

# **Industrial Static Var Compensator (SVC)**



## Dear Customer,

### **Customer confidence**

*Customer orders and customer satisfaction have continued to reward our investments in quality, R&D, design and manufacture. Our strict commitment to high quality has given us access to the highly competitive industrial market.*

*Our supply of SVC solutions for arc furnace applications include projects in the Ukraine, Morocco, Russia and the Middle East to mention few of our latest successes.*

*Nokian Capacitors' reactors, capacitors, thyristor valves and control systems are manufactured all under one roof, which is a unique advantage that no other supplier in the world can meet.*

*We use reliable components to design systems that match the criteria of leading steel industry integrators and add value to their system deliveries. Our understanding of the steel-making process makes us an ideal partner to deal directly with steel manufacturers as well.*

### **Power quality for steel industry**

*Nokian Capacitors' commitment to continuous development of digital SVC control systems and high voltage key component technology have strengthened our position as a major SVC supplier for electric arc furnace (EAF) and rolling mill applications in the steel industry.*

### **Competence is the key**

*With a focus on optimal performance for the customer and continuous improvement, we have proven that we possess the elements which customers need. Innovative and hard-working personnel, which understand the customers needs and cooperation with international partners is the backbone of the company and the best companion to the customer.*



*Kari Tuomala  
Managing Director*



# Historical milestones for Nokian Capacitors

**1957**

- Founding of Nokian Capacitors

**1964**

- Installed first light-optic signal transmission
- Installed first complete solid state electronics

**1971**

- Fast reinsertion system for the world's biggest Series Capacitor

**1975**

- First Series Capacitor in the world with non-linear resistor

**1977**

- SVC for Electric Arc Furnace (EAF) with flicker compensation

**1978**

- The first to use the 735 kV double tuned filter for Utility SVC
- Utility SVC for support of a 330 kV grid

**1988**

- Provided capacitors for the biggest Series Capacitor 1056 Mvar in the world

**1989**

- Forced triggered Spark Gap & Metal Oxide Varistor

**1994**

- Digital Protection & Control System (NDP)
- New design of free standing Thyristor Valves for SVC application

**1995**

- Manufactured capacitor unit sizes up to 1000 kvar

**1997**

- Started using laser powered measuring system for platform electronics (Series Capacitor bank)

**2001**

- Built a 345 kV Utility SVC with new Digital Control System
- New NDP+ Protection & Control system with Field Bus System

**2002**

- 1500 Mvar HV filter banks compensation turnkey project
- 400-500 kV Series Capacitor bank turnkey deliveries (incl. civil works, installation and commissioning)

**2003**

- Full scale seismic test available for SC
- Forced triggered Spark Gap for 450 kV crest Ulim

**2005**

- Launched remote service concept

**2006**

- Provided many service contracts for Series Capacitor
- The world's biggest 400 kV Series Capacitor bank, 1008 Mvar, turnkey delivery to India



## Tailored electricity

Nowadays, the quality of the electricity supply is becoming more important due to the use of sophisticated computer controlled systems. This has been recognised by the electrical utilities, which penalise user for disturbances.

The Static Var Compensator (SVC) is designed to decrease disturbances caused by changes in reactive power and voltage fluctuations in the normal operation of transmission lines and industry distribution systems. Disturbances may be caused by line switching, line faults, non-linear components such as thyristor controls and rapidly varying active or reactive loads. A typical source for these kind of disturbances are electric arc furnaces and rolling mills.

These disturbances result in harmonics that load the supply network and cause voltage fluctuations. Varying loads can also create disturbances in the form of phase unbalance and voltage flicker phenomenon as well as create a need for additional reactive power.

The benefits of an SVC can be seen within a steel plant as a stable power factor in spite of varying loads at the plant, and externally when the disturbances do not effect the supplying grid. In short, the Static Var Compensator effects the following:

- Flicker reduction
- Voltage stabilisation
- Reactive power compensation; improved power factor
- Increased voltage on the load bus
- Reduction of harmonics

Nokian Capacitors ensures the high quality of the Static Var equipment by manufacturing the main components such as capacitors, reactors, thyristor valves and the digital control and protection system, in-house.

**The achieved benefits of the SVC will improve production and the quality of steel at the factory.**

*130 Mvar, 20 kV, 50 Hz, Outokumpu Polarit, Tornio, Finland*



## Experts at your service

The services of Nokian Capacitors range from analysis and design, delivery of the SVC to after-sales services. We also carry out tests and reactive power / distortion measurements to ensure that the performance levels of the SVC are met as determined in the beginning of the project. Our global sales network contributes to projects with knowledge of the local environment and customs.

