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European Clearinghouse: Analysis of Events related to Modifications of Nuclear Power Plants

*Summary Report of an
European Clearinghouse
Topical Study*

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1. INTRODUCTION

Modifications are implemented in Nuclear Power Plants (NPP) for many different reasons: for safety reasons (for instance, following a Periodic Safety Review), for economic motivations (power uprate or optimization of maintenance activities), to correct existing failures or deficiencies or to cope with the plant ageing [1].

It can be expected that the number of modifications will increase over the coming years, for the operating NPPs but also for the NPPs under construction, considering the life time of the NPPs and the continuous upgrading of safety, security and environmental requirements.

It must be ensured that all modifications are designed, implemented and tested in such a manner that the safety of the plant as well as the safety of workers and environment is not degraded.

This Summary Report presents the results of a study [2] performed by the European Clearinghouse on Operating Experience Feedback of NPP with the support of IRSN (Institut de Sûreté Nucléaire et de Radioprotection) and GRS (Gesellschaft für Anlagen und Reaktorsicherheit mbH). This study covers NPP events related to modifications to Structures, Systems and Components, to process software, to operational limits and conditions, to operating procedures and to management systems, considering both permanent and temporary modifications.

2. METHODOLOGY

This report summarizes the analysis of modification-related events reported to the International Reporting System IRS database, US Licensee Events Reports (LER) database, French IRSN database and German GRS database.

For this report, we screened 1160 IRS reports and 817 LERs. The screening period runs from the start-up of the database for IRS and from 1995 for the LERs and ends on 31 December 2009. After screening, 133 IRS reports and 250 LERs were found to be applicable, to which 267 French event reports and 119 German event reports were added, leading to a total amount of more than 700 events.

To help identify generic recommendations, the events were classified into several categories according to the main steps of the modification process [1]: design, fabrication and supply, implementation, post-modification tests, documentation and secondly, into sub-categories related to components: civil engineering, electrical components, I&C, mechanical components, ventilation, fire protection and core (see Figure 1).

