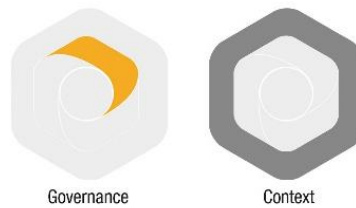


Chapter 10. International Approaches



Governance

- 2.1 Management system design
- 2.2 Management system document
- 2.5 Management reporting
- 2.6 Customer facing quality documents
- 2.7 Establishes quality control regimes
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Chapter 10
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10.1 Overview of International Approaches

This section will be viewed from the point of view of a UK based nuclear professional either working in an international environment or receiving goods from overseas. Because nuclear is a global industry with a limited number of design organisations and a large supply chain, virtually no country operates independently; yet each country has its own legal and regulatory system including codes and standards. Until a universally accepted standard is available, in the interests of safety and economy, nuclear professionals need to consider how the approaches of any licensee/operator, supplier, or sub-tier supplier, fits into the national requirements they have to satisfy; and vice-versa.

10.2 International organisations

Several major organisations provide information to assist as described below.

The International Atomic Energy Agency (IAEA) [1] supports international governmental regulatory authorities. IAEA was set up in 1957 by the United Nations under the banner “Atoms for Peace; it works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. In 2018 it had 170 member states. Within the IAEA the organization is divided into Departments:

- Department of International Cooperation
- Department of Nuclear Energy (NE) which has three Divisions;
 - Nuclear Power
 - Nuclear Fuel Cycle and Waste Technology
 - Planning, Information and Knowledge Management
- Department of Nuclear Safety and Security which has three Divisions;
 - Radiation, Transport and waste Safety
 - Nuclear Installation Safety
 - Nuclear Security
- Department of Nuclear Sciences and Applications which has four Divisions;
 - Human Health
 - Environmental Laboratories
 - Physical and Chemical Sciences
 - Joint FAO/IAEA Nuclear Technologies in Food and Agriculture
- Department of Safeguards

The Organisation for Economic Co-operation and Development, Nuclear Energy Agency (OECD / NEA) [2] consists of 33 countries. The brings together a selection of countries from North America, Europe and the Asia-Pacific region in a non-political forum dedicated to sharing and disseminating state of the art knowledge in the field of nuclear energy. Within NEA there are various Divisions:

- Division of Nuclear Safety and Regulation (NSD) which has two committees:

- Committee on the Safety of Nuclear installations (CSNI)
 - Committee on Nuclear Regulatory Activities (CNRA)
- Division of Radioactive Waste Management and Decommissioning (RWMD) which has three committees:
 - Radioactive Waste Management Committee (RWMC)
 - Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM)
 - Advisory bodies to Governments (ABG)
- Division of Radiological Protection and Human Aspects of Nuclear Safety which has one committee:
 - Committee on Radiological Protection and Public Health (CRPPH)
- Division of Nuclear Science
- NEA Data Bank
- Division of Nuclear Technology Development and Economics

NEA also provides the secretariats to:

- Generation IV International Forum (GIF)
- International Framework for Nuclear energy Cooperation (IFNEC)
- Multinational Design Evaluation Programme (MDEP)

[World Nuclear Association](#) (WNA) [3] is an association of local nuclear associations and global commercial organisations engaged in the nuclear sector. The WNA [Country Profiles](#) [4] provide an overview of nuclear power developments across the world.

10.3 National Approaches

In all cases it is important to fully understand the vocabulary / terminology used in different countries. Older descriptions rather than ISO 9000:2015 vocabulary may be used. Examples are; Quality Assurance Programme instead of Quality Management System, Quality Manual instead of Quality Plan and Quality Plan instead of Inspection & Test Plan.

USA, France, Japan, South Korea and Russia are all addressed because of the significance of their global activities.

10.4 USA

10.4.1 Governmental organisation

US Department of Energy (US DoE)

US DoE [5] is responsible for Nuclear energy in relation to supply but a more significant amount of their effort falls under the banner of National Security and Safety, where they identify four priorities:

- Ensuring the integrity and safety of the country's nuclear weapons

- Promoting international nuclear safety
- Advancing nuclear non-proliferation
- Continuing to provide safe, efficient and effective nuclear power plants for the United States Navy.

DOE own 21 national laboratories, generally operated / managed by contractors. The Idaho National Laboratory (INL) is the home for significant nuclear programmes; but significant activities are undertaken at Oak Ridge National Laboratory, Los Alamos National Laboratory, Brookhaven National Laboratory, Argonne National Laboratory and Savannah River Site.

In the USA, all nuclear weapons deployed by the United States Department of Defence (DoD) are actually on loan to DoD from the National Nuclear Security Administration (DOE/NNSA), which has federal responsibility for the design, testing and production of all nuclear weapons. NNSA in turn uses contractors to carry out its responsibilities at the following government owned sites:

- Design of the nuclear components of the weapon: Los Alamos National Laboratory and Lawrence Livermore National Laboratory
- Engineering of the weapon systems: Sandia National Laboratories
- Manufacturing of key components: Los Alamos National Laboratory, the Kansas City Plant, and Y-12 National Security Complex
- Testing: Nevada Test Site
- Final weapon/warhead assembling/dismantling: Pantex

Nuclear Regulatory Commission (NRC)

NRC [6] reviews and issues licenses for the construction and operation of commercial nuclear power plants, research reactors and other nuclear fuel cycle facilities; and it licenses the possession and use of nuclear materials for medical, industrial, educational, research and other purposes. Regulatory authority for nuclear materials licensing has been transferred to 34 states under the NRC's Agreement states program. The NRC also regulates gaseous diffusion uranium enrichment facilities which the US Enrichment Corporation (USEC) lease from DoE.

