

In for the long haul

With the mining market booming again, key new mine truck models and technologies will help operators to further boost mine productivity, reports Paul Moore

The new 795F AC be used in Sweden and Canada following testing in the Bingham Canyon mine



Overall, market commentators have seen a marked increase in relative demand for the largest trucks of over 240 t capacity, with demand hotspots including iron ore, copper and coal overburden haulage. Caterpillar has begun to make progress with its electric drive truck, the 795F AC, Russia's BELAZ has launched a 360 t capacity model, while Chinese player XEMC is soon to launch a 300 t model. However, as the mining boom ramps up again, tyre shortages are likely to again become an issue, as discussed elsewhere in this issue.

Of course, the discussion as to what would happen to the former Terex Unit Rig line of trucks, now part of Bucyrus, should the Caterpillar acquisition of Bucyrus proceed, is also interesting. Caterpillar has already put its own hydraulic mining excavator program on hold in anticipation of acquiring the Bucyrus excavator business, the former Terex O&K business based in Dortmund. With the trucks, however, the Bucyrus truck installed fleet is very small relative to Caterpillar's. Previously it

would have brought Caterpillar an electric drive truck range, but the company has already developed its own 795F AC and at some point will roll out the 793F AC, which is ready to go but currently on hold. It may be that Caterpillar would choose to keep the better selling lines such as the MT4400AC and the new MT6300AC. The other point to bear in mind is the success of the former Terex trucks in the Chinese coal market, where Caterpillar itself has yet to make an impact; and the advantages of the North Hauler joint venture, which would be a major asset.

Established OEMs

Caterpillar announced its 795F AC truck back in 2008. The 313 t truck is a new size class for Caterpillar, and, as a result, has been the primary focus of the Caterpillar AC electric program, though this also includes the 793F AC, which has yet to be made available commercially, though the mechanical drive counterpart, the 793F, is in the current range. A number of new orders are now in place

and/or being delivered for the 795F AC since the field follow testing at Bingham Canyon, while the first two of nine units are now running at Boliden Aitik. Most of this fleet has now been delivered and is now being used in day to day production. Other customers include Detour Gold, which last year announced a key mine truck fleet contract with Caterpillar dealer Toromont. The Detour deal is for the life of mine requirement of up to 36 Caterpillar 795F AC haulage trucks for its 100%-owned Detour Lake gold project in northeastern Ontario. The initial purchase release of 18 trucks has been issued with six trucks to be delivered in the December quarter of 2011 and 12 more planned for delivery in late 2012. In June 2010, Caterpillar announced that it is accelerating capacity expansion plans for trucks in Decatur, with an additional 30% capacity now coming on line. Decatur is the main truck production facility for mining classes, including the 795F AC. It produced its 10,000th large mining truck in January this year since production began in 1984. It also



The new EH4000ACII is manufactured in Japan and joins the EH3500ACII and EH5000ACII in Hitachi's new line up

recently announced in October 2010 the shipping of the 500th 797 large mining truck to a coal mining contractor in Australia. The 797F that marks the milestone represents the third generation of the largest mechanical-drive truck ever built.

At the forthcoming Conexpo-Conagg show, Caterpillar will showcase two new smaller quarry-class machines. A new G-series 775 off-highway truck will be shown, and it is the first Caterpillar machine to go into production with a Tier 4 Final emissions solution. The new B Series ADT models now include the 735B, offering a 32.7 t payload, the 740B with a 39.5 t payload, and the 740B EJ with popular ejector body, carrying a 38 t payload. All three models are available with either Tier2/Stage2 equivalent or Tier 4 Interim/Stage IIB certified emissions configurations to meet the needs of customers around the world. Both configurations feature revised transmission and traction control systems that enable higher productivity. The new trucks also focus on reducing driver effort and cutting operator fatigue through improved cab design.

