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Case Study on Configuration Management System Strategy and Implementation at Krsko NPP, Slovenia

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1. Introduction

Most of the world's nuclear power plants (NPP) and nuclear facilities have adopted Configuration Management (CM) programs, software, and supporting processes for their facility. However, there is a great deal of misunderstanding about what is needed for nuclear configuration management, what tools should be in place, and even why the NPP should have a formal CM program. Many NPPs do not fully understand the importance, methodology or strategy for Configuration Management.

This paper is divided into two general topics. First, the general requirements for developing and implementing a CM strategy are described, including:

1. Introduction
2. CM Strategy
3. CM Processes
4. CM Lifecycle
5. CM Data Systems and IT Solutions

This is followed secondly by a case study in Section 6 of the well-known Krsko NPP in Krsko, Slovenia. The case study will describe how the Krsko NPP Configuration Management program has contributed to the achievement of a world-high record of operating excellence and commercial availability.

2. Configuration Management Strategy

The purpose of having CM is to ensure that there is a continuous and provable matching and synchronization of the Design Basis, Plant Equipment/Components, and the Documents and other Facility Configuration Information (FCI) that support the first two [1]. This requirement extends to components of NPP operation that may not be immediately considered as part of design, such as spare parts, bills of material, maintenance and procurement processes. The best strategy is to have an overall understanding of:

(1) How the capture and maintenance of CM information impacts and determines NPP safety and performance,

(2) How virtually every NPP process, organization and process can affect the integrity of CM, and

(3) The best sources and methods to capture, validate, utilize and maintain CM data.

An overall CM strategy begins with understanding of the importance of CM. As NPP's are designed, constructed and maintained, changes occur in the design of the NPP, and components and parts are replaced as they wear out or fail on defect. How these changes follow, or impact, the NPP design basis and safety cases, and understanding how an incorrect or careless decision can compromise plant safety and viability, are the primary purposes of having CM.

In order to have a CM strategy, the NPP takes such understanding and creates a Plant Program which describes the high-level purpose, goals and requirements for NPP-wide implementation of CM. The elements of the CM program, and where they are to be applied in the Information Management System (IMS), how they are to be implemented in plant operating procedures, how they may be audited or verified, and how management may measure success and compliance through Key Performance Indicator (KPI)'s, are the key points of the CM Program document.

Frequently the state nuclear regulatory body (RB) for the NPP will already have a CM policy and even a reference CM program description, to be utilized in developing the NPP CM program. The RB may also refer to industry standards and organizations (such as INPO, EPRI and IAEA) for guidance and methods to implement the CM program. The RB will likely include CM audits and review as compliance and non-conformance criteria for NPP licensee's.

3. Configuration Management Processes

The CM Program takes into account the IMS procedures, process, organizations and interfaces of the NPP operation to determine the workflows, systems and data capture points required for CM. The best understood areas for CM are Engineering Design Change and Design Basis items such as Design Criteria, Design Requirements and Margin Management. However, the large majority of NPP operations, processes and functions have at least some impact on CM. Materials, Procurement, Work Management and even Operations depend upon accurate and timely configuration of the NPP to conduct work and make safe operating decisions.

The three basic CM elements that affect NPP processes are Design Basis, Equipment and Documents. Any NPP function or work process that utilizes one or more of these must be developed with CM in mind. This relationship is often represented as the CM "Triangle" shown in *Figure 1*. The diagram indicates the two relationship qualities that define CM, those being equilibrium and co-equal importance.

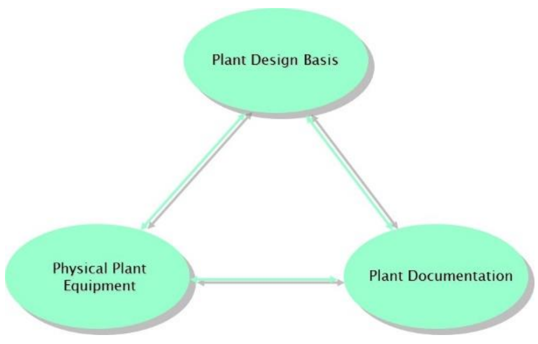

Figure 1: The CM "Triangle"

4. Configuration Management Lifecycle

Throughout the NPP lifecycle, configuration management for the NPP must be maintained [2]. The processes and organization for the NPP will change somewhat over NPP life, but the maintenance of CM will be a consistent requirement. *Figure 2* illustrates such a relationship model, where the CM elements are established and finalized during NPP design and construction, to be utilized over operating life.

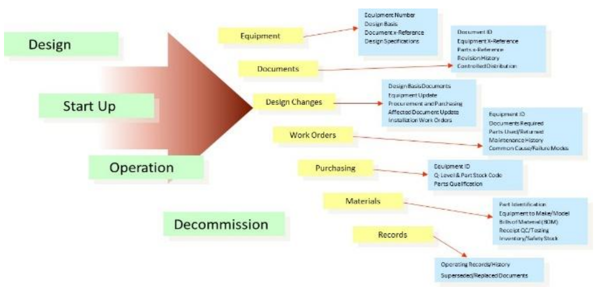

Figure 2: CM Elements for NPP Lifecycle

During construction of the NPP, but also over NPP life, a large number of suppliers and vendors will be involved in the development of designs, and delivery and installation of components. Key design and configuration information must be transferred to the NPP Owner through the process of Handover/Turnover. The type, format and volume of such data should be specified contractually and agreed between suppliers and the NPP.

