Moving the Ventilation Report into the 21st Century

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MOVING THE VENTILATION REPORT INTO THE 21\textsuperscript{ST} CENTURY

John Rowland\textsuperscript{1}

\textbf{ABSTRACT:} Over the last three decades there has been significant technological change in both coal mine monitoring and ventilation modelling capabilities in the underground coal industry. During this time there have been substantial changes in statutory ventilation monitoring requirements to reflect such changes in our industry’s monitoring capability. Somewhat contrastingly, there has been very little change in the mandatory regulatory requirements relating to ventilation quantity and gas contamination readings that need to be taken on a monthly basis. On top of that there has been no official mention made of any requirements to model or predict ventilation circuit changes in the mine office, before attempting such procedures underground.

Using the NSW coal mines regulations as the basis for the opinion it is the writer’s belief that whilst the skill level requirements of minesite ventilation officers has been substantially elevated over the last quarter of a century there has been no step change in the mandatory output requirement of the monthly statutory ventilation survey and accompanying report.

In the 20th century it was not uncommon for the mine ventilation survey to comprise a handful of readings which were then entered into a pro-forma book and then hidden away until the next survey. The data measured was insufficient to accurately delineate the circuit and little or no thought was given to utilising the data to build a mimicked model of the ventilation circuit. Unfortunately in the 21\textsuperscript{st} century there has been insufficient regulatory change to date to ensure such basic practices are elevated to a higher level.

Current ventilation modelling software programs are very user friendly and relatively simple to maintain and update but even the most recent changes in the regulations have all but ignored the value of such tools.

With some careful planning the ventilation surveyor should set up both his quantity and pressure survey stations in a manner which will afford not only statutory compliance but allow him to accurately define the ventilation circuit to a level that will allow him to maintain an accurate ventilation model of the circuit. The maintenance of such a tool will afford far safer change procedures relating to ongoing circuit adjustments.

The final ventilation report that is assembled should be a useful tool and ideally communicated to the frontline supervisors to assist them with their ongoing understanding of the circuit in which they work.

It is hoped that some of the tips contained in this paper relating to report inclusions and representation of such data may help at least some ventilation officers streamline their monthly data collection/collation process and with a minimum amount of work. The output is an accurate snapshot of the circuit to utilise for model validation that should double as a useful training tool.

The Australian coal industry has an outstanding safety reputation and we must ensure we properly utilise all available technologies to keep it that way.

\textbf{INTRODUCTION}

There have been significant changes in technology over the last 30 years along with an elevation in the educational level and importance placed on the role of the Ventilation Officer (VO) in underground coal mines in Australia, and particularly in NSW. From a time in the 1970’s when a ventilation model conjured images of the scaled down steel ducting in the ventilation laboratory at Wollongong TAFE to the remarkable tool it is known as today there has been relatively little change in the prescribed routine duties of minesite ventilation officers.

\textsuperscript{1} Dallas Mining Services Pty Ltd
Even though modern regulatory theorists espouse the virtues of self regulation and are admitting to be moving away from specified or prescribed legislation, the current NSW regulations still prescribe minimum requirements relating to the regular collection of air quantity and gas determinations around the mine.

Unlike the self regulation expected relating to the use of auxiliary fans underground which was all but left out of the 1999 NSW underground regulations, the locations and frequencies that air and gas determinations must be taken are still prescribed by legislation. Any preference towards prescribed or unprescribed legislation will probably be debated ad infinitum but the fact remains that the ventilation regulations relating to physical duties carried out by the ventilation officers have changed little over the last three decades. Also, if only the minimum prescribed readings are taken as detailed in the regulations, then insufficient information will have been collected to foster any real intimacy with the operating circuit.

The level of knowledge and skill of the current incumbent group of ventilation officers however, is thankfully far higher than in times past even if the specific regulations demand little more from them regarding a ventilation survey and report, than it did in the 1970’s. Fortunately most ventilation officers have moved with the times and have a far greater level of understanding and control over their ventilation circuits than in the old days when it was basically an add on job, and the standard of the average modern ventilation report reflects that.

There are still however, a number of sites without operating or active ventilation models with which to carry out predictive analysis of circuit changes and the law makes no mandatory prescription in this regard. The regular maintenance of a ventilation model though is a relatively simple task given some careful planning about the data required to be collected on a monthly basis. As such the maintenance of a validated model should be encouraged as a high priority.

It is a fact that with some key preparation in the office, most of the hard work is done by the Excel spreadsheet, and the underground duties required to collect the data should be well in reach of even the busiest of ventilation officers.

