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Effective Work Management for Sustaining Operational Excellence at Nuclear Power Plants

EFFECTIVE WORK MANAGEMENT FOR SUSTAINING OPERATIONAL EXCELLENCE AT NUCLEAR POWER PLANTS

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2024

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FOREWORD

Nuclear electricity generation has been facing critical economic challenges under a competitive electricity market. As a result, nuclear power plant owner/operator organizations now need to re-evaluate their business model and management processes to become more robust and resilient so nuclear generation can continue to play a role as a low carbon source of electricity.

One of the key factors in overcoming economic challenges and sustaining operational excellence in plant operation and management is an effective work management process, as it ensures that plant management can make the decision to use the right resources for the right task at the right time for the safe and efficient operation of a nuclear power plant. A work management process considers individual tasks for a given activity and connects with the organizations involved in the performance of the tasks to establish decision points and streamline the effective use of tools, methods and data. It includes interactions among internal departments and groups and with external organizations. From this context, the effectiveness of work management processes needs to be continually and frequently evaluated, updated and maintained, particularly in an environment where the factors and drivers impacting nuclear power plant operation and management are rapidly changing. It can be achieved by learning from worldwide good practices on work management processes and adapting and implementing effective processes quickly.

This publication provides nuclear industry leaders and managers with specific ideas and practices on how to sustain operational excellence through an effective work management process. The aim is to preserve the gains made in safety, performance and cost and to address the factors that affect these gains.

The IAEA wishes to thank all the experts involved for their contributions. The IAEA officers responsible for this publication were H. Varjonen and A. Kawano of the Division of Nuclear Power.

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1. INTRODUCTION

1.1. BACKGROUND

The nuclear power industry is experiencing the economic pressures as most other modern industries and is working to increase revenues and to reduce costs, all while maintaining a sufficient margin of safety for the public, and while reducing the risks to which its workers are exposed. In the case of the nuclear power industry, increasing revenues means maximizing the operation time of nuclear power plants (NPPs). Reducing costs means lowering expenditures for maintenance during normal operation and during refuelling outages. While these two goals may at first seem to be in conflict with the goals of maintaining a sufficient margin of public safety and reducing risks to nuclear workers, more than thirty years of NPP operation have demonstrated that both goals can be simultaneously fulfilled in implementation of well-developed management system [1, 2].

The work management process (WMP) is one of the key cross-functional processes in the management system to achieve both above goals. It describes how work needs to be planned for maintaining plant equipment reliability on its design basis and to be implemented in a safe and efficient manner at NPPs. It generally covers and connects the plant main processes e.g., operation, maintenance, engineering, radiation protection, etc.; and cross-functional programmes e.g., corrective action, as low as reasonably achievable (ALARA), plant life management.

The IAEA Safety Guide GS-G-3.5 "The Management System for Nuclear Installations" [2] refers to it as "work planning and control", and describes the principles on how to implement it. It is discussed as a part of the whole management system. The IAEA Safety Guides SSG-74 "Maintenance, Testing, Surveillance and Inspection in Nuclear Power Plants" [3] and SSG-76 "Conduct of Operations at Nuclear Power Plants" [4] also describe the principles on how to implement it focusing on maintenance, testing, surveillance and inspection, and in operation in NPPs respectively.

WMP is also defined by the Institute for Nuclear Power Operations (INPO) AP-928 (2017) [5] as the 'process by which maintenance, modification, surveillances, testing, engineering support, and any work activities that require plant coordination or schedule integration are implemented.' While the processes described in this document are implemented widely in the world, it is valuable to identify ongoing challenges and opportunities NPP owner/ operating organizations are facing and discuss possible resolutions in WMP based on the updated information and practices.

1.2. OBJECTIVE

The objective of this publication is to identify challenges and opportunities related to WMP that NPP owner/ operating organizations are facing, to share best practices for addressing those challenges and to discuss considerations for effective WMP. It aims to assist leaders and managers in those organizations to improve effectiveness of WMP and in that way to sustain operational excellence. It also aims to complement existing standards and guides on WMP [1–6].

1.3. SCOPE

The publication discusses the WMP in NPP owner/operating organizations. It focuses on identifying updated common challenges in WMP and introducing the best practices for addressing them, including the discussions on work prioritization, backlog management, resource management, performance indicators to measure WMP effectiveness, and interface roles and responsibilities in WMP.

In connection with the preparation of this technical publication, an on-line survey was implemented for individuals who are directly working with WMP and in other positions related to WMP. The purpose of this survey was to figure out the main issues and problems that they face in their work and, accordingly, to highlight issues that they see as an opportunity to improve the quality of their work.

Based on this survey result, the discussions on WMP in this publication focus on the areas of operation, maintenance, engineering and radiation protection, and do not include some areas like emergency preparedness, chemistry etc., that are included in the discussions of the whole management system.

1.4. STRUCTURE

This publication is divided into six sections. Section 2 provides an overview and update of WMP and summary of survey results. Section 3 discusses common challenges and opportunities in six sub-processes of WMP and introduces some good practices. Section 4 describes other considerations for effectiveness of WMP. Section 5 concentrates on advanced technologies which can be used in WMP. Section 6 compiles conclusions and recommendations to improve WMP in general.

Details of survey results and good examples/practices of WMP are provided in the appendices.

2. OVERVIEW OF WORK MANAGEMENT PROCESS AND SURVEY RESULT

This section starts from the overview of WMP, introduces some updates related to WMP and survey results provided by 13 Member States.

2.1. OVERVIEW OF WORK MANAGEMENT PROCESS

WMP is discussed in many existing publications and the typical process is shown in Fig. 1 with 6 sub-processes. This cyclic process is consistent with Deming's PDCA concept and the discussions in the IAEA Nuclear Energy Series NG-T-1.3 "Development and Implementation of a Process Based Management System" [6].

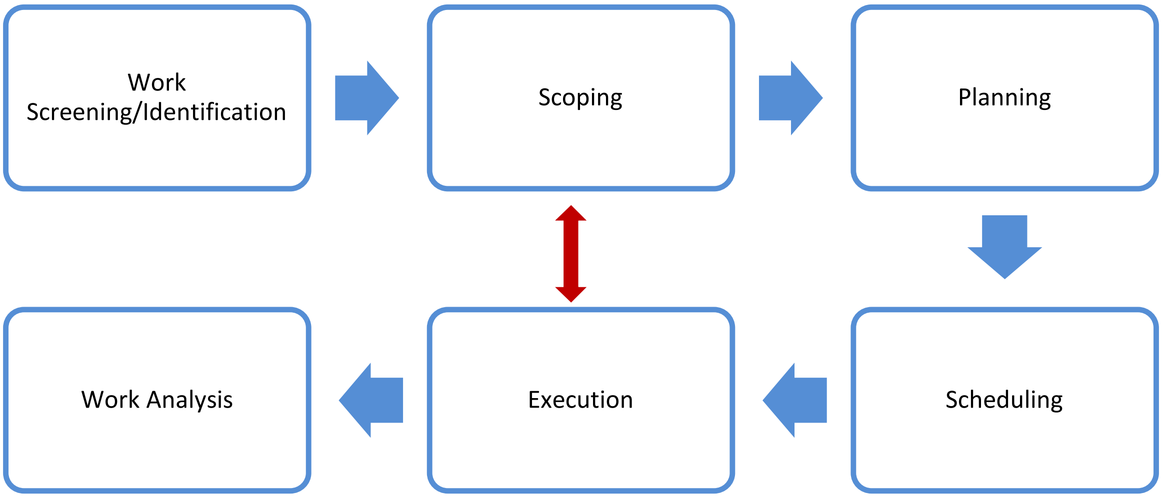

FIG. 1. Typical Work Management Process

The screening process of incoming works is the sub-process for proper work classification and prioritization. The concept of graded approach can be applied here [2, 7]. The identification of the most efficient and cost-effective process to prepare and execute work is also required to maximize equipment and plant reliability.

The scoping process is the sub-process for maintaining and improving equipment and plant reliability. Effective collaboration between different disciplines like operation, maintenance and engineering is key to properly define work scope and maximize accomplished amount of works.

The planning process is the sub-process for enabling safe and efficient execution of works with minimized risks. This process includes the steps to assess and review quality of planning from the context of securing necessary resources and the appropriate level of technical details in work packages.

The scheduling process is the sub-process for ensuring that safe and efficient works are implemented without any unnecessary conflicts of areas and resources between groups/organizations. Advanced preparations and close communications between them are key for successful scheduling process.

In the execution process workers need to be accountable for planned and scheduled works by being knowledgeable enough and prepared well in advance. This process includes using human error reduction tools. Timely sharing work progress with their supervisor and associated groups is also key for successful execution.

The work analysis process after completion is the sub-process for continuous improvement of WMP. It is necessary for successful analysis that all the associated groups, organizations and people reflect on all sub-processes from preparation through execution and discuss them for improvement in a collaborative manner.

This brief summary of each WMP is consistent with the objectives and principles described in the IAEA Safety Guide GS-G-3.5 [2] and the IAEA Safety Guides SSG-74 [3] and SSG-76 [4].

INPO (the USA) Work Management Process Description, AP-928, Revision 5 [5] discusses guiding principles for effective WMP as:

- "Ensure nuclear, radiological and industrial safety by providing timely identification, screening, scoping, planning, scheduling, preparation and execution of work necessary to maximize the availability and reliability of station equipment and systems."
- "Manage the risk associated with work."
- "Identify the effects of work to the station and work groups, and protect the station from unanticipated transients resulting from work."
- "Maximize the efficiency and effectiveness of station personnel and material resources."

2.2. STREAMLINED WORK MANAGEMENT PROCESS

Some countries have faced economic challenges and have been continuously making efforts to further streamline WMP. For example, Efficiency Bulletin of Nuclear Energy Institute (NEI, the USA) :17-20 "Further Streamline the Work Management Process" [8] introduces the US effort as:

"Further simplifying the work management process will allow station resources to be used more efficiently, increasing maintenance activity output and improved equipment and plant reliability."

"The streamlined work management process continues to advance nuclear safety and plant reliability by [8]:

- Providing a long-range, resource loaded work management cycle schedule that includes required preventive and predictive maintenance, surveillance testing (ST), and ready-to-work design changes;
- Providing a proper methodology for work prioritization to ensure the right work is done in the right time-period;
- Providing a consistent WMP for managing the risk to nuclear safety and plant reliability while maintaining equipment performance;
- Providing a WMP that optimizes the use of station resources in a cost conscience manner to support the safe and reliable operation of NPP."

The WMP proposed includes "a cycle plan with functional equipment groupings to lay out preventive maintenance and surveillance work with routine documents automatically generated. Automation of work management documents for routine work will be critical to the success of this streamlined process as it eliminates the need for someone to perform these actions, which allows greater focus on screening, approving, scheduling, and executing work on a significantly reduced timeline." Fig. 2. below is the top-level process map for the new simplified process [8].

