Specification for a SCADA-System in the Water Industry (e.g. WinCC V7.2)

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1 Task and Objective

Within the framework of the project, a higher-level process control system (SCADA) is to be installed in the plant. The installation of the SCADA system includes the connection of various automation systems (PLCs). In particular, the higher-level control system is to perform the following functions:

- Central monitoring of the operational equipment by acquiring and processing as well as depicting all specified process tags such as measurement values, system status messages and fault messages.
- Storing of data in long-term archives for later analysis in the form of reports and graphics.
- Forming of values through arithmetic or logic operations with process data.
- Depiction of the operational and process-related equipment in dynamic plant flow diagrams as color graphics screen with display of all required data in analog and/or digital form.
- Depiction of measurement data in the form of trend curves and tables.
- Online parameterization of the system by means of convenient, mask-oriented dialogs and menus as well as corresponding help texts (help function).
- Logging of all data and statuses using reports; setup of industry-specific, standardized reports – such as ATV reports – for documenting the operation with the specific calculations.
- Open, documented programming interface (API) for processing (in read and write mode) the process data (actual values, archive values, messages) in third-party systems and own applications.
- Access to process data and archive data across networks by means of a Web-based solution.
- Contractually regulated update service for the software components used. It is therefore possible to keep the system up to date with the latest version of the software.
- Also taken into account must be that all essential functions of the SCADA software are to be executed based on the standard VDI/VDE 3699.

1.1 Plant Specification

1.1.1 Operator Terminals

For the use of the control system, the following configuration shall be provided:

Quantity	Designation/Location	Function required
....	Single-user computer	System configuration Data archiving Data export Data import Process visualization Process operation Report output
....	Central computer (server)	System configuration Data archiving Data export Data import Process visualization Process operation Report output
....	Redundant partner server	Functions identical to the central computer. Automatic synchronization of the data and assumption of all functions should the server fail (“hot-standby”).
....	Central archive server	Central data archiving/Data export of all servers belonging to the system.
....	Operator terminal (client)	Process visualization Process operation Input of laboratory data Output of fault messages
....	Operator terminal (Web client)	Process visualization Process operation Output of fault messages
....	On-site station (panel)	Process visualization and operation with low hardware requirements.
....	Display and diagnostics station (office PC)	Process and data display Analysis

1.1.2 Range of Information

The anticipated range of information, which must be transferred between the control system and the PLC level, is summarized in the following tables. The tables list the minimum requirements made on the control system with regard to the range of information that is to be transferred and processed.

Quantity	Type
	PLC to be connected
	Binary signals
	Measurement values
	Commands
	Setpoint values
	Counter values
	Laboratory data
	Calculated values

Quantity	Type	Binary signals	Analog signals
	Motor		
	Pump		
	Fan		
	Slider		
	Valve		

Furthermore, 25% are to be included as reserve.

1.1.3 Process Screens

Quantity	Screen type
	Plant screen
	Trend curve screen
	Setpoint value screen
	Tables/Statistics
	Alarm screen
	Diagnostics screens

1.1.4 Archived Process Values

Quantity	Basic cycle	Compression cycle	Compression type AVG / MIN / MAX / without
	500 ms		
	1 s		
	2 s		
	5 s		
	10 s		
	30 s		
	1 min		
	30 min		
	60 min		

The archive system should be able to keep the following values available for the specified time periods. Within the specified time periods, it should be possible to access these archive values to, for example, compare them to the current values:

Archiving type	Storage period	Storage destination/ Data source
Actual value archiving/ Trend curves	1 Year	Short-term archive (1)
Compressed values	10 Years	Long-term archive (2)

- Archive values from time period (1) = short-term archive should be presentable within 2 seconds.
- Archive values from time period (2) = long-term archive should be presentable within 3 seconds.
- Where applicable, values/archives already exported from the system should be integrable again into the system.

1.1.5 Messages

Quantity	Type
	Discrete messages
	Messages from the PLC (in chronological order)
	Limit value messages

2 Requirements on the Control System

2.1 Basic System Requirements and System Properties

The design and function of the SCADA system are to be state-of-the-art as process information and operating system and its hardware and software must be future-proof.

The control system is to be a modern system with an attractive user interface, open to the office and process environments, mature and reliable in its functions, easy to configure, scalable for simple and complex tasks. It should also be possible to operate the system and obtain support worldwide.

Commercial PCs are to be used as operator and server stations. Office PCs or industrial PCs can be used on which Microsoft Windows 7 32/64-bit® (Business/Enterprise/Ultimate), Windows Server 2008 SP2 32-bit ®, Windows Server 2008 R2 SP1 64-bit®, Windows XP Professional SP3® or Windows Server 2003® can be run. This way, the control system benefits from the innovations and savings available in the PC market.

The SCADA system software is to be offered as

- Complete package (containing configuration software and runtime component)
- Runtime package (runtime component only)

If the project grows, an upgrading of the tag count is to be possible at any time. The later expansion is to result in the same total license costs as purchasing the larger solution from the start.

For new plants:
The communication channels for connection to the controllers (e.g., SIMATIC S7 Protocol Suite, SIMATIC S7-1200/1500 channel, SIMATIC S5 [Ethernet Layer 4, AS511, serial, PROFIBUS FDL], SIMATIC 505 [serial, Ethernet Layer 4, TCP/IP], SIMOTION) by means of different communication media is to be included in the product package of the control system just like the drivers for simple connection types, such as point-to-point via the MPI interface or Ethernet TCP/IP.

Note the following in case of a plant migration:
The communication channels for connection to the controllers (e.g., SIMATIC S7 Protocol Suite, SIMATIC S7-1200/1500 channel, SIMATIC S5 [Ethernet Layer 4, AS511, serial, PROFIBUS FDL], SIMATIC 505 [serial, Ethernet Layer 4, TCP/IP], SIMOTION, MODBUS TCP/IP Allen Bradley E/IP PLC5, Allen Bradley E/IP SLC50x, Mitsubishi controllers of the FX3U and Q series) by means of various communication media is to be included in the product package of the control system just like the drivers for simple connection types, such as point-to-point via the MPI interface or Ethernet TCP/IP.

It should also be possible to establish a connection to controllers from different manufacturers, such as Lantronix, Digi, Moxa, Black Box, B&B Electronics, Comtrol, etc., by means of a software solution.

Furthermore, a connection via the standardized software interface OPC to other devices and applications by different manufacturers is to be possible.

The control system is to be characterized by the following system attributes:

- PC-basis and standard operating system
    - Can be run on all commercial IBM/AT compatible PC platforms such as 32-bit and 64-bit Pentium® processors and AMD® processors.
    - 100% 32-bit and 64-bit software designed for the standard operating system Microsoft® Windows.
    - Mainframe (server) with Windows Server 2008 SP2 32-bit® or Windows Server 2008 R2 SP1 64-bit®. For projects with up to 3 clients, Windows 7® SP1 32/64-bit® (Ultimate, Business and Enterprise) or Windows XP Professional SP3® can also be used as server operating system.
    - Central long-term archive server with Windows Server 2008 R2 SP1 64-bit®
    - Operator stations (client) with Windows XP Professional SP3® or Windows 7 SP132/64-bit® (Ultimate, Business and Enterprise)
    - Hardware and software from the PC sector can be used directly (e.g., LAN cards).
    - Can be used as single-station or multi-station system with client/server structure.
    - Scalable performance by selecting corresponding hardware platforms (for example through multiprocessor systems).
    - Scalable availability by selecting the corresponding redundant hardware.

- Operator control and monitoring modules

    - Graphics system
      For the freely configurable visualization and operation via fully graphical objects (Windows, OLE, OCX and ActiveX objects; .NET Controls, XAML Controls), with the option of making all properties dynamic and with online configuration. A standardized industry-specific block library from the manufacturer is to be utilized as the basis for creating the plant screens.
      Screen objects are to be executable in a type/instance concept, i.e., changes are to be made at a central location and be transmitted to all object instances of the same type, without having to change every single instance.

    - Notification system
      For the logging and archiving of events with display and operating options based on DIN 19235; freely selectable message classes, message display and reporting; freely selectable sorting at the online moment. Hitlist for displaying the most frequently occurring messages. Display of the message duration.

    - Process data archiving
      For the acquisition, archiving and compression of measurements values so that they can, e.g., be displayed in trend curves or tables and be processed further. Central data archiving on an archive server.

- Reporting system
  For the time-or event-driven documentation of messages, operations, archive contents and current data as user reports (process data) or project documentation (backup documentation of configuration data) in a flexible, freely selectable layout.

- Processing functions
  For the configuration of actions at objects and the formulation and editing of scripts with ANSI-C syntax or Visual-Basic. The editing is to take place via a system-internal C or Visual Basic interpreter.

- Standard interfaces
  Out of the 32/64-bit Windows world are an integral part of the control system: standard database Microsoft SQL Server 2008 R2 SP1 (32-bit)® for configuration and process data with accessibility via ODBC or OLE-DB.

- Programming interfaces (API)
  Are to be present in all application modules of the control system and offer accessibility to data and functions. A function library enables the programming of independent applications, with which the basic functionality can be expanded.

• System openness

  - Access to configuration data (lists) and archived process data via the standard database interface (ODBC/SQL), C-API or OLE-DB.

  - Integration of Windows application blocks (ActiveX Controls).

  - Exchange of data with other Windows programs via the OPC interface.

  - Highly flexible through scripting languages in ANSI-C or Visual Basic.

  - Configuration wizards expandable through user wizards and Visual Basic for Applications (VBA).

  - API programming interface with access to control system functions.

  - Connection to the SIMATIC S5, S7, 505, SINAUT ST1/ST7, IEC 60870-5-101/104, DNP3 and PLCs by other manufacturers (e.g., via manufacturer-spanning PROFIBUS or OPC; MODBUS) such as Allen-Bradley.

