Fan specification and tender adjudication for mine ventilation engineers

An overview of the approach to specifying and selecting the most suitable fan for underground mining operations

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The correct specification and then selection of primary or major fans for an underground mine is a critical decision, not only in terms of fan capital and operating costs, but also in terms of safety and reliability, which usually has a major impact on mine production. In addition, fan manufacturers may spend tens of thousands of dollars preparing proposals for a purchase enquiry for primary fans, especially where they have complete responsibility for the installation (turnkey projects). There are many good reasons to thoroughly and fairly adjudicate fan tenders.

The following article is an excerpt of a paper to be presented at the Australian Mine Ventilation Conference 2017 in August. The full paper describes the fan tendering process, starting with the initial fan specification through to the final award.

Background

Primary and secondary fans are the heartbeat of the mine ventilation system and need to perform their job at the required duty continuously for many years. There can be a bewildering range of fan types and options available for the mine ventilation engineer. It is not uncommon to find mines using fans that are less than ideal and, in some cases, unsuitable for the application, or to find expensive fan options or accessories installed that add no value. There can also be instances where other important options are not selected that are really needed. In most cases, this results from the mine ventilation engineer not understanding the key requirements of the fan application so that the specification is wrong or incomplete, or not communicating these requirements to the tenderers. In some cases, it is due to the ventilation engineer being 'sold' on matters by over-enthusiastic or even unscrupulous fan salespeople, or due to poor technical assessment of fan offers.

The process

For a successful major fan installation, it is important to understand the process on four levels:

1. the limits of the mine design process
2. how to specify the fan requirements
3. the role of the fan supplier
4. how to correctly assess (adjudicate) fan tenders.

The fan duties (the single most important criteria for a fan installation) are developed from a ventilation model or models, which in turn come from a mine design and schedule. It is important to understand the limits and uncertainties of the mine design and the schedule. Any design needs to be 'stress tested' and also risk-assessed to ensure potential flaws or shortcomings are understood, especially with respect to the impacts on the primary ventilation and the fan duties. Whilst it may be tempting to add in a margin of 'fat' in the fan duties in terms of pressure or volume (or both) to cover contingencies, this can easily be overdone, resulting in a fan that is far larger and more expensive to buy and to operate than needs to be the case.

In terms of mine fan specification and evaluation, there is already some excellent work available, eg Stachulak and Mackinnon (2001). However, this paper provides additional information and looks at the process specifically from the perspective of achieving success via a turnkey project, which is different to most earlier work where the ventilation engineer or the mine client has already made many of the key decisions in the supply (such as the type of fan and overall configuration, etc). In a turnkey contract, the supplier (usually the fan manufacturer) provides not only the fan but also the electrics, the civil design (and usually the actual civil works), transport, assembly and commissioning, and this is done in the context of a more open set of specifications.

The key success factors in a turnkey project are getting the specification correct, adjudicating the tenders accurately, cooperating with and facilitating the contractor during site works (but otherwise 'getting out of the way'), and performance testing the fans using not only the aerodynamic criteria but also the other critical specification issues. All this needs to be backed up by a practical and robust warranty and financial guarantees by the supplier. There is usually a premium to pay for this type of contract over the theoretical cost if the principal were to manage each of these tasks via separate contractors, but the risks to the mine in managing all these separate packages are substantial and, in most cases, mining companies do not have

Primary and secondary fans are the heartbeat of the mine ventilation system.

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the skill set, or the people with the time, to competently do this.

By contrast, a turnkey package covering mechanical, electrical and civil works generally offers clients a number of benefits such as:

- a single line of responsibility for the complete system (no issues of split responsibility)
- a lower cost of project delivery, taking into account the cost of risk
- a shorter delivery period
- greater reliability and service life of the installation.

