

ABB Review

The corporate technical journal
of the ABB Group

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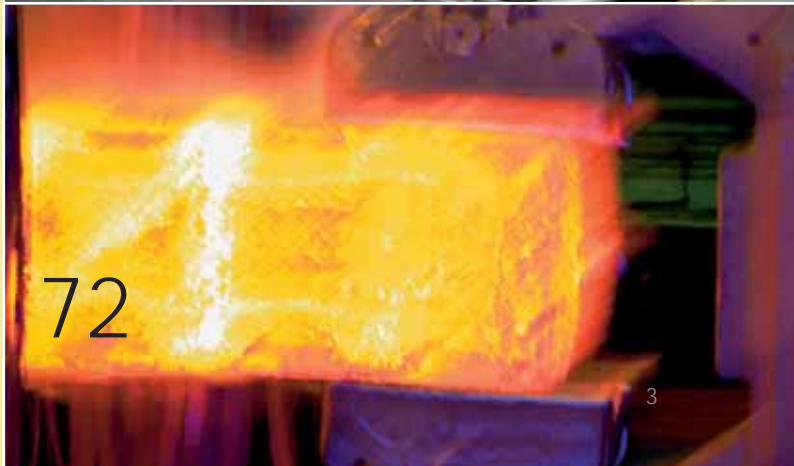
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ABB Process Automation – Focusing on customer needs

ABB is a global leader in the supply of electrical and automation technologies. Our Process Automation team is charged with delivering products, services, and complete industry solutions through a variety of channels. However what we deliver is only valued if we can clearly demonstrate how it meets the critical business needs of customers, in particular in the areas of operational profitability, capital productivity, risk management and global responsibility.

Many customers would suggest that maximizing production efficiency is the most important requirement of a process automation solution. To that end, our industrial business units are constantly developing applications that allow plants or equipment to run at maximum output, consistently producing high-quality products. Our IndustrialIT solutions integrate engineering, operations and maintenance activities on a common technology platform, thus improving overall plant efficiency and safety. Our Asset Management and Performance Service solutions minimize downtime and help to reduce variable costs such as labor, maintenance and consumables. In this era of record energy consumption, our solutions for energy management help plant operators to reduce both cost and environmental impact.

ABB customers expect a high return on their automation investments, and we offer many ways of improving the productivity of capital. Our early involvement in projects helps to optimize engineering and design cycles, thus lowering project costs while meeting or exceeding design goals. Overall procurement and commissioning costs are further lowered by customers who select ABB as their main electrical, automation, analytic or instrumentation partner. To ensure both performance and longevity for these investments, we offer industry's most comprehensive lifecycle management program.

Risk is a major characteristic of any process automation project. Project inefficiency or poor product quality can add cost, delay schedules, or increase project hazards. To reduce these risks, our Centers of Excellence develop tested, certified and reusable industrial applications for repeatable performance, shorter project schedules and

smoother start-ups. Through our global account program, we also develop customer-specific "best practices" to ensure consistent project delivery regardless of size, complexity, scope or geographic location.

Like ABB, most companies today are embracing a renewed commitment to social responsibility. Customer investments in our integrated safety and control systems help ensure safe and secure working conditions for employees, protection of the environment, and the re-use of installed assets. This approach helps customers protect their reputation and license to operate, while meeting ever more demanding regulatory and compliance requirements. ABB's commitment to social responsibility reflects well on customers who share our high standards for business ethics, health and safety, and community spirit.

Viewed collectively, the business needs of our customers are complex. Viewed individually, each one is yet another opportunity to deliver proven solutions for power, productivity and sustainability that help make the world a better place. Many of the products, applications and services that fulfill these business needs are showcased in this ABB Review Special Report. I hope you find the collection of articles informative and interesting. Most importantly, I invite you to explore the world of ABB Process Automation, and to learn of the many products, services and solutions on offer to help improve your productivity.

Veli-Matti Reinikkala
Process Automation Division Head
Member of the Executive Committee
ABB Ltd

ABB Industrial^{IT}

Providing the business value proposition for automation

Larry O'Brien, ARC Advisory Group



ABB introduced its Industrial^{IT} concept in 2000, the goal of which was to expand the role of industrial automation beyond that of a traditional DCS system. This was to be accomplished by integrating the domain of traditional process control with the domain of IT technologies and applications. The combination of industrial focus and IT infrastructure would deliver a unified information system for control, engineering, maintenance, planning and more.

Automation Systems

Nowadays, end users are finding that technology alone is no longer sufficient to justify automation purchases. Instead automation must provide solid business value benefits based on a combination of metrics, such as enhanced asset availability, return on assets, reduced lifecycle cost, and many other strategic and financial objectives ¹. Industrial^{IT} provides this value proposition with an open technology platform that provides seamless access to data from all areas of the plant and the enterprise. Therefore, ABB's goal today is to show the bottom line economic impact and improved business performance that can be obtained through implementation of Industrial^{IT} solutions.

The following article is an executive summary of an ARC Advisory Group report¹⁾ on ABB's Industrial^{IT} architectural concept.

800xA is core of the Industrial^{IT} offering

At the core of all Industrial^{IT} solutions is the System 800xA Extended Automation control system²⁾. Extending the core of System 800xA hardware and applications are ABB and third party products that have been tested and certified (Industrial^{IT} Enabled³⁾) to verify proper operation with an 800xA

system. A powerful object-oriented technology called Aspect Objects underlies all of the Industrial^{IT} offerings and resides at the core of System 800xA. Simply put, Aspect Objects allow users to view any aspect of the automation scheme, from a pump or a valve to a process unit or pressure transmitter, as a software object. Each object in the system has a number of attached aspects ^{Factbox} that can range from integration to computerized maintenance management systems (CMMS) and Enterprise Asset Management (EAM) systems to schematic drawings and trending information. Aspect Objects provides the key real-time linkage between equipment and applications.

800xA supports ARC's Collaborative Automation vision

A key aspect of ARC's vision for Collaborative Process Automation Systems (CPAS) includes a single, unified environment for the presentation of information to the operator, as well as the ability to present information in context to the right people at the right time from any point within the system. System 800xA provides these functions with a single window environment for information access and context sensitive decision and action tools, and builds on a common environment for engineering, operations,

information management, and asset optimization. System 800xA also provides a common operator environment for ABB's entire portfolio of safety and process control systems, providing access to information across the enterprise as well as context sensitive decision and action tools that allow the right users access to the right information at the right time from any point within the system.

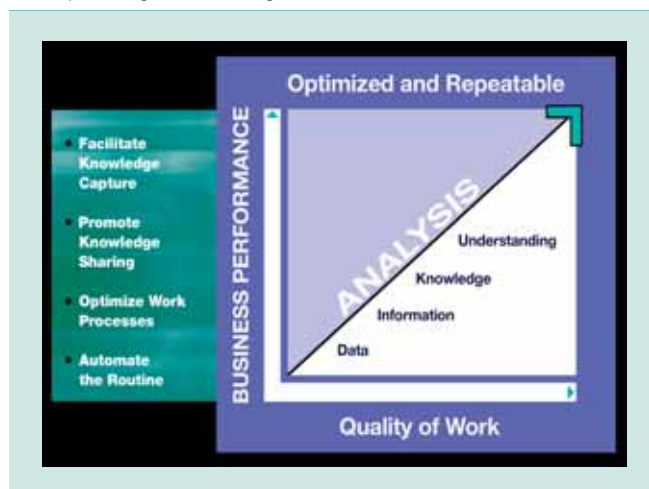
Capital deployment is reduced through planned upgrades for installed systems and the use of Overall Equipment Effectiveness tools.

In the next phase of their evolution process automation systems will be considered the sentinel of plant performance. They will continue to facilitate process control but will also become the primary source of manufacturing data and information for Collaborative Manufacturing Management (CMM) applications all within a robust environment. Similarly, a key strength of System 800xA is its ability to extend its reach beyond the traditional functions of the Distributed Control System (DCS) to include functions

1 Core business values



2 Empowering the knowledge worker



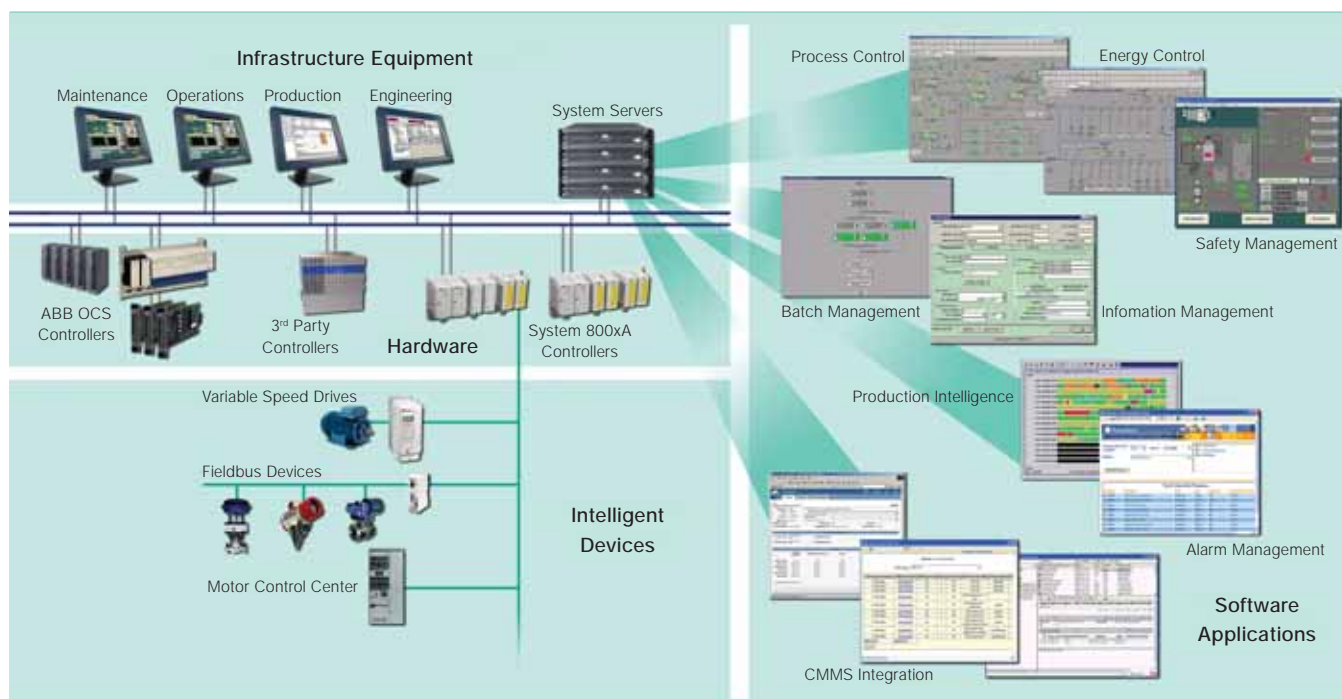
Footnotes

¹⁾ The full, 32 page article can be found on www.abb.com/industrialit

²⁾ www.abb.com/product/us/9AAC115756.aspx?country=US (October 2006)

³⁾ This symbol on products from ABB and its strategic partners means a product has been tested and certified for compliance with Industrial^{IT} standards for information, integration, and architecture.

3 Extended automation



such as production management, safety and critical control, advanced control, information management, smart instrumentation, smart drives and motor control centers, asset management, and documentation management capabilities.

Over US\$ 20 billion or almost 5 percent of production in the process industries is lost to unscheduled downtime.

Reduced total cost of ownership and enhanced asset utilization

The three core areas where Industrial^{IT} provides business value are:

- Increased productivity
- Reduced total cost of ownership
- Enhanced safety through reducing risk and providing a high level of security.

The value proposition of an automation system rests in its ability to provide enhanced asset utilization and reduced total cost of ownership (TCO). Companies are in business to make money through adding value. The amount of profit resulting from this endeavor is directly related to the

asset utilization rate. A recent ARC survey conducted with 107 operations and management personnel – 86 percent of which came from the process and hybrid industries, showed a definite shift toward making return on assets (ROA) the primary criterion in justifying process automation.

ABB offers a path to reduced TCO through reduced engineering and design costs from integrated front end engineering tools, standardized workflow processes around the ISA 95 standard and standard ERP/CMMS connectors. Capital deployment is reduced through planned upgrades for installed systems and the use of Overall Equipment Effectiveness (OEE) tools. Maintenance costs can be reduced by integrating operations and maintenance data, through the integration of control systems with ERP systems, and by embedding operator knowledge about maintenance into the process automation system. Daily operating expenses can be reduced by offering contextual data access, reducing cycle times, and consolidating multiple data sources.

Increased productivity not just about cutting costs

In most cases, manufacturing assets are capable of performing design

Factbox Aspect Object technology

The following extract has been taken from "The ABCs of Industrial^{IT} ABB Review 1/2002, pages 6–13.

Aspect ObjectTM technology associates information with the plant and business entities (the objects) it belongs to, by organizing these objects to mirror reality and by providing powerful functions for navigation and searching. Expanding further, the Industrial^{IT} concept defines the collection of information required to support each plant component as an Aspect Object – containing all the characteristics, or Aspects of the device. Aspect Objects can also be things such as finished products, raw materials, sales and manufacturing orders. An electric motor for example could be represented by an Aspect Object containing all the real-time information connected with it. This might include design drawings, control diagrams, maintenance information, location, quality information and configuration information. It is important to realize that an Aspect is not just the real-time information connected with a particular Aspect Object; it also defines a set of software functions that create, access and manipulate this information.

Automation Systems

specifications. Reliability and utilization, however, are suffering from constrained human performance. According to ARC, over US\$ 20 billion or almost 5 percent of production in the process industries is lost to unscheduled downtime. Up to 78 percent of that is readily preventable. Human error, primarily operator error, is responsible for 40 percent. This can be addressed by using both the operators and the automation more effectively.

The biggest change in plant performance improvement for the 21st century and a key vehicle for reducing this unplanned downtime will come from the empowerment of the knowledge worker. Manufacturing will undergo fundamental organizational changes because of operators becoming knowledge workers empowered with information ². This proliferation of information is causing organizational structures to flatten, pushing down the authority and responsibility associated with the distribution of information. A higher level of coordination at lower levels is also required.

ABB's Industrial^{IT} solutions enable knowledge workers in several key ways, but probably one of the most important factors include providing information in context. Another important factor includes providing a unified platform for plant and asset maintenance management that also automates the transactions between the automation system and computerized maintenance management systems (CMMS), also known as Enterprise Asset Management (EAM) platforms ³.

Maintenance is one of the most significant and untapped areas of cost savings in plants today, and also one of the most overlooked. According to DuPont, for example, maintenance is the largest single controllable expenditure in the plant, with maintenance budgets accounting for around two-thirds of annual net profit. According to Dow, the cost of unnecessary maintenance is about the same size as the total plant profit. Shell Global Solutions estimates that about 63 percent of maintenance labor results in no action at all.

ABB's approach to plant maintenance is to provide an environment where information is transparently accessible to users in both the process control system and the maintenance system environments, regardless of where the information has originated. This is consistent with ARC's view that information should be provided in context so the maintenance personnel have access to all the information they need when they need it, regardless of its source or location.

Increased safety and security has direct impact on profitability

ARC believes that end users must take an integrated approach to plant safety, plant security, and risk reduction. Through its approach to the integration of control and safety systems, ABB provides enhanced plant security, and reduced risk through an integrated approach to project management where it can serve as the main automation contractor (MAC). Unscheduled downtime – unexpected stoppages resulting from equipment failure, operator error, or nuisance trips – is the nemesis of all manufacturers. Providing a path toward better safety and security also means providing a path toward increased reliability.

Maintenance is one of the most significant and untapped areas of cost savings in plants today, and also one of the most overlooked.

Implementation of an integrated control and safety system, such as the integrated critical control capabilities of ABB's System 800xA High Integrity (see next paragraph), allows users to significantly reduce risk and realize the benefits of an advanced strategy for critical condition management (CCM). Aside from the safety aspect, ABB reduces risk by providing a single point of responsibility through its MAC capabilities. On the software side, the company has embedded functionality such as secure design practices, patch programs, audit trails, and advanced access control.

System 800xA High Integrity is a IEC 61508 and IEC 61511 compliant Safety Instrumented System (SIS) that spans the safety loop, including Safety Integrity Level (SIL) rated controllers, field devices, I/O modules, and field actuators. Embedded safety and control are within the same architecture providing a common high integrity system environment for production control, safety supervision, and production monitoring. This architecture provides the option of combining control and safety functions within the same controller or keeping control and safety functions separate within the same system. With safety and process applications executing within the same system environment, and even within the same controller, System 800xA offers safe, instant interaction between applications.

ABB's positioning of Industrial^{IT} around the three primary domains of reduced cost of ownership, increased productivity, and reduced risk is a good fit with this increased focus on business value. ABB also has advanced capabilities in products, services, and vertical industries to help end users realize the business value and increased performance potential of automation. In terms of offering a high degree of functionality and a wide array of advanced applications, ABB is very strong and has a lot to offer. The future success of the company depends largely on its ability to successfully provide its customers with sustained and measurable benefits from automation that provide a path to continuous improvement for business performance and profitability.

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Footnote

⁴ *Founded in 1986, ARC Advisory Group is a research and advisory firm in the manufacturing and supply chain sector. www.arcweb.com

Mastering the assets

Asset Master software improves productivity

Eric Olson

Every year, heavy industries spend billions of dollars on maintenance; yet, equipment failure is the principal cause of production losses. There is now a wide appreciation that the development of new monitoring technologies is critical to reducing downtime and containing cost. Most importantly for industrial work practice, employing asset management will impel a shift in work culture, from routine and reactive maintenance to proactive maintenance.

As ships were to seafarers in the 15th century, the computer was to information processing in the 20th century. From number crunching to problem solving, it has become an indispensable tool in the ever-increasing complexity of today's work environments.

The history of computing is peopled with the most picturesque characters: Charles Babbage and his "Analytical Engine"; Ada Byron, who anticipated

computer programming by more than a century; John von Neumann, who proposed storing a program as electronic data; and Alan Turing, who believed that an algorithm could be developed for almost any problem.

Today, large organizations expect to examine and monitor the status of even the most remote outpost at the push of a button. Networks make this possible. It was in the 1970s that ARPANET was set up to connect

research organizations throughout the US. In time, this evolved into a worldwide network – the Internet. Taking advantage of networking technologies, it is now possible to create richer and more powerful applications that enable organizations to achieve higher operational efficiency.

Each progression in the evolution of information technology has been the result of a timely idea. The focus today is on integrating disparate tech-

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nologies and systems to achieve the next level in industrial automation.

Creating Asset Master –

a complete asset management tool Every year, heavy industries spend billions of dollars on maintenance; yet, equipment failure is the principal cause of production losses. There is now a wide appreciation that the development of new monitoring technologies is critical to reducing downtime and containing cost. Most importantly for industrial work practice, employing asset management will impel a shift in work culture, from routine and reactive maintenance to proactive maintenance. Complete asset management in industrial plants is an emerging opportunity and a present challenge, as changing customer needs tend to raise the bar in innovation.

The first step in defining Asset Master or “must have” features was to identify specific industry needs: The application needed to be capable of managing all areas of field instrument engineering, commissioning, and maintenance. It had to support ABB and third party devices. It needed to provide easy access for online and offline device configuration, parameter setting, online monitoring and

tuning, diagnostic alerts, asset monitoring, calibration management and integral work order processing. Finally, it needed to be scalable. The application had to focus on specific instrumentation needs for device management, while supporting direct integration into large scale process automation systems such as 800xA. Thus instrumentation and automation users alike could benefit from a common set of engineering resources and components.

Today, large organizations expect to examine and monitor the status of even the most remote outpost at the push of a button.

Most of these desired features for Asset Master were already present in ABB’s 800xA System and thus, it provided the perfect platform for creating Asset Master. By concentrating on providing a scaled down version of this functionality the precise needs of instrumentation users could be achieved. A six-tiered strategy was under taken for supporting a number of use cases **Factbox**.

The tiers provide extensive scope, from an “electronic screwdriver” at one extreme to a full device management tool installed on the common network using a central database at the other. Customers can start with a small maintenance based application and grow it into a larger control system using the same configuration data and navigation methods for both.

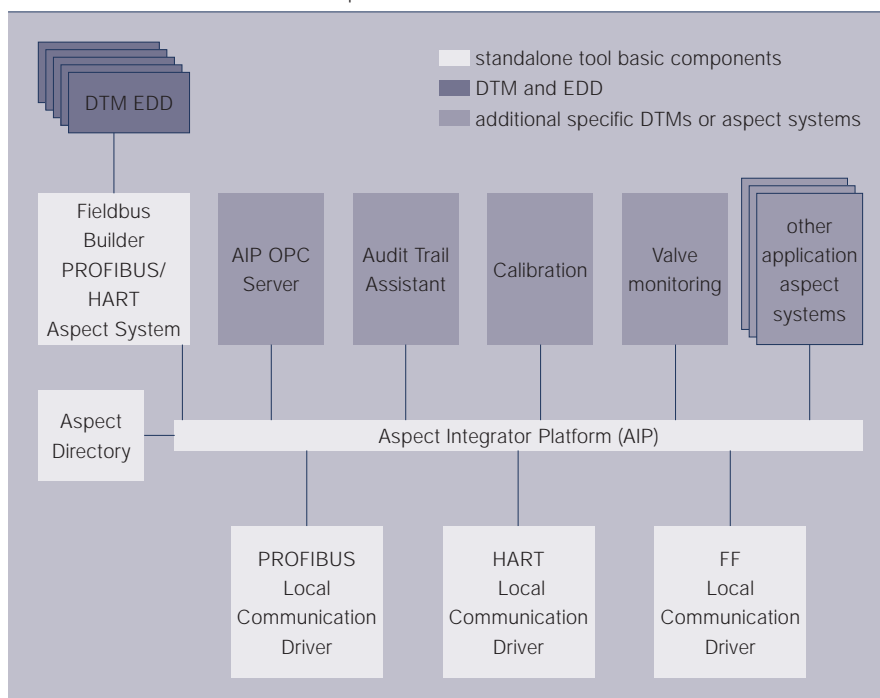
Named Asset Master, the software application for Tiers 3 through 5 is a single tool for all instruments, independent of the manufacturer of the device or the communication protocol (eg. HART, PROFIBUS, or Foundation Fieldbus).

Asset Master Architecture

Asset Master is based on the 800xA System and makes use of common features and components. It can be upgraded by using existing 800xA components such as audit trail, calibration management, maintenance trigger, etc. **1** shows the 800xA System architectural concept. The goal is to reuse as many components as possible.

The functionality of Asset Master will be synchronized and expanded with each release of 800xA. The initial release of Asset Master, scheduled for early 2007 will run on a stand-alone

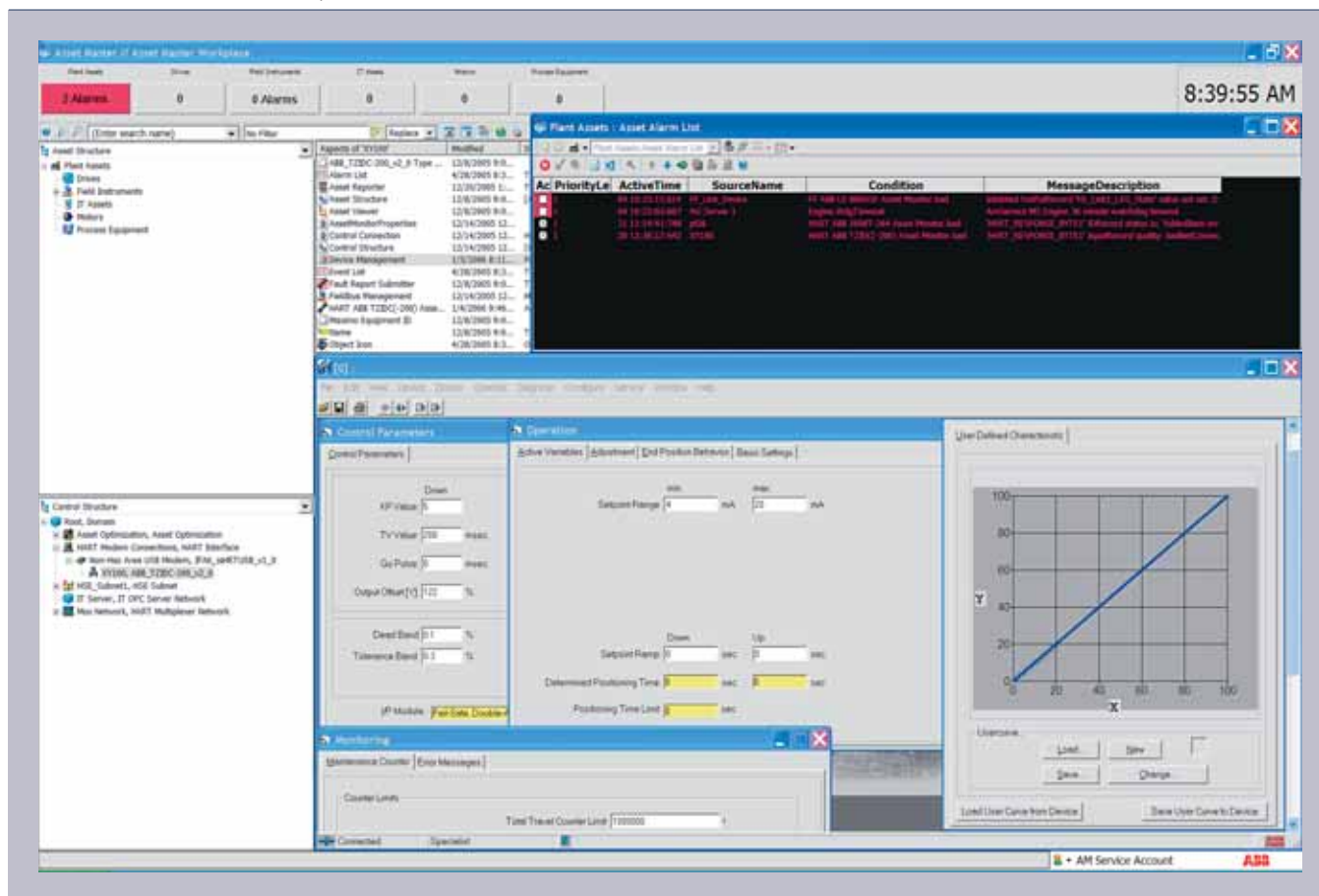
1 800xA software architecture concept



Factbox Six-tiered approach to asset management use cases

- **Tier 1:** Device configuration – PC – based setup tool, factory configured devices, and local device Human-Machine Interface (HMIs)
- **Tier 2:** Device configuration – Hand-held configuration of ABB and third-party devices and hand-held calibrator
- **Tier 3:** Configuration and visualization – 800xA based stand-alone PC configuration and visualization tool (base offering)
- **Tier 4:** Calibration – Device management calibration software (option to base offering)
- **Tier 5:** Asset optimization – Asset monitoring and reporting (option to base offering)
- **Tier 6:** 800xA – automation system (upgrade from base offering + options in Tiers 4 & 5)

2 Asset Master maintenance workplace



PC. It will employ a new Asset Master workplace derived from the existing maintenance workplace.

Instrument connections with Asset Master will be made in support of two primary use applications:

- point-to-point access for bench work configuration (HART via modems, PROFIBUS via adapters, and Foundation Fieldbus via ABB's LD800HSE)
- multiplexer access for online network configuration.

The Mobility hand-held calibrator for integrated calibration is an optional extra. In support of asset optimization, interfaces to asset condition monitoring and Computerized Maintenance Management System (CMMS) are also available as optional offerings.

Considering the rise in transfer of digital information over cellular networks, an option for SMS messaging

to cell phones and pagers will also be supported. The 800xA includes all of these optional features and provides them unaltered for use by Asset Master.

Every year, heavy industries spend billions of dollars on maintenance; yet, equipment failure is the principal cause of production losses.

Asset master functionality

Asset Master runs on Windows XP from a single PC workstation, and provides concurrent connections with HART, PROFIBUS, and FOUNDATION Fieldbus devices. Software installation is straightforward, usually taking less than 2 hours. Support for HART modems and PROFIBUS adapters goes beyond earlier online 800xA capabilities to provide offline bench configu-

ration of the connected fieldbus devices. A search function simplifies efforts in identifying all fieldbus devices connected to the modem, adapter, or linking device.

The Asset Master Workplace display environment focuses on maintenance needs and is comprised of an alarm band that identifies asset condition events organized by asset type (pressure, flow, etc.), a browser for organizing and selecting assets and their displays or data functions, and a viewing area to see the selected display or data 2.

This workplace reduces the time it takes to comprehend the state of all plant assets. Asset monitors are provided to identify not only the fault, but also the probable cause and the suggested corrective action. Asset conditions can trigger a cell phone message to designated personnel. Graphical based DTMs monitor and configure HART and PROFIBUS devices to

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improve plant operation and production. FOUNDATION Fieldbus device and network configuration is integrated with the LD800HSE linking device for setting up and monitoring the Link Active Scheduler and function block applications. Device calibration notices and asset conditions can be used to trigger a work order submittal to a Computerized Maintenance Management System (CMMS) such as MRO Maximo or SAP / PM that can then be tracked through completion from the Asset Master workplace.

Because Asset Master uses a streamlined version of 800xA, it can easily integrate into larger 800xA systems. This allows a site to start small with Asset Master and grow over time into a larger 800xA system.

Key benefits

In the area of Fieldbus Device Management, Asset Master provides significant benefits. Primarily, it offers a single tool to configure and diagnose multi-vendor devices, thus reducing capital expenditure on tools and training and removing the user's burden of selection.

The full value of intelligent field devices, that provide critical information on their own health and the health of processes and equipment around them, can be realized only when used in combination with asset optimization software. Asset Master offers improved productivity through choice of devices that best fit the application, independent of fieldbus-type.

Asset Master reduces configuration time by using pre-configured field device objects with extended functionality to access device data, asset information and documentation. It also enables faster commissioning through certified devices and approved field device libraries.

It is in the area of Asset Optimization that Asset Master provides tangible economic benefits by reducing maintenance costs over a plant's life cycle and thus boosting the bottom line.

Independent of asset type, Asset Master provides a single interface for engineering, notification of plant maintenance

and asset optimization information. Real-time monitoring and alarming of asset Key Performance Indicators (KPI) facilitate fast, reliable implementation of corrective actions. Asset Master collects, aggregates and analyzes real-time plant asset information to provide advanced warning of degrading performance and/or impending failure. Asset Master's reporting features provide visualization of current health conditions, while its analysis features provide the ability to drill down to the root cause of failure. Integration of disparate CMMS, DMS and Fieldbus engineering tools provides users with a single view, leading to quick and efficient assessment of maintenance needs.

Customers can start with a small maintenance based application and develop it into a larger control system using the same configuration data and navigation methods for both.

Included standard with ABB manufactured instrumentation are highly integrated and comprehensive asset monitors that enable Asset Master to not only identify faults but to show probable cause and suggested corrective actions. This can reduce the mean time to troubleshoot and / or repair the fault leading to improved productivity.

In his book on predictive maintenance, Keith Mobley [1] points out that in the US alone, every year, upwards of \$200 billion is spent on plant equipment and facilities maintenance. Every year, ineffective maintenance management results in a loss of more than \$60 billion. Thus, maintenance can represent 15 to 60 percent of the cost of goods produced, depending on the specific industry. In an oil refinery, for example, the failure of a single valve during peak hours can result in a loss of hundreds of thousands of dollars. A one percent decrease in productivity can reduce output by hundreds of barrels a

day. Therefore, implementing Asset Master creates a substantial savings potential.

Asset Master can provide another significant benefit by ensuring industry compliance. For instance, pharmaceutical units, subject to rigorous Food and Drug Administration (FDA) regulations, rely on the trustworthiness of electronic records generated/managed by critical systems. A recent FDA regulation, 21 CFR Part 11, covers electronic records and signatures that affect production, quality and distribution of drugs in pharmaceutical units. With integration of Mobility Device Management System (DMS), Asset Master can provide users with FDA regulation 21 CFR Part 11 – enabled calibration solutions. In an industry where data integrity is critical to product quality and/or public safety, systems must be overall compliant with FDA regulations. Integrating DMS in the control system offers versatile plant life cycle management and organization allowing the user to derive maximum value from plant assets.

Reusing several 800xA award-winning features resulted in reduced development time for Asset Master and an end-to-end Asset Management Tool that assures compliance with industry regulations. Even now, the combination of intelligent field devices and asset management software is setting new standards for what can be expected and accomplished from the control room. This growing trend in using Asset Optimization will most likely accelerate in the future, fueled by the need for output improvement and cost reduction.

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Remote services

High tech means high service performance

Gordon Cheever, John Schroeder

“Emerging technologies” is a term probably heard most often in the world of research and development, and is usually associated with new products. In general, such a term does not tend to appear in the same sentence with “after sales service and support.”

Yet for companies like ABB with a huge client installed base, advances in technology are changing the way firms approach the subject of support. In addition, these same advances are directly helping clients improve their return on assets:



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With an installed base of more than \$100 billion worth of automation products and systems worldwide, ABB is constantly working on ways to improve the way these systems are supported. Remote services use existing and cutting edge technologies to support field engineers, irrespective of location, in ways only dreamed of five years ago. The Internet, together with advances in communications and encryption techniques, has contributed enormously to this. Remote service developments are a direct result of clients' changing needs. ABB has been told clearly in almost every industry it serves, that it must continue to improve the return on assets of the systems it delivers. This does not mean customers want less support, but rather more support at lower costs. Remote services are designed to maximize knowledge bases in the most cost-effective manner. The result should ensure that the best knowledge is in the right place, at the right time, to support the clients' assets. With a large number of different

types of products, this can be a complex undertaking.

Remote service benefits

A well-executed remote service offering can reduce unnecessary maintenance and downtime, improve production efficiency, track causes of failures, provide root cause data and fault diagnosis and recommend actions. It can provide predictive notification of impending failures allowing proactive instead of reactive corrective actions. Finally, it can allow remote specialists to apply their expertise to any factory in the world 24 hours per day, 7 days per week.

ABB's Remote Service business provides predictive and diagnostic capabilities serving all aspects of a plant – automation, equipment performance, equipment health, mechanics, electrification, electronics, and production to provide a complete solution.

Three levels of remote monitoring service are available to align with customer needs:

Remote troubleshooting

Remote troubleshooting provides expert on-demand, diagnostic remote support assistance in the event of a specific problem or failure. A demand-driven connection to the drive equipment is initiated to begin the troubleshooting process.

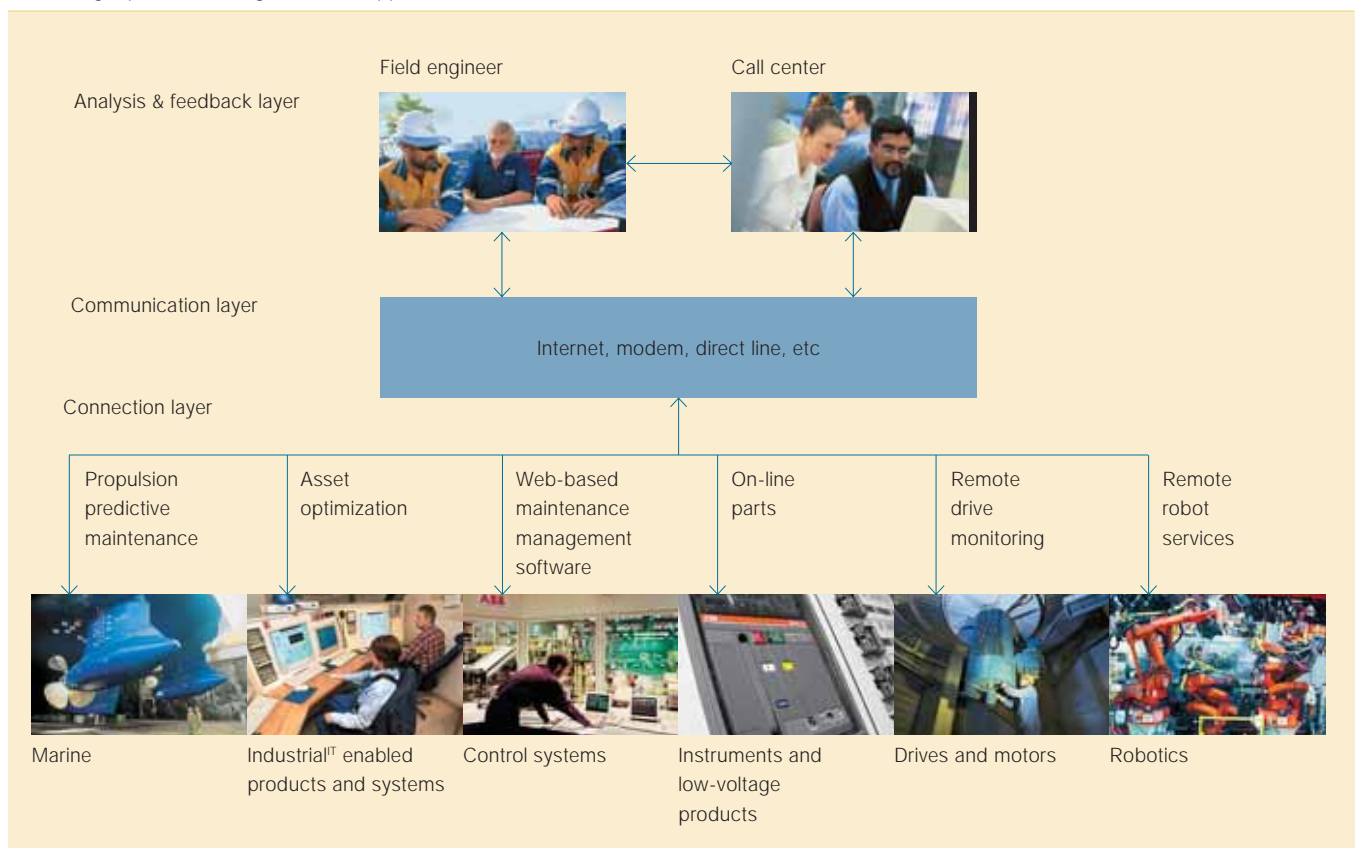
Periodic maintenance

Periodic maintenance provides a managed monitoring service for collection of equipment health information four times per year. Skilled support specialists provide expert data analysis based on established equipment benchmarks.

Continuous monitoring

Continuous monitoring provides continuous monitoring of key parameters. It automatically sends a message to an ABB monitoring center when parameters exceed limits. ABB specialists analyze the alarm and remotely access the device to further diagnose the issue. Corrective action recommendations are provided to the customer if required.

Remote services use existing and cutting-edge technologies to support on-site and field engineers, thereby ensuring the best knowledge is in the right place, at the right time to support the clients' assets.



Two types of alarms are generated:

- Predictive alarms: Device has not yet failed but key parameters indicate that a problem may occur.
- Reactive alarms: A problem has occurred and needs to be diagnosed.

Asset Optimizer as a key component

The Asset Optimizer, from ABB's Industrial^{IT} product portfolio, takes remote services a step further. The asset monitoring software acquires and analyzes asset status and condition information. Powerful analysis algorithms developed from ABB's deep process and maintenance knowledge, provide predictive and proactive information and alarming functions. Once an alarm is generated, ABB's remote monitoring engineers are notified. In addition to the alarm, the Asset Optimizer also provides important data related to the issue for ABB's remote expert to analyze and determines the root cause of the problem. On-site operators and maintenance personnel can also be notified when an abnormal condition has occurred that requires some form of maintenance action.

Advances in technology are changing the way firms approach the support of installed equipment, as well as helping clients improve their return on assets.

In addition, the Asset Optimizer can be directly linked to most computerized maintenance management software systems for automatic work order generation. This feature provides a powerful, integrated solution connecting site management, operations, maintenance, and ABB's remote service engineers allowing seamless communication and fast, efficient actions.

Remote services at work

The following examples illustrate how remote services in use today are giving customers more value at less cost:

Remote paper plant support

ABB provides remote services to a North American paper manufacturer that produces high performance linerboard. The remote service includes monitoring Control Loop and Quality Control System (QCS) performance. ABB's QCS solution is designed specifically for the pulp and paper industry and is designed to measure and control the weight, moisture and caliper (thickness) of the linerboard.

The remote service provides monitoring of the health of QCS System's scanners and sensors, the PID control loops, as well as the quality of the product. If potential problems are indicated (by monitor "trips"), ABB's remote monitoring center is alerted. These alarms often occur before a failure has even taken place.

The remote service has provided significant value to this customer. The remote monitors recently sensed abnormal changes in a device that was not scheduled for immediate maintenance. The device was replaced during a scheduled production stop. When the process came back up, all signals were normal. This paper plant was able to save approximately ten hours of unscheduled downtime by predicting when the device was about to fail, and changing it at the most cost-effective time – before an unplanned stoppage costing tens of thousands of dollars in losses could occur.