The writer has hit some hurdles and obstacles over the last decade whilst measuring and modelling a myriad of ventilation circuits. Many lessons have been learned during this time and the suggested paper inclusions and techniques to assist with circuit delineation detailed herein will hopefully be of some assistance, at least to the more uninitiated.

Without doubt one of the most valuable learning’s however is not assuming that front line supervisors either won’t understand or don’t want to learn more about the ventilation circuit for which they are the minders. They are like sponges and at all costs should be afforded access to the information to make both the ventilation officers’ job an easier one and more importantly the minesite a much safer place.

A 21ST CENTURY MINDSET VERSUS A 20TH CENTURY ONE

Assembling a ventilation report in the 21st Century should be:

1. Where the total underground flow distributions can be determined.
2. Where the efficiency of individual splits can be determined and tracked.
3. Where the condition of groups of appliances can be assessed and remedial works prioritised.
4. Where the total distribution of particular contaminants such as gas, heat or dust can be identified and managed.
5. Where the mine resistance/equivalent orifice can be determined and trended.
6. Where the operating point on the fan is recorded and used to substantiate the accuracy of existing curves or even build an operational curve if there is not one available.
7. Where the power and efficiency of fans can be validated against claimed performance.
8. Where the base data enables the maintenance of a ventilation model that can accurately predict ventilation change results.
9. Where the model accuracy is such that intricate and complex ventilation changes can be done using pressures alone with the only flow recordings being validation readings on completion.
10. Where management see the benefit of distributing the report to the underground workforce and in particular the supervisors that can learn greatly from the contents.
11. Where the report itself becomes a communication vehicle for any ventilation matters of interest such as “how to take a bag sample” or “how to build a stopping” and so on.

12. Where the report becomes entrenched as a long term training tool for front line supervisors, Deputies and Undermanagers.

13. Where people are heard to remark “How come I didn’t get a copy of the vent report last month?”

Assembling a Ventilation Report in the 20th century was:

1. Carrying out the survey to only satisfy the minimum regulatory requirements.
2. Having insufficient data to maintain even a rudimentary ventilation model.
3. Carrying out ventilation changes using the “gut feel” method.
4. Having no real idea of where all the flow is distributed throughout the mine.
5. Not knowing where all the gas contributions come from throughout the circuit.
6. Not using the opportunity to slowly espouse your ventilation knowledge to the people who maintain the integrity of the mine in your absence.
7. Burying the report under a pile of books until the next survey
8. Still hearing people say “what are you doing with that wand thingy??

It is extremely doubtful that a ventilation model could be maintained in a satisfactory state of tune by taking only the specified readings in the ventilation regulations in either state, but this paper focuses particularly on the requirements in NSW coal mines.

A “satisfactory state of tune” implies the model needs to be of a standard that will enable the ventilation officer to accurately predict resultant changes to mine wide pressure and flow distributions throughout the circuit. Obviously without such knowledge there is no way of accurately predicting resultant changes in gas contaminations throughout the circuit pursuant to a major ventilation change. Ventilation changes in the absence of an accurate ventilation model are ad hoc, risky and almost always subject to some rework causing them to drag out over a substantially longer time frame, impacting negatively on both safety and production.

If a mine’s routine monthly ventilation survey affords the ability to both comply with the mandatory regulations and to maintain a model which will accurately predict the results of any intended circuit changes then the work done will be well worthwhile. All the data can be easily compiled into an interesting and informative report which is then distributed as a powerful training tool to statutory supervisors or anyone else that cares to learn more about the ventilation circuit.

If only the regulatory minimum data is collected to do nothing more than to satisfy the regulations and the report is subsequently hidden under a pile of books in the report room, then it is likely that the intricacies of the ventilation circuit will not be understood by either the management or the workforce.

If persons reading this paper “resemble” the above remark they should not feel too threatened because at one stage we all used to do it that way and the regulatory changes have been altered insufficiently to ensure an entrenched cultural change has occurred at all sites over the last 30 years.

It is still quite legal and accepted in some circles and arguably sufficient in the most benign of mines to comply with only the mandatory minimum requirements on a monthly basis. Unfortunately though all mines are basically treated equally and to regard the minimum number of mandatory determinations sufficient for a gassy mine would be risky indeed.

In the 1970’s, taking the ventilation readings was a job which was normally annexed to the undermanger in charge’s other duties and when running a mine with 6 CM units and 500 people the process of delegation almost always ensured that the taking of the readings fell onto other shoulders. The author is well aware of this having been the subject of such delegation when employed as a colliery surveyor in a south coast mine in the 1970’s when he would take the required readings basically for reasons unknown then fill in the report and file it away until the next month.

