WORLD NUCLEAR ASSOCIATION

International Nuclear I&C and Electrical System Standards Tables with URLs

Version 1, May 2020

Cooperation in Reactor Design Evaluation and Licensing Working Group

This document brings together the nuclear power plant instrumentation & control and electrical system standards used by the Institute of Electrical and Electronics Engineers (IEEE) and International Electrotechnical Commission (IEC) communities. Both sets of standards are used in different parts of the world. This document is intended as a starting point for identifying similarities and conflicts between the two sets of standards to facilitate harmonization.

The base nuclear safety requirements in this area are given by the International Atomic Energy Agency (IAEA) on the IEC side and the US Nuclear Regulatory Commission (NRC) on the IEEE side. For the IEC the IAEA safety standards, most notably SSR-2/1, SSG-30, SSG 34, SSG 39 and SSG 51, lay out requirements and high-level recommendations that are used within the IEC domain. For IEEE, the NRC regulations given in 10 CFR 50 provide the main requirements, but NRC also promulgates standards in the form of Regulatory Guides that describe practices NRC considers acceptable. Often these Regulatory Guides qualify consensus standards with clarifications and modifications that NRC considers necessary. In addition, certain NRC "NUREG" documents, while they have no official regulatory function, act as de-facto standards.

IEC SC45A is the main IEC subcommittee responsible for nuclear facility standards, but the nuclear community also makes use of standards from IEC SC45B (Radiation Protection), TC65 (Industrial Process Measurement Control and Automation), and TC77 (Electromagnetic Compatibility).

The IEEE Nuclear Power Engineering Committee (NPEC) is the main committee responsible for IEEE nuclear facility standards, but a number of other entities participate. These include the IEEE Computer Society, the IEEE N42.18 Committee, IEEE Power and Energy Committee, IEEE Energy Development and Power Generation Committee, IEEE Switchgear Committee, IEEE Protective Relay Committee, IEEE Transformer Committee, IEEE High Voltage Surge Protection Device Committee, IEEE Stationary Batteries Committee, the International Society of Automation, the American Nuclear Society, the Health Physics Society, and the American Society of Mechanical Engineers.

This document consists of tables that show the IEC and IAEA electrical and I&C nuclear standards alongside the corresponding IEEE and NRC documents. The tables also show documents that have no equivalent.

The tables provide a basic view of the correspondence between related standards. They identify a relatively complete set of standards for electrical and I&C domains in the US. Such a listing is not thought to exist elsewhere.

Clicking in any box in the tables will take the user to further information given by the responsible standard organization. In the case of NRC, the user will be taken directly to the documents in question.

This document offers no further analysis or conclusions. Those steps are left to the reader. This document is a product of the CORDEL Digital Instrumentation & Control Task Force (DICTF) of the World Nuclear Association and it will be regularly revised following future evolutions and updates of the relevant I&C standards.

Errors and omissions should be sent to CORDEL@world-nuclear.org.

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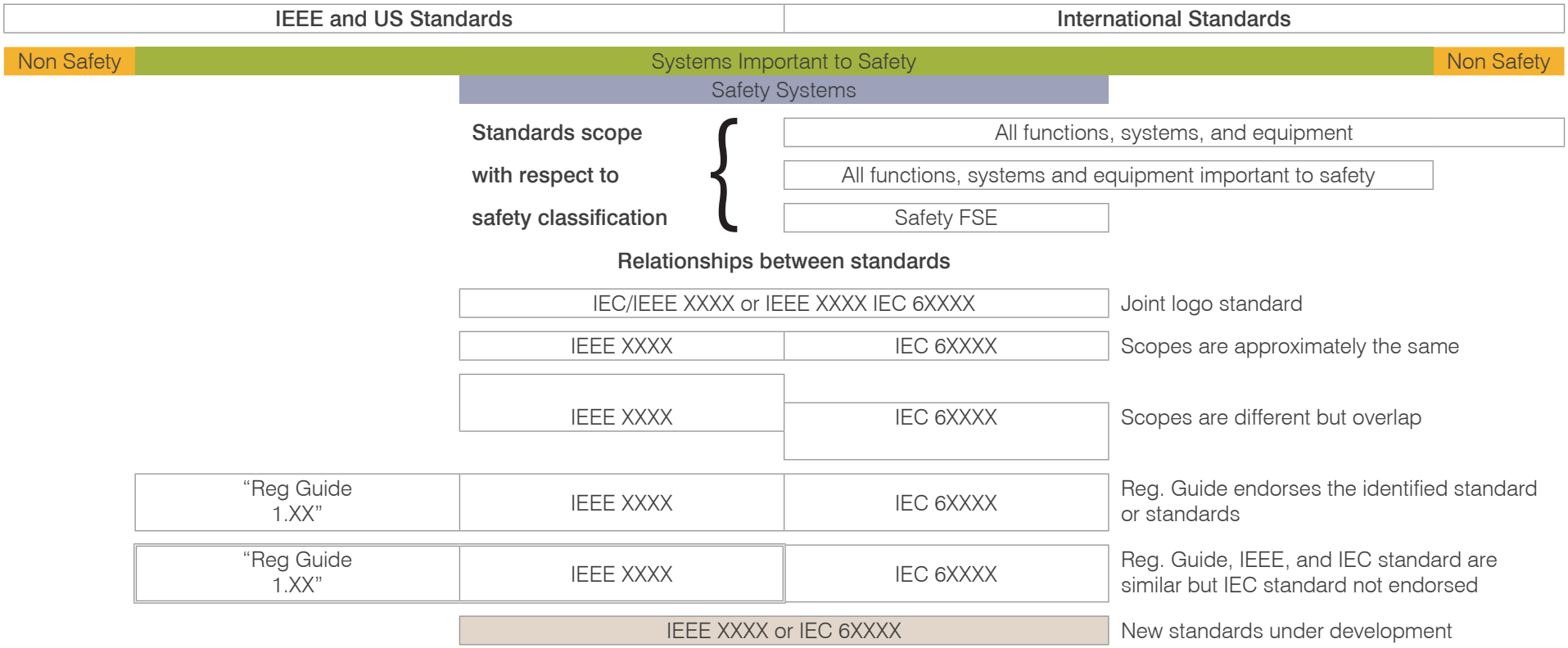
The CORDEL Secretariat of the World Nuclear Association would like to convey its gratitude to Gary Johnson [Independent Expert and ex-Senior Safety Officer at the IAEA] for collecting and providing the information in these comparison tables, to IEEE and IEC colleagues for agreeing to use the respective information for this publication, and also to colleague Richard Petrie for his assiduous work in designing this reference tool.

Key to Tables

Scope of Page



Notes

1 To allow for compact presentation of this material, the standard names given in this document are shortened by omitting the full name of the standards organization and safety classification.

2 The boxes generally include a URL in small text. These will take you to the standards organization website for the standard. For NRC documents the URL returns the actual document.

3 Blue text and outline indicates standards that were not developed by IEC SC45A, IEEE NPEC, NRC, or IAEA.

4 Reg Guides deal with safety systems. They are shown under the green bar for readability

5 This document gives an overview of where to find related standards. It is not designed to make a detailed comparison of each standard.

6 Errors and questions should be reported to CORDEL@world-nuclear.org — Your comments will be taken into account in the following revision of the document.

