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Automation, Software and Information Technology

**Assessment of the Point Guard I/O Safety Modules
1734-IB8S and 1734-OB8S
Rockwell Automation, USA**

**Report-No.: 968/EZ 342.00/09
Date: 2009-02-05**

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Test object: Point Guard I/O Safety Modules 1734-IB8S and 1734-OB8S

Customer/Manufacturer: Rockwell Automation
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Mayfield Heights, OH 44124
United States of America

Order-No./Date: 7000019534 dated 2008-10-10

Test Institute: TÜV Rheinland Industrie Service GmbH
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Inspectors: Dipl.-Ing. Matthias Haynl

Test location: see Test Institute

Test duration: December 2008 - February 2009

The test results are exclusively related to the test samples.

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1. Scope

The following report presents the results of the type approvals of the Point Guard I/O Safety Modules 1734-IB8S and 1734-OB8S for safety related applications.

The 1734-IB8S and 1734-OB8S have been subject to an assessment in accordance with IEC 61508 Safety Integrity Level 3 (SIL 3) and ISO13849-1 Performance Level e (PL e) and Category 4 (Cat 4).

This test report contains the essential safety engineering aspects, that were assessed during the inspection and identifies the various test steps, that were performed to provide evidence, that the test object complies with the safety-relevant requirements of the product specification and the relevant standards.

2. Applicable standards

- /N 1/ IEC 61508, parts 1 - 7:1998-2000**
Part 1-7: Functional safety of E/E/PES safety-related system
- /N 2/ ISO 13849-1:2006**
Safety of machinery - Safety related parts of control systems
Part1: General principles design
- /N 3/ EN 62061:2005**
Functional safety of safety-related electrical, electronic and programmable electronic control systems
- /N 4/ IEC 61131-2:2007**
Programmable controllers
Part2: Equipment requirements and tests
- /N 5/ EN 60204-1:2006**
Safety of machinery - Electrical equipment of machines
Part 2: General requirements
- /N 6/ NFPA79:2007 ERRATA 2 2008 06/18/2008**
Electrical Standard for Industrial Machinery
- /N 7/ ANSI/RIA R15.06-1999**
American National Standard for Industrial Robots and Robot Systems -
Safety Requirements
- /N 8/ ANSI B11.19-2003**
American National Standard for Machine Tools -
Performance Criteria for Safeguarding

3. Test object description

The Point Guard I/O Safety Modules 1734-IB8S and 1734-OB8S (see Table 1) are utilized in the POINT I/O platform and can communicate safety messages via network adapters to connect to EtherNet/IP or DeviceNet networks (see Table 2).

A list of common applications and compatible partners is specified /U 15/.

The 1734-IB8S and 1734-OB8S can be configured through software using either the Network configuration tool (RSNetWorx) or the GuardLogix programming tool (RSLogix 5000).

3.1. Safety related aspects

The 1734-IB8S and 1734-OB8S combine two previously TÜV certified toolkits LEATEK¹ (see /U 17/) and TIOM² (see /U 18/) into one compact design. The basic architecture is further the 1oo2 architecture and therefore the hardware fault tolerance (HFT) of one was assigned. To achieve the targeted safety integrity level the safety related parameters have to be:

- Safe Failure (SFF) ≥ 90 % (see /N 1/, part 2, table 3)
- Average Probability of a dangerous Failure on Demand (PFD) < 10⁻³ (see /N 1/, part 1, table 2)
- Probability of a dangerous Failure per Hour (PFH) < 10⁻⁷ 1/h (see /N 1/, part 1, table 3)

3.2. Test samples

The necessary tests of the 1734-IB8S and 1734-OB8S were carried out at the Rockwell facilities in Milwaukee and Cleveland. Additionally Rockwell provided a test system to the Test Institute. It was used to verify partly the tests carried out at Rockwell and to incorporate additional tests.

Catalogue Number	Description	Series	F/W Rev.
1734-IB8S	Point Guard I/O Safety Modules	A	1.1
1734-OB8S	Point Guard I/O Safety Modules	A	1.1

Table 1: Point Guard I/O Safety Modules

Catalogue Number	Description	Series	F/W Rev.
1734-PDN	DeviceNet Adapter	B	none
1734-AENT	EtherNet/IP Adapter	A	3.1

Table 2: Point Guard I/O Network Adapter (suitable for safety loops up to SIL 3)

The test samples were stored at the Test Institute.

