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Ageing Management Program
A key Issue for Operating plants and New Design

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1 Abstract

During the past 10 years many works have been done on Ageing Management Program of Safety classed components in different countries.

The paper will describe all the different aspects concerning these programs, and in particular the EDF step by step procedure and the major results.

To-day, EDF is preparing the 3rd ten-year shutdown of all these 3-loop plants (34 plants). During the associated Safety Review, a specific task is devoted to ageing effects and control of all the safety concerned components. A large list of components has been reviewed : mechanical, civil engineering, instrumentation and control, cables, non metallic components. Few non safety but important in term of availability components are considered, like turbine or some balance of plant components. A general review of results and difficulties for 40 and 60 years are presented in the paper.

The second part is devoted to a short review of external works that are included in the EDF procedures : IAEA, NEA-IAGE, EC-NULIFE, EPRI-MRP…

The major conclusions are clearly supporting the needs of more international procedure harmonization on all the different topics.

2 Introduction

Managing ageing and remaining lifetime of an industrial facility is a concern that must be taken in account as part of daily activities. Bad practices may be detrimental in the short as well as the long term and the capital assets are of considerable value.

Ageing management of Nuclear Power Plants is an essential issue for utilities, in term of safety and availability and corresponding economical consequences.

Practically all nuclear countries have developed a systematic program to deal with ageing of components on their plants.

EDF recognised since the beginning of plant operation the importance of that need for its nuclear facilities: 58 PWR (Pressurized Water Reactor) units built on 20 sites are producing more than 75 % of electricity used in France (fig. 1). Keeping these facilities in good operating conditions as long as possible is absolutely vital for EDF.

For nuclear power plants, "good operating conditions" undoubtedly means safety and cost-effectiveness.

In parallel, in 2001, USNRC (United State Nuclear Regulatory Commission) produced a specific document to be used for US utility license renewal: Generic Ageing Lesson Learns" (GALL report [1]). Different other countries are on the way to develop their own Ageing Management Program and the corresponding Safety Requirements, like: Japan, Netherlands, and Hungaria…

3 LIFETIME MANAGEMENT POLICY

At EDF, the lifetime management policy of the nuclear power plants is based on four principles:

- daily operation and maintenance activities, with an effective experience feedback organization taking advantage of the high level of standardization of the units,

- "Exceptional Maintenance Program" is charged to identify possible future problems, to estimate potential consequences and to propose appropriate measures to be taken. Of course, consequences of the "anticipation / no anticipation" choice must be integrated on the whole plant lifetime.

- every ten years, a complete safety review of each group of similar plants, including ageing evaluation of Systems, Structures and Components (SSC)

- a Life Management Program, at corporate level, which permanently scrutinizes operation and maintenance activities to identify decisions which could impair plant lifetime and which surveys research and development programs related to ageing phenomenon understanding.

4 AGEING MANAGEMENT PROGRAM REVIEW

The major objectives of this 10-year basic activity is to justify that all the safety important systems, structures and components (SSC), concerned by an ageing mechanism, remain in the design and safety criteria, including all feedbacks from the field.

This ageing occurs along normal operation, including periodic tests and routine maintenance activities (like opening and closing of components).

This ageing of SSC's is considered under control through different actions:

- prediction and detection, early in the SSC life, of degradations that can affect design rules (integrity of barriers) or safety function of the plant (final safety analysis report: FSAR),

- definition of mitigation and corrective actions (including repair, replacement) to assure the safety level of the plant and the economic competitiveness of the final decision on anticipation process bases.

This ageing management program review is formed of 3 steps [2]:

- selection of structures and components,

- specific report to continue operation of the more sensitive components and structures

- synthesis report.

All these reports have to be prepared in accordance with the French regulation, as the decree for surveillance of primary and secondary system [3], the different French Codes & Standards, as RCC-M [4] and RSE-M [5] and the corresponding plant Final Safety Analysis Report (FSAR).

5 FRENCH PROCEDURE FOR AMP REVIEW

5.1 Structure and component selection

The selection is based on the FSAR that defines rules for safety importance of components and structures:

- mechanical components: class 1-2-3

- electrical components: class 1E

- civil engineering structures: connected to safety

Around 15000 components are concerned by plant. The selection is based on the different ageing degradation mechanism that can affect a part of each components and structures.