Overarching Documents

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

USNRC 10 CFR 50 Domestic licensing of production and utilization facilities	IAEA SSR 2/1 Rev. 2 Safety of nuclear power plants: Design
	IAEA SSG 30 Safety Classification of Structures, Systems and Components in Nuclear Power Plants
	IAEA SSG 34 Design of electrical power systems for nuclear power plants
	IAEA SSG 39 Design of instrumentation and control systems for nuclear power plants
	IAEA SSG 51 Human factors engineering in the design of nuclear power plants
	National regulations

IEEE 603™-2018
Standard criteria for safety systems

IEEE 279™-1971
Criteria for protection systems

IEC 61508:2010
Functional safety of electrical/electronic/programmable electronic safety-related systems

IEC 61513:2011
Instrumentation and control important to safety - General requirements for systems

Notes

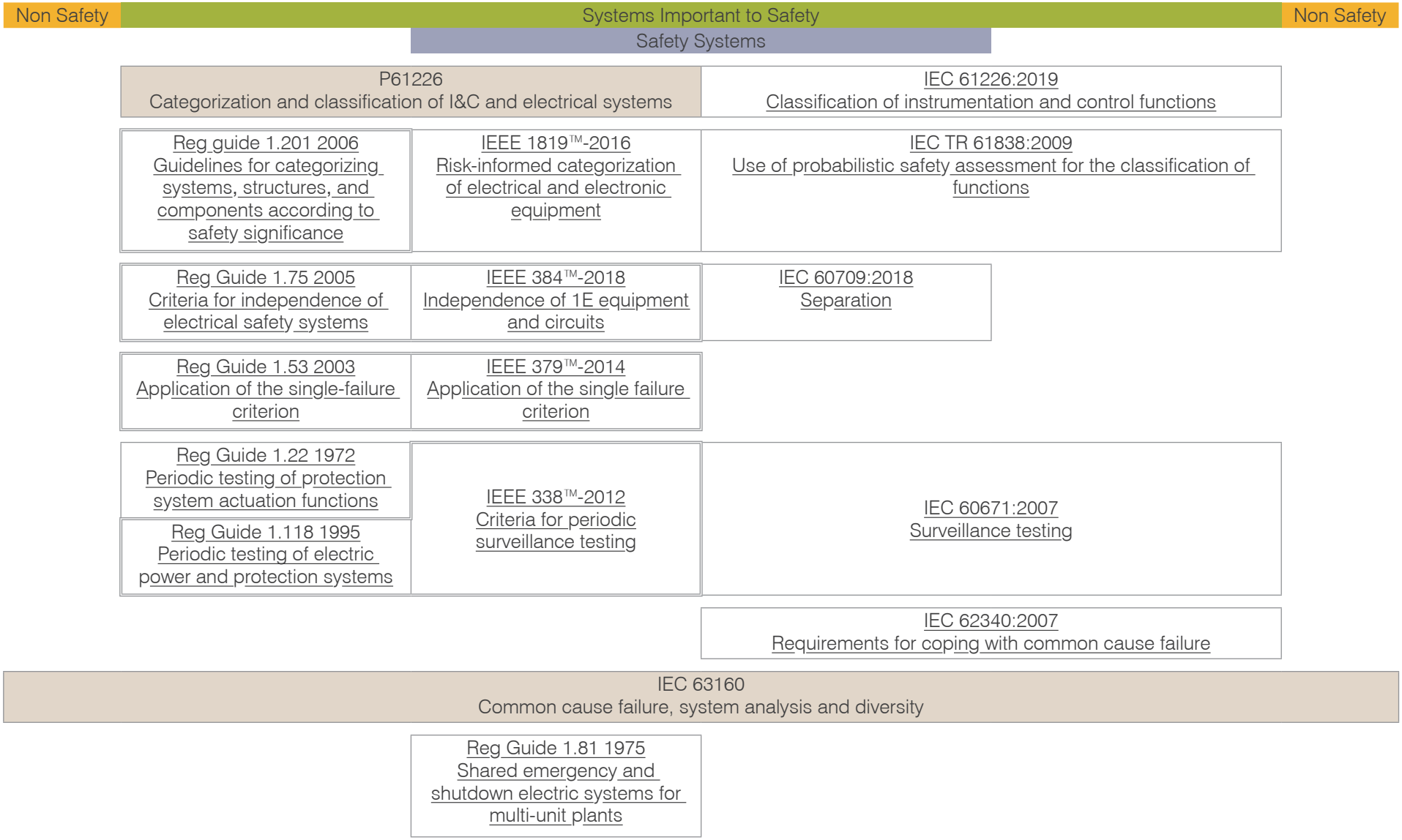
1 IEEE 603-1991, IEEE 279-1971 and IEEE 279-1968 are incorporated into the requirements of 10 CFR 50. Each plant must comply with one of these depending upon the date of the plants construction permit. For plants having construction permits issued before January 1, 1971 the requirements analogous to the IEEE-603 and IEEE-279 series are given in plant licensing documents.

2 The scopes of IAEA SSG 39 and IEC 61513 are quite different from IEEE 603™ but together they address most, if not all, of the requirements given in IEEE 603™

