Information and Control System of ČSM Coal Mine Preparation Plant

Roman Danel
ATP Soukup s.r.o., Ostrava, Czech Republic

Jiří Skotnica
ATP Soukup s.r.o., Ostrava, Czech Republic

ABSTRACT: This paper presents a view on the latest way of the coal product preparation control where the preparation plant is treated as a link in the chain of planning, production and sales procedures from setting up, exploitation and coal preparation to the sales of mining production. The coal preparation plant control system described here compasses only a part of the aforementioned chain but the criterion of the system integration in the corporate management was observed as one of the primary criteria. The control system of ČSM Coal Mine preparation plant and sales was designed in 1992 to 1996 by ATP Soukup s.r.o., the leading supplier of coal preparation plant control systems in Ostrava region. The most notable systems are installed at ČSA Coal Mine's Doubrava preparation plant, Lazy Coal Mine's Dukla preparation plant and ČSM Coal Mine's ČSM preparation plant. ATP Soukup s.r.o. offers also improvement and automation of technological sets and deals in development and manufacture of process variable sensors for the coal preparation plants.

1. CONCEPT AND OBJECT OF THE CONTROL SYSTEM

The preparation plant and sales control system at ČSM Coal Mine is not the first installation of our company in Ostrava-Karviná Area (hereinafter "OKR"). The crucial point of all installations was to cope with the control of basic technologies, such as heavy-liquid separation, jigging, separation by flotation as well as dewatering, storage, etc.

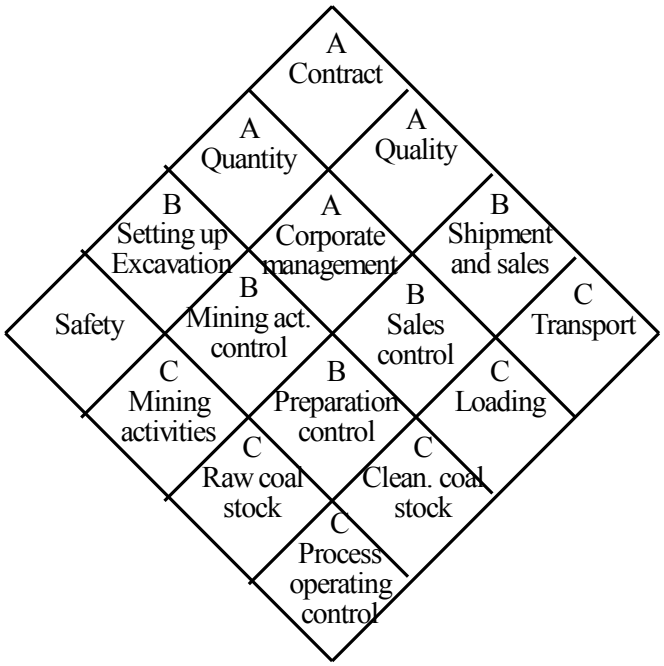

Fig. 1 - Production and quality control system

The control techniques for the above technologies have been described both in our company literature and in other professional publications and it is not possible to refer back to them within the scope of this paper. However, these works formed a basis for the design of the system design described here.

Figure 1 shows a simplified form of the mining company control system as a set of interconnected and interacting blocks.

The main block is the "Preparation Plant Operating Control" (*Fig.2*). This block can be displayed using a division according to the main controlled processes.

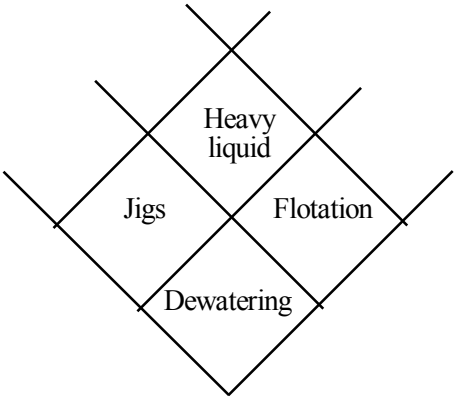

Fig. 2 - Operating control of the preparation plant

The resolution of the local process control systems allowed to implement the complex control of the preparation plant., i.e. including monitoring the performance and yield of different technologies, main quality parameters, output per hour, shift and day for the entire preparation plant, that is the main economic data (*Figure 3*).