In order to do that systematically and with a minimum of references that support the decisions, we proposed a specific grid with one line per component, structures, or element for each potential degradation mechanism. In the same time different other information's are collected through the columns:

- is the degradation mechanism potential or encountered in French or International similar plant?

- did we encounter difficulties that can have affected a safety function?

- is the degradation mechanism analyzed in the design report? If yes, what is the expected life in this report?
- is the present maintenance program adapted, easy to adapt or un-adapted for this degradation mechanism?
- is the repair easy or difficult for this degradation mechanism and this location?
- is the replacement of the component easy or difficult? Do we have any risk of obsolescence of the components (no vendor available or no manufacturer of this type of components)?

After the completion of the grid each component or group of components (with similar function or similar degradation or similar design…) is affected in 3 categories: 0-2 (fig. 2):

- 0: no complementary studies
- 2: prepare a specific justification report to confirm the continuation of operation

A specific data sheet is attached to each line of the grid in order to collect all the references used to complete the grid.

5.2 Report to justify continuation of operation

For the category 2 components or structures, a report has to be produced to justify on what basis continuation of operation can be permitted.

This report has to collect and identify references and present it as follows:

- introduction
- description: design, materials, fabrication process, water chemistry
- design basis: regulation, codes & standards, specification and guidelines
- operating experience and ageing mechanism
- assessment methods of corresponding ageing mechanisms
- inspection, monitoring, leak detection
- mitigation, repair, replacement
- synthesis of ageing management program recommendations

5.3 Synthesis report

This synthesis report has to collect the major information of the 2 previous steps: selection and report to justify continuation of operation. A comparison is done with existing practices for the component or the structure (fig. 3).

IA set of recommendation based on the different information collected and the economic aspect of the decisions is finally done.

6 STATUS OF FRENCH APPLICATION

The oldest French plant has been in operation since 1977 and EDF is preparing the 3rd 10-year shutdown for this plant and a group of 28 similar plants (3-loop PWR).

The first application of the procedure, discussed herein, led to around 31 locations on different components in category 2, 260 in category 0 and 115 in category 1 (intermediate situation that needs few short-term complementary analyses. The corresponding 12 "Component report to justify continuation of operation" were made for the end of 2004, and are to day in improvement process for some of them.

Finally, for a large list of components and structures the existing AMPs, developed at the plant level, are adequate. The list of category 2 location/damage can be attributed to 12 components and structures where existing AMPs have to be reviewed for, and if necessary, improved upon for certain aspects:

- reactor pressure vessel
- reactor pressure vessel internals
- steam generator
- pressurizer
- main coolant line of primary system
- auxiliary lines connected to primary system
- reactor coolant pump
- containment
- other civil engineering structures
- I&C components
- cables for "hot points" only
- electrical penetration in the containment

7 COMPARISON WITH INTERNATIONAL APPROACHES

The EDF approach has been compared with AIEA guidelines [6,7,8], GALL report and similar programs in Japan, Switzerland or other countries [13].

7.1 Comparison of GALL report applicability to French PWRs

For example for the GALL report [1]:

- the approaches are similar but some degradation understandings are different
- different objectives : Licence Renewal / Periodic Safety Review
- larger scope in GALL report (PWR and BWR, safety and non-safety SSCs)
- similar, but not identical list of components, locations, degradation mechanisms for PWRs

For mechanical components: different regulation, different Codes & Standards, specific AMP leads to difficult comparison. For the same degradation mechanism different solution can be used by Utilities.

Different understanding of some degradation mechanisms between EDF practices and GALL report proposals, as:

- limited “potential” degradation based on laboratory knowledge in the GALL report, more in EDF practices
- GALL report is more based on USA than International field experience; more international cross checks in EDF approach
- more environment effect in fatigue in GALL report than in EDF practices
- less thermal ageing in GALL report than in EDF practices
- no high cycle thermal fatigue in GALL report

7.2 IAEA reports supporting development of AMP review

In the past 15 years IAEA- Nuclear Safety has developed different documents for ageing management and long term operation: programmatic documents, technical documents on ageing of components and some good practice technical documents (fig. 4, 5).

Now IAEA- Nuclear Safety is preparing a Safety Guide document on Ageing Management of Nuclear Power Plant for beginning of 2008.

Figure 5 present the generic scheme proposed by IAEA to develop an AMP.

