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TECHNICAL REPORT

colour inside

Nuclear power plants – Instrumentation and control important to safety – Use and selection of wireless devices to be integrated in systems important to safety

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – USE AND SELECTION OF WIRELESS DEVICES TO BE INTEGRATED IN SYSTEMS IMPORTANT TO SAFETY

FOREWORD

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IEC TR 62918, which is a technical report, has been prepared by subcommittee 45A: Instrumentation, control and electrical systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
45A/947/DTR	45A/963/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

a) Technical background, main issues and organisation of the Standard

The ad hoc meeting of the IEC Technical Working Group on Nuclear Power Plant Control and Instrumentation, held in Yokohama in May 2009, resulted in the recommendation to develop a technical report addressing the applicability of incorporating wireless technology throughout nuclear power plant systems, regardless of the categorizations such as non-safety, important to availability and important to safety.

This technical report addresses this recommendation and one of its main objectives is to pave the way for the development of a standard on the topic. The technical report addresses concerns regarding the application, safety and security of integrating wireless technologies into the systems of nuclear power plants. It reviews the motivation for use of wireless applications in nuclear power plants, wireless technology considerations, and the feasibility of incorporating wireless technology in nuclear power plants.

It is intended that this Technical Report be used by operators of NPPs (utilities), systems evaluators and by licensors.

b) Situation of the current Technical Report in the structure of the IEC SC 45A standard series

IEC 62918 as a technical report is a fourth level IEC SC 45A document.

For more details on the structure of the IEC SC 45A standard series, see item d) of this introduction.

c) Recommendations and limitations regarding the application of this Technical Report

It is important to note that a technical report is entirely informative in nature. It gathers data collected from different origins and it establishes no requirements.

d) Description of the structure of the IEC SC 45A standard series and relationships with other IEC documents and other bodies' documents (IAEA, ISO)

The top-level document of the IEC SC 45A standard series is IEC 61513. It provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 61513 structures the IEC SC 45A standard series.

IEC 61513 refers directly to other IEC SC 45A standards for general topics related to categorization of functions and classification of systems, qualification, separation of systems, defence against common cause failure, software aspects of computer-based systems, hardware aspects of computer-based systems, and control room design. The standards referenced directly at this second level should be considered together with IEC 61513 as a consistent document set.

At a third level, IEC SC 45A standards not directly referenced by IEC 61513 are standards related to specific equipment, technical methods, or specific activities. Usually these documents, which make reference to second-level documents for general topics, can be used on their own.

A fourth level extending the IEC SC 45A standard series, corresponds to the Technical Reports which are not normative.

IEC 61513 has adopted a presentation format similar to the basic safety publication IEC 61508 with an overall safety life-cycle framework and a system life-cycle framework. Regarding nuclear safety, it provides the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector, regarding nuclear safety. In this framework IEC 60880 and IEC 62138 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 refers to ISO as well as to IAEA GS-R-3 and IAEA GS-G-3.1 and IAEA GS-G-3.5 for topics related to quality assurance (QA).

The IEC SC 45A standards series consistently implements and details the principles and basic safety aspects provided in the IAEA code on the safety of NPPs and in the IAEA safety series, in particular the Requirements SSR-2/1, establishing safety requirements related to the design of Nuclear Power Plants, and the Safety Guide NS-G-1.3 dealing with instrumentation and control systems important to safety in Nuclear Power Plants. The

terminology and definitions used by SC 45A standards are consistent with those used by the IAEA.

NOTE It is assumed that for the design of I&C systems in NPPs that implement conventional safety functions (e.g. to address worker safety, asset protection, chemical hazards, process energy hazards) international or national standards would be applied, that are based on the requirements of a standard such as IEC 61508.

NUCLEAR POWER PLANTS – INSTRUMENTATION AND CONTROL IMPORTANT TO SAFETY – USE AND SELECTION OF WIRELESS DEVICES TO BE INTEGRATED IN SYSTEMS IMPORTANT TO SAFETY

1 Scope

This Technical Report describes the state of wireless technology for industrial applications in fossil and chemical plants and discusses the specific issues to be addressed in order to apply wireless technologies to nuclear power plants.

The review of the technology behind wireless communication and the status of existing implementations are described in Clauses 7 and 8, respectively. Issues associated with wireless implementations in nuclear facilities are discussed in Clause 10, and final conclusions are presented in Clause 11 of this Technical Report.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61513, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

IEC 62591, *Industrial communication networks – Wireless communication network and communication profiles – WirelessHART™*

IEC PAS 62734, *Industrial communication networks – Fieldbus specifications – Wireless systems for industrial automation: process control and related applications (Based on ISA 100.11a)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
access control
protection of system resources against unauthorized access; a process by which use of system resources is regulated according to a security policy and is permitted by only authorized entities (users, programs, processes, or other systems) according to that policy

3.2
authenticate
verify the identity of a user, user device, or other entity, or the integrity of data stored, transmitted, or otherwise exposed to unauthorized modification in an information system, or to establish the validity of a transmission

