Generic Qualification of the Rosemount 3051N Pressure Transmitter

Summary of Activities and Results

Technical Report

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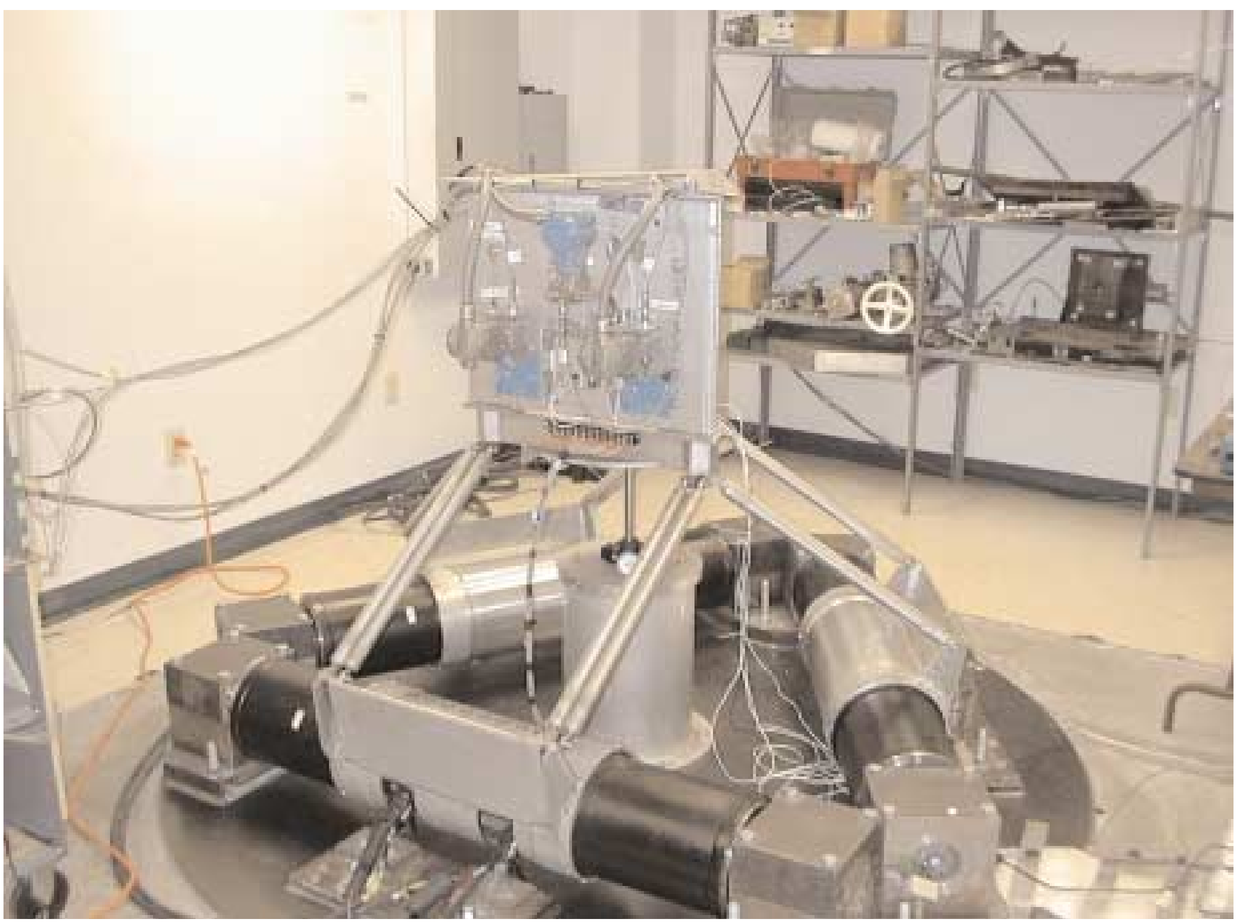

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1001468

Final Report, June 2001

EPRI Project Manager
R. Torok

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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CITATIONS

This report was prepared by

MPR Associates, Inc.
320 King Street
Alexandria, VA 22314

Principal Investigators
J. Thomas
D. Herrell
S. Steiman
R. Carritte

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REPORT SUMMARY

As its nuclear power plants age, the electric power industry is focusing on the development of cost-effective replacements for many obsolete components used in instrumentation and control systems. This report documents a pilot application of an EPRI-developed approach for evaluating commercial digital equipment to assess its adequacy for nuclear safety applications. The subject of the exercise was a commercially available smart pressure transmitter with broad applicability as a replacement for obsolete analog transmitters.

Background

Utilities are using commercial digital equipment more and more, but their processes and procedures for evaluating such equipment to ensure adequate quality for nuclear safety-related applications are still developing. Also, significant licensing uncertainty still exits, and utilities have been hesitant to commit resources to such efforts. EPRI has developed an approach for these evaluations and has obtained Nuclear Regulatory Commission (NRC) concurrence that the approach is acceptable. However, experience with the approach is limited, and questions remain as to how it can be applied in a way that is both technically defensible and cost-effective. Utilities now require pilot applications of the approach on real components to demonstrate details of its use and ensure ultimate acceptability of future qualifications for similar devices.

Objectives

To make selected commercial digital components available for nuclear safety systems by performing tests and evaluations qualifying them for such applications; to help clarify and stabilize the regulatory environment for commercial digital components in nuclear plants; and, to demonstrate the approach for evaluating commercial digital equipment described in EPRI TR-106439, *Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications,* and TR-107339, *Evaluating Commercial Digital Equipment for High Integrity Applications*.

