**IGALL PROGRAMME TERMS OF REFERENCE**

**1. Background**

According to the IAEA Safety Standards [1], “the design for a nuclear power plant shall take due account of ageing and wear out effects in all operational states for which a component is credited, including testing, maintenance, maintenance outages, plant states during a postulated initiating event and plant states following a postulated initiating event.” Also, according to the IAEA Safety Standards, “The operating organization shall ensure that an effective ageing management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant” [2]. Data on operating experience can be collected and retained for use as input for the management of plant ageing.

Systematic ageing management provides for the availability of safety functions throughout the service life of the plant and decommissioning, taking into account changes that occur with time and use. This requires addressing both physical ageing of systems, structures and components (SSCs), which results in degradation of their performance characteristics, and obsolescence of SSCs, i.e. their becoming out of date in comparison with current knowledge, standards and regulations, and technology [3]. Effective ageing management throughout the service life of an SSC requires the use of a systematic approach that provides a framework for coordinating all programmes and activities relating to the understanding, prevention, detection, monitoring and mitigation of ageing effects on the plant components or structures and includes maintenance, in-service inspection, testing, and surveillance, as well as operations, technical support programmes (including analysis of any ageing effects and degradation mechanisms) and external programmes such as research and development [3–5].

The IAEA started to develop guidance on the safety aspects of ageing management in the 1990s [6]. Subsequently, many reports on the subject were published, providing general methodological guidance [7–9], as well as specific guidance for selected major nuclear power plant structures and components, such as reactor vessels, reactor internals, piping, steam generators, containment, etc. [10–20].

In recent decades, the number of IAEA Member States giving high priority to continuing the operation of nuclear power plants beyond the time frame originally anticipated (typically 30–40 years) has steadily increased. Recognizing the need to assist its Member States in dealing with the unique challenges associated with long term operation (LTO), the IAEA conducted the Extrabudgetary Programme on Safety Aspects of Long Term Operation of Water Moderated Reactors in 2003–2006 [21]. The outcome of the programme was consolidated in a Safety Report on Safe Long Term Operation of Nuclear Power Plants [22]. Ageing management is one of the focal points of Refs [21, 22].

General recommendations on methodology, key elements and implementation of the effective ageing management programmes (AMPs) for SSCs important to safety of nuclear power plants are provided in the IAEA Safety Guide on Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants [3]. Ref. [3] however does not provide comprehensive information on specific AMPs and TLAAs to address ageing effects of specific structures and components.

In parallel with the development of the safety related publications described above, the IAEA also developed and published documents focused on engineering, technological and scientific aspects of ageing management [23–25].

To complement the existing guidance and technical information described above, a need was identified to establish a process to collectively and systematically document and analyse research results and operating experience. The resulting effort addresses various types of water moderated reactor. The process facilitates exchange of technical information on ageing management among participating Member States. The results provide guidance on what constitutes an acceptable AMP for specific structures and components, and on ageing effects and degradation mechanisms, as well as tools for assessing existing plant programmes.

The United States Nuclear Regulatory Commission (NRC) has developed a consistent approach to ageing management in connection with license renewal for operating plants [26–29], and, at the request of the IAEA, agreed to provide the current revision of the GALL Report [29], as a basis to be used in developing this report.

The development of this report was initiated in May 2009 during a Technical Meeting at the IAEA and conducted through the IAEA Extrabudgetary Programme on International Generic Ageing Lessons Learned in 2010–2013 [30]. This IGALL Phase 1 was continued in the years 2014 to 2015 as IGALL Phase 2 and in the years 2016 to 2017 as IGALL Phase 3. Phase 4 of the EBP will follow in the years 2018 and 2019. The individual goals achieved in the different phases are described in chapter 4.

**2. Programme objective**

The Programme objective is to develop a general framework needed to effectively pursue experience and lessons learned on AM. The Programme will facilitate exchange of experience accumulated in Member States operating NPPs, on identification, establishment, implementation, and improvement of AMPs. Consideration of lessons learned worldwide for various types of reactors will assist MS in implementing effective and harmonized AM.

The International Generic Ageing Lessons Learned (IGALL) Safety Report will contain for SSCs important to safety:

* A generic sample of ageing management review (AMR) tables;
* A collection of proven ageing management programmes (AMPs);
* A collection of typical time limited ageing analyses (TLAAs).

