THYSSEN MINING Report 2014/15

www.thyssen-schachtbau.de

IMPRINT

Publisher:
THYSSEN SCHACHTBAU GMBH
Sandstraße 107-135
45473 Mülheim an der Ruhr
Phone +49 208 3002 - 0
Fax +49 208 3002 - 327
info@ts-gruppe.com
www.thyssen-schachtbau.de

Editing:
Franz Stangl
Jeanette Meier
Joachim Gerbig

Translation (english):
KeyCom Konferenzdolmetschen
Christa Gzil

Translation (russian):
Lisa Zaydman

Layout:
Iris Huber, denkbetrieb.de, Werl

Photos:
Employees TS Group
Archive TS
Archives TS-Subsidiaries
Employees from project partners

Printing:
Druckhaus Cramer, Greven
www.cramer.de

Cover picture:
Ursula Ahlers
Mining activities of THYSSEN SCHACHTBAU (collage on canvas)

Cover picture inside:
Freeze pipe drilling in the Russian Federation (Oil on canvas)

THYSSEN SCHACHTBAU employees while working safety training

IMPRESSUM

THYSSEN MINING Report 2014/15

CONTENT

The members of the Executive Board of THYSSEN SCHACHTBAU GMBH, Dipl.-Kfm. Michael Klein (l.) and Werner Lüdtke

Ladies and gentlemen,
business partners and associates,
fellow colleagues,

we should begin by thanking you all for your interest in, and positive response to, last year's publication, Thyssen Mining Report 2012/13.

The latest Thyssen Mining Report 2014/15 will again be covering in some detail the diverse international activities of the THYSSEN SCHACHTBAU Group and of Thyssen Mining Construction of Canada Ltd.

Our combined workforce of some 3,600 made a significant contribution to the strong business development of both companies in 2013 and while the market situation and economic conditions were less than favourable, we succeeded in increasing our total revenue to almost 550 million euros and as a result have further strengthened our market position. Backed by a technically skilled and highly motivated workforce we will continue to be reliable and innovative partners to national and international clients in the mining and construction industries.

The activities of the various Group companies are now briefly outlined below.

THYSSEN SCHACHTBAU Group

The THYSSEN SCHACHTBAU Group operates nationally and internationally as a specialist contractor for the mining, shaft sinking and drilling, production and services sectors. Our leading market position has been built around the ability to develop and successfully implement innovative solutions for the fresh challenges that are always arising in the complex and specialist field of mining and subsoil operations. By offering an extensive range of services in-house we are able to provide our customers with turnkey solutions, from project planning supported by feasibility studies and the preparation of all the necessary engineering through to the professional execution of the work.

Occupational health and safety is another key aspect of the Group's remit and our performance in this important area has been consistently improved over the years with the result that the company now has the lowest accident rate in this sector of industry.

At national level the Group's main focus of activity continues to be associated with the coal and salt mining sectors and with permanent disposal sites for radioactive waste.

In addition to our national and international affiliates we also maintain business establishments in Switzerland, Austria, Macedonia, Australia and Russia.

THYSSEN SCHACHTBAU GMBH – Shaft sinking and drilling division

This division has been operating at national and international level for more than a hundred years and has already completed more than 280 mine shafts for clients all over the world. It is now one of the world's leading providers of specialist mining services and as well as conventional shaft construction the division also specialises in cementation work, freeze sinking and fully mechanised shaft boring.

The major projects currently being developed in Russia have proved to be a huge challenge in every respect. We have now opened agencies in Moscow, Norilsk, Kotelnikovo, Perm/Usolye, Solikamsk, Kaliningrad and Saratov so that we can better undertake our ambitious business objectives across the country. The workforce in Germany and at our project locations has been gradually built up in line with the division's positive business results in recent years, enabling us to meet the complex demands of the market as and when they arise.

While THYSSEN SCHACHTBAU's highly developed mining technology has always attracted established customers from the raw-materials industry, power station operators and tunnel construction firms are also now beginning to use the company's technical services. To supplement this, the Group has its own Technical Office where all permit and execution plans can be professionally drawn up for the different mining projects being undertaken by our various companies. These services are also available to customers outside the THYSSEN SCHACHTBAU Group.

The significant increase in capital assets of recent years as a result of extensive, future-oriented investments now forms the basis for an ongoing programme of successful ventures at home and abroad.

THYSSEN SCHACHTBAU GMBH – Mining division

The mining division is primarily engaged in vertical and horizontal excavation projects at RAG Deutsche Steinkohle AG's German-based collieries.

This mainly comprises roadway drivages and major cavity excavations, along with a wide range of underground mining services. The mining division is also involved in mine drainage operations as part of the coal industry's inherited liabilities programme. With a technically skilled and highly trained workforce the mining division is now on a sound financial footing and well equipped to face the challenges that lie ahead.

THYSSEN SCHACHTBAU GMBH – Administration department

All company operational units are now commercially managed and supported by the central administration department, which comprises legal affairs, finance and accounts, financial control and taxation, manpower services, IT, purchasing and health and safety management.

TS BAU GMBH

TS BAU, which currently has branch offices in Jena (Thuringia) and Riesa (Saxony), has been in operation since the mid-1990s and now handles contracts from all over Germany.

As well as structural and engineering assignments, including turnkey projects, the TS Bau range of services includes landfill site construction, roadbuilding, track-laying and civil engineering work, demolition with waste recycling, specialist mining operations, pipeline construction, trenchless pipe-laying and high-tech water pipe and sewer pipe renovation. The company's successful portfolio also includes two participating interests in landfill construction and raw-materials production.

The company has a workforce of 370 and currently handles nearly 50 million euros of business a year.

DIG DEUTSCHE INNENBAU GMBH

DIG has been one of the top names for high-quality commercial fit-outs for nearly 50 years. The firm's range of activities include general contractor services for full-performance assignments, with the focus very much on major projects. This comprises consultation, planning and execution services for standardised drywall installations and challenging major-project fit-outs for national and international clients, including airports, hospitals, banks hotels, shopping centres and office buildings.

DIG was also in overall charge during the design and execution of the major internal fit-out now completed at Europe's largest building site – ‚The Squaire' at Frankfurt international airport.

TS Technologie + Service GmbH

TS Technologie + Service is a forward-looking engineering services provider. The company uses the latest technology to provide solutions on a bespoke basis, from concept planning and design through to technical installation.
T + S specialises in welding engineering, machining, assembly and repairs, building services, crane and gate technology and electrical engineering. The company can also carry out plant maintenance and dismantling work, either on a one-off basis or as part of a package solution. With an impressive array of plant and equipment spread over some 7,600 m^2 of workshop space, including crane capacity for components weighing up to 80 t, the company is well equipped to handle all kinds of large-sized and heavy fabrications. The procurement of two large boring mills has further expanded the range of services available to clients, mostly from the power generation, steelmaking, mechanical engineering and mining sectors.
By maintaining close lines of communication with its customers the company has consolidated its reputation for supplying high-quality products, delivered on time.

OLKO-Maschinentechnik GmbH

OLKO-Maschinentechnik, which was acquired in 2012, is a leading manufacturer of winding machines, friction winders, mobile and fixed rescue winches and plant and equipment for the building materials sector.

Since joining the TS Group OLKO has seen its business volume more than double and with its 100-strong workforce now has the capacity to supply shaft construction equipment and the associated winding and materials conveying technology from a single source, the only company in the world to provide this level of service for shaft construction and winding machine projects.

As well as engaging with is domestic customers and business partners OLKO has therefore succeeded in gaining a strong foothold in the international market.

It is also the first operator in this area to have delivered and commissioned a materials transportation system to China.

EMSCHER AUFBEREITUNG GMBH

Emscher Aufbereitung, which is now the largest producer of pulverised coal in Europe, has been involved in the crushing and drying of fuel for the PCI sector since 1957. The company operates six crusher-drier units at its Duisburg plant and knows all there is to know about the technical complexities of this type of operation, which involves having to accommodate quality variations in the globally-sourced grades of coal and petroleum coke that pass through the crushing and drying plant.

The company has been delivering PCI coal to ThyssenKrupp Steel AG since 1987 and is now the sole supplier to all its German-based blast furnace operations. With an existing production capacity of some 2.1 million tonnes the plant is able to guarantee supply security for the sensitive blast furnace operations 365 days a year.

Thyssen Schachtbau Immobilien GmbH

The company is responsible for managing the entire property portfolio of the THYSSEN SCHACHTBAU Group in Germany. While this mainly comprises office buildings and workshop facilities it also includes houses, rental properties, building plots and industrial sites.

The company currently operates one of the region's largest photovoltaic plants at the Thyssen industrial park in Mülheim an der Ruhr, where a new environment-friendly energy concept is now being planned and developed. This comprises a completely new condensing boiler and circulating pump system, new lighting and a new heating system for all the workshop facilities.

Thyssen Mining Construction East OOO

Established in Moscow in 2008 the company is mainly responsible for organising plant and machinery imports and exports with Russia and for recruiting local workers for specialised rock blasting work in the Russian market.

TOO SCHACHTBAU Kasachstan

Established in 2011 as a joint venture with our partners SCHACHTBAU NORDHAUSEN GmbH (each with a 50% holding) the company remit is to acquire contracts and projects in the Kazakh market.

The first major assignment is now under way, a 4,150 m underground drivage at Chromtau.

Thyssen Mining Construction of Canada Ltd.

The company with head office in Regina, Saskatchewan is specialized in sinking of potash shafts with difficult and challenging terrain. TMCC has established a series of subsidiary companies and JV partnerships aimed at extending its range of services and geographical presence within North America. These are: CMAC-Thyssen, based in Val D'Or, Quebec, AMC is a joint holding, Jetcrete North America, Sovereign-Thyssen and the Thyssen-Abergeldie JV.

Dear readers,

our clients and business partners continue to be central to all our operations. Advanced technology, innovative ideas and rigorous application of the highest standards when it comes to quality, reliability and adherence to deadlines – this is what sets the TS Group apart.

Add to this a committed and highly motivated workforce – and we should like to take this opportunity to thank all of them for their tireless efforts and focussed approach.
As you will gather from the individual company reports we are now in a position to provide our German and international customers with an extremely wide range of services and a highly diversified product portfolio.

We trust that you will enjoy reading about the interesting projects that have been carried out under the TS banner and hope that the Report provides an informative insight into the varied and wide-ranging activities of our Group companies.
With our very best wishes

Michael Klein   Werner Lüdtke

Works council THYSSEN SCHACHTBAU GMBH

The THYSSEN SCHACHTBAU GMBH Works Council: Looking back at 2013 and assessing the prospects for the years ahead

Ladies and gentlemen, fellow colleagues,

The year 2013 again presented some tough challenges for everyone at the company. This was due on one hand to the difficult business environment surrounding RAG and the German coal industry, which is partly political in nature, but can also be attributed to the ever increasing challenges mostly on the shaft sinking and drilling division, particularly as a result of ongoing – and often extremely complex – international projects. All this impacts increasingly on the workforce and every member of staff is being called upon to give a hundred percent to ensure that the company remains a successful player in this market in the years ahead.

Review

We should now like to present a brief progress report that provides an insight into the activities of the Works Council. During 2013 the Works Council held 37 operating committee meetings covering the following themes and decisions:

Staff recruitment	105
Departures, incl. temporary contracts, sub-contracted labour and pension based retirements	202
Staff transfers	241
Staff appraisals	277
Participation in health and safety committee meetings	4
Project visits and site inspections	86
incl. with authority representatives	14
Works Council meetings and works meetings (January 1 to August 31, 2013)	8

A number of our Works Council colleagues are also involved on a voluntary basis with the social courts and industrial tribunals and sit on the pensions committee of the BGRCI. These various commitments illustrate just how wide-ranging are the activities of the Works Council representatives.

Outlook

The Works Council will continue to rely on your support in the performance of its tasks and responsibilities. Please speak to us and get involved as much as possible. In this way we can work together to help THYSSEN SCHACHTBAU develop and move forward to greater success.

Demographic changes have already resulted in a shortage of skilled labour and this trend is set to accelerate over the coming years. Our response must therefore be to focus even more on vocational training and qualifications.
This approach to human resource management will lay the foundations for our competitive abilities in the years to come. And all sides will be called upon to do their bit. The company can drive and support this development, but for us employees it is essential to recognise that we must remain part of the knowledge society – for only through lifelong learning can we maintain our high level of performance in a rapidly changing world.

Some of the specific issues that will occupy our attention in the future are summarised below:

Job satisfaction

We can speak about job satisfaction when the following conditions are met:

1. A secure and regular employment relationship
2. Performance-based pay
3. Recognition of performance
4. Respectful conduct towards our fellow workers
5. Personal development opportunities
6. Good qualification opportunities
7. Job scheduling that avoids ongoing, systematic work overload
8. Job requirements that match each worker's age and personal experience

Job satisfaction is not a ‚complete stress-free package' or ‚feel-good package' for employees, but rather it describes the conditions that each of us needs to be able to perform efficiently and deliver good results. Motivated employees who feel appreciated, who feel fit both physically and professionally, who feel that they are being treated fairly and whose job gives them a good standard of living, are a priceless asset for any company.
Reconciling work and family life

Female employees - and perhaps more especially their male colleagues - would like to be more actively involved in family life. Some 60% of fathers and 40% of mothers support a reduction in the weekly working hours so that they can spend more time at home. There is therefore a significant interest in achieving greater reconciliation between work and family life.

Occupational health and safety

Health and safety is another subject that is particularly close to our heart. While 2012 saw the lowest accident rates ever recorded in the history of THYSSEN SCHACHTBAU, the targets set for 2013 were unfortunately not fully achieved and this area will therefore require a huge collective effort if health and safety performance is to be improved in the months to come. Every accident is one too many and we can never rest on the laurels of our success, as the recent statistics show. While statistics are impersonal things, behind every figure there is a human being with a family whose health and financial situation will be affected by an accident at work.

Thank you for your trust in us

On behalf of myself and all my colleagues on the Works Council we would like to take this opportunity to thank you for the trust that you have placed in us. We also want to wish you all the best in your future endeavours and will conclude by extending a traditional miners' greeting to all of you whose job it is to go underground on a regular basis.

Bernd Grätz · graetz.bernd@ts-gruppe.com
Chairman of the Works Council

Two safety management systems in place at THYSSEN SCHACHTBAU GMBH: SMS and SCC

THYSSEN SCHACHTBAU GMBH is a safety-certified company that operates a systematic occupational health and safety system:

SmS

THYSSEN SCHACHTBAU GMBH has had the ‚system-oriented safety‘ (SmS) quality seal since 2004, which is the equivalent of the international OHSAS 18001 standard (Occupational Health and Safety Assessment Series). In Germany SmS approval is awarded by the BG RCI in Bochum (Liability Insurance Association of the Raw Materials and Chemicals Industry). In the re-audits of 2008 and 2011 THYSSEN SCHACHTBAU was able to demonstrate that it had a systematic health and safety protection system in place.

SCC

The internationalisation of the Shaft Sinking and Drilling division now requires the existing Safety Management System to be extended to include ‚Safety Certificate Contractors‘ (SCC for short). The Safety Certificate Contractors is a set of rules for a certifiable management system. It was developed in the petrochemical industry for companies wishing to operate as contractors and combines all aspects of occupational health and safety and environment protection. It is therefore a unified health, safety and environment management system.

The firm has set itself the ambitious target of introducing the SCC management system company-wide by the end of 2014. SCC is therefore a combined occupational health and safety and environment management system that seeks to prevent unsafe actions, unsafe situations, operational stoppages and accidents that can be attributed to the conduct and actions of contractors‘ staff.

SCC imposes minimum requirements on the company‘s occupational health and safety and environment protection management system. It sets a minimum standard and can be used to assess the safety management performance of contractors according to recognised uniform criteria. SCC certification is based on the German normative regulations that have been drawn up in accordance with German labour protection legislation.

The certification process is built around the principle that certification can only take place when the appropriate policies and documentation guidelines have been in force for at least three months. During certification every aspect of occupational health and safety and environment protection is examined by an accredited author on the basis of the following SCC checklist.

SECTION	
1	MANAGEMENT POLICY, ORGANISATION AND COMMITMENTs
2	HAZARD ASSESSMENT
3	TRAINING, INFORMATION AND INSTRUCTION
4	AWARENESS
5	PROJECT PLANNING
6	ENVIRONMENT PROTECTION
7	PREPARATIONS FOR EMERGENCY SITUATIONS
8	INSPECTIONS
9	OCCUPATIONAL HEALTHCARE
10	PROCUREMENT AND TESTING OF MACHINES, EQUIPMENT, APPLIANCES AND WORKING MATERIALS
11	PROCUREMENT OF SERVICES
12	NOTIFICATION, REGISTRATION AND INVESTIGATION OF ACCIDENTS, NEAR-MISSES AND UNSAFE SITUATIONS

Two-stage auditing

Auditing is a two-stage process. In stage 1 the company's health, safety and environmental documentation is assessed and an initial audit is carried out in-house in order to determine, through discussions with the management and workers, that the company is ready to undergo certification. When this first-stage audit has been successfully completed stage 2 can be planned and implemented. As well as visiting the company head office the auditor also travels out to different job sites, workshops and assembly sites, inspects the health, safety and environmental conditions under which the employees are working, questions members of staff during the course of their work and looks at the evidence for assessing all the relevant checklist questions.

Current status of in-house certification preparations

THYSSEN SCHACHTBAU has been operating the SmS occupational safety management system (OHSAS 18001) for ten years. The aforementioned minimum requirements of the SCC management system are included in the SmS system, however worker training is not part of the SmS remit. The task as it is at present is therefore to organise worker training sessions and to test all members of staff and provide them with the necessary qualification.

Training

Operational staff and management personnel are trained in accordance with specified criteria. Managers are trained and examined externally in accordance with the Doc. 17 standard applied by the German Society for Petroleum and Coal Science and Technology (DGMK). Operational staff are trained and tested on site in accordance with DGMK Doc. 18.

What remains to be done?

The gaps and deficits highlighted by questionnaire analysis need to be closed and corrected. This includes the assessment of operational managers under consideration of industrial health, safety and environmental aspects, the introduction of Last Minute Risk Analyses (LMRA) immediately before starting work, the investigation of accidents without lost working time, the updating of accident statistics with management signature and compliance with SCC thresholds.

Outlook

True to the principle that ‚actions speak louder than words' we are now well on track and fully expect SCC certification to be attained by the end of 2014. And there is every reason to hope that this certification will provide an additional stimulus for greater success in our health and safety procedures and will enable us to stay at the forefront of contractor safety certification in the national and international mining industry.

Burkhard Büdel · buedel.burkhard@ts-gruppe.com
Christian Emmerich · emmerich.christian@ts-gruppe.com

Thyssen Mining Construction of Canada Ltd – A short Overview

Established in 1964 to sink potash shafts in the challenging ground conditions of Saskatchewan, Canada, Thyssen Mining has retained its North American head office in Regina, SK, ever since. Saskatchewan has the world's largest potash reserves and the world's richest uranium mines, and Thyssen Mining has grown into one of Saskatchewan's largest private companies.

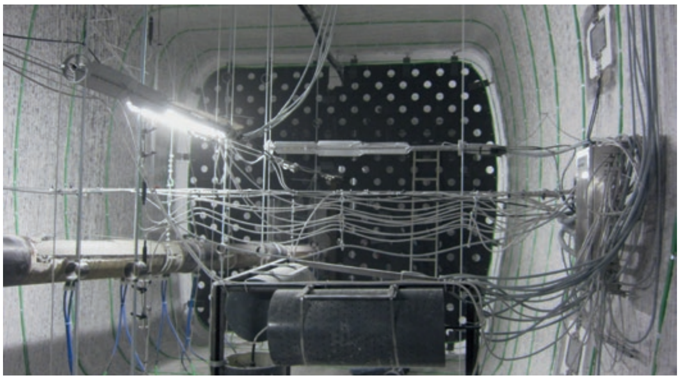
Thyssen Mining has created a number of subsidiaries and joint ventures to expand its range of services and its geographic presence across North America. CMAC-Thyssen is a Quebec-based company with an office in Val d'Or, the center of the province's gold mining industry, providing underground mining contracting services and manufacturing a range of unique production drilling equipment. AMC is a company jointly owned with the Redpath group and specifically formed to service the potash mining industry by providing shaft sinking and related services. Jetcrete North America is a joint venture providing specialized shotcrete and concrete services to the North American mining industry. Sovereign-Thyssen provides grouting and water sealing solutions using a proprietary polymer grout called NOH2O. Our latest venture, the Thyssen-Abergeldie JV, will provide blind-shaft boring services to our Canadian customers.

Lastly, Thyssen Mining is proud of our longstanding and highly successful relationships with our First-Nation, Méti and Inuit partners through the Mudjatik Thyssen Mining JV (Saskatchewan), Youdin-CMAC-Thyssen (Quebec) and Sarliaq (Nunavut).

I thank our clients, partners and employees for making Thyssen Mining a safe, productive and world-class underground mining contractor.

René Scheepers
President
RScheepers@thyssenmining.com

Head office in Regina, SK, Canada



Pic. top left: Hoist engine, a product of the OLKO-Maschinentechnik
Pic. bottom left: Construction of sealing dam in rock salt strata
Pic. right: Shaft refurbishment during the construction of the permanent disposal site Konrad

THYSSEN SCHACHTBAU GMBH: Tradition, innovation and success at a high level

THYSSEN SCHACHTBAU GMBH: a specialist mining contractor with operations in Germany, Switzerland, Austria, the Balkans, Poland, Russia and Kazakhstan. The TS motto ‚fully committed' epitomises a corporate culture that is forward-looking and designed for sustainable success.
The THYSSEN MINING GROUP, comprising Byrnecut Mining (Australia), THYSSEN Mining Construction of Canada und THYSSEN SCHACHTBAU (Germany) achieved a record turnover of 1.2 billion euros in 2013 with a manpower base of 6,500 employees. The Group operates as a global provider of mine development and mineral extraction services.

THYSSEN SCHACHTBAU – business developments

THYSSEN SCHACHTBAU, with its head office in Mülheim an der Ruhr, has traditionally undertaken shaft sinking and drilling operations and underground roadway drivage projects. The company currently has branch offices in Moscow (Russia), Almaty (Kazakhstan), Sedrun (Switzerland), Graz (Austria), Skopje (Macedonia) and Katowice (Poland).

Since the company was founded in 1871 its operational activities have mainly centred on shaft sinking, roadway drivage and drilling. As a mining-focused company TS's core competence has always been associated with development drivages in coal and in stone, in other words the creation of the underground infrastructure needed for operating a mine. Following the contracts recently awarded by OAO Norilsk Nickel the company portfolio now also includes the construction of complete mining infrastructure on greenfield sites. Overall business performance has increased substantially in particular over the last two years.

During the reporting period the number of employees engaged in ‚Shaft sinking and drilling' increased to nearly 850. Together with their colleagues in ‚Horizontal drivages' the combined workforce of the two mining departments now stands at some 1,200. This does not include administrative staff. The average age of the division's personnel is 41.

Investment has continued in modern plant and machinery and in measures aimed at enhancing the skills and qualifications of the workforce. This will ensure that maximum technical performance can still be delivered at innovation level for years to come.

In 2012 and 2013 the company's business operations mainly focused on challenging projects carried out in the Russian Federation. This involved the construction of two mining complexes, which included sinking deep mine shafts in Norilsk for OAO Norilsk Nickel and the complex and demanding drilling and freeze-shaft projects undertaken for EuroChem in order to develop the potash salt deposits at Gremyachinski und Palasherski. And innovative assignments have also been completed for the German permanent waste disposal industry. In addition, the company is developing new technology for the non-mechanised loading of shaft sinking debris and for highly mechanised, pilot hole-based shaft boring.

Specialist mining operations in Germany

In Germany the company's activities have traditionally focused on the coal, potash and salt mining industries and, especially in recent years, on the preparation of underground storage repositories for radioactive waste.

Initial cut of the shaft boring by using the shaft boring machine VSB VI

THYSSSEN SCHACHTBAU has been carrying out development drivage work for the RAG-managed German coal mining industry for many years using both mechanised roadheading machines and conventional heading methods based on drilling and blasting.

Germany's underground disposal industry for radioactive waste continues to be one of the company's mainstays: most of this effort is concentrated at the Konrad waste storage facility, which is operated by the German Service Company for the Construction and Operation of Waste Repositories (DBE). The Konrad project involves converting the two surface shafts at the former iron ore mine for operation as a final waste repository, extending the shaft-inset areas and renovating sections of the disused mine workings. The rope winding installations at the two shafts also have to be replaced. This construction work forms part of an extensive remit to be undertaken by DBE with a view to providing the Federal Government with storage capacity for radioactive waste material. The task of converting and preparing the former iron ore mine for use as a repository for radioactive waste is expected to be completed by 2020.

At the now disused, DBE-operated Morsleben radioactive-waste repository (ERAM) TS has successfully constructed an in-situ stopping in the salt zone as part of the long-term safety certification for the waste storage site. This structural seal is about 25 m in length and contains some 500 m³ of salt concrete along with extensive measuring instruments. Pressure tests have since confirmed that the stopping meets all the requirements in respect of sealing technology and structural tightness.

In the interim THYSSEN SCHACHTBAU has also been commissioned by DBE to construct a vertical sealing element for the Morsleben repository. This type of structural seal is required, for example, for the sealing of surface shafts as part of the mine closure procedure.

Working in conjunction with OLKO-Maschinentechnik the company has supplied and installed a new winding system for the Bartensleben shaft, which forms part of the Morsleben waste repository. THYSSEN SCHACHTBAU and OLKO-Maschinentechnik also won a contract from K+S KALI GmbH to design, supply and install a winding installation for the 800 m-deep Fürstenhall shaft at the Siegfried-Giesen reserve mine.

More than 12 years of specialised civil engineering work in the Alpine region – now extended to include operations in the Balkans

THYSSEN SCHACHTBAU has been continuously involved in shaft construction, raise boring and core drilling activities in Switzerland for more than 12 years. To put these operations on a more sustainable basis the company has now teamed up with the Swiss firm IMPLENIA Bau AG to establish the long-term joint venture TIMDRILLING.

Over the last five years numerous exploration boreholes and raise-bore shafts have been completed by a team of engineers specially set up in Austria for this purpose. These operations have further consolidated the Alpine market. This business has now been extended to the Balkan area and contracts have subsequently been acquired and successfully completed in Macedonia, Slovenia and Bosnia.

In Macedonia a contract was acquired for the construction of 10 raise-bore shafts. A commission in Slovenia involved the drilling of exploration boreholes up to 800 m in depth, while a series of brine leaching holes were required as part of an assignment from a rock-salt mine at Tuzla in Bosnia.
The success of this venture has depended very much on the untiring efforts of the personnel directly involved, who have shown a very high level of commitment and enthusiasm.

Shaft sinking in Russia

The company's Russian operations comprise shaft sinking projects in the Volgograd, Perm and Krasnoyarsk regions. These operations involve sinking depths in excess of 2,000 m and freeze shafts with freeze-wall depths of as much as 820 metres. In addition, two complete ore mining complexes are currently being constructed in Norilsk for OAO Norilsk Nickel.

Coal mine in Poland

New markets in Kazakhstan and Poland

THYSSEN SCHACHTBAU's business objective of strategic market expansion has now been entirely fulfilled with the setting-up of new subsidiaries in Kazakhstan and Poland.

THYSSEN SCHACHTBAU has joined up with SCHACHTBAU NORDHAUSEN GmbH, Nordhausen, to set up the specialist mining company ‚TOO SCHACHTBAU Kasachstan' in Almaty with a view to establishing itself in the medium term as a specialist contractor to the Kazakh mining industry. The first contract has now been acquired with a programme of

Construction of two turn key mines in Norilsk, Siberia

Raise boring in Macedonia

Freeze hole drilling, freezing and unfreezing in the Russian Federation

Tunneling with hard ground conditions in Chromtau, Kazakhstan

extensive underground roadway drivages for the chromite mine ‚Tenth Anniversary of Kazakhstan Independence', which is operated by Donskoi GOK, a subsidiary of the Kazakh mining company AO TNK Kazchrome. The drivage operation commenced in August 2013 and is expected to last until 2017.
In early 2013 TS also joined with Dortmund-based Deilmann Haniel GmbH to set up the Polish specialist mining contractor Deilmann-Thyssen Schachtbau sp. z o.o., with head office in Katowice.

THYSSEN SCHACHTBAU – future business strategy

The company's overall economic situation looks good. There is now a high degree of specialisation and the company has established unique selling points in areas such as freeze shaft sinking, freeze boring technology and the construction of hydraulically tight underground stoppings for permanent waste disposal sites.

The leading position that has been achieved in the freeze shaft construction sector has been successfully maintained thanks to a series of innovative technical developments based on in-depth experience and expertise. The company's portfolio now includes both cast-iron tubbing systems and composite linings with welded steel-plate cylinders.

Personnel and training: a strong affinity and identification with the company

The increase in personnel to some 1,200 can mainly be attributed to shaft construction projects in Russia and more than half of our workforce are now engaged in operations outside Germany. Our employees have an average length of service of more than 12 years and the low staff turnover and long period of affiliation attest to the strong bonds and sense of loyalty that they feel towards the company.

Most of our employees take part in regular skilling and qualification programmes based on a management and work-safety system. The company's basic principle has always been to employ highly skilled and motivated personnel and to provide them with the latest machinery and equipment and this has laid the foundations for a positive business development and strategic market expansion. Using targeted training and education programmes we have been able to maintain and extend our body of expertise. Maintaining company know-how and keeping our workers' skills at a high level are the company's most important objectives.

Well-trained personnel with a sound knowledge of their craft have, through their own innovative ideas, played a part in shaping and driving the latest technological advances. An in-house Technical Office responsible for delivering the required project planning services has always been integral to corporate policy-making. The rapid growth in employee numbers also calls for our management and corporate culture to be fostered and trained to meet the challenges that lie ahead. We shall be working rigorously and consistently to achieve this through 2014 and the years thereafter.

Research and development

After many years of inactivity in this area the company has again become strategically active in developing new technology for the shaft sinking industry and is now working intensively with RWTH Aachen on a non-mechanised system capable of loading sinking debris from the shaft floor as the excavation work progresses.

We have also teamed up with Herrenknecht AG and Murray & Roberts Cementation of South Africa to develop a new generation of pilot-hole shaft boring machines for hard rock conditions. This project aims to analyse and build on the experience that RUC-Cementation and THYSSEN SCHACHTBAU acquired during the 1980s and 1990s from their joint operations with shaft boring machines.

THYSSEN SCHACHTBAU has bored deep shafts over 8 m in diameter in Germany, Switzerland, Australia, the USA and South Africa. At a depth of about 3,500 m in the Western Deep Levels gold mine in South Africa the company successfully drilled through rock with a rated strength of over 550 MPa. Fully mechanised shaft sinking based on the pilot-hole method has now been developed to perfection and on the basis of this experience a new generation of pilot-hole shaft boring machines (the V-mole system) is now being designed and put into service that will make shaft sinkings of 8 to 11 m in diameter a feasible proposition.

Workplace safety: re-auditing for ‚System Oriented Safety' (SmS) and initiation of the new Safety Contractor Certificate (SCC)

Targeted seminars and training sessions were again held in 2012 and 2013 aimed at maintaining health and safety protection standards. The company continues to meet the requirements for a systematic and effective workplace safety system based on the SMS seal of approval and this has now been audited and verified by the BG RCI (Mining and Chemical Industry Employers' Association). Workplace safety standards continue to improve year on year in an exemplary manner.

There is no doubt that the SMS initiative, which was launched by the Industry Employers' Association in 2004 and monitored by them ever since, has made a significant contribution to the declining accident rates. The SmS certificate, which recognises that an undertaking meets systematic health and safety requirements based on the OHSAS 18001 standard, was again awarded to the THYSSEN SCHACHTBAU operational departments for a further three years following a successful audit in 2011.

As a result of the expansion in international business the THYSSEN SCHACHTBAU Safety Steering Committee decided that in addition to the SMS management system the company would undergo an audit in accordance with the internationally recognised SCC safety programme.

Certification to DIN EN ISO 9001

In order to meet company requirements and fulfil our contractual obligations to clients, as well as to provide effective support for the application of the legal basis and the duties resulting therefrom, the THYSSEN SCHACHTBAU Shaft Sinking and Drilling Division has introduced an integrated management system that covers all quality and work-safety aspects of our operations. This system complies with the stipulations of DIN EN ISO 9001 and also meets the requirements of the BG RCI's SMS certification.
In July 2011 the process was successfully concluded and the certificate was duly awarded by the TÜV Rheinland certification body. The company constantly strives to improve its operating methods and corporate procedures and this effort has become an integral part of every-day operations. The next audit will take place in 2014.

Establishment of THYSSEN SCHACHTBAU-Engineering

THYSSEN SCHACHTBAU has now set up a new section – THYSSEN SCHACHTBAU-Engineering (TS-E) – that will operate alongside our Technical Office in delivering project services: TS-E will in future provide external engineering services,

Chromium ore mine „tenth anniversary of Kazakhstan's independence"

particularly in areas such as project planning, engineering and construction supervision. The established and experienced Technical Office has traditionally been responsible for preparing approval stage and final design plans for projects that have been acquired by the Shaft Sinking and Drilling and by the Horizontal Drivages departments. The Technical Office therefore operates primarily as an internal project planning service.

THYSSEN SCHACHTBAU: ‚fully committed' to ongoing business operations

Work on the two mining complexes in Russia, where sinking is under way at the Norilsk WS-10 and SKS-1 shafts, is expected to continue until 2019. The Konrad project, where preparations are ongoing on a permanent storage site for radioactive waste with negligible heat generation, has good prospects of running until 2020.

The Norilsk and Konrad projects continue to pose real challenges for the TS engineering teams and these operations will represent the base workload for the next five to seven years.

THYSSEN SCHACHTBAU is well equipped to meet the future and is looking forward to a range of fresh challenges at national and international level. Our aim is to work together to secure and consolidate what has been achieved. Being ‚fully committed' is essential to our corporate culture. This principle has brought us strategic and innovative success for many years and it defines how we go about our business.

Owner: Claudio L. Graf Zichy-Thyssen: driving tradition, innovation and success

Graf Claudio, the great-grandson of the founder August Thyssen, continues to maintain close links with the company, with mining and shaft construction still at the centre of his business interests. He embodies the values of tradition and innovation and in paying regular visits to the different operating companies he is carrying on the philosophy and tradition-conscious, sustainable approach of the Thyssen firm. The special bond that exists with the Thyssen family has also carried through to the workforce and as a result has created a special working environment for us all.

The THYSSEN MINING GROUP (THYSSEN SCHACHTBAU, TMCC, Byrnecut Mining) engages in specialist mining operations around the world in connection with the development and extraction of mineral resources. Even during times of crisis Graf Claudio was in no doubt about the Group's success and capabilities. He remains convinced that the company will achieve sustainable growth year on year in line with the global rise in demand for raw materials – products that can only be accessed via mine shafts, underground roadways and boreholes.

THYSSEN MINING GROUP teams up with OLKO-Maschinentechnik to create an international system supplier for shaft sinking and winding technology

The integration of Olfen-based OLKO-Maschinentechnik into THYSSEN SCHACHTBAU means that shaft construction projects will in future involve not just the actual sinking work but also the installation of the permanent shaft winding system as part of a single-source operation, thereby streamlining the interfaces normally associated with such a complex assignment.

This combination creates a positive synergy for the benefit of clients requiring professional support for the planning, construction and refurbishment of mine shafts. Investment costs and construction times for mine installations can be significantly reduced and a much greater and varied use can be made of the permanent winding equipment for shaft sinking or shaft renovation work. This applies particularly to shaft headgear, rope sheaves, winding machines, hoists, shaft fittings, signalling systems and control and automation technology, along with power supply equipment.

To our employees

Everyone at THYSSEN SCHACHTBAU has again contributed very successfully to the company's performance in a difficult and very competitive market.

The incorporation and application of new organisational structures with the introduction of new, quality-assured procedures, the integration of new staff members and the need to take on new duties all pose a huge challenge for management and employees alike. This process has to be rigorously implemented if we are to continue to hold our own in a competitive environment.

Strict adherence to our core competence, the innovative development of shaft sinking, roadway drivage and boring technology, and the inner cohesion and special corporate identification displayed by everyone at the company – these factors have had a lasting and sustainable impact on the THYSSEN SCHACHTBAU success story and on this basis we are well positioned for the future. We look forward to all the new technical challenges that await us at home and abroad and as usual we will be working in close partnership with our clients every step of the way.

Norbert Handke · handke.norbert@ts-gruppe.com

Office at the brand new business address

New markets 1: DTS is launched in Poland

At the ‚Krefeld talks' between the Board of THYSSEN SCHACHTBAU GMBH and its shaft sinking and drilling division held more than ten years ago the specialist mining contractor THYSSEN SCHACHTBAU determined to re-define its strategic objectives in response to the impact of the German Government's decision to phase German hard coal out of the national energy mix: the company was to maintain business interests in at least three countries and its ‚shaft sinking and drilling' division would remain a successful market player with at least three ongoing contracts in each national base. This approach would reduce the company's over-reliance on the German hard coal industry and safeguard the future of the 140 year-old business.

The company has now obtained commissions in the Balkans and in the Alpine region as well as in Russia and Kazakhstan. THYSSEN SCHACHTBAU also has a major involvement in drilling and ground-freeze operations at eight shaft construction sites in Russia. The healthy level of orders being acquired in Russia then led to the establishment of a subsidiary in Moscow - Thyssen Mining Construction East OOO (TMCE) - and to the setting up of a number of branch offices in the main mining regions of the Russian Federation.

This market presence was also to give THYSSEN SCHACHTBAU a greater prominence in central and eastern Europe. As a

Warm welcome in Poland

Ceremony for the foundation of the DTS

result of this, since 2011 the company has received a number of invitations from potential clients in Poland and the Czech Republic to tender for their shaft sinking and bunker construction projects, particularly in the hard coal mining sector, and in so doing to apply its technology know-how in mining and shaft sinking.

On the basis of a market analysis of the traditional mining regions of Poland and the Czech Republic, both of which have an enormous potential for development drivage projects in the years ahead, the Shaft Sinking and Drilling Division decided to set up a stand-alone company in this market too. At the same time a similar venture was being considered by the Dortmund-based company Deilmann-Haniel GmbH. On this basis the two companies took the joint decision to establish a new company right in the heart of the Upper Silesian coalfield, trading under the name Deilmann-Thyssen Schachtbau sp. z o.o. – or DTS for short – with its head office in Katowice.

The launch was celebrated at a ceremony held in the Katowice office on March 6, 2013, in the presence of prominent guests representing the government, church and mining industry. Speeches were given wishing the DTS team every success in their new venture.

The two experienced Polish managers who were recruited to head up the new company are not only familiar with the actualities and particularities of the Polish market but can also communicate effectively in both languages. A bi-lingual team was also assembled around the two company managers to help win the first business contracts. Polish personnel were to be included in the workforce when executing future orders.

The two parent firms will provide active flanking support for the development of the new company and will provide backup by way of project planning services and the provision of plant and equipment, experienced personnel and financial resources.

There is long tradition of cooperation between German and Polish mineworkers at German collieries and Polish workers have for decades worked alongside their German colleagues in development drivages and shaft sinking projects for the German hard coal industry. This situation is now being reversed and the partnership will henceforth be continued in Poland, one of the mainstays of the European mining industry.

Given these traditional ties, along with the positive market situation in the Polish hard coal industry, the technical expertise of the two parent companies and their strong financial support, there are hopeful signs that DTS can gain a foothold in the Polish market in the very near future and in so doing establish itself in the medium term as a stand-alone specialist mining contractor.

With a number of invitations to tender for planning and feasibility studies, a bunker construction project and shaft deepening work DTS has mainly received a positive response to its efforts to date and it is hoped that this will soon lead to its first commission.

Markus Gevers · gevers.markus@ts-gruppe.com
Thomas Jank · jank.thomas@ts-gruppe.com

Political districts of the Republic of Kazakhstan

THYSSEN SCHACHTBAU and SCHACHTBAU NORDHAUSEN are both represented in the brand new logo of SCHACHTBAU Kazakhstan.

New markets 2: JV company set up in Kazakhstan

After numerous requests , THYSSEN SCHACHTBAU GMBH and SCHACHTBAU NORDHAUSEN GmbH took a joint decision in 2008 to push ahead with major business acquisitions in Kazakhstan. THYSSEN SCHACHTBAU had already been engaged in various commissions from Kazakh companies since 2006. In 2011 the partnership set up the limited liability company ‚TOO SCHACHTBAU Kasachstan', with each partner having a 50% holding. In 2008 TS won and successfully delivered a planning contract for a deep shaft sinking project. In October 2012, the first major contract was drawn up with plans to drive a mine roadway through difficult geological conditions.

The Republic of Kazakhstan

The Republic of Kazakhstan is the world's ninth-largest country, with a surface area of 2.7 million km² and a population of 17 million. The official languages are Kazakh and Russian. The national currency is the Tenge. At the start of the contract in October 2012 the exchange rate was about 190 Tenge/Euro, subsequently rising to 250 Tenge/Euro in May 2014.

Kazakhstan is enormously rich in natural resources and is ranked between 1 and 3 in the world (2010) for lead, chromium, manganese, uranium and zinc production. The country is now set to take the number-one spot for uranium mining, while also being the world's eighth largest coal producer .

About 60% of the industrial production is based on mining, oil, and gas extraction. The industrial production Along with the engineering and the construction industries provide the basis for an expected growth in GDP of around 6% a year.

Definition of the partnership, company structure and objectives

After THYSSEN SCHACHTBAU's entry into the Russian mining market as a specialist mining contractor with the construction of two mining complexes, a number of shaft sinkings and several exploration and freeze-hole drilling projects, in 2006, the company began to receive an increasing number of enquiries from Russia's resource-rich neighbour, Kazakhstan.

In 2008 THYSSEN SCHACHTBAU and SCHACHTBAU NORDHAUSEN signed an agreement on the joint performance of specialist mining activities in Kazakhstan. In 2011 this led to the formation of a joint company in Kazakhstan under the name ‚TOO SCHACHTBAU Kasachstan', with each partner holding a 50% stake. While the main objectiveof the acquisition venture was shaft sinking, roadway drivage and drilling and ground-freeze operations,in addition, the new company would also be responsible for roadbuilding and environmental projects as well as for repair and retailing services.



Impressions from Kazakhstan

When the joint company was being founded, THYSSEN SCHACHTBAU and its resources were still involved in expanding and consolidating its business operations in Russia. For this reason SCHACHTBAU NORDHAUSEN took over the lead role in Kazakhstan and in 2010, as sole owner, set up ‚SCHACHTBAU Kasachstan' with its head office in Almaty. THYSSEN SCHACHTBAU took out a 50% stake of the company in 2011.