In parallel, IAEA- Nuclear Power has developed different documents on technical best practices [14, 15]. Some of these documents are under revision process regularly, like the procedure for Reactor Pressure Vessel (RPV) residual life evaluation procedure [16].

A special program has been launch on Long Term Operation (LTO) of VVER plants [17].

7.3 Other support organisation

2 other organisations have play a role in supporting AMP activities:

- OECD-NEA- IAGE group developed programmatic synthesis [9], best practice documents [12], state of the art document and comparison of AMP practices in different countries [11]
- European Community supports Research activities [10,18] and programmatic documents [19]

8 CONCLUSION

After more than 5 years, the EDF Ageing Management Program has been developed to be included in the 3rd 10 year shutdown of French 3-loop PWRs. A first evaluation has justified a 40 year operation period, with a limited complementary set of studies to guarantee, if needed 60 years of operation. During this project EDF take benefit of the design and operation rules, in particular the detailed surveillance program of the mechanical components, with a set of high performance qualified inspections for class 1 components. A specific program has been developed and updated for the non-mechanical components as civil engineering, I&C or cables.

All these studies are done with a large comparison with international similar programs : IAEA, OCDE-NEA and EC activities.

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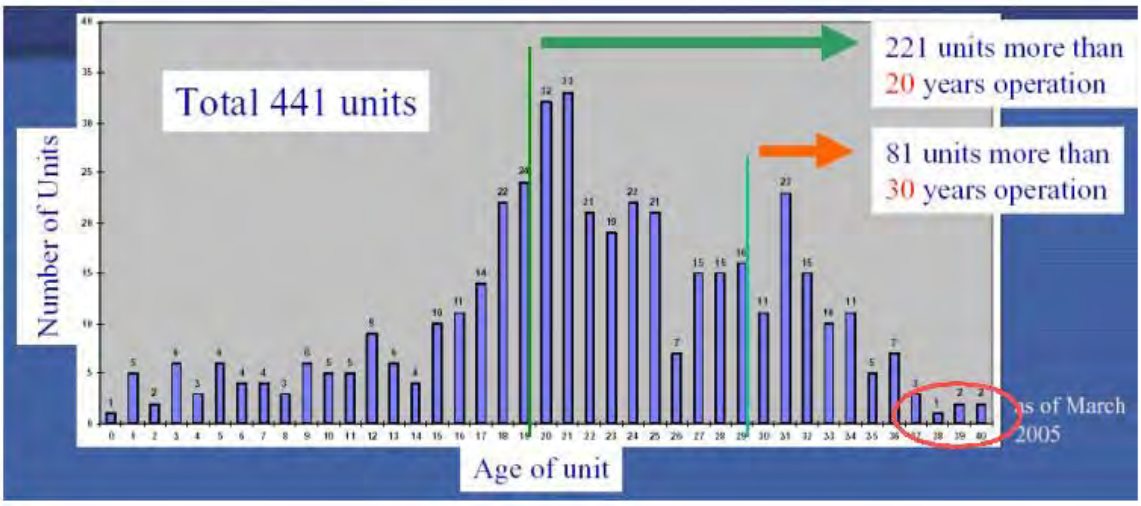

