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MVA Technical Guidance Note:

Structure of the Mine Ventilation Department and the Role of the Ventilation Engineer (VE) and Ventilation Officer (VO)

1.1 Setting up the ventilation department in an underground mine

The size and capability of the mine ventilation department depends on a number of factors, especially:

- The size of the operation—larger operations will need more than one VO and therefore some structure to the vent organisation to provide the necessary coordination
- The nature of the ventilation hazards—operations with significant hazards (radon, methane, etc) will need more experienced and better trained staff. In addition, some operations may require ventilation staff not only on call, but actually on site 7 days per week, or even 24/7.
- The range of responsibilities of the vent department. Some mines want the vent department to take on “ancillary” roles such as dust, noise or DPM monitoring, management of the site working-in-heat protocols, energy savings/audits, company representative on various regulatory reviews, etc.
- The stage of mine life. A mine that is starting up or embarking on a major development or construction program will probably require more ventilation staff that one where the mine is in a “steady state” mode.
- Whether the workforce is domiciled at a nearby town or is a FIFO. If FIFO, then some person on site will need to provide ventilation input over the full roster coverage. If domiciled locally, then perhaps having the vent staff on an “on call” basis with a “call-in” roster may be sufficient.
- Staff development policies—whether it is company policy to rotate inexperienced engineers through the role of VO (i.e. graduate development/rotation) or not.
- Recruitment and retention issues—recruiting and retaining capable and experienced ventilation staff is expensive not only for the salary package, but also such staff will want (and need) to attend professionally relevant conferences, peer networking opportunities and training to stay up to date with their skills. They are also likely to want new technical challenges from time to time and also a career path. Otherwise they will inevitably be “poached” by other organisations and much of the mine’s investment is wasted.
- Whether the ventilation staff report to the mine planning department or the mine operations department. There are advantages and disadvantages of both approaches. If reporting to the operating department, the vent staff may have easier access to mine workers, supervisors and management and perhaps resources to install or maintain fans, ducts and vent controls; however, “ventilation” may be a relatively low priority to the operations manager in which case they may struggle to get sufficient priority. If reporting to the mine planning department, they should have good input into future mine designs and schedules, but may have a more adversarial relationship with the mine operators.
- The role of the ventilation department in the event of specific mine emergencies such as an underground fire, sulphide dust or methane explosion, etc. If the incident management team requires competent on-site ventilation support, then that must always be available.
- The split between how much ventilation competence is retained on site versus available off-site

Fundamentally there are three satisfactory models for a ventilation department on a mine site:

- Retain the minimum possible ventilation support on site (usually a graduate engineer with no prior ventilation experience), backed up with a competent and experienced Group Ventilation Engineer, probably based in a major city and servicing all of the mines in that Group. The Group Ventilation Engineer needs to not only be called in “as required” by the site VO (i.e. on a reactive basis), but needs to take some pro-active technical oversight of the ventilation standards at the mine, as well as reviewing mine designs and schedules etc. It would be normal for him to have a site visit every 2 to 4 months (depending on local factors) for an inspection, discussions, reviews of mine plans, mentoring of the site vent staff and planning team, etc. The Group VE not only provides technical support, but also helps with recruitment or appointment by internal transfer or development of new ventilation staff (as required), and provides the longer-term focus and coordination as ventilation staff come and go through the mine.

- Retain the minimum possible ventilation support on site, backed up by a longer-term relationship with a suitable ventilation consultant. In this case, the consultant takes on the role of the Group Ventilation Engineer.
- Develop a self-contained ventilation department on site, which, for a larger operation, may consist of a Ventilation Superintendent (5 to 10 years experience, including management experience), a Ventilation Engineer (2 to 5 years experience, provides technical support and stands in for the Vent supt when away), and several ventilation officers (some of whom could be graduate mining engineers doing a rotation through the ventilation department). For a smaller operation, the department may consist of a senior ventilation officer (the section supervisor), a graduate mining engineer and at least one ventilation officer.

One advantage of the above approaches is that most or all of the company’s graduate mining engineers get experience in mine ventilation, under the mentoring of an experienced ventilation professional, and therefore gain some valuable skills and a positive outlook on ventilation, that will be valuable to them in the future whether they go into a mine planning, mine operations or specialist role.

Less satisfactory, or unsatisfactory, models include:

- An inexperienced site engineer in the role of ventilation officer with no competent technical support or technical oversight on or off site
- An inexperienced site engineer in the role of ventilation officer with no competent on-site support and who must, only on the basis of his own *in*experience, determine when to bring in outside specialist advice (and then justify this to management)
- An inexperienced site engineer in the role of ventilation officer “backed up” by a site senior mining engineer or operations manager, unless the senior mining engineer or manager *is a competent ventilation engineer in his/her own right*

These models are unsatisfactory because the graduate engineer is left with the only option of learning by his mistakes, which can be unsafe in many cases, expensive for the operation, result in morale problems for the workforce or unnecessary conflict with management, and embarrassing for graduate. The result of these models is that the engineer is left with a poor understanding of ventilation, poor habits and unacceptable or poor ventilation standards (as well as a poor attitude) as he then progresses into other roles.

Irrespective of how the reporting relationship is set up, it is vitally important that the mine vent staff have good input into both mine planning and mine operations, and have the respect of both. However, respect is earned not demanded, and comes about by being highly competent and therefore providing good, well-regarded advice and being seen to “add value”. In turn, this means the ventilation department must have the required range and depth of skills and experience to handle the routine ventilation problems of the mine.