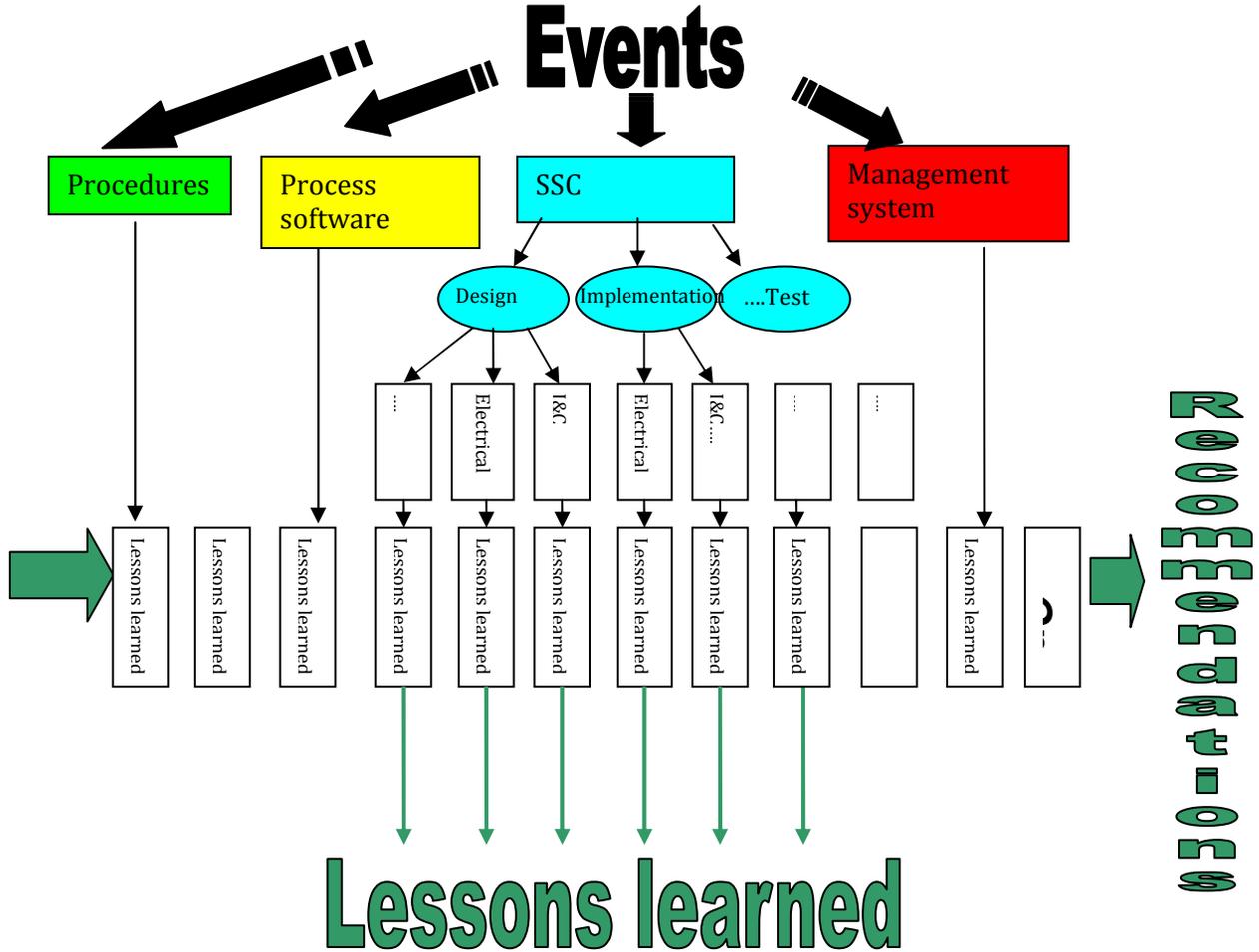


Figure 1 – Structure of the study

The categories and sub-categories were screened to identify both lessons learned about specific components and generic recommendations for the different components and/or modification stages. The generic recommendations are presented in section 4 and the lessons learned are given in appendix.

3. MAIN FINDINGS

This section gives the main findings from the analysis of the IRS reports. Other results concerning the analysis of selected LERs as well as event reports selected from IRSN and GRS data bases are available in the study [2].

Figure 2 shows the distribution of the IRS modification events into categories corresponding to modification process steps: the two steps where the failures

occurred mainly are design (about 40% of IRS reports) and implementation (about 30%).

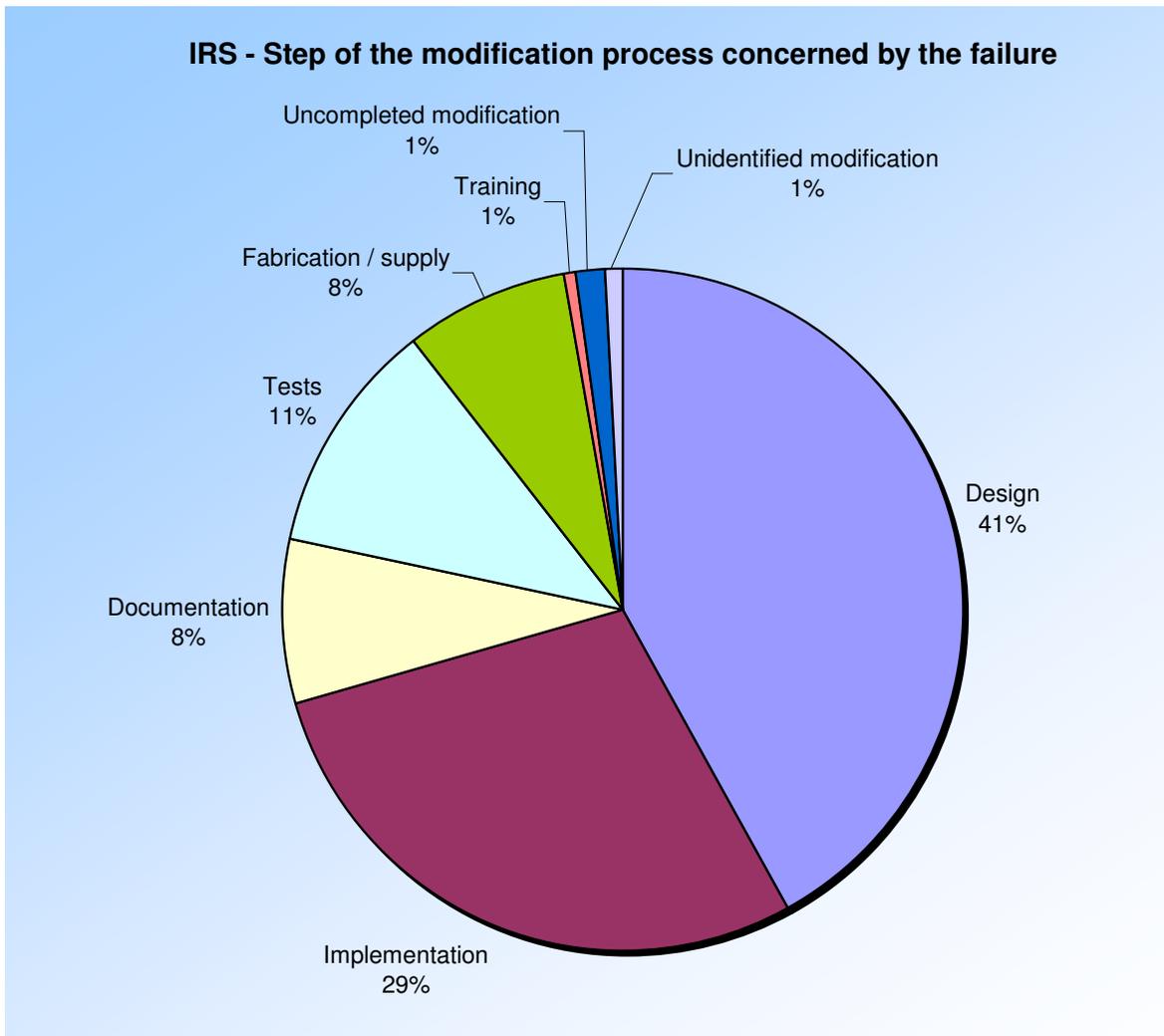


Figure 2 - Steps of the modification process when the reported events occurred

Figure 3 shows the distribution of IRS events according to groups of components: the most reported events concern mechanical components (about 40%), then I&C and electrical components (respectively 28% and 22%). It should be stressed that it does not mean that mechanical components are more affected than other components by modification failures. For such a conclusion, it would be needed to compare for each group of component the ratios between the number of events and the number of modifications implemented, which is unfortunately not available.

