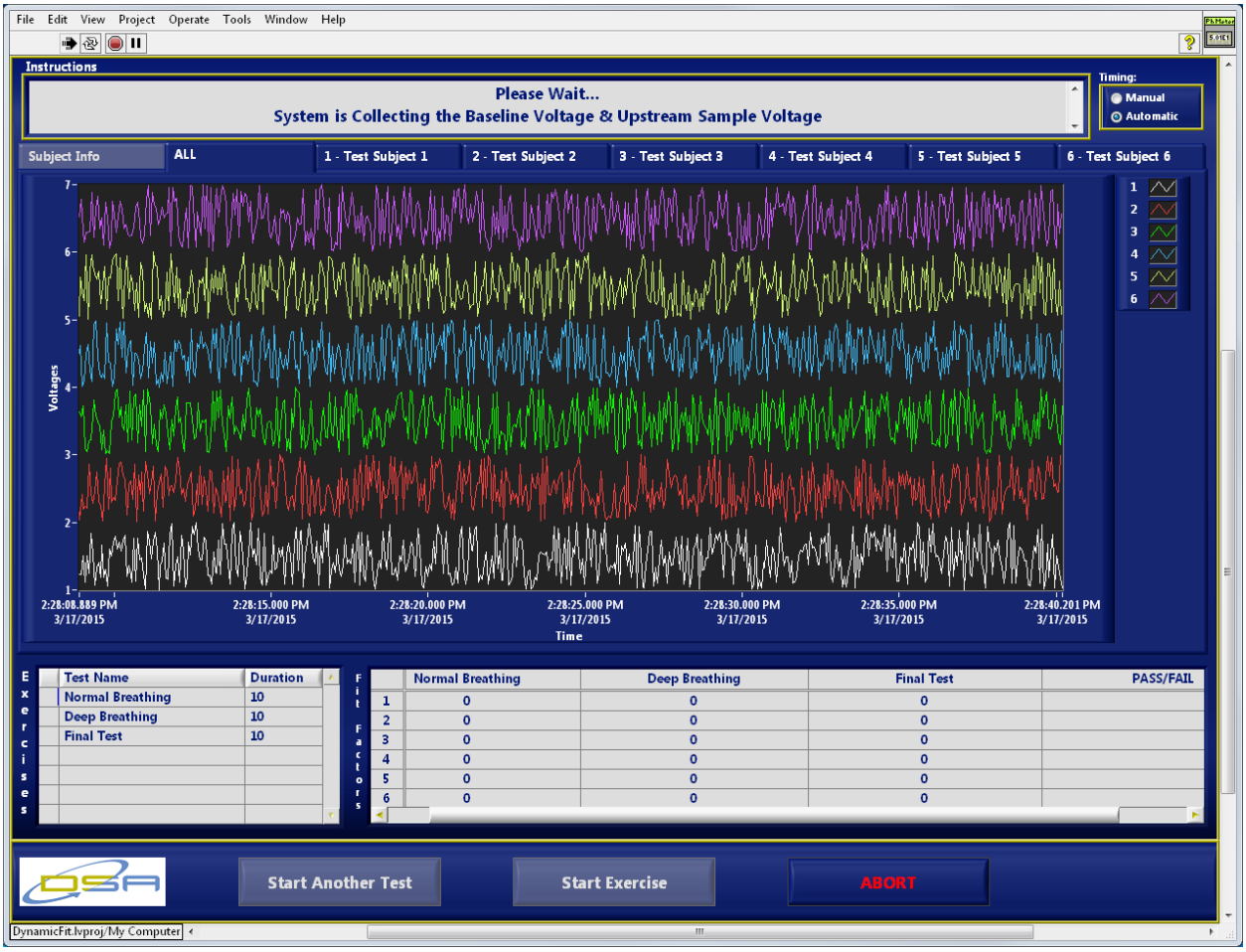

Figure 2: Baseline Data Collection

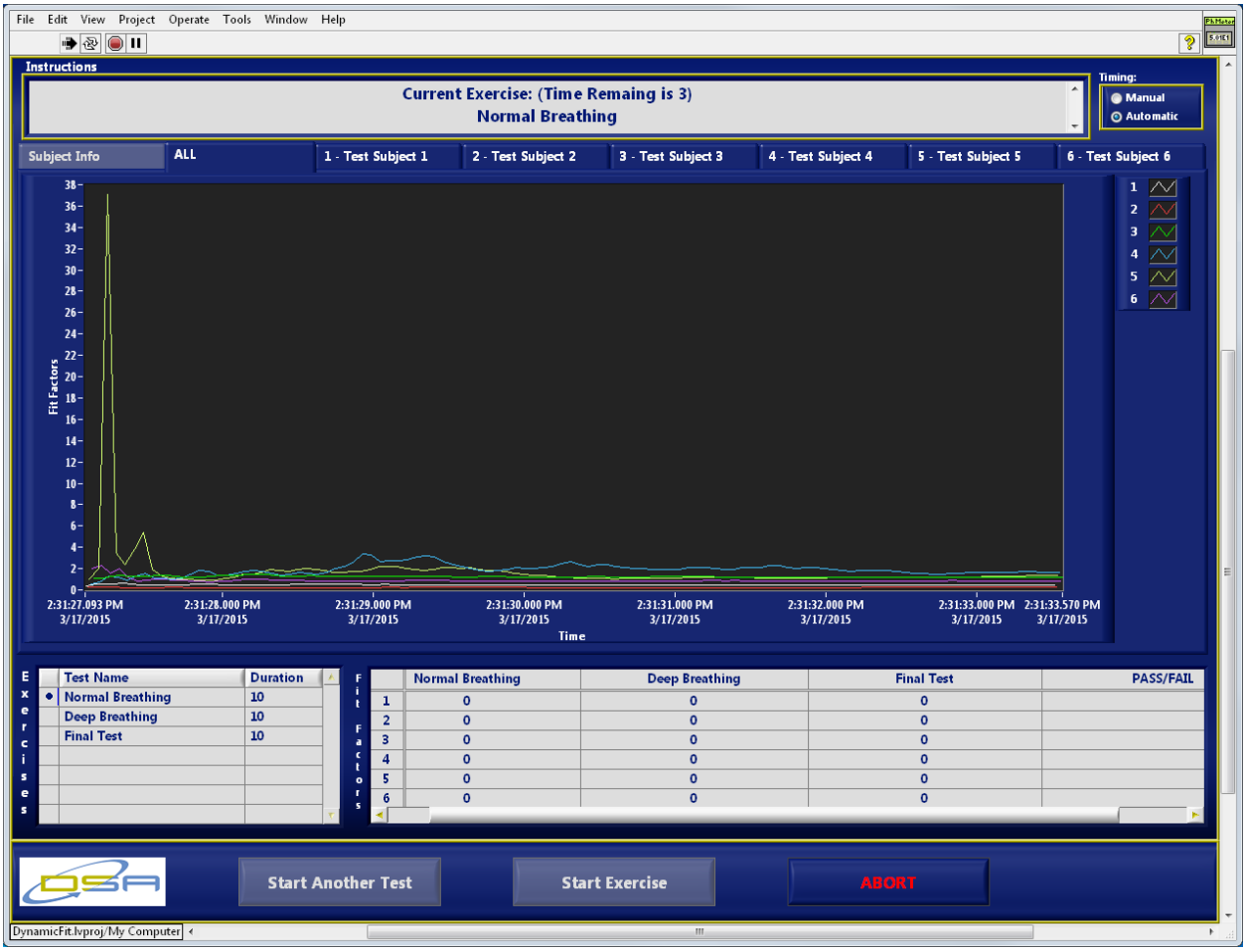