3.3
communications protocol
set of standard rules for data representation, signaling, authentication and error detection required to send information over a communications channel

3.4
cybersecurity
actions required to preclude unauthorized use of, denial of service to, modifications to, disclosure of, loss of revenue from, or destruction of critical systems or informational assets

3.5
Defense in Depth
DiD
application of more than one protective measure for a given safety objective, such that the objective is achieved even if one of the protective measures fails

[SOURCE: IAEA Safety Glossary, edition 2007]

3.6
denial of service
prevention or interruption of authorized access to a system resource or the delaying of system operations and functions

3.7
Distributed Control System
DCS
type of control system in which the system elements are dispersed but operated in a coupled manner. A DCS is similar to a supervisory control and data acquisition (SCADA) system except that a DCS is usually located within a more confined area (such as a factory). It uses a high-speed communications medium, which is usually a separate wire (network) from the factory's primary local area network (LAN). A significant amount of closed-loop control can reside in the DCS.

3.8
Electromagnetic Compatibility
EMC
capacity of electrical equipment or system to function satisfactorily in its electromagnetic (EM) surroundings without radiating EM disturbance variables that are unacceptable for other equipment in these surroundings. Requirements are balanced with regard to interface transmission and immunity in case of EMC.

3.9
encryption
cryptographic transformation of data (called plaintext) into a form (called ciphertext) that conceals the data's original meaning to prevent it from being identified or used by outsiders. Decryption is the corresponding reversal process

3.10
Industrial, Scientific and Medical band
ISM band
section of radio spectrum allocated by the International Telecommunication Union (ITU) and many national regulators to ISM use. Radio communication systems that use these frequency bands are typically free for use but typically operate under a "license- exempt" regime that sets limits on power, spectrum spreading techniques, or duty cycles. Any device that transmits in the ISM bands must be "type-approved."

3.11
interoperability
ability of diverse systems and organizations to work together (inter-operate)

3.12
Intrusion Detection System
IDS
type of security management service for computers and networks. An intrusion detection system (IDS) monitors, gathers, and analyses information from various areas within a device or a network to identify possible security breaches, including intrusions and misuse.

3.13
risk assessment
process of systematically identifying potential vulnerabilities to valuable system resources and threats to those resources; quantifying loss exposures and consequences based on probability of occurrence; and [optionally] recommending how to allocate resources to countermeasures to minimize total exposure

3.14
trustworthiness
likelihood that an entity will behave as expected. In the context of industrial automation, attributes of trustworthiness include reliability, security, and resiliency

3.15
Virtual Private Network
VPN
VPN extends a private network and the resources contained in the network across public networks like the Internet. It enables a host computer to send and receive data across shared or public networks as if it were a private network, with all the functionality, security and management policies of the private network

3.16
vulnerability
flaw or weakness in a system's design, implementation, or operation and management that could be exploited to violate the system's security policy

4 Motivation

Aging nuclear power plant equipment and systems can benefit from additional instrumentation to detect and prevent equipment faults. Installing wired sensors into existing plant can be costly, cumbersome, and time consuming. In addition, as shown in Figure 1, the cost of installing wired sensor is often higher than the actual sensor itself. A wireless sensor network can eliminate cost of installing wires for the transmission of sensed data.

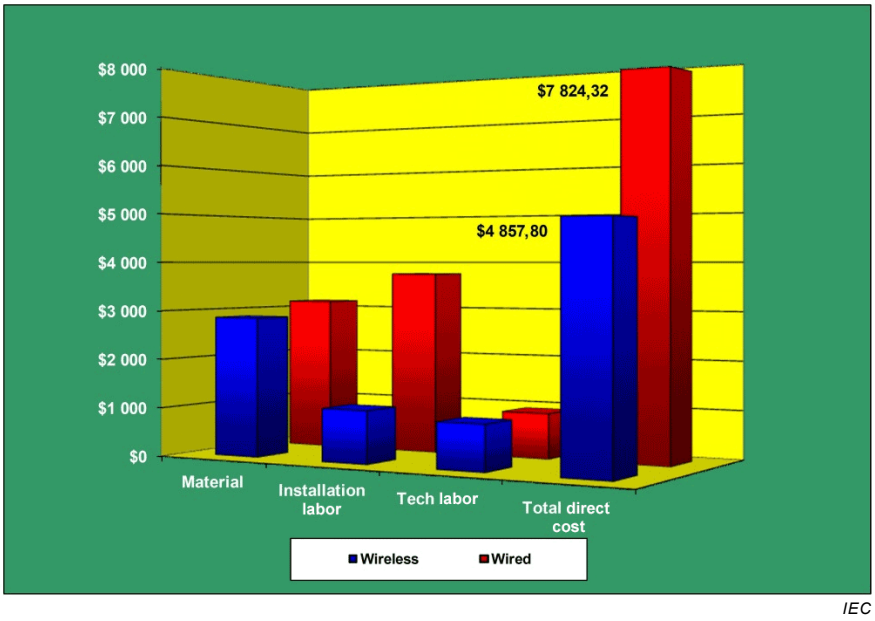

Figure 1 – Cost comparison – Wired versus wireless for an extensive building automation system

