ISA 95 and the RtPM Platform

The ISA 95 standard has become extremely visible in the automation world. The ISA 95 standard defines a model for manufacturing operations, including the reporting and analysis functions that are critical to effective manufacturing. This white paper provides an overview of the ISA 95 standards and explains how OSIsoft's Real-time Performance Management (RtPM™) Platform provides the right answer for manufacturing operations data collection, reporting, and analysis.

An Overview of the ISA 95 Standards

The ISA 95 Enterprise/Control System standard defines interfaces between business functions and manufacturing operations functions. It also defines a new reference model for manufacturing operations systems that is rapidly becoming the new model for MES (Manufacturing Execution System) applications.

- In late 2000 the first part of the standard was released, followed by Part 2 in late 2001.
- In mid 2002 the World Batch Forum (WBF) released the first XML schema (B2MML - Business to Manufacturing Markup Language) based on the Part 1 and Part 2 standards.
- In early 2004 a stable version of Part 3 was available and was being used by end users and vendors. Part 3 should become an official ISA standard in early 2005.

Part 1 and Part 2 of ISA 95 have two main elements; they define the boundary between business logistics functions (Level 4) and plant floor functions (Level 3), and they define a standard format for data exchange across the boundary. Part 3 of ISA 95 describes the functions and activities within Level 3. (See Figure 1.)

The business planning and logistics (Level 4) functions are supported by ERP (Enterprise Resource Planning, PLM (Product Lifecycle Management), or SCM (Supply Chain Management) applications. The plant floor systems (Level 3) are made up of data historians, analysis tools, MES systems, DCS systems, and database tools.