NRC inspects and enforces related to nuclear plants and provides independent expertise and information under the banner of Regulatory Research.

The NRC establishes requirements for the design and manufacture of packages for radioactive materials. The Department of Transportation regulates the shipments while they are in transit and sets standards for labelling and smaller quantity packages (See Title 49, Transportation, of the U.S. Code of Federal Regulations).

10.4.2 Legislation

US Code of Federal Regulations (CFR) Part 10 relates to Energy. [Title 10](#) [7] of the Code of Federal Regulations is binding on all persons and organizations who receive a license from NRC to use nuclear materials or operate nuclear facilities. The parts of Title 10 most commonly referred to are:

- [Part 50 ' Domestic Licensing of Production and Utilization Facilities'](#). [8]; and
- [Part 52 ' Licenses, Certifications, and Approvals for Nuclear Power Plants'](#) [9]

Part 60 and Part 63 relate to a geologic repository for the disposal of high-level radioactive waste; and Part 72 relates to an ISFSI (Independent Spent Fuel Storage Installation) for the storage of spent fuel licensed or an MRS (Monitored Retrievable Storage Installation) for the storage of spent fuel or high-level radioactive waste.

From a 'quality' perspective the main Section is Part 50 Appendix B which though promulgated in 1970 was last amended in 2007. NRC's [NUREG 1.28](#) 'Quality Assurance Program Criteria (Design and Construction)' [10] provides guidance on what staff find acceptable for complying with provisions relating to licensing referring to 10CFR50 Appendix B. It indicates in Part C that NQA-1-2008, NQA-1-2012, and NQA-1-2015 "*Quality Assurance Requirements for Nuclear Facility Applications*," provide an adequate basis for complying with the requirements of Appendix B to 10 CFR Part 50 subject to some identified exceptions.

Note that because of the historical birth of nuclear generation in the USA, and its subsequent spread to many nations, 10 CFR 50 and especially Appendix B have become the basis on which many countries and organisations have developed.

10.4.3 Guidance

DOE

[10 CFR Part 830](#) – Nuclear Safety Management [11] is the applicable set of regulations applicable to activities (including providing items and services) that affect, or may affect, the safety of DOE nuclear facilities, excluding NRC regulated, Naval nuclear propulsion, transportation nuclear waste and space activities . Sub part A Quality Assurance Requirements is addressed in Sections 830.120, 121 and 122.

[DOE Order DOE O 414.1D](#) [12] establishes the Quality Assurance Program for the DOE, based on 10 criteria (1-Management/Program, 2- Management/Personnel training and Qualification, 3- Management/Quality Improvement, 4- Management/Documents and Records, 5- Performance/Work processes, 6- Performance/Design, 7- [Performance/Procurement](#), 8- [Performance/Inspection and Acceptance Testing](#), 9- [Assessment/Management Assessment](#), and 10- [Assessment/Independent Assessment](#)). Specific guidance is provided on Suspect and Counterfeit Items referencing to [IAEA TECDOC-1169](#) [13].

Guidance is provided in:

[DOE G 413.3-2 QA Guide for Project Management](#) [14]

[DOE G 414.1-4 Safety Software Guide for Use with 10 CFR 830, Subpart A, Quality Assurance Requirements](#) [15]

[DOE G 450.4-1C Integrated Safety Management System Guide](#) [16]

(NRC)

The NRC approach to [Quality Assurance for New Reactors](#) is described on the NRC website [17]. The [Standard Review Plan](#) (NUREG-800) [18] provides guidance to NRC staff in performing safety reviews. [Safety Evaluation Reports](#) [19] document the reasons for NRC approvals. A [construction inspection program](#) [20] is carried out and [inspection reports](#) [21] are issued.

NRC undertakes a significant programme of [inspection and oversight of industry vendor activities](#) [22]. Vendor QA Inspection reports are [published](#) [23]. NRC periodically accompanies the Nuclear Procurement Issues Committee (NUPIC) [24] teams on audits to evaluate suppliers furnishing safety-related components and services and commercial-grade items to nuclear utilities.

NRC [lists by criteria](#) all applicable Quality Assurance (QA) Inspection for New Reactor Licensing and Vendor QA Inspection reports that have either a Notice of Non-conformance (NON) or Notice of Violation (NOV) [25].

NRC organises meetings and workshops about vendor oversight activities. [Summaries of the workshops](#) are available on the NRC website [26].

10.4.4 Standards

American National Standards Institute (ANSI)

ANSI is the U.S. member body to ISO and, via its U.S. National Committee, the International Electrotechnical Commission (IEC). ANSI is also a member of the International Accreditation Forum (IAF). ANSI does not write standards; rather, the Institute accredits standards developers that establish consensus among qualified groups. 220 distinct entities are currently accredited to develop and maintain nearly 10,000 American National Standards (ANS). All ANS are developed as voluntary documents but U.S. federal, state, or local bodies are increasingly referring to ANS for regulatory or procurement purposes. Many ANS are also national adoptions of globally relevant international standards. In the nuclear field ASME is the relevant body.