3.3. Inspected documents

Testing was mainly based on the following documents:

- /U 1/ Point Guard I/O Safety Modules SRS, rev. 0.1**
Rockwell Automation
- /U 2/ Point Guard I/O Safety Modules Functional Requirements Specification, rev. 4.000**
Rockwell Automation
- /U 3/ Point Guard I/O Safety Modules Verification & Validation Plan, rev. 1.0**
Rockwell Automation
- /U 4/ POINT Guard I/O Safety Modules IEC 61508-2 Table Responses, rev. 1.1**
Rockwell Automation

¹ Low End Adapter Toolkit

² Toolkit I/O Monitor

- /U 5/ POINT Guard I/O Safety Modules IEC 61508-3 Table Responses, rev. 1.0**
Rockwell Automation
- /U 6/ Point Guard I/O Safety Modules Hardware Design Document, rev.1.000**
Rockwell Automation
- /U 7/ Schematic - No. 10000007136 (ver. 02), 10000007137 (ver. 02)**
Rockwell Automation
- /U 8/ Point Guard I/O Safety Modules High Level Design, rev. 1.001**
Rockwell Automation
- /U 9/ DeviceNet Safety I/O Phase 2 and PointGuard Embedded Software Documentation (compiled html help file), dated 2008-12-05**
Rockwell Automation
- /U 10/ Embedded C++ Coding Standard, rev. 0.3**
Rockwell Automation
- /U 11/ VHDL Coding Style Guide, Last Revised 1999-05-07**
Rockwell Automation
- /U 12/ FMEA - Point Guard I/O Safety Modules I/O, rev 1.1**
Rockwell Automation
- /U 13/ QTP for Point Guard I/O Safety Modules, 1734-IB8S, rev. 1.08**
Rockwell Automation
- /U 14/ QTP for Point Guard I/O Safety Modules, 1734-OB8S, rev. 1.09**
Rockwell Automation
- /U 15/ Installation & User Manual (Catalog Numbers 1734-IB8S, 1734-OB8S) Publication 1734-UM013A-EN-P - Preliminary - November 2008**
Rockwell Automation

3.4. Presented test reports and certificates

The following tests and test reports were performed by other accredited test labs.

- /U 16/ Certificate No. 968/EL 381.00/06**
TÜV Rheinland Industrie Service GmbH
- /U 17/ Report-No.: 968/EL 323.03/06**
TÜV Rheinland Industrie Service GmbH
- /U 18/ Technical Report 1734-IB8S, EMC Evaluation, Report #233925**
Rockwell Automation
- /U 19/ Technical Report 1734-OB8S, EMC Evaluation, Report #766273**
Rockwell Automation
- /U 20/ Technical Report 1734-IB8S and 1734-OB8S Environmental Test (Shock and Vibration), Report #612604, Report #554658**
Rockwell Automation
- /U 21/ Technical Report 1734-IB8S and 1734-OB8S Environmental Test (Temperature and Humidity), Report #183548 and #233426**
Rockwell Automation

**/U 22/ ODVA DeviceNet Safety Composite Test, ODVA
File Number 10638.01 and 10639.01
ODVA Inc.**

**/U 23/ ISO9001:2000 certificate, valid until 2010-03-17
Det Norske Veritas Certification, Inc.**

4. Performance of tests and results

4.1. General

The measuring and test equipment, which has been used by the TÜV Rheinland Group in the tests described in the following, is subject to regular inspection and calibration. Only devices with valid calibration have been used. The devices used in the various tests are recorded in the inspector's documentation.

All considerations concerning tolerance of the measurements, so far applicable, are stated in the inspector's documentation, too.

In cases where tests have been executed in an external test lab or in the test lab of the manufacturer and where the results of these tests have been used within the here documented approval, this has occurred after a positive assessment of the external test lab and the achieved test results in detail according to the Quality Management procedure QMA 3.310.05.

4.2. Test steps

The assessment of the 1734-IB8S and 1734-OB8S was subdivided into a conceptual assessment and a main inspection. The steps outlined below were performed as part of the conceptual assessment.