Figure 1: *ISA 95 Level Definitions*

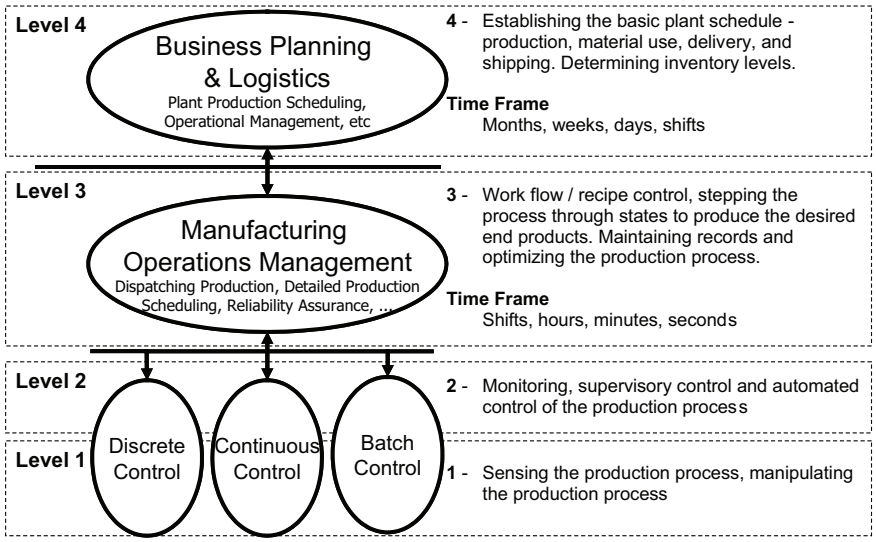

Figure from ISA 95.00.03 Draft 20

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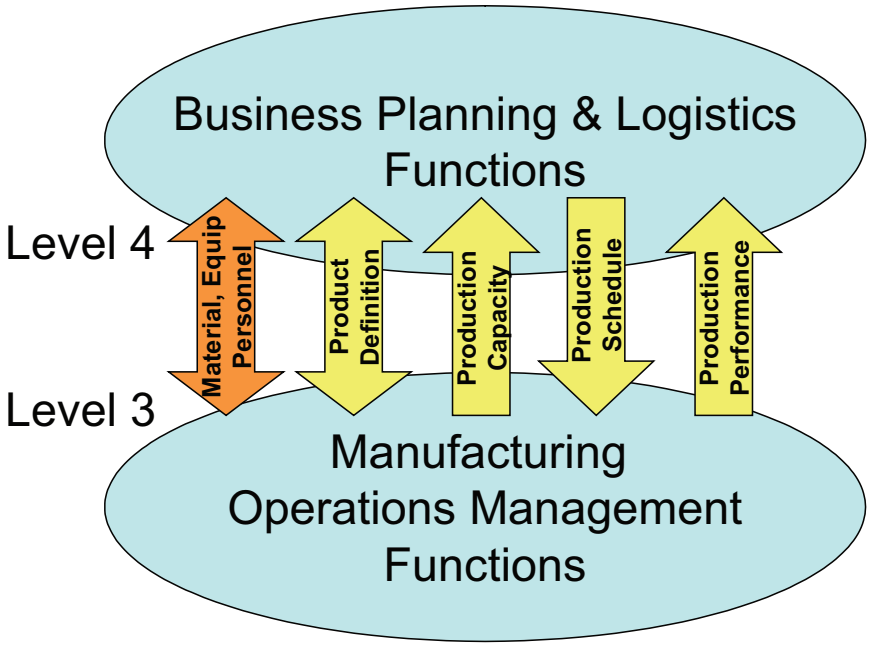

Figure 2: *B2MML Exchanged Information*

Figure 2 illustrates the type of information defined in the standard that is exchanged between Level 3 and Level 4 systems. The WBF B2MML schemas define standard document formats for exchanging information on: equipment, material, personnel, production capacity, product definitions, production schedules, and production performance. The exchanged documents are XML (eXtended Markup Language) files. The schemas are freely available and are provided by WBF under an unrestricted use open-source license.

The ISA SP95 committee has continued working on Part 3 of the standard and it will become a formal standard in early 2005. Part 3 defines a new model for manufacturing operations management, and includes the functions of MES, LIMS (Laboratory Information Management System), and CMM (Computerized Maintenance Management). Part 3 provides a standard model for describing all of the activities that go on in a manufacturing company that control the personnel, equipment, and material to make products. Part 3 extended the MESA (Manufacturing Enterprise Solutions Association) definition of MES with addition functions and added new models for inventory movement control, maintenance management, and quality lab operations.

ISA 95 Part 3 is already being used by many end-users in their requirement specifications, especially in the process industries. In particular it has been used in the chemical, pharmaceutical, biotech, food and beverage, energy, pulp and paper, and consumer packaged goods industries.

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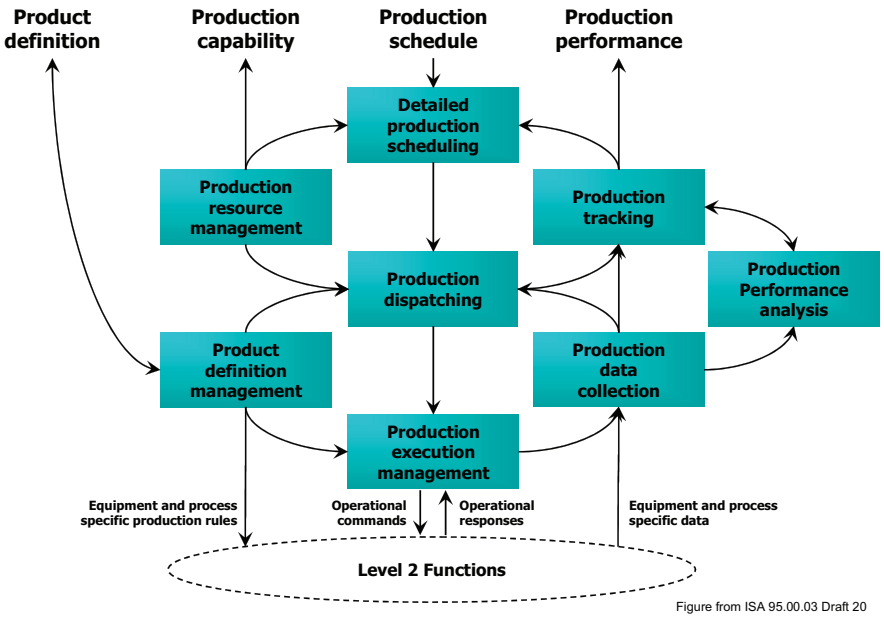