2.1.1 Option Packages

In addition to the basic packages, the system is to be expandable through the option packages listed below. They are to be integrated into the user interface, i.e., a switching with standard keyboard shortcuts such as Alt-Tab or Ctrl-Esc between the different applications is not permitted for safety reasons. Likewise, the shortcut Ctrl+Alt+Del must be deactivated to prevent unwanted access to the operating system and the task manager.

2.1.1.1 Option: Server

Multi-station systems operate according to the client/server principle. The server stations run under Windows 2008 Server SP2 32-bit ® or Windows 2008 Server R2 SP1 (64-bit)® and use its safety-related operating system mechanisms. Servers take on central tasks, for example, process link and archiving for stations in the multi-station system. Client stations which run on Windows XP Professional SP3® or Windows 7 SP1 32/64-bit ® (Business, Enterprise or Ultimate), use the services of the server. They communicate with the server using their own terminal bus that can also connect them with the office level. The TCP/IP standard protocol is used for communication between the operator stations. A corresponding PC LAN is used as network. The clients are "to look" for the server specified in their projects automatically, which means they can be added at a later time without having an impact on the system.

If the server computer is not used as operator station, it should be possible to run it as Windows service. This means no user has to be logged in (on the computer) and interactions are not necessary. This also means that the server computer can be used in an existing IT landscape.

The server may be used as operator station for up to four clients; if there are more clients needed, the server is used only for server functions. It should be possible to configure 18 (even redundant) servers and 32 clients. The platform for the central computer server is either Windows 2008 Server SP2 32-bit® or Windows 2008 Server R2 SP1 64-bit®. All configuration and process data are centrally stored in the project directory on a drive (usually on the server) so that access and changes are possible from all stations (online configuration). On the client should also be stored local pictures and it should be possible to process local actions to speed up picture selection and reduce the load on the server. It should be possible to activate changed project states during operation without having to interrupt the process mode.

2.1.1.2 Option: Redundancy

The Redundancy option is to permit operation of two central computers at the same time. Data integrity is to be ensured by automatic archive synchronization. Any operator actions are to be synchronized online. This ensures, for example, that if a message is acknowledged or commented in a redundant system, this is also synchronized on the partner.

The redundancy concept is also intended to protect process control and operation because the clients automatically switch over to the active server when the other server fails. This way, all clients remain available for monitoring and operation of the processes.

If one of the two stations fails, the other station takes over archiving of messages and process data. This ensures complete data integrity. When the failed partner returns, all process values and messages that occurred during the time of the failure are to be synchronized automatically with the partner server. Two identical servers are once again available this way.
The synchronization of the archives for the time period of the failure is to take place in the background without an impact on the ongoing application and will be signaled by a system message after successful synchronization.

If errors occur in additional applications running on the redundant servers, redundancy witchover is to be enabled automatically. The redundancy option is to provide "hot standby" functionality.

2.1.1.3 Option: Central Process Historian

All long-term related process values and messages are saved efficiently and securely by a central Process Historian. All connected servers and clients can access the archives by means of a transparent access. As an expansion, the central Process Historian can also be designed redundantly. This increases the availability. Process values and messages of several SCADA systems can be combined in one central Process Historian. (see section 3.6. Central archiving)

2.1.1.4 Option: Web-based Access

The option Web-based access is to provide the possibility of performing process operations and observations via the Web (Intranet/Internet), without requiring changes to the configuration. This results in the same display, operation and access possibilities for the process screens and archives as with the operator stations on-site:

- Operator control & monitoring, analysis and diagnostics via the Web.
- Dynamic depiction of the process by means of Visual Basic and ANSI-C scripts.
- Multilingual through switching of the language while in runtime.
- Individual assignment of and access rights to the screens and start screen for different Web users.
- Different authorization levels define unique access rights.
- High degree of security through separation of the server-local project and the Web project.
- High-performance change-driven transfer of the data – Internet HMI callback.
- Additional security mechanisms such as routers, firewalls, proxy servers, SSL encryption and VPN technology.
- It should be possible to operate mobile on-site HMI devices as Web clients (e.g., rugged on-site devices or mobile panels as affordable alternative to PCs on all commercial operating systems such as Windows® 7, 2008, XP Professional, support of Microsoft® Terminal Services).

For safety reasons, the applications are to be visualized on the Intranet/Internet using an integrated Web browser of the application, as an alternative, the use of Microsoft Internet Explorer is to be supported. The access software can be installed on any number of computers. Only for the duration of the active access does a client need to be licensed on the server. This method grants a large number of users access to the process, with only the accesses taking place simultaneously requiring a licensing.
Likewise, a licensing on the client should enable the access to the process, even if the number of permitted connections has already been exhausted.

2.1.1.5 Option: Web-based Analysis

It should also be possible to perform an analysis of the process data via the Web. The analysis is to be implemented directly in the Web browser:

- Depiction of the messages in tabular form.
- Filter options for the individual parameters of a message.
- Specification of the time period (absolute and relative).
- Graphical depiction of the process values in trend curves.
- Tabular depiction of the process values.
- Export of the process values or messages into file.
- Direct connection of MS Excel® to the system (online analysis).
- Creation of reports with MS Excel® (analysis of archive data).
- Automatic mailing to an email recipient.
- etc.

The option Web-based analysis is an important component for the target-oriented process optimization through the transparent depiction of the data from the SCADA system.
The Web-based analysis is to serve for the

- Display
- Analysis
- Evaluation
- Distribution

of current process statuses as well as historical data and messages from the process database. Furthermore, it is to provide the process data to all function levels of a company via the Web. Powerful tools for the depictions and analysis of current process statuses and historical data (measurement values, messages, application data) from the process database should make it possible to efficiently monitor and analyze the production as well as to create reports and to distribute them to the affected persons. The analysis options are to be expandable with Microsoft Excel® for additional analyses.
For the display, the setup a client on any office PC should be possible. As data provider, a server or client computer integrated into the process is used. The option should also include the display of process screens, but without operating possibilities (access protection).

2.1.1.6 Option: Database connections across systems

The option for database connections across systems is to use standard interfaces to connect the automation level (controls) with the IT world and ensure the flow of information in both directions. Examples for such interfaces are the OPC for automation and SQL database interfaces in the IT world. Systems from different manufacturers are to be integrated by a variety of standard interfaces. Configuration work (without programming) should be cost-efficient and use standard software. The procedure is documented based on an example. Process visualization is usually connected by means of an OPC DA or OPX XML server interface with an external database. It should also be possible to access the archived messages and process values in the visualization database by means of an OLE DB provider. Data exchange at runtime can be activated as application or as system service. The communication connections can be controlled embedded in the SCADA client, with the Web client controlled by user operation or run as separate application.

2.1.1.7 Option: Diagnostics of Plant Objects

The option diagnostics of plant objects is to enable the system-integrated central diagnostics of all system components for visualizing the maintenance information of the entire automation technology. Starting from the field level/machine to the bus systems and protocols, field modules, PLC all the way to the PC level, all components can be centrally diagnosed. In doing so, the data is automatically adopted from the hardware configuration. A manufacturer-spanning and uniform display of maintenance and diagnostics data is made possible. All diagnostics events are to be logged, likewise all operator actions by the maintenance personnel – thus assuring the traceability of the events and operator actions. They are also the basis for later analyses to optimize the plant.
While in operation, the plant management depicts all connected control components (PLC, operator devices), switching devices, drives, networks (e.g., PROFIBUS, PROFINET), etc. and monitors the current plant status with uniform symbolism. In doing so, the program not only responds after an error has occurred (i.e., corrective maintenance), but also to warnings generated by the components that are to prevent errors before they happen (preventive maintenance). Such condition-based measures have to be scheduled so that the available resources are optimally utilized.
The diagnostics system is to enable a connection to existing systems such as SAP. Likewise, maintenance order management systems are to be connectible. It should be possible to initiate maintenance orders in these systems directly from the diagnostics system.
An optional notification via SMS, e-mail, pager, etc. should be possible.
Here, if necessary, a listing that can be shortened depending on the offering.

The diagnostics system is to be seamlessly integrated into the existing operating structure – no separate tool is to be used – to avoid increased training.
The diagnostics system is to be executable together with the process control system on one computer, but also on a separate computer. A diagnostics via the Web is to be possible as well (display of the maintenance and diagnostics information/screens via the Web including operation).

The diagnostics views (including messages, diagnostics/device/maintenance information, navigation) are to be generated automatically by means of the existing configuration to avoid a new, additional and complex configuration.

The diagnostics views are to be integrated into the existing process control and also be usable on a separate diagnostics station.

The overall system is to offer uniform, integrated diagnostics, even when dealing with multiple subordinated systems and processes of various kinds (e.g., process industry and manufacturing industry).

Information from the diagnostics system can be transmitted to and exchanged with other systems through the same interfaces as those of the basic system (example: all devices “undergoing maintenance”, all devices with maintenance request “highest priority”, all operator actions in the context of the diagnostics, etc.).

In addition, it should be possible to include mechanical, wearing components and component assemblies in the diagnostics, e.g., motors, pumps, gears, etc.

A diagnostics via the Web (Intranet/Internet) is mandatory.

2.1.1.8 Option: Maintenance Management

In the control system, a module containing maintenance functions is to be fully integrated – thus supporting the plant operator in the inspection, service and maintenance of the plant.
By combining calendar intervals with operating hour meters and switching cycle counters, optimal maintenance dates/maintenance intervals are to be determined. In addition, an order is to be activatable directly through process signals.

For the maintenance reports, it has to be possible to define maintenance objects (e.g., pump, slider) that are linked to an input/output signal. Maintenance orders are assigned to these maintenance objects, whose interval counters count depending on the

- Runtime
- Calendar time
- Number of switching cycles

The performing of maintenance is acknowledged by the user and stored in the system.
The intervals for the actual and total times are to be correctable (necessary, e.g., when replacing pumps).