The ‚TOO' in Kazakhstan corresponds to the German ‚limited liability company', which means it is an independent enterprise with two shareholders. This continues the approach that THYSSEN SCHACHTBAU has taken over many years, namely only to enter a new national market and set up a company when there are good prospects of long-term employment with a sufficient volume of sales for a stand-alone company. Both partners were sure that this was the case and for this reason decided that they required more than just a short-term company structure, such as a subsidiary or similar set-up.

The new company is financed, in accordance with the articles of agreement, either by capital contributions from the shareholders or by debt obligations of the company. The governing bodies comprise the of a board of partners, the supervisory board, the managing director and the audit committee.

First commissions

After a small planning contract in 2008 associated with the construction of a deep shaft for the chromite mine ‚Tenth Anniversary of Kazakhstan Independence', which is operated by Donskoi GOK (a subsidiary of TNK KazChrome based in north-west Kazakhstan), the first major order was received in October 2012. The company currently has a staff of 70 employees working on this commission.

Franz Stangl · stangl.franz@ts-gruppe.com
Albert Holstein · holstein.albert@ts-gruppe.com
Eduard Dorn · dorn.eduard@ts-gruppe.com

Source
Nemitz, Fabian: Economic trends at the turn of the year 2013/14 – Kazakhstan, page 4.

New markets 3: On the trail of Alexander the Great – THYSSEN SCHACHTBAU GMBH in Macedonia

Makedonska Kamenica

The road from the capital Skopje leads through deep ravines and fertile plains with rice-fields, small settlements and countless stork's nests perched on the chimneys and pylons. In summer suicidal tortoises can be seen crossing the road. And what is most remarkable is the contrast you see everywhere between the modern and the living reality of something that seems to date from tales your grandfather told: the farmer on a donkey-cart trundling along a main highway and sitting next to him his grandson totally absorbed in his smartphone. Finally the road winds its way along the edge of an enormous reservoir and into a barren and secluded range of mountains that form the natural border with Bulgaria. A place where strangers rarely set foot. The people we meet here are exceptionally friendly and helpful. Their hospitality overwhelming.

This wonderful part of Alexander the Great's empire is home to Europe's largest lead and zinc mine. The place is called Makedonska Kamenica and it is dominated by mining. The monuments erected to the miners and the name of the main road through the town (which translates as ‚miners' street') speak for themselves.

"Glückauf" (the miners greeting is written above the portal) for the dedication of the tunnel „Golema Reka" (Big River)

Construction of the inclined slide holes under cramped conditions

After the mine was forced to close during the difficult times that followed the collapse of Yugoslavia, a substantial modernisation programme funded by a new investor has now succeeded in increasing production year on year and in making sustainable use of the mine's huge mineral deposits by employing a fully-developed mining concept.

Raise boring technology replaces Alimak shaft sinking

The mine's management introduced the latest mining equipment – ranging from drill jumbos to personnel transport systems – and altered the roadway profiles to suit the new plant. This modernisation drive was not restricted to machinery alone, for there was also a major re-think on health and safety procedures, with huge efforts being made to improve things in this area.

The stated objective is to eliminate the industrial accidents associated with the hazardous nature of the work below ground. In pursuit of this target THYSSEN SCHACHTBAU was commissioned to introduce the latest fully-mechanised raise-boring technology in place of the accident-prone and dangerous Alimak based shaft sinking equipment.

Moving to next drilling site

Three vertical raises of 25 to 35° have now been completed from boring chambers between the individual working floors. This will provide new ore and waste chutes and a new ventilation shaft. A Wirth HG 160-2 raise boring machine was specially modified for this operation and set on steel runners so that it could be more easily manoeuvred by mobile loader in the development drivages, where the cross-section is never more than 16 m². Ore production is not to be interrupted by the raise boring work, a requirement that presents a significant logistical challenge when moving from one underground drilling site to the next, sometimes over long distances and around tight curves. By May 2014 the team had completed eight boreholes ranging from 69 to 183 m in length.

Students and teachers at the nearby Goce Delcev mining and metallurgy university in Shtip have also been enthusiastic about the raise boring operations. The client, SASA, is the first mine operator to use this technique in the Balkan region.

THYSSEN SCHACHTBAU establishes a branch office in Macedonia

In order to carry out the commission the company set up a branch operation in Macedonia that will be managed from the existing office in Austria. With this project THYSSEN SCHACHTBAU will be taking its first steps in a region in which the modernisation of existing mining facilities is currently the main focus of investor interest. As there are still significant geological deposits as yet undeveloped in the resource-rich Balkans area there is a very promising market here for mining contractors. And the region's energy production capacity should not be underestimated either: European development funds are now being mobilised that will help exploit the enormous potential that exists, particularly for renewables, in this mountainous region with its abundant water resources.

Bianca Seberkste · seberkste.bianca@ts-gruppe.com
Raimund Bartl · bartl.raimund@ts-gruppe.com
Stefan Schichtel · schichtel.stefan@ts-gruppe.com

Drilling jumbo BTRK-2 for drilling blasting and block (Hilti) holes

The final 2,170 metres of roadway drivage at Auguste Victoria colliery heading for Wulfen number 2 shaft

Stone drift ‚DB NW 60', currently being driven at Auguste Victoria mine with a rising gradient of 7.5 to 9.5 degrees and to a final length of 2,170 m, will serve as the main water pumping route for Herne-based RAG Deutsche Steinkohle AG when mining operations at the colliery come to an end. In July 2012 THYSSEN SCHACHTBAU GMBH began work on the RAG contract to extend crosscut number 6, ‚NO 60', at a depth of 1,110 m, by a further 20 metres in a north-west direction with a view to establishing a bridge to the diagonal drift ‚NW 60'.

The break through towards Wulfen number 2 shaft is being excavated at a depth of 830 m. In September 2013 the drivage had reached the 853 m mark in a south-west direction. It then continued at an average incline of 7 degrees until the 963 m point, crossing through Zollverein 5 and Zollverein 6 seams in the roadheading process.

The need to traverse the Lembecker fault zone, which has a fault level of 40 m, posed a significant challenge in terms of workplace safety and the quality of the drivage profile. The team hit the fault zone on October 9, 2013, and were soon facing real problems in the form of roof cavities up to 7 m in height. The crossing proved to be an extremely difficult one and the roadhead slice had to be shored up repeatedly with a chain covering (to prevent further falls of ground) and filled via standpipes. The drivage could ultimately only continue by reducing the steel arch setting interval to 0.6 m and employing manual excavation methods to a large degree. A 3 metre-long reinforcing shield was also brought in to provide advance support for the roof. The Lembecker fault zone was finally traversed on November 10, 2013, after a distance of 37.5 m and the drivage was then able to resume its planned rate of advance under much better geological conditions.

Mechanised heading equipment	
Twin-arm drill jumbo	BTRK 2
Loader	K 313 S
GTA work platform	AMG 2800
Backfilling system	Elefantino
	7 m³ materials bunker
Mechanised debris clearance equipment	
RAG standard chain conveyor	PF 3
	Hydraulic transfer station and alignment device
Crusher	WB 1300
Chainless pusher system	With wall prop
Belt conveyor installation	Belt width 1200 mm
	Top and bottom belt conveying

GTA stage AMG 2800, loader K 313 S and crusher with chain conveyor in a drift

In December 2013 the team began to achieve a daily heading performance of 4 m in solid rock. Then on January 6, 2014, they encountered the second of the large fault zones, the ‚Kusenhorster Blatt', that ran for some 106 m through the line of the drivage. When the fault had been passed the roadheading then resumed its normal progress on February 25, 2014. Both fault zones had been traversed without accident or first-aid incident.
During the drivage phase colliery engineers carried out checks on the quality of the support work and twice gave it at 100% rating. This was a 'first' for a conventional drivage at Auguste Victoria and an achievement that was highly commended by the RAG support engineer.
The planned break-through to Wulfen number 2 shaft is expected in mid-2015. Before then there will be two more fault zones to cross. The high quality of THYSSEN SCHACHTBAU's roadway drivage work can be attributed to optimised working procedures and the careful approach taken by the tunneling crew. Even when the geological conditions were at their worst the drivage quality rating averaged 95%, with a figure of 100% actually being achieved in October 2013.
As 'DB NW 60' was to be the last roadway drivage ever undertaken at the colliery the workplace became the focus for an increasing number of underground visitors. One of the highlights took place in January 2014 with the final colliery visit of department head PV Thomas Nolde who planted a 'golden anchor' in the company of the works management and other division and section heads.

Mario Richter
richter.mario@ts-gruppe.com
Andreas Boy
boy.andreas@ts-gruppe.com

Tunneling crew of THYSSEN SCHACHTBAU at the Auguste Victoria mine

Development of key projects for the future of Prosper-Haniel colliery

As well as carrying out a number of small-scale operations at the RAG Deutsche Steinkohle-operated Prosper-Haniel colliery in 2013, the THYSSEN SCHACHTBAU GMBH on-site team was also commissioned to undertake two major, future-oriented projects at the mine: The drivage of main seam road E 566 to develop hard coal panels in seam G2/F and the excavation of stone drift D 348 to mine level 7, with a connecting roadway in the Zollverein 1/2 seam, will open up future extraction fields that will secure coal production at the colliery until 2018.

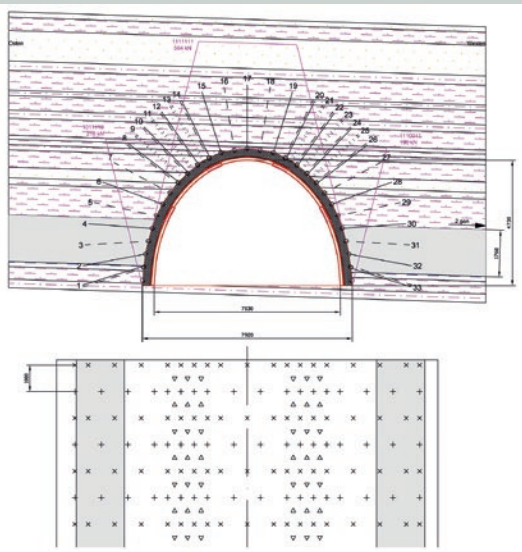
Main seam road E 566

The first project comprised the excavation of the new main seam road E 566 in the Haniel West section. The work commenced in 2012 and was completed in June 2013 with the roadway breaking through to the southern connection. This roadway will be needed for working a number of hard coal panels in seam G2/F and therefore has a huge infrastructural significance for the colliery. The mine planning engineers opted to use a Voest Alpine AM 105 roadheading machine for the excavation of seam road E 566.

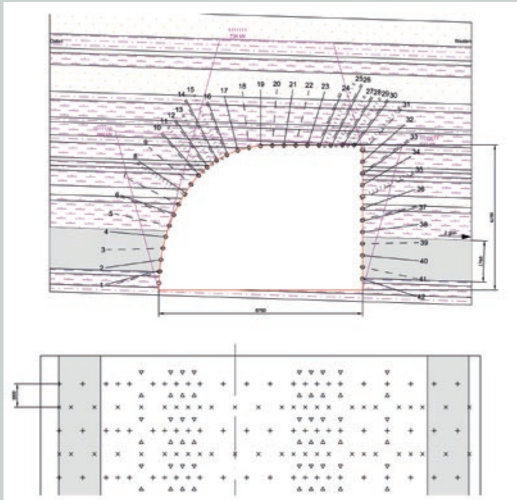
In November 2011 THYSSEN SCHACHTBAU was also commissioned to excavate a new turnout in gate road 192.1 that will later be used for driving the new seam roadway. After completing the start-pipe for the roadheader system and commissioning the machine itself the 250 m-long inclined stone drift was then excavated as far as the seam G2/F horizon. A 1,500 m-long section of roadway was then to be constructed along with several enlargement zones and five turnouts for future gate roads.

In order to counteract the anticipated convergence movements it was decided to install ‚type A' combination supports throughout. This meant that after the roadheader had excavated the roadway profile the rockbolts were systematically installed, followed by standing steel arch supports and concrete backfill. The bolting grid varied from 24.5 to 28 bolts per metre of roadway, depending on the local cross section.

While the roadway widening work and five turnouts certainly posed a challenge for the skills and craftsmanship of the tunneling crew, the problems that arose when cutting through several fault zones called for real mining expertise and a high level of physical fitness. Cutting a passage through the coal seams with the 120-tonne roadheading machine proved to be a real challenge here too and the heading performance rates varied from 2 m/d to more than 10 m/d depending on the particular geological conditions.



Rock bolting scheme in theory and practice



Rock bolting scheme at the roadway junction

Branching –
rock support with bolts and lagging mats

One special feature of the project is given by the high number of roadway junctions. While a tunnel cross section is normally only created at the beginning or end of a roadway heading, this project called for five such structures to be constructed of varying size. The support concept for the roadwy junctions also involved the use of ‚type A' combination supports, this time with a higher rockbolting grid and using 3 m-long rock bolts.
After the rock cavity had been created and the temporarily support system installed, this comprising rockbolts and weldmesh lagging, the steel arch supports were set in place right along the roadway and immediately backfilled with concrete.

Abzweig-Polygonträger mit Ausbaubögen

Due to the hard geological and tectonic rock conditions, intensive floor convergencies, esspecially floor heave has been occured in the course of the drivage operation. This was only made possible by using a sinking loader to guarantee an contineously road heading work.
The E 566 seam road project was brought to a successful conclusion in early June 2013 with the breakthrough to counter-heading D 389. The roadheading installation has now been dismantled and already set up in another drivage.

Inclined stone drift D 348 and drivage in Zollverein 1/2 seam

The second of the two projects involved the excavation of inclined stone drift D 348 in the direction of mine level 7 and its continuation in the Zollverein 1/2 seam horizon. The roadheading operation started in 2013 and continued into the following year. The creation of these roadways will provide access to future hard coal longwalls for development in the years ahead and therefore constitute an important basis for ensuring stable production from Prosper-Haniel colliery up to the year 2018.
In early 2012 THYSSEN SCHACHTBAU was awarded the contract to construct inclined stone drift D 348 to connect with Zollverein 1/2 seam horizon. Due to the infrastructural significance of the drift for ventilation, transport, compressed air and water supply the planners also opted for a ‚type A' combination support system that would ensure the long-term stability of the roadway. After about 1,000 m of drivage at a

Break through

dipping gradient of 9 degrees the heading reached the Zollverein 1/2 seam. The project was then completed with the construction of a large roadway intersection, also featuring ‚type A' combination supports that would create sufficient space for the infrastructure requirements of the mine.
After about 400 m of drivage in gate road 123.2 THYSSEN SCHACHTBAU was also awarded the contract to excavate rise heading no. 123.8. In view of the exceptional thickness of seam ZV 1/2 (currently > 4.5 m) the technical planners decided to use a category C shield support system. This is the first time that Prosper-Haniel mine has opted to employ this type of shield support, which has a maximum extension height of about 5.2 m and weighs about 40 tonnes per unit. In order to allow the complete shield units to be installed during the equipping phase without the need for further assembly work the roadway cross section had to be opened out to an appropriate size. After comparing alternative designs and undertaking technical calculations and feasibility studies it was decided that the heading would be driven using an asymmetrical profile and would be fitted with ‚type A' combination supports.
The size of the excavated profile meant that the drivage work had to be undertaken in two phases. In phase one the forward zone was excavated to 6.8 m of floor width and fitted with steel profile arch supports. Phase two then started some 100 m back and the roadway was excavated to its final 10-m width. Excavation work on the enlarged profile commenced in mid-October 2013. This exceptional and highly challenging drivage project was successfully completed in 2014.

Ulrich Barth · barth.ulrich@ts-gruppe.

Source: Planning documents supplied by Prosper-Haniel colliery, RAG Deutsche Steinkohle AG

Middle branch of raise

Road heading with temporary support

Conventional roadway drivage operations at RAG Anthrazit Ibbenbüren colliery

The underground deposits at RAG Anthrazit Ibbenbüren mine constitute the most northerly hard coal seams currently being worked in Germany. The 400 m-thick strata series lies at a depth of between 1,100 and 1,500 m and contains a total of eleven workable seams (seams 43-74). The deposits comprise high-quality anthracite coal with an ash content of 3 to 4%, a volatiles content of between 5 and 6% and a sulphur content of less than 1%.

The mine workings at Anthrazit Ibbenbüren are accessed by five surface shafts. The ground-breaking coal winning technology deployed by RAG is a benchmark for the international underground-mined coal industry. Operations are computer controlled from the colliery's surface control room and Ibbenbüren colliery is in many respects a recognised leader of innovation and technology that has already found national and international application outside the mining industry.

The north shaft extends 1,545 m below ground and is one of the deepest in the whole of Europe. The mine's principal customer is the 770 MW coal fired power station that is sited adjacent to the colliery.

Colliery facts and figures

Men on books as at 1.09.2013	2,413	
Annual production	Approx. 1.9	mt saleable
Average working depth	1,323	m
Maximum depth	1,580	m
Colliery take	92	km²
Roadway network	91.1	km

Key data for RAG Anthrazit Ibbenbüren colliery

THYSSEN SCHACHTBAU GMBH is currently contracted to drive three conventional roadways featuring a type A combined rockbolt support system with concrete backfill. The essential roadway data are presented in the following table.

Roadway	Length [m]	Cross section [m²]
Roadway 10 North seam 54	1,100	30.8
Roadway 10 North seam 54 – counter-heading	716	30.8
Eastern main seam road 7/8 West seam 51	300	34.0

Key figures for current drivage projects being undertaken by THYSSEN SCHACHTBAU GMBH at RAG Anthrazit Ibbenbüren colliery

The following technical equipment is employed for conventional roadheading operations:

- BTRK-2 1300 drill jumbo
- DH G210 loader
- TA M 2000 steel arch manipulator
- GTA 8200 curve-going telescopic rockbolting platform
- GTA 5400 support platform
- backfilling system
- Montanbüro Elefantino materials pump

The mine has now successfully standardised the mechanised roadheading equipment in all its drivages. This strategy brings organisational and economic advantages as far as the deployment of the heading crews is concerned and equipment repair and maintenance and spare parts availability also benefit in the same way.

The high risk of gas outbursts has compelled the mine to employ systematic exploratory drilling in the drivage zones, the results of which then determine the weekly rates of advance. Because of the gas hazard roadheading machines are not used in the conventional development zones.

Drivages 10 North, seam 54 and 10 North, seam 54 counter-heading are located at the mine's western perimeter. In spite of the stresses imposed on the heading crews by having to work under arduous climatic conditions, combined with the long travelling distances to the workplace and having to work through several fault zones, the average daily rate of advance was about 5.5 m. The drivage of the eastern main seam road, seam 51 will provide a link to the gate roads ‚7 west' and ‚8 west'. The THYSSEN SCHACHTBAU roadheading team recorded very good rates of advance in this drivage too. High health and safety standards, a good heading performance and adherence to the rigorous quality standards imposed by RAG Anthrazit Ibbenbüren colliery were all key factors in ensuring that the project ran smoothly.

Arno Lehmann · lehmann.arno@ts-gruppe.com

Tunneling with permanent support

Approaching to Aktobe

Chromium mine „tenth Independence Day of Kazakhstan“

Driving a deep-level roadway in difficult geological conditions at a Kazakh chrome-ore mine

In early 2011 SCHACHTBAU NORDHAUSEN GmbH and THYSSEN SCHACHTBAU GMBH set up the joint venture company ‚TOO Schachtbau Kasachstan' whose main remit was to be shaft sinking, roadway drivage and drilling and ground-freeze projects.
The first contract was acquired in October 2012 and involved the excavation of a 4,150 m-long drivage for the Donskoi GOK chrome-ore mine which is owned by TNK Kazchrome. Contract signing was immediately followed by project planning, plant acquisition and personnel mobilisation operations and the organisation of on-site facilities.
On August 15, 2013, the first blasting phase took place at a depth of 900 m for the ‚480 m horizon drivage' project at the ‚Tenth Anniversary of Kazakhstan Independence' mine. After a difficult start-up phase in 2013, followed by a period of good progress in 2014, almost 700 m of roadway with two curved sections, a rail-station area and roadway junction had been completed by the end of June 2014.

Drivage contract signed

After a planning contract was awarded in 2008 for sinking a deep shaft for the chromite mine ‚Tenth Anniversary of Kazakhstan Independence', which is operated by Donskoi GOK (a subsidiary of TNK KazChrome AO) in the north-west of the country, a second contract was then acquired from the same company in October 2012. These contracts gave the partnership its first foothold in the Kazakh project sector.
As with any overseas assignment, entering the project market in Kazakhstan was understandably fraught with risk and unpredictability. The stated strategic objective was to gain a foothold in this prosperous, resource-rich country and to deliver projects by deploying locally-based core competences. The maxim is to build up the business step by step and to get to know the laws and peculiarities of the country and the demands and expectations of the client.
According to Kazakh law a contract for services must always be a fixed contract and the contract value may not change during the execution of the work. How was this to be done when you had to drive some 4,150 m of roadway at a depth of 900 m in difficult ground and when there was only limited information available on the conditions to be encountered along the route of the drivage?
The contract was drawn up so as to allow for a number of variations in the composition of the strata and to define these in the best possible way. Here the most likely rock category was used as a basis for the firm-price contract and deviations from the normal conditions of ‚rock class 5' were provided for in the annexes. The contract was finally signed on October 29, 2012.

Preparations

As the contract negotiations were under way in 2011/12 work permits had to be arranged for the 51 expatriate staff who would be required to carry out the work from 2013 to 2016. These arrangements then had to be approved by the Kazakh parliament in June 2012. The deployment of this joint German-Austrian workforce constituted one of the basic provisions of the contract .

The two partner companies forming TOO Schachtbau Kasachstan drew up and signed a contribution agreement that defined their respective responsibilities in similar fashion to a consortium agreement. SCHACHTBAU NORDHAUSEN was to have a technical role while THYSSEN SCHACHTBAU would have commercial responsibility for the conditions under which the two associates were to provide resources to SBK in order to arrive at the best possible result for the project.

14. November 2012: Face at the north cross-cut to the west, jointed rock mass with slicks and talcum covering, previous support method

Strata prognosis

The chromite deposits of Chromtau are located on the southern fringes of the Ural mountain chain. The strata identified in the subsoil pillar are gabbro amphibolite and a serpentinised peridotite complex. The rock had undergone severe folding and shearing and was broken up to different degrees of intensity (cataclastic, mylonitic and brecciated alteration). The fault planes, joint planes and shear joints are therefore extremely pronounced. Extreme pressure and temperature conditions during the metamorphosis phase, which involved the alteration of the basic minerals, resulted among other things in sericitisation and chloritisation. In the rock mass this promotes smooth-faced mineral and joint planes, along with mineral in-fills with low friction values.

The chromite deposits are therefore affected by plate-tectonic processes. Large sections of the proposed drivage route lie in medium to strongly fissured serpentine rock with sericitic vein in-fill. The rock mass disintegrates readily, especially in association with water, and is prone to crumbling. New roadheading techniques and support systems of a type never before attempted in Kazakhstan are therefore required in order to control the convergence problem. The client's traditional support method, which comprises steel arches and hand-placed stone backfill, can only provide a long-term solution in those areas where the strata conditions are favourable.

Planning phase (the project)

In former Soviet territories approval planning is regarded as the P phase and the detailed design planning is the RD phase. These phases together constitute ‚the project'. As part of the approval planning stage for the drivage project the support engineers had to develop the most effective support concept for the various rock classes. The most suitable machine technology for the support system could then be chosen on this basis. Donskoi GOK was ultimately persuaded that a roadway cross section of just under 15 m^2, instead of the 11 m^2 originally planned, was essential for a high-quality heading and support performance.

Two stone drifts – whose central sections merge to form a single roadway – are to be excavated from the existing workings to the new mine district and linked at several points by connecting roadways. Donskoi GOK had already completed some of this operation itself, but some of the sections are no longer useable because of high levels of convergence. Henceforth Schachtbau Kazakhstan will solely be responsible for roadheading work on the 480 m level, while Donskoi GOK will be involved with back-up operations.

SCHACHTBAU NORDHAUSEN, working on behalf of Schachtbau Kasachstan, drew up the changes to the approval and detail design plans within just two months and in February 2013 the ‚project' was approved by three Russian and Kazakh institutes. Donskoi GOK then notified Schachtbau Kasachstan in writing that the order could be executed.

Static calculations

The work of calculating the stress redistribution in the strata and the support load is carried out using plane-surface models for successive heading and support phases.

Key to roadway model:

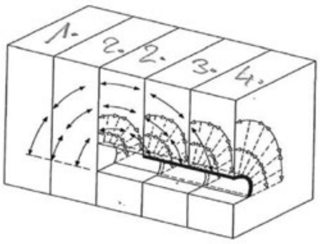
1. Primary status of rock mass
2. Preliminary stress relief in excavated area
3. Partial stabilisation
4. Full stabilisation/support lining

The first machines arriving the site

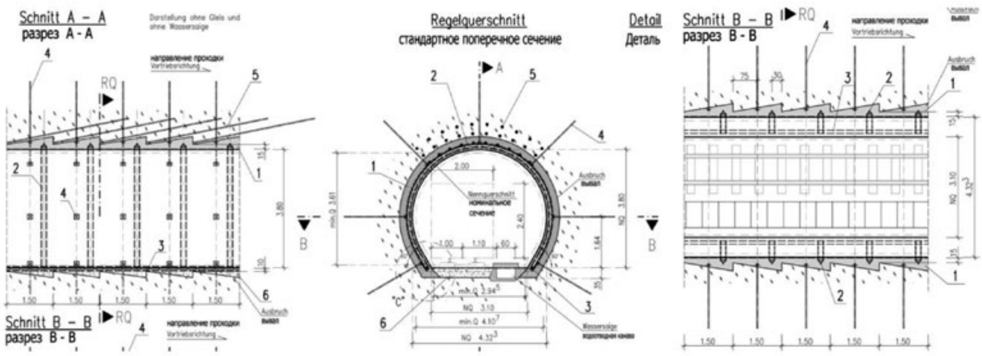
10- and 15-09-13 driving in AKL 7.1 with steel arch support

Drilling jumbo with telescopic carriage is setting rock bolts

Haulage with ITC 120



Model for static calculation



construction: e.g. excavation class 6 (section A-A; cross section; detail; section B-B)

The calculations were undertaken using the finite element method. The model calculates the changing stress, force and deformation levels on the basis of changes in stiffness during the individual drivage phases.

The shotcrete layer and radially installed rockbolts are included as load-bearing support elements. Additional support measures also constructively increase the load-bearing capacity of the system during the construction phase.

A new type of roadheading and support concept for the Kazakh mining industry

The need to ensure high rates of advance and high safety standards throughout could only be met using innovative technology based on highly mechanised drilling and blasting processes. This would also make it possible to react quickly to any unexpected geological conditions by adapting the mechanised equipment and support concept.

The geomechanical requirements imposed the use of a composite rockbolt-shotcrete system for the support and

Three-way switch in the cross section of 15 m²

First concrete mixer below ground at 15-08-13

Shot crete manipulator MEYCO Oruga with telescopic arm applicate the first support layer

The protection by the holy Barbara could be prayed in the self driven drift

lining of the drivages. This would keep the anticipated convergence to a minimum, and indeed the drivage rates achieved to date bear this out, with convergence levels measured in just a few millimetres.

This concept has long been standard practice in the German mining and tunnelling sector. However, the chosen machinery and support concept is something completely new for the Kazakh mining industry, where the mechanisation and flexibilisation of roadheading and support setting is not yet part of the roadway drivage process. To ensure that the mechanisation systems and flexible working methods were introduced systematically and without any teething problems the decision was taken to deploy a full roadheading team recruited from the two JV companies.

Selecting the most effective equipment for the small roadway cross section proved to be much more difficult. It was finally agreed that the following plant and machinery could best meet the varied demands and requirements of the roadheading project:

- Twin-boom drill jumbo type AtlasCopco Rocket Boomer 282 with two telescopic drill feeds. This machine employs extension rods to drill all the necessary holes, including those for the small-profile radial bolts. The on-board air-water flushing system conserves the structure of the rock mass and also has the capacity to blow the shotholes clean.
- ITC Terex-SCHAEFF 120 F4 tunnel excavator-loader: as expected, this machine has performed very well in operations, including trimming of the newly exposed rock face, loading of the debris into 4.5 m³ tubs and assisting in the installation of the grid-arch system.
- Mark-built mobile track turnout with three parallel rail tracks: this system can be drawn up close to the loader and can accommodate a set of about seven tubs. Each full tub is quickly taken away and the next empty tub run up alongside the machine. The centre track can also be used for manoeuvring the heavy items of plant. This shunting operation has functioned to everyone's satisfaction.
- Shotcreting system based on the MEYCO Altera shotcreter and MEYCO Oruga spray manipulator: these machines match the requirements exactly. The spray manipulator with its extendible 4-m spraying arm allows the initial support layer to be applied almost immediately to counteract poor rock conditions.

Memorial for the soldiers who has been killed during the Great Patriotic War in Chromtau

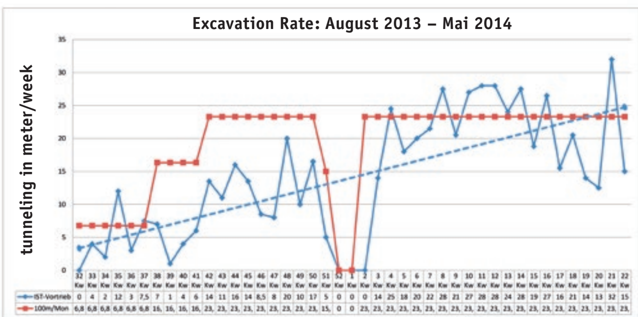
Pic. right:
Break through to the north-drift after 666 m tunneling work at 5 July 2014

- Mühlhäuser concrete remixer: with a capacity of 3.2 m³ of shotcrete the system can process three units per pull. If geological problems produce overbreak cavities these can also be filled with shotcrete.
- Hartmann type HA MP 1125/750 S stationary concrete mixing plant: the shotcrete is prepared separately in the shaft hall, which has a direct rail connection to the shaft. The hall itself is fully insulated and fitted with radiant heaters to ensure that the required temperature of +5° C can be maintained even when outside temperatures are as low as -40° C. The aggregates are supplied by mobile loader and cement is delivered in big-bags into temporary silos before being weighed and fed into the mixer.

Progress report and interim assessment

After a nine-month period of mobilisation the first pull was completed on 15 August 2013. Then after a few days a difficult fault zone was encountered that delayed progress for five days. Yet here too it was clear that the chosen drivage concept was almost perfectly suited to cope with the difficult geological conditions. No one had to enter the hazard zone and every operation in the drivage cycle could be carried out by mechanised technology operating from within the safe area and without any risk of personnel injury or damage to equipment.

Increasing the driving performance



At the same time it was made clear how important it is to apply the 5 cm-thick shotcrete layer as quickly as possible to create an early support shell. This action immediately prevents any break-up or detachment of the rock and also seals the strata and protects against moisture ingress.

In spite of the initial learning phase and the poor rock conditions, a total of 172 m of roadway had been completed by December 2013, this representing an advance of 1.35 m/day. During the first five months of 2014 this performance was increased to 3.1 m/day. In 2014 the local geology began to show its better side and the roadway alignment was mostly dead straight. During this same five-month period a rail-station area and roadway junction were also constructed, with 25% of the drivage having to be excavated under non-normal ‚rock class 6' conditions. The daily advance rate is determined to a large degree by the geological conditions and roadway layout.

Conclusions

The make-up of the heading crew and the choice of drivage concept and support/stabilisation system have proven their worth in every respect under the extremely difficult and demanding geological conditions present in the foothills of the Ural Mountains. The management team is now successfully developing ways to fully exploit the potential for further improvements in performance.

Sergej Hübscher · huebscher.sergej@ts-gruppe.com
Franz Stangl · stangl.franz@ts-gruppe.com
Eugen Hoppe · hoppe.eugen@ts-gruppe.com

The primary MDS-tunnel with concrete-segment lining

Cameco Cigar Lake Project – New Austrian Tunneling Method (NATM)

History

At Cameco's Cigar Lake Mine site, located in Northern Saskatchewan, Canada, there have been many evasive challenges to overcome in order to reach the second richest uranium ore deposit in the world. In early 2006, the Cigar Lake Mine suffered a drastic set back due to a water inflow during the sinking of Shaft #2 and several months later, another inflow on what was then the intended production level of the mine (465mL). Although the original inflow in Shaft #2 was localized to the shaft only, the second inflow resulted in the eventual flooding of the mine.

Original Tunneling Method – Mine Development System (MDS)

During the remediation period while the mine was flooded, the underground freeze program was suspended for obvious reasons. Upon re-entry to Cigar Lake's underground in late 2010 after months of engineering, remediation, and ground rehabilitation, the underground freeze plants and freeze tunnels were ready for repair, and in a few short months, the water-bearing sandstone and unforgiving unconformity surrounding the uranium ore body was again ready to be frozen from the underground freeze tunnels. The freeze plants were turned on and underground mine development and construction was full speed ahead, driving closer towards First Ore.

During the original MDS development of both freeze tunnels and production tunnels, the tunnels were lined over their entire length, with six (6) pre-cast concrete segments that formed a perfect circle.

These dowelled segments, acting in unison, created a solid 170 meter long cylinder, suitable for future use during production, with no requirement of any additional ground support.

Unfortunately, during remediation when the underground freeze program was suspended, water migrated behind the concrete segments and when the freeze plants were turned on again in early 2011 after the mine was dewatered, the saturated ground around both the freeze and production tunnels began to swell (ice jacking), and inevitably, the pre-cast concrete segments began to crack and spall, and in some cases, completely fall out.

Although Cameco expected to continue developing with the original method of driving freeze and production tunnels using the MDS tunnel boring machines, they knew that another solution was required to properly address the issues at hand. Prior to any decision, Cameco performed extensive analysis on the existing tunnels and found that swelling of the ground was much greater than originally expected; the more that the saturated sandstone continued to swell during the freeze meant increasingly greater forces exerted on the original pre-cast concrete segments and thus it was apparent that corrective actions were required.

New Austrian Tunneling Method – NATM

Through extensive research, Cameco decided that the New Austrian Tunneling Method (NATM) was the most advantageous tunneling method to use given the unfavorable underground circumstances. NATM's unique design allows for the necessary deformation of the tunnel structure that was required during Cameco's analysis of the saturated, ice-jacking ground surrounding the tunnels.

Cracks and spalling on the concrete lining effected by freezing pressure

NATM – How it Works

The geology of the formation surrounding the Cigar Lake ore body is largely comprised of sandstones which contain pockets of unstable R1 ground conditions along with random clay slips throughout the formation. For this reason, the ground conditions in the both freeze and production tunnels (current and future tunnels) are typically considered to be quite poor.

The NATM method focuses on sequential excavation or advancement where unsupported ground is kept to as minimal as possible.

At Cigar Lake, the tunnels are advanced at full face, one (1) meter intervals as follows:

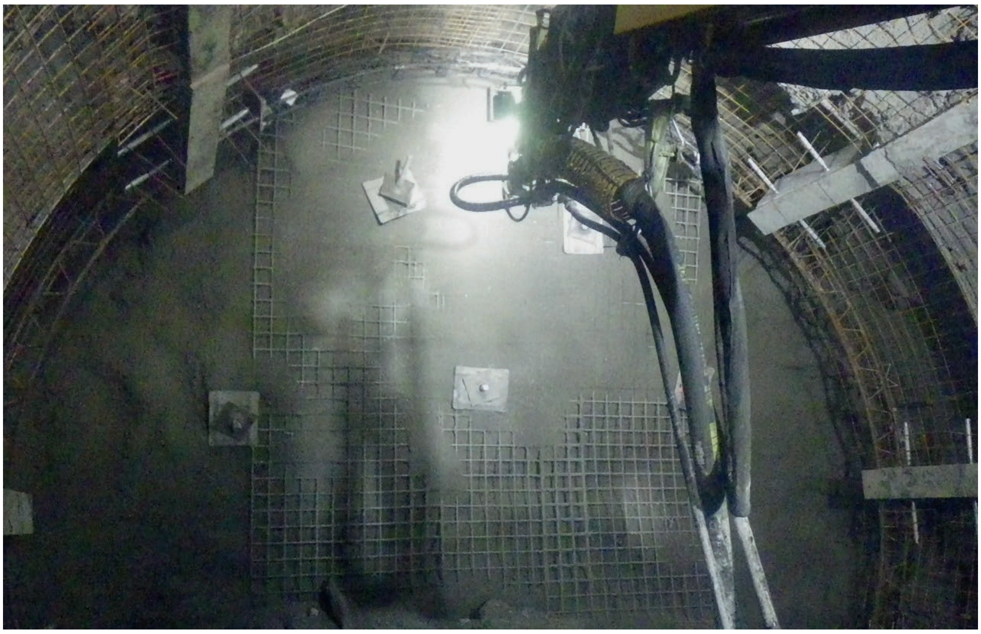
- Excavate full face, walls, ribs, and back using Terex ITC 120F2 (has option of pineapple cutter or hydraulic hammer)
- Skim Coat of Shotcrete on face, walls, ribs, and back (2 to 3 inches)
- Install five-piece (5) yielding arch set complete with arch spacers and yield blocks (6 total)
- Install first layer of screen
- Shotcrete face, yielding arch set, spacers, yield blocks, and screen with 35 MPa shotcrete mix (approximately 6 to 7 inches)
- Install second layer of screen
- Shotcrete face, yielding arch set, spacers, yield blocks, and screen with 35 MPa shotcrete mix (approximately 6 to 7 inches)
- Repeat process as ground conditions permit

Because the NATM method is adaptive or "living" based on the geology encountered, the tunnel advancement methodology is always changing and thus it is very important to have experienced and competent field engineers that make design changes on the fly.

If additional ground support is required to support the open excavation, 10 x 4 to 6 meter long hollow core bars are installed radially around the tunnel.

Also, if poor face conditions are encountered, the face is dowelled using 6 to 8 meter long hollow core bars, otherwise the yielding arch set, yield blocks, screen, and shotcrete make up the primary ground support.

First shotcrete layer at the tunnel face; beginning of the tunnel 765, bad ground conditions



If the ground conditions worsen to a point where the open excavation (supported with hollow core dowels and shotcrete skim coat) is unsafe, the tunnels are advanced in a two-thirds, one third manner where the upper two thirds are always supported ahead of the excavation and shotcreting of the lower third, ensuring the workers are always under supported ground. Again, this methodology can also change as ground conditions change.

The NATM method uses shotcrete, which when bonded to in-situ rock, takes advantage of the inherent geological strength available in the surrounding rock mass to stabilize the tunnel. Yielding arches are spaced every meter to coincide with the one meter advance. Six yielding blocks are spaced out evenly in between two yielding arches; these yielding blocks allow the tunnels to squeeze or yield while the yielding arches and shotcrete support the weight and pressure of the surround rock mass.

To ensure the elevation and accuracy of the tunnel development, constant survey is required. Surveyors install up to seven extensometers and prisms radially around the tunnel at ten meter intervals along the length of the tunnel. The other important aspect of the tunnel survey is the continual monitoring of ground movement which is used to populate predictive models that allow the client to more accurately anticipate arch or ground failure; this is monitored using Multipoint Borehole Extensometers (MPBX) and pressure cells between the virgin rock and shotcrete. Upon completion of the tunnel, ground checks are finalized to provide a baseline for monitoring. Although the tunnel is completed, continual monitoring of the tunnels will continue for the life of the mine, allowing the client to gain a better understanding of the ground behavior for future development of freeze and production tunnels.

Award of Contract – 765XC Tunnel Development

Because of Mudjatik Thyssen Mining's (MTM) expertise in underground development and strong focus on safety shown to Cameco, MTM was awarded the NATM contract for developing the 765 Jet Boring System Production Tunnel at Cigar Lake Mine. Each tunnel is driven approximately 60 meters below the uranium ore body to allow adequate access for the Jet Boring Machine which will be used to mine the uranium ore in 2014.

The tunnel begins with a launch chamber and ends with a receiving chamber. Depending on the ground conditions, these chambers are typically conventionally mined via drill and blast (approximately 5.0-10.0 meters in length). Each tunnel has a finished diameter of 5.0 meters and is being excavated in 1 meter increments. Each tunnel will be approximately 170 meters long and currently advance at a rate of just less than 1 meter per day, for a total of 7 months to drive a single tunnel.

Additional Work Awarded – 765XC Production Tunnel Outfitting

Upon completion of the 765 Jet Boring Production Tunnel, MTM was awarded the 765 Jetbore Services Production Tunnel Outfitting contract. This contract outlines the scope of work involved with outfitting the production tunnel with the following services:

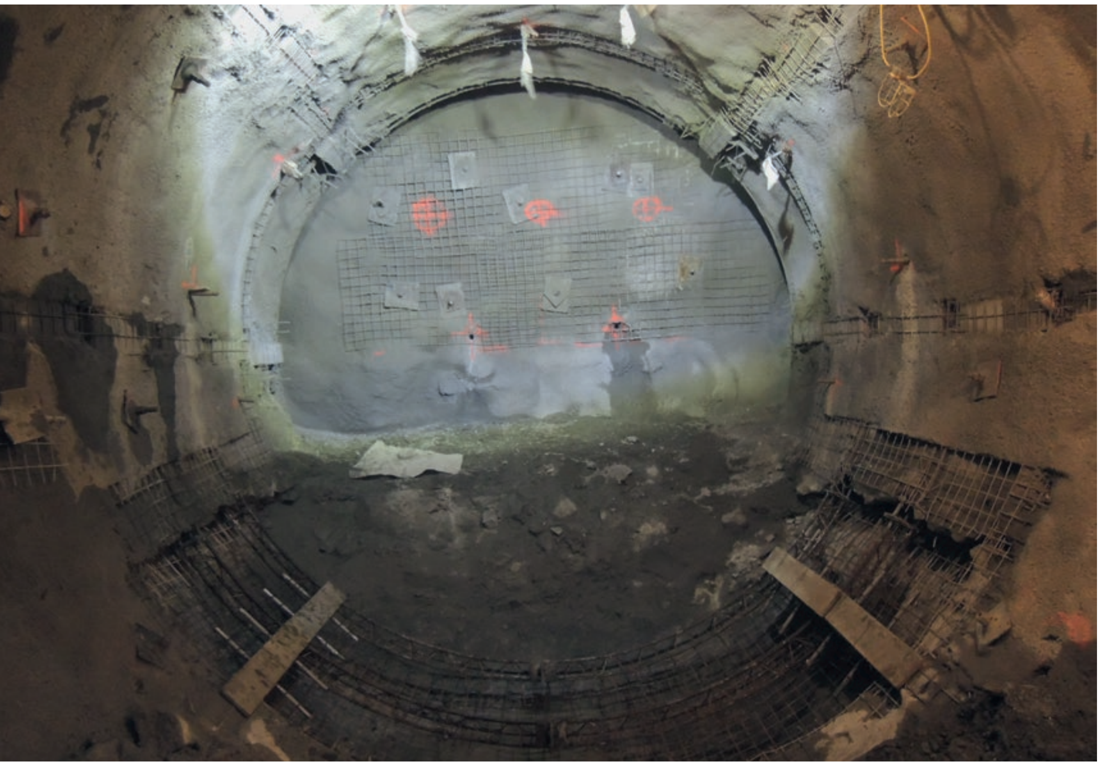
- One set of airlock doors (in receiving chamber)
- Sleepers and rail
- Pipe supports
- 1 x 2 inch air line, 5 medium to low pressure water lines, 1 x 3 inch high pressure FMC line, 1 x 6 inch ore slurry line
- Concrete pump and concrete line
- Sump and sump pump

The tunnel is enclosed at the north end (receiving chamber) by a set of double doors, effectively creating an air lock. The purpose of the airlock system is to produce a contained atmosphere in the event of a spill or increased radon progeny; any and all airborne contamination will be localized to the tunnel and exhausted through a borehole below on the 500mL where it is exhausted up Shaft #2. The bore hole, located at the south end of each production tunnel, is drilled from the 480mL to the 500mL during NATM tunnel development. Fresh ventilation to the JBS drilling team is provided via rigid ducting above the air lock door system.