Figure 3: *Manufacturing Operations Management Functions*

Part 3 defines a model for functions that take place in manufacturing operations. (See Figure 3.) It does not define the applications that support the functions, but instead defines the various tasks that take place and how the tasks interrelate. This model is becoming the standard positioning model used by automation and ERP vendors to describe their solution suites.

The production model is driven by *production schedules* that are developed by the business system and sent to production. The *production schedules* are then used by a detailed production scheduling activity to define *detailed production schedules* containing *production work orders.*

The *production work orders* are dispatched based on time and events, the *production work order* is executed and data is collected in a production data collection activity. Some of the information flows to Level 2 are defined in ISA 88, OPC, Fieldbus and other standards. Other data flows shown in Figure 3 will be defined in the ISA 95 Part 4 standard.

The collected data is used in a production tracking activity that relates the time-series information to the work order (recipe) information to generate a report on *production performance* and production tracking information. The collected data, and the data from production tracking, is used in a production analysis function to generate reports and KPIs.

There are functions for the management of the production resources; personnel, equipment, and material. These functions manage the current status and the expected future availability of the resources (such as vacation schedules, planned maintenance, etc.).

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There are functions that manage the recipes, procedures, and work instructions needed for production. Selected parts of this information are shared with ERP and PLM systems, especially in the area of BOM (Bill of Material) integration.

OSIsoft's position on the ISA 95 Standards

OSIsoft encourages the work done by the ISA SP95 committee and the WBF working group. The ISA 95 standards provide a much needed set of standard definitions needed for manufacturing operations.

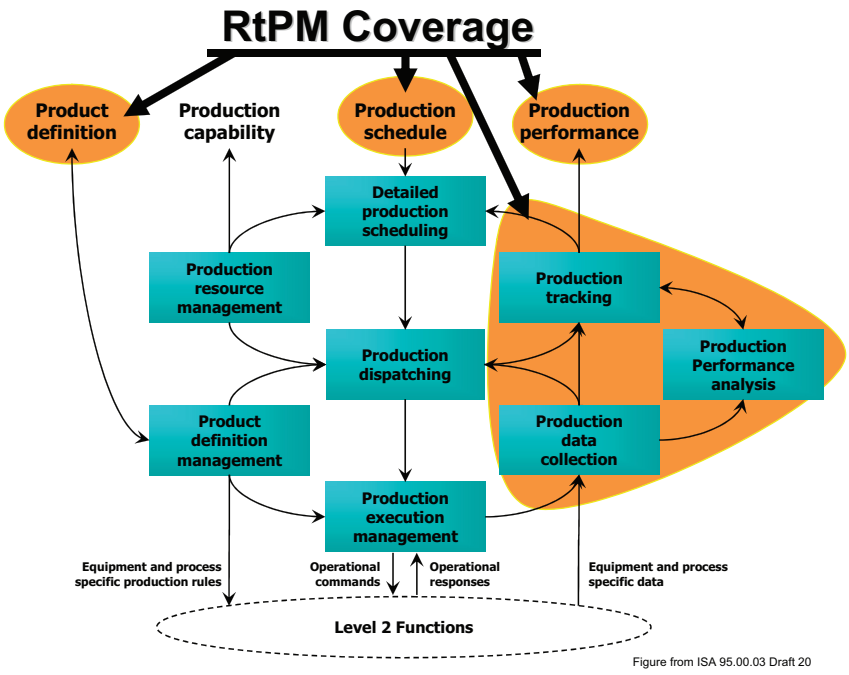
The ISA 95 standard defines a wide range of reports and KPIs used in manufacturing operations. These reports and KPIs require real-time data collection from a wide range of systems. The RtPM Platform provides the best-in-class solution for data collection, product definition, reporting, and KPI generation. RtPM's overlay of the ISA 95 Part 3 framework demonstrates where RtPM adds value and complements end users' existing systems.