The ventilation staff (or at least the vent supervisor) must also have sufficient confidence and maturity to recognise when the operation needs some external input (e.g. from specialists) or additional temporary resources and be prepared to negotiate with management to ensure these are provided in a timely manner.

It is also very important that each person on the ventilation team has a clearly written job description so that accountabilities are clear, and that all legal regulations and companies policies are covered within the range of job descriptions of the vent team.

1.2 Training regimes for ventilation staff

A competent ventilation professional will have:

- Sound understanding of ventilation theory, usually from a formal education supplemented by specific specialised ventilation courses
- Mentoring under the influence of an experienced competent ventilation person. This can either be achieved on site (if the mine has such a person) or at a different mine site by recruitment or by a secondment
- At least 2 years (preferably 5 years) of practical experience in the role of an area ventilation officer or ventilation engineer attached to a competent ventilation department

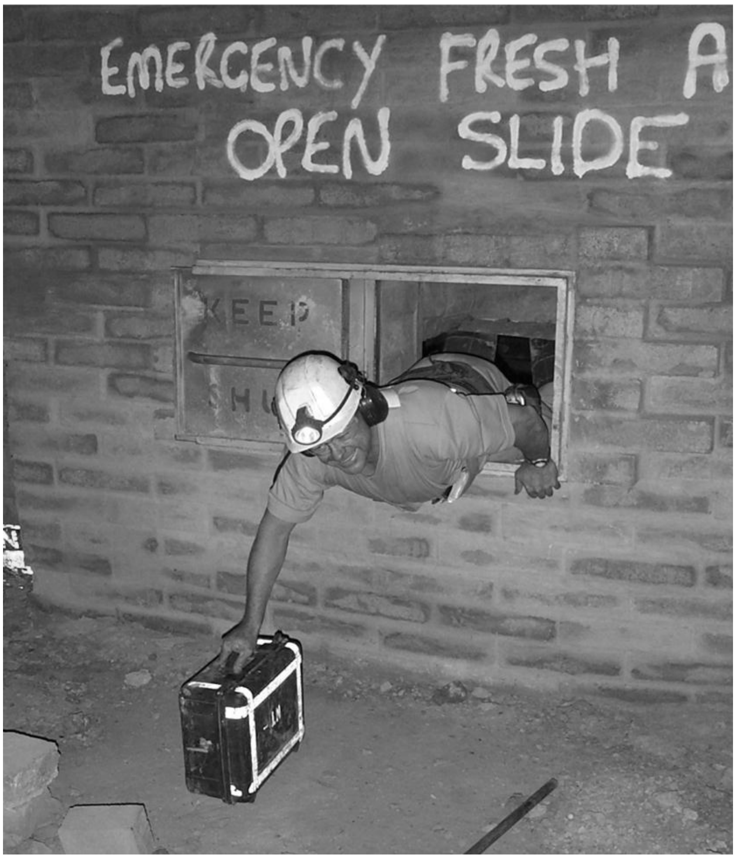
1.3 Typical job description for ventilation officer

It is critical for the ventilation officer to be aware of the various standards and requirements of his job. He must also have the technical knowledge, experience and personality to be able to "stand up" to others in the operation (including management) who may, for various reasons, wish to adopt poor ventilation practices.

It is very important for the ventilation officer to always be "on the front foot"; otherwise the ventilation suffers, he loses credibility and the operation ultimately suffers from a ventilation plan that is technically poor or poorly implemented. Too often, mining operations are continually in "reactive" mode on ventilation: a problem occurs seemingly without warning, "bandaid" solutions are found that at least make the immediate problem go away. However, in many cases the underlying problems are not addressed and subsequent issues are then worse.

As a general rule, it is wise to adopt the highest "good practice" standards and then, and only if necessary, to back off and adopt a lower standard. Never agree to any practice that is illegal and if you are requested to adopt any practice that does not meet accepted industry standards, you should always notify the manager of this and, if he wishes to proceed, obtain his written instruction to continue along this path. This may need to be tactfully done; but written instruction to adopt anything other than good practice is essential, particularly when it comes to health and safety, of which ventilation (including safe egress) is a critical area.

Figure 1 Duties over and above the call of duty are sometimes required of the VO!



1.3.1 Safety issues for a ventilation officer

It is very important for the ventilation officer to observe the same safety protocols as anyone else in the mine. It is not uncommon to find ventilation officers who believe they are "above the law" in terms of entering hazardous travelways without following procedures, etc. This can result in "close calls" and even tragedy.

It is best when doing anything other than routine ventilation work in safe areas to take someone else along, and to maintain radio contact or have some other sort of pre-arranged procedure, such as personal tagging.

An example of a fan test that went wrong (the Pitot tube got caught in the surface fan blades) is shown in Figure 2!