Approach

First, the project team identified high-priority components—devices that are likely replacements for equipment that is obsolete, but still widely used in safety systems. The initial list included single loop controllers, smart transmitters, time delay relays, recorders, and pressure switches. Participating utilities then selected specific models well suited to their planned applications for more in-depth assessment and, ultimately, qualification. Qualification activities included various tests and evaluations that give indications of the component's quality and design adequacy—including the software— and demonstrate that it can meet the requirements of nuclear safety-related applications. This device was somewhat unusual in that the equipment supplier has a subsidiary company with an active nuclear quality assurance program. The subsidiary performed

some of the qualification tests and evaluations, and plans to supply the transmitter to the nuclear industry as a nuclear safety qualified device. All evaluations were performed generically to the extent feasible, with the intent of qualifying the device for a broad a range of applications.

Results

This report summarizes the study's various tests and evaluations; the complete qualification records will be held and maintained by the equipment supplier. The transmitter investigated in this study was designed and manufactured using commercial practices, rather than the more stringent quality assurance (QA) processes required when components are built specifically for nuclear safety systems. Had it been developed under a nuclear-grade QA program, the documentation might have been more complete, the design more rugged, and the testing activities more extensive. Still, good commercial practices and an evolutionary design process have resulted in a relatively simple, reliable device with an extensive, successful operating history. It is expected that the 3051N pressure transmitter, if prudently applied, will be adequate for most mild-environment safety-related uses in nuclear plants.

EPRI Perspective

This exercise is an excellent example of how EPRI guidelines on commercial-grade digital equipment can be used to extend the traditional equipment qualification/dedication process to software-based systems. It also was an excellent example of collaboration, with EPRI and its sponsors approaching a manufacturer as a group to make the process more efficient for all parties. In this case, having a nuclear qualified supplier associated with the equipment manufacturer provided a unique opportunity to make the qualified device available to the industry more efficiently than would otherwise have been possible. We expect this report to be helpful in supporting and guiding future qualification and commercial-grade dedication efforts.

While the "generic qualification" data should greatly reduce the total utility effort, application-specific issues should still be addressed before this device is used in a safety-related system. For example, utilities should carefully consider component behaviors and failure modes in the context of the plant system and safety function. Application-specific issues for pre-qualified platforms and guidance for addressing them are contained in a separate report, EPRI 1001045.

Keywords

Digital upgrade
Instrumentation and control
Qualification
Commercial-grade item dedication
Commercial off-the-shelf software
COTS
Smart transmitter

ABSTRACT

In response to the growing challenges of obsolescence and increasing maintenance costs faced by nuclear utilities, EPRI has undertaken a generic qualification project to qualify commercial digital instrumentation and control equipment for use in safety-related applications. This report summarizes the methods and results of a series of tests and evaluations performed as part of a pilot project to qualify a smart transmitter for use in safety-related applications. The evaluations support the conclusion that when properly applied as described in this report and in the vendor's technical manual, the Rosemount 3051N is considered acceptable for mild environment nuclear safety-related and non-safety-related plant applications. The qualified transmitter will be offered by Rosemount Nuclear Instruments, Inc. for procurement under their 10CFR50 Appendix B quality assurance program. Detailed documentation of the qualification activities, including results of the various tests and evaluations, resides in Rosemount's documentation. Rosemount Nuclear Instruments, Inc. will provide specifications and guidance for use of the transmitter in safety-related applications, including any limitations or restrictions, to prospective users. Additional guidance on the application of generically qualified devices can be found in the EPRI report "Guideline on the Use of Pre-Qualified Digital Platforms for Safety and Non-Safety Applications in Nuclear Power Plants," EPRI 1001045.

CONTENTS

LIST OF TABLES

1 INTRODUCTION

This report provides a summary discussion of various tests and evaluations undertaken to qualify a commercially available smart pressure transmitter for use in safety-related applications in nuclear plants. The project was undertaken in part to demonstrate the approach developed by EPRI for evaluating commercial digital equipment. The approach is documented in EPRI TR-106439, *Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications* (Reference 1), and EPRI TR-107339, *Evaluating Commercial Digital Equipment for High Integrity Applications* (Reference 2). EPRI TR-106439 has been reviewed and endorsed by the U.S. Nuclear Regulatory Commission, but the approach is still quite new to both licensees and regulators, and the details regarding how best to apply it are still evolving.

Qualification of digital equipment for safety-related applications involves more than the environmental and seismic testing used for hardware-only equipment. It also includes assessment of such things as software quality, software architecture, fault tolerance, and other issues that need special attention for digital technology. The accumulated data from all the evaluations and tests is used to demonstrate 'qualification' subject to the bounds of those activities. In this case the device under evaluation is relatively simple and has broad applicability. The qualification activities were intended to be independent of plant application to the extent possible, hence the term "generic qualification."

The smart transmitter evaluated in this project is the Rosemount 3051C, which is manufactured as a commercial device by Rosemount, Inc., Measurement Division (RMD). Rosemount Nuclear Instruments, Inc. (RNII), plans to offer this transmitter to the nuclear power industry as a qualified device under their 10 CFR 50 Appendix B quality assurance program. The qualified version of the 3051C has been given a new model designation, 3051N, by RNII, who will perform additional tests and evaluations and update documentation as necessary to maintain the qualification in the future. This report describes the full set of qualification activities that were undertaken on the project. Some were performed directly by RNII; some were performed by EPRI/DOE. The detailed documentation for the activities performed by EPRI/DOE has been provided to RNII for their use in the future maintenance of the qualification.

This project concluded that the results of the generic qualification activities, plus the future activities planned by RNII to support ongoing procurements, provide a "preponderance of evidence" supporting the acceptability of the transmitter for nuclear applications. This "preponderance of evidence" developed by the combination of the qualification activities provides reasonable assurance that, when properly applied as described in this report and in the vendor's technical instructions, the transmitter is acceptable for nuclear safety-related and non-safety-related applications in mild environments.