**Our global sales network contributes to projects with knowledge of the local environment and customs.**



*130 Mvar, 30 kV, 50 Hz, Sonasid, Morocco*



*130 Mvar, 30 kV, 60 Hz, Rajhi Steel, Saudi Arabia*

# Functional benefits of the Static Var Compensator

The benefits of reactive power compensation, more constant voltage levels and reduced distortion levels are transferred to the end user as production increases, total power losses are reduced and reactive power penalties are avoided. Static Var Compensators increases the quality of power in many respects.

**The pay back time of the SVC investment ranges typically between one to two years.**

## Flicker reduction

Rapidly varying reactive power causes voltage fluctuations at the point of common coupling of a steel plant. The human eye perceives this frequency of voltage fluctuations as flickering lights.

## Voltage stabilisation

Electrical Arc Furnace (EAF) operations can be intensely unbalanced especially in the beginning of the melting process. The three-phase induction motors suffer due to the unbalanced voltage supply. The unbalanced voltage causes reduced efficiency, overheating, noise, torque pulses and speed pulses to motor operations. The SVC operates in single-phase control mode, thus balancing the voltage.

## Reactive power compensation

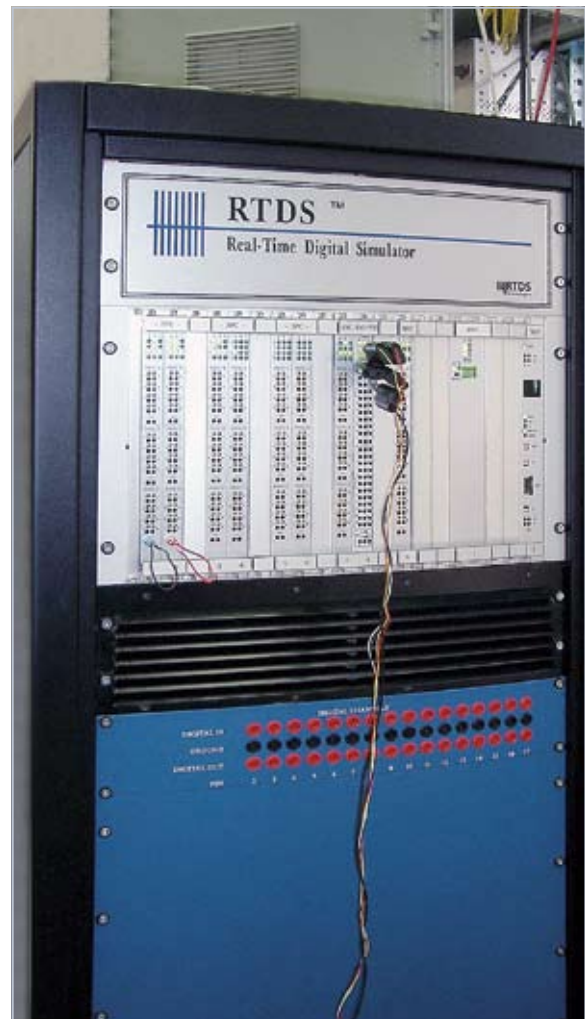
Transmission of reactive power leads to significant voltage drops and current increases in the networks, which limits the transmission capacity of active power. Public utilities maximise their transmission line capacities by advising their customers to utilise local reactive power compensation. The Static Var Compensator maintains the demand of reactive power within the limits set by utilities, thus avoiding penalties.

## Reduction of harmonics

Non-linear loads, like Electrical Arc Furnaces, generate harmonic currents. The harmonic currents load the network and lead to voltage distortions. Distorted voltage may cause malfunctions in sensitive computerised devices or process control equipment.

The filter circuit of the SVC system is designed to absorb harmonics generated by loads as well as by Thyristor Controlled Reactors (TCR). The total harmonic distortion (THD) and individual harmonic voltages are limited below specified levels.

*Nokian Capacitors uses Real Time Digital Simulator (RTDS)<sup>®</sup> to help in factory tests.*



# Economical benefits

## Energy savings

Compensation and improving the quality of power increases the capacity of active power transmission and reduces energy consumption. Thus, the unnecessary overload of the power network can be avoided. Both your company and the environment benefit from the more efficient use of electricity and saving in the consumption of energy.