Figure 1. Age of world Nuclear Power Plants

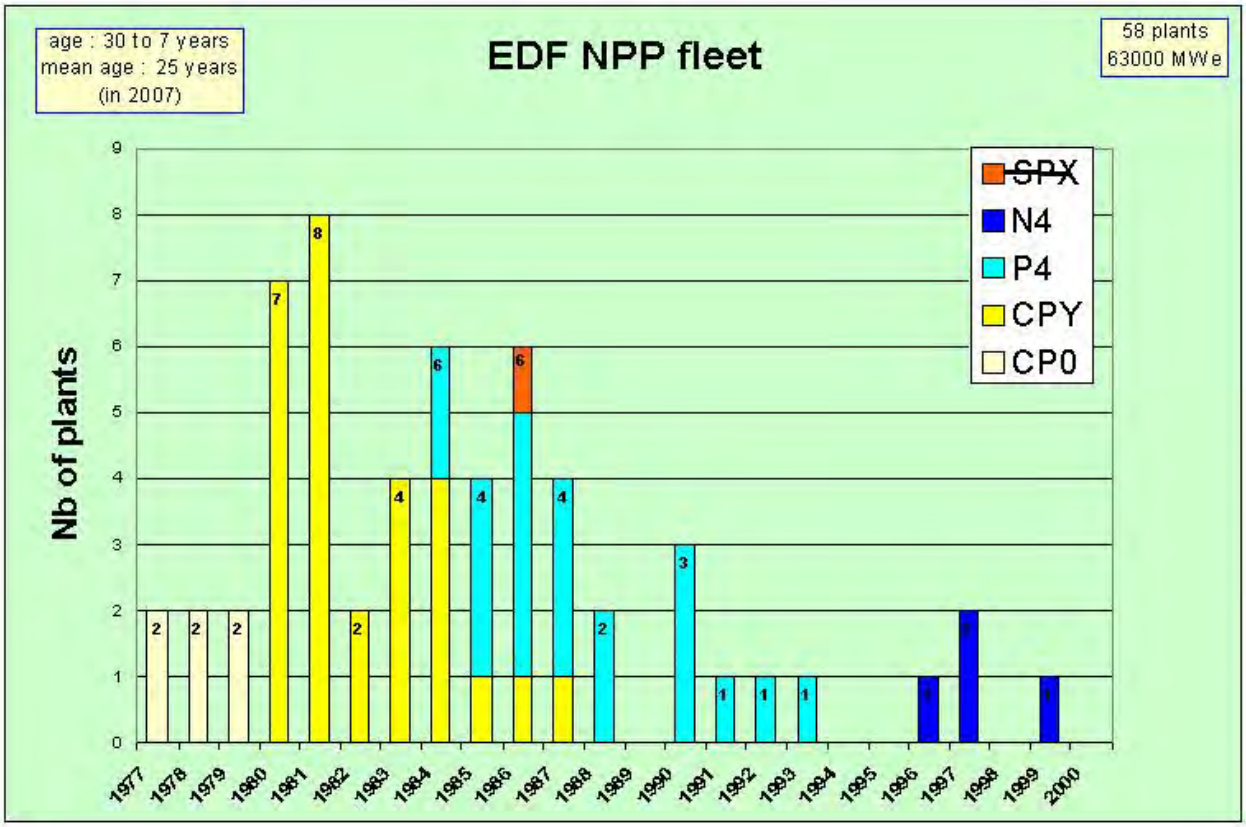

Figure 2. Age of EDF Nuclear Power Plants

Degradation mechanism	Encountered		Predicted	
Existing maintenance program	OK	Difficult to be OK	OK	Difficult to be OK
Repair and replacement difficult	2	2	0	2
Repair or replacement not difficult	0	2	0	0

0 : nothing, without any new information
2 : prepare a detailed ageing analysis report