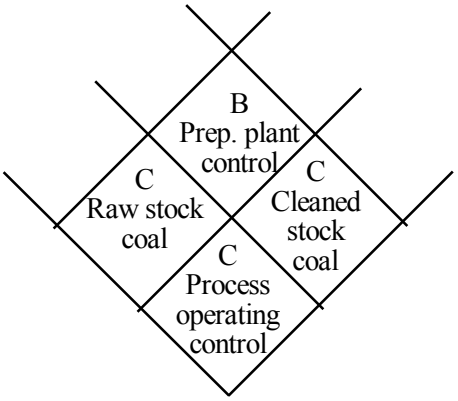

Fig. 3 - Complex control of the preparation plant

After the preparation plant control system implementation it could be proceeded with the sales control. The cleaned product storage process is linked directly with the loading and transport process and in interaction with the shipment system the Sales Department was formed (*Figure 4*).

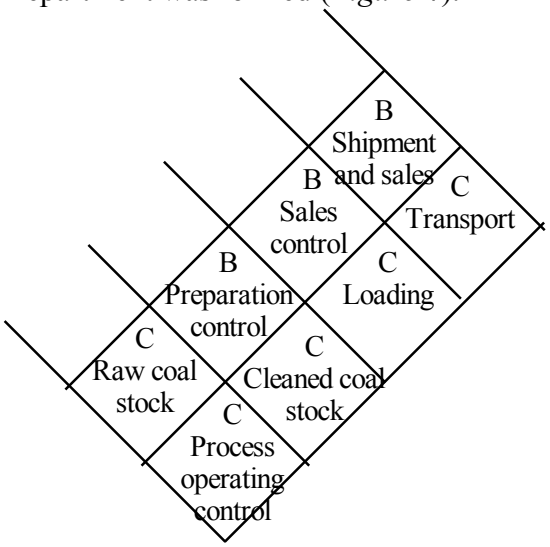

Fig. 4 - Sales control

This control system allowed to add the control at corporate level to the existing systems. The sales control is followed directly by the quality control which passes backwards the material flow through the complete preparation process. Both the quality and quantity of sold products must comply with the parameters agreed in the particular contracts. To be able to fulfil this requirement the quality control should be pursued during the complete production process. This requirement is observed in the coal preparation process and actually the sections "Mining Activity Control", "Setting up, Excavation" and "Mining Activities" are missing to finalize the control diagram (*Figure 1*). The new corporate Quality Control Department will be (possibly) supplemented by these sections by which the mining control system will be finished and the control procedures will not be started as late as by the information on the raw coal stock as it is done actually. The mining activity control is, of course, connected with the safety control. It is a system the operation of which is directed by a set of explicitly stipulated regulations. It seems as if it was outside the quality control system, nevertheless it is indispensable for its operation.

2. LEVELS OF THE CONTROL SYSTEM

Now we shall turn to Figure 1 where we shall work in the information flow and production flow. We shall obtain a logical division of production and quality control into the control levels (*Figure 5*).

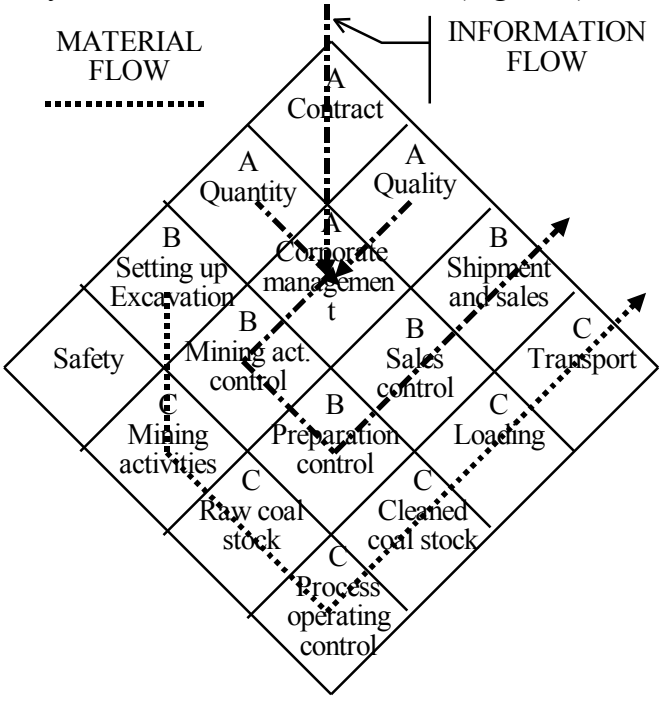

Fig. 5 - Material and information flow

In accordance with this concept we applied the following control level differentiation:

- process level marked by letter "C" in Figure 5
- Dispatching level marked by letter "B" in Figure 5
- management level marked by letter "A" in Figure 5

In naming we follow the share of people in the control process. The differentiation into the control levels has no direct relation to the system architecture regarding the hardware configuration or system software solution structure (Figure 6).