3 Within IEC, IEC 61513 is considered to be a nuclear specific implementation of IEC 61508

4 IEC 61508 has seven parts

Safety Methods

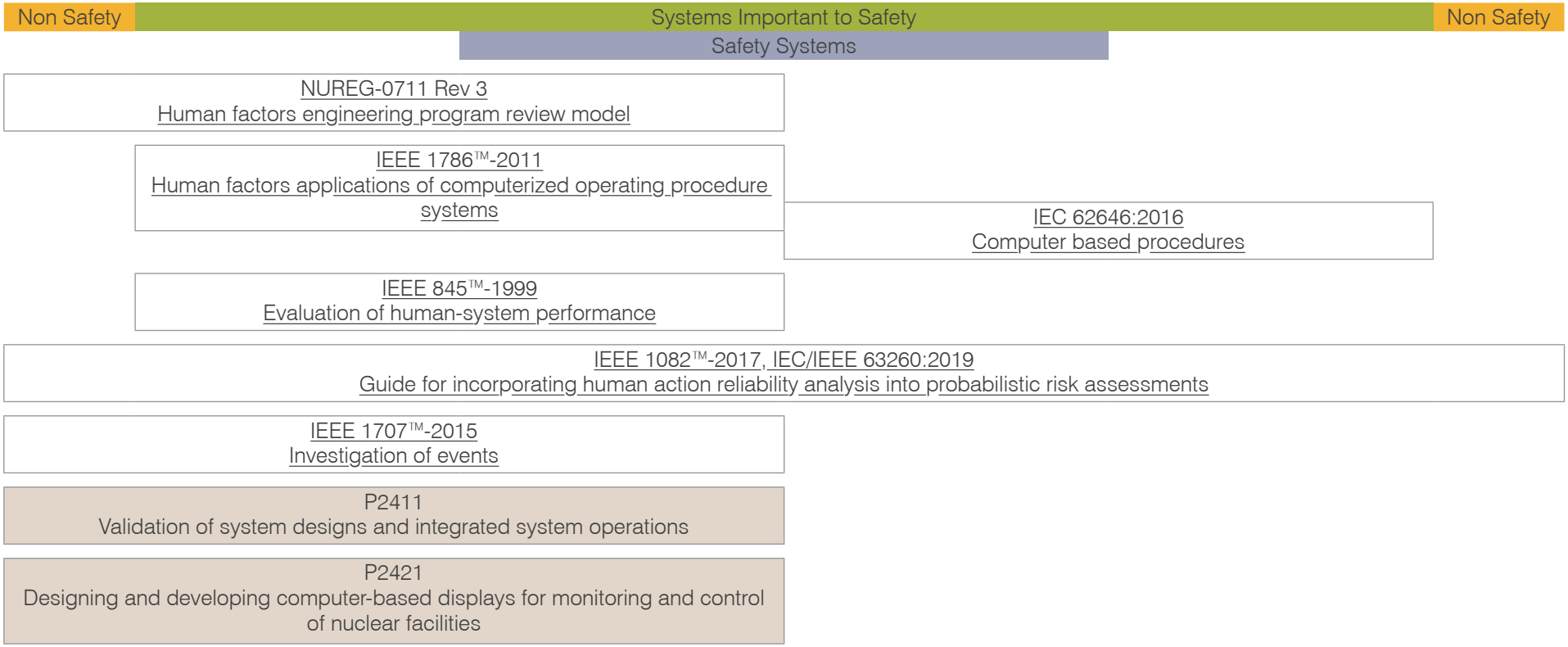


Notes

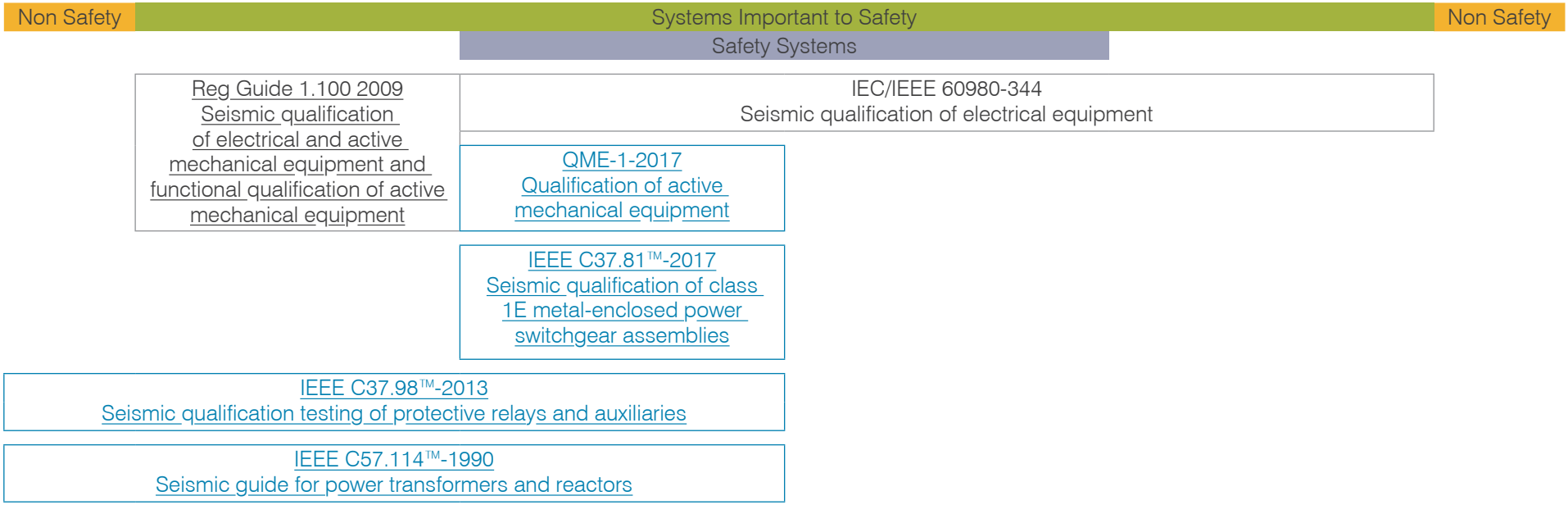
RG 1.81 is concerned with system interactions. Sharing of onsite power systems at multi-unit power plant sites generally results in a reduction in the number and capacity of the onsite power sources to levels below those required for the same number of units located at separate sites. The reduced capacity could cause undesirable interactions. Examples of such interactions are (1) the interconnection of engineered safety feature (ESF) control circuits of each unit such that failures and maintenance or testing operations in one unit affect the availability of ESF in other units, (2) coordination required between unit operators in order to cope with an accident in one unit and safe shutdown of the remaining unit(s), and (3) system overload conditions as a consequence of real accident in a unit coincident with a false or spurious accident signal in another unit.

Reliability and Hazards Analysis

Human Factors Engineering



Seismic Qualification



Lightning Protection

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

Reg Guide 1.204 2005 Lightning protection	IEEE 665™-1995 Generating station grounding
	IEEE 1050™-2004 Instrument and control equipment grounding
	IEEE 666™-2007 Design guide for electric power service systems
	IEEE C62.23™-2017 Surge protection

Notes

Lightning protection requirements apply to all systems - including non-safety systems
Reg Guide 1.204 endorses IEEE 666™-1991, IEEE 1051™-1996, and IEEE C62.23™-2001
IEEE 663 and IEEE 1050 are endorsed by both Reg Guide 1.180 and Reg Guide 1.204 hence they are shown twice in this document.
Reg Guide 1.204 extends the endorsement to include numerous other standards referenced in the four standards identified above

Environmental Qualification (Equipment that is typically in harsh environments)

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

Reg Guide1.89 1984 Environmental qualification of electrical equipment	IEC/IEEE 60780-323:2016 Electrical equipment important to safety- qualification
Reg Guide 1.209 2007 Qualification of safety-related computer-based I&C	

Reg Guide 1.211 2009 Qualification of safety-related cables and field splices	IEEE 383™2015 Qualifying electrical cables and splices

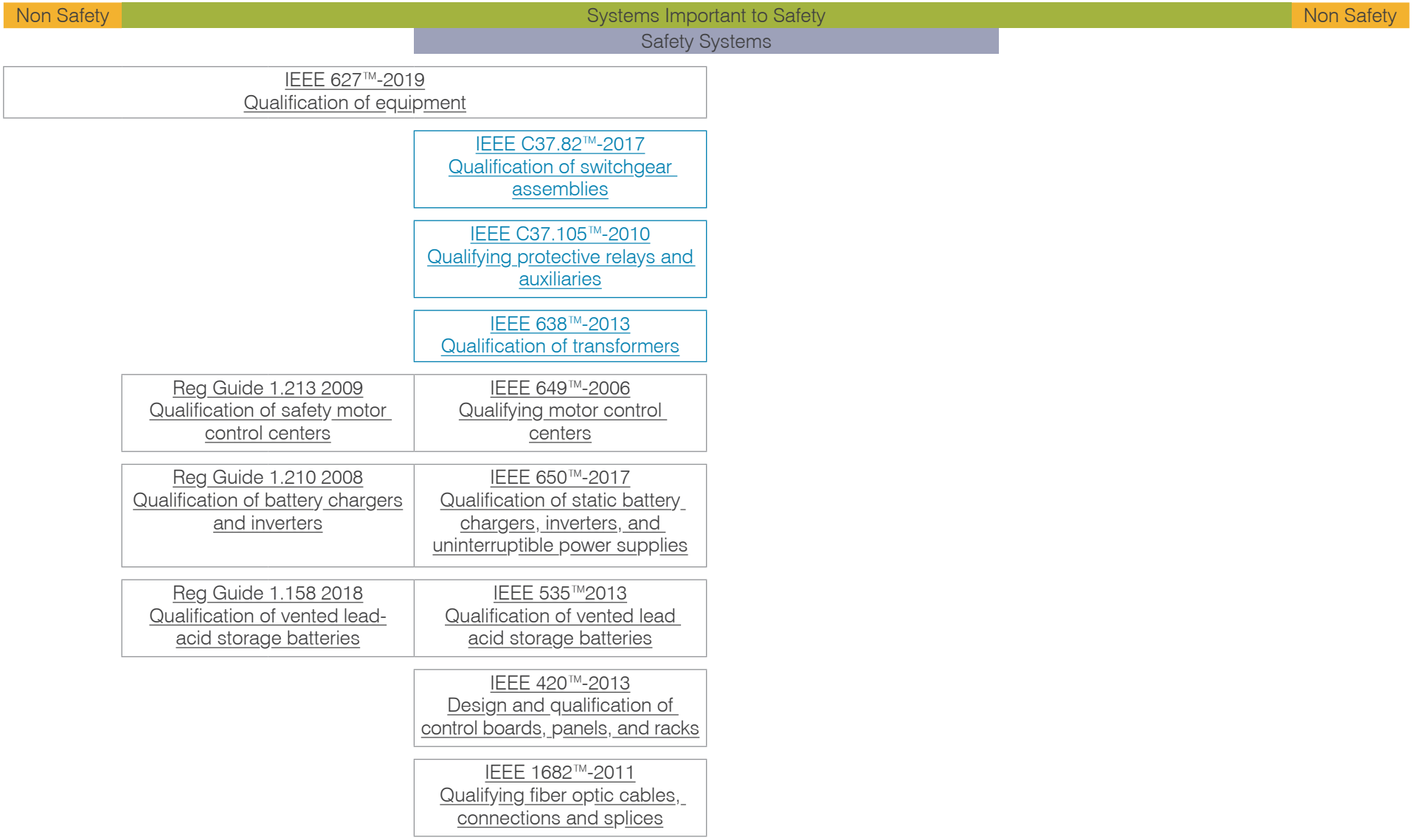
Reg Guide 1.156 2017 Qualification of connection assemblies	IEEE 572™-2019 Qualification of 1E connection assemblies

Reg Guide 1.40 2010 Qualification of continuous duty safety related motors	IEEE 334™-2006 Qualifying continuous duty 1E motors

Reg Guide 1.73 2013 Qualification tests for safety-related actuators	IEEE 382™-2019 Qualification of safety-related actuators

Notes Reg Guides 1.89 and 1.209 endorse IEEE 323™-198., Reg Guide 1.211 endorses IEEE 383™-2003. Reg Guide endorses IEEE 572™-2006. Reg. Guide 1.49 endorses IEEE 334™-2006. Reg Guide endorses IEEE 382™-2006.

