



Achieving Target Output at Lisheen

Zinc, Lead and Water

Lisheen Mine is owned by a Joint Venture between Anglo American plc and Ivernica West mc, with Anglo American plc managing the operations.

The Lisheen mineral deposit was discovered in 1990, and construction of the underground mine, and surface workings, commenced in 1997. Production of zinc and lead concentrates got underway in September, 1999. However, due a series of start-up challenges, the mine did not reach targeted levels of production until late-2001. Unexpected flooding of the 1.5 km-long decline caused an eight-month delay in its completion, and the development needed for production startup had to be fast-tracked.

The mine bought back the Atlas Copco drillrigs used by contractor Skanska, to form the nucleus of the production fleet, and has since added four Atlas Copco Rocket Boomers and three Boltec rigs.

Geology

The orebodies exploited by the Lisheen operation are hosted in a NE-SW trending belt of Carboniferous aged carbonate rocks, commonly termed the Rathdowney trend. These formations are similar to the host rocks of other major base metal deposits in Ireland, including Tara Mines, Silvermines and Tynagh.

The ore occurs close to the base of a unit of fine grained, dolomitized limestone, termed the Waulsortian Formation. This is underlain by the Argillaceous Bioclastic Limestone (ABL), a dark shaley limestone which forms the lithological footwall to mineralization.

The Lisheen orebodies occur as two principal zones, Main Zone and



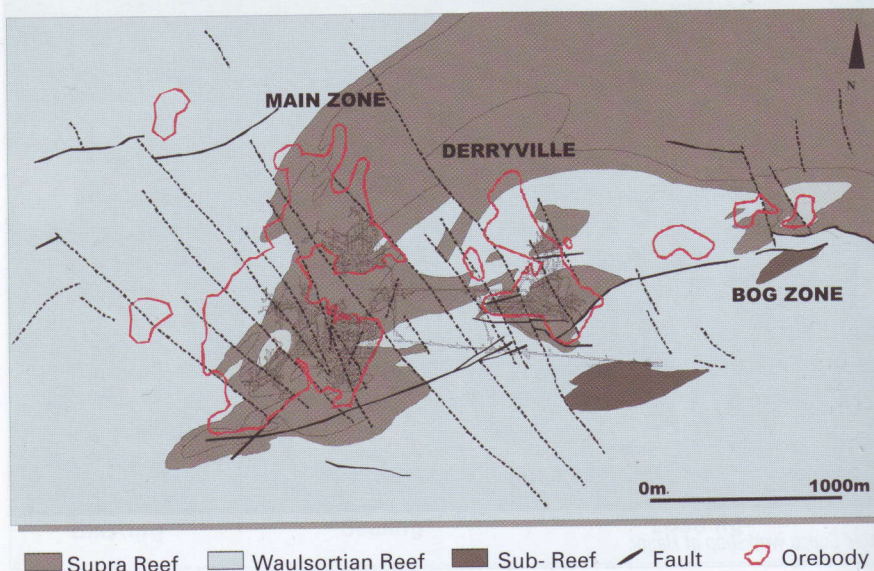
Aerial view of Lisheen Mine.

Derryville Zone, and a series of satellite orebodies such as Bog Zone. The low point of the orebody is some 205 m below surface, and the shallowest point is some 165 m below surface. In detail, tight monoclinical rolls and small scale faulting deform the ore lenses. Ore elevation differences can range between 3-7 m, and can occur over short distances, causing

significant mining problems, and contributing to ore dilution.