Figure 3: Main Data Collection and Countdown

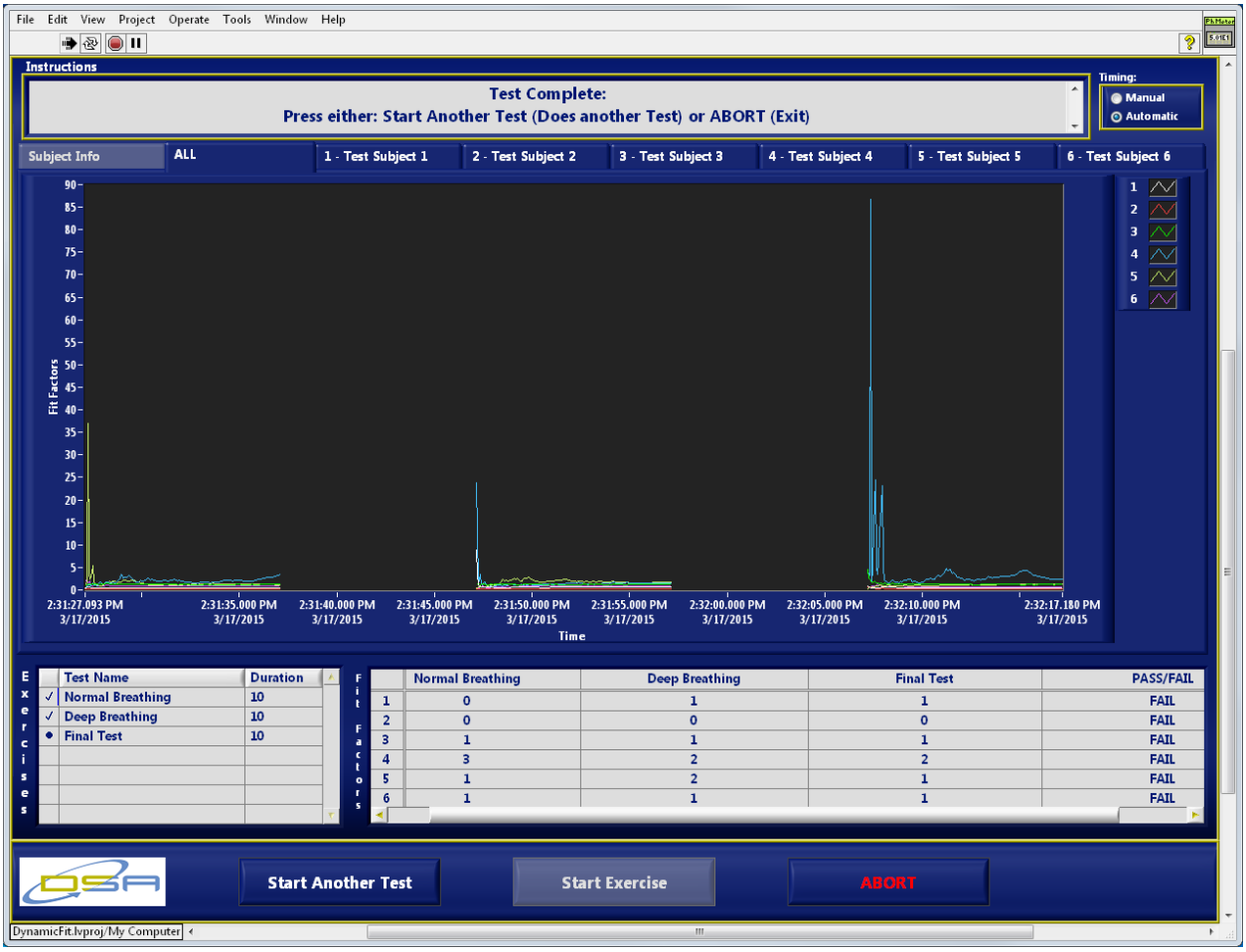

Figure 4: Completed Set of Exercises