__Figure 2 Safety in the workplace__

1.3.2 Recommended minimum duties for a ventilation officer

a) All statutory duties

b) Workplace environmental checks (temperatures, dust, gases, anything else in the environment underground that is a ventilation related hazard)

c) Checks on mine daily logs (e.g. dust reports, temperature reports, fan outages)

d) Volume surveys

e) Gas surveys, including face re-entry times

f) Diesel engine gas checks (exhaust)

g) Fan performance tests

h) Fan repair records for each fan, including motor history

i) Fan database (record of where each fan is, etc).

j) Monthly benchmarking reports (Key Performance Indicators (KPIs), ventilation cost performance, etc)

k) Stock levels for all ventilation items (e.g. ducts)

l) Checks on unventilated headings for barricades and signs

m) Diesel unit database (height, width, travelling speeds on flat and up/downhill, engine kW, engine type, fuel consumption, etc)

n) Record of ventilation-related standard drawings for the mine (e.g. DBRs, vent doors, bulkheads, fan installation)

o) Record of heat illness incidents including location, temperatures, wind speed, etc

p) Plans for ventilation power saving (e.g. switching fans off)

q) Ventilation job sheets (ventilation construction and repair work)

r) Records of all fan and other purchase requests

s) Fire plans, escape routes, high risk areas, copies of emergency procedures (fire, power failure, etc) as affects ventilation officer duties. Call-in systems.

t) Location of electrical reticulation system in regards to fans affected by various sub-stations, etc (see handout)

u) Ventilation future design schematics or process flow diagrams (PFDs), particularly for the following summer period, which is usually the most stressful time on the mine's ventilation system (see handout)

v) Ventilation changeover "cartoons" [schematics]; these are basically to ensure coordination between different groups (e.g. electrical contractors, civil contractors, mining crews—in heavy congested areas where the ventilation capacity is limited) (see handout)

w) Update and issue small-scale ventilation circuit plans to operators, control rooms and cribrooms, etc regularly

x) Ventsim models carefully documented and named

y) Pressure drops across key fans and ventilation controls

z) Review mine design plans or design layouts for ventilation issues

aa) Review mine schedules for any activity that needs to be ventilated

bb) Forecast fan and power requirements (at least yearly)

cc) Primary fan performance (checked daily assuming the information is telemetered)

dd) Refrigeration plant performance (checked daily assuming the information is telemetered)

ee) Underground cooling device performance (e.g. cooling towers)

ff) Surface WB/DB temperature profile

gg) Company and statutory standards relevant to ventilation work, including noise requirements, etc

hh) Participate in risk assessments that may have a ventilation related component

ii) Participate in incident investigations that may have a ventilation related component

jj) Other records as required (e.g. noise, dust, illumination)

1.3.3 Annually or longer timeframe

a) It is vital that you as the ventilation officer know what "lead time" exists on the various sorts of ventilation decisions that may need to be made in the future. For example, say the lead time to investigate and design a new ventilation shaft to the surface and then develop a raiseboring specification, issue, evaluate and award a tender, and then for the contractor to mobilise to site and complete the entire job is 12 months, then you need to have your "feelers out" for this sort of decision at least 12 months in advance. If the shaft then needs a fan installed, then perhaps the total lead time may be closer to 18 months or two years. For conventional shaft sinks with major surface or underground fans, the lead time might be three years. This means that you need to be reviewing the longer-term plans and inputting these into Ventsim so that if there is a need for a new shaft, that you can "get the ball rolling" in sufficient time for the shaft to be completed and operational before it is needed.

b) Likewise, you need to be aware of the lead-time on supply of booster or auxiliary fans so that, if these are required, then they are on-site before they are needed.

c) Clearly, you also need to be familiar with any statutory requirements that must be complied with annually.

1.3.4 Quarterly

a) All statutory duties

b) Install revised/updated ventilation circuit plans in appropriate locations, e.g. surface or underground notice boards.

c) Produce updated Fire Plans and circulate in accordance with Fire Emergency procedures

d) Audit primary ventilation airflows and perform other audits as arising from Risk Assessments and Company safety and health standards. Measure leakage, high resistance regions (e.g. blockages) and air recirculation, if any. Issue ventilation job sheet for defects to be rectified and keep track of outstanding jobs.

e) Audit key components of the safety system with respect to ventilation, especially egress. Conduct audit of all Fresh Air Bases (number, location, standard), Fire Refuge Bays (number, location, standard), Refuge Chambers, Escape Routes (access, signage). Produce document on recommendations, defects, etc.

f) After discussion with other responsible persons, tune underground cooling towers and other cooling devices [twice yearly: going in to wet season, and going in to dry season].

g) Accompany testing officer or occupational hygienists on Legionella checks, dust monitoring etc

1.3.5 Monthly

a) All statutory duties

b) Collate designated KPIs and provide designated portion of Monthly ventilation report

c) Ensure gas testing of diesel units' exhausts is carried out in accordance with legislation. Obtain copy of records and file in binder.

d) Perform tests on selective headings: Gas test development faces when mucking in progress and also after firing for re-entry times, concentrating especially on headings which are "firing anytime" (independent firing)

e) Measure pressures at key fans and across key bulkheads and record and file information

f) Update Fire Plans (by hand annotation) so a set is always up to date for an emergency

g) Implement power saving measures as required

h) Perform audits as required by company safety and health standards

1.3.6 Weekly

a) All statutory duties

b) Produce a weekly prioritised ventilation work list, attend weekly ventilation meeting with ventilation team.

c) Attend weekly planning meeting or other weekly meetings as required. Come prepared to answer all reasonable questions at these meetings.

d) Review all mine designs (stope designs and other) as issued and ensure ventilation will meet standards.

e) Maintain ventilation circuits (direction and volumes) on "master plans" on wall in vent office. Update development metres (plot new face locations) on wall plans fortnightly or more often for headings which are close to breakthrough or otherwise need more frequent monitoring

f) Anticipate breakthroughs and schedule necessary work to maintain vent standards and minimise disruption to operations after the breakthrough has occurred

g) Maintain "pin board system" (or equivalent database) in which every fan is identified, including its location (u/g, in surface fan stockpile, in surface workshop, etc), fan number and voltage

h) Visit fan repair workshop and fan storage yard to stocktake fans and fan parts (all identified separately, including locations). Update fan status board in ventilation office.

i) Update fan and dust filters database.

j) Monitor stock levels of vent equipment, especially fan parts.

k) Reviews all mine record book entries, copies and files any relevant to ventilation and follows up with written reports.

