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Z10 13 07 29902 006

Safety-Related Programmable System

800xA Safety

Manufacturer:

ABB AB Control Technologies

PAPR/XAA

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721 59 Västerås, Sweden

Report No.: AV 84798C

Revision 1.1 dated 2013-08-16

Testing Body:

TÜV SÜD Rail GmbH

Generic Safety Systems

Certification Body:

TÜV SÜD Product Service GmbH

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Revision Log

Version	Name	Date	Changes/History
1.0	P. Weiß	2013-08-12	Initial version based on report AO63111C, version 2.3 dated 2010-02-18
1.1	P. Weiß	2013-08-16	Formal changes



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1 Target of Evaluation (ToE)

In 2011 the company ABB AB Control Technologies assigned TÜV SÜD Rail GmbH for testing and certifying of the safety-related programmable system 800xA Safety according to Category 4 PL e according to ISO 13849-1 and SIL 3 according to IEC 61508 series and IEC 62061.

This report summarizes the user related results of the tests and inspections performed on the relevant parts of the system 800xA Safety, based on the certification requirements outlined under clause 3.1 and reported by the documentation listed under clause 2.5.

1.1 Definition of Terms

The following terms are used in this report with a meaning defined as follows:

CBM	Control Builder M is the certified engineering tool for the AC 800M controller
Common cause failure	Failure, which is the result of one or more events, causing coincident failures of two or more separate channels in a multiple channel system, leading to system failure
Controller	Refers to the standard AC 800M process controller
Controller configuration	HW configuration or setup of a controller, including configuration of I/O, communication, access variables, resources/tasks (cycle-time, priority, etc) in addition to the I/O connection.
Demand response time	Time from a demand to a sub-system and until the correct state on this sub-system output, is achieved.
Diversity	Different means of performing a required function.
Failure	The termination of the ability of a functional unit to perform a required function.
Fault	Abnormal condition that may cause a reduction in, or loss of, the capability of a functional unit to perform a required function.
Fault avoidance	Use of techniques and procedures, which aim to avoid the introduction of faults during any phase of the safety lifecycle of the safety-related system.
Fault detection and reaction time	Time from occurrence of a fault and until it is found and reported as an output of this sub-system.



Fault tolerance	Ability of a functional unit to continue to perform a required function in the presence of faults or errors (NOTE: Assuming safety functions, not process availability issues).
Hot replacement	Replacement of HW that may be done with power connected to the unit.
On-line replacement	Replacement of HW/SW part that does not affect the process in control.
Process safety time	The maximum time a process is allowed to run with a faulty safety critical output.
PM	Processor Module as specified in the related annexes
Random hardware failure	Failure, occurring at a random time, which results from one or more of the possible degradation mechanisms in the hardware.
Redundancy	Existence of means, in addition to the means which would be sufficient for a functional unit to perform a required function or for data to represent information.
Safety Controller	Specifies the AC 800M HI, comprising the Processor Module with safety firmware and the Safety Module, as one unit (I/O sub-system excl.).
Safety I/O	Certified I/O module for safety related field instruments.
SM	Safety module as specified in the related annexes
Safety system	Safety system specifies the Safety controller and the I/O sub-system.
Sub-system	Part of a system (e.g. component as I/O module, I/O system or SW "package").
800xA Safety	Comprehensive safety and process automation system, which consist of safety critical and non-interference products/modules. This includes for example the AC 800M High Integrity controller, S800 High Integrity I/O, Control Builder M engineering environment and the 800xA Operator Workplace.
1oo1D	One channel hardware architecture, with external diagnostic
1oo2D	Two channel hardware architecture, with mutual diagnostic



Safety critical input signals are read from the process with the safety-related I/O modules or read from other AC 800M High Integrity systems via safety-related application communication.

Safety critical output signals are sent from the AC 800M High Integrity controller to the safety-related I/O or to other AC 800M High Integrity systems via safety-related application communication. The safety-related I/O is responsible for the safety-related output to the process.

2.1.1 Processor Module and Safety Module

2.1.1.1 Architecture 1oo1D for SIL 1-2, CAT 3, PL e

The "single-channel" process controller AC 800M is combined with a Safety Module in a 1oo1D architecture. Internal self-diagnostics have been realized in the Processor Module, PM, and in the Safety Module, SM. The program flow of the application execution and the I/O scanning in the PM is supervised by diagnostics running in the SM.