This report is for information only and should not itself be used as the basis for applying a 3051N transmitter. Judgments regarding the acceptability of the 3051N for specific applications should be based on the qualification documents and associated quality assurance records held by RNII. Also, guidance on appropriate and acceptable use of the transmitter, including limitations or restrictions (e.g., on configuration, calibration, wiring practices, etc.) will be provided to prospective users by Rosemount Nuclear Instruments, Inc.

Generic Qualification Activities

The 3051N qualification activities addressed the generic functional and application requirements established by an EPRI working group that represented the utility sponsors of this activity. The activities also addressed digital issues related to the dependability, reliability, and built-in quality of the 3051N and its behavior under abnormal or faulted conditions.

The 3051N generic qualification activities consisted of the following:

- Critical Digital Review (CDR) to assess the design integrity, built-in quality, and dependability of the 3051C
- Operating History Review in which users were contacted on a sampling basis to check actual operating history of 3051C transmitters in service
- Independent Review of RMD Electromagnetic Compatibility (EMC) Testing to compare the test methods and results against current industry and NRC guidance on EMC
- RNII Seismic Testing to demonstrate seismic adequacy
- RNII Dedication Activities including a Commercial Grade Survey of RMD

This set of activities is typical of what is required for most commercial digital devices to determine if they are acceptable for use in safety-related applications. As described in EPRI TR-106439 (Reference 1), the results of these activities are combined to form an overall judgment of acceptability for commercial devices. Section 2 of this report, *Preponderance of Evidence*, summarizes the results of each qualification activity listed above, and then provides the overall conclusion drawn from these activities regarding acceptability of the 3051N for nuclear applications. Detailed results of the RNII Seismic Testing, the RNII Commercial Grade Survey of RMD, and the 3051N Dedication Activities are contained in RNII reports.

2
PREPONDERANCE OF EVIDENCE

The generic qualification activities listed in Section 1 for the Rosemount 3051N transmitter were based on a set of generic functional and application requirements established by an EPRI working group that represented the utility sponsors of this activity. The activities specifically addressed the technical and licensing issues associated with digital equipment and software-based systems such as reliability, dependability, built-in quality, and behavior of the equipment under abnormal or faulted conditions. The objectives, results, and conclusions of each activity are summarized below. The model 3051N will be manufactured as a 3051C commercial device and supplied as a nuclear qualified device following completion of the dedication activities.

Summary of Critical Digital Review (CDR)

The overall objective of the CDR was to assess the design integrity, built-in quality, and dependability of the 3051C and to gain assurance that the transmitter will function in a mild environment in accordance with RNII published specifications. The CDR was performed based on the guidance provided by EPRI TR-106439 (Reference 1), which has been accepted by the USNRC and is referenced as an acceptable Method in the Standard Review Plan Chapter 7 (Appendix 7.0A). Supplemental guidance on performing a CDR, given in EPRI TR-107339 (Reference 2), was also used. The review used the software life cycle process evaluation guidance in the Standard Review Plan, Branch Technical Position HICB-14 (Reference 3), and the design integrity guidance of IEEE Standard 7-4.3.2-1993 (Reference 4).

It is expected that the Rosemount Model 275 HART® Communicator (referred to here as the "275") will be used to configure the transmitters. The CDR did not review any other configuration device for acceptability. The 275 does not require qualification or dedication, as it will be treated as measurement and test equipment (M&TE). However, interactions between the 3051C transmitter and the 275 were evaluated to assure that the M&TE does not adversely affect the potential safety functions of the transmitter.

The CDR included an architecture review of the 3051C and 275 devices; review of their hardware and software development, validation, and testing processes; and an analysis of failure mechanisms of the major 3051C components. The review consisted of documentation reviews and technical interviews with key RMD, RNII, and Fisher-Rosemount Performance Technologies Division (manufacturer of the 275) personnel knowledgeable in the above areas, and technical reviews of design and development documentation, including internal design control procedures.

Key findings of the CDR are summarized below.

Simplicity

As a digital, microprocessor-based device the 3051C transmitter is relatively simple in its architecture, hardware, and software. Its primary function is to transmit a single 4-20 ma signal in response to a single process measurement. (Although the smart transmitter provides capability for digital signals to be communicated on top of the 4-20 ma analog signal, nuclear applications are not expected to make use of this feature. Use of digital communications during operation, while the 3051N is performing its safety function, was not addressed by the generic qualification activities. Use of digital communication was addressed only as part of configuration and calibration of the device when the 275 Communicator is employed as M&TE for this purpose.) A single loop architecture is used for digital processing and control flow, with no internal looping. The embedded software is very small in size (less than 8K of executable code). The hardware is also relatively simple, and partly as a result of this the transmitter employs only limited diagnostics; this helps limit the size and complexity of the software.

Limited Variations

A single version of the software is used for all 3051C transmitters, regardless of whether they are measuring absolute, gauge, or differential pressure (this is set in the application-specific configuration of each unit). This and the overall simplicity of the device strengthen the use of historical data in evaluating adequacy of the transmitter (results of the operating history review are discussed below).

Enhanced Software Development Process

Although the 3051C transmitter is an older product that was not originally developed under a formal design control process, newer releases of the 3051C have been developed under enhanced processes. The CDR included a review of the current RMD design and development practices, which were used in developing Release 4 (the current release) of the 3051C software. These practices were compared to the expectations established in the NRC Standard Review Plan, Branch Technical Position (BTP) HICB-14 (Reference 3), and the design and development practices were found acceptable for nuclear safety-related software development. In addition, an external agency audited and certified RMD to the Software Engineering Institute (SEI) Capability Maturity Model-Software (CMM-SW) Level 2. This provided additional assurance that the processes currently used are of high quality.