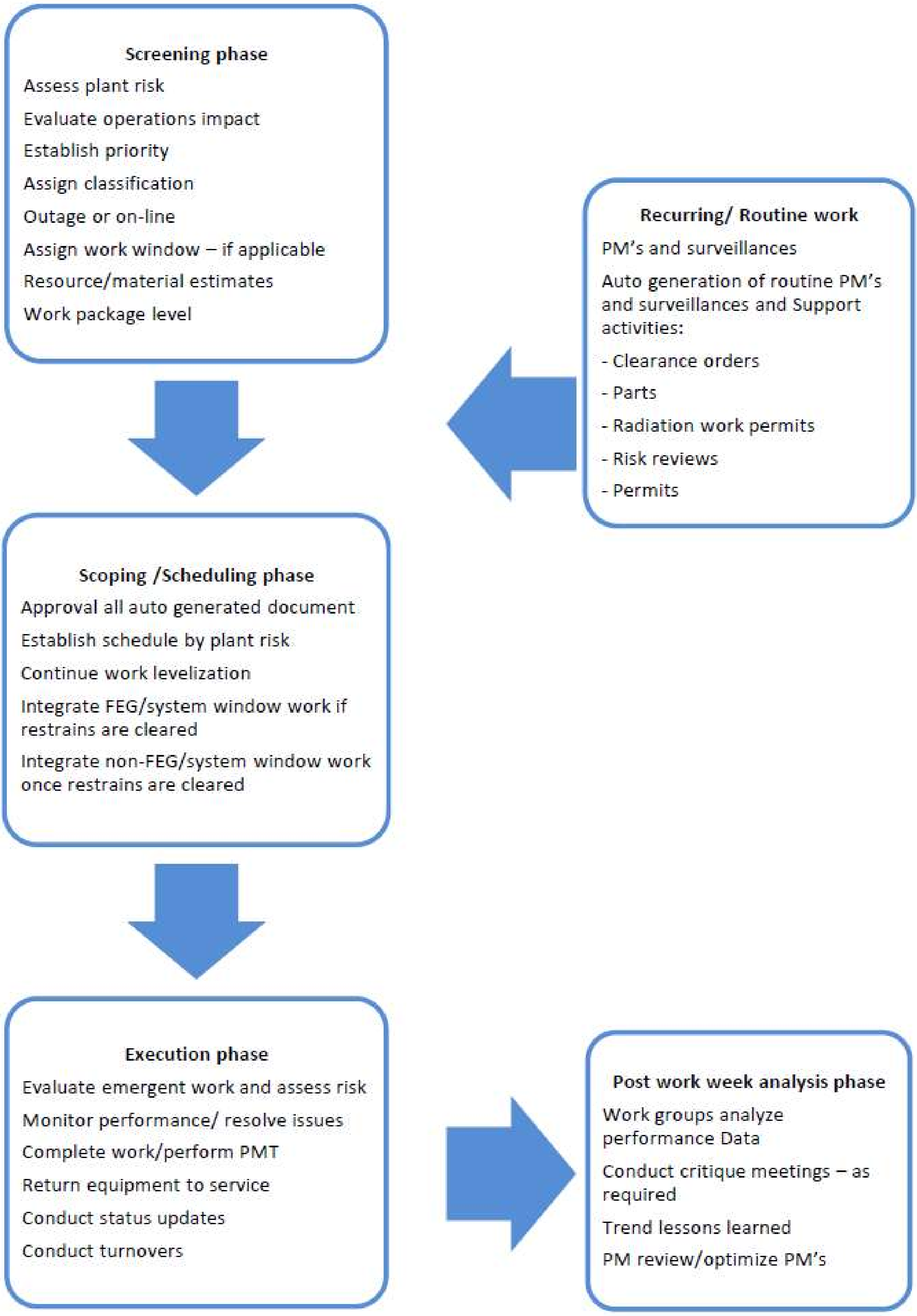

FIG. 2. Top-level process map for simplified work management process

2.3. SUMMARY OF SURVEY RESULTS

In order to understand current challenges and opportunities in WMP worldwide the survey was implemented. 40 responses were received from 13 Member States (Armenia, Canada, Hungary, Japan, Korea, Mexico, Romania, Russia, Slovakia, Sweden, Switzerland, UAE, USA). More than 90% of the respondents are working in work management or work planning positions in NPPs. Respondents experience in WMP was more than 10 years on average. The survey questions were prepared in such a way that the respondents had opportunities to describe the biggest challenges and to highlight best practices for each sub-process of typical WMP (See Fig. 1). The detailed survey results are shown in Appendix I.

According to the survey, the challenges faced by the respondents during the WMP are similar and common among NPPs, regardless of country or work experience in WMP. However, such aspects that the respondents with less experience have not encountered were pointed out by the respondents with more experience.

Below are listed the dominant challenges that can be found in the answers of most of the respondents. Some suggestions and possible solutions to address these challenges are discussed in Section 3.

Direct challenges:

(a) Lack of resources;
(b) Ineffectiveness and uncertainty in planning
(c) Excessive administrative process

Underlying issues that could cause the above challenges were recognized in the areas of:

(a) Knowledge transfer to the next generation;
(b) Co-operation/interface between different departments/disciplines;
(c) Conservative/conventional preventive maintenance programme
(d) Supply chain

At the same time when there are some challenges, respondents have found some good practices and opportunities to improve WMP. Five good practices or opportunities to improve the WMP are listed below:

(a) Using cross-functional planning teams;
(b) Long term maintenance planning and PM standardization;
(c) Using fix-it-now (FIN) team;
(d) Benchmarking and using international operational experience ;
(e) Using new advanced technologies like artificial intelligence (AI).

3. CHALLENGES AND OPPORTUNITIES OF WORK MANAGEMENT PROCESS

Each sub-process of typical WMP offers unique challenges and opportunities for the NPPs. The discussion in this section will focus on excellence (to-be-status) for each sub-process, common challenges experienced, and identified good practices (opportunities) for overcoming the challenges.

3.1. SCREENING PROCESS

3.1.1. Excellence in the screening process

Priorities are well defined, communicated and adhered to. New deficiencies are scheduled or otherwise resolved based on their priority. Previously prioritized work is periodically re-evaluated based on the aggregate impact of deficient equipment or operational conditions. (See Ref. [2, 7] – graded approach)

A committee consisting of representatives from work management, operations, engineering, maintenance, logistic function (e.g. scaffolding, spare part, cleaning etc.), Fix-it-Now (FIN), and other relevant organizations works together to review and evaluate new tasks. Their objective is to determine the appropriate priority and classification of identified deficiencies based on factors such as safety significance, operational impact, and impact on emergency preparedness. Additionally, when making collaborative decisions, the committee takes into account the potential effects on core damage frequency or risk for the specific operational mode in which the work will be carried out (e.g., online, outage, reduced power) [9–18]. Further details on work prioritization and examples are discussed in Appendix II.

Backlogs are understood by performing periodic review to ensure that the backlog is accurate. Many cases are observed, where the original problem that was identified, either no longer exists or has changed (actual deficiency has degraded or the scope of the problem has expanded). If the scope has changed or the significance of the deficiency has changed, there may be a possibility that the impact either on system health or plant reliability may have also changed.

When a collegial decision has been made that the deficiency will not be fixed, clear criteria that are used to delete or void an existing documented deficiency are established. This criterion ought to address system health and plant reliability vulnerabilities if deleted. Additionally, safety, radiological and chemistry concerns also need to be evaluated if voided.

3.1.2. Challenges experienced in the screening process

Some organizations tend to unnecessarily assign a high priority classification to a large percentage of new corrective maintenance (CM)[1] or deficient maintenance (DM)[2]. This causes undue burden on the work management and maintenance processes to constantly rearrange scheduled work to accommodate these artificial ‘high priority’ work items. Often these artificial

[1] Corrective maintenance is a task that is performed to restore the functions of systems and equipment which have broken down.

[2] Deficient maintenance is a task that is performed to repair a equipment defect or failure which affects or could affect the safety of operations, or that causes an interruption to the services being performed.

high priority work activities are forced into the current work week, becoming emergent work, further disrupting the schedule that maintenance has prepared to implement.

In some organizations prioritization systems lead to classifying a large population of outstanding backlog items that are prioritized as 'routine' or 'normal' or schedule within the normal WMPs. However, these never get worked and become a very large backlog. This can result in a lack of confidence in the WMP and prompt artificial high priorities.

Some organizations do not have the individuals who are competent enough with integrated plant knowledge and experience at the new work screen meeting, as a result, there is no advocacy to discuss the importance of the corrective or deficient work item.

Survey results from the industry also indicated that often the screen process is challenged due to overall station resources. For example, the stations cycle plan is already full of predesignated work such as PM work and there is little or no margin to add new work without proper allocation of available resources.

Here we have different challenges listed for screening process, and other sub-processes in WMP as well:

- Scope of work changes significantly;
- Equipment failures which can cause safety or operability issues;
- Prioritization and scheduling contradictions;
- Large number of functional failures;
- Reworking due to a poor quality of the first-time activityNumber of equipment deficiencies;
- Not integrated operating experience of the site or fleet or external.
- Repetitive problems with same SCCs (e.g apparent cause treated but not the root cause);
- Risk related equipment is out of service;
- Duplicate work orders have not been evaluated in advance;
- Ageing SSCs;
- Modification projects late in progress.

3.1.3. Good practices identified in the screening process

Nuclear power plants typically perform a periodical detailed backlog review by the new work screening committee to ensure consistency. The periodicity commensurate with the priority level. More details on backlog review and management are discussed in Appendix III.

FIN team is used for validation and disposition of a high percentage of all CM, and DM in preparation for the New Work Screening Committee[3].

Work Management identifies the 'next possible' opportunity to work the deficiency in accordance with the cycle plan and appropriate Functional Equipment Grouping (FEG)[4].

[3] A group of individuals that possess the knowledge and experience to evaluate new work requests. The team typically meets daily and determines the priority based on the urgency to resolve the issue (in accordance with the station prioritization matrix).

[4] The pre-defining grouping of multiple equipment subcomponents around a common system isolation based on the interval of preventive maintenance or out-of-service consideration. It is also an integral component when developing the cycle plan and quarterly schedule.

Planning comes to the meeting being prepared to discuss parts availability, work history, estimated resources and interface needs.

Engineering comes to the meeting being prepared to discuss equipment history, trending, redundant equipment performance/status and share operating experience of the previous activity.

System/component owners such as chemistry, security emergency preparedness, logistic and other groups come to the meeting to advocate for the timely repair of their equipment if necessary.

The station priority system is well understood and frequently referenced during the meeting. The priority assigned is agreed to by all members of the committee and challenged as appropriate.

When conditions change or additional information becomes known, the deficiency is brought back to the New Work Screening Committee for additional review and the priority is adjusted as needed. Expectation for disposition of all new deficiencies within 3 days[5]. Disposition could include assigning to FIN team, scheduling in a future work week, or voiding due to duplication or validation that there is no real deficiency. Periodic reviews are performed of all online CM, DM and others to re-validate prioritization and that the deficient conditions still exist or has not changed (Periodic Backlog Validation).

3.2. SCOPING PROCESS

3.2.1. Excellence in the scoping process

The proposed scope of work, which aims to enhance equipment and plant reliability, undergoes a thorough review and acceptance process by the engineering team. The selection of work items for inclusion or exclusion in the proposed scope is made with the input of a multidisciplinary team. During this evaluation, factors such as safety implications, equipment reliability, operational priorities, long-term planning, preventive maintenance (PM)[6] strategies, estimated resource, competencies, just in time training and requirements are considered.

The effective bundling of work is prioritized to optimize equipment availability, minimize risk, and reduce operational burdens. The selection of equipment deficiencies and work activities is carefully made to ensure that a maximum amount of work can be accomplished in a safe, reliable, and efficient manner.

The planned work undergoes ongoing assessment with the involvement of a multidisciplinary team. Changes in the work scope, whether additions or removals, are made based on considerations of safety impact, equipment reliability, operational priorities, long-term planning, preventive maintenance strategies, and estimated resource needs to execute the work.

The stations cycle plan is effectively used and communicated to lay out the work windows over a several year period. This information is used by station personnel to assist in making decisions on work sequence, integration of system/plant health, seasonal readiness, and outages.

[5] In urgent cases conservative decisions could be made and actions be taken by operators.

[6] Preventive maintenance is a maintenance task that is periodically scheduled to help prevent unexpected failures in the future.

3.2.2. Challenges experienced in the scoping process

Nuclear Power Plants do not effectively match the amount of selected scope in a work week with the number of workers/resources available to perform the work, resulting in an ineffective WMP.

Engineering lacks participation in the scope selection process and over relies on work management to select the correct scope without a complete understanding of system health requirements.

Engineering does not review system backlogs from an aggregate standpoint when recommending work as part of the scope selection process. The aggregate review should take into account both work order backlogs and the PM backlogs for a particular system. In many cases, implementation of a work order will eliminate the need to perform a periodic PM task on its scheduled frequency, and as a result of the work order, the schedule dates for the PM task can be re-baselined.

The stations cycle plan is not used effectively to identify logic related activities, such as performing the correct PM or repair work before being needed to support seasonal readiness or outages.

Incorrect prioritization or classification of work challenges the differentiation of the important work versus the non-important work during scope selection.

Long lead time parts or engineering restraints are not identified early enough in advance which challenges the successful completion of the work activity.

3.2.3. Good practices identified in the scoping process

Engineering establishes standards and expectations to review upcoming system backlogs, system performance, system health reports prior to the scope selection meeting to establish their recommendations of work they would like performed.

Engineering reviews previous PM performance in advance of the scope selection meeting looking for the opportunity to change to the PM interval to free up the opportunity to perform CM or DM related work instead. Operating experience from the previous task is integrated in the review including the reworking.