RtPM and the ISA 95 production model

The Part 3 standard defines the functions performed by MES systems but also defines other functions typically associated with the shop floor operations. The main areas supported by the RtPM Platform, illustrated in Figure 4:

- Production data collection
- Production performance analysis
- Production tracking
- Product definition

Figure 4: *RtPM Functions within Production Operations*



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Production data collection

A vast majority of the data collected in manufacturing operations is time series data. The functions of data collection are defined in ISA 95 Part 3, note the last underlined sentence:

> "Production data collection is the collection of activities that gather, compile and manage production data for specific work processes or specific production requests. Manufacturing control systems generally deal with process information such as quantities (weight, units, etc.) and associated properties (rates, temperatures, etc.) and with equipment information such as controller, sensor, and actuator statuses. The managed data may include sensor readings, equipment states, event data, operator entered data, transaction data, operator actions, messages and other data of importance in the making of a product. The data collection is inherently time or event based, with time signals or event signals added to give context to the collected information."[1]

Time series data collection is a foundation element for production, maintenance, quality labs, and inventory movement operations. Using the PI System, RtBaseline provides the real-time information infrastructure for RtPM and is the best-in-class solution for production data collection. RtPortal's visualization tools provide the interface to the collected data, and RtReports (part of RtAnalytics) provides an out-of-the-box system that manages and generates reports for some of the most demanding and sophisticated industry applications.

Some of the specific tasks listed in the ISA 95 standard supported by RtPM include:

a) Providing interfaces to the basic process or manufacturing line control system, laboratory information management systems, and production management systems for automatic collection of information
b) Providing standardized or on-demand reports for operations and manufacturing personnel
c) Maintaining information for local process and production analysis and for reporting to higher-level logistics systems
d) Maintaining information for product tracking to enable tracking and tracing capability such as tracing products to specific material lots, equipment and/or operators
e) Providing compliance monitoring and alarm management functionality (event logging and sequence of events)
f) Providing product quality information for comparison against specifications. [2]

[1] ISA 95.00.03 Draft 21 Clause 6.9.1
[2] ISA 95.00.03 Draft 21 Clause 6.9.3

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Production performance analysis

Data by itself does not provide value, it must be analyzed to convert it into information. The analysis activities use the time-series data collected about the process and merge this with other information about production to generate KPIs, predictive indicators, SPC, and SQC information. The functions of production performance analysis are defined in ISA 95 Part 3, again note the underlined sections:

> "Production performance analysis is the collection of activities that analyze and report production to business systems. This would include analysis of information of production unit cycle times, resource utilization, equipment utilization, equipment performance, procedure efficiencies, and production variability.
> …
> Relationships between these analyses and others may also be utilized to develop KPI reports. This information may be used to optimize production and the use of resources. Such information may be provided on a scheduled basis, it may only be provided at the end of production runs or batches, or it may be provided on demand." [3]

RtAnalytics provides analysis tools supporting production performance analysis tasks. RtAnalytics is a best-in-class application and toolkit for production performance analysis with RtPortal providing the interface to the analytical information.

Some of the specific tasks in production performance analysis supported by RtPM include:

a) Producing reports of performance and cost.
b) Evaluating constraints to capacity and quality.
c) Reporting on performance tests that determine capacity.
d) Comparing different production lines and creating average or target runs.
e) Comparing and contrasting one run against another.
f) Comparing production runs to identify "golden" runs.
   Note: "Golden" runs are runs that are the best run ever produced, where best may be the highest quality, or lowest cost, or any other criteria.
g) Comparing runs against defined "golden" runs.
h) Predicting the results of a production run, based on the current and past performance. This may include the generation of production indicators.[4.]