**3. Scope**

The Programme will compile proven AMPs and typical TLAAs ageing management of passive and active structures and components (SCs) for NPPs with PWR (incl. WWER), BWR, CANDU and PHWR reactors that can have an impact, directly or indirectly, on the safe operation of the plant and that are susceptible to ageing degradation.

The information provided will be relevant for plants in operation, for plants considering LTO, as well as for new plants including new designs. Although the Programme will be focused mainly on management of physical ageing, technological obsolescence of SSCs important to safety will be also addressed. Conceptual aspects of obsolescence (such as consistency with current knowledge and standards) are out of Programme scope.

The IGALL Safety Report is not intended to facilitate comprehensive identification of components and structures for ageing management. In particular this report does not address identification of structures and components (scoping and screening) for long term operation and should not be used as a checklist or as a scoping and screening document. Scoping and screening is described in [22].

The information provided in this report will represent proven practices of participating Member States. Some all of these proven practices may not be applicable to every NPP or Member State.

**4. Implementation**

**IGALL Phase 1 (2010-2013)**

Following the presentation and discussion of the EBP proposal to the Permanent Missions of the IAEA Member States, the EBP was initiated in the middle of 2010.

EBP activities were in its Phase 1 guided by a Steering Group composed of senior Member State representatives, implemented by three working groups (WG), coordinated and reviewed by a Clearing Group. The 3 WGs dealt with the following areas:

* WG1- mechanical components;
* WG2- electrical and I&C components;
* WG3- civil structures and components.

The Programme implementation relied on voluntary in kind and financial contributions from Japan and the USA as well as in kind contributions from Argentina, Belgium, Brazil, Bulgaria, Canada, China, the Czech Republic, France, Germany, Hungary, India, Mexico, the Netherlands, Russian Federation, Slovakia, Spain, Sweden, Switzerland, the Ukraine, the European Commission and the NEA of the OECD.

The EBP activities relied heavily on work carried out by the participating experts in their countries. The EBP meetings served mainly co-ordination purposes.

The products of the IGALL Phase 1 activities include:

* IGALL Safety Report (providing guidance on using the IGALL database);
* IGALL database (containing AMR tables and proven AMPs and TLAAs);
* IGALL-TECDOC-1736, Approaches to Ageing Management in MS: IGALL Final Report.

IGALL Phase 1 deliverables are posted on IAEA publicly available web sites:

<http://gnssn.iaea.org/NSNI/PoS/IGALL/SitePages/Home.aspx>

The IGALL EBP participants pointed out the importance of maintaining the EBP products as living documents and concluded that the IGALL EBP activities should continue in the future to improve the products and incorporate future operational experience, results of research and development and new proven AMPs and TLAAs as well as new contributions of Member States.

Abovementioned deliverables of IGALL Phase 1 were approved by IGALL Steering Group in September 2013 and published in 2014. IGALL TM held in September 2013 recommended to the IAEA to continue to promote and support IGALL Safety Report use and implementation by all MS operating NPPs. The IAEA should develop and implement a programme with two objectives:

1. Provide a forum for exchange of experience and support to MS in applying IGALL as a tool to address ageing management and safe LTO;
2. Enhance the completeness of IGALL Safety Report.

**IGALL Phase 2 (2014-2015)**

EBP activities were in its Phase 2 guided by a Steering Committee (SC) composed of senior Member State representatives and implemented by four WGs. The four WGs dealt with the following areas:

* WG CANDU - CANDU mechanical components;
* WG WWER – WWER mechanical components;
* WG EI&C - electrical and I&C components;
* WG OBS – technological obsolescence.

Working Groups activities in their respective areas include:

1. Explain to newcomers the IGALL development and ways of utilization;
2. Collect additional AMPs, TLAAs and AMR lines;
3. Use pilot plants to demonstrate the utilization of IGALL;
4. Use the results of IGALL comparison with reference (pilot) plants to identify new lines in AMR tables and additional proved AMPs and TLAAs to supplement IGALL;
5. Review and compare the information collected, identify common elements and differences;
6. Reconcile the differences, in order to harmonize the efforts;
7. Prepare new set of AMPs, TLAAs and AMR lines for SC approval.

WGs and SC worked through a web-based structure of data collection organized for purpose of the Programme: http://gnssn.iaea.org/sites/auth/NSNI/ExtPRJ/IGALL/DB/SitePages/Home.aspx.

An IGALL TM was organized in November 2015, and provided additional advice for IGALL Phase 3. IGALL Phase 2 was completed and results were approved by SC in November 2015.