- Review of SRS and FRS according to IEC 61508
- Review of measures for avoiding systematic failures as part of the hardware and software development
- Evaluation of measures for detection of random failures during operation
- Review of the verification and validation plan
- Assessment of the requirements for the management of functional safety on project/product level

Based on the conceptual assessment the main inspections were performed with the inspection steps mentioned below.

- Review of the documentation as part of the development life cycle
- Judgement of the FMEA at component level regarding the relevant failure mode requirements for SIL 3 (IEC 61508) and PI e / Cat. 4 (ISO 13849-1)
- Review of the safety relevant parameter calculations (PFD/PFH, SFF) with regard to SIL 3
- Performance and verification of functional tests and fault insertion tests
- Review of the submitted test reports (EMC, Environmental)

Documents containing details of the investigations were produced during the course of the above series of tests. These documents are stored at the Test Institute.

/D 1/ Hardware FMEA Safety I/O, rev. 1.0
TÜV Rheinland Industrie Service GmbH

/D 2/ Functional test results and Fault Insertion tests, rev. 1.0
TÜV Rheinland Industrie Service GmbH

4.3. Inspection to the requirements of IEC 61508

4.3.1. Inspection of the documentation for completeness and correctness

The documents /U 1/ and /U 2/ were presented by the customer as the actual specification. These documents were checked for completeness, consistency and correctness according to the requirements of /N 1/.

Result:

The presented documents are found to meet the requirements of the test basis with regard to completeness, consistency and correctness.

4.3.2. Assessment of the management of functional safety

The assessment was carried out by inspection of the specified management and technical activities/procedures as part of the development cycle to achieve the required functional safety as well as the consideration of the responsibilities (persons, departments and organizations) for the development cycle.

Result:

The reviewed policy and strategy (RA TQCS) detailed mandatory requirements (e.g. verification and validation activities, management and communication policies) and was classified as sufficient according to /N1/.

The overall functional safety assessment was done by the Test Institute, whereby the required minimum level of independence was achieved.

4.3.3. Assessment of measures to avoid failures during the different phases of the life cycle

Techniques and measures to control and avoid systematic failures during the different phases of the lifecycle were inspected in accordance to /N 1/. The following techniques and measures were subjected to evaluation:

- Project management according to ISO 9001:2000
- Documentation and review activities controlled by RA TQCS Policy (e.g. development cycle procedures, design validation procedures)
- Structured design in hardware and software
- Controlled firmware development process and using of programming guidelines (C++ and VHDL) to achieve consistent firmware and documentation
- EMC and environmental tests with increased levels for safety related products
- Consistent and comprehensible installation and user documentation (see /U 15/)

Result:

The inspected techniques and measures described in /U 4/ and /U 5/ to control and avoid systematic failures during the different phases of the lifecycle are sufficient according to the requirements of SIL 3 to /N 1/.

The measures taken into account to avoid systematic faults during the CPLD development comply with the SIL 3 recommendations for the intended additions to IEC 61508-2.

The verification and validation plan /U 3/ deals with all individual phases of the lifecycle of the product.

4.3.4. Assessment of measures to control failures during operation

The measures to control failures during operation were evaluated regarding to the requirements of IEC 61508-2, Annex A. The implemented measures are described in /U 12/ and were analyzed concerning the required diagnostic coverage under the subjected fault model. The following essential measures to control failures during operation were confirmed:

- Over- and under voltage monitoring with safe shut off
- Combination of temporal and logical monitoring of program sequences (Execution Sequence Diagnostic, I/O Heartbeat Watchdog Test, Timer Diagnostics)
- 32 bit CRC algorithm for the invariable memory ranges (start up and run-time background diagnostic)
- RAM Galpat data diagnostic as part of the run-time background diagnostic
- Safety Protocol Cross Compare
- I/O with automatic checks (Pulse Testing (read back association), True/Complement CPLD Diagnostic, Serial Output Stream Status Test)

Result:

The implementation of the measures to control failures during operation were proven by functional tests documented in /U 13/ and /U 14/, fault insertion tests documented in /D 2/ and the analysis of the corresponding software sources as well as the detailed inspection of the VHDL behaviour description (CPLD).

The above results have shown, that the measures to control failures during operation are in accordance to the requirements of SIL 3 to /N 1/.