Equipment Qualification (Equipment that is typically in mild environments)



Notes Reg Guide 1.210 endorses IEEE 650-2006, Reg Guide 1.210 endorses IEEE 650-2006, Reg Guide 1.158 endorses IEEE 535-2013

Electromagnetic Interference

Non Safety | Systems Important to Safety | Non Safety

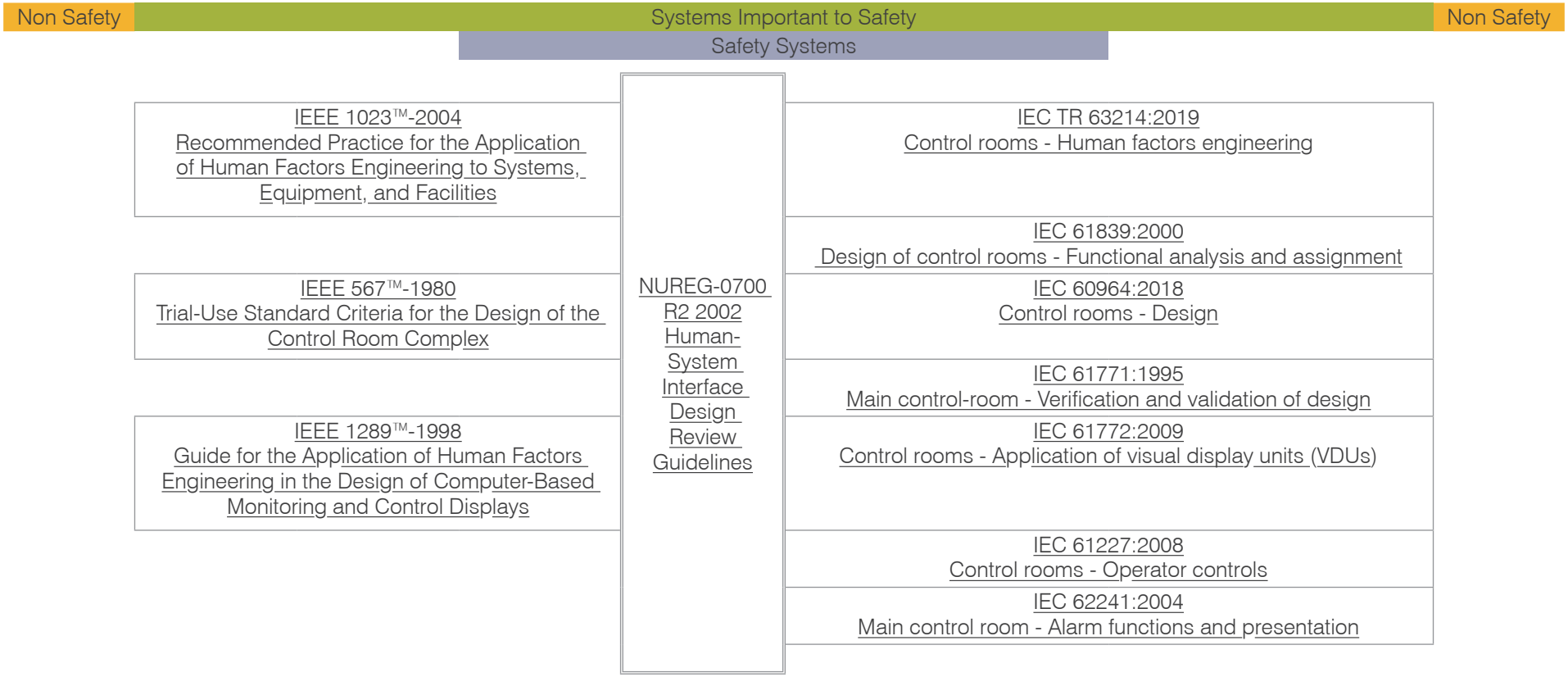
Safety Systems

Reg Guide 1.180 2019 Evaluating electromagnetic and radio frequency Interference in safety instrumentation and control systems	IEEE P2425 Electromagnetic compatibility testing of electrical, instrumentation, and control equipment	IEC 62003:2020 Requirements for electromagnetic compatibility testing
	IEC 61000 Series Electromagnetic compatibility	
	MIL-STD-461G Control of electromagnetic interference characteristics of subsystems and equipment	
	IEEE C62.41™-1991 Surge voltages in low-voltage AC power circuits	
	IEEE C62.45™-2002 Surge testing for equipment connected to Low-Voltage AC Power Circuits	
	IEEE 1050™-2004 Instrument and control equipment grounding	
	IEEE 473™-1985 Electromagnetic site survey	
	IEEE 518™-1982 Installation of electrical equipment to minimize noise inputs to controllers from external sources	
	IEC 665™-1995 Generating station grounding	