Projects that have sourced electrical systems and civil works separately have had problems such as:

- Major disputes between contractors and the client, most of which are associated with issues of split responsibility.
- Foundation problems on sites. Fan foundation stiffness and natural modes of vibration do affect fan rotating assembly critical speeds.
- In the case of using variable voltage variable frequency (VVVF) drives, there are complex vibration issues that arise mainly with axial fan blade vibration. This issue also depends on who manufactured the variable speed (VS) drive (VS drives are not all equal in this regard).
- Serious electrical problems on sites, eg operators find that they do not know what the safety and management systems for the fans need to be. In many cases this information is the fan manufacturer's proprietary knowledge and they will not provide this information to their own electrical competitors.
- Delays in final commissioning (not uncommon to be in excess of 12 months).
- Reduced warranty periods due to delays in completion.
- Substantial additional rectification costs to the client.

In summary, splitting responsibility for the success of a major turbo-mechanical, civil and electrical installation such as a large mine fan invites problems and subsequent disputation. In some cases, the dispute is never really resolved to anyone's satisfaction, and the mine owner usually 'wears' most of the downside by way of a de-rated fan or increased maintenance costs and downtime. Even if the installation itself goes well, if there are subsequent problems, the legal and 'moral' ability to enforce after-commissioning support (particularly after the warranty period is over) is much lower where a non-turnkey approach has been used and the responsibilities have been divided.

Finally, splitting responsibility for the job (such as to an overall engineering, procurement, construction and management (EPCM) firm from a third party EPCM contractor) is unlikely to save either time or money. One large Australian fan manufacturer found that appointing a third party to engineer, procure, construct and manage a fan supply and install is likely to have these additional negative effects:

- adding at least 25-40 per cent to the real cost of the fan project
- adding anything up to a year longer to project delivery
- overall supply not well integrated (at best), and generally ending up with 'problem' sites.
- the EPCM contractor may have little or no interest in 'after sales' support.

Apart from these issues, the other very important benefit of a turnkey project is that it 'opens the field' to suppliers developing innovative solutions. These solutions would otherwise have never been considered by the principal, whose experience of fan installations, and of current technological developments in turbo-machinery, is usually very limited. The reason that freeing up the tenderers from excessively rigid and pre-defined solutions is so effective is because the suppliers have by far the best understanding of their product. Assuming the specification is sound (and hence they also have a sound understanding of the client's performance requirements and constraints), then they are free to compete with one another in terms of quality, capital cost, operating cost, delivery, etc.

For this reason, the Australian preference (and certainly this author's preference) has been to use turnkey contracts for key ventilation infrastructure such as primary fans.

Understanding how to specify the fan requirements

For a successful turnkey project, the following general principles apply:

- The client needs a suitable project manager or 'champion' who has experience with turnkey contracts, and preferably with primary fan purchases using this system.
- Do not start off with more constraints than necessary, but ensure all absolutely fixed boundaries are provided. This means there must be very strong input and ownership of the specification by all the stakeholders at the mine site before the tender documents are issued. However, the project manager must ensure that frivolous or unnecessary constraints are adjusted or eliminated.
- The objective in a good specification is to not close off innovative offers but neither is it to be wasting tenderers' (or the principal's) time in evaluating offers that do not meet the 'must comply' criteria.
- Give as much useful information to the tenderers as possible (the client's musts and wants), including the weighting for the criteria that will be used for the adjudication on the 'wants'. It is worth noting to the tenderers that these criteria and weightings are not binding on the principal, as once the adjudication process starts, it may become apparent to the principal that the weightings need to be adjusted or new criteria added or original ones changed in value. But with good preparation, the amount of such changes should be minimal. Providing the adjudication criteria and weightings to the tenderers will significantly help them target their offer or offers and will also make it much easier to compare offers within and between tenderers.
- Give any new information to all tenderers during the adjudication so they all have the same information. It is unethical and may even be illegal to provide information selectively to the tenderers.
- However, questions relating to a particular tender can go to just that tenderer, providing no new information or advantage is given to that tenderer over the others. For example, this may be important where doing otherwise might jeopardise some innovative aspect of a tenderer's offer by disclosing it to other tenderers.