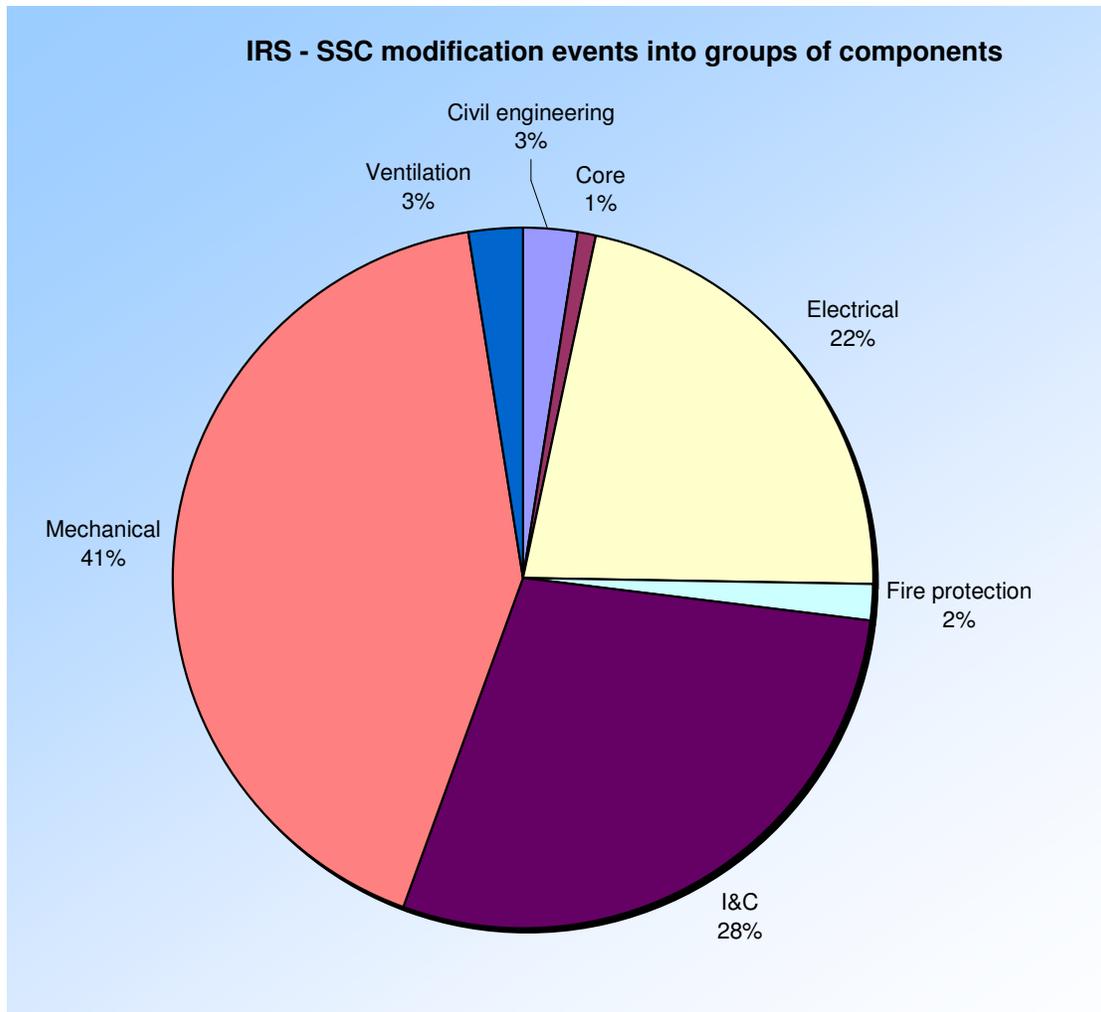


Figure 3 - Groups of components involved in the events

Figure 4 gives an overview of the detection time of the failures reported in the IRS database. It has to be noted that this detection time was calculated using the date of the modification implementation which was mentioned only in 69 out of 133 IRS reports.

The average detection time of the failures is about 4 years, without any significant differences between groups of components (Process software and ventilation components seem to have singular detection times but the number of events is very low, so no conclusion can be raised).