Still now though in the 21st century there are a number of mines that take little more than the readings as required under the current regulations only to file the report away without properly understanding and utilising the data.
With a simple circuit diagnosis, appropriately positioned quantity and pressure stations can be established around the mine which will not only satisfy the mandatory regulations but afford the Ventilation Officer the control that he needs over the ventilation circuit, and with only a little extra work.

INDUSTRY CHANGES AND EVENTS IN THE LAST 30 YEARS

The author is of the opinion that the ventilation regulations have not gone close to reflecting industry changes in technology over the last 30 years. There have in fact been only relatively minor changes to the mandatory quantity and gas readings that are still required to be periodically taken. The advent of computer programs including Excel and obviously modelling programs such as Ventsim have been largely ignored in many circles, and especially during the regulatory updates. It is a fact that the regulations have specified a dramatic elevation in the knowledge base of the site Ventilation Officers and also given them a mandate to focus on ventilation related issues as a priority, which is admirable and sensible. Why though with such an increased focus from one perspective has there been so little change to the specified regulations that are designed to ensure the safety and control of the mines’ ventilation systems. Regulatory authorities will no doubt claim that “we have the ventilation arrangements, what more do we need?” The fact that there is no clear evidence of a mandatory requirement to properly and adequately delineate the circuit makes the “Ventilation Arrangements” something of a toothless tiger.

There have been numerous warnings given the disasters that have befallen the industry over the last 30 or so years. 17 men were lost in a disaster at Box Flat in Ipswich in 1972 and then a further total of 37 lives were lost in the Moura area in central Queensland between 1975 and 1994 in three separate catastrophic ventilation related disasters.

In the NSW fields there were 14 fatalities in the 1979 Appin mine disaster, which was supposedly pivotal in the upgrade of the regulations, pursuant to that event. On top of that a further 30 people were fortunate to escape when Endeavour Colliery (formerly Newvale No. 2 mine) exploded in 1995. Unfortunately, due to the lucky outcome rather than the inherent potential, this incident was largely ignored. It is no coincidence or surprise that these worst of occurrences that have been encountered in over 30 years have all been ventilation related.

CHANGE HISTORY OF THE NSW VENTILATION REGULATIONS

The NSW CMRA of 1912

The 1912 Act and its pursuant regulations were still in force in NSW up until it was replaced in 1984 by the regulations made pursuant to the NSW Coal Mines Regulation Act 1982 No. 67. Figure 1 depicts an example generic mine layout showing ventilation and gas readings that were required to be taken under the 1912 regulations up until 1984, on a monthly basis. Obviously all acts of parliament require a high degree of interpretation but the writer and a number of colleagues are of the belief that in summary the following minimum tasks were required to be carried out at that time, on a monthly basis.

1. Measurement of air quantities in the main intakes near the mine entry.
2. Measurement of air quantities in the panel intakes 100 m outbye the first working place.
3. Determinations of inflammable gas (methane) in district returns.

The NSW Coal Mines Regulation (Ventilation-Underground Mines) Regulation 1984

The 1984 upgraded regulations required quantities to be measured every 28 days at the same sites from the 1912 regulations as detailed above and also at the intake side of the face machines including miners and longwall and shortwall units. Extra methane gas determinations in excess of the 1912 requirements were required at the commencement of each hazardous zone in the mine. These extra inclusions are shown in Figure 2.
The upgraded 1999 regulations were the first pursuant to the Moura No 2 mine disaster which changed the demographic of the ventilation profession in that a far higher level of training and ventilation knowledge was required to fill the role of a VO at a NSW coal mine (and a similar result with the rewrite of the Queensland regulations). With this change in the required knowledge base of the ventilation professional, there was also the advent of a documented Ventilation Control System (VCS) in NSW. This would ensure that a well documented management plan would be assembled to manage the various system components. This was seen as a proactive move and a shift away from prescriptive regulations. Still though, and in some contrast, the regulations continued to stipulate the mandatory readings required to be taken around the circuit on a monthly basis and many sites continued to summarise their circuit performance by measuring at little more than these locations. Only minor changes were made to the stipulated determinations that were required to be measured and recorded under the new regulations.

They included a monthly determination of the carbon monoxide, carbon dioxide and oxygen content in the ventilation district returns described as parts of the mine ventilated by a separate air split. These extra requirements are detailed in Figure 3.
The NSW Coal Mine Health and Safety Regulation 2006 under the NSW Coal Mine Health and Safety Act 2002

This regulation was rewritten and declared in force in late 2006 and included some changes. In particular the mandatory ventilation officers (VOs) qualification from UNSW was still a requirement but an amendment was made to include the allowance of a certificate of competency to be a manager of a mine, as an appropriate qualification. This was due mainly to the industry’s inability to attract people into the VO's roles which was, and still is, an industry wide problem.