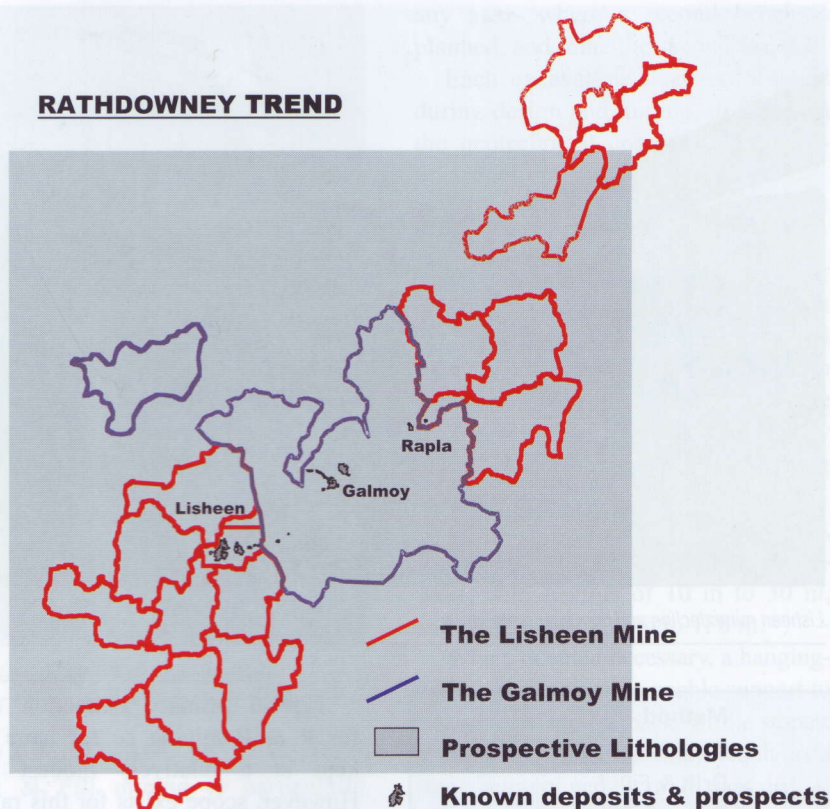
Mineralogically, the orebodies comprise massive sulphide lodes of sphalerite, galena and pyrite. Moderate silver grades are seen in several sections of the orebody, and iron levels vary considerably, both between ore lenses, and within individual ore lenses. Several deleterious

Lisheen mine geology plan.





RATHDOWNEY TREND



Regional geology plan showing exploration holdings.

elements are known in the Lisheen and Galmoy ores, the principal ones being nickel, cobalt, magnesium and arsenic.

The Waulsortian forms the aquifer to both the Lisheen and Galmoy mines. The aquifer is fracture controlled, and connected directly to the surface drainage system via a conjugate set of steep dipping NE and NNW trending joints and fissures, which have been extensively karst weathered. Water ingress to the workings in both mines occurs principally when one of these structures is intersected, and significant flow rates can occur over short time spans.

Variable Conditions

The mine produces 1.5-1.6 million t/year of ore at a nominal head grade of 11-12% zinc and 1-2% lead.

The proven and probable ore reserves are drilled off to a minimum of 30 m and 45 m drill centres in the thinner areas of the orebody. However, due to structural complexity, significant variations in geometry can be experienced over these short distances.

The predominantly thin, flat orebody, makes hangingwall exploration drives uneconomic. All infill exploration holes are therefore drilled from surface, which is nominally 180-200 m

above the orebody, making it very expensive. The thicker, and generally much higher-grade areas, are drilled off to 15 m centres. These offer a higher return, in terms of information, in the open stopping areas.

Several challenges are present at Lisheen. Key amongst these are the water inflow into the mine, which is now steady at 80 Ml/day, or 925 lit/sec; orebody variability in thickness, dip, and grade; and ground conditions presented by singular features and faults, weathered areas, and jointing.

Orebody variability is by far the most significant ongoing issue. The rapid changes in floor gradient, that follow the geometry of the orebody, have an adverse effect on both the productivity and maintenance costs of the sophisticated mobile heavy equipment in use. Each of these items is allocated a 10 h weekly maintenance slot, partly to allow the fitters to repair damage caused by the harsh mining environment. Roof scaling is also necessary after every blast, and the two available machines clock up huge hours. These are equipped with Atlas Copco SBC 610 hydraulic hammers.

Each of the three production zones comes under the supervision of a mine captain, and the whole is coordinated

Typical production face markup showing barren zone at left.





by a senior mine captain. Equipment is allocated to the mine captain of each zone.

Mining Methods

Three mining methods are employed at Lisheen, namely Room and Pillar, Drift and Fill and Long Hole Open Stoping. These methods contribute nominally 75%, 10% and 15% respectively to the total production at the mine.

The mining method chosen for any particular area is a function of thickness of the orebody and the expected degree of geological variability, or geometry.

Generally, the following parameters are applied in the selection of mining method:

Thickness	Geological Variability	Method
Thin (<5m)	Low	Drift & Fill
	Med/High	Room & Pillar
Medium (5-8m)	Low/Med	Multi Pass Drift & Fill
	High	Multi Pass Room & Pillar
Thick (8-15m)	Low	Open Stoping (uphole retreat)
	Med/High	Multi Pass Drift & Fill
Very Thick (>15m)	Low/Med/High	Open Stoping

Ground conditions are taken into account in detailed design of the panel or stope in question. For example, if an area is earmarked for long hole stoping, it will be evaluated as to the need for hangingwall support drives, and modelled with stope dimensions to suit.

