

standards such as the European UCTE, and were achieved at moderate retrofit costs. The new technology allowed the utilization of existing power fluid pumps and systems, and hydraulic servomotors with their pilot valves. The maintenance costs were reduced by removal of hydraulic control components. Control valve's oscillation was eliminated thereby extending steam distribution system's life, and reducing spare parts costs. Savings were also obtained on the turbine oil system maintenance due to the lowered requirements for oil purity and quantity.

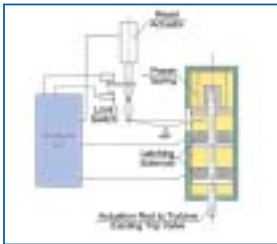
**All-Electric Overspeed Trip Simplifies Testing Procedure and Extends Turbine Lifetime**

Overspeed faults, which might occur in the steam turbine operation, may cause loss of life and enormous damage.

Traditionally, turbines are protected from destructive overspeed trips through the use of a mechanical trip mechanism. Problems with this device such as its difficult adjustment, low accuracy and repeatability of the trip point, are well known. In addition, the mechanical overspeed trip test must be performed regularly. This test is associated with an increase of turbine speed above its design condition and with significant increase of centrifugal forces to the rotors and bladings, what causing additional lifetime consumption of the rotating parts. Shaft vibration may rapidly increase during this test. There are documented incidents of blading failures on aging turbines.

A solution to these problems has traditionally been replacing the mechanical trip device with the

electronic (EOT) protection devices, which are available from various manufacturers. Compressor Controls Corporation offers the Guardian(r), an advanced 2-out-of-3 overspeed system with data communication and self-test features. Some steam turbine OEM's supply all-electric trip systems with their new steam turbines as a standard offering since the 90's. However, a traditional way of upgrading existing mechanical trip systems with a new EOT device by connecting it to the original Mechanical Trip Solenoid proved to be ineffective. The solenoid is usually an energize-to-trip device; hence, it is not always reliable and it is slow.



Electrical Trip Actuator

To enhance the EOT performance and help integrate it into any turbine safety system, CCC developed the Electrical Trip Actuator -- a de-energize-to-trip, spring-operated mechanism that replaces the ineffective mechanical trip solenoid. This mechanism is driven by the EOT output, and trips the turbine's original Emergency Trip Valve. The new EOT systems with the Electrical Trip Actuator are fast acting and reliable. A single component failure doesn't cause a turbine trip. All components can be tested with the turbine on-line.



*For more information on CCC products and services or to discuss unique solutions for your specific turbomachinery control needs, contact your CCC Sales Representative or the CCC office nearest you or e-mail solutions@ccglobal.com.*

*CCC is the world leader in turbomachinery control solutions. We are uniquely qualified to solve your turbomachinery control problems. We will help you achieve maximum performance of your turbomachinery, regardless of your equipment or process, while providing superior customer services.*



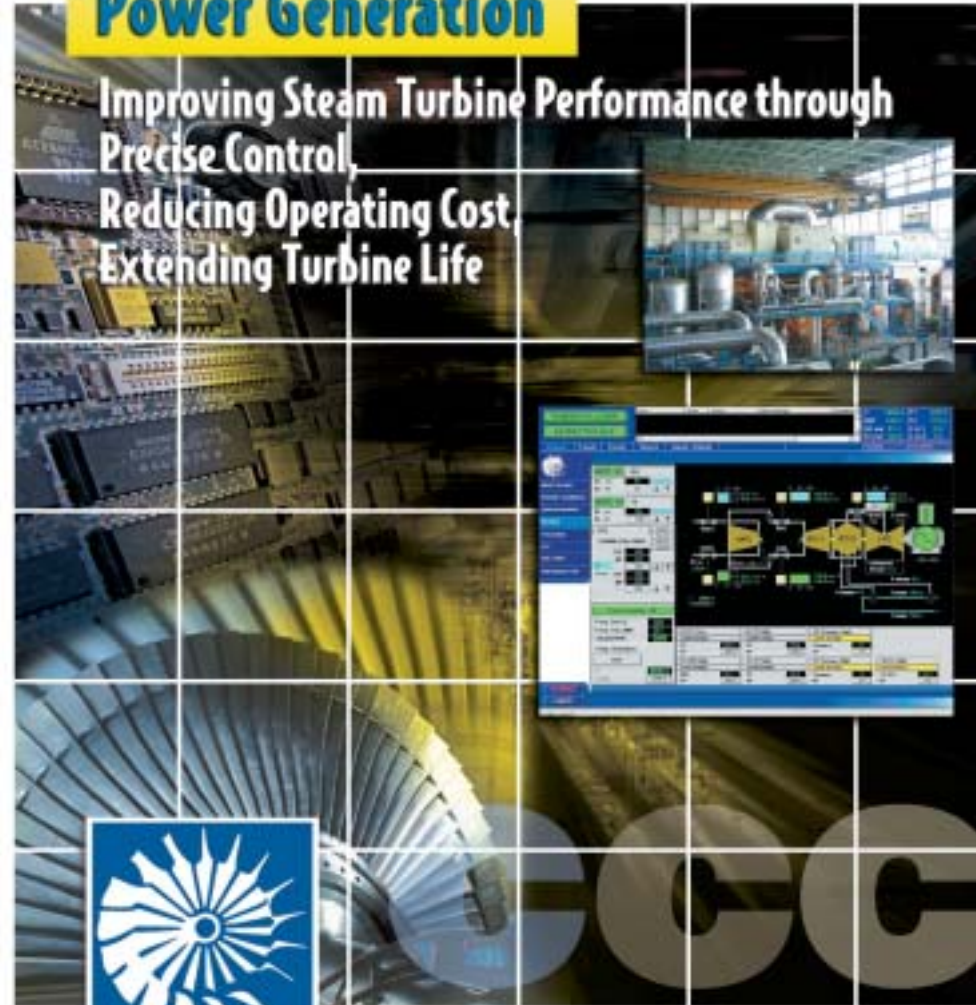
**Compressor Controls Corporation International Headquarters**  
4725 121st Street  
Des Moines, Iowa 50322-2316 USA  
Phone: (515) 270 0857  
Fax: (515) 270-1331

