WHITE PAPER

Lubrisense™ 2016 17

LUBRICATING GREASE & MINING
Unearthing Potential through Protection

Mark Wheeler
Market Development Engineer, Global Key Accounts
AXEL CHRISTIERNSSON INTERNATIONAL AB

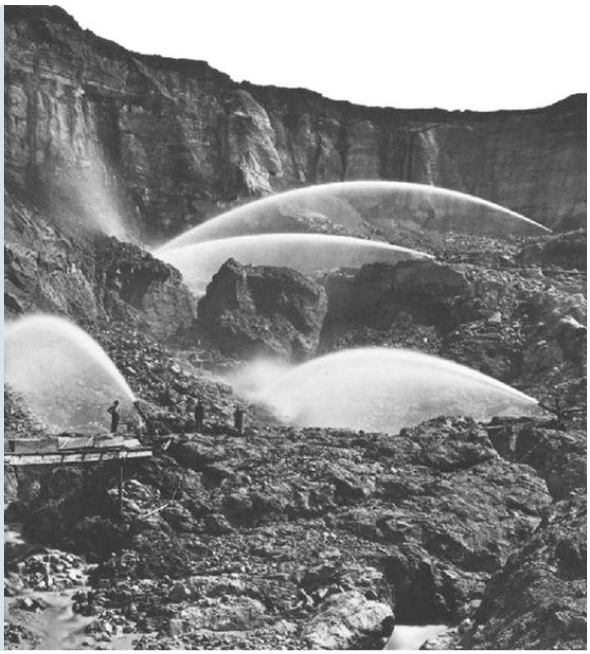
Developing Solutions for Asset Management in the Mining Sector

by guest writer Peter Macourt,
Harrison Manufacturing Company Pty Ltd

AXEL
AXEL CHRISTIERNSSON

LUBRICATING GREASE & MINING

by Mark Wheeler



The History of Mining
The value of the metal and mineral reserves that exist naturally as part of the earth's crust has long been recognised and consequently their exploration and extraction has been going on for many years.

Primitive and dangerous in the early years, mining techniques have transformed over time with technological advances enabling improved capability, increased operational efficiency and enhanced health and safety, whilst simultaneously reducing the impact of mining activity on the environment.

The Mining Market Today
As a market segment, mining exists in two distinct forms; namely underground mining and surface or open cast mining.

As an industry, the revenue generated annually is worth billions of dollars which alone gives some insight into its value and importance. However, when you also consider that a wide variety of other diverse global industries such as those producing cars, computers, medicine and material for infra-structure like steel are becoming increasingly reliant on the supply of mined commodities for their own growth and development, this really does underline how pivotal the mining industry is to the wider world's economy.

Therefore, with such a responsibility on its shoulders, productivity within the mining industry continues to be a priority as it aims to restore and create sustainable value into the future.

Key to overall productivity and cost effectiveness is operational efficiency, which in turn is dependent on a combination of equipment reliability and cost control.

Mining Equipment & Components
Excavating, processing and transporting material within a mining operation requires dedicated, specialised equipment. A key element in ensuring the reliability and cost effectiveness of such equipment is the appropriate selection, application and management of the correct lubricating grease technology.

Before selecting or indeed developing grease technology for any given application, it is first essential that the operational demands of the equipment and the environment are fully understood.

Mining equipment can be split into two distinct categories; namely mobile and fixed plant. As the name suggests, mobile plant is equipment that is frequently relocated within a mine for the purposes of extracting and transporting overburden.

Examples of mobile plant include:

- Mining trucks
- Giant bucket wheel excavators
- Drag lines
- Electric mining shovels
- Mobile crushing plant & transfer conveyors

Conversely, fixed plant describes equipment that remains in a fixed location within the mine. Examples include:

- Mills
- Crushers
- Conveyors

In terms of both cost and size, the scale of the equipment required to extract product effectively and efficiently can be matched by the large cost implications of equipment failure and downtime,

highlighting the importance and value that can be gained by adopting the correct process of grease selection.

The capability and productivity of all mining equipment relies on a wide range of components and mechanisms for drive and movement. And whilst the associated manufacturers do what they can to contribute to the components' durability for use under such harsh operating conditions, it is only in combination with appropriate lubrication that these components become fully functional and deliver to their full potential in terms of expected life.