Room & Pillar Mining

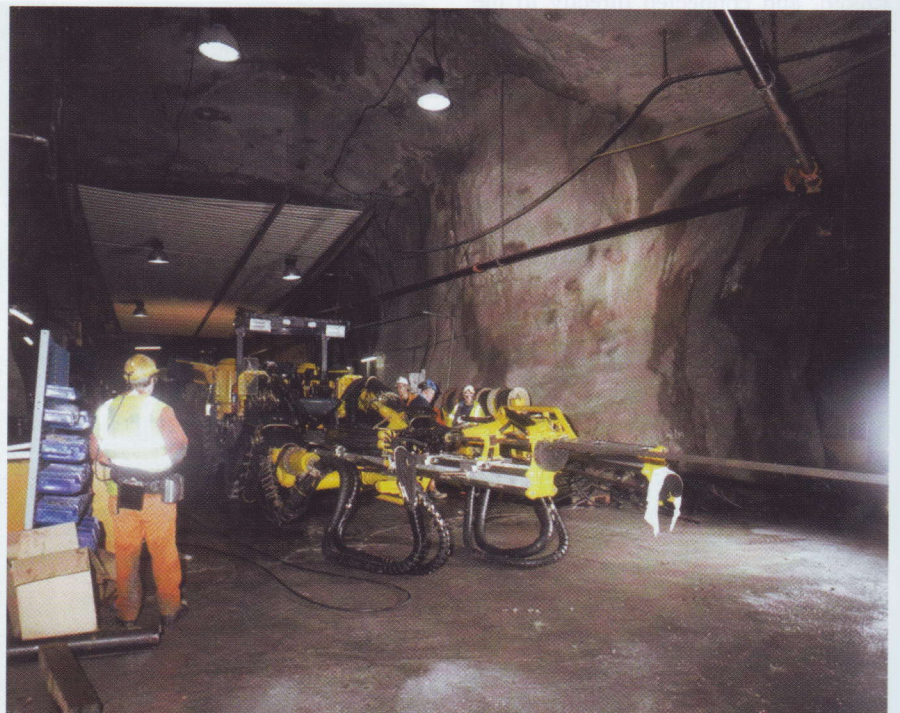
Room & Pillar mining has proved to be the most appropriate method for mining thin areas of the Lisheen orebody. The primary advantage of this method is the flexibility to make changes to layout according to the geology encountered. Changes would typically be in the form of: orientation of the primary mining direction to best run on apparent dip of the orebody; stopped headings in the event that waste, or sub-economic mineralization, is encountered; and re-prioritized headings when very poor ground, or waste, is encountered.



Lisheen mine decline and conveyor installation.

Typical primary extraction ratios for R & P mining so far have been kept at a relatively modest 75%. However, scope exists for this ratio to be pushed substantially higher, and the mine is conducting trials in several areas, with a view to evaluating the optimum. The influence of paste backfill in establishing the overall costs for the mine plays an important role in determining the primary mining ratio.

Atlas Copco Rocket Boomer M2 D under maintenance in dedicated drillrig workshop bay.





Atlas Copco rockdrill service container.

Drift & Fill Mining

Drift & Fill mining is particularly appropriate when orebody complexity is low, countering the relative rigidity of the required planning layout. D & F mining has proved to be most useful in the extraction of areas that are not thick enough for efficient long hole stoping. Safe access for men and materials is a primary concern, so strict protocols are applied for all geotechnical evaluation and support recommendations.

The principal components of D & F mining at Lisheen are: mine the top drive to the hangingwall at around 5 m-wide x 5 m-high, with support as required; strip the hangingwall drive to 10 m-wide, and support as required; if necessary, carry out small scale (AQ/BQ size) diamond drilling in the hangingwall drive, to establish the extent of grade in the floor (this stage can prove extremely beneficial, due to the presence at Lisheen of sporadic disseminated mineralization, which can quite often make good grade over short distances); apply 50 mm steel fibre reinforced shotcrete to the back and sidewalls to floor level; if final excavation is planned to exceed 7 m in height, install cablebolts when and where required; mine the first bench less than 5 m-high, for safety reasons; rockbolt sidewalls, and shotcrete in

any areas where a second bench is planned; and mine the second bench.