The JBS machine moves back and forth through the production tunnel on a track system. Before the installation of the track system, consisting of sleepers and rail, a smooth, sloped concrete slab must first be poured to ensure that all water and cuttings produced by the jetting process will run down to the sump where they are pumped to the Run Of Mine Ore Storage Tanks. This proves to be a difficult concrete pour because of limited access, rough road ways in the tunnel (caused by shotcreted arches), and the constant water coming from both the sill and the back. Because of the excess water and the nature of the vertical construction joint, a bonding agent must be placed between the concrete and shotcrete prior to pouring of the concrete slab.

After the concrete pour, the sleepers and rails are installed. Sleepers are placed every 1 meter in between the yielding arch sets. This ensures that the weight of the JBS (when drilling) is effectively supported. The installation of the sleepers is a tough task due to the inconsistency of the tunnels caused by shotcreting; it is hard to keep tunnels perfectly straight and smooth. MTM was able to install, align, and grout the sleepers so that the rail was installed with little to no deflections in any direction.

With the rail system installed, pipe supports for JBS support services are next to be installed. A pipe car was designed and manufactured to be used in the tunnel to facilitate the installation of production services in a safe and efficient manner. Pipe supports were drilled every three meters to fit



Full assemled steel mesh, ready to applicate shotcrete

Carriage for fitting equipment in the mine transport-gallery

The mine transport-gallery 765 after fitting rails and utilities

in between the yielding arches, similar to the placement of the rail sleepers.

The pipe supports were engineered so that adjustments could be made over the life of the tunnel as the ground pressure forces the tunnel to creep caused by the ice jacking of the underground freeze system.

There are a total of nine pipe lines that are installed in each tunnel. The air and water lines are used for jetting as well as services on the Jetbore machine. The FMC high pressure threaded, hammerlock style pipe is used for providing high pressure jetting water to the Jetbore. The concrete line is for backfilling the excavated production cavities and the ore slurry line is used to pump uranium ore slurry from the JBS to the ROM's Ore Storage Tanks where it is stored and processed.

Upon completion the 765 Tunnel Outfitting contract, MTM is looking forward to beginning work on the development of the next production tunnel at Cigar Lake.

Kayne Ulmer · kulmer@thyssenmining.com
Nolan Basnicki · nbasnicki@thyssenmining.com

Pic. left: WS-10 shaft headframe is highlighted against the Polar night

Pic. right: SKS-1 shaft facilities

Winding systems and construction equipment for ultra-deep shaft sinkings: examples based on the ongoing WS-10 and SKS-1 projects in Norilsk

As sinking depths continue to increase, the construction and lining of mine shafts to access new areas of mineral deposits, and the completion of shaft installations for civil engineering projects, now poses an enormous challenge for clients, project engineers, and contractors alike.

As a result of rising commodity prices and the depletion of ore bodies, mining companies now find themselves forced to access deposits that from a working depth viewpoint were previously not considered as economically viable. This recent trend now calls for new and increasingly efficient techniques and methods, particularly in shaft construction, so that these ultra-deep zones can be accessed and then extracted with minimum risk and cost effectively.

In order to extract an area of rich ore-bearing measures OJSC MMC Norilsk Nickel took a decision in 2006 to develop the Skalisti ore mining complex close to the town of Talnach, in the Norilsk region of the Russian Federation. A key part of the overall project involves the construction of two shaft installations, WS-10 and SKS-1. These two complexes in the tundra north of the Arctic Circle are positioned about 2,000 m apart.

General data for the WS-10 and SKS-1 projects

Both shafts are currently in the sinking phase. The surface facilities, comprising more than 30 individual buildings, are being constructed in parallel with the shaft work. Both mines are scheduled to go into operation at the end of 2019 and Norilsk Nickel estimates that the shafts will have an operating life of at least 50 years.

The two Norilsk shaft sinking projects are very similar in terms of their framework conditions, dimensions and terms of reference, which means that the contractor can use fairly similar procedures and methodology in both cases. This applies particularly to the concept development, detailed planning of the surface shaft complex, delivery and equipping of the shaft system and mining installations with all their technical equipment, and to the execution of the construction and assembly work. The only essential difference between the two commissions is that in the case of the SKS-1 project, the client, OJSC MMC Norilsk Nickel, is responsible for supplying the permanent winding installation, the permanent ventilation plant and the permanent power supply equipment. WS-10 shaft is being constructed with a final diameter of 9.0 m over its entire length from the surface to its final depth of 2,056.5 m. The WS-10 upcast ventilation shaft will also serve as a transport route for the excavation material from roadway drivages (240,000 t/year) and as an emergency escape shaft for the mineworkers. It will also be used for transporting large items of plant and equipment, and materials, to and from the underground workplaces.

In accordance with mining authority and operational requirements the WS-10 shaft will be equipped with two shaft winding systems – a skip installation for the heading debris and a winding cage for emergency escape and materials transport. The WS-10 skip installation will be supplied in automatic shaft winding mode that will provide for the essential winding parameters that are transmitted to the shaft operating personnel. The cast-iron tubing will be fitted in the upper section of the shaft to a depth of about 138 m, which corresponds with the permafrost zone. The remainder of the shaft column is being supported with a concrete lining.

The SKS-1 shaft will serve as the production shaft and will be equipped with a skip winder and a cage winding system. The main objective of SKS-1 will be to store about 1.5 million t of ore a year.

Like WS-10, the SKS-1 shaft construction project includes the simultaneous erection of the permanent surface infrastructure at the shaft sinking site, the sinking and lining of the 2,050-m-deep shaft and the excavation of the underground connections (including the shaft insets), along with the installation of the permanent winding, transport and supply equipment. An underground ore loading station and headframe ore unloading plant are being planned for the shaft winding system.

The same technology is being employed for both shaft excavations. The drilling and blasting work will involve the use of a 6-arm shaft boring machine that can deliver a length of pull of up to 5 m.

In the current SKS-1 sinking the debris is being loaded out using a twin-compartment hoisting machine from OLKO-Maschinentechnik GmbH, Olfen. This machine uses a 3-bucket system with a payload capacity of 5 m³ and/or 7 m³ per bucket. The buckets are loaded using pneumatic cactus grabs with payloads of 0.8 m³ and 1.2 m³. This loading equipment was also manufactured by OLKO.

The sections of shaft below the foreshaft zone are being fitted with a combination support system composed of rockbolts, wire mesh and shotcrete, plus an inner lining of steel fibre concrete, according to the local geological conditions. The sinking concept provides the permanent 40 - 60 cm-thick steel fiber concrete lining that will be applied from the in-shaft platform, an operation that can be carried out almost independently of the loading work under way on the shaft floor. This method of working allows the sinking operation to proceed at a much faster pace than the traditional approach, where the shaft lining is concreted into place by a team working on the shaft floor. As a result, standstill times for maintenance and repair of the concreting and/or sinking equipment are kept to a minimum. The distance between the shaft floor and the last section of shaft lining is maintained at 25 m to 35 m.

Loading sinking debris with the 1.2 m³ grab and 5 m³ bucket

The shafts are given their permanent guide fittings during the sinking phase so that the shaft complex can be commissioned soon after it has reached its final depth. The two shafts are sunk with the help of a highly-mechanised, 7-deck sinking platform system that forms the heart of the entire shaft sinking installation. The main feature of this platform system is that it is not suspended from ropes but rather that it has supported itself against the shaft lining, which consists of in-situ concrete blocks that are 4.5 m in height and capable of ‚walking' downwards.

Self-advancing sinking platform

The following two factors played a decisive role in the development and design of the ‚walking shaft sinking platform':

Six-arm shaft boring rig in action

1. The total weight of the working platform with its on-board equipment would exceed the load carrying capacity of normal suspension ropes. An increase in rope diameter would only raise the dead weight of the rope, thus the required rope safety factors could not be maintained.
2. The local strata are highly stressed and exhibit high deformation levels, which prevents the support system from being installed directly from the shaft floor.

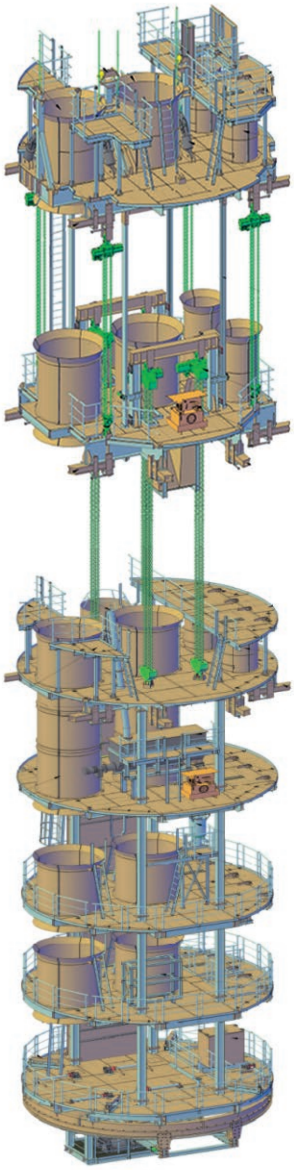
If the shaft lining would be installed directly on the shaft floor during the sinking phase, and immediately after the shaft walls would be exposed, the support elements would have to be at least 1,000 mm thick to absorb all the shifting movements. This would result in a high consumption of concre t 24 hours when the concrete is still weak, it would have to absorb the highest loads exerted by the rock mass. This would in turn cause micro fissures to formin the concrete, which would directly result in a reduction in the support's strength.

All previous shafts sunk for Norilsk Nickel exclusively used cast-iron tubing to construct the shaft linings. Transferring this support technology to the WS-10 and SKS-1 shafts would have required a tubing wall thickness of at least 80 mm to 100 mm and the cost of the tubing would have far exceeded that of the concrete lining, also 1 m in thickness.

For this reason it was decided initially to fit the shaft with a temporary, yielding support system in addition to reducing the in-shaft stresses by controlling the build-up of convergence levels so that there is less stress acting on the permanent shaft lining when it is finally installed. This approach allows the thickness of the concrete lining to be kept to about 40 cm.

Following an in-depth analysis and verification of the factors listed above, the engineering team had to search for new technical solutions for the retention and movement of the platform. The team finally opted for a multi-deck working platform system that would allow the sinking operations to be carried out regardless of the shaft depth and would therefore permit the shaft lining to be set in place and the shaft fittings to be installed in parallel with the main sinking work.

This multi-deck platform system can be compared to a high-performance tunnelling machine in terms of its method of operation. In this case the drivage is moving in a vertical direction and a fully lined and equipped shaft is created behind (above) the drivage system.



Scheme of the seven-deck shaft platform: working and support unit

The shaft lining is installed using a sliding formwork system that is set up for a concreting length of 4.2 m and a circumferential joint 0.3 m in height. On the basis of these dimensions the length of pull and the interval between the steel buntons are designed for a block dimension of 4.5 m.

The platform system is composed of two units: the support unit, which comprises decks 6 and 7, and the working unit, which consists of 5 decks.

Both units can be operated and deployed independently of one another with a maximum distance of 40 m. The working platform is designed to move in a series of progressive steps. Only the topmost deck (number 7) is activated by ropes operated from a set of four platform winches. The working unit, comprising decks 1 to 5, is entirely operated by compressed air-driven chain hoists that are installed on deck 6 (bottom level of the support unit).

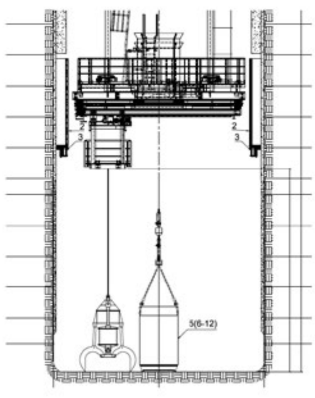
The sinking cycle includes the following main operations:

1. Sinking – the main, time-critical process – consists of:
   a. Drilling and blasting work
   b. Muck loading
   c. Support (rockbolts, wire mesh and shotcrete)
2. In-situ concreting
3. Installation of shaft fittings
4. Deployment of the working platform

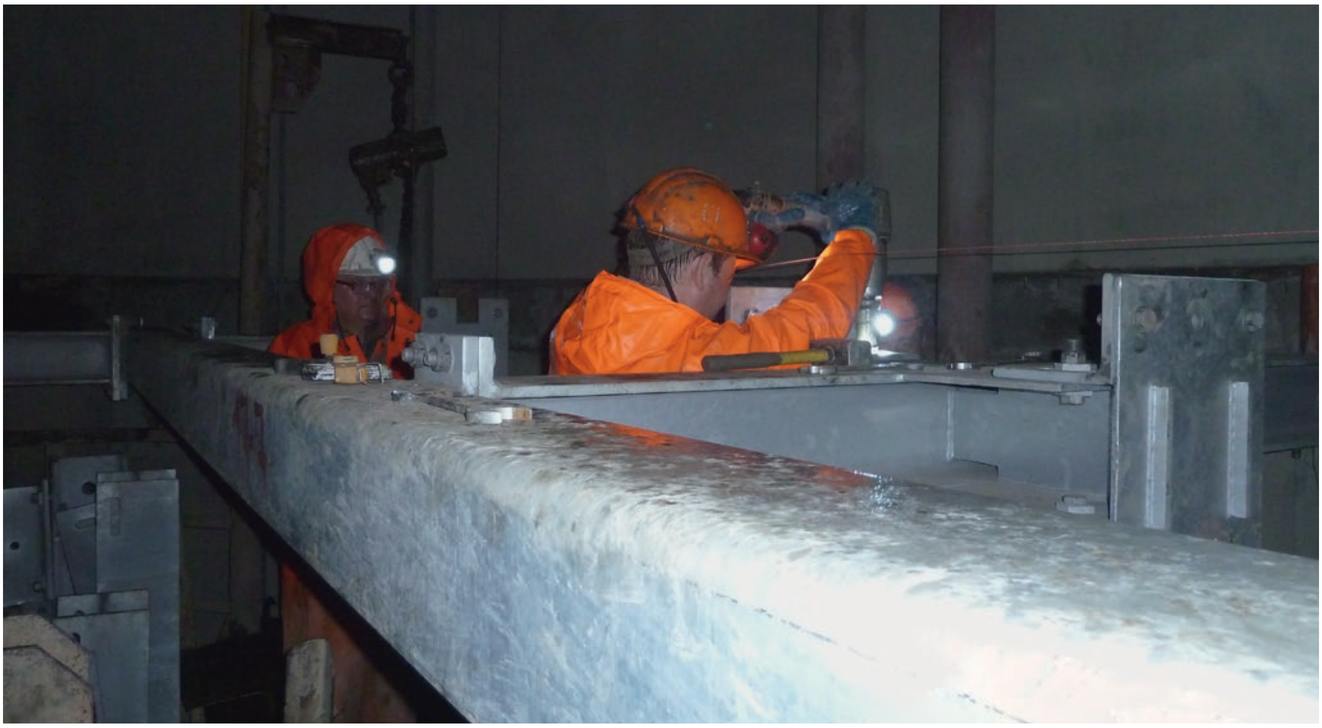
All the above operations are undertaken from the platform and are for the most part executed simultaneously. This type of platform system is a novelty for the national and international shaft construction industry: the self-advancing system is a concept that will for the first time enable shaft platforms to be deployed down to practically any depth. The South African mining industry uses large friction winches with endless ropes up to 12,000 m in length for moving large shaft working platforms. Yet, even this technology has its limitations in terms of the manufacture and transportability of the ropes. The platform concept described here therefore represents an important milestone when it comes to the reliable sinking of ultra-deep shafts and this system will increase in demand in years to come.

Summary

Heavily fluctuating economic situations and unstable commodity prices are placing greater demands on the deadlines for new mining projects. Against this background, the pace at which the shaft sinking, construction, and installation work can be carried out is becoming increasingly important, as every additional month that can be used for mineral production provides the client with an extra 20 to 30 million euros of project refinancing capital.



Schematic view at the rock support and shaft lining operation



Shaft buntons are installed in parallel with shaft sinking in WS-10

In this respect the expression ‚modern shaft construction technology' has now come to mean ‚faster shaft sinking technology'. In the tunnelling and engineering industries, as well as in the roadway drivage sector, an increased pace can be achieved by deploying larger and more powerful machines. In the world of shaft sinking such an approach soon reaches its limits since available space is restricted and it is not possible to increase the performance of all the plant and equipment without compromising safety levels and equipment reliability. Maximum working pace can only be reached if and when all operations are synchronized, if there is regard for relevant health and safety requirements, and all the processes mesh together like cogs in a gear-wheel. In this way losses and waiting times can be reduced to almost zero. In the course of the two major shaft construction projects in Norilsk all manner of innovations, technical ideas and project management processes were successfully implemented.

With the new shaft working platform the design engineers have created an advanced system for conventional shotfired sinking projects that is suitable for high rates of advance in ultra-deep shafts. This system can reliably achieve average annual sinking rates of 600 to 700 m of fully lined and fitted-out shafts with a final diameter of 9 m.

THYSSEN SCHACHTBAU GMBH is working systematically on the development of new shaft construction methods and technologies and on the continuous improvement of existing, tried and tested techniques and also is seeking to adopt proven solutions to the growing demands of the market. All this will continue to confirm and consolidate the international standing of TS as a leading international shaft construction company.

Dr. Oleg Kaledin · kaledin.oleg@ts-gruppe.com
Peter Runkler · runkler.peter@ts-gruppe.com
Wilhelm Borgens · borgens.wilhelm@ts-gruppe.com
Alexey Shirokov · shirokov.alexey@ts-gruppe.com

Pic. left: Shaft sinkers while grouting work inside the foreshaft

Pic. above: Draining of grouting material

SKS-1 Norilsk shaft tubbing successfully sealed with emulsion grouting – NOH2O (SCEM 66)

The SKS-1 project: shaft sinking and sealing cast-iron tubbings in the foreshaft zone to a depth of 150 m

In 2011, THYSSEN SCHACHTBAU GMBH was contracted by OOO Norilsk Nickel to sink the SKS-1 shaft at Skalisti mine. After completing the surface buildings and installations, and the construction of the shaft cellar, fan drift and shaft neck, work started on the sinking of the 150 m-deep foreshaft in early 2012.

The sinking operation used conventional drilling and firing, with cast-iron tubbings installed as the shaft lining. Between the 105 and 140 m levels the sinking encountered water-bearing strata that resulted in an inflow of water into the shaft amounting 3 to 5 m³/h. Small inflows affected the entire tubbing column, especially in the area around the fan drift.

In order to minimize the flow of water from the foreshaft and prevent it from affecting the main shaft sinking phase, a grout injection of the tubbing column between the 16.5 and 140 m levels, was employed.

Two decks of the seven-deck sinking stage were used as a working platform for the injection operation. This installation was operated by two platform winches that could traverse the entire depth of the foreshaft. The compressed air-powered emergency winch provided for the foreshaft sinking was used for manwinding duties. An additional power winch, which was available as an emergency unit, was employed for transporting the grout injection equipment and materials.

Phase 1: Injecting the tubbing column with cement emulsion

The injection operation was carried out in two phases. In phase one, the entire length of the tubbing column was injected from top to bottom with a cement suspension. This succeeded in reducing the water inflow into the shaft by about 50%. In phase two, the column was then re-injected from bottom to top with NOH2O. Two specialists from the SOVEREIGN-THYSSEN Joint Venture were in attendance throughout this phase of the operation.

Pic. above left: Injection mounting for the sealing material "NOH2O"

Pic. above right: Arrangement of the injection pumps on the working platform

Pic. left: Shaft sinker while monitoring of the grouting process

Phase 2: Injection of the tubbing column with NOH2O (SCEM66)

The scope of the work was to seal tubbings in the shaft column section from 16.5 m to 140 m below the surface (tubbing rings number 6 to number 88) to prevent water inflow by grouting with NOH2O (SCEM 66). Work was scheduled for the summer with a plan to complete the labor before temperatures reached freezing condition, in order to achieve optimal penetration conditions in the upper permafrost section. The preliminary work of the dye injection was utilized to determine a suitable drilling and grouting pattern. The lower section of the tubbings from ring number 88 to ring number 50 was the target area we focused on, as this was the transition zone between the water bearing formation and permafrost formation. Although all the tubbings were leaking from top to bottom, the section below the permafrost produced the majority of the water inflow and was the level where water was intersected during excavation.

A staggered drilling pattern was adopted within the 9 m shaft and on average, every 3rd tubbing was horizontally drilled and every 45 degree grout port was also drilled, where possible. Although injection pressures were kept to a minimum the grout migrated both horizontally and vertically, reporting in some cases, 11 rings higher than point of injection. The grouting phase was accomplished in one continuous operation from ring 88 to ring 6 in just over two weeks. The total shaft water intake was 3.6 cubic meters per hour prior to injection. On completion, the tubbings were absolutely dry with no water flowing down the shaft walls. The project was completed safely, successfully and on schedule. The final shaft lining was classified as "dust dry".

Grouting material is leaking out of the tubbing joints- a sign of effective grouting

Leakage of grouting material between tubbings

The grouting material take effect, the tubbing surfaces are drying

Chemical grouting material ready for the removal

View inside the foreshaft SKS-1

The grouting material is leaking out from an expansion hole

SOVEREIGN-THYSSEN Joint Venture: providing shaft sealing services throughout Europe

SOVEREIGN-THYSSEN Joint Venture

Thyssen Mining Construction of Canada has 30 years of experience working in the high grade uranium mines of Northern Saskatchewan, including the McArthur River and Cigar Lake uranium mines, which use large-scale and long-term ground freezing to stabilize the ground and form a water barrier.

SOVEREIGN has been the world leader in providing grouting solutions at problem sites where all previous grouting initiatives have failed. SOVEREIGN provides not only the site specific formulated proprietary grouting materials, but also designs the drilling program for optimum grouting results. SOVEREIGN then acts as the project manager for this grouting process. This approach has generated many well documented success stories over the past 42 years.

The SOVEREIGN-THYSSEN Joint Venture was created when after working on several projects together as separate entities; both parties realized that there was a mechanical synergy between their areas of expertise: shaft sinking, especially with applying shaft freezing method and emulsion grouting. Each company enhanced its own capabilities by the use and availability of the other's technology.

In addition to the technical synergies between the two very different approaches to controlling ground water inflows, the Joint Venture has also brought together two world leaders in their fields, each of whom has a long and credible track record in their areas of expertise.

It is our belief that the combination of our products, services and experience makes us the world leader in the area of water sealing technologies, which is also attributed to the global unsolicited demand for our services.

The SOVEREIGN-THYSSEN Joint Venture will be providing and carrying out sealing work for the deep mining industry (shafts, roadways and other cavities) and tunnel construction sector as part of its strategic services segment in the future. The polymer-based injection material ‚NOH2O' (SCEM 66) has proved so convincing that clients can be guaranteed a successful sealing operation. This product can even cope with water inflow rates of more than 50 m³/hour and hydraulic pressures of as much as 60 to 80 bar.

This service segment will provide THYSSEN SCHACHTBAU GMBH with an opportunity to fulfill its duty as a specialist mining contractor while underlining the company's expertise in injection and sealing technology.

Dietmar Schilling · schilling.dietmar@ts-gruppe.com
John Minturn · jminturn@thyssenmining.com
Andreas Neff · neff.andreas@ts-gruppe.com

Freezing heads beneath the shaft collar of the K3 shaft

Mosaic K3 and Newmont Leeville Projects

Mosaic K3 Project

In 2012, Thyssen Mining Construction of Canada Ltd (TMCC) was tasked with reviewing a proposed freeze system design for Mosaic's K3 Potash project in Saskatchewan. The design entailed freezing two six m diameter shafts to a depth of 485 m. With freeze hole drilling already in progress, a number of reviews were completed in a very short time frame.

Drawing on many years of experience in freezing Potash shafts in Saskatchewan, TMCC indentified a number of areas in which the existing design could be optimized, resulting in a reduced freezing time.

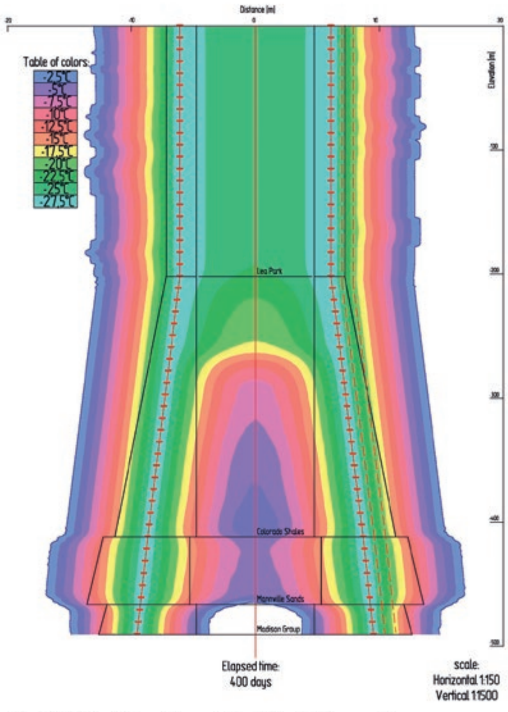
As a result, with little time prior to scheduled freeze system startup, TMCC was asked to redesign the freeze system using the in-progress freeze hole geometry.

Due to time constraints, the design was built as a "Just in Time" model. As the weight pipes, brine pipes, headers, and distribution network were designed, they were immediately sent for fabrication and once complete, to site. This was the second recent project in which the brine pipe was fused to the weight pipe and headers providing a quick and easy connection.

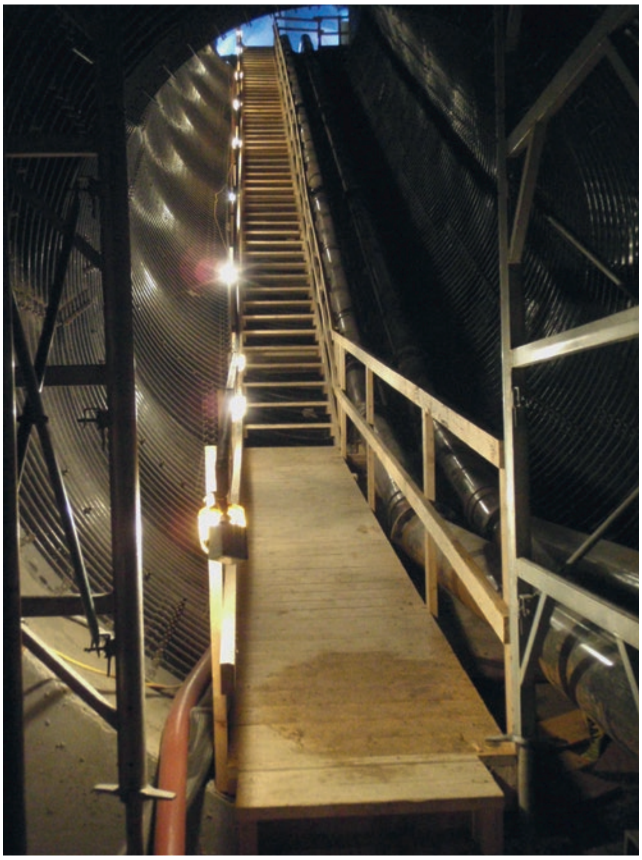
The brine distribution system was a closed system. The client requested that all brine would be contained if a leak were to occur. Distribution lines to and from the shaft were constructed of preinsulated fused HDPE pipe and placed in lined containment boxes.

Five 800 kW refrigeration plants were previously purchased and installed by the contractor. After review, TMCC recommended the purchase of 3 additional 1250 kW refrigeration plants and a significant increase in system brine flow throughout the system. The 800 kW plants were

not designed to flow the desired quantity of brine. Thus, a recirculation system allowed brine to flow at a higher volume through the freeze pipes relative to the freeze plants. This maximized the refrigeration power available for a longer period of time.



Predicted freezing development after 400 days



Brine pipes in the air drift beneath shaft head

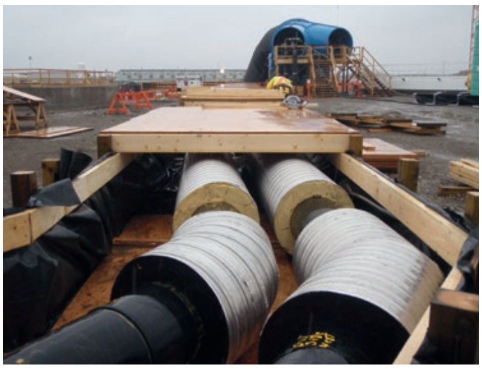
In the initial stages of freezing, the 5 x 800 kW plants froze one shaft while the 3 x 1250 kW plants froze the other. Once the freeze load subsided, the system was reconfigured and both shafts were cooled by the 3 x 1250 kW plants.

Freeze wall growth was monitored in three locations at each shaft. It was determined in the initial review that the temperature monitoring holes were placed too close and an additional hole was drilled further outside the freeze circle. Monitoring hole temperatures were recorded using a downhole fibre optic system capable of a real time resolution of 0.5 m.

This project also made use of wireless instrumentation. Because of the proximity of both shafts to the refrigeration plants, wireless flowmeters were employed on each freeze header. This eliminated a reasonable amount of wiring in the subcollar and to the refrigeration plant master controllers and allowed for some flexibility in placement.

The system worked as designed and freezing occurred as expected with little maintenance required while operating at brine and ambient temperatures lower than -35 °C.

Freeze wall verification was recently completed to assess wall thickness and was found to have grown to a thickness greater than expected. Both shafts are currently in the sinking phase and were at a last known depth of approximately 400 m.



Pic. left:
Encased brine pipes toward the shaft

Pic. right:
Freezing plant at K3 shaft with 1.250 kW installed power

The Newmont Leeville Project

Newmont Leeville Project

TMCC was selected to sink a ventilation shaft required for this operating Newmont Leeville gold mine too to continue expanding production. The shaft site is located in Northern Nevada where temperatures can be surprisingly extreme. In order to successfully sink through a lot of questionable ground, ground freezing was required. TMCC was responsible for the design, drilling, installation, and operation of the freeze system at Newmont's Leeville Mine Site.

The directionally drilled holes were set to a depth of approximately 580 m. Freezing was required due to very wet and unstable ground from approximately 120 m down to 580 m from surface.

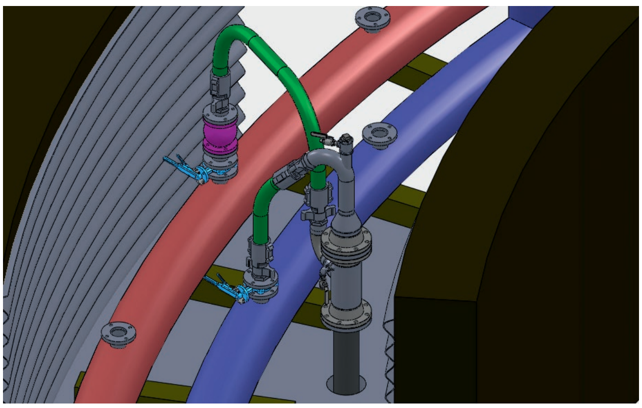
Freeze hole drilling at this site was slightly more challenging than previous projects. The drilling depth was crucial as the holes ended less than 15 m above a new shaft station. The drilling crew was local and had little experience in drilling holes this accurate in very challenging ground conditions.

Additionally, due to environmental requirements, the holes had to be preabandoned prior to filling with brine. This was required to eliminate the chance of aquifers at different depths mixing.

Despite the drilling challenges, the holes were completed within tolerance and in good time.

The freeze system is comprised of four TMCC owned refrigeration plants. Two large skid mounted plants are used in addition to two smaller trailer mounted units. This allows for a large amount of operational flexibility. The four plants feed

Model of arrangement of the freezing heads



HDPE pipes before mounting

Supply- and return pipes for brine

into a set of brine pumps which pumped brine to the shaft through a containment trench. The shaft site is quite small and fitting all of the required equipment close to the shaft proved challenging.

The freeze plants are controlled by a central control system. This system automatically loads and unloads each of the freeze plants as capacity dictated. In addition, the control system controls brine flow in the event of system brine loss. This system has worked very well with few problems.

An effort was made to focus on the data acquisition aspect of our freezing operations. This was done to better understand how to predict freeze times prior to and during freezing. Learning from recent jobs, the number and positioning of the temperature monitoring holes was closely studied. It was decided to stay with a borehole fibre optic system that TMCC is familiar with. As with the K3 project, the fibre system is capable of outputting data over 30 times per second every 0.5 m of temperature control hole depth. This data is collected a few times per day and is used in addition to the freeze plant and brine data.

Time was spent analyzing the curves generated by the temperature control holes at various depths and times. From this information, the projected time required to achieve the necessary thickness was calculated. As freezing continued, the calculations were regularly checked and adjusted to fit.

This system has given us a better understanding of how advanced the freeze wall is ahead of the shaft bottom, as the sink progresses.

The information provided by this system is sure to help us understand and better predict freeze wall growth on future projects, increasing bid accuracy and improving project management.

Geoff Witwicki · GWitwicki@thyssenmining.com
René Scheepers · RScheepers@thyssenmining.com

Freezing plants on racks after installation

Geographical location of THYSSEN SCHACHTBAU projects in Russia and Kazakhstan

The freeze is over – now things are warming up!

On June 30, 2012, THYSSEN SCHACHTBAU GMBH was commissioned to manage the artificial thaw at the freeze shafts for the Usolski Combine potash mines in the Perm region of Russia. The drilling and ground-freeze operations at the shaft sites was previously described in the Thyssen Mining Report 2012/2013. After a 17-month freeze phase the client (EuroChem) now intended to thaw out the freeze walls of the two shafts as rapidly as possible so that the hydro-isolation sealing of the tubing column could be undertaken ahead of schedule.

Artificial thawing is something of a novelty in the history of freeze shaft sinking. In previous years it has taken up to three years to complete the natural thawing of freeze shafts of this kind. After a six-month ground warming period the artificial thawing process was concluded in early November 2013.

Project background

The Usolski Combine potash mine, which is being developed by EuroChem, is located in the Palashersky sector of the Verkhne-Kamsky deposits and close to the town of Berezniki. THYSSEN SCHACHTBAU has been freezing number 1 and number 2 shafts to a depth of 270 m since the end of August 2011. This operation is designed to prevent water ingress through the shaft walls during the sinking process. The ground freeze was halted in April 2013 when the sinking work had been completed.

It is a requirement of any artificial thawing process that the amount of modification work needed to the freeze plant is kept to an absolute minimum. THYSSEN SCHACHTBAU have devised a system than can be used without the need for any major alterations to the existing equipment – the freeze units are merely replaced by a heating system and the other parts of the plant remain unchanged. Containerised heaters were considered to be the best option as they could easily be substituted in place of the existing freeze-plant containers.

The client wanted to retain three of the freeze machines as a contingency in case of an accident in one of the shafts, so that the freeze could be initiated again at any time. Three of the six existing freeze machines were therefore replaced by three heating units delivering a total of 4,200 kW. After a short conversion phase of 8 days the heating system went into operation.

Heating plant during commissioning

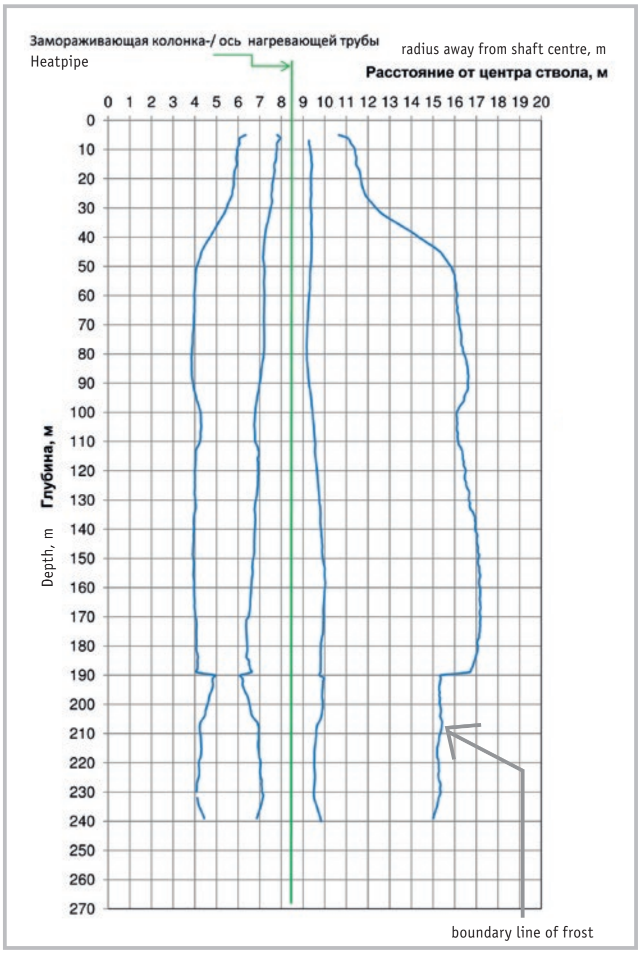
Process description

The system operates by supplying heat energy to the strata via the existing freeze pipes. The freeze process employed a refrigerant based on potassium acetate. This medium can also be used for the heating process provided that certain conditions are met. The surface temperature of the heat exchangers must be limited to 20 °C in order to maintain the chemical stability of the medium. The system is operated in a similar manner to that of the freeze process.

The heated ‚refrigerant' is delivered to the two shafts by five powerful centrifugal pumps. As with the freeze process the ground temperatures are measured by three fibre optic cables laid close to the shaft and running down through the entire freeze wall section. This system produced a temperature profile that could be used for a back-calculation of the freeze wall. A vertical section taken through the ice body showed the first visible impact of the artificial thawing process as the limits of the freeze wall began to shrink back.

The heat delivered through the freeze pipes, the natural warming effect of the strata and the in-shaft airflow meant that the thaw was being driven on three fronts. The area immediately around the freeze pipes felt the greatest heating effect and it was in this zone that the most rapid shrinkage of the freeze wall occurred. The freeze wall boundary facing

Centrifugal pump for circulating refrigerant or heating medium



Internal view of the heating plant showing the heating units

Pic. left:
Vertical section through the freeze wall showing the first visible impact of the artificial thawing process

the strata was initially affected mainly by the natural ground heat and so tended to recede more slowly. The freeze boundary facing the shaft column was subjected to the heat effect of the shaft ventilation system.

The heating plant

The modern freeze shaft industry has never before used heating equipment for the targeted thawing of freeze shafts. The containerised design of the heating plant allows the units to be safely and easily transported to the site by HGV and also means that little time and effort is required in order to convert from freeze to heating mode.

The connections for the existing pipe circuit are identical to those fitted to the freeze machines. The heating plant consists of two flow heaters connected in series and arranged one above the other inside the container. Each heater has an output of 700 kW and the medium is forced through the units by a centrifugal pump. During the heating process measurements are taken of the flow and return temperature, operating pressure and rate of flow.

The heating plant placed significant demands on the client's power supply circuit. The thermal output from the machines is regulated by thyristor controllers. One of the characteristics of these thyristors is that they transmit the full amount of current in a certain sequence. When thyristor control is used the power circuit is loaded in a very particular way, especially when several machines are switching into the current in synchronisation.

Outlook

In devising a system for the artificial thawing of the two freeze walls at Palashersky THYSSEN SCHACHTBAU has successfully pioneered a new development for the freeze shaft sinking industry. The artificial ground thaw at the Palashersky shaft site significantly reduced the strata thaw-out time and allowed the client to proceed with the mine development work earlier than planned. Thanks to the new technique the overall duration of this challenging freeze shaft project was reduced by more than six months. THYSSEN SCHACHTBAU is confident that artificial ground thawing will become an established practice in future freeze shaft projects of this kind.

Tim van Heyden · vanheyden.tim@ts-gruppe.com
Björn Wegner · wegner.bjoern@ts-gruppe.com
Joachim Gerbig · gerbig.joachim@ts-gruppe.com

Intermediate heading at Gotthard base tunnel – portal access tunnel

THYSSEN SCHACHTBAU‘s Swiss branch looks back at 12 years of success

THYSSEN SCHACHTBAU has been actively involved in the internationally acclaimed Gotthard Base Tunnel project in Switzerland since it began in 2002. The company was first commissioned to construct and equip the 800 m-deep Sedrun II shaft and subsequently called in to undertake a whole range of services for the tunnel construction firms. Although the main phase of the Gotthard Base Tunnel project has been completed, THYSSEN SCHACHTBAU GMBH continues actively engage in other commissions in Switzerland.

Sinking Sedrun number 2 shaft – Gotthard Base Tunnel

THYSSEN SCHACHTBAU’s involvement in Sedrun began on May 2002, with the delivery of equipment and the completion of the preliminary work. The equipment was transported through a 900 m-long access gallery to a chamber that formed the starting point of the blind shaft. The access gallery and chamber that were used to sink the two blind shafts (Sedrun number 1 and number 2 shafts) were about 1,340 m above sea level. The heavy Wirth HG 330 raise boring machine supplied by our partner company Murray & Roberts Cementation, RSA, was assembled on June 2002, and the pilot drilling then commenced. As soon as the pilot hole broke into the tunnel level (about 550 m above sea level) in

Break-through of the shaft drilling with the shaft drilling machine VSB VI

Pic. left: Transportation of heavy loads: lowering at shaft head
Pic. above: Transportation of heavy loads: unload of a overlong transport trolley

the end of August, the operation switched over to raise boring mode and the pilot hole was then enlarged to a diameter of 1.8 m, working from the bottom upwards. The raise boring operation was completed by September 2002, and the boring machine was then de-commissioned.

The VSB VI shaft boring machine was then assembled and installed to widen the shaft to a diameter of 7.0 m. The winding machine was also installed at the same time. The first trial run was carried out in December and shaft sinking proper was taken up with the VSB VI on January 2003.