[3] ISA 95.00.03 Draft 21 Clause 6.11.1
[4] ISA 95.00.03 Draft 21 Clause 6.11.3

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Production tracking

Information about sensors, tags, calculated values and other time based information must be converted into product and material related information. Production tracking functions use the collected data and analysis to provide tracking information, calculating actual production and consumptions. The functions of production performance analysis are defined in ISA 95 Part 3 as:

> "Production tracking is the collection of activities that prepare the production responses for Level 4. This includes summarizing and reporting information about personnel and equipment actually used to produce product, material consumed, material produced, and other relevant production data such as costs and performance analysis results. Production tracking also provides information to detailed production scheduling and Level 4 scheduling activities so schedules can be updated based on current conditions." [5]

While RtPortal provides some production tracking functionality, RLINK is an important part of the production tracking solution. RLINK, a member of RtBaseline's product family, and RtPortal provide a best-in-class solution for production tracking and SAP connectivity in the process industries. RLINK also provides connectivity to other business level systems such as JD Edwards, MRO's Maximo, and Indus Passport.

Some of the specific tasks in production tracking supported by RtPM include:

a) Recording the start and end of movements and collecting updates to lot and sublot quantities and locations as they occur.
b) Translating process events, including production and movement events, into product information.
c) Providing information for tracking (recording) and tracing (analysis).
d) Generating production responses and production performance information. The information may be provided on demand or on a defined schedule, and may be provided to people, to applications, or to other activities.
e) Generating electronic records related to the production process. This may include records required for regulatory or quality management purposes.[6]

[5] ISA 95.00.03 Draft 21 Clause 6.10.1
[6] ISA 95.00.03 Draft 21 Clause 6.10.3

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Product definition

Information about products is an important element of manufacturing. Recipes at multiple different levels of detail and with different purposes must be managed and changes coordinated, and product information needs to be synchronized with business level product information such as bills of materials and routings. Product definitions are defined in ISA 95 Part 3 as:

> "Product definition information is shared between product production rules, bill of material and bill of resources. The product production rules contain the information used to instruct a manufacturing operation how to produce a product. This may be called a general, site or master recipe (IEC 61512-1 and ANSI/ISA-S88.01-1995 definition), standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used. The product definition information is made available to other Level 3 functions and to Level 2 functions as required." [7]

The RtPM Platform includes ProcessPoint, a member of the RtBaseline family, which is Product Lifecycle Management for the process industries. ProcessPoint provides a data repository for data and document management that captures all of the information about a product during its development and lifecycle. It's a platform for product data management and collaboration providing complete specification management, formulations, recipes, multilevel bills of material, an audit trail of product and packaging changes, and more. ProcessPoint is the world class enterprise-wide PLM solution for process, with strong ties to production operations.

[7] ISA 95.00.03 Draft 21 Clause 6.4.4

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Applications built using the RtPM Platform

Many of the applications built using the RtPM Platform address specific problems referenced in the ISA 95 standard. Some of the applications are listed in Table 1, detailed information on these applications are available from the OSISoft RtAPP brochure and the OSIsoft web site at www.osisoft.com/rtapps.aspx.

Table 1: *Production Operations Applications*

APPLICATIONS USING THE RtPM PLATFORM	ISA 95 PRODUCTION OPERATIONS
Applications using the RtPM Platform	ISA 95 Production Operations
Alarm Management	Production Data Collection
Analyzer Performance	Production Analysis
Automated Reports	Production Data Collection
Balanced Scorecards	Production Performance Analysis
Batch Quality Monitoring	Production Tracking
Certificate of Analysis	Production Tracking
Control Loop Monitor	Production Performance Analysis
Data Reconciliation	Production Performance Analysis
Downtime Monitoring	Production Performance Analysis
Energy Management System	Production Performance Analysis
Hierarchical Process Data Views	Production Data Collection
Key Performance Indicators (KPI)	Production Performance Analysis
Manual Data Recording	Production Data Collection
Manufacturing Intelligence Data	Production Performance Analysis
Material Balance	Production Tracking
Material Pricing	Production Performance Analysis
Material Usage Tracking	Production Tracking
Multi-Plant Equipment Performance Monitor	Production Performance Analysis
Operating Envelope Data	Production Performance Analysis
Operations Data Warehouse	Production Performance Analysis
Operations Desktop	Production Data Collection Production Tracking
Operator Handover	Production Data Collection Production Tracking
Plant Performance Overviews	Production Data Collection Production Tracking
Process Monitoring	Production Data Collection Production Tracking
Process Performance Monitoring	Production Performance Analysis
Production Integration to ERP	Production Tracking
Production Plan Comparisons	Production Performance Analysis
Root Cause Analysis	Production Performance Analysis
Six Sigma	Production Performance Analysis
SPC/SQC Production Quality Control	Production Performance Analysis
Total Effective Equipment Productivity	Production Performance Analysis
Troubleshooting Equipment Startups	Production Performance Analysis

