PLANNING A DUST FREE COAL MINE

ROGER F. J. ADAM
R.A. SYSTEMS, Pittsburgh, PA, USA

ABSTRACT

Silica and coal dust have been responsible for the death of more miners than all other mining hazards together. Progress in dust control has been made but, still today, air ventilating many underground coal mines is too dusty to be really safe for the unexposed miners!

Some new techniques such as water jet cutting, foam generation, air scrubbing, and remote control, will still bring some progress. However, achieving a dust free mine requires recognizing respirable dust as the main concern at the stage of mine design and planning. Water being the common mean to fight dust, any coal moisture limitation should be eliminated from the working face to the power plant including the preparation plant. Replacing belt conveyors by an hydraulic transport is the optimum solution. Slurry density control and regulation by an expert system make this solution technically and economically feasible. Hydraulic transport will permit to maximize the efficiency of all dust control techniques using water.

Progress in dust control in underground coal mines has been made but, still today, air of many mines is too dusty. The amount of 2 mg of respirable coal dust per m^3 of air, considered as dangerous, represents only half of a millionth of the coal produced if one considers 1,000 tons per shift in a face with a ventilation of 8 m^3/s (13,000 cfm). As demonstrated by the experience of the last forty years, dust control is a problem which will probably never be solved while using current mining methods.

It is time to design and develop economically competitive dust free mines.

Dust sources are many, and their contribution to miners dust exposure may be very different from one mine to another. Among these sources of respirable dust, coal cutting, coal handling, coal transport, roof caving and roof drilling for bolting are the main sources. If we take the example of longwall mining, Figures 1 and 2 illustrate dust concentration distributions measured in longwall faces with the position of the exposed miners.

Three basic approaches are used to reduce the exposure of miners to respirable dust:

- Reduce the respirable dust production.
- Suppress the airborne dust produced.
- Keep the miners in areas of lower dust concentration.

The last approach, helped by the development of remotely controlled equipment is efficient for one dust source only and should be used as the last resource.

It appears that water is the common mean to fight dust: water injection in the solid coal, water sprays on the cutting drums, water sprays at each coal transfer point.... That results in a major problem because mines are designed to handle and produce coal with a limited moisture content for either technical or commercial reasons. In the mine itself, the main limitation comes from the belt transport system but, outside it may come from the cleaning plant or from the power plant. In the U.S. the coal preparation plants are, by chance, equipped with wet screening, but it is worth mentioning that dry screening in a cleaning plant limits the moisture content of the "run of mine" coal at a 6% level and prevents a good dust control in the mine.

Today, a dust free mine is a real possibility but achieving this goal requires, first of all, to recognize respirable dust as a top priority at the mine planning and design stage. Trying to control respirable dust in mines not adequately designed is almost impossible.

Taking this novel approach, several mining methods can be selected and appropriate equipment developed.

DUST SOURCES AND CONTROL

We saw from Figures 1 and 2 that, in a longwall face there are three dust sources of almost equal importance: coal cutting and loading, roof caving, belt conveyor and transfer points. In room and pillar mining there is generally no roof caving but roof bolting may be a main source of respirable dust.

We will briefly review for each dust source, promising development and techniques already tested, such as water jet cutting, foam generation, hydraulic transport, which could eliminate dust sources and be combined to obtain a global approach to the development of a dust free mining method, but, also could be used individually to improve dust control in existing mines.

Coal Cutting

Coal cutting is the first dust source. As shown on Figure 3

each bit is crushing coal in very fine dust at its top. The major steps to reduce this source of dust were:

- The development of "wet drums" where water sprays are located on the cutting drum itself;
- The use of a small number of larger bits allowing to fit each bit with a water spray;
- Water injection in the solid coal ahead of the face.