Maintenance resources (by discipline) are well understood by work management and engineering as part of the scope selection process. Understanding maintenance resources allows accurate scope selection and prevents work being selected that cannot be performed because of resources gaps.

Work activities (PM Tasks, Surveillance test and work orders) have accurate resource estimates allowing the station to set targets for scheduled work vs resources. Typically, this target is set between 90% and 110% of committed resources per discipline.

3.3. PLANNING PROCESS

3.3.1. Excellence in the planning process

The level of detail in work planning and instructions is determined by considering the safety significance and complexity of the task, as well as the training, experience, and skills of the workers. Supervisory oversight is also considered.

In the planning process, the necessary resources for the work activity, such as tools, equipment, materials, information on expected operational status of the unit and logistic support (e.g. radiation protection, cleaning, scaffolding, spare part, etc.), are identified early enough to support the schedule effectively. Appendix IV discusses the model for effectively making resources available as ‘demand/supply maintenance resource model’.

Experienced personnel, equipped with approved criteria and guidelines that align with the WMP, carry out the work planning. Plans are developed, encompassing key activities and steps, post-maintenance testing, interfacing activities, and support groups. Planners conduct task verification or walk-downs to ensure that the quality of the work package meets station standards for the planning milestone. This ensures that the maintenance personnel can utilize the work package during the execution of work activities, including the use of human error reduction tool to avoid the occurrence of event or poor quality of maintenance task.

Work plans undergo assessment to ensure that the appropriate level of risk is maintained during work execution. Contingencies are developed and incorporated into the work plans when necessary to manage the appropriate level of risk.

As work documents are developed and additional reviews are conducted, the assessment of integrated risk considers the risk associated with work execution.

3.3.2. Challenges experienced in the planning process

The work packages developed to support work execution lack sufficient technical detail for workers to successfully implement the instructions, or the work packages have excessive amounts of detail and take an extraordinary amount of time for the planners to develop and are cumbersome to implement. For example, individual steps are referenced from many different attached documents requiring workers to manoeuvre from document-to-document challenging successful completion.

The planning milestone is frequently not met, and it might place all downstream milestones at risk as a result.

There is not enough time allotted for proper work planning to meet the planning milestone and planning restraints are not resolved in a timely manner to meet the milestone.

Difficulties are encountered in identifying all necessary parts and services to procure in advance of the work execution. In some cases, this leads to parts not being on-hand in time for the work, or no parts available in the case of additional deficiencies identified during PM and CM implementation.

Survey results from the industry also concluded that challenges exist in managing the delays and timetable associated with the equipment repair. Additionally, the survey indicated that there are often too many documents that need to be attached to the work order.

The original scope of work was incorrectly identified or not fully understood and through the planning process the task becomes significantly more complex, challenging the successful completion. Planned work packages that have met the planning milestone are returned just prior to execution with significant gaps.

Upon completion of work, critical and constructive feedback on the work package technical content, resources, job duration, sequencing of steps, materials and coordination are not captured.

3.3.3. Good practices identified in the planning process

A graded approach [2, 7] is used in determining the level of detail needed in each work package. This is determined by the work groups and planned accordingly.

During the planning process, planners typically identify any risk associated with the scope of work from a maintenance/work standpoint. For example, a planner would identify any risks associated with rigging and lifting, working near or around energized components, foreign materials, working at heights, and excavating, as well as potential plant shutdown and safety issue. These identified risks, based on the scope of work, are factored into the station's risk management process and a risk level is assigned based on the activity that results in the highest risk. The identified risk is continually evaluated throughout the remainder of the process. The planner identified risk is also factored into the overall integrated risk which is typically performed by operations during their review. In some cases, the risk of the work being performed may be relatively low, however, the risk associated with securing the system, hanging the clearance, or restoring the system may be the highest risk and is also factored into the overall integrated risk.

Workability reviews are integrated into the planning milestone. The workability review is performed by a senior member of the maintenance shop and determines the preliminary acceptance of the work order in order to meet the planning milestone, eliminating rejection later down the road.

Consistent post job reviews are performed providing feedback to the planning department. Feedback includes work package technical content, resources, job duration, sequencing of steps, materials, and coordination.

Individuals performing the planning function frequently perform walkdowns with key maintenance personnel to reach an understanding on the format, technical content, and level of detail needed by the work group.

Commonly used work instructions are proceduralized such that they can be used repeatedly, as specified by any individual work package. For example, calibration procedures for a model of pressure instruments used in multiple applications is proceduralized, such that any given work package can simply specify calibration in accordance with the approved procedure rather than re-create the steps each time. The common procedure is revised over time, based on worker feedback, gained at pot-job briefing, to obtain just the right amount of detail.

Automation is utilized to the maximum extent possible to ensure reproducibility of the task. This includes the automatic ordering of parts following the last completion of a task, automatic generation of permits (safety tags, fire impairments, and other permits), automatic generation of a radiation work permit and automatic generation of operational impact reviews.

Planning established metrics to monitor performance, quality, returns, errors (e.g. reworking) as part of their continual improvement mission.

3.4. SCHEDULING PROCESS

3.4.1. Excellence in the scheduling process

The analysis and scheduling of work activities aim to optimize equipment availability while minimizing operational risk.

During the early stages of schedule development, any challenges and conflicts that may hinder the successful completion of work are identified. This allows for proactive measures to be taken, providing the necessary attention and resources to address and resolve these issues as needed.

Schedules are created with an appropriate level of detail to identify periods of heightened core damage frequency risk during both online and outage periods. This enables the implementation of specific measures and precautions to mitigate potential risks during these critical periods: Graded approach of scheduling based on integrated risk level[7].

Throughout the WMP, cross-discipline horizontal and vertical reviews[8] are utilized to identify and address scheduling conflicts. Progressive reviews are conducted to delve into greater levels of detail, with a particular focus on key safety system work.

Contingency plans, designed to mitigate risks, are reviewed in advance, and effectively communicated to relevant stakeholders.

When evaluating the inclusion of emergent work activities in the schedule, factors such as inoperable or out-of-service equipment, the impact on maintaining defence-in-depth and operational risk [9–18], as well as the potential disruption of scheduled activities and resources, are carefully considered.

The integrated schedule undergoes regular assessments and adjustments to resolve conflicts and minimize risk [9-18]. Schedule changes are evaluated based on predefined criteria, and approval from management at the appropriate level is obtained, aligning with the associated risk and impact on performance goals. Schedule changes and identified impacts are communicated to the staff in charge of activities to avoid discrepancies.

Resources required for the scheduled work are confirmed and allocated. These committed resources are continuously monitored, and any gaps identified are promptly addressed to ensure seamless support for the scheduled work.

Personnel make adequate preparations for work implementation, considering the level of risk involved, the significance of the component to work execution, and their own knowledge and experience related to the scheduled tasks. Additionally, work group interfaces and coordination points are identified as part of the preparation process.

3.4.2. Challenges experienced in the scheduling process

Inadequate work group preparation or walkdown contributes to delayed or unsuccessful work completion.

Clear standards are not set for the level of walkdown expectation to be performed based on the complexity or frequency of the task.

Vertical reviews are not effectively performed resulting in numerous work groups all working in the same area at the same time.

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[7] The graded approach to the schedule is applied based on significance of integrated risk level. The most important work is scheduled with very close monitoring (hourly). Less important work is scheduled to the day and general work is scheduled to the week.

[8] Horizontal review is a look at the schedule by all work groups as to the activities that are happening that hour or day regardless where they are happening. Vertical reviews consider the area, space and equipment that everyone is working on to ensure that the work can be done at the same time in the same area.

Work groups use different scheduled tailored for their needs only, thus minimizing their ability to look ahead and understand other support activities.

Workers are not made aware of their work assignment until the morning of implementation. The change of schedule with impact is not clearly communicated to the workers. Thus, significantly challenging their readiness and ability to be prepared to execute the work in accordance with the schedule

Walkdowns and readiness reviews are performed without physically looking at parts, only to find out that on the day of execution the part is not the correct part or is not actually available even though the computer showed it was available.

3.4.3. Good practices identified in the scheduling process

Important work is identified, and additional levels of readiness are applied with additional management oversight.

When needed all involved work groups perform a walkdown together to discuss interface, logistics, coordination of workers in the area and equipment.

Additional preparation and coordination meetings outside the standard work management meetings are held to ensure a successful work window for important work.

Workers are given their work assignment several weeks (4-5 weeks) in advance to allow for preparation and ownership of their assigned work. For sensitive activities, the requested “Just in time training” is arranged for the staff in the schedule with a margin to prepare for the case in which the task is postponed from the initial schedule (e.g. for a reactor shut down operation, the operation teams on shift before and after the initially assigned will also have dedicated training on simulator).

Stations dedicate a small portion of each work week for workers to get prepared for an upcoming workweek. For example, the first four hours of each Monday are dedicated for workers to review, perform final walkdown, coordinate with others for their upcoming work two weeks out. Those workers are then held accountable to implement their work as scheduled.

3.5. EXECUTION PROCESS

3.5.1. Excellence in the execution process

Workers are prepared to execute the scheduled work by referring to the work order in his/her procession (typically 4-5 weeks in advance). This is only accomplished by ownership of the schedule by the work groups prior to and during the work week.

Worker has a dedicated time to perform pre job briefing and coordination meeting in case of multiples task.

Workers know their schedule, as a result they are looking ahead and keeping downstream workgroups informed of their progress and expected completion time.

3.5.2. Challenges experienced in the execution process

Actual work durations are different than scheduled duration.

Survey response from the industry indicated that in many cases not all work groups are held accountable for their portion of the execution task on the schedule. For example, operation department is often not held to the same accountability standard that other work groups are held to for their activities in the schedule, such as clearance orders, removal of equipment from service. It is important that schedule accountability is demonstrated by all work groups that are on the schedule.

Workers are not familiar with their schedule work or the schedule, as a result they are not looking ahead or communicating with downstream work groups as to their progress.

3.5.3. Good practices identified in the execution process

Stations have daily expectations for the time until the workers are in the field starting to perform work.

Timely and accurate completion of work is factored into workers' performance reviews. For example, when work is completed error free and on time, workers are recognized and as necessary rewarded.

Workers keep their supervisor and management informed of job status and when necessary, notify their supervisors of job challenges or delays in a timely manner. Work groups often utilize a 10-30-60-minute rule to ensure that the appropriate level of the organization is notified when challenges are identified. The 10-30-60 minute rule are simply defined as the following:

- 10 – minute – If you are delayed more than 10 minutes as a worker (work group), contact the supervisor with the reason for the delay and expected completion time for the delay to be resolved;
- 30 minute – if the delay is expected to exceed 30 minutes – contact the work week manager (during on-line work) or the Outage Control Center (OCC, during an outage);
- 60 minute – 60 minutes prior to completion of your task – communication should be made to the next work group, such that they can be ready to proceed without delay.

Workers' names appear on the schedule for the activities that are assigned to them. This practice transferers the ownership of the work from the manager or supervisor to workers.

3.6. WORK ANALYSIS PROCESS

3.6.1. Excellence in the analysis process

Insights gained from gaps identified in planning, scheduling, and execution are carefully reviewed and integrated, as appropriate, to improve future practices.

The performance of WMP is regularly assessed, tracked over time, and critically evaluated. Corrective actions aimed at addressing performance gaps are identified and monitored until completion.

Following the completion of work, workers and relevant support personnel participate in post-job critiques to analyse the completed tasks and gather insights for improvement.

3.6.2. Challenges experienced in the analysis process

Work week critiques lack the required attendance to identify opportunities and successes for the organization to learn from.

Work week critiques focus only on the execution or implementation and do not identify preparation opportunities or successes for the organization to learn from.

Work week critique analysis does not consistently apply cause codes, thus challenging the ability to correctly diagnose common themes associated with performance gaps, especially for cause analysis of reworking linked to gaps (e.g. poor quality of task, spare part failure, etc.).

Work week critiques do not address committed resources versus work scope changes over the length of the process (scope selection through implementation) to identify opportunities for improvement.

3.6.3. Good practices identified in the analysis process

A common set of performance indicators are typically used to compare work management performance between NPPs. Comparing performance to other NPPs enhances the ability to identify areas where performance can be improved and can lead to benchmarking NPPs that have strong performance in a particular area. A typical set of work management PIs are shown in Appendix V [5].