Disciplined Change Process

Development of Release 4 of the 3051C was performed under the current RMD process based on a set of documented functional and design requirements. Release 4 of the 3051C and the corresponding latest release of the 275 Communicator were both tested formally to their respective requirements, and they underwent integrated testing to verify coordination of the two releases. This testing was judged to be complete and comprehensive. There was also strong evidence of regression testing for the 3051C (checking it against the full set of specifications) with sufficient objective documentation for the CDR to evaluate and accept the test results.

Culture of Continuous Improvement

RMD was found to have a corporate culture that involves elements of continuous process and device design improvements. For software, this culture of continuous process improvement goes well beyond the requirements of a CMM-SW Level 2 process. As an example of device improvement, the measurement accuracy and stability of the 3051C were found to have improved significantly since the transmitter's introduction.

Extensive Installed Base

More than 1.5 million 3051C transmitters have been shipped. More than 0.5 million of those are Release 4, which started shipping in 1998. This extensive installed base, with long-term field experience, makes the review of operating history particularly useful and important.

Important Application Information

In addition to providing information for judging acceptability of the digital device, the CDR also provides information that helps the application engineer better understand the device and its inner workings. Most important, it provides information that may be critical to ensuring the device is properly applied in the plant. Some examples of the kinds of information developed in the CDR for the Rosemount 3051N transmitter are given below. Prospective users of the 3051N should read the CDR section of the detailed qualification report, available from RNII, before applying the transmitter in critical plant applications.

- Technicians and engineers should have clear procedural guidance for calibration and configuration of the 3051N. This guidance should include independent verification of the 3051N configuration at the completion of calibration or configuration activities. In addition, since configuration and some surveillance activities can be performed from a central location other than at the individual transmitter, guidance should be provided to minimize the risk of making unintended changes to the wrong 3051N. Any failures or unexpected behavior while a 275 is connected to the 3051N should result in a complete review of the 3051N configuration.
- Typical of many digital devices, the 3051N transmitter's behavior on power-up is not the same as the older analog transmitters it will replace. Behavior of the output during the power-up transient and the time required to reach a final, accurate reading should be considered for each application of the transmitter (see the detailed CDR results for more information).
- The effect of the transmitter's digital signal (riding on top of the analog 4-20ma signal) on other process loop components should be evaluated.
- Administrative procedures for making configuration changes, and use of security features to prevent changes, should be considered.
- For each application, the desired action to be taken under "failsafe" conditions should be determined, and the transmitter configured accordingly. Otherwise, a default behavior will result that is different from older analog transmitters and may not be appropriate for the given application.

- Coverage of the internal self-diagnostics (i.e., which faults are detected, and which are not) should be considered. As with other digital devices, self-testing provides a great deal of additional capability to detect and allow early repair of transmitter faults. However, some faults are not covered by this testing and must be dealt with by other means. See the qualification report and Rosemount technical information for details.

Summary of Operating History Review

The operating history was assessed by surveying a sample of users of the 3051C transmitter. The goal of the survey was to evaluate the operating history to assess whether the 3051C has demonstrated sufficient quality and dependability in service to be used in nuclear applications and to look for any evidence of undesirable system behavior or trends in failures. Nine users of the 3051C transmitter were surveyed. Six of the users were commercial industry users and three were nuclear plant users with non-safety related applications. Nearly all of these users use the 275 to configure the transmitters.

Method

The survey was conducted by telephone using a pre-defined list of questions (see Appendix A). The questions were designed to determine if the operating history data is applicable to nuclear safety-related applications, and if so, assess the operating history data for failure incidences or unexpected behavior in service and for any information that might indicate the potential for performance problems with the 3051C transmitter in nuclear safety-related applications. The questions helped guide the telephone conversations and ensure completeness and consistency in the survey. They also helped in documenting the results.

In performing this type of survey, it is important to reach people who have sufficient first-hand knowledge of the equipment's operating history to provide valid and meaningful results. For this survey, the contact who provided the needed information was typically an instrumentation and control engineer or a maintenance engineer or supervisor who was knowledgeable of, and in many cases responsible for:

– the equipment
– its performance in service
– root cause evaluations of failures (whether formal or informal), and
– communication with the vendor regarding any failures or performance problems.

It is also important to ensure that the survey data are relevant. In this case, the applicability of the operating history data to nuclear safety-related applications was established by determining whether:

1. the number of units in use at the facilities surveyed was sufficiently large to draw meaningful conclusions,

2. the units had been in service for a sufficient amount of time under conditions similar to a nuclear mild environment,
3. the transmitters were configured in the same manner as expected for nuclear service, running the same software modules, with the same execution profiles,
4. the transmitter applications were considered critical to the safe operation or economic viability of the facility, as would be the case in nuclear safety-related applications,
5. the transmitters were installed and operated in a manner similar to the anticipated nuclear safety-related applications, for example, similar configuration options, configuration method (Model 275 Communicator), calibration methods, etc., and
6. the installation environment at each facility was comparable to the anticipated mild installation environment at a nuclear power plant.

When assessing the adequacy of a commercial digital device for nuclear safety-related service per EPRI TR-106439 (Reference 1), the operating history data are used in combination with the information from other activities such as the CDR and commercial grade vendor survey. All of these activities are carried out in accordance with a 10 CFR 50 Appendix B quality assurance program. However, the individual pieces of data or information developed in the telephone survey are not individually verified. Rather, the information is checked for consistency across the users who were surveyed, and consistency with what was learned in the CDR, during testing, and the vendor survey. An overall judgment is formed regarding the applicability of the operating history data as one input to determining acceptability of the digital device.

