Air Pollution Monitor for TRISTAN

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Introduction

In the summer of 1988, sixteen superconducting RF cavities were installed to increase the beam energy of TRISTAN and they began to be effective operation in November [1]. One of the obvious problems created by the installation of superconducting equipment to the tunnel is oxygen-poor in case of bursting the liquefied gases.

Air pollution in the tunnel from poisonous gases formed by synchrotron radiations is also becoming serious problem as upgrading TRISTAN. It is the purpose of this paper to show the special safety control problems and the system used in TRISTAN to give a solution for these problems.

An air pollution monitoring system to detect a shortage of oxygen and contamination of the air in the tunnel is newly introduced into the previous distributed safety and interlock system (DSIS) [2]. The system includes detectors for oxygen-poor, for ozone and nitrogen-dioxide and for a small amount of smoke. It keeps watch on the environmental pollution in the tunnel and supervises the information which is necessary for safety operation for TRISTAN. DSIS and the new system are functionally subdivided, but the latter is hierarchically connected to the former to provide interlock signals for other accelerator devices.

Oxygen deficiency

Oxygen deficiency at the Nikko area (one of the colliding points where superconducting cavities were installed) is related to the burst of the cryostats. Each cryostat for the cavities contains 1,100 liters of liquid helium and 100 liters of liquid nitrogen. The volume of air in the related region is 3600 m^3. Therefore, if the liquefied gases burst into the tunnel in an instant, the oxygen content in the tunnel falls into eighteen percent after one hundred seconds for the worst. This percentage is the Japanese guideline of environmental hygiene for working conditions.

Table 1. Influence of oxygen shortage

oxygen content by volume	symptoms
18%	the Japanese guideline of environmental hygiene
16%	insensible
12%	disordering in breathing disordering in the heartbeat
10%	difficulty in breathing nausea
7%	death of half the person before 6 minutes and all until 8 minutes
4	instant death

Table 1 gives the influences of oxygen shortages for the human health. The lower level of oxygen content that has no effect on human health is 16 percent from table 1. It takes three minutes to fall into 16% after the burst of liquefied gases. That is to say, the worker in the area must evacuate within three minutes.

It is also required accuracy of ±3% for the oxygen detectors to be stable for at least six months without calibration, since the TRISTAN runs more than four months after it once gets to be operated.

Air pollution by synchrotron radiation

The ozone and nitrogen-dioxide are created by synchrotron radiations. The content of these poisonous gases in the tunnel gains in quantity as raising energy and intensity of the beam.

Ozone has an influence on the human respiratory organ; a person falls into difficult breathing from the ozone of 0.5~1.0 ppm and the capacity of human lungs is failing. It is reported that the nitrogen-dioxide of 5~8 ppm gives the same effect as ozone of 0.5~1.0 ppm. To get useful information for above influence, the detection of ozone and nitrogen-dioxide must be sensitive and stable, having enough rejection against the noise.

Implementation

Considering above requirements, the main objectives of the present system for the air pollution monitor are summarized in the following points:

(a) quick response of the system;
(b) high sensitivity of the pollution detection;
(c) reliability and stability of the system;
(d) assurance for the safety of the personnel;
(e) flexibility for future extension corresponding to upgrading TRISTAN;
(f) centralized monitoring of all information;
(g) real-time graphic presentation of environmental status;
(h) visible and audible alarm.

Detectors: In consideration of these criterion of (a), (b) and (c), we adopt the detector of oxygen deficiency with galvanic cell method with a compensation of the temperature. Galvanic cell is composed of electrochemical active parts and thin oxygen penetrative film. The output signal of galvanic cell is proportional to the concentration of oxygen. The long term stability of the detector is within 5% for 800 days. The detector also shows good linearity as shown in Fig. 1. We installed fourteen oxygen detectors on the wall at regular intervals of ten meters in Nikko area.

The ozone and nitrogen-dioxide detectors are introduced for monitoring the environmental pollution in the tunnel. The detectors give an important information to the personnel entering into the tunnel. The detectors used for these gases are also Galvanic cells like the oxygen detectors.

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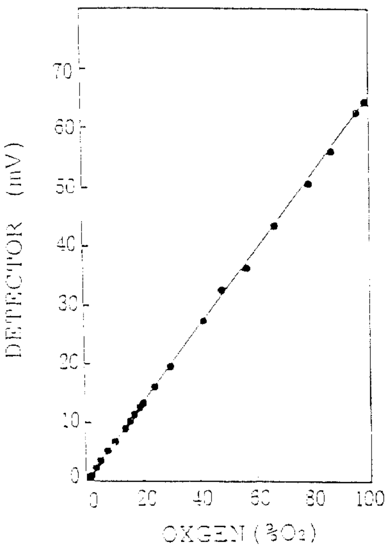