Each excavation stage is assessed during design and mining, to establish the geotechnical conditions and support requirements for the area.

Open Stope Mining

Open Stopping at Lisheen has so far been confined to the uphole retreat style of mining from a single footwall drive. Several twin level stopes with hangingwall and footwall access are planned, for areas where the orebody is too thick for uphole retreat mining with present equipment.

Depending on ground conditions, stope widths vary from 10 m to 15 m-wide, with heights of 10 m to 30 m, and lengths from 30 m to 150 m.

Where deemed necessary, a hangingwall drive is mined to enable support to be installed into the backs of the stopes. Varying ore thickness may result in a stope being mined by multi pass drift & fill, rather than as an open stope, where insufficient pillar would be left between the hangingwall and footwall drives.

Uphole retreat stopes are mined as follows:

Design gradient footwall drives are driven, sometimes leaving ore in the floor to avoid ponding of water in stope during the remote mucking phase, or mining the drive as waste or low grade to ensure full extraction high grade ore.

If necessary, small scale (AQ/BQ size) diamond drilling is carried out in the hangingwall drive to establish the extent of grade in the roof, and the exact location of the hangingwall.

The uphole rise and slot are planned for the highest point of the stope (in some cases, due to the undulating nature of the ore, two slots may be required); the slot and rings are drilled using 64 mm diameter bits; selected blastholes are extended at 51 mm-diameter for subsequent installation of 6 m-long fully grouted cablebolts (these do not extend to the collar of the blasthole, rather, they are only installed in the hangingwall); the upholes are blasted, and remote-control LHDs used to muck out.

Atlas Copco Rocket Boomer 322 mounted with COP 1238ME rockdrill at a production face.





Ore Transport

Ore is trucked to an underground crushing/conveying system. The crusher station has a primary grizzly above a 300 t bin, which feeds a Nordberg C 140 BS jaw crusher via a hydrostroke feeder and a vibrating grizzly. The undersize from the vibrating grizzly, and the sized product from the crusher, are fed via a second hydrostroke feeder onto a 1,500 mm-wide accelerator belt, which discharges onto the 200 m-long transfer conveyor. The 600 t/h main conveyor system, which is furnished with 1 m-wide steel cord belt, is suspended from the roof of the 6.5 m-wide x 5.5 m-high decline.

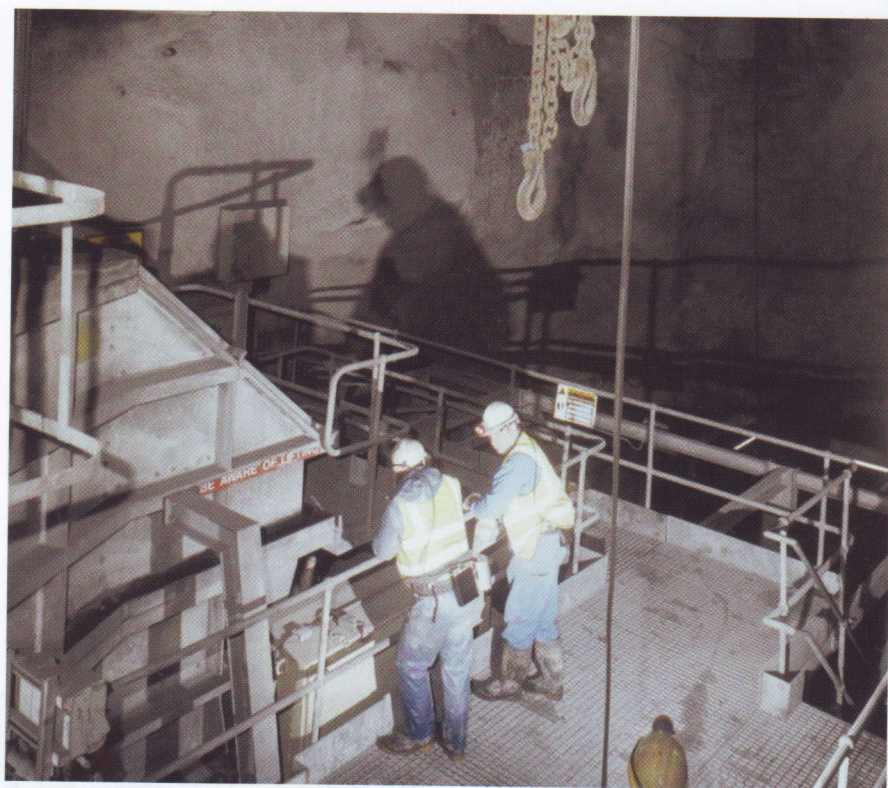
At surface, the ore is stocked in a 50,000 t-capacity covered storage, with 15,000 t live take-off to the processing plant. The resulting concentrate is trucked to Cork for shipment.

