UNDERGROUND APPRAISAL

Being able to access a coal seam from underground workings provides an opportunity never afforded to those who seek gas purely from surface operations. It also poses challenges and sometimes advantages in measurement, because of the environment.

Geology

The first task in appraising any coal seam reservoir is to understand the geology. In the underground situation, this is facilitated by being able to map the seam in great detail. The salient features are the coal bedding, including potential sealing bands and most importantly the cleating. The cleats are the sub vertical fractures within the coal seam. The cleat spacing defines the distance over which diffusion must take place before Darcy flow in the cleats can take place. The nature of the cleats themselves is most important – do they have infill of clays or carbonates? Such infill can seal a seam very effectively. The hardness variation of the coal is also important as the coal's mechanical properties will strongly effect how the coal seam responds to changes in effective stress brought about by drainage. Such changes are caused by a lowering of fluid pressure and the shrinkage of the coal as it gives up gas and dries.

Underground Test Methods

Gas Content

The most basic test of reservoir properties is the assessment of the reservoir pressure and gas content. Gas content is customarily measured by taking core, placing it in a canister, and measuring the gas it desorbs. This technique has limitations in the underground environment because the coal is desorbing from the time it is cut and because the time it takes to retrieve the core may be excessive in the underground environment. Frequently the assumptions used to arrive at a lost gas from the core are violated because of the time lag before the core can have its desorption rate measured.

There are significant advantages to be had from drilling and flushing cuttings from a hole for gas content measurement. This can be done using either air or water. The former offers the quickest return of cuttings and is appropriate in drier seams. It is shown schematically in Figure 1. Here the chips are collected very quickly and the volume of cuttings from a given section of drilling may be measured and used as an indicator of sheared or otherwise outburst prone coal. Nonetheless it is quite possible to water flush shorter holes at a high rate, while collecting the chips and

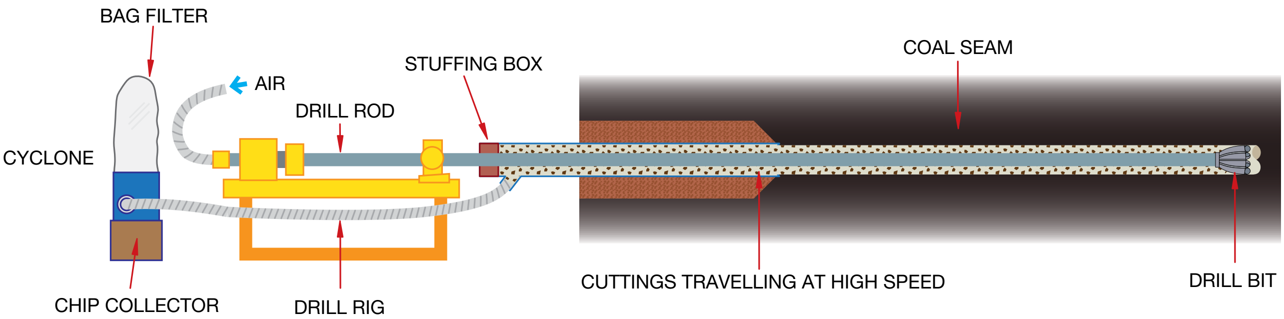

Figure 1. Dry drilling sampling system

Sigra Pty Ltd
93 Colebard St West, Acacia Ridge, QLD, Australia, 4110
+61 7 3216 6344 info@sigra.com.au
CSRC-UA-04/2010

placing them in a canister for desorption. Once canister desorption has slowed it is possible to grind the cuttings to determine the residual gas, as would be customary in core desorption. The lost gas while the cuttings are in transit is determined by the solution of the diffusion equations. Not only can the gas content be determined but so too can the diffusion coefficient of the coal. This process can yield highly accurate results.