Detection time of IRS events

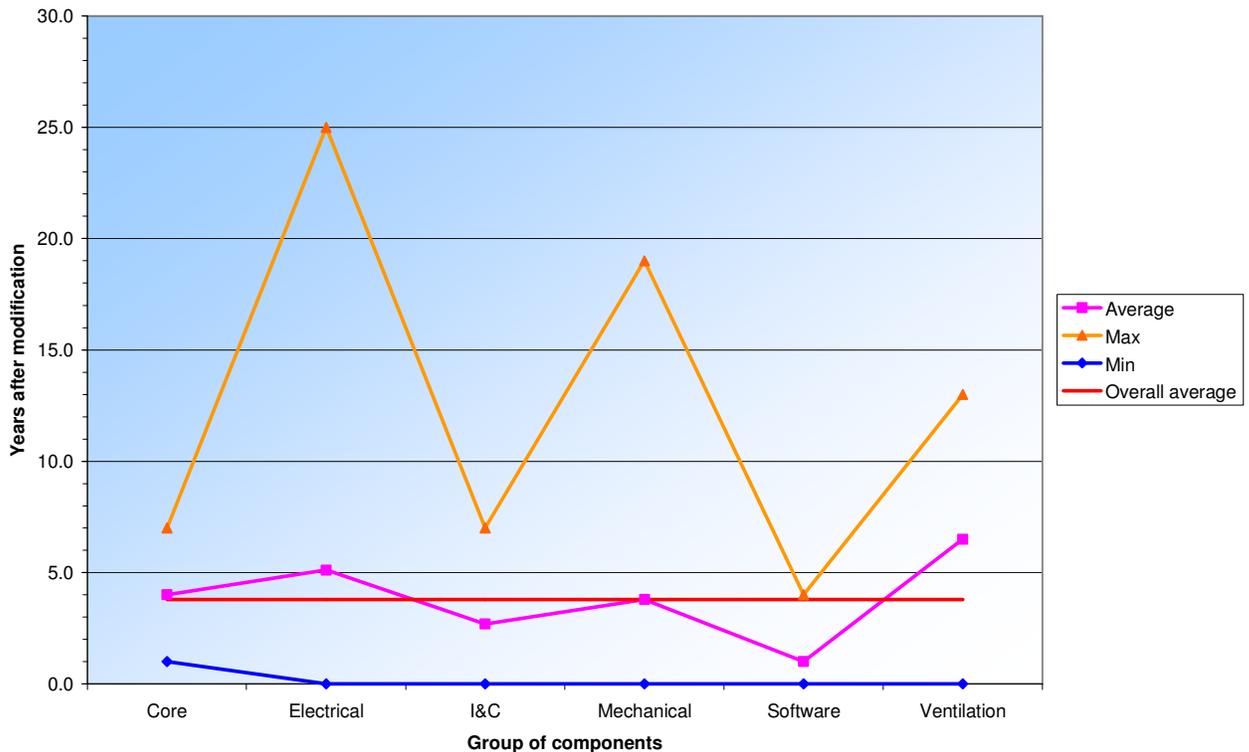


Figure 4 - Detection time of the failure

4. RECOMMENDATIONS

4.1. Modification design

- A same level of quality assurance and quality control is required to design, implement and test a modification which has been already successfully implemented in another unit (plant). Specifically, the differences between the units (plants), in terms of equipment or operating conditions, should be properly assessed before any duplication of design documentation, implementation procedures or test procedures.
- The design and licensing basis of the plant should be maintained and verified during any modification process. This could be verified by a review group independent from the group in charge of the modification design.
- The safety review of a modification to be implemented should allow to assess both the conditions to perform the modification and the complete design of the modification.

- During the modification design process, the interactions between safety-related systems and non-safety related systems should be properly evaluated, in order to verify that the modification will not lead to operating conditions (in normal or accidental situations) which are not analyzed in the safety analysis report.
- The modification process should include during the design stage a review of the operating experience about similar modifications already implemented, in order to avoid the recurrence of similar failures.
- The modification process should also include an assessment of the modification's impact on the operation margin, in order to ensure that a system intended to provide protection against abnormal situations do not actuate under normal plant conditions.
- The modification process should include specific requirements concerning configuration and material changes for environmentally qualified equipment, to ensure adequate review and documentation.
- The modification process should include an assessment of the impact of the modification on the safety considering the maintenance and calibration activities to be carried out.
- The introduction of new manual actions should be properly assessed, considering the additional risk of human error.
- A modification should be classified not only according to its safety significance but also according its potential to adverse safety functions (during implementation, test or operation) even though the concerned equipment is not safety-classified.

4.2. Fabrication and Supply of components

- Any modification to a component should be qualified, even if it is considered as a minor one. The associated qualification programme should be properly assessed and documented, considering the operating and environmental conditions of the modified component.
- When purchasing equipment, specific requirements - for example for Environmental Qualification (EQ) or seismic qualification - which the standard vendor's products may not comply with - should be properly reflected in the vendor's documentation, in the installation instructions and in the modification package, to ensure that the specific components are correctly supplied, installed and tested.
- The supply process should address the specific case where material was ordered and stored in the framework of a modification and where the modification is subsequently cancelled, to ensure the material is not installed without the adequate review. More generally, the supply process should identify the material substitutions which require a modification for installation.

- Moreover, when a component is modified, it should be verified whether the component's spare parts in the warehouse are still compliant with the new design and whether the procurement requirements have to be changed to meet the new design requirements.
- The supply process should allow to verify that the new installed equipment had no not-required devices or functionalities which may have adverse impacts on safety.
- Any modification of operating material (oil, Emergency Diesel Generator petrol, chemicals...) should be assessed properly. In case the knowledge is not available in the plant, this change should be implemented after prior consultation with supplier / manufacturer of relevant equipment.