Fig. 1 Linearity of an oxygen detector

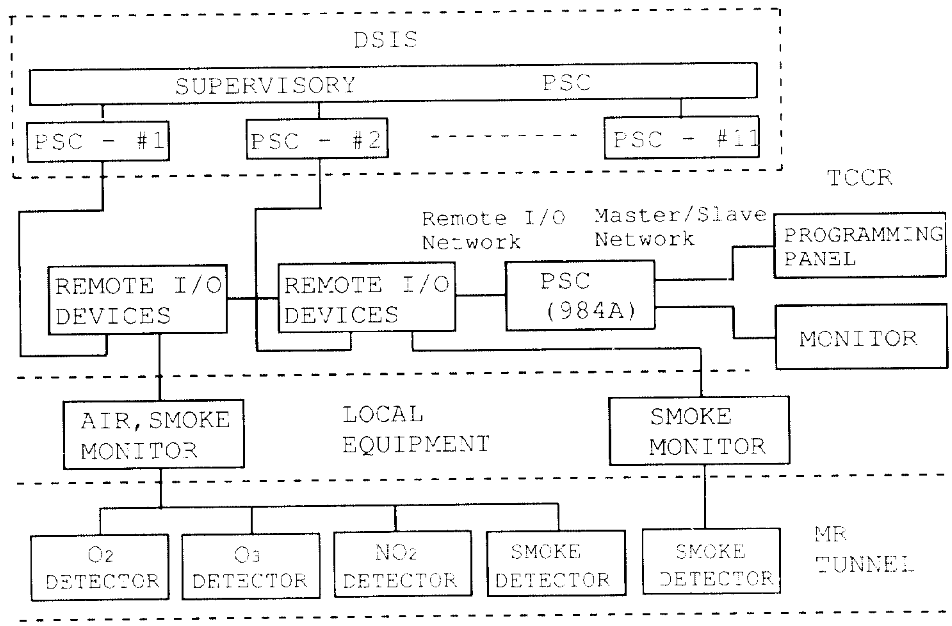

Fig. 2 A schematic description of the system

Network: Fig. 2 shows schematic description for the system. The programmable sequence controller (PSC) has been used, like DSIS, because PSC permits a high system flexibility and has proved its reliability in many industrial installations. All PSCs for DSIS are based on the Yasukawa's Memocon-SC, but the present system consists of 984A-PSC by Gould. Gould's 984A is faster than Yasukawa's PSC in scan time and provides high-speed remote I/O network. 984A is available for graphic tool using IBM PC and compatibles.

Signals from each air pollution detector around the tunnel are gathered to the local equipment. The local equipment transforms all signals into 4~20mA current loop and transfers to the input ports of the remote I/Os. The remote I/Os send signals in response to 984A's commands. 984A summarizes all signals and sends important interlock functions to the DSIS.

Communication network of 984A includes a remote I/O network and master/slave network with two ports. 984A controls two remote I/Os through high-speed remote I/O network which operates at 1.5 Mbits/sec. Master/slave network connects 984A and two remote intelligent terminals (J-3100-SGTs by Toshiba) for programming and data acquisition. These terminals in the central control room enable us to control the system and to display graphically the environmental data of the tunnel, using 19200 baud communication ports. The functions of the system are principally divided into two kinds, which are for the interlock and for the monitoring.

Interlock: Once the oxygen content detected by any of fourteen oxygen detectors becomes lower than the environmental standard, 984A sends the interlock signals to DSIS. Then DSIS prohibits personnel from entering into the tunnel by controlling the entrance and announces the state of emergency for oxygen automatically. The time-delay of the deficiency alarm was measured within 15 sec.

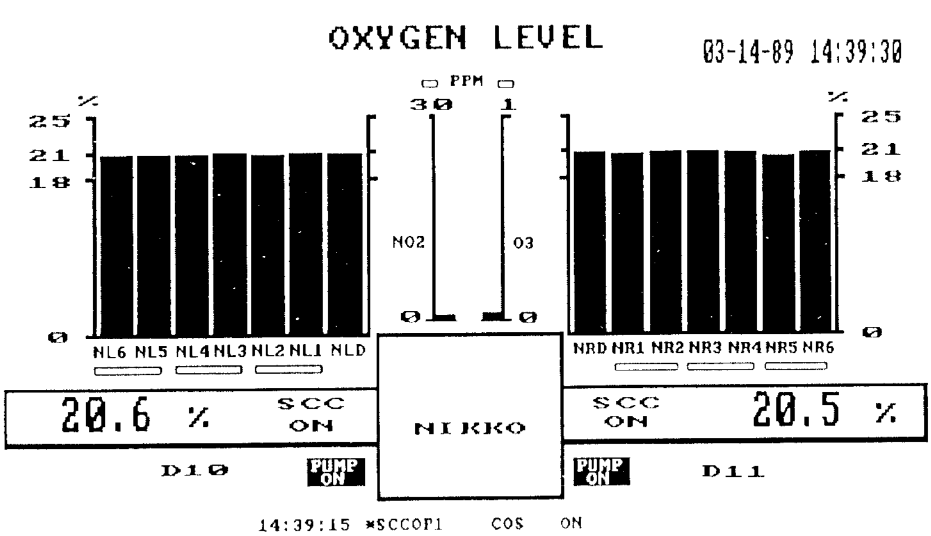

Fig. 3 Real-time graphic presentation of environmental status

Monitoring: The present system monitors not only oxygen but also ozone and nitrogen dioxide. The real-time graphical information is serviceable through the broadband CATV network [3].