Another significant change was the inclusion of a modified management plan which was to be known as the mine’s “Ventilation Arrangements (VA’s)”. These arrangements were an upgrade of the former “VCS” from the previous regulations and focused more heavily on the control and maintenance of the mines ventilation system, amongst other issues. This was again seen as a proactive move and well complimented by a vastly improved monitoring control system.

Another change involved a formal audit of the “Ventilation Arrangements” system on an annual basis. A copy of these audits was intended to be forwarded to the department in some early draft versions but this initial requirement was surprisingly omitted in the final legal document. Despite this, these mandatory audits have become a constructive reality check for mine operators, to assist them with both the intention and compliance of their arrangements, on an annual basis.

Notwithstanding the fact that the new 2006 regulations had given the sites far more flexibility to organise and control their own ventilation systems around a practical framework, they continued to specify the mandatory locations that ventilation quantity and gas determinations would be taken. There was minor wording changes made in relation to these locations but the requirement remained fundamentally the same as the previous regulations. The minimum specified total quantity and gas determinations required under the current regulations as generally interpreted by VOs is shown in Figure 4.

**MINE AIRFLOW MONITORING VERSUS MINE AIRFLOW MEASUREMENT AND CONTROL**

There have been substantial technological advances in telemetric capabilities over the last 30 years and there has been a metamorphosis in the monitoring requirements around the mine as a result. In the 1912 regulations the only gas monitoring referenced dealt with the mandatory requirement to monitor the return side of a longwall face along with a directive to monitor continuous miners, if seen necessary by the chief inspector. In the current legislation there are vastly improved requirements on the locations and requirements of monitors and detectors and of course a complete section surrounding the requirements of the mines’ “Monitoring Arrangements”. One can only wonder then why the technological advances in ventilation pressure measurement and ventilation modelling has not brought about a similar scale of change during the same period.
Monitoring regimes are somewhat reactive protecting the miner after a malfunction or event. This is not dissimilar to how personal protective equipment fits into the hierarchy of controls in safety systems at the bottom of the control process. Just as a methane alarm trip may protect a live electrical installation, a dust mask will protect a worker in a dusty uncontrolled atmosphere. Conversely it could be argued that to ensure that ventilation circuits are accurately delineated and then properly modelled to control the process and hopefully eliminate a hazard before it manifests itself is a far more proactive approach. In this manner the reliance on the more reactive and protective sentinel is lower, but still available as required. It is likely that the circuit that is measured, modelled and validated will surely have less reactive monitoring trips or events than one that is not.

A balance between accurate circuit measurement and control and the more reactive safety net of a monitoring system is a sensible approach.

**REQUIREMENTS TO BUILD A USEFUL VENTILATION REPORT AND MAINTAIN A MODEL**

If one examines these mandatory minimum quantity and gas requirements as summarised pictorially in Figure 4 there is no way it could be argued that this alone would be sufficient to maintain anything but the most elementary of ventilation models. The mandatory required data under the regulations will highlight both total and face ventilation flows and thus overall volumetric efficiency but will not afford the proper determination of discrete leakage paths, nor pinpoint where specific gas contamination is being contributed throughout the circuit.

Ventilation models themselves are acutely sensitive to the resistances of the roadways and it is these resistances that disburse the flow magnitudes to the particular branches. The branch resistances simply cannot be validated without taking pressure determinations. The only reference to pressure in the 2006 NSW ventilation regulations relates to a pressure gauge on the main fan. This fact suggests that the determination of not only regulator pressures but ventilating pressures in general is a requirement that is seen to be of minor importance as long as some air flows and some gas concentrations are measured. This point is well substantiated by the complete lack of the words "model", "predict" and "simulate" in the 2006 NSW ventilation regulations which demonstrates that the expected maintenance of a validated model with which to do risk based assessments on circuit changes is definitely not demanded, and possibly not even expected.

**What data is actually required to properly measure the circuit?**

The answer to this question is a relatively simple one.

**Quantities:**
- A sufficient quantity of data must be collected to delineate the total circuit flows. I.e. The ventilation surveyor needs to establish stations so that all the air entering the mine is
accounted for as either intentional flows or unintentional leakage and the magnitudes and locations of those flows is properly identified.

**Contaminants:**
- Gas determinations if taken at the above sites will provide a mine wide gas balance such that the gas contribution in litres/sec or litres/min from all areas can be identified and then monitored on an ongoing basis. (NB. This does not need to be done with chromatographic analysis if one (or better still two) accurate hand held instruments are utilised which makes it very quick and easy and accurate enough for routine trending)

**Pressures:**
- Pressure determinations at various sites are required to allow the Ventilation Officer to update the ventilation model. Without a model the pressures are of little use but definitely required if branch resistances need to be adjusted during the regular validation of an accurate ventilation model.