The following overviews are to be retrievable on the screen by the user:

- Status of all service jobs
- Recommended maintenance dates
- Maintenance announcement dates
- Maintenance schedule dates
- Dates for today, tomorrow, last/next month/week
- Percentage availability or exceeding of the interval

The following must be implemented:

- Management of all maintenance data and associated documents
- Maintenance through combination of performance measurement with calendar and event control
- Automatic (one-time/cyclical) or manual maintenance activation
- Overview with maintenance jobs as table and as object structure
- Manual damage recording and repair jobs
- Job management and disposition
- Job feedback with configurable feedback and weak spot codes
- Post-processing of job feedback
- Long-term archive with filter and export function
- Master data management, can be imported and exported for creation and change, for example, with EXCEL
- Automatic or manual logging of all maintenance data
- Integration of maintenance data in industry-specific reports
- Free display of maintenance data possible in process pictures

2.1.1.9 Option: Machine Status Monitoring

The system is to offer the possibility of recording the machine status and of depicting the course of the status changes in graphical and tabular form. By means of formulas, specific metrics such as availability are to be determined and depicted in the process control system. Common standard values such as MTBF are to be stored as predefined formulas. Different values are to be comparable with each other and displayable in graphical form, e.g., as bar chart. Immediate analyses are to be possible on the basis of archived values.

2.1.1.10 Option: Message Forwarding

This module automatically forwards messages and alarms from the subordinated automation systems to pagers. Thanks to the modular design, country- or application-specific paging services, other process connections as well as the shift management can be easily integrated.

In the Web-based module, pages can be directly initiated from the user interface and changed at any time. The following paging services are supported:

- SMS via GSM modem with acknowledgment capability.
- Voice dialog by telephone.
- E-mail sending.
- Output of message on the display of HiPath®/Hicom® telephones.
- Output of message via paging systems.

The previously-defined service units (e.g., mechanics, electricians, etc.) will be assigned to individuals in the so-called phone book. Shift management is to be used to define the time at which persons in the respective service unit are to receive the messages. Using an alternate path strategy ensures that the message will be sent successfully even if some persons cannot be reached by then forwarding it to other persons, if necessary.

2.1.1.11 Option: Telecontrol technology

The system is to be capable of directly connecting to telecontrol substations, i.e., without a PLC as interface. This means that the central computer operates as telecontrol center with regard to the data connection. Via modem connection (e.g., analog modem, ISDN, DSL, GPRS, UMTS), current process values as well as messages from the substations are processed by the control system. Control commands and setpoint values are entered by the operator in the control system and transmitted to the substations for further processing. Messages and measurement values archived in the control system must be transferred exactly in time, i.e., with timestamp, to the control system, and be chronologically entered there into the archive (preprocessing of the process data in the telecontrol substations).
The status information of the substations is to be displayed in the control system by means of standard screens. The operator must be notified directly at the graphics objects (e.g., actual value fields) about faulty substations.
Analog values can be converted via a linear raw value adaptation from the raw value into the physical value and vice versa. Counter values receive an overflow treatment and can be processed with regard to their interval quantities. They are likewise transferred to the control system exactly in time and processed.
The transmission paths to the stations are to be designed redundantly. Should one connection path fail, the alternate path is to be automatically used.

2.2 Uniform, window-oriented User Interface

By means of individually configured user interfaces, the process events are to be transparently controlled and optimized with the control system. Functions are to be available that ensure an efficient and reliable process operation.
The design of the user interface is to offer a flexible and task-appropriate depiction of the process dialog. For a better overview, a split – for example – into overview, work and button areas can be performed. This ergonomic and process-oriented arrangement of the process screen as well as the structuring of the process screens in a hierarchy are to be automatically created by wizards. Already configured screens can be placed object-oriented with the mouse at the intended location in the hierarchy tree.
All area and detail screens are to be directly selectable via globally valid keyboard shortcuts.
It should be possible to embed other applications into the user interface of the control system to enable a seamless operation (by configuring corresponding OLE containers). Furthermore, it has to be possible to access OCX/ActiveX and .NET objects. With that, the functionality of other programs is to be homogeneously integrated into the user interface of the control system.

An overlapping stop is to protect against the overlapping by other screens, i.e., screens are displayed or hidden depending on their size or the configured screen layer (decluttering). This ensures that an operator immediately sees important feedback from the process – e.g., via output fields or message displays – and can respond to it without delay.
In runtime, process screens can be enlarged with the mouse (zooming) and screen sections be moved with the mouse wheel (panning).

The control system is to utilize the following input media familiar from the Windows world:

- Keyboard
- Mouse
- Touchscreen or on-screen keyboard
- Support of two finger multitouch gestures
- Support of two-hand operation

If the standard pointer is positioned over operable objects, it is to change its appearance (I/O field: mouse pointer plus cursor; object operable by mouse: mouse pointer plus arrow). The extra object is freely adjustable.

The control system is to record tag operations.
Recorded are:

- Date of the event
- Time of the event
- Name of the logged on user
- Name of the object/parameter that was operated
- Old value prior to the change
- New value after the change

Operations in critical process situations are thus traceable and reproducible. The display and operating functions are to be supplemented by project-specifically formulated actions. In critical situations, the control system can thus accurately guide the operator in the elimination of the problem and prevent downtimes (automated operator guidance).
The handling of an alarm automatically leads into the screen with the malfunction.

2.3 Option of continuous online configuration

We assume that a comprehensive configuration system is integrated in the system which the user can use to adapt the scope of functions and functionality to the changed requirements without programming knowledge. The system is to provide the option to make these parameter assignments in runtime. This means in practice that the respective editor can run in a second window during operation and that the project engineer can make changes to the application without having to exit process operation and without having an impact on background activities. It should also be possible to make configuration changes on a operator station.

2.4 Object-oriented Data Model

The objects that are physically present in the plant are to appear as such in the system, a pump with various parameters, for example, as a structured tag with several parameters. A major advantage of object orientation is that the real world (the technological process) can be mapped relatively closely to the IT world. All signals and values that are part of a unit (pump, slider, etc.) are combined and processed together in form of structured tags.

2.5 User Administration

Each operation of the process, the archives and the control system is to be lockable against unauthorized access, which includes making changes to setpoint values, the selection of screens or the calling of the configuration software from the process operation.
There are different access levels that enable the setup of a hierarchical access protection as well as exclusive authorizations for individual users.
Password and user name determine the access rights of an operator. They can also be newly defined during the process operation. For this, a convenient user administration is to be provided.
It is to be possible to centrally manage the user administration of all computers that are part of the system. In doing so, the system integrates itself into the user administration and security system of Windows. It does not matter whether the Windows security system is implemented on the basis of work groups or via a domain (e.g., corporate network).
In the case of a connection failure to the central user administration, it must be ensured by means of an “emergency operator” that the process operation remains possible, albeit with restrictions.
An automatic logging off after a predefined time is also possible, as is the locking of the access following multiple incorrect password entries. Changes to the access assignment can be performed online – plant-wide and across applications.
The operator identification can optionally be carried out via a smart card.
This mechanism must be integrated into the central user administration.

2.6 Openness and Integration Capability

2.6.1 Open Interfaces for Standard Software

The integration of standard Windows applications such as MS® Excel, MS® Word or MS® Access is to be possible via the standard mechanisms OLE/ActiveX and OLE-DB/SQL. Any application program (e.g., custom data management, analysis, process optimization) is to work together with the control system via the integrated C programming interface, and then be able to use control system data as well as control system functions.

To enable a manufacturer-spanning communication, the control system is to be OPC-capable. Through it, current process data is to be made available to other computers and applications, and also be read from them. Thus, any computer connected to the network is to have access to all data of the control system.
A standard database (e.g., Microsoft SQL Server 2008®) is employed to store (transaction-safe) all list-oriented configuration data such as tag lists and message texts, but also current process data such as messages, measurement values and application data records. The database is accessed via the open programming interface C-API or OLE-DB.
The system is to support the programming language Visual Basic for Applications (VBA) to flexible meet the functional requirements – particularly during the engineering phase.

2.6.2 Open Interfaces for Application Software

It is crucial for the control system to offer options for the homogeneous integration of other applications and application blocks into the user interface for the process operation. It should be possible to integrate application windows as well as OLE Custom Controls (32-bit OCX objects) or ActiveX Controls into the control system application – as if they were objects belonging to the control system.
To make graphics objects dynamic, the use of the scripting languages ANSI-C and Visual Basic should be possible.

2.7 System Behavior during Malfunctions

After a malfunction has been cleared (e.g., restart of a PC), the startup is to automatically proceed in such a way so that the operation of the overall system resumes without requiring operator intervention. In doing so, the process image on the operator stations is to be updated; gaps in the data acquisition are to be marked.

2.8 Efficient Configuration

The configuration user interface of the control system is to include wizards, editors and tools that enable an efficient configuration.
It should be possible to manage and modify all texts (graphics objects, messages, etc.) from a central location. By exporting the texts into Microsoft Excel, they can be translated for multilingual projects independent of the system.
When employing SIMATIC PLCs, it should be possible for the symbolic tag designations created there to be directly assumed by the control system. This reduces the configuration work and the susceptibility to errors.
For the mass configuration of the configuration data, the option of influencing the entire database via Microsoft Excel is to be available. In this way, e.g., tags can be created/changed, messages be generated and archives be configured in a very short time.
To test the configuration even without a process connection, a tool is to be provided, with which process values can be simulated. The tool should be able to simulate different curve shapes (sinus, square, random, fixed value, ramp).
In the graphics system itself, frequently used parameterization steps are to be automated by wizards. A variety of wizards for influencing the configuration is to be supplied:

- System functions (e.g., for assigning system functions to buttons).
- Standard dynamics (authorizations, set/reset bits, move objects, fill objects with color, etc.)
- Assignment of screen navigation functions to individual objects.