Remote robot support

When an issue arises concerning an installed robot, the on-site plant engineer calls ABB's global robotic expert center. The plant engineer then creates a direct link between the center and the installed equipment, but only after ensuring all local safety requirements are in place. Off-site experts review the equipment, diagnose the problem and either take direct action or provide instructions to the site engineer, who can then solve the problem.

The robot can also diagnose the problem itself, and then call ABB's global Robotic Expert Center for support. However, this raises safety concerns at the site. A balanced compromise is

reached with a combination of automatic and manual processes.

Remote power utility support

A major power utility producer in the United States recently experienced an issue that was preventing a startup. Using their support line subscription, they called ABB for technical support late on a Friday night. The caller feared he would not get results at that hour, and when he was told someone would return his call shortly, he felt certain his fears would be realized.

ABB holds the view that technology for technology's sake is not always the best solution.

Imagine his delight when an ABB Service Engineer (SE) returned his call within 30 minutes. The SE immediately proceeded to solve the problem. There was no waiting until the next business day – no waiting for an engineer to fly to the site!

This ABB customer had been resetting several modules. One had continued to report an error. By utilizing continuous monitoring, the service engineer determined that the module had to be reloaded, which he did remotely.

The service engineer utilized ABB's Remote Diagnostic Services (RDS) technology to optimize the power utility producer's assets in real-time.

The module was successfully reset. Delays and uncontrolled maintenance costs were avoided, while the startup stayed on schedule.

Remote condition monitoring

ABB holds the view that technology for technology's sake is not always the best solution. When it comes to vibration analysis in condition monitoring, for example, the company balances its services to provide a cost-effective, tiered approach. This means that an appropriate technical solution is determined based on the consequences of the asset failing and/or its cost. In the following, the case is considered of a simple low-cost motor in a non-critical application that is best supported

Operational profitability



when data is gathered manually. Vibration data is collected using small handheld devices. This data is then loaded onto a PC where a software application “decides” whether the vibration data is within specification. If not, the system will automatically upload the data to global ABB condition monitoring experts where another more in-depth software application screens it for recommendations. It then passes the final data and pre-analysis to dedicated vibration experts. A final review is done, and recommendations or work orders are sent back to the local site. In general, the level of automation for this process is based on asset costs versus human intervention costs at the client’s site. The systems for high-cost critical assets automatically and continuously monitor vibration data and provide specific analysis and work intervention 24 hours a day.

Remote power plant support

Kentucky’s primary energy services provider is Western Kentucky Energy, or WKE. In a recent pilot program, WKE’s Green Station in Sebree, Kentucky, (USA), utilized asset optimization to provide diagnostic service for their Harmony process control system (Harmony Continuous Monitoring). Asset monitors installed on-site sent critical asset data to the ABB monitoring center around the clock.

Remote diagnostics recently detected a failed backup communication mod-

ule before it became a costly issue. Had the primary communication module failed, the redundant module would have been unavailable and production would have ceased.

ABB must continue to improve the return on assets of the systems it delivers. This doesn’t mean customers want less support, but rather more support at lower cost.

Instead, WKE was notified in a timely manner, was able to schedule maintenance on the failed redundant unit during routine maintenance, and a costly stoppage was avoided completely. Production capacity was ensured and maintenance costs kept low through remote continuous monitoring.

Remote site asset monitoring enables optimized control system performance through continuous retrieval and evaluation of system performance indicators against established norms. If there are on-going issues, remote diagnostics will catch them. Coupled with automated incident reporting, remote monitoring provides reduced maintenance cost, enhanced production

quality, improved maintenance planning, and increased uptime.

Conclusion

ABB’s Remote Service business provides predictive and diagnostic capabilities serving all aspects of a plant – automation, equipment performance, equipment health, mechanics, electrification, electronics, production, and quality to provide a complete solution for our clients’ needs.

The primary benefits of Remote Services are that they increase asset availability and improve production efficiency. In addition, they maximize operations and maintenance effectiveness.

Remote Services can greatly contribute to the operational excellence and financial performance of a customer plant. The combination of powerful predictive and diagnostic analysis along with experts available 24 hours per day, 7 days per week can provide a highly effective means to remain competitive in the marketplace.

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Winning the battle with downtime

Tony Musgrave

In continuous manufacturing 90 percent of all potential failures are likely to be caused by just 10 per cent of the installed equipment. When planning preventive maintenance, it therefore makes good business sense to focus on this high-risk group. Risk Based Inspection (RBI) enable people to do exactly that. Recent experience has shown that ABB customers can benefit from a dramatic saving in time and cost by using this tool.

Operational profitability

Plant engineers fight a continuous battle with downtime. Although key contributors, maintenance and repairs are not, however, the only cause for concern; increasingly, it is the threat of business interruption, with its effect on output and profitability. The viability of a process, even the business itself, may be on the line as a result.

ABB Eutech¹⁾ has developed a Risk Based Inspection (RBI) method that enables companies to substantially increase plant reliability, reduce the number of plant failures and cut the time re-quired for regular inspection/maintenance.

Recent results with four customers in the chemical and petrochemical industry provide compelling evidence of major savings. The total cost of inspection, for example, could be reduced by 49 to 80 percent. Average inspection intervals were increased by between 35 and 57 percent, with an average increase of 44 percent. And more than half the plant equipment could be removed from the invasive inspection programs.

The bottom line is that RBI reduces downtime, planned or unplanned, for a saving in maintenance costs. The time and capacity/availability that is released as a result has a direct, positive effect on a plant's output.

The principles of RBI

RBI is a knowledge-based method that uses risk as a basis for prioritizing and managing an inspection program. In this definition, "risk" is seen as the result of the probability of future failure and the likely consequence of that failure.

Generally speaking, the level of risk associated with the different pieces of

equipment that make up a plant is variable. However, this fact is seldom reflected in the inspection routines applied across the inventory of equipment. Risk-based inspections focus the inspection and maintenance effort on those areas where the risk and its potential effects are greatest.

The prime objectives of an RBI program are to:

- Focus effort on identifying and reducing the safety and business risks.
- Achieve increased plant availability by ensuring that outages only take place for essential inspections.
- Reduce the maintenance costs associated with unnecessary or excessive dismantling and preparation.
- Improve safety by getting rid of hazards associated with preparing for inspections.

RBI is becoming the preferred tool by which "good engineering practice" is measured. Its predictive approach is designed to eliminate excess and inadequacy by concentrating inspection effort on real risks ¹. Use of RBI has shown to be effective in reducing the number of unforeseen breakdowns.

The ABB approach to RBI

ABB's RBI process is built around an asset care strategy that is designed to monitor the plant throughout its life-cycle. This involves the acquisition of detailed knowledge and requires a good understanding of the behavior of every component in the plant under its current duty conditions. Multi-disciplinary in its approach, it looks at parameters such as the design/construction quality, inspection/maintenance history, and the service conditions, including normal and abnormal excursions. The review identifies all failure mechanisms and associated risks.

This accumulated knowledge and experience helps engineers to decide what equipment needs to be inspected and when, as well as to establish where failure would be least acceptable and cause the most problems. This makes it easier to see where effort has to be focused in order to maximize the return. It facilitates the optimization of examination intervals whilst at the same time identifying equipment for which non-invasive examinations would be equally effective.

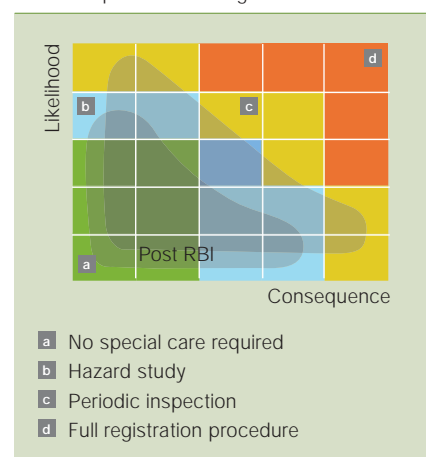
Average inspection intervals were increased by between 35 and 57 percent, with an average increase of 44 percent.

Up until now, ABB's experience has been mainly with pressure vessels. However, exactly the same approach is adopted when assessing risks for rotating equipment, critical instrumentation and structures.

The company's RBI approach relies on harnessing company and consultants' expertise as well as the use of sophisticated software tools.

ABB has refined its proven RBI approach into an efficient, streamlined solution called Risk Based Inspection⁺ ². The result of experience gained through hundreds of projects, it focuses on delivering tangible results by:

- ¹ RBI risk matrix: moving the operating risk envelope to a safer region



Factbox Typical recent results

Study	A	B	C	D
Average inspection interval before/after RBI study (months)	31 / 44	No data	54 / 85	48 / 65
Vessels moved to non-invasive inspection	16 out of 26	76 out of 157	90 out of 179	41 out of 82
Reduction in inspection costs	58%	49%	61%	81%

Operational profitability

- Accumulating comprehensive knowledge of the risks associated with specific plant assets.
- Significantly reducing the total cost of inspections.
- Achieving longer intervals between inspection/maintenance turnarounds and reducing the time needed for them.
- Ensuring much improved equipment availability and reliability, and minimizing unforeseen breakdowns, resulting in more uptime.
- Building greater confidence in equipment integrity.
- Providing an established path to all necessary regulatory approvals.

An outstanding example of the success of Risk Based Inspection+ implemented in close partnership with a customer is a project ABB undertook recently for Victrex plc, a UK polymer producer.

RBI delivers for Victrex

Victrex manufactures PEEK™ polymer, a high-performance thermoplastic with exceptional chemical, wear, electrical and temperature resistance. It is used in critical applications in the industrial, automotive, electronics, medical, aerospace and food industries around the world.

The company is actively expanding its markets for PEEK polymer through intensive marketing, customer-focused service and a commitment to product quality. Victrex is in the fortunate position of enjoying very high demand for its product. Its major challenge is to increase production while controlling overhead and investment costs.

Working with ABB, Victrex engineers were aiming to break out of the vicious loop that had always linked higher output to investment in new

plant. The general rule was that an annual increase of 100 tons in output always required an investment of \$1.5 million.

In recent years output has been raised from 1000 tons per year to 2000 tons in two jumps of 500 tons, first in 1996 and then again in 2000. In each case almost \$10 million was invested in new plant ².

Saving time, saving cost

The inspection and maintenance routines were a prime target for close examination. It was seen that time and cost savings could make a vast difference to output, efficiency and profitability of the plant.

Before RBI the inspection regime was prescriptively invasive on all items, regardless of the risks associated with them. It is a fact that, very often, extensive inspection during the shut-down periods reveals no deterioration. However, there are occasions when unexpected problems are found, and these can lead to unplanned repairs that increase the outage time.

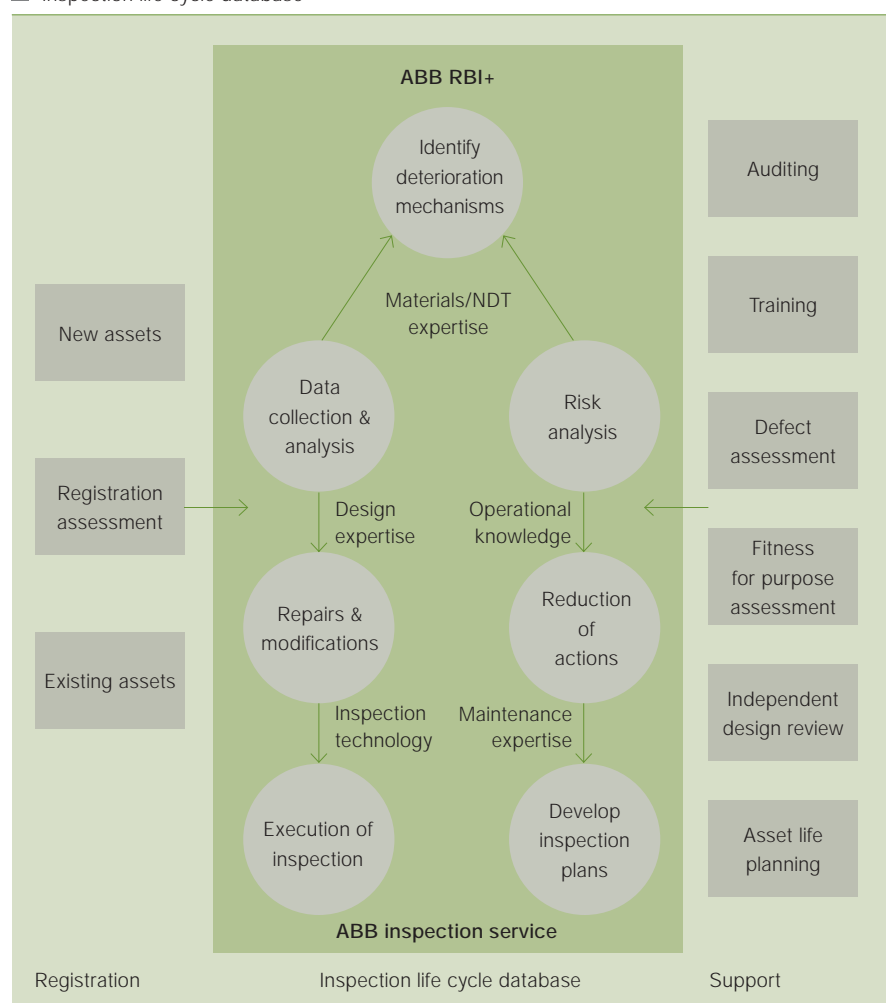
All inspection and maintenance work on the main pressure vessels must comply with Pressure Systems Safety Regulations 2000. These look mainly at how the safety performance and condition of the vessels reduce workplace risks as far as is reasonably practical.

As a Victrex engineer puts it, “The total cost of inspection includes decommissioning, decontamination and preparation for internal inspection. All this time and effort just to find that, more often than not, everything is OK! This led us to question our approach.”

It was this questioning that steered the company toward a knowledge-based approach to understanding the behavior of the plant.

The RBI objective was to raise plant availability from 80 to 85 per cent – from 290 days to 310 days per year – which is the “world-class standard” for similar batch specialty chemical processes.

² Inspection life cycle database



Operational profitability

It was concluded that the main contribution to increasing plant availability would come from a reduction in the annual shutdown time. This would need to be cut from 35 days to 21 days.

The potential financial benefit of saving a large amount of downtime was estimated to be almost \$10 million. Such an amount would result from an improved gross margin and reduced short-term investment needs.

None of this means that future plant expansion is ruled out, but Victrex immediate priority was to get the most return from its existing facility before embarking on further major investment.

For both ABB and Victrex there were some essential steps in ensuring that RBI delivered the desired benefits. Above all else there was the need to harness all existing in-house knowledge and experience and link it to ABB expertise. As a starting point, the in-house team members were to pool all their knowledge and experience. This data, both qualitative and quantitative, together with historical records of previous inspections and a thor-

3 The Victrex plant



ough analysis of the causes of lost output in the last 12 months, provided the basis for the knowledge base on which the RBI plan would be developed.

For Victrex, a UK polymer producer, the potential financial benefit of reducing downtime through RBI was estimated to be almost \$10 million.

A full understanding of the results of past inspections of pressure vessels during shutdowns was vital, since preparing for and carrying out invasive inspections accounts for much of the time and effort involved in a shutdown. Knowing and understanding the failure mechanisms each item is susceptible to, and where to look for them, helped the team decide on the adequacy of non-invasive inspection. This proved to be a major benefit. Thoroughly gathering and assessing salient historical data, plus the use of ABB advanced software tools, enabled the team to develop an inspection routine that prioritizes and responds to risks and foreseen failure scenarios. It also minimizes the risk of unexpected failure.

Having carried out the full review and created an RBI program, the results have proved immediate and impressive. The first shutdown to be affected, in October 2001, required only

nine days. The necessary engineering and maintenance work was completed in four days. The total cost of the exercise was half the amount budgeted.

The next shutdown period, a little less than a year later, was cut from 35 days to 20 days. The team expects shutdowns to be kept to this level in future years as some of the equipment gets older and wear and tear increases.

Besides the welcome time saving it provides, RBI has met and exceeded expectations. During a recent period of high demand, the gross margin has been improved by more than \$9 million over eighteen months of operation and other savings on capital investment and associated depreciation exceed \$3 million. Year on year shutdown savings are running at almost \$100,000. Victrex engineers admit that their initial desire to apply RBI was an act of faith. They saw the opportunity and believed that the goals would be achieved, but they had no previous experience to refer to. As Andrew Anderson, Engineering Manager of Victrex says, "The past experience, professionalism and expertise of ABB were vital elements in steering the work forward and in providing the confidence in the achievability of our objectives."

The Victrex experience shows quite clearly that Risk Based Inspections can provide the benefits businesses need to save on preventive maintenance while minimizing the risks of failure.

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Factbox ABB Risk Based Inspection¹⁾ in brief

- What equipment should be inspected?
Where would failure be unacceptable?
- Where should effort be focused?
- Which techniques should be used?
- How can the examination intervals be optimized?

Benefits

- Increased knowledge of the risk of operating assets
- Significant reduction in the total cost of inspection
- Longer turnaround intervals, and reduced turnaround durations
- Improved equipment availability and reliability, helping to maximize uptime
- Increased confidence in equipment integrity
- Established path to regulatory approval

Footnote

- ¹⁾ ABB Eutech is the process solutions center of excellence within ABB's petroleum, chemical, life science and consumer goods industries business area.

Drive monitor

Embedded product intelligence that enhances lifecycle management and process performance in drive systems

Maciej Wnek, Michal Orkisz, Jaroslaw Nowak, Stefano Legnani

Good products offer more to customers when they are combined with comprehensive support and maintenance programs. Optimal performance and minimal maintenance costs (which drive increased operational profitability) can be achieved through service agreements over the lifetime of a product, but effective lifecycle management requires continuous tracking of asset history – operation, wear, damage, and maintenance. Careful monitoring of the condition and performance of assets allows the implementation of predictive maintenance programs that significantly reduce maintenance costs and the risk of asset failure. Without this information, performance suffers and maintenance costs rise.

ABB Medium Voltage (MV) drives in cooperation with ABB Corporate Research has developed a new customer support system – The DriveMonitor – software and hardware that allows an operator to monitor the performance of an MV drive system, collect data and store the drive's history, all from a remote computer. Drive performance monitoring provides also deep insight into the process status – useful extension in analyzing the Operational profitability.



Operational profitability

Real plant systems comprise a wide variety of assets. Some are straightforward, simplistic even, while others are “intelligent,” capable of self-diagnosis or even self-correction. All of these assets need careful monitoring. Large and critical assets often come with their own supervisory control systems, but all of the assets in a process chain are information providers – either directly, via in-built sensors, or indirectly, by reporting on other assets in the chain.

Cost-effective data collection and processing

An efficient lifecycle management system requires scalable tools that can be adapted to the nature of an asset, its value, status, and general maintenance policy. The first aspect to be considered is the comprehensiveness of the system: whether it be a single asset (eg, a drive), or a whole produc-

tion line, which contains many assets. The second aspect is the availability of data: from “what’s already there” to dedicated measuring systems that detect vibrations, current, corrosion etc. The third aspect relates to increasing levels of knowledge content and diagnostic functions: at one extreme having a simple limit threshold, at the other, having advanced lifetime prediction algorithms.

An efficient lifecycle management system requires scalable tools that can be adapted to the nature of an asset, its value, status, and general maintenance policy.

To target low tool costs one has to concentrate on scalability and configuration flexibility. Similar assets should be treated similarly, but with individual attention dependent on their context in the system. For example, two electric motors might be identical, but if one is running a ventilation fan of low importance and the other a critical fume-exhaust fan, their maintenance programs would be similar, but the level of investment in each

would differ according to their importance.

A scalable system is not the same thing as a combination of different approaches that address different aspects of lifecycle management. To be efficient, a tool must guarantee full data interoperability, single data entry points, and unified interfacing, usage and reporting. Multiple systems can be combined in an IT integration project, but only a scalable tool can provide true maintenance optimization.

In short, individual assets must be assessed to determine the level of investment that can be justified by their individual roles in a process.

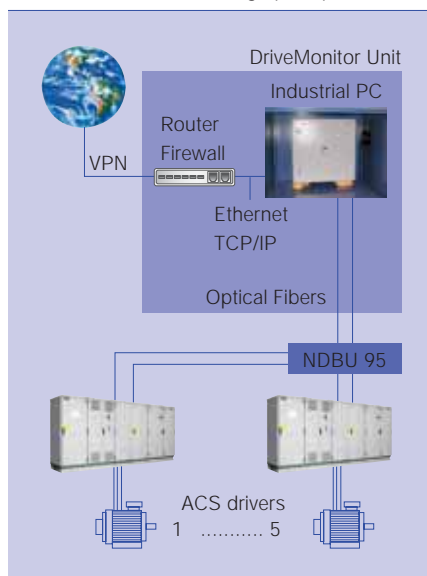
A good condition assessment system is:

- expandable, to accommodate single or multiple asset objects
- able to apply rules of various complexity to the assets – vibration-based, temperature-based, electrical test-based, operation data-based, statistics- and history-based etc.
- able to acquire data from various sources, eg, drive systems, control systems, vibration measuring tools, manual entries, and the asset itself.
- ABB has used this methodology in the development of its Asset Opti-

1 MV drive – an asset with a broad technology span and a rich information source



2 The DriveMonitor™ design principles



3 DriveMonitor – Analyzing the system's heartbeat. Drive information can be utilized on various diagnostic levels – from the converter unit to the process section



mization/Asset Monitors concepts and DriveMonitor is a part of this truly scalable solution ■.

ABB Drives – assets as “knowledge containers”.

ABB MV Drives focuses attention on product design and development, but also on configuration and optimization in relation to customer applications. A quick look “under the hood” of a drive unit will immediately show that the technological complexity of this “torque delivery plant” ranges from copper bars to electronic circuit boards. Its software ranges from assembler code to the newest high-level languages. To obtain the highest possible performance from such a device over its entire lifetime requires some attention. However, drive units, such as the MV Drive from ABB, are huge banks of data, recording information relating not only to the drive convert performance, but also to the driven equipment, and even to the whole downstream production process. Efficient use of these drive data is the first step towards the lifecycle management – at first for the converter itself, ultimately for the whole drive-powered process.

Efficient lifecycle management

A pragmatic approach to lifecycle management issues should answer the following questions:

- What should be done to the asset in order to maintain the highest performance and the lowest costs.
- When should this action be taken?

Ideally the asset should be intelligent enough to provide this information to the operator. Alternatively, the intelligence can be embedded as the asset extension – intelligence that utilizes fully the amount of data processed in the drive.

In order to keep tool costs down, maintenance systems should be flexible and able to accommodate a wide range of asset types.

The DriveMonitor system is designed to meet these requirements. On the one hand it provides continuous monitoring and analysis of the drive state and operation, supports root-cause analysis (RCA) and helps to follow predictive maintenance paths. On the other, it provides a platform upon which to offer the customer unique extension features that, by utilizing drive signals, allow the operator to visualize the whole shaft state along with process-related KPI's, etc.

DriveMonitor: embedded intelligence, scalable and secure

The DriveMonitor system consists of a hardware- and a software layer **2**. The hardware layer is a properly interfaced industrial PC that is factory installed in the most powerful new ABB MV Drives (it can also be offered as an upgrade to existing models). The software layer automatically collects and analyses selected drive signals and parameters. The DriveMonitor hardware is based on an industrial PC platform to provide the expected longevity and remote accessibility. Virtual Private Network (VPN) solutions are used for remote access to ensure high security.

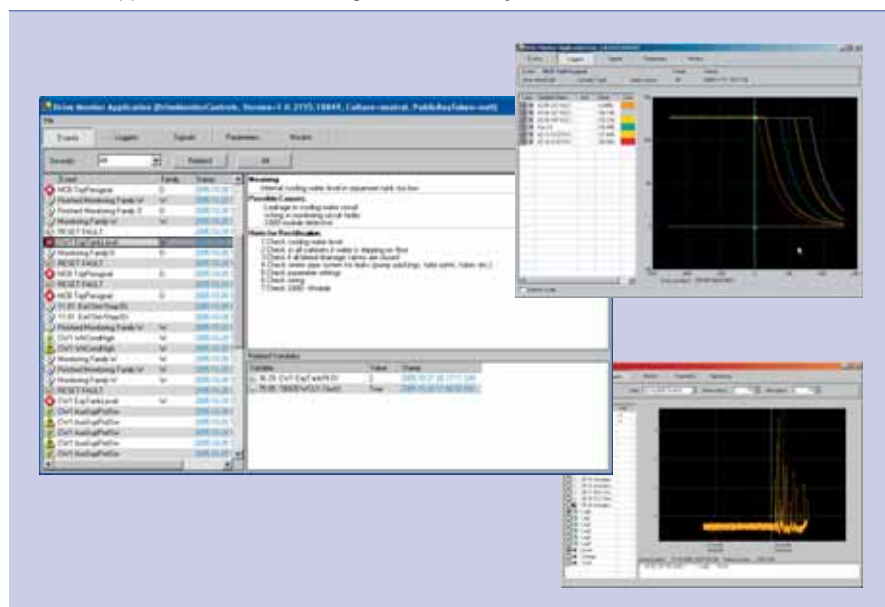
Scalability – the biggest challenge

The DriveMonitor software layer is extremely flexible with respect to the configuration of diagnostic rules, the range of the assets with which it can be used, its alarm and reporting functions, and its data intake sources. Being compatible with ABB's Asset Monitor family, DriveMonitor opens the door to the whole ABB Asset Management portfolio, with Asset Optimizer and other Asset Monitors as optional extensions. DriveMonitor can be easily integrated into automation systems using the ABB 800xA platform (other systems can be connected through OPC¹⁾ servers). The DriveMonitor is designed to be used with a single drive, and with large systems. There are possibilities for expansion to include other measurements such as corrosion, vibrations, additional temperature sensors, etc. It provides millisecond-based sampling rates with year-based scheduling, event-driven actions and alarms, and more. The various DriveMonitor components can be distributed to different computers. For instance, several DriveMonitor units can be configured in parallel to cover larger installations and the results can be brought to a central control room PC for operator convenience.

Application area

The basic function of the DriveMonitor is to “watch” the converter part of

Extended support information facilitating root-cause analysis



Footnote

¹⁾ OPC-OLE for Process Control

Operational profitability

a drive shaft system **3**. It continuously monitors the drive status and responds when that status changes. Changes in drive status can be caused by drive faults (unexpected drive stoppages), alarms (signals crossing threshold values), user-defined parameter changes, and higher level, DriveMonitor-generated application-specific alarms.

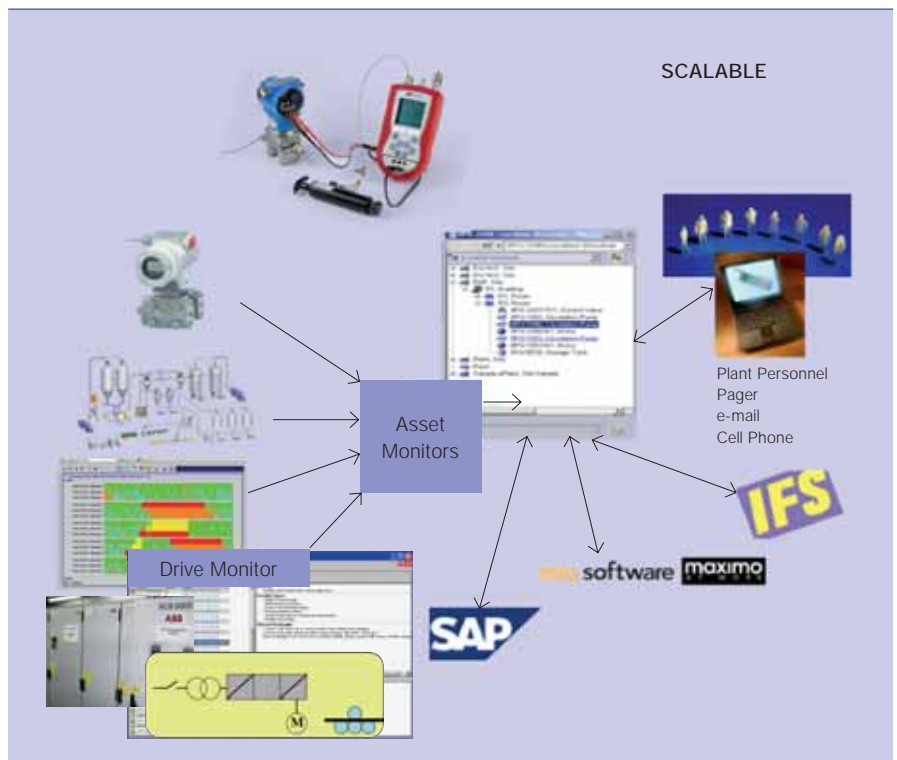
ABB MV Drives focuses attention on product design and development, but also on configuration and optimization in relation to customer applications.

With extra diagnostic packages, DriveMonitor can follow other shaft train components such as the main circuit breaker, the transformer, and the driven machine. At the highest level, specialist packages directly related to specific application areas (such as rolling mills, water pumps, and compressors) can be integrated into the system. This kind of expansion can be done at any point in time depending on the customer's needs. It is also possible to incorporate extra measurements that go beyond the drive signals. DriveMonitor-based diagnostic routines are valuable extensions to plant-level Asset Management program such as ABB Asset Optimization solution. The DriveMonitor block is an easy fit to already installed ABB control platforms and on the other hand can be a good start for plant Asset Management solution.

Oil and gas – Ras Laffan pumping station

The pumping station consists of 27 pump units using, in total, more than 19 MW of power delivered by ABB electrical motors and ACS6000 drives. All drives are supervised by the monitoring package, but as an extension, the data from the ABB AC800M controllers that control the pump line operation are processed by the diagnostic package. Without requiring additional investment in hardware or measuring devices, the system watches the status of the motors and the pumps' temperatures, operating conditions and vibration levels processed

DriveMonitor – shaft-line overview



for the controlling purpose by AC800M units. In this way, a high added value is obtained at low investment cost. All results are integrated into the 800xA Workplace panel giving the operator visually compatible status information – not need to learn yet another platform for condition monitoring as it is typically the situation in industrial plants.

DriveMonitor™ continuously monitors the drive status and responds when that status changes.

Rolling mills – Seeing the process “heartbeat”

ABB Drives are very powerful and configurable units in a process. Their status is not only converter-related, but reflects several parameters that reflect the process status. These parameters include shaft torque, phase current and phase voltages. These data – as provided by the drive unit and analyzed by the DriveMonitor – can return valuable process status information regarding process outliers, process drift and changes. Again, at

no hardware investment, drive data is mapped against traditional process information from the control platform – and all this is enabled by systematic and coordinated development of the ABB Asset Management platform – both from the product and the system sides.

Concluding remarks

ABB process automation offers complete systems for the plant asset management that are in all respects compatible with ABB's product portfolio – generating high level benefits at low investment costs. 1+1 can equal 3 or even 5 in this case.

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Control loops – pleasure or plague?

A plant floor view within the process industry

Alexander Horch

Control loops are a vital part of the process industry and are especially important when it comes to quality, economy and safety. In fact, a significant portion of incorrectly tuned automatic control loops can actually decrease production performance rather than improve it.

The availability and effectiveness of a control system is essential for operating the process safely and at maximum performance, ensuring quality of production and its profitability. Supervision and improvement of controller performance is therefore vital and important.

Performance monitoring of closed loops – or Control Loop Condition Monitoring (CLCM) as it is also known – is used to automatically assess controller performance. In this article, ABB's control loop condition monitoring technology is reviewed.



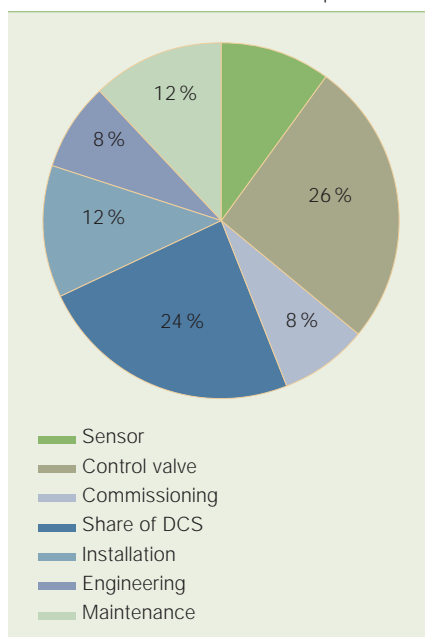
Operational profitability

Control loops are an intrinsic part of any automation system. It has been estimated that control loops have an asset value of \$25,000, with a cost distribution as shown in 1. According to a recent editorial from the Hydrocarbon Processing Journal [1], “Without properly tuned control loops to minimize variability, and updated process models used by the advanced controls to reflect real constraints and business objectives, substantial benefits are lost”. In other words, “include control loops in asset management”.

Automated CLCM is highly attractive in most plants because there are simply too many control loops to be maintained by one service engineer on a regular basis, ie, at least every six months. Another reason why many industries are interested in CLCM is its inherent non-invasiveness.

CLCM works like a doctor's stethoscope: it obtains a diagnosis by passively listening to the process. Typically, no more information than standard DCS tags – setpoint (SP), process variable (PV), controller output (CO) etc. – is required. In a typical production plant in the process industry, for example, there may be up to several thousand control loops. 2 shows a typical and important loop performance ranking result, including typical data for each category.

1 Cost distribution of a control loop.



The need for CLCM?

Assessment of control loop behavior is as old as controller design. In the design phase, the designer usually creates a controller that satisfies some given performance specifications. Unfortunately, these performance specifications often cannot be evaluated using measurement data obtained from normal plant operation.

In helping to resolve this issue considerable research has been carried out to develop a holistic and non-invasive methodology that can automatically assess controller performance. An overview of ongoing research is presented in [3].

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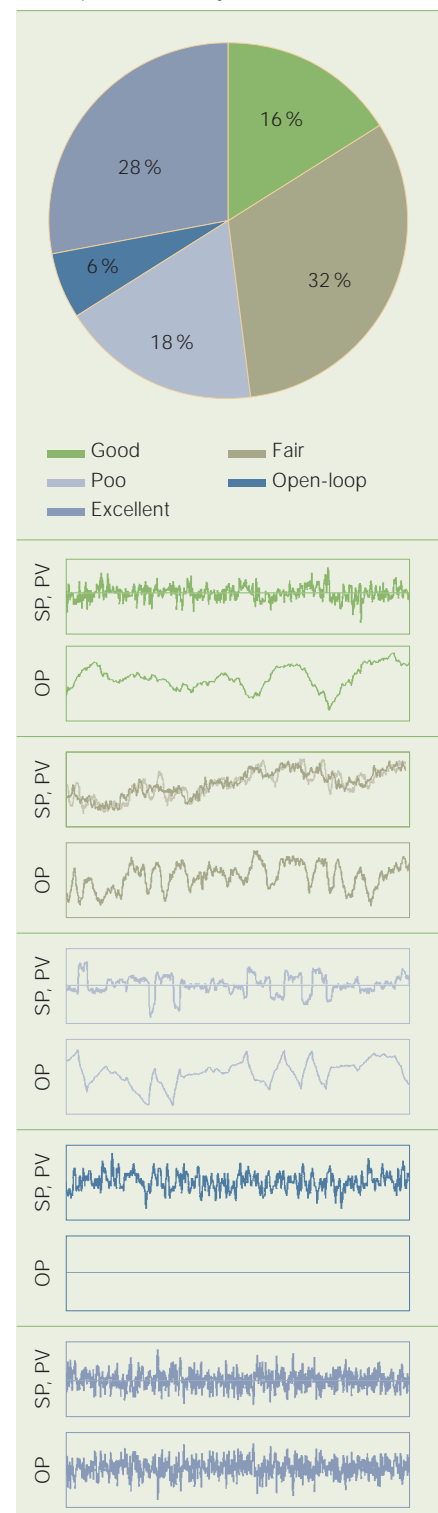
The most obvious and serious control loop problem is a persisting oscillation. Reasons are manifold: bad controller settings; external problems; valve friction; equipment failure; or process-related reasons. Irregular deviations from targets are more difficult to analyse. Luckily nowadays, oscillations and poor performance can be automatically detected – with help, for example, from what is known as the Harris Index [2]. However, the main challenge of diagnosing bad performance remains.

CLCM typically focuses on basic control loops that are vital in achieving the targeted product quality and plant performance. However, in situations where highly advanced control loops are used, more advanced supervision functionality is needed. Advanced control (eg, a model-predictive controller) relies heavily on the assumption that the underlying basic control loops perform satisfactorily. CLCM ensures this requirement.

CLCM in industry

The chemical, petro-chemical and pulp and paper industries were the first to apply CLCM methods and have, over the years, built up considerable experience. More recently,

2 Loop ranking overview for a typical plant in the process industry.



there have been successful applications in power plants. The increasing number of academic research groups and the increasing interest from different automation system vendors is another indication of the usefulness of CLCM.

CLCM includes single-loop analysis (bottom-up) as well as plant-wide analyses (top-down). ABB is first to offer this superior combination.

This interest is also an effect of the more general trends affecting asset management. These trends have been recently published by the ARC group [4]:

- Deliver recommendations, not only pure information.
- Extend the usage of current assets (no trend to replace current equipment).
- Provide tight integration with the IT environment.
- Reduce plant staff and increase competitiveness by creating a new maintenance paradigm.

Modern CLCM tools strive to support these trends. In fact ARC recommends the combination of control loop condition monitoring with a controller tuning tool.

ABB has adopted this idea and integrated both functionalities into what it calls the Optimize^{IT} Loop Performance Manager (LPM) tool [5].

What's on offer from ABB

ABB offers CLCM functionality on different levels of its Industrial^{IT} automation palette [3].

Optimize^{IT} Loop Performance Manager (LPM)

ABB's Optimize^{IT} Loop Performance Manager (LPM) is a general and powerful tool for controller performance condition monitoring. It combines both control loop assessment and controller tuning functionality, and runs with any automation architecture via OPC data connectivity [4]. The latest version also includes a Plant-wide Disturbance Analysis module which has proven to be able to locate plant-wide disturbance root causes very successfully.

LPM's control loop auditing not only indicates the best and worst performing loops in a plant section, but it also gives detailed analyses on how to remove identified problems. These problems include discrepancies in the final control element, external disturbances, and controller tuning.

Controller hardware: Control^{IT} AC800M

On the field device level, some basic functionality exists for control loop condition monitoring. For example, oscillations due to valve stick-slip be-

havior are very common. These oscillations can be automatically detected by ABB's AC800M controller. Not only this but the AC800M controller can overcome the sticking valve movement by adding pulses to the manipulated variable so the valve moves to the desired position [6]. [5] shows a typical measurement signal (PV) in a control loop exhibiting stick-slip and the corresponding AC800M functionality.

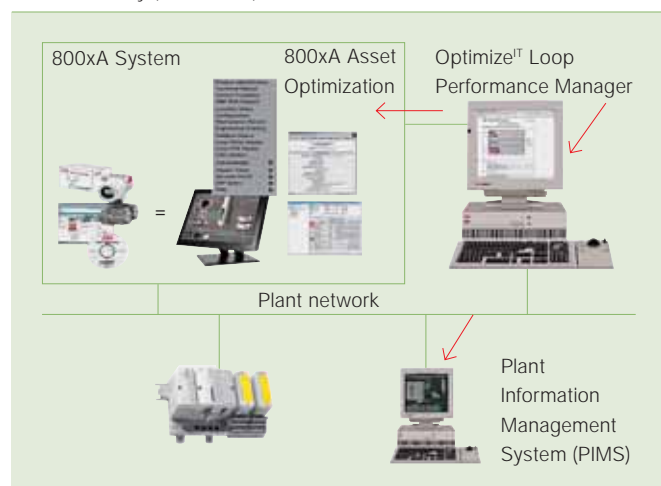
The controller can detect sticking valves and apply a stiction compensator algorithm to guarantee best possible controller action until the next valve maintenance.

CLCM is able to detect loop performance deficiencies and can contribute to substantial gains once the appropriate maintenance actions have been taken.

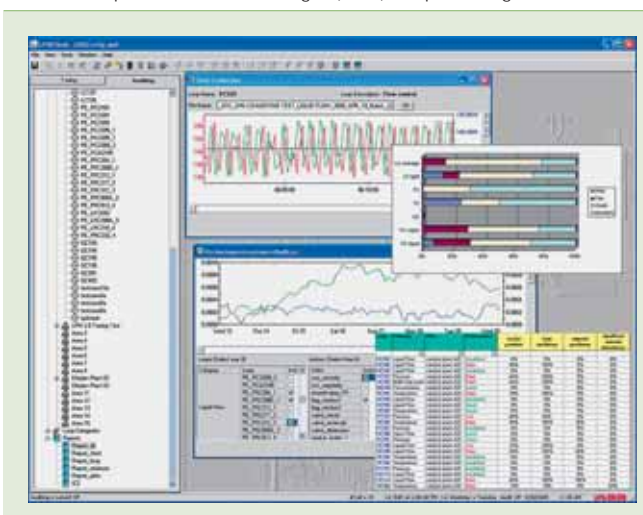
System 800xA: Asset Optimization and control loop asset monitoring

ABB's 800xA Asset Optimization System includes fully automatic loop monitoring functionality via a so called "Control Loop Asset Monitor". By that the detection and diagnosis of control loop problems is fed into the asset optimization data handling of the 800xA system [7]. Messaging, con-

3 Automation architecture indicating controller condition monitoring functionality (red arrows).



4 ABB Loop Performance Manager (LPM): loop auditing window.



Operational profitability

nection to the computerized maintenance management system (CMMS), and access to historical data and other real-time plant information helps the user trace problems and initiate corrective actions.