The American Society of Mechanical Engineers (ASME)

ASME Nuclear Engineering Division (NED) focuses on the design, analysis, development, testing, operation and maintenance of reactor systems and components, nuclear fusion, heat transport, nuclear fuels technology and radioactive waste. ASME:

- provides centralized, independent, third-party certification for quality assurance programs in conformance with the ASME NQA-1 standard;
- accredits Inspection agencies including Independent Third-Party Inspection Organizations; and
- issues N-type Certificates of Authorization which allow Certificate Holders to certify and stamp newly constructed components, parts, and appurtenances used at a nuclear facility with the Certification Mark in accordance with Section III of the ASME BPVC. The Society issues six different N-type certificates, and an owner's certificate

The principal standard is ASME-NQA-1-2017 Quality Assurance Requirements for Nuclear Facility Applications.

US NRC in Reg Guide RG 1.28 Rev 5 (Oct 2017) stated that “staff determined that the NQA-1b-2011 Addenda to ASME NQA-1-2008, NQA-1-2012, and NQA-1-2015 provide the most current guidance for QA” and also stated “staff reviewed guidance from the International Atomic Energy Agency (IAEA) and did not identify any standards that provided useful guidance to NRC staff, applicants, or licensees”.

The following provide additional information:

- STP-NU-051 Code Comparison Report for Class 1 Nuclear Power Plant Components Prepared for: Multinational Design Evaluation Programme Codes and Standards Working Group January 27, 2012 addresses ASME III vs RCC-M, JSME, KEPIC and CSA. Specific sections of each comparison address Quality aspects.
- Comparison of ASME Specifications and European Standards for Mechanical testing of Steels for Pressure Equipment - December 2005.

10.4.5 Design & Manufacturing Organisations / Operators

US nuclear power plants are a mixture of PWRs and BWRs and have generated about 20% of U.S. electricity since 1990. Almost all the US nuclear generating capacity comes from reactors built between 1967 and 1990. According to the U.S. Energy Information Administration (EIA) there were 92 nuclear reactors were operating at 54 nuclear power plants in 28 states on 1 July 2022. The current status of [nuclear power in the US](#) [27] and a list of [operating nuclear reactors](#) [28] can be found on the WNA website.

Current major Design/ Construction Organisations include:

- [Westinghouse Electric Company](#) [29] that is also a nuclear fuel fabricator. Current reactor design is AP1000.

- [General Electric](#) [30]. Nuclear business is carried by [GE Hitachi Nuclear Energy](#) (GEH) [31]. Current systems are ABWR (Advanced Boiling Water Reactor). ESBWR (Economic Simplified Boiling Water Reactor) and PRISM (sodium cooled SMR) are in development stages,

The USA has three main fuel fabrication facilities to convert enriched uranium oxide into solid pellets for fuel rods.

- Westinghouse has a 1500 t/yr fuel fabrication plant for PWR and BWR fuel at Columbia, South Carolina.
- Global Nuclear Fuel-Americas(owned by GE, Hitachi and Toshiba) has a 1500 t/yr plant at Wilmington, North Carolina,
- Orano (formerly Areva) has a 1200 t/yr capacity fuel fabrication plant at Richland, Washington .

Additionally, BWX Technologies' Nuclear Operations Group subsidiary Nuclear Fuel Services (NFS) manufactures US Navy fuel at Erwin, Tennessee. It also converts highly enriched uranium (HEU) to low-enriched uranium (LEU).

10.5 France

10.5.1 Governmental organization

The Atomic Energy Commission (CEA)

French nuclear legislation began to develop from the time the Atomic Energy Commission (CEA), the public agency set up by the State in 1945 reporting directly to the prime minister, no longer held a monopoly for nuclear activities i.e., from the time nuclear energy applications entered the industrial stage, thus requiring the involvement of new nuclear operators. This development had several landmarks:

- In 1963, a system for licensing and controlling major nuclear installations was introduced, setting government responsibility in matters of population and occupational safety. Prior to this, procedures concerning the licensing and control of industrial activities were dealt with by the Préfet, the Government local representative, for each Département. In 1973, this system was expanded to cover the development of the nuclear power programme, and better define the role of government authorities.
- In 1966 a Decree included Euratom Directives as part of the French radiation protection regulations.
- In the 1980's, the enactments setting up the CEA were amended so as to strengthen its inter- ministerial status and a tripartite Board of Administration including staff representatives was created. Governmental decisions are prepared by the Atomic Energy Committee, which acts as a restricted inter-ministerial committee on nuclear energy matters. CEA is now answerable to the Minister for Industry, to the Minister for Research and to the Minister of Defence.

- In 1992 the main task of CEA was laid down by the Government; to concentrate on developing the control of atom uses for purposes of energy, health, defence and industry, while remaining attentive to the requests made by its industrial and research partners.
- In 1999, the inter-ministerial committee more specifically requested CEA to “strengthen long-term research on future reactors capable of reducing, and even eliminate the production of long-lived radio-active waste”. In addition, CEA was given a particular responsibility for R&D on alternative and renewable energies.
- In 2009 it was re-named Commission of Atomic Energy and Alternative Energy (still abbreviated as CEA).
- It has 14 research reactors of various types and sizes in operation, all started up 1959 to 1980, the largest of these being 70 MWt. About 17 units dating from 1948 to 1982 are shut down or decommissioning. CEA since 2006 have been looking at the design of a GenIV reactor.

Security

Security is the responsibility of the Nuclear Security Authority of the Ministry of Ecology, Sustainable Development and Energy and the Ministry of Defence.

Autorité de Sûreté Nucléaire (ASN)

The regulations for large nuclear installations, termed ‘Base Nuclear Installation (BNI), were supplemented with regard to procedures by an Instruction of 1973 and a Decision of the same date (amended 1976) which were internal instruments issued by the Minister for Industry. The authorities primarily involved in the licensing procedure for the setting up of BNI were the Minister for Industry and the Minister for Ecology and Sustainable Development. For this purpose, the Central Service for Nuclear Installations Safety (SCSIN), set up in 1973 within the Ministry of Industry, was reorganised as the Directorate for Nuclear Installations Safety (DSIN).