Station continually self-analyses their workweeks performance, always looking for improvement opportunities in the process, preparation, or execution. Many stations will document work management related issues on a weekly basis and then quarterly look for the largest gaps and perform a more detailed review/analysis of those gaps. It is important that the stations top 2-3 gaps are identified and communicated. By doing this, the entire station can focus on those gaps.

Each work group discusses both successes and opportunities for improvement, sharing those successes and opportunities for improvement with others in the meeting.

Work week critiques address both successes and opportunities for improvement in the preparation and execution processes.

Resource accountability and alignment along with scope changes (addition or deletion of work) are well understood and trended.

The corrective action programme or other trending programmes are consistently used to document both successes and opportunities for improvements.

4. CONSIDERATIONS FOR EFFECTIVENESS ON WORK MANAGEMENT PROCESS

The critical elements that impact on WMP effectiveness are discussed in this section. They include:

- Organizational effectiveness
- Computer software integration
- Resource accountability and alignment
- Effective Fix-It-Now team

The discussion in this section will focus on excellence (to-be-status) in each element, common challenges experienced, and identified good practices (opportunities) for overcoming the challenges in the same way as Section 3.

In addition, the consideration on ALARA principle is also discussed in this section, and good examples of WMP implementation in Japan are introduced in Appendices VII and VIII. Appendix VII describes WMP of Tokyo Electric Power Company Holdings, Inc. (TEPCO). Appendix VIII describe how Kaizen principle is applied and contributes to effective WMP in TEPCO.

4.1. ORGANIZATIONAL EFFECTIVENESS

Personnel selected for key roles in WMP need to have the skills, talent, and training to successfully work with NPP personnel of all levels to coordinate the elements of the WMP. Because work management personnel are shepherds of the WMP, and do not have authority over the multiple departments who support the process, the key members have to have leadership traits that enable them to be effective without inline authority. In addition, the support of management from all departments is essential in developing a culture that embraces the key principles of effective WMP discussed in Section 2.1. Typical work management interfaces roles and responsibilities in the work process are discussed in detail in Appendix VI.

4.1.1. Excellence in organizational effectiveness

Station leaders define and communicate clear expectations regarding work management standards. They emphasize the importance of adhering to schedules to uphold nuclear safety and minimize operational risk.

Managers are responsible for ensuring that emergent issues and work are managed in accordance with established processes. Failure to do so may result in disruptions to scheduled work and unintended negative impacts on nuclear safety.

Managers actively supervise the readiness of planning and preparation milestones. They identify and address any performance gaps in WMP. Furthermore, they ensure that lessons learned from both station-specific and industry-wide operating experiences are incorporated into subsequent work planning activities and schedules.

4.1.2. Challenges experienced in organizational effectiveness

Managers endorse or do not challenge work management work arounds. Examples include endorsement of unnecessary assignment of high priority classification or support of using lists that bypass the WMP.

Management does not challenge and require actions to recover known gaps identified from performance indicators or preparation milestones.

Management do not respect nor endorse the WMP, continually using ‘management discretion’ to bypass or deviate from the process.

Management does not have a clear understanding of the roles and responsibilities of work groups associated with the WMP, as a result frequently holds the work management organization accountable for performance gaps of others. For example, holding work management accountable for maintenance not completing work as scheduled.

4.1.3. Good practices identified in organizational effectiveness

Management holds the correct individuals/work groups accountable for their portion of the WMP (preparation milestones and implementation).

Senior management periodically monitors preparation performance and attends selected meetings. For example, most plant General Managers are sponsors of the final schedule review meeting/certification meeting.

Work groups are frequently recognized for their performance, specifically for important work that was completed error free and in accordance with the schedule.

4.2. COMPUTER SOFTWARE INTEGRATION

Effective use of computer software is key for implementation of WMP. The project of computer software integration needs to be supported by strong leadership of senior management of NPP operating organizations, since it often requires huge human and financial resources. It is also important that all the associated departments and organizations work with it for developing and updating robust set of data, promoting its consistent use based on effective training and ensuring compatibility with other software.

4.2.1. Excellence in computer software integration

Work management software and supporting applications are all integrated together to assist in scheduling, tracking, and reporting performance. For example, PM work orders and support documents, such as clearance orders, radiation work permits, materials requests, logistic requests, spare part, would be automatically generated and require minimal administrative effort. This initiative will save work preparation administrative burden. While a work order is used to accomplish work, excellence in integration would allow the worker to close the work order and the closure status of the work order would automatically update the completion time in the scheduling tool. Similarly, other applications such as the tagging application would automatically update the scheduling tool once tags are completed.

4.2.2. Challenges experienced in computer software integration

The work management platform does not provide the required granularity within work steps to identify or analyse performance gaps.

The work management platform does not interface with other key programmes and processes, such as the supply chain process, inventory management, equipment reliability process, scheduling process, and resource management tools.

The work management platform does not provide the automatic generation of performance indicators and milestone performance.

The work management platform limits the ability to perform parallel activities, such that everything has to be done in series.

4.2.3. Good practices identified in computer software integration

The work management platform is well integrated with the other key programmes and processes.

Scheduling durations can be derived from the work management platform and or vice versa. Status of work can be updated using either the schedule or the WMP (work steps).

Performance of WMP can routinely be observed and monitored using the tools provided within the work management platform. For example, work activities that do not meet a particular milestone are readily displayed with restraints easily identified.

4.3. RESOURCE ACCOUNTABILITY AND ALIGNMENT

Necessary resources for the work activity need to be identified and secured early enough for effective implementation of WMP, as discussed in Section 3.3. Since the resource estimation includes some uncertainties, it is essential to make consistent efforts of developing relevant robust database that enables precise estimation and to make it accessible for planners and associated staff by using available advanced technologies.

4.3.1. Excellence in resource accountability and alignment

Managers possess an understanding of the resources required to effectively implement WMPs. These resources are carefully monitored and planned in advance to ensure the successful execution of the designated work.

Resources necessary to complete the scheduled work are confirmed and committed. Committed resources are continuously monitored, and any gaps that arise are identified and promptly addressed to provide adequate support for the scheduled tasks.

4.3.2. Challenges experienced in resource accountability and alignment

Committed resources used to select works in the work scoping/planning processes are frequently changed throughout the preparation process, resulting in frequent changes of the selected works in the efforts to keep alignment between resources and work scope.

Changes in resources are not tracked throughout the process. As a result, gaps are not analysed or corrected.

The station cycle plan is not used to identify work weeks where the resource demands will be higher or lower than normal based on work week windows or other utility commitments such as resource sharing.

Job estimates are inaccurate, and as a result the alignment of resources and work scope is frequently challenged.

Actions to fill alignment gaps in resources are not taken. As a result, some work are removed to align works with the provided resources, challenging completion of important works and backlog reduction.

4.3.3. Good practices in resource accountability and alignment

Committed resources as compared to the selected works are tracked throughout the process and discussed in the post-work critique in the following week.

Scope add/drop process address required resources that will either be needed to achieve the addition or respond to resources abundance if works are removed.

Stations address possible inaccurate job durations assigned to PM task by using more accurate tracking tools and employing post job critiques that address actual job durations. These new/improved durations are applied to similar work.

Full disclosure of resources is frequently communicated to the management team. For example, each maintenance discipline identifies the total number of personnel on payroll as compared to the total number of personnel being committed to the WMP.

A demand/supply model is frequently performed and presented to the senior management team. (See the Appendix IV)

4.4. EFFECTIVE FIX-IT-NOW TEAMS

Fix-It-Now team can achieve essential roles to quickly sweep and solve minor equipment and plant issues that can be burdens for maintenance to execute scheduled works and consequently contribute to WMP effectiveness, if the team is well resourced and empowered by management. It is also necessary that FIN team's roles are well understood and supported by all associated groups and organizations at NPPs.

4.4.1. Excellence in effective fix-it-now team

An effective FIN team has one primary goal and only one primary goal and that is to protect the published schedule from disruption due to high priority work. Secondarily, an effective FIN team plays a key role in taking as much routine incoming work as possible.

A FIN team is a special cross-functional work team that is assembled as an autonomous work group capable of performing work with minimal additional resources and support. This team accomplishes work outside the normal cycle schedule on a real time and immediate basis. This results in shorter cycle times for fixing degraded equipment and will free up planning, scheduling, tagging and major maintenance resources.

Fix-It-Now teams effectively manage incoming work, protect the schedule, and provide timely resolution to high priority work. Most of the FIN teamwork is accomplished using tool-pouch, minor maintenance and single person tasks that do not require detailed work package planning and do not increase the risk of a plant transient or other consequential event.

4.4.2. Challenges in effective fix-it-now teams

Many FIN teams are not fully staffed, organized, and maintained as an autonomous cross functional team with enough skill, limiting their ability to protect the schedule and perform the majority of new incoming work. The resolution thereby of simple equipment deficiencies is unnecessarily delayed by requiring all work to be routed through the WMP, requiring detailed planning. Often key members such as an operations representative are missing, resulting in the FIN team getting work approved and released by the on-shift control room staff.

Fix-It-Now teams do not utilize the full extent possible the use of tool pouch and minor maintenance work packages. As a result, the FIN team becomes just an extension of the maintenance shop and requires the same planning detail and the main maintenance shops.

Fix-It-Now teams are not effectively utilized to perform investigation of all new work deficiencies. This results in delays in resolving simple equipment deficiencies.

Measurement of FIN teams' effectiveness is not used or understood, preventing the opportunity to identify performance gaps and close them.

4.4.3. Good practices in effective fix-it-now teams

Fix-It-Now teams are fully staffed with an active senior reactor operator (SRO) who has full authority to approve the issuance of permits (tag outs) and full authority to release the start of work.

Fix-It-Now teams set performance goals and monitor their performance against those goals. Typical FIN team goals are FIN team will take ownership of 75 percent of all new incoming work and 90 percent of all new high-priority work.

Fix-It-Now team members are on long-term assignments or rotation to the FIN team. This enables the necessary team building, relationship needed for the FIN team to become an autonomous work group capable of performing work with minimal additional resources and support.

Fix-It-Now teams are comprised of highly skilled, highly trained, self-starters, self-motivated workers who require minimal direction, supervisor, or oversite.

4.5. CONSIDERATIONS OF ALARA

The principle of keeping occupational exposure, ALARA, is a crucial regulatory influence on WMP in relation to controlling occupational exposure. It is fundamental to the current application of radiation protection (RP). Striking a balance between reducing public doses from routine operations, where individual exposure levels are generally very low, and minimizing occupational exposure, which can lead to genuine reductions in exposure for a relatively small number of individuals, is essential when implementing this principle [19].

Personnel responsible for RP have discovered that through effective planning, preparation, implementation, and review of tasks, occupational exposures can be minimized to the lowest reasonable level achievable. This overarching concept is commonly referred to in the WMP. If applied correctly, WMP can result in a decrease in the number of workers required to perform a task, the amount of time spent in radiologically controlled areas, and the overall cost of the work. It also contributes to reducing occupational exposures in an ALARA manner.

When considering the implementation of ALARA principle through WMP, there are several factors that contribute to optimal worker performance and can be enhanced through worker involvement.

Workers are expected to contribute to reducing radiation doses by carrying out their tasks with high quality, minimal exposure, and ideally, at a low cost. To achieve this, workers must possess comprehensive technical knowledge and receive appropriate training for their job.

In addition to technical expertise, there are other important aspects for workers to perform well in accordance with ALARA principle:

- Personnel ought to be familiar with the ALARA principle to understand management objectives, reflect these general ideas, and apply them effectively in their specific work areas.
- Personnel should embrace the ALARA principle for their own safety and the benefit of the organization.
- Workers are encouraged to think critically about the tasks they are performing and strive to enhance their performance within procedural requirements, drawing on their own experience.
- Workers should propose new tool designs or modifications to existing tools, facilities, or components based on their experience and considering radiation safety aspects. These suggestions aim to improve work conditions during operational shutdowns.
- Workers ought to be aware of potential issues and be able to respond to unexpected problems in a safe and efficient manner, utilizing their knowledge and assigned responsibilities.

5. ADVANCED TECHNOLOGY USED IN WORK MANAGEMENT PROCESS

This section briefly outlines the possibilities of advanced technology use in WMP.