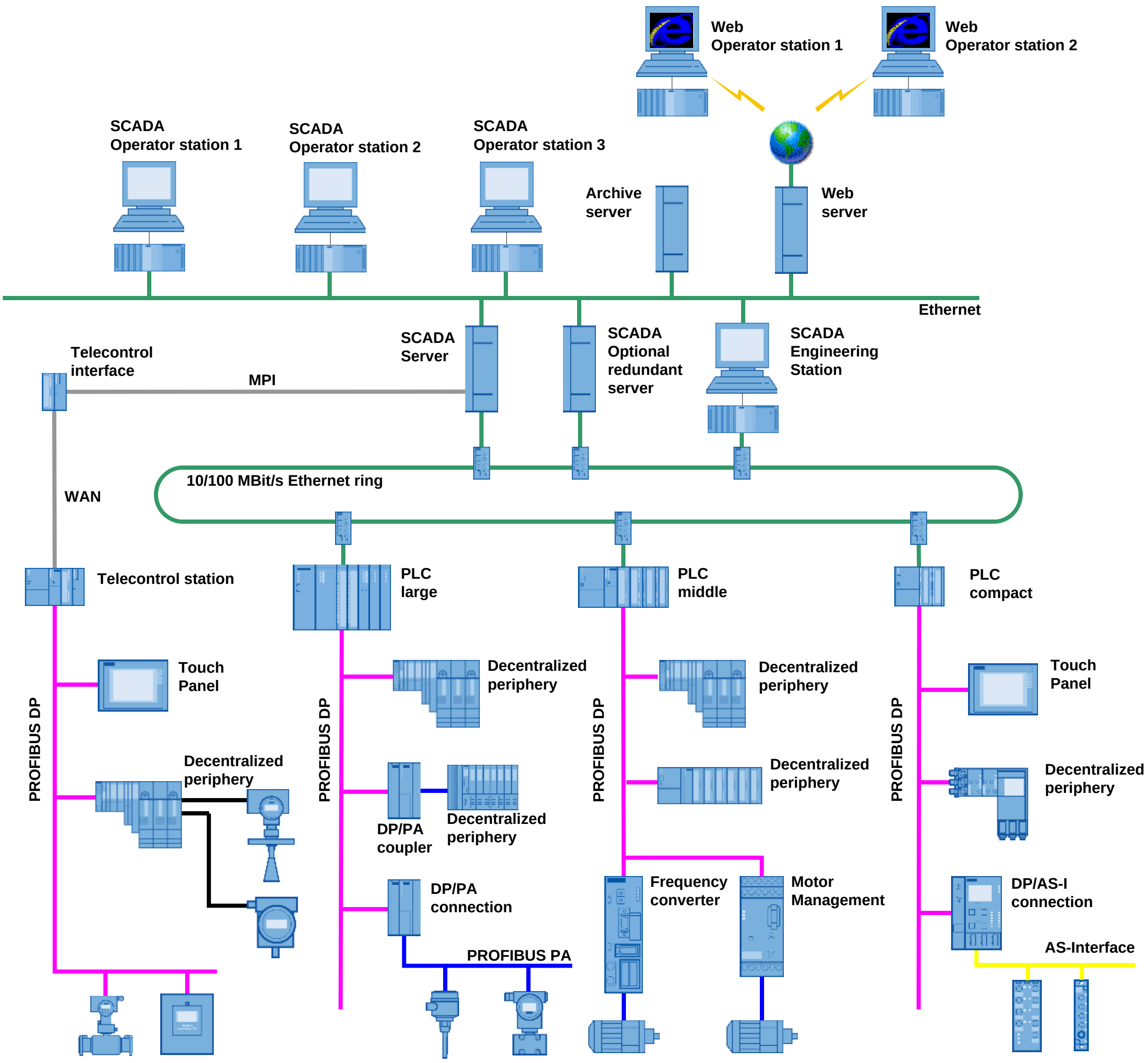
Furthermore, it should be possible to create own wizards to make the user-defined configuration more effective.

3 System and Plant Concept

3.1 Plant Configuration

The plant configuration required is depicted in the “Process Control System Configurator”. The acquisition, processing and data management of the process data are to be carried out on a central computer (server). For the functions operator control and monitoring, multiple operator terminals with one monitor each shall be provided in the control room.
It should be possible to carry out all of the functionality on any operator terminal.
A LAN (Ethernet, IEEE 802.3) shall be provided.

3.1.1 Configuration Process Control System



3.2 Central Computer (Server) / Single-User Computer

The server primarily has the following tasks:

- Communication with the automation devices.
- Real-time data processing.
- Management of the databases (the databases contain the entire parameterization of the system as well as the long-term archive).
- Backup/archiving and reimport of data to storage.
- Editing place functions.
- Time synchronization of all network-connected computers by means of a central time service (DCF77 or GPS).

The server is to meet the requirements of the process operation (time response, multitasking, failure safety). A PC with state-of-the-art technology is to be offered (main memory, hard drive capacity). The selection of the PC is to be carried out in such a way so that expansions of the main memory and the hard drive double the required values. The computing performance is to be measured so that during normal operation, the utilization is no greater than 60%. The server computer is to be designed for continuous operation (24/7).

3.3 Operator Terminals (Clients)

These computers are primarily intended for tasks such as:

- Selection and display of process screens.
- Process operation.
- Operation of all information functions and reports.

Each operator terminal consists of a visualization computer with a high-resolution graphics display. The screen diagonal has to be at least 19” with a resolution of at least 1280 x 1024 pixels. Furthermore, the use of monitors in 16:9 format (1920 x 1080 pixels) and 16:10 format (1680 x 1050, 1920 x 1200, 2560 x 1600 pixels) is to be supported. For large screen projections, a minimum resolution of 10,000 x 10,000 pixels is to be possible.

Selected process pictures are to be constantly updated regardless of the screen on which they are displayed. The system should offer the option to arrange individual process pictures independent of each other on the screen. It should be possible to hide the shared background picture. The individual process pictures are thus arranged as independent picturewindows in the monitor or on the large screen projection. Each monitor includes a keyboard and a mouse. The keyboard is mainly used for manual input of measured values and parameters. Process operation (triggering commands, input of setpoints, picture selection, message acknowledgment, etc.) takes place mainly via mouse operation. It should be possible to expand the operator station by at least three additional monitors. It must be possible to operate the displayed process pictures of the connected monitors independent of each other, which means picture selections on the first monitor only refer to this monitor and are independent of the picture selection on the other monitors. The various views (pictures) can be assigned to freely selected monitors. It should be possible to save the created view/assignment of process pictures and connected monitors and open it again at any time.

3.4 Printers

The printers in the control room or at the local operator terminals are generally used for the operational management and the proof of events. One of the printers should be a color printer; with it, hardcopy outputs of the color graphics screens are to be possible.
The second printer logs process and archive data such as current actual values, alarms or measurement values.

3.5 Local Network (LAN)

The connection of the PLC level to the central computer takes place via a local network. The connection of all computers belonging to the control system among one another is to be performed in accordance with IEEE 802.3 (Ethernet). Here, TCP/IP protocols are to be used as standard.
Optionally, simple PROFIBUS/PROFINET connections are to be possible.

3.6 Central Archiving

By means of a central server, all process values and messages are stored safely and with good performance. All connected servers and clients can access the archives at any time via a transparent access. As an expansion, this central archive can also be set up redundantly – thus increasing the availability.

4 Software Components of the Control System

4.1 Operating System

Throughout the local network (control system), the use of the following operating systems is stipulated:

- Central computer (server): Windows Server 2008 SP2 32-bit®
  Windows Server 2008 R2 SP1 64-bit®
- Operator terminal (client): Windows XP Professional SP3
  Windows 7 SP1 32/64-bit (Business /Enterprise / Ultimate)

4.2 Database System

A database system, for example, SQL Server 2008 R2 SP1´(32-bit) is to be used for keeping archives and managing the plant parameters. In addition to the required range of services for the databases, the option for changes to or creation of new applications by the customer must be taken into consideration in the offered licenses. The selected database system as well as the tools required by the customer as part of the database application must be included in the offer.

4.3 Graphics System

The graphics system of the control system is to process all inputs and outputs on the screen during the process operation. The screens for the visualization and operation of a plant consist of simple as well as complex graphics objects. During the configuration phase, they are integrated into the screens with the aid of the graphics editor, which is part of the control system.

For designing and operating an attractive user interface, a number of objects are to be available:

- Static objects
  - Line, connector (line element)
  - Polygon, polyline
  - Circle, circular segment, circular arc
  - Ellipse, elliptical segment, elliptical arc
  - Rectangle
  - Rounded rectangle
  - Static text

- Ready-made objects

    - Table window, trend curve window, message window, report window and screen window
    - OLE objects
    - OCX (ActiveX) objects (OLE Controls), .NET Controls
    - Input/output field
    - 2D and 3D bars
    - Graphics objects (BMP, WMF, EMF, GIF, JPG, DIB, ICO, PNG)
    - Status displays
    - Text lists, multiline text (with scrollbar)
    - Combo boxes, list boxes
    - Group displays

- Windows objects

    - Buttons (rectangular, round, symbolic, with text)
    - Checkboxes
    - Pull-down menus
    - Slider object

- Pipe objects

    - Polygon pipe
    - Tee pipe, double-tee pipe
    - Elbow pipe

The appearance of all graphics parts should be dynamically controllable. Parameters on geometry, color, pattern, etc. can be directly addressed and specified via tag values or from programs.
Thus, for example, a line is to be colored red, green or blue, a circle is to change its size or a group object is to move on the screen. Status displays can be controlled by means of alternately displaying and hiding individual, superimposed graphics objects.
In this way, the process, the processing in the control system, actions or also standard Windows applications can actively influence the display.