In 2002, the DGSNR (General Directorate for Nuclear Safety and Radioprotection) was created as a result of the merger of DSIN and the former Central Board for Protection against Ionizing Radiations (OPRI). As a consequence, in addition to nuclear safety, DGSNR also held the responsibilities of the former OPRI regarding radioprotection. It also co-ordinated and defined controls for the radiation protection of workers and was involved in the safety plans to be put in action in case of radioactive incident. DGSNR reported to the Ministers for Industry, Health and Ecology and Sustainable Development. At the local level, DGSNR’s actions were relayed through the nuclear divisions of the Regional Directorates for Industry, Research and Environment (DRIRE). These Directorates were in charge of the survey of nuclear installations and monitoring reactor shutdowns and all pressurized components, and provided technical support to the “préfet”, in particular in case of accident.

DGSNR was assisted in decision making by the Institute for Radiation-Protection and Nuclear Safety (IRSN). The IRSN could also undertake studies or research on protection and nuclear safety problems on request of any concerned ministerial department or agency (Law n°2001-398 AFSSE of 9 May 2001).

In 2006, an Act on transparency and safety (The TSN Act) created the [Authority for Nuclear Safety](#) (ASN-Autorité de Sûreté Nucléaire) [32]. ASN is an independent administrative agency headed by 5 members designated by the President of the Republic and the Presidents of the two Parliament Assemblies. The agency is consulted before decisions concerning nuclear safety, nuclear security, and radioprotection are taken by decrees. It can also complete the legislation on technical matters, but its decisions may be homologated by the Ministers in charge of these questions. The ASN also has the responsibility of:

- Organizing and directing the control of nuclear installations (designation of inspectors, delivery of permits).
- Monitoring radioprotection over the national territory. Proposing and organizing public information on nuclear safety.
- Establishing the procedures for licensing large nuclear installations (licenses for setting up, commissioning, disposal, etc.).
- Helping the management of emergency situation in the event of an accident involving radioactive exposures.

ASN publish national [regulations](#) [33] and [safety rules](#) [34] on their website. The website also includes a link to the [annual report](#) on the state of nuclear safety and radiation protection in France [35]. The 2021 report includes a section on regulations that includes a description of the general framework for the legislation and regulation of nuclear activities.

10.5.2 Quality and management systems

The [Order of 7th February 2012](#) [36] setting the general rules for BNIs, requires that the licensee define and implement an Integrated Management System (IMS) designed to ensure that the safety, radiation protection and environmental protection requirements are systematically taken into account in all decisions concerning the facility. The IMS needs to specify the steps taken to manage important activities. The licensee IMS must be able to maintain and continuously improve safety particularly through the development of a safety culture. The BNI order also requires that the licensee supervises and monitors its contractors.

An overview of EDF's quality policy and programme for nuclear power reactors is provided in section 13 of the [7th National Report to the IAEA Convention on Nuclear Safety](#) dated August 2016 [37].

10.5.3 Design & Manufacturing Organisations/Operators

In 2017/2018 the French government enforced significant changes on the overall organization of their nuclear industry, with the latest designations as shown below. AREVA SA as the former overarching group continued in existence to:

- complete the EPR OL3 reactor project in Finland, with the necessary resources, in compliance with its contractual obligations;
- close residual Renewable projects once its contractual commitments are fulfilled;
- create the nuclear pole of excellence New NP intended to be ceded to EDF;

Areva NC (formerly known as Cogema) carry out most of the fuel cycle activity. Uranium conversion is undertaken at Malvesi and Pierlatte plants in the Rhone valley. Since 2003 Areva own a 50% share of Urenco's Enrichment Technology Company (ETC). Areva manufacture fuels at several plants in France and Belgium. Used fuel is sent to Areva's La Hague plant in Normandy for reprocessing. Recovered plutonium is sent to Melox near Marcoule where Areva fabricate it into mixed oxide fuel (MOX). ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs) is responsible for the national waste disposal programme. It is undertaking research into deep geological repository and operates the LLW disposal facility at the Centre de l'Aube. ANDRA also operates the Morvilliers facility (CSTFA) to hold VLLW. ANDRA's Centre de la Manche facility next to La Hague received LLW and short-lived ILW up to 1994 and is now capped. In January 2018 Areva NC was retitled as [Orano](#) [38] in which Japan Nuclear Fuel Ltd (JNFL) and MHI have invested a 5% stake.

Areva NP (previously known as Framatome) with inputs from Siemens and EDF are the designers of the European Pressurised Reactor (EPR). In January 2018 Areva NP was retitled as [Framatome](#) [39] (owned by Électricité de France, Mitsubishi Heavy Industries, and Assystem).

[Électricité de France \(EDF\)](#) [40] is the operator of France's nuclear power stations.

In May 2017 EDF announced the creation of the Edvance engineering joint venture with Areva NP, to design and build nuclear islands and control systems for new reactors globally. EDF will hold 80%, Areva NP 20%.

Waste disposal is being managed by the Agence Nationale pour la gestion des Déchets Radioactifs – ANDRA which is design9ng a repository at Bure (Centre Industriel de Stockage Géologique, CIGEO) which is scheduled to start construction in 2020.