Some of the essential information that needs to be in the specification includes:

- A very clear understanding of the location (reference plane) at which the fan duty applies and the duty itself. In most cases, for surface fans this will be the collar total pressure (CTP), collar airflow and density.
- The resistance curve for the fan (for surface exhaust fans, the collar total pressure versus flow). This is particularly important if the fan is in 'competition' (parallel) with other fans, eg multiple surface exhaust fans, even if these are on different shafts.
- A clear understanding of the essential features for the offer to be complying. Apart from these truly 'essential features', the specification should otherwise take a minimalist approach to further demands. In addition, non-complying offers should be invited in the sense that they may present clever or innovative opportunities. Any such offers should be strictly protected from disclosure to other tenderers.
- For most fans, the duty will change over the life of the fan, so that it is appropriate to give several fan duties (eg duty A, B and C).
- Whether the fan can be a single fan or must be twin (or trifurcation, etc) fans. In general, if the mine will be severely affected by a ventilation shaft going offline (other than by power failure), then multiple parallel fans should be specified. Power failure is excluded, as this will take the entire fan installation offline, whether it is a single or multiple fan. If there are multiple primary ventilation shafts so that other useful activities can be done underground with an entire ventilation shaft offline, then a single fan is usually more appropriate, as it is quicker to build, cheaper to operate and maintain, has higher efficiency and lower running costs.
- The site power cost, both per kWh and also the 'capital charge' for each additional MW of power.
- The life of the mine, as this has a significant bearing on the appropriate mix between capital and operating costs in terms of assessing the lowest lifetime ownership cost (or 'net present cost') of the installation. Where the fan has several duties, then the tenderer should be told that the fan will have (say) three years at duty A, then 13 years at duty B, and then two years at duty C, so that the tenderer can understand the relative importance of each duty.
- A clear understanding of the battery limits of the scope of supply and the nature of the contract.
- It is of no use to simply specify the national or international *in situ* fan test codes that will be applicable to any performance tests. It is equally important to also nominate the specific manufacturing tolerances and measurement uncertainties that will be applicable to the site performance tests.

The principal's responsibilities

Correctly specifying the fan and then evaluating the tenders is clearly the responsibility of the principal. However, the principal must then remain responsible for their choice of supplier and, *ipso facto*, the actual choice of fan. For example, if the principal chooses the cheapest option, disregarding the potential risk of excessive corrosion or erosion on the fan blades, then the cost of that decision must be borne by the principal.

Another current problem is where ventilation on demand (VOD) systems are being purchased by the principal from third parties, and primary fans are then retrofitted with variable speed drives as part of that VOD installation. These fixed speed fans may never have been designed for VOD operation, and certainly no design checks would have been performed for anything other than the synchronous motor speed. There may be major impacts on rotor dynamic issues such as half critical speed resonance or foundation resonance.

Finally, items such as providing clear and realistic details of the space available for the fan and associated works, including during installation, can be critical. For example, primary fan installations may require 130 tonne (or larger) cranes for installation of the fan and ductwork. Laydown area is also important, preferably close to the fan to avoid double-handling. B

This is an excerpt from a paper to be presented at The Australian Mine Ventilation Conference 2017, which will be held in Brisbane from 28–30 August. View the program and register at **www.austminevent.com.au**.

References

Brake D J, 2013. Performance and Acceptance Testing of Main Mine Ventilation Fans, in *Proceedings AusIMM Australian Mine Ventilation Conference*. Adelaide, SA, 1 - 3 July, pp 141–148.

Stachulak J S and Mackinnon K A, 2001. Mine Ventilation Fan Specification and Evaluation, in *Proceedings of the 7th International Mine Ventilation Congress: June 17–22, 2001*, Cracow, Poland (ed Stanislaw Wasilewski), pp 203–211 (Research & Development Center for Electrical Engineering and Automation in Mining).