An alternative system to enable gas content and sorption pressure to be determined from cuttings in deep holes has been developed by Sigra. This involves the use of a borehole pressurisation tool. This is attached to a solidly cemented standpipe and contains a rotary seal and a pressure regulator that maintains borehole pressure. This pressure prevents the ingress of gas from the borehole. The cuttings that are retrieved into a pressurised canister have had minimal desorption and their sorption pressure can be measured. This can be related to gas content through the sorption isotherm. Figure 2 shows this equipment.

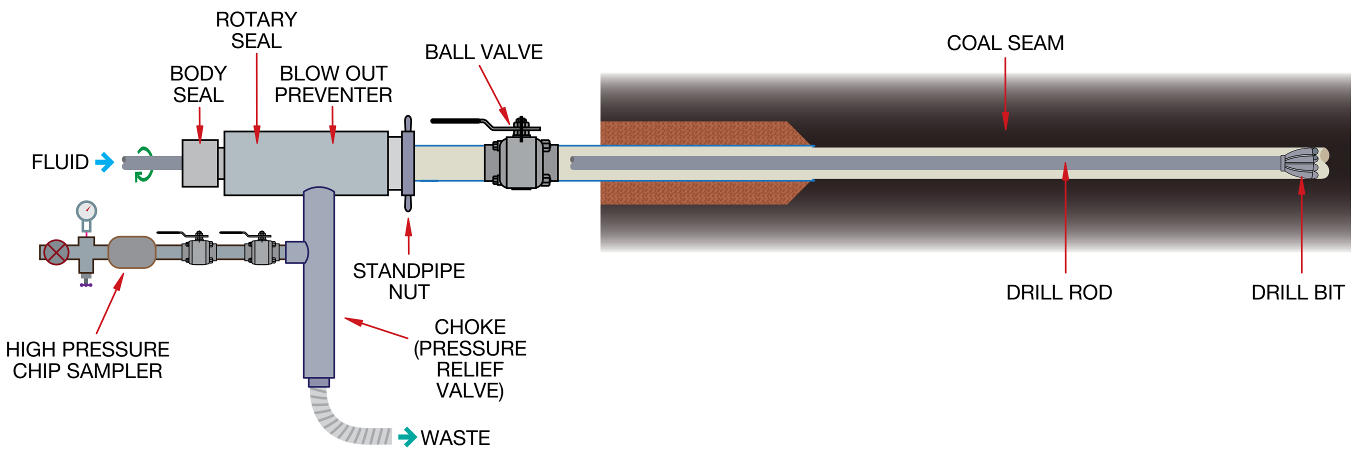

Figure 2

Incremental Flow Testing to Determine Homogeneity of the Seam

Coals are very inhomogeneous and the flow measured from a borehole usually is not released evenly over its length. The flow depends on many factors such as the coal ply in which the hole is drilled, cleat direction and intensity, stresses within the coal, direction of the hole and major jointing within the seam.

It is therefore highly desirable to measure the flow coming not only from a borehole but from each section of a borehole. The process shown in Figure 3 can be used to determine the flow at various locations along shorter holes. Here a single packer is pushed to the back of the hole and then inflated, before the flow is measured. The packer is then deflated and moved out by say a test rod length, before being re-inflated and the flow measured again. The flow per unit length is therefore the difference between measurements, or the slope of the flow versus distance curve. This process may be repeated over the length of the hole to get a complete flow profile.