At Komatsu, the other global truck leader in fleet terms, there have been several key orders and developments. The 860E trolley assist fleet at the Sishen iron ore mine in South Africa is now 29 strong and running well according to the company, though they are not currently running under trolley as the overhead infrastructure is in the process of being overhauled. Komatsu is also in the process of shipping its first non-trolley 860E fleet to

The new 360 t 75601 from BELAZ will work initially at KRU Bachatski in Russia

Assmang in South Africa, a major manganese miner. The fleet will be five strong initially. There may also be plans to offer trolley versions of other Komatsu trucks – including the 960E – in the future but this will be dependent on market demand. Several major projects are considering the use of trolley assist.

The first 960E fleet is at a Peabody operation in Wyoming, where the initial ten trucks had GE drives and a further four trucks with Komatsu drives have been delivered. Other 960E fleets worldwide include eight running at an Australian coal mine and two each at two Chilean copper mines.

For Komatsu too, the introduction of Tier 4 compliant engines has been a key focus. As of March 2011, all Komatsu trucks delivered to North American customers will meet EPA Tier 4 interim regulations. Komatsu works with Cummins in a joint venture in engine development. The 860E already had an interim Tier 4 engine, the 960E engine did not require much alteration, with the 830E and 930E Tier 4 compliance requiring a longer term project.

Komatsu has also reached some delivery milestones. It recently announced in January the production of the 1000th 930E since its launch in 1996. After 14 years on the market, the 930E has become the best selling ultra-class mining truck in the world. Currently, there are fleets of 930Es located in North America, South America, Africa, Asia and Australia. In Canada they are running at both Syncrude and Suncor, as well as for the main contractors, NACG and KNC Mining. It is also significant in being the model used as a part of Komatsu's Autonomous Haulage System, currently operating at Rio Tinto's West Angelas iron ore mine. In other models, Komatsu has now shipped over 1,400 830E models, of which 575 are the newer AC drive version.

Hitachi has just launched its new 220 t class EH4000ACII truck. Like the current EH3500ACII model, the new EH4000ACII utilises AC-drive technology and load-responsive Insulated Gate Bipolar Transistors (IGBTs), which have been developed by Hitachi. This combination enables smooth operation and optimal speed control, as well as increased productivity and reduced fuel consumption during the haul cycle. Equipped with a Cummins QSKTA60-CE engine, the electric-drive EH4000ACII delivers more efficient power transfer to the road than mechanically driven trucks. This is due to the elimination of heavy rotating parts such as the transmission and torque converter. The truck also has more controlled braking power compared with the previous model. It is designed around an even six pass loads from a Hitachi EX3600-6 and five loads from a Hitachi EX5500-6.

The standard ROPS/FOPS cab complies with ISO 3471 and 3449 requirements, and the newly designed air-ride seat – combined with a three-point rubber ISO mount – helps to reduce operator fatigue. Four emergency engine stop switches are located at various



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The Komatsu 860E fleet at Sishen now numbers 29

points outside the cab and a wide stairway is provided for quick and easy access, inspection and maintenance. The truck is also equipped with rear- and side-view cameras, as well as two front-view mirrors, to enhance all-round visibility.

The first three EH4000ACII trucks were sold to Comiskey Earthmoving in Australia, with the highest hours achieved to date being 3,525. A further 10-unit order for Peabody at Wilkie Creek, Australia, is under assembly in Brisbane, to be delivered progressively over this year by September. And another 10 trucks are to be delivered to contractor NRW to be used at the Middlemount or Oaky Creek mines.

Greg Smith, International Sales Manager for heavy and mining equipment at Hitachi Construction Machinery Europe said of its commonality with the other ACII types: "The common features between the EH3500ACII and EH4000ACII are the Hitachi Drive System, Trailing Arm and Accutrak Suspension system, Cab monitoring system and LCD display and camera systems. The main technical differences are the braking systems being wet disc for the EH4000ACII and dry disc for the EH3500ACII as well as and the engines – as the EH3500ACII uses a QSK50. The EH5000AC is still supplied with a Siemens drive system."