LLW and short lived ILW is disposed of at ANDRA's facility in the Aube district, whilst VLLW is disposed of at Morvilliers facility (CSTFA). A previous site at ANDRA's Centre de la Manche facility next to La Hague closed in 1994 and is now capped. A site for the disposal of long-lived LLW (FA-VL) has been being sought since 2008 and in the interim FA-VL will be stored at Morvilliers VLLW site.

10.5.4 Standards

Association Française de Normalisation (AFNOR)

AFNOR is the French national organization for standardization and its International Organization for Standardization member body.

The AFNOR Group develops its international standardization activities, information provision, certification and training through a network of key partners in France who are members of the association; it also operates internationally.

French Association for NSSS Equipment Construction Rules (AFCEN)

“Ever since its inception in 1980, AFCEN has been driven by a mission to establish a series of technical rules reflecting on-the-ground practices, feedback from industry and the latest knowledge in a bid to guarantee the superior level of quality and safety required for operating nuclear reactors. These objectives are also the values that guide the tremendous technical work of AFCEN's editorial groups, which currently feature over 750 experts.

AFCEN was initially founded by electric utility EDF and nuclear steam supply system manufacturer Framatome. AFCEN's name is often associated with the RCC-M construction code for mechanical components that it publishes. Since its creation, AFCEN has considerably broadened its scope of activities.

First of all, AFCEN extended the range of technical fields covered, with three codes for mechanical components: RCC-M (fabrication), RSE-M (in-service inspection) and RCC-MRx (high-temperature reactors, experimental reactors and fusion reactors); one code for electricity and I&C systems (RCC-E); one code for nuclear fuel (RCC-C); one code for civil engineering works (RCC-CW), and one code for fire protection systems (RCC-F).

Furthermore, AFCEN clearly began setting its sights on increasing the association's international footprint in 2010 and opening its doors to a new audience other than its founder members, which raises new challenges when authoring technical rules that are regularly revised, updated and championed by larger expert focus groups, which in turn offers greater credibility in today's industrial environment. China has long been a hotspot for international deployment of AFCEN codes. The United Kingdom is the country boasting the second highest contribution with two EPRs slated for construction.”

RCC-M ‘Design and construction rules for mechanical components of PWR nuclear islands’ has been significantly modified since the first edition (January 1980). The 2017 edition is the most recent version of the code; it integrates 36 modification files.

- The 2018 edition will incorporate a significant change in the code, since it will be compatible with all the findings from the commissioned studies related to the Nuclear Pressure Equipment Regulation. Those findings will be worked into the body

of the code, featured in a specific appendix for France or described in technical publications.

- This edition, along with its specific appendix and technical publications, will enable French industry to address the requirements of the new Nuclear Pressure Equipment Regulation of December 30, 2015.
- The new 2018 edition of the code will also incorporate the feedback on the code's use in current projects (EPR UK, TSN, FA3, replacement steam generators) and on the results of the studies of international groups (UK, China, Europe and MDEP), which are monitored by ASN.

RSE-M 'In-Service Inspection Rules for Mechanical Components of PWR Nuclear Islands' applies to pressure equipment used in PWR plants, as well as spare parts for such equipment. It does not apply to equipment made from materials other than metal being based on the RCC-M code for requirements relating to the design and fabrication of mechanical components.

The first edition was published in July 1990 and has been routinely revised / modified; the latest version is 2017 with a 2018 consolidation being prepared.

RCC-E 'Design and construction rules for electrical equipment of PWR nuclear islands' describes the rules for designing, building and installing electrical and I&C systems and equipment for pressurized water reactors. The first edition was published in 1981 and several editions have succeeded that up to the latest in 2016.

RCC-CW 'Design and construction rules for civil works in PWR nuclear islands' explains the principles and requirements for the safety, serviceability and durability of concrete and metal frame structures, based on Eurocode design principles (European standards for the structural design of construction works) combined with specific measures for safety-class buildings. The first edition (as RCC-G) was published in 1980 and several editions have succeeded that up to the latest in 2017.

The RCC-CW code is available as an ETC-C version specific to EPR projects (European pressurized reactor). ETC-C 2010 edition was the first version prepared and published by AFCEN, was used for the generic design assessment of the EPR project in the United Kingdom.

RCC-C 'Design and construction rules for fuel assemblies of PWR nuclear power plants' scope covers:

- fuel system design, especially for assemblies, the fuel rod and associated core components,
- the characteristics to be checked for products and parts,
- fabrication methods and associated inspection methods.

RCC-C 2018 (English) edition is the most recent version with a 2019 (French & English) edition scheduled.

RCC-F ‘Design and construction rules for PWR fire protection systems’ defines the rules for designing, building and installing systems used in a PWR nuclear plant for managing the risk of fire outbreak inside the facility in light of the nuclear hazards involved and thereby control the fundamental nuclear functions. The code also defines the rules for analysing and justifying the means used to create the safety demonstration.

RCC-F 2017 edition is the most recent version with a 2020 edition scheduled.

EDF published a reference document called ETC-F for the design of fire protection systems which was not published by AFCEN but acted as a starting point for a fire protection code that AFCEN produced in 2009 which led to the 2017 edition of RCC-F.

RCC-MRx: ‘Design and construction rules for mechanical components in high-temperature structures, experimental reactors and fusion reactors’ was developed for sodium-cooled fast reactors (SFR), research reactors (RR) and fusion reactors (FR-ITER). It provides the rules for designing and building mechanical components involved in areas subject to significant creep and/or significant irradiation. In particular, it incorporates an extensive range of materials (aluminium and zirconium alloys in response to the need for transparency to neutrons, Eurofer, etc), sizing rules for thin shells and box structures, and new modern welding processes: electron beam, laser beam, diffusion and brazing.