**IGALL Phase 3 (2016-2017)**

EBP was continued during the years 2016 and 2017 based on the decisions taken at the SC meeting in December 2015. The objectives to be performed during IGALL Phase 3 were fixed as follows:

* 1. Prepare IGALL Safety Report, version 2018;
	2. Update IGALL database and enhance its completeness;
	3. Support MS in implementing and using IGALL.

Topics 1 and 2 were processed within the working groups, whereas topic 3 was the task to be performed by IAEA.

To achieve the goals described in topics 1 and 2, three working groups dealt with the following areas:

* WG1- mechanical components;
* WG2- electrical and I&C components;
* WG3- civil structures and components;

and worked according to the objectives approved at the SC meeting in December 2015:

* 1. Collect MS proposals for improvement of the main text (sections 1-5 of SRS 82) and incorporate approved changes;
	2. Assure consistency with new NS-G-2.12;
	3. Update References, Appendices I, II, and III, list of abbreviations, list of contributors;
	4. Collect additional AMPs and TLAAs;
	5. Update or add reference documents in all AMPs and TLAAs after evaluation of impact;
	6. Update operating experience in all AMPs;
	7. Improve consistency and use of definitions, particularly of ageing effects/degradation mechanisms in AMR table, SRS 82, AMPs and TLAAs.

All WGs results were presented during SC meetings in December 2016 and December 2017; all finalized documents initially developed and/or comprehensively reviewed and updated during IGALL Phase 3 were finally approved by SC. As not all of the tasks, originally planned to be performed during IGALL Phase 3, were fully completed, the postponement of their finalization to IGALL Phase 4 was as well approved by SC.

Based on these approvals, SRS 82 will be published in 2018; all other approved documents like AMPs, TLAAs, and the AMR master table will be uploaded on the publicly available website for common use.

**IGALL Phase 4 (2018-2019)**

Tasks and organizational structure for IGALL Phase 4 was determined based on IGALL SC advice during the meeting in December 2017. In particular, the following topics were approved by SC to be performed during Phase 4:

**IGALL Phase 4 objectives and tasks:**

1. Enhancement of AMPs and TLAAs:
	1. Collect new AMPs and TLAAs and update existing AMPs and TLAAs
	2. Use US NPPs plant-specific AMPs, plant-specific TLAAs and plant-specific AMR line items for IGALL enhancement (US industry participation necessary)
	3. Evaluate impact of final GALL SLR on IGALL AMPs
	4. Check possibility of consolidation of existing AMPs and TLAAs
	5. WG1 – AMPs and TLAAs from AGR
	6. WG2 – AMP for optical cables
	7. WG2 – Consider AM of spare parts storage
	8. WG3 - Consideration of spent fuel pool ageing management (liner and structure)
	9. WG3 - Consider fatigue analysis of steel containment (US NRC Regulatory Guide 1.57)
	10. WG3 – Check consistency of AE/DM in AMR and AMPs and TLAAs
	11. WG3 - Address in AMR/ AMP / TLAA the irradiation effects on properties of concrete (use e.g. GALL SLR)
2. Enhancement of AMR:
	1. Column ‘further action’ – consolidate information in ‘further action’ column (other than TLAAs) and develop description of ‘further action’ intention, use descriptions of the further evaluations which are identified in the “further evaluation” column of the NRC GALL AMR table defined e.g. in SRP, part 3.1.2.2 for improvement of IGALL
	2. Systematic review and consolidation of definitions for ‘structure/component’, ‘critical location/part’, ‘material’, and ‘environment’
	3. Develop a pilot on use of EPRI MDM format to enhance AMR table
	4. WG1 - Column ‘System’ – change title to ‘System/ functional group’ and agree and consolidate terminology
	5. WG1 - PWR RVI part consolidate and enhance
	6. WG1 – consolidate items in tables 107 and 108
	7. WG2 – check consistency of AE/DM for similar EQ and non-EQ equipment
3. SRS 82 improvement:
	1. Create Integrated AMP (requirements, scope, content, monitoring of effectiveness, etc.)
	2. Develop a statement/ description how to handle maintenance measures and processes in the interaction with AMPs
4. Specific tasks:
	1. Guidance for regulators to review NPPs` preparedness for safe LTO (WG dealing with Regulatory Aspects of LTO preparation).
	2. Develop TECDOC experiences in ageing management during delayed construction periods, prolonged outages, extended shutdown and post final shutdown
5. Tasks for IAEA secretariat:
	1. Develop and implement workshop/ training for “junior” experts on IGALL use (EPRI offers help)
	2. Improve IGALL public and restricted website
	3. Invite observers, e.g. from new built companies, on a regular basis
	4. AMR – hyperlink terms to definitions, AMPs and TLAAs on IGALL public website