Liebherr has also been busy with its truck program. The market for the 363t capacity T282, now in its T282C variant, is very strong, with recent deliveries of a large fleet to Peabody Coal and a new fleet at Vale. The T282C is currently running at Liebherr's proving grounds in Emporia, Virginia. A fleet of T282C trucks with high altitude packages are also being shipped to South America, while ten T282C trucks have been purchased by an Australian mine. There has also been a desire within the group to be able to once again offer customers a range of truck sizes beyond the one ultra-class type. The long awaited 290t capacity TI274 is due to be commercially available in the next couple of years. Several TI274 trucks are now in existence and are operating at the company's proving grounds. The model has two side-by-side independent rear axles with all four rear wheels independently driven by individual motors. Its rear suspension and dump body support points are spaced farther apart and integrated into the dump body of the truck. The hoist cylinders were also relocated to the front of the chassis, which allows the forces created by the payload to be directed straight to the ground for a more optimised chassis weight.

A second truck, the 220t capacity T264, is due to be commercially available in the March quarter of 2012. The prototype is in the factory in Newport News, Virginia. At Newport News itself, a US\$25 million expansion is underway, with a view to meeting expected demand and to accommodate production of these new truck types.

In May 2010, Bucyrus commissioned the first of two additional MT3700AC haul trucks at the New Gold Mesquite mine in southern California. These haul trucks, capable of hauling payloads of 205 short tons, were the first Bucyrus trucks delivered in the US since the company's acquisition of Terex Mining in early 2010, and were the first to be painted in Bucyrus branding. This delivery brought Mesquite mine's fleet to a total of sixteen Bucyrus MT3700AC haul trucks. The Bucyrus MT3700AC haul trucks are powered by MTU 16V4000 engines, and are electrically driven by a GE AC drive. The uphill loaded speeds are substantially improved over mechanical and DC electrical powered trucks, providing a productivity benefit to its owners.

Finally, Russia's BELAZ has its ultra class program, including the 320 t 75600 but now joined by the 360 t 75601. This truck uses an MTU 20V4000 common rail fuel-injection engine, and is equipped with Michelin 59/80R63 tyre, as opposed to the Bridgestone 55/80R63 used on the 75600. The 75601 truck is largely based on the basic 75600 platform, but with an increased body size. The new truck is to be used at the KRU Bachatski mine in Siberia, one initially, with plans to deliver a larger fleet if the first machine is successful.

Designed and manufactured in Australia, the Haulmax purpose-built range of trucks aims to fill the industry acknowledged void between traditional mining trucks and conventional on-highway trucks. The company has equipment located in South Africa (coal), Jamaica (bauxite), New Zealand (coal) and Tanzania, as well as various locations around Australia (mineral sands, iron ore). A number of operations are considering the Haulmax product, including sites in Canada, Chile, Brazil, Peru, the US and Kazakhstan. In May 2010, Solid Energy placed orders for additional mobile plant and equipment for its Stockton open pit coal mine, which included four new 3900 Haulmax trucks with Goughs CAT, following the successful testing of a 3770 model. The Haulmax equipment operates along with Caterpillar 773s and 777s. The mine is operated jointly by Solid Energy and Downer EDI Mining NZ Ltd through the Stockton Alliance. The new trucks complete Stockton's coal mining fleet and upgrade its primary coal haulage capacity.

Built to reach satellite pits with extended haulage distances upwards of 50 km cycles, the Haulmax 3900 series truck features proven Caterpillar components, together with the custom designed and built axle system, and oil cooled multiple wet disc brakes on both rear axles, helping the truck to reduce the issues associated with maintenance and repair costs on other truck types.

New players

The market has been following developments at China's XEMC with interest, given the potential for the company's trucks to become more widely used in the domestic Chinese market. International Mining spoke to Chaojun Duan, responsible for the International Marketing Department at XEMC, who states that XEMC has now produced more than 500 of its 108 t trucks, which are all used in the Chinese domestic market local market and are equipped with DC electric drive systems and Cummins KTA38 engines. There are also three larger models, the 154 t, 220 t and 300 t designs.