4.3. Modification implementation

- The proper implementation of a modification should be checked against the original requirements and not against subsequent documentation (provided by a contractor or not).
- Any change of the planning or sequences of a modification implementation, including modification packages which may be implemented partially or in several stages, should be properly assessed and documented with regards to safety, security and operability of the concerned system. The original work documentation and risk analysis should be revised accordingly.
- Similarly, any change of the initial modification work scope should be formalized and processed according to predefined procedures.
- If feasible, any modifications affecting redundant components / systems should be implemented only after appropriate testing, for example in one of the redundant systems, in order to avoid any common cause failures.
- Modification packages should specify the orientation of the safety related components and equipment and should record the before and after orientation to ensure that proper orientation is maintained unless otherwise specified by the modification.
- The absence of foreign material which may challenged the operability of safety-related systems should be checked by a Foreign Material Exclusion (FME) programme, by cleaning activities and by post-modification testing.
- The modification process should include a specific stage to identify explicitly the impact of the modification implementation works on the Technical Specifications (TS) requirements and surveillance as well as on the functionality of other equipment. This stage should allow the compliance with the TS during the works (including post-modification testing) and should allow the delivery of adequate clearance orders.

4.4. Post-modification tests

Scope of Post-Modification Testing

- The Post- Modification Testing (PMT) should not rely only on the documentation or tests provided during the supply process and should be considered as an additional line of defence in case the supply documentation is deficient or the manufacturer / acceptance tests do not allow to test a complete system in a real configuration.
- The comprehensiveness of the post-modification tests should be assessed and those tests should be performed under conditions as close as possible to real operating and/or accidental conditions and should cover the full range of the boundary conditions and functions of the modified system.
- The suitability of surveillance tests for Post-Modification Testing should be carefully assessed, to ensure that all aspects of the system configuration during operation are tested. The post-modification testing should allow to verify that connected safety-related systems are not improperly affected by the modification.
- The operability and the ergonomics of manually operated valves should be included in the scope of the acceptance and/or post-modification tests.

Implementation of the tests

The completion of the Post-Modification Tests programme should be ensured as follows:

- The respective responsibilities for the PMT should be explicitly identified and this distribution of responsibilities should be available prior to the modification implementation, so that the required actions can be included in the modification planning and distributed to the relevant departments.
- The modification documentation should identify all actions that require to be completed prior to the system restoration.

The post-modification testing programme should consider the additional work load for the Main Control Room personnel, specifically in the case of large modernization programmes, and if needed, include specific measures to maintain the safe operation of the plant during the tests.

4.5. Training

The training department should be involved in the development of a modification, in order to ensure that every concerned staff will be trained to have a proper

understanding of the design change. More specifically, the training programme should allow the staff in charge of revising / reviewing the procedures following a modification to assess properly the impact of the modification on administrative controls, procedures, or licensing basis.

The training needs due to the implementation of a modification should be assessed at the design stage and the training should be delivered before the modification is operated.

4.6. Documentation

Surveillance test programmes

To ensure that the surveillance test programme reflects properly the modifications, the modification documentation should identify the critical functional tests and performance requirements of the new design and should provide with a comparison between old and new design to ensure that such new designs are verified to meet their requirements (e.g., Technical Specification, In-Service Inspection, Motor-Operated Valve program, etc.)

The surveillance (periodic) test programme should take into account the modifications properly, namely:

- the surveillance programme should obviously include the new safety-related components
- the tests procedures concerned by the modification should not focus only on the modified component but should allow to verify what the performance of the whole concerned system is
- the compliance of the surveillance programme with the “as-built” should be verified through periodic detailed auditing of tests procedures
- this assessment process should not focus only on existing surveillance procedures but should consider the necessity of creating new ones

The modification process should ensure that the surveillance tests of the new design consider properly the system response to Design Basis Accidents (DBA). Moreover, the performance of the surveillance tests should not challenge the system operability in case of DBA.

Drawings modification

The drawing modification process should allow to ensure that all the drawings affected by a modification are identified with pending changes in the interval between the approval and the implementation of the modification, when the

drawings are revised accordingly. This is to avoid that the affected drawings are improperly used during this interval for the design of other modifications or activities.

The drawing modification process should contain mechanisms which allow to ensure that a proper notification of the changes is made to the department in charge of the concerned system and that the modified drawing is issued after the modification is implemented, so that it reflects the “as-built” situation.

Documentation availability

In order to allow an adequate assessment of a modification impact on the plant safety, it should be ensured that all the relevant plant design and operating documentation is easily identifiable and accessible, through Electronic Document Management System for instance.

4.7. Operating procedures

The modifications of the plant design documentation and plant Technical Specifications are not necessarily connected to physical modifications. Therefore, in addition to the modification process, another process should be implemented in order to ensure that any change of the design documentation or Technical Specifications will be properly assessed and reflected in the plant procedures.

When a system operating conditions and/or function are modified (for instance, when it is used for another purpose than foreseen at the design stage), it should be ensured that this new use is considered as a modification and assessed in compliance with the modification process.