Unearthing a Solution

So when faced with a need to recommend a lubricating grease for a given application, where should we start? As already mentioned above, only by understanding the operating conditions and the challenges they create can we begin to start formulating our ideas around the most appropriate solution.

When it comes to mining, just one look at the equipment in action and on location provides an immediate insight into the common challenges faced by the components and lubricating grease that operate in such environments.

In mining equipment, mechanical movements range from rotation, sliding, rolling, rubbing and reciprocation. Sometimes they occur in isolation, but quite often they occur in combination and simultaneously. When this is combined with relatively low operating speeds, extremely heavy loading, high vibrational activity and shock loads, it is no surprise to learn that those nice, surface separating hydrodynamic lubrication regimes are very hard, if not impossible to achieve in this sort of environment.

Frequent attempts to bring moving metal surfaces into close and potentially damaging contact, further highlights the severity of operating conditions. However, every cloud has a silver lining and with such insights we can also begin to understand what will be necessary in a lubricating grease to ease the situation and keep things moving.

It is, of course, little wonder then that when faced with such harsh conditions, the grease lubricant will contemplate a bid for freedom.

Therefore, the primary consideration when selecting the most appropriate grease for a particular application is that, when applied, it actually has the ability to remain present once in operation to do its job.

Resistance to the rigours of the dynamic component in operation is undoubtedly one element of the equation, but at this point, it is perhaps also important to highlight the need to recognise the potential of external factors to actively disrupt the effectiveness of the lubrication process.

Mining applications are, due to their very nature, exposed to a variety of external contaminants such as water. A suitable lubricating grease must therefore be able to provide adequate resistance to the adverse effects of water contamination, whether it be structural softening, or in the worst case scenario, complete washout.

Similarly, the presence of airborne dirt and dust is an unwanted, abrasive and consequently life limiting addition to the operation of a mechanical component and the effectiveness of the lubricating film. Therefore, the grease also needs to act as a self-sealing barrier capable of keeping abrasive contaminants at bay.

Taking the above points into consideration, the process of tailoring the technology can start. From a lubricating grease formulator's perspective, the technology at our disposal can be split into the now familiar three fundamental components:

- Oil soluble & non-soluble additives
- Liquid phase including both base oil & polymeric technology
- Thickener technology

The Additives

In terms of oil soluble additive technology, it's not difficult to understand that in addition to the usual base line technologies employed to protect and prolong both lubricant and component surfaces in most applications such as anti-oxidants and corrosion inhibitors, the amount and type of each particular component needs to be tailored to ensure their performance capabilities align with application demands.

In mining, robust EP, anti-wear performance and the need for good corrosion protection are in particular focus.

Furthermore, due to the frequent occurrence of boundary lubrication regimes, many mining greases will also include solid additives in the form of molybdenum disulphide or graphite. Both are examples of lamellar solids; layered structures capable of delivering excellent lubrication and resistance to shock load conditions in applications where sliding, reciprocating and oscillating motion are particularly prevalent.

In combination with slow speeds and heavy loads, the result is often that the bulk grease is completely "squeezed out" and in such instances, the solid lubricant "plates out" on the metal surface and acts as the sole remaining contributor to the lubrication process.

In components such as the boom foot, boom arm and bucket pins, an audible indication that the selected grease is suitable and doing its job well is operational movement without "pin squeak"

which again, is a phenomenon that can be managed and eliminated through the inclusion of solid additives.

As already mentioned, due to the heavy duty nature of operations in the mining sector, the boosting of oil soluble additive treat rates as well as adopting solid lubrication technology are essential ingredients in the battle to protect metal surfaces, extend component life and therefore maintain equipment productivity.

The Liquid Phase

That said, the additives cannot be expected to resist such harsh conditions alone and indeed the liquid phase can be very influential in the overall process of effective, efficient lubrication.

Indeed, as speeds decrease and loads increase, the base oil viscosities typically seen in traditional multipurpose EP 2 greases would cease to be sufficiently effective.

Therefore, in the interests of creating a liquid lubricant phase with enhanced film strength that is better able to keep surfaces apart and thus contribute to extending the capability of the grease to lubricate better for longer, base oil viscosities are typically required to increase.

Due to the relatively low temperature demands of many mining applications, the most widely used lubricating grease in this segment tends to be mineral oil based. As base oil viscosity is increased overall grease mobility will, in turn, get progressively worse and is a factor for particular consideration where grease-lubricated components are being serviced through centralised lubrication systems. The issue of grease mobility in relation to increasing base oil viscosity can be further exacerbated when ambient operating temperatures are lower.