**Where should the quantity and gas data be measured?**

(No not that the suggested sites to measure flows and contaminants listed below ignore any mandatory statutory requirements. These must be done by law but are not dealt with again here. Only the most practical and suitable locations to enable the maintenance of a ventilation model are listed)

Regardless of the layout of the mine the selection of appropriate survey stations follows a similar pattern and a similar set of rules but a careful analysis of each individual circuit is always required.

Using the previous generic longwall layout the quantity and gas determinations should be kept simple and to a minimum number and taken at the following sites as summarised in Figure 5.

These locations detailed in Figure 5 include:

**Figure 5 - Summary of proposed quantity and gas station locations**

**Pt 1** - includes a flow determination in both main returns near shaft bottom which combined with a determination of all gases provides the total mine flow and total individual gas makes reporting to the mine fan.

**Pt 2** - includes a flow determination in both main returns just outbye the L/Wall corner which provides the total leakage in this outbye area of the mains and thus the average resistance of appliances in this zone as well. The gas make determination here quantifies the gas contribution in the main returns between the outbye side of the L/W and the shaft.
Pt 3 - includes a flow determination in the Longwall tailgate which also provides the flow from the mains headings inbye the Longwall by difference. The Longwall tailgate gas make determination similarly identifies the total gas make from the mains inbye the wall by difference.

Pt 4 - includes a flow determination in both main returns just outbye the development gate panel return which provides the total mains leakage between here and the Longwall and thus the average resistance of appliances in this zone of the mains can be determined also. The gas make determination here will calculate the gas emission between here and the longwall by difference.

Pt 5- includes a flow determination in the last line of cut throughs in the mains along with a gas make determination in the intakes which highlights the total intakes gas emission from the surface to that point. A gas determination is taken in the return which will highlight face area gas emission at time of survey.

Pt 6- includes a flow determination in the maingate panel intake which by difference will highlight the mains leakage between Pt 4 and Pt 5 and appliance resistance averages can then be determined in that area. A gas determination here in the intake and a gas determination in the return will highlight both total intake emission to the start of the maingate and total panel emission in the maingate district as well.

Pt 7- includes a flow determination in the maingate panel intake around the last line of cut-throughs which by difference will highlight the maingate panel total leakage magnitude and again appliance resistance averages can then be determined in this area. A gas determination in both the face intake and the return behind the fan will determine both the maingate intake gas emission and the face area gas emission by difference and also the total return heading emission by difference also.

Pt 8- includes a flow determination in the blind companion road which, with a gas determination will highlight seal leakage rates and overall gas emission if any.

Keep It Simple Stupid (KISS)

Although it is an oversimplified Longwall mine circuit it should be noted that the total quantity distribution in Figure 5 has been ascertained at eight different sites with a mere eleven velocity determinations at, with the exception of the face area readings, what should be established pre-existing stations. The total minewide gas balance has been ascertained with only fourteen individual readings per gas of interest. This is not a lot of underground work with most of the calculation work done not by the surveyor but by “Excel”.

The learning here is “keep it simple stupid” as you will note in Figure 6.

![Image of a schematic diagram representing a Longwall mine circuit with labels A to G and a belt indicating direction of flow.](Figure 6 - Keeping data collection fast and simple)
The writer has seen ventilation surveys with well over twice as many readings taken than were actually required which can make the difference between a one and a two day survey and the difference between sufficiently accurate data and possibly too much data to properly reconcile. If the total flow in Figure 6 is required, then Kirchhoff’s 1st law says the total intake flow equals the total return flow with no contribution from other splits. Why measure all seven or even the five intake roadways (one with a conveyor in it!!) when two accurate return flow determinations at A Hdg and G Hdg will arguably provide the most accurate determination of the total flow.

**Why and what pressure data should be measured?**

1. *Pressure determinations to quantify key resistance values in the initial establishment of the ventilation model.*

   Critical branch resistance values that normally require a one off determination may include:
   a) The Longwall face including the BSL and gate end shock losses.
   b) Shafts and unusually shaped mine entries.
   c) The resistance of the various styles of overcasts that are in use.
   d) Resistances of any falls, areas or stowage or other immovable hindrances to flow.

   Such frictional pressure losses generally need to be measured once unless the resistance changes for any reason. They are not included in the set of pressure readings required monthly to assist with the maintenance of the ventilation model.