## Increase in productivity

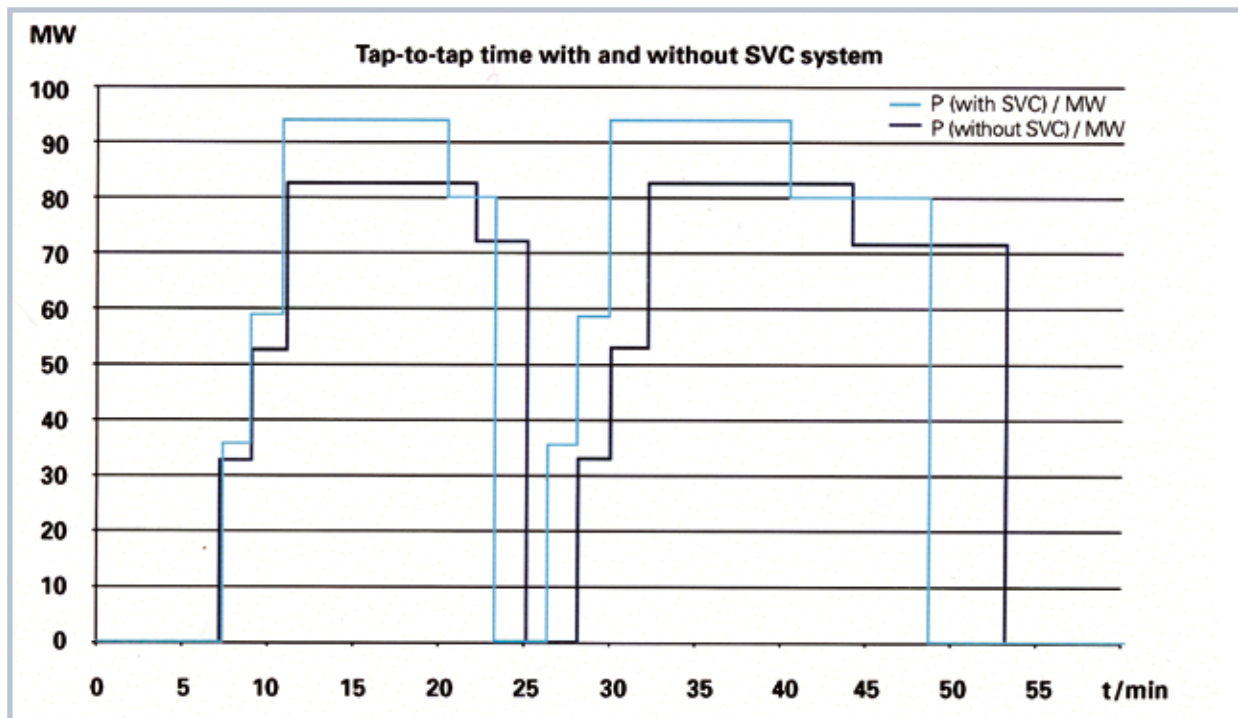
The SVC system can keep a steel plant bus voltage practically at a constant level. This decreases the steel processing time and thus increases productivity. The SVC system also reduces production breaks and expensive restart procedures.

The arc furnace, stabilised by the SVC, also has a considerable positive effect on the consumption of electrodes, heat losses and the lifetime of the furnace's inside lining.

As the improved quality of power from the network reduces the stress on equipment, its lifespan increases, thus lowering the maintenance and replacement costs.

