Fermi National Accelerator Laboratory

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The New Experimental Areas Oxygen Monitor

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Because of the nature of the beamline requirements for oxygen monitoring equipment to operate ancillary equipment such as exhaust fans, doors and cryogenic valves, and because of the well known problems of the oxygen sensors installed in high radiation areas, a new design for sensing the oxygen content of ambient air was needed. A new monitor system was designed to solve these problems and some others that compromised the reliability and the maintenance of the monitoring system.

From the operating experience gained with the Accelerator Standard Oxygen Monitor System currently installed in many locations in the experimental area, from suggestions solicited from the Safety Group and from the Cryogenics Group, I designed a new Experimental Areas Standard Oxygen Monitor. Many suggestions were carefully considered and a design that incorporates most of them was constructed. I will summarize a list of the important improvements that will be of interest to the users of the system, and explain how these functions will make the oxygen system easier to live with.

New Functions and Features

1: Four channels
2: Color coded alarm indication
3: Self testing with trouble indication
4: Latched alarm and trouble indicators
5: Battery condition indication
6: Keyed maintenance bypass of all alarms
7: Individual color keyed level indication for each channel
8: Individual input connectors for each channel
9: Expanded external status contacts
10: Dedicated FIRUS port with alarm and trouble status
11: Dedicated control system alarm status for each channel
12: Dedicated control system trouble status for each monitor
13: Simplified sensor installation and calibration
14: Simplified fusing
15: External access to the battery for testing

1. The new monitor has four channels instead of two. This will in many places save a lot of rack space.

2. The alarm indicators are green when normal and red when in alarm instead of a single green light that goes out when in alarm. Each channel has two individual LEDs to indicate the alarm condition. In an alarm condition, with a single glance one can pick out of a rack of monitors the channel in alarm.

3. Four new color coded trouble indicators are used to assess the internal condition of the monitor. The old system had no indicators or monitoring of these conditions. Two LEDs indicate the condition of each trouble function. A green one to indicate normal and a yellow one to indicate a fault. In addition all of these conditions are summed to a single general trouble status and this information is available to FIRUS and the beamline control system for automatic reporting to the proper people should any of these faults occur.

> 1. "AC Fail" Indicates a loss of AC power, a blown AC fuse, or an internal failure of the main power supply.
>
> 2. "DC Backup Fail" Indicates a blown DC fuse, or an internal failure of the battery charging power supply.
>
> 3. "O2 Over 23%" Indicates that any of the four channels are reading over 23% oxygen. This condition does not sound the alarms as it did before.

4. "Alarms Bypassed or Disconnected" Indicates that either of the connectors that attach the strobes and sirens to the monitor has been disconnected, or that the bypass key has been inserted and turned to the bypass position.

4. The red alarm and yellow trouble LED indicators on the front panel are latched. Should an alarm or trouble condition occur and then clear, the green normal indicators will come back on, but the alarm or trouble indicators will remain lit also. They can only be cleared by pressing the "Display Reset" switch on the front below the indicators. If the switch is pressed while still in an alarm or trouble state, the indicators will go out and then relight when the switch is released. You cannot clear an alarm or trouble that is still in progress with the reset switch. This function is useful for finding short nuisance alarms, or when an undetected power failure has occurred.

5. "Battery Ready/Charge" This indicates whether the battery is fully charged or is charging. If the "Charge" light on a particular chassis is seen to be on when there have been no recent power failures, or is on and off frequently, the monitor should be reported for a possible battery or charger failure.

6. "Maintenance Bypass" This keylock switch allows the maintenance people to service the sensor cells without disconnecting the alarm cables at the back of the chassis or jumpering out of any external devices such as FIRUS or cryogenic valves. It is never advisable to tamper with a system once it has been installed and tested. The maintenance bypass allows the system to undergo routine maintenance of the cells without having to disturb the electrical connections or causing false alarms to the occupants of a protected area. The keyswitch bypasses all of the external alarms including FIRUS, the control system status, any auxiliary equipment, and the strobes and sirens. It does not bypass the internal indicators on the front so that when the work is completed the system can be checked for alarms before removing the key. A trouble status is sent to FIRUS and the control system when this keyswitch is turned to the bypass mode to prevent the possibility of accidentally leaving a key in a monitor after the work is completed. The key cannot be removed in the bypass mode.

7. Each channel has its own oxygen level display visible at all times. There is no need to manually switch between channels to see all of the readings and to make a mental comparison of the numerical value to the trip points. The level of oxygen is indicated by a moving bar

display which changes color and position with the percent of oxygen. With a single glance at a group of monitors and noting an 'all green' condition, the safety of entering an area can be determined. Each display has ten bar segments arranged in a vertical strip. In the normal condition, one or two of the center green bars will be lit. As the oxygen level drops, the green bars go out and the bars below them begin to light and go out in sequence through yellow to red. When the bottom red bar is lit the system is close to a low oxygen level alarm. The alarm should sound just before the last bar goes out. If the oxygen reading goes up, the green bars go out, and the bars above them begin to light in sequence through yellow to red. The top red bar will remain lit no matter how high the oxygen reading goes beyond the upper level of 23%. After the top bar is lit, the "O2 Over 23%" trouble status light should come on indicating that an abnormal reading is present and should be investigated.

8. Every channel has a separate connector for each oxygen cell. The present system has two sensors paired into one connector. This makes calibration and troubleshooting of one or the other sensors difficult because both have to be disconnected to do work on either one.

