ČKD ELEKTROTECHNIKA, a.s., a member of ČKD GROUP, has a long term tradition in development and production of electrical equipment, especially semiconductor applications.

We supply our products to the following segments:
- mining industry and metallurgy
- oil, gas, chemical industry
- power engineering
- environmental protection
- infrastructure
- processing industry

Production programme ČKD ELEKTROTECHNIKA includes:
- static var compensators
- regulated electric drives
- control systems
- converter stations for city public transport and railways
- very high voltage sources for electrostatic precipitators
- complete supplies of technological units
- special applications of power electronics
- technical support, testing, commissioning and maintenance services

Our competitive advantages:
- we are focused on the supply of products and services on the individual projects
- we offer technically optimal design reflecting minimization of total costs in the case of investment activity, especially with renovation or modernization of existing equipment
- we pay significant attention to customer service, modernizations, deliveries of spare parts and consulting
1. WHY IS REACTIVE POWER COMPENSATION SO IMPORTANT

- Asynchronous electromotors as well as distribution and rectifier transformers constitute the basic load in industrial grids;
- During operation inductive load generates reactive power which causes oscillation between the load and the source (generator);
- Inductive load doesn’t create any useful working load; it generates a magnetic field which causes additional harmful load in power grid.

Reactive power is a negative factor, affecting the whole grid, with the following consequences:

- additional losses in conductors due to increased current
- reduction of power distribution network capacity
- total harmonic distortion (THD) causing interference, affecting operation of electric devices and microprocessor technology which results in production process disturbance, with negative influence on main power equipment:
  - Transformers – increased transformer temperature, even without load. Change of acoustic parameters (higher noise level). Decrease of power and degradation of insulation materials of transformers.
  - Cables – increase of cable temperature, cable insulation breakdown.
  - Electric motors – temperature increase of electric motors at nominal load. Possible resonance effects. Electric motors run with non-standard time delay. Change of acoustic parameters (higher noise level).
  - Capacitors – increased temperature, breakdowns, and explosions.
  - Fuses – THD have negative impact on fuses, resulting in unexpected and misguided equipment cut-offs.

Fields of application of the static Var compensators

SVCs are intended for use in power-intensive production processes in the following sectors:

- metallurgy
- mining
- processing industry
- railways

SVCs can be used in various electric systems generating or consuming reactive power:

- asynchronous electric motors
- transformers
- induction and arc furnaces
- electric drives of pumps, fans and compressors
Reactive power compensation allows:
- improved power factor – causes reduction of current losses as well as overall costs of electric power;
- reduction of the load in power distribution network units (supply lines, transformers and distribution plants), thus increasing their operational lifespan;
- reduction or elimination of harmonics – increasing efficiency of the equipment due to reduction of failure rate caused by breakdowns of distribution network units (cable lines, power transformers) and microprocessor devices, minimum malfunction of protective devices;
- increasing reliability and cost-effectiveness of power distribution networks, and thus, reduction of operation costs;
- electrical arc furnaces (EAF) in steel-making industry – shortening of tap-to-tap time, electrode savings, reducing wear of furnace lining due to more stable arcs, substantial flicker reduction;
- voltage stabilisation, increased voltage on the load bus.

Economical benefits of the Static Var Compensator
Operation of the technological electric equipment in power grid with non-rated parameters and significant distortion of the harmonicity of supply voltage results in economic losses due to increased power consumption, increased production costs, shortening of equipment lifespan and decrease of operation reliability and breakdowns of power supply systems. SVC can be used for the purpose of reduction of harmonics, stabilization of voltage, minimization of flicker disturbances on own and neighbouring facilities. As a result installation of SVC systems results in significant increase of technological and economical effectiveness of operation of industrial equipment.

Example of economical efficiency of SVC installation at EAF (steel works):
Increased and stabilized voltage on the load bus after installation of SVC allows decreasing steel processing time up to 15% reduction of one heat time, and thus increasing productivity by 15% owing to:
- Energy savings;
- Reduction of active power losses in the transformer;
- Reduction in consumption of electrodes;
- Reduction in consumption of natural gas and oxygen;

Remark
Economic effect can be much more significant after implementation of penalty charges for consumed reactive power.
### Basic SVC concepts:
- with dynamic automatic current control with thyristor control (static var compensator – SVC)
- step controlled compensator, with and without harmonic filters
- combined type – step controlled combined with static var compensator

### Basic principle of SVC functioning
Static var compensator system provides dynamic reactive power and is directly connected to the bus of an electric appliance.