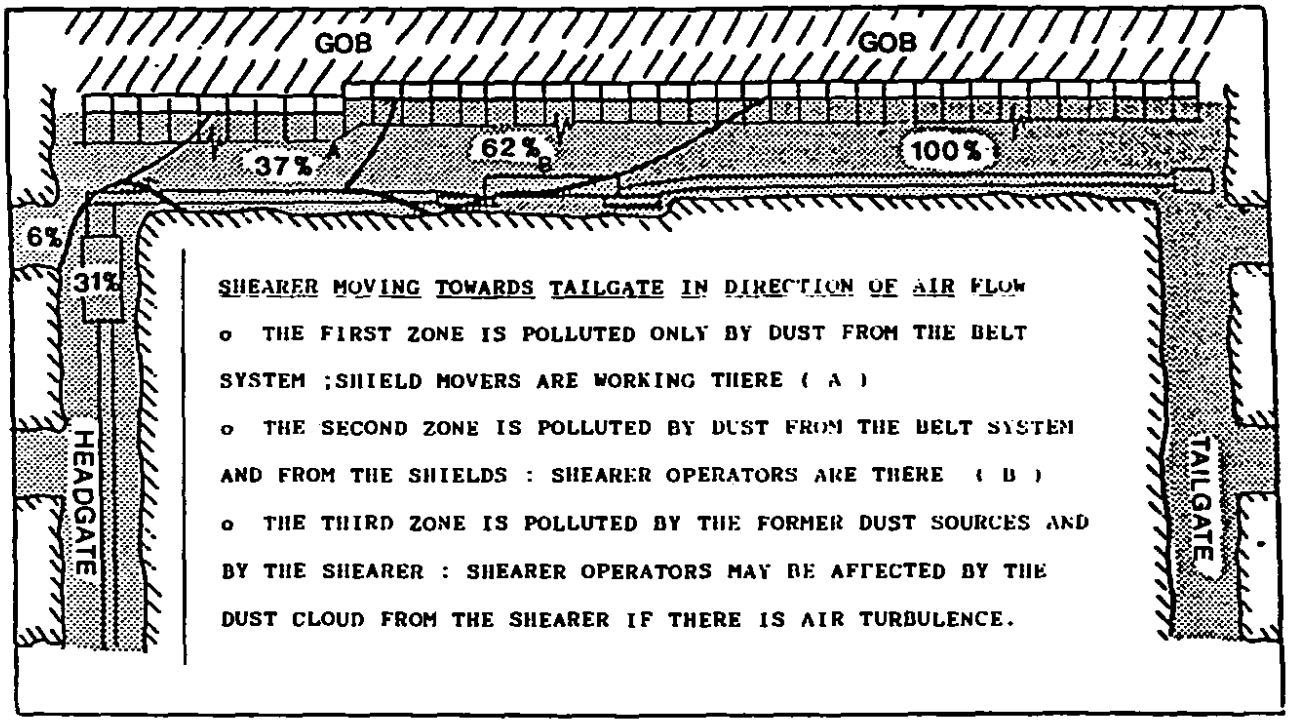


Figure 1. Longwall dust source contribution of total dust make for head-to-tail passes.