**CCC Worldwide**  
Houston, Texas, USA • Rio de Janeiro, Brazil  
London, UK • Amsterdam, The Netherlands  
Milan, Italy • Moscow, Russia  
Dammam, Saudi Arabia  
Dubai, United Arab Emirates • Beijing, China  
Singapore, Republic of Singapore

**An ISO 9001:2000 Certified Company**  
A Roper Company  
E-mail: solutions@ccglobal.com  
Website: www.cccglobal.com

**CCC Solutions for Power Generation**

**Improving Steam Turbine Performance through Precise Control, Reducing Operating Cost, Extending Turbine Life**



## Turbomachinery Control is Our Only Business

In 1974 Compressor Controls Corporation (CCC) changed the world of turbomachinery control with its revolutionary new solution for compressor antisurge control. The spirit of innovation has been driving the company ever since.

As of Fall of 2004, CCC systems are operating on over 7,500 turbomachinery trains around the world. Among them are steam turbine generators of different makes and power, such as Siemens (150 MW), Westinghouse (250 and 450 MW), GE (380 MW), LMZ (200, 300 and 800 MW), Turboatom (300 MW), UTMZ (100 and 250 MW), and smaller turbines driving generators and boiler feed pumps.



Turbomachinery control is our only business. With our tradition of innovation, many years of hands-on experience and a wide range of successful installations around the globe we are uniquely qualified to provide superior turbine control solutions and outstanding customer services that improve your power generation unit performance and save energy.

## CCC's All-Digital Control System Improves Turbine Performance and Saves Money By Reducing Maintenance and Operating Costs

CCC's Series 5™ control system is a state-of-the-art digital controller for new steam turbines and the retrofit of obsolete analog electro-hydraulic (EHC) and hydraulic controls (HC). Some of the advantages of the new digital control over the analog EHC and HC are:

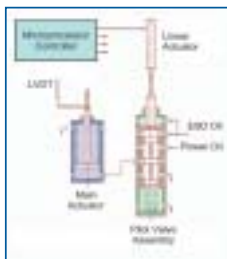
- Flexibility and increased precision of controls because functions are determined by software rather than hardware
- Advanced operator interface
- Communication with plant DCS
- On-line repair capability for redundant systems
- Higher reliability.

Still, a digital controller traditionally must be supplemented with analog electrical-hydraulic transducers (EHT) for converting its demand signal into a control valve position. The turbine control systems with digital controllers and analog EHT are known as digital electro-hydraulic controls (DEHC). Despite of the DEHC advantages over EHC and HC, some drawbacks of analog EHT are still intrinsic to the DEHC:

- High sensitivity to oil contamination and oil quality
- Pilot valves must oscillate to create the desired system sensitivity to a control signal but the oscillation results in fast wear of steam distribution parts.

For years CCC and other control system suppliers tried to employ different methods to eliminate these problems. The most popular solution was the installation of additional filters for fine purification of the control oil, plus the implementation of separate lubrication and control systems. These solutions have proven either inefficient or required considerable investment.

The EHT is an original part of an EHC system, and the aforementioned solutions to improve the EHT performance must be implemented in the system's original design. If those measures are sufficient and EHT performance is satisfactory, then it can



CCC All-Digital Electro-Mechanical Control

be integrated into the new DEHC system for simple and inexpensive retrofit.

However, for the retrofit of an HC system that has no EHT, end users had to consider significant investments to implement the solutions for upgrading to digital control.