Results

The results of the operating history survey reinforce the finding from the CDR that the 3051C transmitter has acceptable quality and dependability for nuclear safety-related use in a mild environment, and that the 275 provides an acceptable means of configuring and calibrating the transmitters. The following key points, summarized from the operating history questionnaires, form the foundation for this judgement. These points address each of the criteria for assessing operating history – extent, relevance, and success – that are given in EPRI TR-106439 (Reference 1) and endorsed by the NRC in the Standard Review Plan Chapter 7.

Extent

- More than 9,400 transmitters covering all models (3051CG, CD, CA) and a variety of range codes are installed at the nine plants that were contacted for this survey. This is judged to be a sufficiently large sample to make a sound judgement on the quality and reliability of the transmitter based on its operating experience when added to other assessments, including the CDR. This is also judged to be a sufficiently large sample to detect any significant unexpected or undesirable behaviors or trends in faults or failures of units in service.
- The time in service ranges from new transmitters installed for three months to the first commercially available 3051C transmitters installed eight or nine years ago, thereby representing all four releases of the transmitter software.

Relevance

- The Rosemount 3051C transmitter uses the same software, regardless of the application. The same software modules are used, performing the same functions, and using the same program control flow in all transmitters. Therefore, any industrial experience with the transmitters is relevant.
- Rosemount 3051C transmitters are used routinely in applications that are considered critical to plant operation, both for safety and for economic reasons. Use in safety and economically critical application demonstrates the industrial users' trust in the quality and dependability of the 3051C. Examples of critical safety functions include overpressure and excess flow protection for a chemical pipeline, and overpressure trips of chemical reactors, vaporizers, compressors, and incinerators. The transmitters are commonly used in redundant I/O protective systems utilizing 2-out-of-3 channel trip logic. They are also used in economically critical applications such as metering product flows to a customer, where transmitter failure could cause interruption of service to a customer. Many of these pressure, flow, and level monitoring applications are critical in regard to public safety. Most of the users surveyed (over 99% of the 9,400 transmitters) use the 275 to configure their 3051C transmitters. Additionally, most users calibrate their transmitters in a similar manner to that expected in a nuclear plant.
- The transmitters are installed in rugged industrial environments that are comparable to if not more severe than the anticipated "mild" installation environment in a nuclear power plant. Examples of these conditions include the heat and humidity of the southeastern United States for transmitters installed outdoors, and the acidic, corrosive environment of transmitters installed inside containments at chemical plants.

Success

- Of the more than 9,400 transmitters in use by the nine customers surveyed, the only failures that were reported were directly attributable to either severe (beyond the manufacturer's recommended) environmental conditions or misapplication by the user. There were no reported incidences of microprocessor failure or software bugs. Of all the transmitter failures reported, none failed in such a manner that the failure was not readily apparent to the operators, i.e., a transmitter never "flat-lined" at a steady state value such that failure would not be obvious. Many of the plants have failure tracking mechanisms in place, which provide confidence in their knowledge of failure rates and causes.
- There has been no reported incidence of a 3051C transmitter losing its configuration parameters throughout its service life in the plants surveyed from software errors, while the 3051C has been operated in the equivalent of a mild nuclear environment.
- There has been no reported incidence of improper or unexpected configuration of a 3051C transmitter using a 275 resulting from faults or failures in the 275 software. Instances have been reported of configuration errors introduced by technicians and engineers.
- There were no reports of unexplained failures or inexplicable behavior, despite the fact that the Operating History Survey and CDR were specifically looking for any evidence of this type of behavior.

- The users surveyed look favorably on RMD as a quality vendor and are confident that RMD has responsive quality systems in place to diagnose the cause of a failed transmitter and report the cause back to the user.
- All of the nine users surveyed are satisfied with the quality of the 3051C transmitter. Additionally, all of the six commercial industry users plan to continue using the transmitters in their critical applications, and two of the nuclear utilities plan to use the 3051C in nuclear safety-related applications when the qualification program is completed.

Summary of Independent Review of RMD EMC Testing

EPRI Report TR-102323-R1 (Reference 5) defines recommended generic electromagnetic susceptibility and emissions test levels for establishing electromagnetic compatibility (EMC) of equipment installed in nuclear power plant applications. These levels are based on actual in-situ measurements of electromagnetic interference (EMI) levels in nuclear power plants. TR-102323-R1 also endorses standard test methods published in Military Standards 461 and 462, as well as industry standards published by the International Electrotechnical Commission (IEC). In its Safety Evaluation (Reference 6) issued April 17, 1996, the NRC staff concluded “that the TR-102323-R1 recommendations and guidelines provide an adequate method for qualifying digital I&C equipment for a plant’s electromagnetic environment without the need for plant specific EMI surveys if the plant specific electromagnetic environment is confirmed to be similar to that identified in TR-102323.”

Although RMD did not perform EMC testing specifically to meet EPRI TR-102323-R1, substantial testing was performed in accordance with European EMC directives, NAMUR recommendations, and IEEE standards. As part of the generic qualification program, the RMD EMC testing underwent an independent review in which it was evaluated and compared to the requirements of EPRI TR-102323-R1.

This review concluded that the emissions and susceptibility testing performed previously by RMD provides reasonable assurance of the electromagnetic compatibility of the 3051N transmitter for safety-related applications provided the transmitter installation is consistent with the following:

- The transient protection terminal block is installed.
- The 3051C product manual wiring practice recommendations are followed, including grounding the transmitter case.
- The installed location of the transmitter is several feet from any strong magnetic field sources such as rotating machinery, large power transformers, or isolated phase buses.
- The transmitter signal cables are routed separate from power cables.
- The transmitter is installed indoors and the interconnecting cable does not run outdoors, or the cable is run in continuous conduit and the ground system is common between both ends of the cable.