5.1. ELECTRONIC WORK PACKAGE

Electronic work packages (EWP) is basically a work package that has been prepared (developed) by a planner on his/her desktop computer and downloaded to a tablet which is taken to the field instead of a paper copy of the work package. While this is the simplest explanation, the EWP allows a great deal of technology advantage. For example, the EWP can be a very simple work package with minimal details, if the worker needs additional detail, they can click on an attachment that may contain a video, vender manual, or detailed assembly drawing. Using EWPs in the field does not necessarily require station internet in the power block. In cases where internet is not available the work package is downloaded to the EWP but has no interaction with other platforms without exiting the power block and uploading more information. Where internet is available, the use and opportunities become endless. For example, if a worker needs a revision to an EWP, the planner can make the revision from his/her desk and upload the revision to the EWP and all the worker needs to do is download the revision.

5.2. USE OF STATION WI-FI TO IMPROVE/EXPEDITE WORK ORDER STATUS AND COMMUNICATIONS

Stations that have improved power block Wi-Fi capabilities have found many additional opportunities because of the enhanced Wi-Fi capability. These include the ability to use EWP live at the job site, transmitting emails, documents, and text messages live time from the work location to planners, engineers, and supervision, using the EWP to provide live time schedule updates and notification of job status to subsequent work groups. The capabilities and use of enhanced Wi-Fi can become endless and can significantly improve worker safety and efficiency.

5.3. USE OF ARTIFICIAL INTELLIGENCE FOR NEW WORK SCREENING AND SCOPE SELECTION

Some stations have developed artificial intelligence (AI) to assist in the screening of new work that comes to the New Work Screening Meeting. The AI helps in determining the classification, priority, and any special coding along with proposed scheduled date. The AI uses key terms in the description of the deficiency to assist in this assessment.

Some stations have also developed AI to assist in the selection of work as part of the scope selection process in support of scope selection milestone. The AI helps in determining the “right work at the right time” based on priority, special coding, resources, and due dates of PM tasks. The AI uses inputs in the scheduling tool to assist in this selection of work.

5.4. USE OF KIOSK MACHINES FOR WORK STATUS TRACKING

Many power plants have installed Kiosk stations throughout the power block to improve work status updates and communications. Even if the station does not have EWPs, bar codes on the hard copy paperwork order can be scanned at Kiosk stations and communicated back to the work management and scheduling platforms. The Kiosk stations can also be used with the stations electronic clearance order programme to communicate status and allow approval remotely at the Kiosk station. Some stations have used the Kiosk (remote) updates and integrated those updates into key scheduled activities that are displayed on electronic billboards in areas of the plant and administrative buildings.

5.5. USE OF BARCODING OF EQUIPMENT TO IMPROVE HUMAN PERFORMANCE AND CONFIRM WORKER QUALIFICATIONS

Stations have placed a significant effort in mitigating human performance error traps. One of the most common approaches has been the installation of bar-coded tags on plant equipment. This practice provides the worker the ability to scan the bar code on the component and the bar code on the work package to provide additional correct component verification. In some cases, stations have also integrated the workers qualification matrix as related to equipment that they are qualified to work on and a method of confirming worker qualifications.

6. CONCLUSIONS

The WMP is one of key cross-functional processes for sustaining operational excellence, that reunite operation, maintenance, engineering, and other departments of NPPs. Essential elements of this overarching process are clear roles and responsibilities and meticulous preparation of deliverables like work packages through close collaboration across departments and organizations.

The survey discussed in this publication identified common challenges, and they were categorized into lack of resource, ineffectiveness and uncertainty in planning and excessive administrative process. The underlying issues/causes were in the areas of knowledge transfer to the next generation, co-operation/ interface between different departments/disciplines, conservative/ conventional preventive maintenance programme and supply chain. Discussions to find possible solutions and to provide the readers with some suggestions and good practices to overcome these challenges were also made for each sub-process of WMP in this publication.

The publication discussed additional considerations for effectiveness of WMP emphasizing the need for cross-functional work, and provided brief outlines of use of advanced technology. Typical key performance indicators (KPIs) to measure effectiveness of WMP and successful individual processes are also introduced in Appendices.

While all these contents are surely good references for NPP owner/ operating organizations, the challenges and problems are always unique to specific organizations and countries. It might be valuable for NPP owner/operating organizations to periodically implement an intensive analysis to understand the underlying issues of WMP by using several examples of their critical challenges and problems they experienced in WMP for certain time of period, e.g. 1 year, 3 years. It would be an extended post-work analysis process. Effective tools like 3 whys, maybe even 5 whys, will facilitate this process to identify the most critical factor. It is also important to create the mechanism for gaining diverse perspectives from external people or organizations in this analysis process. Once the underlying cause is identified, its solutions can be applied to address other challenges/ problems in WMP and even improve other processes at the same time.

Finally, it is crucial that all relevant managers to WMP understand the importance of this process and possess the necessary knowledge, skills and expertise to serve for this process in a collaborative and consistent manner.

APPENDIX I. SURVEY RESULTS AND ANALYSIS ON WORK MANAGEMENT PROCESS

I.1. QUESTIONS AND SUMMARY OF ANSWERS

The following questions were provided, and the figures below show a part of summary of answers:

Question 1. In which country or international organization, you are working?

Question 2. Your position in work management process? (See Fig. 3)

1. Work management;
2. Work planning;
3. Other (please specify).

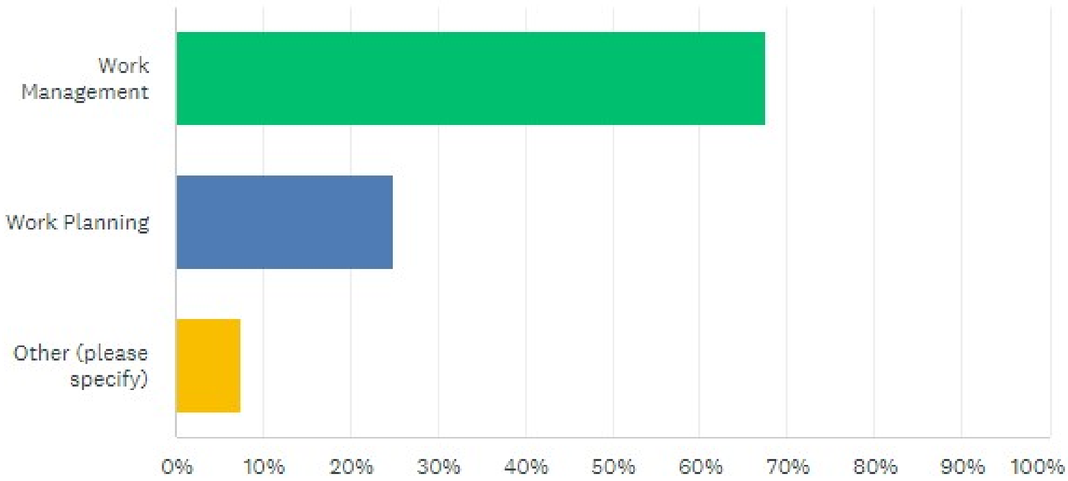

FIG. 3. Position distribution in WMP.

Question 3. Please share your total work management experience (years). (See Fig. 4)

1. 0-5 years;
2. 6-10 years;
3. 11-15 years;
4. 16-20 years;
5. More than 20 years.

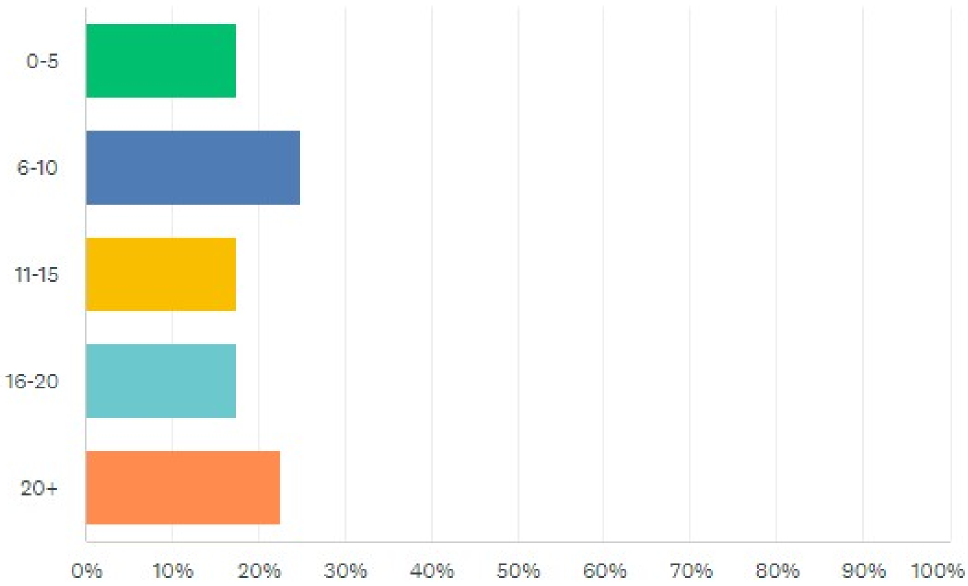

FIG. 4. Experience distribution in WMP.

Question 4. The very experienced senior turnovers any strengths, challenges, recommendations for improvement to junior staff according to knowledge transfer programme. Did you have any roles and responsibilities evolved over the years? (See Fig. 5)

1. Yes;
2. No.

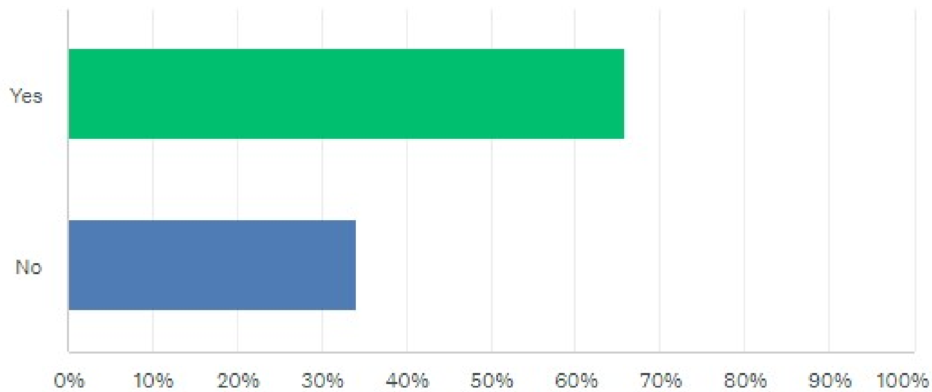

FIG. 5. Turnover of knowledge transfer.

Question 5: If yes, which changes had the greatest impact and why?

Question 6. Which of the following work management sub-processes do you think offer the greatest potential for future streamlining? (See Fig. 6)

1. Screening process;
2. Scoping process;

3. Work order planning;
4. Succession planning;
5. Scheduling and coordination;
6. Execution process;
7. Analysis and reporting.

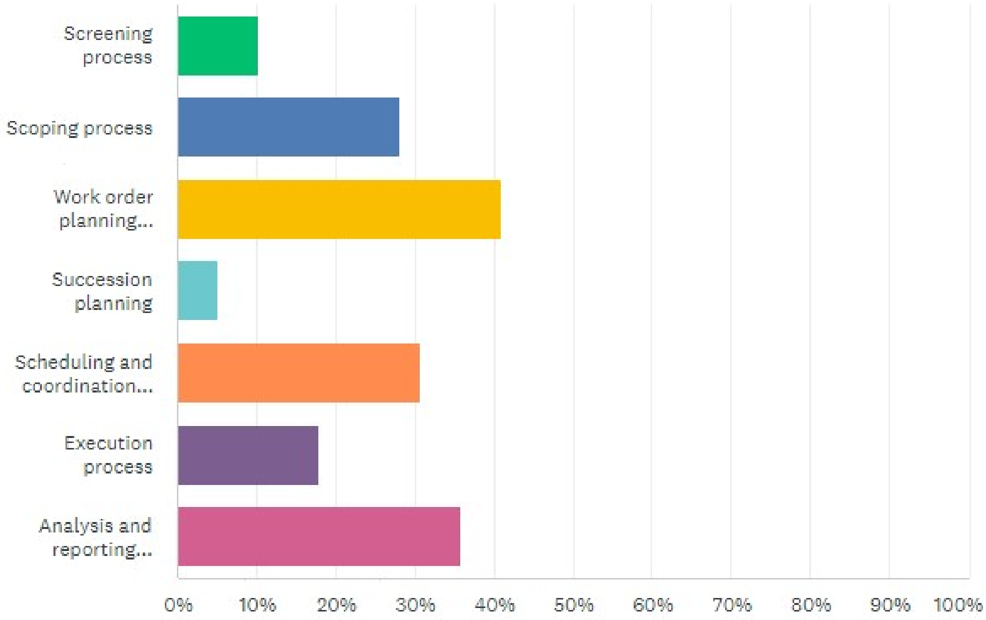

FIG. 6. Potential streamlining in WMP.