1.3.7 Daily

a) All statutory duties

b) Picks up printouts from Mine control room (or views screens) of performance of ventilation system: status of surface and u/g fans last 24 hrs, status of WB, DB, CO monitoring, performance of surface and u/g refrigeration plant (MW(R) sent u/g, etc) including u/g cooling towers.

c) Inspect Mine Control log for ventilation issues: heat illness, dust reports, etc.

d) Picks up ventilation record sheets (hot jobs, stop jobs, temps, heat illness reports, dehydration tests)

e) Reviews data, discusses ventilation problems/issues with relevant stakeholders

Goes Underground:

f) Visit workplaces u/g (each workplace at least twice per week).

g) Follows up on hot job, stop job, safety report sheets, reports of gas or fumes, workplaces which resulted in heat illness or reclassifications and dust reports within 48 hours

h) Measure/audit vent parameters at workplaces. At least: WB, DB, CO, WS, Airflow, evidence of leakage and recirculation esp at underground fans

Back on Surface:

i) Picks up printout from weather bureau of climatic outlook (WB, DB, BP) for next three days (where applicable)

j) Notify Ventilation Coordinator and Mine Manager immediately of any breach or impending breach of the Mines Regulation Act.

k) Notify relevant stakeholders daily of any defects or impending defects of the safety and health standards or ventilation standards.

l) Completes Daily Ventilation Report and issues as required.

m) Files all paperwork in relevant binders

n) Where a serious safety incident occurs (Lost time or High potential), measures (or has measured by responsible person) environmental conditions on the job and notes standard of ventilation on the job. Puts in report to ventilation coordinator. Contributes to accident/incident investigation as required.

o) Liaises with key customers and colleagues (other ventilation officers and mine superintendents) at least three times per day and mine managers at least once per week. Maintains ventilation log (diary) of all key points from all conversations, meetings attended, etc.

p) Maintain database of "TO DO" and follow-up items using work diary. This effectively forms a continuous "handover" sheet.

q) Record key conversations and notes in work diary. Confirm all key items in writing with the parties to the item.

1.4 Recommended activities done by or involving specialists

a) Shaft resistance (barometric pressure) surveys

b) Design of mine refrigeration, gas drainage or other specialist systems such as outburst, spontaneous combustion, etc

c) External audits of systems, procedures, etc

d) Occupational hygiene measurements such as silica dust, DPM

e) Mine egress where they involve variations to accepted "good practice" standards

f) Checking the calculations or ventilation model etc on which any decision with consequences costing more than $0.5 million is concerned. This would include major fan purchases, new ventilation shafts, etc

g) Main fan performance tests or any other performance test (e.g. refrigeration plant) where the vendor has provided a warranty or where a commercial dispute could subsequently arise and any expert witness testimony is required

h) Accident/incident investigations where ventilation could have been a contributing or relevant factor and there could be significant financial or technical consequences for the company

i) Auditing internal ventilation or ventilation-related safety or health standards or hazard management plans.

1.5 Control of the ventilation system

1.5.1 Designated Authorities to alter ventilation system

Adjustments to the ventilation system can easily fall into the trap of "too many cooks spoil the pie". It is very important that it is clear as to who is authorised to do what! This is particularly true of the actual ventilation system itself (i.e. the physical ventilation system including fans, controls, etc). One method of achieving tight control over the ventilation system is to divide ventilation system changes into three groups, as shown in Table 1. Note that the typical examples of "minor", "moderate" and "major" can vary VERY significantly between mines, depending on the potential hazard that could be created with each change.

Table 1 Control of ventilation system by division of changes into categories

Authorised Person	**Shift supervisor**	**Ventilation officer**	**Underground manager**
Type of change to system	**Minor**	**Moderate**	**Major**
Examples	Breakthrough/cut-through in a development area Building a stopping in a development area	Change in the primary ventilation network Commissioning or removal of an airlock between intake and return Change in setting of a regulator Installation or relocation of an underground fan	Changing a roadway from intake to return or v/v Sealing off an area of the mine Any change that will have major (>20%) impact on mine resistance Adjusting the main fan Stopping the main fan or running on only one fan

1.5.2 Fan blade pitch angles

It is important that fan blade angles be adjusted in accordance with manufacturer's recommendations. If necessary, obtain a copy of these instructions from the manufacturer. Do not set the blade angle to too "aggressive" a pitch, or the fan motor will be overloaded. Keep careful record of the blade angle for later reference. Take a PHOTO of how the blades were set so that this can always be checked at a later date, if necessary. Once the fan is running again, check the motor amps to ensure the motor is not being overloaded.