Working at an average sinking rate of 5.5 m/day, the machine finally achieved the desired work on June 23, 2003. The initial supports, consisting of rockbolts and weldmesh screens, were installed as the sinking progressed and a 30 cm-thick shotcrete layer was then applied to form the final support system.

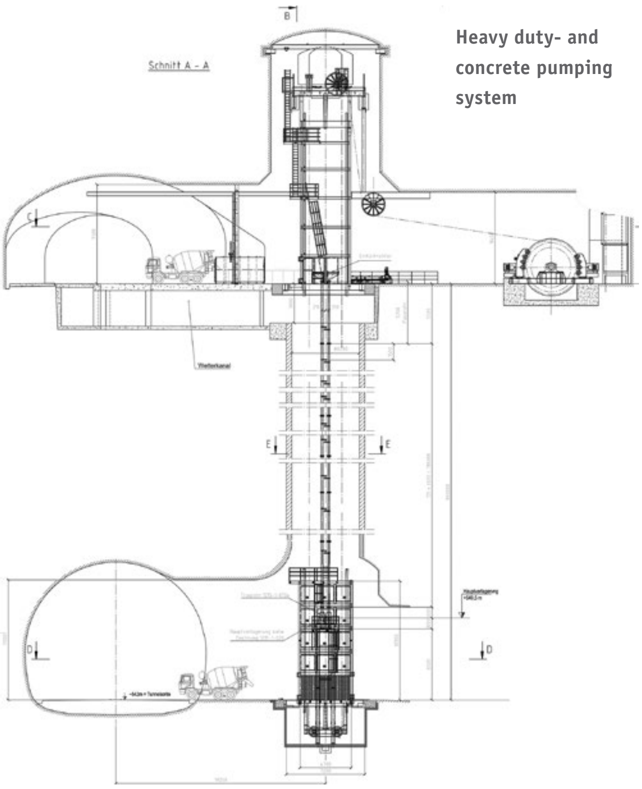
After the VSB VI had been dismantled, a special fireproof shotcrete was applied by a team working upwards on the support platform. Supply pipes were also put in place for the shaft number 1 tunnel drivage and the winding system was converted for the heavy duty operations that would be required during the operational phase.

After a mere 23 months the shaft was finally ready for operation in March 2003 and could be handed over to the client complete with its winding system and shaft infrastructure.

Winding operations in Sedrun number 2 shaft – Gotthard Base Tunnel

THYSSEN SCHACHTBAU GMBH commissioned the shaft in March 2004 and was also responsible for its subsequent operation. Since then the shaft has served as a supply route for all heavy transports heading for the tunnel construction site and its 22 t payload and dimensional capacity of 3.5 m × 3.5 m × 12 m has meant that excavators, drill jumbos, shotcreting rigs, crushers and vehicles could all be taken underground with little or no dismantling required. The shaft also acted as an important ventilation route for the tunnel excavation work.

In May 2010, the travel speed of the winding installation was converted from 1.0 m/s to 2.0 m/s, which meant that it could then also be used for manwinding duties. Number 1 shaft was no longer available for this work as it had already been converted for future use as part of the normal rail operations. Two concrete drop-pipes were set up in number 2 shaft to supply concrete for the finishing work needed in the



Heavy duty- and concrete pumping system

Pic. above, left:
Fitting of the concrete downpipe
Pic. above, right:
Exploration drilling with Diamac 282 at Emmoson

Dismantling of API standard pipes at shaft 1

multifunction chamber. After this had been completed the pipes were removed.

By mid-2013, when the underground excavation work had been completed, all the ‚old' pipes were removed from number 1 and number 2 shafts and the winding machine was de-commissioned. After 11 years of continuous service this marked the end of THYSSEN SCHACHTBAU's involvement with the Gotthard Base Tunnel project.

Specialist mining activities in Switzerland

As well as constructing, equipping and operating the Sedrun II shaft for nine years THYSSEN SCHACHTBAU GMBH was also involved in carrying out a number of other interesting assignments at the Gotthard Base Tunnel. This included all the installation and withdrawal work needed for the tunnel supply pipes during the drivage phase and a range of exploration drilling activities for the intermediate heading between Sedrun and Faido. As the latter operation was continuously hampered by large amounts of water and high pressures the holes had to be fitted with 3,000 psi blowout preventers. Before beginning this operation the drilling team was given appropriate blowout training to oil and gas industry standards .

And the team was and is active in other areas away from the Gotthard Tunnel project. As well as exploration drilling at the Emmosson pumped storage power station and at the Albula Tunnel, to name but two, the company has found an important market for itself in the raise boring sector. Following the completion of projects at Rotzloch, Schattenhalb and Taschinas TS is now preparing to use raise boring technology to carry out an inclined boring for the Stoos cable railway and will also be undertaking exploration drilling work at the Ceneri Base Tunnel.

An ongoing presence in Switzerland

Switzerland will continue to offer promising opportunities for specialist mining contractors. The country's topography and location at the heart of Europe mean that new infrastructure, in other words tunnel projects, will always be required. While perhaps not always measuring up to the scale of the Gotthard project, these tunnelling commissions will take the form of exploration work, access shafts and ventilation shafts and all kinds of service activities.

Pumped storage power stations will continue to be an interesting field of activity. Even if upheavals in the energy market, and to an increasing degree public opposition too, have led to a cooling down in the recently anticipated construction boom, Switzerland – with its natural environment of closely spaced mountain peaks and valleys and its large expanses of surface water – will never be able to do without these installations completely.

Establishment of TIMDRILLING with partners IMPLENIA Schweiz AG

After twelve years of operating in Switzerland THYSSEN SCHACHTBAU GMBH is now looking to the future with high expectations. In 2008 we set up the long-term joint venture TIMDRILLING with our partners IMPLENIA AG. TIMDRILLING will also be focussing on exploration and preventer-supported drilling services along with raise boring projects.

Michael Müller · mueller.michael@ts-gruppe.com
Axel Weißenborn · weissenborn.axel@ts-gruppe.com

Tramming and sighting of 30t-hoist with truck-mounted crane, shaft Neuhof

Replacement of shaft pipes and cables at the K+S KALI owned Neuhof-Ellers potash mine

The K+S KALI owned Neuhof-Ellers facility at Fulda in Hessen is the most southerly K+S potash mine in Germany. The mine produces a range of specialist fertilisers, including its key product Korn-Kali®. Neuhof-Ellers was the first mine in the world to use the ESTA electrostatic separation process for the dry, brine-free preparation of raw salt.
THYSSEN SCHACHTBAU and its joint venture partners Deilmann Haniel GmbH have now completed a number of projects at the Neuhof and Ellers shafts.

Renewal of shaft pipes

In early 2012 the JV partnership ‚Neuhof-Ellers', comprising specialist mining contractors THYSSEN SCHACHTBAU GMBH, Mülheim/Ruhr, and Dortmund-based Deilmann Haniel GmbH, were contracted to renew two API pipe systems in the winding shaft (Neuhof) at the Neuhof-Ellers potash mine. This involved the removal and replacement of the 538 m-long 3½" API pipe that is used for transporting materials and brine. The second API pipe, which supplies diesel fuel to the mine, was first to be examined and only replaced if this was deemed necessary.

After completion of the planning work and the preparation of the necessary permits and licences the old materials and brine transport pipes were decommissioned and removed from the shaft in June 2012. As the available space at the shaft surface was somewhat restricted, and the pipes were not to be re-used, the sections were not unbolted from their fixtures but instead were cut up into 2 m-long sections, working upwards from the shaft bottom, and then taken away. This work was carried out by a team working on a platform mounted on the skip conveyance. Once the entire pipe system had been removed the existing carrier brackets were strengthened and made ready for the installation of the new pipes.

As work in the winding shaft had to be restricted to those very brief holiday periods when no operations were under way, the work of installing the new pipe system had to be scheduled for a later date.

Mobile crane used to install the new API shaft pipes

Just before Christmas 2012 the opportunity presented itself and the new pipes could be fitted during the mine's holiday shutdown period. The new system was assembled from 27/8" API pipe sections.

After all preparations had been made the new pipes were installed using a mobile crane. The work was managed from the shaft surface and was completed in a single day. The 9 m-long sections were picked up by the crane from the storage area and each pipe was then lowered into the shaft and positioned on top of its forerunner, which was held in place in a special spider clamp. The two pipe sections were then screwed together to a pre-set torque using hydraulic power tongs. A computer linked to the power tongs was used to generate a log of each individual joint connection. When the connections are properly made the pipe joint can effectively be considered as hydraulically tight.

When every two adjoining pipe sections were screwed together a joint safety clamp was fitted around the connection in order to secure the existing pipe column and the spider was then released. Completing this step of the operation meant that the entire string was being held in place by the crane, which was then able to lower the column into the shaft by a further section length until the upper end of the last pipe to be fitted could be fixed into the spider. The entire length of pipe was then being retained again by the spider and a safety clamp was also provided as an additional safeguard against slippage.

The crane hook was then detached from the pipe string so that the next length of pipe could be collected and set on top of the existing column. The next cycle could then take place with the attachment of another section of pipe and the gradual extension of the string.

Digital radio-camera system used for the first time

The mining authorities would not allow the pipe installation work to be supervised and monitored by personnel standing in the shaft cage. However, the vertical pipe track in the shaft had a number of constrictions and projecting edges to negotiate as it passed down through the cast-iron tubbing segments .

In order to get through these problem areas the project team decided to use a digital radio-camera system for the first time. The camera was mounted along with a light in the nose cone of the pipe string and fitted with a power pack.

The system delivered a high-quality colour image throughout the pipe installation period that could be monitored on a colour screen set up at the surface. When negotiating critical points the pipe string was either lowered very slowly or held in place until any swaying had ceased, after which it could then be safely lowered again without touching.

Fitting of the 20 KV-cable, shaft Neuhof

Once the pipe column had been installed and detached from its surface mountings, and after the obligatory pressure test to confirm that the shaft pipe was leaktight, the shaft was handed over to the client on December 23, 2012, ready for winding duties to recommence.

The surface and in-shaft pipe connections were then completed during a third operational shutdown at Easter 2013. This final phase of the project meant that the entire operation had been carried out within the specified cost and time frame, without any accidents or incidents and to the complete satisfaction of the client and JV partnership alike.

Replacement of shaft cables

In March 2013 the same JV was awarded the contract to install two 20 kV cables in the Neuhof shaft and one 20 kV cable in the Ellers shaft. Five old cables were also to be removed from the Neuhof shaft.

As the shaft cables played a key role in supplying the mine with electrical power this replacement operation could not be split over several holiday periods but had to be undertaken during a single time slot lasting no more than two weeks in July 2013. This not only called for precise planning but also required the use of suitable technical equipment to ensure that the operation ran smoothly and without any incidents.

A tight time schedule

As soon as the planning process had been completed the site was set up and preparations began for the operation to commence, as far as possible.

Tramming of the 30t-hoist at shaft Ellers

A special cable winch was provided so that the cables, each of which weighed some 5,200 kg, could be lowered down into the shaft. Shortly before the planned installation work was due to commence, on Sunday, July 7, 2013, the site was notified that the delivery of the 30-t winch, scheduled for July 5, 2013, would be delayed because the equipment was still committed to its previous project – and its transport was not permitted at the week-end for legal reasons.

Teamwork, picture of the team after hooking the last 20 KV-cable into shaft Ellers together with associates from K+S

The extremely tight time schedule, which had been planned down to the nearest hour, was therefore compromised from the outset.

As soon as the winch arrived at the Neuhof shaft, work was able to commence on July 9, 2013. The cables, which had been supplied on wooden reels, first had to be rewound on to the winch drum. The cable was then lowered down the shaft with the help of the winch, hauled to the connection point at pit bottom and then attached to each of the cable crossbars working upwards. The extremely cramped site conditions imposed very high demands on the logistics: the winch had to be moved and positioned very precisely by the crane without interfering with the struts of the headgear or with the winding ropes. The winch was then moved across to the Ellers shaft where the operation was repeated for the cable there.

After the cables had been successfully installed in both shafts the new lines were tested, connected up above and below ground and immediately put into service. This meant that the mine once again had access to its full energy supply capacity.

The five cables that were no longer required for the Neuhof shaft were then decommissioned and taken away. As some of these cables were very old and their strength condition could not be assessed it was not possible to use the winch to withdraw them from the shaft. They therefore had to be cut up into 2-m lengths, working upwards from the shaft bottom, and then transported away.

As when removing the API pipes this work was carried out from a working platform mounted on the skip conveyance. Here too proper preparation was the key to the success of the operation: as the cables requiring removal were spaced at about 3 m from each other behind the buntons, as measured from the shaft conveyance, the salvage work being undertaken from the retractable platform was continuously interrupted by the need to extend and retract the platform over almost the entire length of the shaft column.

Against all the odds and difficulties, particularly the delayed arrival of the winch, the project - including some additional work commissioned later - was delivered within budget and on time and, more importantly, accident and incident-free. The planning and execution of this fairly unusual shaft operation once more demonstrated the reliability, efficiency and flexibility of TS as a specialist mining contractor and trustworthy partner.

Clemens Mock · mock.clemens@ts-gruppe.com
Jörg Schwarz · schwarz.joerg@ts-gruppe.com
Axel Weißenborn · weissenborn.axel@ts-gruppe.com

Konrad final waste repository – modernisation of the shaft winding system and extension of adjacent shaft inset zones

Ripped roadway to filling station with chain conveyor

Konrad iron-ore mine, which closed in the 1980s, is now being made ready to meet the requirements of a final storage facility for radioactive waste with negligible heat generation. The key aspects of the conversion programme involve the renovation of the existing Konrad 1 and Konrad 2 shafts and the extension of the adjacent shaft inset zones. The two joint venture partnerships for the Konrad shafts, ASK 1 and ASK 2, comprise mining specialists THYSSEN SCHACHTBAU GMBH and Deilmann-Haniel GmbH. They have been commissioned by DBE (German Service Company for the Construction and Operation of Waste Repositories) and expect to complete the operation by the year 2020. The project will be an important step towards the creation of a safe, long-term storage facility for radioactive waste material for the next decade and beyond. In 2009 ASK 1 was awarded the contract to modernise and refit the Konrad 1 downcast shaft as a manwinding and materials transport shaft and then in March 2010 ASK 2 was commissioned to retrofit the Konrad 2 upcast shaft and to excavate new entries in the shaft-pillar area. These operations were described in the Thyssen Mining Reports for 2010 and 2012/13.

Background

The 4 to 18 m-thick oolitic iron-ore horizon extends over a distance of 8 to 15 km. The ore-bearing rock zones where it is planned to excavate the waste storage chambers are located at a depth of between 800 and 1300 m. The clay-marl overburden of the Lower Cretaceous, which can be up to 400 m thick, creates an effective barrier between the waste storage zone and the overlying, water-bearing limestone of the Upper Cretaceous. The ore deposits are therefore unusually dry when compared with typical iron-ore workings due to the fact that there is no hydraulic connection between the near-surface aquifers and the mine cavities that will be used for storing the waste material. Beneath the deposits the Jura rock beds create a seal against the deeper water-bearing strata. These extremely favourable geological and hydrogeological structures make Konrad mine an ideal site for the establishment of a final repository for low to medium-level radioactive waste.

Modernisation of the hoisting plant Konrad 1, pipe bracket assembly

In Germany it is the duty of the State authorities to provide safe storage facilities for radioactive waste material. In this respect maximum priority is given to minimising the susceptibility to damage of the two key resources ‚human health' and ‚the environment'. This poses significant challenges for the joint venture partners when it comes to meeting the strict quality control and documentation standards required for the duration of the project.

Modernisation of Konrad 1 shaft by ASK 1

shaft guide brackets

In June 2012 work began on installing the pipe brackets for the guide fittings in the southern shaft compartment. The partial-construction permit conditions applying in this case meant that all core holes and drill cores associated with the drilling work required for fitting the guide brackets had to be examined and assessed by experts from the LBEG (State Office for Mining, Energy and Geology) in Lower Saxony before the horizontal guide fittings could be installed. In July 2012 the team unexpectedly discovered that the expansion mineral ettringite was present in four of the drill cores extracted from the shaft brickwork and these findings were subsequently verified by the Building-Industry Materials Testing Institute at Braunschweig University. As a result of this situation it was then decided that the stability of the existing shaft brickwork should be further investigated. For ASK 1 this requirement meant a temporary halt to the bracket installation work. This change to the works schedule also meant that all the core holes needed for the fixing of the pipe brackets down to the 1,200 m level had to be drilled earlier than planned. All the resulting drill cores were submitted to the Materials Testing Institute for analysis.

The investigations and calculations aimed at determining the load bearing properties of the shaft brickwork produced the following results and recommendations:

- No brickwork damage was found as a result of sulphate expansion. The formation of ettringite therefore does not affect the load-bearing characteristics of the shaft lining.

- There is not expected to be any progressive damage impact on the existing brickwork lining.
- The guide brackets already installed in the shaft can be left in place.
- It is recommended that highly sulphate-resistant materials are used for the future cementation work.
- The butt joints in the influence zone of the bracket locations are to be upgraded by taking appropriate actions depending on their design and composition .

All upgrading measures had to be submitted to the appropriate authority and would only be cleared for use with the latter's approval. The guide bracket installation work was then resumed at the end of April 2013 with the proviso that the shaft brickwork first had to be renovated. The horizontal guide fittings were cemented into place at vertical intervals of 6.0 m. A total of 1,409 guide brackets were finally installed in the southern compartment of the Konrad shaft.

As part of the joint renovation work, and depending on the position of the core hole in the joint pattern, the old grouted joints were cut away to a depth of 40 cm using hydraulic concrete chainsaws and were then cleaned and filled with highly sulphate-resistant rockbolting grout.
Quality assurance was maintained in that all the work was undertaken on the basis of inspection protocols and everything was documented accordingly.

Replacement of the shaft winding installation

According to information currently available, the renewal of the Konrad 1 shaft winding installation by ASK 1 will comprise the following measures, which are to be undertaken while the mine remains fully operational (manwinding and materials transport will use Konrad 1 shaft):

- installation of steel guide fittings (brackets and guide rails)
- removal of the existing wooden guides and buntons
- replacement of the bottom frames at the insets on levels 3, 4 and 5
- installation/extension of a number of pipe runs
- installation of electrical supply cables.

According to the current works schedule the south compartment of Konrad 1 shaft is to be handed over fully refurbished to the DBE in November 2014. The mobile shaft platform is to be preserved.

At the end of 2015 ASK 1 is to continue its involvement by refurbishing the northern compartment. The modernisation and refurbishment of the Konrad 1 shaft winding installation is expected to be completed by ASK 1 in January 2020.

Conversion of Konrad 2 shaft and extension of adjacent shaft inset areas

Conversion of Konrad 2 shaft

Once ASK 2 had been commissioned in March 2010 to retrofit Konrad 2 upcast shaft and extend the adjacent shaft inset areas the first phase of the project focused on preparing and revising the permit applications and manufacturers' production plans for all the plant and equipment needed to carry out the operation.

Because of the contractually agreed time schedule it was necessary to undertake work simultaneously at different levels. This coordination effort was achieved by installing a safety platform system in accordance with the Technical

Pic. above:
Modernization of the hoisting plant Konrad 1 – core drilling

Pic. right:
Modernization of the shaft hoisting Konrad 1 – guide rail assembling
all pictures: Photograph: Jörg Scheibe, Hermannstr. 1, 38114 Braunschweig – documentary photography/ photo design on behalf of ASK1

Slotted shotcrete support system with systematic rockbolting

Requirements for Shafts and Inclined Conveying Systems (TAS). It was also necessary to establish a permanently accessible second exit route as an additional security measure in the event of a breakdown to the winding system in Konrad 1 shaft.

After some major modifications had been made to the planning specifications in 2011 the first set of revised planning documents for the temporary winding equipment to be installed in Konrad 2 shaft was submitted to the client in March 2012. Since then the technical engineering offices of the JV partners have been engaged in drafting and submitting additional documents for the approval planning process. During this period the operational activities in Konrad 2 shaft have primarily focused on establishing the second secure exit from the mine workings.

The technical operations to refit Konrad 2 shaft commenced in 2014 with the installation of a shaft platform above level 3.

Renovation and extension of adjacent shaft inset areas

After the refurbishment of the ‚old shaft-inset road' on mine level 2 at Konrad 2 shaft, work commenced in 2012 on the renovation and excavation of the shaft inset extension (SIE). By altering the excavation sequence ASK 2 was able to introduce a four-shift system in order to begin excavating the SIE and its turn-off to the repository transport road north (RTR north).

Technical data	Shaft inset extension	SIE turn-off to RTR north
Drivage direction	From mine workings to shaft 2	From SIE to RTR south
Roadheading system	Two-part (crown and floor)	Two-part (crown and floor)
Length	35 m	20 m
Width	11 m	20 m
Height	9 m	9 m
Supports		
Consolidation layer		
Layer thickness	3 cm shotcrete reinforcement	3 cm shotcrete reinforcement
Bolt type	Powerthread K60-25 GRP bolts	Powerthread K60-25 GRP bolts
Bolt length	2 m	2 m
Bolt density	1 bolt per m²	1 bolt per m²
Outer lining		
Outer lining thickness	20 cm slotted shotcrete lining	20 cm slotted shotcrete lining
Concrete type	35/45 XC 3 XA 3	35/45 XC 3 XA 3
Reinforce-ment	Q 188 mesh, single layer	Q 188 mesh, single layer
Bolt type	G12 Wiborex 30/11 yielding head bolts	G12 Wiborex 30/11 yielding head bolts
Bolt length	12 m	18 m
Bolt density	1 bolt per m²	1 bolt per m²

A number of new roadheading machines of the type used in the tunnel construction industry were procured for the drivage operation. Every member of the workforce was trained to operate the new machines and each man was assigned a learning and induction period. After about two months the new technology had become part of the routine and the drivage operation then began to perform better than expected.

In May 2013 work began from the shaft inset extension to excavate the crown section of the turn-off for RTR north. This operation was completed in August 2013, one month ahead of schedule.

One particularly interesting aspect of the operation concerned the level of convergence expected. The client's geomechanical engineers had predicted about 75 cm of convergence movement and according to the calculation model this would start to develop soon after the drivage commenced. However, no significant signs of convergence were evident by the end of June 2013. The client's project managers were initially amazed at this and the failure of the predicted convergence to develop was immediately attributed to the oversized design of the support system. Then in July 2013 major convergence movements suddenly occurred of a magnitude that was greater than forecast. These unforeseen movements were attributed to the excavation of the junction road to RTR north. The level of convergence exceeded the permissible limits and auxiliary measures, in the form of additional rockbolts and strata injection, had to be taken to stabilise the rock body. The convergence movement was monitored by mine surveyors from DBE. A system of tell-tale extensometers and convergence measurement stations was set up ASK 2 for this purpose.

Photo of the face crew

Transport roadway north, bottom excavation with excavator

Plant and equipment

DASK 2 purchased a completely new set of plant and equipment specially for the project, comprising the following items:

- TEREX TE 210 and TC 125 tunnel excavators
- dhms BTRK1-E-P drill jumbo
- CAT 279C compact track loader
- CAT 908H free-steered loader
- Merlo P 36.7 forklift
- dh EQ200 shaft digger
- Niederholz PF 1 400 chain conveyor
- BASF Meyco Oruga mobile spraying manipulator

All excavation work at Konrad mine must be carried out with minimum rock degradation and using as little service water as possible. When selecting the roadheading system the team therefore opted for a tunnel excavator from the firm TEREX. Tunnel excavators are designed so that the dipper arm can also rotate about the longitudinal axis of the machine. With the TEREX model the arm can slew about 45° in either direction. This additional rotation allows the machine to cut very accurate profiles at all times.

The excavator was supplied with a range of attachments for use in the different phases of the drivage operation:

- Verachtert CW40 mechnical quick-change system
- ripper bucket with two 660 mm teeth
- Schaeff WS90N milling head
- Wimmer W660 hydraulic rock drill
- ripper chisel
- backhoe bucket.

High-precision rockbolting

Another special feature of the project, which imposed the very highest technical requirements, involved the use of yielding rockbolts up to 18 m in length. Installing rockbolts of this kind calls for a very high level of performance from machine and operator alike. ASK 2 is under a contractual obligation not to exceed a maximum deviation of 1/30 of the borehole length when carrying out the systematic rockbolting work. For an 18 m-long bolt this represents a maximum deviation of 60 cm. The client performs continuous borehole surveys to check that the permitted hole deviation is not being exceeded. The operation uses rotary drilling with air flushing, whereby the jumbo operator has to control the drill feed in a carefully regulated manner. This means never using too much feed pressure, as otherwise the hole will deviate from the preset drilling route. The specification for an absolutely straight drilling line is governed by the bolt installation requirements and the need to allow for a free-play section. This calls for a huge effort on the part of the rockbolting team. As soon as the hole is drilled to its end-point the yielding bolt is inserted section by section. An 18 m-long yielding head bolt weighs about 100 kg. After the bolt has been inserted into place it is fixed against the rock face with a washer plate so that it cannot slip out of the hole or be forced out during the bonding process. Bonding is achieved using a two-component silicate resin. Only the final two metres of bolt are bonded in order to maintain the action of the free-play section. The bonding process is fully documented and the fixing duration and grouting pressure of each resin component, along with the amount of resin pumped in, is logged and stored as computer data. Each bolt is pull tested as an individual safety measure and for quality-assurance documentation purposes. These tests are carried out by ASK 2 on its own initiative and are not part of the contract performance.

Conclusions

The work completed to date shows that the JV teams have adjusted extremely well to the high performance targets set for the underground waste repository. Despite the changes introduced to the plan of operations, which have been an ongoing and unavoidable aspect of the project, the workforce has always been able to respond by displaying great flexibility. We are confident that any future obstacles can be overcome by good collaboration and teamwork between the specialist project managers and their motivated workforce and that the completed project will be handed over to the client ready for its intended purpose by 2020.

Natascha Groll · groll.natascha@ts-gruppe.com
Thomas Dreyszas · dreyszas.thomas@ts-gruppe.com
Hubertus Kahl · kahl.hubertus@ts-gruppe.com

‚Three Brothers Shaft' with cobbing table, mine shaft building and machine building

Renovation of the ‚Three Brothers Shaft' as an access point for the Rothschönberg adit

The Rothschönberg adit, which has been in operation since 1877, is the largest in the former Freiberg silver and lead mining area and is still used as a water drainage gallery for the Brand, Himmelsfürst and Freiberg/Halsbrücke districts. After the disastrous floods of 2002 a number of collapses occurred along the adit, with the result that water started to back-up in an uncontrolled way. This posed a serious risk for public safety and order and the Saxony Mining Authorities in Freiberg – which are responsible for the control of hazards and risks associated with former mining installations – therefore commissioned a management concept that would ensure the long-term operational viability of the Rothschönberg adit. The concept that was proposed found that for the future maintenance of this important drainage tunnel it would be necessary to carry out renovation work on the ‚Three Brothers shaft' to provide a southern access route.

The Three Brothers Shaft is located in the Zug district of Freiberg just to the east of the B101 main highway that connects Freiberg to Brand-Erbisdorf. The shaft is 282 m in depth and comprises a 144 m vertical section and a 138 m inclined section at varying angles ranging from 65° to 85°.

The cross-section is quite different in the upper and lower parts of the shaft and the overall profile is divided up into a double-section winding compartment and a continuous ladderway. When silver mining ceased at Freiberg in 1913 parts of the mine continued to be used and from 1914 to 1972 the shaft served as an access point for the underground power station.

The extremely challenging operation to repair and renovate the Three Brothers Shaft is being carried out by the Jena branch of TS BAU GMBH on behalf of the mining authorities of Saxony. The work is being supervised by the Freiberg office of G. U. B. Ingenieur AG.

Shaft work

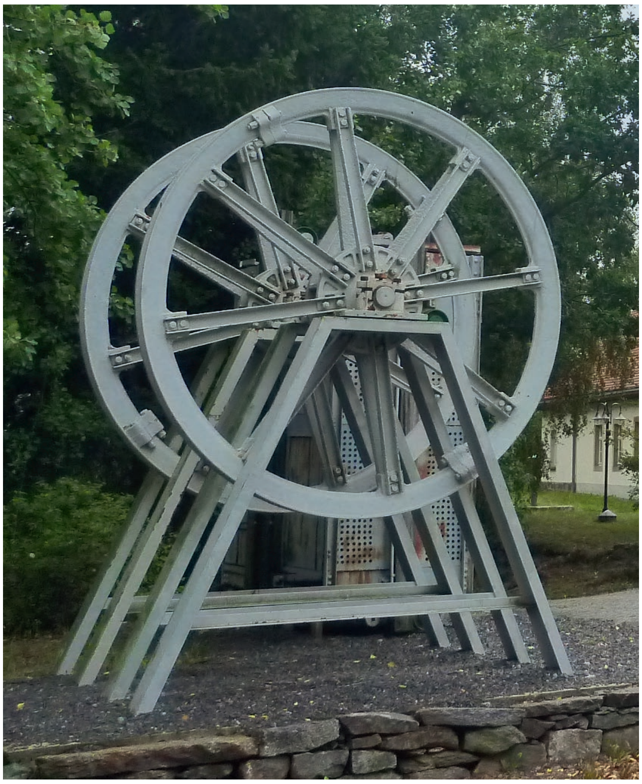
The surface renovation work being carried out is subject to a listed-building preservation order and any impact on the current group of buildings, consisting of an ore pass, shaft building, machine-house with workshops and hand-picking table, is to be kept to a minimum. The original headframe, which is of historical interest, is to be retained as a load-free structure and incorporated into the new headgear frame. In order to make the shaft accessible again the following measures were needed:

- execution planning, structural-engineering calculations and equipment design work
- construction of a durable set of foundations and housing for the shaft-winding and manriding winch
- technical modifications to the winding house
- erection of a new headframe
- removal of all the original shaft fittings, renovation and reinforcement of the shaft contour (without altering the profile or course of the shaft)
- construction of a proper in-shaft drainage system
- installation of a new, single-section winding compartment with a winding cage
- construction of a continuous ladderway
- power supply and signalling system
- establishment of main and auxiliary shaft landings.

Outlook

This construction project is set to be an extremely challenging and unusual assignment. The different gradients and profiles encountered along the line of the Three Brothers Shaft mean that conventional technology cannot be used for the repair and renovation work. The lack of complete data on the current conditions prevailing in the shaft means that much of the planning and design work – involving some creative thinking and implementation – will have to be undertaken as the operation progresses. The operating permits and planning documents have now been completed and preparatory work is currently under way with the construction of the foundations and enclosures, the stripping-out of the winding house and the laying of the foundations for the headframe structure. The next Thyssen Mining Report will present the progress of the construction work.

Olaf Einicke · einicke.olaf@ts-gruppe.com



Sheave next to the shaft

Site preparations –
the situation above ground

RAG shaft drainage: installing DN 1000 GRP pipes for a mine water pumping system

One of the most pressing tasks associated with the decommissioning of RAG's disused collieries in the Rhine/Ruhr, Saar and Ibbenbüren coalfields, where the coal seams have been worked in some cases for 100 years or more, is to establish a systematic routine for collecting and managing the mine water that continues to build up in the abandoned workings. This operation will at the same time prevent any further ingress of water into those areas that are still in active production and, following the ultimate closure of the industry, will allow the water to be put to further use or discharged into water courses.

This de-watering programme also brings work for the specialist mining contractors. The joint venture partnership of THYSSEN SCHACHTBAU GMBH and Deilmann-Haniel GmbH was commissioned to install protective pipe systems (cladding pipes) for the submersible pumps that are required to raise mine water to the surface of the RAG-operated Rossenray 2 shaft.

Using GRP cladding pipes

In-shaft cladding pipes are mainly constructed from GRP material (glass-fibre reinforced plastic). After the cladding pipes have been installed the shaft is completely filled with a cohesive material so that the submersible water-extraction pumps can beinstalled, operated and removed within the protection afforded by the pipes. The cladding pipes will ultimately serve as a lost formwork for the maintenance of the pumping system.

Crane track is used for moving the pipes into the pithead building

Pipes being transferred from the crane track to the transport winch

Installation of GRP cladding pipes and assembly of 2 × 700 m-long pipe runs

Rossenray 2 shaft is part of West colliery in Kamp-Lintfort. The mine ceased production at the end of 2012 and the site has now been chosen as the back-up station for all RAG mine drainage operations on the left bank of the Lower Rhine. The role of the back-up station is to come into action when needed, such as in the event of a breakdown at another mine pumping station, to drain the water inflow in order to prevent an unacceptable rise in the underground water levels in the disused mine workings.

The mine water drainage operations being undertaken in Rossenray 2 shaft at West colliery called for the installation

Cladding pipes in place with support brackets fitted

of two GRP pipe runs each 700 m in length and 1,000 mm in diameter. The individual pipe sections measure 6 m in length and feature socket ends with a coupling sleeve and rubber collar to provide an effective seal when the system is in place. The pipes are to be installed from the bottom of the shaft upwards and to be attached using at least one pipe bracket at each of the existing shaft buntons to prevent kinking and help maintain the stability of the pipe run. A pressure test is also to be carried out on the system after installation.

As part of a preliminary study three different proposals were submitted for the pipe installation work and one acceptable concept was then developed on this basis, in consultation with RAG, Herne, the relevant mining authorities and Deutsche Montan Technologie, Essen, (DMT). After the site had been prepared and equipped and a temporary scaffold in the shaft cellar removed, work could start on the installation of the pipe runs using the following method of operation:

The crane track already in place at the shaft site is used to transport the individual sections of pipe into the shaft hall, where they can be taken up by the pipe transport winch. This winch then delivers each pipe to its final installation position in the shaft. This transport operation is accompanied by the existing shaft conveyance (cage unit). A radio system, or alternatively a mechanical knocker line, is used to send signals to the transport winch. Here the accompanying cage must always take up a position above the manoeuvring pipe as safety regulations prohibit any work being carried out beneath suspended loads.

A working platform, which is attached to the shaft cage and equipped with overhead protection and a fall arrester system, is then deployed to serve as a standing area for the fitting team. As soon as each individual pipe section reaches its installation level it is taken up by a second suspension system operating from the winch, guided into the exact fitting position and inserted into the coupling sleeve of the pipe beneath.

The transport rope, now relieved of its load, is then accompanied by the cage back to the top of the shaft and a new work cycle can begin. The relevant signals are once again sent by radio and/or knocker line to the machine operator at the installation winch, who has already switched over from his previous position manning the transport winch, so that there is no risk of both winches being operated at the same time.

As a result of changes to the loading specifications, which have been introduced for safety reasons on a recommendation from expert bodies and mining authorities, additional support plates are now being fitted to the pipe holders and shaft buntons so that the structure is now better equipped to counteract any horizontal forces that may arise when the shaft is being filled.

Summary and suggestions for the organisation of future projects

The described method of operation for the mounting and installation of such a large quantity of GRP pipes, which were fitted in a single session working upwards from the bottom of the shaft, does have its advantages. These include faster fixing times and the fact that the mountings and fixing points for the GRP pipe runs can be of a more lightweight design than when steel pipes are used.

The basic prerequisite is to have a thorough understanding of the general conditions and operating environment inside the shaft. And in this respect the devil is very much in the detail: the project calls for detailed planning, a systematic static calculation of the structures involved, high-quality manufacturing standards for the pipe holders, mountings and fixings with adherence to the tightest production tolerances, and most importantly of all the availability of an experienced team of shaft fitters to ensure that the installation work is carried out reliably and accurately. Provided all these requirements are met, a GRP shaft pipe system of this kind can be mounted and installed quickly and without interruptions.

It is also beneficial if commissions of this type are executed by a single contracting firm, as this avoids having to interact with other suppliers and subcontractors.

Veit Passmann · passmann.veit@ts-gruppe.com
Michael Bork · bork.michael@ts-gruppe.com
Thomas Jank · jank.thomas@ts-gruppe.com

Demounting of the old hoisting engine drum

Installing a new mine winder at Fürstenhall shaft for the K+S owned Siegfried-Giesen reserve mine

Just before Christmas 2012, and following an extensive procurement procedure, THYSSEN SCHACHTBAU GMBH was awarded the contract to renew the mine winder at the Fürstenhall shaft, which is part of the Siegfried-Giesen reserve mine. The existing installation, which dates back to the 1960s and has a winding speed of 0.4 m/s, was to be replaced by a new winding system equipped with a cage conveyance capable of taking up to 30 persons and operating at 4 m/s, or alternatively carrying a 13 t payload operating at 1 m/s. After a 12-month construction period the new installation was handed over to the client ready for operation.

Siegfried-Giesen reserve mine consists of four operational districts served by the shafts Siegfried-Giesen, Glückauf-Sarstedt, Fürstenhall and Rössing-Barnten. The four shafts range from 750 m to 1,050 m in depth and the mine was producing crude potassium salt up to the year 1987.

Siegfried-Giesen reserve mine

K+S AG has been keeping Siegfried-Giesen mine open as a reserve facility since 1987. The mine, which lies between Hildesheim in Lower Saxony and Hanover, will therefore be available for the production of the remaining potash at some future date.

With a view to maintaining potash production in Lower Saxony in the long term K+S AG carried out feasibility study in 2010–2012 aimed at examining the technical and economic conditions under which mining could be resumed at some future point. The study indicated that such a venture would have good prospects of success. The next step was to clarify the licensing and approval situation by undergoing a regional planning procedure, which was concluded in November 2013 with a positive outcome. The preparations for the mine planning approval process then began immediately after, with a final investment decision not expected before 2016.
As the surface facilities had been extensively decommissioned at all four mine sites K+S KALI took the decision to go ahead with upgrading one of the shafts, in parallel with the upcoming studies and investigations, so as to create an efficient access point from which an underground survey could be made of the mine workings. The only viable choice fell on Fürstenhall, as this shaft still had structural buildings in the form of a shaft house and various items of infrastructure. Moreover, this was the only one of the four shafts that had a small winding cage system still in operation.

Fürstenhall shaft

The Fürstenhall site, at the south-western edge of the small town of Ahrbergen, is one of the four accessible openings to the underground workings. While the other three shafts could only be entered using a mobile winch, Fürstenhall still had a fixed winding system dating back to the 1960s. This installation had a winding speed of about 0.4 m/s and was able to provide permanent access to the mine.

As this winding system could no longer meet today's requirements (not only was it outdated but it had too small a conveyance and an inadequate performance, with a winding time of more than 20 minutes) the decision was taken to upgrade the installation by installing a modern winder.

The aim was to install a system with a winding cage capable of transporting up to 30 persons at 4 m/s and a payload of up to 13 t at 1 m/s. The existing drum hoist was also to be replaced by a modern winding machine. Various modifications and rebuilds were also to be carried out as required on the surface headgear installation and underground pit bottom facility. At the end of December 2012 THYSSEN SCHACHTBAU was commissioned to carry out all this installation and construction work. The shaft winder was to be supplied by TS subsidiary OLKO-Maschinentechnik GmbH, while Siemens was to be responsible for providing all the electrical technology.

Planning

Main challenges

1. Incorporate the new winding system completely into the existing installation
2. No external changes to the shaft and winding house
3. Non-winding period to be kept to an absolute minimum (a few weeks)
4. Some structures were more than 100 years old
5. Screen and digitise documents dating back more than 100 years
6. Investigate and factor-in modifications carried out over the last 100 years
7. Preserve and maintain old structures and integrate new units
8. Work to be undertaken in very cramped and confined conditions
9. Work to be carried out close to a densely populated area
10. Light and noise emissions to be kept to a minimum

The existing winder did not have the normal headgear installation resting on a set of foundations. The upper storey of the shaft house (the ‚7 metre platform') contained a steel structure dating back to the 1960s and it was this that supported the hoisting sheave. As the new winder, unlike its predecessor, was to be designed to a specific breaking load, the old steelwork structure could no longer be used for the new set-up as it could never meet the load requirements. A new headframe therefore had to be erected in parallel with the existing structure and, moreover, it also had to fit in with the 7 x 3.6 m-large air funnel drawing through the winder house from the shaft collar to a depth of about 15 m. Designing the system to the limits of the rope breaking strain meant that a conventional headframe system had to be constructed whose forces would be transferred directly into the ground rather than merely into the existing steel lattice construction of the 7-metre platform.

Hoisting sheave platform with rope sheave

From old ...

Work at the site began in April 2013. In the interim the client had set up a container facility alongside the shaft, complete with washrooms. Apart from the shaft building and machine house there were no other facilities at the site. As K+S still had to use the shaft for its own personnel and materials movements during the early morning shift, the work had to be carried out during the evening and night shifts.

The first stage of the operation was carried out in the shaft and involved raising the height of the bottom edge of the brickwork support at the 750 m level by about 2.5 m so that the bottom landing could be excavated to a larger profile. The new bottom frame that would subsequently be installed was to be designed so that items measuring up to 9 m in length could be transported out from the landing.

Work then commenced on the surface foundations for the new headframe, comprising a steel structure below pit-bank level along with the first section of the headframe to a height of some 7 m. This phase of the project was to be undertaken without restricting winding operations in the

Hoisting engine in the winch house with support frame and gear support

Bottom frame on 750-m floor, view from southwest toward the gate

shaft. Work was also carried out at the same time on the installation of the electrical equipment for the new winding machine, including a state-of-the-art control cabin.
The headframe rebuild was completed in December, to be followed by the modification work in the shaft sump. The old shaft platforms also had to be removed and replaced by new units. The existing rope take-up station with its pair of gravity tensioned guide ropes was replaced by a new hydraulic rope take-up system for four guide ropes. This was followed by the construction of the bottom frame on the 750 m level, which had previously only comprised the sump cover without any additional fixtures.

When all the work that could be undertaken while maintaining the existing winding system had been completed at the beginning of December 2013, the guide ropes and winding rope were discarded, the cage dismantled and the old winding machine shut down, part dismantled and lifted from the winding house by means of a mobile crane.

... to new

After extensive modification work in the winder house the new winding machine was installed in early January 2014. Because of the very cramped working conditions, and the large loads involved, the drum and motor-gearbox unit had to be lifted into position as separate units and then connected up within a very confined space. As some of the components were as much as 30 t in weight, and the main shaft and gearbox had to be mated together with millimetre accuracy, the operation made great demands on all concerned.

The old rope-pulley system on the 7-metre platform was dismantled as the work went ahead on the new winder. The new rope pulley was then fitted into place after the remaining parts of the new headframe had been installed inside the air funnel. THYSSEN SCHACHTBAU, OLKO-Maschinentechnik and Fairport Engineering worked closely together to design an overwind protection system that would ensure a reliable and safety-engineered delay in every operating mode, despite the very restricted space conditions and short braking paths. Fürstenhall was therefore the first mine shaft in Germany to be equipped with a ‚SELDA' system.
During this time the required control and signalling equipment was also installed at the bottom frame and in the headframe. As this work was under way the only access to the mine was provided by the automatic hoist in Siegfried-Giesen shaft.
At the end of January the new winding machine turned for the first time and after undergoing a preliminary inspection test the new winding rope was pulled on. The new rope was then used to fit the four guide ropes and the new hydraulic rope tensioning system was put into operation. The project was completed with the installation of the new twin-deck cage conveyance.
Fürstenhall shaft therefore had a completely new winding system ready for service, with only some minor residual work left to be done.