Industrial applications

Without any doubt, industries experience various control-loop related problems. These problems may vary depending on the industry in question.

According to a recent editorial from the Hydrocarbon Processing Journal, “Without properly tuned control loops to minimize variability, and updated process models used by the advanced controls to reflect real constraints and business objectives, substantial benefits are lost”.

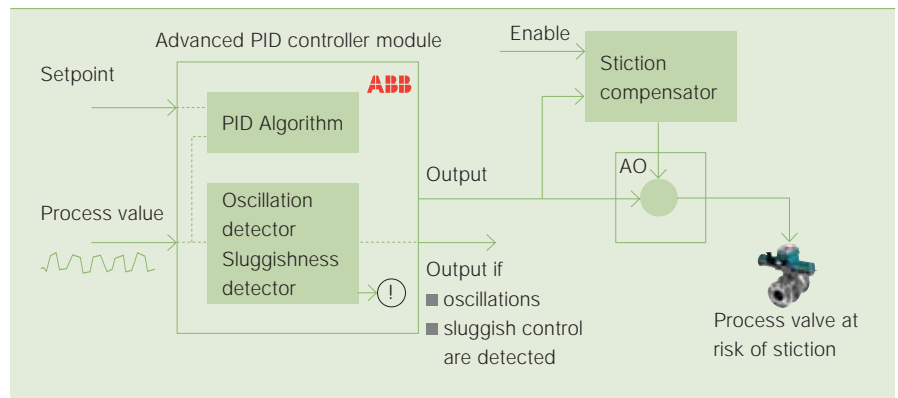
A simple example is to compare the high-precision position controller in a disc drive with a surge tank level controller in a paper mill. Obviously, both controllers share the same task but their respective benchmarks should be set on two different scales.

Consequently, some of the control performance monitoring methodology would fit the first application, some of it the other. Since control performance monitoring traditionally originates from the process industry, most established methods focus on the problems that are typically encountered in this industry.

Diagnosis of controllers in the (petro-) chemical and pulp and paper industry

Figure 5 shows a subset of data before and after a performance improvement initiative in a pulp mill. CLCM methods detected oscillatory control

5 Oscillation detection and stiction compensation function overview in the 800M controller. The process value exhibits typical stiction behavior.



loops, and experiments verified the diagnoses. The subsequent improvements are obvious from the data collected later.

Diagnosis of controllers in power plants

CLCM-related problems in power plants are very similar to those in other industries. Some aspects, however, do differ, such as the total number of control loops is somewhat lower than in the chemical industry. This allows greater sophistication when it comes to the configuration and tuning of each of the loops. Cascades, feed forward and more advanced control logics are also more common and CLCM needs to take such configurations into account.

One important point is the ability to classify CLCM results by the current load situation in the power plant. Controller behavior is typically a function of the load (eg, high, low, start-up,

ABB's CLCM has caught the attention of various industries, and many are starting to apply such techniques.

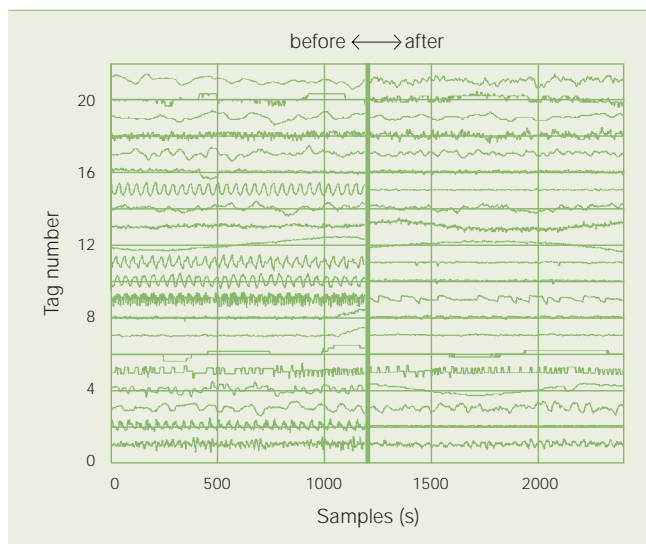
load change) or of other properties like raw material type etc. Modern CLCM methods do consider such conditions.

Diagnosis of control-relevant disturbances in cold rolling mills

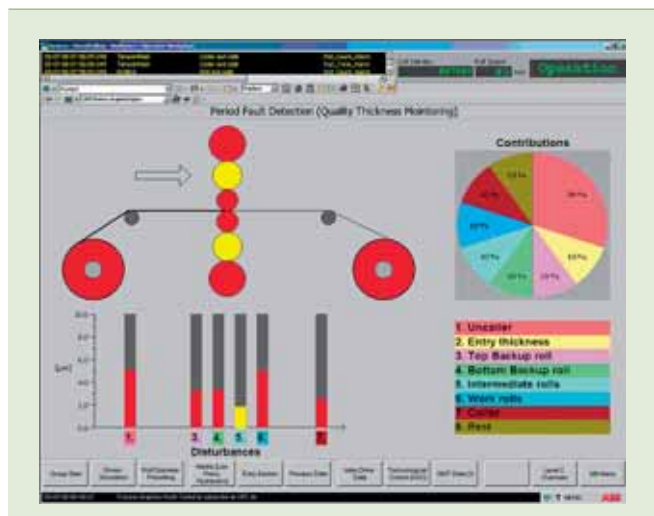
In the rolling mill industry, a few highly sophisticated control loops are needed for tension and thickness control. However, the application of standard CLCM methods in the rolling mill industry is perhaps not as straightforward as in the chemical industry, as recent applications of these methods have produced results that are difficult to interpret.

On the other hand, where CLCM functionality has been specially designed for rolling mill applications, the results have been very encouraging. To be more specific, CLCM functionality has been successfully designed to diagnose and remove periodic

6 Improvement of controller performance after application of CLCM with subsequent maintenance.



7 ABB Operate^{IT} screen for the diagnosis of periodic disturbances.



disturbances which are predominant in rolling mills [9], and a typical automated diagnosis screenshot is shown in 7.

Beyond single-loop controller condition monitoring

CLCM is able to detect loop performance deficiencies and can contribute to substantial gains once the appropriate maintenance actions have been taken. However, there are cases where the plant is not properly optimized even though the controllers are performing well. In such cases, it is highly probable that the current controller structure is not sufficient. A systematic and fast way of assessing the controller landscape and the prevailing automation infrastructure is by using a benchmarking service provided by ABB [10].

Conclusions

CLCM is inherently a passive and automatic technique which has caught the attention of many industries. The benefits gained by removing control per-

The benefits gained by removing control performance bottlenecks and performance degradations due to bad control are substantial.

formance bottlenecks and performance degradations due to bad control are substantial. So much so that more and more industries and companies are starting to apply such techniques.

ABB's research and product variety has enabled a flexible application of CLCM across many different industries. These applications have been adapted so that the existing hardware at a customer site is used. CLCM can be applied to any process architecture regardless of whether ABB's 800xA System or a third-party DCS is installed.

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Not on my watch

How ABB's Power Management System prevents multi million dollar shutdowns

Otto van der Wal, Per Erik Holsten

Energy is vital for industries to operate. Many of ABB's energy-intensive customers require a reliable and stable energy supply for the motors that drive compressors, pumps, fans and machines. Some operate in areas where the public electricity supply is unreliable or non-existent meaning they must rely heavily on their own generation capabilities. An unscheduled trip in, for example, a refinery or a liquefied natural gas (LNG) plant due to a total loss of power could result in several days of lost production. When translated, this represents a value exceeding \$-10 million.

Because of this dependence on electricity and the volatility of energy costs, combined with a growing environmental consciousness and more stringent legislation, efficient energy management is becoming ever more important.

ABB's Industrial^{IT} Power Management System (PMS) is a family of unique solutions that ensure reliable and stable energy supply for energy-intensive industries. The PMS balances energy demands with the available energy supply, thus preventing disturbances or even blackouts in operations. Furthermore, it enables a company to control its energy costs, to enhance safety, and to mitigate environmental and health impacts.

The situation in nearly any black-out is almost always the same: one part of a system fails forcing nearby equipment to absorb its load. This equipment is then pushed into an overload mode causing it in turn to fail. These multiple failures snowball and a large area ends up in the dark with potential dire consequences including potential loss of life, loss of production and damaged equipment.

It is imperative that process upsets and shutdowns are avoided as they will have a negative effect on the financial, environmental and social performance of a company. Power supply reliability and power quality affect both throughput and safety; therefore avoiding black-outs and power disturbances are of substantial value to any process plant. Equipment must be monitored continuously to ensure optimal performance and stability over time. The extremely fast dynamic properties of the electrical process require quick response times – of the

order milliseconds – to prevent protection relays from issuing trip commands leading to a domino effect in terms of equipment overload.

Inefficiency isn't just costly in terms of excessive fuel consumption; high emissions can rack up the cost still further. Solutions that help lower operating costs while reducing environmental impact are sorely needed by industry.

One such solution, ABB's Industrial^{IT} Power Management System (PMS), helps achieve stable operation whereby the electrical plant as a whole can withstand larger disturbances from within or from outside the plant. This application package contains not only the traditional SCADA functionality but also a full complement of electrical solutions including Power Control and Load Shedding, two major functions that are described in details in this article.

A common platform for process control, safety, power generation and utility control

The PMS is based on ABB's Industrial IT Extended Automation System 800xA

[1, 2], which is designed to monitor, control and protect all sections of a process plant. This common Industrial^{IT} platform provides control functions, and a flexible and well organized single-window interface that allows operators to work efficiently. In addition, advanced functions such as intelligent alarm filtering, consistency analysis and operator guidance help reduce the need for operator intervention and, more importantly, these functions can prevent incorrect interventions.

The importance of systematic operator training in a realistic setting is increasingly acknowledged as a prerequisite to reach operational best in class targets. The Industrial^{IT} Training simulator can be integrated with a multitude of process and electrical simulators. Because it runs on the Industrial^{IT} platform, the PMS can be conveniently deployed in the integrated Training Simulator, where control strategies – such as load shedding priorities – and “what-if” simulations can be tested prior to deployment **1**.

PMS main functions

The PMS provides an integrated set of control, supervision and management

functions for power generation, distribution and supply in industrial plants. Such broad functionality is partially represented by modules commonly used by the industry under different names¹⁾.

By checking the open/close positions of critical circuit breakers in the electrical network and using its internal “knowledge” of the electrical network topology, the Network Determination function can determine network contingencies.

In addition to the traditional functions of supervisory control and data acquisition (SCADA), the system offers:

■ SCADA electrical functions:

- *Generator control* including integration with the governor and excitation controller.
- *Circuit breaker control* including integration with protection relays, event monitoring, time synchronization with 1ms resolution. Synchronization between two electrical islands must be performed and checked by the PMS before a circuit breaker is closed. The generators used for synchronization can be selected manually or automatically. This is performed by the *synchronization* function.
- *Transformer and tapchanger control*: the mode control function changes the control mode of tap-changers, governors and excitation systems according to the status of the electrical network **2**.
- *Motor control* including integration with motor control centers, time synchronization, automatic sequential re-start and re-acceleration release after load shedding or under-voltage.

■ **Network Determination**: This and the mode control function are important supporting functions for the Power Control, Load Shedding and Synchronization features. See

Factbox

Factbox Network Determination

The Network Determination function is an important supporting function for the Power Control, Load Shedding and Synchronization functions.

By checking the open/close positions of critical circuit breakers in the electrical network and using its internal “knowledge” of the electrical network topology, the Network Determination function can determine network contingencies.

The PMS uses sophisticated matrix calculations to determine electrical network contingencies. Network contingencies must be calculated in a matter of milliseconds after a circuit breaker position has changed and are therefore determined by complex logics. To give an idea of the complexity and size of the necessary logic, an electrical network with one grid connection and eight generators has $2(1+8) - 1$ possible network contingencies.

The electrical network matrix is a square matrix with same number of columns and rows. Each column and row represents a (main) bus bar in the electrical network. The cells in the matrix represent circuit breaker positions which are the connections between the (main) bus bars.

The Network Determination function calculates the electrical network contingencies from this matrix – it calculates a “reduced” network matrix. The number of rows in this reduced network matrix is equal to the number of sub networks (or network islands) in the electrical network. The reduced network matrix is used by: Power Control to calculate imported and generated power and balance loads in sub networks; Load Shedding to calculate imbalances between available and required power; Synchronization to check which power sources (grid and generators) are available to achieve synchronization.

Operational profitability

- **Power Control** including tie-line control, peak shaving and load sharing.
- **Load Shedding** including both fast, slow and frequency based.

Both Power Control and Load Shedding are described in greater detail in the following paragraphs.

Power Control

The objective of the Power Control function is to maintain stable operation. It does this by sharing active and reactive power demand among different generators and tie-lines in such a way that the working points of the generator sets are as far as possible from the border of the individual PQ-capability diagrams so the plant can withstand bigger disturbances ¹.

The importance of systematic operator training in a realistic setting is increasingly acknowledged as a prerequisite to reach operational best in class targets.

In the following paragraphs, the control strategies contained within the overall Power Control package are described.

Tie-line control

The Tie-line control function, which is part of Power Control, optimizes the power exchange with the Public Power Company (PPC) to an adjustable setpoint based on contractual obligations, such as the maximum 15 minutes peak value used in Europe.

It works as follows: the PMS measures the imported (or exported) power, or the transmitted power between different locations, by counting pulses from energy meters. From these measurements, a sliding 15 minutes power demand forecast is calculated. When power demand tends to exceed contracted electricity import limits or a setpoint specified by an operator, the PMS will initially try to increase in-plant generation to avoid exceeding the contractual obligations. If this is not possible, the Tie-line control func-

tion will interface with the Load shedding function (see Peak Shaving below) to shed sufficient non-critical loads.

Active Power Control

As part of Power Control, the Active Power Control module performs frequency control and active power flow control at an exchange point with the grid. It monitors the actual network configuration and sends an active power setpoint to the participating generators to:

- Maintain the bus bar frequency at a pre-defined value if that particular network is isolated.
- Or maintain an active power flow between a particular network connected to the grid.

Active Power Control Aspect decides if frequency control or power flow control is applicable. This decision depends on the actual network configuration. This means no operator interaction is required after a network configuration change.

The active power setpoints are sent to the participating generators, ie, the generators that act in Governor Auto-mode.

Power mismatch

In the case of frequency/voltage control, the working point, taken from the bus bar, is subtracted from the setpoint. In case of active power control,

the difference in [Hz] is converted into an active power unit [MW].

In case of power flow control, the power working point at the exchange point is subtracted from the power setpoint.

PI control

The input to the PI control element is power mismatch. The output of the control element increases/decreases as long as there is a mismatch at the input of the PI control element.

Participating factor

The operator can assign a participating factor to each generator. This determines to what extent the generator will participate in power control. To decide on the most suitable participating factor, the operator can look at calculated factors based on the available control margins. There are participating factors for active power control and reactive power control.

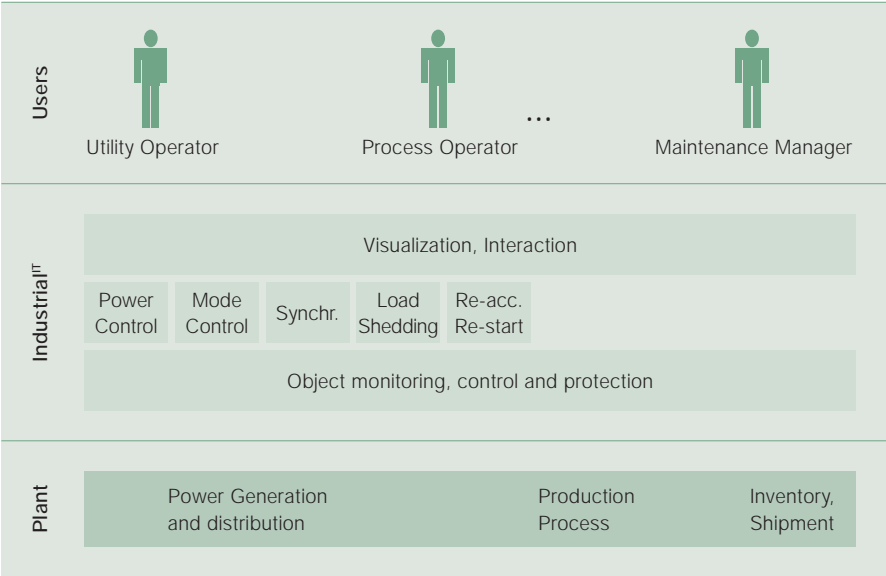
Power setpoint per generator

A power setpoint can be set to keep the generator at a desired spot in the generator capability curve without affecting the frequency/voltage or active/reactive power flow control.

Reactive power control

The Reactive Power Control module is the Object Control Aspect for voltage control and reactive power flow control at an exchange point with the

¹ What is needed for an efficiently operating plant.



grid. It monitors the actual network configuration and sends an reactive power setpoint to the participation generators and/or transformer to:

- Maintain the bus bar voltage at a pre-defined value. Maintain a reactive power flow between a particular network and the grid, or another network.
- Maintain the powerfactor at the exchange point.

The Reactive Power Control Aspect decides if voltage control or reactive power flow control is applicable depending on the actual network configuration. This means that no operator interaction is required after a network configuration change.

The reactive power setpoints are sent to the participating generators and transformer.

Also a reactive power setpoint can be set to keep the generator at a desired spot in the generator capability curve without affecting the voltage and/or reactive power flow control.

Reactive power control in cooperation with transformer control

A transformer is used for main control when it participates in voltage control or reactive power flow control. Transformer control maintains the voltage or reactive power flow at a desired setpoint and the remaining mismatch between setpoint and working point

(measured value) is minimized by the AVR control of the participating generators. Control parameters as gain and time integration are adjusted in such a way that the transformer control prevails.

Load Shedding

The PMS Load Shedding function ensures the availability of electrical power to all critical and essential loads in the plant at all times. Load shedding is achieved by switching off non-essential loads when there is a shortage of power generation capacity in the electrical network of the plant.

There are four different types of load shedding:

- **Fast Load Shedding** is based on electrical energy balance calculations. As soon as one or more electrical islands are detected (using network determination software), the system calculates if there is enough electrical power available in every individual island to power the loads. If not, any existing demand surplus is shed. The shedding process is dictated by priority tables, which are based on the operational conditions of the process.
- **Frequency Load Shedding** (or back-up load shedding) uses a frequency drop as an input to activate load shedding. Activation of an actual shed command can be based on a frequency decay or by passing a fre-

quency threshold. Frequency Load Shedding is usually used as an independent back-up system for fast load shedding

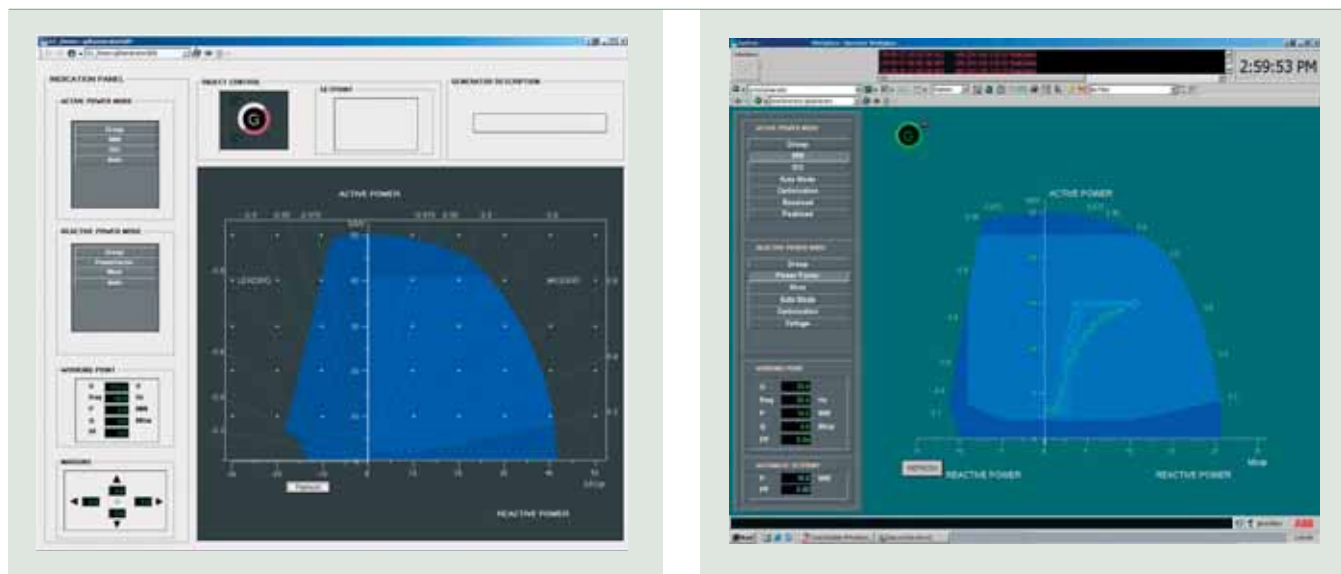
- **Slow Load Shedding** is used when an overload has occurred. For example if a transformer is loaded at 120 percent, switching off some loads to bring the transformer back to its nominal load is by far the best solution. The system advises the operator which non-critical loads he can switch off. This manual effort must be done within a specified period of time otherwise the system will do it automatically.

– Peak Shaving is another type of slow load shedding and occurs when the following situation arises: if in-house generation is maximized but it seems highly probable the 15 minutes sliding maximum power demand will exceed the contracted maximum value, then some of the low priority loads are shed. **Manual Load Shedding** is mainly used when one of the afore-mentioned conditions for Slow Load Shedding occurred but operations did not allow the system to shed automatically.

How much to shed?

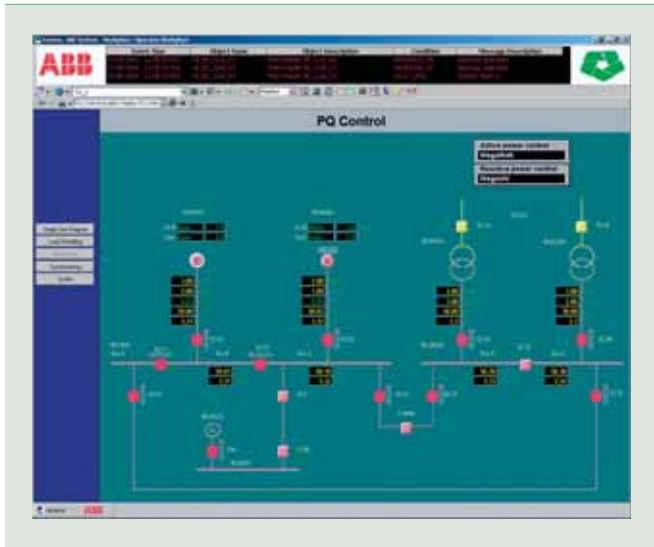
The ABB system is fast because it doesn't wait for a decrease in frequency before it starts to shed loads. Instead, its decision to shed – as well as how much should be shed – depends

2 Generator Capability diagram with working point and mode selections.



Operational profitability

- 3 Single Line Diagram indicating that four motors have been shed after a generator trip.



- 4 Graphical presentation of the accumulated effect of shedding the loads assigned to the 20 load shedding priorities.



on the balance between the amount of power generated and consumed in every island. To execute load shedding within 100–250 ms of a disturbance, however, many calculations must be done in advance.

Deciding how much power should be shed depends on the number of priorities used, the size, in MW, of the load shed groups, and the availability of system measurements.

ABB's load shedding set-up is very flexible because an operator can adapt (online) the priority of the various plant loads to the process operating conditions and the electrical network 4. Also at the moment the system determines the shedding order, it considers how much spinning reserve is available. To utilize this reserve, the system can, and will if necessary, change the operating mode of a generator.

The coordination between load shedding and re-acceleration is also important. Re-acceleration is disabled when a load shedding action is required, and is immediately restarted once the conditions for load shedding have vanished.

Summary

The PMS benefits are clearly visible during:

- *The plant definition phase:* the improved system stability allows tighter dimensioning and thus reduced costs.

- *Plant start up:* the PMS will ensure the power system capacity is not violated at any time by holding load start commands until the system can provide the power required to start a particular load. This helps get the plant safely on stream as quickly as possible.

- *All phases of plant operation:* the PMS will control generators and transformer tap-changers to ensure stable power system operation, as well as monitoring and controlling active and reactive power exchange with the public grid. The general workload and number of interventions from the operators are reduced.

- *Maintenance planning:* comprehensive data are recorded and aggregated on the condition of the electrical assets. The appropriate ABB Industrial IT Asset Monitors can monitor this data automatically, and the responsible people are notified when actions must be taken. The ABB Industrial IT Asset Optimizer workplace provides the overview of equipment health and the base information needed to plan maintenance campaigns.

The PMS can also be part of a broader electrical system delivery from ABB. In certain industries such as chemical, petrochemical, cement and steel, energy costs represent approximately 30 to 50 percent of the total production cost. ABB's PMS can pay for itself

in a short space of time just by ensuring greater efficiency of power generation, import and usage under varying operating conditions.

The investment can easily be justified in both green and brown field plants, and several examples of recent installations exist around the globe. The same system is used for both electrical and process control allowing cost reduction in training, spare parts and maintenance.

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Footnotes

- ¹⁾ Electrical Control System (ECS).
- ²⁾ Electrical Integrated Control System (ELICS).
- ³⁾ Integrated Protection and Control System (IPCS).
- ⁴⁾ Power Distribution Control System (PDCS).
- ⁵⁾ Load Management System (LMS).
- ⁶⁾ Electrical Network Monitoring & Control System (ENMCS).

Experience counts

Mondi Packaging Frantschach can rely on ABB
Marja-Liisa Parkkinen



The 125 year old Mondi Packaging Frantschach mill sits in the Lavant Valley amid the breathtaking beauty of the southern Austrian Alps. Three paper machines produce approximately 250,000 tons of sack and kraft paper per year. Frantschach's high quality pulp and paper are used to produce high quality end products. Producing pulp for the Melitta coffee group as well as luxury paper bags based on its kraft paper, the mill's overall export rate is more than 80 percent of production. Quality is the key factor and to maintain such high quality, the company's strategy is to modernize continuously to ensure it has the most up-to-date technology. And helping Frantschach in this task is one of its many long-term partners, ABB.

The Mondi Packaging Frantschach ¹ **Factbox** mill has three paper machines, the PM 6, 7 and 8, that produce approximately 250,000 tons of sack and kraft paper per year. The wire width of the PM 6 is 490 mm and the sack paper produced covers 60-125 grams per m². With a speed of 920 meters per minute, the PM 6 is one of the fastest sack paper machines in the world. The PM 8 also produces sack paper and has a wire width of 510 mm and a speed of 830 meters per minute, while PM 7 produces kraft paper of 30-150 grams per m² with a speed of 350 meters per minute. The Frantschach mill also produces approximately 50,000 tons of unbleached market pulp per year, and uses spruce and pinewood as the raw materials. Franz Maischberger ² is Head of the Project Department responsible for Electrical, Process Control and Process IT. He has been working at the mill for 29 years; his passion for stable state-of-the-art technology is one of the reasons for Frantschach mill's position as a technological forerunner. Mr Maischberger says that "the mill's strengths lie in: quality; Research and Development; employee skill; two highly efficient sack paper machines; and just-in-time delivery". Its outstanding approach to sack paper production sets the standard for many other Mondi sack paper mills.

End products

Frantschach's sack and kraft paper goes under the brand name of "ADVANTAGE". Sack paper needs to be of the very highest quality when one considers that some customers fill them with 25 or 50 kilos of cement, producing some 4,000 sacks per hour!

Operational profitability

Frantschach enables customers to achieve this by paying special attention to factors such as printability, strength, energy absorption and porosity¹⁾. Very few sack paper producers are able to meet such quality requirements. The world-renowned coffee filter brand, Melitta, acquires Frantschach's unbleached pulp. Other special pulp grades produced by the mill are used in the production of isolation material for transformers. Meanwhile the luxury paper bags used in many shops are based on Frantschach's kraft paper.

Quality is the key factor that embraces end products, the paper production process, the pulp mill process, the woodyard process as well as the staff's know-how. According to Mr. Maisch-

berger, "We work alongside customers worldwide to achieve world grade quality. We want to be our customers' preferred, long-term partner." The same attitude emerges when Mr. Maischberger refers to suppliers. He prefers major, global suppliers who, in the long run, provide high quality.

Quality is a key factor – to maintain such high quality, the company's strategy is to modernize continuously to ensure it has the most up to date technology.

Basis for high quality

Several factors have contributed to the mill's reputation as a high quality pulp and paper producer. First of all, the company's strategy is to continuously modernize to ensure it has the most up-to-date technology. This is helped by the fact that it has reliable long-term partnerships with major P&P industry machine, and equipment and system suppliers. The Frantschach mill is currently reconstructing its wood yard and raw material mixing at a cost of approximately 20 million euros.

Secondly, the company identifies best practices in its production processes and is constantly accumulating experience through its "Knowledge for Production" continuous learning system. Each shift worker logs information on any incidents or problems, as well as the related actions and solutions. This means that all experiences related to the process are available online around the clock.

The third factor concerns health and safety. Mr. Maischberger says that "safety, health, environmental friendliness and a zero rate of accidents are our working environment goals". "This is a question of attitudes rather than techniques," he continues. As a result of this ambitious program, safety performance has developed significantly over the last few years.

ABB – a long-term partner

Equipment and PCs bearing the ABB logo can be found all over the mill. The second generation of Manufacturing Execution Systems (MES) solutions – the equivalent of Collaborative Production Management (CPM) – have been deployed in production planning and optimization, production tracking and quality management ³. Three quality control systems delivered by ABB perform online quality control on

1 The 125 year old Mondi Packaging Frantschach mill sits in the Lavant Valley amid the southern Austrian Alps



2 Franz Maischberger is Head of the Project Department responsible for Electrical, Process Control and Process IT



Factbox Mondi Packaging

The Mondi Packaging Frantschach is member of the Mondi Packaging Group, a leading European paper and packaging (P&P) company. It is active in the bag and flexibles business and has more than 100 production facilities worldwide.


The Mondi Group is owned by the Anglo American Group. Mondi operates worldwide and is principally involved in producing paper, packaging solutions, coating and business paper. In 2005, it employed 16,278 people with sales totaling 3,092 billion euros.

Mondi Packaging Frantschach GmbH is located in the Lavant Valley in Austria and was founded in 1881. It is responsible for all R&D within the Mondi Packaging Paper Division. The mill employs more than 500 people and in October 2006, it celebrated its 125th anniversary.

Mondi Packaging Frantschach mill has won several awards in recent years because of its attention to quality and innovation. In particular it has won countrywide environmental improvement and innovation awards.


Taking care of the environment

The nearby town of Frantschach-St. Gertraud has some 3,000 inhabitants, and the area is renowned for skiing in winter and its hiking and biking routes in the summer. Environmental issues are therefore of great importance to Mondi Packaging Frantschach and due to solid technology improvements, waste water figures have dropped to an 1,500 Inhabitants Equal Value, while SO₂ emissions have tumbled from 1,800 mg/m³ to 40 mg/m³. In 1998 the mill was certified according to the Environmental Management System ISO 14001.

PM 6, 7, 8 and the flash dryer , while ABB's Automation System, which already covers the paper machines, the pulp mill and the power plant, has just been upgraded and extended to now cover the wood yard.

CPM

Approximately 10 years ago, ABB delivered an MES system to the Frantschach paper mill. Some years later it was decided to install a new system because (a) the original MES system was nearing the end of its lifecycle and (b) Frantschach mill's corporate structure changed when it became a member of the global Mondi Packaging Group. For these reasons, the mill decided to acquire new production planning, production tracking and quality management systems from

 The second generation of MES solutions have been deployed in production planning and optimization, production tracking and quality management




 Three ABB quality control systems perform online quality control on PM 6, 7, 8 and the flash dryer



ABB in 2002 to cover the production scheduling of the flash dryer, paper machines, winders and rewinders as well as warehousing and logistics. According Mr. Maischberger, "Our experience of ABB's earlier systems was decisive in our decision to purchase another CPM solution from them, as well as the financial aspect. The applications were designed as multi-mill solutions, possibly covering similar mills belonging to Mondi Packaging in the future."

The company identifies best practices in its production processes and is constantly accumulating experience through its "Knowledge for Production" continuous learning system.

A template solution, a proto system based on ABB's Industrial^{IT} CPM solution, was created as a first step. IT specialists from the Frantschach mill and ABB's Helsinki base worked together to install the new system. Even though it was based on a standard CPM solution, many customized features were incorporated to ensure that it fitted perfectly into the mill's processes. A challenging additional aspect was the linking of the ABB-CPM solution to a centralized SAP system built simultaneously. The system now supports 70 concurrent users.

A fundamental new feature of the template/proto solution is the Capability to Promise (CTP) feature, which gives a 100 percent assurance online to customers that Mondi Packaging Frantschach is able to deliver the right quality at the right time. Another unique feature, the integrated planning functionality, enables paper producers to forecast the amount of pulp needed for paper and market pulp production and to balance this with the planned production of bulk pulp.

The project was called SPARK 2, and lasted three years. Mr. Maischberger said that "the reasons underlying our

investment decisions – improved processes, quality and better customer service – have all been borne out." A similar system, based on this Frantschach template, was successfully installed at the Mondi Packaging Dynäs mill in May 2006.

Enterprise integration the key to success

A fully integrated mill means that every aspect of the mill can be controlled. The wood yard was modernized and is also controlled using the control system delivered by ABB.

The original pulp mill control system was delivered between 1996 and 2000 and was upgraded in 2006 to include the latest advanced features of the current system. This system comprises 12 ADVANT AC450 controllers and 16,000 input/output points gathering information on processes, with about 20 operator workstations. The paper mill system is based on ADVANT AC460 technology which operates all three paper machines on one Distributed Control Network. Therefore sitting in a conference room, for example, an operator can connect online to the pulp and paper mill processes and simultaneously display the continuous cooking process, paper machine operation and QCS in real time.

Access rights are set up so that each user gets the required information for timely and informed decision-making. In the same way, online history data is made available immediately. This fully integrated solution is helping to improve the productivity of the entire mill.

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Footnote

¹⁾ Printability, strength, total energy absorption and porosity are the most important quality features in sack paper. Frantschach has a quality control system for every paper machine; these ADVANT 1190 systems have been controlling basic paper properties for many years.

Finding the right balance

Electrification solution for the pulp and paper industry

Marja-Liisa Parkkinen, Juha Willman



For over 30 years ABB has supplied electrification solutions to green field pulp and paper mills as well as to ones that have been modernized. To create the best economical and technical solution for the customer requires superior knowledge and extensive experience, both of which are in abundance at ABB. This short article gives a brief overview of how the company approaches these solutions.

A total electrification solution covers basic and detailed engineering, supply site management, supervision, erection and commissioning of the entire electrical solution. ABB's long-term and extensive experience in such electrification projects for the pulp and paper industry enables the company to implement an electricity distribution plan for a complete pulp or paper plant based on relatively limited initial data. At the very least this initial data should include lists of consumers and a plant layout. However, in reality consumer information at the beginning of a project can be extremely limited. In such cases ABB's experience in various types of pulp and paper plants can be exploited by complementing the initial data with experimental data from other projects of similar types. In addition, other technical matters related to the process in question, including power stations, should be considered.

Network calculations

Good basic skills acquired from working with electrical systems, together with an advanced network calculation program ensure a network configuration in which margins are managed, unnecessary over dimensioning is avoided and solutions that are technically the simplest are obtained. In some cases the network dimensioning is checked by using operational modes which are very different from one another. From the point of view of dimensioning, situations in which the network is at its weakest – including isolated operation – form the most challenging situations. ABB uses the

Neplan network calculation program to carry out the electrotechnical dimensioning of a network. This program can model all the central electrotechnical parameters, and it helps engineers find the most reliable dimensioning of an entire network for various normal and abnormal situations.

ABB's extensive experience in electrification projects enables it to implement an electricity distribution plan for a complete pulp or paper plant

Energy efficiency

In addition to purchasing costs, other factors which can optimize overall costs should be considered during the design phase. Energy costs and losses, for example, are increasing all the time and in the future their share of the total costs will be even more significant. With this in mind, ABB has dedicated much R&D towards improving the efficiency of various apparatus and decreasing their losses.

Total losses are not only positively affected by the most constructive solution for an electricity distribution system, but also through basic choices such as the voltage levels used. The recent tendency towards larger units in pulp and paper plants is noticeable in the processes themselves and in the single units of process equipment em-

ployed. The use of larger units has meant that optimal voltage levels have had to increase. For example, 690 V has replaced, to a large extent, the 400 V value which was very popular as a low voltage. Due to its greater stiffness it can also replace, or at least partly, 3 kV and 6 kV as a motor voltage. In electricity distribution, a voltage of 33 kV has often replaced lower distribution voltage levels.

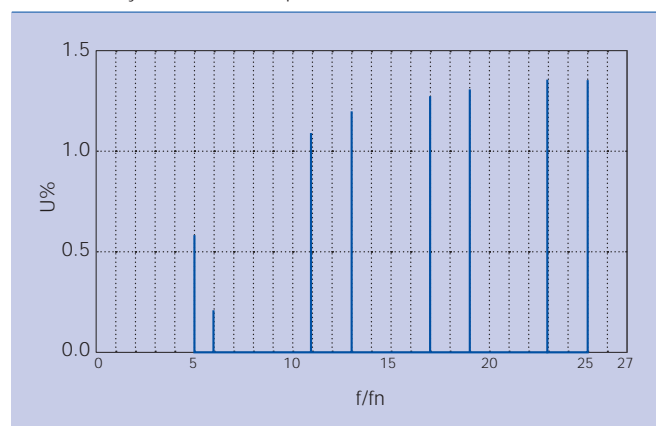
Compatibility

As a rule, a new electrical system is related to an already existing system but it has limitations or requirements imposed on it by the older system. However, the new system creates its own preconditions for future plant extensions. For this reason, the most probable scenarios for future extensions should also be taken into consideration when designing a new network. In other words, the future extendibility of a plant depends to a large extent on the basic decisions made in the current design.

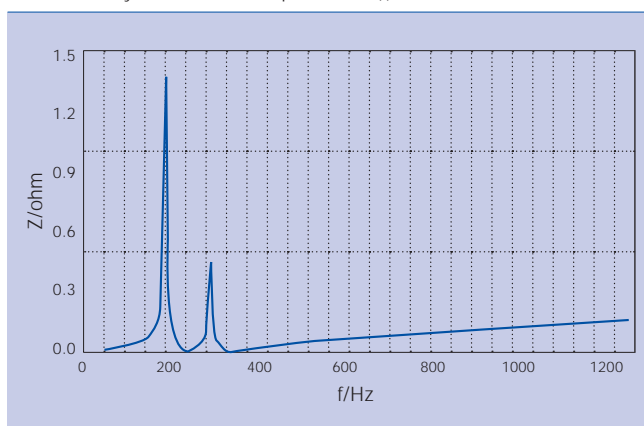
To successfully implement large systems, the quality of electricity and the compatibility of the equipment and systems are of the utmost importance. Compatibility is partly an equipment-related factor but it can also be affected through different constructive solutions of the systems to be used.

