



**SIEMENS**

*Ingenuity for life*



Maximum productivity  
with maximum safety

Ready for the future – with more than  
110 years of experience in hoist systems

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# Maximum productivity with maximum safety

Safe and efficient transport of material and persons is top priority for underground mines. The shaft hoisting system plays a key role – or more precisely, the interaction / interface of drive, control and safety system. This calls for a technically and economically efficient solution – so that safety increases with reduced costs.

## You can expect ...

- a high throughput of your shaft hoisting system
- maximum safety for personnel, material and equipment
- long life cycle of drives and motors
- high availability as a basis for economical operation
- high profitability of your investment



K+S AG  
Mine Hattorf  
OEM Siemag Tecberg GmbH

# The challenge: Raising performance and safety

There is high demand for low-price raw materials with rising competition in the sector. Consequently mines are producing at capacity limits.

The performance of a mine largely depends on the performance of the shaft hoisting system. The mine shaft with its hoisting equipment can be a bottleneck for the mine's production – a place where maximum transportation of people and material in compliance with the highest safety standards is required. Consequently, the demands placed on hoist motors and their electrical converters are enormous. Maximizing plant availability and degree of utilization is an absolute must for the smooth and cost-effective running of a shaft hoisting plant.

Industrie 4.0, a German initiative for 'Internet of things' means introducing more intelligence to the process industry over the entire plant life cycle – from planning to commissioning, including operations and maintenance, some steps that were previously completed manually will be done without human intervention.

## Your challenge is our challenge

In each individual hoisting cycle, skips or other conveyances travel up and down the shaft at speeds of up to 20 m/s with payloads up to 60 tons. A typical 15-second acceleration phase and the gentle slowing down at the end of the hoisting cycle places particularly high demands on the drive, control, regulation and safety equipment.

Increased focus on the site conditions for each mine shaft and tailoring a solution to suit is vital. The following must be considered:

- Electrical converters and their power supply must be adequately overrated to prevent overloading
- Efficiency must be optimized
- All equipment must be easy to maintain, thus reducing downtime while qualification requirements of maintenance personnel can be reduced
- Consideration must be given to operate systems on mine sites where the electrical network is weak
- Consideration must be given to the applicable national electrical regulations to reduce the impact of reactive power, harmonics etc.

# The right drive for your application

After the conceptual design of the complete winder and taking main production data such as hoisting capacity, conveyance type etc. into consideration, the next step is the selection of the most suitable drive system. Siemens comprehensive portfolio provides a sound base for the most appropriate solution.

## Your requirements ...

<b>Economic parameters</b>	<ul style="list-style-type: none"> <li>• Investment</li> <li>• Operating costs</li> <li>• Reliability/availability</li> <li>• Maintenance costs</li> </ul>
<b>Permissible levels of system disturbance</b>	<ul style="list-style-type: none"> <li>• Reactive power</li> <li>• Harmonics</li> <li>• Overall efficiency</li> <li>• Voltage dips</li> </ul>
<b>Performance requirements</b>	<ul style="list-style-type: none"> <li>• Speed</li> <li>• Acceleration torque</li> <li>• special high torque, low speed modes, closed loop control and communication requirements</li> <li>• Response to setpoint changes</li> <li>• Torque quality</li> <li>• Hoisting cycle time</li> <li>• Open, standardized communication</li> </ul>
<b>Type of construction</b>	<ul style="list-style-type: none"> <li>• Ground/tower (Headgear)</li> <li>• Type of rope carrier (Koepe/drum winder)</li> </ul>

## ... define the appropriate solution

<b>Motor</b>	<b>Converter</b>
<p><b>Conventional solution:</b> A synchronous motor, flange-mounted to the main shaft of the hoist.</p> <p><b>or</b> A high speed induction motor connected to the hoist main shaft via a gearbox.</p>	<p><b>Cycloconverters:</b> High performance with low investment costs. Here the Sinamics SL150 has established itself as a standard – one of the most reliable cycloconverters in the world.</p>
<p><b>The alternative:</b> An integrated machine. Here a synchronous motor is integrated in the a Koepe drum – a unique design-solution used mainly in cramped winder rooms.</p>	<p><b>Voltage source converters (PWM):</b> The innovative, future-oriented solution in the field of high-performance, adjustable speed drives Sinamics SM150. Advantages include minimum reactive power consumption and system disturbances.</p>