Figure 5: Modified Application with New Function

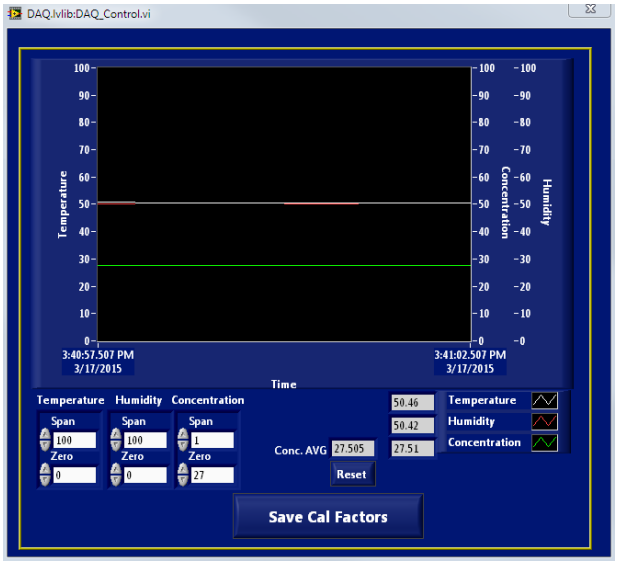

Figure 6: Environmental Indicators Window