Additional fault monitoring of the safety controller is realized by the safety-related I/O, checking the CRC from the SM and the safety-related data from the PM.

2.1.1.2 Architecture 1oo2D for SIL 1-3, CAT 4, PL e

The 1oo2D architecture is realized with the PM and SM, whereas the application program is executed in parallel within both modules. Verification of the two results is implemented in the PM and independently in the I/O via comparison of the inverted CRC (from SM) and the related data (from PM).

All safety integrity measures roughly described in the chapter above for the 1oo1D architecture are additionally in place.

2.1.2 Control Builder M

The Control Builder M is enhanced with safety functions in order to support its use as an engineering environment for safety applications. Additional software packages are included in order to perform the necessary diagnostics and to support execution-environment for safety-related applications.

For the user, this includes e.g.:

- Standard library items classified in order to show their usability in safety application building
- Standard Safety libraries
- Possibility for SIL classification of user-defined libraries and applications

The Control Builder M is used as a configuration and programming environment of the safety-related applications.



2.1.3 AC 800M High Integrity I/O modules

The S800 High Integrity I/O modules are designed with a “hidden” 1oo2 structure with diverse execution and internal mutual supervision. Fault detection and control is implemented by the combination or comparison of the results calculated by the diverse hardware channels.

The modules can be located in central or decentralized DIN rail assemblies.

2.1.4 Safety configuration

Safety configuration is necessary for installation and modification of the safety-related programmable system AC 800M High Integrity using the Control Builder M tool.

2.2 Hardware Components under Certification

The safety-related system components belonging to this certification are listed in the current revision of the Annex A to this report. This allows the components to be used to process safety critical signals and functions.

For details on architectural, configuration and implementation requirements please refer to the user manuals and the Safety Manual for the safety-related programmable system AC 800M High Integrity.

2.3 Software Components under Certification

A list of the software components with the valid version numbers is shown in the current revision of the Annex A to this report.

2.4 Communication

A safety-related communication between the AC 800M High Integrity controller and the S800 High Integrity I/O modules has been realized, using the standard ModuleBus telegram with an included safety layer.

To exchange safety critical process signals and results calculated in 1131-applications, a peer-to-peer communication, including a safety layer, between AC 800M High Integrity systems could be configured and used. Safe peer-to-peer communication is realized by either using dedicated library modules (MMS) or Communication Variables (IAC).



2.5 Safety manual

The conditions and rules for safe use of the safety-related programmable system AC 800M High Integrity are laid down within the user documentation “AC 800M High Integrity – Safety Manual”, “AC 800M Controller Hardware”, “800xA Safety, Reliability and Availability Data”, “S800 I/O, Modules and Termination Units” and “S800 I/O, Getting started”.

In addition to the components documented in the Annex A their corresponding MTUs, ModuleBus and CEX-Bus inlets, outlets and termination units, cables etc. are listed in the relevant ABB user manuals, possible to connect to and to use in the safety system.

2.6 Redundancy

Redundancy for the safety-related programmable system AC 800M High Integrity increases availability without having influence onto the safety of the system. Techniques and measures are included to allow switching from a faulty module to the standby module within a time that allows carrying on the process in a safe manner without interruption.

The AC 800M High Integrity controller and the S800 High Integrity I/O modules need no redundancy to fulfil the requirements of the intended safety levels mentioned in chapter 4.1.

2.7 Availability

AC 800M High Integrity controller is certified up to SIL 3 in a single configuration which from CPU point of view contains one PM and one SM unit working in a functional pair. Redundancy of these units is not required for achieving or maintaining the safety integrity. Redundancy of AC 800M High Integrity can however be arranged by using two PM and two SM units in a quad(ruple) structure (i.e. four CPUs) to achieve better system availability. Redundancy increases system availability using the SIL 2 or SIL 3 system configuration. Adding redundancy does not affect safety integrity, it only increases availability. Details can be found in the document “800xA Safety, Reliability and Availability Data”.

Availability calculations are not in the scope of this certification and therefore are not regarded by TÜV SÜD Rail GmbH during the functional safety assessment.