Examples of properties that are to be dynamically changeable:

- Object color and pattern
- Background color and pattern
- Line color, width, type, beginning, end
- Font
- Write direction horizontal, vertical
- National language of label texts (by operation)
- X and Y coordinates in pixels
- Display of objects (visible/invisible)
- Circle radius
- Start angle, end angle
- Edge radius
- User authorization (by operation)
- Lower limit, upper limit of bars
- Hysteresis behavior of bars
- Scaling and scale graduation for trend curves (by operation)
- Filling of any polygon (also with patterns)

The control system should also offer the possibility of using already existing graphics or photographic material for the design of the screen. Graphics files with the format BMP, WMF, EMF, GIF, JPG or other can be imported via OLE. Furthermore, it should be possible to directly integrate AVI and animated GIF files.
With the graphics system, user-defined menus can be created – just like the ones familiar from Windows applications. This menu structure can then either be displayed in all or selected process screens. By means of individual VB scripts, the desired functions are stored at the individual menu items. Thus, screen jumps as well as any action can be realized.
Another possibility for the menu navigation is provided by ready-made navigation bars with integrated process control functionality. These can be parameterized via user-friendly editors. The process operation control/navigation made possible with this is described in the chapter "Process Operation Control and Process Visualization".

4.3.1 Global Design Templates

By means of global design templates, the process visualization can be given a uniform "look & feel". The graphics system supplies a wide range of different templates, which can be used or adapted. Through innovative 3D effects and Windows effects, the visualization can be adapted. Each object can be provided with shadows and the "hover effect" can be selected, which changes the depiction of the object as long as the mouse pointer is over the object.
Changes made to the global templates have an effect on all process screens used. For example, by using and centrally modifying the global color palette, a subsequent adaptation is possible at any time without much effort.
It is to be possible to export the global templates from the projects and to import them.
The system is to offer a type/instance concept for graphical objects, i.e. the user can configure an object, with further changes being made centrally at the type and propagated to all instances.

4.4 Processing of Basic Data

4.4.1 Message Processing

The message system processes the results of functions that monitor the events occurring in the process, the automation level and the system. It depicts acquired message events optically and acoustically and archives them electronically and on paper. Direct access to the messages and a sorting in ascending and descending order, as well as supplemental information on the individual messages, ensure a swift error localization and correction. A hitlist is to provide the operator with easy access to the most frequently occurring messages. Furthermore, it should be possible to display the duration of the individual messages, i.e., the length of time from the occurrence until the clearing and/or acknowledgment.
The message structure should be freely definable and thus match the special requirements of the plant. A message consists of message blocks that can also include tag values. For each individual message, it should be possible to implement

- a minimum of 10 tag connections
- a minimum of 10 user-defined texts

Each message of a project is to lie in a sorted storage comprised of 18 message classes with 16 message types each. A priority is to be assignable to the individual messages to ensure that in the case of multiple simultaneously occurring messages, the message with the highest priority is displayed first. Seventeen message priorities (0–16) shall be provided.
A total of at least 150,000 different messages should be configurable. If there is a large number of messages, it is important to be able to hide messages. This decreases an information overload for the operator of the plant. Messages can be hidden automatically depending on the process status or manually by the operator. It should be possible at any time to display all hidden messages.
All incoming messages are saved by the system, whether they are hidden or visible.
During the commissioning or when expanding or servicing the plant, it should be possible for messages from presently unused modules to be specifically locked by the user while the operation is ongoing. If a message event of a locked message occurs, no display and no archiving of the event take place. It should be possible to list the locked messages in runtime and, if necessary, to unlock them.
Through the described option of the message forwarding, the function scope of the message system is to be fundamentally expandable. This should ensure a faster response time in the case of a malfunction.
If a message event occurs, the operator is to be informed about this independent of the selected process screen, and have the option of directly switching to the affected process screen.
If messages are triggered directly by the controller and noted with a timestamp there, they can be integrated into the message system at any time, even retroactively. There, the messages are archived in chronological order and displayed.

The control system is to generate messages from:

- Bit tags,
  which the data manager manages in the Tag Management. They can be process tags or internal tags. Thus, actions can process any monitoring function and trigger messages from the control system with the action “Write tag”.

- Analog tags
  With the aid of the limit value monitoring, any number of limit values should be definable for a tag. If one of these limit values is violated, a message is generated.

- System monitoring
  - Group messages
  - Process and archive operations

- Arriving message telegrams
  - from the process
  - from the automation
  - from an action

The message system is to consist of a revolving archive, where always the latest entries are deleted. The archive can be exported into a long-term archive by shift, day, week or month. The archive size is to be limited only be the available hard drive space. The system is to automatically notify the operator, if the space on the hard drive is too small.
A continuous load of 10 messages/second (with a central message archiving on a separate server at least 100 messages/second) should be processable. A message surge of at least 2000 messages in 10 seconds every 5 minutes should be possible without a message loss.

4.4.2 Measurement Value Processing

The SCADA system archives measurement values from the automation system. Recorded measurement values are to be processable with definable actions before being saved. The data is to be stored in segments and made available for a specific time period in a kind of revolving buffer. The size or time period of the individual segments and of all segments is to be configurable as needed.
The archived data is to be supplied to the process visualization during this freely definable time period of all segments. Simultaneously, a backup mechanism is to be activatable, which allows individual segments of the archive to be stored in a separate storage location. There, the data remains available even after the revolving time, and can be viewed at any time from the visualization.
The recording of the measurement values is to occur cyclically or event-driven via the Tag Management. With that, process values as well as values from internal tags, values from any application and manual inputs can be recorded. The processing should yield average values, sum values, minimum values, maximum values and also be freely formulable in an action.
The storing secures the processing results in the measurement value archive on a hard drive medium. The recording cycle is to be freely definable within a range.
The archiving cycle should be as large as the recording cycle, or be a multiple of it. Average values, sum values, minimum values and maximum values are calculated from the recorded values between two storing times. Measurement values recorded are to be immediately written to the hard drive – so that no data loss can occur (instantaneous values). If an error occurs during the measurement value recording, either the last value or a configurable replacement value can be stored.
To reduce the data quantity in the archive database, the archive tags of a specific time period can be compressed. For this, a compression archive is generated, where each archive tag is stored in a compression tag. The archive tags are preserved and can still be copied, moved or deleted. The compression archive – just like the process value archive – is stored in the archive database. The compression is achieved by applying mathematical functions. For this, one of the following functions is applied to the archived process values of an indicated time period:

- Maximum value: Stores the largest process value in the compression tag.
- Minimum value: Stores the smallest process value in the compression tag.
- Average value: Stores the average value of the process values in the compression tag.
- Weighted average value: Stores the weighted average value of the process values in the compression tag. The time period during which a recorded value has the same value is considered in the calculation of the weighted average value.
- Sum: Stores the sum of the process values in the compression tag.

For a fast recording of values, they also are to be kept as revolving buffer in the main memory (online trend curves).
The control system is to offer different methods for the archiving of measurement values. It archives measurement values cyclically or event-driven, individually or in blocks.

The following methods are to be distinguished:

- Cyclic-continuous archiving.
- Cyclic-selective archiving.
- Acyclic archiving.
- Archiving only upon a change.

The control system is to offer options for chronologically archiving and displaying process values that are archived by the controller with a timestamp and arrive in blocks in the control system.

4.4.3 Commands/Setpoint Values

Switching operations or the issuing of commands are to be performed by the system user via plant screens (process screens) or other operating masks intended for that. The execution of a command (bit command or setpoint value) is – when configured accordingly – expected by the control system in the form of a feedback and monitored. The setpoint values configured in the system must be assigned as physical values via an operating mask. The unauthorized issuing of commands and setpoint values is password-protected by the control system. Locked (deactivated) commands and setpoint values are not issued.

4.5 Process Operation Control and Process Visualization

This component enables the user to monitor the process, intervene in the process, and define or change system and process parameters; for this, the fully graphical display units with keyboard and mouse are available.
The operator control and monitoring of the process primarily take place by employing

- Process screens
- Process information
- Trend curve screens
- Message analysis system

4.5.1 Process Screens

To make it easier for the user to operate the control system, the process screens are to be organized in the form of a hierarchically structured operating tree:

- Plant overview
- Area overview
- Plant section screen
- Detailed object information

The graphics editor of the control system is to offer functions that are customary in powerful Windows graphics programs. Functions for the precise positioning, alignment, rotation, mirroring and passing on of graphical object properties are to be included. Likewise functions for grouping, block generation and the import or embedding of externally edited texts, graphics and videos (BMP, WMF, EMF, GIF [also animated], AVI and JPG formats or via OLE).
Its ability to have multiple pictures (screens) open at the same time allows for a fast copying between different pictures. For this, the clipboard or – to make it easier – drag & drop can be used. Working with the block library and configuring a status display with up to 32 different statuses take place analogous.
With grouped objects, the graphics editor is to permit a direct changing of the properties of the individual objects, without having to break up the grouping beforehand. Likewise, the properties of multiple selected objects are to be changeable simultaneously (e.g., the line color).
The user interface of the graphics editor is to be customizable. The size and position of the individual palettes for colors, zooming, alignment functions, object types and styles are variable; if needed, individual palettes not required can simply be hidden. Frequently used functions are to be available as icons on the toolbar.

The graphics editor is to contain the following:

- Exact coordinate display.
- Dimension display.
- Pixel-precise positioning of objects using cursor and tab keys.