The impact assessment of new design documentation or new Technical Specifications should not only consider the impact on the plant procedures but on the planning of the activities as well.

4.8. Organization

Change of the plant organization

Any organizational change should consider the impact of the modification on the interfaces between different entities / departments to ensure that all safety-

related activities implemented jointly by those entities / departments will still be performed properly and exhaustively.

Interfaces in the modification process

The modification design review should include an interface review process to make sure that all the aspects of the modification which are at the interface of different disciplines have been properly designed / reviewed by the competent personnel, that the different contributions are consistent and allow the compliance of the entire modification design with the original requirements.

The relationship between licensees and vendors concerning modifications should be implemented through a quality assurance programme in order to ensure the proper evaluation of the modifications.

Administrative controls of the implementation of modifications.

A process should be set up in order to ensure that the modification are timely implemented and tested. This process should include a time limitation for the completion of the modification, a track of the modification status and, in addition, a regular review of the modifications with “open” status to define and assign formally the actions to be implemented in order to complete the modifications.

Changes of the modification packages

The modification process should specify how the changes of the modification packages have to be handled. For instance, any changes of the modification packages should be properly documented, assessed and recorded.

4.9 Temporary modifications

- The temporary modification process should ensure that the temporary modifications are properly assessed prior to the installation, considering also the EQ and Common Cause Failure.
- The temporary modification should be tracked and should be included timely in the plant documentation.
- The temporary modification process should not be used for permanent modifications as the temporary modification process may allow “lighter” technical review for modifications implemented for a short duration which is not adequate for permanent modifications.
- The plant procedures should include a management oversight in order to verify that the temporary modifications are justified, so as to minimize the number of temporary modifications.

4.10. Unidentified modifications

It was found worthwhile to address the very specific case where the events were not caused by a deficiency in the modification process but by the non-application of this process because the modifications were not identified as such.

As example, an event report concerns the failure of a High Head Safety Injection to start via a manually-initiated start from the Main Control Room. This failure was caused by a wire which was accidentally cut inside a junction box while an adjacent redundant unterminated (not connected) wire was removed. The later was removed for industrial safety purpose, outside the modification process, therefore without adequate review and post-activity testing.

This event shows that any modification to the plant, even simple tasks as removing not connected spare cables, should be considered through the modification process, in order to define the adequate modification classification, to assess properly its impact on safety and to specify the proper post-modification testing, if any.

5. CONCLUSIONS

A lot of recommendations raised from the operating experience are related to the impact assessment of modifications and reveal the difficult to ensure a comprehensive assessment when modifying an existing situation. This assessment should not include only a risk analysis for the implementation stage like any other activities but should evaluate the modification impact on existing equipment (at short and long term), on connected systems, on operating end emergency operating procedures, on maintenance and calibration activities, on surveillance tests, on design documentation, on activities planning, on organization, on training, etc.

This shows clearly that the modification management process of the utility should be strong enough to ensure that all aspects of the impact assessment are covered at the design stage and, on the top of that, to allow the involvement of different entities in this process (designer, plant utility, contractor, different department in charge of concerned components and documentation).

Besides the ordinary post-activity tests, the post-modification tests programme should be designed in order to detect any deviation which may have occurred during the design stage or any negative impact which may have not be identified

during the modification assessment, which means therefore that the scope of the post-modification tests should be as comprehensive as possible.

6. LIST OF ACRONYMS

CCF	Common Cause Failure
DBA	Design Basis Accident
EQ	Environmental Qualification
FME	Foreign Material Exclusion
GRS	Gesellschaft für Anlagen und Reaktorsicherheit mbH (Germany)
HELB	High Energy Line Break
IRS	International Reporting System
IRSN	Institut de Sûreté Nucléaire et de Radioprotection (France)
LER	Licensee Event Report (USA)
NPP	Nuclear Power Plant
PMT	Post-Modification Testing
TS	Technical Specifications

7. REFERENCES

- [1] IAEA safety guide NS-G-2.3 “Modifications to Nuclear Power Plants”, 2001
- [2] Analysis of Nuclear Power Plants Modifications Events, European Clearinghouse Topical Study SPNR/CLEAR/11 11 004 Rev.00

APPENDIX: LIST OF LESSONS LEARNED

This appendix summarizes the lessons learned per group of components.

Group of components	Lessons Learned
Valves	<p>The modification / addition / removal of a valve should be designed considering the following factors, when relevant:</p> <p style="padding-left: 40px;">The position indicator of valves to be installed should be assessed regarding the risk of human error.</p> <p style="padding-left: 40px;">The hydraulic impact of a valve modification / addition / removal should be properly assessed, considering all the possible alignments.</p> <p style="padding-left: 40px;">The need for manual operation of remote-controlled valves in some specific scenarios should be considered during the modification design.</p> <p style="padding-left: 40px;">The throttle position of newly installed flow-regulating valves should be determined considering the potential debris blockage of these valves.</p> <p style="padding-left: 40px;">New parts material should be selected considering its susceptibility to environmentally assisted stress-corrosion cracking.</p> <p>After the modification is implemented, the post-modification tests should be carried out, considering the following:</p> <p style="padding-left: 40px;">Any modification of a part of a valve should be assessed/tested regarding the dynamic behavior of the valve (closing/opening times with different fluid characteristics).</p> <p style="padding-left: 40px;">The functionality of a new valve (ability to actuate by manual or remote control) should be verified in the real environment (real location and real surrounding equipment), in order to identify any interference with other components.</p> <p style="padding-left: 40px;">The operability of a new valve (from closed to open position and vice-versa) should be checked by verifying the absence or presence of flow and not by the position indication, which may be incorrect.</p> <p style="padding-left: 40px;">When relevant, the commissioning tests should allow verifying that the valves travel limiters are properly adjusted.</p> <p>Finally, if relevant, it should be ensured whether the torque value for manual operation is still applicable after the modification and the procedures should be changed accordingly.</p>