Jörg Schwarz · schwarz.joerg@ts-gruppe.com
David Voll · voll.david@ts-gruppe.com
Axel Weißenborn · weissenborn.axel@ts-gruppe.com

Visible comparative sizes - a half rope drum can fit on a truck

OLKO-Maschinentechnik supplies two turnkey shaft hoisting systems to Turkmenistan

On the basis of a feasibility study that was carried out in 2010 OLKO- Maschinentechnik signed an agreement in September 2011 with the Belarusian company Belgorchimprom of Minsk to develop, design, manufacture, assemble and commission two complete shaft winding systems for a new potash mine in Turkmenistan. The project is valued at around 30 million euros.

Turkmenchemie, which owns the ‚Garlyk' potash mine, plans to commence extraction in 2015. The potash will be mined at a depth of about 420 m and will be used for producing fertiliser. The annual production is to be about 9.5 million t.

OLKO is to supply the entire winding equipment for two shafts, each system comprising a double-drum winder, complete with a COBRA01 controlled, multichannel braking system for both the production shaft and the service shaft. As well as extensive engineering services, which include the planning and design of the headframes, shaft fittings and bottom frame, the contract also provides for the supply of complete loading and unloading stations and other equipment, such as a large manwinding cage with counter-weight, material skips, rope sheaves, mine-car decking system and complete emergency winding system.

Well prepared to load:
rope sheaves

Skip with transport equipment

Delivering the contract within the very short time-frame available, with tight deadlines for both the engineering services and manufacturing requirements proved to be a real challenge for everyone involved. During the inspection and approval process, which lasted from December 2012 to April 2013, the client and end-user expressed their complete satisfaction and went on to praise the very good working relationship that had been established. Such a complex project calls for close cooperation and open communication between the manufacturers, the project developers Belgorchimprom and the future mine operators. Regular project meetings were held in Minsk and these created a special bond of trust that should lay the foundations for future joint projects in the former CIS states.

A huge effort was needed to put together all the different items of equipment, which were sourced both in-house and from reputable German manufacturers, and to pack everything up and transport it all the way to Turkmenistan. This unusual shipment presented a huge challenge for the logistics department in Mülheim. Even the transit arrangements appeared to be something of an adventure, with several different routes available to the planning team. Garlyk mine is located in the border triangle of Turkmenistan-Uzbekistan-Afghanistan and can partly be reached by sea. This involves a cross-country trip to Romania, followed by a crossing of the Black Sea to Georgia and then onwards via Azerbaijan to the Caspian Sea. Crossing the Caspian then takes you on to Turkmen soil. This itinerary was ruled out, as was the ‚southern route' through the Balkans, across Turkey and through Iran. The Münsterland-based shipping company ultimately chose to go by the ‚northern route', travelling through Poland, Ukraine, Russia and Kazakhstan to Turkmenistan. The equipment would have to travel a distance of some 6,000 km and pass through some very sparsely populated and remote areas.

With 1,400 t of freight divided into more than 400 individual packages, some weighing over 40 t, the operation was certainly no easy undertaking.

For a young company like OLKO, which had previously operated mainly within the domestic market, this was the first international contract on such a scale and for this reason a great deal of attention had to be devoted to it. The contract, which involved a large part of the company's entire product range, is an important flagship project and all parties have expressed their satisfaction with the progress achieved to date. In awarding the contract to OLKO without any international references for a project on this scale the client demonstrated a large measure of trust and confidence in the company - and OLKO is determined to live up to it. The success of this operation, and the positive results achieved to date, has already brought further orders from the international mining sector.

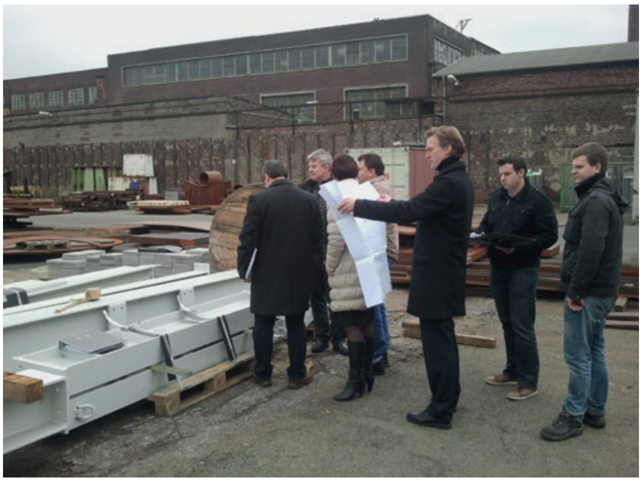
As well as having presented the best technical concept for the Garlyk project, the fact that OLKO had its own certified workshops and was able to draw almost exclusively on acknowledged German companies for component production and supply – including its subsidiary TS Technologie + Service GmbH in Mülheim an der Ruhr – played a huge part in winning the contract. Such a procurement strategy means that OLKO

Well prepared to load: drum halves

is in a position to stand out from almost all the competition. And this is a huge strategic advantage within the company too. The production problems that can sometimes arise when dealing with complex products of this kind can be offset by the fact that suppliers can be reached quickly and easily. The company's own specialist engineers can react rapidly to the situation and there is no elaborate infrastructure involved. The OLKO management is generally convinced that having in-house production facilities and access to experienced and qualified sub-suppliers constitutes a real advantage in the international market.

Furthermore, although OLKO is a relatively new company it has personnel in key positions who have many years of experience in the design, manufacture and installation of shaft hoisting systems. By successfully completing its first major international contracts OLKO has been able to demonstrate its professional competence and expertise. The company now intends to develop and expand the international side of its business.

Matthias Junge · junge.matthias@ts-olko.com
Carsten Schmidt · schmidt.carsten@ts-olko.com



Factory acceptance in Olfen

Pic. left: Winch of Nordberg prior purchasing
Large pic.: Nordberg-winch after assembly and commissioning with walkway surfaces, stages and new alternating current motors

Newmont Leeville Sinking Hoist Refurbishment

In June of 2013, Thyssen Mining Construction of Canada Ltd (TMCC) was awarded the Shaft Sinking contract for Newmont's Leeville Ventilation Shaft #3 in Calrin Nevada. As one of the main components of the shaft sinking plant, TMCC purchased a used Nordberg double drum, single clutch sinking hoist. The 12ft (3.66 m) diameter x 96in (2.44 m) face sinking hoist was constructed in 1948 with some minor upgrades prior to TMCC acquisition in 2013. To ensure the sinking hoist operated within the strict MSHA and Saskatchewan Mines Regulations, a number of refurbishments were required to modernize the sinking hoist; this ensured a big step towards the safe operation and care of the sinking hoist for any potential future projects in both Canada and the United States.

TMCC's Engineering, Mechanical, and Electrical personnel worked closely with ABB (Electrical) and Siemag Tecberg (Mechanical) during all phases of the refurbishment and upon

Main shaft – after non-destructive testing with ultrasonic and magnetic particle completion, the sinking hoist was shipped to site for assembly and commissioning by TMCC's hoist installation crew. Following TMCC's maintenance department collaborated to formulate a detailed preventive maintenance program tailored to the Nordberg sinking hoist and its respective upgrades.

Design Criteria

The sinking hoist upgrades were constrained by the following design criteria:

- Hoist Type: 144 in (3.66 m) Double Drum
- Drum Size: Nominal 144 in (3.66 m) Diameter x 96 in (2.44 m) Nominal Face Width
- Hoist Ropes: 1.88 in (48 mm) Diameter
- Hoisting Distance: 2,398 ft. (731 m)
- Skip Duty Condition:
  - Rope Speed balanced Skips 1,800 fpm (9.14 m/s)
  - Rope Speed unclutched 600 fpm (3.05 m/s)
  - Skip Weight 7,716 lbs. (3,500 kg)
  - Skip Load 27,558 lbs. (12,500 kg)
- Number of Hoist Ropes 1 per cage/skip
- Rope Safety Factor 7.05 Static at Sheave (maximum load condition)
- 2 x 1060 HP (790 kW) AC motors @ 419 RPM

Refurbishment

The sinking hoist refurbishments consisted of both mechanical and electrical upgrades and were as follows:

1. Main Shaft:

Upon arrival to TMCC's shop in Regina Saskatchewan, the main shaft was sand blasted in preparation for Non-destructive Testing (NDT), a method for detection of cracks. The main shaft was Ultrasonic Tested (UT) over its entire length and Magnetic Particle Tested (MT) in strategic areas of anticipated high stress concentrations.

Any cracks or areas of concern that were discovered were gouged out and refilled with weld metal. All repairs were retested with the same inspection criteria to avoid any defect.

2. Hoist Drums:

The hoist drums were also NDT Tested in their entirety via Ultrasonic and Magnetic Particle Testing. To ensure a robust inspection, the shells were removed to allow for thorough examination of the hubs. Any and all defects were repaired and retested, again ensuring structurally sound hoist drums.

Additional repairs to the clutched drum hub included line boring of the hub, removing rust and debris ensuring the hubs holes were within tolerance for the main shaft bushings. The clutched drum babbitt bushings were re-babbitted; spray welding techniques were used to build up the outside diameter of the babbitt bushing to ensure a proper fit into the drum hub.

The original Nordberg hoist was eccentric as it had the friction braking material fastened to the actual braking path of the drum. Part of the modernization of the sinking hoist included relocation of the friction braking material from the drum to the more traditional location of the drum calipers. This upgrade required machining of the drums brake path to eliminate vibration / reverberation caused by the air gap between the drum and the drum calipers.

3. Bull Gear and Pinion Gears:

Previously the Nordberg hoist was used as a production hoist, moving large volumes of material at high speeds with minimal man travel; the hoist's original speed was 3,200 fpm (16.25 m/s), far too fast for a shaft sinking operation. To slow the production hoist down to a reasonable sinking hoist speed of 1,800 fpm (9.14 m/s), new pinion gears were fabricated, reducing the number of pinion teeth from 29 to 20. The final gear ratio is 10.2:1.

In addition to the new pinion gears, four new spherical roller bearings were purchased. Repairs and upgrades to the bull gear included the purchase of new bolts and 'Super Nuts', used for adequately fastening the two bull gear halves together. The Bull gear was also NDT Tested and re-machined,

Machine processing of the brake surface on a winch drum

removing any gouges and deformities on the meshing surfaces.

As the number of teeth on the pinion gears decreased so did the bull gear diameter, resulting in the modification of the bull gear guard to fit the new shaft centerlines.

4. Bearings:

The Nordberg hoist has three main shaft bearings; Gear Outer, Gear Inner, and End. Similar to the pinion bearings each is a spherical roller bearing submerged in an oil bath. Two of the three original bearings were replaced and the third was rebuilt.

Refurbishment of the bearing pillow blocks and bedplates included sand blasting, NDT Testing, and painting.

5. Brakes:

The two braking systems, pinion and drum, were designed and supplied by Siemag Tecberg. As mentioned above the drum caliper friction braking liners were relocated from the drums to the drum calipers. This modification required new brake liners to be fabricated as well as modification to the calipers to properly accept the new brake liners. The original brake linkages were re-used after each separate piece was NDT Tested. New pins were fabricated.

Siemag Tecberg supplied new parallel motion spring engines, used to activate the drum brake calipers, replacing the old counter weight style drum brakes. The spring-applied, hydraulic-released spring engines offer a fast acting, two stage, failsafe, compact, braking force. The drum brake path of 14' (4.27 m) offers 618,670 ft-lbs (839 kN-m) of braking effort for each drum.

For emergency, secondary braking, Siemag provided two Twiflex dual piston calipers for each pinion. The pinion brakes

Mounting of the bearing on the main shaft

are also spring-applied, hydraulically-released, each supplying 26,105 ft-lbs (35.4 kN-m) of braking effort.

6. Clutch / Hydraulics:

The original spring-applied clutch system was replaced with a Siemag Tecberg supplied double acting hydraulic cylinder. Also included in the clutch application upgrade was a new mechanical / electrical interlock system to ensure that the sinking hoist is not clutched out without the having the appropriate brakes applied.

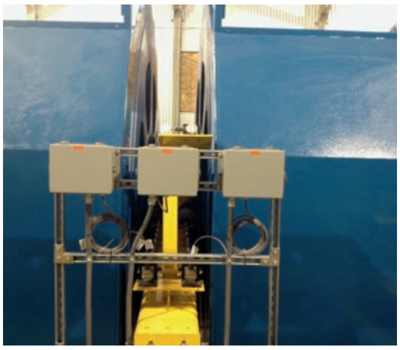
To compliment the braking assembly, Siemag supplied a new Hydraulic Power Unit (HPU). The HPU operates the drum spring engines, pinion caliper brakes, and clutch. It contains two 60 HP (45 kW) motors, a 100 Gallon (375 lt) reservoir, a cooling unit, two separate filtration systems, and a heat pump used for cold start up. The HPU design is redundant, offering fail-safe's for each critical component. Working in conjunction with the drives, it controls the response for emergency braking with the use of flow controls and pressure relief valves.

7. Depth Indicators – Lilly Drives:

The original Lilly drives were replaced with encoders. There are five encoders used to monitor the sinking hoist. Each motor has an encoder (2), the fixed drum has a single encoder, and the clutched drum has two encoders.
The upgraded encoder system required the original Lilly Drive bedplate to be modified to suit the upgrades.

Preparing for mounting a rope sheave half

New Siemag drives for drum brake during test phase with new hydraulic aggregate



Depth finder – Lilly drives

HMI devices and machine controls

8. Motors:
ABB supplied three new 1,000 HP (790 kW) AC drive motors. The third motor was ordered as a spare, in the unlikely event of a motor failure. The motors are coupled to the pinions with a new Falk gear coupling arrangement.

9. Hoist Drive:
A complete new drive system was ordered from ABB. The hoist drive was containerized to allow for easy shipping, setup, and space savings in the hoist house. The Drive Container was fully assembled by ABB at their manufacturing facilities and shipped to site where it was unloaded and terminated.

The Drive Container included the hoist operators cubical that housed the new HMI system as well as the hoist controls.

ABB also supplied the drives for the sinking winches and the shaft obstruction system, resulting in a fully integrated, semi automated system.

10. Hoist Access:
Splash guards and a hoist pit floor were designed and built to allow access to the new drum spring engines and depth encoders.
Catwalks were designed and fabricated to facilitate access to the drum caliper adjustment turnbuckles.

Conclusion

The combination of a methodical mechanical refurbishment, quality craftsmanship, new hoist drive system and shaft obstruction assembly has resulted in the safest sinking hoist setup ever operated by TMCC. Great pride was taken by all groups involved in refurbishing the Nordberg sinking hoist. TMCC's belief in Safety, Quality, and Cost can be witnessed in each bolt, wire, and bell signal rang.

Steve Dempsey · sdempsey@thyssenmining.com

Winch-container (in the background)

Drilling site for the 300 m-deep exploration hole in difficult terrain

Breaking new ground!

The Graz branch of THYSSEN SCHACHTBAU has been active in Austria and the neighbouring regions since 2010 and the office in Macedonia and other Balkans-based activities are also run from there. The branch has recently completed a conventional shaft sinking project and this paper will present and describe two other interesting commissions undertaken by the Graz-based engineering team.

Exploratory drilling for a safety gallery to serve an existing motorway tunnel in Switzerland

In March 2012 the Austrian branch was awarded the contract to act as general contractor for an extensive programme of exploratory drilling work in Switzerland. For THYSSEN SCHACHTBAU this was to mean a challenging agenda of geotechnical survey work.

Work commenced in June 2012. During the preparatory phase the company invested in two new drilling machines (a Wirth Eco1 driller and an Ellettari EK400 crawler-mounted rig) so that the work could be undertaken according to the required methods and guidelines. New drilling tools were also procured for large-calibre dry core holes (DN 278).

Drilling on a motorway access road

Some 36 individual exploratory holes were drilled out from the existing road tunnel and along the motorway for the full length of the new tunnel route, of which 10 km or more runs under residential and farming land. Because of the proximity to dwellings the drilling team had to comply with strict noise and emission regulations. All the diesel powered equipment was fitted with the latest particulate filters. During the drilling period a total of six machines were needed in order to meet the various operating requirements and strict deadline conditions.

In the tunnel portal zones ram core drilling was used for the large-diameter dry core holes. The drilling diameter was 278 mm and the holes were drilled to a depth of up to 40 m. The drilled holes were then lined as wells or fitted with sliding micrometers.

The holes along the route of the motorway were drilled both from the surface (in the service lane) and from points below ground (in the emergency escape tunnel). A Diamec 262 rig and a 116-mm double core pipe were used for the underground drilling work in the confined conditions of the escape tunnel. A preventer system was employed to protect the underground boreholes from high-pressure water and gas ingress. As the motorway was to be kept open to traffic during this operation the drilling work not only demanded a significant organisational effort but also had to be carried out in accordance with the strictest safety regulations.

The exploratory drilling along the motorway was undertaken with the road only partially closed and the traffic flow was impeded to a minimal degree with some lanes closed off for certain periods. By removing the crash barriers and taking down the noise-insulation panels the most inaccessible drilling points could easily be reached by mobile crane.

The deeper holes (down to 300 m) were begun as destructive drillings and switched over to wire-line core barrels at 150 m depth. Drilling accuracy was a very high priority and it was essential to survey the holes by gyroscope probe on a continuous basis in order to keep the hole on its specified path. Gas measurements for methane and carbon dioxide (CH_4, CO_2) were also carried out and digitally logged throughout the drilling operation.

Extensive geophysical and geotechnical measurements were made in the survey holes with a view to obtaining the required data. One especially noteworthy aspect of the operation is that crosshole measurements were used – the first time this technique had been deployed at this depth anywhere in the world. An appropriate set of equipment was devised specifically for this project and the measurements were completely successful.

Drilling next to the Kerenzerberg highway

The holes were subsequently to be fitted out with sliding deformeters, inclinometers, piezometers and geothermal probes.

Injection and drilling work for a pressure shaft and hydropower plant

In January 2013 the Austrian office won a contract for a major injection drilling programme. A tunnel construction company had driven a 1,450 m-long inclined shaft, a 2,700 m-long gallery and a 150 m-deep vertical shaft as part of an extension project for a hydropower plant in the Tyrol. The inclined/pressure shaft had also been fitted with a steel-plate lining. In order to ensure a friction-locked connection between the concrete lining and the surrounding strata and at the same time to activate the load-bearing capacity of the rock THYSSEN SCHACHTBAU was called in to undertake strata injection work as the primary means of support and to back this up with a programme of consolidation and contact grouting.

For each stage of the operation it was first necessary to carry out injection tests in order to optimise the grouting parameters. The input data (maximum grouting pressure and injectability of the strata) for the subsequent test injection were then determined from the results of the water permeability test (water pressure test).

Only when the results of the injection tests were available was it possible to proceed with the strata injection work, whose objective was to reduce the permeability of the rock, prevent further water ingress and fill any cracks and fissures present in the rock body. Creating an effective contact

Injection and drilling work for a pressure shaft and hydropower plant

Grouting material being injected through the concrete tubbings in the inclined shaft

between the strata and the shotcrete lining or tubbing support ensures that the rock maintains its load-bearing capacity when subjected to internal water pressure. After the main excavation work had been completed the strata around the pressure shaft was reinforced via borehole injections carried out through the openings in the tubbing. This rock injection process was undertaken at a maximum injection pressure of 20 bar.

A contact injection stage (roof gap injection) was also carried out to fill the gap between the support system and the concrete shell with a cement suspension introduced through pre-fitted injection sleeves. The contact grout was injected at a low pressure of maximum 5 bar.

As many as four injection pumps were used for the grouting operation, this ensuring that the injection pressure could be kept as uniform as possible over the entire grouting profile. The cement-water mixture was processed using a high-performance colloidal mixer that produced a stable suspension that could be injected by high-pressure pump. The entire operation was automatically monitored and logged and supported by an automatic pressure limiter.

The rock injection work was carried out according to a grouting intensity number (GIN). Here the excavation criteria are based on a definition of the specific energy after determining a GIN value. This rules out the simultaneous presence of large quantities of injection medium and high injection pressures and is designed to reduce the risk of fracking (rock fracturation) due to the injection process.

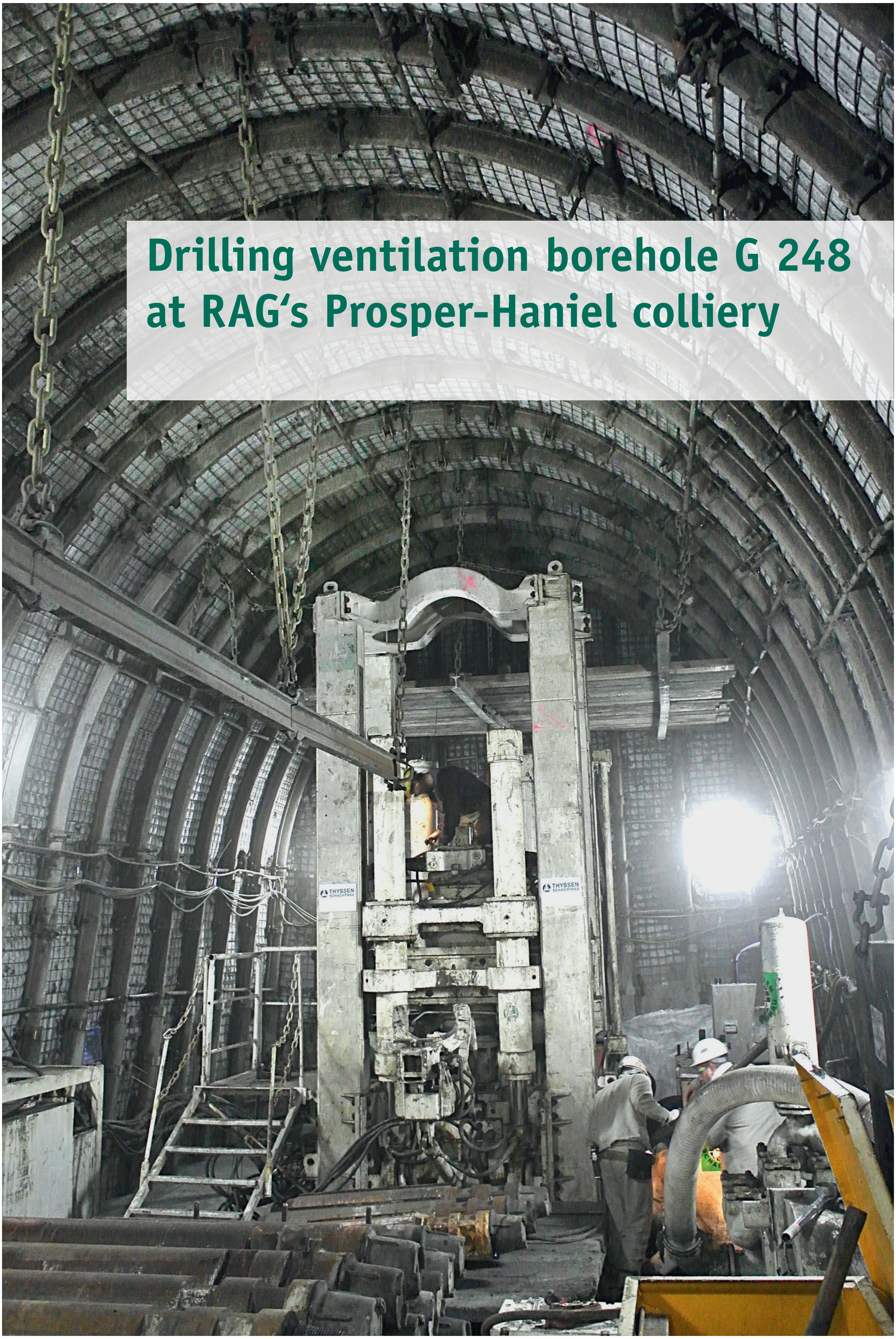
After the injection work had been completed core drillings and water pressure tests were undertaken to determine the permeability of the strata and hence to monitor the success of the grouting operation.

Once again THYSSEN SCHACHTBAU and its associates in the Alpine region were able to demonstrate in-house expertise, flexibility and commitment in the planning, preparation and delivery of challenging assignments to the complete satisfaction of the client.

Since 2010 the Austrian branch of TS has successfully undertaken more than 20 projects involving all kinds of drilling work, supplemented by injection, measurement and documentation activities. The office is currently engaged in a shaft sinking operation, with THYSSEN SCHACHTBAU providing active support.

Florian Wieltsch · wieltsch.florian@ts-gruppe.com
Tamara Portugaller · portugaller.tamara@ts-gruppe.com
Raimund Bartl · bartl.raimund@ts-gruppe.com
Franz Stangl · stangl.franz@ts-gruppe.com

Drilling ventilation borehole G 248 at RAG's Prosper-Haniel colliery



Raise drilling machine HG 250 in the drilling chamber I 547

In the autumn of 2011 the RAG-operated Prosper-Haniel colliery issued a tender for ventilation borehole G 248. The mining division of THYSSEN SCHACHTBAU GMBH was subsequently commissioned to undertake the work.

The engineering services were drawn up by the THYSSEN SCHACHTBAU Technical Department in collaboration with DMT consultants in Essen, the Arnsberg District Authorities in Dortmund as the supervising body, Prosper-Haniel colliery in Bottrop as the client and the Mining Division's ‚vertical projects' office. The steelwork was supplied by TS Technologie + Service GmbH, a subsidiary of THYSSEN SCHACHTBAU.

The G 248 borehole project was divided into four construction stages:

1. Conventional excavation of drilling chamber I 547
2. Creation of the ventilation borehole by the raise boring method
3. Insertion of shaft lining in the form of steel casing
4. Installation of supply pipes and power cables

The difficult geological conditions expected during the raise boring work in project stage two required the project engineers to develop some sophisticated alternative solutions. The team consisted mainly of personnel from the specialist mining company Bergbau-Spezialgesellschaft Ruhr-Lippe mbH, another THYSSEN SCHACHTBAU subsidiary.

	Drilling chamber I 547	Ventilation borehole G 248
Length	18.0 m	147.0 m
Width	7.0 m	3.6 m
Height	7.5 m	
Supports	TH 25 with extension bars	3.20 m casing with ladder way
Backfill	Hydraulic remote supply	Hydraulic remote supply
Material	HT 33	HT 33

Table 1: Key data for the ‚ventilation borehole G 248' project

Fitting of the lining segments with annular assembly crossbar

Supply pipes

Pipes		Cables	
4	50 mm material pipe	3	10-kV cable
2	200 mm cooling pipe	2	blue cable
1	150 mm mine-water riser pipe	2	fibre-optic cable
1	300 mm gas pipe		

Table 2: Supply-line dimensions for ventilation borehole G 248

Drilling chamber I 547		Ventilation borehole G 248	
1	DZ 2000 loader	1	HG 250 / HG 160 2 Aker Wirth raise boring machine
1	PF I armoured conveyor	1	directional drilling system from Micon-Drilling
1	PF I elevating conveyor with side discharge	3	roller bits (311 mm diameter)
	manual drilling tools	1	10" drill rod
		1	Sandvik 3600 mm extension reamer head
		1	DH G 211 loader
		2	PF I chain conveyor
		1	40.2 l uni-mixer

Table 3: Machines and equipment for the borehole G 248 project

Drilling chamber

The preliminary work began in January 2012 with the completion of the start cross-section in E 547 and the conventional excavation of drilling chamber I 547. The dimensions of the drilling chamber (Table 1) were determined by the break-through point in BP 124.0 and by the dimensions of the HG 250 raise boring machine.

The excavation work on the start cross-section and drilling chamber was to be undertaken without affecting the transport of hard coal from the mining districts or the mine's normal diesel-trolley movements. When the supports had been fully installed in the start cross-section and drilling chamber the drivage equipment was dismantled and the concrete foundations laid for the HG 250 machine.

Drilling operation

When the HG 250 raise boring machine had been set up ready for use, a pilot hole 147 m long and 311 mm in diameter was successfully drilled down through the centre of the future ventilation hole using a rotary vertical directional drilling system (RVDS) supplied by Micon Drilling. After completion of the pilot hole the drilling work was temporarily halted as planned so that the missing steel arch supports and bell profile complete with steel headframe could be installed at the point where the pilot hole had broken through the roof of the bottom roadway. This period was also used to commission both chain conveyors that would be employed for loading out the excavation debris and to assemble the extension reamer head for the raise boring machine and the G211 loader. The debris clearance system was then made fully operational with the installation of the loading cage.

Because of the difficult and highly variable geology and tectonics drilling rates of as little as 2 to 3 m/day were recorded in the extremely hard sandstone beds. During the raise boring phase the maximum performance was 8 m/day. When cutting through the hard coal seams the raise borehole wastending to caving, which meant in miner's terms that

Service shaft

Construction for fitting of supply circuits

stone and lumps of hard coal became detached from the rock mass causing serious overbreak cavities in the raise bore hole.

Installation of the casing

The continuous caving of rock into the raise borehole forced the project team to re-think the well-proven method for installing steel casing. The installation of the steel lining would normally be fitted in successive stages with the help of the boring machine and working from the bottom upwards. However this installation technique had to be abandoned due to safety considerations: the falling rock and hard coal meant that in the case of ventilation borehole G 248 the steel lining had to be installed gradually working from top to bottom. This was achieved by means of a special hydraulic lifting system supplied by Lantenhammer. This equipment had been adapted to suit the project parameters and to cope with the particular conditions prevailing in the deep hard coal mining industry. It was also checked and tested by DMT specialists and approved for use in accordance with the Arnsberg District Authority planning procedures.

The new technical system for the casing stage comprised four lifting cylinders and a circular assembly bridge. The hydraulic system from the HG 250/160 2 was used as a power source.

This lifting system proved to be extremely efficient: after a short learning period the shaft sinking team was able to assemble and fit two to three rings per working day complete including the required ladder way. When the entire steel casing had been installed the annulus at the bottom roadway end was sealed and then gradually filled with HT-33 concrete suspension material working from the bottom upwards. It took three times more building material than originally planned to completely fill of the ring space between steel lining and surrounding rock including overbreak cavities.

Assembling of buckling protection

Support structures of supply circuits

Installing the supply pipes and cables

A special mobile installation rig was set up at the top of the borehole to facilitate the placement of the pipes and cables. An assembly platform was also erected at the bottom of the hole. A step-by-step procedure was employed whereby the individual sections of pipe were screwed on to the existing pipe string at the bottom of the run and the entire string of pipe was then drawn up into the hole so that the next pipe section could be attached. After assembly the pipes were positioned correctly and secured using specialbend protection.

The electric cables (Table 2) were also guided into the bore-hole from the bottom end and then drawn up into the shaft before being fixed to the steel lining with support brackets.

Summary

The completion of ventilation borehole G 248 was a huge challenge for the team from the ‚vertical projects‘ office. The difficult geomechanical conditions, which produced a series of overbreak cavities into the raise borehole when traversing the hard coal seams, created real problems during the project processing. Furthermore, the HG 250 machine had to be replaced with an HG 160 machine due to suffered gearbox damage during the boring operation. And finally, the steel casing could not be installed using the conventional method of working from bottom to top but had to be fitted from the top of the hole downwards using a brand new type of lifting equipment. This innovative system which had previously only been employed for surface lifting work also proved effective below ground and was to contribute to a successful project conclusion.

Wiethold Krawiec · krawiec.wiethold@ts-gruppe.com

Pic. above:
Future of floating up to Stoos

Pic. left: The access to Stoos has to be modernized, the line is already visible

The world's steepest funicular railway

THYSSEN SCHACHTBAU GMBH was awarded the contract for the replacement and modernisation of the funicular railway at the Swiss village of Stoos which has been getting on in years. As well as refurbishing the system the project will also focus on improving the local tourist infrastructure.

Stoos is a car-free mountain village and a ski resort in the Morschach district of the Swiss canton of Schwyz. The village lies on a high plateau at a height of 1,305 m. It has 106 inhabitants and accommodation for some 2,200 visitors. The ski area reach-es to a height of 1,922 m. Access is via a road from the village of Muotathal and by a funicular railway from Schwyz-Schlattli or by cable car from Morschach.

The existing funicular railway in Stoos can transport 1,000 persons an hour. It was first built in 1933 and takes passengers up to 1,383 m, spanning a height difference of 786 m. At a gradient of 78 % the installation is one of the steepest funicular rail-ways in the world. The current operating approval apply to the end of 2016. As it was considered too expensive to renew the existing funicular railway the Stoos Railway Company now plans to construct a new modern system.

History of the funicular railway

The history of the funicular railway can be traced back to 1411 when such a device was first described in a military firework book of that year. These earliest funicular railway systems were essentially used for transporting persons and materials to cas-tle buildings on steep hill tops. The world's oldest preserved funicular railway is thought to be the cable system at Hohensalzburg Fortress, which was erected in 1495, while one of the oldest passenger-carrying funicular railways is the water-ballast Prospect Park Incline Railway that first opened in 1845 at Niagara Falls in the USA. The first of the modern funicular railways to be built in Europe was the 1862 installation that operated between Rue Terme and Croix Rousse in the French city of Lyon. This system was shut down in 1967 and re-opened in 1974 as a rack-and-pinion railway.
Some of the earliest funicular railways were built as water-ballast systems, though fixed steam engines were also used. Many of the water-ballast installations were converted to electric drive at the beginning of the twentieth century. Electric powered systems allow lighter cars to be fitted and these require less braking force and can therefore travel faster. This in turn increases the transport capacity of the installation.

Pic. left:
Existing line

Pic. right:
Preperatory operations for raise drilling site

Development of the new Stoos funicular railway

The Stoos railway has to negotiate a gradient of 110 %. The new installation will fea-ture spacious gondolas with large window areas giving unobstructed views. Each gondola will hold a maximum of 136 passengers. Operating at its maximum speed of 10 m/s the system can transport 1,500 persons an hour. The funicular railway elctri-cal drive is positioned at the top station. The bottom station will have a cable tension-ing system while half way up the track – as with the current system – there will be a passing point for the two cars. [1], [2]

Terms of reference for the shaft builders: drill two pilot holes using raise boring technology

Constructing the two tunnel sections at a gradient of about 110 % necessitates drill-ing a pilot hole for each tunnel in order to excavate the final cross-section. This means that in order to complete the tunnel faster and more easily the plan is first to drill pilot holes that will later serve as gravity chutes for the removal of the material produced during the final full-section excavation. The excavated material is collected at the bottom of the shaft and taken away without the need for time-consuming transport activities that would impede the tunnel excavation work.

Job-site inspection of a different kind

On 16th July 2013 THYSSEN SCHACHTBAU was awarded the contract to drill the two pilot bores. The holes needed for the two tunnel sections were, respectively, 1.8 m in diameter and about 60 m in depth (length) in the case of the ‚Ober Zingeli' sec-tion and 1.4 m in diameter and 245 m in depth for the ‚Zingelifluth' section. Both pilot holes are to be completed using the raise boring method. Each operation will involve setting up the raise boring machine at the top end of the excavation and drilling a pilot hole (9 7/8 „) down through a predefined section of the tunnel profile using the directional drilling technique.

When the pilot hole reaches the bottom end the directional drilling tool with its roller bits is dismantled and the reaming bit unit (1.8 m or 1.4 m) is power-tightened to the drill string remaining in the borehole. The assembly is then drawn upwards by the slow rotation of the reamer bits. The cuttings fall to the bottom of the inclined hole under influence of gravity and are then collected and transported away so that the drilling operation can continue uninterrupted.

Construction processPreparations are currently under way on the mobilisation of the raise boring equipment. Work is expected to commence at the site in June 2014.

Tilo Jautze · jautze.tilo@ts-gruppe.com
Joachim Gerbig · gerbig.joachim@ts-gruppe.com

Sources
[1] http://wikipedia.de
[2] http://seilbahn.net

Hadanger fjord with a view of Torsnes

Norway adventure: drilling an inclined shaft for a hydro power plant

Road tunnel projects have already improved the transport infrastructure around Hardanger Fjord. Plans were laid at the same time to build a small hydro power plant to supply electricity to the local area. The inclined shaft required for this project, which was to be set at 43° from the vertical and would be 1.4 m in diameter and 230 m in depth, was to be constructed using the raise boring method.

Norway (Hardanger Fjord)

Norway lies on the Scandinavian Peninsula and has borders with Sweden to the east and with Finland and Russia to the north-east. The country's geography is characterised by mountain chains and high barren plateaus (fjells). The highest mountain on the mainland is the Galdhøppigen, which rises to 2,469 m. The 25,000 km-long Atlantic coastline consists of many deep, narrow inlets (fjords) that bring sea-water far into the interior of the country. In addition to the capital city Oslo (population 586,000) Norway has four other large towns with more than 100.000 inhabitants.

The Hardanger fjord is located on Norway's south-west Atlantic coast and is about 170 km in length. There are several larger offshore islands, notably Stord, Bømlo and Tysnesøy. The fjord, which is up to 725 m in depth, runs in a south-west to north-east direction and includes the larger island of Varaldsøy. The area around Hardanger fjord is known as Hardanger and is a very popular holiday destination. The key tourist attractions include a visit to the Trolltunga (a high cliff with spectacular views over the fjord), a walk on the Folgefonna Glacier and a tour of one of the area's magnificent waterfalls (photos).

Site of Torsness, reservoir and inlet structure

Assignment

The Norwegian company Kruse Smith AS was commissioned to construct a small hydro power plant in the vicinity of Torsnes on Hardanger Fjord in order to exploit the area's water power potential for regional electricity supply purposes. Kruse Smith AS had already completed a road tunnel project in the same area.

The hydro power plant consists of three separate structures. The upper installation comprises a barrier for the water supply and for the diversion of the local river towards the inclined shaft. The second structure is the inclined shaft and the third is the connecting tunnel that serves to divert the water into the fjord.

The contract provided for the construction of the 43° inclined shaft, which was to be 1.4 m in diameter and about 230 m in length. The shaft was to be completed using the raise boring method.

Project execution

Kruse Smith AS established contact with THYSSEN SCHACHTBAU GMBH via permanent joint-venture partners TIMDRILLING and Swiss-based Implenia Bau AG. Due to the limited available resources in Norway for raise boring operations, and the tight time schedule involved, the contract had to be awarded as quickly as possible.

After several visits to the construction sites in Norway, followed by appropriate equipment scheduling, the JV was in a position to submit a suitable bid. Given the short timeframe the contract was awarded to TIMDRILLING Norway a mere three days later, with THYSSEN SCHACHTBAU appointed as subcontractors.

Four weeks after the contract award stage the plant and equipment had been mobilised and transported to the site, where work was able to commence on May 29, 2012. The difficult terrain made the site preparations a very time-consuming task that called for a huge amount of improvisation on the part of the entire crew (photos). This included setting up the Wirth HG 160/2 raise boring machine in a very narrow recess and having to maintain the flushing drilling mud circuit at different height levels and in an extremely

Assembling of tip cylinder, HG160-2

Lifting a drilling rod into position

Successful heading through

challenging landscape topography. What is more, the drill rods had to be changed over from a height of about 5 m using a digger crane and an additional solids pump had to be installed in order to remove the drilling debriscuttings.

After the pilot hole had been started the drilling work had to be interrupted at a depth of about 30 m in order to replace the substructure with a concrete foundation that could cope with the demands of the raise boring machine. The pilot hole started up again two weeks later and after 11 days had reached a depth of 203 m.

While this was going on Kruse Smith AS completed the tunnel drivage to the foot of the borehole. To ensure that the tunnel and shaft met up at the same point, with any small corrections that might prove necessary, measurements were carried out at this depth in order to fix the position and orientation. A Single Shot Instrument was employed to measure the inclination and azimuth twice. The readings were then calculated and coordinated with the results obtained by Kruse Smith AS. No borehole corrections were needed and the pilot hole reached its final depth four days later. Shortly after, the Kruse Smith tunnel also arrived at its end point.

Norway's statutory holiday period then suspended the work for two weeks. At the end of the holiday the Hardanger region was affected by extremely heavy rainfall that overflowed the river banks and completely flooded the construction site. And the crew will not spared nothing at all. (photos)

After some repair work had been made to the raise boring plant, which included having to replace the electric motors, and the reamer bit had been fitted for a 1.4 m diameter bore, the raise boring process itself could begin in earnest. As the geological and geomechanical conditions were perfectly suited to raise boring work the bore hole reaming was completed in just 16 days without any further significant incidents.

Summary

The raise bored shaft for a small hydro electric installation in Norway, which was completed in partnership with Implenia Bau AG/TIMDRILLING Norway, demonstrated that THYSSEN SCHACHTBAU has the capability and versatility to deliver projects within a very short time span. It further showed that local administrative requirements also have to be respected in full if the project is to be successfully managed and executed.

Tilo Jautze · jautze.tilo@ts-gruppe.com
Joachim Gerbig · gerbig.joachim@ts-gruppe.com

View from shaft over the camp and the Hadanger fjord

Global shaft sinking projects: analysis and expected development trends

1 Introduction

About 70% of the world's minerals are currently extracted by opencast mining methods. However, it must be assumed that much of this production will soon move to the underground mining sector. The following chart, as produced by Rio Tinto (2011), predicts that by 2018 about 50% of all ore extraction will be produced by underground mining methods.

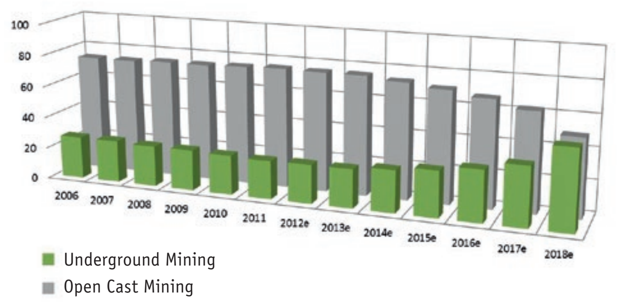


Figure 1: Opencast versus deep mining (Rio Tinto, 2011).

The development prognosis presented in Figure 1, combined with the fact that underground mining is closely tied in with the shaft sinking industry, was used as an opportunity to analyse past and current shaft construction activities and examine the prospects for future projects of this kind, as well as to present possible development trends. The research covered more than fifty years of shaft construction history and included current and planned shaft sinkings along with all projects carried out since the 1960s. The survey examined and analysed a total of some 450 shaft construction operations. At this point it must be noted that there are few sources relating to shaft sinkings in China and that for this reason the statistics include little or no data from that particular region. In their paper entitled ‚Current situation and development for China's 1,000 m deep shaft sinking' Long Zhiyang and Gui Liangyu state that more than 40 shafts with final depths of over 1,000 m have been sunk since 2000 (Walker, Simon, 2012). It must therefore also be assumed that many more mine shafts have been constructed in China during the period extending from the 1960s to the present day.