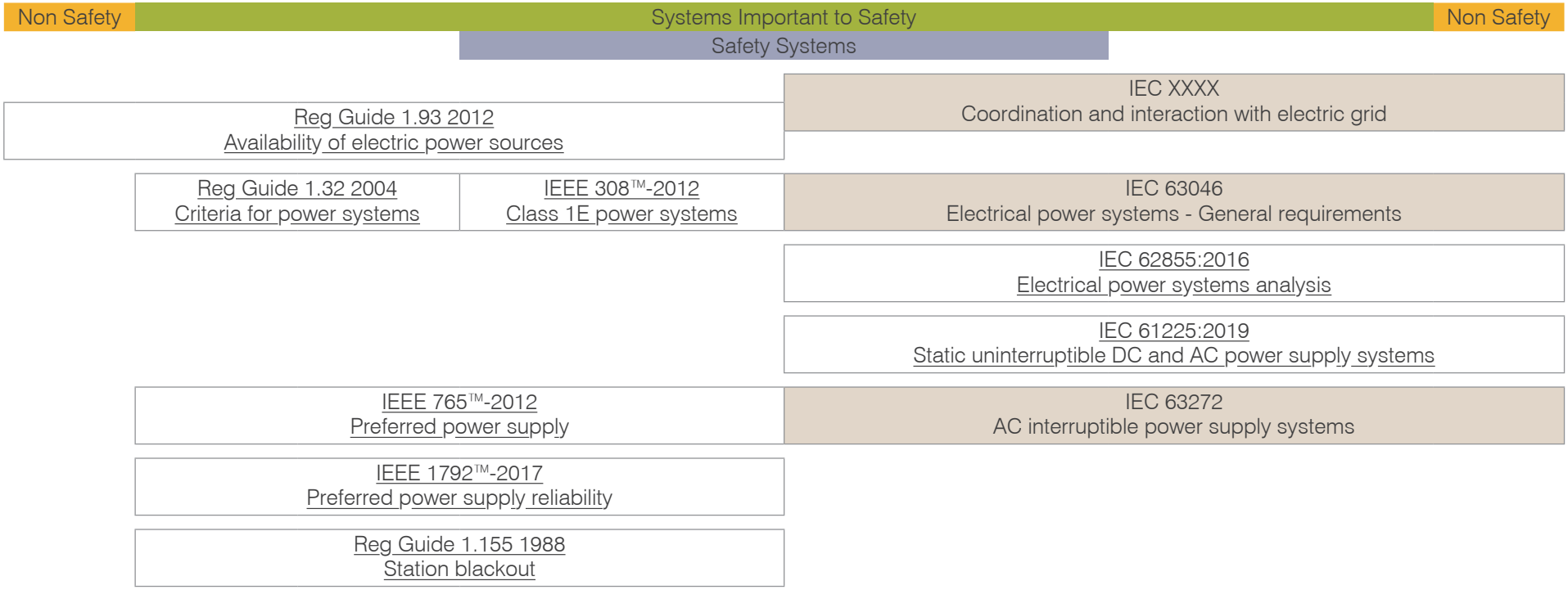
Notes

Reg Guide 1.180 endorses MIL-STD-461E, and IEEE 1050™-1996
Although the Reg Guide title deals with safety systems, all plant EMI sources must be dealt with to protect against safety system failure
The IEC 61000 series has 113 parts. Reg. Guide 1.180 and IEEE 62003 identify the specific parts to be considered
IEEE 663 and IEEE 1050 are endorsed by both Reg Guide 1.180 and Reg Guide 1.204 hence they are shown twice in this document.

Control Rooms

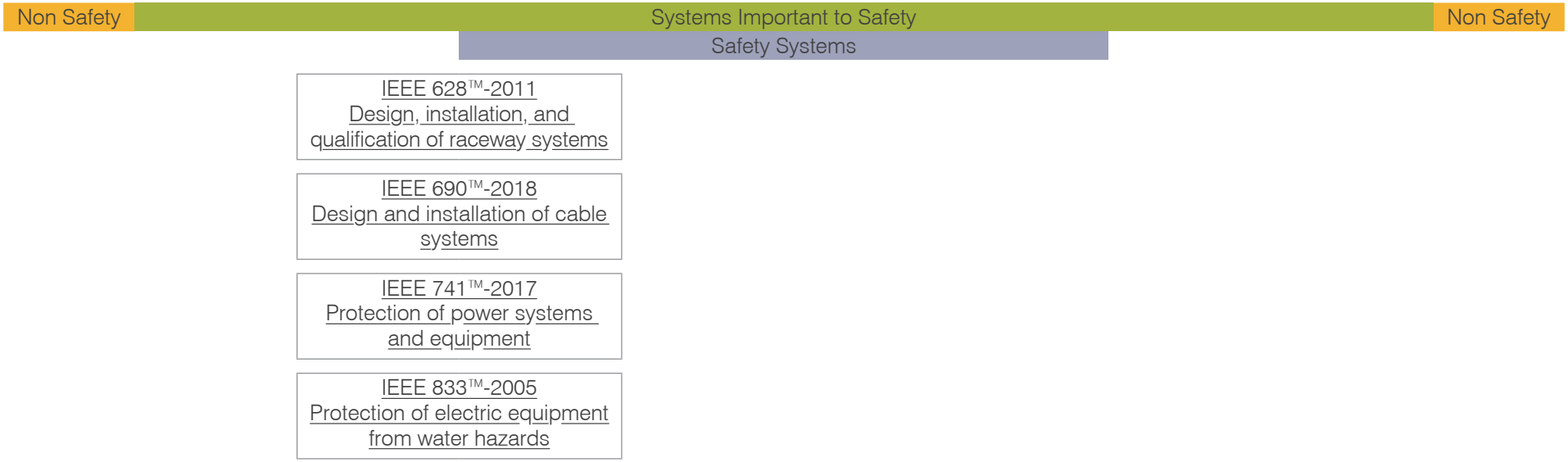


Electrical Systems

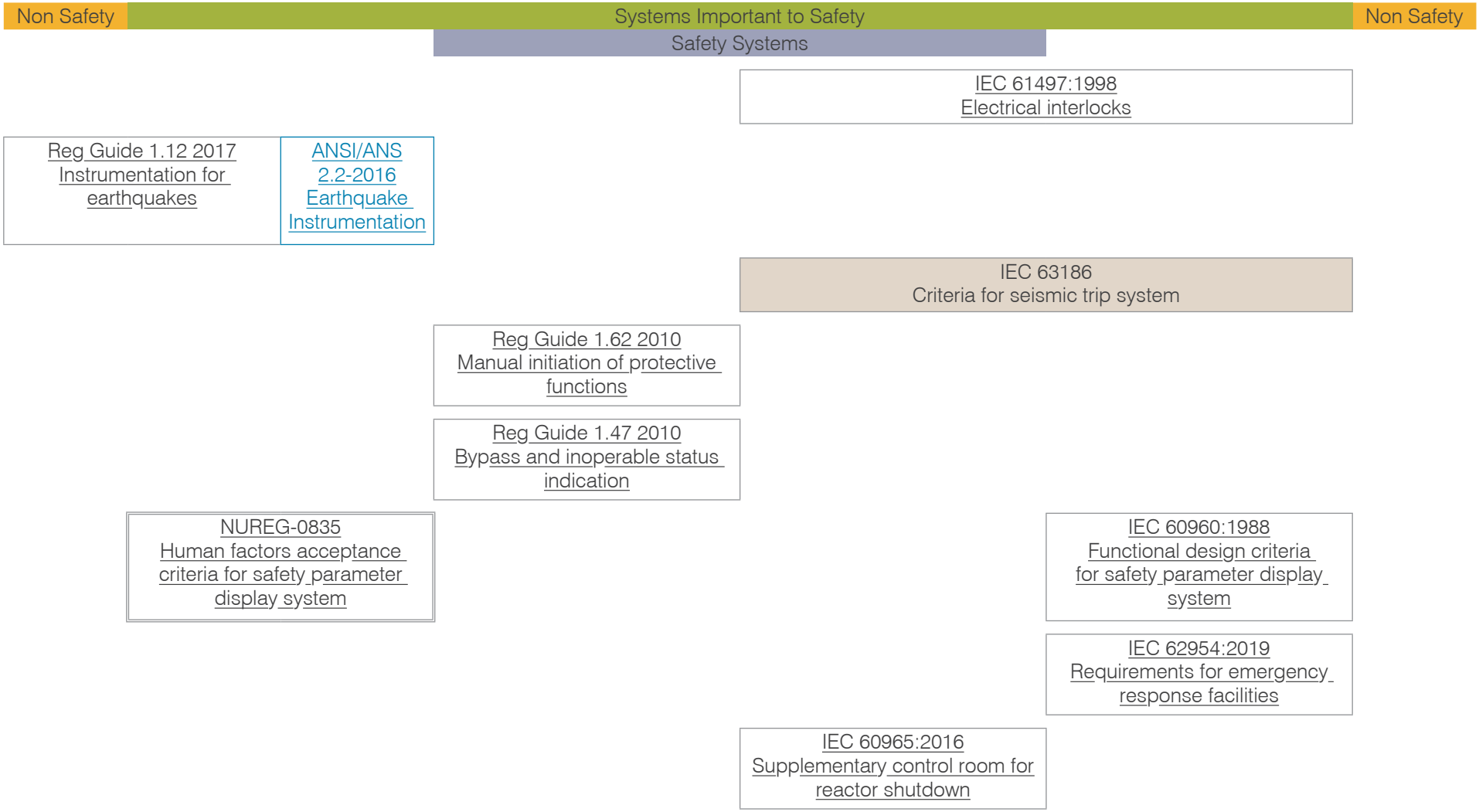


Notes Reg Guide 1.32 endorses IEEE 308-2001

Electrical Supporting Systems



I&C Systems Outside of Containment



In-Containment Monitoring

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

Reg Guide 1.133 1981
Loose-part detection program for the primary system of LWRs

ANSI/ISA 67.03:1982
LWR coolant pressure boundary leak detection

IEC 60988:2009
Acoustic monitoring systems for detection of loose parts

IEC 61502:1999
PWR - Vibration monitoring of internal structures

IEC 60910:1988
Containment monitoring instrumentation for early detection of developing deviations from normal operation in LWR