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Maintenance, quality labs, inventory operations management

ISA 95 and the RtPM Platform cover more than just the production areas of a company, and here RtPM provides outstanding value and functionality. The other manufacturing areas are maintenance operations management, quality operations management, and inventory operations management.

Each of these areas includes data collection, analysis, and tracking functions, and RtPM has been used in every one of these areas. RtPM has the added advantage of being able to combine information from all of these areas for analysis, KPI calculations, and process predictions. RtPM is the best-in-class solution for all manufacturing operations areas, it provides a single solution for time-series data collection, analysis, and tracking functionality no matter where the function is performed.

The ISA 95 standard defines a generic model for how work can be performed in any operational area. The generic model demonstrates that similar functions are performed by different groups on different data sets. The ISA 95 standard defines:

- **Maintenance operations management**: The collection of activities that ensure the availability of personnel, equipment and tools for both manufacturing operations and manufacturing operations management.

  Maintenance: The maintenance operations management model follows the same pattern as production except that the controlling elements are maintenance requests. A detailed maintenance scheduling activity generates maintenance work orders which are dispatched and executed according to a detailed maintenance schedule. Equipment and human generated data is collected as a result of executing the maintenance work orders. Data is collected in order to predict or detect maintenance problems. Maintenance data collection, tracking, and analysis functions, even though usually done by a maintenance group, have been implemented using the RtPM elements. (See Table 2.)

- **Quality operations management:** The collection of activities related to measuring and reporting on quality. The broad scope of quality operations management includes both quality operations and the management of those operations in order to ensure the quality of intermediate and final products.

  Quality Tests: Quality test operations management follows the same pattern, but in this case the controlling elements are quality test requests. A detailed quality test activity generates quality test work orders which are dispatched and executed according to a detailed quality test schedule. Data is collected during the execution of the test, from equipment and human entry, and this is used in test analysis and test tracking. Quality test data collection, tracking, and analysis functions, even though done by lab personnel, have been implemented using RtPM Platform elements. (See Table 2.)

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- **Inventory operations management:** The collection of activities that manage the inventory of product and/or material (maintaining perpetual inventories), perform periodic and/or on demand inventory cycle counts, manage the transfer of material, measure and report on inventory and material transfer capabilities, and coordinate and control the personnel and equipment used in material transfer.

  Inventory Movement: Inventory also follows the same pattern, but the controlling elements are inventory movement requests. The requests generate inventory movement work orders, which are dispatched and executed. Data is collected as a result of the work orders (such as what materials were moved, what equipment used, the new and old locations, and quantities), and this data is used to generate inventory movement responses and is used in analysis. Inventory movement data collection, tracking, and analysis function have been implemented using RtPM Platform elements. (See Table 2.)

- **Supporting Operations:** There are also supporting functions within manufacturing operations defined in ISA 95 for management of information, management of compliance (such as FDA, EPA, USDA, OSHA), management of incidents and deviations, management of documentation, and management of configurations (changes). Some of these functions are also supported by RtPM.