4.3.5. Hardware design inspection

The hardware design was inspected by performing the Hardware-FMEA under consideration of representative hardware faults at component level. The Hardware-FMEA is documented in /D 1/ and based on the schematic drawn up in /U 7/. The assessment was carried out regarding the diagnostic coverage and the fault model required by /N 1/ for SIL 3 and under consideration of the hardware architecture (see /U 6/). The function- and fault insertion tests were performed in co-ordination with the developer.

Result:

The Hardware-FMEA at component level has shown, that the implemented measures to detect failures during operation are adequate for the considered fault model.

The performed function- and fault insertion tests have shown no dangerous failure in relation to the fault model required by /N 1/. The results of the function tests and fault insertion tests are documented in /D 2/.

4.3.6. Software design inspection

The software assessment was done by:

- Review of the architecture and the basic safety strategy for the embedded software
- Assessment of the software design at architectural level and review of the implemented measures to detect failures during operation (e.g. RAM test Galpat) at code line level
- Checking programming guidelines used for the software and the CPLD
- Verification of Software Tests (functional testing, white-box testing, statistical testing)

Result:

The architecture of the software is characterized by a clearly structured design combining two previously TÜV certified toolkits (LEATEK³ and TIOM⁴). No obvious deviations from the firmware architecture described in /U 8/ were identified during the review of the software sources documented in /U 9/.

No obvious deviations from the stipulations of the specifications /U 8/ were identified in the course of checking the software design /U 9/. The implemented measures to detect failures during operation were inspected at code line level and were judged to be sufficient regarding the SIL 3 requirement.

The inspection of the software based on the coding guidelines /U 10/ and /U 11/ has revealed no significant deviations.

The functional tests documented in the manufacturer's test plans /U 13/ and /U 14/ were judged to be sufficient.

The combination of functional testing, white-box testing and statistical testing provides evidence that each software module satisfies its associated specification.

Testing of the software version V 1.1 (1734-IB8S and 1734-OB8S) did not reveal any identifiable deficiencies that contravene the requirements of SIL 3 of the IEC 61508 regarding the software life cycle.

4.3.7. Calculation of the safety related parameters

The calculation of the safety relevant parameters was based on /U 7/ and the resulting FMEA at component level, performed by the manufacturer, and was carried out under consideration to the SIL 3 requirements of /N 1/. The expected failure rates of the components are based on a third party data base.

Result:

The following values were calculated by the manufacturer, reviewed and accepted by the Test Institute:

Catalogue Number	PFH (1/h)	PFD _{av} (T=10y)
1734-IB8S	1,3 E-10	5,9 E-6
1734-OB8S	1,4 E-10	6,1 E-6

Table 3: Safety related parameters in reference to /N 1/

³ Low End Adapter Toolkit

⁴ Toolkit I/O Monitor

The calculation of the safety relevant parameters has shown, that the requirements of SIL 3 to /N 1/ are fulfilled.

The review of the components failure rates, resulting from a third party data base, correlates with the SN 29500 and was accepted by the Test Institute.

4.4. Assessment regarding the ISO 13849-1

The 1734-IB8S and 1734-OB8S were inspected regarding the requirements for Performance Level e (PL e) and category 4 (cat. 4) to /N 2/.

Result:

All single failures will be detected by appropriate diagnostic measures. The effectiveness of these diagnostics were assessed during the /N 1/ assessment. For components which are not covered by diagnostics the failure accumulation up to 3 failure in combination were considered. The resulted effects of the failure accumulation have shown no loss of the safety function.

The safety structure, diagnostics and the detection of failures comply to the requirements in /N 2/. No obvious deviations from the Performance Level e (PL e) and category 4 (cat. 4) requirements to /N 2/ were identified during the inspection.

Catalogue Number	MTTF _d	DC _{avg}	PL
1734-IB8S	≥ 100 years	High	e
1734-OB8S	≥ 100 years	High	e

Table 4: Safety related parameters in reference to /N 2/

4.5. Application specific considerations

4.5.1. Requirements according to NFPA 79 - 2007

The NFPA79-2007 from the National Fire Protection Association contains the electrical requirements for industrial machinery.

In the following table the relevant general and specific requirements are listed. These requirements are applied to the 1734-IB8S or 1734-OB8S.