Summary of RNII Seismic Testing

Seismic testing was performed by RNII to the requirements of IEEE Std. 344-1987 and IEEE 323-1983, using the Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake (OBE) Required Response Spectra (RRS) that were derived from the Seismic Qualification Reporting and Testing Standardization (SQURTS) full-level RRS. Based on the results of this testing, the Model 3051N Smart Pressure Transmitter has demonstrated the capability to provide the safety functions summarized in Table 2-1. For current seismic performance specifications, refer to the 3051N Product Data Sheet (PDS) (Reference 7) and the Rosemount 3051N Seismic Qualification Test Report (Reference 8).

Table 2-1
3051N Seismic Specification Summary

<table>
<tr><th>Model</th><th>Range Code</th><th>During Seismic Accuracy**</th><th>Post Seismic Accuracy</th><th>Specified Seismic Maximum Working Pressure</th><th>Structural Integrity</th></tr>
<tr><td rowspan="6">3051ND</td><td>0</td><td>Not Specified</td><td>Not Specified</td><td>750 psi</td><td rowspan="15">Maintained throughout Prescribed Seismic Vibration</td></tr>
<tr><td>1 ***</td><td>0.75% of URL (adjustable damping ≥ 1.6 seconds)</td><td rowspan="9">0.25% of Span</td><td>2000 psi</td></tr>
<tr><td>2 ***</td><td>0.75% of URL (adjustable damping ≥ 0.8 seconds)</td><td rowspan="4">3000 psi (glass filled TFE o-ring)
2000 psi (EP o-ring)</td></tr>
<tr><td>3</td><td>0.75% of URL</td></tr>
<tr><td>4</td><td rowspan="2">0.25% of URL</td></tr>
<tr><td>5</td></tr>
<tr><td rowspan="4">3051NG</td><td>2 ***</td><td>0.75% of URL (adjustable damping ≥ 0.8 seconds)</td><td rowspan="4">Upper Range Limit</td></tr>
<tr><td>3</td><td>0.75% of URL</td></tr>
<tr><td>4</td><td rowspan="2">0.25% of URL</td></tr>
<tr><td>5</td></tr>
<tr><td rowspan="5">3051NA</td><td>0</td><td rowspan="2">Not Specified</td><td rowspan="2">Not Specified</td><td rowspan="4">Upper Range Limit</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td><td rowspan="3">0.25% of URL</td><td rowspan="3">0.25% of Span</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td>3000 psia (glass filled TFE o-ring)
2000 psi (EP o-ring)</td></tr>
</table>

** Factory damping set at 0.4 second unless otherwise noted.
*** Panel style mounting bracket (Option Code B2 or BS) required for specified "During Seismic Accuracy" performance..

Summary of RNII Commercial Grade Dedication Activities

"Commercial grade dedication" refers to a process used in the nuclear power industry through which equipment not specifically designed and built for service in nuclear safety-related applications can be accepted for such service. Basic components are "items designed and manufactured under a quality assurance program complying with 10 CFR Part 50, Appendix B, or commercial grade items which have successfully completed the dedication process" (10 CFR 21.3). "[D]edication is an acceptance process undertaken to provide reasonable assurance that a commercial grade item to be used as a basic component will perform its intended safety function and, in this respect, is deemed equivalent to an item designed and manufactured under a 10 CFR Part 50, Appendix B, quality assurance program" (10 CFR 21.3). These acceptance activities typically involve verifying specific "critical characteristics." Critical characteristics are defined as "those important design, material, and performance characteristics of a commercial grade item that, once verified, will provide reasonable assurance that the item will perform its intended safety function"(10 CFR 21.3). Other EPRI reports have been written describing methods for commercial grade dedication of digital devices (References 1 and 2). In this case, RNII will purchase commercial grade 3051C transmitters from RMD and "dedicate" them for nuclear safety service use as 3051N transmitters. This section describes the activities necessary to support this dedication.

RNII performed a commercial grade survey of RMD to evaluate the design, manufacturing, testing, and quality assurance programs applicable to the 3051C. The critical characteristics used in this survey are provided in Tables 2-2 through 2-6 below. RNII used the results of this survey and of the associated critical digital review to establish additional dedication activities for the 3051C. The survey is a dedication activity. The RNII basic model number for procurement of the dedicated transmitter will be 3051N.

To supplement the existing RMD design and quality controls, RNII has established additional activities that it will undertake to verify the physical, performance, and dependability critical characteristics of the 3051N's that it processes. Where periodic monitoring and control of a critical characteristic is not performed by RMD, at least one of the following methods will be used by RNII for verification.

- RNII Quality Assurance Inspectors will periodically follow transmitters through the manufacturing process to confirm that the RMD quality assurance procedures are being followed properly. This process is referred to as Source Inspection.
- Visual Receiving Inspection will be conducted by RNII Quality Assurance Inspectors.
- Performance Testing will be conducted using test equipment that will verify performance specifications.
- Destructive Testing will be conducted on a sample basis to verify correct materials of construction, and test the performance limits that could potentially damage the transmitter.
- RNII will conduct Engineering Evaluations to assure that changes to the design of the 3051C Transmitter do not adversely affect the information published in the 3051N Transmitter Product data sheet.

RNII Inspection procedures have been developed for the source and receiving inspections and the performance testing. The sample size for the source inspection and the visual receipt inspection will be 100%. The level of sampling for the performance testing will follow a 95/05 plan in accordance with Draft Regulatory Guide DG-1070.

The destructive testing will be performed on one unit out of every fifty received by RNII. RNII Receiving Inspection will coordinate this effort. Controls provided by the RNII Quality Assurance Program prevent units used in destructive testing, or in any test activities that could result in shortened life or reduced accuracy, from being sold to customers.