Figure 3. First ranking process of EDF Ageing Management Program

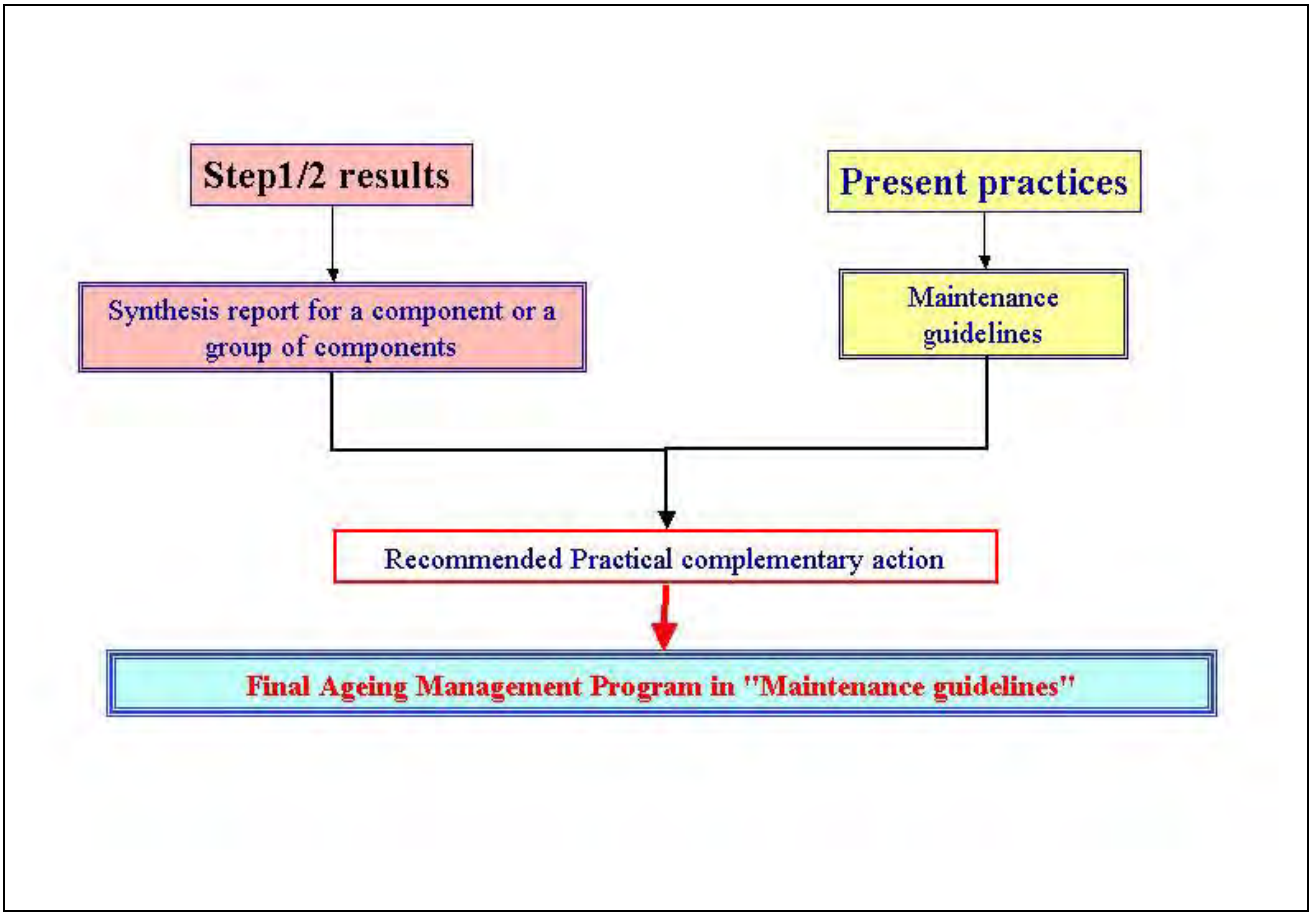

Figure 4. Mixing process of Ageing Management review and existing maintenance program