2. *To determine in conjunction with measured quantities the frictional resistances of the various changing or dynamic circuit features at the time of survey.*

   With reference to the generic longwall circuit shown in Figure 7 locations would include:
   a) All regulators that are offering any measurable resistance to flow including supposedly “open” regulators examples of which would be at Pt6 and Pt7 in Figure 7.
   b) Any other dynamic resistance such as “weekend” style bag that may be erected across an auxiliary fan to promote duct flow during a panel flit. The writer has measured these at well over 100Pa which will substantially alter the validity of a ventilation model if missed. Another example of a critical resistance would be in a high pressure gassy mine that utilises tight tailgate corner bag to sweep air to the back of the T/G chock. The pressure on this appliance may conceivably represent 5% or greater of fan pressure on a face utilising high volumes of air. These are labelled as Pt8 and Pt9 in Figure 7.

3. *To assist with the general validation of the ventilation model.*

   Strongly advised locations include:
   a) Fan pressure which should be measured as close to the blades as practicable by direct measurement or trusted monitoring. This indicates total circuit pressure at the time of survey and the mine resistance/equivalent orifice by \( P = RQ^2 \), as shown at Pt 1 in Figure 7.
   b) Across selected stoppings which will validate total combined exhaust and intake losses directly inbye that point and outbye it by difference. Examples of these sites are shown at Pt 2 and Pt 3 in Figure 7.
   c) Across the L/W panel entry which will determine the L/W circuit resistance including the mains returns between the M/G and T/G as shown at Pt 4 in Figure 7.
   d) Across the maingate panel entry as shown as Pt 5 in Figure 7. This is the most important pressure on the most dynamic circuit and will enable the M/G panel mesh resistance to be determined and updated. This mesh resistance can be altered on the model using a minor adjustment to the roadway dimensions or k factors to ensure the modelled panel entry differential pressure is the same as that measured across the panel entry stopping during the survey.
Routine Pressure Stations

e) Random differential pressures should be ascertained at various sites around the circuit to assist with general model validation. As long as a good cross section of locations is chosen, their positions are relatively unimportant. When the returns are accessed it is wise to measure the differential pressure across the access door, which can be done in an instant with an electronic manometer. Further to this if pressure differentials are determined adjacent to quantity stations then these values can be used to validate and/or adjust the resistances of the total roadways (both intakes and returns) between these quantity/pressure station locations.

How much total raw data needs to be collected?

Obviously it depends on the size and layout of the mine. An analysis of monthly routine surveys at 10 operating mines the author has surveyed (one of which would be arguably the most complex circuit in the country) showed the following results:

- Nine out of the ten pits could be surveyed in one day by one person and the other was two full days.
- The average number of quantity/gas determinations per mine was 31.
- The average number of pressure determinations per mine was 16.
- The highest number of quantity/gas and pressure readings was 63 and 31 respectively.
- The lowest number of quantity/gas and pressure readings was 21 and 10 respectively.

All surveys gathered sufficient data to accurately validate and maintain all site ventilation models on a monthly basis.

Generation of the ventilation report after the raw data is collected.

After the collection of the raw data the rest of the report can be prepared relatively easily using linked Excel cells to update most of the pages, some examples of which are detailed below.

VENTILATION REPORT INCLUSIONS TO CONSIDER

Raw Data Notes/Base Pages

These notes form the basis of the whole report and make excellent reference material if a flow needs to be checked remotely or a ventilation change is carried out under instruction. If this is available to
the deputy underground it is a simple task to direct him to any station if required. An example of an excerpt from a base page is shown in Table 1, which may include details such as:

- Station location and cross-sectional area
- Station Identification
- Last measured average velocity
- Previous gas makes at each station
- Temperatures
- Regulator details and previous pressures

Mine Schematic

This is an extremely functional plan. It serves as a useful multipurpose tool in that when included in the ventilation report it shows details such as overcasts and regulators and summarises all the flow, pressure and even gas data collected on the base pages which is a powerful training tool for front line supervisors, deputies and undermanagers.

Both Figures 8 and Figure 9 are contrasting examples of circuit schematics generated in Excel. The level of detail is a personal choice but most of the measured quantities and pressures should be depicted on the schematic.

Table 1 - Example of raw underground data

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<th>DATE</th>
<th>LOCATION</th>
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<th>AREA m²</th>
<th>QUANT m³/s</th>
<th>CH4 %</th>
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<th>CO2 %</th>
<th>CO2 max %</th>
<th>TEMP °C</th>
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TOTAL 85 206 81

323 PANEL

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<th>QUANT (m³/s)</th>
<th>PRESSURE DROP (Pa)</th>
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<td></td>
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<tr>
<td>P3 1-Jan</td>
<td>323</td>
<td>2.42</td>
<td>13.2</td>
<td>21.8</td>
<td>500</td>
<td>measured</td>
<td></td>
</tr>
</tbody>
</table>

From a technically functional viewpoint the schematic acts as the reference tool to update the ventilation model. The model simply cannot be updated without a pictorial interface to compare the changing model to, whilst updating it.