2 Developments in global shaft sinking activities

A survey of international shaft sinking projects undertaken from 1960 to the present day shows a continuous increase in the number of completed sinkings. The only exception was in the 1990s when a slight decline was recorded (see Figure 2).

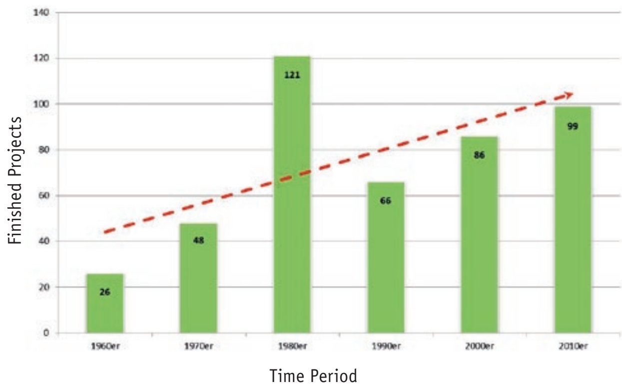
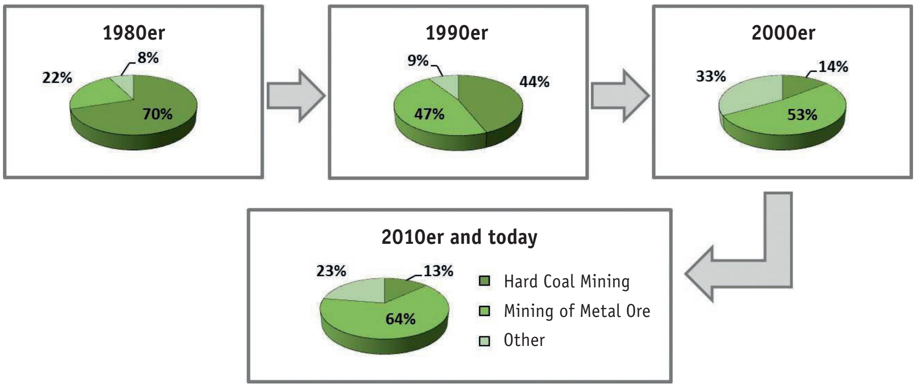


Figure 2: Trends in global shaft sinking projects.

The rise in the number of shaft construction projects can essentially be attributed to the increasing switch from surface extraction to deep mining. This development is being driven by rising commodity prices that make cost-intensive subsurface mining a more feasible proposition. The reduction in the number of shaft sinkings in the 1990s can be explained by the ongoing decline in coal production in Europe (International Energy Agency, 2013). Even by the 1980s some 70% of all mine shafts were being sunk by operators in the coal mining industry. Over the course of the following three decades, right up to the present, there has been a continuous fall in the number of colliery-based shaft construction projects, while shaft sinkings in the ore extraction sector (especially in the gold, copper, nickel, platinum, lead and zinc ore mining industries) have increased significantly. Current shaft construction projects are intended mainly for the development of potash, copper, gold and platinum mines (see Figure 3).

Figure 3:
Breakdown of shaft sinking projects according to target material.



More than 70 shaft sinking projects are currently at the construction or planning stage. Table 1 lists a number of selected operations under way around the world.

Project	Country	Depth [m]	Diameter [m]	Contractor
Shaft 10, Resolution Copper Miner	USA	2,133	8.53	Cementation Canada
SKS-1 mineral shaft, Skalisti mine	Russia	2,050	9	THYSSEN SCHACHTBAU
Main shaft, Impala Mine #17	South Africa	1,920	10	Shaft Sinkers
Production shaft, Lac Des Iles Mine	Kanada	1,500	6	Dumas
Shaft #1, Cixi Mine	China	1,341	8	China Coal No. 5 Construction
Shaft #2, Oyu Tolgoi mine	Mongolia	1,335	10	Redpath
Shaft GG-1, Polkowice-Sieroszowice mine	Poland	1,300	7.5	Pebeka S.A.
Production shaft, Ernest Henry mine	Australia	1,000	7	Byrnecut Australia
Production shaft, Rampura Agucha mine	India	950	7.5	Shaft Sinkers
Shaft #1, Ust Jaiwa mine	Russia	520	8	Deilmann-Haniel
Service shaft,				
Gremjachenski mine	Russia	1,150	7	EuroChem-WolgaKali
Skip shaft No 1, Gremjachenski mine	Russia	1,150	7	EuroChem-WolgaKali
Skip shaft no 2, Gremjachenski mine	Russia	1,150	7	US30
Service shaft WS-10, Skalisti mine	Russia	2,050	9	THYSSEN SCHACHTBAU
Ventilation shaft no 3, Leeville Mine, Newmont Mining Corporation	Nevada, USA	625	7.9	Thyssen Mining Construction of Canada

Table 1: Shaft construction projects being planned or undertaken in 2014.

3 Shaft sinking figures and trends

The key characteristics of any mine shaft are the finished diameter and the depth. The survey found that the average shaft diameter currently stands at about 7.2 m. While even in the 1970s shafts of more than 10 m in diameter were being constructed, a look back over recent decades shows that the average finished shaft diameter, which stood at 5.9 m in the 1960s, has continuously increased right up to the present (see Figure 4).

If this trend continues it can be assumed that average shaft-diameter figures will go on increasing and diameters of around 7.9 m can be considered realistic by the year 2060, which represents an increase of 2 m in 100 years.

This trend is associated with the demand for greater winding capacities and air throughputs and has been made possible by the increased stability of modern shaft linings and the availability of high-performance shaft sinking technology (Klein, Schachtbau, 2002).

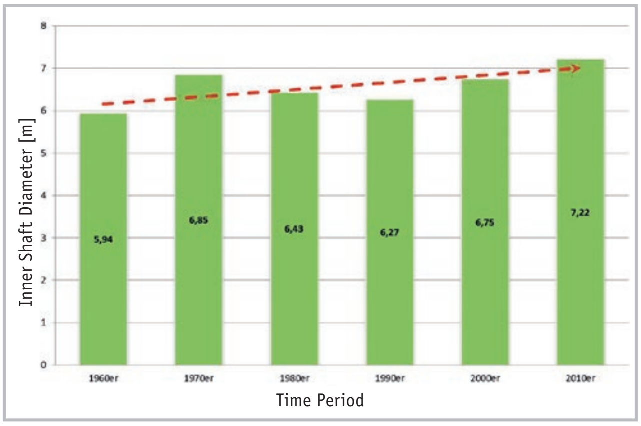


Figure 4: Developments in average shaft diameter.

A key example of the need for greater shaft winding capacity is provided by the Oyu Tolgoi mine in southern Mongolia. This gold and copper facility currently works an area of deposits with a low mineral content where the block caving method has proved to be an economically feasible method of extraction. This system produces more than 100,000 t of raw product a day – a huge quantity of material that has to be taken to the surface via a shaft 10 m in diameter (Tollinsky, 2012).

Modern mines frequently comprise extensive underground workings that have to be adequately supplied with fresh air. While in the 1960s the average mine roadway was around 9 m² in cross section, it is now not uncommon to have roadway profiles of as much as 24 m². With minimum air speeds of 0.5 m/s this means increasing the available airflow from 4.5 m³/s to 18 m³/s. If this air is supplied via shaft, the ventilation intake flow will be restricted not only by the limited air velocity in the shaft but also by the shaft diameter. This is based on the linear relationship between airflow and shaft diameter (Brake & Nixon, 2005).

Over the reference period it has also been possible to witness a moderate increase in shaft depth. Whereas the average depth was around 930 m in the 1960s, today's shafts now reach to an average of 1,050 m - and the world's deepest mine shafts are as much as 3,000 m in depth. However, shafts of this scale have to be constructed offset, as even today's shaft sinking methods reach their physical limits at depths of this magnitude. Based on the trend depicted in Figure 5 it can be accepted that average shaft depths will reach a figure 1,100 m by 2060. This development illustrates that mineral extraction will gradually be transferred to ever greater depths as global reserves contained in shallow deposits gradually become depleted. Opencast mines will be converted to deep mining facilities and mines will also have to develop their underground workings in order to be able to access the deeper-lying deposits. Typical examples of such a development are the mines of Grasberg in Indonesia and Kiruna in Sweden.

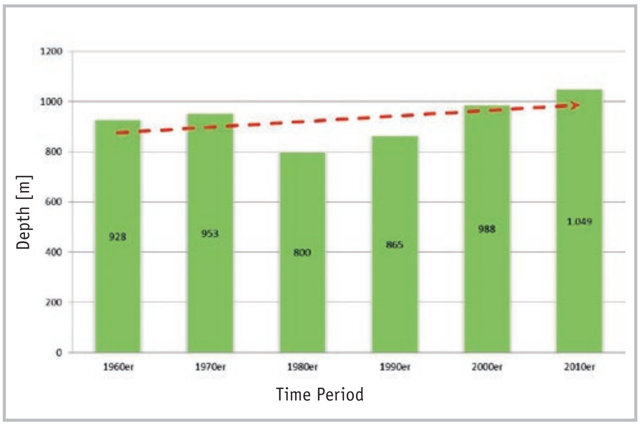


Figure 5: Average shaft depth.

Shaft construction is one of the most time and labour consuming tasks involved in the construction of an underground mine and the shaft sinking work can take up as much as 60% of the entire project duration (Tuck, 2011). It is therefore vitally important to choose an efficient and cost-effective sinking method. Generally speaking the choice lies between the conventional system, which involves drilling and firingblasting, and the mechanised system. Other specialised sinking techniques are also available to cope with anticipated strata stability and water inflow problems (freeze sinking and strata injection technology).

The main advantage of conventional shaft sinking lies in its flexibility in respect of shaft depth, and diameter and the geological conditions of the site. However, the drawback with this technique is that the is given by individual tasks of drilling, blastingfiring, muck loading, strata support and shaft lining cannot be fully synchronised and even when the latest technology is employed daily sinking rates never exceed 3.5 to 4.0 m.

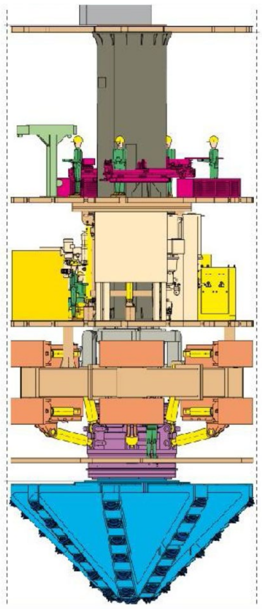


Figure 6: New Herrenknecht shaft boring machine for pilot hole-based projects

Compared with the conventional system mechanised shaft sinking presents advantages when it comes to sinking performance and working safety. The increased sinking rate is mainly attributable to the high parallelisation factor for cutting, loading, strata support and shaft lining. However, as will be explained below, the range of available applications to mechanised sinking technology is limited to certain specific framework conditions. (Handke, Berger, Schmäh, & Künstle, 2007)

While mechanised shaft construction systems are often the focus of specialist literature, an analysis of current shaft sinking projects shows that about 70% of all shafts are still being constructed by conventional means. As Figure 6 shows, mechanised techniques tend to be used in stable ground and in hard-rock conditions. The trend also clearly shows that mechanised sinking is mainly suited to relatively shallow shaft projects (< 760 m) and smaller diameters (< 5.8 m).
The performance figures for standardised raise boring technology (maximum depths of about 600 m, diameters between 1.5 m and 6.0 m) reflect the typical applications for mechanised shaft sinking described here (Sandvik Mining and Construction, 2013).

One exception when it comes to the efficiency of mechanised sinking at greater depth is the pilot-hole method: because of the V-shaped boring head used in this case this system is internationally known as ‚V-mole shaft boring'. Using this technology THYSSEN SCHACHTBAU GMBH has been working in joint venture partnership with Murray & Roberts RUC-Cementation in South Africa, Australia and Europe where a large number of shafts have been successfully sunk in hard rock conditions to depths of 1,000 m and with drilling diameters of up to 8 m. Daily drilling rates of more than 10 m have also been achieved. At present the Joint Venture is working with the Schwanau-based firm Herrenknecht AG to develop a new type of pilot-hole shaft boring machine that will be suitable for drilling diameters of up to 11.5 m.

The Primsmulde shaft in Germany is a superlative example of the mechanisation potential and application of V-mole boring technology in terms of shaft diameter and depth. This shaft have been constructed in stable cap rock, started with a pilot hole raise bored to a diameter of 1.83 m and then widened to a final diameter of 8.2 m over a length of 1,260 m. A former Wirth type SBVII shaft boring machine was used for the project.

This research shows that special sinking technology based on the drilling and blasting method is normally used in non-stable hard rock affected by several water inflows. The same also applies in the case of large shaft diameters (> 5.8 m) and shaft sinking levels below 760 m depth. Pressure from contracting entities often forces shaft construction companies to resort to well-proven and flexible conventional sinking methods, especially under such difficult operating conditions.

A 7-deck, high-tech working platform system was used for the very first time when sinking the over 2,000 m-deep WS-10

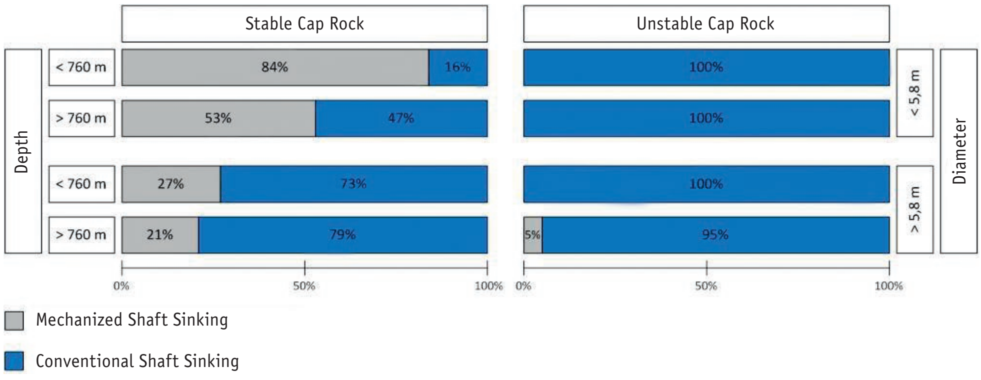


Figure 7:
Sinking method in relation to strata stability, shaft depth and diameter.

and SKS-1 shafts for the Norilsk project. This innovative system allowed a number of individual working tasks to be undertaken in parallel with the result that 50 to 60 m of shaft section could be completed on a monthly basis, including the installation of the permanent shaft guides and supply lines. This sophisticated platform system also retains the flexibility of conventional shaft sinking techniques: shaft insets and landings can easily be created as part of the sinking operation and difficult and complicated geological and tectonic conditions can still be overcome in the conventional way.

4 Outlook

The transition to deeper working levels and the need for larger shaft diameters will henceforth present shaft construction companies with the challenge of developing cost-effective, high-performance methods for accessing mineral deposits under difficult operating conditions. As well as extending the operating range of mechanised sinking technology this will also mean improving and refining conventional shaft sinking techniques. This research has shown that despite the benefits of mechanised technology in terms of sinking performance and work safety, the well-proven conventional sinking method is, and will continue to be, the most widely used system.

Conventional shaft sinking still has development potential and reserve capacity, especially in respect of the parallelisation and technical refinement of the individual working routines. Highly time-consuming tasks, such as muck loading and hauling, remain key areas for improvement.

Conventional loading systems can for example be adapted to suit the characteristics of the muck pile. Shovel design and size, penetration capacity, pick-up performance, cycle time, discharge performance, susceptibility to wear, reach and storage capacity are all important factors affecting the loading performance. The rock blasting process can also be customised to render the debris more suitable for the available loading system. In principle, pneumatic loading and conveying technology could be introduced in place of more conventional methods. This would ultimately help raise sinking performance and improve workplace safety levels and in fact pneumatic loading and conveying equipment is currently being developed specifically for the shaft construction industry.

Thorsten Kratz · kratz@bbk1.rwth-aachen.de
(RWTH Aachen University,
Institut für Bergbaukunde I (BBK I))
David Opitz · opitz.david@ts-gruppe.com
(THYSSEN SCHACHTBAU)

Bibliography

Brake, D., & Nixon, T. (2005). Current trends and future opportunities in underground hardrock ventilation practice. Perth: Underground operator's conference.

Handke, N., Berger, E., Schmäh, P., & Künstle, B. (2007). Further development and prospects in the field of mechanised shaft sinking. Glückauf.

Herrenknecht AG. (2013). Canada: First Operation of a Shaft Boring Roadheader SBR. Schwanau: Herrenknecht AG.

International Energy Agency. (2013). World Energy Outlook 2012. Paris: IEA Publications.

Klein, J. (2002). Schachtbau. Luxemburg: Office for official publications of the European Community.

Rio Tinto. (2011). Trends in Metal Mining after 2013. Hollywood: Golbal Metals & Mining Conference.

Sandvik Mining and Construction. (2013). Raise Boring Equipment. Von http://construction.sandvik.com/sandvik/0120/Internet/Global/S003713.nsf/Alldocs/Raise*boring*products*2ARaise*boring*brochure/$FILE/raiseboring12671a.pdf. Requested on September 8, 2013.

Tollinsky, N. (2012). Sudbury Mining Solutions Journal. Von http://www.sudburyminingsolutions.com/4555.html. Requested on October 1, 2013.

Tuck, M. (2011). Underground Horizontal and Inclined Development Methods. In P. Darling, Mining Engineering Handbook (S. 1180). USA: Society for Mining, Metallurgy, and Exploration.

Walker, Simon. (Juli 2012). Deep Thinking: Shaft Design and Safety for a New Generation of Mines. Engineering and Mining Journal, S. 38-44.

Comparative aspects of cast-iron tubbings and steel-concrete composite lining systems

The growing international demand for potash and rock-salt products has resulted in an increased level of shaft construction activity around the world as the mining industry seeks access to deep-lying potash and salt deposits. In the Volgograd, Perm and Kaliningrad regions of the Russian Federation alone there are currently 13 potash mining shafts now at the planning or sinking stage, while in Canada there are five potash shafts now under construction.

The potash deposits of the Perm region, which were discovered back in 1916/17, are the second largest in the world. Extraction and development has continued right up to the present day, with most of this operation being run by UralKali. There is also an extremely rich body of potash deposits in the Volgograd area: here EuroChem is currently sinking three mine shafts with a view to developing the deposits at Gremyachinski.

THYSSEN SCHACHTBAU GMBH is now involved in the planning and construction of ten potash shafts in the Russian Federation. When planning the shafts for the Gremyachinski potash mine (Volgograd region), and for the Palasherski and Polovodovski deposits in the Perm area, it was evident that THYSSEN SCHACHTBAU and its Russian clients and technical institutes had different views on, and took a different approach to, the shaft support technology that should be used for the project.

German shaft support systems

The Russian mining industry has little knowledge or experience when it comes to the composite concrete-steel shaft linings that have frequently been used in Germany over the years. The floating version, which features a filling joint (asphalt or aerated concrete) between the outer casing (brickwork or concrete panels) and the inner lining (comprising a fully-welded sheet-steel casing and a continuous concrete column), is termed a ‚sliding lining' by shaft construction engineers.

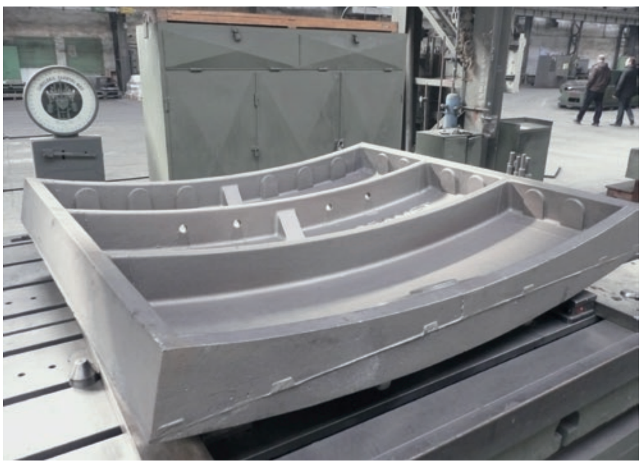
The sliding shaft lining system, which is frequently used in non-stable, water bearing overburden, is time-consuming and expensive to construct. In Germany 21 sliding shafts of this type have already been completed and this support system has proved to be technically superior, durable and practical maintenance-free. In 1969 the German mining industry adopted a series of calculation guidelines for the engineering based assessment of this type of shaft lining system.

Russian shaft lining systems

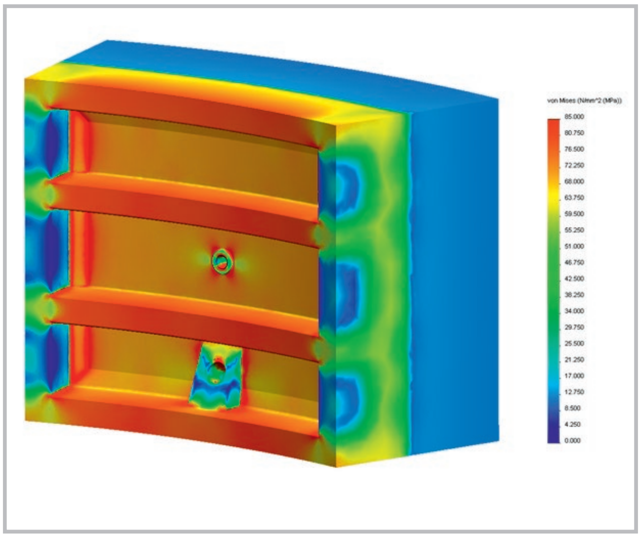
The Russian potash mining industry has always preferred bolted, cast-iron tubbings, with flat lead packings inserted in the joints. This system is still used even under difficult hydrological conditions, despite the fact that it does not provide a fully-effective seal against ground water ingress.

Against this background it was therefore considered necessary to undertake a comparative analysis of the advantages and drawbacks of the two systems. THYSSEN SCHACHTBAU has recently carried out a literature search of this subject area and has also completed a study project that is reproduced below in extract form.

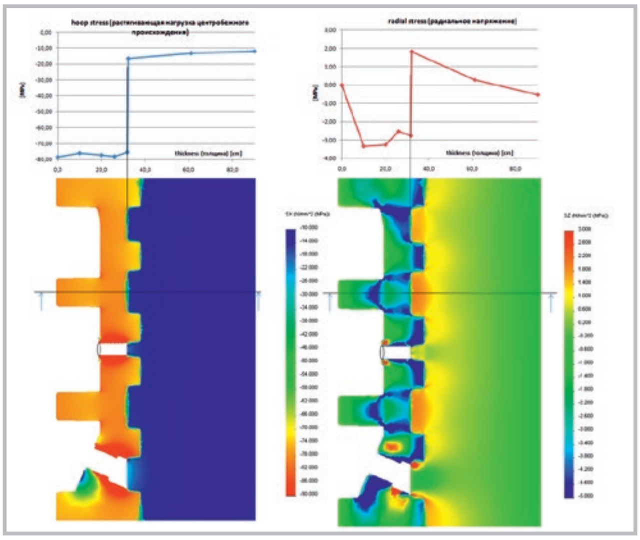
The study focused on the effectiveness of the sealing system against water ingress, as this is of fundamental importance when sinking shafts in water-bearing ground – particularly in the case of potash and rock-salt mines. The sealing system helps ensure the long-term stability of the shaft and protects the deposits from water inflow. Here it is assumed that for



Blank cast iron tubbing after demoulding and sandblasting in manufacturing process



Results of the stress analysis, Tubbing 7.0-120, thickness of concrete 58 cm, depth 642,35 m



Value and behavior of the hoop and radial stress within the cast iron tübbing element and the back fill concrete

the entire operating life of the shaft the primary sealing system can only be in the form of a bolt-connected, cast-iron casing or welded sheet-steel lining and that a standard steel-concrete lining is unable to ensure a permanent seal – especially when subjected to high water pressures.

Cast-iron tubbing system

In Germany cast-iron tubbing supports have already been used in more than 300 coal mining shafts and in about 280 shafts for the potash and salt industries. German cast-iron tubbing is designed in accordance with DIN 21501 standard. This tubbing, which is the world's most commonly used type, differs in several respects from the Russian-made version.

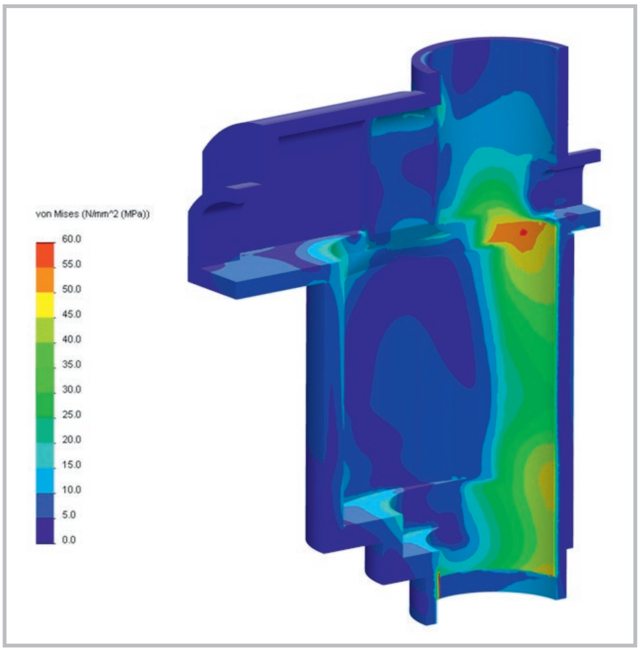
German tubbing features internal flanges and ribs to provide reinforcement along with a series of external ribs to create a better bond with the backfill concrete. Russian tubbing has a more concentrated system of ribbing on its outer surface. A series of angled grouting holes is provided on the lower edge of the tubbing segments so that backfill concrete can be poured through when connecting the tubbing sets together. Each tubbing segment also has bolt-up injection holes that can be opened for subsequent injection sealing purposes.
The individual tubbing segments are bolted together in the shaft to create closed rings. The tubbing rings can be built upwards on carrier rings in sets of 15 to 40 m in height or can be assembled working downwards by attaching each ring to the already installed column. Each method has a number of important advantages and drawbacks and the engineers have to weigh these up in each individual case.

The early side-wall protection provided when the tubbing rings are suspended below one another as the sinking progresses, for example, can be considered as both an advantage and a disadvantage. On one hand this technique gives good overhead protection for the shaft sinking team, but on the other it exposes the support system to strata convergence forces at a very early stage and the tubbing therefore has to absorb unnecessarily high stresses. In the Russian Federation the engineers and shaft construction teams building the tubbing columns now always prefer the underslung method – in other words the rings are fitted seamlessly from top to bottom.

When installing tubbing supports it must always be borne in mind that water can never be completely prevented from seeping through the sealed joints between the individual segments. Although the joints are sealed using lead inserts, they do have weak points in the form of incomplete gap infills and the plastic behaviour of the lead layers. When rock pressures are at a high level this plasticity can mean that the lead is completely squeezed out of the joints.

Up to the end of the 1950s cast-iron tubbing was the standard support method for deep shafts in the German coal, potash and salt mining industries. The last shaft to be supported using this technique was Lohberg 3 at Dinslaken, where sinking commenced in 1960.

Over the following years the German mining industry gradually replaced tubbing with the sliding shaft lining system. The latter not only provides a complete seal against water ingress but is also less sensitive to deformation movement generated by mine workings close to the shaft pillar.



Von Mises- stress (0 until 60 MPa) at the designed shaft landing site

The floating shaft lining system has undergone many modifications and developments over the years. This includes:

- an internal load-bearing steel casing in combination with a non-reinforced concrete inner cylinder, with an outer steel casing as a sealing layer
- an outer load-bearing steel casing in combination with an inner steel-reinforced concrete cylinder, with no inner steel lining
- a friction-locked system based on in-situ concrete or in combination with preformed concrete blocks, chipboard panels and backfill
- sliding joint fillings using materials of different kind and of different densities.

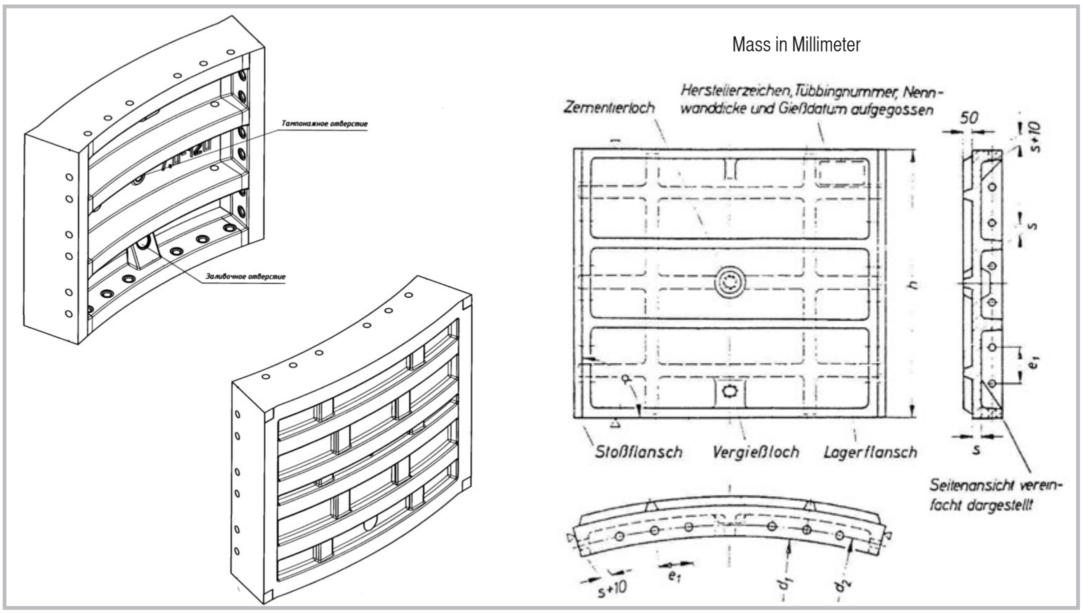
The last sliding shafts sunk by THYSSEN SCHACHTBAU were the Gorleben 1 and Gorleben 2 shafts that were completed between 1986 and 1999. These were required as exploration shafts for the proposed Gorleben permanent disposal facility for radioactive waste.

Watertight ‚floating' shaft linings

In the case of sliding (floating) shaft linings the mine water is kept back by a fully welded outer steel casing, while most of the external forces are absorbed by an inner reinforced concrete cylinder and in some cases by another internal steel lining. too. Fluid asphalt is generally used to fill the annulus between the outer casing and the inner shaft cylinder. The asphalt separates the outer casing from the inner lining and allows the inner lining to absorb a certain amount of deformation without suffering any damage.

Comparative assessment

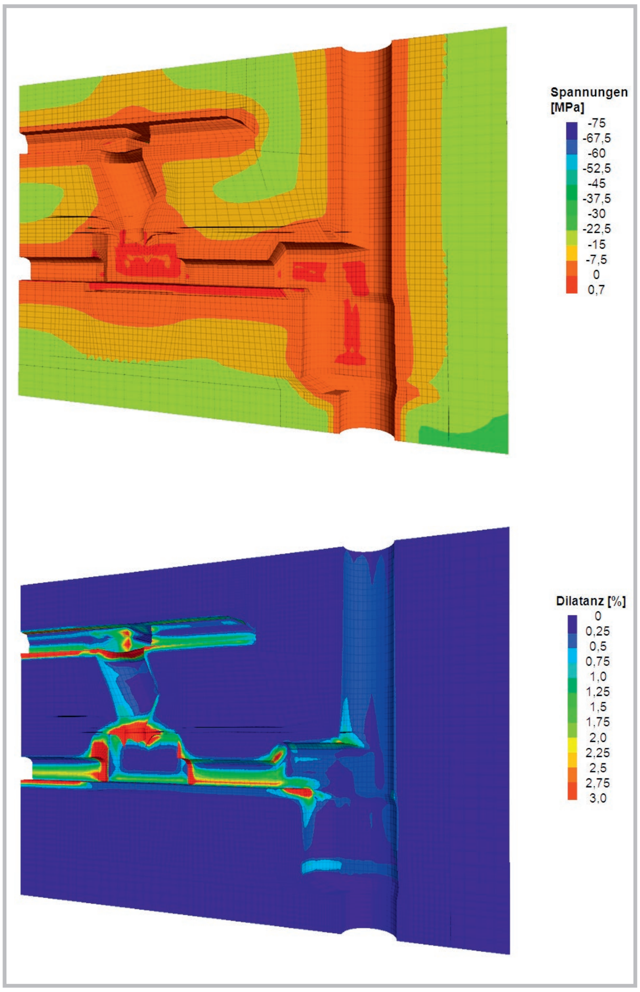
The two shaft support systems outlined above have now undergone a comparative assessment by THYSSEN SCHACHT-BAU that was based on technical aspects such as sealing against water ingress, corrosion resistance and the resulting maintenance frequency. The following table presents a direct comparison between the main features of each technique.

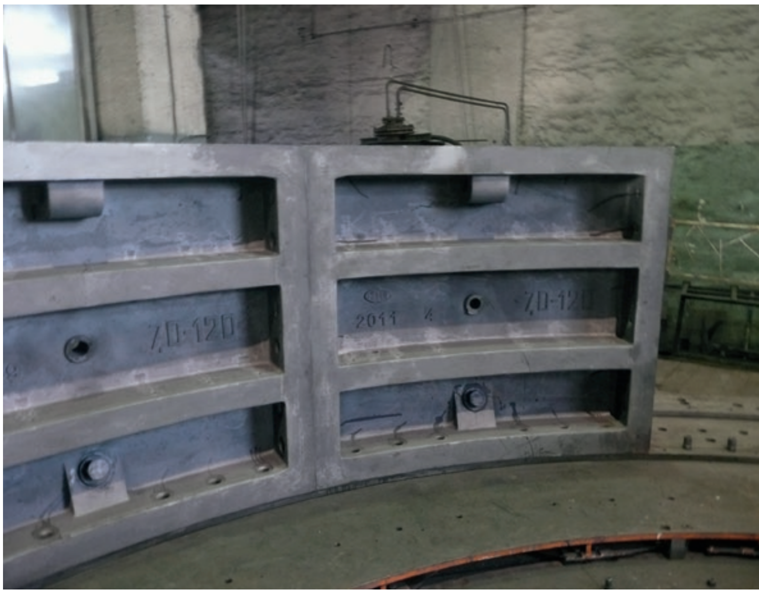


Pic. left: Scheme of the Russian cast iron tubbing segment, i.e. 7.0-120 GG35

Pic. right: Scheme of the German cast iron tubbing segment

	Sliding shaft	Tubbing shaft
Sealing against water ingress	Complete (fully welded steel casing, additional seal created by asphalt joint)	Incomplete (plastic behaviour and possibility of joint lead being squeezed out)
Response to temperature changes	– possible length changes – sealing effect is not endangered	– possible length changes – gaps developing can endanger the seal ⇒ air warming or heat insulation required
Corrosion resistance	*Inner steel casing:* – inner surface less vulnerable to airflow and temperature changes – use of a protective coating provides a relatively simple remedy *External surface of outer steel casing:* Less vulnerable due to use of backfill	*Inner surface of tubbing:* vulnerable to – water ingress – airflow – temperature changes (safe when dimensions are sufficiently large) *Outer surface of tubbing:* Less vulnerable due to use of backfill
Maintenance outlay	Low maintenance	High maintenance due to: – bolt tightening routines – caulking of joint lead – grout injections
Reaction to mining influences	Insensitive (sliding joints can absorb deformation)	Sensitive (rigid support system)
Air resistance	Low, due to smooth inner surface	Large, due to reinforcing ribs, otherwise cladding is needed
Manufacturing and installation logistics	Only a few European manufacturers have the capacity to roll the steel segments to the shaft radius. Highly qualified welders from the tank and shipbuilding sector are needed to weld up the steel segments	There are numerous tubbing manufacturers in Europe. Assembly is relatively easy and uncomplicated. Local workforce can be used
Labour and costs	Very labour-intensive and expensive type of shaft support	Simple and relatively cheap shaft support system
Limitations to use	Depending on design, simple tubbing columns can be used to a maximum depth of 800/1,000 m (wall thickness limited to 140 mm) Underslung method can be used to a maximum column length of 1,000 m	Simple steel cylinders can be handled to a depth of 600/700 m. For longer/deeper steel columns possibility of using a combination of double steel cylinders Because an outer support casing has to be installed this system is technically and economically better than cast-iron tubbing down to a support length of 400/500 m





Test assembly of the cast iron tubbing segment at the surface.

Pic. left above:
Minimum of the normal stress at the shaft landing site after 50 years life time

Pic. left:
Structural displacement at the shaft landing site after 50 years life time

Conclusions

Any comparative analysis must take account of the fact that the industry has only acquired 40 years of experience as far as the stability and water-tightness of steel shaft casing systems is concerned. However, this type of support has often been used in the German coal, potash and salt mining industries and the system has stood the test of time to date.

In spite of its drawbacks in terms of water-tightness and high maintenance requirements in the operational phase, tubbing remains a viable alternative for difficult geological and hydrological conditions. SOVEREIGN is one company that can supply excellent and very effective injection technology and polymer-based injection products designed to create an all-round seal against residual water ingress.

In Russia there is still little or no enthusiasm for sheet-steel linings as a method of supporting mine shafts in water-bearing or unstable ground. However, Russian engineers essentially have no operating experience with this type of shaft support and prefer instead to rely on the well-established cast-iron tubbing system that is so familiar to mineworkers and tunnel construction engineers alike.

As it can draw on years of experience with both types of shaft support system THYSSEN SCHACHTBAU will continue to be a reliable partner for its Russian clients, especially when it comes to assessing the practical application of these techniques and similar methods and demonstrating the best available technical and economic solutions.

Henning Zirbes · zirbes.henning@ts-gruppe.com
Joachim Gerbig · gerbig.joachim@ts-gruppe.com

Inspection of tubbings and acceptance sampling in the ukranian manufacturer's works

TS launches THYSSEN SCHACHTBAU-Engineering

THYSSEN SCHACHTBAU GMBH has now set up a new section – THYSSEN SCHACHTBAU-Engineering – that will operate alongside its Technical Office in delivering project services. The new department will henceforth provide external engineering services, particularly in areas such as project planning, engineering and construction supervision.

The Technical Office has traditionally been responsible for preparing approval stage and final design plans for projects that have been acquired by the Shaft Sinking and Drilling and by the Horizontal Drivages (Mining Division) departments. The Technical Office therefore operates primarily as an internal project planning service.

Developing external business

By establishing THYSSEN SCHACHTBAU-Engineering the company will henceforth be able to provide project planning services for external clients and contractors.

Project planning	Care/maintenance and stabilisation of disused shafts in the coal, potash and salt mining industries
	Shaft consolidation and shaft lining concepts
	Exploration and development projects for the extraction of lignite, baryte, oil shale, talc, etc.
	Shaft winding equipment and headframes in conjunction with OLKO-Maschinentechnik GmbH

	Shaft cabling and pipe work, winding rope changeover
	Ventilation and mine drainage measures
Studies and analyses	Pre-planning and pre-design studies for shaft sinking/deepening and bunker construction projects
	Drilling concepts for exploration wells, gas extraction holes, core drillings, investigation boreholes, utility supply bore holes, etc.
	Exploration work, assessment reports, mining subsidence analyses, survey reports on abandoned mines and professional care and maintenance
	Shaft and roadway support statics
	Ground-freeze projects and freeze concepts, including measurement support services and control
	Certification of import licences for Russia and Kazakhstan
	Functional and weak-point analyses for machines, plant and equipment
Inspection and construction supervision	Shaft care and maintenance, stabilisation and support of underground workings and cavities
	Construction and drilling operations above and below ground
	Manufacturing, e.g. production of cast-iron tubbings

Beyond engineering theory to operational expertise and hands-on experience

THYSSEN SCHACHTBAU-Engineering operates as an engineering office and consultancy. Access is maintained to the operational side of things in that THYSSEN SCHACHTBAU-Engineering – as part of the THYSSEN SCHACHTBAU company – is constantly involved in the execution of specific projects and is engaged in hands-on planning and engineering activities in line with market demands.

THYSSEN SCHACHTBAU-Engineering is mainly active in the field of mining and civil engineering, but also undertakes geotechnical and drilling work. Its operations are supported by modern, efficient IT solutions such as COMSOL MULTIPHYSICS that can be used for the numerical modelling of interlinked structure-mechanical, thermal and other physical parameters.

Current projects

Tubbing and wedge-crib planning for EuroChem in the Russian Federation

THYSSEN SCHACHTBAU-Engineering is currently involved in designing tubbing and wedging crib systems for three potash shafts at Gremyachinski mine being developed in the Volgograd region by EuroChem. Thyssen Mining Construction of Canada (TMCC) has also been providing know-how and experience for this project.

Comparing international mining standards

THYSSEN SCHACHTBAU-Engineering is presently engaged in a study aimed at comparing the rules and guidelines applied by various countries with regard to potash mining operations. This will seek to analyse the following factors:

- ergonomic aspects, such as permitted temperature levels, air speeds, etc.
- technical guidelines on maintenance schedules for conveyors, winding equipment, etc.
- labour law and work organisation provisions

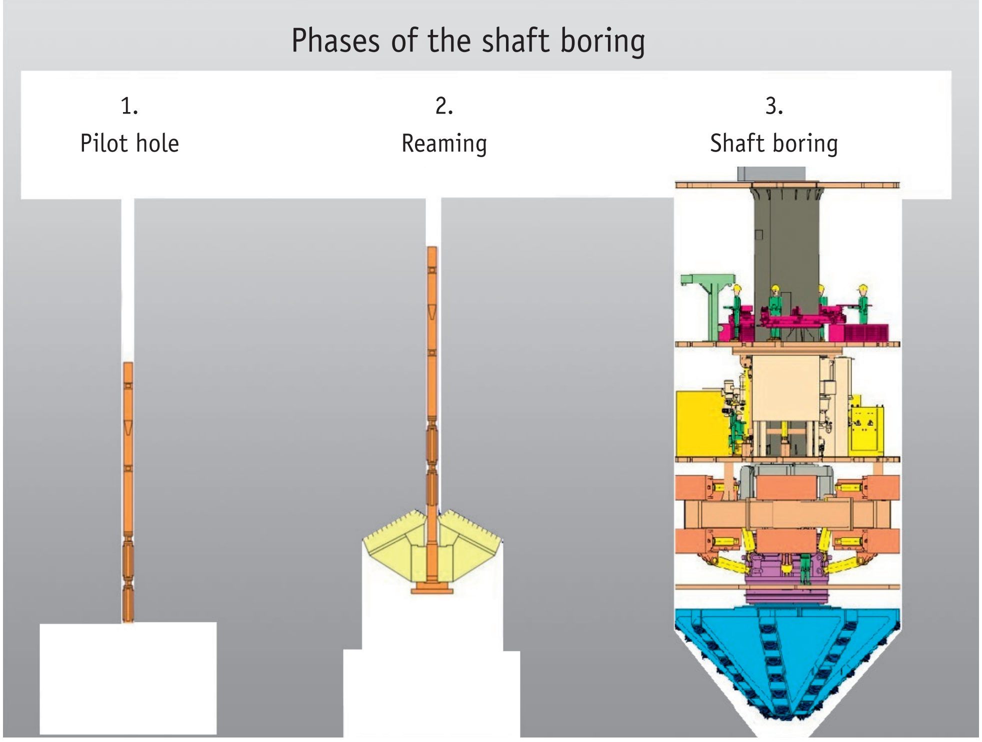
Preliminary drilling and approval and design planning work for shaft sinking projects

THYSSEN SCHACHTBAU-Engineering is involved in preparing approval and design plans for two shaft projects, namely the Polovodovski project being developed by the potash mining company UralKali and the Asse V shaft at Asse mine.