It is through this process of carefully balancing the need for a robust lubricant film whilst maintaining good grease mobility across a range of ambient temperatures that have led most OEMs of mining equipment to require multiservice greases with fluid phase viscosities of between 460 cSt and 680 cSt typically.

In warmer climates, these values may be higher and similarly, in colder climates, lower viscosity mineral oils may also be used. Of course, for operations

DEVELOPING SOLUTIONS FOR ASSET MANAGEMENT IN THE MINING SECTOR

In geographically large countries, logistics efficiency plays an ever increasing part in the make or break profitability of businesses in many parts of the economy. This is certainly true in a country like Australia, and especially so for the mining sector. Geographically, Australia is 31 times the size of the entire UK. In fact the whole of Western Europe would fit comfortably inside Australia's boundaries, while Continental USA is just 4% larger in total – it is indeed a big country.

However, for such a large country, Australia is very sparsely populated with just 24 million people – about half the population of Spain, a third that of the UK and less than 10% of the USA. It has a 10,000km long coastline, with over 85% of residents living within 50km of the coast. Over two thirds of the population lives in just five capital cities, all coastal based. The green coastal fringe quickly gives way to a dry and arid centre – 35% of the country is classified as desert, with a further 35% considered semi-arid.

It is a country of enormous mineral wealth, with the world's largest identified recoverable reserves of gold, iron, lead, nickel, uranium and zinc, along with significant proportions of the world's reserves of coal, copper, diamonds, silver, bauxite and aluminium.

regularly running in sub-zero temperatures an alternative approach is to switch away from mineral-based greases to semi-synthetic or fully synthetic-based greases for optimised low temperature mobility.

Another contributor to the fluid phase of many mining grease formulations are polymers. Sometimes the primary purpose for their inclusion is to simply boost base oil viscosity, however, perhaps more commonly they are used to increase both the adhesive and cohesive properties of the grease, thereby enhancing resistance to water as well as a barrier to other external contaminants.

Such features are particularly beneficial in those exposed applications where the primary function of the lubricant is to cling on and act as a robust protective barrier between the metal component and the elements. Wire rope and chain greases, for example, tend to benefit from the use of greases containing polymers as they help to increase surface adhesion and reduce fling off.

So far we have looked at those challenges within the mining segment that determine how the additive and fluid phases of the grease formulation are best

combined in order to contribute to extending the lifetime of both components and grease.

However, fully functional, finished greases are, as we know, not thick oils but thickened oils, so let's finalise our formulation by focusing on this unique ingredient that differentiates a grease from an oil: the thickener.

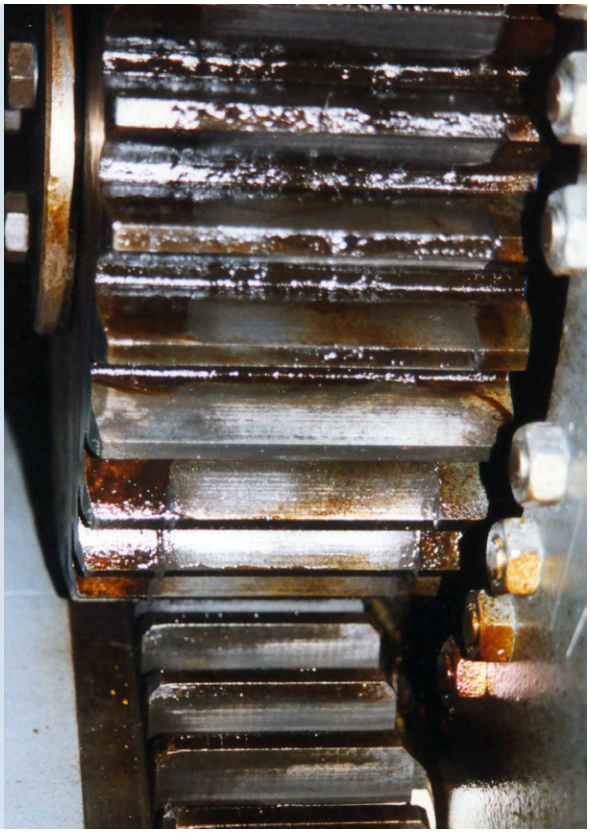
Australia's mining industry is one of the five largest in the world. Recently collated figures show Australia as:

- Largest global producer of bauxite
- #2 producer of iron ore, alumina lead & manganese
- #3 producer of gold, nickel, zinc, uranium and brown coal
- # 4 producer of aluminium, silver and black coal
- # 5 producer of tin

Australian mining contributes 10% of total GDP, employing 2.5% of the working population. (ref Mining Australia). There are over 400 currently active mines, split evenly between the east coast and western part of the country.