1.5.3 Process Flow Diagrams and Schematics

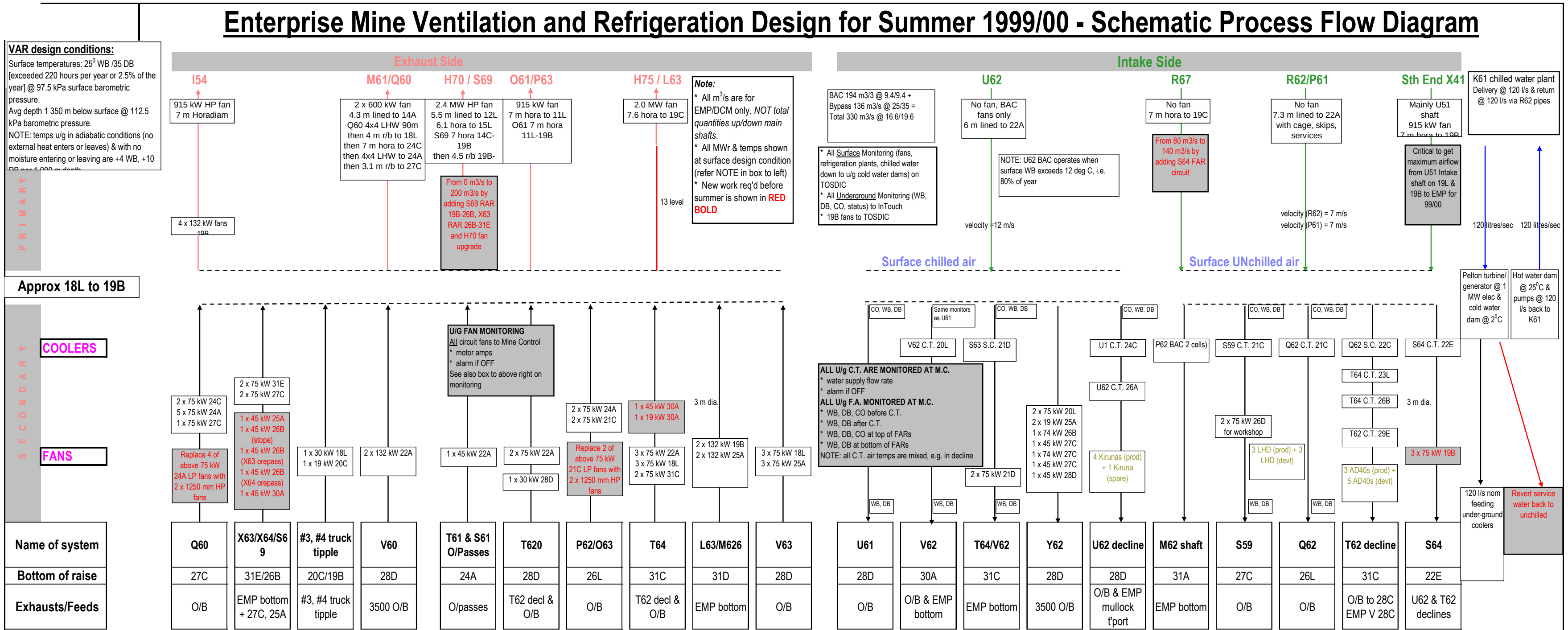
It is highly desirable for the ventilation officer to be able to obtain both "ownership" from all stakeholders and formal consent from line managers for your ventilation strategies, and then to be able to *maintain* awareness of what needs to be done as the plan unfolds.

A very helpful way to achieve this is to come up with a one page (typically A4 or A3) colour schematic that shows how the ventilation of the mine will be implemented at some future "snapshot" in time. As summer is typically the period that the ventilation system is under most strain, it is wise to create this snapshot for at least each summer.

The best time to do this is typically the February prior to the summer in concern (this assumes Southern Hemisphere). The financial year for most Australian mining companies is from July to June, and the budget process typically starts in about February or March. Clearly a ventilation strategy needs to be in place for the following year before the budget process gets too far underway, as there will be capital costs for additional raises, fans and other equipment. Furthermore, ventilation staff are typically very busy from late September until early in the New Year as summer approaches and the ventilation system struggles under the impact of getting back into shape from its winter period. Therefore January is often the first time that the ventilation system can be examined for the following summer in significant detail. Note, however, that if items have a lead time of more than a few months, then you will need to develop a PFD for the next two summers. This is because if funds cannot be spent until the "new year" starts in July, then this will be insufficient time to get any substantial new raise or fan installed in time for the coming summer.

Examples of PFDs are shown in the figures below:

Figure 3 Overall ventilation and refrigeration PFD



AIRFLOW BALANCE

Primary			Secondary		
Exhaust	**98/99**	**99/00**	**Exhaust**	**98/99**	**99/00**
I54	270	270	Q60 24A	100	100
M61	280	280	Q60 24C	90	80
P63/O61	400	350	T62 22A	20	20
H70/S69		200	R61	20	20
H75/L63	130	130	T620	80	70
Total	1080	1230	V60	130	110
Intake	**98/99**	**99/00**	P62/O63	95	90
U62	330	330	T64	120	115
R62/P61	420	400	V63	120	120
R62/M62		100	L63	130	130
South End/X41	250	190	S69		200
R67	80	210	Unchilled air top of mine	175	175
Total	1080	1230	Total	1080	1230
Unchilled air consists of:			**Intake**	**98/99**	**99/00**
19B winder		20	T64	100	100
20C belt		35	V62	130	130
20L M62 shaft		15	U61	90	60
19B dust extraction		65	Y62		100
21L belt		40	M62	40	160
Total		175	S64	170	140
			S59	60	45
			Q62	80	70
			Declines (fed from R62)	235	250
			Unchilled air top of mine	175	175
			Total	1080	1230

AIRFLOW ALLOCATION

Supt or Area	Air allocation
M62 complex, top and bottom (all unchilled)	110
Fixed plant installation	85
23 Fill horizon	40
25A S63 north drive (truck devt)	40
Other Unchilled Ore Handling	65
Development	355
Production drilling	30
Ringfiring	45
Production mucking	75
Stope filling	20
Diamond drilling	15
Raiseboring	30
Misc drilling & prod services (incl elsewhere)	
Timbermen	25
27C workshop	45
Declines (split evenly)	250
GRAND TOTAL	1230