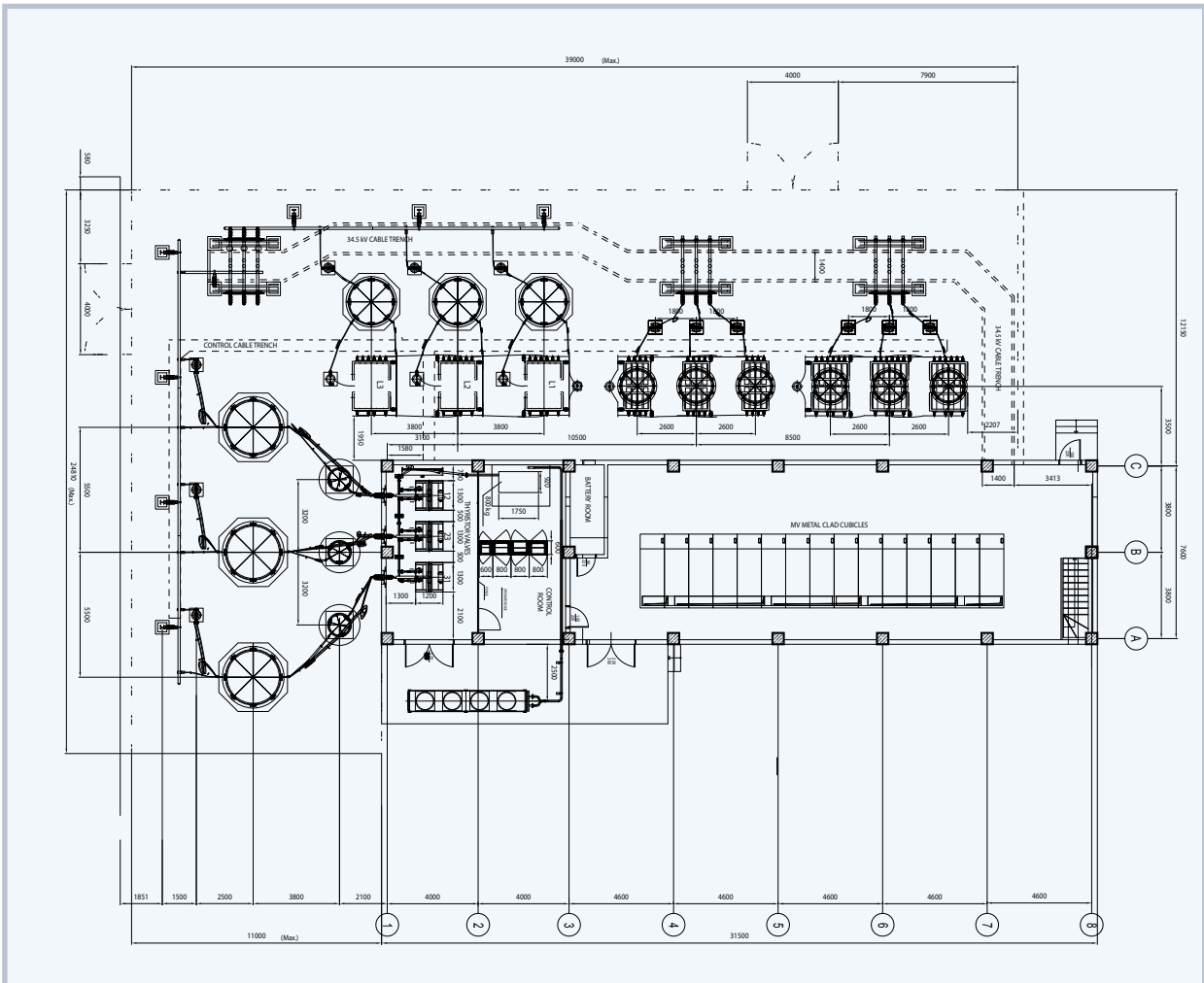
## Benefits of the SVC:

- Increase in productivity
- Energy savings
- Reduction in consumption of electrodes
- Reduction of heat losses
- Increase lifetime of furnace inside lining



This figure shows the influence of the shortened tap-to-tap time as increased steel production. The melting time of the changes decreased from 53 minutes to 48 minutes once the SVC was installed. This is a 9.4% reduction of one heat time - the total increase of the productivity can be transferred to the steel tons via saved time for each heat.

## Tailored SVC installation



Typical layout and space requirements of an SVC installation.

Every SVC installation is different. The scope of the SVC installation depends on the technical and economic needs of each customer.



A 130 Mvar / 21 kV-50 Hz SVC installation at the Outokumpu Polarit steel plant, in Tornio, Finland. The filter banks and thyristor controlled reactor are located in the outdoor switchyard, while the thyristor valves, control and protection system and switchgear are located inside the pre-assembled building in the back.



# System parameters determine the design of the SVC

Each plant has its own quality requirements for the supply of power, thus the SVC must always be tailor-made. The design of the SVC depends on the fault level and load parameters. In case of a high fault level, the main parameter of the SVC design might be reactive power compensation while flicker and harmonic reduction are major concerns for a low fault level.