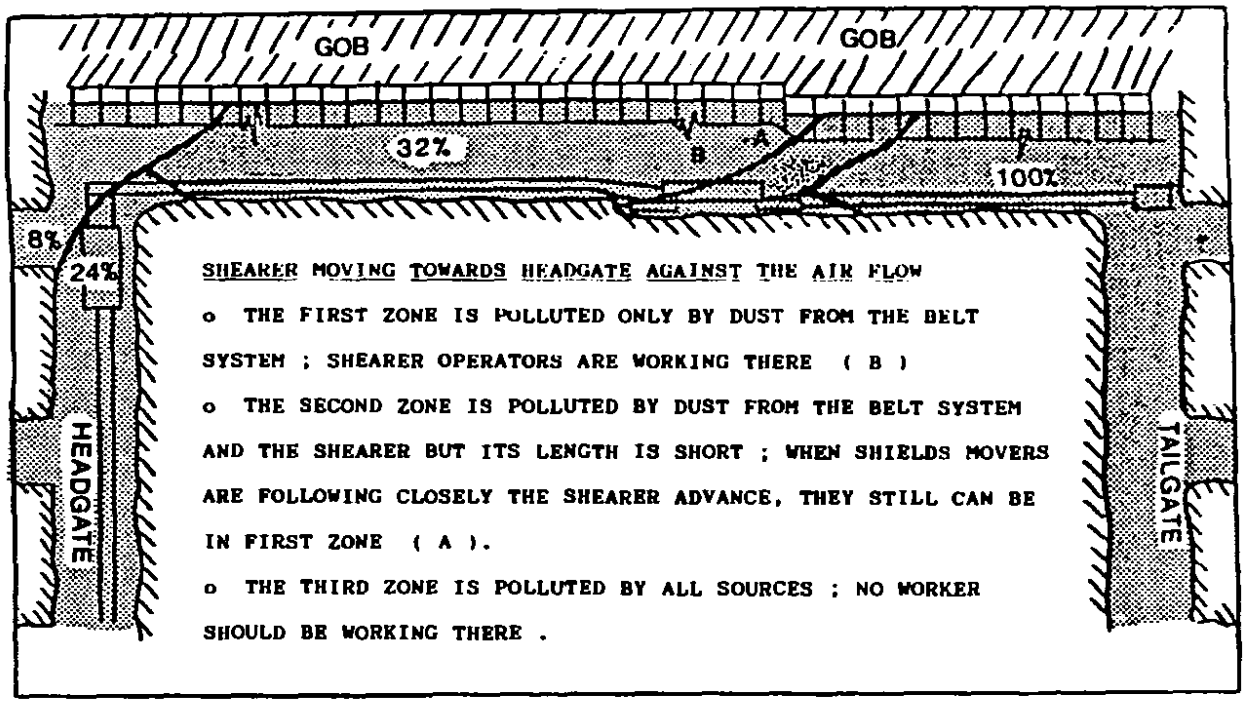
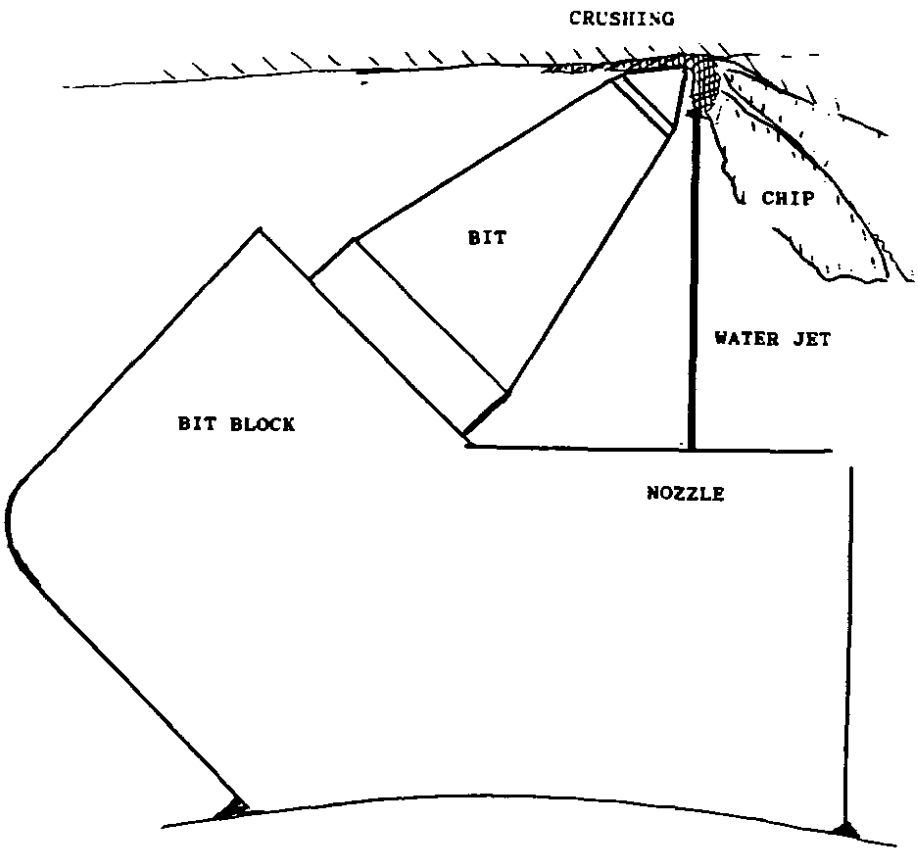


Figure 2. Longwall dust source contribution of total dust make for tail-to-head passes.