UNDERGROUND COOLING TOWERS AND TEMPERATURES

Device	water flow	Air in temp WB	Water in temp	Airflow thru CT	Bypass airflow	Total airflow (incl bypass)	Mixed Air out temp WB	Refrig kWr
20L M62 BAC	35	27.5	7	104	56	160	24.5	2,638
21D S63 SC	5	24.5	5	50	50	100	23.2	335
21C S59 CT	5	27.5	9	40		40	26.3	335
21C Q62 CT	6	27.5	9	130		130	27.4	402
22E S64 CT	20	22.7	8	60	80	140	25.9	1,424
22C Q62 SC	4	26.5	9	20	45	65	26.2	251
23L T64 CT	9	27.5	10	30	50	80	25.6	528
24C U61 CT	8	25.5	11	30	80	110	26.2	435
26B T64 CT	7	27.5	11	20	80	100	26.2	381
20L V62 CT	4	25.5	9	30	70	100	23.5	201
29E T62 CT	4	25.5	12	20		20	24.8	201
26A U62 CT	8	26.5	11	20	80	100	27.0	469
23E P45 SC	4	30.5	13	30	20	50	27.2	201
20L control rm	1							
Service Water	Nil							
TOTAL	120	Net cooling after "coolth" losses in pipes, dams etc						7,897

NOTE: Changes to this document are subject to SH&E "Plant modifications"

NOTE: All underground refrigeration machines use R22 refrigerant, which is colourless, non-toxic, non-flammable, insoluble in water, and has a faint ether odour. Surface refrigeration machines use ammonia, which is highly toxic. Special precautions for design and operation apply.

Additional fans associated with M62 ore handling system, to be installed before commissioning:
1 x 45 kW & 1 x 19 kW M626 RAR 30C to exhaust V63 belt
1 x 45 kW fan M626 RAR 31E to exhaust transfer belt
1 x 19 kW fan V63 conv access 31E to feed FA to picking belt & 1 x 19 kW fan T6361 RAR 31E to exhaust picking belt
2 x 22 kW fans 30A to feed fresh air to south side of tipple, 1 x 45 kW fan 26B to exhaust X64 orepass
1 x 19 kW fan 31E U63 RAR for drawpt exhaust, 1 x 19 kW fan 31E T6365 RAR for crusher jaws, 2 x 22 kW fan 31E T63 RAR to exhaust 30A tipple
2 x 45 kW fan 20L M61 RAR to exhaust skip tipping, 2 x 1.5 kW fan 20L M62 shaft for winder chamber exhaust, 1 x 45 kW fan L63 h/w drive 19B to exhaust M62 sub-station

Distribution: Date: 21 May 1999
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Figure 4 Refrigeration Plant PFD