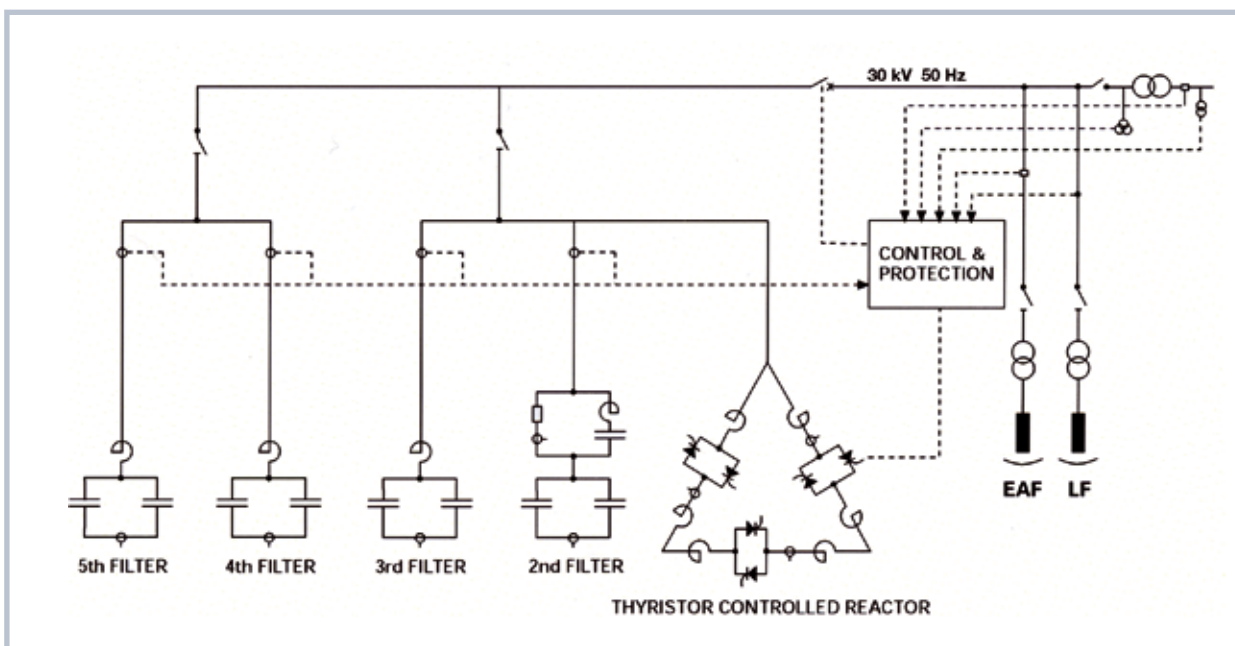
The location of the SVC, once installed, can be fixed or relocatable. While outdoor equipment is usually built as fixed structures, indoor equipment is often located within a container that is easily relocatable. It is possible to use a modular design of the SVC. This makes transportation, installation and commissioning at the site fast and easy.

## Tailored and flexible project delivery

A successful delivery begins with an accurate assessment of the requirements for an SVC. Nokian Capacitors can provide consultative help already when determining the scope of supply.

As a competent team of experts will be on incharge of the project, on site, for as long as needed. In the beginning of a project, Nokian Capacitors analyses the network, its load and the physical space in which the SVC is to be installed. Changes in the reactive and active power are measured as a function of time, as well as distortions caused by harmonic currents. The fault level of the network is also checked, in case it is not already known. Based on these measurements, the size of the SVC is calculated, the parameters for the filters and flicker reduction are assessed.

Since Nokian Capacitors manufactures the main components of the SVC, it has full control of its delivery times. In fact, Nokian Capacitors is recognized for having exceptionally fast delivery times, without compromising the flexibility and individual service provided to its customers. Specific needs are also taken into consideration by Nokian Capacitors' international sales network team. The team provides high quality documentation (such as installation, operation and maintenance manuals) and operation training in the customer's language according to their requirements.



This figure shows the single line diagram of an SVC installation. The number of filter banks and switchgear configuration depends on specific project requirements.

# Digital control & protection at the heart of performance

The digital control system measures changes in the reactive power consumption and initiates corrections to either generate or consume reactive power. The software and hardware of the control system are designed by Nokian Capacitors, which are based on commercial circuit boards. The control system communicates easily with the other systems operated by the steel plant.

The SVC control system is based on three Motorola CPU powered PC boards in a virtual machine environment (VME) rack. The units are the master board, which calculates the output of the SVC, the slave board, that takes care of Programme Logic Control (PLC) operations and the communication interface, which transfers data between the VME rack and the Human Machine Interface (HMI) computer. The operations of the SVC are controlled through a user interface screen.

The control system and local HMI computer is connected to the remote HMI generally located in the control and operation centre, via Ethernet links. The remote HMI controls all the local operations and surveillance functions in the same manner as the local HMI computer.