Most objects are to have clear configuration dialogs, which enable the parameterization of the essential properties of an object in a dialog box. This dialog box is to be automatically displayed as soon as the respective object is placed in the screen.
In addition, the graphics editor should provide options to practically manipulate all properties of an object and to also make them dynamic. Dynamic properties are highlighted in bold in the properties box for clear visibility.
The graphics editor should offer multiple options that build on one another for making object properties dynamic. In the simplest case, such properties are connected directly to internal tags of process tags. A dynamic dialog allows simple value conversions to be performed or value ranges for color changes to be defined.
Flexible dynamics are to be possible through the direct integration of scripts – either C scripts in ANSI-C standard or Visual Basic Scripts.

Via a direct connection, control system objects are to be able to influence the properties of other objects, e.g., the position of a slider influencing the rotational angle of a gauge pointer.
A dynamic wizard is to make complex dynamic functions easily accessible to the configuration staff.
The graphics editor is to support a configuration of 32 screen layers. In complex screens with many superimposed objects, individual layers can be hidden to make the depiction clearer.
Common Microsoft aids – such as tooltips for the online project – are of course integrated into the control system and can be configured in a few steps. This configuration as well is to have a multilingual definition.

Once an object has been created, it is to be stored in a library, from where it can be retrieved. This enables company-, technology- or industry-specific standards to be established that contribute to a fast project creation. The control system features a block library – which is subdivided into a global and a project-specific library, and a function library – which is employed in the configuration of actions.
The global library contains ready-made objects sorted by subject, which are part of the control system's delivery scope (valves, motors, conductors, gauges, etc.). This library can be industry-specifically expanded at any time. The project-specific library is intended for the individual project. The objects can be configured in multiple languages.
Each graphical object, independent of its complexity, is stored in the block library. They can be pure graphics or the objects can have specific processing routines or even process connections. By means of standardizations, even larger projects can be quickly carried out.
The blocks in the library can be listed by name. Alternatively, they can also be depicted as icon for the quicker and easier identification of the individual objects. The integration of such an object into a process screen is then easily possible via drag & drop.
New objects can be added to the library just as easily.

Among others, the global library is to contain the following object classes:

- Shut-off fittings and gate valves
- Displays and gauges
- Control panels, buttons and switches
- ISA and E symbols based on DIN 30600, ISO 7000
- Conveyors, motors
- Conductors, valves and tanks
- Scales
- Etc.

The user object enables a configuration in block technology. In doing so, any graphical objects can be grouped into a new object, and relevant interface parameters for the process connection be defined. The names used by the configuration staff can be stored multilingual, e.g., "Upper limit" for English and "Obergrenze" for German. Via drag & drop, the user object is to be stored in the library and then be integrated in the control system screens. Only the user-specifically defined parameters are connected to process tags. The global library contains a series of such user objects (e.g., gauges) and, if required, can be expanded during the configuration at any time.
The benefit of HMI systems (Human Machine Interface) lies in the central operator control and monitoring of the processes. For this, screens are drawn that provide a view inside the plant. Typically, there is more than one process object of the same type, e.g., motors, pumps, regulators and valves. The control system is to show how costs for configuring the graphical depiction of these process objects can be minimized. It enables the standardization of the operation and depiction of such objects via the faceplate method. The control system is to offer a highly efficient mode of configuration: Functions that are required again and again are to be defined only once; in doing so, each function call can work with its own data.

In a usual control system screen, it should be possible to integrate screen windows that provide a window area for other control system screens. For example, one and the same screen is to be displayed multiple times as daughter screen in a mother screen. In runtime, each daughter screen is a referenced copy of a configured screen. Each runtime copy works with separate data. The configuration is to take place centrally so that changes are immediately effective in all calls of daughter screens from all relevant mother screens. Thus, the main objective is the central changeability of screen sections that are needed again and again – making it unnecessary for changes to be performed at many places.
Each runtime copy designated as instance of a screen type works with a separate, structured data record. The control system is to permit the use of such data records, which are based on freely definable data structures with derived tags.
The configuration of a faceplate instance initially corresponds to the configuration of a regular control system screen, which is typically smaller than the display area. In the course of the configuration, the graphical layout and the internal processing routines are defined. In doing so, the elements of a structure are referenced in the dynamics.
The creation of faceplate instances of a finished faceplate type means to place screen windows in a mother screen and to call the faceplate type from there. The faceplate is the linked with a structure instance and thus has the connection to the corresponding data.
For the depiction of the objects (e.g., pumps, sliders, motors) and the object statues (e.g., on/off, remote/local) in the process screens, the contractor has to create symbol sets comprised of standardized symbols; the symbols are to be used throughout all process screens. The system also has to allow the customer to modify the existing symbols as well as create new ones. Changes made to the symbol set must be automatically transferred by the system to all process screens. Detailed information belonging to an object depicted in the process screen can be visualized if needed. For this, an additional window with the corresponding object data is displayed after clicking on the object in the selected screen.

For existing process screens, the tag connections of all objects selected are to be changeable at once in a separate editor. It is possible to connect them to the new tag by directly entering a new name or by using “Find and Replace”. As a result, duplicated process screens can be quickly and easily supplied with the proper tags.

The graphics editor is to offer a powerful concept for employing centrally defined faceplates. A faceplate is a standardized screen object, which can be centrally stored as a project-wide type. These types can be integrated into the process screens as an instance. The use of such faceplates reduces the configuration work, since a faceplate can be utilized in multiple screens. Since the changes are performed centrally, they apply to all instances of the faceplate. The faceplates can be furnished with changeable properties from the visualization, which can be directly made dynamic when using the faceplates.

Contents and structure of all plant screens are to be coordinated together with the customer in the context of preparing the requirement specification.

4.5.2 Trend Curve Screens

Archived values (instantaneous values or compressed values) can be depicted in trend curves and tables – on the screen and in reports. Colors and patterns, for example, indicate limit value violations, replacement values, faults and time leaps.
The trend curve window is to offer a toolbar for trend curve operations.

By means of this toolbar, the following operations are to be possible:

- Call of the help
- Call of the configuration
- Jump to the first data record
- Jump to the previous data record
- Jump to the next data record
- Jump to the last data record
- Enlarge section
- Reduce section
- Select size of section with the mouse
- Enlarge/reduce time axis
- Enlarge/reduce value axis
- Move trend curve area
- Move axis area
- Return to original view
- Select data connection
- Select trend curve
- Select time period
- Previous/next trend curve
- Stop/start update
- Print display
- Export data as CSV
- Turn reading ruler on/off
- Select statistics area
- Calculate statistics
- Connect/disconnect backup

A tooltip help is to explain the meaning of the individual icons. If desired, custom-designed buttons can be configured and supplied with corresponding operating functions. For authorized operators, it should also be possible to change the parameterization while in runtime, e.g., apply different colors to trend curves or rearrange groups.
The access to the archives is supported by a targeted, direct selection of measurement location groups, measurement locations and individual measurement values. The selection can occur by name or time window. The values of a display section can be focused on in detail with the reading ruler and the zoom functions. In doing so, the scaling of the time and value axes is to be adapted accordingly and the trend curve values be interpolated for the depiction. For a trend curve window, a common or also a separate axis per trend curve with different value range is to be configurable. For the data analysis of any time period, two reading rulers are to be available. By selecting the reading ruler, another window can be displayed, in which the individual values including timestamp at the ruler position are shown.

To aid in the analysis, the individual trend curves are to be freely moveable along the time and value axes.
Limit value violations are to be marked by a configurable color change when output in the trend curve window.
From the trend curve depiction, it should be possible to perform statistical analyses. These refer to a freely selectable time period, which can be defined via two rulers. The following calculations are to be possible for the individual trend curves:

- Minimum
- Maximum
- Average value
- Standard deviation

Furthermore, the number of measurement points and the time period selected are to be displayed.
Through the configurable direction of the trend curve depiction, a horizontal and vertical “write direction” of the trend curves can be set – making possible a recorder function. Compared to the normal trend curve depiction, the recorder function swaps the x- and y-axes. As time axis, the y-axis is used. With the recorder function, it can also be defined whether the current time is plotted at the top or bottom border of the trend curve window.
If multiple trend curves are depicted simultaneously, the control system is to offer the option of staggering the trend curves. Through this setting, the trend curves to be depicted in a trend curve window are shown on top of each other. For each trend curve, the value range of the y-axis to be depicted can be defined.
Directly from the trend curve window – via a button on the menu bar – it should be possible to export the currently selected trend curve data or all trend curve data contained in the archive. The trend curve data is transferred into a CSV file and can be further processed in Microsoft Excel.
In a trend curve window, current values as well as already archived values are to be displayed. Thus, for example, the trend curve from a previous day can be displayed as reference. Process values can be depicted scaled in the trend curve window. When selecting a trend curve, the y-axis can be reduced to the appropriate scaled. Furthermore, individual trend curves can be selected via a configured button or a selection box.

4.5.3 Message Logging / Analysis / Acknowledgment

The message list can be displayed via line-oriented message windows. Statuses of messages should be distinguishable by color at any time. Freely definable selection filters specifically direct the view of the message display to individual process or plant sections. Any number of selections can be conveniently saved – to be available again at any time. In a client/server system, the selections are to be centrally managed by the server.
Ascending and descending sorting of alarms provide for a fast and efficient fault analysis. Different combination options exist. For example, all messages already cleared can be automatically removed from the display, if they no longer meet the applicable selection criterion. In a process screen of the SCADA system, multiple different message windows can be used.

In the message window, the following different depictions are possible:

4.5.3.1 Dynamic Message Window (Process Message Window)

This view only contains the arrived, presently still pending and not yet acknowledged messages. Messages that have already been cleared can be configured for automatic removal from the view.

4.5.3.2 Message Window with Archive View

In this mode, all messages recorded in the short-term or long-term archive up to that time are displayed – including the already cleared ones. If necessary, newly arriving messages can be displayed in an additional message window.