As to the compatibility of the networks in pulp and paper plants, harmonics from loads and voltage drops resulting from the starting process of motors are the most important factors. These should also be taken into ac-

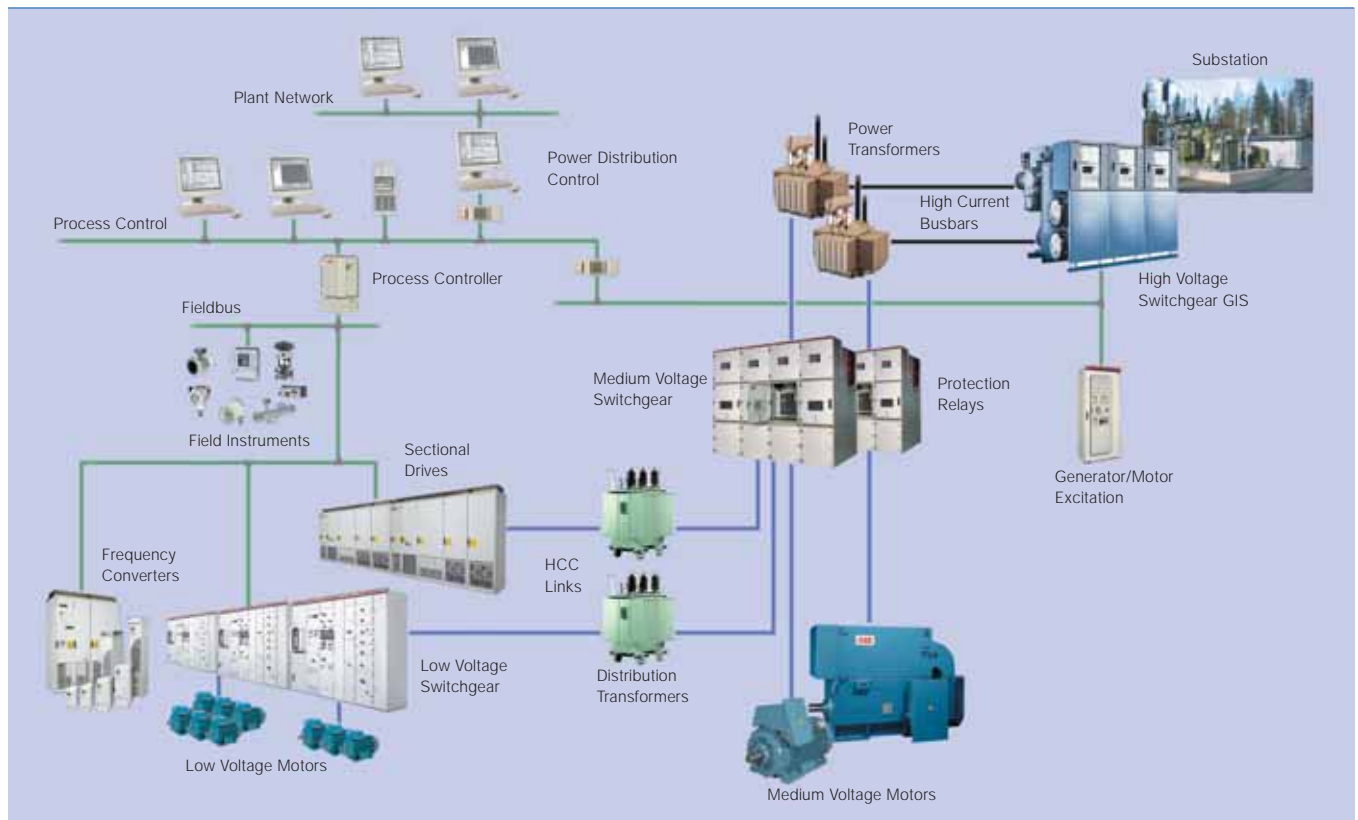
Network analysis – Harmonic spectrum



Network analysis – Network impedance Z(f)



Operational profitability



count in network calculations in addition to loading and short-circuit currents. By modelling a network accurately, it is possible to ensure (a) sufficient margins for different design parameters even in the most difficult situations and (b) sufficient compatibility for different parts of the network. However, significant cost differences may arise between various solutions. By optimally proportioning the immunity levels of the equipment and the amount of interferences generated in the network, significant savings can be obtained when compared to generous over-dimensioning. Unnecessary over-dimensioning of the quality of electricity causes extra investment costs.

The voltage drops that occur during the starting process of a motor no longer represent a limiting factor for the motor size because of modern techniques. As effective starting methods are now available, the under-voltages encountered during motor start-up can always be adjusted to acceptable levels. However, these requirements should be checked in all switching situations where start-up is required. In fact, the normal operation of the

motor appears to be the only limiting factor. Motor starting is an especially demanding operation in an isolated network if the motor is large compared to the generator. In this situation the dynamic behaviour of the generator and the excitation system should also be considered. In short, the optimal choice and dimensioning of the starting arrangements of motors has an important effect on costs and availability.

There are techniques available that almost completely eliminate the large harmonic currents created by motors in the network. However, their elimination is not always the most optimal solution. In the end correct reactive power compensation and harmonic filtering have the most significant effect on costs.

Implementation design

The application design process also uses network modelling. It gives basic values for dimensioning parameters and determines different solutions for relay protection. In addition to basic protection functions, such as short-circuit and earth-fault protection, different kinds of advanced protection solu-

tions, including "load shedding" and "islanding", can be modelled and the operational values can be accurately determined.

The said optimized criteria are also included in project-related standards and guidelines – such as design and dimensioning instructions – which are created together with the customer. These standards and guidelines take into account ABB's extensive experience in the pulp and paper industry, the advantages of modern solutions, the results of network modelling and the customer's knowledge of local conditions to give the best possible end result.

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Peace of mind

Enabling increased productivity and profitability in the cement industry with ABB's System 800xA

Heikki Tanskanen, Alfredo Zeta

It is no secret in the cement business – as with many other industries – that basic automation solutions are fast becoming a commodity product. However many “patchwork” automation systems exist either because plant managers have had no choice but to buy the equipment they need from various suppliers or the overall concept was never properly considered or thought out to begin with. In many cases, the end result is a poor unsatisfactory working solution.

This is where ABB Process Automation and its family of Industrial-IT® System 800xA products and solutions stand out and differentiate themselves. ABB uniquely identifies itself not only as an automation product supplier, but also as: a manufacturer and supplier; an engineering, commissioning, services and support partner; and a cement process specialist. This “single point of responsibility” is what cement customers are looking for in a competent automation partner.

The construction and modernization of cements plants is, in many ways, very similar to other industries. Cement customers and producers aim to produce a high quality end product efficiently using the most cost effective means possible, while at the same time minimizing overall environmental impact.

Global players in the cement industry comprise companies such as Holcim (Switzerland), Lafarge (France) and Heidelberg (Germany) as well as a number of small local companies. The majority of cement projects, including complete new plants as well as re-vamps and modernizations, usually occur in developing countries and emerging markets – including Asia and the Middle East. This is no surprise because booming and emerging economies are usually accompanied by a need for new buildings, bridges and other infrastructure.

Challenges facing the cement customer
Each project is unique in its complexity and is heavily dependent on local conditions. Not many people realize that the cement manufacturing process is in fact a chemical process which is fully dependent on the quality of local raw materials and their inherent natural variations. The cement manufacturing process is also demanding in terms of energy consumption and environmental considerations. Cement production demands a sound automation solution which can deal with these variations at a moments notice, and adapt to it's “new conditions” as efficiently as possible. In addition, an automation solution can only be successful when the client's automation partner and supplier fully understand the complexities of the cement manufacturing process,

Operational profitability

and has the experience necessary to realize these unique solutions.

What is common to all cement manufacturers, as well as to most industries, is the necessity for operational excellence, productivity and profitability, minimized environmental impact, global and local competence, responsibility and support, all of which can be summed up as risk management and minimization. Building a brand new greenfield cement plant is clearly a major undertaking but the modernization of an old plant to the latest standards, production and efficiency levels while it is still in operation¹⁾ demands a whole different set of skills and competences for the supplier and partner.

This is where ABB shines and stands out as the leader in the field. ABB's Minerals Business Unit, based in Switzerland and with worldwide responsibility for all cement customers and projects, has clearly established itself as the industry leader in automation solutions.

ABB's distinctive approach

ABB's cement organization has been serving customers since the 1960s, and during this time it has amassed a wealth of experience. One of the main reasons the company has always provided world class automation solutions to its customers is because it is also the developer and manufacturer of the full range of products that it supplies. All automation related hardware, software, tools and engineering as well as service and support are provided to its customers' base worldwide via ABB without the involvement of external third parties. ABB's process knowledge, built into standard packages, libraries and automation solutions for the cement industry, has been continuously evolving since the 1960s. Today, this knowledge is fully implemented and standardized in ABB's Industrial^{IT}® (IIT) System 800xA platform.

For the cement industry, for example, a suite of re-usable objects for control

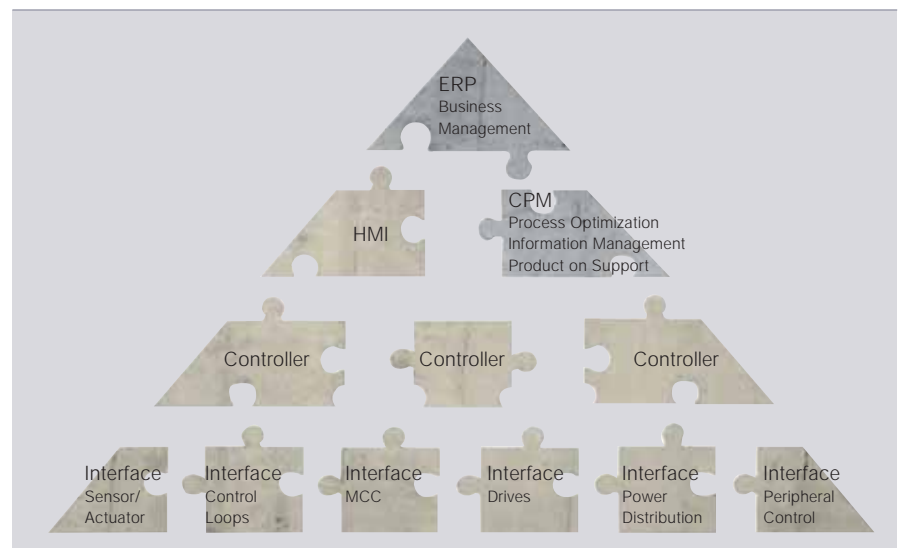
applications based on four decades of experience exists. System 800xA embraces the principles of open, real-time networking with its unique integrated object oriented system environment for operations, control and engineering, and provides a scalable solution that spans and integrates loop, unit, area, plant and inter-plant controls.

The System 800xA Minerals Library, for instance, includes pre-engineered modular objects containing control logic, human machine interface (HMI)

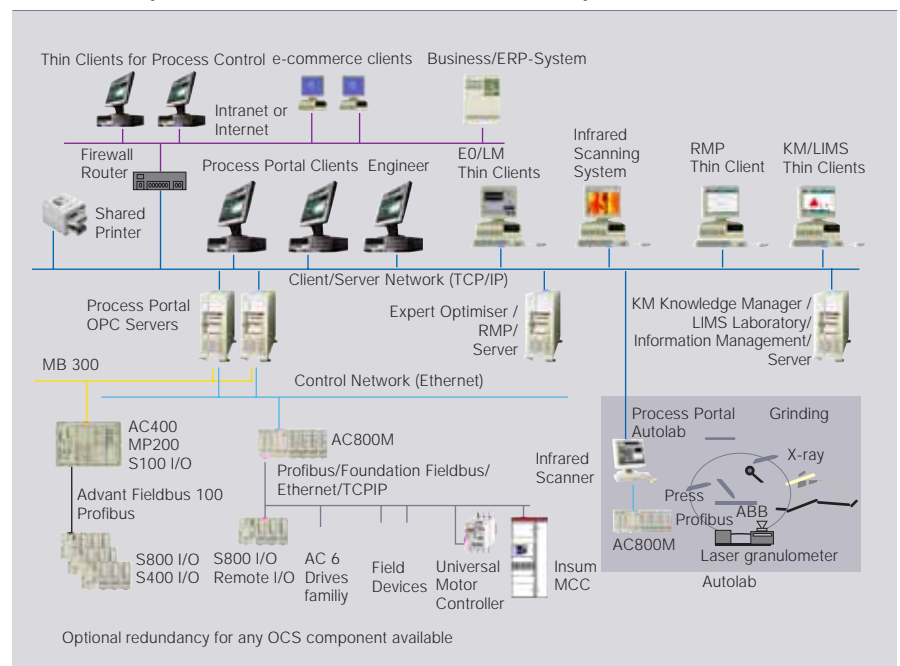
and communication for application development with drag-and-drop facilities **1**. It provides a complete set of operator functions, realistic process displays with graphic elements and faceplates, superior trending capabilities, intelligent alarm and event handling with remote messaging, reporting, as well as integrated drawings and wiring diagrams.

Such features give ABB the unique advantage of being able to handle very complex projects, from turnkey new greenfield plants to those that

1 Modular automation



2 Industrial^{IT} System 800xA in the Cement and Minerals industry



Footnote

¹⁾ Stringently planned and minimized downtimes are essential.

need revamping and modernizing under severe time, budget and schedule constraints **2**. The advantage for the customer is long term supplier commitment and the assurance that, as its business evolves, its automation partner, ABB, can always provide a professional, reliable and compatible solution to the existing, older technologies installed in the plant.

Holcim (Maroc) Settlat plant

Holcim's new Settlat cement plant (see title picture) is located south of Casablanca in Morocco. At the end of 2004, Holcim decided to establish a complete cement factory by adding a new cement grinding plant and a clinker production line. Operation of the grinding plant was scheduled for the third quarter of 2006, and the clinker production line is expected to be in full operation by the end of 2007. The main quarry is located 25 km from the main plant and provides the raw materials for the process. A railroad links the two locations.

ABB engineered, supplied, installed and commissioned the complete system – including electrical distribution – within the planned but very demanding short construction schedule. The IIT 800xA based solution was implemented in a step by step fashion, thanks to its plug and play functionality. Software compatibility throughout

the project was ensured with solid engineering foundations, consistent methods and the use of standard libraries which comprised ABB's years of process experience with similar projects.

Holcim Settlat not only has ABB's leading automation solution, but it will also benefit from advanced energy monitoring and reduced consumption, environmental management and power monitoring. On top of this, the company will profit from ABB's production information management and optimization capabilities. Finally, the overall automation solution will be combined into one system at the main plant and remote quarry, all using the same design and application principles, thus simplifying overall operation and maintenance.

ABB – more than just automation

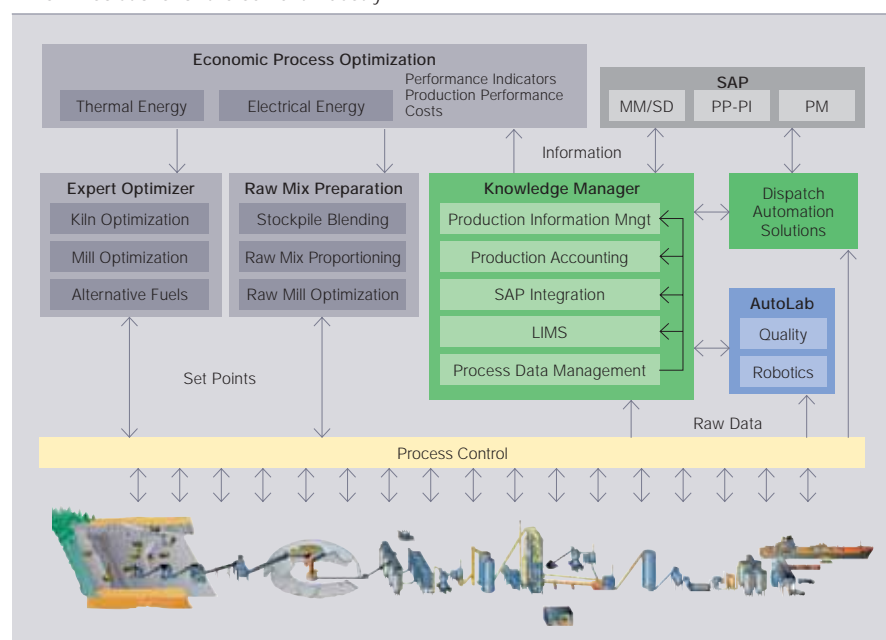
As a leading provider to the cement industry, ABB takes on the sole responsibility of providing quality products, solutions and standards, and the means for increased productivity and efficiency while always considering the customer's Total Cost of Ownership (TCO) and environmental impact. Because of proven methods, modules, technologies and platforms, planning and experience, ABB's automation solutions are in a class of their own. More impressively, complete turnkey

solutions are also provided that cover: the raw materials needed (RMP-Raw Material Preparation); optimization (EO-Expert Optimizer); labs (AutoLab); knowledge management (KM-Knowledge Manager); and dispatch. In addition, electrification to automation to integrated ERP systems and non-ABB products are also covered.

Pure automation, in the traditional sense, is greatly expanded with IIT to include CPM (Collaborative Production Management) **3** and ERP (Enterprise Reporting Systems) as well as access and control of substations, power distribution, MCCs, generators, quality and laboratory systems, expert and optimization systems as well as business systems including SAP. This also includes the seamless integration of industry standard technologies like TCP/IP, Fieldbus/Profibus and others. In addition, ABB's turnkey solutions can also include full electrification, cabling, sensors, motors and drives, lighting, fire and video systems as well as the installation and commissioning of all items provided.

ABB has installed automation systems for over 500 production lines, 30 in the last three years alone. The company's installed base and advanced automation solutions save customers over € 100 million per year on energy costs alone. Four decades of experience combined with its ability to develop and manufacture the full range of automation products it supplies means ABB can take sole responsibility for complete automation solutions. ABB products are complemented with the company's skills, which are in turn transferred to local teams and partners to be used in the industries and markets they serve. Customers therefore have peace of mind in the knowledge that, as their own businesses grow, ABB's automation solutions will grow with them.

3 CPM solutions for the cement industry




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Age is no issue

Evolution of automation systems to improve return on assets

Mark W. Taft



"Naturally, ABB's first priority is to look after its installed base and provide a cohesive evolution path to its new technology while simultaneously preserving the investment of its clients. It is a tough balancing act to follow, and one that has never been undertaken on such a large scale by any automation system supplier, but ARC¹⁾ believes that ABB is performing this task at a level that exceeds the industry norm," says Larry O'Brien, ARC's Research Director for Process Industries, when commenting on ABB's control system evolution strategies.

Recent investments in "greenfield" plants with state-of-the-art technologies have primarily been directed towards facilities located in the developing world. To remain competitive the "brownfield" manufacturing sites of North America and Europe must significantly improve their ROA (return-on assets).

Nurturing brown fields for green bucks
This challenging global environment is driving the owners of "brown field" plants to search for competitive advantages in the extended use of automation. Several strategies can be adopted:

- **Reduce unplanned downtime.** The ARC Advisory Group has estimated this to represent two to five percent of current production.
- **Implement reliability centered maintenance techniques** to reduce costs and optimize maintenance practices. The maintenance budget in a typical chemical plant is estimated to be two thirds of net profit. According to a US Federal Energy Management Program Report, savings in the double-digit percentage

range can be gained through improved maintenance techniques in such plants.

- **Increase personnel productivity.** Providing real-time access to relevant information facilitates empowered decision-making and action, enabling cost and productivity advantages, which is vital to the business process improvements necessary to achieve greater ROA.

Integration failed in the past

In the last decade, billions of dollars were spent on new ERP (enterprise resource planning) systems. The intent was to integrate the business world with the manufacturing process. In most cases the basic ERP implementation projects overwhelmed the organization and integration was never realized. Further business process improvements and the implementation of best-in-class processes require close integration of plant floor automation with business systems. A renewed attempt to harness the substantial improvement available through information integration will drive automation investments over the next decade.

Aging workforce

A massive turn-over of intellectual talent in process manufacturing plants is projected in the next 5-10 years. There is an urgent need to capture that experience and knowledge and make it available via the automation and information management systems to the operations, engineering, and maintenance personnel of the future. Much data is already being collected via the applications running in the existing automation and peripheral systems on the plant floor. However, it is not accessible as knowledge in an integrated, contextual fashion to those people who need it, when they need it.

Aging automation infrastructure

Morgan Stanley estimates the value of installed automation systems in process manufacturing facilities that have reached the end of their lifecycle to be \$65 billion. Plant floor installations are a collection of aging, disparate and loosely or non-connected sys-

Footnote

¹⁾ ARC DCS Worldwide Outlook, September 2005

tems. These “closed” systems are a barrier to integration. Manufacturers require a migration plan to help them remain competitive. At issue is the massive investment that has been made, both intellectual and capital. Automation users understand the need to balance the benefits of modernization with the requirement to achieve highest possible return on existing investment. Many migration solutions require extensive rework, automation application redevelopment and disruptive “rip and replace” of existing system content just to return functionality to current levels of performance. This approach sacrifices the experience and knowledge automation owners have accumulated in their applications. So how can these companies upgrade their systems while preserving this knowledge?

The answer is automation evolution!

Evolution vs. migration

ABB's Industrial^{IT} System 800xA Extended Automation software facilitates the addition and integration of the new capabilities to prior generation automation systems. ABB's pledge of “evolution through enhancement” ensures that new advances in automation systems technologies strengthen, rather than compromise prior automation investments. Automation system evolution is a process of simple, gradual advancement to a highly integrated, extended automation environment. The task of merging disparate control system families into a cohesive modern automation system, while preserving customer investments, has

been a formidable challenge, which has led to the development of System 800xA.

ABB's pledge of “evolution through enhancement” ensures that new advances in automation systems technologies strengthen, rather than compromise prior automation investments.

System 800xA extends the reach of traditional automation systems beyond process control, to achieve the productivity gains necessary for manufacturers to succeed in today's business. This scope is accessible from a single user interface that presents information and provides interaction in a context appropriate to each user's responsibility. Extended Automation objects created within System 800xA provide a foundation for the efficient development and continuous improvement

of production applications with a predictability unattainable by other automation offerings.

The system's architecture is built upon ABB's patented Aspect ObjectTM technology²⁾. Aspect Objects relate plant data (aspects) such as I/O definitions, engineering drawings, graphics, trends, etc., to specific plant assets (objects). This unique architecture lets customer-owners integrate best-in-

class products, applications and services from ABB and Industrial^{IT} certified supplier-partners with existing automation installations – regardless of the original system's origin – to create an extended automation environment. The 800xA system supports total plant management and control, removing the barriers of traditional distributed control systems.

Evolutionary customer benefits

Whether a customer-owner's original system nameplate says Advant, DCI, Freelance, INFI 90, Master, Melody, MOD 300, Satt, Symphony, or that of a competitor, it can and should be used as the foundation on which to build a System 800xA installation **1**. This evolutionary approach offers many fundamental deliverables to ABB's customer-owners.

By combining new System 800xA applications supporting asset optimization, information and production management and ERP integration with existing systems, new productivity potential may be achieved.

The reuse of intellectual investments in existing systems via direct re-hosting of applications, or via application translation tools and services reduces risk, and shortens implementation schedules and “switch-over” time. Engineering efforts focus on improvement rather than recreating functionality that already exists.

Footnote

²⁾ See also ABB Review 1/2002 pages 6–13.

1 An 800xA evolution builds on existing architecture



2 ORLEN is Central Europe's largest refiner of crude oil and ethylene



Capital productivity

System 800xA Process Portal supports standard displays, faceplates and operating philosophies from prior generation “Operator Station” products to maintain a familiar operations environment. The knowledge that operators, engineers, and maintenance personnel have gained through use of their existing system will provide a foundation for improvement. Training can be focused on learning new capabilities of the system.

The reuse of intellectual investments in existing systems via direct re-hosting of applications, or via application translation tools and services reduces risk, and shortens implementation schedules and “switch-over” time.

By evolving an automation installation in a step-wise fashion customer-owners address their business needs in a time-frame appropriate to their investment appetite. For example, the addition of Asset Optimization capability to an existing installation provides the opportunity to mine the intelligence of existing HART field devices to implement asset monitors. The asset monitors facilitate a move in maintenance strategies to a reliability centered approach. The new software runs in concert with the existing in-

stallation and provides the foundation for the addition of other System 800xA capabilities.

ABB’s tested and proven evolution project execution services and procedures ensure low-risk, cost-efficient and predictable results for every evolution step. Detailed evolution planning services provide a well thought out execution plan for predictable performance throughout the step-by-step evolution program.

ABB’s product life-cycle support policy provides predictable support for installed products, and a commitment to provide functional replacement products to keep the plant running. This policy allows customer-owners to evolve their system in a step-wise fashion with the confidence that the foundation will be supported, and available for production over the planned evolution period.

Project briefs

When Molson Brewery in Canada, needed to expand and upgrade their 20 year old Network 90 system, Everest Automation helped them evaluate all options. Molson chose to extend their existing system by adding System 800xA Process Portal because of the many benefits it offered, such as personalized workspaces and views that provide better visibility into their process, remote device configuration capability and continued use of their original system investment.

According to system integrator Joe Sollazzo, this solution “allowed Mol-

son to seamlessly and effortlessly connect Process Portal to the existing system, and have operators view the old system as well as the new, on one common platform – a very real investment savings.”

PKN ORLEN is Central Europe’s largest refiner of crude oil and ethylene.

2 ORLEN’s first blending control and optimization system was successfully commissioned in 1998. Adding new controllers and operator stations to the existing MOD 300 system extended the DCS. On-line and off-line optimization and planning functions were valuable extensions.

By evolving an automation installation in a step-wise fashion customer-owners address their business needs in a time frame appropriate to their investment appetite.

“ABB systems protect our investment very well. There are many examples in the company where we started from a very small, single node and then migrated to huge control systems. This is a good example of step-by-step evolution. The ABB system is well suited to this approach,” said ORLEN’s Manager of Process Automation, Waldemar Nagórko. “We achieved all our targets with our ABB control system upgrade; optimal use of more components, optimized costs, elimination of re-blends, very good

3 Tissue-making machine



4 Alunorte plant in Brazil



prediction and control of more product properties resulting in reduced production costs and reduced give-aways."

CMPC Tissue SA is a leading participant in the pulp & paper market active in over 50 countries on five continents. To meet its ongoing goal of constantly improving efficiency by utilizing the most advanced control technologies, the company recently upgraded its more than ten year old control system in the Talagante mill located in Chile.

CMPC's Talagante mill had been operating successfully with an ABB Master system. CMPC decided to reduce maintenance costs by combining a new mill expansion with the evolution of the existing system. Cost was further reduced by the re-use of existing applications. The mill expansion was directly integrated with the existing systems via evolution to System 800xA.

"ABB's Investment 'enhancement through evolution' control system upgrade strategy gave us the possibility of maintaining, or 'porting-over' a whole engineering process, rather than having to start over," says Sr. Reinaldo Uribe, Project Manager

of CMPC Tissue's Puente Alto Mill. "We never have the opportunity to change everything at once. The ability to make incremental improvements over time is very important. This is the way you protect your investment and your company. From the beginning, ABB has met all our requirements."

Incremental additions and functional extensions have delivered dramatic productivity improvements for ABB automation customers, while building upon the value of the baseline capital and intellectual investment they made in their original systems.

Alunorte, in the Pará state in Brazil, is presently one of the five largest alumina refineries in the world ⁴. It began its production with two lines in 1995, utilizing ABB's Master technology. When a third line was added in 2003, the Master technology was evolved to fully integrate with an Advant control system for all lines.

Alunorte further enhanced its automation by adding System 800xA when it began its second and latest expansion project. The Extended Automation system utilizes fieldbus communications (both Profibus and Foundation Fieldbus), as well as ABB's Real Time Production Intelligence (Real-TPI) software. This expansion will allow Alunorte to produce up to 99 percent of the operational time, slashing downtime to just one percent making the plant the largest, most efficient alumina production facility in the world when installation is completed in 2006.

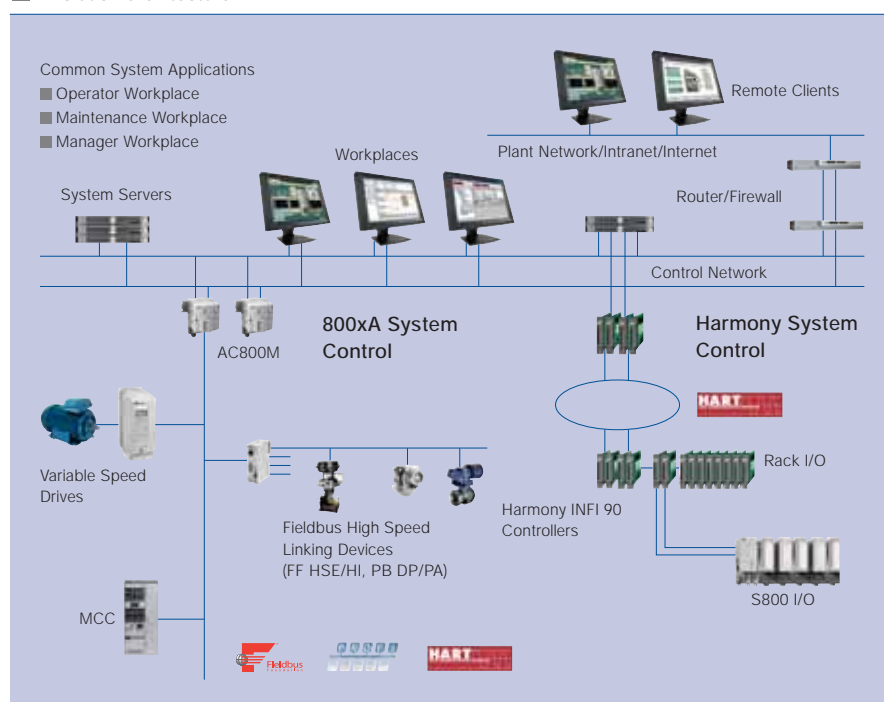
"The ABB system has helped Alunorte reach production goals since start-up. If the DCS can give you good data, you can change the data into information. If you have the power of information you can change everything, but you need the right tool to make the change. Alunorte drives for improvement and ABB is one of the most important partners in our efforts to increase of production capacity," said Jorge Aldi, Process & System Development Manager, Alunorte.

Conclusion

As illustrated above, incremental additions and functional extensions have delivered dramatic productivity improvements for ABB automation customers, while building upon the value of the baseline capital and intellectual investment they made in their original systems. Planning is a key component to a successful step-wise evolution program ⁵. That's where a collaborative effort between ABB and customer-owners to map out the best strategies will help to minimize production losses, and maximize the benefit of each increment of the program. ABB's overall goal is to mitigate risk, while extracting maximum value from our customer-owners' automation system investments.

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⁵ Evolution architecture.





Integrated engineering

Engineering tool integration for process industries

David Dobson, Robert Martinez

The design of a process plant is a daunting task. Numerous sensors and actuators need to be installed and connected, cables must be laid and cabinets wired. The instrumentation within the plant is specified and designed by different teams. Highly complex documentation is required to keep track of all this. It is essential that such documentation is updated as modifications are made during the lifecycle of the plant.

What is needed is powerful software that supports the designers in this complex process, improving flexibility and driving down costs while maintaining high levels of data quality and traceability. This is best achieved within a database. Rather than storing the finished documentation, for example, in the form of diagrams, the database holds the underpinning design information that enables the automatic generation of such documentation.

The engineering of a process plant starts with a conceptual design phase known as FEED (Front End Engineering and Design). In this phase, the description of the material flows through the equipment are defined. This is typically performed by an EPC (Engineer, Procure, Construct) Company. The EPC uses design tools to model the process layout in all dimensions and other tools to model the physical properties of the process, such as temperature and pressure. Once the overall design is complete the detail design and procurement processes can begin.

The project then enters the detailed engineering phase where the EPC produces piping and instrument diagrams (P&ID) using 2D computer-aided design software. Instrumentation engineers use design tools to specify the details of each sensor and actuator on the P&ID. In parallel, the control engineers develop the control strategy drawings which show how the devices need to work together in real time to control the process. The safety system undergoes a similar process resulting in the specification of cause and effect matrices to define the inter-lock logic.

The output of this phase is the starting point for ABB's own technical activities which, in the case of automation includes hardware engineering, application software, and Human Machine Interface (HMI). The control system engineers use the company's own programming and system configuration tools, such as those included with 800xA Engineering Studio. The main project deliverables for detailed automation and electrical engineering are shown on the right-hand side of **1**.

Once designs are agreed, projects enter a manufacturing and testing phase, typically culminating in the Factory Acceptance Test (FAT) followed by shipment and installation including a Site Acceptance Test (SAT). After acceptance the system is handed over to the client for commissioning leading to operation and on-going maintenance.

There are many variations of the above process. Functions such as tele-

coms, electrical systems and analytics are increasingly important and could be within ABB's scope of delivery.

All large projects have a common need to manage complexity. For a plant with tens of thousands of instruments, a huge volume of inter-related information must be managed. This information originates from diverse sources; from people working in separate teams; in separate companies, often on separate continents; each with their own set of specialized tools.

The engineering challenge 1:

Globalisation of engineering

The traditional model of the project engineering lifecycle as described above is being challenged by the intense competitive pressures of globalization.

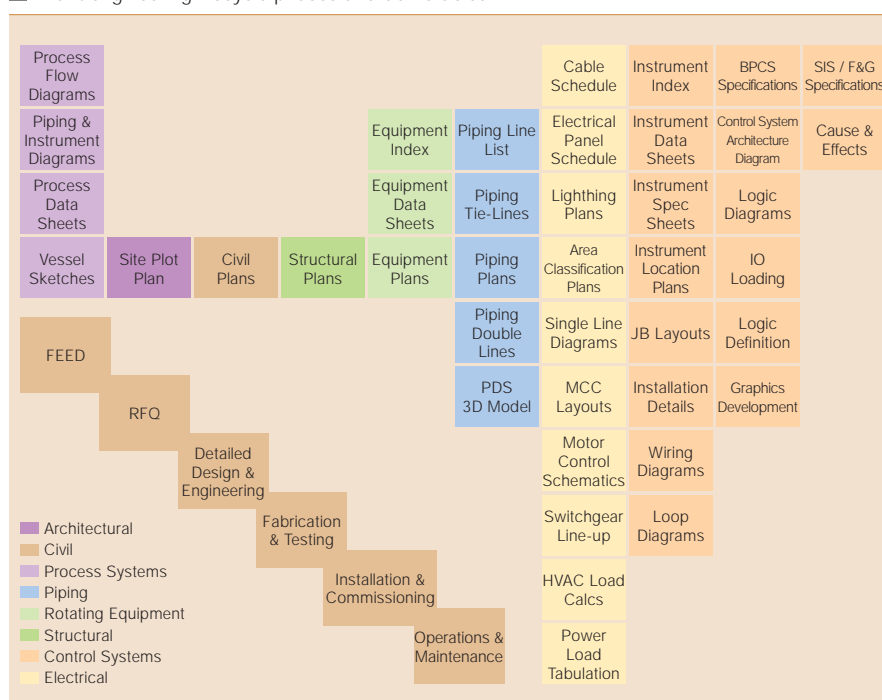
Shorter delivery schedules force project engineering partners to work in new ways and break the traditional linear engineering model in order to allow more tasks to be performed in parallel. Cost pressures force the project engineering partners to outsource more tasks to high-efficiency engineering centres. More stringent safety and environmental regulations are forcing project engineering partners to

produce more and better documentation. More demanding customers insist on handover of a high-quality engineering database along with their process plant including systems to keep this data synchronized with plant changes so that the database stays "as-built".

Progress in IT is allowing project engineering partners to upgrade their own tools and add features to cope with these new challenges. A central prerequisite for this is the ability to exchange data with globally distributed teams, and to manage, with full traceability, the evolution of this data throughout the lifetime of the project. To support these requirements, engineering and design tools are becoming data- rather than document-oriented with the drawing document with rendered from this data. Data is also being increasingly standardized in neutral formats promoted by organizations such as the IEC (International Electrotechnical Commission).

As the world's largest process automation and electrical supplier, ABB is investing in tools, methods and standardisation strategies which are transforming the shared data from an engineering burden into a high-value asset

1 Plant engineering lifecycle phases and deliverables



Capital productivity

for both project engineers and end-customers. The financial return from this effort is high as automation engineering typically accounts for half of the total control system package, and electrical engineering for more than one third of the total electrical package. Effective execution of engineering impacts on the project schedule, costs and on ABB's perceived capability to deliver such projects to a growing global market.

The engineering challenge 2: Delivering the digital asset

For end-customers, effective management of engineering information is vital for the safety and maintenance of the plant over its lifetime. For process industries, sources estimate that the value of well-managed electronic engineering data is approximately two percent of the total cost of the plant.

A large part of this engineering information is design data for tens of thousands of instruments and their input/output (I/O). For a process plant, instrumentation is about 10 percent of the capital expenditure (CAPEX) but about 20 percent of the operational expenditures (OPEX). Engineering companies eager to win contracts focus on reducing the former, but it is OPEX which most affects the operator's bottom line.

It should therefore be no surprise that end-customers are pushing for greater standardization and improved handling of process engineering information, as recommended by industry consultants ARC in a recent report ².

The call for greater inter-operability and for vendor independence of engineering design data is a frequent request in many areas other than process design. In device communication, for example, the data handled is real-time instead of design data, but the underlying issues are the same. For example, vendors who acted early to embrace open fieldbus standards had a sales advantage. As the technology opened the door for a range

of new products and services such as asset management.

The engineering challenge 3: Integrate automation and instrumentation design

There are a number of instrumentation design software packages on the market. These packages attempt to centralize plant instrumentation design information so that it can be easily accessed, manipulated and updated, thus ensuring consistency across the different instrument tasks and deliverables. All such packages address the project lifecycle information requirements from early conceptual design and engineering to construction, maintenance and decommissioning. The commonly used packages include Intergraph's SmartPlant® Instrumentation (SPI) and Innotec's Comos® PT. Currently SmartPlant® Instrumentation (formerly INtools) has a dominant position worldwide, particularly with the major EPCs, while Comos PT's market is mainly European, but growing.

These packages use a database to hold all data related to the design of the instrumentation system – from the

field instrument (sensor element or valve) through to the connection to the control system. This data is either obtained from other design sources e.g. P&IDs, or entered during the design process. Outputs from the system include instrument schedules; hook-up details for purchasing and installation; panel designs; cabling details and alarm data. All these are very relevant to ABB's project engineering processes. The data flows are summarized in ³.

These packages may also have modules or interfaces that facilitate valve and orifice plate calculations. They enable significant parts of the control system to be automatically configured, allow the telecommunications system to be engineered and also enable interfacing with maintenance, calibration and purchasing systems.

ABB is working together with Intergraph and Innotec looking at ways of making instrumentation design data available to all the engineering partners and their systems. The three key technologies being used to achieve this are:

- Shared type-libraries and a mechanism for mapping between these types
- Vendor-neutral XML-based format for data exchange to preserve object relationships
- Web services communication for open transport between vendors' systems

The first result of these efforts is realized as a shared type-library for S800 and S900 I/O hardware and ABB's Process Engineering Tool Integration (PETI) application software, as discussed in the following sections.

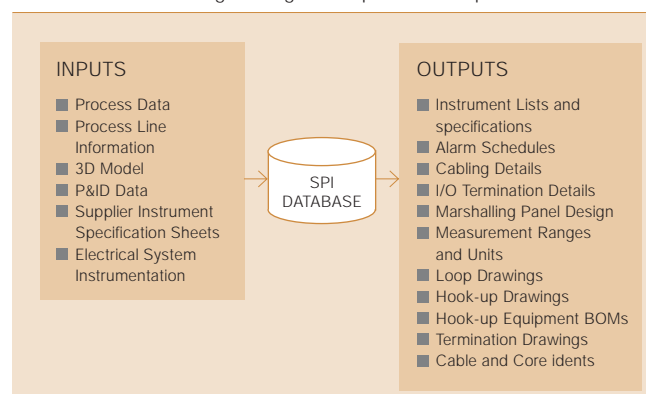
Shared libraries: Accelerating hardware engineering

In order to help instrumentation and hardware design engineers to use the SPI package efficiently, a set of definition files has been developed by ABB to represent the most common 800xA hardware components. Once imported into SPI, these libraries can be used to create objects such as

² Extract from an ARC insight document
Oct.28, 2004

From an operations perspective, engineering & design tools coupled with information management solutions form the basis of lifecycle engineering. Having this data available greatly reduces plant downtime, improves plant performance, and assists in better plant revamp planning.

³ Plant instrument engineering data inputs and outputs



I/O modules. The SPI user can drag and drop the desired I/O module type onto the project window. The field signals can then be allocated to the I/O channels and automatically cross-wired to the field terminals and IS barriers as required. Drawings may then be generated from the SPI system showing the correct termination numbers, terminal layout, cable and core numbering etc.

S800 and S900 I/O definition files are available for download by third parties from the Intergraph website, or for ABB users only, from ABB's internal SolutionBank.

The expanded SPI Reference Explorer folder in /4 shows some of the defined combinations of S800 I/O modules and termination units. The "My List" option allows a subset of I/O modules and bases to be defined for use on a particular project, thus aiding design standardization.

800xA has, from its inception, used the idea of type libraries to define frequently used objects within the automation project's applications. These libraries have been developed for a number of industrial sectors e.g., chemical and pharmaceutical, oil and gas, utilities and for common functional areas such as field devices, equipment modules and safety applications.

The extensive use of type-libraries is a key element in automating the generation of application objects which are based on information from the engineering database system used by the Instrumentation and Control System Hardware Engineers. ABB's Process Engineering Tool Integration (PETI) provides a mechanism to map interconnections between SPI instrument entities and the 800xA aspect object types. Instrument tags created in SPI are used to auto-create the corresponding objects within the 800xA control and functional structures. The SPI property is then used to set attribute values in 800xA. Once the object has been created, changes made to parameters during installation and

commissioning can be automatically written back to the SPI database, maintaining this as the "master".