Further information on the [AFCEN standards](#) [41] can be found via their web site and in the following:

- [Proceedings of the ASME Pressure Vessels and Piping Division Conference, July 26-30 2009](#) in Prague: [42]
- PVP2009-78036. An Overview of QA/QC Requirements in Present NPP Projects: P Malouines (AREVA).
- PVP2009-78046. Adaption of RCC-M Design and Construction Rules to the Evolution of Projects Needs, Regulatory Evolutions and International Exchanges: J-M Grandemange (AFCEN).

10.6 Japan

10.6.1 Governmental Organisation

Originally (1956 onwards) the Atomic Energy Commission (JAEC) promoted nuclear power development and utilization; several other nuclear energy-related organisations were also established: the Nuclear Safety Commission (NSC), the Science & Technology Agency; Japan Atomic Energy Research Institute (JAERI) and the Atomic Fuel Corporation (renamed PNC in 1967 and Japan Nuclear Cycle Development Institute (JNC) in 1998).

In 2001 the Nuclear & Industrial Safety Agency (NISA) was created as a Japanese nuclear regulatory and oversight branch under the Ministry of Economy, Trade and Industry (METI).

In 2003 The Japan Nuclear Energy Safety Organization (JNES) was created to work with NISA.

A merger of JNC and JAERI in 2005 created the Japan Atomic Energy Agency (JAEA) under the Ministry of Education, Culture, Sports, Science & Technology (MEXT). JAEA is now a major integrated nuclear R&D organization.

The Fukushima Daiichi accident, of March 2011, resulted in significant changes in attitude to nuclear power and organisations. In October 2012 the new [Nuclear Regulation Authority](#) (NRA) [43], under the Ministry of the Environment, took over from NISA, merged with NSC and was separated from METI.

10.6.2 Operators

Before the Fukushima Daiichi Nuclear Power Station accident about 30% of Japan's energy came from 54 commercial nuclear reactors (24 PWR + 26 BWR + 4 ABWR). By May 2012 all had been shut- down. 9 had re-started by 26 October 2018 and 10 had announced decommissioning. A summary of the current status of [nuclear power in Japan](#) is provided on the WNA website [44].

Operators are represented in the [Japan Nuclear Safety Institute](#) (JANSI) [45].

Japan Nuclear Fuel Limited (JNFL) operate Reprocessing, MOX, Enrichment and disposal, and Waste control facilities. The Nuclear Waste Management Organization of Japan (NUMO) is tasked with implementing final disposal -geological disposal- of high-level radioactive waste (HLW) and low-level radioactive waste containing long-lived nuclides (TRU waste) with site selection programmed for late 2020s.

10.6.3 Design & Manufacturing Organisations

All the existing PWRs are 2-, 3-, and 4-loop versions (600 to 1200 MWe classes) constructed by Mitsubishi.

The first ABWRs (1315 MWe) were built by a consortium of General Electric (USA), Toshiba and Hitachi. Four further ABWRs are in operation or under construction whilst eight of the planned reactors in Japan are ABWR.

Hitachi-GE talks of its 1500 MWe class "global unified ABWR", and is developing a high-performance 1800 MWe class ABWR. Hitachi was also developing 600, 900 and 1700 MWe versions of the ABWR.

10.6.4 Standards

In March 2014, following the Fukushima Daiichi Nuclear Power Station accident, 'New Regulatory Requirements for Light-Water Nuclear Power Plants' were introduced by modification of the Regulations that had existed since 1957. (Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors). The NRA issued detailed requirements in 'Ordinances' called up in the Articles of the Act. Additionally, NRA (and the former NSC) establish Regulatory Guides.

NRA endorsed two voluntary consensus standards:

- JEAC 4111-2009 "Quality Assurance Rules for Safety in Nuclear Power Plants"; and
- JEAC 4209-2007 "Code for Maintenance at Nuclear Power Plants" providing specific provisions for quality assurance and maintenance activities

JEAC 4111 was revised in 2013 and is supported by Application Guidelines in [JEAG 4121 - 2015](#) [46]. The original JEAC 4111, produced in 2003, had ISO 9001:2000 as its basis and also incorporated the contents of the IAEA Safety Standard 50-C/SG-Q (1996). JEAC 4111-2009 incorporates the contents of ISO 9001:2008 and complies with IAEA GS-R-3.

10.7 China

Mainland China has about 45 nuclear power reactors in operation, about 15 under construction, and more about to start construction. The government's long-term target is for 58 GWe capacity by 2020, with 30 GWe more under construction.

10.7.1 Governmental Organisation

The National Nuclear Safety Administration ([NNSA](#)) [47] was set up in 1984 under the China Atomic Energy Authority ([CAEA](#)) [48] and is the licensing and regulatory body which also maintains international agreements regarding safety and non-proliferation safeguards. In January 2011 the State Council Research Office (SCRO) recommended: "The NNSA should be an entity directly under the State Council Bureau, making it an independent regulatory body with authority," although its international roles would continue to be through the CAEA.

NNSA has been working closely with the US Nuclear Regulatory Commission (NRC) in relation to the AP1000 and has adopted some parallel regulations. This, with a high level of IAEA and OECD involvement, gives the NNSA strong international credibility.

Regulation is based on [The Act of the People's Republic of China on Prevention and Control of Radioactive Pollution](#) [49] effective October 2003.

A Five-Year Plan of developing Nuclear and Radiation Safety Regulations (2016-2020) had already (2015) reviewed nuclear and radiation safety regulations and standards along with 46 drafts of department rules, guides, standards, and technical documents. These included the 'Safety Rules of Nuclear Power Plant Quality Assurance'.