Need more information?

Have you a job that needs doing? Come and talk to us. Advice, planning, testing and monitoring are all part of our services, from feasibility studies on architectural and structural design as part of the draft planning stage through to the invitation of tenders and detailed design planning. And we can also act as general contractors for complex project assignments.

Rainer Lietz · lietz.rainer@ts-gruppe.com
Tim van Heyden · vanheyden.tim@ts-gruppe.com
Joachim Gerbig · gerbig.joachim@ts-gruppe.com
Henning Zirbes · zirbes.henning@ts-gruppe.com



The three phases of shaft drilling with pilot hole manufacturing

Mechanised shaft boring

Herrenknecht AG has now developed a new generation of advanced, high-performance shaft boring machines in close collaboration with THYSSEN SCHACHTBAU GMBH and Murray & Roberts Cementation. The new systems have the capacity to bore shaft diameters up to 9.5 m, meanwhile their powerful new drive concept can achieve sinking speeds almost twice the previous norm. The mechanical elements have been kept deliberately robust to cope with the adverse working conditions and demands of today's shaft sinking projects. The boring machine is operated and controlled by using standard technology and no specialist knowledge is required on the part of the operating personnel.

THYSSEN SCHACHTBAU and Murray & Roberts Cementation, RSA (formerly RUC Mining Contractor, RSA) first signed a long-term joint venture partnership onw shaft boring in 1987. In 2014, this global agreement was extended for an additional 10 years. While the partnership was formerly restricted exclusively to mechanised shaft boring using the pilot hole method, the new extended agreement covered shaft boring from the solid (full-section boring).

In order to achieve even greater shaft boring performance levels, a new shaft enlargement machine was designed by a joint venture study group under the technical leadership of Herrenknecht. The end result was a mechanical drivage system which can be used with immediate effect for pilot hole-based shaft boring operations. The new SBE technology (shaft boring machine for shaft enlargement) is primarily suited to sink shafts in hard rock conditions. The Herrenknecht company offers fully-integrated technical solutions for mechanised roadway drivage operations.

Since the 1970s THYSSEN SCHACHTBAU has been involved in sinking more than 50 shafts using the pilot hole-based boring method. This represents an accumulated total depth of nearly 20 km. In previous years, this type of shaft boring machine was built and supplied by Aker Wirth GmbH of Erkelenz.

The pilot hole-based mechanised shaft boring technique that was developed in the 1980s and 1990s by the JV of Murray & Roberts Cementation and THYSSEN SCHACHTBAU, specifically for the hard rock mining conditions of Australia and South Africa, is now known as the ‚V-mole system'.

The term ‚V-mole' is used to denote a rodless shaft boring machine which was coined by shaft construction engineers as an abbreviation for ‚vertical mole', as opposed to the concept of the ‚horizontal mole' that commonly signifies a tunnel boring machine.

The machine produces final shaft diameters of 5.5 to 8.2 m and operates at an average shaft sinking rate of 8.2 m/d, with already achieved peak performance levels of up to

37.5 m of completed shaft per day . An excellent example is the sinking of four surface shafts for Jim Walters Resources, Inc. in Brookwood, Alabama, USA. As a result of the V-mole shaft boring system, this project established a new world shaft sinking record by achieving 494 m a month at a boring diameter of 7.0 m.

These four shafts were the first V-mole shafts constructed as surface shafts. The bored shafts completed prior to this project were staple shafts or shaft extensions. Another ‚first' for the four Alabama shafts was that the boring and shaft lining operations were carried out simultaneously.

At the Western Deep Levels gold mine, operated by the South African mining company Anglo American Corporation, strata with compressive rock strengths of over 550 MPa (the Alberton Lava formations) were successfully bored at a depth of 3,000 m using a new design of the hard-rock boring head. This project also employed another innovative technology: split-set rockbolts were systematically used for strata reinforcement with a steel-fiber shotcrete coating followed by a shotcreting robot to produce the final shaft lining.

The last deep shaft sunk by the JV using this method was the Sedrun II shaft that forms part of the Gotthard Base Tunnel in Switzerland. This shaft is 800 m in depth and has a bored diameter of 7 m. The shaft was constructed and handed over as a turnkey facility within 12 months.

Shaft boring phases

Sinking a shaft using the pilot hole and enlargement method essentially involves three main working phases:

Phase 1: Drilling the pilot hole using directional drilling technology (from the top downwards)

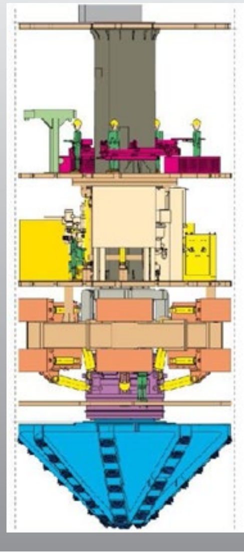
Phase 2: Widening the hole using a raise boring machine (from bottom to top)

Phase 3: A shaft boring machine is used to widen the hole of the final shaft diameter with simultaneous installation of the shaft lining (from the top downwards).

This technique requires a bottom roadway to be placed beneath the deepest point of the proposed shaft. There must also be sufficient underground transportation capacity for the drilling debris along with continuous downcast ventilation throughout the sinking phase. The pilot hole also has to remain absolutely stable for the duration of the subsequent enlargement stages.

Specification of the brand new shaft drillingmachine

Power:	4 x 400 kW
Rotation:	1,5 – 5 rpm
Torque:	12.000 kNm
Axial load while drilling:	8300 kN
Drilling stroke:	1000 mm
Speed, up to	4 m/d
Push per cylinder (12 active):	17.000 kN
24 cylinders, each with a drilling stroke of:	400 mm
Installed power:	880 kW
Total weight, ca.:	400 t



Shaft drilling machine on pilot hole: performance date and schematic design configuration

The shaft boring machine basically comprises the same components as a tunnelling machine. The drilling/boring operations and shaft lining work are undertaken in parallel. The limiting factor for the depth of the bored shaft is not the shaft boring machine itself but rather the technically feasible depth of the initial pilot hole, usually between 1.8 and 2.4 m. Provided that intermediate levels are available for the drilling of the pilot hole the main boring machine essentially has the capacity to construct shafts of unlimited depth.

Mechanical equipment and facilities for the shaft boring system

Constructing a new shaft using the pilot hole technique requires the following sinking plant and equipment:

Surface

- sinking headframe with rope pulley platform
- shaft cover with hatchways
- laser platform with plumb-line systems to monitor the verticality of the bore
- platform winches of about 40 t payload for the multideck working platform
- single-drum winding machine with a payload of 6 t to operate the sinking bucket
- emergency escape winch/service winch with 3 t payload
- suspension-cable winch for holding and advancing the shaft supply lines
- conventional infrastructure items such as the electrostation, compressor plant, concrete mixing unit, dry materials silo, site offices and washrooms, tools and workshop containers and storage areas

In-shaft

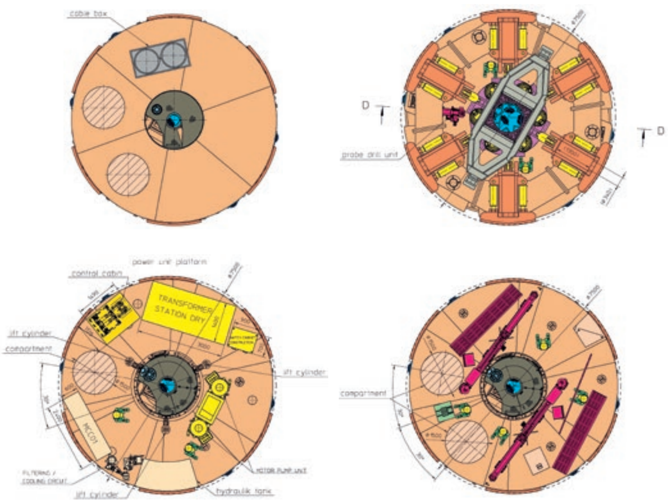
- multideck working platform for the installation of the shaft lining
- V-mole shaft boring machine with boring head and gripper unit, along with platforms for installing the shaft support system and carrying out the exploration drilling and injection work

Bottom roadway

- equipment for loading and removal of the drilling and boring material
- dust extraction systems
- water pumps for the removal of mine water and service water.

Raise boring the pilot hole

Before the boring work commences it is common to construct a 10 m-deep foreshaft for the assembly of the shaft boring machine. The shaft collar and eventual fan drift, which are cut and cover excavations, are usually completed in conjunction with the foreshaft. The safe deployment and operation of the shaft boring machine calls for a pilot hole with a deviation from the vertical target axis of up to half the diameter of the hole (i.e. at D 1.8 m = max. deviation of 0.9 m). This requirement is based on the geometry of the boring-head center point: any greater deviation of the pilot hole would prevent the center of the boring head from engaging into the pilot hole. This preciseness calls for continuous monitoring and active steering of the pilot bore, a requirement that can be met by employing the latest vertical directional drilling systems throughout the entire drilling phase. These systems permanently measure the inclination of the hole in two axes and simultaneously affect the required corrections to the course of the hole. The measurement data istransmitted online to the boring equipment operator.



Herrenknecht shaft drilling machine, view of the different stages

The pilot hole is subsequently widened to the next diameter stage using a powerful raise boring machine. The raise is completed at a steady pace of around 30 m/d and the drilling debris is continuously collected and removed from the bottom of the hole. This operation is commonly carried out using a Wirth HG 330 SP raise boring machine from Murray & Roberts Cementation.

The raise-bored hole is used as a ventilation route during the shaft construction phase and also acts as a clearance route for the debris generated by the shaft boring machine, this material falls due to gravity onto the shaft floor chamber or bottom roadway.

The SBE shaft boring machine

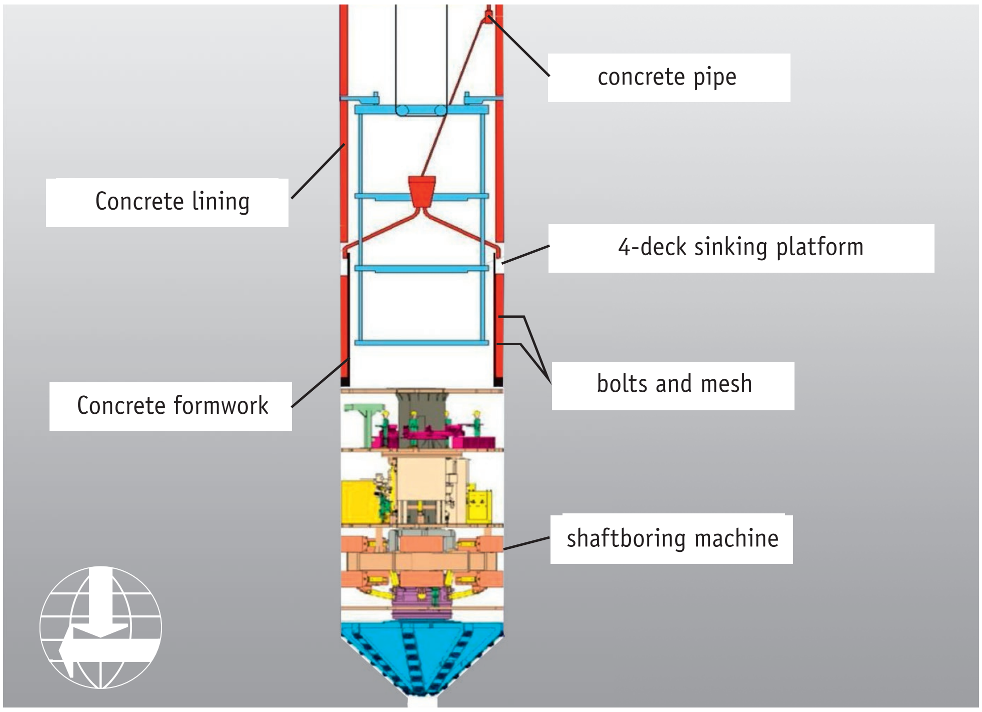
The shaft boring machine comprises of the following main components:

- boring head
- inner kelly with bearing and drive
- outer kelly with tensioning system on two levels
- control station with all operating and display instruments
- laser targeting device for vertical steering
- supporting platform with shotcreting equipment and rockbolting rigs
- reconnaissance and injection platform.

The boring head is fitted with discs or carbide cutters that can be changed from inside the head as they wear away. The outer kelly is held in place hydraulically by tension pads set at two levels which creates the abutment for the thrust system that forces the inner kelly with its rotating bore head against the drilling face. The inner kelly is mounted on an articulated frame set inside the outer kelly and can be steered in any direction using a set of hydraulic cylinders. This ensures precise vertical control of the shaft boring machine. The target axis of the shaft is permanently relayed to the machine operator via the laser targeting system.

The rotating rockbolting platform is positioned on the deck above the boring head. This platform, which is equipped with two high-performance hydraulic drill feeds, systematically installs the rockbolt supports and full-cover wire mesh. The performance of the drill feeds is matched to the lift height and cutting speed of the boring machine, which ensures that the shaft boring and support operations are able to continue uninterrupted. A dry spraying unit mounted on the boring

Shaft drilling machine on pilot hole: applicating the final shaft lining



machine is used to apply an immediate supporting layer to the newly exposed side walls. The machine is about 15 m in height and has an overall weight of 350 t.

Multideck working platform

The multideck platform is suspended approximately 15 m to 20 m above the shaft boring machine on ropes operated from the platform winches. This working platform follows the machine as it excavates the shaft.

The multideck platform is equipped with an integral shuttering system or shotcreting robot to place the concrete shaft lining. Moving shuttering systems with concrete block heights of about 9 m were first successfully developed at the Oryx Mine shaft boring project in Australia. The lining for the bored shaft can be constructed using any suitable support system as this installation work is undertaken independently of the machine boring operation. Concrete lining has proved to be an effective support system for deep shafts. This can be placed as in-situ concrete using moving shuttering, but can also be installed as sliding lining using a sliding formwork system, or can be spray applied as shotcrete with or without reinforcement.

A storage magazine for the in-shaft supply lines is also installed on the multideck platform and, depending on the form and type of the lining system used, a concrete silo with a remixer to process the concrete delivered down the drop-pipe can also be positioned there.

The boring machine is assembled in the 10 m-deep foreshaft, with only the boring head and lower tensioning section positioned within the shaft. After installation, the machine gradually bores itself into the ground and the sinking equipment is successively completed. Once the complete sinking system is fully installed, the shaft cover is set in place and the pre-assembled headframe is moved into position at the top of the shaft.

The debris produced by the boring head falls down the pilot bore, while the shaft boring and lining operations carry on continuously and in parallel until the bottom roadway is reached. The new Herrenknecht shaft boring machine aims to achieve 15 m to 20 m of vertical advance per day for shaft diameters of up to 11.5 m.

After the boring machine has broken into the bottom road, it is ‚parked up' in its final position, stripped down to its essential elements and then transported out.

Advantages of shaft enlargement technology

The shaft enlargement method is one of the most effective shaft sinking systems now available, the world shaft-sinking record is held by a mechanised boring machine working from a pilot hole. The benefits of this shaft boring method – compared with conventional sinking by drilling and blasting or set against other mechanised excavation systems – lie in its higher sinking speed and increased precision in respect of verticality and profile circularity, which in turn conserves resources and minimizes the amount of vibration stress acting on the local strata. The sinking cycle is a continuous process and is not interrupted by stoppages for shothole drilling or for clearing the shotfiring fumes. From a technical viewpoint this system brings a number of advantages:

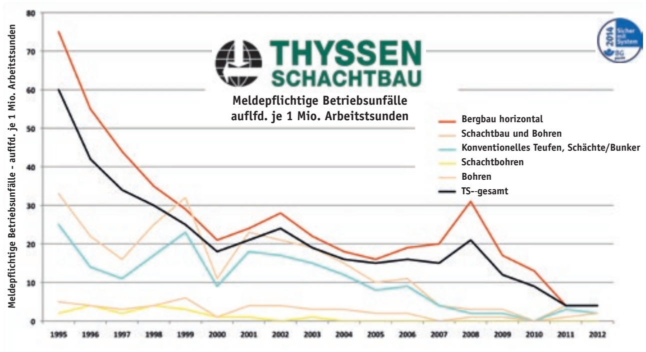
- high safety levels during shaft sinking because of the high degree of the mechanization involved
- acceptable working conditions for the sinking crew
- no blasting cycle, which means no in-shaft vibration and no loss of ventilation quality due to the presence of shotfiring fumes
- continuous operating process results in high boring rates of 8 to 15 m/d of completed shaft
- good synchronization of excavation and support operations
- non-destructive and almost fissure-free excavation of the shaft cavity
- minimal overbreak, resulting in the economic use of support and lining materials
- the shaft project can be commissioned and refinanced at the earliest possible date.

Herrenknecht Maschinentechnik

Mining companies have to be innovative if they want to adopt a modern, efficient and safe approach to mining projects of the future – and Herrenknecht AG can provide them with the new machines and technology they need. When accessing deep-lying deposits or developing an underground mine infrastructure mining companies must not only take mineral production to a new level of efficiency, but must also create a safe and acceptable working environment for their employees.

Mechanised shaft sinking offers the perfect solution and Herrenknecht is constantly expanding its multi-faceted portfolio of products in order to meet the demands of its customers. The company is able to fall back on its cross-sectoral technical know-how as tunnel construction methods and technologies are increasingly included in the new business opportunities provided by the mining sector.

Synchronized working cycles allow the shaft sinking machine to achieve a better overall sinking performance and this in turn raises the capital value of the project. Working closely with their partners THYSSEN SCHACHTBAU GMBH and Murray & Roberts Cementation, the Herrenknecht company has successfully developed a new generation of advanced, high-performance shaft boring machines.



Accident rate in mechanized shaft drilling (yellow) compared to all other mining work

Summary

Extremely long lead times and an enormous amount of advance financing are required to develop an area of mineral deposits where the mine's planned production levels can be achieved. This calls for specialized technology capable of accessing the target deposits as quickly and as efficiently as possible. Shaft boring from a pilot hole can make an important and significant contribution to the achievement of this objective: reducing the shaft sinking time by 25% to 30% by employing a shaft boring machine, as opposed to conventional shaft sinking methods, which saves a significant amount oftime before the new mine comes into operation.

As well as being more cost efficient, the shaft boring method brings further benefits, such as a high level of safety in the workplace and a real improvement in the working conditions inside the shaft.

THYSSEN SCHACHTBAU and Murray & Roberts Cementation are ready to provide their customers with a high performance package through the introduction of innovative, mechanized shaft boring technology along with the Herrenknecht shaft enlargement machine that has been developed and designed as part of a JV partnership which is now ready for deployment.

Eduard Dorn · dorn.eduard@ts-gruppe.com
Rudolf Makosch · makosch.rudolf@ts-gruppe.com
Hubertus Kahl · kahl.hubertus@ts-gruppe.com
Norbert Handke · handke.norbert@ts-gruppe.com

Drill site REMLINGEN 15 of Asse GmbH

Asse mine: planning work for the Asse 5 shaft sinking

The ‚Asse no. 5 shaft' joint venture (JV Asse 5 Shaft), comprising Deutsche Montan Technologie GmbH, Essen (DMT), K-UTEC AG Salt Technologies, Sondershausen and THYSSEN SCHACHTBAU GMBH, was commissioned in early 2011 to prepare concept design for the new Asse 5 shaft at Asse mine in Remlingen, in the Wolfenbüttel district. The client is the Federal Agency for Radiation Protection, Salzgitter (BfS).

The mine now requires an additional shaft with a high-performance winding system for the salvage and recovery of the radioactive waste stored below ground. A suitable shaft collaring point was chosen and the surface drilling site prepared. The JV Asse 5 Shaft supervised the drilling work and was also charged with analysing the geological and geotechnical survey results from a shaft engineering standpoint.

The findings obtained from several exploratory holes will serve to confirm the suitability of the chosen shaft drilling site. In addition, these data will be used to clarify various other aspects of the project, including the sinking operation, the shaft lining, the position of the insets and the layout of the connecting tunnels.

The new Asse 5 shaft is part of the scheme to retrieve radioactive waste and transfer it back to the surface

Between 1967 and 1978 some 126,000 drums of low- to intermediate-level radioactive waste were put into storage at the former Asse research mine.

Following a decision at the end of 2008 that Asse II mine would in future be administered as a final waste repository operational responsibility for the facility was transferred to the BfS on January 1, 2009. After assessing and comparing various closure options aimed at complying with the remit under the German Atomic Energy Act to shut down the site, the BfS decided that the radioactive waste should be retrieved and safely returned to the surface. This operation will require a shaft with an efficient winding system and suitable infrastructure equipment.

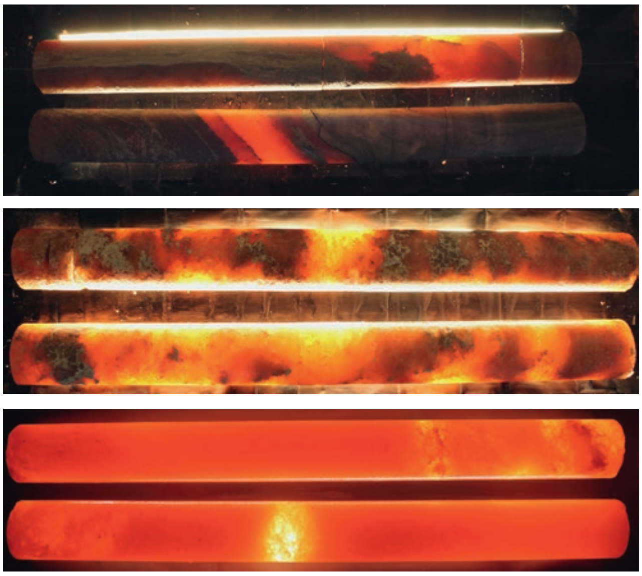
Execution of the exploratory drilling and analysis of the results

After a suitable site had been chosen for the ‚Remlingen 15‘ exploratory shaft drilling, Asse-GmbH initiated the necessary approval procedures for the drilling work at the end of 2012.

At the same time the JV Asse 5 Shaft began drawing up initial design plans for the drilling project under commission from the BfS, on the basis of which Asse-GmbH as the mine operator had issued a Europe-wide call for tenders following the completion of the detailed engineering plans. After Asse-GmbH had selected and instructed the contracting firm for the shaft exploratory drilling, and the subcontractors had been appointed for the associated geophysical and geo-hydraulic tests to be undertaken by JV Asse 5 Shaft, the drilling work was able to commence in June 2013. This operation was supervised by JV Asse 5 Shaft, which took over responsibility for the geological management of the operation on-site in order to ensure immediate logging and documentation of the core samples.

THYSSEN SCHACHTBAU is currently carrying out similar work at two shaft sinking projects for the potash mining industry in Russia. This involves shaft exploratory drilling work and the preparation of drilling programmes, followed by geological, hydrological and geotechnical analysis for subsequent shaft-engineering operations. The experience acquired from these contracts will prove useful for the Asse 5 shaft project.

Saliferous rock - cores of borehole REMLINGEN 15 from different depths



JV Asse 5 Shaft has now drawn up the safety and verification plan in which concepts will be presented for processing the available evidence relating to the safety and serviceability levels during the construction and operational phase of the new shaft as part of a nuclear classified facility. This supporting evidence, together with the approval design for the nuclear waste retrieval process, must be submitted to the relevant authorities as a subsequent stage in the official procedure.

Evaluation of preferred options for the retrieval of radioactive waste

In the current design planning stage JV Asse 5 Shaft is conducting a variant comparison that will examine specifications from the safety and verification plan, together with various influences that will act on the design and structure of the shaft and the functional and economic aspects of the installation. Using the results obtained from the Remlingen 15 exploratory drilling and the additional underground survey holes drilled out from the existing workings towards the new Asse 5 shaft it is planned to execute a further stage in which the number of variants will be limited to two or three. From these the BfS will then select a variant that will be the focus of further planning.

This preferred variant will then provide a basis for subsequent design planning work and will serve both as a system description and as subject matter for the very final presentation that will be made to the approval authorities, participating third parties and public bodies.

Thomas Jank · jank.thomas@ts-gruppe.com
Markus Westermeyer · westermeyer.markus@ts-gruppe.com

View over the mine facilities

pic. right: 95 metre high headframe

Materials supply plant for Kouzidong colliery

China has now approved the construction of nine new mines with a total planned production capacity of more than 100 million tonnes of coal. This figure is six times more than in the previous year and is equivalent to ten percent of total US coal consumption. Kouzidong colliery in Anhui Province produces up to 8 million tonnes of coal a year and has reserves estimated at 730 million tonnes.

In 2012 Olko-Maschinentechnik GmbH won the contract to deliver a materials supply plant for the mine. Rather than using the Big Bag system, a 150 m³ surface-mounted overhead silo with a tandem dispatcher will be used to deliver the material via five individual 20 m³ intermediate stations to three 12 m³ mobile on-site units.

The scale on which China is now expanding its coal output based exclusively on large mining complexes reflects the target set by the Government in Beijing to increase production capacity by 860 million tonnes by the year 2015 – which is more than the entire annual coal output of India. According to official data China produced 3.7 billion tonnes of coal in 2012 – almost half of the world's total output. Most of the new production sites are in regions like Inner Mongolia and Shaanxi. This confirms the strategy of closing smaller collieries, such as those located around Beijing, and concentrating production in major coalfield centres.

Coal mines on this scale are rarely seen anywhere else in the world and these installations are usually linked to coal-fired power stations and chemical facilities.

One of these large mines is Kouzidong 2.

Kouzidong 2 colliery is operated by SDIC Xinji Energy Co., Ltd. and is located in the Yindong district of Fuyang city in Anhui Province.

This unusually large mine produces up to 8 million tonnes a year and has coal reserves of 730 million tonnes that will last for another hundred years. A total of 3.8 billion Yuan (about 440 million euros) is being invested in the project.

The mine has ten workable seams with an average thickness of 28 m. The main-shaft headframe is 95 m high and weighs 1,310 t, making it the world's largest colliery headgear system. The cooling system for the main shaft, auxiliary shaft and ventilation shaft, and the associated underground workings, are also on a scale not matched anywhere else in the world.

Following the completion of the mine development project the operators plan to install the most advanced technology and management methods. The automated processes, control systems, IT-based management, safety monitoring and overall management philosophy will set new standards for China's coal industry.

150 m³ building material hopper

In 2012 Olko-Maschinentechnik was commissioned to deliver and install a materials supply system to create an efficient transport facility for the necessary materials below ground. The laborious ‚Big Bag' method used at other collieries was considered unsuitable for a mine of this size.

To supply the equipment required for one area of the mine, a number of transport containers had to be shipped by sea out to China. While this was a major challenge for Olko, it was not an insurmountable problem.

The project drew on years of experience in the material's supply business and was based on procedures that have been tried and tested at many German mines.

The shipment comprised the following components:

Surface plant:

- one 150 m³ steel overhead silo
- container unit with 2 × 0.5 m³ tandem dispatchers with controls and power supply
- piston compressor unit with several refrigerant dryers

Underground plant: intermediate stations

- five intermediate stations each comprising one fixed 20 m³ materials bunker
- 2 × 1 m³ tandem dispatchers
- water separator
- pipework and controls

Underground unit: on-site station

- three mobile site systems comprising
  - one 12 m³ materials bunker
  - one continuous mixer with high-density solids pump
  - control unit
  - hydraulic drive unit
- lifting beam for transporting the units by overhead monorail
- pipework and controls

Fully automatic switched transfer pipe.

Surface plant

150 m³ silo

The silo is essentially required to separate the dry material from the delivery air and provide an intermediate storage point. The silo is constructed in segments. The standard 150 m³ unit has a useful volume of 147 m³ of dry material and consists of the following main components: silo segments, outlet cone, aeration nozzles, cartridge filters, ladder system, swing crane, vent pipe, and filler pipe. The silo roof is accessible and provides hatches for inspection, maintenance and repair purposes. It is also fitted with an electric winch for small loads of up to 250 kg and features a system of platforms, stairways, ladders and fall protection devices.

The silo is filled with material via a 100-mm pneumatic feed line. The silo truck with its delivery parks close to the silo and connects its filler hose to the silo feed pipe. The silo vehicle is fed with compressed air and the air-dried material mix is then entrained by the air stream and blown into the silo. The delivery air then passes through the cartridge filer system before being ejected in a clean state into the environment, while the material is deposited inside the silo. The filling process is fully automatic and is monitored by a control system inside the container.

The material is transported below ground through a star feeder comprised of a Y-branch pipe and discharge valve located in one of the two pressure vessels fitted to the tandem dispatcher beneath the silo. When one of the two discharge valves is opened, the filler pipe is connected to a pressure vessel. During the discharge process the ring nozzle is fed with compressed air in order to improve the flow and prevent bridging. Speed-regulated star feeders are used to ensure a constant filling.

Tandem dispatcher and dispatch container

The tandem dispatcher is used to transport the dry material over large distances. In order to achieve an almost continuous delivery the two pressure vessels are filled and emptied as a two-way process. A feed screw system takes the material from the pressure vessels and delivers it to the conveying line. Each pressure vessel is vented into the upstream silo via an 80-mm vent line.

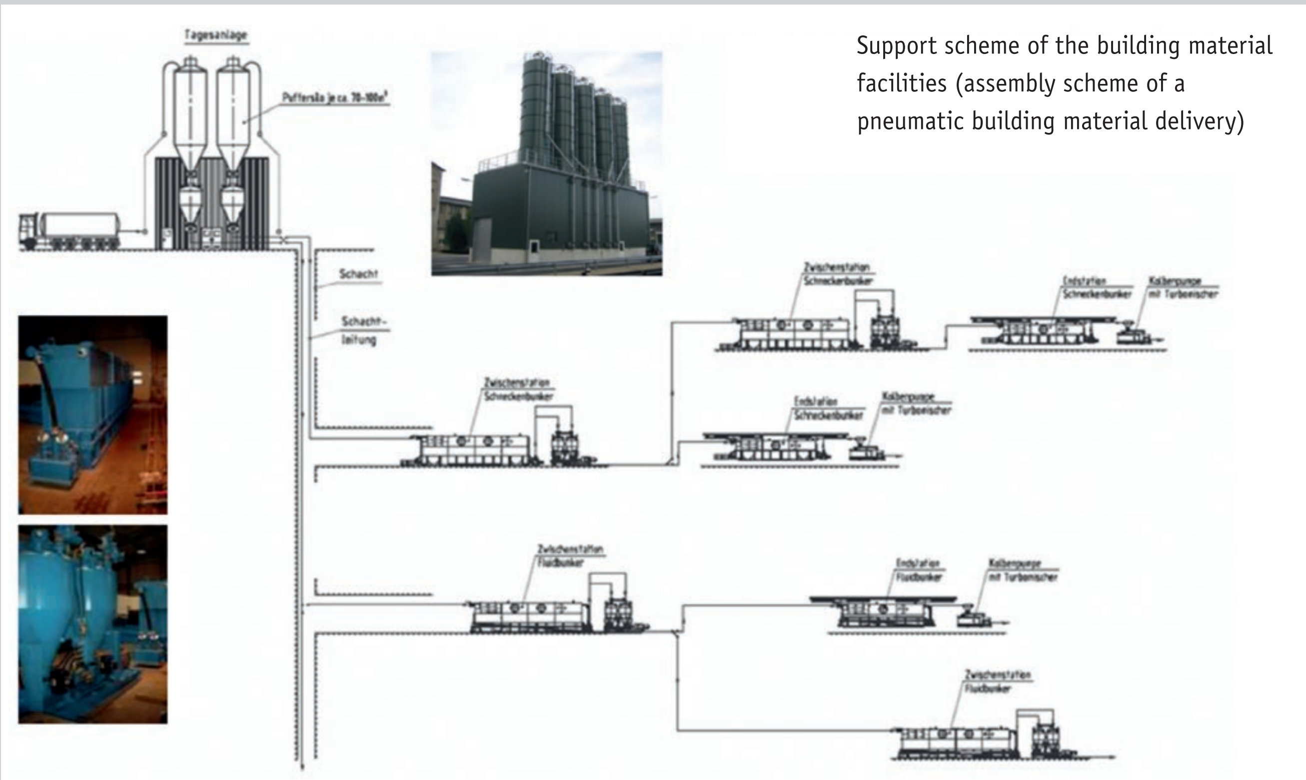
An electro-pneumatic control system monitors and controls the surface plant and switches the drive elements. The system can operate unattended in automatic mode. The amount of air entrained in the conveying stream is measured and regulated in the upstream measurement and control loop.

An OPC server is used to monitor and control the entire material supply plant. This can also store error logs and data in all parts of the system, which can then be selected and displayed. The server is set-up for remote maintenance via a remote connection.

Tandem-transmitter-station with associated control system

Intermediate station

The fixed intermediate station is used as an interim holding point for material before it is sent through the 100 to 150-mm conveying pipe to the downstream equipment some distance away. This may be another intermediate station or the on-site consumption point. The maximum delivery range and output will depend on the type of material employed, the quantity of air used, the pipe dimensions and the delivery route.



Support scheme of the building material facilities (assembly scheme of a pneumatic building material delivery)

Screw feed bunkers type 20 and 12 m³

The bunkers that are used to separate the dry material from the conveying air act as interim holding points, and deliver the material to the downstream equipment when required. The carrier air is sent through the filter and vented to the atmosphere in a clean state. The bunkers are designed as variable modular units. This means they can be extended either vertically or horizontally and can also be employed as interim bunkers or final bunkers. The main components are: screw trough and worm shaft, airlift, drive unit, bunker hood spacer ring and a compact filter.

Electro-pneumatic control

The electro-pneumatic control monitors and controls the intermediate station and switches the drive elements. The system can operate unattended in automatic mode. The system comprises the following key components: a pneumatic control cabinet, compact station, IPC with display screen, PLC, keyboard and power supply units.

Mobile site unit

The mobile site unit mixes water into the dry material, if required, thus supplying the roadway drivages with concrete. The entire plant is slung beneath the overhead monorail on a lifting beam so that it can keep up with the roadhead as it advances. The mobile unit consists of a spiral feed bunker of 12 m³ capacity, a hydraulic pump with hydraulics, the lifting beam with its walking gear and backstop mechanism, and an electro-pneumatic control system.

Intermediate- respectively final hopper as modular construction system

Overview of an on-site plant on an overhead monorail rail track

Lifting beam with advancing gear

The lifting beam and walking gear, the trolley, coupling rods and on-site overhead monorail installation provide mobility for the site unit to advance manually as required to keep up with the moving roadhead. The walking gear and backstop mechanism provide a reliable means for preventing any inadvertent rolling away of the installation when working on an incline. The curve-going suspension system is designed to oscillate rising and falling gradients, meanwhile the electrohydraulic walking gear ensures that heavy loads can be safely accommodated and moved using the overhead monorail system (I-140E/V rail). The brake trolleys are activated hydraulically and closed by spring pressure, which means that the installation will be safely retained in the event of a power failure. The end backstop mechanism attached to the lifting beam is also used as a final safety device. This effectively prevents the system from rolling back in the event of a failure in any of the connecting components.

Current situation

Currently, the installation is being installed and commissioned. The collaborative effort and coordination required to install the electrical engineering, control engineering, mechanical equipment and steelwork constitute a huge challenge for OLKO in carrying out the Chinese colliery project.

There is great potential for supplying additional material facilities of this kind. The support provided by OLKO's Chinese office is helping to ensure that the inevitable obstacles are avoided so that the project can be brought to a successful conclusion.

Key technical data

Silo with portal steelwork	Technical data
Main dimensions (L × W × H)	approx. 6500 mm × 4000 mm × 25300 mm
Useful/nominal volume	147 / 150 m³
Throughput at 25 rpm	approx. 35 m³/h
Tandem dispatcher type 2 × 0.5 m³	**Technical data**
Main dimensions (L × W × H) / weight	approx. 4600 mm × 3100 mm × 2500 mm /2500 kg
max. delivery pressure	4 bar
max. delivery range	approx. 1,400 m (acc. to material/environment)
Throughput	approx. 10 m³ (acc. to material/environment)
Electropneumatic control	**Technical data**
Main dimensions (L × W × H)	approx. 3200 mm × 2100 mm × 2600 mm
Voltage	380 / 230 / 24 V
Frequency	50 Hz
Screw feed bunker type 20 m³	**Technical data**
Main dimensions (L × W × H)	approx. 13400 mm × 1200 mm × 3200 mm
Empty weight	approx. 8000 kg
Useful/nominal volume	15 / 20 m³
Throughput	approx. 10 m³/h (acc. to material/environment)
Electropneumatic control	**Technical data**
Main dimensions (L × W × H)	approx. 3300 mm × 900 mm × 1200 mm (per unit)
Voltage	660 V / 50 Hz
Output	approx. 5 KW
Concrete pump with mixer	**Technical data**
Main dimensions - pump (L × H × W)	approx. 4700 × 2400 × 1800 mm / 2400 kg
Main dimensions - power unit (L × H × W)	approx. 2450 × 1500 × 1550 mm / 2400 kg
Throughput	approx. 20 m³/h (acc. to material/environment)
Lifting beam with walking gear	**Technical data**
Net weight	approx. 4000 kg
max. attached load	2 × 134 kN
max. traction/holding power	approx. 60 / 200 kN
max. gradient	approx. 31.5 degrees
Holding force of backstop	approx. 360 kN
Travel speed	approx. 45–60 m/h

Hubertus Niehoff · niehoff.hubertus@ts-olko.com
Uwe Kösterke · koesterke.uwe@ts-olko.com

Tier 1 Structural Steel Erection – Looking Northeast

Cameco Cigar Lake Project – Run of Mine (ROM's)

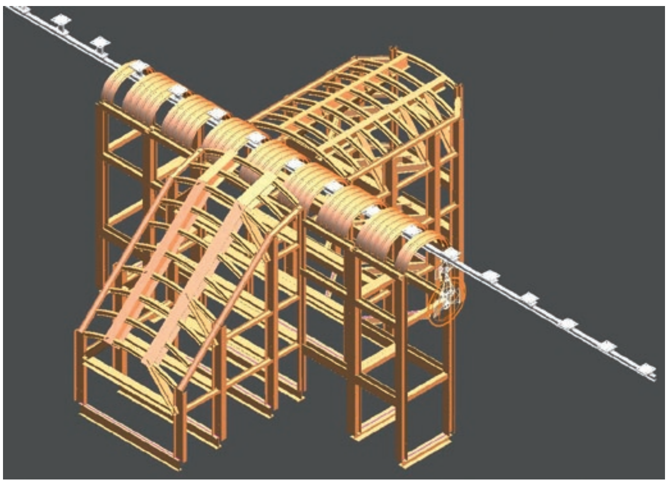
Award of Contract – C&S

In 2011 Mudjatik Thyssen Mining Joint Venture (MTM) was awarded the civil/structural scope of work for construction of the world's first Run of Mine (ROM's). Cigar Lake's ROM's is the first of three major underground processing stages; in the ROM's the uranium slurry is stored and screened. Subsequent processes involve sizing and mixing the uranium ore slurry to the proper specific gravity suitable for pumping vertically up Shaft #2 a distance of 500 meters. The uranium ore slurry is temporarily stored on surface at Ore Loadout until it is shipped to McLean Lake where it is further processed into yellowcake.

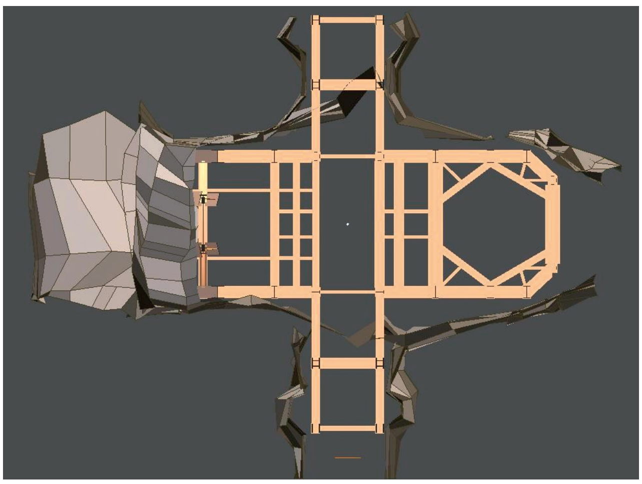
More specifically, the ROM's contains the following areas for processing:

- North and South ROM steel lined ore storage sumps. Central ROM area which houses the clamshell/crane system, weir overflow chutes, and ore hopper; and
- East wing which houses the top portion of the Recycle Water Tank (RWT), pumps, bubbler panel, and other miscellaneous piping and equipment

Run of Mine – Structural Steel Isometric



Run of Mine – Structural Steel Plan



- West wing which houses the world's smallest water flush cone crusher, screw feeder and magnet, sand separators, and associated motors, pumps, and hydraulic power packs
- Recycle Water Tank Raise.

Construction Methodology

MTM proposed a "top-down" construction method that proved to be beneficial both in terms of cost and schedule, but more importantly, in terms of personnel safety. The top-down method saved on installation of extensive ground support that would have otherwise been required to stabilize the once flooded area.

10 Ton Clamshell Monorail & Rebar Installation – Looking South

Tier 1 Construction – October, 2011

Because of the inflow suffered at the Cigar Lake Mine in 2006, major work was required to the loading pocket and underground skipping arrangement in early 2010 and as a result, the ROM's cavern was initially used as a re-muck. This substantial re-muck kept the underground from becoming muck bound and allowed excavation to continue in other important process areas in the mine while the ROM's construction methodology was being finalized.

After re-establishing the ROM's area in 2011, construction of Tier 1 began by leveling and removing muck. As muck was removed, additional ground support and overhead lifting lugs were installed to facilitate the structural steel erection. Next, the installation of Tier 1 structural steel and the 10 ton clamshell monorail were completed prior to the extensive rebar mat installation.