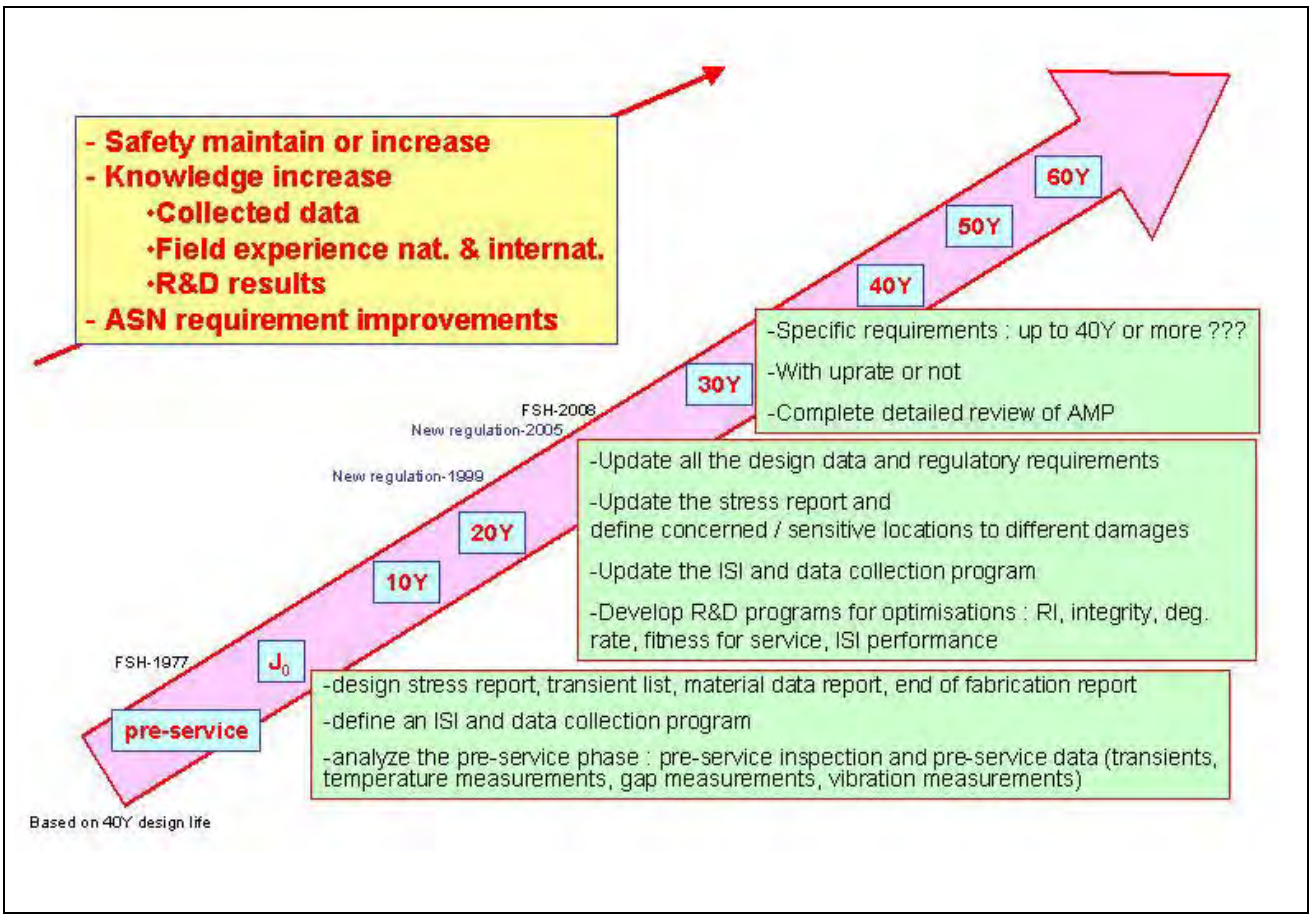

Figure 5. Ageing Management Tasks along the plant life

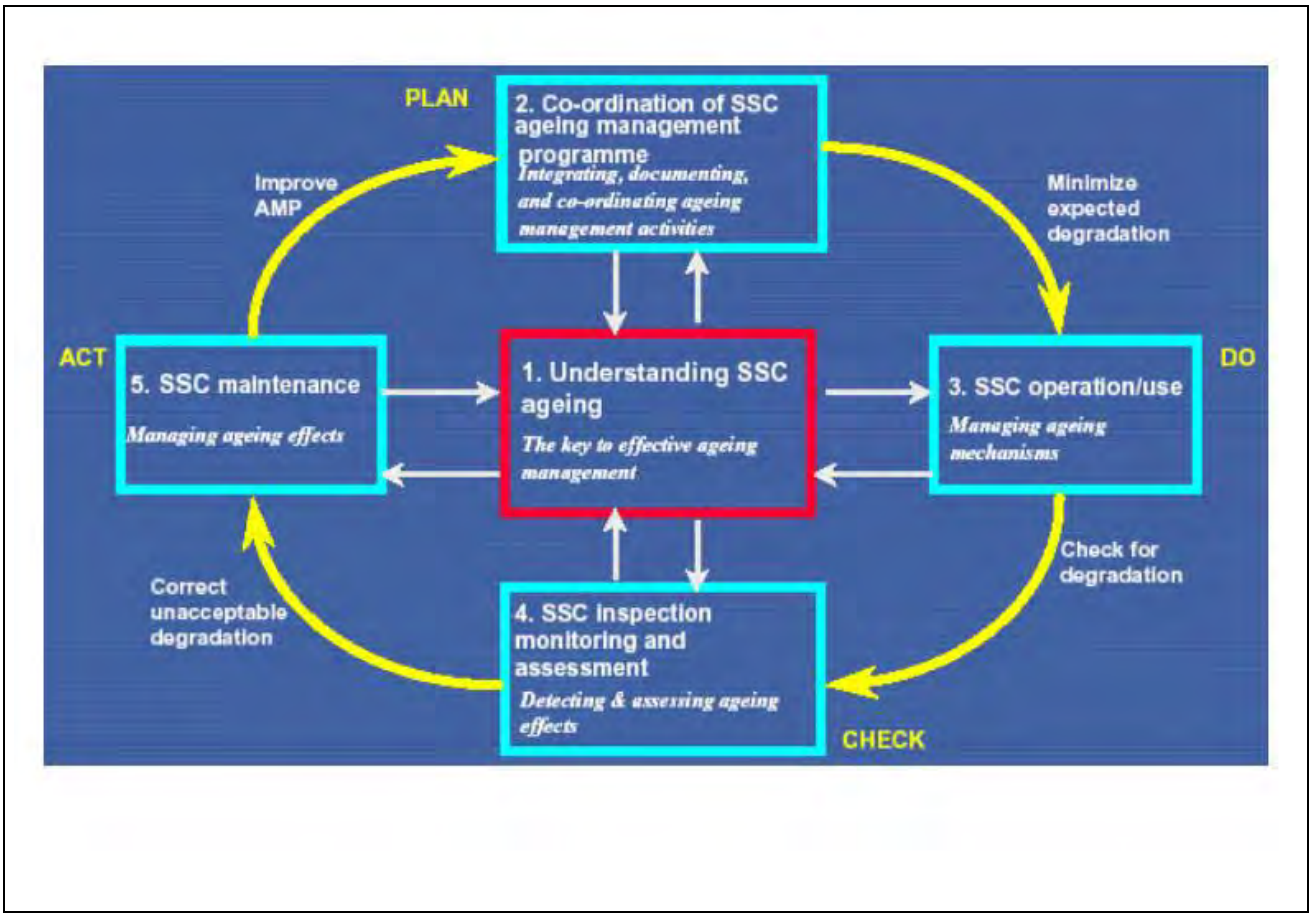