Fig. 3 shows an example of the real-time graphic presentation of environmental status. NO_2 and O_3 content are indicated in the center of the figure and oxygen levels from fourteen detectors are shown by bars, on both sides.

J-3100-SGTs store all data of above information in order to refer as a trend at any time. Fig. 4 shows the trend of the oxygen content of one of the detectors. This graph shows some fluctuations in the range of 2.3%. The sources of fluctuations are considered as following:

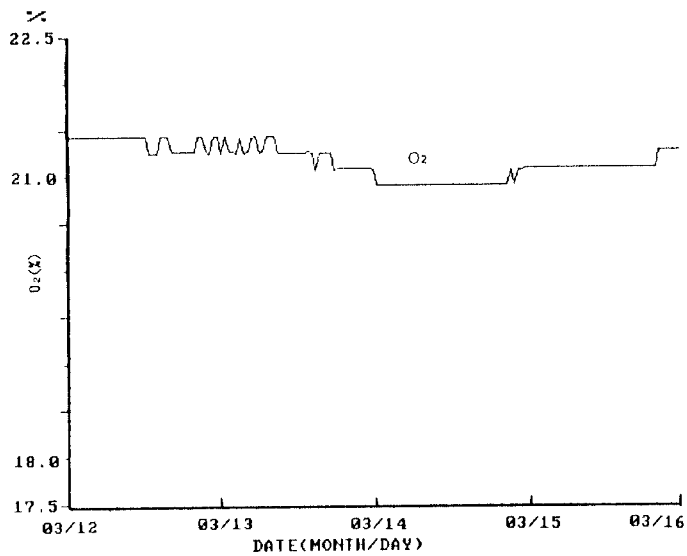

Fig. 4 A trend of the oxygen content

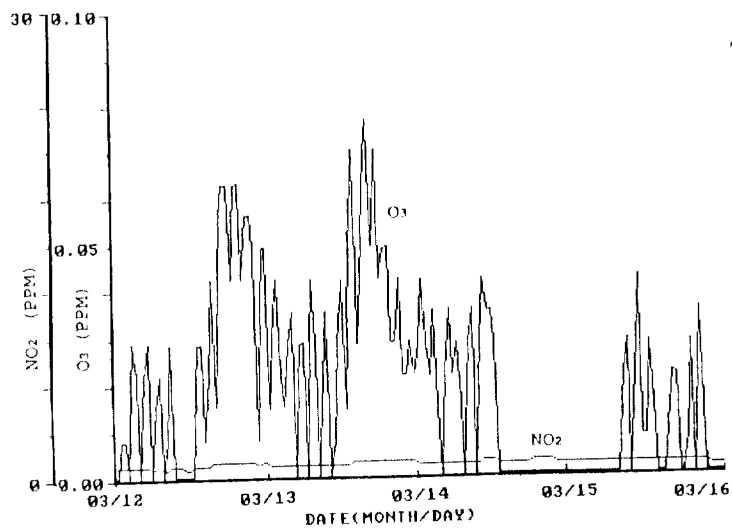

Fig. 5 A trend for O_3 and NO_2

(a) humidity in the tunnel;
(b) temperature of surroundings;
(c) pressure of the atmosphere.

The humidity in the tunnel is controlled in the range of 30~45%. The alteration of the detector sensitivity by this humidity is within 1%. Temperature of surroundings is controlled 20~24°C. This temperature fluctuation is almost negligible. The deviation of atmospheric pressure is within 2%. The effect by this deviation is estimated 2%. The most probable candidate for the fluctuation in Fig. 4 is the deviation of atmospheric pressure.

Fig. 5 shows the trend for O_3 and NO_2. NO_2 measures about 1 ppm, but the content of O_3 is changing from 0ppm to 0.08ppm according to the beam intensity.

Conclusion

The system of air pollution monitor for TRISTAN has installed to meet the requirements according to the TRISTAN upgrade. As a result of six months usage from last October, the system is confirmed stable work.

Acknowledgements

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References

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[3] S. Takeda et al., "Man-machine Interface of TRISTAN," IEEE Trans. Nucl. Sci. NS-32 (1985) 2062