Monitoring System for Industrial Gases Pollutants

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ABSTRACT

The system is designed for monitoring gas pollutants in air, in a chemical plant. It consists of gas detectors with transmitter and modules for environmental conditions measurement, data loggers and a central monitoring station which role is to collect data, generate alarms if pollutants concentration becomes over limit and create database.

A dedicated software permits data collecting and processing in order to get solutions for minimising human and technological risks.

The system role is monitoring the pollution sources and the surrounded areas that might be affected, for keeping gas pollutants concentration at an acceptable level and to minimise the pollution effects.

1 INTRODUCTION

The chemical plant being monitored is one of the greatest of our country, manufacturing both inorganic and organic products and represents a major source of air pollutants. The plant is located near-by a town with more of 100 000 inhabitants and is surrounded by populated areas.

The air quality surveillance system in function before was using manual gas sampling tubes with bellows, made by Draeger. This system had the major disadvantage of not supplying real-time data. Increased concern in air quality required by the forthcoming EU integration has determined the initiative of designing and implementing an integrated system of air gas pollutants monitoring.

The work deals with gas pollutants. The pollutants of major interest are: chlorine, chlorine hydride, sulphurous dioxide and ammonia.

Table 1 Alert and action concentration for the monitored gas pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Alert concentration</th>
<th>Action concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ppm] [mg/m³]</td>
<td>[ppm] [mg/m³]</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.02 0.07</td>
<td>0.03 0.10</td>
</tr>
<tr>
<td>Chlorine hydride</td>
<td>0.14 0.21</td>
<td>0.20 0.30</td>
</tr>
<tr>
<td>Sulphurous dioxide</td>
<td>0.09 0.25</td>
<td>0.12 0.35</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.30 0.21</td>
<td>0.42 0.30</td>
</tr>
</tbody>
</table>

By order of the Romanian Ministry of Environment the “action level” is defined as the level of concentration of certain pollutant equal to the maximum admissible level stipulated
by standards, and the “alert level” represents 70% of “action level”. This levels are important because they are the settling alarm levels: 1-st level: the local alarm and 2-nd level: the chemical alarm.

Concentrations values for the two levels of these gas pollutants are presented in table 1. Air monitoring stations are placed near the sources, in order to determine the maximum contaminant concentration, and on the plant perimeter in order to determine the surrounded populated area exposure [1].

2 MONITORING SYSTEM OVERVIEW

The monitoring system is organised on three hierarchical stages, as presented in figure 1.

![Figure 1 Hardware structure of monitoring system](image)

The first level includes local transducers, which are 4-20 mA 2-wire transmitters: gas detectors with plug-in electrochemical sensor, thermometers, pressure and wind speed transducers. The gas detectors use the highly successful capillary diffusion technology, resulting in a low temperature coefficient and a direct response to concentration, relatively unaffected by pressure [2].

The sensors were calibrated every two month, because of their drift, which may reach 2% of FSD (Full Scale Domain) per month.
The second stage includes data loggers, designed and realised in order to accomplish the following tasks:

- analogue measurements from transducers;
- data transmitting;
- commands transmitting and receiving;
- local displaying of measured parameters;
- measuring range and alarm setting;
- events counting.

Each of this modulus is composed of a CPU, a radio modem, a radio emission-reception station and a power supply.

CPU, structured on a Philips Semiconductors 80C552 microcontroller, realises the following functions:

- analogue measurements from transducers, which involves: measuring transducer selection, conversion of input analogous signal into binary and binary to ASCII, calculus of measured parameter value;
- local displaying of measured parameter;
- communication with radio modem on RS 232 serial port.

Each data logger can receive up to 8 input analogous signals (can be connected up to 8 transducers). The schematic of CPU is presented in figure 2.

*Figure 2. Schematic of CPU with 80C552 microcontroller*

The 80C552 microcontroller is a single-chip 8-bit microcontroller with 10 bit A/D converter, also functioning as arithmetic processor [3]. The buffer 74HCT573 realises the separation of address words from data words. EEPROM 27C256 is the program memory. The driver MAX 232 realises data transfer from microcontroller via serial interface RS 232, to the PC.
The third stage, the dispatcher, consists in an emission-reception radio station, a radio modem, a PC and a power supply and realises the following tasks:
- dialogue with local equipments of data acquisition;
- dialogue with human operator;
- data base creating;
- data base consulting;
- reports editing.

The software architecture follows the hardware structure of the monitoring system: there is a local soft package for the data loggers, a central soft package for the dispatcher and the communication software, which administrates communications between the mentioned levels in order to provide data security and check for errors.

The local software package consists in:
(i) application software, which realises analogue and digital data readings, outputs enable, data-base up-to-date, local displaying of measured parameters on a LCD display. Data are not processed on this level, they are only acquisitioned in files that contain informations about the measuring point, the day and the moment of measurement, the detector and the gas pollutant, the measured value. The application software (i) is written in ASM 51 assembler.

(ii) communication software, which has tasks defined for messages emission and reception, error checking, received messages enable, is also written in ASM 51.

The central software package consists also in:
(iii) application software, which manages the order and periodicity of measurements in automatic or manual way, compares the measured concentration value with the preset values, signalling the reaching of the “alert concentration” and getting chemical alarm when the “action concentration” is reached, realises the “autotest” and “autocal” functions every day - automatic, or at operator request, commands the supply switching into back-up battery at line falling, processes data acquisitioned from the files generated by the acquisition driver, displays requested data on the PC display. The application software (iii) involves the application of GIS (Geographical Information System) as a tool for data collection and analysis [4] getting a supporting spatial data set for evaluating the air quality and the populated areas exposure.

(iv) communication software, which administrates the communication with data loggers and with the application software (iii), is written in C++.

3 CONCLUSIONS

The system using digital data acquisition supervised by PC has the advantage of decreasing human errors and improving measurement accuracy and also to supply real-time data, which is a major help in chemical alarm situations.

The system is hierarchically structured and open, permitting further development by new subsystems integration.

By using such a monitoring system an objective air quality control and risk management becomes possible.

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REFERENCES