The 220 t truck, known as the SF33900, saw a lot of interest in 2009/2010 as it was the first large capacity model to come from China. The company states that it has now built more than 40 units of the 220 t class truck, which are mainly being used in the Inner Mongolian coal

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mining region, where the average availability achieved has been more than 94%.

Chaojun Duan comments: "The domestic Chinese haul truck market is very big, and we expect more than 300 units of our 220 t and 300 t truck will be purchased in the next two years alone." The first 300 t class unit is due to be completed by the end of March 2011. Both the 220 t and 300 t models have General Electric AC drives and Cummins QSK60 engines.

XEMC also states that it has done a lot of research into the export market since 2008, and claims to have established a long term collaboration with Rio Tinto in 2010, part of which will see an XEMC truck delivered to Rio

XEMC has now built 40 220 t trucks, which are operating mostly in Inner Mongolia. A 300 t truck will also be produced this year

Tinto in Australia sometime in the next year. Other focus markets are South Africa, North and South America, the Middle East and India.

Cummins' relationship with XEMC was reinforced recently after the two parties officially signed to extend their long term supply agreement (LTA) in September 2010. A previous agreement had been signed in 2009.

According to the agreement, Cummins will continue to be the exclusive engine supplier to XEMC, powering its new range of large mining

haul trucks, including the new 300 t model.

A statement by Cummins China said: "The cooperation between Cummins and XEMC has successfully brought another important customer base for Cummins in China and for Cummins global mining business, whose strategy is to be the preferred supplier to all mining OEMs by offering superior products and taking great care of customers."

Cummins' first entry into China's mining market came as early as 1975, with the cooperation between Cummins and XEMC starting in the 1980s. "We are delighted to be able to complement our products and strength with Cummins' expertise and leading technology," said Li Jiping, Chairman of

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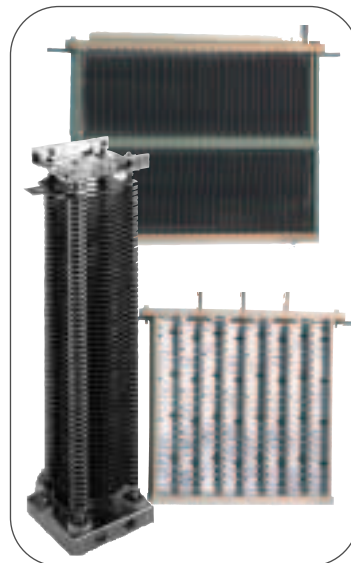
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Another much talked about offering is the new truck design from European Truck Factory (ETF). A new company, ETF is in the process of developing an innovative haul truck solution which it believes represents the most significant change in the approach to mine haulage in 50 years. ETF will offer 155 and 218t payload models - the MT170 and the MT-240. The main focus will be on the MT-240, and the company is completing a demonstration model of this machine, which will be shipped from Germany in April/May 2011 to a test site. The advantage of the ETF range, according to CEO Eddy de Jongh, is that in rigid trucks, each truck size has different major components, including engine, frame, axles, drive line and tyres. In ETF's case, each truck size has the same major components.

The key element of the new concept is the trucks themselves are not repaired the trucks in the workshop but the components, resulting in much higher availability. The major

components can be swapped and repairs carried out while the truck is in production. Power-packs, tyres and cabins can be swapped in only 15 min and complete axles in 45 min. Mining trucks mostly operate 50% of the time empty, this means that their large engine power is not needed or used on empty hauls.

The trucks have an all-wheel-drive system that makes it possible for them to operate on slippery roads, which significantly increases utilisation. Tyre costs are saved through all-wheel-steering; oscillating axles; a unique suspension; central tyre inflation system; automatic axle lift; equal load spread over all wheels; automatic 'on the fly' wheel alignment; pressure and temperature sensors and load spillage prevented by design.