CUTTING ACTION OF A CONICAL BIT

THERE IS A CRUSHED AREA AT THE BIT TOP WHICH IS ASSUMED TO BE THE MAIN SOURCE OF DUST FROM CUTTING OPERATION. A HIGH PRESSURE WATER JET AS REPRESENTED IN FRONT OF THE BIT WAS FOUND VERY EFFICIENT FOR DUST ABATMENT .

Figure 3. Cutting action of a conical bit.

The next step will probably be:

- Water jet assist cutting; a jet of high pressure water is directed at the source of dust, the tip of the bit. Surface and underground tests showed a 75% reduction of the dust produced without exceeding a 3000 psi water pressure.[1] The development was retarded by technological problems but at least three projects are ongoing;

- A joint research by Eickhoff and the U.S. Bureau of Mines using high pressure rotating seal and phasing system to supply the HP water to the bits;[2]

- Two solutions to intensify the water pressure in the cutting head to avoid HP rotating seal and phasing system. One of them developed by R.A. Systems, Figure 4, with the support of Pennsylvania Energy Development Authority allows retrofitting existing machines with new cutting drums.[3] The other one[4] is proposed by Minnovation (G.B.).

Water jet assisting cutting is a solution to decrease dust production while using a small amount of water and could be used on shearers in longwall as well as on continuous miners in room and pillars sections.

Coal Handling and Transport

In addition to the dust generated by mechanical cutting each time coal falls by itself from the face or is mechanically loaded, coal breakage produces dust unless coal is very wet. To avoid using a large amount of water, water infusion ahead of the face is the most efficient way to reduce dust production during coal loading with an added moisture of about 3% only.[5] The same apply for coal transport: unless coal is very wet, transport on belt conveyor generates dust at least at each transfer point. Dust generation is due to secondary breakage but also to the air drying the coal transported. From the dust control point of view, belt transport is not a good solution. It is a major source of pollution of the air intake and it is obviously very difficult to reduce the exposure to sources polluting the air intake.