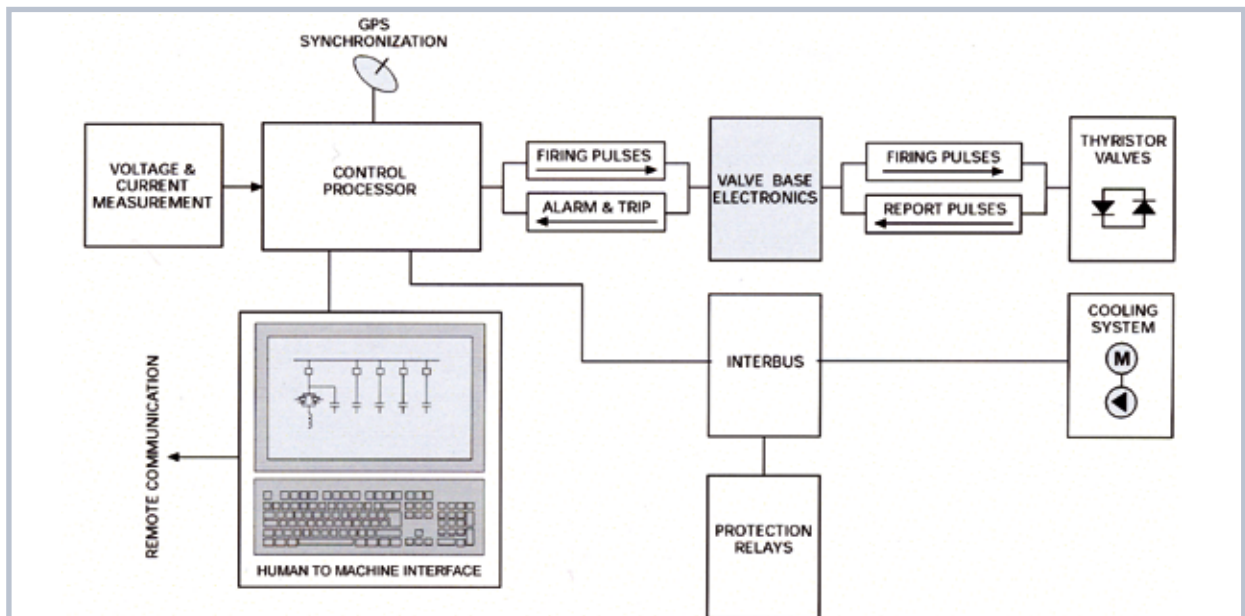
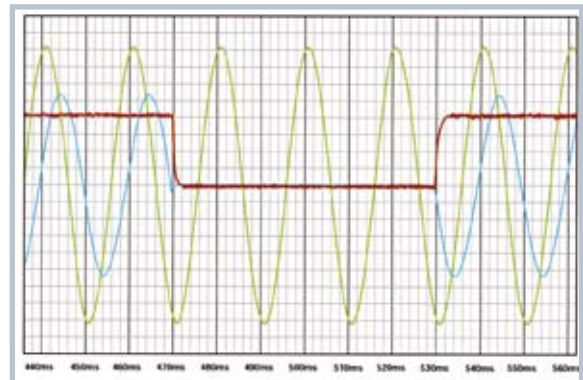
The performance of the control system is essential for flicker reduction. The main parameter is the response time of the SVC control system, which varies between one to three milliseconds depending on the degree of the load current. Thus, the maximum response time of the complete SVC installation is 10 ms in a 50 Hz network due to the point of wave firing of the thyristor valves.

The control system meets all EMC (Electro Magnetic Compatibility) requirements. Nokian Capacitors runs a simulation in an RTDS (Real Time Digital Simulation) environment when developing the digital control system of each plant.

**The software and hardware of the control system are designed by Nokian Capacitors.**

### Step responses of the control systems.

The figure on the right shows the measured step response of the control system. The green curve is the phase voltage. To the left of the curve, the 60 degree lagging current (red curve) is stepwise interrupted. To the right there is a stepwise switching on the load current. The blue curve is the measured reactive power signal used to control the thyristor valves. The thyristor valve causes an additional delay depending on the point of wave switching requirement. This may be between 0 to 10 ms.



Block diagram of the control system.

# Quality System

Nokian Capacitors' Quality System fulfils the requirements of the ISO 9001:2000 standard. The ISO 9001 certificate was received in 1993 and updated to ISO 9001:2000.

Environmental aspects have always been taken into account during the design, manufacturing and delivery of Nokian Capacitors' products. In 2000 Nokian Capacitors received the certificate conforming to the environmental standard, ISO 14001. In 2004, Nokian Capacitors received the IQNet 2004 certificate and in 2005 the OHSAS 18001 certificate.

**We participate  
in IEC, CIGRE and IEEE actions.**



# Static Var Compensator in industrial applications - Photogallery



Myanmar, 3 filter.