With mining's heavy investment in physical equipment, maximising productivity of assets is a continuous challenge to operators and their suppliers around the world. With the distances involved in the Australian industry, this challenge is made even greater. One company in Australia has developed a solution that has created significant financial and time savings for their clients in the area of grease and lubricant logistics management

Harrison Manufacturing Company is based in Sydney, the largest city in Australia. Established in 1923, Harrison Manufacturing Company (HMC) is a privately owned company and Australia's largest grease manufacturer, offering a full spectrum of high performance grease and lubricating products to domestic clients and throughout the Asia Pacific region. HMC is a full service contract manufacturer, manufacturing customers' own formulations as well as a comprehensive range of greases HMC has developed in-house to meet the demanding local environments, in tailored packaging, with a range of pack sizes from 400gm cartridges all the way to 20,000kg format.



The Thickener
Thickeners are the technology platform from which all lubricating greases emerge and provide the foundation for the many structural properties key to delivering effective lubrication and protection under operating conditions beyond the capability of traditional lubricating oils.

It is the thickener/oil combination that gives lubricating grease its multiphase, matrix structure enabling its unique viscoelastic properties to behave as a solid under static conditions with the potential for controlled flow under conditions of dynamic shear.

The amount and type of thickener can have a significant influence on many grease properties from consistency, thermal and mechanical stability through to low temperature mobility and water resistance.

Furthermore, there are several thickener types that represent useful technology platforms for mining greases, depending on the usual factors around application and conditions of operation.

GLAM – Grease & Logistics Asset Management
Mining in Western Australia takes place in some of the world's richest mining country, with huge reserves of iron, gold, diamonds, copper, zinc, alumina and nickel. Mine development activity peaked in 2012/13, and while the industry is currently off these recent highs, there is still significant levels of activity occurring at existing mines. Australian mining is a heavy user of greases and lubricants, with a competitive landscape in place among the major global players in the Grease & Lubricant sector.

HMC has been filling intermediate grease bins, typically around 1.25T capacity, at the Sydney headquarters on the east coast for a number of years, supplying to clients in the mining sector all around Australia. HMC saw an opportunity to significantly reduce turnaround times for the benefit of all stakeholders. Supply and refilling from the East Coast to Western Australia was proving to be very expensive and too slow In response to this challenge, HMC assessed there was an opportunity and developed a Grease and Logistics Asset Management system (GLAM) that began with the simple premise of reducing turnaround times for intermediate grease bins. The program initially focused on refilling at regional supply hubs as close as practicable to the main mining centres, as well as offering maintenance services at those same hubs for grease bins that became damaged or needed general maintenance during the course of their working lives. The first regional hub has been implemented in Perth, Western Australia, 4000km from HMC's home base in Sydney with an impressive immediate impact in terms of cost savings and asset turnaround times.

Prior to the Perth hub opening, HMC supplied a range of products from the Sydney base to G&L marketers in Western Australia. This involved transcontinental transport from Sydney to Perth (4000km), then further intrastate transport that could total over 6000km in a single one way journey for a 1.25MT capacity grease bin. Added to that, grease bins

Depending on the market and operational demands, grease platform technology will and does vary. Some markets around the world are still using bitumen-based mining lubricants until such time as legislation or supply determines otherwise, but regardless, there are a variety of grease technologies ranging from the more conventional to the next generation, high performance technologies with enhanced potential to deliver versatility and reliability.

Conventional Thickener Technology

Anhydrous Calcium technology represents an excellent cost-effective platform for greases requiring excellent water resistance, corrosion protection and surface adhesion in combination with good pumpability at lower temperatures.

For this reason they are an excellent platform for multipurpose greases particularly suited to the lubrication of plain bearings, wire ropes, chains, rails and geared applications across a range of mining equipment where operating temperatures are not excessively high.