- Maximum SVC’s reactive power is generated by capacitors of harmonic filters and is equal to maximum reactive power of the appliance.
- Reactive power control is conducted by thyristor valve which regulates current of TCR reactors and compensates excess reactive power of the capacitors in harmonic filters.

Control and protection system of the static var compensator provides quick reactive power load, while maintaining controlled parameter, protecting SVC equipment, monitoring and signalizing failures and it also can be tailored in compliance with customer’s wishes. Response time of the SVC control system to changes of controlled parameters is 5 ms for EAF and 25-100 ms for general industrial applications and transformer substations.

SVC control and protection system allows unmanned operation of the equipment.

Rated power and combination SVC device components are defined for particular projects depending on parameters of the power supply system as well as type and power of compensated load.
Basic components of the SVC system:

- Thyristor-controlled reactor (TCR) consists of a three-phase thyristor-controlled transformer and three reactors. Power generating section of the thyristor-controlled transformer is made up by one or several COMPACT modules, manufactured by ČKD:
  - Voltage (current) control using reactor
  - Smooth control of the output power, from maximum ($\alpha=90^\circ$) up to full blocking of the element ($\alpha=180^\circ$).

- Control and protection unit MODULEX:
  - TCR control and communication with the master system
  - Capacitor battery and filter reactors
  - Air cooling of thyristor valves:
    - Cooling of thyristor valves; cooling power designed in compliance with local operational conditions

Example of SVC Layout

Thyristor valve and control unit cabinet are located indoors
TCR reactors and harmonic filters are located outdoors
3.1. Air-cooled thyristor valve

The basic SVC component device is the thyristor valve which regulates current in TCR reactors and, thus, totals SVC power. Thyristor valve consists of three power blocks (each block for one phase). Each block has optical thyristors, RC circuits, thyristor switching-state signalization and coupling system. Operating voltage of the converter depends on the quantity of series-connected thyristors. The controller sends electric switching signals to the optoelectronic system, where these signals are converted into optical ones. Optical signals are transmitted to the thyristors via optical cable. In this way, optoelectronic controller provides correct switching of all necessary thyristors, connected in series. The optical thyristor also includes overvoltage protection using avalanche diodes (BOD) to switch the thyristor when the injection impulse has not been sent. Thyristors and damping resistors are cooled by fans.

Three-phase thyristor converter for SVC to 10 kV

The power unit (single phase) three-phase thyristor converter for SVC 22/27.5/33/35 kV (up to 400 A)

The power unit (single phase) three-phase thyristor converter for SVC 22/27.5/33/35 kV (more than 400 A)

Example of a three-phase thyristor converter for SVC 35 kV, 110 MVar
3.2. Main advantages of air cooling

The cooling system of SVC’s thyristor valve manufactured by ČKD ELEKTROTECHNIKA is based on use of company’s own ALTRA heat pipes.

The air cooling system has a lot of advantages compared with water cooling:

- Reliability of operation
  - The air cooling system is less sophisticated compared to water-cooling systems. Proper operation of cooling system based on heat pipes doesn’t require extra electronics, mechanical and rotating components, and as a consequence there are fewer potential sources of failures.
  - Heat pipes used in ČKD ELEKTROTECHNIKA’s converters operate in closed loop with no forced circulation of coolant and the fan is the only mechanical component of the cooling system.
  - The air passing through the power blocks cools not only heat pipes but also other components (capacitors, resistors etc.).

- Simplicity of operation and maintenance
  - Heat pipes are completely sealed and do not require additional maintenance.
  - Air cooling eliminates the use of additional equipment such as coolant cleaning, water-cooling systems, pipes, couplings, etc.

Heat pipe thermal cycle

1) Working fluid evaporates to vapour absorbing thermal energy.
2) Vapour migrates along cavity to lower temperature end
3) Vapour condenses back to fluid releasing thermal energy
4) Working fluid flows back to higher temperature end
3.3. MODULEX – Control and protection unit

Due to wide range of parameters, air-cooled converter units MODULEX can be utilized in low-voltage applications of low or medium power systems. Control unit consists of semi-conductor converter block which includes power circuits with potential-free modules, turn-on pulse units, overvoltage protection and high speed fuses. Depending on particular project, converter unit MODULEX can also contain microprocessor regulator EMADYN of various types as well as touch screen panel.

Power supply circuits of the converter unit MODULEX have been designed for maximum feeding voltage 500 В, ±10%, 50Hz.