Sidmed SVC, Spain



Sidmed, Spain SVC 65 Mvar, 20 kV, 50 Hz



OUTOKUMPU POLARIT, Tornio Finland SVC 130 Mvar, 20 kV 50 Hz



SVC for Danieli, Italy. Factory tests at Nokian Capacitors

# Highlights of NC Service Concept

## A Series Capacitors delivery includes:

- Series capacitor equipment
- Installation
- Commissioning
- Civil works (in turnkey projects)
- Spare parts
- Training

## NC Service also has these services that the customer can take advantage of:

### 1.

NC Remote Service guarantees expert operational support worldwide and aims at uninterrupted transmission. Nokia Capacitors has a hotline service for phone and e-mail support.

### 2.

Documentation

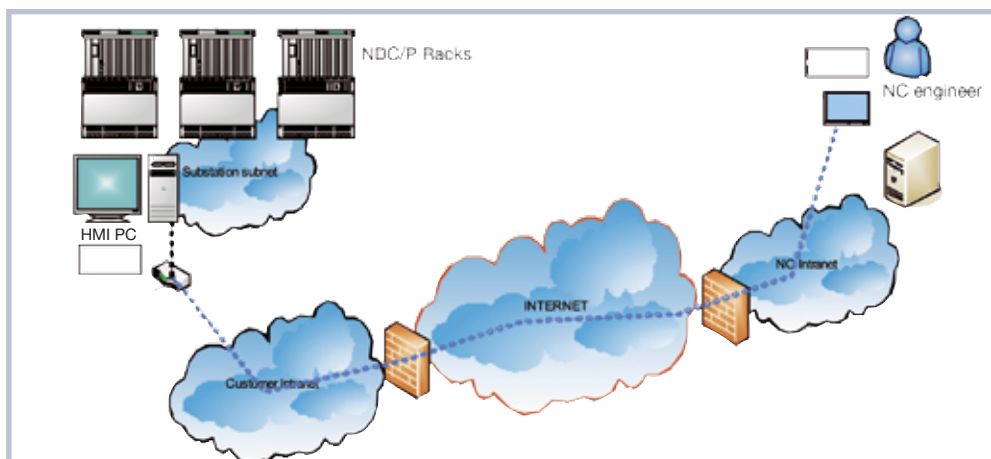
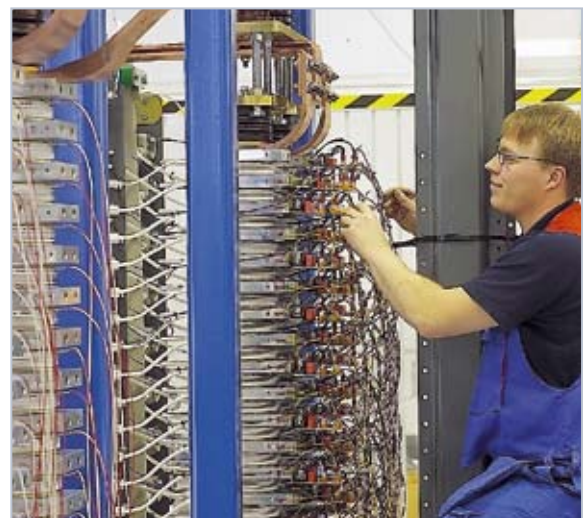
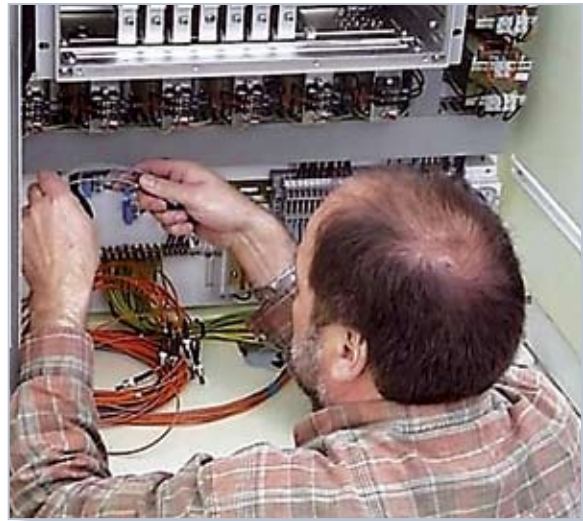
Each project has its own scope of delivered documents. It is possible to download the complete documentation from our Share Point web server. The documentation consists of the following:

- General Documents
- Studies
- Specifications
- Quality Documents
- Test reports
- Drawings
- Manuals

On our Share Point web server, the customers' own contract documentation can be easily found (with a user name and password).