3 Certification Requirements

3.1 Basis of Certification

The certification of the safety-related programmable system AC 800M High Integrity will be according to the regulations and standards listed in clause 3.3 to 3.6 of this document. This will certify the successful completion of the following test segments:

I. Functional safety

- Analysis of the system structure (FMEA system)
- Analysis of the hardware (FMEA component, quantitative analysis)
- Analysis of the software
- Fault simulations and software tests
- Test of the fault prevention measures
- Functional test

II. Electrical safety

III. Susceptibility to environmental errors

- Climate and temperature
- Mechanical effects

IV. Electromagnetic compatibility

V. Safety information in the product documentation (safety manual, operating instructions)

VI. Product-related Quality Management in manufacturing and product care.

Certification is dependent on successful completion of all above listed test segments. The testing follows the basic certification scheme for Safety Components of TÜV SÜD Rail GMBH.

3.2 Certification Documentation

Documentation of this certification is based on the following reports:

- Technical Report, No.: AV85029T (on system level)
- Modification Reports related to minor system modifications



- Technical Reports of new system components using a technical safety concept of already certified components
- AC 800M High Integrity – Safety Manual
- AC 800M High Integrity – Reliability and Availability

Additional information regarding installation and use of the AC 800M High Integrity controller and the S800 High Integrity I/O modules can be found in:

- S800 I/O, Modules and Termination Units
- S800 I/O, Getting Started
- AC 800M – Controller Hardware

Based on the specified purpose of use of the safety-related programmable system AC 800M High Integrity in safety critical process applications, the certification is based on the following set of standards. The issuance of the certificate states compliance with these references unless specifically noted otherwise.

Some of these standards have been updated during system development and modifications. Therefore component or module specific information about the compliance to the standards is given in the current revision of the Annex A.

3.3 Functional Safety

The testing for functional safety is performed using the following standards and guidelines:

IEC 61508-1: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 1: General requirements
IEC 61508-2: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 61508-3: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 3: Software requirements
IEC 61508-4: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 4: Definitions and abbreviations
IEC 61508-5: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 5: Examples of methods for the determination of safety integrity levels



IEC 61508-6: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3
IEC 61508-7: 2010	Functional Safety of electrical/electronic/programmable electronic safety-related systems Part 7: Overview of techniques and measures
IEC 62061: 2005	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
EN ISO 13849-1: 2008	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design
EN ISO 13849-2: 2012	Safety of machinery - Safety-related parts of control systems - Part 2: Validation
IEC 61511-1: 2003	Functional safety - Safety instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and software requirements
EN 61131-6: 2012	Programmable controllers – Part 6: Functional safety
UL 1998: 1998	Software in Programmable Components

3.4 Basic Safety and Environmental Safety

To complete and to specify the technical requirements resulting from the essential requirements of the directives listed above the testing of Basic Safety is covering the following standards:

EN 61131-2: 2007	Programmable controllers - equipment requirements and tests
EN 50178: 1997	Electronic equipment for use in power installations
UL 508: 1999	Industrial Control Equipment



3.5 Electromagnetic Compatibility

To complete and to specify the technical requirements resulting from the essential requirements of the directives listed above, the testing of Electromagnetic Compatibility is covering the following standards:

EN 61131-2: 2007	Programmable controllers – Part 2: Equipment requirements and tests
IEC 61000-6-2: 2005	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
IEC 61000-6-4: 2011	Generic standard - Emission for industrial environments
IEC 61326-3-1: 2008	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
IEC 61326-3-2: 2008	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specific electromagnetic environment



3.6 Application Standards

Because of the expected applications of the system following additional standards and regulations were considered:

Machinery Applications	
IEC 60204-1: 2005	Safety of machinery – Electrical equipment of machines
NFPA 79: 2012	Electrical Standard for Industrial Machinery
EN 1037: 2008	Safety of machinery - Prevention of unexpected start-up
EN ISO 13850: 2008	Safety of machinery - Emergency stop - Principles for design
Process Industry	
ISA S84.01: 1996	Application of safety instrumented system for the Process Industry
EN 54-2: 1997 EN 54-2 A1: 2007	Fire detection and fire alarm systems - Part 2: Control and indicating equipment
NFPA 72: 2012	National Fire Alarm and Signaling Code
Burner Systems	
EN 298: 2012	Automatic burner control systems for burners and appliances burning gaseous or liquid fuels
EN 50156-1: 2004	Electrical equipment for furnaces and ancillary equipment - Part 1: Requirements for application design and installation
NFPA 85: 2011	Boiler and Combustion Systems Hazard Code
FM 7605: 1999	Programmable Logic Control based Burner Management Systems