The *Nuclear Safety Law of the People's Republic of China*, which was to be implemented in January 2018 is divided into eight chapters, with a total of 94 articles.

Key contents include guidelines, principles, responsibility system and technical and cultural guarantee for ensuring nuclear safety; the qualifications, responsibilities and obligations of the operating agencies of nuclear facilities; the permit system for nuclear materials; the safety system for nuclear and radioactive waste; the emergency system for nuclear accidents; the nuclear safety system; the information disclosure and public participation system, etc. In addition, laws related to nuclear safety also include the Administrative Regulations formulated by the State Council of China. Existing nuclear safety administrative regulations put forward the overall requirements for the safety supervision and management of civil nuclear facilities, the supervision and management of civil nuclear safety equipment and the safety management of radioactive waste.

Further information is available in [China's Nuclear Energy Guide - 2017](#) [50] by the China Nuclear Energy Association (CNEA)

10.7.2 Operators

The main nuclear operators are China National Nuclear Corporation (CNNC) and China General Nuclear Power Group (CGN), with SPIC (via its nuclear power business State Nuclear Power Technology Corporation – SNPTC) a third one.

An overview of the status of [nuclear power in China](#) is available on the WNA website [51].

10.7.3 Design & Manufacturing Organisations

Westinghouse has agreed to transfer technology to SNPTC over the first four AP1000 units (Sanmen and Haiyang for CNNC & CPI) so that SNPTC can build the following units (CAP1000 transitional to CAP1400) on its own. Six more at three sites (Sanmen, Haiyang and Lufeng for CGN) are firmly planned after them. At least 30 more are proposed to follow.

In 2014 SNPTC signed a further agreement with Westinghouse to deepen cooperation in relation to AP1000 and CAP1400 technology globally and “establish a mutually beneficial and complementary partnership”. In November 2018 successors of the two companies – State Power Investment Corporation (SPIC) and Westinghouse (under new ownership) – signed a further cooperation agreement.

CNNC had been working with Westinghouse and Framatome (now Areva) at SNERDI since the early 1990s to develop a Chinese standard three-loop PWR design, the CNP-1000. In October 2011 CNNC announced that its independently developed ACP1000 (or CP1000) was entering the engineering design stage, initially for Fuqing units 5&6, with 1100 MWe nominal power and load-following capability.

Two new 300 MWe CNP-300 PWR units have been built at Chasma in Pakistan by the China Zhongyuan Engineering Corporation. CNNC was seeking to sell the CNP-300 to Belarus and in Africa, and these will probably now become ACP300 or SNP/CNP350. Countries identified as having been in discussions are Pakistan, Romania, Argentina, UK (Bradwell), Iran, Turkey, South Africa, Kenya, Egypt, Sudan, Armenia, Kazakhstan.

Many other small reactor projects have been in development. Plans were announced to develop, market and build the Advanced Fuel Candu Reactor (AFCR) and also small high-temperature gas-cooled reactor (HTR)

10.7.4 Standards

Basic requirements under the Nuclear Safety Law include:

- Regulation on the Supervision and Management of Civil Nuclear Safety Equipment (Promulgated on July 11, 2007);
- Supervision and Management Regulations on the Design, Manufacture, Installation and Non-destructive Testing of Civilian Nuclear Safety Equipment (HAF601-2007);
- Management Regulations on Civilian Nuclear Safety Equipment Non-destructive Testing Personnel Qualifications (HAF602-2007);
- Management Regulations on Welding Operation Qualification of Civilian Nuclear Safety Equipment Welders (HAF603-2007);
- Supervision and Management Regulations on Imported Civilian Nuclear Safety Equipment (HAF604-2007).

Among them, [HAF604](#) is specifically for the import of civilian nuclear safety equipment [52].

In September 2017, the UK Foreign & commonwealth Office (FCO) and British Standards Institute (BSI) produced a 'Report on the application of codes and standards in the UK and Chinese civil nuclear energy industries' (BSI private circulation ref NCE/2-18-0063).

10.8 South Korea

About a third of Korea's electricity is generated from 25 nuclear reactors. In 2017 the new government decided to phase out nuclear power over 45 years. This decision was overturned in 2022 and a target was set for nuclear to provide a minimum of 30% of electricity in 2030. The current status of [nuclear power in Korea](#) is summarised on the WNA website [53].

10.8.1 Governmental Organisation

The Atomic Energy Commission (AEC) is the highest decision-making body for nuclear energy policy and is chaired by the prime minister. It was set up under the Atomic Energy Act.

The Nuclear Safety and Security Commission (NSSC) [54] was formed in October 2011. Previously the high-level Nuclear Safety Commission (NSC), chaired by the Ministry of Trade, Industry and Energy (MOTIE), was responsible for nuclear safety regulation with the Korean Institute of Nuclear Safety (KINS). KINS became a technical support organisation under NSSC.

The Korea Atomic Energy Research Institute (KAERI) [55] is responsible for R&D,

The Korean Institute of Nuclear Non-proliferation and Control (KINAC) [56], with greater independence, under MEST is responsible for nuclear material accounting and the international safeguards regime, though it appears been transferred to the NSSC.

MOTIE is responsible for energy policy, for the construction and operation of nuclear power plants, nuclear fuel supply and radioactive waste management. The Kansai Electric Power Company (KEPCO), KHNP, KNFC, NETEC and heavy engineering operations come under MOTIE, and KEPCO seems to have a controlling role with respect to the others.