Question 7: Screening process: List 3 of the most significant challenges you dealt with in the screening process? (detailed).

Question 8: List 3 good practices you dealt with in the screening process? (detailed).

Question 9 Scoping process: List 3 of the most significant challenges you dealt with in the scoping process (detailed).

Question 10: List 3 good practices in the scoping process (detailed).

Question 11. In planning process, do you have enough time and resources for detailed/multidisciplinary work planning? (See Fig. 7)

1. Yes;
2. No.

Question 12: If not, what are the main problems?

Question 13: Planning process: List 3 of the most significant challenges you dealt with in planning process (detailed).

Question 14: List 3 good practices you dealt with in planning process (detailed).

Question 15: Scheduling process: What kind of challenges have you encountered while working to ensure material availability?

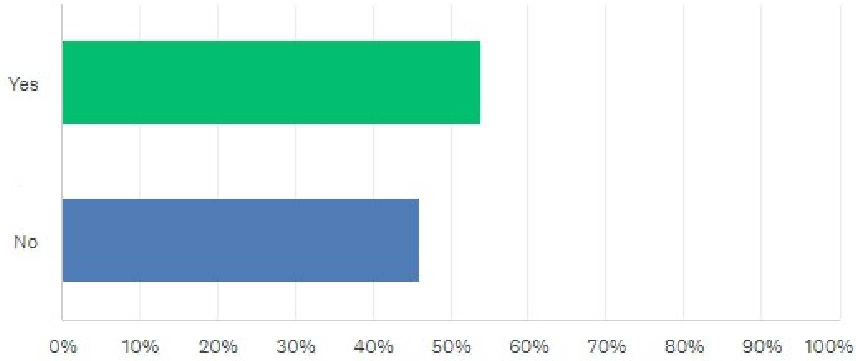

FIG. 7. Distribution of time and recourses.

Question 16: Scheduling process: List 3 of the most significant challenges you dealt with in scheduling process (detailed).

Question 17: List 3 good practices you dealt with in scheduling process (detailed).

Question 18: Execution process: List 3 of the most significant challenges you dealt with in the execution process (detailed).

Question 19: Execution process: What kind of challenges have you experienced while rescheduling your work orders during the execution process?

Question 20: List 3 significant strengths in the execution process (detailed).

I.2. CHALLENGES IN EACH SUB-PROCESS OF TYPICAL WORK MANAGEMENT PROCESS

Significant challenges for each sub-process answered of WMP by respondents were categorized into:

a) lack of resources;
b) Ineffectiveness and uncertainty in planning;
c) Excessive administrative works.

A collection of examples from survey results are found below. Though some of results might be better allocated to other sections/processes, the categorizations defined by survey responders were not changed.

I.2.1. Screening Process

I.2.1.1. Lack of resources

— “Resource adjustments such as workers, materials and equipment are not considered properly”.
— “Too many "other" proactive type work requests do not consider enough resources to complete the PM programme, corrective, and deficient work”.

- “FIN team does not have all the support resources to work independently to complete work orders, so it takes longer to get done for many work orders”.

I.2.1.2. Ineffectiveness or uncertainty in planning

- “There are a lot of normative and regulation documents which should be considered for screening and scoping processes in advance”.
- “There are difficulties to plan the work scope when changing the regulator’s requirements”.
- “There are difficulties to plan the work scope based on the results of investigation of equipment failures due to lack of prior information and basic knowledge”.
- “There is no process to systematically determine the priority of work execution. At the screening stage, the risk is not fully evaluated”.
- “It is difficult to predict the required work time, so it is difficult to supply and demand manpower”.
- “When equipment is damaged, it is difficult to select a replacement range for parts and impact of degradation on other associated equipment”.

I.2.1.3. Excessive administrative works

- “There are too many administrative work items for classified as general inspection”.
- “There are too many papers works due to sharing unnecessary experiences including less important in-house experiences”.
- “If an unexpected new work item occurs during work, all technical administration work needs to be renewed even though a lot of time and resources are spent on site review”.

I.2.2. Scoping Process

I.2.2.1. Lack of resources

- “The lack of confidence in keeping the delivery time of services and maintenance resources”.
- “Difficulty in securing materials due to external obstacles such as customs clearance”.
- “Not enough qualified resources to execute all of the work orders that we would scope if resources were not an issue”.
- “Necessary documents and drawings are not available”.
- “Order long lead-time parts”.

I.2.2.2. Ineffectiveness and uncertainty in planning

- “It is often the case that several maintenance items are shared with one job list”.
- “The PM programme is too big to execute the complete programme along with the other work orders (correctives, deficient, other)”.
- “It is difficult to expand the scope of work due to the limitation of manpower in the planned process”.
- “The process was redesigned due to the occurrence of an unexpected event during maintenance”.
- “It is necessary to review whether the inspection period and activity classification for general inspection and disassemble inspection are effectively described”.

- “The regulatory requirements and operator requirements for the duration of current outage as well as future outages influence the determination of current work scope”.
- “There are many items from manufacturer that cannot be maintained, especially including equipment manufactured from overseas”.
- “There are many unnecessary overhauls because all facilities are maintained in proportion to the planned PM period, not in proportion to conditions such as the number of starts and operation time”.
- “Analysis and countermeasures for expected problems in dismantling disassembling equipment”.
- “Lack of engineering engagement”.

I.2.2.3. Excessive administrative works

- “The scope of work between departments is ambiguous. It is necessary to comply with the work responsibilities according to the division of roles at NPPs”.
- “When maintenance of instrument and control (I&C) is required during mechanical maintenance, a dispute arises over who is responsible for the maintenance activity”.
- “PM data input items (isolation conditions, inspection contents) are insufficient or not entered”.
- “It is hard to provide services such as maintenance and installation under the contract with foreign companies”.
- “The scope of work is determined according to the periodic and planned PM contract with the resident partner”.
- “There are difficulties in selecting the scope of emergency and preemptive measures in the field”.
- “The delays of approving design changes by the regulator for executing refurbishment works”.
- “It takes too long leading time of spare parts due to the order lead time and vendor lead time. Thus, schedules were changed many times”.
- “Procurement process is based on the expenses. However, the components that are not in pre-maintenance list still difficulties in purchasing the spare parts in due time”.

I.2.3. Planning Process

I.2.3.1. Lack of resource

- “Motor operated valve (MOV), air operated valve (AOV), solenoid valves also require communication with other discipline (instrument and control (I&C), electrical engineering). However, each discipline requires its own work planning, not integrated. Hence, the resource and time are very limited to communication all at once”.
- “Resources have reduced, and the site hasn't prioritized planning weeks vs. specific shop tasks”.
- “In case of emergency and unplanned abnormalities, there is not enough time to secure manpower. In some cases, sufficient professional personnel in the relevant work were not secured due to selfishness of the department. It is an atmosphere that tries to avoid the overload of inter-departmental work”.

I.2.3.2. Ineffectiveness and uncertainty in planning

- "When selecting work items for planned (PM), there are large differences in the number of works, scope, and analysis".
- "It is difficult to secure the sufficient time and manpower to figure out relevant works and procedures in case of emergency".
- "In order to consider the contents of maintenance work due to a sudden failure in a timely manner, it is necessary to explain to the relevant departments the importance and priority of how much time and resources should be spent on each maintenance work".
- "Supply chain and procurement engineering should be reviewed prior to the scope commitment phase with considering vendor lead times. The spare part delivering time isn't well considered when scoping a work order".

I.2.3.3. Excessive administrative works

- "There is no group specializing in work management operation, and the maintenance department is also in charge, so resources are insufficient".

I.2.4. Scheduling Process

I.2.4.1. Lack of resources

- "It is difficult to obtain spare parts for the items that are not classified as pre-maintenance item".
- "Just in time supply chain is not always working properly".
- "It is a case in which the contract process is delayed after a purchase request from the maintenance department. It is necessary to focus on securing materials rather than reducing inventory"
- "Material purchases should be made according to the specific demand control and work requirements of the maintenance department, but we have more inventory than necessary".
- "There is a shortage of materials available. In the case of foreign materials, there are many cases where materials are not purchased even after requesting them long time before. Even in the case of domestic products, there may be no materials available sometimes, so materials are secured often through on-site purchase depending on the situation".
- "Due to the burden of material inventory cost, the head office is very restricting the purchase of materials, which is becoming a critical issue in plant maintenance".

I.2.4.2. Ineffectiveness and uncertainty in planning

- "The delays of equipment delivery for refurbishment and extending NPP operation life".
- "Ordering parts too late, obsolete parts, lead times too far out".

I.2.4.3. Excessive administrative works

- "The actual documentation is absent. The manufactures disagree to procure the necessary documentation".

- “There are too many approval steps in the pre-purchase process to secure materials”.
- “In the case of quality grade materials, it takes time to review and confirm the documents, such as checking the authenticity of the documents”.
- “The roles of staff for procurement are excessive at each stage of the material purchasing process. For example, each step including material registration, selection of required number of materials, budget calculation, and technical review requires involvement of the staff requested”.
- “Lack of a good and maintained bill of material (BOM)”.

I.2.5. Execution Process

I.2.5.1. Lack of resources

- “Low quality of worker executing”.
- “Resources are less than our PM requirements”.
- “The problems with the contractors’ qualification and responsibility”.
- “The spare parts do not match physical size or the quality with document”
- “After the maintenance work has taken place, keeping condition of the spare parts can be left in adverse condition for further maintenance”.
- “Effective management is difficult as one supervisor needs to handle multiple work orders within the outage period”.
- “When unexpected equipment defects occur, there is not enough time to respond”.
- “There are some work orders that don’t complete as scheduled due to equipment defects found during maintenance”

I.2.5.2. Ineffectiveness and uncertainty in planning

- “The contractors don’t meet deadlines of the developing documentation and final report”.
- “The need to execute a large scope of additional works”.
- “It is insufficient to reflect the previous history of (PM) plans and maintenance intervals”.
- “The start of the work is delayed because NPP line-up is not ready”.
- “In the fields of mechanical, electrical, and instrument and control (I&C), work was delayed due to work interference, and disputes over liability occurred”
- “Due to unforeseen circumstances (equipment could not be restored, workers did not gather due to corona virus), it was necessary to urgently adjust changes in related departments and work processes”.RP protection issues of the parts and components”.
- “Multi-discipline work has not been well reviewed for local operators to form a proper line-up”.
- “The work line-up is delayed due to the passive response of the shift operating section”.
- “The work schedule was delayed because the manager listened only to the worker's verbal report and did not check the on-site maintenance status directly”.
- “The scenarios of prevention and emergency measures in case of industrial safety accidents are insufficient”.
- “If the previous process is delayed and the later process needs to be changed, the process may be adjusted or changed without sharing sufficient information”.

I.2.5.3. Excessive administrative works

- “Efforts should be made to comply with the maintenance procedures”.
- “Excessive technical administration document work that is biased towards the supervisory section”.
- “Information may not be obtained from management even if maintenance work does not proceed as planned”.
- “There are too many safety related documents such as fire protection, radiation safety, management of heavy loads, and control of import and export”.

APPENDIX II. WORK PRIORITIZATION PROCESS AND EXAMPLES

The essence of the first guiding principle is doing the right work at the right time. This is best managed by effective prioritization processes and active participation by the appropriate representatives at the new work-screening meeting. Active participation is essential to fully understand the urgency of returning that particular piece of equipment to service. The prioritization scheme shown below will not cover every conceived scenario. Only strong involvement by representatives at the screening committee and communication of the nature of the deficiency, the effects to the power plant, and the recommended priority or urgency to return the piece of equipment to service make for a strong effective prioritization system.