2.1 Process level

The process level is directly connected with the process. The people share is limited to supervision and control parameter setting. In particular it concerns the direct control of technological sets in the distributed control units, automatic data input, etc.

2.2 Dispatching level

The dispatching control is ensured through the control rooms, dispatching rooms, loading control workplaces, foremen workplaces, etc. where the following user information on the controlled process is available:

- operating information from the process level on the actual process status
- information from the dispatching level processed in a wider scope and including evaluating and checking data relating to the course of a shift and day

The significant feature of the information is it is calculated and verified mostly in order to obtain a complex view on the controlled process as a whole.

2.3 Management level

Very often the management level is automatically assigned to the corporate top management level. In our concept its function is extended to the lower control structures; in this specific application to the preparation plant and sales department managers. These people can utilize a number of tasks providing them an overview of the production and sales in various modes in a long time period. In addition they can use various tools allowing them to prepare reports, analyses and other documents necessary for the production control and monitoring.

3. STRUCTURE OF THE CONTROL SYSTEM

The preparation plant and sales control system without considering the hardware used is shown on *Figure 6*. The hardware used for the development of both systems is described below.

Both the preparation plant control system and the sales control system have no strictly defined borders

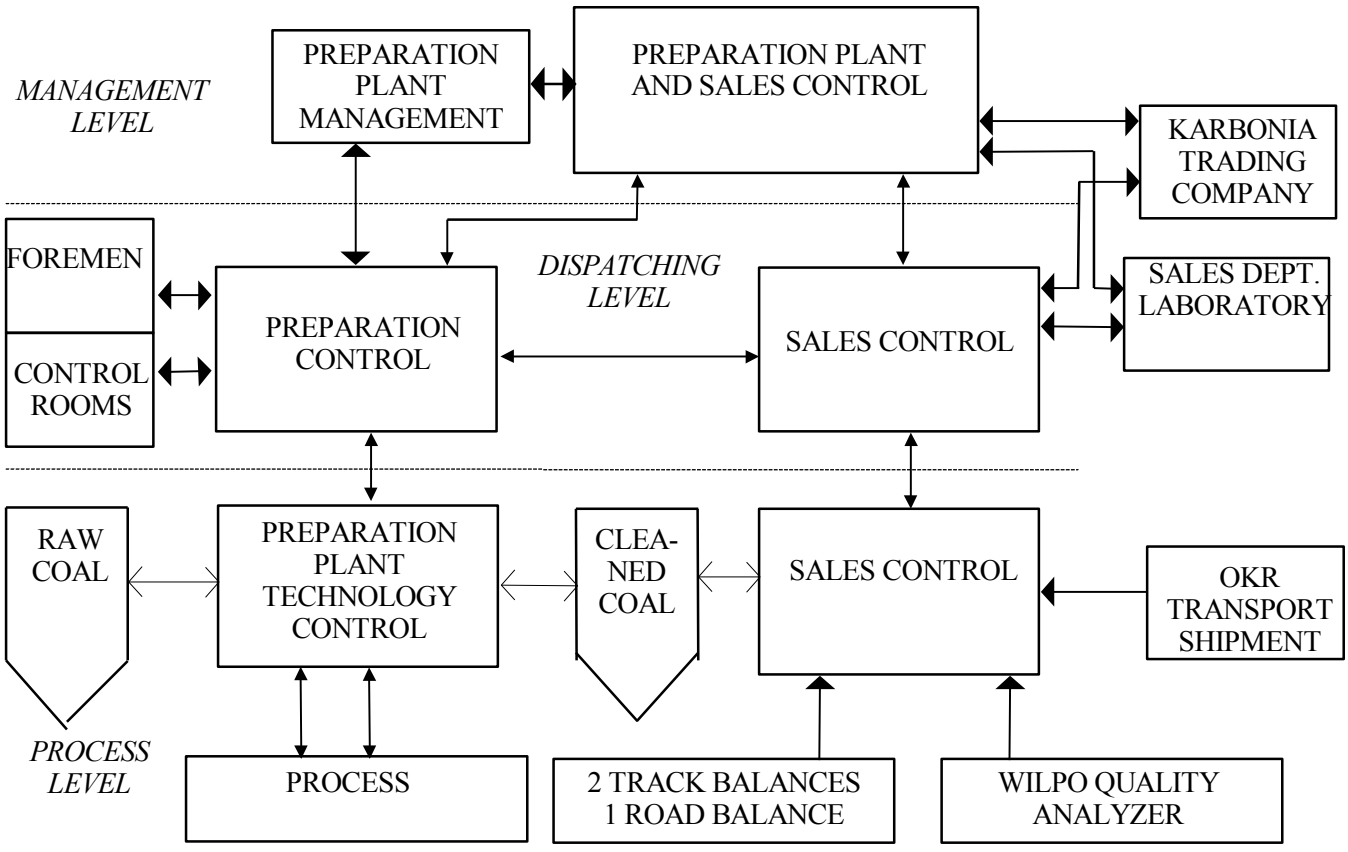

Fig. 6 - Structure of the control system

and are interpenetrating. For example a part of the sales control system input information is processed and in an limited extent presented on the preparation plant control system hardware and vice versa. Both systems are divided into two control levels and their data are connected at the dispatching level.

At the process control level the systems are connected to the process. The preparation plant control system is connected to the preparation plant sensor base and direct control of the technological sets. At this level the sales control system receives automatically processed data on the railway wagon and lorry weighing by the track and road weighers and on the product quality from the WILPO cleaned product quality analyzer. In addition to this information also data on the wagons drawn to the mine siding are received from the local shipping system of OKR - Transport.