RtBaseline, RtPortal, and RtAnalytics provide some of the most robust, sophisticated, and cost effective implementation in industry in Management of Compliance, Management of Incidents and Deviations, and Management of Documentation. RtReports simplifies regulatory compliance of electronic reports with an out-of-the-box reporting system that generates and manages compliant electronic batch reports.

The RtPM Platform supports multiple functions within the ISA 95 framework, more than just data collection, but also data validation, analysis, real time actions, and business integration. RtPM provides best-in-class functionality across all areas of manufacturing.

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Table 2: *Other Manufacturing Areas Supported*

RtAPPS	OPERATIONS AREA
Condition Based Maintenance (CBM)	Maintenance Data Collection
Continuous Emissions Monitor (CEM)	Maintenance Data Collection
Downtime Monitoring	Maintenance Data Collection
Environmental Compliance Monitoring	Management of Compliance
General Ops Documentation & Equipment Specification	Management of Documentation
Hazardous Waste Tracking	Management of Compliance
Incident Investigations	Management of Incidents and Deviations
Inventory Management	Inventory Data Collection
IT System Monitoring	Management of Information
Key Performance Indicators (KPI)	Maintenance Performance Analysis
	Inventory Performance Analysis
	Quality Analysis
Lab Quality Data Integration	Quality Test Data Collection
Lab Terminal Operations Reports	Quality Test Data Collection
Maintenance History and Status	Maintenance Data Collection
	Maintenance Performance Analysis
Maintenance Lockout Procedures	Maintenance Data Collection
Manual Data Recording	Maintenance Data Collection
	Quality Test Data Collection
	Inventory Data Collection
Manufacturing Intelligence Data	Maintenance Performance Analysis
	Inventory Performance Analysis
	Quality Analysis
Operating Envelope Data	Maintenance Data Collection
	Management of Incidents and Deviations
Product Compliance Monitoring	Management of Compliance
Product Development Trials	Management of Information
	Management of Documentation
Quality Monitoring/Analysis	Quality Data Collection
Shared Inventory Management	Inventory Tracking
Troubleshooting Equipment Startups	Maintenance Data Collection
Waste Treatment Monitoring	Management of Compliance

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Summary

The ISA 95 standard is being used by end users to:

a) provide a framework to understand and specify the many different software systems used in manufacturing, and
b) better integrate their ERP systems with their shop floor systems.

This white paper demonstrated the scope of the RtPM Platform within the ISA 95 framework.

- RtPM provides best-in-class production data collection, production analysis, and production tracking for the process industries and for continuous and batch production. Users have built some of the industries' most robust, sophisticated, and cost effective applications using the RtPM Platform.
- RtBaseline uses the PI System to provide the most extensive standard connectivity to real-time data.
- RtBaseline uses ProcessPoint to supply Product Lifecycle Management for the process industries. ProcessPoint provides a data repository for data and document management that captures all of the information about a product during its development and lifecycle.
- RtBaseline uses RLINK for ERP connectivity for production tracking and automating maintenance programs such as the Plant Maintenance modules of JD Edwards, MRO's Maximo, and Indus Passport.
- RtAnalytics uses elements such as the Advanced Computing Engine to provide a rich set of analytical tools to generate KPIs, predictive indicators and other analysis information.
- RtAnalytics uses RtReports as an out-of-the-box reporting system that generates and manages regulatory compliant electronic batch reports from the RtPM Platform and other data sources.
- RtPortal is a standards-based "self-service" set of applications that makes it easy to visualize, and personalize real-time performance management data delivery as actionable information to individuals throughout the organization.

The RtPM Platform already provides a rich interface to SAP and OSIsoft's use of the B2MML standard will follow the emerging industry standard for integration. RtPM captures actual costs of operations, eliminating manual data entry into SAP, and providing information for asset efficiency, available-to-promise, and quality improvement business processes.

The RtPM Platform is the infrastructure for both maintaining operations and for continuous improvement. It is used by thousands of companies to solve a wide range of performance issues before they become problems. It provides comprehensive visibility into the manufacturing arena, allowing timely insight and action.

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