In *Figure 3*, the application of processes that affect CM are shown over NPP Life. Over the NPP lifecycle, in spite of good intentions and efforts, the actually configuration of the NPP design basis and components may begin to diverge, or "drift" from the original design as stated in the FCI. This would be represented in *Figure 1* as a "break" in the CM Triangle, as equilibrium is lost. Depending upon the duration and severity of the divergence, a concerted effort may be able to restore the configuration by document and drawing review alone, to identify errors and omissions. However, this is sometimes not sufficient, and a process known as "Design Basis Reconstitution (DBR)", must be undertaken. This process consists of "freezing" the design change process, and physically inspecting (by walkdown and FCI review) the NPP design to restore equilibrium by synchronizing documents and the physical NPP with the design basis.

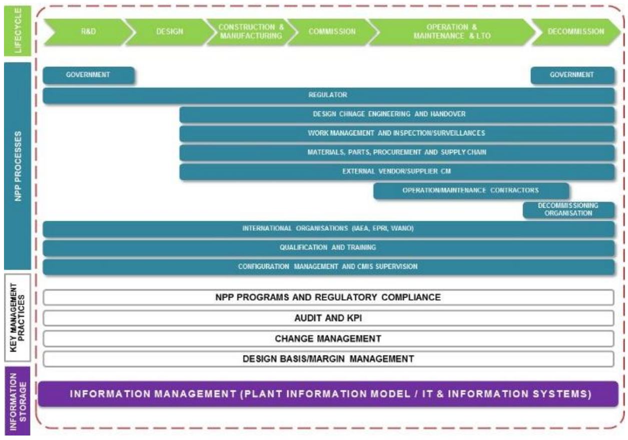

Figure 3: CM application over the NPP Lifecycle

5. CM Data Systems and IT Solutions

Strategically it is very difficult, or impossible, to maintain CM at NPP's without a technology solution to support the CM and related processes. Since most of the raw data for configuration comes from NPP design, maintenance. Materials and operations, the NPP Configuration Management can be supported by an existing NPP Maintenance Resource Optimization (MRO) system, if deployed. If such a system is not available, or not complete, the NPP should consider acquisition or development of a CM Information System (CMIS) to collect, evaluate and manage CM data. Since the correlation of MRO and CMIS data is very high (>90%), simultaneous development of an MRO should then be considered also.

The functionality of such a system with respect to CM should encompass, as a very minimum, collecting data and cross-references for the five elements in *Figure 4* [3]. Each of these element includes processes, procedures and software, and contain about 70-80% of the NPP's business rules. The Data Attributes are the items that must be linked by process and software to ensure CM Triangle.

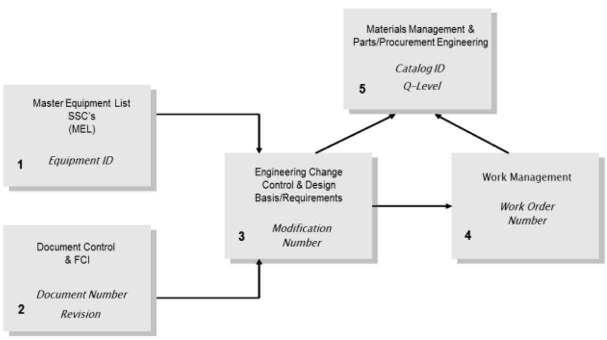

Figure 4: NPP MRO/CMIS basic IT Elements for CM

6. Krsko Plant Management Information System (KPMIS)

The Krsko NPP in Slovenia is frequently referenced by World Association of Nuclear Operators (WANO) and IAEA as a benchmark of configuration management and design change success, in addition to a generally overall superior operating record. The 705 MWe Westinghouse model 60 plant has been operating for over 30 years, and has undergone numerous life extension activities, including replacement of steam generators in 2001.

Among operating NPP's, the Krsko NPP in Slovenia, for example, is regarded to have one of the best developed CM program implementations in the industry, and it is no coincidence that Krsko NPP rates of un-availability, operating incidents and unplanned shutdowns are among the lowest in the world.

The Krsko NPP received the highest total rating for nuclear safety and operational readiness. By presenting the review results, the mission members pointed out the above-average high implementation of recommendations of international operational experiences and safety achievements [4]. The Krsko NPP is also listed by IAEA for achieving an effective availability factor (EAF) of over 92% over 5 years (2010-2015), one of only 15 nuclear power plants out of 460 worldwide to do so [5].