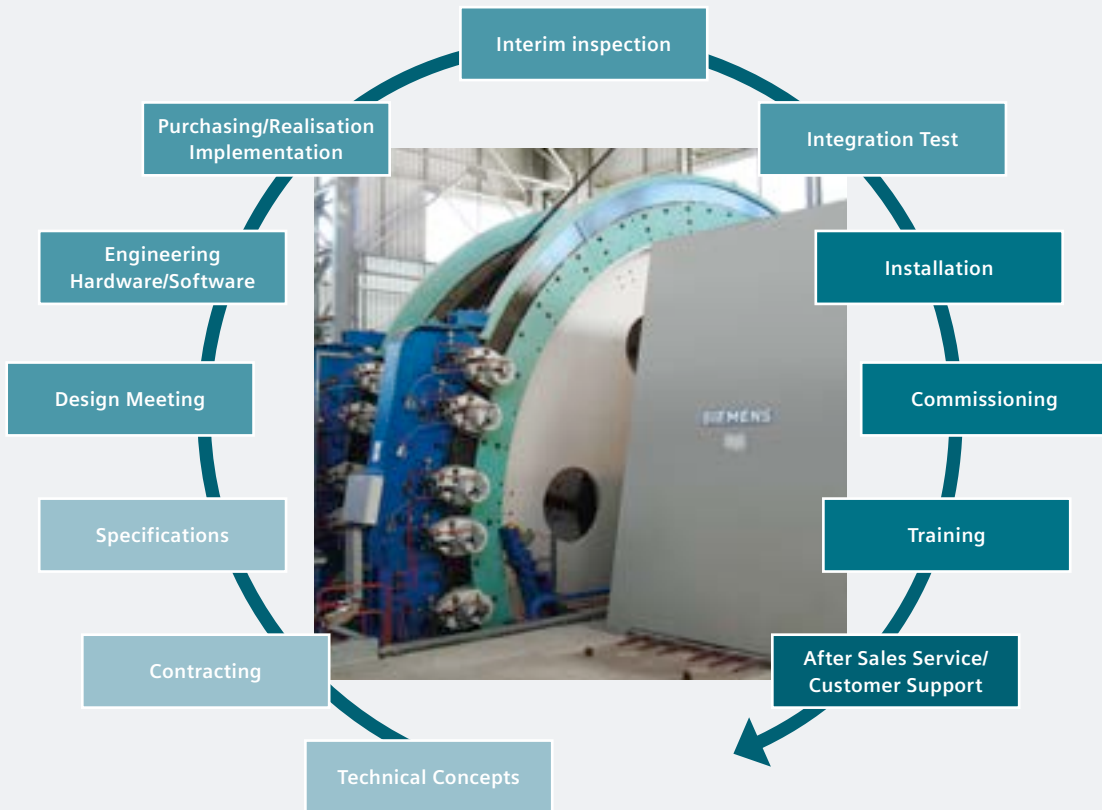
# A complete solution

In implementing your solution you naturally want to avoid loss of time and costly coordination efforts. Our deep understanding of hoist systems based on long-term experience enables us to support you from the conceptual phase to commissioning and production phases. We support you by presenting all the possible technical solutions using innovative techniques. Throughout the planning and construction phase we support you in terms of coordinating meetings, training and optimization of your plant in cooperation with third party suppliers.

This also includes installation, commissioning and optimization of the complete drive system – including transformer, converter and motor. Our hoisting systems concept consists of highly sophisticated automation including drive control,

monitoring unit and visualization in your selected language. Our solution is tailored to regional or national laws and regulations as well as your customer-specific demands. If required, we also perform electrical network studies to ensure proper operation of the entire plant. After commissioning we offer support in terms of modernization, updates and regular services.