Geotechnical

All primary support at Lisheen is by fully resin-grouted and tensioned 2.4 m-long steel rebar installed using the three Atlas Copco bolting rigs. In specific circumstances, 1.8 m-long bolts may be installed, and one of the bolters has been modified to handle these. One of the Atlas Copco Boomer 322s is being converted by the addition of a RAS rod adding system for the longer bolts.

In long hole stoping areas, where the back and sidewalls are to be extracted at a later stage, fibreglass bolts are used, in order to minimize the risk of damage to the materials handling system. Cablebolting is carried out in areas identified by the mine captain and the geotechnical engineer. These are typically 6 m-long, and fully grouted and tensioned.

In some areas of the mine, the hangingwall of an uphole retreat stope may require cablebolting. Lisheen is currently working on a method where the blastholes are overdrilled, at a reduced diameter, into the hangingwall for the length of the cablebolt. The bolt is then inserted up the blast-hole, into the hangingwall, and fully grouted in place, leaving the blasthole available for the extraction stage. This



Main underground crusher installation.

method is designed to reduce redundant drilling and cablebolt installation.

Geotechnical monitoring is at an early stage of development. Plans are in place, however, to carry out remote monitoring of critical areas of the mine, in order to provide baseline information for more accurate geotechnical modelling.

Mobile Equipment

Lisheen operates a modern fleet of mobile trackless equipment. Key equipment includes: six loaders with six 40t trucks; six Atlas Copco drilling rigs; three Atlas Copco bolters; and a variety of smaller drilling rigs, service and utility vehicles.

The drillrigs embrace three generations of Atlas Copco, comprising a pair of Boomer 322s equipped with COP 1238 rock drills, a Rocket Boomer 332S equipped with COP 1838ME rock drills, and two Rocket Boomer L2 C and one M2 D, all with COP 1838ME rock drills. The L2 C models are CAN-bus controlled, and the M2 D is direct controlled. The standard hole depth is 3.9 m, to achieve a 3.5-3.6 m pull, and face areas can range from

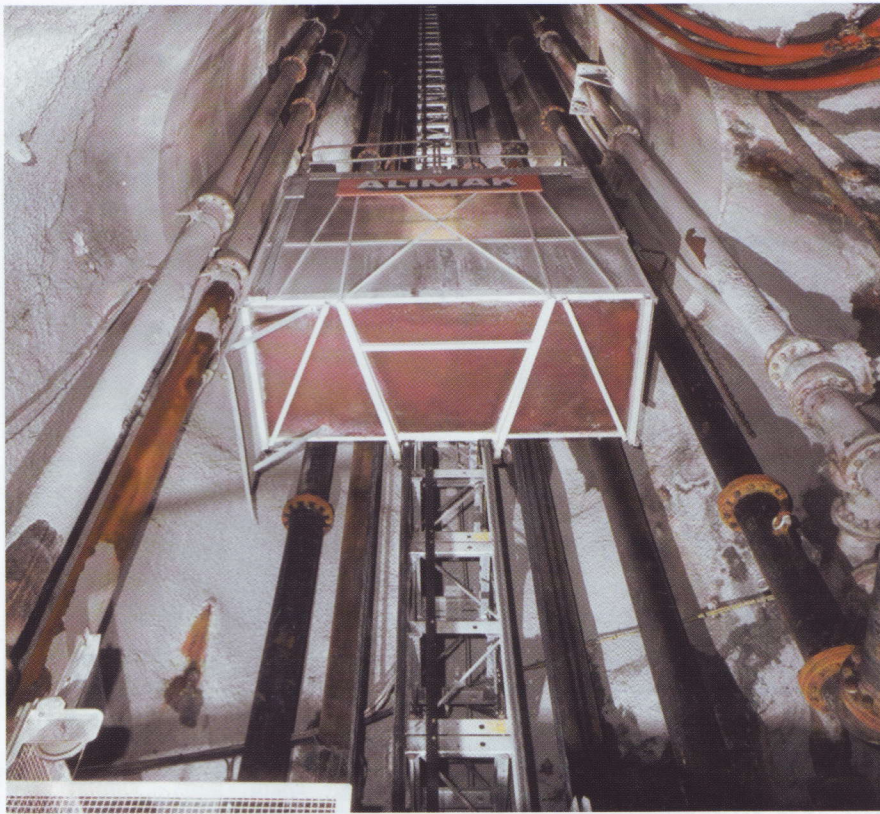
4 m-wide x 4 m-high to 10 m-wide x 6 m-high, with benches up to 5 m-high. The driller decides on the pattern according to the situation, and may use up to four 102 mm burncut holes. Average consumable returns are 4,500 m/shank and 160 m/bit.