Group of components	Lessons Learned
Pipes	<p>The lessons learned from this study concern mainly the design stage of pipe modifications:</p> <p>It should be verified whether a modification is susceptible to change the vibration conditions of a pipe (for example, by modifying support / restraint, by adding or removing weight supported by the pipe). If yes, it should be ensured that the new conditions will not lead to vibration fatigue failure. A thorough analysis of the vibrations of a system should be carried out prior to the modification of a component which may add or remove weight supported by the pipe (support, pipe, valve, valve actuator, valve handle) or prior to the modification of the system geometry which may change the vibrating behaviour of the system. When available, the operating experience should be analyzed with regard to vibrations. If the modification is found to be susceptible to change the vibration conditions of the system, it should be ensured that the new conditions will not lead to vibration fatigue failure</p> <p>When designing and implementing modification to piping and valves which may change their weight, it should be ensured that small radius pipes connected to the concerned piping / valves do not come into contact with adjacent structures. This verification should also consider the movements due to the thermal expansion of the main pipes.</p> <p>Any pipe modification should include a review of the concerned restraints / supports to ensure that they are adequately changed (or unchanged) regarding earthquake or High Energy Line Break (HELB) loading.</p> <p>A pipe modification should avoid the creation of dead volume where chemical and / or radioactive particles may accumulate over the years or in case of accident.</p> <p>The modification of drain lines or open ended lines, even if not safety-related, should be assessed in an adequate review process if they are connected to a safety-related system.</p> <p>The freezing risk should be considered when modifying pipes submitted to outside temperatures.</p> <p>Any modification which may impact the thermal-hydraulic condition of the Reactor Coolant System should be assessed regarding its impact on the calculation of the Core Thermal Power.</p>

Group of components	Lessons Learned
Instrumentation and Control	<p>Several lessons learned concern the design stage of modification or addition of new instrument and instrument impulse lines:</p> <p>When an instrument tap location is modified, the characteristics of the fluid should be updated for the setpoint calculation, if relevant (e.g. pressure height correction, temperature, density...)</p> <p>When an instrument is replaced, the new drift value should be considered in the surveillance programme.</p> <p>When a new instrument is installed, it should be verified that its static and dynamic characteristics meet the design objectives. For instance, the calculation of the new setpoint should consider all the error contributors properly and include the appropriate margins to ensure that the measured parameter complies with the Technical Specifications under any conditions.</p> <p>Any modification of pressurized tanks level transmitters should consider properly the weight of air and/or gasses in the measurement loop uncertainty and in the transmitter scaling calculation.</p> <p>Any relocation of off-line monitors should ensure that this modification still allow a sufficient sample flow to guarantee representative measurements.</p> <p>The modification work packages concerning instrument tubing and sensors should identify unusual piping configurations that could contribute to air entrapment, and the relevant adequate system isolation requirements; i.e., bypassing trip units or removing components from service, in order to prevent inadvertent actuations during and following installation.</p>

Group of components	Lessons Learned
Instrumentation and Control	<p>As far as control functions are concerned, the followings can be underlined:</p> <p>A modification of the containment isolation actuation logic should be assessed regarding the potential pathways through the containment by considering every kind of scenario (automatic/manual action, implemented/not implemented action).</p> <p>Any change of a safety-related system operating logic design should consider the specific operating conditions which may be caused by maintenance or surveillance tests activities.</p> <p>Any change of the control air system should include an assessment of the modification impact considering the failures of individual air supply sources and not only the complete loss of the air system.</p> <p>Finally, concerning the post-modification tests, the operating experience allowed to raise these lessons learned:</p> <p>In case a circuitry is changed, the verification of the change design should include a fire protection review and the post-modification testing should include the appropriate tests, so as to ensure that the modified circuitry will operate properly if some connected components fail to operate because of a fire, as postulated in the plant design documentation.</p> <p>The Post-Modification Testing for instrumentation should include, in addition to calibration of newly installed components, verification of proper connections to the affected system/train. Where practical, PMT should include assurance that the installed instrument responds appropriately to changes in the process variable.</p>