In addition, when combined with appropriate base oils and additives, anhydrous calcium grease can be used to formulate biodegradable greases which, as mining operations become increasingly mindful of the need to limit environmental impact, brings obvious benefits.

Conventional lithium technology in combination with the right choice of base oils and additives represents a very good multipurpose platform for most heavy duty applications within a mining operation due to its structural and thermal properties.

Naturally, not as water resistant as anhydrous calcium greases, such performance can easily be enhanced through the use of higher viscosity base oils and/or the inclusion of polymers ensuring that lithium-based technology is the most commonly referenced thickener system in the multiservice grease specifications of most heavy duty/mining equipment manufacturers.

Recognising the strengths that come from anhydrous calcium and lithium technology individually, it is also possible to combine such technologies in a single *calcium/lithium* platform in order to maximise the benefits of both.

requiring repairs or adjustments needed to make a deviation of over 2000km to the OEM for repair and maintenance work before returning to Sydney for refilling. A grease bin that required repairs could take upwards of four months to complete a single circuit.

In setting up the hub in Perth with a refilling and maintenance facility, grease bins now only need travel from the mine back to Perth before returning to service, reducing asset downtime by well over 50%.

Adding GPS Tracking & Telemetry to Increase Efficiency

Once the launch program was proven, HMC viewed the next horizon, involving the addition of GPS tracking of grease bins and adding Telemetry units that allow for remote reporting of content levels of bins, providing accurate assessment of future requirements to both client and supplier.

Complex Thickener Technology
Moving away from conventional thickener technologies, complex thickeners were developed as an advanced technology capable of enhancing the thermal stability of the finished grease when compared with their conventional thickener counterpart.

In the mining industry as in many other industries *lithium complex* based products have seen an increase in popularity as the next generation multipurpose lithium grease capable of delivering improved thermal stability. The additional benefit of lithium complex technology over lithium technology in mining is its enhanced mobility and pumpability at lower ambient operating temperatures which can translate to benefits in terms of both lubrication and application when dispensed via centralised lubrication systems.

Aluminium Complex thickeners are naturally very adhesive and tacky, thus function very well in those applications demanding resistance to water wash and "squeeze out" from on or between metal surfaces.

Consequently, wire ropes and open gears are examples of application areas that can benefit from the use of such technology, when coupled with an appropriate base oil/additive combination.

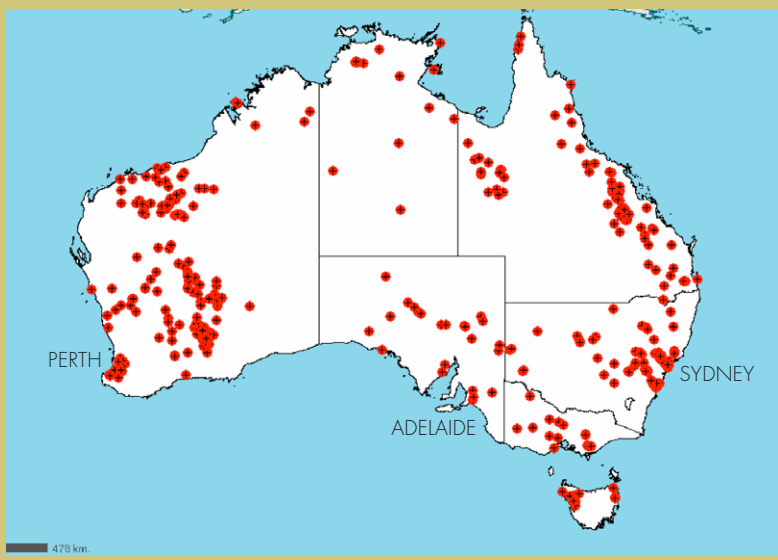
Functional Thickener Technology
Functional thickeners are so called because of their ability to deliver enhanced protective performance through technology built into the thickener system itself, which would otherwise be derived from the use of more traditional oil soluble additives.

In recent years, advances in the development of one such functional thickener technology; *calcium sulphonate complex* has seen early disadvantages related to poor lubricity at lower ambient operating temperature overcome.

As a consequence, its combination of excellent water resistance, corrosion protection and load carrying capability has seen this technology emerge as an increasingly popular platform on which to formulate a wide variety of lubricating greases for mining equally suited to wire rope or open gear applications.