Front-end hoses are a major source of breakdown, mainly due to the poor underfoot conditions, and super tough hose is used by the mine, despite its greater cost.

Two Atlas Copco Boltec 335SH are equipped with COP 1432 rock drills, and the third bolter is mounted with a COP 1838.

Rock drills are overhauled every 400 h by Atlas Copco under contract, as part of the planned maintenance programme, and their resident engineer also contributes to the resolution of technical issues. As a result, refurbished rock drills are now a stock item, rather than a cause of breakdown, and their maintenance history is instantly available.

Day to day maintenance is carried out in a modern and fully equipped underground workshop, which has six dedicated bays located between the east and west main haulages, one for



Emergency escape cage is installed in fresh air raise.

each major group of machines. The LHD maintenance bay is equipped with a long, two-machine inspection pit and 15 t overhead travelling gantry crane. There are two stores containers, a canteen and offices. Overhauls and rebuilds are outsourced, and carried out off-site. Maintenance planning is facilitated using a MIMS enterprise resource planning system, with weekly cost reviews and monthly reporting.

Ventilation

Primary ventilation is provided by four permanent fan installations. Due to environmental noise pollution restrictions enshrined in the Integrated Pollution Control Licence (IPCL) granted to the mine, the primary fans are located at the base of the ventilation shafts in the mine. A total ventilating airflow of 535 cu m/sec is exhausted to surface through four 3 m-diameter raise-bored holes.

Due to the flat nature of the ore-body, many areas of the mine are ventilated using parallel horizontal return airways, with flyovers installed over established intake airways.

Twin 42 KW axial flow fans are installed in places requiring secondary ventilation, with twin 90 KW fans for longer pushes.

Dewatering

Currently, the mine pumps 70 Mlit/day, 47 Mlit of which is clean water from boreholes, and can be safely discharged into the local river after aeration and heating to ambient temperature. The remaining 23 Mlit comprises the mine make of water, which is classified as dirty, but may be used in the mill. Pumping is a significant cost, accounting for 65% of the underground electricity bill, and 10% of the total underground costs. The mine now has installed capacity to handle 200 Mlit/day.

The clean water is collected and pumped to surface from a station equipped with Clarke Chapman Mackley pumps powered by Alstom motors.

Backfilling

Lisheen is embarking on a Cemented Rock Fill (CRF) system designed to

dispose of waste rock without hauling it to surface. This can be placed with secondary extraction in mind. In lower grade areas, the mine uses a waste packer, which permits up to 95% extraction without the cost of cemented backfill.

It is planned to fill the void left by the mining with cemented tailings from the processing plant. This will enable subsequent safe extraction of the pillars, facilitating a high extraction ratio for this high-grade deposit. A backfill plant is currently under consideration to be available during 2004.

Control Room

The Lisheen mine control and monitoring system is located at the underground crusher station, and is continuously manned. Screens allow monitoring and control of material handling, dirty water system, clean water system, ventilation, electrical switchgear, and fuel oil transfer. Shotcrete is presently brought in by mixer trucks operating from surface, but a scheme is well underway to equip one of the ventilation shafts with a drop pipe.

Recent regulations require availability of a refuge facility in each blind end, and Lisheen has four 20-man MineArc systems installed. These will sustain life for up to 24 h in an emergency, independent of external support.

Approximately 220 people are employed in the mining department including all technical support, maintenance and management. ■

Acknowledgements

Atlas Copco is grateful to Lisheen Mine for permission to publish this article, which is based on submitted material and observations made on a site visit to the property. Particular thanks are due to Don Cunningham, general manager, and Brian Keady, mine manager, for facilitating the underground visit, and to mine engineers Wade Stephenson, Steve Ridge and Pat Gray for their help and assistance at site.