**Our 24/7 service helpdesk assists and supports you – the plant operator – around the clock.**





# How can we support you?

The following overview will help you to find your individual solution.


Converter \ Motor	Sinamics DCM	Sinamics S120	Sinamics S120 (parallel)	Sinamics SM150 IGCT
		DC converter emergency mode possible	PWM low voltage converter	PWM low voltage converter single converter emergency mode possible
Fast running <b>DC motor</b> with gear unit	good solution for smaller winders	technically not possible	technically not possible	technically not possible
Low speed <b>DC motor</b> , direct coupled	good solution for modernisation when the existing motor is kept	technically not possible	technically not possible	technically not possible
Fast running <b>induction/asynchronous</b> motor with gear unit	technically not possible	very good solution for smaller winders (200 to 600 kW)	very good solution for medium sized winders (500 to 2000 kW)	motor and converter size don't fit
Low speed <b>induction/asynchronous</b> motor, direct coupled	technically not possible	unsuitable motor type for mine winder (efficiency/airgap); Typically converter power too low	unsuitable motor type for mine winder (efficiency/airgap);	unsuitable motor type for mine winder (efficiency/airgap);
Fast running <b>synchronous</b> motor with gear unit	technically not possible	technical possible; seldom used for mine winders; high speed induction motor preferred	technical possible; seldom used for mine winders; high speed induction motor preferred	not used at mine winders
Low speed <b>synchronous</b> motor, direct coupled	technically not possible	technically good; too expensive motor for small winders	good solution for medium sized winders (1000 to 1500 kW)	very good solution for medium to bigger winders (3 to 6 MW)
Integrated winder with <b>synchronous motor</b>	technically not possible	technically possible; but too expensive solution for small winders	technically possible; cost intensive	very good solution for medium to bigger winders (3 to 6 MW)

## Widely used converters and motors

1. Cyclo-converter	2. PWM converter (DC-Link)
 <p>6 pulse or 12 pulse AC-AC converter air cooled; fuseless design: + robust, reliable high overload capability easy to maintain</p>	 <p>PWM converter in single or parallel configuration, uses IGCTs or IGBTs (water or air cooled) + line feedback (Harmonics) no power factor compensation plant necessary</p>

Sinamics SM150 IGCT (parallel)	Sinamics SM150 IGBT	Sinamics SM150 IGBT (parallel)	Sinamics SL150 6pulse	Sinamics SL150 12pulse
PWM converter medium voltage  single converter emergency mode possible	medium voltage PWM converter	medium voltage PWM converter  single converter emergency mode possible	Cyclo-converter  emergency mode possible; V-Connection, see page 13	parallel Cyclo-converter  6pulse emergency mode is possible, see page 13
technically not possible	technically not possible	technically not possible	technically not possible	technically not possible
technically not possible	technically not possible	technically not possible	technically not possible	technically not possible
motor and converter size don't fit	good solution for smaller and medium sized winders (800 to 1500 kW)	converter oversized for smaller motors	unsuitable because of motor frequency	unsuitable because of motor frequency
unsuitable motor type for mine winder (efficiency/airgap);	unsuitable motor type for mine winder (efficiency/airgap);	unsuitable motor type for mine winder (efficiency/airgap);	unsuitable motor type for mine winder (efficiency/airgap);	unsuitable motor type for mine winder (efficiency/airgap);
not used at mine winders	good solution; seldom used for mine winders; high speed induction motor preferred	good solution; seldom used for mine winders; high speed induction motor preferred	unsuitable because of motor frequency	unsuitable because of motor frequency
very good solution for big winders > 6 MW	good solution for medium sized winders (1000 to 2000 kW)	good solution for medium sized winders (1500 to 3500 kW)	very good solution for medium to bigger winders (1 to 4 MW)	very good solution for big winders up to 17.5 MW
very good solution for big winders > 6 MW	possible solution for medium sized winders (1000 to 2000 kW)	good solution for medium sized winders (1500 to 3500 kW)	very good solution for medium to bigger winders (1 to 4 MW)	very good solution for big winders up to 17.5 MW