Our aim is to fulfil our customers' needs.

Nokia Capacitors follows the security policy provided by SSL. That policy covers all documentation on our web server.



NC Remote Service

# Data required for the design of a Static Var Compensator

Having read about the operational and economical benefits of the SVC, we now invite you to contact us to discuss the issues listed below.

Each SVC is designed individually, taking into consideration the special characteristics of the plant. The following list is an example of the information required for the design of an SVC for an arc furnace or rolling mill application. In case not all of the information is available, the preliminary design of the SVC can be done using the limited data.

<b>Data required for the design of an industrial SVC</b>		
<b>1. Schematic diagram of the system to which the SVC will be connected</b>		
<b>2. Data for the Point of Common Coupling (PCC)</b>		
2.1	Rated voltage	_____
2.2	Frequency	_____
2.3	Maximum and minimum short circuit power	_____
<b>3. Data for the step down transformer</b>		
3.1	Voltage (primary/secondary)	_____
3.2	Rated power	_____
3.3	Short circuit reactance	_____
<b>4. Load data (Arc Furnace)</b>		
4.1	Type: Electric Arc Furnace (EAF), Ladle Furnace (LF), AC or DC Furnace	_____
4.2	Series reactor rated inductance	_____
4.3	Power of furnace transformer	_____
4.4	Primary and secondary current of furnace	_____
<b>5. Transformer</b>		
5.1	Short circuit reactance	_____
5.2	Secondary circuit reactance	_____
5.3	Severity factor Pst	_____
5.4	Harmonics generated by the furnace (normally up to 23rd harmonics)	_____
5.5	Load cycle of the furnace	_____
5.6	Information about the used scrap metal	_____
<b>6. Data for rolling mill</b>		
6.1	Power (active, reactive)	_____
6.2	Load cycle	_____
6.3	Generated harmonics	_____
<b>7. Power utility's requirements for the PCC</b>		
7.1	Power factor or requested reactive power window	_____
7.2	Total voltage harmonic distortion, THD	_____
7.3	Odd voltage harmonic distortion	_____
7.4	Even voltage harmonic distortion	_____
7.5	Flicker Pst	_____
7.6	Voltage fluctuation	_____
7.7	Voltage unbalance	_____
7.8	Current distortion (if specified)	_____

## Our Competence Portfolio

- Project Management
- System and Equipment Studies
- Electrical Engineering
- System Engineering
- Software Engineering
- Requirements Analysis and Management
- System Architecture Design
- Hardware Design
- Software Design, HW/SW Interaction
- UML (Design methodology)
- Software and Hardware Implementation
- C/C++ (Programming languages)
- Testing Methodologies
- Real-Time Operating Systems
- Protocols
  - IEC 60870-5-101
  - IEC 60870-5-103
  - IEC 60870-5-104
  - DNP 3.0
  - TCP/IP
  - MODBUS
  - PROFIBUS
  - IRIG-B
- Control and Protection Systems
  - Real-time measurement and modeling
  - I/O intensive real-time applications
  - Algorithms, PID-controllers, Laplacian transform, matrices and vector algebra



## Highlights

- Efficient method to maximize power transmission capability
- High availability with low maintenance costs
- High reliability with full redundancy
- Designed to endure severe conditions - from freezing to extreme heat
- Remote operability and service

Nokian Capacitors has 50 years of experience in reactive power compensation. Combining in-depth knowledge of modern digital technology, industrial control and our world-class high voltage products we are a unique combination of excellence. Don't miss the opportunity to work with an industry leader – contact us!



**Most high voltage equipment is made at Nokian Capacitors.**

## Other products

In addition to Industrial SVCs, Nokian Capacitors is also a manufacturer of:

- Series Capacitors
- Utility Static Var Compensators (SVC)
- SVC MaxSine
- MaxSine active filters
- Railway series capacitors
- Air core reactors
- Shunt capacitor banks
- Filter capacitor banks
- High voltage capacitor units
- Low voltage capacitor units
- Control and Protection System for capacitor banks
- Power factor controllers
- Unbalance relays
- Capacitance meters (clamp type)
- Enclosed Medium Voltage (MV) banks



In line with our policy of ongoing product development we reserve the right to alter specifications.



Nokian Capacitors Ltd.  
Kaapelikatu 3, P.O. Box 4  
FI-33331 Tampere, Finland  
Tel. +358 3 3883 11, fax +358 3 3883 360  
[www.nokiancapacitors.com](http://www.nokiancapacitors.com)

EN-OS01-02/2007