An open approach: Neutral format for data exchange and web services

The project engineering partners use a wide variety of tools with incompatible data representation. As these tool providers release new versions, formats from earlier versions become obsolete. Preserving the design data across tools and across the decades of a process plant's lifecycle is the motivation for using a standard format based on XML to represent design data. The CAEX standard XML-based format originated within ABB. It is now an approved DIN standard and currently under review by IEC. This ultra-flexible format is used within PETI to represent plant design data for bi-directional transport between the engineering system and 800xA, as shown in 5.

PETI offers two different ways to access the engineering database. A stand-alone import/export utility can be used by the EPC to export the data as a file for subsequent import by the control system engineer. Alternatively, a web service can be used to extract data and transfer it electronically. In either case the data is transferred in CAEX format.

Integrated Tools in Use:

Experience from Projects

The PETI package has been used successfully on one recent chemical and pharmaceutical project in the UK, and is currently being used on several oil and gas projects in Norway and the UK.

UK ChemPharm and O&G

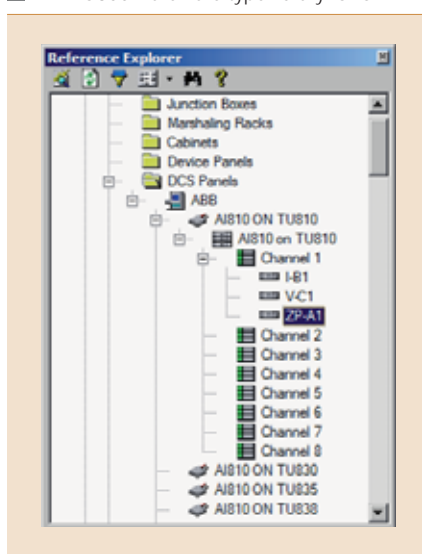
In the UK ChemPharm project, the ABB hardware design engineer worked within the EPC's offices using their SmartPlant® Instrumentation system to design the I/O and controller cabinetry supplied by ABB. The hard-wired I/O system adopted was S900 and a significant amount of Foundation Fieldbus instrumentation was also used, particularly for control valves. The SPI was used to generate "strip" drawings, showing all terminations and interconnecting wiring and pneumatics. These were used in conjunction with externally-prepared standard panel designs to build the 12 panels required. The same documentation was used for inspection and testing. No other detailed design documentation was required.

6 shows one of the completed panels with examples of the SPI documentation used. A similar approach is now being used for two UK based oil and gas projects but with the ABB hardware design engineers based in the ABB offices and working on the EPC's SmartPlant® Instrumentation system. These systems will remotely use terminal server technology to maintain system security.

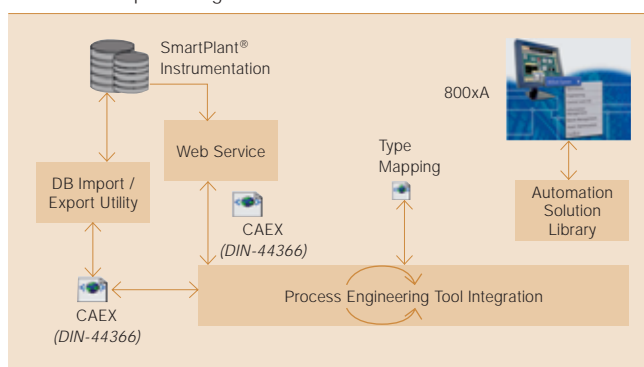
Norwegian oil and gas

BP has been supportive in the use of PETI on the Valhall project based in Norway and have guided ABB in ex-

4 ABB S800 Hardware type library for SPI



5 Data Transport using CAEX between SmartPlant and 800xA



Capital productivity

tending PETI to support an online version of their alarm response manual (ARM). The ARM data is centralized in SPI but will be shared with operator graphic displays on ABB's 800xA system. PETI enables experienced operators and process engineers to view and, if the security level permits,

6 Completed cabinet with an example of wiring diagrams automatically generated with PETI



modify alarm settings as a single shared dataset, allowing the master engineering database to be kept "as-built" throughout the lifetime of the plant.

End-customers are also interested in the ability for 800xA operators to access SPI loop drawings, instrument specifications and other documents directly via the operator workplace. These documents, which are relevant to operations and maintenance functions, are rendered live from the SPI database server, where they can readily be maintained "as-built". Some examples of this 800xA Workplace integration are shown in the screenshots in 7.

One outcome of these projects has been a refinement of engineering work-flows between customer, EPC, ABB and other package suppliers. Early agreement between all parties on standards to be used for libraries and data transfer between systems is essential.

SmartPlant integration: An enabler for a main automation contractor

In some large contracts, the automation vendor has an expanded role typically known as "Main Automation Contractor" (MAC). In this role, ABB can be additionally responsible for the instrumentation scope, creating the instrument list from the received P&IDs and ensuring each instrument is fully

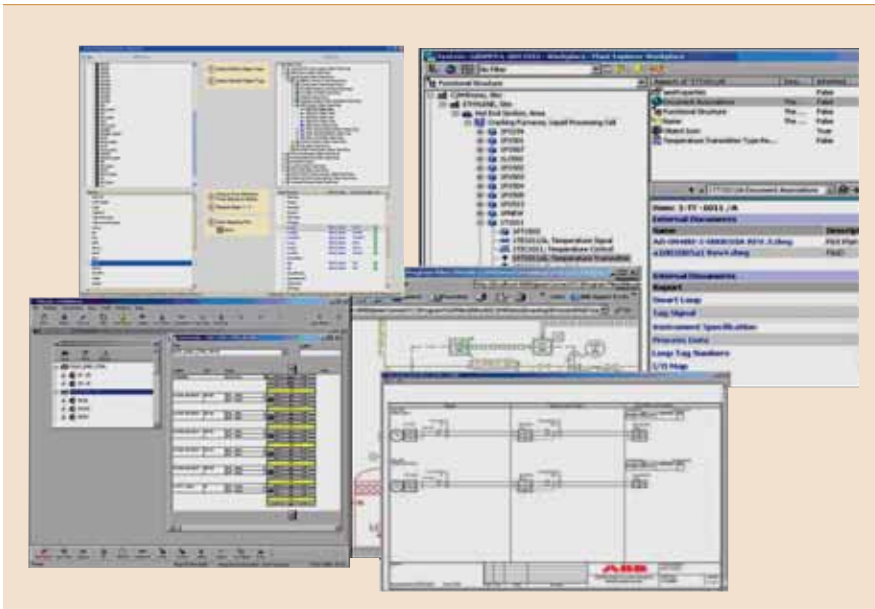
specified and capable of fulfilling its process line function. A similar level of responsibility with respect to switchgear, cabling and the electrical instrumentation engineering applies if the electrical package is included within ABB's scope.

Progress in IT is allowing project engineering partners to upgrade their own tools and add features to cope with these new challenges.

In addition to these engineering responsibilities come the added data management tasks related to purchasing, installation, commissioning and documenting all these devices.

The data integration approach described here is a key enabler for ABB in this strategic role. Instrument lists will no longer be issued to the MAC by the EPC. Effective execution requires that this interface be automated, and in addition end-customers will expect that a MAC contractor's database will be fully integrated with other design databases, for example P&IDs and 3D plant models. Use of SPI as the instrumentation and panel design tool will help minimize the risks of taking the MAC role. The SPI database has out-of-the-box synchronization with P&ID, Electrical and 3D design, and because of the PETI interface also with 800xA.

7 PETI screenshot (top left) and workplace integration of SPI with 800xA



The systems businesses within ABB already function as system integrators. Using this new technology ABB can additionally develop the MAC role to become the data integrator. The engineering database system will deliver advantages for both the owner/operator and ABB during the plant lifecycle.

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Integrated electrical and automation systems

Tom F. Nestli, Peter Tubaas

As process plants get larger and more complex, automation systems must handle an ever-increasing number of signals. At the same time, the number of electrical consumers increases, making an electrical control system essential. The electrical control system is an automation system in itself providing an interface be-

tween the process control and the electrical consumers and actuators. ABB takes responsibility for all these systems and their integration. By letting ABB handle the integration and all the interfaces, customers benefit from faster project execution, reduced re-engineering, higher quality, and higher operational efficiency.

Capital productivity

Electrical systems are clearly a core part of any process plant, providing electrical energy to drive motors, energize heaters, power lighting and auxiliary equipment. The electrical system is invariably complex, relying on thousands of components and kilometers of cabling. The complexity of the system increases with the size of the process plant. Such large process plants are reliant on automation systems to operate efficiently and safely. These automation systems will typically respond to tens of thousands of signals in a quick, predictable and reliable manner. The seamless integration of the electrical and automation systems are highly desirable in a process plant, a benefit recognized by ABB at the Statoil Snøhvit – or Snow White – liquefied natural gas (LNG) plant. Here, the Electrical Control and Supervision System (ECSS) communicates with a wide range of equipment and ensures a stable power supply to the LNG facility.

Snøhvit

The Snøhvit field – named after the fairytale character snow white – was discovered more than 20 years ago. The road to develop this gas field has been long and winding, but the project is finally close to production start. It is planned to go on-line during the summer of 2007.

The past few years have turned the uninhabited island of Melkøya ¹, not far from the town of Hammerfest, into the largest building site in Northern

Europe, and the largest construction project that Norway has ever seen.

No system is more critical to the processing plant than the combined safety and automation system.

Soon, gas from the Snøhvit field, approximately 140 kilometers offshore in the Barents Sea, will be flowing into the gas processing plant for treatment and shipping to the global LNG market. The core products of the plant will be liquefied natural gas (LNG, 5.67 billion m³/year), liquefied petroleum gas (LPG, up to 250,000 tonnes/year) and condensate (up to 900,000 m³/year). All products will be exported by ship.

Snøhvit is the first development in the Barents Sea. The oil and gas fields were discovered in the early 1980ies. Combined with the adjacent Albatross and Askeladd fields, Snøhvit contains more than 300 billion m³ of natural gas. Gas will be extracted from the seabed using subsea equipment, which are operated remotely from Melkøya. The subsea control system was delivered by ABB in the UK (now Vetco Aibel). The topside of the subsea control system, which is an integrated part of the overall Safety and Automation System (SAS), was delivered by ABB in Norway.

Complete control of the plant

Snøhvit is an extremely complex installation. The process is extensive,

encompassing subsea control processing, complex LNG processes, and storage and loading of the final products.

No system is more critical to the processing plant than the combined safety and automation system. The number of signals running through the Snøhvit process is enormous; the Process Control and Data Acquisition (PCDA) system has to handle more than 30,000 signals simultaneously. An unscheduled halt in production is extremely expensive. Therefore, ABB's control systems are constructed and tested to provide the highest level of security and minimal downtime.

The hot exhaust gases from the gas turbines are used to provide heat for the parts of the process that demand high temperatures.

The philosophy of process plant owners in general, and Statoil in particular, is to provide its operators with a "single window" into the plant. ABB's 800xA Extended Automation system provides this facility and was, therefore, chosen for the Snøhvit project.

Plant power demand

Complexes for liquefied natural gas require a reliable and stable energy supply. Most LNG plants are, however, situated in areas in which the pow-

MS Nordlys, one of the ships of Hurtigruten – The Norwegian coastal ship operator – entering the port of Hammerfest.



¹ Map of northern Norway.



er supply is either unreliable or non-existent. The Snøhvit plant is no exception and must, therefore, rely on its own power supply.

Snøhvit contains more than 300 billion m³ of natural gas. Gas will be extracted from the seabed using subsea equipment, which are operated remotely from Melkøya.

To meet the power demand, the Snøhvit plant contains a 1.65 TWh power plant with five gas turbine-driven generators of about 50 MW each. These power the large refrigeration compressors of up to 65 MW, driven by variable-speed electrical motor, that are required to liquefy gases. The hot exhaust gases from the gas turbines are used to provide heat for other parts of the process. This set-up saves energy and provides about ten additional uptime days per year due to the much higher availability of electrical drivers (as compared to gas turbine drivers).

The Snøhvit plant not only includes its own power station and large compressor drivers, but also a large distribution network with several thousand relatively small electrical consumers. A large variety of ABB electrical components are included in ABB's deliveries to the plant. These include high voltage switchgear of the EXK-0 type,

rated for 145 kV, and medium voltage switchgear of the UniGear ZS1 type, rated for 6.6 kV and 11 kV. Also included are optical arc detection systems to provide early detection and quick protective action of switchgear to extinguish arcs. Further, MNS type switchgear is used at low voltage levels of 400 V and 690 V. Some 500 cubicles supplying power to about 2,500 consumers are included at these voltage levels; of which some 600 consumers are Insum starters (intelligent motor starters) and 75 consumers are variable speed drives of ACS 800 type. ABB's protection and control unit (REF542) is used throughout the plant to provide the highest level of security and selective protection actions in the event of a fault in the power system.

Electrical control and supervision system

The complex nature of the electrical system requires an automated ECSS. This system is required to unite the thousands of motors, switches, contactors and circuit breakers, and to minimize the effects should a fault develop. A single unscheduled shutdown for the entire plant is extremely expensive.

The ECSS is at the heart of the electrical system and communicates with the vast range of ABB products using serial links and Ethernet. It is also linked with the automation system and other third-party deliveries. The system consists of 48 AC800M controllers. The ECSS processes some 44,000 signals at

any one time – more than the plant's automation system. The ECSS provides a wide range of functions, enabling a stable power supply to the plant, lowering operation costs and reducing emissions, while at the same time increasing safety.

The past few years have turned the uninhabited island of Melkøya, not far from the town of Hammerfest, into the largest building site in Northern Europe, and the largest construction project that Norway has ever seen.

An important part of the ECSS is the Power Management System (PMS)¹⁾. Since a relatively small fault may lead to a cascade of equipment shutdowns that could affect a large part or the entire plant, faults must be handled quickly and appropriately to avoid a domino effect. ABB's PMS is also based on the 800xA Extended Automation system and is designed to monitor, control and protect all sections of a process plant. It includes functions such as:

- Supervisory control and data acquisition (SCADA), including generator, circuit breaker, mode and motor control
- Power control, including tie line control, peak shaving and load sharing

An ABB engineer taking an overview of the plant at Melkøya
(Photo: Peter Tubaas, ABB)



Two ABB engineers discussing the plans for the day at the LNG plant in Melkøya (Photo: Peter Tubaas, ABB)



Capital productivity

- Load shedding, including fast, slow and frequency based load shedding, as well as manual load shedding

ABB can draw on more than 50 years of experience with automation and electrical systems to optimize their integration.

Probably one of the most important and most frequently relied upon parts of the PMS is the load shedding function, which helps ensure that the consequences of any one fault in the electrical system has the smallest possible impact on the functioning of the plant. ABB has delivered and commissioned more than 30 PMSs worldwide, demonstrating that the PMS substantially improves plant uptime, efficiency and reliability.

The ECSS not only provides an interface between the process plant's automation and electrical systems; it also provides indispensable functionality and reliability in a plant where a system shutdown could cost millions of dollars. Although full communication and data exchange with the process plant's automation system is provided, the ECSS is not depending on it to operate. On the contrary, the ECSS can operate in isolation to ensure safe

and reliable operation of the electrical system.

Main electrical vendor approach

In the past, oil companies and engineering, procurement and construction (EPC) contractors have very often purchased different types of equipment (eg, transformers, high voltage switchgear, medium voltage switchgear and low voltage switchgear) under separate contracts. Project risks can be reduced, however, by including most of the electrical equipment and systems – as well as engineering – under one large contract. The result is lower costs and faster project execution with safer systems that are fully integrated and interoperable. Safety is improved during installation and commissioning since project co-ordination is more easily achieved with only one contractor.

Statoil recognized the merit of such an approach and merged all purchases of high voltage, medium voltage and low voltage switchgear, as well as the ECSS, for the Snøhvit project into a single contract. In addition to equipment delivery, ABB has provided a wide range of engineering services, including a long list of electric network studies. These are required to ensure safe operation and maximum efficiency of the plant.

Since the Snøhvit plant is physically connected to the northern Norwegian

power grid, it soon became of interest to study the dynamic behavior of the entire plant – including the gas turbine generator sets – and its connection to the grid. ABB has performed a dynamic stability study that was used to set and adjust the parameters of the power management system, as well as the dedicated generator control algorithms. This ensures not only stable operation of the process plant, but also ensures that the process plant contributes to the stability of the northern Norwegian power grid – as required by the grid operator.

Complexes for liquefied natural gas require a reliable and stable energy supply. Most LNG plants are, however, situated in areas in which the power supply is either unreliable or non-existent.

ABB at the cutting edge

ABB can draw on more than 50 years of experience with automation and electrical systems to optimize their integration. Uniting the electrical and automation systems is becoming a necessary feature of large process plants. Operating such plants without an automated system is almost unthinkable, not only for safety reasons, but also for reasons of cost savings and increased efficiency. Customers like Statoil rely on experienced companies like ABB to ensure safe and reliable plant operations.

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Footnote

¹⁾ See article "Not on my watch" on pp 30–34 of this issue of ABB Review Special Report.

Powerful renovation

Rejuvenating the Scholven coal-fired power station to meet new market requirements

Harald Bruns, Stefan Lauxtermann



Many of Germany's existing power stations will continue to operate well into the next decade, so it is very important to optimize and maintain existing installations. E.ON Energie, the largest privately-owned provider of energy services in Europe, recognizes the key role of process control systems as the data, information and nerve centers of its plants. Outdated technology and new operational requirements demand focused capital investment. E.ON Energie has, therefore, implemented a program to upgrade the process control infrastructure at the 2200 MW, six-unit Scholven power plant in Gelsenkirchen, Germany. This included replacement of the 345 MW Unit C process control system with ABB's System 800xA.

Capital productivity

E.ON Energie is a multinational corporation, serving 15 million customers across Europe with gas and electricity. It relies on state-of-the-art control systems to ensure customer satisfaction on a local level and to maximize efficiency across the group. When the process control system at the company's Scholven power plant needed updating, E.ON approached ABB with a clearly-specified list of requirements. These included:

- fully automatic operation of the power station processes during normal load operation, start-ups, load ramps, shutdowns, standstills, and during upsets
- an ability to operate and monitor the entire system from one control console using individual displays and large screens
- straightforward process monitoring to be carried out by a single process operator
- fast and accurate fault analysis to minimize the risk of outages and to reduce downtime, should outages occur
- time- and fuel-optimized startup with full consideration of material constraints – changeover time from oil to coal firing to be as short as possible

Although originally designed to operate as a base load unit, the changed market conditions now require the Scholven power plant to serve as an intermediate load unit. The operating modes that must be supported when generating power are “turbine follow mode”, in which the turbine controls the live steam pressure, and “boiler follow mode”, in which the boiler controls the live steam pressure. Both modes must support the coordinated unit control for pure and modified sliding live steam pressure typical for one-through boilers. The unit must satisfy the UCTE grid code requirements for both primary and secondary frequency control. Primary frequency control is achieved by throttling the main steam valve. Secondary frequency control is accomplished while maintaining primary control capability. This means that the load changes resulting from increased demand may be ramped up by means of feed-forward control using the fuel flow only.

A further requirement was, that the unit had to be able to follow demands from dispatch control center, ie, to be able to accommodate frequent, highly dynamic load swings and triangles. E.ON also specified a need for partial load or island system operation; ie, load rejection to auxiliary systems demand (house load) or island network operation. Partial load operation at 33 percent (400 t/h of live steam) of the full rating of the unit was specified (recirculation).

Scope of the replacement program for the process control system

In addition to installing the new process control system, ABB redesigned the entire control room. The existing actuators and sensors had to be upgraded and, in some cases, replaced. All upgrades accommodate E.ON's need for the entire power production process to operate automatically during start-ups and shut-downs. Most of the existing field cabling remained intact, although some new wiring was required to accommodate the newly installed actuators and sensors.

The plant's new turbine control system is based on the ABB's System 800xA with AC 870P controller. This was used to implement a Turbotrol® turbine control application package for the regulation and protection of

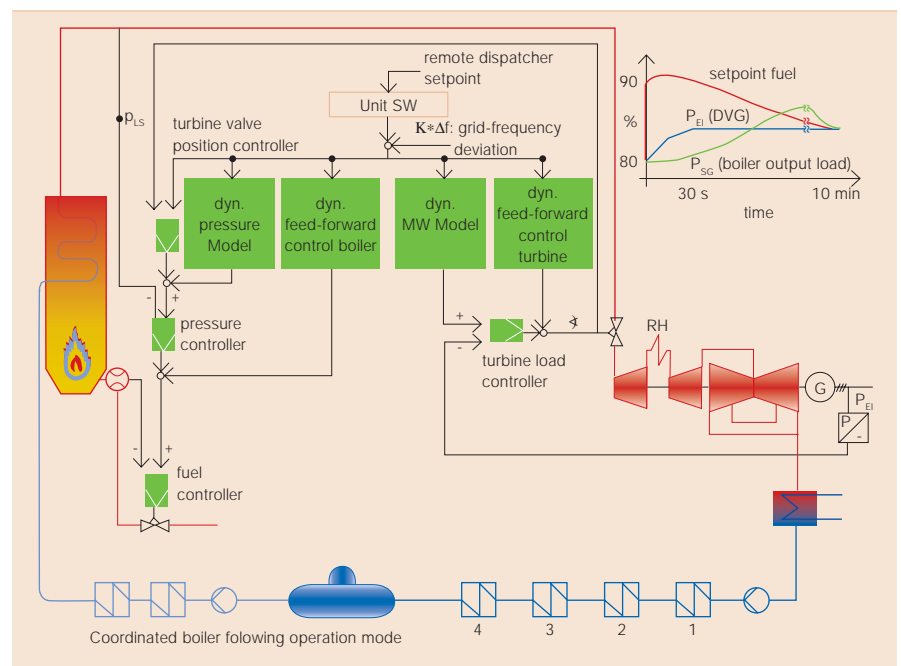
the main turbine. The integrated turbine, the unit and the process control platform creates numerous synergies and advantages for users.

The control system for the plant's soot blowers and burner had already been implemented using PLCs (program logic controllers). Both systems were integrated via Profibus (process field bus). The design of the interface ensured that the systems could be monitored and operated in accordance with E.ON's specified project standard.

Model-based unit control

ABB's Modan automation concept was used to meet the challenging specifications regarding primary and secondary control capability. This concept coordinates the two main control variables of the power plant; fuel set point and turbine control valves, on the basis of dynamic parallel models. It consistently applies a combination of model-based feed forward control and dynamic set point control. This is done for the turbine control as well as for the set points of the main steam valve pressure and fuel control. The Modan unit control is patented and uses the turbine control valve and the fuel set point value for the steam generator as control variables. The basic outline shown in **1** is greatly simplified and applies to „turbine follow op-

1 Outline of model-based unit control



eration". The Modan concept also allows other operating modes such as „boiler follow operation".

Control room design

The unit control console ² was installed in a new twin control room that serves units B and C of the plant. The newly-designed room incorporates clearly defined work areas for the operators, shift superintendent, electricians (auxiliary systems) and the electrical equipment isolation management.

The control system change-over for unit B and the move into the new control room are scheduled to occur during the annual maintenance shutdown in 2007.

The display screens are only the external indication of a significant increase in the degree of automation at the plant. As a result of the enhancements, the operators' job description has changed from manually controlling the process to one monitoring and correcting a now fully automatic controlled process. It was therefore all the more important to design the control room environment to be stimulating so that employees would be better able to concentrate. The individual objectives that were achieved are as follows:

- Carefully designed control room architecture with clear separation of areas for units B and C.
- Central positioning of the screens for auxiliary services at the shift supervisor's workstation.
- An area that allows shared use of the equipment isolation counter for the two units.
- Direct and indirect work area illumination; the ceiling is used as a reflector to provide an evenly lit work area.
- Ceiling, equipped with micro-porous acoustic panels, evenly distributes air and minimizes noise.
- Low-level lighting to improve visibility of larger screens.

A novel concept for operation and monitoring

In choosing System 800xA, E.ON selected a process control system that

² The new control room at Scholven



has a broad range of new functions, while maintaining a uniform user interface. The scope of the functions goes far beyond conventional operating and monitoring systems, encompassing both information management and engineering.

The underlying data access, storage and management system is based on ABB's patented aspect-object technology. The „objects" represent process elements of varying complexities, such as drives and measurements, coal mills, feed pumps, turbines or boiler systems. The „aspects" are characteristic data associated with these components that are required for system operation and maintenance.

Using this system, aspect data is stored only once and can be called upon from various objects. Examples of aspects include:

- Function diagrams
- Operation and diagnostic displays
- Maintenance management functions
- AutoCAD drawings (eg. connection drawings, P&I-diagrams)
- Monitoring camera images

- Files in PDF format for scanned-in, non-processable documents such as manuals
- Supplier web sites
- Microsoft Excel documents (tabular calculations, adapted protocols, etc.)
- Microsoft Word documents (operating and calibration instructions, data sheets, etc.)

This ends painstaking searches for data that are distributed across various locations, computers and applications. Users navigate intuitively through the entire plant and

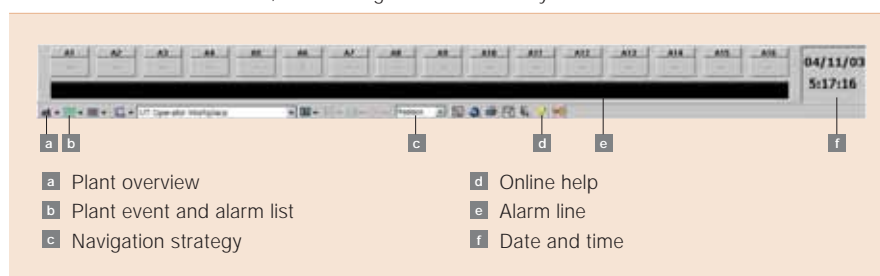
are therefore able to maintain a constant overview.

Users can configure the process displays to suit their own particular responsibilities, setting their own preferences, allowing them to choose appropriate work methods. The fast, flexible, secure access to relevant information and data makes it possible for operators to carry out their monitoring and operating activities efficiently and accurately.

Alarm management for fast reaction to faults

A range of new features has been integrated into System 800xA. One example is a distinct plant overview in the header line ³. A summary alarm line appears underneath it. It shows the most recent unacknowledged alarm that has the highest priority. In System 800xA, users can jump directly from the header line to the associated plant diagram. Another key feature is that the header line indicates how many messages there are per plant sector and which has the highest priority.

³ Plant overview header line, a new integrated feature of System 800xA



Capital productivity

The entire alarm list can be selected from the unit area or from a dedicated selection point at the top of the screen. It is possible to store individual notes for each alarm for the alarm list as well. The individual alarm list elements can be shown or hidden and be listed in any order. The alarm list can also be sorted by the individual elements. This can be very useful, for example, to sort according to time stamp, plant equipment tag or priority. The alarm list can be exported directly to Excel for further analysis using "copy and paste".

Analyzing the process using trend curves

Processes can be reliably analyzed with the help of trend-chart displays. A wide range of functions, some quite innovative, are available in System 800xA to generate such trend charts. Both real-time data and historical data are presented seamlessly in these charts. The time interval can be selected by the user. Real-time trend characteristics can be compared to curves generated yesterday, last week or last month using the „time offset“ function. A zoom function is also available, which can be used to call up all data within a particular time interval to the exact minute ⁴. New functions for the chart displays include a magnifying glass and the ability to create horizontal lines or define horizontal and vertical areas.

Process quality monitoring

As a result of the liberalization of the energy market and changing environmental restrictions there is a need for detailed knowledge of the current and the historical quality of the process management in power plants.

As a consequence plant operators face a multitude of challenges. On the one hand, the liberalization of the energy market creates an ever-increasing cost pressure. On the other hand, environmental restrictions aim to reduce the output of carbon dioxide. Both challenges can be dealt with through re-

duced fuel consumption by increasing the efficiency of energy conversion in the power plant.

An alternative to cost-intensive construction of new power plants is to improve the quality of energy conversion in existing power plants. Even if the efficiency of the process cannot be ramped up arbitrarily by changing the way a plant operates, an attempt can be made to come as close as possible to the operational optimum.

The implementation of process quality management systems at the different power plants within E.ON is designed to allow plant personnel to monitor and optimize plant operation in order to achieve sustained improvements of the process quality.

E.ON's decision to implement process quality monitoring in most of their plants was also driven by the requirement to have comparable operational key parameters of their main production units.

The process quality management system at the Scholven power plant's Unit F consists of one server PC and several clients. The PIMS database for storage of analog and binary process values, calculation results and validated values is installed on the server PC. The process values are collected from different control systems sources (Siemens Teleperm, ABB 800xA). Pro-

cesses such as the following also run on this computer

- Calculation of current performance indicators of all major plant components and the total plant.
- Simulation of load dependent reference data of all major plant components.
- Calculation of the quality factors of all major plant components and the total plant process data validation.

Calculations resulting in trends and process graphics can be viewed on various client computers located in the main control room and in the administrative building. Client computers can be used to cre-

ate and modify the simulation or data validation model. A network license for the engineering software is for this purpose installed.

E.ON KGW1 plant management decided to implement a pilot project for the Scholven power plant's 676 MW unit F. After successful implementation and acceptance in October 2005, an order followed for the implementation of process quality monitoring for units C and E.

Outlook

After Unit C had been successfully restarted on schedule, E.ON gave ABB the order to upgrade Unit E process control system to System 800xA. The changeover took place during the 2006 maintenance outage. E.ON also plans to upgrade the process control system for Unit B during the 2007 maintenance outage. These steps will make optimum use of potential synergies.

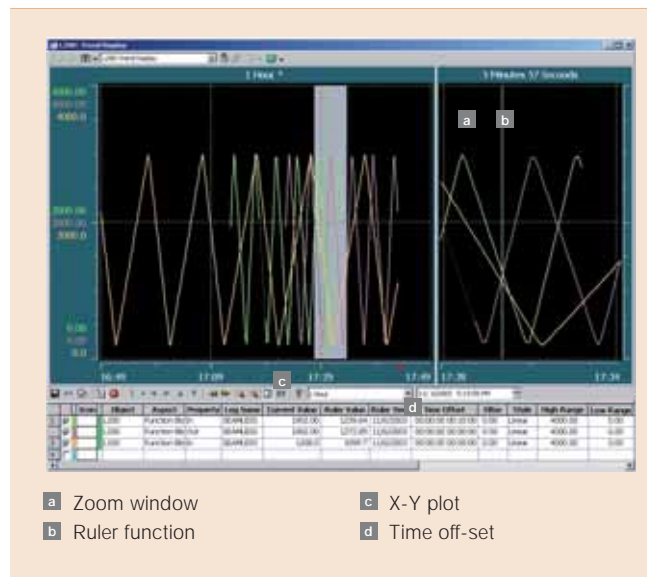
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⁴ Zoom function showing all data within a chosen time interval.



Analytics in Shanghai

Serving the needs of the Asian market and beyond

Barry Williams, Dan Mantey



The design, construction and installation of analytical sampling systems are critical to the safe and efficient operation of modern industrial plants. This is especially true in heavy manufacturing process such as petrochemicals and refining. These sampling systems, and the large shelters that house them, were in the past typically built by specialized companies in North America or Western Europe and then shipped across the globe. The boom in petrochemical and oil and gas investment in China and Southeast Asia, and the Middle East changed the market dynamics. Responding to this need ABB made a strategic decision in 2002 to locate an Analytical Systems Integration Unit (SIU) in Shanghai, P.R. China.

Capital productivity

In doing this, ABB saw that it was positioning itself to better serve the needs of the Asian market, especially China. This included covering the long term service needs of its customers. By designing and building systems in China, ABB could both reduce the costs of fabrication and avoid large shipping costs from North America and Europe. To ensure success it was necessary for ABB to recruit and properly train local personnel with the necessary engineering skills and the motivation to ensure the on-time delivery of high quality analytical sampling systems.

The Shanghai SIU started operation in January 2003 with only four full-time staff. Initial projects were subcontracted to a local third party vendor for manufacturing. In the meantime a plan was formulated to develop a totally integrated SIU, which would employ all ABB personnel. All key functions would be located in the same facility in order to assure tight control of project management, quality and customer communications. The plan was fully realized in April 2004 when the operation moved to the Waigaoqiao Free Trade Zone in Shanghai.

It was also recognized that the Shanghai SIU would need to increase its personnel considerably in order to ensure that projects could be executed and delivered in a timely and efficient manner. The initial focus was to find project managers, analyzer specialists and system design engineers. ABB sets high expectations for techni-

cal excellence, knowledge of the business, experience, specialist skills, project management capabilities and inter-personal skills, which are all required to meet the challenges and the demands related to working with both Chinese and international clients.

ABB was fortunate to secure the services of knowledgeable Chinese personnel with experience of analytical systems from the oil, gas and petrochemical fields. The very capable local staff was supplemented by several key expatriates from Europe with a broad range of experience in supplying large scale analyzer systems globally.

Poorly designed analyzer systems have a significant additional financial impact over the life cycle of the plant due to plant shut-downs, design changes, increased maintenance, and increased call out charges and spare parts holdings.

ABB's goal was to deliver projects with the same quality, methodology and efficiency as from the SIUs in Europe and America. Despite the high experience levels of the local Chinese staff a considerable amount of skills training was required and implemented via the following courses:

- Project managers – ABB accredited Project managers course.
- Engineers and designers – external and internal technical courses tailor-made to meet their job requirements.
- Sales, engineering and service personnel – ABB product and third party analyzer courses.
- Workshop personnel – electrical, mechanical and welding courses.
- All staff – safety training.

ABB's Shanghai SIU is now a totally integrated operation and has a staff of 61, which is engaged in the following disciplines: external/internal sales, project management, engineering, design, procurement, business support, quality assurance, manufacturing, inspection, testing, commissioning, training, service and support. The 2000m² Shanghai SIU facility was custom designed and purpose built to meet our manufacturing floor space requirement complete with test, welding, stores and material quarantine areas.

The Shanghai SIU initially served the rapidly expanding market in China, especially in the chemicals sector. Now, after building upon a strong reputation for providing quality analyzer systems, the Shanghai SIU exports systems to other countries in the Asia Pacific region, as well as servicing the European and Middle Eastern markets.

Since its start in 2003 and until the end of 2006, the Shanghai SIU has



Factbox Major project applications awarded to ABB Shanghai SIU

Application	System delivered	Year of order
LDPE	2 Houses	2003
OXO & AA/AE	5 Houses + Field Systems	2003
LDPE	pH/Conductivity/Hydro Leak	2003
LOP	7 Houses + Field Systems	2003
MA/PA/FA	7 Houses + Field Systems	2003
Olefins	4 Houses + Field Systems	2004
Thermoxidizer	1 House	2004
Methanol	1 House	2004
Isocyanates	7 Houses + Field Systems	2004
Naptha	FTIR Analyser/Sample	2005
Acetic Acid	1 House + Field Systems	2005
CEMS	3 Houses	2006
OXO & AA/AE	2 Houses	2006
Acetic Acid	1 House	2006
Silicone	9 Houses	2006
Refinery	8 Houses + Field Systems	2006

successfully delivered over 47 analyzer houses. These deliveries include about 185 ABB analyzers **Factbox**. Over 33 percent of the delivered analyzers are manufactured by ABB, while the remaining share is sourced from various third party suppliers. There are several customers in China, who use third party analyzers, but still require ABB to design, construct and deliver the sampling system due to the quality of its work.

ABB considers its people its greatest asset and the staff in Shanghai is not viewed any differently. It has been instrumental in ensuring a continually expanding operation resulting in both an increased market share and client

base. Sales personnel are encouraged to bring prospective customers to the facility to see the quality of the ABB products first hand.

The Shanghai SIU has been awarded and works to the following quality assurance standards:

- ISO 9001: 2000
- ISO 14001: 2004.

Since its start in 2003 and until the end of 2006, the Shanghai SIU has successfully delivered over 47 analyzer houses. These deliveries include about 185 ABB analyzers.

The Shanghai SIU assumes total responsibility for the project from purchase order to client handover; ongoing service support is also available via ABB's strong service network, which is present in China as well as in almost any other end-user destination country. Services range from spare parts support and demand service to full resident maintenance service contracts. ABB in China currently has a dozen service engineers dedicated to analytical systems. This enables ABB to provide its customers with excellent local after sales support. Within China this is a real ABB advantage,

since most suppliers do not manufacture analytical systems in the country. The number of service engineers will continue to increase both in China and abroad as customers demand faster response times from this highly trained cadre of personnel.

This full value-chain approach provides the clients with a single communication channel, and the same ABB multi-discipline project team is involved in the project throughout its life cycle. This results in reduced costs, long term reliability, ease of maintenance and most importantly, lower total cost of ownership due to partnering with a single solutions provider.

The number of service engineers will continue to increase as customers demand faster response times.

The majority of clients now realize that poorly designed analyzer systems have a significant additional financial impact over the life cycle of the plant due to plant shutdowns, design changes, increased maintenance, and increased call out charges and spare parts holdings.

ABB Shanghai SIU's fully integrated operation with a multi-national and multi-discipline staff has the experience and track record to handle major global analyzer system projects. ABB is able to take advantage of the cost structure of the operation, which allows the SIU to deliver quality analyzer systems at extremely competitive prices in this very price oriented market place.

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Process Analytical Technology

Integrated PAT solutions for the Life Sciences industry
Thomas Buijs



Pharmaceutical manufacturers have been providing medicines for more than 60 years using tried and tested formulations and manufacturing and quality management processes. In recent years new innovations in measurement, control and IT technologies have helped them to manage their processes more efficiently, with higher productivity as a result.

In addition to these innovations, a specific initiative has also been making its presence felt. Known as the Process Analytical Technology (PAT) Initiative, its goal is to understand and better control the entire manufacturing process within the pharmaceutical industry. Processes are actively managed to achieve a high degree of repeatability and efficiency, and quality assurance becomes continuous and real-time activity.

ABB is working in partnership with its customers to deliver a systems approach to PAT. From measurements to process improvement, ABB supports PAT implementation and the delivery of real business benefits.

Process Analytical Technology (PAT) is a system for designing, analyzing, and controlling manufacturing processes based on an understanding of the scientific and engineering principals involved, and identification of the variables which affect product quality. The PAT initiative is based on the FDA (The US Food and Drug Administration) belief that: “quality cannot be tested into products; it should be built-in or should be by design.”

The primary goal of PAT is to provide processes which consistently generate products of a predetermined quality. Effective PAT implementation is founded on detailed, science-based understanding of the chemical and mechanical properties of all elements of the proposed drug product. In order to design a process that provides a consistent product, the chemical, physical, and biopharmaceutical characteristics of the drug and other components of the drug product must be determined.

The role of on-line advanced measurement systems is pivotal to realizing the benefits of PAT. However, the transformation of process performance to provide greater efficiency and cost effectiveness, in addition to assured quality, requires much more than the application of measurement technologies.

Realizing such gains also requires an integrated measurement, control, workflow management and information environment which meets the needs of research and development, manufacturing and quality processes within the business.

Using PAT, ABB offers a unique industrial solution so that its customers in the Life Sciences industry can enhance their processes to deliver the benefits of PAT, from process investigation right through to achieving operational excellence.

The benefits of PAT

In a nutshell, the benefits of PAT can be summed up in the following sentences: PAT improves asset uptime and availability for pharmaceutical unit operations by up to 40 percent. Costs are reduced by up to 30 percent while fundamental product quality is maintained. How this is achieved is outlined in the following paragraphs.

Better process understanding

The physical and chemical processes involved in the manufacture of pharmaceuticals are complex and not well understood. However, during both the development and manufacturing stages, PAT-enabled processes provide access to information rich data – in real-time – which can be “mined” to find the critical quality parameters through multivariate analysis. Once these are determined, it is then easier to establish accurate control schemes for the relevant process parameters so that a more robust process can be established in a shorter timeframe and right-first time production is ensured.

Repeatable batch trajectory

Quality control requires a highly detailed level of process understanding. ABB offers a combination of advanced and regulatory control based on robust process models that deliver verifiable results. The PAT solutions detect and manage critical control points in the process so that deviations from a required profile are correctly managed and fed back into the high performance control zone.

Reduction in overall cycle time

Processing to a quality-based endpoint is a key part of the PAT quality assurance regime. This eliminates wasted cycle time associated with processing using a fixed time-based endpoint including subsequent reprocessing time – and provides a streamlined workflow through the facility.

Reduction in Quality Assurance (QA) costs

Reduction in Out of Specification (OOS) events and consequent investigation leads to significant cost savings. PAT enabled unit operations reduce the reliance on laboratory testing and associated lead times, thus reducing the overhead costs associated with product quality.

Improvement in Overall Equipment Effectiveness (OEE)

OEE is the industry accepted tool to measure and monitor production performance. It can be applied at the machine, manufacturing cell or plant process level. Making cycle times repeatable and reducing in-batch down-time through improved control

and early fault detection delivers a more flexible agile asset with much improved OEE.

ABB's PAT Center of Excellence (CoE)

Following the need to offer an integrated approach to PAT, ABB created a CoE in 2004. Its mandate is to develop ABB products and services which will enable customers to reap the benefits of PAT. The PAT CoE builds on ABB Analytical's experience of providing Pharmaceutical PAT Fourier Transform Infrared¹⁾ (FTIR) and Fourier Transform Near Infrared (FT-NIR) analyzers to the market for the past ten years, as well as ABB's position as a leader in Automation and Control, in particular with its 800xA platform.