### 3. Synchronous Winder motor



synchronous motor, bearingless overhung design, 1 MW to 20 MW:  
+ robust design  
high efficiency  
easy installation  
maintenance free



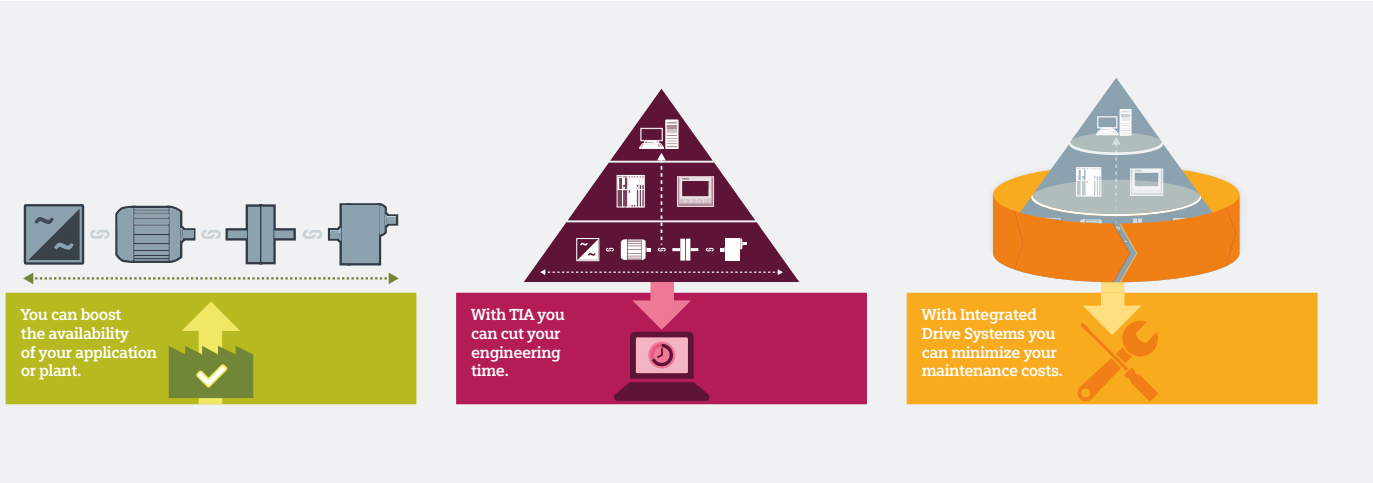
RAG Deutsche Steinkohle AG  
 Mine Bartensleben  
 OEM: OLKO-Maschinentechnik GmbH

# Integrated Drive Systems (IDS) for Mine Winder

Our Integrated Drive Systems offer more than single drive components they result in additionally more productivity, reliability and efficiency.

As an original equipment manufacturer for the mining industry we strive to provide you shorter time-to-market and shorter time-to-profit. As a mine operator, you expect components to effectively operate together in a reliable way with low maintenance cost.

Siemens can fulfill all of your requirements – with our Integrated Drive Systems (IDS), the world’s first true one-stop solution for entire drive trains. IDS stands for perfect interaction of all components, reduced engineering effort, high CAPEX control and reduced maintenance cost.







# The brain of each hoist “Winder Technological Controller”

The **Winder Technological Controller (WTC)**, supplied by Siemens, is literally the brain of each mine hoist based on more than 100 years of mine hoist experience. It was developed to maximise mine hoist's **EFFICIENCY** and **SAFETY**. The design is in accordance with the German mining regulation (TAS) as well as international regulations or standards among others: MA, SIL.