RNII will repeat commercial grade surveys of RMD on a triennial basis to verify that the established systems remain in effect to assure that changes to the design of the 3051C transmitter do not adversely affect the information published in the 3051N Transmitter Product Data Sheet.

Conclusions

The results of the RNII commercial grade survey of RMD and the qualification and dedication activities described above are considered to provide reasonable assurance that the 3051N will perform in accordance with the specifications provided in the 3051N Transmitter Product Data Sheet (Reference 7). Tables 2-2 through 2-6 below summarize the critical characteristics, acceptance methods, and acceptance criteria. See the current revision of the Rosemount 3051N Commercial Grade Dedication Report (Reference 9) for the current list of critical characteristics, acceptance methods, and acceptance criteria.

Based on the information gathered from the dedication and qualification activities described above, it is concluded that there is sufficient objective evidence of adequate design process, product quality, and dependability to accept Software Release 4 of the Rosemount 3051N transmitter for use in nuclear safety-related and non-safety-related applications, when properly applied as described in this report and in the vendor's technical instructions. Similarly, sufficient objective evidence of adequate design process and product quality was identified and reviewed to accept the 275 for use as M&TE with the 3051N transmitter, so long as the utility takes reasonable steps to assure proper training and provides appropriate guidance for technicians and engineers for configuring, installing, and testing the 3051N.

Table 2-2
Physical Configuration

Critical Characteristic	Acceptance Method	Acceptance Criteria
Pressure Type	Receipt Inspection	Per 3051N Product Data Sheet
Range Code	Receipt Inspection	Per 3051N Product Data Sheet
Output Code	Receipt Inspection	Per 3051N Product Data Sheet
Process Connections	Receipt Inspection	Per 3051N Product Data Sheet & Thread Size per Applicable Standard
Isolating Diaphragm	Receipt Inspection	Per 3051N Product Data Sheet
Fill Fluid	Receipt Inspection	Per 3051N Product Data Sheet
Housing and Cover Materials	Receipt Inspection	Per 3051N Product Data Sheet & Thread Size per Applicable Standard
Options (Brackets, Meters)	Receipt Inspection	Per 3051N Product Data Sheet
Nonhardware Options (Calibration data sheets, Hydro testing)	Receipt Inspection, Source Inspection	Per 3051N Product Data Sheet & Certification
Software Requirements	Receipt Inspection	Correct Revision Level
Process Connections	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Process isolating Diaphragms	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Drain/Vent Valves	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Wetted O-Rings	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard

Table 2-3
Materials of Construction (Non-Wetted)

Critical Characteristic	Acceptance Method	Acceptance Criteria
Housing and Covers	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Module Housing	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Bolts	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Fluid Fill	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard
Paint	Receipt Inspection	Per 3051N Product Data Sheet
Cover O-Rings	Commercial Grade Vendor Survey and Destructive Testing	Chemical and Physical Properties per Applicable Standard

Table 2-4
Performance Specifications

Critical Characteristic	Acceptance Method	Acceptance Criteria
Reference Accuracy	Commercial Grade Vendor Survey and Performance Testing	Per 3051N Product Data Sheet
Ambient Temperature Effect	Commercial Grade Vendor Survey and RNII Engineering Evaluation	Per 3051N Product Data Sheet
Static Pressure Effect	Commercial Grade Vendor Survey and Performance Testing	Per 3051N Product Data Sheet
Dynamic Performance Dead Time Update Rate	Commercial Grade Vendor Survey and Performance Testing	Per 3051N Product Data Sheet
Mounting Position Effects	Commercial Grade Vendor Survey and Performance Testing	Per 3051N Product Data Sheet
Seismic	RNII Test Report, Commercial Grade Vendor Survey, and RNII Engineering Evaluation	Per 3051N Product Data Sheet
Power Supply Effect	Commercial Grade Vendor Survey and Performance Testing	Per 3051N Product Data Sheet
EMC (EMI/RFI) Effects	Third Party Test Lab report, independent review to compare to EPRI TR-102323 requirements. Commercial Grade Vendor Survey and RNII Engineering Evaluation	Per 3051N Product Data Sheet
Overpressure Effect	Commercial Grade Vendor Survey and RNII Engineering Evaluation	Per 3051N Product Data Sheet
Drift	Commercial Grade Vendor Survey and RNII Engineering Evaluation	Per 3051N Product Data Sheet

Table 2-5
Specification Limits

Critical Characteristic	Acceptance Method	Acceptance Criteria
Sensor Limits – Minimum Span	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Power Supply Limits	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Overpressure Limits	Commercial Grade Vendor Survey and Destructive Testing	Per 3051N Product Data Sheet
Static Pressure Limits	Commercial Grade Vendor Survey and Destructive Testing	Per 3051N Product Data Sheet
Burst Pressure Limits	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Temperature limits Ambient, Storage, Process	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Humidity Limits	Commercial Grade Vendor Survey and Destructive Testing	Per 3051N Product Data Sheet
Turn on Time	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Volumetric Displacement	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet
Damping	Commercial Grade Vendor Survey and Rosemount Engineering Evaluation	Per 3051N Product Data Sheet