The PAT CoE leverages ABB's global resources, which include experienced research and development personnel, application specialists, chemometricians, process engineers, IT engineers, senior validation consultants and advanced process control specialists. Its mandate covers the entire range of PAT applications:

- Initial integration with Manufacturing Excellence programs
- Multivariate analysis
- Basic and advanced analyzers
- Data gathering
- Data storage
- Data mining
- System integration
- Connectivity with manufacturing and business systems
- Advanced Process Control (APC)

Analytical and measurement technologies – the platform for PAT

At the heart of any PAT system is a series of measurements made on real processes under realistic manufacturing conditions. Data from conventional process measurement systems (eg, temperature, pressure and flow) give some insight into manufacturing processes so as to achieve a basic level of process understanding. However, manufacturing processes are usually too complex for simple approaches to be effective in achieving process understanding and control. An in depth degree of understanding and tight con-

Footnote

¹⁾ See also “Waves to data”, ABB Review 3/2006 pp 73–74.

Risk management

trol can only be achieved by employing the correct technologies to measure relevant process parameters. These technologies are often based on chemical composition and/or physical form measurements, ie analytical techniques.

ABB has top class analytical technologies, from FT-IR/NIR spectroscopy right through to mass spectrometry and Gas chromatographs. Fully integrated into ABB's Industrial IT (IIT) concepts, the systems have unparalleled connectivity capability and provide a robust measurement platform for all PAT applications. Connected to the IIT information backbone, the process data developed can be used in everything from advanced control to process troubleshooting.

FT-IR/NIR analytical solutions

FT-NIR is, by far, the most widely used and proven analytical technology for PAT applications. ABB has ten years of experience in supplying off-line, at-line and on-line FT-IR/NIR PAT solutions to the pharmaceutical industry and is a preferred supplier of most of the leading companies. Turn-key analytical solutions are provided for research and development for scale-up, drug substance, and drug product manufacturing.

Typical drug substance solutions include:

- Reaction monitoring
- Fermentation monitoring
- Crystallization monitoring
- Dryer monitoring
- Solvent Recovery monitoring

Typical drug product applications are:

- Raw material identification
- Blend monitoring
- Spray coating monitoring
- Fluid bed dryer monitoring
- Solid dosage form content uniformity
- Moisture in lyophilized solids

Even though the available analytical technology fulfills a wide variety of measurement needs, there is still a very wide Information Technology gap which is preventing the industry from efficiently gathering and using this data in real-time for process understanding and control. To be more specific, most of the advanced PAT analyzers currently available do not share a common user interface and data format, and do not offer the connectivity required to efficiently exchange this data with plant and business systems. Furthermore, the data is highly scattered and is not available in real-time in a central location.

The Industrial^{IT} for Process Analytical Technology suite

To address these drawbacks, ABB is currently developing an Industrial^{IT} PAT suite that features an integrated IT platform using proven analytical and automation core components. This platform is based on the award winning 800xA Industrial IT Automation technology²⁾. The concept **1** is based around a flexible, modular, scalable and open architecture **2** which uses OPC – a standard communication protocol – to exchange data between modules.

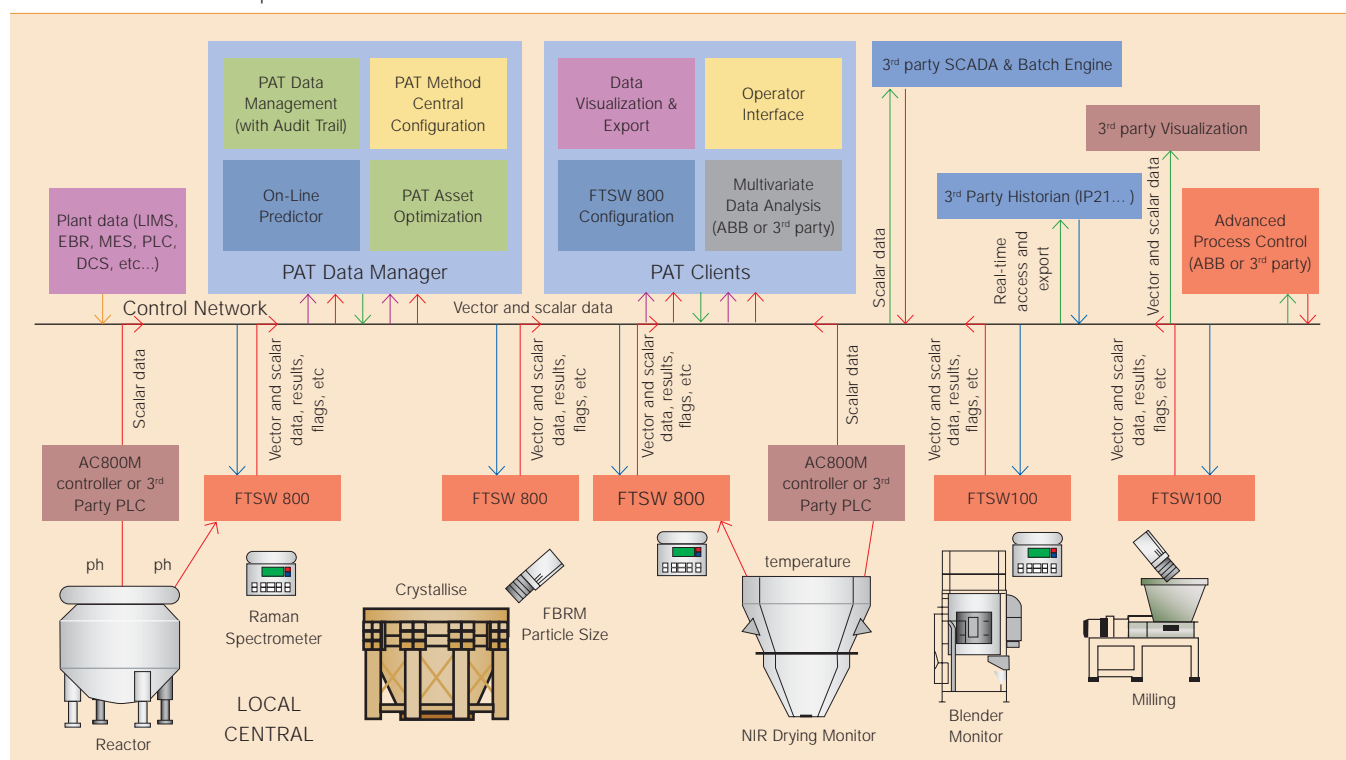
FTSW800 – Analyzer control process software for data acquisition

This flexible, open architecture process analyzer software **3** is designed for implementing analytical methods and control sequences. It offers a single platform for the local control of multiple analyzers from spectroscopy (IR, UV-VIS, Raman etc) to other advanced analyzer types (particle size, acoustics, HPLC, mass spectroscopy etc). In addition, it provides unified engineering and

Footnote

²⁾ <http://www.abb.com/productguide> Information on ABB's 800xA Industrial^{IT} Automation technology is found under the "Control Systems" section.

1 Industrial^{IT} for PAT concept



operator interfaces as well as tools for multivariate analysis and predictions.

Data storage: PAT data manager

The management of PAT data is highly complex not only because the flow of information is enormous, but because it also includes a mix of data formats (spectral, vector and scalar data) that makes it difficult for standard historians to handle. Furthermore, the centralization of PAT data is not sufficient as it needs to be combined with the batch information coming from the

process control system (PCS) and the business systems.

ABB's PAT data manager is unique in that it stores all the data in a single distributed database and can handle huge flows of both scalar and vector data coming from the analyzers, the PCS and SCADA systems: It handles the batch structure data, the vector and scalar data, alarms and events as well as a complete audit trail. It can also exchange data with other third party historians

Data mining, visualization, multivariate analysis, and batch Management

The Industrial^{IT} for PAT suite includes a wide range of modules to provide an operator workplace, central method configuration, multivariate analysis batch configuration and management as well as asset management for analytical and process equipment. The system also has the ability to connect to third party commercial multivariate analysis tools for off-line and real-time predictions.

Control

Controlling processes in a flexible and repeatable manner requires process understanding to be realized within regulatory and advanced control environments, while at the same time taking advantage of a range of process models. This is facilitated by dynamic solutions – predict, control and inferential measurement platforms which integrate with operator interface, and regulatory control and process data management components.

The way forward

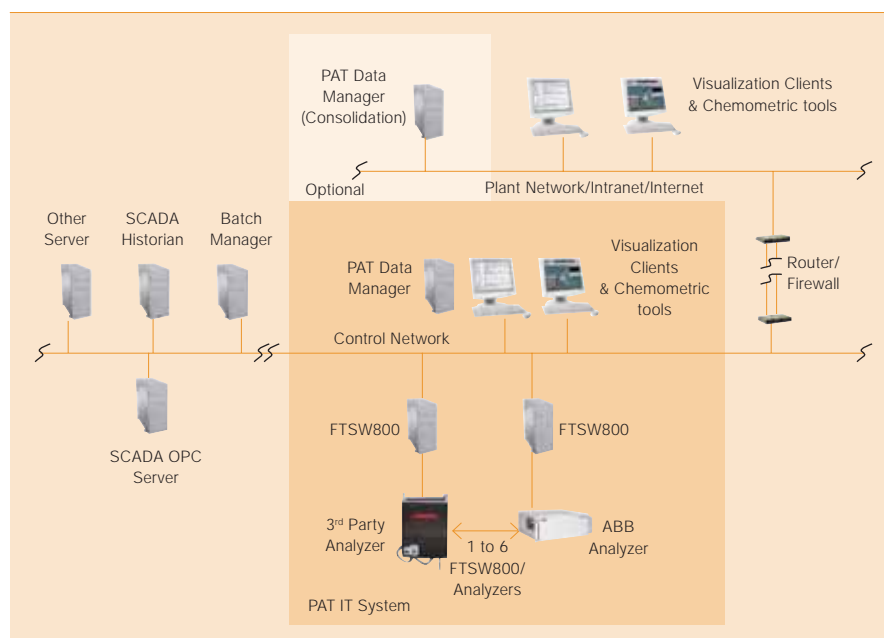
PAT provides an opportunity to move from the current “testing to document quality” paradigm to a “continuous quality assurance” paradigm that can improve a company's ability to ensure that quality has been “built-in” or is “by design”. Not only that, but it gives companies a greater insight and understanding of their processes; it provides the potential for significant reduction in production (and development) cycle times; and it minimizes the risk of poor process quality.

PAT will revolutionize the way pharmaceuticals are made and will forever change the face of the industry. This is why ABB's investment in PAT is the single biggest development initiative in Life Sciences, and it also presents the company with an exceptional opportunity to become the market leader in Life Sciences.

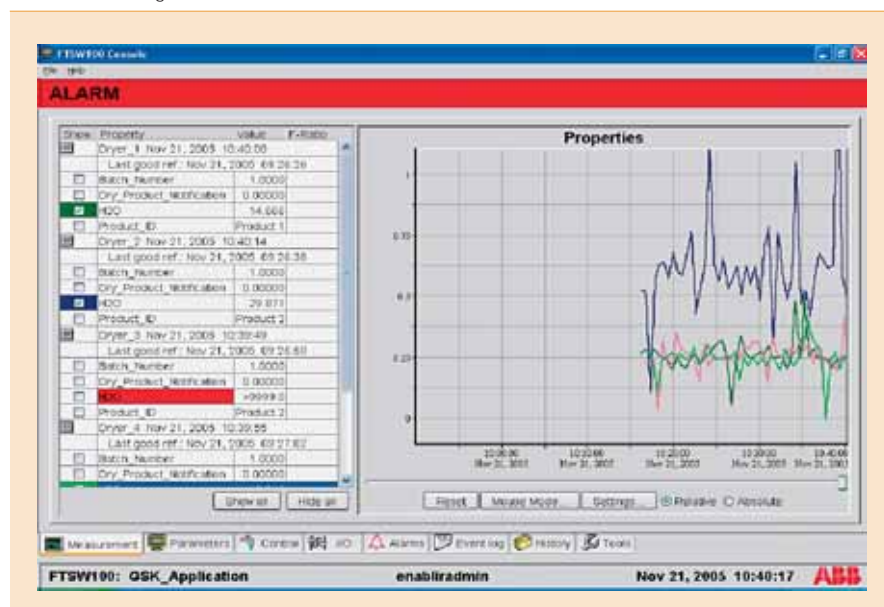
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2 Industrial^{IT} for PAT network architecture



3 Local trending with FTSW800 software



Flexibility guaranteed

Streamlining applications and process changes
with ABB's Extended Automation System 800xA libraries

John Croft

Today's processing industries are experiencing increased demands to reduce schedules and costs, while maintaining more stringent quality and safety standards. The trend towards consolidation of the process control, shutdown, facility, electrical control and maintenance management systems into a single unified platform continues, with increasing

demands for access to additional, relevant and up to date information.

ABB's Extended Automation System 800xA responds to these demands. It integrates the process control with all extended automation applications and smart devices in a single operations, engineering and information management environment. By extend-

ing the device and equipment libraries within the System 800xA. ABB has introduced the world's first truly generic, reusable software library for batch applications in the pharmaceutical and fine chemical sectors.



The ability of ABB's Extended Automation System 800xA¹⁾ to gather information from multiple plant sources and transform it into relevant information for a diverse set of users such as maintenance technicians, process engineers, production managers, or plant operators enables plants to perform smarter and better with substantial cost savings.

The advantages of using the System 800xA device and equipment libraries on a project result from using standardized configurable objects with preserved integrity and inheritance, while ensuring and maintaining the necessary flexibility.

Now ABB has taken things to a new level. To extend the device and equipment libraries, the company has developed a library²⁾ of objects and templates which effectively provide pre-engineered components to engineer a batch application with the minimum of configuration. Furthermore, these components can be used over and over again without any need for project specific controller programming. The ability to employ truly generic Phases, Unit and Equipment Module

structures, and device objects results in significant time savings in specification, engineering, testing and validation, all of which ultimately reduces the time to market for new products. Similarly it allows process engineers to make changes to existing recipe operations and Phases without the need for programming expertise.

Extending the equipment library

The extensions to the equipment library build upon the already proven libraries in order to deliver similar benefits for batch applications. They provide a comprehensive library of generic Phases, Unit and Equipment Module templates, together with a toolkit of components designed to optimize the specification and building of batch applications utilizing ISA S88³⁾ style Equipment Modules and customized Process Units. Generic Phases enable new products to be introduced by developing new recipes only, all in compliance with cGMP (current Good Manufacturing Practices) and FDA (Food and Drug Administration) validation requirements, thus minimizing the scope and complexity of testing. Because it has been designed to be integrated with standard device library control objects, the equipment library shares common terminology, engineering principles, security and naming conventions. This ensures the information displayed to operators is consistent while engineering and testing time is greatly reduced.

These extensions were possible because of the Aspect-Object™ design of ABB's Extended Automation System 800xA. They break new ground by distributing the control intelligence through a control hierarchy, thus enabling truly generic, pre-tested and reusable library objects to be provided for Units, Equipment Modules and Phases **1**. It is the only system that provides truly generic Phases that can be used out of the box. It removes a level of complexity, meaning that highly qualified programmers are no longer needed. A process engineer can carry out much of the application engineering at the recipe level. This way the system maximizes reuse at the phase level, allowing customer engineers to focus more on what they actually make rather than on the intricacies of programming.

ABB has introduced the world's first truly generic, reusable software library for batch applications in the pharmaceutical and fine chemical sectors.

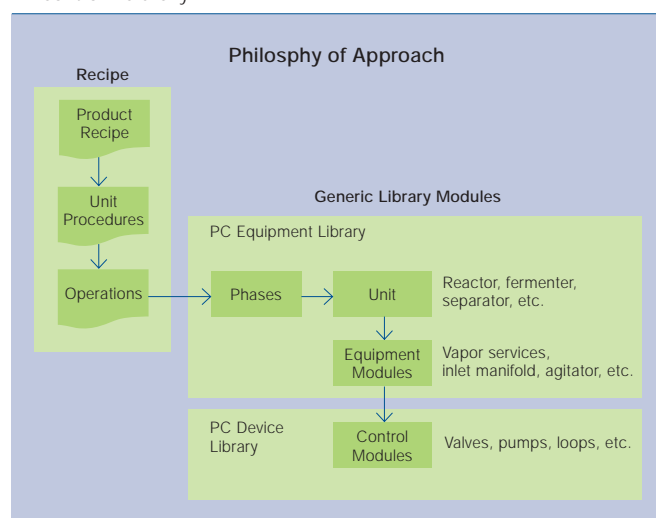
With other available systems, each batch application needs significant configuration and controller programming every time for every project, particularly for Equipment Modules and Phases. This incurs additional time and cost as these components

Footnotes

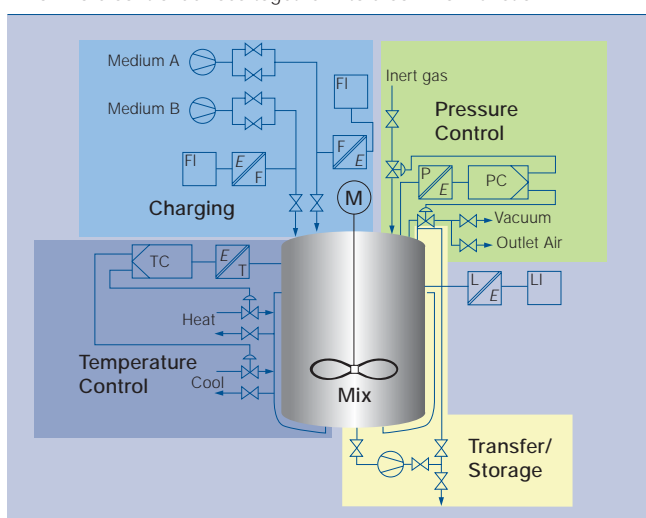
¹⁾ For more indepth information, please refer to www.abb.com/product/us/9AAC115756.aspx?country=US (November 2006)

²⁾ A library is a collection of foundation objects (component solutions) from which unique instances can be created. Each instance is effectively a clone of the foundation object.

1 The library extensions distribute the control intelligence through a control hierarchy

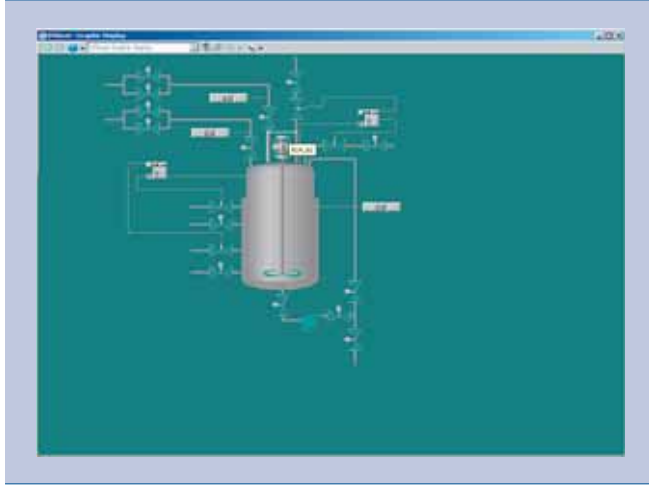


2 Devices are encapsulated in Equipment Modules, which combine one or more control devices together into a common function



Risk management

- 3 Units are configured to represent the physical plant units and comprise multiple equipment modules, associated process measurements and applicable process phases



will invariably need to be re-validated. In addition, the new libraries, allow manual control at all levels via faceplates, and they provide the granularity, transparency and diagnostics to enable efficient commissioning and maintenance.

The component objects provided by the libraries include Control Modules, Equipment Modules, Units and Phases. These objects are used to build up single devices, from Equipment Modules and Units, to operations and recipes that ultimately control the plant.

The use of an S88 structured framework and a pre-tested and proven component library makes specification, implementation and configuration of control systems less complex and less time consuming. The library components are also used in a hierarchical manner.

The libraries

The device library provides a large portfolio of tested process control devices such as motors and on/off valves. Each device is represented in the library by an object enriched with

“aspects”, including controller code, faceplate and graphic display element which support device management over the entire life cycle. Devices have configurable general options, including alarm and state colors, user-definable functions and text with native language support. Devices are encapsulated in Equipment Modules, making the reuse of complex packages of device control simple, accurate and repeatable. Equipment Modules combine one or more control devices together into a common function 2, which in turn can be used across several units to provide a high degree of reuse, as well as ensuring operating consistency through the plant, and reducing engineering and testing effort. Units are configured to repre-

Factbox The ABB System 800xA extended libraries when applied to batch processes deliver:

Capital Productivity: Leveraging System 800xA's object-oriented technology, the libraries provide the ultimate balance between flexibility and standardization. This minimizes project specific library development and the project specific software, thereby minimizing the cost of developing a batch automation solution while maximizing the plant operability.

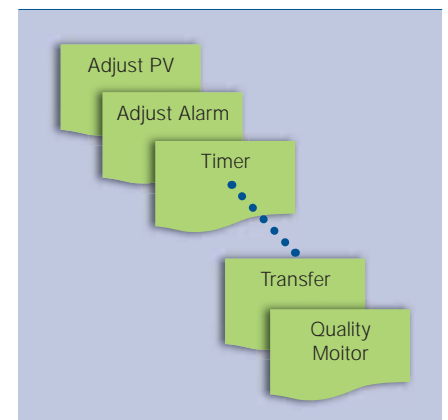
Global Responsibility: The library objects are developed under stringent Quality Assurance standards, tested and encapsulated to ensure functional integrity. This can greatly reduce project testing and compliance documentation, especially for validated projects.

Risk Management: The fact that ABB maintains the libraries minimizes risk by ensuring the future migration and upgrade path. It enables modifications and enhance-

ments to be made as plant requirements develop over time logically and consistently. In addition remote support and service is simplified which minimizes the risk to plant production.

Operational Profitability: The use of the libraries provides efficient commissioning and maintenance due to the transparency, granularity and diagnostics. Operator response time to process and batch events is reduced; they can immediately see the root cause affecting a phase, an Equipment Module or a Unit and can fully trust that the trip and interlock displays are correct and up to date with the configuration, because they are automatically built.

- 4 The library of generic Phases requires no configuration. Parameters define the actions to be taken by a Phase to achieve a process action



sent the physical plant units **3**. They comprise multiple Equipment Modules, associated process measurements and applicable process phases. The Units include the state model for handling process upsets and control device physical errors, and they provide a feature for monitoring quality critical process values.

A library of generic Phases **4** is included; these require no configuration (logic is unchanged for each instance of use) no testing and no validation. The set of generic Phases was selected to maximize reuse. Parameters define the actions to be taken by a Phase to achieve a process action. All of the generic Phases are available to operations under batch recipe control and can be supervised by an operator

from the Phase faceplate under manual control.

Operation procedures represent the process steps necessary to control the manufacture of a batch of products. They drive the plant via one or more process Phases by supplying suitable parameters. In addition, operation procedures generally handle the coordination of multiple phase initiations and non time-critical activities, such as operator questions, monitoring for phase start conditions, data recording.

The ABB library objects are developed under stringent Quality Assurance and Safety Assurance standards, and are tested and encapsulated to ensure functional integrity. They are main-

tained by ABB to ensure future migration and upgrade paths.

System 800xA in Korea

Engineers can select which foundation objects to use from the libraries to satisfy the requirements of an automation solution, and this makes the libraries applicable for most application sectors. Korea's Yeochun NCC Co. Ltd (YNCC)⁴⁾ demonstrated this by selecting, in a strongly competitive environment, the 800xA integrated process control and safety system to upgrade the petrochemical company's number two ethylene plant in order to improve the facility's performance. YNCC selected ABB and System 800xA due to features such as integrated control, safety and the advanced process/interlock visibility provided by the ABB Device Library and the distributed control system's Aspect Object technology.

According to the company, "Using ABB's expertise and the device library, the engineering will be simplified and made consistent across the solution, and commissioning costs will be reduced. Device library objects not only ensure the best practice in device engineering and control, but also automatically generate displays for operators of any interlocks that may be present that could delay production. As a proven and fully supported ABB library, YNCC is assured that future upgrades and enhancements to the system software will be implemented without issue and retesting. This optimises YNCC's capital productivity not only for the initial installation, but also over the life cycle of the plant."

John Croft

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Footnotes

³⁾ ISA S88 batch production standards define good design and operation practices to improve control of batch manufacturing plants.

⁴⁾ Yeochun NCC Co. (YNCC), Ltd is Korea's leading petrochemical company.

Factbox What do these libraries mean to:

The Financial Director?

"We can implement a full automation solution for our batch plant, with all its inherent benefits, for significantly less cost than previously. The solution benefits both CAPEX (capital expenditure) at the engineering and installation phase and OPEX (operating expenditure) throughout the entire life cycle of the system and plant."

The Business Manager?

"We have a plant automation solution that gives us the flexibility to introduce new products, improve productivity and make delivery promises with the minimum of risk. It enables manufacturing to be adjusted at short notice thereby allowing new products to be introduced much faster. Similarly we can scale up production utilizing proven solutions based upon these objects and the flexibility of the 800xA batch management package."

The Plant Manager?

"I have confidence that I can maximize my plant throughput, consistency and quality because my automation is based upon a proven solution route that is easily understood by my operations staff. We can sort out plant upsets quickly and efficiently ourselves. My operators like the control and supervision it gives them – they can feel in charge of the plant and can confidently optimize production. By having a consistent approach to the control I can utilize my oper-

ating staff flexibly – I do not need to select based upon system operating experience."

The Process Engineer?

"I can readily understand how the control is structured and therefore I can sort out most problems without the need to call in a control engineer or automation specialist – I feel more in control. I can easily modify existing recipes to improve productivity, quality or yield and can introduce new product recipes myself."

The Automation Specialist?

"I can authorize a batch automation solution that is secure and flexible with the minimum of risk. Because it adheres to S88, I need to provide the minimum of training to new staff."

The Control Engineer?

"I can focus on the processing requirements rather than the system when engineering a batch solution. I can engineer a batch solution with the confidence that the operations staff will be able to maintain it throughout its lifecycle – I will not get called out so often to sort out problems, such as which interlock is holding up production. I can focus on investigating control techniques and improving productivity."

Center of excellence

Serving local and global markets from China

Jane-Zhen Yu, Sidney-Yueshan Chen



With the goal of minimizing project risk and increasing engineering reuse and quality, ABB Process Automation has established an organizational model called “Center of Excellence”, or CoE. Each ABB industry unit has established one or more CoEs to serve the unique needs of a particular market or industry. The role of the CoE is to develop products and applications for a particular market and to then make them available for global use by local ABB units. The CoE is also responsible for technical development and technical leadership in project execution, together with

local ABB units. Local ABB units are distributed in different countries around the world and represent the interface to the ABB customer during project execution, as well as for daily contact. The CoE represents ABB’s industry know-how, while the local ABB unit is the contact to the customers. Finally, the CoE provides strategic sales support to major project pursuits around the world, ensuring that ABB is offering the most optimum solution to meet a customer’s budget and functional requirements.

Historically, ABB CoEs were based primarily in Western Europe and North America. Traditionally, this is where ABB's core competencies resided for many industries. However, in view of the huge capital investments in Asia, coupled with the wide supply of highly educated engineers throughout the region, it was time for ABB to commit to an Asian based CoE. The booming steel industry in China gave ABB its chance. Within ABB's Metals business, it was decided to establish a CoE for Processing Line and Tube Mills (CoE PLT), in Beijing, China. Since its establishment in 2002, the CoE PLT has become one of the most successful units in ABB Process Automation. Benefiting from the local dynamic and booming steel industry and its own technical and engineering competence, CoE PLT has undergone a rapid development, and has strived to extend its footprint in and outside China.

Why China for processing line and tube rolling mill CoE?

"It has been proven as a very wise decision," said Christer Skogum, head of CoE PLT and Process Automation division North Asia. *"In our global management team, we have a clear and common understanding – many of the future demands exist in the 'new' world, and our local team is ready to take on the business in both the new markets as well as the old traditional markets"*

"Our first-ever center of excellence in Asia has achieved a remarkable achievement," proudly added Fu Jianpeng, head of the local business unit for metals in China, "we have increased business 500 percent since its establishment."

Today 50 percent of the world's steel production is in Asia, and 85 percent of the incremental growth is in China. The country reached 349 million tons in 2005 and forecast an additional 10 percent growth in the year after. The rapidly growing market gives CoE PLT a fabulous opportunity to develop its business and people. The new projects in China are among the world's leading lines in terms of capacity and technology. Some examples where CoE PLT has delivered process automation solutions are:

- Pangang Group Ø340 tube mill line – world largest seamless steel tube production line
- Ningbo Baoxin stainless steel line – world largest stainless steel processing lines
- Taiyuan Iron & Steel – world largest cold annealing and pickling processing line
- Baosteel processing line – the world third fastest steel production line

A mixture of local and expatriate experts form a winning team

The success of the CoE PLT was dependent on ABB's ability to deliver the high quality of engineered solutions which were expected of the customers, but to use local Chinese engineers and project managers for implementation. The decision was taken to relocate key ABB Metals engineers to Beijing, where they could develop local competence while using the experiences built over many years with projects in Europe and the Americas. The project operation team continues to be the key to success.

Each ABB industry unit has established one or more centers of excellence to serve the unique needs of a particular market or industry.

Narendra Gupta, an ABB veteran in the metal field, who has been in China since 1999, leads the operation team. The team focuses on project

execution and management as well as technology development and localization. The CoE's early successes have allowed the local team to build up extensive field experience in technology, application and project management.

"Our team is formed by a group of young professional, well-educated and very hard working people. They are located where the business is in the world and where abundant skilled engineers are available at world-class cost structure," said Christer. "They are always ready to learn new things and will bring our metals business to the next level."

References in the domestic market

Pangang Group Ø340 tube mill line – world largest seamless steel tube production line

ABB's CoE PLT China team helped Pangang Group Chengdu Iron & Steel Co., Ltd. (CSST) build a tube production line for the largest scale in 2005 ■.

The seamless steel tube production line was a key project in metal industries. This was recognized as high technology project by the National Reform and Development Commission during the period of macro control on metals and some other over-heated industries. The line has set a few records in the metal industry:

- The Ø340 tube mill line adopted the most advanced technology including the latest process control system and medium voltage drive system.



Risk management

- The diameter of 340 mm is the largest scale seamless steel tube in China.
- The shortest cold and hot commissioning period (less than three months).
- The sole line in the industry which has a one-time hot trial success.

ABB's scope of delivery includes MV and LV drives, basic automation, level II process control and LV motors.

The Ø340 line is another successful reference of ABB CoE PLT China team, after the completion of two similar projects in Tianjin City and Hunan Province.

Ningbo Baoxin stainless steel line – world largest stainless steel processing line

ABB technology supported the development of the world's largest stainless steel processing line in Ningbo Baoxin Stainless Steel Co., Ltd. 2, and helped Baoxin more than double its production capacity.

CoE PLT provided equipment and systems to help develop the largest hot and cold annealing and pickling line in the world, as well as state-of-the-art rolling mills. ABB will supply specialized technologies for rolling, flatness control and metal conditioning, as well as process control products, drives and motors.

This work will support Baoxin's drive to boost its current annual output of 300,000 tons of finished products to 700,000 tons. ABB has already designed, engineered and commissioned a complete annealing and pickling line for another part of the Ningbo facility, as well as providing other specialized equipment and technologies.

Taiyuan Iron & Steel – world largest cold annealing and pickling processing line
CoE PLT won an order from Taiyuan Iron & Steel Group, to supply the world largest cold annealing and pickling processing line in 2004.

1 Pangang Group's Ø340 tube mill line is China's largest seamless steel tube production line



2 ABB helped the Chinese steelmaker Baoxin more than double its production capacity and create the world's largest hot and cold annealing and pickling lines



Under the terms of contract, ABB is providing the customer with a basic automation system, a computer process system, and AC drives and motors for the line. Production capacity is expected to reach 500,000 tons annually. The delivery is slated for completion in one year.

Today 50 percent of the world's steel production is in Asia, and 85 percent of the incremental growth is in China. The country reached 349 million tons in 2005 and forecast an additional 10 percent growth in the year after.

Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO), founded in 1934, is a giant iron and steel complex whose main product is steel plate. It is China's largest stainless steel production enterprise.

Baosteel processing line – the world third fastest steel production line

CoE PLT helped Baosteel 3 to build a steel processing line with a speed of 1,040 meters per minute, making it the fastest production line in China, and the third fastest in the world.

This is the first carbon steel production line at Baosteel Shanghai headquarters.

ABB has successfully executed many projects for Baosteel group, one of the major iron and steel makers in China.

CoE China – serving industry needs outside China

The success of the CoE PLT in China rapid, but not surprising. However, the real key to a successful CoE is the ability to support projects globally, not just within the Chinese market. CoE PLT is supporting many orders outside of China, in countries as diverse as Netherlands and Mexico. These

projects include AC/DC motors and drives, automation systems, control desks, movement control centers (MCCs), electrical and mechanical erection, full system engineering and commissioning.

The key to success

ABB has CoEs in metals, chemicals, oil and gas, pulp and paper, marine and other industries. ABB is convinced this is the right approach to ensure consistent project execution, regardless of industry, scope or geographic location. The success of the CoE PLT in Beijing shows that such centers can be located close to the market demand without sacrificing quality or efficiency.

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Rolling mill simulator

A new platform for testing, analysis and optimization of cold rolling mills.

Axel Brickwedde, Frank Feldmann, Nicolas Soler

The cold rolling of flat metal products especially in tandem or multi-stand mills is a highly complex process where the product quality is influenced by various aspects. With the help of a hardware-in-the-loop simulator, the complete rolling process can be simulated and tested in real-time. This allows pre-commissioning and pre-optimizations before the actual commissioning work is done on the plant site. This reduces project schedule and safety risks and guarantees a much faster plant start-up.

In hot and cold rolling mills, the demands on mill profitability, productivity and product quality are on the rise. Thickness and flatness tolerances are decreasing while surface quality must further improve. At the same time, mill flexibility has to match the growing variety of products, while high mill productivity (throughput and yield) is a key issue to remaining competitive in the global economy. Strip quality and mill throughput are influenced by various factors such as mechanical design, electrical and hy-

draulic equipment, auxiliary supplies and control strategy. The many associated variables have to be tightly controlled to meet product quality targets. The entire control process enters into extreme parameter ranges, especially when one considers controlling up to 40 tons of moving parts to a precision of 1 μm with rolling speeds of up to 100 km/h.

To be able to control such a large and complex plant and meet the high demands on process speed and product

quality, a powerful controller is needed to handle all required functions from low level binary control up to advanced and sophisticated control solutions. The high end AC 800PEC controller from the 800xA Automation platform is outstandingly well suited to meet these requirements [1].

The complexity of the process and the corresponding requirements with respect to the control system are rising with the number of stands being involved. Tandem Cold Rolling Mills (TCM) with up to four or five stands in a row can be considered as a most demanding example of what has to be handled by the control system [1]. Some of the main aspects explaining the complexity are:

- highly non-linear process, eg with respect to roll-gap
- interstand coupling and interaction via strip
- loop interactions from interstand-tension and thickness control loops
- rolling speed dependant transport-delay between stands
- on-line tracking for head, tail and strip weak points
- synchronization required for all stand interactions
- variety of different disturbances, eg eccentricities, coil-bump, input-thickness and hardness disturbance, Coulomb friction, etc
- various operational modes, eg threading, acceleration / deceleration, tail-out, low / high speed
- large range of thickness reduction from 6 mm down to 0.2 mm

Risk management

Exploiting the full production potential requires an overall and well-integrated approach to cold rolling mill automation, optimization, control, adaptation and supervision.

This approach has to cover:

- mechanical and hydraulic systems
- drive trains
- material flow
- visualization and control system
- modeling and simulation
- pass scheduling and set-up
- technological control
- supervision and diagnosis solutions

To efficiently design, test, analyze and optimize such a complex system, simulations based on a process model are necessary. This is the best and only way to fully understand the complete system with its various interactions without having the actual plant available.

Therefore a non-linear dynamic process model of a multi-stand cold rolling mill was developed to meet the technological demands of such a complex system with respect to required product quality, disturbance rejection, plant stability and reliability, safe operation and fast commissioning. This is especially important in case of a re-vamp in order to keep the downtime to set up the new automation system as short as possible and to guarantee a fast start-up to full operation.

Off-line simulation

Based on process and plant data as well as measurements and data record-

ings from the actual rolling operation, a non-linear dynamic simulation model of the process was developed, validated and extended with respect to control functionalities [3]. This allows the simulation of rolling a complete coil including threading, acceleration, deceleration, tail-out, changeover between different operational control modes for thickness and tension control, tracking of head and tail and dynamic program change, eg for continuous rolling.

This simulation setup can be used to test and develop new control concepts in order to improve thickness quality and to meet the increasing demands with respect to off-gauge length. For this purpose the complete process model is realized as an off-line simulation programmed in MATLAB®/Simulink® [3], thus allowing flexible testing, optimizations and evaluations with far more degrees of freedom than on the actual plant.

The performance of different control strategies, mechanical configurations, sensor equipment and drives can be compared in simulation studies. From these, the most suitable setup can be selected and effective process improvements identified. Dynamic simulation can also be used to analyze customer specific problems such as oscillations, which can have a negative impact on product quality.

On-line hardware-in-the-loop simulator

The non-linear process model [3], which was developed for off-line sim-

ulation, was transferred and compiled for real-time mode (using MATLAB Real Time Workshop® [3]) and downloaded onto the ABB Process Controller AC 800PEC. Connecting this plant model to the AC 800PEC process controllers that handle the complete automation and application software for the actual plant allows full rolling operation as a Hardware-in-the-Loop (HIL) simulation in real-time [2, 4].

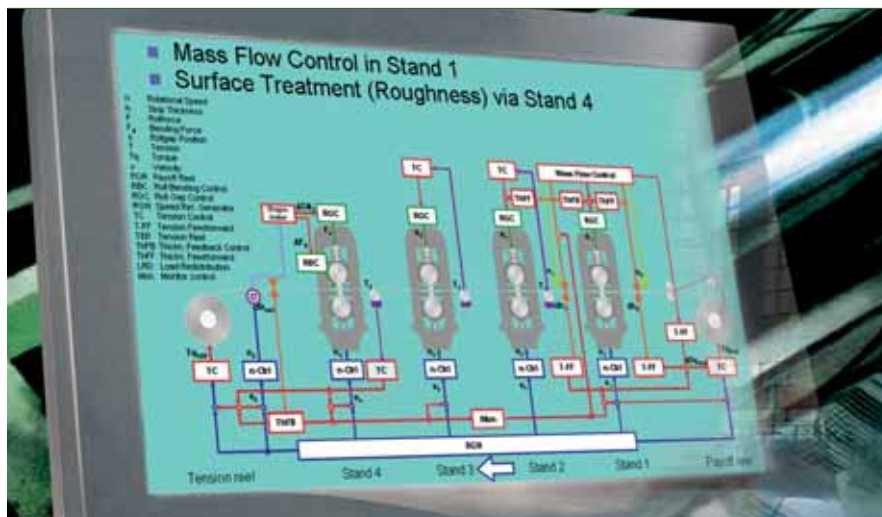
The result is a highly dynamic plant- and process-simulator that acts in real-time and allows ghost rolling for:

- Testing in the lab without having the actual plant available.
- Testing, pre-commissioning and pre-optimization of controller-application software.
- Testing of interface and interaction, eg between the application software of the different controllers.
- Data evaluation and analysis based on process signals that would not be available on plant site as measured signals.
- Testing without risk of strip-breaks, instabilities or causing damages to the actual plant.
- Testing without the need for various test-coils.
- Training for operational personnel to get familiar with the new automation system as well as man-machine interaction.
- Reducing on-site commissioning and plant start-up time.

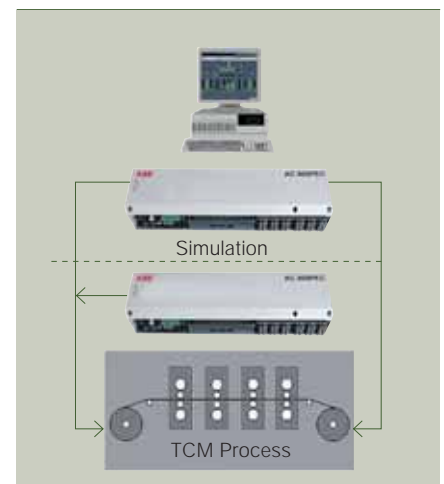
Modular and Scalable

The non-linear dynamic process mod-

1 Four stand rolling mill configuration



2 Ghost rolling using tandem cold rolling mills (TCM) process model as real-time simulator



el for off-line and on-line simulation consists of different modules for coil-er/uncoiler, strip, stand, actuators, sensors, filters, control, etc. [3]. This allows the modular and flexible design of different multi-stand cold rolling mill configurations. The plant described here is a four-stand cold rolling mill with an uncoiler at the entry and a coiler at the exit side.