**Organization of IGALL Phase 4:**

* + 1. **Steering Committee**
* 1 representative of each MS and each international organization, WG chairpersons
* 30 MS + OECD/NEA, EU JRC, EPRI appointed their representatives
* SC chairman – Mr. A. Hiser, NRC, USA (to be confirmed)
* IAEA Technical officer – Mr. R. Krivanek

SC meetings:

* 17-19 December 2018 in Vienna
* December 2019
	+ 1. **WG1 – mechanical components**
* WG chairman – Mr. J. Heldt, Leibstadt NPP, Switzerland
* IAEA Technical officer – Mr. R. Krivanek
* Tasks 1, 2 and 3

4 subgroups (can be modified as needed by WG):

* General (WG1G) – Mr. M. De Smet, Tractebel, Belgium
* PWR/VVER (WG1P) – Mr. S. Ratkai, Paks NPP, Hungary
* BWR (WG1B) – ???
* CANDU/PHWR (WG1C) – Mr. K. Kirkhope, CNSC, Canada

WG1 meetings:

* 26-29 June 2018, Washington, D.C., USA (hosted by NRC)
* 9-12 October 2018, Amsterdam, the Netherlands (hosted by EU JRC)
* 26-29 March 2019, Vienna or Europe
	+ 1. **WG2 – EI&C components**
* WG chairman – Mr. M. Calatayud, Cofrentes NPP, Spain
* IAEA Technical officer – Mr. new IAEA staff + Mr. S.Kunito
* Tasks 1, 2 and 3

3 subgroups (can be modified as needed by WG):

* EQ (WG2Q) – Mr. T. Minakawa, NRA, Japan
* Cables (WG2C) – Ms. ???, NRC, USA (to be confirmed)
* EI&C components (WG2E) – Mr. B. Willey, EDF, France

WG2 meetings:

* 4-7 June 2018, Vienna (VIC M6+MOE16+MOE18+MOE19)
* 2-5 October 2018, Angra NPP, Brazil (hosted by Angra NPP)
* 9-12 April 2019, Vienna or Europe
	+ 1. **WG3 – civil structures and components**
* WG chairman – Mr. E. Gallitre, EDF, France
* IAEA Technical officer – Mr. K. Makela
* Tasks 1, 2 and 3

3 subgroups (can be modified as needed by WG):

* Concrete containment (WG3C) – Ms. M.Sircar, NRC, USA (to be confirmed)
* Steel components (WG3S) – Mr. L.Bishnoi, AERB, India
* Other concrete structures (WG3O) – Mr. J. Sabater, Asco-Vandellos NPP, Spain

WG3 meetings:

* 11-14 June 2018, Vienna (VIC M6+MOE18+MOE19)
* 6-9 November 2018, Daejeon, Korea (hosted by KEPRI)
* 7-10 May 2019, Vienna or Europe
	+ 1. **WG4**
* WG chairman – Mr. ??? , NRC, USA (to be confirmed)
* IAEA Technical officer – Mr. new IAEA staff (temporarily Mr. R.Krivanek)
* Tasks 4 - Guidance for regulators

WG4 meetings:

* 24-27 July 2018, Vienna (VIC M6+MOE13)
* 5-8 February 2019
* Q3 2019
	+ 1. **WG5**
* WG chairman – Ms. Sherry Bernhoft, EPRI (to be confirmed)
* IAEA Technical officer – Mr. new IAEA staff (temporarily Mr. R.Krivanek)
* Tasks 4 - Delayed construction periods, prolonged outages, extended shutdown and post final shutdown

WG5 meetings:

* 24-27 July 2018, Vienna (VIC MOE79+MOE15)
* 5-8 February 2019, Toronto, Canada (hosted by COG)
* Q3 2019

**5. Outcomes and outputs**

The IGALL Safety Report will provide detailed information on specific programmes to manage existing and potential ageing and degradation of systems, structures and components (SSCs) that will assist operating organizations and regulatory bodies by specifying:

* A technical basis and practical guidance on managing ageing of mechanical, electric and I&C components, and civil structures of nuclear power plants important to safety;
* A common internationally recognized basis on what constitutes an effective ageing management programme;
* A knowledge base on ageing management for design of new plants, design reviews, etc., and a roadmap to available information on ageing management;
* A collection of proven ageing management programmes for SSCs important to safety developed and implemented in various types of water moderated reactors, which will be periodically updated.