Answering growing customer demands, CCC developed an innovative approach: a control system with a digital electric-to-mechanical transducer consisting of a digital servo drive (DSD) and a linear actuator.

The new CCC all-digital electro-mechanical turbine control (DEMC) system contains no hydraulic control components. The hydraulic is used exclusively as the power fluid. As a result, end users enjoy the following benefits:

- High static and dynamic control accuracy (in particular, grid frequency control accuracy better than 0.02% or 0.01 Hz)
- Precise control of turbine rotational speed during synchronization (accuracy better than 1 rpm)
- True absence of actuator and pilot oscillation
- Reduced requirements to the oil purity and to the filtration system
- Reduced requirements to the supply oil pressure stability



DEMC Linear Actuator Installed on a HP Hydraulic Servomotor of 300MW Utility Steam Turbine

Since December of 2000, multiple DEMC systems have been commissioned on steam turbo-generators sizes ranging from 100 to 800 MW, and on small boiler feed-water pumps steam turbines. Performance results exceeded requirements of the most demanding international

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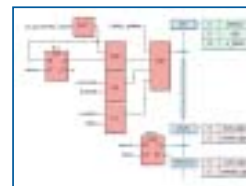
## CCC Control Solutions for Your Power Generation Application

**Control Functions** Whether your steam turbine is a prime mover of an electrical generator or a feed water pump, CCC provides a complete control solution. We offer a wide range of control and supplementary functions to optimize and enhance your steam turbine performance:

- Speed and acceleration control during start-up
- Synchronization and application of load in response to generation dispatch commands
- Pressure control of various forms: inlets, extraction, back pressure, etc.
- Unloading and securing of the turbine
- Sequencing of the above functions under constraint of thermal stress
- Limiting control of various forms: max MW; max inlet, first stage, extraction, back pressure or min inlet pressures
- Power utility grid frequency correction during normal and emergency situations
- Coordinated power generating unit control
- Overspeed protection during load rejection and emergencies
- Protection against serious hazards, e.g., loss of lube pressure, high exhaust temperature, high bearing vibration
- Testing of steam valves and other important protective functions
- Display, alarm, and recording of the above functions and data, data link to plant DCS

- Health check and diagnostics of the control system

**Application Software** The control functions listed above are supported by comprehensive package of our unique, fault-tolerant, field-proven control algorithms for power utility steam



Software Module Coding

turbines. These algorithms are conveniently organized into configurable core software modules:

- Speed Control (SC) - to control turbine with generator off-line and for limiting control of up to six variables,
- Utility Turbine Control (UTC) - to control turbine load with generator on-line while correcting utility grid frequency. It supports on-line frequency simulation mode for testing and documenting control system sensitivity and other design criteria,
- Power-Load Unbalance (PLU) - for handling generator load rejection events. It consists a comprehensive library of algorithms for reliable

detection a load rejection event with or without generator off-line and takes swift correcting actions to prevent turbine Overspeed Shutdown.

- Extraction (EX) for steam single or double extraction/induction control,
- Intercept Valve (IV) for Intercept Valve control,
- Valve Management (VM) - for individual valve sequencing under multi-valve, multi-actuator arrangements. Supports automatic valve characterization, and smooth full-arc, partial-arc transfer for improved turn-down, efficiency and control stability.

### More Than Just Steam Turbine Control

To provide a complete, cost-effective solution for your power-generation unit, CCC focuses on the control requirements for the entire unit and the capabilities of its control system. We design a system that coordinates the turbine-generator control system with the unit steam generation and steam extraction control. The turbine driven boiler feed water pump control is also coordinated with the entire system for better performance and energy savings.

CCC control systems feature a high-speed communication capability that allows implementing advanced loop decoupling strategies to coordinate control of the entire unit and prevent adverse control loop interactions and the associated problems.

## System Hardware and Software

Our control algorithms are implemented in several hardware and software platforms. **Vanguard® and Reliant® Hardware Platforms** support IEC-61131 applications. Both use fully deterministic, multitasking, real-time operating systems. The operating system and application software provide configuration and tuning from a TrainTools workstation with parameters stored in non-volatile controller memory, a variety of Operator Interface Options plus customizable Alarm and Events with controller time-stamping.



**Vanguard® Control Systems** are available in simplex and fault tolerant versions. The hardware configuration is flexible. In fault tolerant systems, modules are hot swappable. Redundant power supplies, FTA-terminated I/O, Ethernet & serial communications.



**Reliant® Controller** - is a cost effective solution for smaller systems available in simplex or duplex versions. Rack/panel mount packaging with integrated terminations, serial communications.



**Guardian® Overspeed Prevention System (OSP)** is a two-out-of-three voting system with the flexibility and ease of do-it-yourself installation and configuration.