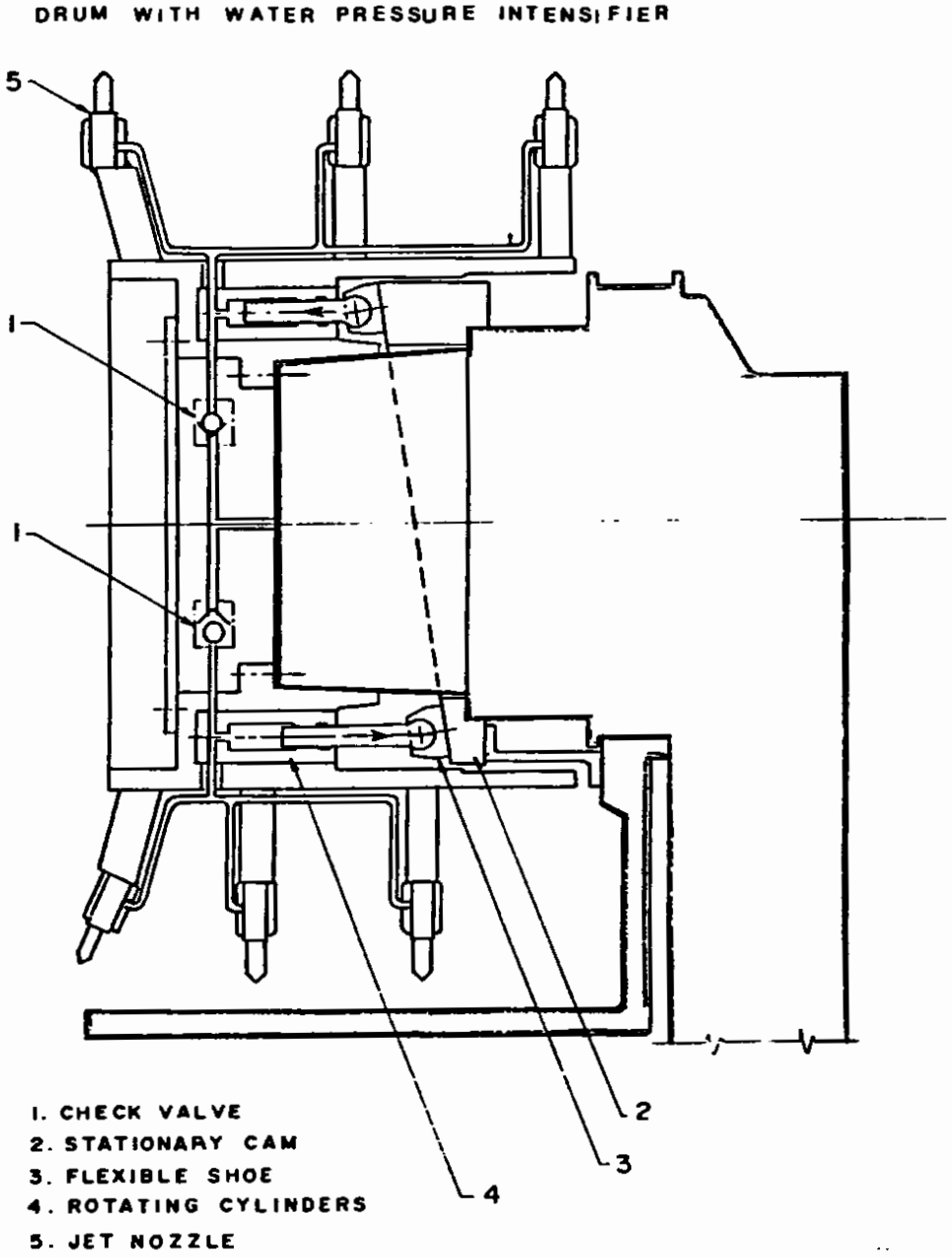


Figure 4. Cutting drum with water pressure intensifier to retrofit shearers with water jet assisted cutting

In planning a dust free mine, there is no doubt that no belt conveyor should be used; they should be replaced by hydraulic transport for two main reasons:

- Hydraulic transport can economically replace the usual belt system and suppress a major respirable dust source.
- It will eliminate the limits a belt conveyor system imposes on the amount of water used for dust control during cutting and loading operations. It is also suitable for hydraulic mining. We do not have to detail the advantages of hydraulic transport. So much has already been said and published on the subject.[6] The replacement of belt conveyors by hydraulic pipelines will have an impact on the mine design by elimination of neutral entries. It would alleviate the regulatory problem in the use of a two entries system. It will also improve mine safety by suppressing the risks of mine fire associated with belt conveyors. However, these numerous studies and the mentioned advantages had little result on the development of hydraulic transport in underground coal mines. Only Consolidation Coal Company conducted underground testing.[6]

We should examine why, currently, hydraulic transport is not used more often for handling coal.

- A problem results from the discontinuity of the coal production (even by "continuous" miners) compared to the continuity requirements of a hydraulic transport network.
- Another problem is the ever-recurring change of length of the pipeline branches during mine operations.
- More important is the need for a good control of the slurry density not only to improve the system efficiency but essentially to prevent plugging pipelines.

Existing mine equipment can be modified to provide a steady flow of product to be injected immediately in a pipeline. The transformation can proceed step by step.

In a first phase, storage capability could help matching current equipment with hydraulic transport. As an example, in a room and pillar section, a continuous miner with water jet cutting and no limit of coal moisture could still load in shuttle cars but, at the transfer point, an increased storage capacity could provide a steady flow of coal in the pipeline. A good control of slurry density and automatic adjustment of the flow with a simple expert system will do the rest. In a longwall method the flow of coal is more steady compared to the case where a continuous miner stops producing every five feet for bolting and moving from one entry to another. Injecting coal in a pipeline was studied by Foster Miller and Ingersoll Rand under Government Contracts. Consolidation Coal Company used a crusher/pump vehicle for direct loading behind a continuous miner.[6,7]

The problem of pipeline extension can be solved, or at least made easier, by using a flexible pipeline similar to the prototype developed and tested by Consolidation Coal company to be attached to a continuous miner to follow it.[6] Only one flexible section per branch will be required as shown on the conceptual design on Figure 6.