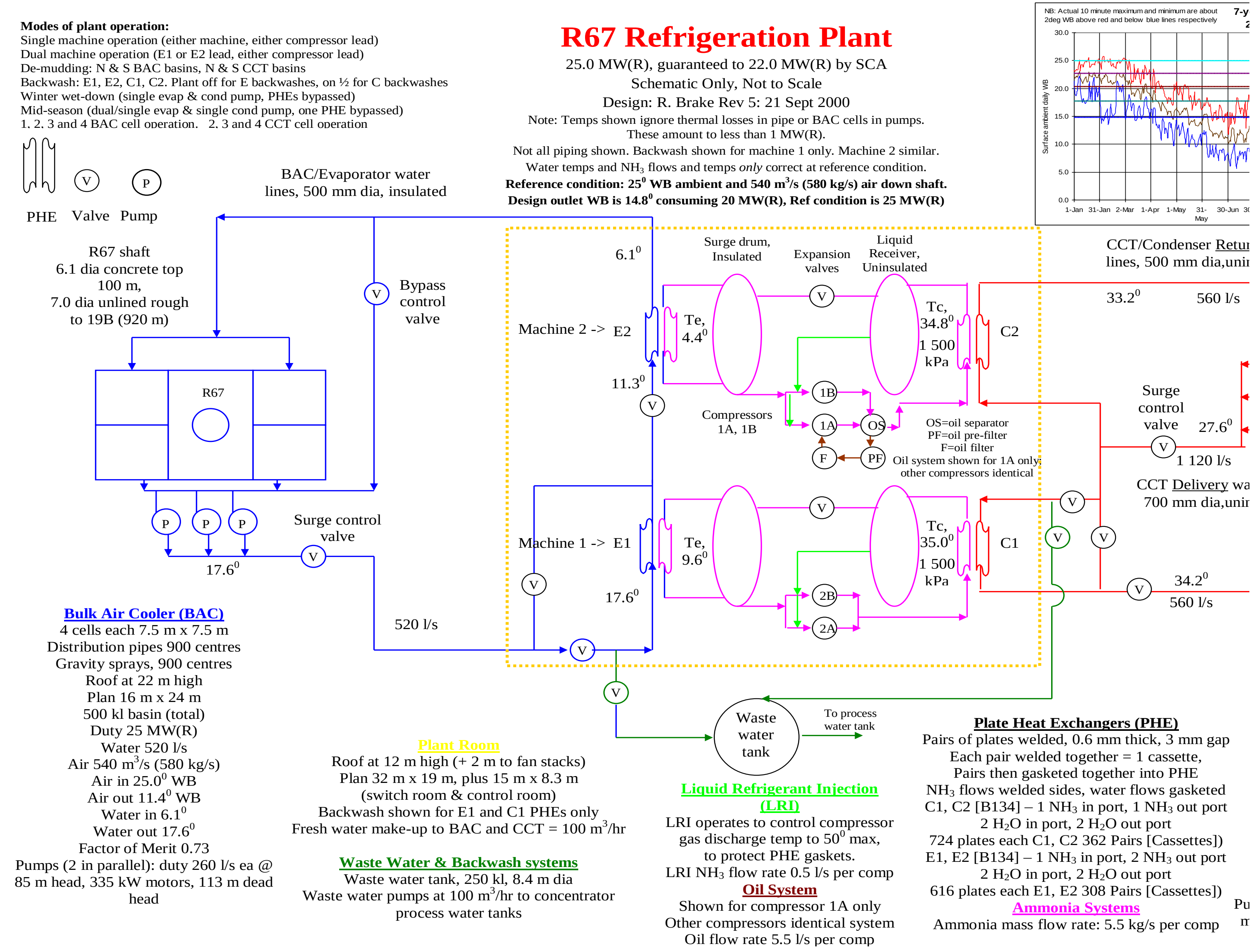
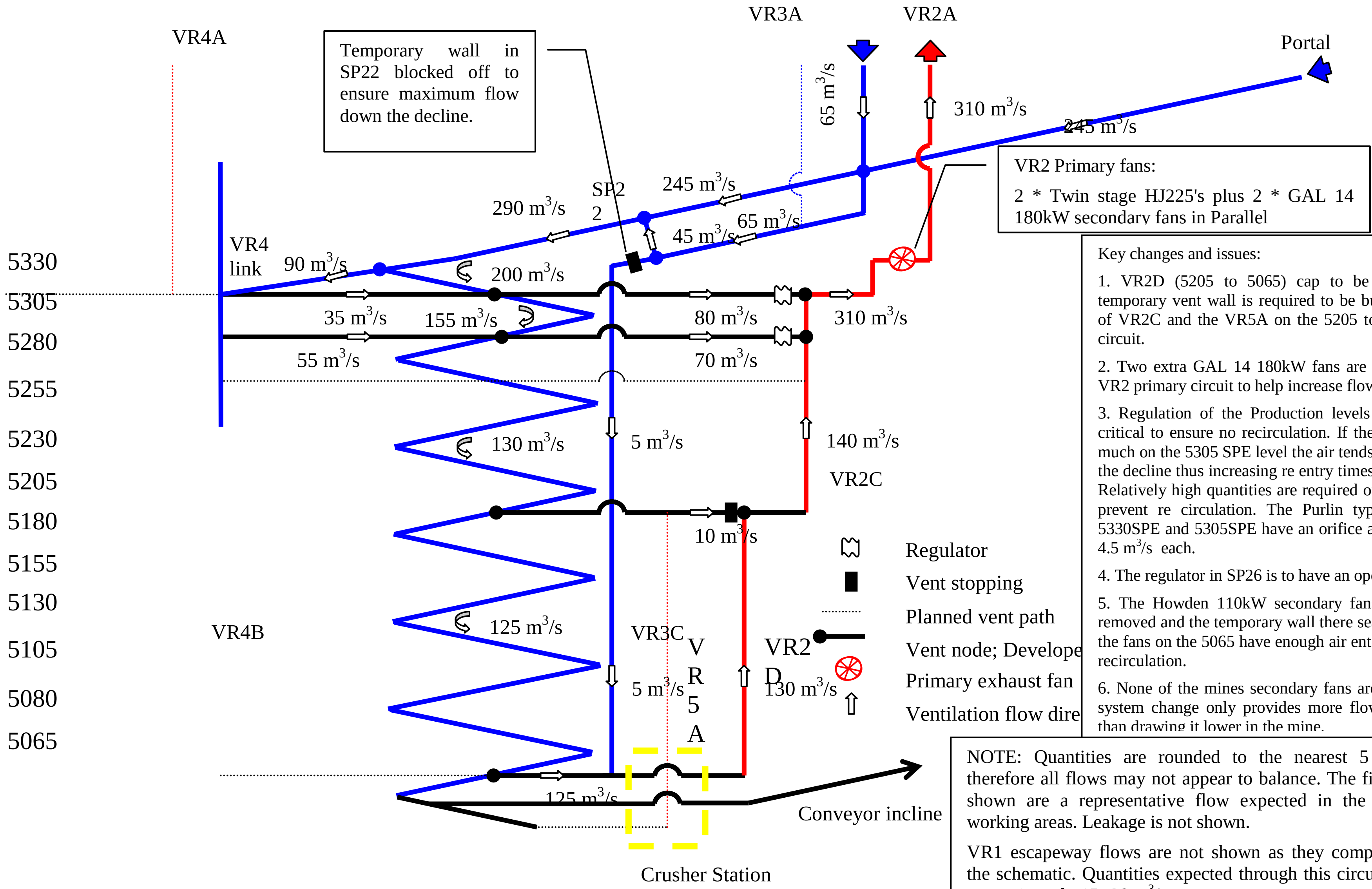


Figure 5 Example of schematic PFD for airflow circuit changes



Key changes and issues:

1. VR2D (5205 to 5065) cap to be blasted through. A temporary vent wall is required to be built between the base of VR2C and the VR5A on the 5205 to complete the lower circuit.