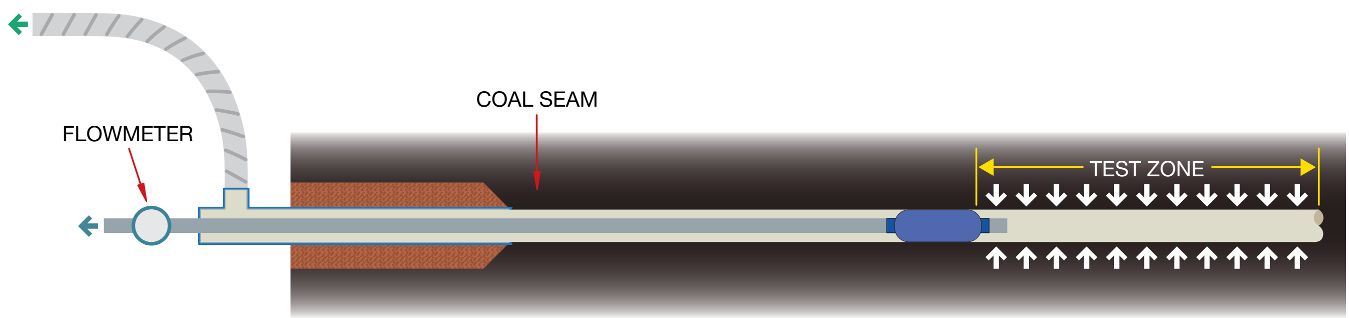

Figure 3. Single packer incremental flow testing

In longer holes this approach cannot be used because the change in flow over a useful change in measurement distance is small compared to the total test section flow. The system shown in Figure 4 is therefore used. In this system, straddle packers are inflated to isolate a section of hole and measure its flow. The flow from the hole behind is bypassed past the packer system.

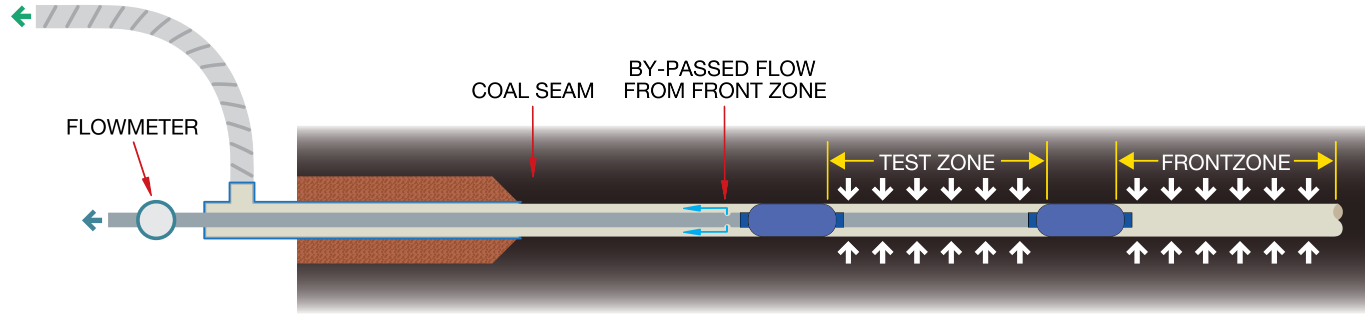

FIgure 4. Straddle packer incremental flow testing

Determining Permeability

The quickest experimental method to determine the permeability of gassy coal seams is to use the system shown in Figure 5. Here a hole is drilled and a single packer is inserted beyond the rib side zone and used to seal the hole, with all flow coming down the test tubing, which is connected to the packer. The flow of water and gas is measured over a period and then the valve on the tubing is closed and the pressure build-up is monitored. It is usual to repeat this for a second flow and build up period. The test technique can be conducted in holes of several orientations so as to determine the directional characteristics of permeability. The exact nature of the permeability must be determined by history matching, using a simulator, because of the complex behaviour of coal seams.