In order to be able to perform useful and dependable evaluations, the process modeling has to be detailed enough to cover all dominant static, dynamic and non-linear effects. Some examples of the features that are being covered are:

Coiler / uncoiler

- variable radius as a function of the rolling process
- multi-mass drive-line configuration
- integrated indirect tension control
- speed control including feed-forward compensation
- modeling of torque-loop

Stand module

- dynamic stand model including non-linear roll-gap
- multi-mass mill drive-line configuration
- speed control including feed-forward compensation
- modeling of position- and torque-loop

Strip module

- dynamic model with variable strip thickness and stiffness
- speed-dependable transport-delay generation for inter-stand distance
- internal modeling for tracking of head, tail and weld-seams

Disturbance module

- input thickness disturbance based on measurements from real plant
- disturbances from hardness and weld-seams
- eccentricity generation for top and bottom backup rolls including harmonics

- coil-bump generation for uncoiler and coiler
- coulomb friction in mill-stands

Control / sensor

- sensors for thickness, tension, speed, roll-force measurement
- speed dependant transport-delay for thickness-measurement
- thickness control, inter-tension control, disturbance rejection loops, decoupling loops, etc.
- bump-less changeover between different control concepts

For the process modeling as hardware-in-the-loop simulation in real-time all dynamic components are discretized and the complete multi-stand process model is executed on one AC 800PEC controller with a task sampling time of 1000 times per second.

The communication between the AC 800PEC with the process model and the AC 800PEC Controllers for the automation and application software is performed via high-speed optical links, providing fast and flexible interfacing and communication. Data-recording for analysis and evaluation can also be performed via optical link connection to an ibaPDA (PC-based process data collection and analysis system) [4].

Ghost rolling with HIL-process simulator
Referring to [2], the TCM Process Model on the AC 800PEC is acting as a replacement for the actual plant. Therefore the application controllers are operating against the process model instead of the real plant.

Different setups and observations can be performed with respect to the HIL-Process Model in on-line mode.

Modes of operation can be selected for the HIL-Simulator, such as:

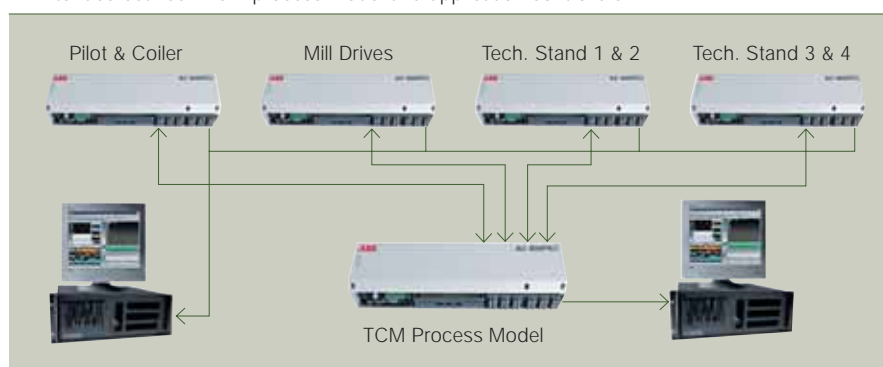
- selection of different test-coils
- selection / activation of different disturbances
- operation without strip
- operation with endless coil

Current process signals and trends during rolling can be visualized. These include speed, thickness, tension, roll-force, forward slip, position and torque.

3 Modular process model for a four-stand tandem cold rolling mill

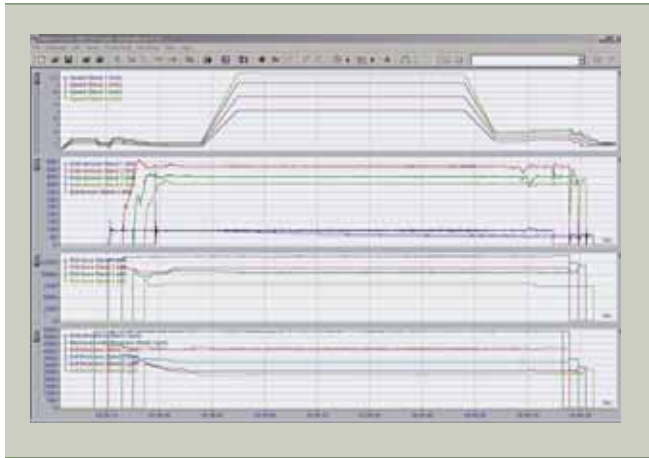


4 Interface between TCM process model and application controllers



Risk management

5 Ghost rolling with HIL-TCM simulator for full coil

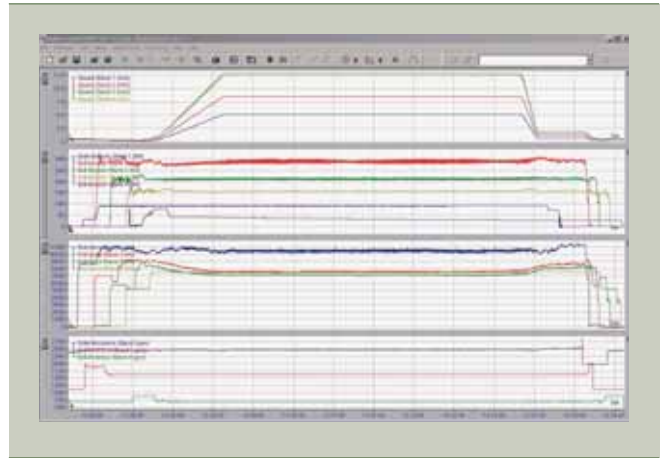


For a more detailed analysis and evaluation the process signals can be transferred via optical link to an ibaPDA [4] 4, 5. This inside view allows a much better and straightforward performance and problem evaluation than on the actual plant. Various process signals are often not available on the plant. There are usually no thickness- and speed-measurements between every stand, and the actual thickness in the gap cannot be measured at all (since the sensor has to be placed after or before the stand). All these process signals are easily available while performing HIL-process simulation and can be used for fast analysis and optimization.

Factbox Various features can be pre-tested using HIL TCM Simulator

- model setup, adaptation and reference generator
- dynamic program change and head- / tail-tracking
- interstand tension- and thickness control including pre-optimization
- disturbance compensation and decoupling control loops
- bumpless changeover between different control modes
- full coil rolling including threading, dv/dt, constant speed and tail-out
- interface setup for communication between different AC 800PEC Controllers
- interface setup to Operator Interface and data-recording system (eg, ibaPDA)

6 Process signals from coil rolling on real plant



Ghost rolling results with TCM HIL-simulator in real time

5 presents the results from performing ghost rolling with the TCM HIL-Simulator in real-time. The rolling of a full coil is shown for a four-stand cold rolling mill with uncoiler and coiler. The process performance is very similar to the one on the real plant as corresponding process signal recordings show 6.

The testing based on ghost rolling with the TCM HIL-simulator proved to be extremely efficient with respect to pre-commissioning and pre-optimization for the plant-related application and control software. The benefit results especially from the fact, that the testing and optimization can be done without the risk of damaging the real plant and without the need for any specific test coils. Also pre-commissioning can already be started long before the actual plant is available for any kind of testing.

Summary / conclusion

- The off-line simulation of the process allows flexible and straight forward optimization and development of new control concepts for cold rolling mills in order to meet future high demands on process performance, quality and reliability.
- The off-line simulator can be used for performance evaluations and plant optimizations already in the design phase.
- The HIL-simulator in real-time provides flexible and efficient pre-commissioning and pre-optimization of the plant related application and

control software, without needing the actual plant and without risking damages to the actual plant.

- The HIL-simulator significantly reduces plant start-up time.
- The HIL- simulator can be applied for demonstration in real-time.
- The HIL- simulator can be used for operator training, without interference with the real plant or risk of causing any damages.
- The HIL-simulator can be implemented in the 800xA automation platform on a single high performance AC 800PEC controller, while operating at a sampling rate of 1000 times per second and communicating with the application controllers via high speed optical links.
- The modular design for process-modeling as well as control guarantees flexible and easy adaptation to different rolling mill configurations and provides realistic process modeling even in real-time.

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The challenge of device integration

Making sure "plug-and-play" equals "plug-and-work"

Ahmad Khan, Stefan Bollmeyer, Friedrich Harbach



The last decade has seen a sustained increase in the acceptability of fieldbus solutions for process automation needs. While the underlying reasons for this trend include rapid advancements in the fields of digital communication and microprocessor technologies, the end result is that the traditional boundaries between centralized control systems and devices in the field have disappeared. In the new

process automation architecture paradigm, intelligent field devices and control systems form a single system, fused by a high-speed digital Fieldbus. Now, in addition to the process value, status, diagnostics and any other information embedded in a device, with its enhanced – and ever growing – "intelligence", can be transferred to the control system, making the device visible and usable from

remote locations such as the process-automation level. Currently, PROFIBUS, HART and Foundation Fieldbus are the most commonly used fieldbus standards. ABB's Device Integration Center tests hundreds of devices every year to ensure maximum intercompatibility of its control systems with devices from a whole range of vendors.

Risk management

Fieldbus integration can provide many benefits to users, yet, despite compatibility standards, there are risks that a system will not work correctly with a given device. A key goal of open vendor independent fieldbus technologies is to integrate devices from multiple manufacturers into automation systems. Theoretically, the implementation of fieldbus standards allows “plug-and-play” connectivity between a device and its automation system. However, several factors make it difficult to achieve this ideal situation. These include:

- Different interpretation of standards among different designers and implementers, by both the device vendors and automation system manufacturers.
- Changes and updates in the standards.
- Differences in the speed with which adaptations to standards are implemented by the automation systems supplier and the device vendors. Frequently the typical lifecycles of devices and automation systems differ, resulting in multiple versions of devices and automation systems being on the market at any one time.
- Attempts to exploit infrequently used standards to provide product differentiators.

ABB's Field Device Integration Center
In 2004, ABB decided to establish a Field Device Integration Center

(FDIC), to ensure that devices and ABB Systems would work together. The goal of FDIC is to provide tested solutions for all the commonly used field devices on the market, when used in conjunction with ABB automation systems.

The DIC is made up of two main centers: Minden in Germany, and Bangalore in India. The activities at these locations are assigned according to individual areas of expertise and technical strengths.

The goal of FDIC is to provide tested solutions for all the commonly used field devices on the market, when used in conjunction with ABB automation systems.

The Fieldbus product management team in Minden focuses on identifying and defining the devices that need to be tested for integration, based on regular interactions with sales and marketing staff, and customers. The targeted devices are prioritized and assigned for integration according to factors such as physical availability of hardware/software and overall market demand for the particular device type. The FDIC web page, accessible via

www.abb.com, provides a list of all devices that have undergone integration testing.

The integration team in Bangalore performs basic connectivity as well as advanced integration tests for field devices. The lab is well equipped with dedicated and standardized test benches to carry out integration tests with the latest released versions of ABB's control systems including 800xA, Melody/AC870P and Freelance 800F.

The integration lab has been modeled on the concept of the software production line. The key features include:

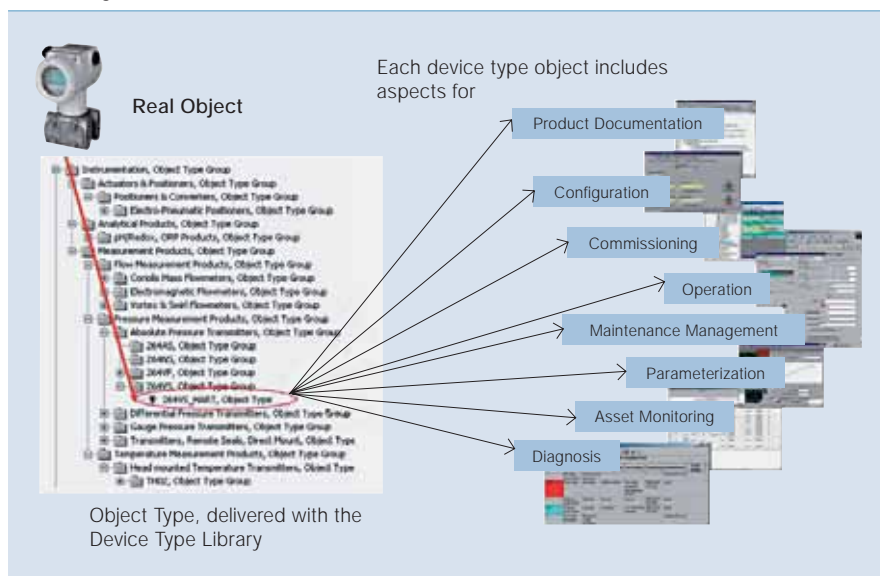
- Standardized software development and test processes, updated with the latest release of standards and specifications
- Inspection of hardware and software to filter out those devices that have a high chance of failing detailed integration tests
- Standardized and strict quality checks for all phases of development, test and release
- Close cooperation with the Fieldbus R&D team in Minden

The Field Device Tool (FDT)/Device Type Managers (DTM) technology is fully integrated with ABB's control systems. The DTM is either generic, working for a family of devices, or specific to a single device. The device-specific DTM is cognizant of all instrument rules, including configuration, diagnosis and maintenance. It has a simple intuitive user interface that allows project engineers to access all device functionalities. A key task for FDIC is to subject DTM's to extensive testing to reduce the risk of losing functionality while using DTM's in ABB's control system. The report for each device tested and released by FDIC carries information about the functioning of DTM in the target ABB control system.

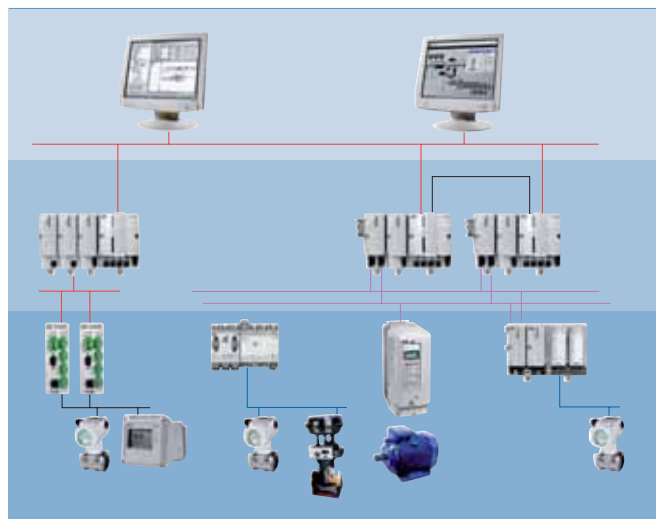
The Integration Cycle

The integration test cycle is typically 12 weeks long and results in a portfolio of integrated devices that is continuously expanding. The integration tests are performed on devices that are available on the open market. A typical integration cycle includes

- 1 ABB's Extended 800xA automation system integrates the three major fieldbus protocols in a single structure



2 Device integration components in a single structure



basic connectivity tests, to verify cyclic data transfer between the device and the automation system, and detailed tests with DTMs to verify the device features including parameters, configuration, diagnostics etc. Detailed tests are also carried out to ensure device asset monitor functionality, which include the assessment of the performance of other higher-level applications such as calibration management, computerized maintenance management, device interoperability, bus master and other key features (applicable to Foundation Fieldbus).

All deviations detected during testing are recorded in a formal defect tracking system and analyzed in consultation with Fieldbus R&D. Depending on the severity of the observed deviation, device software is either released for general use via the ABB Solutions Bank, or rejected. If the device software has been rejected for release, the cause of rejection is informed to device vendor so that necessary improvements can be done for a re-test and release at a later date.

Cooperation with device vendors

Cooperation with device vendors is crucial to the overall success of device integration. The FDIC receives information from device vendors in advance of new releases, including the key inputs required for Device Specific Asset Monitors. It shares results regarding the integration performance of devices with vendors and discusses

any failures observed during integration tests. Feedback from the FDIC often results in improvements in device software and, in some cases, firmware.

Commitment to device lifecycle support
Since it began in 2004, the FDIC has played a key role in making fieldbus solutions easy to implement and efficient to maintain over the device life cycle.

The primary benefits to the end customer include:

- Verified inter-operability
- Re-use of proven solutions
- Reduced engineering and commissioning effort
- Support, via ABB's standard support organization, including access to integration experts.
- Possibility of continuous improvement as FDIC takes care of releasing updated versions of devices
- Reduced risk and improved safety of the manufacturing plant

Since the end of 2005, the FDIC has worked on a standard throughput of 120 devices per quarter. The total number of integrated devices approved each year is approximately 425, from more than 50 device vendors. However, if the FDIC was to evaluate its throughput by the measures used by some of its competitors (who count sub-variants of devices, eg different operating voltage ranges, separately), then the total number of

integrated devices tested would probably be in the region of 1000 per year and the number of devices in the integrated portfolio would exceed 2000.

All deviations detected during testing are recorded in a formal defect tracking system and analyzed in consultation with Fieldbus R&D.

The FDIC is a single point of contact for all fieldbus integration needs, covering the whole suite of ABB's control systems for process automation. It performs an essential service, maintaining ABB's reputation for reliability and interoperability of its control systems.

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The system type test

A global organization ensuring that 800xA performs as advertised
Bill Anderson



In 1999, ABB announced its vision for the next generation automation platform, called Industrial^{IT}. The goal was to combine traditional distribution control systems (DCS) with IT-based business applications to provide seamless integration between the shop floor and the boardroom. Industrial^{IT} required a new process control platform, ABB's System 800xA, which was released in late 2003. Since then, over 1700 800xA systems have been sold. The main advantage of the system is that it supports the progressive development of ABB's previously installed process control systems, worth \$20 billion. Customer satisfaction with the 800xA system is ensured by rigorous testing of new versions by multidisciplinary teams prior to release.

ABB's award winning Industrial[™] System 800xA has been extremely successful since its release in 2003. This success has been due to many factors. Two of the most important are the breadth and scope of its functionality, and its ability to support the evolving development of all ABB's earlier systems. To fulfill the needs of many different industries, business landscapes, and expectations, ABB employs a global support network for the research and development of the system. This structure allows the 800xA system to benefit from truly global development, capitalizing on the skills, talents and market intelligence from a global pool of talent.

Since its introduction, several revisions have been made to improve the performance of 800xA. The latest release, System version 5.0 (SV5.0) was released late in 2006. With each release, companies like ABB must ensure that the new version has been comprehensively tested and is ready for customer use. The problem is how to test a system devised by more than 20 different product development teams to ensure that it meets ABB quality standards in all industries served by ABB, in all locations around the globe. The solution is ABB's System Type Test (STT) organization.

The role of System Type Test (STT)
STT is a global organization with locations in Västerås (Sweden), Minden (Germany), and Wickliffe, Ohio (USA), with additional support for Microsoft security patch testing from Bangalore (India). The objective of the organization is to test the 800xA

system in an environment as close to customers' working conditions as can be achieved.

Each STT location specializes in some aspect of 800xA testing. Minden deals heavily with the fieldbus and I/O (input/output) subsystems, as well as the interface to the Melody Open Control Systems (OCS). Wickliffe specializes in extended applications such as Production Management, Information Manager, and Asset Optimization in addition to the Harmony, MOD and DCI OCS system interfaces. The Västerås center is responsible for ensuring that the core 800xA system (PPA and AC800M), engineering, core history reporting, licensing, calculations, etc. operate properly for all users. The center is also responsible for the 800xA interface to the AC400 OCS, PLC Connect, and Safeguard Connect.

The objective of the STT organization is to test the 800xA system in an environment as close to customers' working conditions as can be achieved

Test planning

Before each new product or revision of an existing product is released, ABB devises a global system test plan that ensures all system level and some product level requirements are tested. The system level test is designed as a whole and is broken down into components for testing at each center. All centers use the same test strategy

and use-case scenarios. Each center focuses on different test cases for each use case in combination with different specialized equipment and applications.

In Västerås, there are 15 test professionals who perform a variety of tasks to make sure the system works as intended. Västerås also regulates product quality for the entire global test organization, ensuring that the test process is stringent and effective, maintaining global customer satisfaction of new releases of the 800xA system, product rollups and service packs. The center organizes personal computers and AC800M controllers into test networks to support the various system versions and system configurations.

Test development process

While development teams are busy designing and implementing functionality, the STT organization is developing new tests or enhancing existing tests. Test development includes both the written procedure, as well as any test configurations and applications required to execute the test plan. Applications used to execute the tests come from several sources. Some were designed by the Västerås test staff to execute specific functions, such as controlled alarm bursts, heavy system load, and other stress conditions. Other applications came from end customers and are used to operate the system in user-typical scenarios. STT creates test cases within the following use cases:

- System-wide installation and configuration



Risk management

- System- and application upgrades
- Application engineering for various system functions
- Run-time characteristics and usability of the system under normal operation and transient conditions.
- Recurrent and complete system maintenance
- Performance characterization of the system under normal runtime and transient conditions.
- System and network security in conjunction with use case for extended systems.
- Use case for special functions

The best results are often produced when engineers from end-user companies are integrated into a test team and able to interact freely with ABB test engineers.

Test execution process

The STT process is designed to take the system through a series of stages that grow in scope and complexity to ensure improvements in system quality at each step.

System Integration Test

At pre-planned stages in the product development process, the product is subjected to a System Integration Test to ensure that the individual components can be installed and run as an

800xA system. This starts with a small system and is integrated, step by step, into a full, working system. The system configurations grow progressively over time, as do applications and basic load, until the system size and capacity is ready for formal testing.

System Type Test

The formal STT is run once the appropriate quality level is achieved. This test is executed on more than 12 different system configurations, distributed across the three centers to create a variety of user scenarios. STT has a wide scope to identify all errors that impact customers.

Release Acceptance Test

When the STT is completed, a Release Acceptance Test is conducted on the final version of the software to ensure that it is ready for release for manufacturing and distribution to end customers.

Keys to success

One key to Västerås' success is collaboration with many internal ABB organizations and end-users. Each test network is lead by an experienced professional tester. The test team is normally composed of a blend of ABB engineers from various specializations such as technical support, operations, and field service. This type of cooperative collaboration benefits all of the organizations in the chain that are expected to provide a full range support to end-users as soon as a release is made. The

best results are often produced when engineers from end-user companies are integrated into a test team and able to interact freely with ABB test engineers. This blend of backgrounds, expectations and experience in a test team provides the balance needed to produce a good result.

The System Type Test process is designed to take the system through a series of stages that grow in scope and complexity to ensure improvements in system quality at each step.

The story of STT in Västerås is one of continuous improvement. Many improvements to the process and innovations have been made over time and more are planned for the future. Automated testing, AutoTest^{IT}, is a growing component of the current tests being performed in all test centers. This innovative tool was developed specifically for 800xA testing in Västerås and has been invaluable as a tool to increase test speeds, reducing cost and helping developers debug issues that are normally hard to reproduce with manual steps. Projects are underway in collaboration with the ABB Corporate Research Center on a new generation of process and tool improvements. The next generation of tools will automate many of the manual steps that testers use to design and conduct tests and to report results.

Finally, another benefit of the STT is not at all related to fixing "bugs". Since STT employs both ABB project engineers and customers, system usability improvements are routinely identified and incorporated into new releases. Ultimately, the role of the STT is to ensure the successful release of 800xA, providing customer satisfaction, straight out of the box.

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Safety management in process industries

The ABB approach

Robert Martinez, Per Christian Juel, Per Fjellidalen

The safe operation of an industrial process requires a structured approach that must be applied to every aspect of every level of operations while seeking to minimize the total risk posed by the process.

ABB has a long tradition of supplying safety systems for industrial processes. This has provided the company with the experience necessary to implement new safety standards such as IEC-61508 and IEC-61511 and integrate these in its System 800xA control system.



ABB has been supplying safety systems to process industries for 25 years and is the most experienced supplier of programmable safety systems. The first safety system was developed and supplied to Mobil Inc. for the Statfjord B oil and gas production platform in 1979. Since then, ABB has been supplying industrial safety systems to most industry segments and major operating companies around the world.

The oil industry has been at the forefront of safety management for many years. National legislation for safety in exploration and development of the oil fields in the North Sea was forcing a shift in safety awareness and supporting technology long before new international standards were introduced. ABB played an important role in the development of the technology that today forms the basis for modern integrated automation and safety systems.

This has provided ABB with the experience necessary to support its process industry customers in facing the technical and organizational challenges and costs related to strict safety man-

Global responsibility

agement regulations. Another important argument in favor of ABB is the System 800xA control system¹⁾, providing a broad collection of “out of the box” services enabling the tightly integrated management required by IEC-61511²⁾: auditing, authentication, access management, document management, asset monitoring and CMMS (maintenance) integration. These and other software services provide functionality which help enforce and prove compliance during the operational phases of the safety lifecycle.

ABB's Corporate Research in Norway performed a gap analysis of the System 800xA platform versus the IEC-61511 management requirements to determine where support of the standard could be strengthened. The study revealed an opportunity to offer complete lifecycle coverage by providing support for this functionality in the following planning and engineering phases:

- Safety project management.
- Hazard and risk assessment.
- Safety function design for integrity and reliability.
- Cause and effect matrix safety programming.

ABB Corporate Research, together with the Safety section of ABB Process Automation, identified the benefits of a System 800xA “Safety Workplace” package, combining the existing and proposed functionality to provide a seamless solution to both engineering and operational users.

The consulting role of safety experts was not forgotten. The proposed safety tool chain was conceived to be portable with a minimum of dependencies and with an open design simplifying the import of data from a variety of sources. These features are essential for ABB's safety consulting engineers at customer sites and in customer training.

In 2004 pre-product prototypes were completed for both safety project management, and cause and effect matrix programming. These prototypes are discussed in the following sections.

Supporting safety project management

The ABB Process Automation business area has implemented formal and TÜV-approved safety management within its safety product development organization. This approval was a necessary pre-requisite for the successful development of the new AC 800M HI safety controller. The knowledge-path needed to gain approval provided valuable input to the prototyping of a tool which can be rolled out to project teams and customers, the “Compliance Manager”.

Compliance Manager helps the user build safety teams, describe member competences and assign responsibilities using a responsibility-accountability (RACI) chart. The built-in compliance editor allows input of any requirement set. The IEC-61511 standard is pre-loaded so that the user can be-

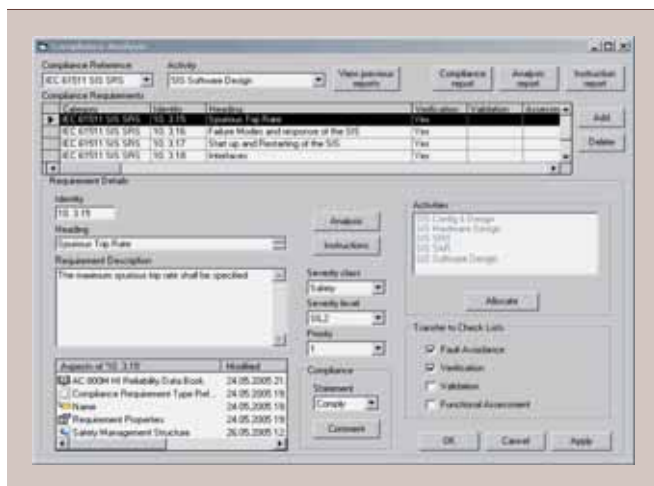
come productive immediately ¹. The user can perform a gap analysis on the requirements and then automatically generate checklists and specification documents. The tool is also loaded with ABB's expert interpretation of IEC-61511 and their applicability to the company's own systems. This feature allows ABB engineers to respond quickly and uniformly to customer safety requirement specifications.

Safety system design and programming

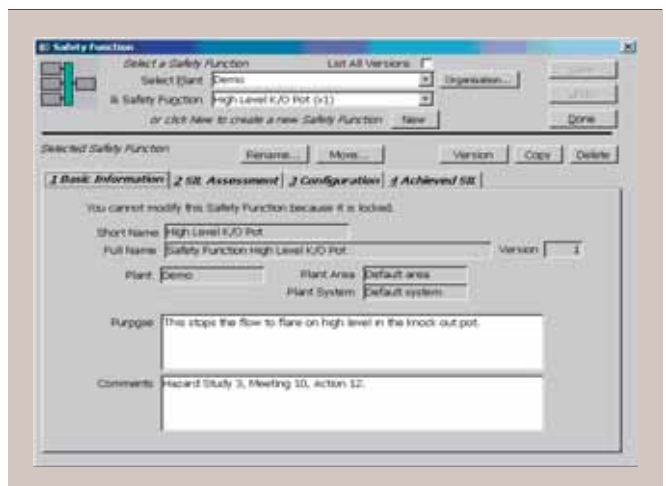
After the Safety Instrumented Function (SIF)²⁾ has been configured, the reliability of all its components is input to a Safety Integrity Level (SIL) calculation to check that it meets the target risk reduction. This calculation is not trivial, especially when the effects of redundancy and common-cause failures are considered. Fortunately, a group of safety engineers at ABB Engineering Services in England had earlier developed a stand-alone SIL calculator called TRAC (Trip Requirement and Availability Calculator) ². The ABB team in Norway compiled a roadmap for integrating the calculator with System 800xA and the other tools in the safety suite.

The SIL calculations are very useful for validating the SIF design, but they can also provide valuable data such as time intervals after which the customer must perform proof-testing on the SIF components. Other useful figures from this phase are the availability and total downtime, mean time between failures (MTBF), and the mean time to restora-

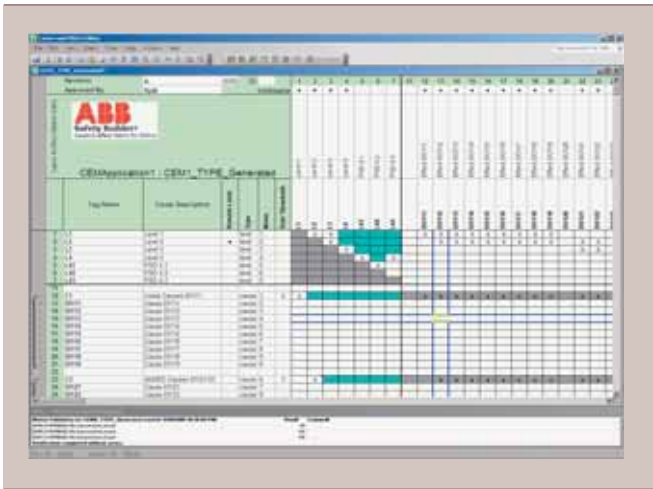
¹ Compliance Manager screenshot.



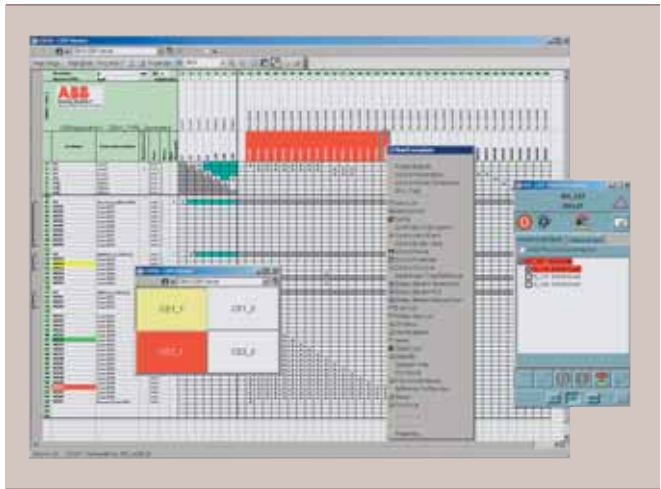
² ABB TRAC (Trip Requirement and Availability Calculator) SIL Calculator screenshot.



3 System 800xA Safety Builder editor screen shot.



4 System 800xA Safety Builder viewer screen shot.



tion (MTTR). There is a strong demand from project teams and sales engineers for integrated tools which can calculate and aggregate this data to all levels of a control structure.

At this stage of the lifecycle, all SIF hardware has been configured, but the safety application software has still to be implemented. The most challenging task in this phase is faced by programmers of large ESD/PSD (emergency/process shutdown) systems. These SIS systems span all process areas and access a huge number of process variables or "tags". Shutdowns are typically structured in a cascading hierarchy of many levels with the higher "emergency" levels tripping lower "process" levels.

Due to these special requirements, cause and effect matrix (CEM) programming has emerged as the de-facto

standard for programming ESD/PSD safety systems or any system with interlock logic. In its simplest form, a CEM is a matrix containing named tags. The matrix symbols indicate that a "trip" of a column's effect occurs when the corresponding "cause" row is triggered [3].

To support CEM programming for IEC 61131 control platforms, ABB developed the "System 800xA Safety Builder" toolkit. The Editor tool helps users specify complex emergency and process shutdown logic visually and intuitively with a matrix grid. High-quality SIL-certified code for the new AC 800M HI controller is automatically generated from this matrix.

The "Viewer tool" can then be invoked to generate a fully-integrated System 800xA operator display and navigation element [4]. The navigation element shows the aggregate alarm, or inhibit status of the entire safety system divided into process areas "sheets". With one click, the operator can drill-down to the sheet in alarm and see at a glance which devices and which levels have been tripped. One-click navigation to all the system's devices is provided.

The System 800xA Safety Builder tools build on the success of the Safety Builder product for Safeguard, adding many new features and more flexibility. System 800xA Safety Builder introduces the powerful concept of "single-source engineering": drawing, programming and display all based on the same un-

derlying document. The design approach enables the underlying CEM document to be shared with contractors who are not System 800xA equipped. They specify the design in the matrix and then send the document back for System 800xA code and display generation [5]. This facilitates flexible and distributed development practices.

Translation errors are eliminated by automatically generating the control logic and operator display from the same safety design matrix. This reduces initial engineering effort by a factor of ten and makes modifications easier to implement, test and trace.

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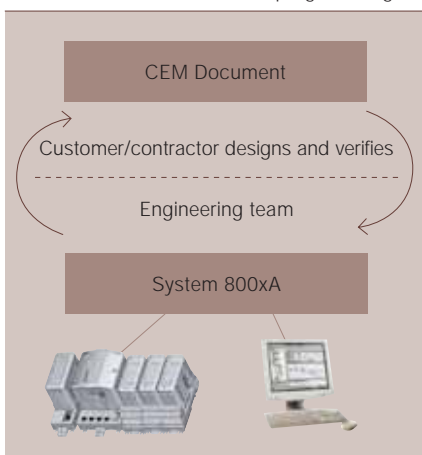
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Footnotes

¹⁾ Taft, Mark W., "IndustrialIT System 800xA, Extending the reach of automation to achieve continuous productivity improvements", ABB Review 1/2004 pp 32-37.

²⁾ See also Martinez, Robert, Juel, Per Christian, Fjellidalen, Per, "Safety management in process industries, Part 1 - Standards", ABB Review 3/2005, pp 47-50 and Martinez, Robert, Fengler, Frank, "Safe Instruments" on pp 96-99 of this edition of ABB Review Special Report.

5 Flexible "cause and effect" programming.



Integrated but separate

Advances in integrated and safety control

Roger W. Prew

End users of older automation systems essentially had to invest in two separate systems; a Basic Process Control System and a separate Safety Instrumented System. Nowadays suppliers differ in their opinions about the acceptability of implementing safety and basic process control functions in a single system with common processors. Some argue that integration reduces overall integrity while safety, which faces ever increasing regulation, is compromised.

The debate about integration is set to continue but one company that has been more constructive rather than vocal about this topic is ABB. As an established supplier of safety systems for hazardous processes since 1979, ABB has recently launched the unique 800xA HI combined Safety and Control architecture as part of the successful 800xA Extended Automation System. With this architecture, ABB has proved that true integration is possible, and functional separation of control and safety is ensured using modern high integrity processing techniques, firewalls and active diagnostics. Not only this but the system is fully compliant with the requirements of the international functional safety standards.

This article looks at the standard requirements and discusses how today's hardware and software technologies, in the hands of professionals operating under rigorous functional safety management procedures, can deliver new system architectures with higher levels of control and management functionality, and safety compliant integrity.

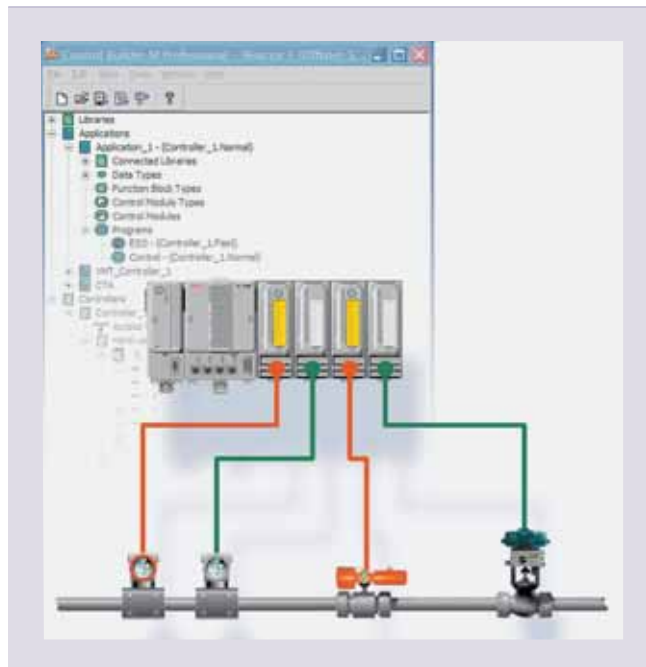


What are the advantages of integrating a Safety Instrumented System (SIS) and a Basic Process Control System (BPCS)? For one thing, the lifetime cost of ownership of the system is significantly impacted, as are project design, engineering and modification costs. At the system definition phase, the flexibility of being able to transfer inputs and outputs (I/O), and functions between the SIS and the BPCS, without materially altering the system architecture, improves the efficiency of the design process and results in a more cost effective solution. During system integration, this same flexibility ensures that the split between BPCS and safety matches the actual requirement and has not been forced into an architecture that was ordered many months earlier.

ABB's 800xA HI combined safety and control architecture has proved that true integration is possible and functional separation of control and safety is ensured.

Cost savings arising from common configuration tools, communications networks, spare parts, maintenance, training, service, and upgrades are obvious, but the biggest advantage is an increase in data access between the safety system, and the Distributed Control System (DCS) application and process management tools.

1 With ABB's System 800xA HI there is an increase in data access between the safety system, and the DCS application and process management tools



tions – only possible if the two applications are executed in a single common controller node – means that expensive field equipment and wiring can be shared between them thus optimizing the physical architecture 1.

Moreover, full integration means that all data associated with the Safety Instrumented Function (SIF)¹⁾, such as the Safety Integrity Level (SIL) calculation, system and field device diagnostics, trip frequencies, trip responses, valve condition and so on, are available to the BPCS Asset Management system. In addition, the high level data collection and analysis tools of a BPCS can be exploited in a common and consistent way by the SIS 2.

Regulations and standards

Process safety has gained corporate importance especially since the cata-

strophic incidents that occurred at Flixborough²⁾ (UK), Servesso³⁾ (Italy), Bhopal⁴⁾ (India) and on board the Piper Alpha⁵⁾ North Sea production platform. Now process safety expertise has extended into the general skill set of engineers and operators, and many industry-wide guidelines for process safety have been developed. The current industry generic standard for electronic and programmable systems, IEC61508⁶⁾, is the result of concerted efforts by industry and regulators over the past 30 years. The global objective of such a standard is to ensure that proper risk reduction strategies are adopted by all industries with hazardous processes so that the incidents mentioned above can be prevented.

This generic standard and the process industry specific standard, IEC 61511⁷⁾, are essentially advisory. However, they are now considered "good practice" by regulators in the UK and other industrial countries and also as a means of determining if a reasonable practical level of electrical, electronic and programmable electronic safety (E/E/PES) has been achieved. The standards are used to benchmark installations and are, to all intent and purposes, considered mandatory.

IEC 61511 defines methods of assessing risks associated with a particular hazardous process and it determines the risk reduction the safety system(s) must achieve. The standard is prescriptive in that risks must be assessed and reduced to "as low as is reasonably practicable". It does not however prescribe what technologies and

Footnotes

¹⁾ A Safety Instrumented System (SIS) contains many safety loops or Safety Instrumented Functions (SIFs), each with its own Safety Integrity Level (SIL).

²⁾ <http://www.hse.gov.uk/comah/sragtech/casexflixboroug74.htm> (January 2007)

³⁾ <http://www.chm.bris.ac.uk/motm/245t/245th/seveso.htm> (January 2007)

⁴⁾ <http://www.bhopal.org/whathappened.html> (January 2007)

⁵⁾ <http://www.answers.com/topic/piper-alpha> (January 2007)

⁶⁾ IEC 61508 is the international standard for electrical, electronic and programmable electronic safety (E/E/PES) related systems. It sets out the requirements for ensuring that systems are designed, implemented, operated and maintained to provide the required safety integrity level (SIL).

⁷⁾ The IEC 61511 standard refines the functional safety requirements laid down by IEC 61508 specifically for the process industry sector. It provides guidance in the proper application of a Safety Instrumented System (SIS).

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architectures should be used to achieve the reduction.