The ETF truck is equipped with four MTU/Mercedes OM 502 V8 engines (Tier 3, 480kW). Each of the four engines is attached to a rear mounted pump drive gearbox supporting four variable displacement hydraulic pumps powering one axle line. Each axle line comprises two independent wheel groups supporting two drive wheels. Each individual wheel group incorporates twin variable displacement drive motors powering a planetary reduction gearbox with independent oil circulation cooling and microfiltration. This

uniquely configured, electronically managed transmission system provides versatility in terms of performance and retarding capability, offering both high operational performance and low overall energy cost.

The German operating company will conduct world-wide deliveries. ETF intends to rent its trucks with life-cycle contracts and this will also be organised out of Germany.

Detroit Heavy Truck Engineering (DHTE) is a new company based in Novi, Michigan. DHTE tells *International Mining* that it "provides numerous years of expertise in designing and supporting heavy equipment for the mining industry." It is set to be the newest entrant into the ultra-class haul truck market, with an electric drive 363 t model, the ELITE 6000, in an advanced development stage. Other models with varying payloads will follow, according to DHTE. The ELITE 6000 will use either an MTU DD 20V4000 or Cummins QSK 78 engine, a Siemens IGBT AC electric drive and 59/80R63 tyres.

DHTE has combined its experience with that of ELITE to develop the new truck. ELITE is itself a manufacturing JV created by China Metallurgical Group Corp and Hunan Valin Steel. The truck brochure states: "Together, using all combined expertise and vision, we have created a new product line for the mining

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The first ETF truck demonstration unit will be shipped this year

industry." A future article in *IM* will cover this new player in more detail.

New technology

Two areas of interesting developments include increased demand for wet disc brakes in large trucks, as well as ongoing research into the use of liquefied natural gas (LNG) to power engines in place of diesel. Cleveland-based consultancy, Pioneer Solutions LLC, has been looking at both of these areas for clients. Pioneer is a broad based engineering services and project management company providing technical solutions for the off highway equipment industry.

There has been a lot of interest in wet disc brakes for ultra class trucks, both on the front and rear axles. Caterpillar as the main supplier of large mechanical drive mining trucks, has wet disc brakes on both front and rear, however, on electric drive trucks they are not used across the board. Komatsu's 860E, 930E and 960E all utilise wet disc brakes, but the 730E and 830E still use dry brakes. The new Hitachi electric drive range has wet disc brakes on the rear axles.

The reason why they are not as standard on electric drive trucks, and especially on the front axles, is that with electric drive, electric retarding is an additional braking method. But the retarder only brakes on the rear axle, which in wet conditions can cause slippage. Installing wet disc brakes can give braking power across both axles and all four wheels. Downhill fully loaded journeys can be especially challenging using retarder braking only.

Additionally, the maintenance intervals on



wet disc brakes are much longer. Dry brakes get very hot, and can glow red, meaning a lot of air has to be pumped into the axle blocks for cooling purposes, but this is a potential fire hazard, especially in coal mining where a lot of coal dust is present. Dry brake pads have to be changed every 6,000-10,000 operating hours.

The use of LNG in place of diesel has been looked at over the years by several companies, mainly to address the issues of high diesel prices, and high prices in logistical terms in getting fuel to mines on a day to day basis. There is also the issue of diesel emissions legislation. In reality the systems tend to use a mix of natural gas and diesel. One of the companies involved is Westport Innovations, which has a High Pressure Direct Injection (HPDI) solution. HPDI uses a diesel-cycle engine that retains diesel performance and efficiency with low methane emissions and around a 25% reduction in greenhouse gases production relative to diesel. Pilot diesel is injected just prior to natural gas to provide energy for auto-ignition of gas injection. Natural gas is then injected at high pressure at end of compression stroke (no pre-mixed air/fuel) HPDI offers low diesel usage under all conditions. The Westport solution offers an average of 4-6% diesel over vehicle operating cycle with no reduced performance and the

same high power and torque as well as the same or higher efficiency.