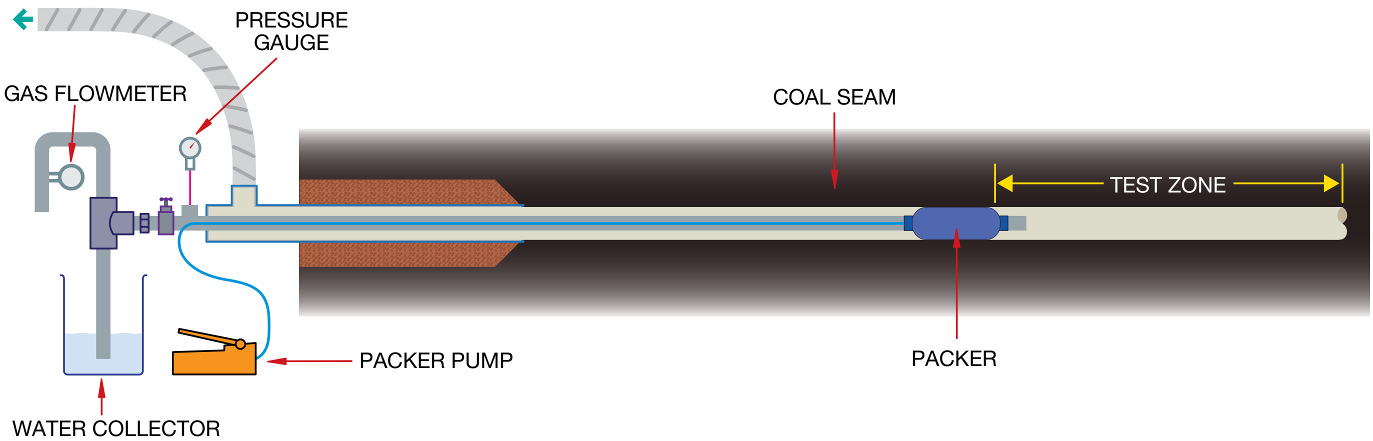

Figure 5. Setup for single in-seam hole underground permeability test

Long Term Permeability and Material Balance

Because of the variations in permeability throughout production, and the need to maintain a check on material balance, it is very useful to conduct longer term drainage tests. The essence of these is to compare the gas produced from the seam with the change in seam pressure, using the latter to arrive at a gas content through the sorption isotherm. Thus the material balance equation may be applied.

Gas in Place = Gas Initially in Place – Gas Drained + Other Sources

The **Gas in Place** is determined by pressure sensing and the use of the sorption isotherm

The **Gas Initially in Place** is either measured directly, or via pressure.

The **Gas Drained** is obtained by flow measurement

The **Other Sources** are gas gained or lost through the ribside or entering the seam via major joints or through the roof or floor.

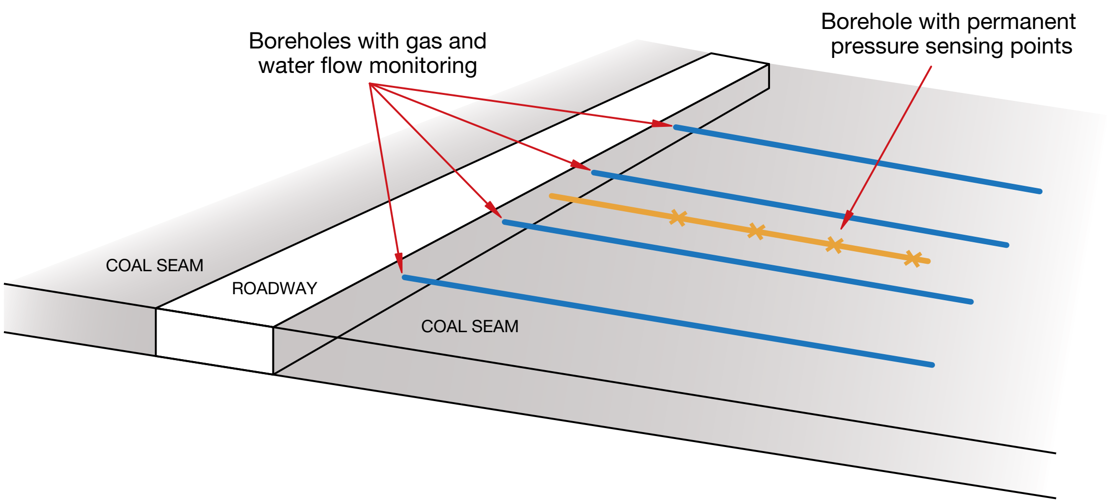

Figure 6. In-seam drainage trial using 4 drainage holes and central pressure sensing hole