2. Two extra GAL 14 180kW fans are used at SP 21 in the VR2 primary circuit to help increase flow.

3. Regulation of the Production levels (5330 and 5305) is critical to ensure no recirculation. If the flow is restricted to much on the 5305 SPE level the air tends to exhaust back onto the decline thus increasing re entry times for the capital areas. Relatively high quantities are required on these levels to help prevent re circulation. The Purlin type regulators on the 5330SPE and 5305SPE have an orifice area of approximately 4.5 m^3/s each.

4. The regulator in SP26 is to have an opening of 0.5 m^2.

5. The Howden 110kW secondary fans in SP22 are to be removed and the temporary wall there sealed. This will ensure the fans on the 5065 have enough air entering them to prevent recirculation.

6. None of the mines secondary fans are to be moved as the system change only provides more flow to the 5065 rather than drawing it lower in the mine.

NOTE: Quantities are rounded to the nearest 5 m^3/s therefore all flows may not appear to balance. The figures shown are a representative flow expected in the main working areas. Leakage is not shown.

VR1 escapeway flows are not shown as they complicate the schematic. Quantities expected through this circuit are approximately 15 -20 m^3/s.

1.5.4 Key Performance Indicators (KPIs)

KPIs will vary according to the particular issues at each mine site. Some guidance on developing KPIs is provided below:

Key issues for KPIs:

Try to make KPIs positive rather than negative (e.g. items complying rather than items not complying)

Involve the people doing the job in compiling the list of KPIs

Involve internal and external customers in compiling the list of KPIs

A relatively poor measure of a key customer requirement is much better than a technically precise measure of something the customer really doesn't care about

Each KPI should relate to one key "output" only (an output being a deliverable of the ventilation system)

KPIs should, wherever possible:

- Accurately and consistently measure the parameter to monitor
- Be easily understood by others
- Be simple to collect
- Be timely – able to allow a response to influence the outcome
- Be reproducible, and
- Readily relate to the aspect to be controlled and/or goals set

Key issues for Targets:

- Focus on high impact targets (some targets have much greater "payback" than others)
- Do not set a target for each KPI (too many targets)
- A comprehensive plan must be developed to address each target (i.e. to achieve the target)
- Must be a single accountable person for each target

Typical KPIs for a ventilation officer in a hardrock mine could include the following:

- Volume flow through mine, m^3/s
- Tonnes ore, waste, fill
- Volume flow (m^3/s) per tonne produced (ktpa), etc
- Total electrical kW of mine fans
- Total electrical kW of surface fans
- Total electrical kW of underground fans
- Total airflow through underground fans
- Surface fan kW per m^3/s moved
- Underground fan kW per m^3/s moved
- Personnel in mine (including contractors)
- Volume of air per manshift
- Number of diesels underground
- Total kW of diesel engine rated power
- Volume of air per kW rated diesel power

- Diesel airflow efficiency (actual airflow/airflow to 'just' meet statutory requirements)
- Metres of horizontal development
- Costs of underground fan power
- Costs of surface fan power
- Cost of fan repairs
- Amount and cost of new vent duct in each size, including bends etc
- Amount and cost of repaired vent duct in each size, including bends etc
- Cost of vent controls
- Metres of duct per metre of development
- Dust reports
- Gas reports
- Unit costs
- Hot jobs
- Total ventilation unit costs, cost per month and year to date, including same periods previous years.

1.5.5 Ventilation Records Database

The ventilation database is principally related to the records that must be kept for statutory or Company related purposes, along with your own needs in terms of the location of fans, maintenance histories, etc.

A Microsoft™ Access™ or Excel™ database is a useful method of keeping records electronically, providing there are resources for data input. Alternately, records can be scanned.

Paper records must also always be kept, particularly as the "paper trail" for statutory or Company requirements.

1.6 Surveys and Audits

1.6.1 Volume surveys

1.6.2 Pressure surveys

1.6.3 Gas and dust monitoring and surveys

1.6.4 Fan surveys

1.7 Recommended list of equipment and software for mine ventilation officer

The following list of equipment and software etc should be available to all ventilation officers. It is simply not possible to perform an adequate job without these devices and support. Note that instruments must all be re-calibrated or at least checked for serious errors at regular intervals.

1.7.1 Minimum requirements

- Averaging vane anemometer that allows traverses (volume surveys), with sufficient rods to reach 0.5 m from the back (roof)
- Stop watch or watch with second hand
- Small digital anemometer for daily spot checks

- Manometer to take daily spot checks (digital or Magnahelic)
- Pitot tube capable of reaching the centre of the biggest duct in use (minimum recommended size is 1.5 m, which allows single point access to the largest ducts generally encountered underground)
- Pressure tubing correct size for instruments (typically ¼ inch or 6 mm)
- Smoke tubes or spray paint cans for direction of flow and also to estimate low velocities
- Pocket knife (for cutting [very small!] holes in vent duct, etc)
- Duct tape
- WB/DB thermometer
- Tape measure (8 m)
- Gas testing equipment for potential routine gases on site
- Exhaust cooling tube for testing hot diesel exhaust fumes
- Ventsim primary ventilation software analysis
- LeakyDuct™ auxiliary ventilation software analysis
- Good ventilation reference text e.g. McPherson
- Bags or pouches to carry equipment. This includes protecting the holes on the Pitot tube.
- Digital camera (for photographing defects etc)
- Laser-type tape measure (e.g. Distomatic)
- Method of transport (e.g. 4WD).

1.7.2 Optional/Desirable

- Infra-red remote thermometer (if using refrigeration or chilled water)
- Noise meter (if required)
- Light meter (if required)
- Dust meter (if required, e.g. optical dust measurement)