The 800xA HI safety system shares a common processing unit and other components with the DCS, and brings a number of significant enhancements to the overall BPCS package.

Current technologies

Many of the stand-alone safety systems currently available on the market pre-date the new IEC standards and employ a variety of technologies to achieve the high integrity control required for safety applications. "High integrity" normally suggests a combination of "fail safe" and "fault tolerance" operation. Fail safe ensures that if a fault occurs the system will react in a pre-determined and safe way whereas fault tolerance minimises the likelihood of a failure that would prevent the system from performing its functions. These two terms often get confused! A fault tolerant system may not be fail safe. Just because it may be redundant or triple modular redundant doesn't automatically make it suitable for safety applications. Also a fail-safe safety system does not require redundancy to achieve its SIL. Redundancy is built in solely to improve system reliability and availability.

The 1oo2 dual, 2oo3 triple and 2oo4 quad systems available on the market today come from a design era that used redundancy and fault tolerance as a means of reducing the probability of a dangerous failure occurring. Today dangerous failure modes can be completely designed out and 100 percent diagnostic cover can be provided to protect integrity without resorting to duplication. The requirements of "fail safe" for "safety integrity" and "fault tolerance" for "availability" can now be considered independently and used when and where they are applicable ².

There is always much debate about the hardware reliability of electronic and programmable systems. However modern surface mount, high integration electronics is considered extraordinarily reliable. In an SIS, the logic solver hardware is the most reliable element in the entire safety loop!

More evidence can be found in some modern simplex systems where the Mean Time Between Failure (MTBF) figures are better than the last generation dual or triple systems. In fact the triple and quad systems suffer from the law of diminishing returns on reliability in that the inherent failure rate rises in proportion to the increase in components and complexity.

A new generation of system

The new generation 800xA Extended Automation System from ABB is flexible enough to either combine the control and safety functions within the

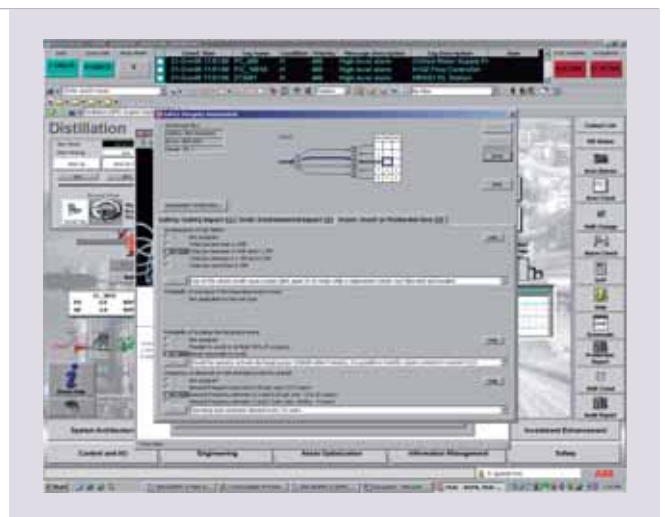
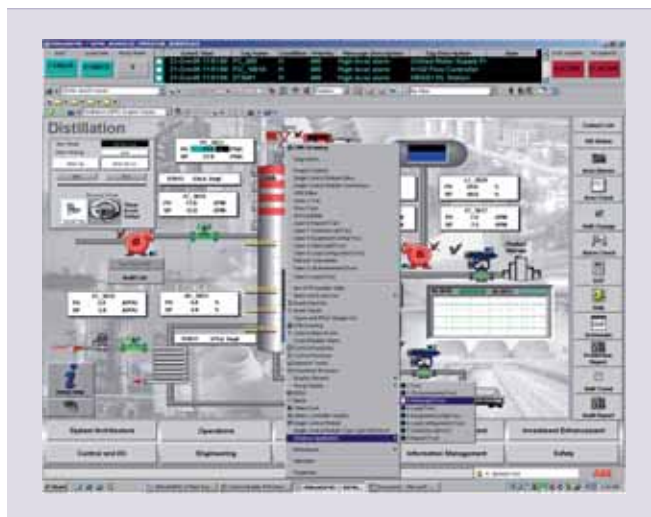
same controller or keep the functions separate but within the same integrated network. Known as the 800xA High Integrity (HI), it is definitely not a "modified DCS" or a DCS with added safety functionality. Instead it is a system designed from the outset to meet the requirements of the safety market and the current safety standards.

Safety related programs are compiled using a limited instruction set compiler certified for 800xA HI safety programs.

There are four key areas that must be addressed for a safety-related system to meet the aforementioned standards. Many incorrectly believe that as long as the calculated Probability of Failure on Demand (PFD) is within the right band, the system complies. A system complies only when the following four considerations are met.

- Reliability (PFD) is of course important and the figures for all subsystems that make up the safety function must form part of the certified data set so that the overall loop SIL can be assessed.
- The Safe Failure Fraction (SFF), which is a measure of the ability of the system to detect and avoid dangerous failure modes, is also part of the certified data set.
- Any constraints or integrity advantage resulting from the complete

² Risk graph for a related safety function to protect against a hazardous event



system architecture must be assessed and the implications on the SIL rating documented.

- Finally, the systematic integrity of the system including the development processes utilized, the lifecycle safety management of the system, and the methods used to develop and prove high integrity software must also comply with the letter of the standard.

A fault tolerant system may not be fail safe. Just because it may be redundant or triple modular redundant doesn't automatically make it suitable for safety applications.

The development of the 800xA HI safety system addressed the above issues. The design teams operated under audited functional safety management processes and the design concept and detail was approved at every stage by TÜV (The TÜV Product Service is considered to be the foremost independent certification authority in the business) ⁴. A certification specialist in the team, helped by third party consultants, steered the detail design continuously confirming compliance with the requirements and the standards.

The 800xA HI safety system shares a common processing unit and other

components with the DCS, and brings a number of significant enhancements to the overall BPCS package including:

- Higher BPCS reliability through:
 - Diagnostics – extensive diagnostic cover is a prerequisite for integrity
 - Determinism – the safety model brings with it a deterministic execution model
 - Integrity – this brings greater reliability and accuracy of measured values and control action
- Faster communication between BPCS and SIS functions allows a higher degree of process control optimization with respect to the actual safety boundaries (or safety distances).

Integrated but separate

The debate about the separation of the safety function from the BPCS will no doubt continue. However the IEC 61508 and IEC 61511 standards do actually recognise that safety and non-safety functions can reside in the same system if “it can be shown that the implementation of the safety and non safety functions is sufficiently independent (ie, that the failure of a non safety related function does not cause a dangerous failure of the safety related functions)” (IEC 61508-2 clause 7.4.2.3). The standards also require that the possibility of common mode dependent failures is reduced to an acceptable level. (IEC 61511 Part 1 clause 9.5.1/2).

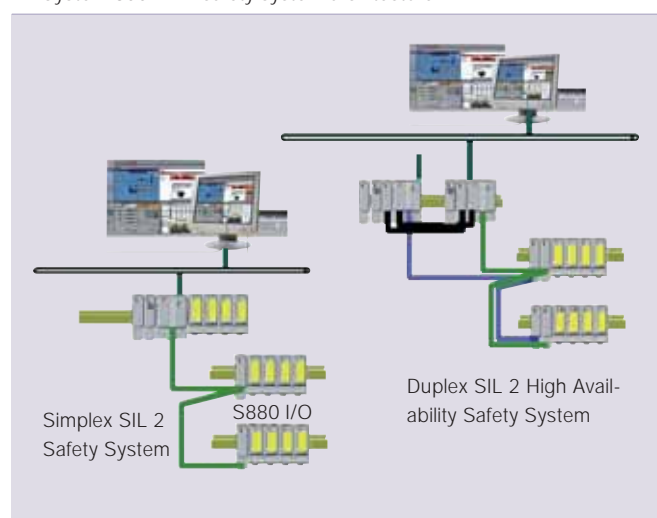
ABB's new generation System 800xA is faithful to these requirements. The

modular nature of the new system meets the standard requirements for functional separation and common mode failures. Memory partitioning, separate execution contexts, firewalls and stack management techniques that come from the defence and high integrity data processing worlds ensure that safety and non-safety programs running in the same processing environment are actually separate and non-interfering. The integrity of the safety function is assured by limiting general communication with the Man Machine Interface (MMI) to read-only, and instituting a “safe write” function for over-rides that can only be enabled by manual intervention at the controller. Peer to peer communications between safety and non safety functions is strictly controlled to ensure integrity of the safety function. Additional Cyclic Redundancy Checking (CRC) and relevance checking means the peer to peer network can be considered a grey channel.

The 800xA HI is a system designed from the outset to meet the requirements of the safety market and the current safety standards.

Detailed analysis was carried out against the “Layers of Protection Analysis (LOPA)⁸” method of risk reduction. This analysis confirmed that the

³ System 800xA HI safety system architecture

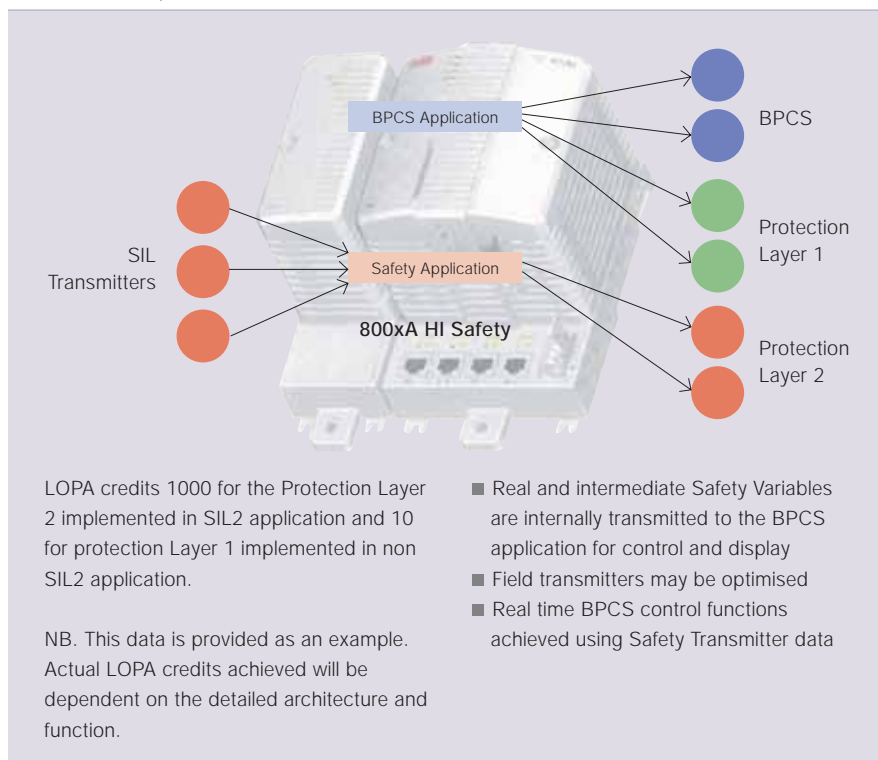


⁴ ABB's 800xA HI safety system is certified to the IEC 61508 and IEC 61511 safety standards, and approved by TÜV



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5 Functional Separation



LOPA credits for protection functions, implemented in the DCS application and operating in either a combined control and safety node or a separate 800xA node, are equivalent to those implemented in systems with totally different control and safety systems **5**. The additional integrity gained from running BPCS applications in the 800xA HI controller outweighs the additional risks from possible common mode failures.

To the oil and gas markets, System 800xA HI offers a redundant architecture that can be independently implemented at the I/O level and at the operator level to add fault tolerance.

Safety related programs are compiled using a limited instruction set compiler certified for 800xA HI safety programs. During the compiling process, additional compiler test suites and CRC ensure the integrity of the com-

plied safety program. The block execution of the application during run time is verified for order, timing and discrepancy. Internal communications between processing elements and I/O are duplicated and double checked using proven techniques to ensure that all erroneous or unexpected messages are ignored. The use of diverse and dissimilar hardware in the I/O and processors, and a TÜV certified Real Time Operating System (RTOS) in the safety module ensure that the System 800xA HI meets the integrity requirements of IEC61511 on all counts.

Highest possible reliability and availability

The 800xA HI design is inherently fail-safe with near 100 percent diagnostic coverage even as a simplex application (ABB claims 99.9 percent SFF and there are actually no known dangerous undetected failure modes in the system). This is achieved by virtue of an initial hardware design intended to fully meet the requirements of SIL3 (Four SIL levels are possible, with SIL4 being the most dependable and SIL1 being the least)⁹⁾. Hardware diversity in the I/O, local CRC and shut-

down control together with the unique processor/safety module architecture eliminates common mode faults. Not only this but audited Failure Mode and Effects Analysis (FMEA) and failure rates place the product within the top 6 percent of the SIL3 band. Audited PFD figures are published and based on a proof test interval of eight years.

Audited FMEA and failure rates place ABB's 800xA HI SIS within the top six percent of the SIL3 band.

In the oil and gas markets safety logic solver systems are expected to (a) run without interruption for at least fifteen years and (b) endure all sorts of upgrades, modification and change during that time. System 800xA HI offers a redundant architecture that can be independently implemented at the I/O level, the processor level and at the operator workplace level to add fault tolerance – and hence high availability – to an already high integrity system wherever it is required. This redundant system can also upgrade the system application safely on line.

The debate about grass roots principles is set to continue but history has shown that progress is being made by challenging the accepted view, addressing the problem from a different direction whilst complying with the standards.

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Footnotes

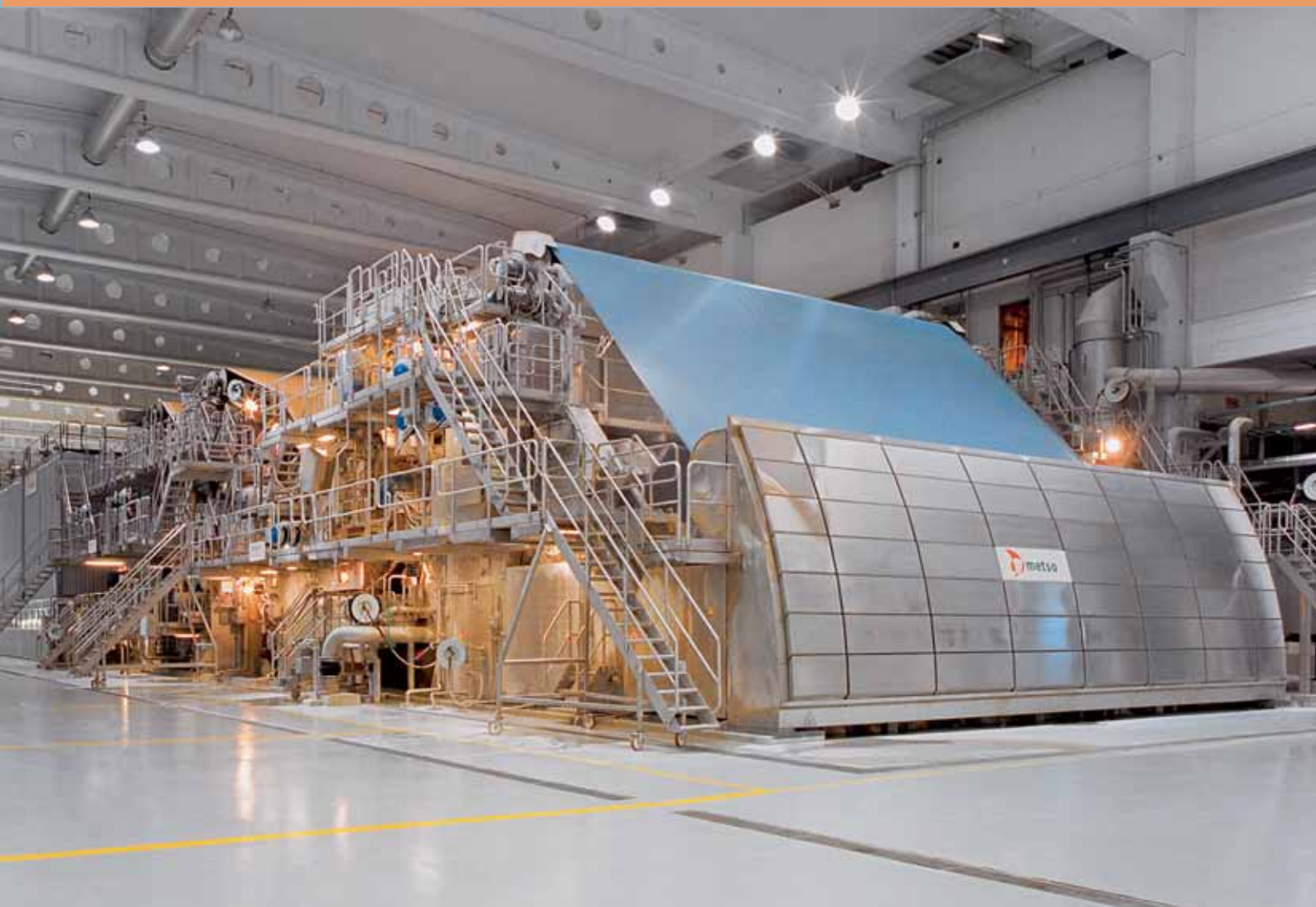
⁹⁾ LOPA is a simplified risk assessment method for evaluating the risk of hazard scenarios and comparing it with risk tolerance criteria to decide if existing safeguards are adequate, and whether additional safeguards are needed. http://www.primatech.com/info/faq_layers_of_protection_analysis_loba.pdf (January 2007)

⁹⁾ For a more comprehensive explanation of SIL, see "Safe Instruments" on pp 96–99 of this edition of ABB Review Special Report.

Setting the standard

Global responsibility for quality and safety
Markku Haikola

ABB is a global market leader in the area of paper machine drive systems. The business model within the company is based on a centrally managed but widely spread discipline. This model enables ABB to address the specific needs of local markets and, at the same time, provide global technological leadership. This in turn ensures the delivery of high quality world class solutions to all customers with the same principal functionality for control and safety.



Global responsibility

For many years ABB has been a pioneer in the development of paper machine (PM) drive systems. The high quality system solutions delivered by the company have been achieved by the consistency and repeatability of the work. In other words, decades of experience and thousands of projects combined with finely-tuned organizational and personnel skills have enabled the development of technological solutions that not only meet process requirements in all paper making production situations but which can also be implemented quickly and efficiently.

If the know-how contained in the global application standards is applied effectively, on-site engineers are able to ensure a high level of engineering reuse of up to 80 percent!

ABB drive systems can be found in many machines including pulp dryers, production machines for different paper types (with on- or off-line coating), the fastest LWC winding machines and the

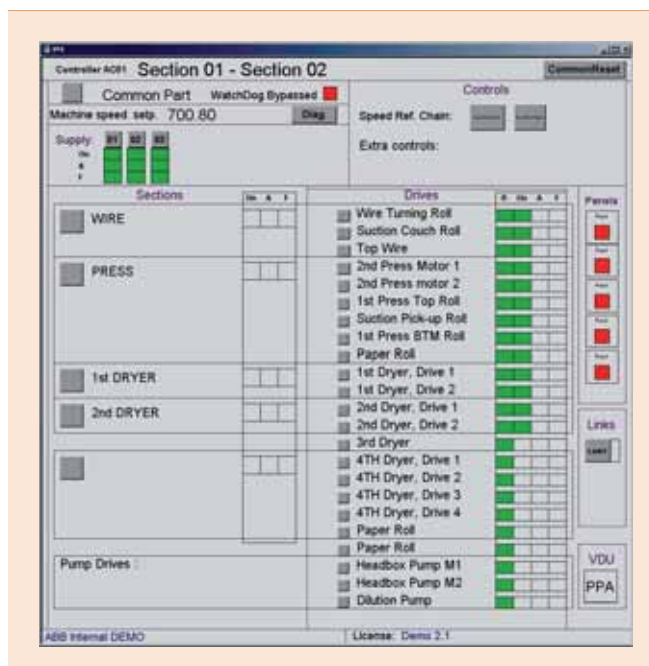
most up-to-date supercalenders for printing papers and many others. Even though the idea of efficient repetitive work is not easy to achieve, ABB implements on time and to the highest quality, an average of two PM drive systems per week! So how does the company do this? To begin with, it is to the customer's and supplier's advantage to standardize and stabilize the work as much as is reasonably possible for quick and smooth start-ups. ABB has been able to do this because of its *PM Drives Network*. The PM Drives Network encompasses a unique business model and a set of solution standards that are the result of years of experience and expertise in paper machine drive solutions. Global application standards constitute the bulk of the network and when the know-how contained in these standards is applied effectively, professional local lead engineers and lead commissioning engineers on-site are able to ensure a high level of engineering reuse of them up to 80 percent! Standard features include proven electrical design for safety and various safety related functions in the system software. Engineering reuse is not the only factor. The quality of ABB's PM drives operation is backed up by clearly defined domains of expertise. For example, local ABB engi-

neering units are authorized at different levels to execute projects to the highest global application standards. These levels are determined by the expected repeatability of the project as well as the experience of project engineers – each project lead engineer is usually certified according to personal experience. The authorized units are then committed to train and develop dedicated PM drive experts to efficiently manage the detailed features of the standards.

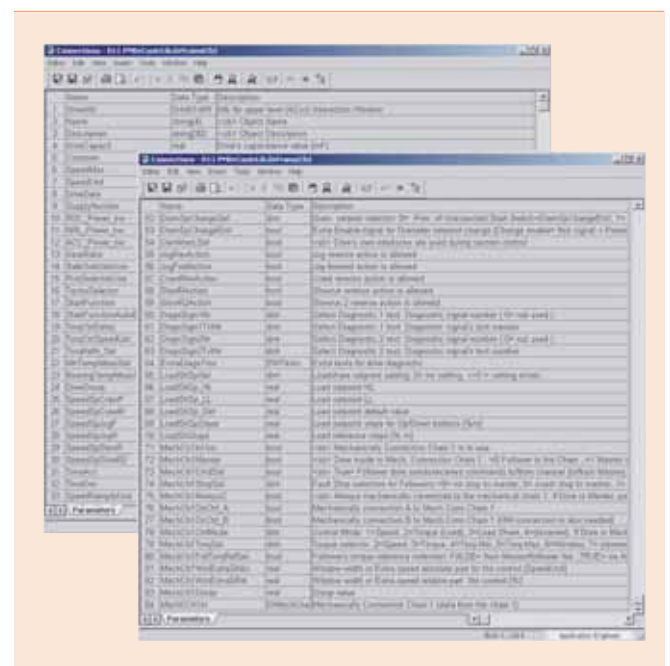
Standards for large, small and complex systems

PM drive systems primarily take care of power transmission from the electrical motors. For a delicate process such as paper making, engineers must have detailed knowledge of the sensitive control of megawatt class motors as well as an excellent understanding of the process characteristics. The motors are regulated by inverters which are themselves highly sophisticated devices with many functions and features. Providing a standard inverter solution for a single unit is not that difficult, but a standard for a coordinated inverter system solution (where tens or even hundreds of inverters are involved) is a demanding task. In spite of the complexity, however, high performance in-

All levels of the global Paper Machine (PM) drive programs are easily monitored and accessed through standard interactive windows in the programming tool



Standards include tens of preconfigured drive settings, transferred automatically from a standard system configuration chart



verter solutions are included in ABB's global application standards.

Large new systems with the latest machine solutions, the most advanced system controls, and general complex integration schemes are typical to only a few of the largest ABB drives projects yearly. In such cases the efficient reuse level can only be centrally maintained. However, ABB's PM Drives Network, with defined standards and certification ensures that all projects, no matter the size or complexity, are supported by experienced personnel at a local level. Operating in this way, ABB will always strive to maintain the highest quality possible.

For small machines and drive systems, ABB has recently launched the PMC800 basic drive. This system is based on the same functionality contained in the PMC800xA solution for high performance machines, but is configured to be used with a wider variety of available products. However more stringent standards are required if global solutions, using a broader selection of components and functions, are to be managed efficiently. Then, with just a little less customization, clients will get all the necessary functionality to fulfil their operational demands.

Safe solutions

The size of a project is irrelevant when it comes to safety. Irrespective of whether it is a small scale revamp a

large new greenfield project, system safety will not be compromised by non-standard engineering. Requirements and standards regarding safety may vary around the globe but the overall aim amounts to the same thing. In this area, the US, Europe and many emerging countries refer to the international IEC safety standards. Having the know-how to implement these and other local standards in a project from scratch requires extensive investment. However, safety functionality is included in ABB's PM Drive Network as a standard global application solution, and is distributed to local specialists. This working model is the safety assurance in ABB drive deliveries. Additionally, the company's global center of excellence for PM drives supplies complete – in terms of safety and functionality – fine-tuned system software packages for demanding machines, or machine parts, such as center winders, calenders, or for special machine concepts.

A global operation

Most paper companies operate globally, and on a global scale customers gain access to the same solutions and consistent services. These paper companies, like many global companies, depend to a large extent on the availability of knowledgeable and experienced local support. However there will always be times when wider service resources are required to solve particular problems. Remote connectivity is one of the most common ways

of getting expert help quickly and effectively. Whether the expert is on site or remotely connected, a global solution is easier to troubleshoot because engineers can quickly navigate the familiar system for any necessary changes.

With ABB's PM Drive Network, customers are offered high quality global solutions with local system service know-how, thus giving them a real competitive advantage.

Many process and machinery suppliers also operate on a global level. Suppliers naturally benefit from a proven solution just as much as the end user. Nowadays, working processes are standardized and the expectations for a smooth and prompt start-up are high. To avoid any unforeseen and costly delays, process suppliers will benefit enormously by being involved with the system suppliers in the development of standards and working processes for projects. These must then be made available to each and every project irrespective of whether they are managed locally or globally.

In the global paper making business, it is very important to meet the same requirements in all parts of the world. Quick start up times are crucial for all customers and this can be achieved if uniform standards and processes exist, ensuring repeatable and therefore prompt work. It is also important for customers to be able to exchange experiences between mills and communication becomes easier if global standard solutions exist. Not only this but maintenance methods and special skills for the different mills or machines can also be unified.

With ABB's PM Drive Network, customers in any part of the world are offered high quality global solutions with local system service know-how. In today's business world, this gives ABB's customers a real competitive advantage.

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Over 250 Paper Machine (PM) drives specialists serve paper makers in ABB's PM drives network



Safe instruments

Safe instruments for a safer process

Robert Martinez, Frank Fengler

The safety of a plant, its employees and its surroundings depends on the ability of the plant to shut down or shift to a safe state should an abnormality occur. A false trigger can lead to a costly shutdown and unnecessary loss of production, whereas a failure to trigger can possibly have more far-reaching consequences. The reliability and safety of a plant is therefore dependent on the integrity of its sensors.

Instruments are classified by their Safety Integrity level (SIL). The SIL of a device determines the applications it is suitable for. In this article, ABB Review discusses failure rates, how they are quantified and how ABB goes about assuring its instruments fulfill the integrity levels that are expected of them.

For process industry system builders and operators, a hazard is the result of a misbehaving process. The safety instrumented function (SIF) must act to bring the process to a safe state. As the name implies, a SIF consists of a chain of instruments to detect this hazardous condition, manipulate the input data in a programmable device (the CPU) and then send a command to the output instruments. These output devices are also known as “actuators” because they act to bring the process under safe control or to shut it down completely. A schematic of a SIF loop is shown in 1.

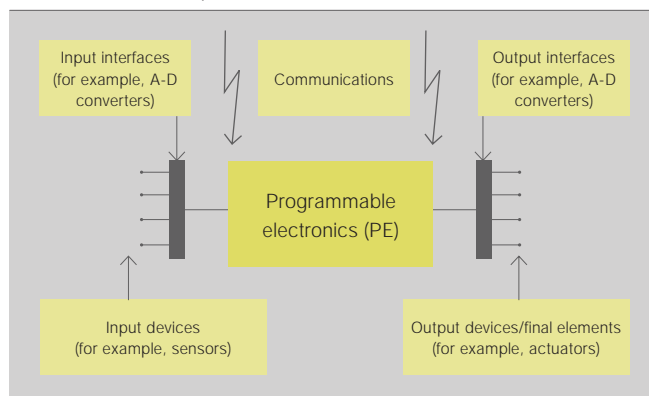
The main challenge for process safety engineers is to identify all the possible hazards related to that process and then to quantify the impact each of

these would have on the plant surroundings. When this “risk level” is known, the process safety engineer can choose SIF instruments with a matching Safety Integrity Level (SIL). The SIL level of the entire chain of instruments is always that of the lowest SIL component ie, “the weakest link in the chain”.

The IEC 61511 standard provides process engineers strict guidance for this task, but also puts responsibility on management, process operators and people in other project lifecycle phases to ensure that the process is adequately protected. This lifecycle approach is so successful that it has become the preferred model for other draft international standards for machinery, nuclear and even for security.

The classification of safety instruments by SIL level is itself an enormous achievement for industry. Born in the aftermath of the tragic chemical plant accident at Seveso, Italy in 1976, this international standard allows engineers to focus on the process hazards, confident that their safety instruments

1 Schematic SIF loop structure



will perform at the required level. This separation of functions is more than just a practical convenience; it carries legal obligations for both the system builder or operator and the safety instrument supplier.

To make this regime work in practice, safety instrument suppliers today must follow the rules in the "sister" IEC standard #61508 "Functional safety of electrical/electronic/programmable electronic safety-related systems" and achieve the desired SIL certification for their products.

"Sister" standards for safety

ABB is in the interesting position of being both an instrument supplier (eg, safety pressure transmitters) and a system builder (eg, safety and automation for oil and gas projects). Thorough knowledge of the application of the IEC safety standards is crucial in maintaining the company's position as a safety leader.

The IEC standards for these two different levels of supply are surprisingly similar and can be mutually understood by a simple change of terms:

- For safety instrument engineers the hazard comes from within the component itself in the form of device failure.
- The process engineer performs a hazard analysis whereas the instrument engineer performs an FMEA (Failure Mode and Effect Analysis).
- For safety instrument engineers it is the impact of a dangerous event on the safe output of the device which must be assessed.

Engineers in both disciplines must quantify the likelihood of their respective dangerous events. The instrument engineers calculations result in a PFD (Probability of Failure on Demand). The PFD value can be directly mapped to a SIL level according to 2. For example, a SIL2 device must fail less than once out of every 100 demands.

Understanding failure rates

The simple PFD value is a powerful number; not only does it determine the market for the device by virtue of its SIL certification, but it also determines the complexity and hence price of the instrument as well as the cost

to the end-customer to maintain it in the field. The PFD calculation is:

$$PFD = \lambda \cdot \tau / 2$$

where:

λ : number of dangerous, undetected failures per hour

τ : testing interval in hours

A lower λ can be achieved in one of three ways:

- Re-design of critical parts
- Increased detection capability
- Increased hardware redundancy

The FMEA document provides valuable input to the first approach: re-design for greater integrity. For ABB's 2600T pressure transmitter 2, some of the key points were; CPU and clock integrity, power supply monitoring, analog output stage integrity and software sequences. Analysis also revealed that λ could be reduced by using an all-welded design in a critical area of the device.

The second approach to reducing λ means adding extra circuitry and software enabling the device to detect a greater number of dangerous internal failures and alarm the system accordingly. This approach increases the Safe Failure Fraction (SFF) of the device, but at the cost of extra hardware and code development. The SFF rating of a device affects the allowable architecture if IEC 61511 or ISA-S84 is being used as the design standard. An SFF rating of 90 percent or greater is needed to use a single transmitter in a

SIL2 application, for example, as shown in 3.

The third approach involves duplicating critical elements to achieve greater Hardware Fault Tolerance (HFT). In ABB's SIL pressure transmitter, for example, a differential inductive sensor provides two independent signals proportional to input pressure and a dual architecture processes these signals independently.

In 3, the columns numbered 0,1,2 refer to the number of simultaneous hardware faults which the device can tolerate. Increasing redundancy clearly has a beneficial effect on SIL but at the cost of some duplicated hardware.

The standard has a loophole which allows suppliers to claim a higher HFT if the device is "proven-in-use". Proven-in-use imposes a significant burden on the supplier who often does not have access to high-quality, long-term historical data showing device failures. Without such data, it is recommended that safety transmitters, for example, have a HFT value of 1.

It is particularly important that software failures be included in this SFF analysis. As software in instrumentation gets more and more complex, field failures due to systemic software errors are increasing. Therefore, any assessment of a device must include the potential software failures and/or have reliable software diagnostics built-in to the device.

Understanding MTBF

Mean Time Between Failures (MTBF) is defined as the inverse of the Safe Failure Rate. The λ data is normally presented in terms of "FITs", failures-in time. Typical FIT data is expressed in 10^{-9} , or the number of failures per one billion hours usage.

$$MTBF = 1/\lambda \text{ (for 1001 architecture}^{1})$$

There is often a trade-off between SFF and MTBF. For instance, one transmitter on the market has a SFF of 96.7 percent and an λ rating of 963, while another has specifications of 70 percent and 490. The first achieves the 90

2 PFD failure rates

SIL	PFD
1	$0.1 < PFD \leq 0.01$
2	$0.01 < PFD \leq 0.001$
3	$0.001 < PFD \leq 0.0001$
4	$0.0001 < PFD \leq 0.00001$

3 Safe failure fraction ratings versus SIL

SFF	0	1	2
< 60%	–	SIL1	SIL2
60–90%	SIL1	SIL2	SIL3
90–99%	SIL2	SIL3	SIL4
> 99%	SIL3	SIL4	SIL4

Footnote

¹⁾ 1001 is explained later on in the article.

Global responsibility

percent SFF criteria for single device usage in SIL 2 applications but has an MTBF that is half of the second device. What the user needs to understand is that safety transmitters are designed to have a very high reliability in terms of their main function but may be less reliable from a pure MTBF perspective. A good rule of thumb for a safety transmitter, therefore, is to specify a minimum of a 100-year MTBF value.

Proof testing to maintain integrity in operation

The second term in the PFD calculation, τ , represents the hours between mandatory proof-testing of the device when in operation. This is a luxury for device suppliers since frequent testing has a beneficial effect on SIL. Operators, however, must bear the burden of proof-testing every such device as often as several times a year – a part of the lifetime operating cost that will not go unnoticed at purchasing time.

As a general rule, actuators such as solenoid-operated valves represent at least 50 percent of the dangerous undetected failures of the entire SIF loop. The sensor accounts for approximately 30 to 40 percent and the remainder is attributed to the CPU and I/O boards, collectively known as the “logic solver”.

The research and development effort invested to achieve the lower failure rates in ABB SIL instrumentation is worth the effort. The typically high failure rates of actuators is an opportunity for sensor and logic-solver suppliers such as ABB to reduce their product's PFD values so that the SIL of the entire safety loop can be preserved. Lower PFD values translate into lower costs and simplified engineering for end customers because they will not need to boost SIL by specifying redundant transmitters or by choosing more expensive actuator valves.

Automation vendors have only recently started to exploit fieldbus-based diagnostic capabilities to offer on-line proof-testing. Such a technique eliminates field visits and will maybe one day even be fully automated. The ABB Corporate Research Center in Norway has investigated this technique for the proof-testing of actuators such as valves by executing a

partial-stroke only, allowing production to continue uninterrupted. Fieldbus diagnostics carry stroke test data to the logic solver where potentially dangerous failures can be detected. In this way, they decrease the device's λ and allow operators to wait longer between mandatory full shut-downs for valve testing. The research center is also investigating the use of new safety variants of Profibus and Fieldbus Foundation to complete the picture for robust safety asset management.

Safety Instrument Portfolio

ABB supplies a range of safety pressure transmitters that use a variety of sensing methods. ABB also offers a range of temperature sensors, positioners and a flowmeter all classified to SIL2. The AC800M-HI High Integrity SIL2 Safety Controller and its associated safety I/O round off the company's safety portfolio. These SIL classifications are awarded after assessment by accredited third-party companies ⁴, an effort which requires ABB to provide thorough documentary proof of compliance.

The 2600T-Series pressure transmitter ⁵ has models certified to SIL2. 37 have recently been sold to Statoil in Norway. Other customers of ABB SIL instrumentation include Tractebel Gas Engineering GmbH (TGE), who have particular expertise in the areas of storage, conditioning and shipping of liquefied gases (LNG and LPG) and petrochemical gases.

A tool for optimizing safety design

The complexity of trade-offs involved in safety instrument design is multiplied when an entire SIF is configured. These can be investigated and visualized in the ABB TRAC tool's Trip Requirement and Availability Calculator. This was developed by John Hunt and Ian Bradby of ABB Engineering Services in the U.K. TRAC is a PC-based software tool used to assist safety, project and maintenance engineers in determining the optimum design configuration and periodic test intervals for safety instrumented functions. TRAC is used by ABB engineering consultants and has also been licensed for use by end-customers worldwide.

The TRAC tool provides the engineer with a systematic and consistent ap-

proach to calculating the required SIL using either Risk Graph or LOPA (Layer of Protection Analysis). TRAC is pre-loaded with both field reliability data and the manufacturer's reliability data, including data for many of ABB's safety instruments. All calculations discussed so far in this article are used within TRAC, permitting the user to focus on the design task.

Finding the optimum configuration

One of the main benefits of TRAC is allowing project engineers to investigate various redundancy schemes. Some standards prescribe the use of redundancy as the cure for system reliability, but do not explain the quantitative analysis this redundancy is based upon. Risk analysis is based on probability theory and can be derived

- ⁴ ABB's 800xA HI safety system is certified to the IEC 61508 and IEC 61511 safety standards



- ⁵ ABB's 2600T pressure transmitter is certified to SIL2



- ⁶ Simplified PFD formulae for redundancy

Architecture	PFD
1001	$\lambda \cdot \tau / 2$
1002	$\lambda^2 \cdot \tau^2 / 3$
2002	$\lambda \cdot \tau / 2$
2003	$\lambda^2 \cdot \tau^2$

from several methods. All methods rely on certain key elements in order to provide objective analysis – failure rates, failure modes, diagnostic coverage and common cause data. The most common architectures used in the process industries are the following:

■ 1oo1 One-out-of-One

When using a single device, the safety is affected by the dangerous failures, the reliability by the safe failures.

■ 1oo2 One-out-of-Two

With 1oo2 voting, if either transmitter fails, then the process is tripped. This increases safety (versus 1oo1) at the expense of reliability.

■ 2oo2 Two-out-of-Two

With 2oo2 voting, both sensors need to fail in order to trip the system. This increases reliability at the expense of safety.

■ 2oo3 Two-out-of-Three

This architecture is very common in the process industries since you have very good safety and reliability, but at the expense of added cost.

A set of simplified equations has been developed to provide a quick risk analysis based on a few key parameters of

the device in question – the safe failure rate, and dangerous undetected failure rate. The analysis typically will assume the same MTTR (mean time to repair) and TI (test interval) values. The equations used are shown in [6].

The good news is that the data required for the calculations shown above is now published by most major vendors and has been included in the TRAC software package. This allows the user to perform what-if analysis, as shown in [7], to assist selection of various vendors and/or architectures.

Finding the optimum proof test interval

The tool represents one approach to calculating SIF proof-test intervals. By focusing on the relevance of the system and consequence of failure on demand, the tool provides a range of test intervals. In many cases, this is likely to permit an extension to existing intervals. Where an integrity level is not defined, test intervals may be justifiably extended to align with the convenience of a plant shutdown or other inspection criteria such as electrical integrity – or simply just repair on breakdown. TRAC provides multiple solutions for testing inputs and outputs within the bounds of the required maximum and minimum allowable probability of failure on demand. For each span of test intervals, the cost of testing is calculated from known annual testing costs. Results are displayed graphically and a comprehensive report is issued in a fully traceable format [8].

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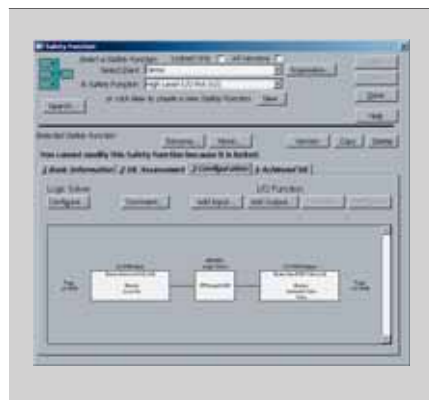
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7 TRAC tool for safety function configuration



8 TRAC tool for proof-test interval optimization



Reduce your risk and improve your efficiency



With System 800xA High Integrity

"ABB's System 800xA provides a cost effective way to integrate our process control and safety instrumented system functions in a unique, scalable hardware configuration, using common user application development tools."

— Edward R. Sederlund,
Process Automation Product Manager,
The Dow Chemical Company



Only System 800xA provides you with a comprehensive high integrity automation solution that makes your plant more efficient while you protect your personnel, equipment and environment. Our revolutionary "same but separate" architecture gives you the flexibility to combine control and

safety functions in one robust controller or keep these functions separate.

This eliminates duplication of engineering effort, reducing implementation costs and integrating information flow throughout the system.

System 800xA reliably reduces your risk while extending your automation reach beyond traditional process control—resulting in dramatic and continuous productivity improvements.

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