LNG has some 60% of the energy of diesel fuel on a volume basis but 115% of the energy of diesel fuel on a

mass basis. HPDI uses about 5% diesel fuel over an operating cycle. Westport has conceptual designs with one or multiple-tanks, with design targets of 12-15 hours between refuels and a sub-20 min refuel time. Existing engines can be retrofitted to be able to use gas technology. The challenge is not necessarily technical, the volume difference means that it can be a challenge to work out where the LNG tank(s) will best go on the truck. For example a 100 t requires a 200 gal LNG tank. This is where Pioneer's expertise has been used, in how best to mount and fit LNG tanks on to trucks.

Bruce Hodgins at Westport commented in a recent presentation: "For most mines, a new LNG production facility will need to be constructed to provide sufficient fuel volume. While some mining companies may be willing to take on the fuel production, there are many experienced energy companies interested in investing in this infrastructure with recovery through fuel sales."

The fuel consumption of one or two mines is an ideal scale for underpinning an efficient LNG production facility. LNG can also use a variety of feedstock sources, including pipeline natural gas, stranded gas wells near mine sites, coal mine methane (CMM) or coal seam methane (CSM) and bio-methane from a wide range of sources (waste).

Natural gas at the mine site can also be used for power generation, process heat, and LNG off-sales to support on-road transportation.

Another company that has developed LNG solutions for mine trucks is Gaseous Fuel Systems (GFS). In October 2010, the company announced that it had successfully demonstrated its Bi-Fuel conversion system for mining vehicles in the US. A Caterpillar 777 has been operating at a commercial coal production facility in Harlan County, Kentucky, with more than 60% gas substitution for diesel without loss of performance. GFS went on to say that it is preparing to launch its first commercial US fleet conversion of mining vehicles in 2011 in Eastern Kentucky and Southern West Virginia. The statement said:



Installation and commissioning of an MTU Tier 4 Series 4000 pre-trial unit in a Liebherr haul truck in April 2009

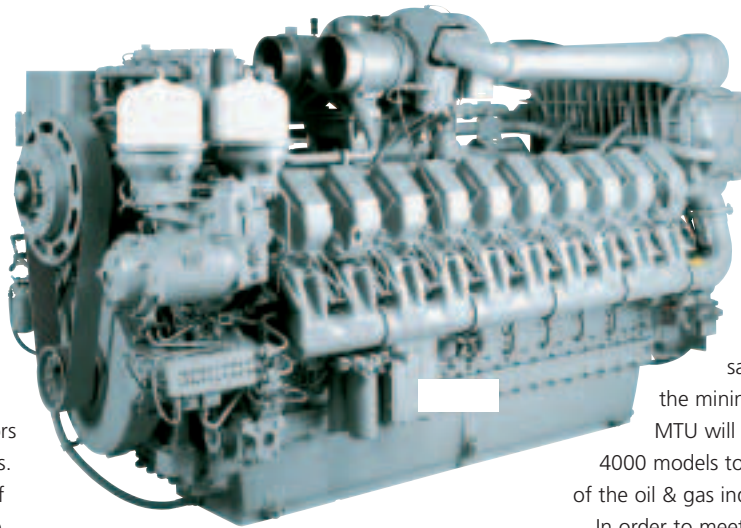
"The region is uniquely suited for the conversion of hundreds of mining trucks to the GFS Bi-Fuel System. There is a unique combination of surface mining and available LNG within a 300 mile driving radius." The GFS Bi-Fuel System will allow mining equipment to operate saving more than 30% on fuel cost using US produced natural gas while lowering emissions.