Another important point is the need for a control system of the hydraulic network. Density control is the key point to prevent any risk of plugging the pipelines and also to keep an optimum solid concentration. If the slurry density is accurately measured at each loading point, it is simple to establish an algorythm to regulate all the network using pumps with variable speed drives.[8]

Roof Caving and Shield Support

Shield support brought progress in longwall roof control, but improvements in safety and productivity were paid by an increase of respirable dust generated when the shields are advanced, compared to other types of powdered roof support. Tentative solutions were better designs of the seal between shields and water sprays on the gob side; still the dust production remains important. Two approaches are possible; if it is the only dust source at the face, the exposure to this source could be avoided by keeping all miners upstream. If not, we suggest testing foam generation behind the shields instead of using only water sprays.

Roof Bolting

Most of the roofbolters used in the U.S. mines are drilling with aspiration and filtration of the dust. It was shown that careful maintenance of the dust collection system could take care of the dust problem.[9] Still a better approach should be wet drilling with or without water jet cutting. In low seams, water jet cutting requires a flexible drill because use of rod extension is not possible. R.A. SYSTEMS is developing such a flexible drill which could also allow prebolting[10] (Figure 5).

Economic Considerations

Some of the proposed solutions such as water jet assist cutting are inexpensive to implement: a shearer or a continuous miner could be retrofitted with water jet assist cutting by changing the drums and using drums with a pressure intensifier which will cost only twice the price of a normal drum. The expense, about five percent of the machine cost, will lower operating costs by increasing bit life and production. Foam generation on shields can be done by using the existing water spray system with no expenses but dust measurements for efficiency control and parameters selection. However, hydraulic transport is a different problem because it will not only result in essential changes of the mine design and in a high moisture content of the run of mine coal, but will also require an important investment in special equipment and appropriate training of all personnel. There is little experience on running an extensive hydraulic network transporting a coarse slurry, with varying factors from the

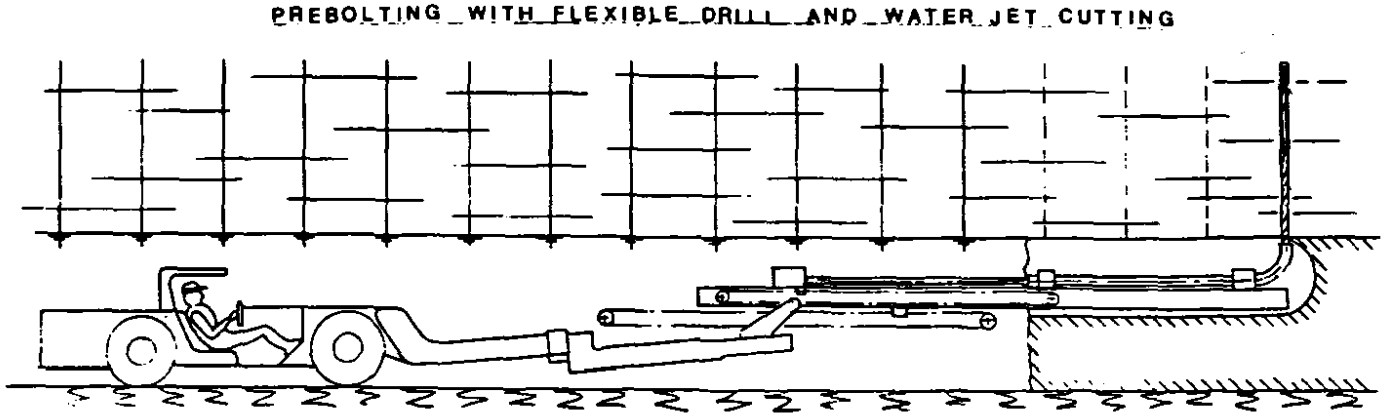


Figure 5. Roof prebolting concept.