4 Results

4.1 Functional Safety

The tests performed and quality assurance measures implemented by the manufacturer have shown that the safety-related programmable system 800xA Safety in conjunction with its software comply with the testing criteria specified in clause 3 subject to the conditions defined in clause 5 and its subsections, and is suitable for safety-related use in applications in accordance with ISO13849-1:2008, CAT4 PL e and in accordance with IEC 61508: 2010, SIL 1-3, for intermittent or continuous operation, as well as for operation with or without continuous supervision, on condition that the "0 state" is defined as the safe state for the binary inputs and outputs.

4.1.1 Fault Reaction and Timing

Fault detection by built-in self-tests or diagnostics will either be fail-safe communicated to the safety controller or set the module itself into the safe state. In case of affected communication, faults in the communication channel are detected by the safety layer or via timeout supervision included in the I/O modules and in the safety controller.

If the faulty module is an input module, the process data and the error diagnostic will be reported to the controller. This will make it possible for the controller to set the values to the fail-safe state on application level. If the faulty module is an output module, all outputs or the faulty outputs are de-energized.

The fault tolerance period of the process controlled by the AC 800M High Integrity controller and the S800 High Integrity I/O modules shall be greater than the worst-case response time.

Additional information is given in the manuals.

4.1.2 Evaluation of fault prevention measures

For the avoidance of failures the following techniques and measures were used:

- Project management
- Documentation
- Structured specification
- Inspection of the specification
- Observance of the relevant guidelines and standards
- Structured design
- Modularization



- Used of well-tried components
- Inspection of the hardware
- Functional testing (also under environmental conditions)
- Operational and maintenance instructions
- User- and maintenance friendliness

The individual measures for the avoidance of failures provide the required degree of effectiveness and are specified in the relevant documents.

4.1.3 Analysis of the hardware safety integrity and hardware simulations (FIT)

The Failure Mode Effect and Diagnostic Analysis (FMEDA) showed that the occurrence of a single fault do not lead to loss of the safety functioning. The individual architectural constraints are sufficient and their corresponding degree of fault detection provide the required degree of effectiveness.

The response time to safety critical faults is application specific and shall therefore be evaluated.

4.1.4 Application Development

The safety-related programmable system AC 800M High Integrity can treat and execute programmed safety-related functions. An intended safety function of the AC 800M High Integrity system can be enforced either by application-programmed functions or by built in fault reaction functions. Responsibility of application programmed safety functions are within the scope of the application engineers.

Acceptance of programmed safety function requires its complete functional testing. After that, complete functional testing is only necessary for changed parts of the programmed safety function.

Loading and changing of safety-related programs in the AC 800M High Integrity system need authorisation by enabling a physical Access Enable input on the Safety Module.

4.1.5 Online loading of safety applications

In general, responsibility for monitoring the process during and after the on-line modification lies entirely within the organisation and person responsible for the on-line modification. Since on-line modifications are generally associated with an increased level of risk the approval of on-line modifications is at the discretion of the testing and inspection centre responsible for approval of the system's application.

The procedure for on-line modifications and existing restrictions are described in the Safety Manual.



Loading of safety program changes and changes of safety related constant parameters while the process is running in observed mode requires at least:

off-line verification and / or

simulation and / or

online testing and / or

similar IEC 61511 compliant verification activities within a well defined modification procedure of the changes prior to downloading them into the safety-related programmable system AC 800M High Integrity controlling the safety critical process.

4.2 Basic Safety and Electromagnetic Compatibility

4.2.1 Basic Safety

The tests of the electrical safety and the environmental stress tests executed by the notified test laboratories Det Norske Veritas and Delta shows that the standards specified in clause 3 are covered.

The tests performed and the quality assurance measures implemented by the manufacturer have shown that the AC 800M High Integrity modules comply with the testing criteria specified in clause 3 subject to the conditions defined in clause 5 and its subsections.

4.2.2 Electromagnetic Compatibility

The documentation of the electromagnetic compatibility tests executed by the notified test laboratories Det Norske Veritas and Delta have been reviewed for completeness. The testing executed has covered the requirements of the standards specified in clause 3.

4.3 Product Specific Quality Assurance and Control

All software and hardware components developed and manufactured in course of the safety evaluation are governed by an ISO 9001 certified quality assurance and control system.