In the simplest sense, a prioritization system is a process or method of determining the urgency of returning a particular piece of equipment or component to service as related to the other deficiencies. Many stations have effective processes that work and that provide reasonable and consistent work prioritization. The key to such processes is that prioritization schemes are dominated by the station operational focus based on significance.

A prioritization scheme needs to meet the needs of the station. This is particularly important as more and more items such as chemistry equipment, RP equipment, security equipment, emergency preparedness and response equipment, and fire protection equipment all compete for the same resources.

Prioritization and execution are different. If work is incorrectly prioritized, or the urgency of returning a particular piece of equipment to service does not have the correct return date, the station needs to evaluate its prioritization scheme. However, if work is prioritized correctly, but the station is unable to execute the return date, execution is the problem — not prioritization. For example, the inability to complete the scheduled date of a priority job could be attributed to FIN teams' inability to manage high priority work or to obtain parts or the inability for the engineering organization to complete a design change. If the station is not meeting its goal for the average age of priority work, an understanding of the cause needs to be evaluated and understood and corrected.

Tables 1 and 2 are the simplified samples of prioritization scheme.

This guidance is general and necessitates some judgment and flexibility in application. For example, a priority 2 or 3 work activity could be required to be worked more aggressively or expeditiously than the target window based on system or station needs and other considerations. In this case, the priority of the work does not change — only the scheduling guidance relative to that specific case.

The new work screening committee needs to determine the priority based on the urgency of returning that particular piece of equipment to service — not based on the cycle plan or upcoming work schedule. The work management organization will determine the scheduled date based on the priority and available window.

TABLE 1. PRIORITIZATION SCHEME

Not Functional	Not Functional	Not Functional or Functional	Functional	Functional	Functional
(Corrective)	(Corrective)	(Corrective or Deficient)	(Deficient)	(Deficient)	(Deficient) or OM
Technical specification (TS) Inoperable	TS Inoperable	TS Operable/ Non TS	Non TS	or OM	
Shut down actions governed by technical specifications	Comp actions required to maintain technical specifications or MR available	Comp actions required to maintain MR available	Monitoring or comp actions required to maintain MR available	MR applicable No actions required to maintain MR Available	MR Availability not applicable

TABLE 2. PRIORITIZATION SCHEME

	Priority					
Immediate Threat to Public Health and Safety • Nuclear, Radiological, Industrial or Security	1	2	3	4	5	5
TS System/Component • Shutdown Actions ≤72 hours	1	2	3	4	4	5
Risk Significant • CDF, LERF, Trip Risk, >2% Curtailment/Ramp, AP-913 critical and MR risk significant	2	2	3	3	4	5
A Workaround • Affects Plant Ops, Chemistry Controls, Security, Appendix R Lights, B5b, EP Equipment, Fire Protection, time critical operator action	2	3	4	4	5	5
Accelerated Degradation • Active boric acid leaks • Chemistry action levels 1 and 2, Steam Cutting, Vibration	2	3	4	4	5	5
TS/ORM/ODCM >14 day • Met Towers, Fire Computer, NPDES, Emergency Lights • Fire Protection	3	3	4	4	5	5
Significant Economic Risk • Curtailment, Outage, balance of plant (BOP) Equipment, Critical Spares	3	4	4	4	5	5

TABLE 2. PRIORITIZATION SCHEME

	Priority					
Quality-Related • Q or Graded Q, Regulatory • Commitments, Programmes, CAP	4	4	4	4	5	5
Burden to an organization (Operations, Chemistry, RP, EP, FP, Security) • No Impact on EOPs, AOPs or Transient Control	4	4	4	5	5	5
Balance of plant (BOP) Reliability/Nonregulatory Programmes/Non-plant SSCs • Other MODs, RPEs, Human Performance, Institute for Nuclear Power Operations (INPO), Shop Equipment, Ancillary Structures, Tools, Run-to-Maintenance	5	5	5	5	5	5

Note: (1) Begin immediately and work around the clock. (Emergency Work); (2) Schedule within the frozen schedule window at its earliest opportunity (3 weeks per the model); (3) Schedule within the frozen scope window at the optimal opportunity (9 weeks per the model); (4) Schedule within the next appropriate work window (Typically, outside scope freeze up to T-36 or T-39); (5) Work only when time allows (fill-in activity).

II.1. WORK PRIORITIZATION

Next chapters list some practical examples of issues which might cause changes in work prioritization during the WMP.

II.1.1. Immediate threat to public health and safety

- Problems presenting an immediate and significant industrial, nuclear, radiological or security safety concern—This category applies to plant and non-plant concerns;
- Following temporary resolution of an industrial safety hazard, the issue may be downgraded to a priority 4 or 5 to track permanent repairs or modifications;
- Examples are as follows:

- Engineering inspection and evaluation identifies that erosion in a feedwater piping elbow has reduced the wall thickness to below the minimum required for structural integrity;
- A 10CFR Part 21 notice identifies that the relays installed in both trains of Safety Injection actuation logic will fail to function in postulated accident conditions due to age;
- A water leak in a storage building is soaking electrical circuits;
- Chemicals or high-energy fluids are leaking in normally accessible areas;
- A risk significant planning standard within the EP (classifications, notifications, dose assessment or protective action recommendations) is unable to be implemented;
- Equipment used in handling irradiated fuel or components (reactor head and internals) such that the problem has a high potential to result in a fuel assembly or

irradiated component suspended from a crane and unable to place the component is a safe location, or damage to a fuel assembly or irradiated component.

II.1.2. TS system or component

- Problems or other issues affecting SSCs required by TS whose failure to meet the LCO requires reducing reactor power level or mode;
- Examples are as follows:

  - A D/G is tested per STP, and it fails to achieve rated voltage within the time allowed by the Surveillance Test Procedure acceptance criteria;
  - Containment sump debris concerns;
  - Pressurizer heater cable inspection reveals unexpected corrosion on the shutdown unit, bringing the operating unit's operability into question;
  - Primary chemistry parameters enter action level 1.

II.1.3. Risk significant

- Problems affecting SSCs classified as risk significant by 10 CFR 50.65, the MR;
- The magnitude of the effect on core damage or on large early release frequency and trip risk should be considered for inclusion in this category;
- Examples are as follows:

  - Maintenance Rule (MR) (a)(1) actions (goal setting) for risk-significant SSCs;
  - Balance of plant (BOP), risk significant, high critical components (See AP-913 [20]);
  - LOCA analysis;
  - PRA shutdown model;
  - Component failure or degradation in which an additional failure would cause >2% unit curtailment or shutdown.

II.1.4. Workaround

- Problems significantly affecting the ability of operators, technicians, or security to accomplish the following:

  - Control reactivity;
  - Respond to transient conditions;
  - Satisfy tech specs on safety-related SSCs;
  - Respond to a plant security threat;
  - Perform actions required by emergency operating procedures (EOPs) or abnormal operating procedures (AOPs);
  - Control critical primary and secondary chemistry;
  - Control radiation exposure ALARA, or process radwaste;
  - Implement the B5b plan;
  - Maintain the operability of the fire programme;
  - Implement the EP;
  - Complete refuelling and forced-outage work required for mode change before start-up;

- Safely move or handle irradiated fuel or components;

— Examples are as follows:

- Chemistry parameters with no action level 2 or 3 limits;
- Boration or dilution valves not stopping flow at the desired or set value;
- Failure of one control rod group position step counter (of two);
- Main annunciator or plant process computer problems;
- Condensate polisher regeneration or radwaste processing systems;
- Troubleshooting efforts to determine appropriate corrective actions for unwarranted rod motion;
- Control board condition reports;
- Security system degradation affecting performance indicators;
- EP equipment out of service;
- B5b equipment;
- Maintenance of functionality of a fire door.

II.1.5. Accelerated degradation

— Problems that can significantly accelerate SSCs degradation;
— Examples are as follows:

- Wet boric acid induced corrosion, steam cutting and saltwater galvanic corrosion;
- Conditions detected by preventative maintenance, rounds, inspection, vibration analysis or thermography (low oil levels, slapping fan belts, plugging filters);
- A review of actual ambient conditions determines the electrical relay life expectancy is or will be exceeded in the current operating cycle;
- An instrument cooling fan fails, causing higher temperatures and increased failures;
- Liquid leak with an unidentified source.

II.1.6. TS/ORM/ODCM >14-day shutdown AOT

— Problems or other issues affecting SSCs required by TS/ORM/ODCM whose failure to meet the LCO may or may not require reducing reactor power level or mode—That is if the action is greater than 14 days or no shutdown action is required;
— Examples are as follows:

- Fire alarm computer;
- Radiation effluent monitor maintenance;
- Meteorological equipment maintenance;
- National Pollutant Discharge Elimination System (NPDES) effluents regulations.

II.1.7. Significant economic risk

— Problems affecting plant and non-plant SSCs can result in significant economic impact;
— Examples are as follows:

- Projects to eliminate high, near-term risk to generation or to restore equipment previously causing lost generation;
- Condenser expansion joints;
- Refuelling or forced-outage work that needs to be completed before plant start-up;
- Simulator;
- Balance of plant (BOP) noncritical equipment;
- Equipment required for seasonal readiness.

II.1.8. Quality related

— Problems affecting SSCs classified as quality or graded quality, or SSCs that are required by regulatory commitments;
— Examples are as follows:

- Corrective action programme;
- Supplemental seismic monitoring system;
- Evaluation of diesel generator emissions for new standards;
- Long-term corrective action (LTCA) personnel safety issues.

II.1.9. Burdens to an organization

— Problems affecting SSCs not included in the Operational Workaround section above but requiring compensatory measures by operations or other department personnel for continued operation;
— Examples:

- Increased operator monitoring or log taking;
- Non-functional automatic features of the radwaste valve control system;
- Lifting of the condensate polisher relief valves;
- Additional fire watches;
- Increased security patrols;
- Grab samples versus inline or automatic monitoring;
- Installation and removal of temporary shielding.

II.1.10. BOP reliability, nonregulatory programmes and non-plant SSCs

— Problems affecting balance-of-plant SSCs that reduce plant reliability;
— Problems affecting SSCs controlled by programmes not required by regulations;
— Problems affecting SSCs not related to, or directly influencing, electrical generation;
— Examples:

- Equipment reliability programmes (noncritical);
- Equipment failure or degradation in which a reliable redundant component is available (for example, turbine sump pumps);
- Projects to eliminate medium risk to generation in the next cycle;
- Projects to save 24 to 48 hours of critical path outage duration;
- Human performance;
- Response to World Association of Nuclear Operators (WANO) or Institute for Nuclear Power Operations (INPO) plant evaluation areas for improvement (AFIs);

- Operating experience assessment;
- Shop equipment;
- Ancillary structures;
- Tools.

APPENDIX III. BACKLOG REVIEW/MANAGEMENT

III.1. DISCUSSION

Backlog management requires periodic reviews of backlogs to validate the accuracy of documented deficiencies and to ensure that the correct classifications are assigned. In some instances, documented deficiencies need to be voided or deleted. This appendix will provide guidance for the periodic review of the backlog and a systematic method to remove a deficiency from it. Additionally, this appendix will provide methods that can be used to reduce backlogs. This approach can also be used for outage backlog reviews; however, the review would most likely be performed by the outage management review team instead of the on-line team.

III.2. PURPOSE

Work order backlogs are reviewed on a predetermined basis to ensure the work has been classified correctly and to identify aggregate issues or trends on systems and components. This review is frequent enough to prevent unwarranted issues from developing but not so often as to burden the station resources conducting the review. The validation review includes, as a minimum, operations, engineering, maintenance, and work management personnel. As a good practice, the review includes personnel from stations within the fleet or from other stations, to help maintain the integrity of the classifications and to provide the benefit of an independent review.

III.3. PROCESS

The on-line work management manager establishes the validation review frequency. The validation review is performed for the corrective, deficient, and other backlogs. Members of the composite review team (similar to the New Work Screening Committee) receive the backlog printout prior to the review meeting, along with the definitions of classification of work. The review meeting consists of a full review of the backlogs. Team members are expected to provide input as to the validity of the current classification. The validation should consider any new information regarding changes to the existing documented deficiency. For example, if the documented deficiency has deteriorated from *deficient*, then the new classification should be *corrective*. The review should also consider the aggregate impact of the documented deficiencies at both the component and system levels.