Group of components	Lessons Learned
Electrical Components	<p>Modifications of electrical components should be designed considering the following factors, when relevant:</p> <p style="padding-left: 40px;">When breakers units are modified, it should be ensured that the new design complies with the seismic qualification requirements (concerning for example the engagement of the breaker unit on the bus bar), if any.</p> <p style="padding-left: 40px;">The pre-charge time of breakers springs should be considered in the design of safety-related electrical components modifications.</p> <p style="padding-left: 40px;">When contactors are replaced by new design, it should be ensured that the new inrush current is compatible with the other components of the circuitry.</p> <p>Modifications of electrical components should be implemented considering the followings:</p> <p style="padding-left: 40px;">The modification procedures should address the case of cables pulled into safety related/seismic class IE panels but not terminated before the equipment is returned to operation, to maintain the seismic qualification of the panel.</p> <p style="padding-left: 40px;">The automatic reset capability of overload relays should be specified in the modification package.</p> <p style="padding-left: 40px;">The modification documentation should allow to verify that no unwanted spare wires are left following the implementation. If spare wires are left intentionally, it should be ensured it does not challenge the protection of the circuitry from short circuits.</p>

Group of components	Lessons Learned
Process Software	<p>For modifications to process software that are safety-significant, a defense-in-depth and diversity analysis should be performed as part of the design process to ensure that the plant has adequate capability to cope with software common-cause failure vulnerabilities, whatever the quality of software design, implementation, and verification and validation program. Moreover, when introducing the same type of software in several applications, extreme care should be taken to avoid common cause errors and dependencies between safety systems assumed to be independent in the plant's safety analysis.</p> <p>When modified software is implemented, it should be ensured that the software configuration control is maintained independently by both the utility and the software manufacturer.</p> <p>Concerning the testing of modified or new software, the extensive testing, verification and validation of new software should be done in the plant environment where it is to be used and should consider all the possible combinations of data inputs. Such an investigation should be carried out in addition to the testing performed in a laboratory environment at the vendor.</p> <p>More specifically, when a PC interface for diagnosis / maintenance devices is back fitted to plant systems, it should be ensured that both the PC interface and the device are included in the scope of modification commissioning tests, so that an unexpected impact of the PC interface and associated diagnosis/maintenance device on the system can be detected.</p>
Pumps	<p>Any modification of safety-related pump's parameters or operating conditions (number of operating pumps, modification of pumps characteristic curve etc.) should be assessed regarding its impact on accidental conditions and on accident studies.</p> <p>The purchase specifications should include full-scope tests of the pumps in order to ensure that the design requirements are met for all the possible configurations.</p>

Group of components	Lessons Learned
Steam Generators	<p>Any modification of the SG internals should include an assessment of the modification impact on the distribution of the particles contained in the secondary side, both:</p> <p style="padding-left: 40px;">to prevent an accumulation of corrosive particles to ensure that the new flow circulation will allow the representativeness of chemical and radioactivity monitoring</p>
Sumps	<p>Any modification of the sumps screens should consider the complete range of operating conditions.</p>
Welds	<p>Any safety-related weld modifications should be designed, reviewed and implemented through the modifications process. The weld reinforcements should be included as well in an adequate modification process.</p>
Ventilation	<p>Any modification of the ventilation systems should consider the impact of this modification on the instrumentation reference legs which are affected by the ventilation systems.</p>
Civil engineering	<p>Any addition or modification of a penetration (drain, hatchway, cable penetration...) should consider the impact of the flow path modification with regards to the propagation of water in case of flood, of steam in case of HELB, of smoke and fire in case of fire and with regards to air flow as far as static and dynamic containments are concerned.</p> <p>It should be ensured by appropriate cleanliness measures that any modification work taking place on building roofs will not prevent the evacuation of rainwater.</p>
Fire protection	<p>It should be ensured that any modification of Fire protection separation walls will not impact the air distribution in such a way that the cooling or the air pressure of a room is questioned.</p> <p>Particular attention should be paid to cables and/or fire barriers modification with regards to the fire risk when the cables are enclosed in small spaces where the ventilation is poor or non-existent or where the fire barriers consist of material with a high thermal insulation ("oven" effect).</p>

Group of components	Lessons Learned
Operating procedures	<p>When accident operating procedures are modified, it should be verified that the new procedure is consistent with the design basis, by ensuring that design basis neutronic and thermodynamic assumptions are still fulfilled. More generally, any modification of operating procedures (normal operation and accidental operation) should be assessed regarding its potential impact on safety.</p> <p>More specifically, any modification to water pressure /level /flow rate conditions in systems connected to safety-related pumps should consider the risk of vortex creation. This risk should be assessed on the basis on analysis and/or tests in accordance with the specific situation of the plant.</p>

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Abstract

Modifications are implemented in Nuclear Power Plants (NPP) for many different reasons: for safety reasons (for instance, following a Periodic Safety Review), for economic motivations (power uprate or optimization of maintenance activities), to correct existing failures or deficiencies or to cope with the plant ageing.

Modifications of NPPs cannot be avoided and it must therefore be ensured that all modifications, including modifications implemented for safety reasons, are designed, implemented and tested in such a manner that the safety of the plant as well as the safety of workers and environment is not degraded. Consequently, lessons learned from operating experience are very important to avoid the occurrence of similar events in future modification process.

This Summary Report presents the results of a study performed by the European Clearinghouse on Operating Experience Feedback of NPP with the support of IRSN and GRS. It gives the main trends and summarizes the main recommendations.

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

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