GPS tracking of bins provides immediate benefits. An effective unit will mean no bin gets left behind, no longer will such valuable assets be lost or misplaced, every single unit, provided the GPS unit is doing its job efficiently, will be able to provide a location whereabouts and be able to be accounted for, resulting in significant savings. For a company with a fleet of over 800 bins, the reduction of bin losses to near zero is expected to run into the tens of thousands of dollars per annum.

The addition of Telemetry systems as well as GPS, where grease and lubricant bin contents are measured remotely and communicated back providing accurate feedback on the content of each bin in the fleet, also creates large opportunities for logistics savings as well as greatly improved



MAP OF AUSTRALIA'S OPERATING MINES
2012/2013 – ALL COMMODITIES

An alternative functional thickener to that of pure calcium sulphonate complex is a hybrid system based on a combination of lithium and calcium complex technology. Much like its conventional soap counterpart, it brings together the strengths of both lithium and calcium complex technology in areas such mechanical stability and water resistance in a more thermally stable, heavy duty package.

Focused on the Future

It is widely recognised that equipment downtime adversely impacts productivity, efficiency and the profitability of any industry. In the mining industry such cost implications are magnified due to the sheer scale of operations and even more so at times when commodity prices are also under pressure.

As a consequence, the valuable contribution that lubricating greases can play in enhancing the reliability of equipment and reducing the costs associated with maintenance and component failures is likely to receive greater attention from operators in the future and play an increasingly important role in their aim to restore and create sustainable value going forward.

Therefore, whilst there is certainly still a place for the on-going use of conventional grease thickener technologies, as mining operators and their customers continue to strive for increased productivity and efficiency, there is also an increasing trend towards the use of more advanced, high performance lubricating greases in the future.

NEXT ISSUE

In the next issue of the Lubrisense™ White Papers we will be exploring the changing landscape of base oil availability and its impact on grease formulations with a particular emphasis on Naphthenic Oils.

As always we encourage and welcome feedback from you as well as suggestions for grease technology topics you would like to see covered in future Lubrisense White Papers.

Editor: Mark Wheeler
mark.wheeler@axelch.com

supply chain efficiencies. By capturing data relating to the current contents of each bin, assessments can be easily made by supply teams for the scheduling of the collection cycles and grease production.

Procurement teams or suppliers accessing the data provided by GPS and Telemetry systems working accurately and in unison mean that demand forecasting and forward requirements can be far more robust and precise, minimising and even eliminating supply shortages. This is particularly attractive in a market with Australia's geographic scale, where close management of supply lead times is absolutely essential. As clients increasingly add severe penalties into contracts with suppliers for failing to meet guaranteed supply and performance rates, management of this section of the supply chain has never been more critical.

Australia's mining industry is spread broadly across the country. Major operations occur in four of the six states, from Queensland in the north, New South Wales in the east, South Australia in the south and Western Australian in the west. A one-way trip via each major mining centre of Australia would cover over 5000 miles (7500kms), nearly one third of the way around the circumference of the Earth. There is no doubt that this adjustment to HMC's business approach has produced huge savings in time, cost and efficiency for all stakeholders, not to mention reducing environmental costs associated with long distance haulage.

By guest writer Peter Macourt,
Strategic Business Development Manager,
Harrison Manufacturing Company Pty Ltd.

Peter Macourt has 25 years' experience in Sales, Marketing and Business Development in the Chemical and Food industries.

AXEL CHRISTIERNSSON AB

P.O. BOX 2100
SE 449 11 NOL
SWEDEN

TEL +46 (0) 303 33 25 00
FAX +46 (0) 303 33 25 90

AXEL CHRISTIERNSSON BV

1 FEBRUARIWEG 13
4794 SM HEIJNINGEN
THE NETHERLANDS

TEL +31 (0) 167 52 29 80
FAX +31 (0) 167 52 22 71

AXEL FRANCE SAS

30 RUE DE PIED DE FOND
Z.I. ST LIGUAIRE
CS 98821
79028 NIORT CEDEX
FRANCE

TEL +33 (0) 49 77 13 71
FAX +33 (0) 5 49 73 95 30

AXEL AMERICAS LLC

1440 ERIE
N, KANSAS CITY, MO 64116
PO. BOX 12337
USA

TEL +1 (0) 816 471 4590
FAX +1 (0) 816 471 2240

WWW.AXELCH.COM
INFO@AXELCH.COM

A COMPANY IN THE FAIRFORD GROUP