In both systems the dispatching control level is the information source for the users responsible for the production configuration in a day's framework. The information selected from this level is used also at the management level. In the preparation plant this information is used by the control room dispatchers and foremen, in the sales control system it is used by the laboratory personnel which provides the results of shipped product analyses and Karbonia s.r.o. trading company which prepares the documents necessary for the official clearing of loaded products.

At the management level the control is made by persons with a complex responsibility for the sales. Here the boundaries of both systems are removed and it is possible to say a common layer of the preparation plant control system and sales control system is formed. The main responsibility for the sales results is born by the preparation plant personnel. However, this is not a rule; in other similar applications the management responsibility lies with the Inspection and Quality Control Department. Obviously also other functions (Sales Dept.) and Karbonia operate at this level with data from the contracts and sales applications.

4. HOW IS THE SYSTEM BUILT UP

The preparation plant and sales control system was built up stage by stage. The initial preparations of the preparation plant control system were commenced in 1991 while a substantial part was implemented in 1993 to 1994. The sales control system was implemented in 1996. Accordingly the used hardware must be viewed on.

4.1 Preparation plant control system

The implementation of this system made for a large project. The result is a complex process control up to the dispatching level. The project included the following main areas:

- improvement and completion of the sensor base
- automatic control of the main technological sets
- automatic control and information system

4.1.1 System sensor base

The system contains about 1200 analogue, binary and counter sensors. A part of the sensors specific for the preparation plant has been developed by our company. The typical analogue sensors are as follows:

- sludge and magnetic suspension specific weight sensors
- continuous ash meters on conveyors
- ash meters for flotation waste rock
- conveyor weigher with analogue output of load
- turbidity meters
- meters of magnetic portion in the suspension
- machine load measurement
- level meters

The binary sensors forming the largest part of the sensors connected to the system are as follows:

- level limit indicators
- machine contactor contacts
- terminal switches

There are two kinds of the counter sensors:

- conveyor weigher outputs for the passed-through quantity measurement
- continuous level indicators for the measurement of granular substance in the bunkers.

In addition to the above mentioned sensors the system includes a number of virtual sensors called "pseudo-sensors" – a combination of real sensors and derived variables calculated in the system.

4.1.2 Automatic control of the main technological sets

Within the control system project the automation of the main technological sets was introduced at ÈSM Coal Mine preparation plant. All applied procedures, equipment and sensors are made by our company.