As part of the certification process TÜV Product Service also performs a procedure that is tailored to the assessed product in order to assess the consistency of product quality while accounting for product modifications and their identifiability (follow-up service).



5 Implementation Conditions and Restrictions

The use of the AC 800M High Integrity system and the S800 High Integrity I/O modules shall comply with the current version of the Safety parts of the manuals:

- AC 800M High Integrity – Safety Manual
- AC 800M High Integrity – Reliability and Availability
- S800 I/O, Modules and Termination Units
- S800 I/O, Getting Started
- AC 800M, Controller Hardware

The relevant implementation and installation requirements have to be followed if the AC 800M High Integrity system is used in safety-related installations.

The recommendations and installation requirements, based on the experience and judgement of ABB AB Control Technologies and documented in the manuals, shall therefore be carefully followed. The information, recommendations, specifications and safety instructions given in the belonging manuals shall be read and understood.

5.1 General application conditions

- 5.1.1. Only modules certified for safety-related operation, as shown in the current revision of the Annex A to this report shall be used for safety-critical signals.
- 5.1.2. The fault tolerance period (process safety time) of the process controlled by the system shall be greater than the worst-case response time of the system.
- 5.1.3. A well-defined shutdown procedure shall be specified.
- 5.1.4. Operator alarms as exclusive means of shutdown are only permitted under supervised operation and if the fault tolerance time of the controlled process is sufficiently long to ensure a safe manual reaction and shutdown and the operator has sufficient independent means to supervise the process. Installations that must react to shutdown conditions quicker than achievable with manual intervention or installations running unsupervised shall incorporate an automatic fault reaction procedure.
- 5.1.5. The S800 High Integrity I/O shall be used in safety-related applications only in combination with the AC 800M High Integrity controller (including safety-related communication via CEX-bus and ModuleBus) and the Control Builder M.
- 5.1.6. The operating conditions as specified in the user manuals shall be met.
- 5.1.7. The timing requirements of the application standards must be approved for the safety-related peer-to-peer communication.
- 5.1.8. The components of the system versions belonging to the certificate Z10 08 10 29902 005 can be combined with the components of system versions related to



this certification report (as stated in the Annex A). As a result, the safety functions build up using these combined system versions shall be used in the certification scope of Z10 08 10 29902 005 only.

5.2 General commissioning conditions

- 5.2.1. Prior to commissioning, a complete functional test of all safety-relevant programmed application functions shall be performed.
- 5.2.2. All timing requirements shall be validated.
- 5.2.3. Any application software modification after commissioning shall result in a complete re-validation of the changed parts of the programmed safety function. The Difference Report identifies the changed part of the programmed safety function, and it shall be verified that this report complies with the intended changes.
- 5.2.4. The proper fail-safe configuration of all safety-critical fail-safe I/O shall be verified. Only configurations covered by the Safety Manual are covered by the certification.

5.3 General run-time conditions

- 5.3.1. Failed modules that are safety-related should be replaced as quickly as practical to minimize the probability of multiple fault accumulation and potential (safe) nuisance shutdown. As a maximum, failed modules should be replaced within the multiple fault occurrence time. The calculations of the Probability-of-Failure-on-Demand for AC 800M High Integrity controller and the S800 High Integrity I/O modules are documented in the AC 800M High Integrity Reliability and Availability.
- 5.3.2. Application program modification during run-time should only be permitted under end-user responsibility.
- 5.3.3. The procedure described in the user manuals has to be followed.
- 5.3.4. The application program modifications shall be limited and simple to verify and validate.
- 5.3.5. The modifications and their interaction with existing program sections shall be thoroughly tested, e.g. using simulation.
- 5.3.6. The modification shall be granted by the approval authority for the plant assessment.
- 5.3.7. Maintenance override is to be limited (time-restriction and number) of logical points according to the relevant application standards. The full responsibility of maintenance overrides lies with the user of the system. The TÜV guidelines for maintenance overrides are to be followed.



6 Certificate Number

This report specifies technical details and implementation conditions required for the application of the safety-related programmable system 800xA Safety by ABB AB Control Technologies on the certificates:

Z10 13 07 29902 006
M6A 13 07 29902 008

Munich, 2013-08-16

A handwritten signature in black ink, appearing to read 'J. Blum'.

J. Blum

Technical Certifier