The ideal embodiment of the test layout is shown in Figure 6. Here a central hole is drilled and fitted with pressure sensing points, either through the use of a multiple packer assembly (Figure 7), or by grouting the hole with either pressure sensors or sensing lines (Figure 8). Two flanking drain holes are then drilled on either side of the pressure sensing hole and the flow from these is measured.

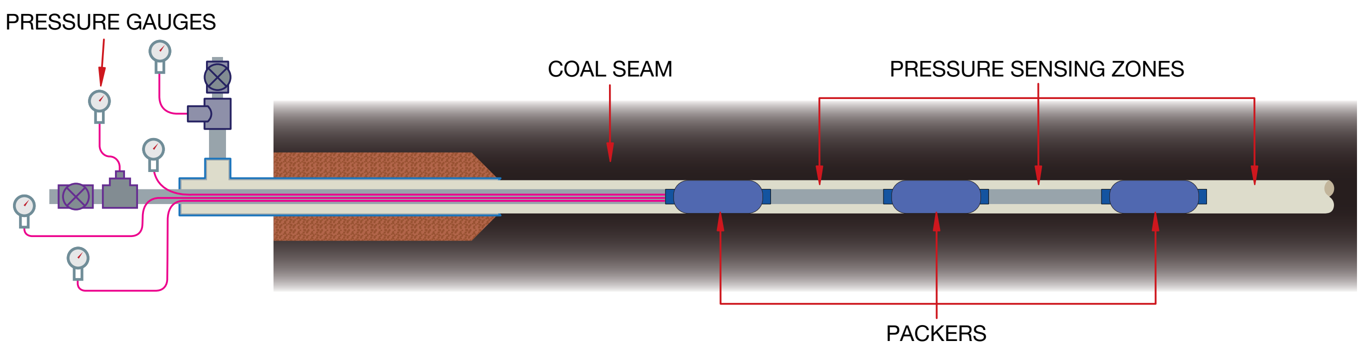

Figure 7. Multiple packer assembly for pressure monitoring in-seam hole

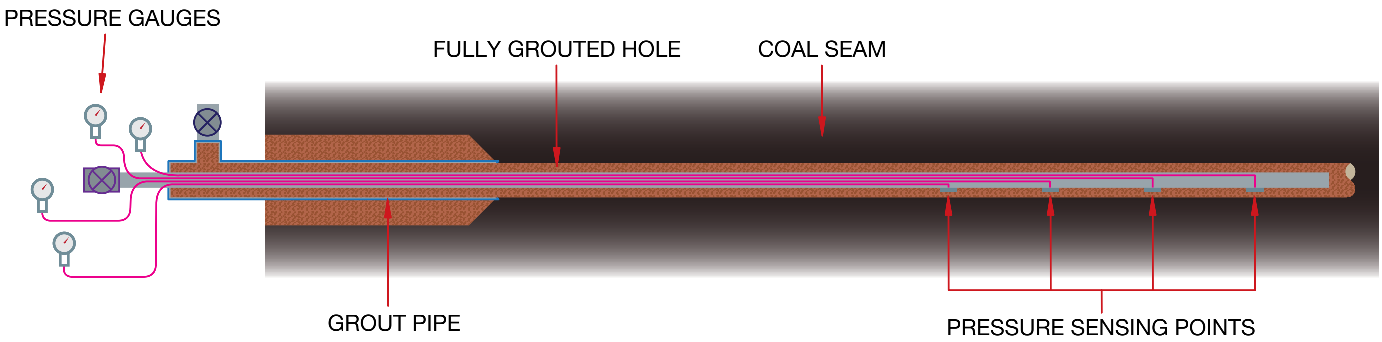

Figure 8. Multiple point permanent pressure sensing in-seam hole

An example of the correlation between the gas content derived at from seam pressure measurement with sorption isotherm and the content derived from the material balance calculation is shown in Figure 9. This example shows a very good match, which indicates that an understanding of the coal seam drainage characteristic has been achieved. The bulk permeability of the coal may be determined through history matching. Note that not all cases show such a good match and in these cases the Other Sources term needs to be investigated.