The Finnish Radiator Manufacturing Co (Finnradiator) has a focus on the design and production of various types of radiators for heavy-duty trucks and off-road vehicles. This includes the design and production of both copper and aluminium radiators. The radiator assembly type can be either sandwich or combicooler. The company has invested in a new CuproBrazed production line in recent years. In radiator technology, the list of OEMs who use brazed copper brass heat exchanger components continues to grow and many familiar OEM brands have joined the ranks of CuproBrazed customers, according to Finnradiorator.

CuproBrazed alloys are anneal resistant, even at the high brazing temperatures of the CuproBrazed process. They maintain a high tensile strength and yield strength into these elevated temperatures, high above the temperatures at which aluminum alloys would fail. The steep drop in the tensile strength and yield strength of aluminum alloys above 200 °C results in reliability issues for aluminum heat exchangers.

Vibrations from the diesel engine and the road add cyclic stress to the internal pressure of a heat exchanger. Anneal-resistant alloys inhibit the healing of defects yet fatigue-resistant alloys prevent defects from accumulating and forming microcracks. CuproBrazed brass alloys are both anneal resistant and fatigue resistant. The corrosion resistance of CuproBrazed heat exchangers has been extensively studied. The excellent corrosion resistance of CuproBrazed products is due in part to the fact that the copper fins, brass tubes and filler materials all have about the same electrochemical potential so there is little tendency for galvanic corrosion.

Numerous other OEMs around the globe are testing cooling systems with CuproBrazed radiators and charge air coolers, keeping in mind existing (on highway), 2011 (offroad) and 2012 (locomotive) EPA emissions standards and similar standards in Europe (EU Stage 3B and 4) and Japan. Finnradiorator believes that there is an industry-wide consensus that present-day radiators and charge air-cooling systems will be inadequate for the higher pressures and



The MTU 20V4000C22 engine

temperatures planned for future diesel engines.

Tier 4 testing in Chile

From 2015, diesel engines in the mining sector in North America will have to meet stringent emissions limits. In order to meet future EPA Tier 4 requirements, MTU has conducted pre-trials with a Series 4000 mining engine at the Chuquicamata mine in Chile. MTU approached the mine's operator Codelco Norte regarding the installation of a pre-trial unit to run tests regarding emission reduction technologies for mining engines. Implementing appropriate technologies is especially challenging in mining applications, where components are strained to the limit. "In order to keep fuel consumption at current levels despite the massive reduction in emissions, we had to increase peak cylinder pressures drastically", explained Ingo Wintruff, MTU Project Manager for the development of the new Series 4000 generation. "The high cylinder pressures present a serious challenge for powerpack, pistons and cylinder heads, particularly in demanding mining applications. So to better assess the engine's performance, we decided to run test under actual field conditions at an early stage."

In 2009, the pre-trial unit was installed in a Liebherr T282. During the test phase, the engine was thoroughly tested and, after 3,000 hours of daily

operation, shipped back for examination to Friedrichshafen. Here, MTU engineers documented and analysed all the collected data. This information also proved especially useful for engines in similar applications that face the same challenges as engines in

the mining industry. From mid-2011, MTU will launch the new Tier 4i Series 4000 models to be used in the pump drives of the oil & gas industry.

In order to meet future emission standards, additional engine internal measures will become inevitable. Thus, future generations of EPA Tier 4 final mining engines will feature cooled exhaust gas recirculation (EGR), two-stage turbocharging system and an improved common rail fuel injection with increased injection pressure as well as a new combustion process with modified valve timing. The objective is to avoid the components used for the after-treatment of exhaust gases.

For coming engine generations, the key to success will be the perfect integration of all these technologies. "Pre-trials such as the one conducted in Chuquicamata will remain crucial when it comes to optimising emission strategies," summarizes Codelco's Wilson Brevis. "We're happy to cooperate with such a renowned engine manufacturer and be part of the development of next generation technologies that will advance the mining business." **IM**

A Haulmax 3900 operating at the Stockton Alliance mine, Westport, New Zealand. Photo supplied by NZ Truck & Driver Magazine