Table 2-6
Dependability - Not Addressed in the Product Data Sheet

Critical Characteristic	Acceptance Method	Acceptance Criteria
Quality of Design and Manufacture, Part 1	Commercial Grade Survey review of the RMD quality program against the applicable requirements of ISO 9001. (Note: This does not assume that an ISO 9001 program is equivalent to a 10 CFR 50 Appendix B program. However, it does credit the ISO program as a contributing element, in conjunction with other factors, that helps establish reasonable assurance that the device is of high quality.)	Established and Documented Quality Program in accordance with ISO 9001. Quality program addresses the 20 parts identified in ISO 9001 including • Quality staff and organization • Quality plans and procedures • Evidence of the Quality program implemented in the production of the 3051C Practices reflect an emphasis on total quality management and continuous product and process improvement.
Quality of Design and Manufacture, Part 2	Critical Digital Review performed by third party based on the guidance provided by EPRI TR-106439 including: • assess the design integrity, built-in quality and dependability of the 3051C • perform architecture review of the 3051C and 275 devices • review of their hardware and software development, validation and testing processes, and an analysis of failure mechanisms of the major 3051C components. The review consisted of documentation reviews and technical interviews with key personnel knowledgeable in the above areas, and technical reviews of design and development documentation, including internal design control procedures.	RMD software development process includes: • Software development plan and organization • Documented design requirements including software requirements • Requirements traceability • Documented software design descriptions • Documented V&V plan • Validation test reporting Evidence that the software development process has been followed for the latest revisions of the software. The CDR evaluated the significant architectural aspects of the 3051C and found the design acceptable.

Critical Characteristic	Acceptance Method	Acceptance Criteria
Quality of Design and Manufacture, Part 3	Operating History review performed by third party. The operating history review demonstrated product stability, reliability and freedom from critical software related errors or failures in similar applications.	Documented product operating history showing product stability, reliability, and freedom from critical software errors or failures in similar applications.
Quality of Design and Manufacture – Summation	The Commercial Grade Survey, Critical Digital Review and Operating History review taken together demonstrate adequate quality of the device.	These factors taken together (Quality Program in accordance with ISO 9001, software development process, and Operating History) demonstrate adequate device quality.
Failure Modes and Failure Management	The Critical Digital Review (CDR) included a review of the failure analysis performed by RMD and an independent failure analysis performed by the third party. The CDR documented the normal failure analysis practices at RMD. The independent failure analysis review included a review of the failure mechanisms of the 3051C that are digital in nature.	Failure modes are adequately addressed based on failure analysis.
Problem Reporting	Review the error reporting and corrective action processes during the Commercial Grade Survey and Critical Digital Review. RNII Engineering Evaluation	RMD has an established problem reporting methodology that will provide reports of problems directly to RNII. RMD will also initiate corrective action through an established RMD program.
Reliability	The Commercial Grade Survey, Critical Digital Review, and Operating History Review. RNII Engineering Evaluation	Commercial Grade Survey, Critical Digital Review, and Operating History Review results indicate that the device is highly reliable.
Configuration Control Fit, Form, and Function Change Control (Reporting System)	Review configuration control during the Commercial Grade Survey. RNII Engineering Evaluation	RMD has a configuration control program that includes: • Documented plans and procedures • Baseline maintenance • Change control • Error-reporting process

3
REFERENCES

1. EPRI TR-106439, "Guideline on Evaluation and Acceptance of Commercial Digital Equipment for Nuclear Safety Applications," October 1996

2. EPRI TR-107339, "Evaluating Commercial Digital Equipment for High Integrity Applications," December 1997

3. USNRC Standard Review Plan, Branch Technical Position HICB-14, "Guidance on Software Reviews for Digital Computer-Based Instrumentation and Control Systems"

4. IEEE Standard 7-4.3.2-1993, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations"

5. EPRI TR-102323-R1, "Guidelines for Electromagnetic Interference Testing in Power Plants," Revision 1; Electric Power Research Institute, January 1997

6. USNRC Safety Evaluation Report dated April 17, 1996; Review of EPRI Utility Working Group Topical Report TR-102323, "Guidelines for Electromagnetic Interference Testing in Power Plants"

7. Rosemount Nuclear Instruments, Inc., "Model 3051N Smart Pressure Transmitter Dedicated for Nuclear Service," Part Number 00813-0100-4808 Rev. AA

8. Rosemount 3051N Seismic Qualification Test Report, Rosemount Report Number D2000059 Rev. A

9. Rosemount Nuclear Instruments, Inc., 3051N Commercial Grade Dedication Report, Rosemount Report Number D2000055 Rev. A

A
APPENDIX

Rosemount Model 3051C Smart Transmitter
Operating History Review Questionnaire

Contact Information

Person Contacted:
Company:
Telephone #:

Application Information

No. Units Installed:
No. Units Purchased:
Length of Service (average):
Model Number(s):
Transmitter Application(s):
Transmitter critical to operations (used in Safety Instrumented System, Emergency Shutdown System, or in an economically sensitive function)?
Transmitter response speed and/or accuracy critical? If so, what response speed and/or accuracy are required?
Transmitter Environment (heat, humidity, EMI, etc.):

Transmitter Configuration/Function

How is the transmitter configured – HART 275, 268, other?
Configuration is constant or frequently changed?
What configuration options do you use – i.e. square root, damping, etc?
How do you handle configuration security – i.e. jumper, local key software lockout or physical removal? Have you ever improperly configured the transmitter with the HART communicator?
Do you use the transmitter as a 4-20 mA device or do you multidrop transmitters? If multidrop, how many transmitters on a pair of wires?

Do you use the local LCD meter? Is it worth having?
How do you calibrate the transmitter – with the HART communicator or with the local ZERO and SPAN adjustments? What is the calibration frequency?

Failures

No. Failed Units:
Reasons for Failure (if known):
Did transmitter fail to the desired output (high or low)?
Effects of Failure:
Corrective Actions (e.g. replace unit, reset system, shut down, etc.):
Transmitter Failure Rates/Replacement/Failure Cause Tracked?
Were you satisfied with Rosemount's response to your failed transmitter?

General

Are there any unfavorable features or unexpected characteristics of the transmitter that you would warn prospective users about?
In retrospect, would you purchase the 3051C smart transmitter again for the same application?

Target:

Nuclear Power

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EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com