Depending on the model validity there may be anything from fifty to a couple of thousand mouse clicks to get the model running and every single mouse click changes all the flows and pressures throughout the circuit. It is an understatement to say this would be tricky if trying to do it from a data sheet instead of a plan that is similar in layout to the model being updated. It is true that all measured pressures and flows could simply be transcribed onto a mineplan for the update process but the value of the schematic as both a communication and model update tool cannot be overstated and, as such, should be included.
Figures 8 and 9 - Examples of Excel circuit schematics

Model Validation Data and Accuracy

When the ventilation model is tuned and validated, the flow and pressure displays should be inserted in the report as evidence of the tool being updated, as detailed in Figure 10. This diagram represents the modelled flows and Figure 11 represents the modelled pressures. A sensible approach is to highlight only the flows and pressures that were taken during the survey onto the model display. This allows a simple comparison of the “as read” and “as modelled” data to assess model accuracy pursuant to the update.

Persons need not panic about the accuracy to the nth degree however as the model is never exactly a “clone” of the measured data. Its accuracy depends not just on the ability of the Ventilation Officer to update the software but also on the quality of the data set that was collected, in what was an operating mine at the time of survey.

The model update process should be likened to tacking into the wind in a sailing boat. Whilst the boat is never going exactly toward the desired direction it is always travelling in the correct general direction.

In a similar fashion the model will never exactly replicate the underground data. It is adjusted on a monthly basis to be as close to the measured data set as practicably possible. Obviously some months it will appear healthier than others and this point needs to be remembered.
Flow Distribution and Leakage Reduction:

This is the evidence that sufficient data has been collected to properly delineate all circuit flows.

The flow distribution sector charts are the living breathing proof that the ventilation surveyor knows exactly where all the air is reporting to underground, as he should.

If the route of travel and the magnitude of all underground airflows are not known then the ventilation model cannot be properly updated nor can an accurate gas balance be executed.

Figure 12 shows the intentional flows on the left which should be monitored and occasionally adjusted as required to ensure they comply with intended requirements. The unintentional or leakage flows on the right are of much more interest. This sector chart is used to continually pareto or prioritise the areas of leakage that should be addressed next.

The primary intention of leakage identification and reduction is to elevate face flows if current magnitudes are deemed insufficient.

If face flows are satisfactory then the improved efficiency brought about by the leakage improvements may afford a reduction in the main fan operating point which will save power and money. This factor is being looked at more closely due to the world economic downturn and more importantly the onset of the Rudd governments emissions trading scheme in 2010 which will see main fan power reduction become a far higher priority. The biggest drivers affecting main fan power usage are both leakage and resistance reduction. As such the VO will play an increasingly critical role in such initiatives.

Mine Gas Balance:

The total gas contribution around the circuit is made up of the individual gas makes determined around the circuit in the mine ventilation air as depicted in the simple example chart in Figure 13. The gas concentration data is simple to collect during the survey and the individual makes are flushed straight out of the raw data and the graph updated accordingly. Further diagnosis may involve plotting the changing gas contributions against seam gas contours or production rates if and as required. The gas data is of pivotal importance when estimating resultant airflows required after a ventilation change to manage the expected gas makes in the individual splits. The data collection also acts as a cross check against the mine monitoring system data.
Mine Resistance Records

The resistance data can be easily graphed so that ongoing improvements and circuit changes can be properly assessed as shown in the example chart in Figure 14. The comments on this graph help with workforce awareness of the resistance reduction campaign and the effects of the removal of circuit restrictions such as the falls and stowage detailed on the chart. Also of note is the increasing mine resistance during the leakage reduction process, which at first glance looks detrimental until the improvement in face area efficiency is taken into account during the same period. Increased face area efficiencies equate to higher face flows if required or a reduction in fan duty and subsequent cost reductions, if face quantities are adequate.
Fan Performance Records

These details are often discounted as irrelevant but the data can be read straight from the monitoring screens at most mines and forms a detailed history of fan flow, fan pressure, input power and mine resistance at any point in time. Typical data is detailed in an example in Table 2. More importantly if there is no fan curve available the data can substantiate the operational part of the curve over time as shown in Figure 15.