Result:

Clause	Requirements	Result
4.4	Physical environmental and operation conditions (covering EMC, climatic and mechanical requirements)	fulfilled, see chapters 4.6 and 4.8 of the report
6	Protection against electrical shock	fulfilled, see chapter 4.7 of the report
9.4.3	Control Systems Incorporating Software and Firmware Based Controllers	see 9.4.3.1, 9.4.3.3 and 9.4.3.4
9.4.3.1	Software modification	fulfilled
9.4.3.3	Software verification	fulfilled

Clause	Requirements	Result
9.4.3.4	<p>Use in safety related functions</p> <p>Control systems incorporating software and firmware based controllers performing safety-related functions shall conform to all of the following:</p> <p>(1) In the event of any single failure perform as follows:</p> <ul style="list-style-type: none"> (a) Lead to the shutdown of the system in a safe state (b) Prevent subsequent operation until the component failure has been corrected (c) Prevent unintended start-up of equipment upon correction of the failure <p>(2) Provide protection equivalent to that of control systems incorporating hardwired / hardware components.</p> <p>(3) Be designed in conformance with an approved standard that provides requirements for such systems</p>	fulfilled, see chapter 4.3.6 of the report

The user shall comply with all other requirements from /N 6/ including requirements that have an effect on the safety configuration (e.g. safety test pulses) of the 1734-IB8S and 1734-OB8S.

4.5.2. Requirements according to ANSI/RIA R15.06 - 1999

The ANSI/RIA R15.06 - 1999 applies beside the manufacture, remanufacture, rebuild, installation, maintenance, testing, start-up and training also to the safeguarding requirements for industrial robots and robot systems.

In table below the relevant general and specific requirements are outlined. These requirements are applied to the 1734-IB8S and 1734-OB8S.

Result:

Clause	Requirements	Result
4.5.3	Single channel with monitoring safety circuits shall include the requirements for single channel, shall be safety rated, and shall be checked (preferably automatically) at suitable intervals.	fulfilled
4.5.4	Control reliable safety circuitry shall be designed, constructed and applied such that any single component failure shall not prevent the stopping action of the robot.	fulfilled, see chapter 4.4 of the report
5.3	<p>General requirements for safeguarding devices that signal a stop:</p> <ul style="list-style-type: none"> - Accompanying documents, - Indicators, that the device is operating - Not adversely affected by environmental conditions - Maximum response time must not be affected by object sensitivity and environmental changes - Provide means for secure attachment - Provide means to restrict unauthorized adjustments or settings 	fulfilled, see the previous chapters of this report

Clause	Requirements	Result
6.4	Software and firmware-based controllers used in place of hardware based components with safety-related devices shall: <ul style="list-style-type: none"> a) be designed such that any single safety related component or firmware failure shall: <ul style="list-style-type: none"> 1) lead to the shutdown of the system in a safe state and 2) prevent subsequent automatic operation until the component failure has been corrected b) supply the same degree of safety achieved by using hardwired/ hardware components per 4.5.4. For example, this degree of safety may be achieved by using microprocessor redundancy, microprocessor diversity, and self-checking c) be certified by a National Recognized Testing Laboratory (NRTL) to an approved standard applicable for safety devices. 	fulfilled, see the previous chapters of this report The Test Institute is not listed as a National Recognized Testing Laboratory (NRTL). Despite this matter of fact, the test objects are in accordance with approved standards for safety devices.
10.1	Requirements for safety circuit performance	fulfilled
11.3	Requirements for safeguarding devices that signal a stop <ul style="list-style-type: none"> - Interface to the robot - Installation so that over- and under reaching of the safeguard is not possible - Start/Restart required from outside the safeguarded space - Provision of control over adjustments or settings being made by others than authorized personnel - Indication on if the device is functioning 	Not applicable to a single 1734-IB8S or 1734-OB8S module (manly installation depending requirements. The manual /U 15/ provide sufficient information for a correct installation. An indication, that the device is functioning, is available.

The user shall comply with all other requirements from /N 7/ including requirements that have an effect on the safety configuration (e.g. safety test pulses) of the 1734-IB8S and 1734-OB8S.