4.5.3.3 Message Window with Hitlist

This display lists the messages sorted by frequency of their occurrence.
In addition, graphics objects should also be able to display message events by changing their appearance. The message can be acknowledged by operating the graphics object.
Message reports continuously document the sequence of messages (message sequence report) or specific views in the archive (message archive report). The printout takes place by page in the case of completely filled pages, or – in the case of a message sequence report assigned exclusively to a line-oriented printer – by line at the arrival of a message.
Via open programming interfaces, the messages can be picked up and, for example, acoustically signaled through a sound card.
Any number of analysis actions can utilize this basis. If a message occurs, an application can aim a video camera at the location of the cause and display the situation on the screen.

The operator is to be able to browse through the messages displayed in the message window by line or by page, forward and backward, and also jump to the beginning or end of the list (short-term/long-term archive).
The messages visible on the screen can be acknowledged individually (single acknowledgment) or completely (group acknowledgment). With a group acknowledgment, all currently visible messages in the message window, or alternatively also all acknowledgment-requiring messages, are acknowledged. The message system can also forward acknowledgments to the automation systems so that they can respond to them.
If desired, individual messages, message classes and message types can be hidden from the acquisition and later resumed (locking and enabling of messages). For example, if a defect in the process control causes a message to permanently occur, the operator can lock the appearance and enable it again after the elimination of the defect.
For each message and each occurrence of a message, the operator can enter a text (message comment) in the message archive, which is stored with the message and can be retrieved at a later time. The person responsible for the next shift can thus be informed – in an electronic way – about the events of the last shift.
Message information can be stored with the messages also in the configuration. This information aids the operator with more detailed instructions every time the message occurs. The message “Motor 25 faulty” could thus also contain information on correcting the fault.
Through integrated jump functions, the system – by clicking on a message – should enable the jump directly into the process screen where the object triggering the message can be found, or enable the execution of a stored action – so that the operator can specifically respond to the cause of the fault (Loop-in-Alarm). The object is to be automatically marked.

4.6 Report System

The control system is to offer an integrated report system, with which the data can be put on paper. In selectable layouts, it prints data acquired during the process operation via

- Message sequence reports
- Message archive reports
- Archive reports
- Operating reports
- System message reports
- User reports
- Hardcopies

as well as configuration data (backup documentation, completely or partially). Prior to the direct output on the printer, the reports can also be stored as a file and be previewed on the screen. Via a corresponding operation, the status of all jobs is to be displayed in runtime.
In the configuration, print jobs are to be specified with the layout, the extent (number of pages) and the printer. It is also possible to set cyclic hourly, daily and monthly reports.
It should likewise be possible to start the report output time-/event-driven or via a direct operation. A separate printer can be assigned to each print job. If that printer fails, a definable replacement printer takes its place (at least three printers should be definable).
The message sequence report is to immediately output arriving messages on an exclusively assigned line printer (line-by-line printing).
The trend curve reports should be dynamically adjustable (e.g. the time period).
Screen views set online and also filters of trend curve and message data can be printed out at any time.

The layout of the report areas is to be composed of static and dynamic objects – as available in the graphics system, i.e., table objects, trend curves and entire screens (in the form of a dynamically generated metafile) can also be integrated into a report. Hardcopies with variable screen coordinates and section sizes can likewise be integrated.
In addition to the process data present in the control system, external data should be integrable, e.g., via ODBC objects or in CSV format.

4.7 Archiving System

The archiving distinguishes between two archive types:

4.7.1 Short-term Archive (Recorder Data)

The short-term archive is used to archive data points acquired by the real-time data processing as quickly as possible. The data stored is primarily used to obtain time curves of measurement values (recorder data).

4.7.2 Long-term Archive

Long-term archiving is the cyclic archiving via the parameterization of selected process data in a database and its further compression in specified time intervals as well as the automatic deletion of archive data after the reaching of a specified age. The data stored in the long-term archive (database) is available for the analysis by the system.

4.8 Requirement Specification

For the control system, it is necessary to prepare a hardware and software requirement specification. The contractor is responsible for the creation of the requirement specification. In the context of the requirement specification, all the details concerning the task definition and the special requirements are clarified and the solution approach is comprehensively described.
If necessary, the requirement specification – in the context of the technical clarification phase – is to be revised in accordance with the requirements and submitted again to the customer.

4.8.1 Scope and Contents of the Requirement Specification

The scope of the requirement specification essentially includes:

- Configuration (hardware and software)
- Function description
- Information lists of the signals processed
- Plant screens

4.9 Screen Creation

For the creation of screens, the following procedure is assumed:

- Screen concept utilizing the dynamic industry library elements (on paper or on monitor)
- Coordination with the customer
- Incorporation of desired corrections
- Coordination with the customer again
- Incorporation of possible required further corrections
- Completion of the screen creation

An exception to this will be the first plant screen.
In this screen, basic attributes such as the screen arrangement, number and position of message lines, colors, symbols need to be clarified with the customer. It is therefore assumed that the screen will be changed several times.

4.10 Documentation

The documentation is to be designed so that the structure and function of the system are clearly and easily identifiable – ensuring an optimum maintenance and repair as well as an easy expansion.

4.10.1 Scope of the Documentation:

- Hardware documentation
- Standard software and system software documentation
- Documentation of the data points (tags)
- User guide
- Backup documentation of the system parameterization
- Hardcopies of the plant screens
- Screen hierarchy (structure of the screen navigation)
- Group display
- Program listings of the plant-specifically created application software

All above-mentioned documents are to be clearly put together and organized in DIN A4 folders (two copies), and presented to the customer for inspection no later than at the conclusion of the trial operation. In addition, a copy of the software system on CD/DVD is part of the delivery scope.

5 Industry-specific Modules for the Expansion of the Control System

5.1 Industry-compliant Archiving and Logging

5.1.1 Basic System Requirements and Properties

The software-based archiving and logging are to meet the industry-compliant requirements (e.g., in accordance with DWA/GFA H260, ATV M260, ATV A128, Hirthhammer Log, TA Waste, TA Air) with regard to time- and event-dependent process data (measurement values, counter values, laboratory values/manually input values, calculated values, faults and messages).

The software is to offer a TCP/IP-based client/server architecture. For very small applications, it is necessary that all software modules (data acquisition, data server, analysis modules) also run on a standard PC. The database is to be designed maintenance-free. The data server stores the process data from the various data sources and continuously compresses it into interval, daily, weekly, monthly and yearly data using different algorithms. The database server continuously calculates the configured operands and also compresses them into interval, daily, weekly, monthly and yearly data. It runs cyclically in the background so that the clients can be supplied immediately with current data. The database server can be set up redundantly.

The software is multi-client-capable and the data storage is document-quality throughout.
The software is to be completely provided with context-sensitive help. All functions are accessible via the menu bar or by clicking the right mouse button.

5.1.2 Data Types

The following basic data types are to be directly supported:

- 32-bit integer
- 16-bit integer
- 1-bit integer
- Floating-point with 14 significant digits
- Floating-point with 7 significant digits
- Alphanumeric with 64 characters
- Alphanumeric with 16 characters

5.1.3 Measurement Value and Counter Value Processing

The acquisition occurs cyclically (≥1 s) or by delta-event method. In three value ranges, a delta value can be independently defined, at which a recording takes place. A validity range can be defined for each value.
The data is to be compressed into interval values, with at least two adjustable intervals (1, 5, 10, 15, 30 min; 1, 2, 4, 8, 12, 24 h) as daily, weekly (1 or 2 weeks), monthly and yearly values.

For the compression into an interval value, the following functions should be selectable:

- Difference to the previous value
- Counter difference with and without overflow
- Consumption from container capacity or scale
- Operating hours from status bits
- Integral
- Weighted sum

For the other compression levels, the following functions should be selectable:

- Arithmetic average value
- Logarithmic average value
- Weighted average value
- Last value / first value
- Sum
- Median
- Standard deviation

For the respective compression levels, the following analyses are to be provided automatically:

- Number of the upper and lower limit value violations
- Average value (5–95 %)
- Percentile value (5–100 %)
- Standard deviation
- Standard deviation from a sample (population-1)
- Minimum and maximum with timestamp

Normally, the overflow of the counter values is to take place at the “natural” limits (e.g., with a unsigned 16-bit value, the counter overflows at 65535). For individual values, the overflow has to be freely adjustable.

The automatically acquired measurement values are to be checked for plausibility, upper/lower limit value violation, measurement location failure and faulty communication to the PLC. Corresponding identifiers have to be stored with the measurement value. In the event of a measurement location failure or faulty communication to the PLC, the specification of a replacement value has to be possible.
In telecontrol configurations, the values in the automation system provided with a timestamp have to be likewise read into the control system and be placed chronologically correct in the archive. This data is then available as well for further analyses.

Recorded values can be manually corrected by users with appropriate password authorization. A corrected value is to be marked accordingly in the reports.

5.1.4 Laboratory Values / Manually input Values

Manually input values do not come online from the PLC, but are manually input, e.g., after being determined in the laboratory. The chronological assignment of these manually input laboratory values is performed by the user. The input of the values has to be convenient. The following options should be available to the user for the input of laboratory values:

- Input via table
- Input via various input masks
- Manual laboratory value import of a file

For laboratory values that are automatically written by a laboratory system into a CSV file, an automatic laboratory value import has to be available.
In principle, manual values can be input for any valid time.
Via the user administration, manual values can be assigned to individual operators for the input.
The retroactive acquisition can be limited in time for each operator.

5.1.5 Derived Data (Calculated Values)

Derived data – so-called calculated values – shall be provided by the system. The quantity may not be limited. The calculation is to take place in the background as soon as a referenced value changes. The compression into interval, daily, weekly, monthly and yearly values is to be performed analogously in the background. By means of calculated value formulas, arithmetic and logic operations for measurement values, laboratory values, calculated values, constants and system status messages can be created.