Upon the inspection of structural steel and rebar, forming commenced. The formwork required engineering as it was an overhead, blind pour using a Schwing Pump; there was greater risk of blowing out the forms due to pump pressure as opposed to a traditional gravity fed pour, which only considers head pressure or total height of pour.

Tier 1 was poured into two separate pours. The first consisted of pouring the North, South, East, and West walls; walls were approximately 12′ in height for a total of 600 cubic yards. Before the second concrete pour, pedestals for a 2 ton service monorail were installed to ensure proper embedment in the overhead concrete pour. The second pour, involving engineered formwork, was an overhead, blind pour of approximately 500 cubic yards. The 2 ton service monorail was installed shortly after the removal of the overhead formwork.

Tiers 2 & 3 Construction

Upon completing Tier 1, the mud slab was saw-cut into several hundred 1 meter squares and mucked out to virgin rock, an elevation well below the bottom of Tier 3 steel. Another mud slab was poured that served as a working platform for the 15 ton Broderson carry deck crane, which was used for installation of Tiers 2 and 3 structural steel and rebar. Structural steel for Tiers 2 and 3 was installed in the ROM's to final elevation. Several structural members on the East wing were temporarily left out to accommodate the future slip forming of the Recycle Water Tank.

Upon the completion of the structural steel and rebar, a QT-100 wear plate was installed in approximately 25 % of both the North and South Ore Storage Tanks. There was a total of 192, 1/2″ × 4′ × 8′ sheets seal welded in place that acted as formwork during the construction for the backfilling of the excavation, which contained the structural steel and rebar mats functioning as a wear surface for the clamshell during production.

Tier 1 Extensive Formwork of Steel Arches – Ready to Pump Concrete

Concrete was poured in various stages to accommodate the elevated concrete floors. The floors were designed to rest on top of the concrete walls located in the center ROMS, making scheduling of concurrent construction activities more challenging. These intricate pours required engineered shoring as well as highly skilled forming and the strategic placement of critical embeds and anchor bolts.

Due to the RWT location in the East wing, only the North, South, and West wings were poured in this manner initially; the East wing was poured upon completion of RWT.

Slipforming of Recycle Water Tank

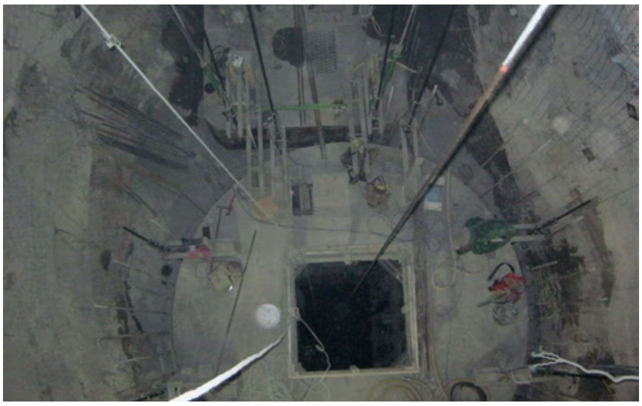
The Recycle Water Tank is exactly as it sounds. The uranium ore slurry from the Jetbore is pumped to the ROM's ore storage tanks where the solids settle in the bottom of the tanks and water passes over a set of overflow weirs where it is cleaned (via sand separators) and recycled back into the Jetbore system.

The RWT is comprised of the following 3 different sections, starting from the 500 mL and extending up past the 480 mL for a total height of approximately 33 meters:

- Section 1 – Steel Tank – Cone from ∅ 0.15 m to ∅ 5.0 m (≈ 7.0 m in height)
- Section 2 – Concrete Tank – Ø 5.0 m × (≈ 15.0 m in height)
- Section 3 – Steel Tank – Ø 3.0 m × (≈ 11.0 m in height and includes transition cone)

The slipform section of the RWT was the first constructed. The slipform design consisted of jacking rods and jacks, a hydraulic power pack, and a series of yokes to connect both sets of wooden forms (∅ 5.0 m circular tank and 3.0 m × 2.5 m rectangular man way/pipe chase). Prior to beginning the slipform, engineered shoring was required to establish a base for the concrete-steel transition embedded.

Slipform, View from Swing Stage Access



The base had to be strong enough to initially jack the forms until the concrete could sustain itself. The average slipform rate of advance was about 6 – 12 yards per hour or about 6 – 12 inches vertically per hour. Because of the nature of the underground slipform operation, the slipform required substantial manpower to keep the project moving ahead on schedule; it was typical to have 20 men involved with the slipform operation between the surface and underground, including a Scanada Slipform representative to oversee the entire job.

During the slipforming of the RWT there were approximately 30 tons of rebar installed and 390 cubic meters of concrete poured. The upper steel tank was the next installed section.

Before installing the ∅ 3.0 m tank rings, a transition cone (∅3.0 m to ∅ 5.0 m) was bolted to the top of slipformed concrete and then poured in place with a self consolidating concrete mix.

MTM site engineers devised a lifting and installation methodology that proved to be very successful for installing the upper portion of the RWT in the limited space available. Tank sheets were pre-welded underground to form rings that were then lowered onto engineered skid beams (installed over the ∅ 3.0 m to ∅ 5.0 m open transition cone) and skidded into position. Each tank ring was then individually raised up, and welded to the next subsequent tank ring placed underneath it. The work continued in this manner until the upper steel tank was completed.

The lower steel tank and cone were the last section installed. Using the knowledge from the upper steel tank, lower tank rings and cone rings were again pre-welded and sent underground equipped for installation.

The lower steel tank had a much heavier construction than the upper steel tank thus, another engineered lifting plan was required to safely and successfully construct the tank in the limited space available. The weight of RWT steel (upper and lower sections) is approximately 38,175 kilograms. The flooded weight of the RWT is 480,000 kilograms with a volume of 480 cubic meters.

Construction of Upper RWT Using Engineered Skid Beams Over Transition Cone; Looking West

Because the top portion of the RWT was completed first, it allowed MTM to complete the elevated floors in the East wing during the construction of the lower steel tank and cone. Again, the floors were poured in 3 separate stages using engineered shoring for each respective pour.

Once the East wing concrete was completed, the installation of the remaining East structural steel began. The structural steel included staircases, ladder ways, and access platforms for access to both the man way/pipe chase as well as each elevated floor in the Center ROM's.

Additional Work Awarded – MPEI

MTM delivered high quality work, that was safe and cost-efficient during the civil/structural scope of work, the mechanical, piping, electrical and instrumentation contract was awarded to MTM as well. The MPEI scope of work contained the following installations:

- ROM clamshell hoist and modifications, clamshell, festoon monorail
- ROM service basket and man basket
- Water flush cone crusher, cone crusher lube, cooling, and hydraulic system, mounting frame, cone crusher service monorails and hoists, cone crusher discharge hopper and hose to 500 mL.
- Sand separators, sand separator feed pumps, and sand separator service monorails and hoists
- ROM portable sump pumps and winches (× 2)
- ROM permanent area collection sumps and sump pumps (× 4)
- Screw feeder and screw feeder discharge magnet
- Overflow weirs, sprayer bars, clamshell hopper and chute
- All piping, fittings, and valves for all associated equipment
- All electrical and instrumentation for all associated equipment

Steel Lined Ore Storage Tanks

After an unsuccessful attempt at hydro testing the shotcrete/concrete lined North and South ore storage tanks, Cameco made a decision to line the tanks with steel.
MTM was also given this work for their continued safe, high quality, and cost-effective efforts shown on the job thus far. With the exception of some minor piping, mechanical, and electrical work to be tidied up, this contract was the last of the work completed prior to commissioning of the world's first Run of Mine. For this reason, all eyes were focused

Construction of Lower RWT – NDE Complete, Ready For Paint

East Wing Structural Steel – Level Access

heavily on both quality and schedule as Cameco inched closer towards First Ore.

A systematic construction approach was devised by MTM engineers and Affordable that proved to be very successful in terms of quality and schedule. Welding repair rates were astonishingly less than 1 % for both ore storage tanks, considering the weld inspection was heavily pursued with 100 % visual inspection, 100 % dye penetrant inspection, and 5 % ultrasonic inspection. As MTM and Affordable continued to perform well under pressure, welding of the ore storage tanks were completed on October 5, 2013, with some remarkable statistics.

To complete the steel lined ore storage tanks, the small opening between the steel tank and the shotcreted excavation was backfilled with a self consolidating concrete to solidify the tanks construction.

On December 9, 2013, the completed turnover packages for both the ROM's C & S and MPEI contracts were submitted to Cameco, a final contractual signoff of a job well done by all parties involved.

Some interesting statistics from the ROM's construction project include:

- The ROM's is the first underground uranium processing facility of its kind
- Over 2 years to complete all required contract scope items prior to commissioning. Over 240,000 man-hours with zero lost time incidents
- 470 tons of structural steel, 265 tons of rebar, 4700 cubic yards of concrete, 118 yards of Gatorpass shotcrete (water-resistant shotcrete mix)
- Over 6000 square feet of QT-100 Wear Plate and A37 Liner Plate
- Over 200 meters of monorail steel
- Excavation measures 65 meters (North to South) × 28 meters (East to West) × 16 meters (height)

Kayne Ulmer · kulmer@thyssenmining.com
Nolan Basnicki · nbasnicki@thyssenmining.com

Steel Lining of South Ore Storage Tank – Looking North

Ore Storage Tank Repair Rates Less Than 1 %

Turbine hall with 100 MW turbine, Hermann Wenzel power plant of ThyssenKrupp AG, TKSE

TS Technologie + Service GmbH: a specialist provider of assembly and repair engineering, crane and gate technology

Assembly and installation services: the Ruhrort power station:
The Assembly and Services department of T+S has to meet its customers' high demands for quality and flexibility. Our long-standing experience and versatility is very much sought after by industrial clients whose day-to-day operations include equipment maintenance and overhauls, conversion and modification work, machine assembly and strip-downs. Our round-the-clock service means that we are always available, even when others have closed down for the day.

For the T+S assembly department the ThyssenKrupp-owned Hermann Wenzel power station is a good example of the kind of challenge that this demand capability has to face on a daily basis. The plant burns blast-furnace gas from the steel industry along with coking gas from the nearby Schwelgern coke works and supplies electrical power and process steam to the ThyssenKrupp smelting works and its coking plant 24 hours a day. The surge current and remnant electricity not required for in-house consumption – known as ‚electrical surplus' – is fed into the national grid. The installation has a total output of 344 MW.

The assembly department, headed by operations director Wilfried Meiss and his site manager Mustafa Öztürk, is continually called on to provide solutions and answers to the constantly changing requirements of its industrial customer. This 365-days-a-year availability is taken for granted by the client, who expects us to provide qualified personnel on a flexible and easily accessible basis for each and every call-out. There must be no production stoppages at the plant, as this would disrupt supplies to the ThyssenKrupp site.

Closed consenser after revision works, Hermann Wenzel power plant of ThyssenKrupp AG, TKSE

Pic. above: Revision works on a condenser in the Hermann Wenzel power plant of ThyssenKrupp AG, TKSE
Pic. left: Assembly of the high-pressure outer jacket after revision works oft he 180 MW turbine, Hermann Wenzel power plant of ThyssenKrupp AG, TKSE
Remark: Pictures 1 until 4 are taken with kind permission from the Hermann Wenzel power plant owned by ThyssenKrupp Steel Europe AG

Professional profile of 20 employees, some with multiple qualifications

Machine fitters
Welders with different certifications
Industrial mechanics
Hydraulic fitters
Electrical fitters

The site manager deploys his team according to the demands, which may change daily or even hourly. And this illustrates the strengths of the department. Several times a year planned overhauls are carried out to gas pipes, slide gate systems and pumps of all types and sizes. The work is undertaken in extremely confined spaces and often very high up. The team has to work at extreme temperatures and to very tight deadlines in order to deliver the completed project to the client on schedule. Routine maintenance work also has to be carried out on the water converters serving the various block-units. After opening the housing covers cleaning balls are propelled through the piping system, which consists of up to 4,000 individual pipes, at a pressure of some 10 bar. When the work has been completed the system is sealed up again and handed over to the client in a turnkey state, complete with all the necessary documentation.

These are just two examples of the permanently changing workload arising at this particular power station, where the client has been placing his trust in our services for almost 10 years.

Crane and gate technology are developing into a specialist service

During the last two years market demands have led to an expansion of the crane and gate engineering section, which specialises in industrial gate systems, lifting gear and technical equipment of all kinds. This section has now become a system provider for a wide range of products and services, working alongside industrial clients as both a partner and a problem solver.

Assembly oft he 20 tons crane after complete redevelopment

Assembly of a new gate system

Customers now attach increasing importance to having as few interfaces as possible and being furnished with extensive documentation guaranteeing high work-safety and work-quality standards. German UVV (accident prevention) inspections, for example, have to be in place for the individual working stages and must be documented in every detail.

The department's current portfolio includes:

- UVV inspections to ASR A 1.7 requirements on power-operated gate and gate systems
- repair and maintenance of crane and gate systems, loading ramps, lifting gear and conveyor systems
- troubleshooting, upgrades and supply of new gate and gate systems of all current makes
- testing of crane installations (container cranes, factory cranes, etc.) and hoisting gear (spreaders and slings) according to BGV D6 regulations
- testing of winches, lifting and pulling devices according to BGV D8 regulations
- inspection of ladders and steps according to BGI 694 regulations
- inspection of load take-up appliances according to BGR 500 regulations on the operation of lifting equipment
- inspection of transporter bridges and mobile ramps according to BGR 233 regulations
- appliances and equipment for rack servicing in accordance with ZH 1/361
- warehouse equipment and appliances in accordance with BGR 234
- testing of personal protective equipment (fall arrestors) in accordance with BGG 906.

The testing service is performed and documented by a team of specialists, crane experts and technicians working in compliance with all statutory requirements and regulations. All the necessary documents are then scanned and sent on-line to our clients the following day for incorporation into their data system. If requested we are able to provide complete datasheets with all technical features, a photographic record of the work and the maintenance logs for the systems engineering.

The crane and gate engineering team, headed by Christoph Obermann, continues to develop its specialist knowledge and skills by completing advanced training courses and qualifications. Technical equipment, such as the department's own mobile platforms with up to 21 m of travel, a flux machine for testing slings and a number of other appliances, is regularly procured to bolster the department's ultra-modern plant pool.

T+S is currently entrusted with the day-to-day care of about 100 crane installations and some 1,000 gate and gate systems. This usually involves the full 365-day service package providing 24-hour cover with prompt reaction times for troubleshooting and the provision of emergency repairs.

Summary

These two T+S departments, with their 365-day client availability, reflect the developing needs of the market served by the assembly, crane and gate engineering departments, along with the associated servicing units that carry out repairs, electro-technical work, welding and machining. This presents an excellent opportunity for us to expand our client base as a provider of one-stop solutions in this field of activity. There is a now a huge demand for flexibility and quality and the level of trust and satisfaction displayed by our customers confirms day-in and day-out that we are on the right track.

If this market strategy does equally well in the steel and power-station sector there is no reason why it should not deliver similar results at collieries, preparation plants and coke works too.

Gerd Hunsmann · hunsmann.gerd@ts-gruppe.com
Wilfried Meiss · meiss.wilfried@ts-gruppe.com
Christoph Obermann · obermann.christoph@ts-gruppe.com

A new control room for EMSCHER AUFBEREITUNG GMBH – switchover completed without interrupting plant operations

After some careful and thorough planning the new control room at EMSCHER AUFBEREITUNG GMBH went into service as scheduled in January 2012 without interrupting the pulverised-coal supplies for ThyssenKrupp Steel Europe (TKSE). The idea of upgrading the control room in the old sector of the plant by installing modern, user-friendly control technology had been in existence for some time. The old control room was outdated and physically too small. Not only that, but it was also isolated in a part of the plant that had been shut down. In addition, the coal pulverising mills had to be made more user-friendly along with the ergonomics of the workstations, which needed upgrading. Renovating the old control room would inevitably have resulted in production losses.

The preparations required for the new control room began in 2010 with the renovation of the network structure. More than one kilometer of fiber optic cable was laid out and a new network splitter was installed. Prior to this, the individual programmable logic controllers for the pulverising mills were replaced and the peripherals of the Siemens S5 control system was upgraded to the latest Siemens S7 system. Data exchange between the management system and the PLC for the pulverising plant would henceforth be ensured by a single Profinet Bus connector.

The next task was to set up a new control room and bring it into operation without causing supply problems for TKSE. It was decided that the large conference room on the first floor of the TKSE staff building would be an ideal location for the new facility. The new premises were divided up to create a technical room, a smaller conference room and the new control room. One key advantage of the new location was its central position and proximity to the other operational departments.

Design specifications

1. Good access to and within the individual rooms
2. Access to a second escape route via external stairway
3. Lighting adapted to suit the working environment
4. Ergonomic design of the furnishings
5. Balanced colour concept
6. Optimum design of cable infeed and distribution with good access to the switch panels
7. Fire-protection engineering
8. Optimised energy usage
9. Air-conditioning for the technical room

In order to improve workplace ergonomics new height-adjustable process control desks were installed and special orthopaedic chairs meant to provide comfort for the foreman's 24 hour shift in the workstation.
The overall planning, technical design of the control system, electrical installations and the coordination of the individual technology areas were carried out independently by EMSCHER AUFBEREITUNG. A total of 2.1 km of new network cables were laid out during the course of the installation.

The new control room features a number of technical improvements:

- redundant power supply
- minimum voltage supply in the event of a power outage
- fault-current monitoring without computer shutdown
- internal lightning protection and surge dissipation
- large display screen
- multi-consoling
- modern camera surveillance system
- digital cameras
- new fire detection system with direct connection to the fire service
- redundant air-conditioning for the technical room.

Multi-consoling allows each computer to be visible to the operators at the different workstations. This means that the various displays can be called-up in outlying offices and even transmitted onto the large screen. The computers themselves are no longer set up at the workstations and have been moved into the technical room. Each workstation consists of a monitor, keyboard, mouse and a transmitter that relays the signals to the computer instantly.
As well as managing and monitoring the pulverising mills, the production staff is also responsible for analysing the pulverised coal samples in the laboratory. As part of the quality control process certain parameters have to be checked on a continuous basis, a reason why the laboratory was set up close to the control room.

The technical room at Emscher Aufbereitung houses the following equipment:

- 2 Siemens WinCC Server systems
- 8 Siemens WinCC Client systems for the individual operator communication and monitoring terminals
- 1 server for the ACRON data collection system
- 1 camera server
- 1 server for multi-consoling
- 1 server for continuous network monitoring
- 2 patch panels
- 12 KW minimum voltage supply
- 1 firewall.

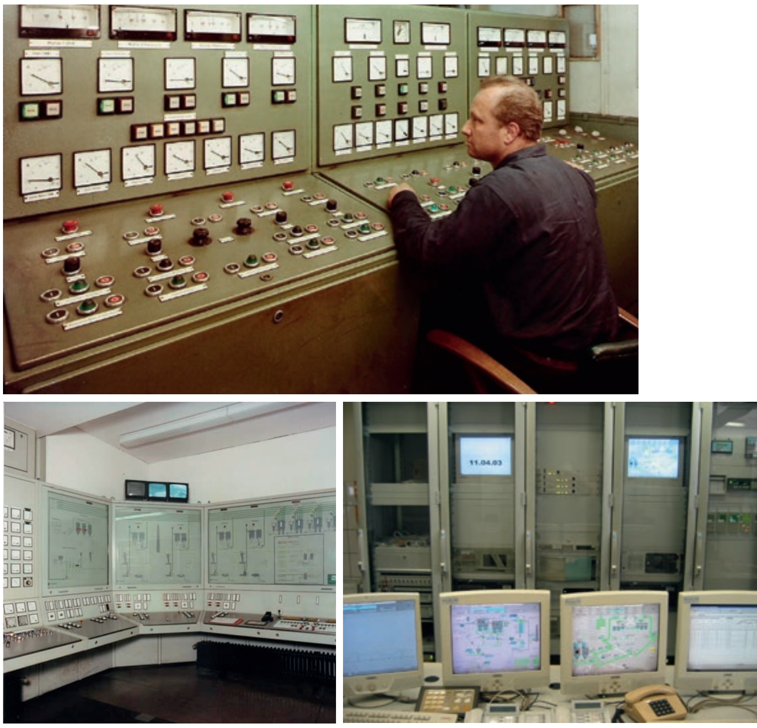
The redundant power supply for the new control room and the power feed for the technical room were already in operation ahead of the switchover, which meant that only residual work had to be carried out on the actual day.

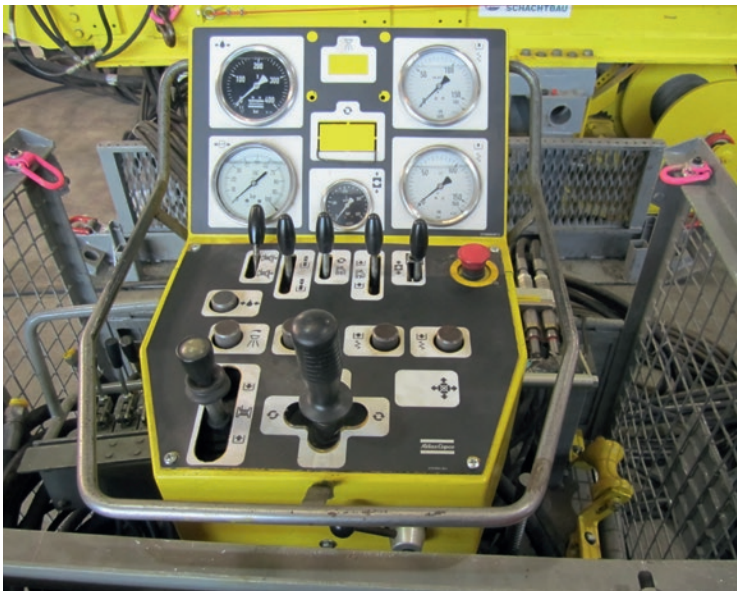
Fuel analysis laboratory

The preparations were completed on January 18, 2012, with extensive tests in preparation for the switchover of the instruments and control systems. The next day the last of the control cables were moved across and the new control room went into service. The pulveriser mills were run down from the old control room and put into a safe operating mode. The shift foreman then left the old control room for good.
After the cables had been changed and the last of the tests carried out, the pulveriser mills were started up trouble-free in the new control room. This was all achieved without any loss of production for TKSE. The new arrangements will greatly improve supply security for pulverised-coal deliveries to TKSE. As long as coal continues to be in demand as pulverised fuel for the steel industry, due to the ongoing modernisation of the pulverisation plant, miners will ensure that this coal is still there to be had.

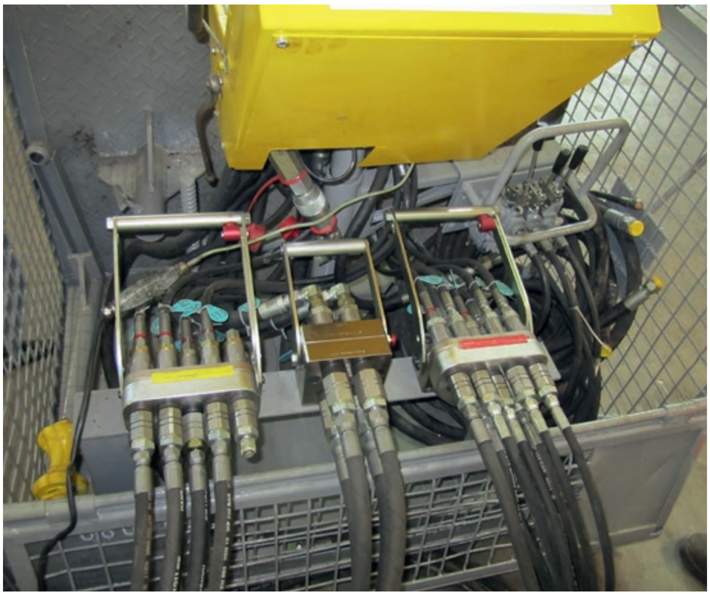
Michael Kluger · kluger.michael@emscheraufbereitung.de
Martin Pfeil · pfeil.martin@emscheraufbereitung.de

Changing face of the control room 1960 to 2000, and finally in 2013 (see main photo)





Modified control station AC Diamec



Control station with quick-multi-couplings

THYSSEN SCHACHTBAU – new home for the company workshops in Mülheim's Sandstrasse

THYSSEN SCHACHTBAU's independently-run servicing workshops are a company department in their own right. As well as open land and covered storage facilities the premises also house workshops for the repair and maintenance of machines and equipment for the company's shaft sinking, drilling and mining divisions.

While continuing to perform their normal duties in the repair and overhaul of mining and shaft-sinking equipment, drills and machines the workshops have also found time to move into a new home.

The workshop and storage facilities were transferred from their previous premises to the front of the old electrical workshops that used to accommodate the crane technology department of TS Technologie + Service GmbH. The stores have now relocated to the cellar space beneath the new factory building.

Part of the main hall space – previously used by the steel construction department of TS Technologie + Service – has now been rented out. All kinds of heavy machinery can be stored in this area and the available crane lifting capacities are also ideal for moving and repairing large plant and equipment. The new facilities enable work to be carried out more efficiently, while the heavy-duty crane installations are able to repair and overhaul large-sized machines and load and unload the transport vehicles.

The former storage building in Duisburg has now been vacated, as the lease expired at the end of April 2014. This logistical and labour-intensive challenge was completed without any interruption to the repair-shop operations.

Deck crane 105.2 on substructure

Further training for workshops personnel

Current safety guidelines require all machines and equipment to undergo an annual safety inspection according to BGR 500 rules. To this effect staff members underwent external training to acquire the appropriate machine inspection qualifications.

HG 160/2 after modification

VW Crafter service vehicle

Modifications and adjustments

In order to keep pace with the latest technical developments modification work is carried out in the workshops on a continuous basis to improve machine handling characteristics, increase safety levels and facilitate component interchangeability. One such action involved fitting several Atlas Copco drilling machines with push-fit multicouplings. This makes it much easier to change over accessory components such as hydraulic power units and, of particular importance, reduces the time required for rigging and derigging on site. Such a modification can save as much as two hours in the case of an AC Diamec 282.

The workshops also achieved a ‚first' by procuring an electrohydraulic loading crane with a radio remote control system mounted on a separate carrier. This installation is set up within the radius of action of a drilling machine and anchored to the drilling site by means of the base frame. The aim is to load the drill pipe quickly and reliably into the machine and to remove it when the work is done. The crane unit can also be used as a support vehicle for set-up and dismantling work and for transporting the pipe boxes. This improves workplace safety levels.

A number of Wirth drilling machines (HG250, HG160) were also given a general overhaul. For safety reasons, and also to facilitate the loading process, the pipe loaders were fitted with an auxiliary joint for the raise boring machine so that the drill pipes can be safely inserted into the loader even when drilling inclined holes. The machines have now been set-up so that they can be withdrawn from the hole and deployed into position as required. This method of operation is needed, for example, when a directional motor is to be employed for directional drilling. The directional drilling lance can henceforth be left in the borehole in one piece.

Cooperation with the construction sites and with purchasing and logistics

Because of the urgency always associated with spares procurement and the transport of spare parts, machines and equipment it is essential for purchasing and logistics to be integrated in an efficient manner. Well-prepared working structures and an experienced and well-trained workshop staff are the prerequisites for a professional relationship with the construction sites. This enables the service workshops to work together with the section stations so that issues can be resolved quickly and effectively and a professional repair and maintenance service made available that can respond to potential problems before they arise.

New workshop vehicle

In order to improve servicing and mobility, and to be able to react quickly by providing hands-on support for the section stations when repair work is required, the workshops procured a new vehicle - the VW Crafter. This means that spare parts, special tools and technical personnel can be delivered promptly to where they are needed so that standstill times for drilling equipment and operating crews can be minimised.

Occupational safety

Working safety has top priority at TS and detailed instruction and training on the operation and working cycles of machines and equipment is regularly provided for workshops personnel and staff at the operating sites. The success of this programme is borne out by the fact that in 2013 the workshops department did not record a single accident or injury.

Summary

The workshops that serve the company's mining, shaft sinking and drilling divisions are an indispensable element in the interaction between departments. They deliver efficiency in the preparatory phase, support the section stations and make an important contribution to better workplace safety.

Meinolf Koch · koch.meinolf@ts-gruppe.com
Peter Tomczak · tomczak.peter@ts-gruppe.com

Introducing DIG Deutsche Innenbau

DIG Deutsche Innenbau GmbH was established in 1968 as a member company of the THYSSEN SCHACHTBAU Group specialising in the design and execution of plaster and stucco work.

DIG, whose head office is at Hofheim (Frankfurt am Main), has over the years continuously adapted its activities to meet changing market demands. By the early 1970s drywall construction – for ceilings, floors and walls – was becoming increasingly popular and this type of work has to this day remained a key aspect of DIG's work.

Since the end of the 1990s DIG has also been meeting builder-owners' demands for complete fit-outs and this area has now become the company's main focus.

From the consultation stage through to work execution DIG has developed into a reliable partner and operator both for standard drywall construction techniques as well as for the more demanding fit-outs required for major building projects. This includes hotels, airports, hospitals, museums, theatres, banks, office buildings and shopping centres.

DIG sees itself as a creative technical partner for architects, project developers and builder-owners. The technical advice provided ahead of project commencement offers real financial benefits for the client. DIG also has innovative and cost-effective solutions for complex assignments that present special technical challenges.

DIG operates as a specialist contractor for all kinds of interior drywall projects nationwide. As well as working to very high standards the company also excels in efficient project management for all kinds of skilled trades and crafts.

As well as meeting the relevant technical provisions for sound insulation, thermal insulation and fire protection, and complying with DIN standards and structural requirements, DIG also keeps a close eye on the financial interests of the builder-owner. The company has a reputation for delivering on schedule, even when deadlines are extremely tight, and always meets the highest quality standards.

Projects

2013 Schön Clinic Bad Bramstedt – drywall fit-out for walls and ceilings
Client – Wolff & Müller Spezialbau

The year 2013 commenced with a drywall fit-out in an extension building that forms part of a psychosomatic clinic in north Hamburg. Commissioned by the general contracting firm Wolff & Müller Spezialbau, the assignment involved the completion of bedrooms and treatment rooms, with specific requirements to be met in terms of structural fire protection and sound insulation. In spite of the tight deadline the building project was successfully delivered on time.

2013 Sumitomo Wolfsburg – drywall fit-out of walls and ceilings
Client – ARGE Sumitomo Wolfsburg

The Sumitomo consortium, comprising the firms of Johann Bunte and Karl Schumacher, contracted DIG to execute a number of drywall fit-outs. A particular feature of the assignment was the need to coordinate the key interface between the ‚cavity flooring' and ‚drywall fitting' phases. By planning the operating schedules well in advance to achieve precise synchronisation of all the different drywall construction stages the subsequent cavity floor and screeding work could then follow without interruption. The project was successfully concluded in early autumn.

2013 Steigenberger Hotel Braunschweig – drywall fit-out of walls and ceilings
Client – Wolff & Müller Hotelbau

In early 2013 we were commissioned to undertake drywall work for this hotel project. Despite several disruptions to the schedule DIG displayed real effort and commitment in meeting the ambitious completion deadline.

2013 Radeberger building Frankfurt – high-grade interior fit-out
Client – Radeberger Gruppe

The contract for the brewing group Radeberger involved practically a complete interior fit-out for the company's new administration building. DIG worked closely with the client's architects during the intensive consultation phase ahead of project commencement. Despite the tight completion deadline close coordination with architects and client throughout the entire building period and a number of outstanding logistic feats (including the trucked delivery, unloading and allocation of 120 t of glass and panel partition walls in just 48 hours) meant that the building was ready on time for its new occupants.

DIG also fitted out an existing building on the same site and undertook additional renovation work following serious water damage.

2013 Palais building at the Deutsches Theater in Berlin – High-quality interior doors
Client – Transumed on behalf of GKV

The newly established door installation unit undertook an interesting contract for the Palais build project at the Deutsches Theater in Berlin. This involved the installation of high-grade internal wood doors from suppliers Schörghuber. The new all-glass, sheet-steel and tubular frame units are built to the latest sound insulation and fire protection standards. Almost every one of the 1,250 individual doors was delivered in perfect condition and all were successfully fitted within the specified deadline. These internal doors are designed to meet the highest requirements.

2013/2014 Thyssen Krupp Quarter, Phase 2 – drywall fit-out of walls and ceilings
Client – Bilfinger Berger

The drywall fit-out for the Q6 office and administration building on the Thyssen Krupp Campus in Essen had fallen well behind schedule and the quality of execution was below standard, with the result that the contractors Bilfinger Berger turned to DIG for support. In no time at all the building was ready for hand-over in perfect condition. The quality and timely delivery of the work was recognised and acknowledged by a grateful client.

2013 Administration office/playschool at Burg Klopp in Bingen – interior fit-out
Client – Bingen municipality

In 2011 and 2012 DIG completed phase one of an interior fit-out at the comprehensive school in Bingen. This included drywall, paint and plaster work. In phase two of the same project this was extended to comprise internal doors, partition modules, furniture, cupboards and lockers. Everything was done to a high level of precision and the wishes and requirements of the planners and Bingen authorities were met in full and on schedule.

2013 Hanau clinic – new cardiology laboratory
Client – Hanau clinic

In 2011 and 2012 the new Hanau clinic building was given a complete make-over in the form of drywall and plasterwork, along with internal doors throughout. This was then followed by fitting out a new cardiology laboratory in one of the clinic's existing buildings. As well as meeting the stringent fire protection and soundproofing requirements that apply to hospital buildings the contracting team also had to provide

effective radiation protection for the clinic staff. This part of the building was also delivered on schedule and in perfect condition in early 2014 and was immediately commissioned for service.

Review and outlook

All construction projects in 2013 were successfully delivered to the client's satisfaction.
After the successful completion of a number of projects right at the end of 2013 another major internal fit-out was concluded in April 2014 as a turnkey assignment. After receiving an order to undertake an interior fit-out for the Grosse Burstah development in Hamburg, along with various drywall construction projects in the Frankfurt area, DIG is very positive about its future prospects.

The company is keen to recruit qualified works supervisors and project managers as it seeks to secure further growth in the years ahead.

Markus Gevers · gevers.markus@ts-gruppe.com
Marco Malm · malm.marco@ts-dig.com

Finance and accounts – introducing an internal service provider

No accounting entries without documentation ...

... these words, which are the motto of the Finance and Accounting Department, can still be heard in one office or another when something unusual has to be entered in the books. And this guiding principle is still followed in every modern accounts office: No accounting entries without documentation. Auditors and accountants are grateful that when this maxim is followed, so much the better. This was certainly the case when providing support for the Russian and Kazakh projects that were supervised from the head office in Mülheim an der Ruhr. Managing extremely complex sets of documents for the various project operations became the order of the day as the team responsible sought to ensure proper tax acknowledgement for all outgoing expenditure.

The department is divided into three sections: accounts, treasury and taxation. The team of 17 staff, headed by Dieter Paffendorf, is a mix of all ages and many nationalities: Poles, Russians, Bosnians and Kazakhs. Their different language skills help overcome the language barriers that exist when dealing with our foreign operating sites. The team also includes some home-grown talent too – seven staff members who started and completed their training at THYSSEN SCHACHTBAU GMBH between 1979 and 2014. This provides familiarity with the company's internal structures and procedures. The department sees itself as a provider of services to both the operational divisions and the different subsidiaries that go to make up the THYSSEN SCHACHTBAU Group and is responsible for handling all the financial procedures associated with them, comprising payables and auditing, receivables and financial accounting.

The balancing of accounts and internal costing is undertaken using the SAP R/3 system that has been successfully used since 1996. Short-term forecasts for the results of individual projects can therefore be obtained at any time.

Company solvency is taken care of by the Treasury section. This is where all the cash flows come together and where the financial plans submitted for all the different companies are used as a basis for credit provisioning or alternatively for the investment of free liquidity. All financial discussions are held centrally, for example with banks or leasing companies, in order to ensure the best possible liquidity management for the THYSSEN SCHACHTBAU Group.

The third column of the Finance and Accounting Department is the taxation section, which is also supported externally by a tax consultant's office. Tax declarations are submitted at the end of each year and all tax-related enquiries are handled both internally and externally.

No accounting entries without documentation: this tried and trusted maxim still applies, in spite of all the electronic tools and support systems that have been rolled out over recent years at the THYSSEN SCHACHTBAU Accounting Department.

Claudia Fazzani · fazzani.claudia@ts-gruppe.com
Dieter Paffendorf · paffendorf.dieter@ts-gruppe.com

THYSSEN SCHACHTBAU Group training opportunities in 2014

During the coming year the THYSSEN SCHACHTBAU Group will as usual be providing in-house training places for enthusiastic young persons.

During the training year 2012/2013 nearly 30 young apprentices took up training places within the THYSSEN SCHACHTBAU Group. The range of apprenticeships available has already been extended to include ‚technical product design' and ‚technical system planning' and in order to widen the options even further the company will, from 2014, be providing training for information technology officers and mechatronics technicians.
During the period under review a total of 16 apprentices completed their training with very good performance results and the majority of the trainees subsequently joined the company. TS continues to follow its policy of meeting most of its staffing requirements from company-trained personnel.

Professional training

Training places in the THYSSEN SCHACHTBAU Group have always been very much in demand and we have now received more than 600 applications for the 2014 training year.
As well as providing the trainees with the relevant knowledge and skills the training programme also runs a series of workshops where students can get to know each other and engage in team building activities.

One of these events took place in October 2013, when training apprentices in the THYSSEN SCHACHTBAU Group went on an organised visit to the Zollverein World Heritage Site in Essen. After travelling on Germany's longest escalator the trainees were taken on a guided tour of the colliery buildings and were given a fundamental insight into the workings of a traditional coal mine.

Lunch was then followed by a tour of the Ruhr Museum, where the group learned about the origins of coal and the unique set of circumstances prevailing in the Ruhr coalfield. The young apprentices showed great enthusiasm throughout the visit and the bad weather certainly did not dampen their spirits.

Traditional apprenticeships

Electronics for industrial engineering
Industrial business management
Mechanics for industrial engineering
IT management (from 2014)
Construction mechanics
Technical product design(new)
Mechatronics engineering (from 2014)
Technical system planning (new)
Cutting machine operation

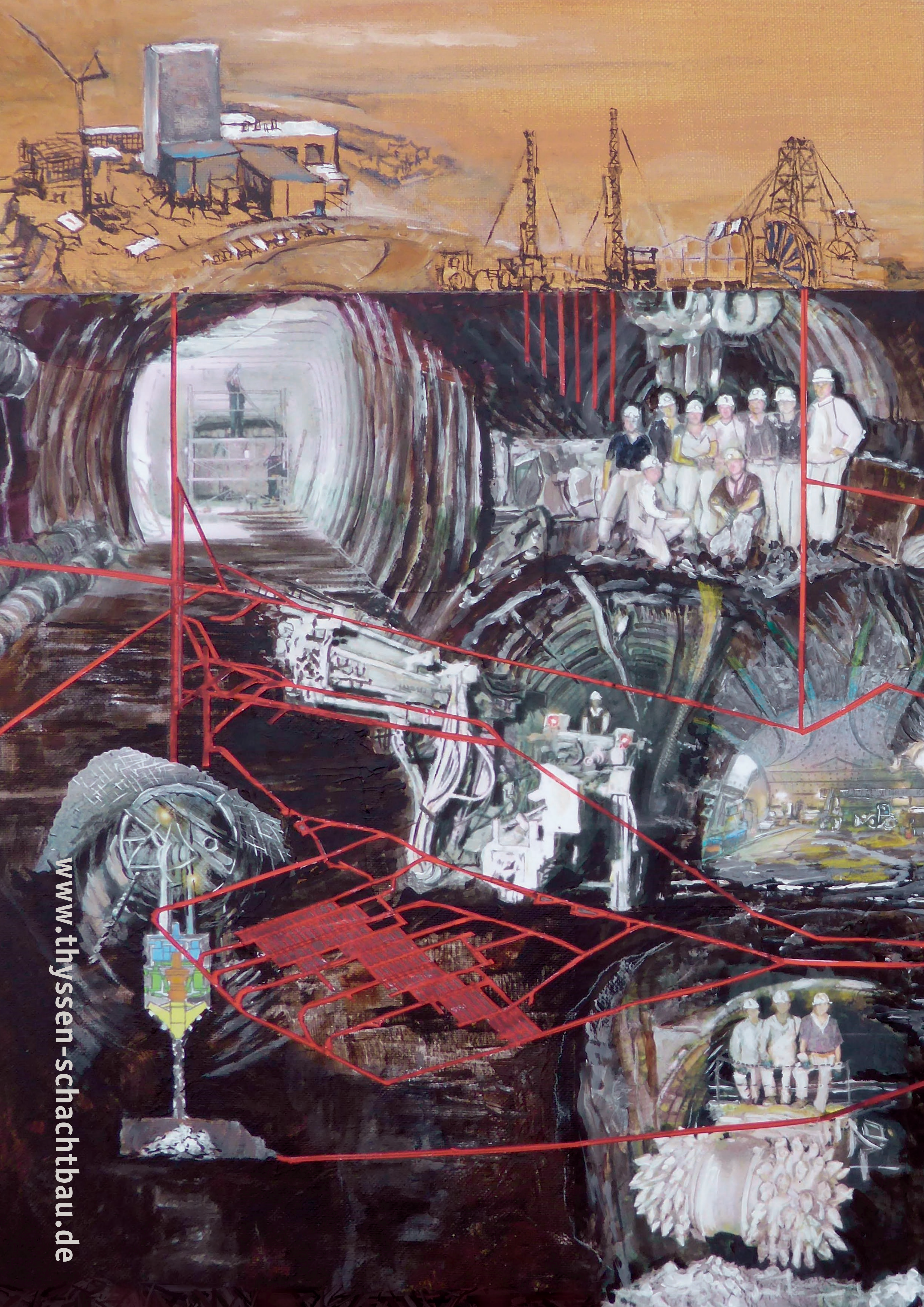
Special apprenticeships at our construction companies

Construction machine operation
Mining and machinery
Concrete and steel-concrete construction
Mining technology
Tracklaying
Canal construction
Roadbuilding

Work experience

As well as running specialist training courses the THYSSEN SCHACHTBAU Group also provides work placement opportunities where trainees can familiarise themselves with the company's many different areas of operation. The opportunities range from two-week student work placements to one-year internships and all have proved to be extremely popular. In 2013 alone some fifty work placement students got to know and appreciate the company in this way. Some of them went on to enrol in one of our training places while others were able to take up permanent positions within the

Ralf Herzberg · herzberg.ralf@ts-gruppe.com


www.thyssen-schachtbau.de