9. Multiple relay contacts are available to operate fans, electrically operated doors, remote status panels, and other equipment. Two sets of normally open/common/normally closed contacts can be used for up to 3 amps at 120 volts AC.

10. A special connector with alarm and trouble status contacts is provided for FIRUS. This connector is alternatively used with the bridging chassis to tie several monitors together into a larger system. FIRUS would then get the summed alarm and trouble status from the bridging chassis.

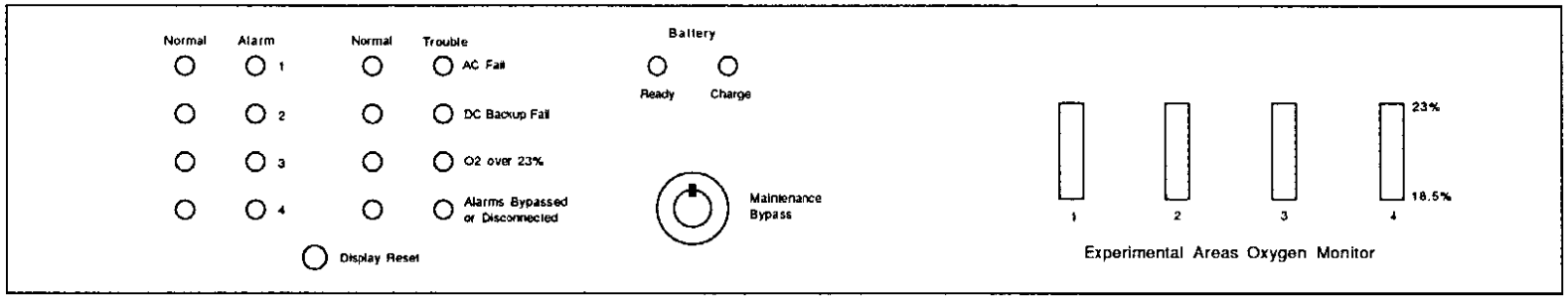
11 & 12. Separate alarm and trouble status contacts are available for supplying information to the beamline control system. Alarm status on each individual channel is provided.

13. The electronics board that was associated with the cell in the oxygen sensor has been eliminated. These units created many problems and increased the time involved to install and replace a sensor. The sensors in high radiation areas would fail sometimes as often as every three days. They required a calibration in place with a custom selection of two gain resistors, and adjustment of two potentiometers. Drift of sensor calibration was frequent and required the return visit to a sensor in some difficult and hazardous places. Cell replacement now is limited to a single trip to the cell location, disconnecting the old cell, and connecting the new one. The calibration is then done at the monitor chassis with a single potentiometer. If the cell changes its reading later, after determining that the oxygen content of the air is normal, a quick recalibration at the chassis is done with no accesses or disturbance of the physics program.

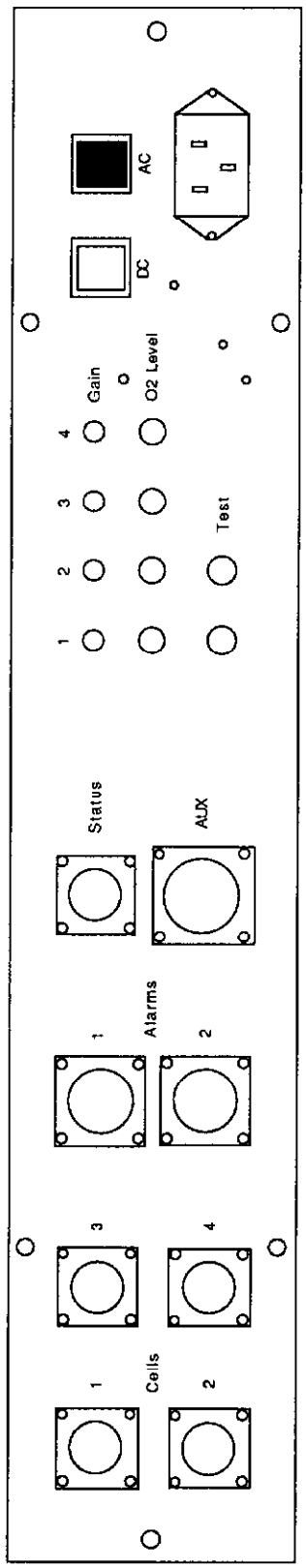
14. The major fuses for the monitor are all on the back panel instead of inside the chassis as before. There is a main AC fuse, and a fuse on the DC backup system. Both of these fuses are monitored and the failure of either is indicated by trouble indicators on the front. There are two secondary AC fuses inside, one for each of the main and backup power supplies. If a problem develops with an individual supply, its own fuse will blow leaving the AC current intact for the other power supply to keep the system in operation without draining the battery. The two internal fuses are located one each inside of the two modular power supplies. Both of these fuses are monitored and indicated for trouble. The alarm drivers for the strobe and siren are electronically protected by current limiting and do not require fuses. The present system has a fuse only for the siren, and it is not replaceable without a major disassembly of the monitor chassis.

15. A pair of jacks on the back panel allow connection of a test instrument directly to the battery to periodically verify its condition and capacity.

Field tests of this new monitor have shown that it is very reliable even when the sensors must be placed in areas where high levels of radiation are frequent. No false alarms have been experienced to date. The flexibility of installation and ease of routine service have greatly decreased the amount of time spent in maintaining the operation of the system. The expanded display of status and levels have made the functional use of the system much easier for the occupants of the areas of coverage.



Experimental Areas Oxygen Monitor Front Panel



Experimental Areas Oxygen Monitor Back Panel