In many instances, a sensor network may be installed in one area of a facility while the sensor readings are to be used somewhere else at the facility (i.e., not within the RF coverage of the sensor network). In such a situation, some form of backhaul network is to be used to get the readings from point A to point B. Both nuclear and traditional fossil power plants have found it financially beneficial to use the same backhaul for the transport of differing types of information (such as security video, sensor readings (from condition monitoring instrumentation), and voice). Such "triple play" usage may further enhance the return on investment (ROI) associated with any or all aspects of such a wireless installation. Process and/or Important to Safety wireless networks shall have a documented specification and only carry data that complies with this specification. Wireless technology enhances facility maintainability since wireless devices are easily upgraded or replaced without major infrastructure impact as technology and or needs change. The general application of wireless technologies in power generation facilities – and in particular nuclear power plants – is far from static. In a 2009 article [3][1], the results of a survey yielded the wireless usage assessment, shown here as Figure 2.

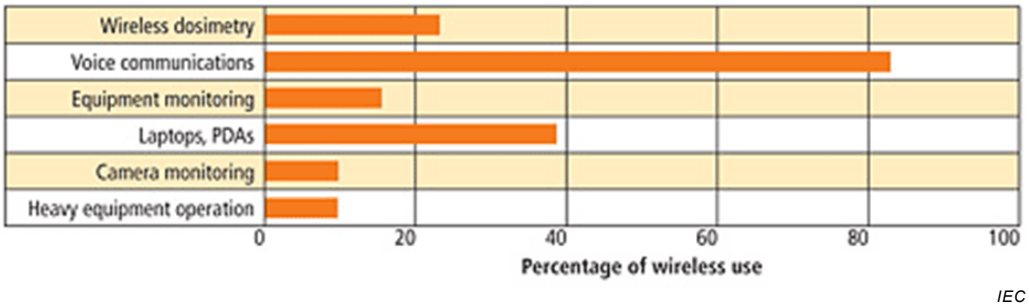

Figure 2 – Wireless use in nuclear power plants

Furthermore, this article related the wide range of possible applications of wireless technology within the nuclear power plant setting. The associated graphic is presented as Figure 3.

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1 Number in square brackets refer to the Bibliography.

In 2006, a study ascertained the state of the art in wireless technology and the implications for nuclear power facilities. The resulting document [30], presented a broad ranging examination of areas where wireless systems could benefit nuclear facilities. The following text, extracted from the report, sets the stage:

> *As the nuclear power industry moves to upgrade many of its older electronic systems, wireless technology may become an attractive alternative to wired systems. One of the largest costs in upgrading systems at nuclear facilities is the cost of running cables in this environment. When cost is considered, the perceived benefit of deploying wireless technology becomes clear. The benefits of using wireless systems in nuclear facilities could expand the argument for cost savings to include the possibility of ubiquitous (ever-present) sensing. To deploy an extensive number of sensors in the current nuclear environment would be cost-prohibitive because of cabling costs. However with wireless technology, additional types of sensors could be deployed to provide a more in-depth understanding of the area or process being monitored. In addition, the number of sensors of any given type could be increased, thereby improving redundancy. Also, with wireless technology, diversity in the types of sensors could be used to improve reliability.*

A specific tenor of that report is summarized in the following statement:

There could also be safety benefits.

Nuclear plant system	Wireless measurement(s)	Application
Heat exchangers	Temperature	Monitor ambient temperature to take into account the effects of such factors as seasonal changes in weather.
Secondary side valves	Position indication	Replace periodic, labor-intensive valve indication readings with continuously monitored wireless measurements.
Inlet water intake	Level, temperature, flow	Monitor factors that affect performance such as changes in level, seasonal temperature variations, and intake flow.
Rotating equipment (pumps, valves, motors, compressors, fans)	Temperature, vibration, motor current	Monitor temperatures, vibration signatures, and load fluctuations to assess condition and improve performance.
Diesel generators	Temperature, level, vibration, motor current	Augment existing sensor readings to provide redundancy and comprehensive performance assessment.
Spent fuel dry cask storage	Temperature, radiation	Eliminate need for underground cabling and conduit by monitoring temperature and radiation with wireless sensors.
Weather station	Temperature, wind velocity, pressure, humidity, etc.	Improve monitoring by replacing failure-prone equipment and cabling with wireless measurements.

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Figure 3 – Possible application areas for wireless instrumentation in a nuclear power plant

In conclusion, the motivation for use of wireless technologies is strong, with several applications already seeing use in nuclear power plants currently. It is likely that the current pace of technology deployment will at least continue and may accelerate in the near term. This technical report includes information important to technology adopters and current users by showcasing the current technologies and applications available in this growing field.

5 Generic applications

The deployment and value of industrial wireless is based on two broad application classes; those requiring mobility and those derived from the reduced cost of attachment – not having