IEC 60911:1987
Measurements for monitoring adequate cooling within the core of PWR

IEC 61343:1996
Measurements for monitoring adequate cooling within BWR cores

IEC 61250:1994
Detection of leakage in coolant systems

IEC 62117:1999
PWR-Monitoring adequate cooling within the core during cold shutdown

Security

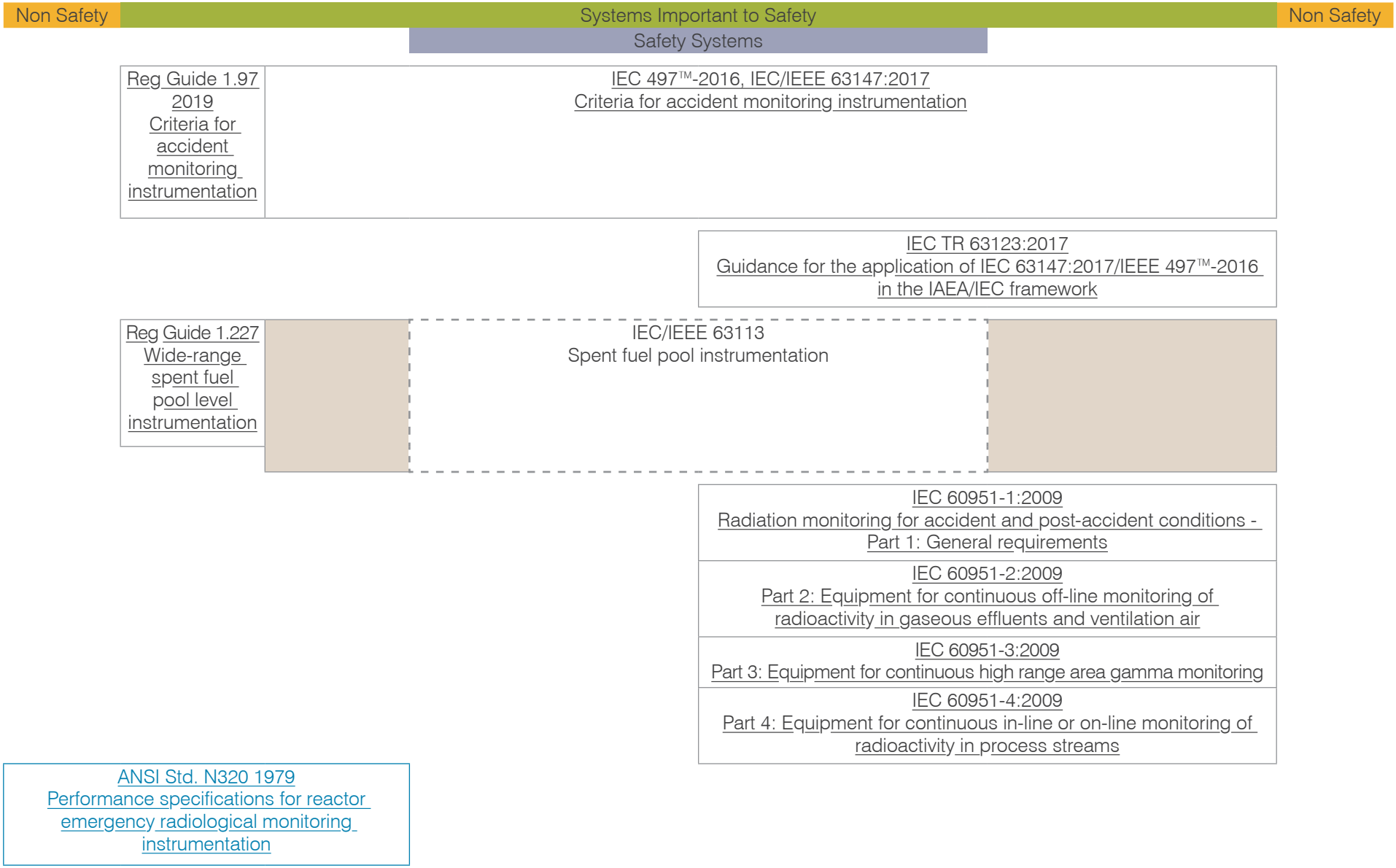
Non Safety | Systems Important to Safety | Non Safety

Safety Systems

Reg Guide 5.71 2010 Cyber security programs for nuclear power reactors	IEC 62645:2019 Cybersecurity Requirements
	IEC 63096 Security Controls
Reg Guide 1.152 Revision 3, Criteria for Use of Computers in Safety Systems of Nuclear Power Plants	IEC 62859:2016 Requirements for coordinating safety and cybersecurity

IEEE 692™-2013
Criteria for security systems

Accident Monitoring



Electrical Equipment

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

Reg Guide 1.63 1987 Electrical penetration assemblies in containment structures	IEEE 317™-2013 Electrical penetration assemblies in containment structures	IEC 60772:2018 Electrical penetration assemblies in containment structures
Reg Guide 1.9 2007 Application and testing diesel generators	IEEE 387™-2017 Criteria for diesel generating units applied as standby power supplies	
P2420 Combustion turbine generator units applied as standby power supplies		
Reg Guide 1.128 2007 Design and installation of vented lead-acid storage batteries	IEEE 484™-2002 Design and installation of vented lead-acid Batteries	
Reg Guide 1.212 2015 Sizing of lead-acid batteries	IEEE 485™-2010 Sizing of lead acid batteries	
Reg Guide 1.129 2013 Maintenance, testing and replacement of vented lead-acid batteries	IEEE 450™-2010 Maintenance, testing, and replacement of vented lead-acid batteries	
IEEE 1106™-2015 Installation, maintenance, testing and replacement of vented nickel-cadmium batteries		
IEEE 1290™-2015 Motor operated valve motor application, protection, control and testing		
Reg Guide 1.106 2012 Thermal overload protection for electric motors on-motor operated valves		

Notes
Reg Guide 1.9 endorses IEEE 387™-1995.
Reg Guide 1.128 endorses IEEE 484™-2002.
Reg Guide 1.63 also endorses IEEE 317™-1983 for. containment penetrations.
IEEE 387™ is under revision with the intent of producing an IEEE/IEC dual logo standard.

I&C Components

IEC TR 62918:2914
Use and selection of wireless devices

IEC 62988:2018
Selection and use of wireless devises

IEC 60744:2018
Safety logic assemblies used in systems performing category A functions

IEC 62808:2015
Design and qualification of isolation devices

Sensors

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

IEC 60515:2007
Radiation detectors - Characteristics and test methods

IEC 60568:2006
In-core instrumentation for neutron fluence rate (flux) measurements in power reactors

IEC 61468:2000
In-core instrumentation - Characteristics and test methods of self-powered neutron detectors

IEC 61501:1998
Wide range neutron fluence rate meter - Mean square voltage method

IEC 60737:2010
Temperature sensors (in-core and primary coolant circuit) - Characteristics and test methods

IEC 62397:2007
Resistance temperature detectors

IEC 62651:2013
Thermocouples: characteristics and test methods

IEC 61224:1993
Response time in resistance temperature detectors (RTD) - In situ measurements