EMADYN D K regulator is intended for switching on/off compensation and control:

- local non-remote control via buttons, switches and EasyView touch screen control panel, installed on the front side of the cabinet.
- remote control via external potential-free contacts
- remote control via RS485 interface (Modbus protocol)

EMADYN D K regulator allows the following operations (within capacity range of the filters and inductive power of TCR group):

- control and regulation of $\cos \varphi$ parameter in the grid
- control and regulation of reactive power in the grid

EMADYN-D-K regulator can control up to three HV breakers (as an option) for connection of not controlled high harmonic filters (if these breakers are installed).
3.4. Outdoor reactors

The reactors are connected with the capacitor banks to provide adjustable filtration circuits for reduction, blocking and/or filtration of higher harmonics.

The reactors are self-supporting structure, air-cooled windings. Reactor windings are made either with or without tappings, depending on the need to provide for required inductivity by change-over switches without load.

Standard parameters of tappings:
- 90 – 100 – 110 %
- 90 – 95 – 100 – 105 – 110 %
- 90 – 92.5 – 95 – 97.5 – 100 – 102.5 – 105 – 107.5 – 110 % of rated inductivity.

Insulation, impregnation and coating material is F temperature class.

The windings are made of parallel aluminium conductors, insulated with fiberglass on aluminium cross-shaped structure, with top and bottom brackets.

Top brackets are fit for lifting and fixing of the unit during transportation, bottom brackets are intended for fitting of reactors on the foundation (supporting insulators).

3.5. Capacitor banks

- Made of reliable capacitors, 600 – 700 kVar, voltage up to 20 kV, outdoor installation, with built-in sectional fuse links and discharge resistors
- supplied as assemblies (capacitor blocks) with insulators and busbars, non-balanced current protection transformer and overvoltage protections (optionally)
Preparatory stage

Operating measurements of power grid
Operating measurements in the conditions of your corporate network of low-, high- and very high-voltage, incorporating voltage and current harmonics, voltage symmetry and fluctuations, power flows, power factor of the basic harmonic, active and reactive el. work, transient phenomena. These measurements can be oriented on establishment of interference sources in the network, on diagnostics of the existing compensation device or on obtaining the underlying documents for the optimum design of the compensation system. Results of measurements are processed by a special software in the form of well-arranged graphs and the measurement report focused on practical consequences for the customer following from the measurements; the simple and clearly formulated conclusion and summary is also not missing.

Technical solution
Technical solution of the static Var compensator system, incl. Set of components and their layout, solutions on modernisations and reconstruction of existing equipment

Delivery of the equipment (standard option)
- Basic design
- Thyristor valve
- TCR reactors
- Capacitor banks and filter reactors
- Control and protection unit
- Cables for auxiliary and switching impulses
- Technical documentation
- Spare parts
- Assembly supervision
- Commissioning
- Personnel training
- Warranty service

Additional options
- Project
- Supply of auxiliary equipment
- Supply of power cables
- Disassemblies and assemblies
One of key-factors of our success are quality services provided to our customers, including technical service, spare parts as well as wide variety of technical service programmes during the entire service life of the equipment. After equipment commissioning ČKD provides full-scope start-up training for customer’s specialists.

- Our service teams use the most advanced technologies and operate in the territories of Europe, Asia and in other regions, including operation via remote access.
- ČKD ELEKTROTECHNIKA offers supply of remote access devices in the scope of delivery to allow remote control of the equipment either by the customer or technical service specialists (via internet or GSM).
- Our clients can download files containing information from regulators and send them for analysis or software modification to ČKD ELEKTROTECHNIKA’s headquarters in Prague. After the analysis and modifications, changed software or recommendations for repair will be sent by technical service department to the customer.
- ČKD ELEKTROTECHNIKA guarantees high level of technical service provided exclusively by highly qualified specialists.
- ČKD ELEKTROTECHNIKA guarantees sending a service engineer to carry out necessary technical service within 24 hours on business days or on the next business day, if the requirement by the customer was obtained on weekends/holidays.
- Maintenance services in the Russian Federation and Ukraine are provided by affiliated companies – ČKD ELEKTROPROM” (Ekaterinburg, Russia) and “ČKD ELEKTROMASH” (Kiev, Ukraine).
### REFERENCES

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In 2012, at Belarusian Metallurgical Plant was placed set SVC for installation “Ladle-furnace”, 33 kV, 32 MVar