## **An integrated solution**

The WTC can be used in new plants as well as to modernize existing facilities. The current WTC system is an integrated solution. The WTC allows for control of all types of hoists such as:

- Friction (so called KOEPE) winders
- Single and double drum winders
- High performance production winders
- Extremely safe personnel transportation winders

## **A maximum of safety and reliability**

The WTC-hardware consists of a double channel system based on Siemens SIMATIC S7. That means all functions and modules are embedded in an automation system using worldwide proven standard components. Especially developed for control and monitoring of mine winders, by using the flexibility and well-proven reliability of this failsafe SIMATIC PLC configuration.

The basic function of the WTC is to control and monitor the movement of the conveyances during each hoisting cycle. Two main tasks are implemented:

- **Control the movement of conveyances:** Closed Loop Control with reference value generator and speed/position controller
- For safety reasons maintain permanent monitoring of the hoisting cycle using failsafe double-channel supervision system

Beside control and monitoring of the hoisting cycle, further necessary tasks and functions are implemented. These are for example:

- Shaft control including loading and unloading for production hoists or level control for service hoists
- Control of power supply and cooling systems
- Interface with rope handling systems like friction winches or clamping and lifting devices
- Interface to mine control centre

# Get flexible: Digitalisation of plant components

Integration of all components in context of Industrie 4.0 approach is becoming increasingly important. The increased digital connection of individual components of the plant leads to better integration of the hoist system into the IT infrastructure of the entire facility. The results: Better planning of production times and more flexibility in planning downtime for maintenance.

## The challenge

Questions to be answered are the following:

- **Preventive maintenance intervals:** Do they have to be fixed or can they be adapted according to the wear and tear of the individual components? Does it make sense to wait for a component to break down or can the breakdown be prevented?
- **Minor modifications:** Are lengthy shutdown times of the whole facility and coordination with product planners, service personnel and supplier really necessary? Can't minor modifications be carried out rapidly and flexibly by remote access?

Double channel  
Siemens WTC



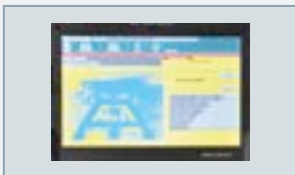
Double channel brake



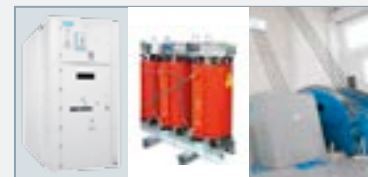
Sinamics Drive



Desk



Remote access Controlled  
by the Customer / mine



Power Elements



Sensor

### Our Solution

Digital networking of all plant components as well as the components delivered by Siemens is state of the art. All plant relevant signals are recorded in real time. Centralized analysis can be done at either site, mine headquarters or remotely at one of the Siemens competence centers. Signals can be collected via bus-communication and allowing recordings can be configured via remote access allowing flexible adaptation to specific requirements.

Long-term storage is possible provided that rules and regulations of the mines and national authorities are upheld.

A further benefit of digitalization is the reduced reaction time in case of unscheduled downtime:

- Due to continuous data monitoring, faults can be located as soon as they occur enabling spare part ordering before the service personnel arrive on site.

### Digital Fingerprint

During commissioning key parameters such as torque, temperature and speed are recorded. From time to time these parameters can be compared with actual recordings.

After that analysis by our competence centers we can support our customers with recommendations on:

- optimizations (performance or efficiency)
- next maintenance intervals and tasks



# Plant availability: Primary goal of every mine operator

Besides the demand for maximum safety and increased performance, the availability of the hoisting facility is a vital factor for the mine. Basically three main aspects influence plant availability:

1. Hoisting facilities from time to time must be driven under special conditions, such as rope shortening, rope exchange or shaft/rope inspection.  
  
These operating modes 'daily/weekly inspection of rope, skip and shaft' must be easily handled and rapidly completed.
2. Hoisting facilities from time to time need maintenance or the exchange of worn components. Mechanical maintenance operations have to be easily and safely handled.
3. Despite careful installation and operation according to regulations, unexpected malfunctions may occur.