Figure 6. Deming principle adapted to Ageing Management Program of NPP

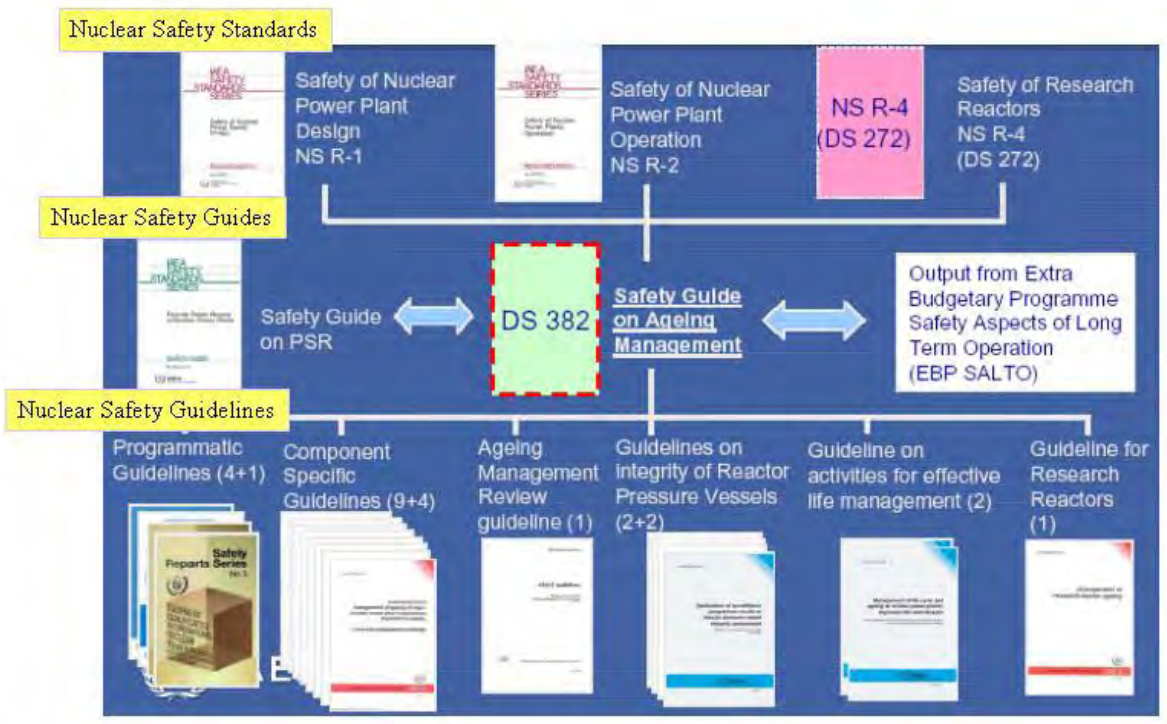

Figure 7. IAEA documents on Ageing Management of Nuclear Power Plants