- Automation of flotation

The flotation process control is performed by flotation agent dosing according to the flotation waste rock ash content with a correction according to the input raw material density and flow value. As a stabilizing element for the main regulation circuit the flotation machine level is regulated by

controlling the flotation waste material outlet value.

– Jigging control

In the jigs the separation is done in the lifting stage with multiple pulsation. To this end we made a complete pulsation control re-design including the slide valve control replacement by disk valve control. The automatic regulation ensures bed height, lift height, air pressure and water feed control with an option to set single, double or triple pulsation.

– Heavy liquid control

The specific weight control in heavy-liquid separators is made by dilution or addition of heavy-liquid suspension. Both the cleaned coal (1. separating cut) and middlings (2. separating cut) are controlled.

– Flocculating agent dosing control

The control is made by the flocculant automatic dosing in the sedimentation tank (DORR) feed according to the solid content in the overflow (return water).

4.1.3 Automatic control and information system

All sensors and local control of the technological sets are connected to the preparation plant control system. The heart of the system is PDP 11/83 computer (a product of Digital) with RSX 11M+ operating system. All input and output equipment is connected to this computer via serial interfaces.

Data acquisition from the sensors is made in data concentrators based on i86 or Pentium processor with RTX operating system. Up to 500 sensors can be connected to each concentrator. The data concentrators contain also tasks for the control of the technological sets.

The system also receives data from two track weighers, road weighers and WILPO shipped product quality analyzer.

The output equipment serves as a user interface. The basic output unit is the terminal. It is a set of equipment which, as a full assembly, contains operator terminal, alarm terminal and graphic station. 10 terminal groups can be connected to the system in the actual configuration. While the process information is displayed in the form of text on the terminals, the graphic station displays process charts and allows to display the selected variable history in the graphic form. The terminals used here are DEC terminals of VT 510 type and the graphic stations are personal computers with 486 series or Pentium processors with PROMOTIC™ software supplied by Microsys Ostrava.

The preparation plant control system is interconnected with the sales control system by local Ethernet with DECnet protocol.

4.2 Sales control system

The sales control system at ČSM Coal Mine was developed by ATP Soukup in 1996 and put into operation in the beginning of 1997, after 2 months' trial operation. Compared with the preparation plant control system run in real time on PDP 11/83 computer (RSX-11M+ operating system) the sales control system allows data evaluation in an unlimited period. It is based on Alpha Server 1000/266 computer supplied by Digital. The computer runs under Windows NT 3.51 operating system and the database Microsoft SQL server 6.0 was selected. The data important for the sales control gathered by the PDP computer from the process and dispatching level of the preparation plant control system are transferred to the Alpha computer database. For the communication between the two different kinds of operating systems ATP Soukup has developed a system of communication tasks based on DECnet with Pathworks software working in the form of task-to-task report exchange. This type of connection allows data acquisition and transfer from any equipment or process connected to the PDP computer (automatic track weighers, WILPO quick quality analyzer, road weigher, sensors in cleaned coal bins, graphic stations, etc.) or data transfer from the sales control system to the preparation plant control system (e.g. loading plan and its alterations initiated from the client workplace in Karbonia trading company are displayed on the preparation plant control room terminals or list of empty wagons from OKR - Transport is printed out at the track weigher workplaces after the data transfer). The communication tasks are written in Microsoft Visual C++ on the Alpha (Windows NT) computer and in Fortran 77 on the PDP computer, As indicated earlier the sales control cannot be separated from the preparation plant control so the Sales Department uses also the PDP 11/83 computer applications. Both control systems are interlinked and partly coinciding.

The sales control system includes client computers - standard PCs with Windows 95 operating system interconnected through the net. For the application development Microsoft Visual Basic was used. In time of this paper preparation 6 stations had been connected to the net which is connected to

ÈSM corporate net. (run under UNIX operating system and used e.g. for data back-up).

5. HOW THE SYSTEM WORKS

5.1 Preparation plant control system

A characteristic feature of the system is its modularity and layering. The modularity allows to modify the system range and behaviour very easily and the layering ensures separation of the different system functional blocks which communicate with one another via the data interface.

From the user's view the vital layers are "data acquisition", "alarms" and " presentation". The function of the other layers is latent for the user and there is no use in describing them here.

The data acquisition layer ensures processing sensor data taken from the data concentrators. The system approaches each sensor separately, i.e. each sensor has a special recalculation, averaging, links to other sensors, etc. Each value is verified in relation to the basic sensor characteristics and other process-related sensors. This ensures other layers are operating using verified information from the process.