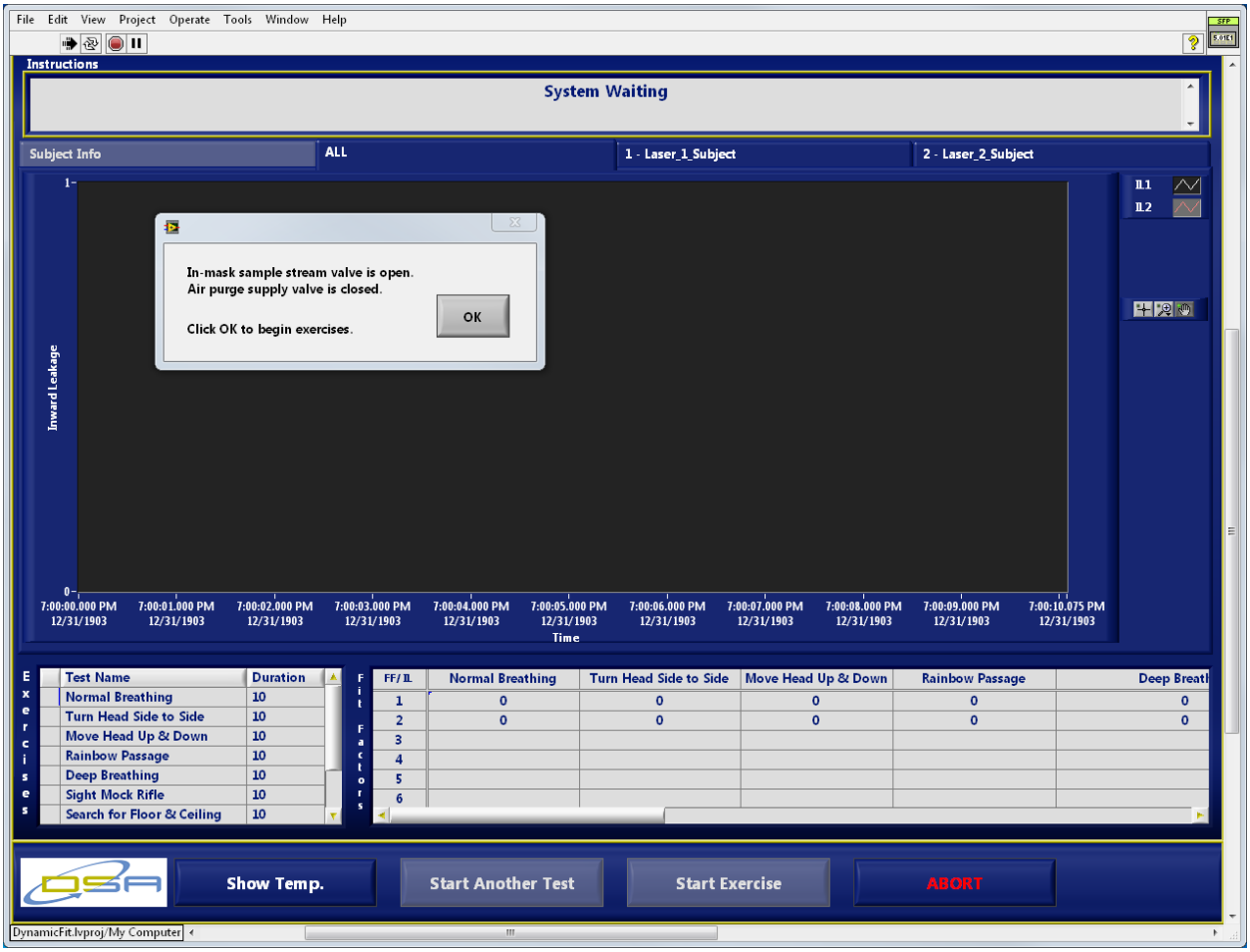

Figure 7: Most Recent Version of Application Integrating Sodium Flame Photometers