In order to allow maximum production, repairs must be carried out rapidly.

## Our solution

An intelligent human machine interface helps the operator to safely and efficiently control specific operating modes.

Our system offers state of the art adaptive individualized calculation models for each hoisting plant, thus maximizing the quality of torque and speed for every operating mode, even during extremely high torque or very low speed conditions. In both cases control must be steady and regular.

Siemens fulfil the five requirements for a successful plant design:

- meet the production requirements of the mine (payload, hoisting speed, overload capability)
- fit for the customer's budget
- fit for ambient conditions (environmental, power supply, local regulations, language, ...)
- ensures high demands on availability, productivity, efficiency
- do all the above with maximum safety

## Your benefits

- optimal investment utilization
- up-to-date state-of-the-art technology
- not every „peanut“ leads to a breakdown (operation processes are maintained as long as possible)
- the entire installation is safe at all times

**Not every „peanut“ leads to a breakdown. How do we realize this requirement?**

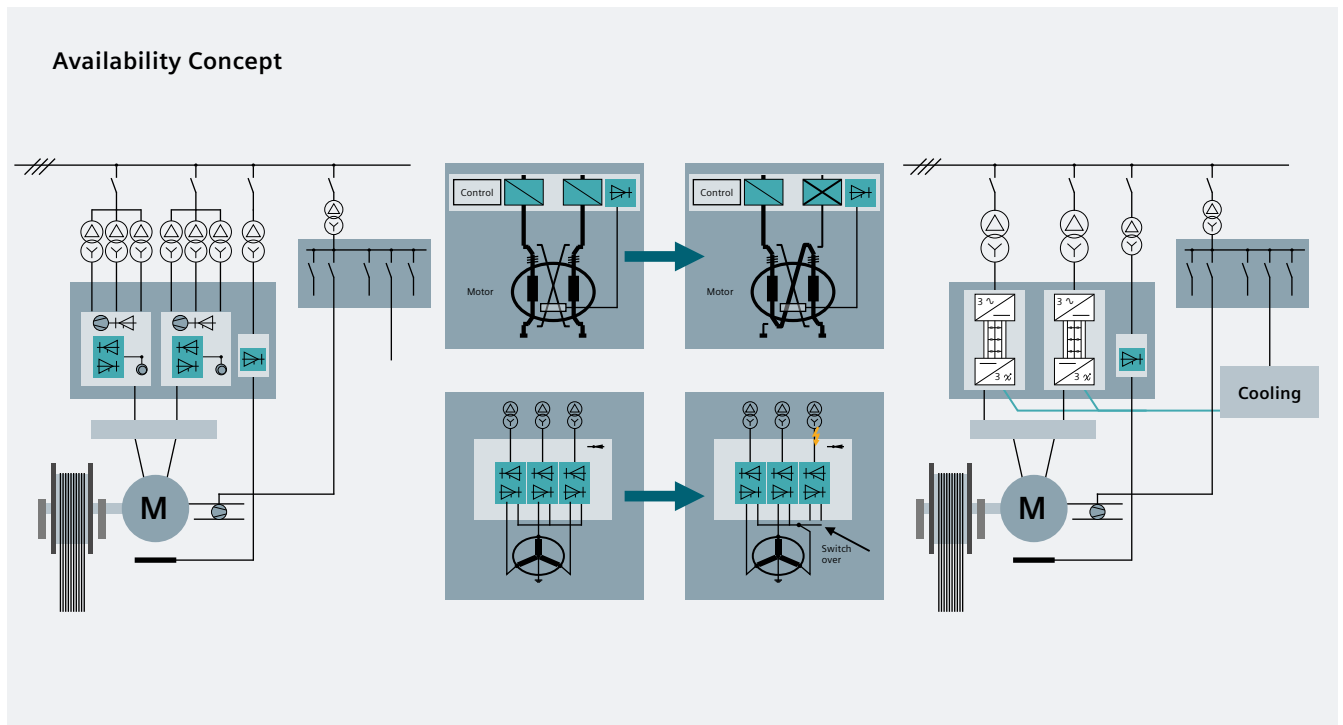
**Full load half speed mode**

All Siemens converters of the Sinamics family can be designed in such a way that partially damaged power sections will not completely shut down the plant.