The Korea Nuclear Association for International Cooperation (KNA) was set up in 2011 as an industry association linking Kepco with suppliers and contractors. KNA is supported by the Ministry of Trade, Industry and Energy (MOTIE).

10.8.2 Operators

The WNA article on Nuclear Power in South Korea [53] includes a list of currently operating reactors. These reactors are a mix of PWRs and CANDUs.

There are three APR 1400 PWRs under construction.

10.8.3 Design & Manufacturing Organisations

KEPCO is actively marketing OPR-1000 and APR1400 units in Middle East and North African countries, as well as Latin America; now focused on Egypt, Saudi Arabia, Kenya, Philippines, Vietnam and Czech Republic.

4 APR 1400 are under construction in the United Arab Emirates (UAE).

Agreements are at various stages between KEPCO with Brazil and Kenya; KHNP with Ukraine; KAERI and Daewoo with Jordan for a research and test reactor (JRTR).

Korea initially bought the CE / CANDU and framatone reactors turnkey before developing the CE System 80 (aka Korean Next-Generation Reactor) with KOPEC as the main designer and Doosan as the main manufacturer.

KEPCO was the preferred bidder in December 2017, with their APR1400, to buy out Nu Gen (Toshiba) at Moorhouse in Cumbria. Toshiba then rejected this scenario and has subsequently pulled out of Moorhouse.

10.9 Russia

10.9.1 Governmental organization

The [Federal Environmental, Industrial and Nuclear Supervision Service](#) (Rostekhnadzor) [58] exercises functions with regards to the state policy and regulatory/legal control including industrial and nuclear supervision (except activities on development, manufacture, testing, operation and disposal of nuclear weapon and military nuclear power installations).

The State Atomic Energy Corporation [Rosatom](#) [59] is one of the global technological leaders and is one of the largest companies of the Russian Federation bringing together nuclear power and power engineering assets, as well as NPP design and construction. SC Rosatom divisions are:

- Nuclear weapons complex.
- Nuclear & Radiation Safety and wastes.
- Nuclear Power – Atomenergoprom, Rosenergoatom.
- Applied and fundamental science, composite materials.
- Atomflot – Arctic fleet of seven nuclear icebreakers and one nuclear merchant ship.

10.9.2 Operators

The current status of [nuclear power in Russia](#) is described on the WNA website [60].

[Rosenergoatom](#) [61] was established in 1992 and was reconstituted as a utility in 2001, as a division of SC Rosatom. It is the only Russian utility. As of December 2021, Rosenergoatom were operating 37 reactors.

In August 2016 a government decree set out plans to build 11 new reactors beyond Kursk and those now under construction by 2030; it brought forward the dates for the first two BN-1200 reactors. The 2030 figure may be delayed due to a 2017 20% budget reduction. Fast reactors are projected as comprising some 14 GWe by 2030 and 34 GWe of capacity by 2050.

10.9.3 Design & Manufacturing organisations

The latest information on the Rosatom website states that Rosatom is building [3 units in Russia and 34 abroad](#) at various implementation stages [62].

OKB Hidropress, a subsidiary of the state atomic energy corporation Rosatom, is a state construction office which works on the design, analysis, development, and production of nuclear power plant reactors, most notably the VVER range.

The main reactor component supplier is OMZ's Komplekt-Atom-Izhora facility. OMZ subsidiary Izhorskiye Zavody is expected to produce the forgings for all new domestic AES-2006 model VVER-1200 nuclear reactors plus exports.

Rosenergoatom has said that reactor pressure vessels for its VVER-TOI reactors would be made by both Izhorskiye Zavody and the Ukrainian works Energomashspetsstal (EMSS) with Russian Petrozavodskmash.

Turbine generators for the new plants are mainly from Power Machines (Silovye Mashiny – Silmash) subsidiary LMZ.

Alstom Atomenergomash (AAEM) is a joint venture between French turbine manufacturer Alstom and Atomenergomash (AEM, an AEP subsidiary), which will produce low-speed turbine generators.

Many of Russia's fuel cycle facilities were originally developed for military use and hence are located in former closed cities. The conversion and enrichment plants were taken over by what became TVEL, part of Rosatom's fuel Division. TVEL has two fuel fabrication plants. TVEL's Novosibirsk Chemical Concentrates Plant (NCCP) produces pure lithium-7, and accounts for over 70% of the world supply of Li-7.

Rosatom and the National Operator for Radioactive Waste Management – FSUE NO RAO – is responsible for coordination and execution of works associated with radwaste management, notably its disposal. This includes military wastes.

Rostekhnadzor oversees a major programme of decommissioning old fuel cycle facilities.

10.9.4 Standards

Two main laws govern the use of nuclear power: the Federal Law on the Use of Atomic Energy (November 1995) and Federal Law on Radiation Safety of Populations (January 1996). These are supported by federal laws including those on environmental protection (2002) and the Federal Law on Radioactive Waste Management (2011). Rostekhnadzor is the regulator reporting direct to the president with Glavgosexpertiza, the Russian State Expert Examination Board, as the authority responsible for appraising design documentation and engineering services.

There are numerous [Federal Standards and Rules](#) relating to nuclear power [63]. NP-090-11 states Requirements for Quality Assurance Programs of Nuclear Facilities.

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Revisions

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April 2019	<p>Rewrite to extend International organizational information.</p> <p>Hypertext links checked and updated.</p> <p>References to standards and other documents updated.</p>	Susan J M Shaw, Richard Hibbert	Iain McNair
January 2023	Content and format updated by NNG.	NNG Steering Group	NNG Steering Group