IEC 62887:2018
Pressure transmitters: Characteristics and test methods

Development of Digital Components and Systems

Non Safety | Systems Important to Safety | Non Safety

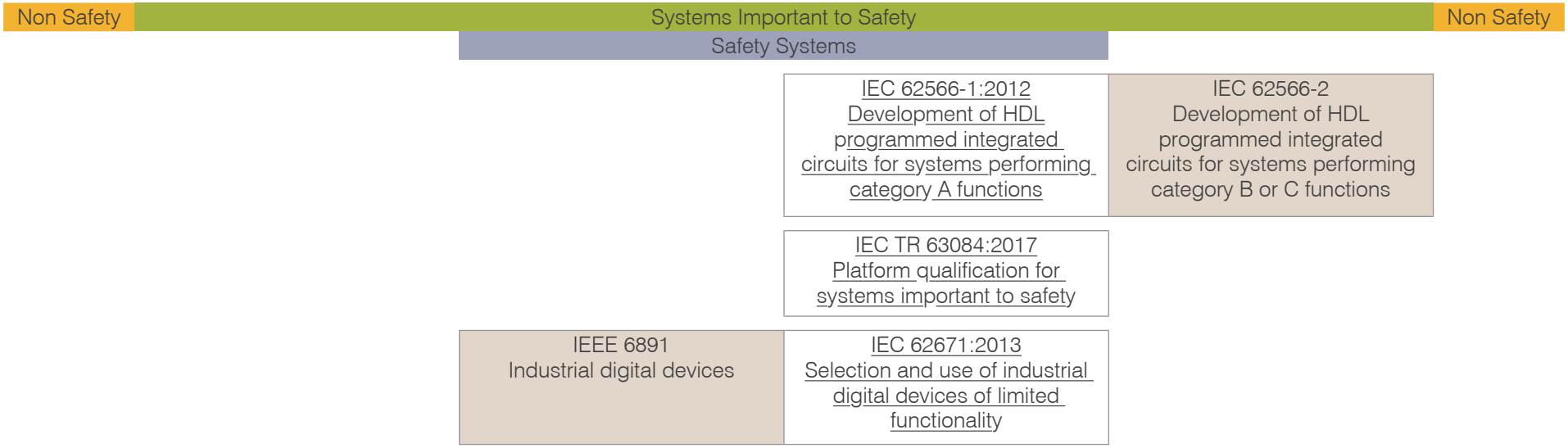
Safety Systems

<table>
<tr><td rowspan="2">Reg Guide 1.152 2011
Use of computers in safety systems</td><td rowspan="2">IEEE 7-4.3.2™-2016
Criteria for programmable digital devices in safety systems</td><td colspan="2">IEC 60987:2007
Hardware design requirements for computer based systems</td></tr>
<tr><td>IEC 61500:2018
Data communication in systems performing category A functions</td><td></td></tr>
<tr><td rowspan="2">Reg Guide 1.168 2013
Verification, Validation, Reviews, and Audits for Digital Computer Software Used in Safety Systems</td><td>IEEE 1012™-2016
System and Software Verification and Validation</td><td rowspan="7">IEC 60880:2006
Software aspects for computer-based systems performing category A functions</td><td rowspan="7">IEC 62138:2018
Software aspects for computer-based systems performing category B or C functions</td></tr>
<tr><td>IEEE 1028™-2008
Software reviews and audits</td></tr>
<tr><td>Reg Guide 1.169 2013
Configuration management plans for software used safety systems</td><td>IEEE 828™-2012
Configuration management systems and software engineering</td></tr>
<tr><td>Reg Guide 1.170 2013
Test documentation for software used in safety systems</td><td>IEEE 829™-2008
Software and system test documentation</td></tr>
<tr><td>Reg Guide 1.171 2013
Unit testing for software used in safety systems</td><td>IEEE 1008™-1987
Software unit testing</td></tr>
<tr><td>Reg Guide 1.172 2013
Requirement specifications for software and complex electronics used in safety systems</td><td>IEEE 830™-1998
Software requirements specifications</td></tr>
<tr><td>Reg Guide 1.173 2013
Developing software lifecycle processes for software used in safety systems</td><td>IEEE 1074™-2006
Developing a software project lifecycle process</td></tr>
</table>

Notes

RG 1.168 endorses IEEE 1012™-2004 The current version of 1012 is a significant departure from the 2004 version
RG 1.169 endorses IEEE 828™-2005
RG 1.152 endorses IEEE 7-4 3.2™ 2003

Digital Platforms



Radiation Monitoring - Systems and Effluents

IEC 62705:2014
Radiation monitoring systems

IEC 61504:2017
Centralized systems for continuous monitoring of radiation

ANSI N42.18-2004
Specification and performance of on-site instrumentation for continuously monitoring radioactivity in effluents

IEC 60761-1:2002
Equipment for continuous monitoring of radiation in gaseous effluents - Part 1: General requirements

IEC 60751-2:2002
Requirements for radioactive aerosol monitors including transuranic aerosols

IEC 60761-3:2002
Requirements for radioactive noble gas monitors

IEC 60761-4:2002
Requirements for radioactive iodine monitors

IEC 60761-5:2002
Requirements for tritium monitors

IEC 60861:2006
Equipment for monitoring radionuclides in liquid effluents and surface waters

IEC 60768:2009
Equipment for continuous monitoring of radioactivity in process streams for normal and incident conditions

Note. Radiation monitoring standards for accident and post accident conditions are listed on the accident monitoring sheet.

Radiation Area Monitoring

Non Safety | Systems Important to Safety | Non Safety

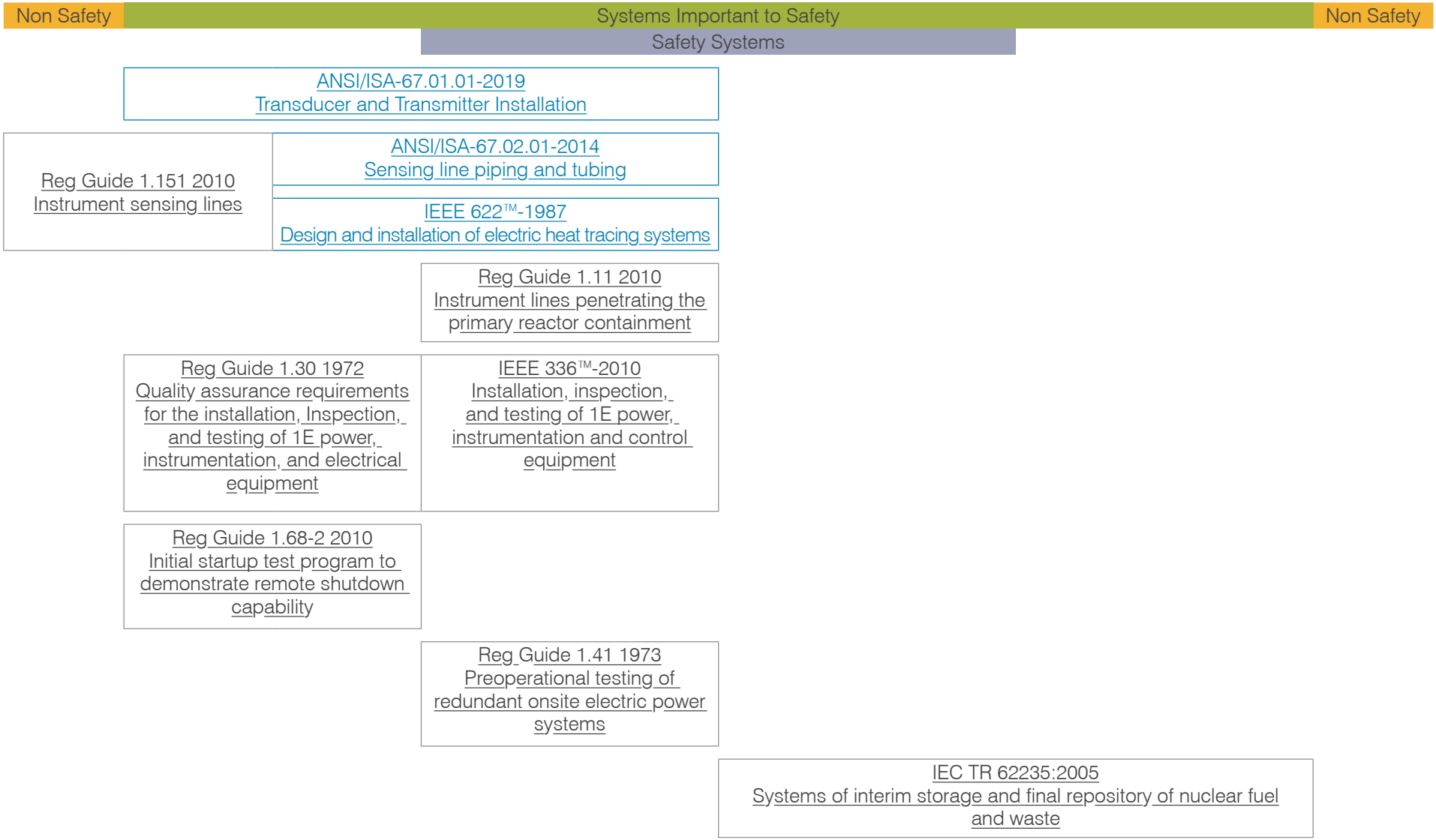
Safety Systems

ANSI/ANS/HPSSC-6.8.1-1981
Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors

IEC 60532:2010
Installed dose rate meters, warning assemblies and monitors - X and gamma radiation of energy between 50 keV and 7 MeV

IEC 61031:1990
Design, location and application criteria for installed area gamma radiation dose rate monitoring equipment for use during normal operation and anticipated operational occurrences

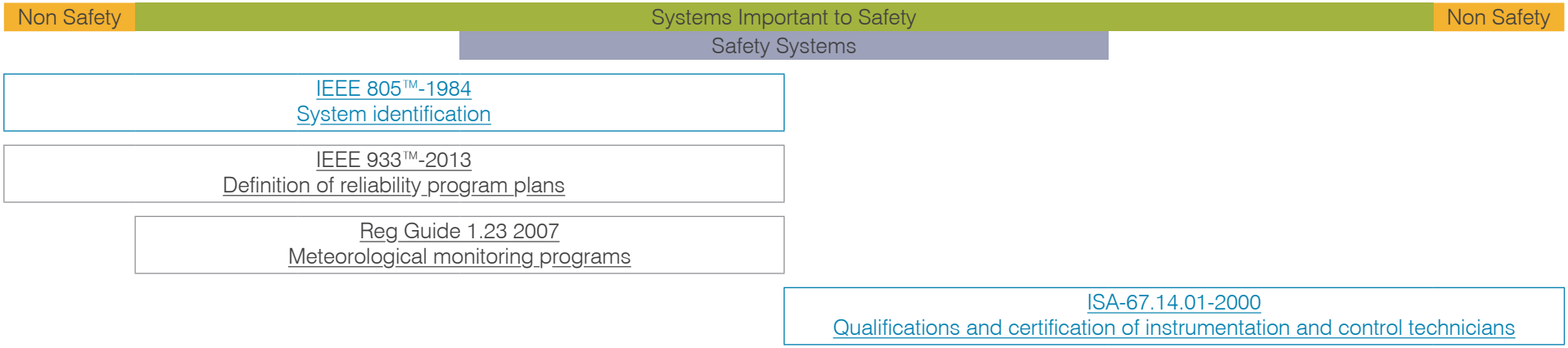
Equipment Installation



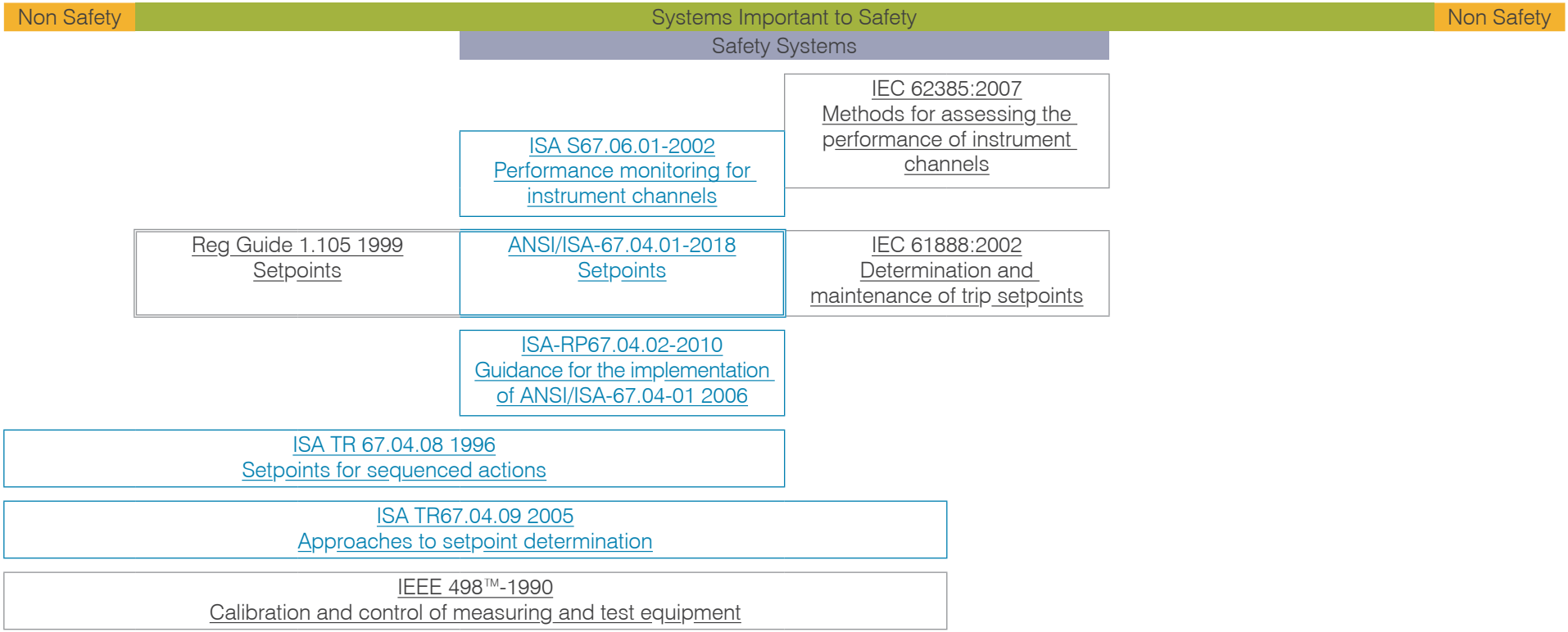
Notes

Reg Guide 1.151 endorses ISA-67.02.02 1999
Reg Guide 1.30 endorses ANSI/IEEE N45.2.4-1972 which has been succeeded by IEEE 336-19

Operational Programs



Instrument Performance and Setpoint Analysis



Notes Reg Guide 1.105 gives guidance on the use of ISA S67.04-1994

Aging Management and Modernization

Non Safety | Systems Important to Safety | Non Safety

Safety Systems

IEC TR 62096:2009
Guidance for the decision on modernization

IEEE 1205™-2014
Assessing monitoring, and mitigating aging effects on electrical equipment

IEC 62342:2007
Management of ageing

IEC 62765-1:2015
Management of ageing: Pressure transmitters

IEC 62675-2:2019
Management of ageing: Temperature sensors

IEC 62465:2010
Management of ageing of electrical cabling

Reg Guide 1.218
Condition-monitoring techniques for electric cables

IEC/IEEE 62582-1:2011
Electrical equipment condition monitoring - Part 1:General

IEC/IEEE 62582-2:2016
Electrical equipment condition monitoring - Part 2:Indenter modulus

IEC/IEEE 62582-3:2012
Electrical equipment condition monitoring - Part 3:Elongation at break

IEC/IEEE 62582-4:2011
Electrical equipment condition monitoring - Part 4:Oxidation induction techniques

IEC/IEEE 62582-5:2015
Electrical equipment condition monitoring - Part 5:Optical time domain reflectometry

IEC/IEEE 62582-6:2019
Electrical equipment condition monitoring - Part 6:Insulation resistance

Notes. The IEC 62582 series may apply to any components that involve electrical insulation

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The Cooperation in Reactor Design Evaluation and Licensing (CORDEL) Working Group promotes the development of a worldwide regulatory environment where internationally-accepted standardized reactor designs, certified and approved by a recognised competent authority in the country of origin, can be widely deployed without major design changes due to national regulations.

International Nuclear I&C and Electrical System Standards List with URLs - Version 1, May 2020