**6. References**

1. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, Safety Standards Series No. SSR-2/1, Rev.1, IAEA, Vienna (2016).
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Commissioning and Operation, Safety Standards Series No. SSR-2/2, Rev.1, IAEA, Vienna (2016).
3. INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants, Safety Standards Series No. SSG-48, IAEA, Vienna (2017).
4. INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, Safety Standards Series No. NS-G-2.6, IAEA, Vienna (2002).
5. INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, Safety Standards Series No. SSG-25, IAEA, Vienna (2013).
6. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Aspects of Nuclear Power Plant Ageing, IAEA-TECDOC-540, IAEA, Vienna (1990).
7. INTERNATIONAL ATOMIC ENERGY AGENCY, Methodology for the Management of Ageing of Nuclear Power Plant Components Important to Safety, Technical Reports Series No. 338, IAEA, Vienna (1992).
8. INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Nuclear Installations, Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).
9. INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation and Review of a Nuclear Power Plant Ageing Management Programme, Safety Reports Series No.15, IAEA, Vienna (1999).
10. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: Steam Generators, IAEA-TECDOC-981, IAEA, Vienna (1997).
11. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: Concrete Containment Buildings, IAEA-TECDOC-1025, IAEA, Vienna (1998).
12. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: CANDU Pressure Tubes, IAEA-TECDOC-1037, IAEA, Vienna (1998).
13. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: PWR Pressure Vessels, IAEA-TECDOC-1120, IAEA, Vienna (1999).
14. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: PWR Vessel Internals, IAEA-TECDOC-1119, IAEA, Vienna (1999).
15. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: Metal Components of BWR Containment Systems, IAEA-TECDOC-1181, IAEA, Vienna (2000).
16. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: In-containment Instrumentation and Control Cables, Volumes I and II, IAEA-TECDOC-1188, IAEA, Vienna (2000).
17. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: CANDU Reactor Assemblies, IAEA-TECDOC-1197, IAEA, Vienna (2001).
18. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: Primary Piping in PWRs, IAEA-TECDOC-1361, IAEA, Vienna (2003).
19. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: BWR Pressure Vessels, IAEA-TECDOC-1470, IAEA, Vienna (2005).
20. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety: PWR Pressure Vessels 2007 Update, IAEA-TECDOC-1556, IAEA, Vienna (2007).
21. INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Aspects of Long Term Operation of Water Moderated Reactors, IAEA-EBP-SALTO, IAEA, Vienna (2007).
22. INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants,Safety Reports Series No.57, IAEA, Vienna (2008).
23. INTERNATIONAL ATOMIC ENERGY AGENCY, Plant Life Management for Long Term Operation of Light Water Reactors, Technical Reports Series No. 448, IAEA, Vienna (2006).
24. INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Plant Life Management Processes: Guidelines and Practices for Heavy Water Reactors, IAEA-TECDOC-1503, IAEA, Vienna (2006).
25. INTERNATIONAL ATOMIC ENERGY AGENCY, Safe and Effective Nuclear Power Plant Life Cycle Management Towards Decommissioning, IAEA-TECDOC-1305, IAEA, Vienna (2002).
26. UNITED STATES NUCLEAR REGULATORY COMMISSION, Title 10 Code of Federal Regulations Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Office of the Federal Register, National Archives and Records Administration, USNRC, Washington DC (2013).
27. UNITED STATES NUCLEAR REGULATORY COMMISSION, Standard Format and Content for Applications to Renew Nuclear Power Plant Operating Licenses, Rev.1, USNRC Regulatory Guide 1.188, USNRC, Washington DC (2005).
28. UNITED STATES NUCLEAR REGULATORY COMMISSION, Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants, NUREG-1800, Rev.2, USNRC, Washington DC (2010).
29. UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned (GALL) Report, Final Report, NUREG-1801 Rev.2, USNRC, Washington DC (2010).
30. INTERNATIONAL ATOMIC ENERGY AGENCY, Approaches to Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) Final Report, IAEA-TECDOC-1736, Vienna (2014).