The alarm layer ensures out-limits process status monitoring. Also here it is essential for the system to produce only the reports identifying only important deviations. Therefore several procedures are introduced which prevent activating short-term alarms immaterial for the control. The activated alarms are displayed, confirmed and archived. The alarm activation and cancellation is two-levelled. At the dispatching level it is fully in the dispatcher's powers and the alarms activated at the management level are obliging for the dispatcher (alarms indicating serious quality and technical deviations).

From the user's point of view the system presentation is essential. The system presentation is made on the terminal groups. As regards the technique it is a presentation in alphanumeric form on the terminals and in graphic form on the graphic stations.

The basic output equipment is the terminal groups on which the user accesses the desired form from the menu. The access is either direct or protected by a password. The second output equipment is the alarm terminal on which the process alarms are displayed.
The graphic station provides the user with a number of process views; from global ones to the views on machine banks. The displays are designed to correspond to the maximum extent with the process sheet displays used recently. However, at the same time they are designed to reflect the operation cycles and sets in the most appropriate way. One of the user friendly features of the graphic station is the user's option to interact with the system in selecting the sensors or calculated values, aggregate them in groups according to their characteristics and display the value history using graphs.

As regards the time the view on the presentation is quite different. From this viewpoint we can divide the forms into two types as follows:
- operational and
- summary

The operational forms give an overview of the actual process status. The summary forms give an overview in a long run and provide information on the production process in the course of a shift, day or month.

Besides the above mentioned outputs the users can also avail themselves with the forms according to which the process can be modified, such as flotation control parameters setting.

5.2 Sales control system

To date the sales control system is presented by twelve separate applications installed according to the needs of the different workplaces. Below are the most important applications:
- daily summary according to types, customers, etc.
- loadings in real time
- monthly loading statistics
- train loadings in real time
- WILPO quick analyzer quality measurement statistics of the loaded products
- daily loading plan
- preparation and print of the inland and export bills of freight
- loaded wagon summary
- loaded lorry statistics
- applications for the inspection, service, keeping code books, etc.

As already suggested some sets display data in real time. Due to the nature of the system the response time may be up to a few seconds so there is not any extreme load of the system. Based on the obtained information it is possible to make control actions in the preparation plant system leading eventually to the optimum performance of the sales and shipment systems.

The preparation plant managers can use the tools designed to create their own forms (Microsoft Office product package) allowing to evaluate the stored

information and flexibly expand the system. Using Microsoft Office the managers create new operating sets with balance characteristics which makes possible to modify and expand the system without any software specialists' assistance.

The connection of external organizations being an integral part of the sales and shipment system is a special section of the system. The system would be incomplete without these organizations. At ČSM Coal Mine it is primarily OKR - Transport and Karbonia. OKR - Transportation brings to the system the important information on empty wagons available for loading. Karbonia is responsible for sales contract signing and wagon shipment. Since Karbonia completes the contracts, it provides the grounds for the preparation plant work. Karbonia lays out daily loading plans according to which the loading is performed. In turn, the sales and shipment system furnishes Karbonia with the information needed to issue the bills of freight. Shortly the system should be expanded by the connection and information exchange with Metalimex a.s., trading company based in Prague which ensures the coal export.

6. BENEFITS OF THE SYSTEM IMPLEMENTATION

The benefits of the system implementation need to be assessed from several points of view. The easiest assessment is associated with direct savings or profit resulting from the automated control of the technological sets. The implementation of flotation control noticeably improved the flotation concentrate quality and substantially reduced the flotation agent consumption. The jigging automation increased the cleaned product yield by 2 %. Only the two items caused the time of return of the funds invested in the system was below one year.

Another benefit is the continuous supervision over the process that provides the managers with a tool allowing them to identify and analyze the deviations from process regulations and eliminate the causes. The presentation of the coal preparation process and sales monitoring results gives the managers information necessary for the production process, quality and cleaned product analyses providing them a strong tool to optimize the production and ensure the product quality compliance with ISO 9000 requirements.

As the system developers we highly appreciated the fact ČSM Coal Mine managers showed a great interest in the system application and contributed in a creative way to the system debugging during the trial operation. Moreover they are still increasing the system efficiency by developing their own applications using the Microsoft Office package tools.