For example cyclo-converters are the most robust and reliable drives, nevertheless it may happen that a transformer, fuse or semiconductor fails. In accordance with our principle that such a breakdown should not stop the production or personnel transport we include a so called half speed full load mode in all our cyclo-converter drive solutions (6pulse emergency mode for a 12pulse Converter or V-connection for a 6pulse converter).

The defective parts are totally isolated; this can be a complete converter system of a 12pulse Converter or a single phase of a 6 pulse converter. The remaining “healthy” system can be operated at full load while the speed is reduced to 50%.

A similar function is also available with PWM converters connected in parallel. This applies to the Siemens Sinamics SM150 or S120 converters.



# Siemens mine winder technological milestones

- 2015** Biggest single winder motor 9MW.
- 2014** Implementation of Digital Finger Print Winder with highest operating modes (3x loading stations; 2x unloading stations; 10x levels man riding)
- 2012** Stand-alone digital supervision system
- 2010** New ergonomic control desk design
- 2008** Fully digitalized multi channel constant retardation brake system
- 2005** First mine winder with a synchronous motor with a PWM converter
- 2001** First mine hoisting machine with Simatic S7 (incorporation of control, supervision, automation and HMI in one system)
- 1998** First remote control desk
- 1990** First mine hoisting machine with dynamic adjustment of jerk limitation optimized to the resonant frequency of the system for prevention of rope oscillations
- 1986** Implementation of a fully digital monitoring and control system  
First mine winder with integrated motor
- 1980** First reference of value generator on a microprocessor basis for jerk limitation  
First mine hoist with a cyclo-converter with a synchronous motor
- 1973** First digital control system  
Implementation of the first electronic speed controller
- 1968** First thyristor-controlled mine hoist
- 1936** Implementation of a mercury arc rectifier on a mine hoist
- 1903** First electrical mine winder in the world

# References:



## Inner Mongolia Yitai Group Co. Ltd., China OEM: Siemag Tecberg GmbH

### Order:

- Two production machines with integrated 9 MW motors
- Two service machines (3,8 MW and 0,5 MW), each with a delivery scope of:
  - Complete drive train consisting of motor, converter and transformer
  - Entire automation control and monitoring systems
  - Services e.g. engineering, commissioning

### Solution:

- Highly efficient hoisting system, that meets the latest safety standard
- Design of all machines from a single source

### Customer benefit:

- Worldwide highest output per shaft
- Low floor space requirement



## Impala platinum mine, Rustenburg, South Africa OEM: Siemag Tecberg GmbH

### Order:

Mine winder complete electrical package, for sinking duty (first order), Mine Winder production retrofit, change to production duty, software only (second order). The customer was highly satisfied with the first two orders, so the same drive system again for the Impala 11c project (third 2nd order).  
Depth: 2,100 m  
Capacity: 7.5 MW

### Solution:

- Conventional drives system with two windings low-speed synchronous motors (7.5 MW, 49 rpm) including motor cooling system

### Customer benefit:

- In case of an faulty a medium-voltage breaker, transformer or converter, it is possible to run the winder in a six-pulse 'emergency' mode.
- Only one electrical system is used for both shaft sinking and production duty.



## Zeche Zollern, Dortmund Germany

The first electric mine winder motor developed by Siemens & Halske and fed by a Ilgner converter was put into operation at the colliery Zollern II in 1903. This mine winder had payload of 5,600 kg and a skip velocity of 20 m/s. The 2 x 540 kW mine winder DC motor from Siemens & Halske was used in the colliery for over a half century. Nowadays, this entire, fully functional unit is one of Germany's major industrial monuments. This is the oldest mine winder in the world – and still running smoothly and reliably.

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