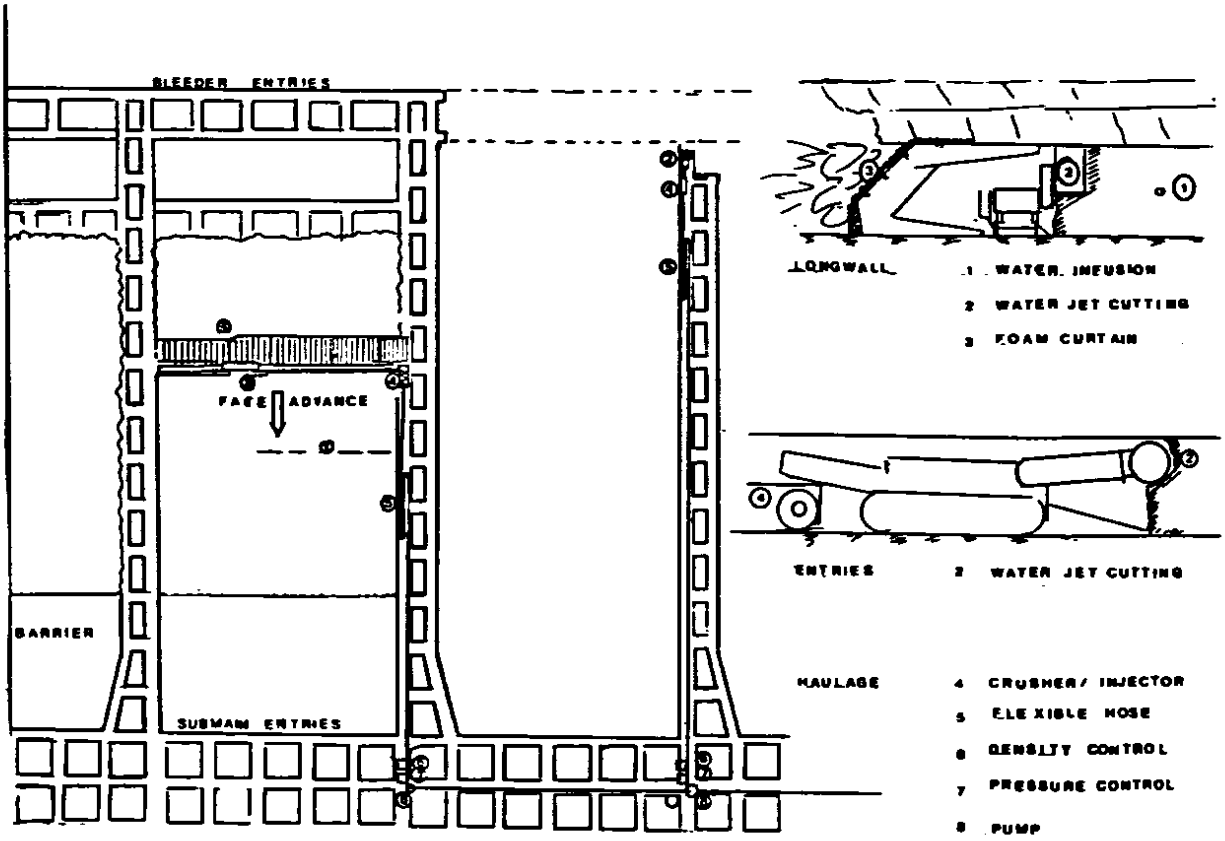


Figure 6. Overview of a dust free coal mine.

size consist and the nature of the raw coal to the length of each branch of the network.

The investment required for hydraulic transport is only half of the cost of the equivalent belt system but there is always a risk factor when comparing a conventional system to a new one. Whatever the risk, it creates a psychological barrier even though the anticipated problems are technically easy to solve:

- Speed control of each pump to maintain an appropriate slurry density to avoid settling of the products; an expert program can be based on accurate density measurements at each produce inlet.

- Pressure control of the network to detect plugging or leaks.

The most difficult problem is to start the network full of slurry after an unexpected stop due, for instance, to a power failure, but several solutions exist.

CONCLUSION

The problem of respirable dust can probably be solved if there is enough will to do it. Some alleviations can be obtained easily but a dust free mine requires hydraulic transport. Such a change in underground coal mining means risks to face and problems to solve but will increase productivity, lower mining cost and protect miners' health.

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