6.1 KPMIS overview

In 1991, shortly before Slovenia's independence from Yugoslavia, plant management realized a classic design basis divergence had occurred during the first 10 years of operation. When this requirement was examined by Krsko NPP management, it was realized there were several problems to be overcome to implement a true CM system:

(1) Krsko NPP did not know what equipment was in the plant, or where the equipment was located.
(2) They did not have a Master Equipment List (MEL).
(3) They did not have an effective or complete document management solution for FCI.
(4) Design documents were not cross-referenced to equipment items, work orders or design projects.
(5) Most plant modifications provided very little documentation as work was performed by third parties with little turnover, resulting in gaps in the design basis.
(6) Other configuration information, such as design basis and even bills of material and parts, did not exist.
(7) A central source of general equipment data, or even what was actually contained inside the plant, was not kept in a facility where it could be referenced by NPP staff.

The Krsko NPP is very well run and had effective internal methods for controlling plant maintenance and activities. The operating and safety record for the Krsko NPP is among the best in the world. As a result, some staff questioned the idea of doing anything about a formal CM program when the plant ran so well. The reasons for establishing the configuration management program, however, cannot be based solely on past NPP performance.

In order to solve the issues of the EQ program and lack of design control, it became clear that a zero-time design basis reconstitution (DBR) was required to support the CM program and any technology solution to be deployed.

6.2 CM Data Acquisition and (re-) establishment of the Design Basis

As soon as Krsko NPP management realized the need for a Configuration Management system, the project commenced in late 1990. The First Phase of the work included:

Design Basis Reconstitution – Through physical walkdown, over 80,000 equipment items were reviewed and updated, to create the Master Equipment List ("MEL"). Legacy plant P&ID's and other drawings were utilized to identify and correct, as needed, equipment locations and relationships, as well as correct equipment numbers, symbols, etc. During this time, all engineering design change activity was "frozen" where possible, and updates to documents from past design change packages were compared to the walk-down results.

The complete process to perform the physical plant walk-down and prepare the documents and data required 27 months to complete. Walk-downs had to be coordinated with Operations and Maintenance departments, both to avoid conflicts in equipment access and to schedule time during refueling outages, which was the only time access to the containment building was possible.

Development of CM Program Plan and Supporting Procedures – The consultant assisted in development of the CM Program Plan documents and supporting procedures for:

(1) Document Management
(2) Records Management
(3) Master Equipment List (MEL)
(4) Equipment Identification and Labels
(5) Data Verification
(6) CM Correction (DUR/DUF)
(7) Engineering Change Control

Population of Databases – The consultant developed temporary databases using MS-Access to store Equipment, Document and Quality Records data as it was acquired, included the specified metadata and attributes to be collected during the walk-downs. This data was then validated against drawings and other documents related to the equipment item, and any errors in documents corrected at the same time.

Scope and Data Decisions – Several types of equipment, document, data and design basis elements to be included in the CM program were reviewed for relative importance to overall NPP safety and operation. This "graded approach" resulted in some typical decisions to be made by any CM program:

MEL and Equipment – Decision and grading for metadata should follow the safety-class and quality class of the equipment item, plus any special category or program, such as Motor-Operated Valve, Fire-Protection, etc.

Documents and Data – Documents to be controlled include any that reference equipment, contain design basis information, or any document that must be revised whenever a configuration management decision, element or parameter changes.

Identification of Design Basis Documents – those documents in the archive stores that could contain design basis information were identified and assigned ownership to the new Krsko NPP engineering organization.

Identification and capture of key data determinants and metadata for Equipment and Documents – since the MEL and Documents are being collected together during the design reconstitution, the data dictionary and schema for the Equipment and Document/Data metadata were developed simultaneously, including provisions for document to equipment cross reference.

Development of Equipment-to-Document Cross-References – While reviewing equipment items with corresponding documents that contained information about an equipment item.

6.3 Important event - Steam Generator replacement

The replacement of the Krsko NPP steam generators in 2000, after about 18 years of power operation, was an engineering effort that rivaled construction of the original plant, in the sense that virtually every system, design basis and supporting calculation had be re-verified and/or modified as appropriate for impact analysis to the plant. It was a true test of the KPMIS and CM Program results. The new steam generators were larger and more efficient, and would result in a power uprate of approximately 10%-15%.

The results were very favorable. The engineering effort took place over a period of about 18-24 months, including building the new steam generators. The engineers, contractors and NPP Krsko management all agreed that this performance and level of success in such a short time frame would not have been possible, or even thinkable, without the quality of the KPMIS,

6.4 IT Architecture and Technology

The NPP Krsko IT architecture at the time of the KPMIS development consisted of a central Oracle Enterprise V6.0 over Hewlett Packard Unix (HP-UX), running on HP 9000-series servers.

The system was developed over approximately a five-year period, modules being written in a serial fashion one after another, in screens such as *Figure 5*.

Figure 5 - KPMIS system user interface. Major equipment list and its detailed information is shown.

7. Conclusions

Since development of the original KPMIS system, several technology upgrades have occurred, The KPMIS system has actually changed very little. NPP Krsko has reviewed KPMIS replacement technology, such as Ventyx Asset suite and other commercial off the shelf (COTS) products compatible with Oracle database products, but has not, to date, announced any significant changes to the KPMIS program.

Acknowledgement

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