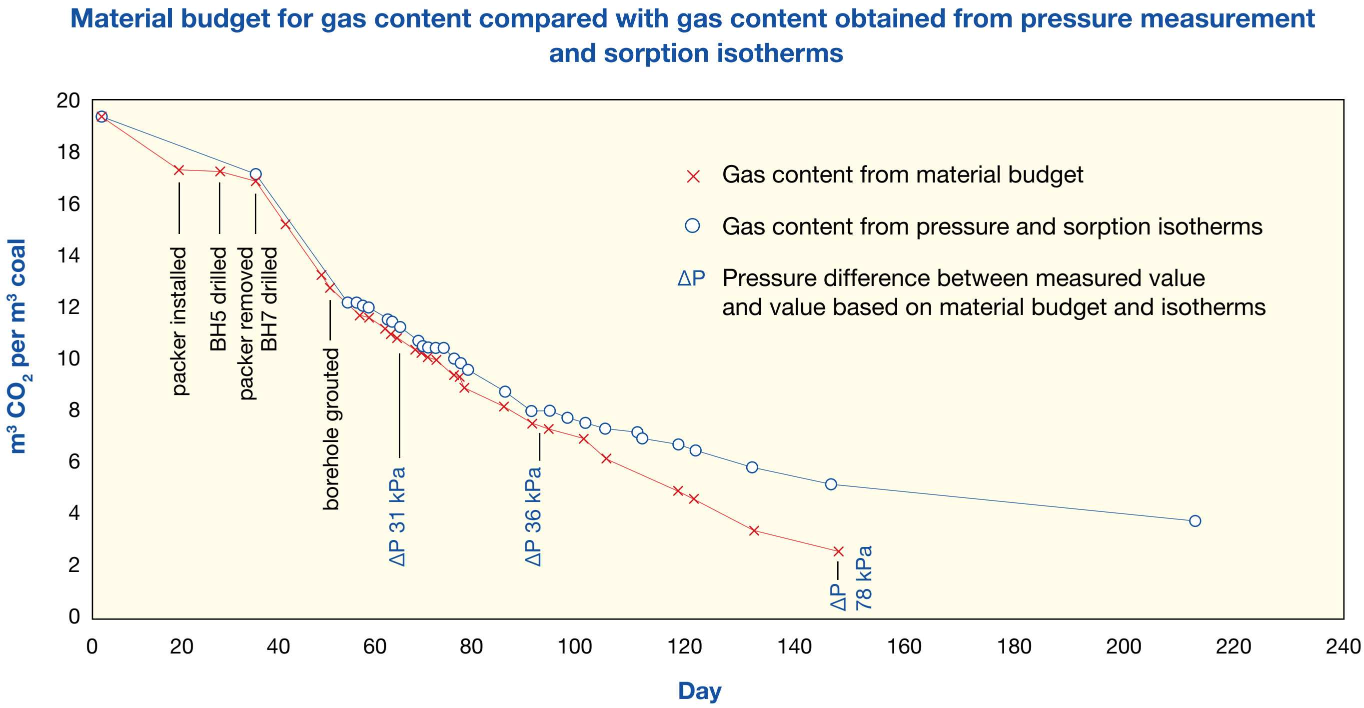

Figure 9. Collinsville no. 2 Mine, borehole 6, 45m depth