4.5.3. Requirements according to ANSI B11.19 - 2003

This standard contains requirements for the design, construction, care and operation of safeguards used at the other ANSI B11 machine tools. The selection and the application of the safeguarding system is provided in the appropriate B11 safety standard for the particular machine tool.

The B11.19 standard provides requirements for different types of safeguards (fixed and movable guards, presence sensing devices, two hand operating control devices, probe protection devices and others).

In the following table the relevant general and specific requirements are defined. These requirements are applied to the 1734-IB8S and 1734-OB8S.

Result:

Clause	Requirements	Result
6.1	Performance of the safety related function(s): When a component, module, device or system failure occurs, such that it or a subsequent failure of another component, module, device or system would lead to the inability of the safety-related function(s) to respond to a normal stop command or an immediate stop command, the safety-related function shall: - prevent initiation of hazardous machine motion (or situation) until the failure is corrected or until the control system is manually reset; or - initiate an immediate stop command and prevent re-initiation of hazardous machine motion (or situation) until the failure is corrected or until the control system is manually reset; or - prevent re-initiation of hazardous machine motion (or situation) at the next normal stop command until the failure is corrected or until the control system is manually reset	fulfilled, see the previous chapters of this report (e.g. chapter 4.4)

The user shall comply with all other requirements from /N 8/ including requirements that have an effect on the safety configuration (e.g. safety test pulses) of the 1734-IB8S and 1734-OB8S.

4.6. Review of EMC

The EMC tests were performed at the Environmental Evaluation Laboratory of Rockwell Automation.

Result:

The product certification lab is audited for compliance to ISO 17025, and is an independent department.

The review of the test results documented in /U 16/ and /U 19/ has shown, that the product requirements according to /N 4/ and /N 3/ are fulfilled.

4.7. Information to electrical safety

The 1734-IB8S and 1734-OB8S are connected to 24VDC powered by the DeviceNet or additional external 24VDC power supplies. All outputs are internally fused and operating to a nominal voltage of 24VDC.

Result:

A power supply that will be used for 1734-IB8S and 1734-OB8S in safety application shall fulfil the requirements according to EN 50178 or similar standards. Power supplies shall fulfil the requirements for Protective Extra-low-Voltage (PELV) or Safety Extra Low Voltage (SELV). No voltage greater than 24VDC is generated by the device.

4.8. Review of the climatic and mechanical tests

The climatic and mechanical tests for the 1734-IB8S and 1734-OB8S were performed by the Environmental Evaluation Laboratory of Rockwell Automation.

Result:

The product certification lab is audited for compliance to ISO 17025, and is an independent department.

The review of the test results documented in /U 20/ and /U 21/ has shown no obvious derivations regarding the climatic and mechanical test requirements stipulated by /N 4/.

4.9. Additional aspects

4.9.1. Programming and configuration tools

For the 1734-IB8S and 1734-OB8S the following parts of software will be used:

- RSLogix 5000 programming software
- RSNetworks Network configuration

Both parts of software are not safety relevant. The special requirements for the PC-based software used for safety related configuration tasks are clearly described in the /U 15/ and have to be observed.

4.9.2. Communication requirements

The 1734-IB8S and 1734-OB8S shall be connected to the DeviceNet or EtherNet/IP network and proceed information with other compatible partners by using the CIP safety communication. The CIP safety communication layer is SIL 3 certified.

Result:

The test results documented in /U 22/ have shown no derivations regarding the compliance to the DeviceNet Safety protocol.

5. Summary

During the assessment no infringement of the functional and safety related requirements outlined in the applied standards could be found. Observance have to be given to the installation instructions /U 15/ released by Rockwell Automation.

On the basis of the above assessment the 1734-IB8S and 1734-OB8S, specified under chapter 3.2, can be used in SIL 3 (IEC 61508) and PI e / Cat. 4 (ISO 13849-1) applications, provided that the conditions outlined below are met:

- The modules shall be configured to perform the safety test pulses for the corresponding inputs (normal closed switches shall used) and outputs (de-energized state shall be the safe state).

The resistance against the environmental conditions (climatic, mechanic, EMC) fulfils the requirements of /N 3/.

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Report released after review:
Date: 2009-02-05

The inspector



Dipl.-Ing. Matthias Haynl



Dipl.-Ing. Heinz Gall