The following functions must be implemented:

- Basic arithmetic operations (addition, subtraction, division, multiplication)
- Logical functions (AND, OR, NOT)
- Arithmetic functions (power, root, sine, cosine, tangent, absolute value, percentile, exponential value, natural and common logarithm)
- Special functions (conditional calculation IF ... THEN, polleni, cosineφ)
- Comparison (<,>,=, ≤, ≥, ≠)
- Constants (Euler's number, Pi, configurable constants)
- Bracketing

A calculated value can be manually corrected. A corrected value is to be marked accordingly in the reports.

5.1.6 Trend Curve Screens

The industry-compliant, archived data – such as measurement values, counter values, laboratory values and calculated values – is displayed on the screen in the form of historical trend curves (load curves).
Any number of trend curves can be assigned to a trend curve screen.

The following functions are needed to facilitate working with trend curve screens:

- Online arrangement of trend curves.
- For each trend curve, a different depiction type (step, marker, line, bar) is to be selectable.
- Individual symbol depiction with different markers (circle, triangle, square, hexagon, cross, X) for normal values, replacement values and “changed values”.
  The size of the markers is changeable.
- Zoom function by making a rectangle with the mouse.
- The start and end times of the trend curve screen can be changed with the mouse and an input mask.
- Moving of trend curves in the x-direction (time offset).
- Trend curves can be freely assigned to a specific value axis.
- A standardized depiction is to be possible (all measurement values are assigned to a joint 0–100% axis and also depicted with it).
- Various depiction forms of graphs are to be possible:
  Time diagrams, frequency diagrams, cumulative frequency diagrams, probability grid in accordance with Dr. Groche, x/y diagrams, overlap diagrams, maximum analyses (e.g., power peaks).
- The different separation of the vertical axis (y-axis) is to be possible:
  In the trend curve screen, each trend curve can be different; it can be linear, logarithmic, Gaussian (percentage scaling according to the Gaussian normal distribution) and digital (for values unequal to zero, the line is drawn; for values equal to zero, the line is interrupted; digital values can thus be depicted especially compact).
- For each trend curve, the upper and lower limit values can be displayed.
- For each trend curve, the value, sum, maximum, minimum, number of upper/lower limit value violations and standard deviation can be depicted. Each trend curve is to be depicted at least five times in the same trend curve screen.
- For each trend curve, the relative and absolute time offsets can be individually adjusted.

- Alarms and messages as well as alarm groups and message groups are to be depicted as trend curve. For the time range depicted, the statistical analyses quantity and duration are to be displayable.

- For the easy analysis of events (e.g., accumulation in the rainwater overflow basin), a convenient selection of an individual event or of multiple events is to be provided. For a specific week, month or year, or a freely definable time period, the events that have occurred are displayed grouped (e.g., by rainwater overflow basin) and can be selected.

- Printout of the current trend curve screen at the push of a button.

For the depiction, e.g., in the process control system, an ActiveX object with the above described functions for the depiction of archived data in trend curve screens is to be provided.

5.1.7 Reports, Logs, Analyses and Balances

The form of the reports and logs must comply with the instructions ATV-DVWK-M 260 “Acquisition, depiction, analysis and documentation of operating data from wastewater treatment plants with the aid of the real-time data processing”.

This is ensured also without the use of additional software such as MS Excel. The list of required reports can be found in the function catalog.

As a general rule, the following applies:

Any number of differently set up daily reports has to be configurable (e.g., abbreviated and long versions). The same applies to weekly, monthly and yearly reports.

The printout, display, archiving on hard drive or sending by e-mail of all reports is initiated manually via the user interface by selecting the desired time period. All reports can also be automatically printed out, displayed, archived or sent by e-mail for a definable time period (e.g., going back one day or month).

5.1.8 Archive Data Storage on external Backup Medium

The data backup program operates parameter-controlled.
It is therefore possible to initiate a data backup without dialogs from another program. A dialog window regularly prompts the operator to backup the data (operator-controlled backup). When performing a data backup, its extent can be selected. All configuration data and measurement data can be backed up. A restoring of the data is to be possible analogous to the backup.

5.1.9 Multi-Client Capability

The software must be able to manage clients.
For each client, a separate configuration can be assigned. With that, multiple plant sections can be managed from one workstation. Each client has access to the full functionality of the software.

5.1.10 Cross-Plant selective Data Management

The plant-wide selective data management enables the setup of a central data storage. With this function, specific data from individual applications can be combined in a central application to, e.g., obtain performance comparisons of individual sections. Via TCP/IP connections (e.g., ISDN, LAN), the data from different plants can be ported into a central application. This function has to be executable automatically or manually. It has to be possible to port selected data types into the central application (e.g., raw data, compressed values, hourly values, daily values).

5.1.11 Event Reports

Occurrences that are not cyclic (e.g., rainwater overflow) are depicted in event reports.
Statistical analyses are possible in daily, weekly, monthly and yearly reports.

An event report is the analysis of data that is not formed over a fixed time period (such as a calendar day), but over a time period determined by external events. An event in turn can consist of multiple partial steps.
By means of the recorded process data, the start and end conditions for such event reports can be searched for and – based on that – analyses be performed.
A report form is assigned to each event.
The analysis of the events consists of a single line, multiple lines or four parts: the start, the end, a data block and a statistic over the time period between the start and the end.
All defined events can be manually corrected and supplemented.

A report page is custom-designed and can result in the output of multiple, physical individual pages.

5.1.12 Alarm and Message Processing

Faults and messages can be displayed in separate windows and be printed out.
It should be possible to interactively define up to 300 alarm windows and simultaneously open up to 8 different alarm windows in the online mode.

For each alarm window,

- the table size, column number and column width can be set.
- a distinction can be made between faults and messages.
- the time period for the depiction can be freely selected.
- the filter criteria can be specified, and thus individual alarms be specifically searched for.
- the online mode can be activated so that new alarms are automatically displayed.

5 window types are available:

- For messages only.
- For faults only.
- For messages and faults.
- Fault statistics with quantity, overall duration, average duration, maximum duration and minimum duration as well as the graphical display of the duration.
- Message statistics with information on the message quantity.

For the depiction, e.g., in the process control system, an ActiveX object with the above described functions for the depiction of archived messages and faults is to be provided.

5.1.13 Maintenance Management

The industry-compliant requirements made on a maintenance monitoring system are to be met. An object to be monitored (unit, drive, machine, motor, structure, etc.) is to be assigned multiple different maintenance jobs. In particular, the following requirements are to be met:

- Monitoring of the operating times, runtimes and switching cycles.
- Calculation of the runtimes and switching cycles from binary feedback or counter values (second, minute, hour).
- Clear depiction in groups and subgroups.
- Filters that limit the number of maintenance jobs in the dialog.
- Storing of maintenance documents (routing slips, safety guidelines, repair instructions) per maintenance and unit.
- Maintenance instructions and list of materials per maintenance.
- Display and printout of the status reports.
- Display and printout of the history reports per unit.
- Logging of unit repairs; does not reset the interval.
- Performing of maintenance with interval reset and input of notes, duration, costs.
- Deactivation of individual maintenance jobs.
- Colored highlighting of the maintenance statuses of the groups and units.
- A minimum of five dependent partial maintenance jobs can be assigned to a primary maintenance job.
- The automatic printout, display, archiving on hard drive or sending by e-mail of all maintenance documents (status reports, unit histories, maintenance instructions, list of material) should be easily configurable.
- By means of OPC, the process control system or other applications are to be supplied with information on the maintenance status of each unit.

5.1.14 ODBC Interface

For the access to the stored data, the industry-compliant software is to provide an ODBC interface, which gives other applications access to the data. The application must employ SQL (Structured Query Language) as the standard language for the data access. Applications offering an ODBC interface – such as MS Excel – can access the data (process/interval/daily/weekly/monthly/yearly data, messages, faults, maintenance data and event header data) in read mode.

5.1.15 DDE/OPC Server

For the depiction of the industry-compliant, stored measurement and maintenance data, e.g., in the process control system, a DDE/OPC server is to be provided. This interface can be used by all DDE-/OPC-capable systems.
Process, interval, daily, weekly, monthly and yearly data is available as current value and value from the previous period.
The exceeding of the maintenance interval, the reaching (in percent) of the maintenance interval for switching cycles, the runtime, the operating time and the last maintenance time are to be available.

6 Quantity Structure and Performance

The basic requirements below represent the minimum requirements for the design/expandability of the system technology.

6.1 Minimum Requirements

6.1.1 Archiving of Process Data

- The system is to support up to 80 tags in the cycle and 5000 values per second for archiving on the server (with process connection).
- The system is to support 120 tags from up to 11 servers on a central archive server without process connection.

6.1.2 Logs

• Number of logs	Unlimited
• Available time periods of the values	Current time period, previous time period and two time periods ago

6.1.3 Trend Curves

• Number of trend curves per trend screen	Unlimited
• Number of measurement values on hard drive	Only limited by hardware (size of the storage medium)

6.1.4 Message System

• Number of message per archive	Only limited by hardware (size of the storage medium)
• Number of configurable messages	150,000
• Number of archivable messages per 1 s (continuous load)	10
• Message surge without loss (not continuous load)	2000 in 10 s
• Number of process tags per message line	10

6.1.5 Reports (no ATV reports)

• Number of simultaneously running message sequence reports	1
• Number of message archive reports (simultaneous)	3
• Number of user reports	Only limited by hardware (size of the storage medium)
• Number of report lines per body	66
• Number of tags per report	300

6.1.6 Multi-User System

• Number of clients for server with operator terminal	>3
• Number of clients for server without operator terminal	>30
• Number of Web clients	>100

6.2 Trademarks mentioned

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