Table 2 - Fans and flow summary

<table>
<thead>
<tr>
<th>SOUTHFORK MINE</th>
<th>MARCH 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No 1 Fan Running</strong></td>
<td><strong>MINING AIRFLOW SUMMARY</strong></td>
</tr>
<tr>
<td>Airflow</td>
<td>96 m3/s Monitoring</td>
</tr>
<tr>
<td>Fan Speed</td>
<td>450 rpm Monitoring</td>
</tr>
<tr>
<td>Current</td>
<td>341 Amps Monitoring</td>
</tr>
<tr>
<td>Voltage</td>
<td>311 Volts Monitoring</td>
</tr>
<tr>
<td>Power</td>
<td>145 kWe Monitoring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>No 2 Fan Running</strong></th>
<th><strong>FACE AREA VENTILATION EFFICIENCY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow</td>
<td>97 m3/s Monitoring</td>
</tr>
<tr>
<td>Fan Speed</td>
<td>455 rpm Monitoring</td>
</tr>
<tr>
<td>Current</td>
<td>306 Amps Monitoring</td>
</tr>
<tr>
<td>Voltage</td>
<td>313 Volts Monitoring</td>
</tr>
<tr>
<td>Power</td>
<td>136 kWe Monitoring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Shaf Filler Pressure</strong></th>
<th><strong>PANEL AIRFLOW EFFICIENCIES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1550 Pa</td>
<td>MIG Efficiency from entry to last line</td>
</tr>
<tr>
<td>Mine Resistance</td>
<td>0.64578 Gads</td>
</tr>
</tbody>
</table>

Ventilation Gas and Drainage Gas Contributions

If the mine has an active gas drainage system and the drainage circuit flow data is readily procurable then the values of the gases detected in both the ventilation circuit and the drainage circuit can be easily tracked on an ongoing basis as shown in Figure 16. Further to this, the performance of the drainage circuit can be monitored in a similar manner to the mine resistance performance as shown in Figure 17 “Drainage capture by %.”
Other Inclusions of Interest

Any interesting ventilation related information should be included in the report to maintain the interest of the reader and to assist with their understanding of a particular topic.

Such inclusions are only limited by the Ventilation Officer’s imagination but some examples are shown grouped together in Figure 18. The value of such inclusions cannot be overstated given their influence on the overall “readability” and thus ongoing circulation of the finished document.
THE VALUE OF SHARING THE INFORMATION WITH THE WORKFORCE

The supervisors such as deputies and undermanagers are the people with the frontline responsibility of ensuring the safety of the workforce underground. Management must supply them with the appropriate resources to do this and training is a significant part of that. If management decides it is worthy to freely distribute the report, the challenge then is to make the report interesting enough for people to actually read it. It may not be totally appropriate from a protocol point of view but personalising the report to a level where individuals are sometimes mentioned along with such things as commenting on raised or lowered standards and attributing that to particular groups guarantees that the report will be very widely read. If it is widely read and contains information that teaches people particular skills and knowledge, then it becomes an ongoing free training tool that will substantially enhance the ventilation knowledge of the employees over time.

The writer is convinced of this value having seen its worth over nearly six years at a very transparent Bowen Basin mine that clearly has no secrets. Whilst difficult to objectively measure it is very apparent that the general ventilation knowledge and resultant respect for the circuit from the supervisors at that site has been well elevated during that period.

CONCLUSION

Regulatory updates have made significant inroads into elevated safety levels in our mines over the last 30 years and the resultant changes to ventilation control processes and systems have been very beneficial in that regard.

Unfortunately though, varying levels of interpretation and understanding have clouded those regulatory intentions to some degree and as such there is a myriad of different interpretations about what constitutes a reasonable compliance with adequate process control in relation to the ventilation systems in our mines. Some operations measure and delineate their circuits on a monthly basis and use an operational ventilation model as a tool with which to do risk based assessments on any intended circuit adjustments. Other more normally benign operations collect the minimum of data and utilise no ventilation modelling at all and the variability is as distinct as that.
One intention of this paper was to demonstrate that the data collection can be a lot simpler than some may think and whilst the specifics of model updates were barely touched on, most ventilation officers will have more than enough ability to maintain their own models if given the time and resources to do so.

It should be remembered also that if the ventilation report is properly configured a considerable amount of useful output will be created for what is not a begrudgingly large amount of input. In a short period of time the mine will be controlling the ventilation circuit rather than the ventilation circuit controlling the mine.
Finally one of the key learning’s in thirty years of waving the wand is that site people really are interested in how it all works. It is not a black art and nor should be treated as such. Take the opportunity at all cost to utilise the ventilation report as a training tool and spread the word. Sure they find mistakes in it!! The author has been notified about those on many occasions but they have been the most satisfying conversations ever because it is concrete proof that it is actually being read, by the people that really matter.