During the review process, the team may consider reviewing the oldest deficiency tags and work orders to ensure they are still applicable and to identify any deficiency tags or work orders that are potential candidates for cancellation. If this type of additional review is implemented, a systematic approach needs to be used to ensure all aspects of nuclear safety, regulatory impact, equipment reliability, and operational risk have been evaluated before cancellation is recommended. Once cancellation approval is obtained using station processes, a method needs to be available to identify this component and the actions taken to ensure identical deficiency tags are not written subsequently.

When considering any backlog reduction initiative, it is important to maintain the integrity of the WMP. In the past, the process stations used to reduce backlogs bypassed many of the established controls built into the WMP, thereby reinforcing undesirable work management behaviours. Many of those processes bypassed performance indicators; and as a result, the impact to the organization was not measured and skewed the norms for industry-reported data.

Backlog reduction initiatives need to be factored into the station WMP. In many cases, the best way to implement a backlog reduction initiative is to treat it as a project that is integrated into the WMP. If the backlog initiative is treated as an emergent initiative and is interjected into the process, many performance indicators and metrics will be affected, primarily scope stability and schedule adherence. In addition, many milestones may be missed, potentially impacting other planned work, and resulting in an inefficient method of reducing the backlog.

Various methods of backlog reduction have been used successfully in the industry. Below is a brief discussion of some of these methods:

— Increase the FIN team size and qualifications and the assigned scope of work:

- Increasing the FIN team's ability to perform work has been successful at many stations, with minimal impact to the on-line WMP;

— Increase the size of the shops with supplemental personnel:

- Using supplemental personnel to increase the size of the shops has minimal impact on the WMP, provided the additional resources are factored into the early phases of the process so that additional work can be selected. This method also maintains discipline in the process, and success and impact can be measured by normal work management performance indicators;

— Use dedicated supplemental resources:

- This allows supplemental personnel to work on a selected scope of work, similar to an outage. This practice also maintains discipline in the process, and success can be measured by normal work management performance indicators, provided the resources and work are accounted for in the WMP. One consideration when using this practice is the level of detail in work packages for supplemental personnel. Identifying the need for additional detail in work packages early in the process, prior to the planning process, will increase the effectiveness of this effort. Through the integration of additional work into the normal WMP, station milestones can be followed, and performance can be measured by the standard work management performance indicators;

— Use the thirteenth week of the 13-week schedule as a backlog reduction week:

- This approach, frequently used in the industry, may be one of the leading factors for stations transitioning from the traditional 12-week schedule to a 13-week schedule. Through this backlog reduction technique, the normal WMP is followed, targeted work is selected early in the process, milestones are followed, and performance can be measured by the standard work management performance indicators.

III.4. PERIODIC BACKLOG REVIEW

— Review *corrective*, *deficient*, and *other* classifications on a periodic basis;

- The review team includes operations, maintenance, engineering, and work control personnel;
- The review will validate the classification;
- The review will look for aggregate issues;
- The review will validate that the work is in the correct subclassification (critical, noncritical, or low consequence);
- The review looks for duplicate or similar work orders that address the same issue;
- The review will validate that oldest work orders are still applicable;
- Ensure all work orders are coded as critical components per the AP-913 definitions;
- Ensure all work orders are not coded as critical components per the AP-913 definitions;
- Review all work orders that are coded as run-to-maintenance/run-to-maintenance components as defined in AP-913 or that are components of very low consequence. Ensure all deficient condition work orders that are not facilities-related do not reside in any other maintenance subclassifications.

III.5. WORK REQUEST AND WORK ORDER BACKLOG VALIDATION PROCESS (EXAMPLE)

- Does the work affect nuclear safety?
- Is the work required for continued operation of a production risk system or component?
- If the work is not performed, could other critical components fail?
- If the work is not performed, could personnel radiation exposure increase?
- Is the work required to address plant health or system health that is in a red or yellow condition?
- If the work is not performed, will there be any industrial safety concerns? Ensure that any potential safety issues are routed through the Station Safety Committee.
- Will there be any regulatory consequences if the work is not performed?
- Does the work belong in the PM Programme?
- Does the request belong in condition-based monitoring?
- Is it cost effective to perform the work?
- Is the work still required? Has other work or plant conditions caused the work to be unnecessary?

If the answer to any of these questions is *yes*, maintain the work in the backlog. If all questions were answered *no*, recommend cancellation of the work order to the Plant Health Committee and initiate actions to flag this in the equipment database for future reference.

APPENDIX IV. DEMAND/SUPPLY MAINTENANCE RESOURCE MODEL

IV.1. FOREWORD

Some of Work Control's more critical functions are optimizing schedules to maintain the lowest practical backlogs, performing PM and ST on due dates, and maximizing the Equipment Reliability Index (ERI). Several industry techniques are used to accomplish these objectives, including accelerated FIN teams and the development of FEGs. One infrequently used technique, which is the focus of this Appendix, is to maximize maintenance resources allocated to field work, balanced with the cyclic demand of resources required.

IV.2. INTRODUCTION

Guidelines such as those described in this Appendix provide criteria for developing, implementing, and maintaining an effective WMP. The limiting factor in meeting goals and objectives is often the field resources available to accomplish the work. In some cases, participation in other initiatives challenges the maintenance staff to maintain the operating units, conduct efficient outages, and focus on core business.

IV.3. BACKGROUND

The predominant industry resource model currently used is for Maintenance to provide Work Control with the number of available resources for each discipline for specific workweeks. This is usually calculated by reducing discipline/crew sizes for vacations, absenteeism, training, supervision, and special assignments. The remainder is allocated for scheduled work. In some cases, resources provided to Work Management by Maintenance do not support the completion of required baseload work.

Another view of the current approach is to assume that the match between resources and required work is essentially at a state of equilibrium or has reached a balance between available resources and workload. Based on this assumption, the next phase is to evaluate challenges that threaten this equilibrium; for example, a preventive maintenance optimization (PMO) programme, resource reductions, maintenance work scope expansion, or other strategic initiatives that required additional resources. This approach may help organizations better understand the need for a supply-and-demand model.

IV.4. VISION

This Appendix discusses supply, demand, and supply validation models that, when used in tandem, provide a tool to maximize Maintenance available field resources without negatively impacting PM and surveillance testing (ST) programmes, backlog goals, and plant material condition. This programme still allows Maintenance to manage remaining resources to support non-field work programmes such as training, planning, procedures, and supervision.

IV.5. DEMAND MODEL

The demand model is a long-term assessment/plan (minimum one fuel cycle) to identify the required Maintenance resources to meet on-line programme requirements. For multi-unit sites, outage requirements can be added to the model as they occur.

The demand model includes the following:

- PM and ST loading;
- Corrective maintenance (CM), deficient maintenance (DM), or other maintenances (OM) scheduled load (excluding FIN);
- Noncyclic project initiatives as identified in the cycle plan.

Assumptions made on the demand model include the following:

- No PM deferrals are as a result of manpower shortfalls;
- Work durations are accurate (including total durations, not just wrench time);
- Efficiency factors are used for bundling work in FEGs;
- The FIN team protects the schedule with emergent priority work completion;
- The model is built using a full operating cycle, with allowance for pre-outage, outage, and post-outage labour demands (two months);
- The current backlog levels are maintained (steady state).

Cyclic demand hour calculations by discipline/crew include the following:

- Mandatory Demand:

• Cyclic on-line PM hours;
• Cyclic on-line surveillance hours;

- Margin Demand:

• Cyclic CM/DM/OM demand hours for a steady state;

- Noncyclic Project Initiative Examples:

• Backlog reductions (if required);
• Special nonrecurring projects (modifications);
• Equipment reliability initiatives over steady state.

Demand model finalization includes the following:

- An efficiency factor, agreed to between Work Control and Maintenance, accounts for bundling efficiencies (usually in the range of 5-15%). Stand-alone PM/ST planned hours do not include gains for bundling work;
- Cycle hours per discipline/crew are divided by 2 months less than the cycle for outage preparation and execution impact (an 18-month cycle equals 16 months of on-line execution; a 24–month cycle equals 22 months of on-line execution);
- The cycle planner adjusts the weekly discipline/crew demand for seasonal considerations (high vacation/holiday periods) such that the total hours equal the cycle requirements;

— The demand and supply models are reviewed with Work Control, Maintenance, and senior leadership, and adjustments/commitments are made to staff or augment to the demand;
— This demand model review and consensus needs to be done four to six months prior to the next cycle plan start. Additional resource demands for issues outside the demand model need to be adjusted for business planning purposes. The demand model is expected to be used for all business planning.

IV.6. SUPPLY MODEL

The supply model is a computer programme that has the following attributes:

— Cycle demand by discipline/crew per week is identified by the proposed demand model;
— Hours available for each discipline/crew are from the time reporting/staffing database. Adjustments are made for the following:

- Approved vacations;
- Training;
- Supervision (nonworkers);
- Sickness;
- Holidays;
- FIN team assignment;
- New employee – First two years count as only one-half full time equivalent (FTE);
- Approved step-ups to supervision;
- Approved special assignments;
- Walkdowns if not scheduled.

The supply model is used to understand resource allocations within Maintenance that may challenge meeting the demand model requirements for field work. It is used with the demand model to negotiate finalized demand commitments used in the supply validation model. When the supply model cannot meet the demand model through consensus between Maintenance and Work Control, leadership team involvement is required. Expected resolutions involve strategies to increase supply, such as reassigning existing resources, increasing overtime budgets, and obtaining additional resources – or, when no alternative exists, reducing company goals (backlog reduction, ERI goals, PM in grace, and so forth) – until a balance between demand and supply is achieved. Once this balance is attained, Maintenance and Work Control are fully accountable to realize company goals and visions moving forward.

IV.7. SUPPLY VALIDATION MODEL

Once the organization commits to the demand and supply models for a cycle, the supply validation model monitors weekly resource allocation of field work to ensure cycle commitments are satisfied. The supply validation model will use a standard work process of 28 weeks, with scoping completed the week of T-16 and schedule freeze meeting T-8 for illustrative purposes.

Maintenance coordinators make manual adjustments for the following:

- Current staffing not accounted for – for example, there are extra resources on the discipline/crew coming out of or going into an outage. Numbers will be different four weeks after the outage, so current numbers are overstated for the period reviewed (four months out). The coordinator will adjust numbers downward based on the steady-state staffing post-outage;
- Potential vacations not yet approved or submitted;
- Potential step-up or special assignments not approved yet;
- Seasonal considerations not yet identified.

The discipline/crew hours, after automatic and manual adjustments, are the supply hours. Any deviations below demand hours are identified and resolved between Maintenance and Work Control. If hours cannot meet demand, then resolution is negotiated. For example, hours may be adjusted upward in another week to account for lower hours in the problem week. Maintenance may determine that overtime or discipline/crew adjustments will accommodate the mismatch for the week. When no satisfactory result can be realized, the leadership team participates in the decision process. Any known shortfalls are documented in the corrective action programme and are trended throughout the cycle to understand the magnitude of supply-and-demand model mismatches, and an evaluation will determine whether the deficiency affects goals. Lessons learned for the next cycle are incorporated in the process for continual improvement.

Any additional maintenance resource requirements identified for non-field work or special assignments or not originally identified would have to come from the margin (non-field staff) and not the production allocation unless supply is greater than demand.

IV.8. CONCLUSION

This process alters existing paradigms from Maintenance providing resources and Work Control determining what work can get accomplished with those resources, to Work Control identifying the demands of the WMP and Maintenance committing to supply the resources necessary to complete the required work. Maintenance manages its remaining resources to ensure sufficient personnel are available for training, procedure writing, planning, and other critical maintenance functions. The final decision on staffing or meeting demand profiles resides with the leadership team, and the result is a shared accountability model, owned by Maintenance and Work Control, that meets company goals and visions moving forward.

APPENDIX V. PERFORMANCE INDICATORS

V.1. GENERAL DISCUSSION

Performance indicators help the station and industry understand the relative health of station equipment and the maturity of the WMP. Also, such indicators provide diagnostics to help identify and address specific detailed performance issues.

The performance indicators in this document are divided into two sections. The first section contains indicators that are available for the industry in the Plant Information Center (PIC). The second section contains indicators that may be used at the station's discretion.

Consider including the following attributes in performance indicators to improve their value as process monitors and diagnostic tools:

- The definition of the indicator clearly identifies the quantity being measured and the source of the data.
- The goal or target is defined and included in the indicator.
- Rolling averages may be used to correct aberrations in data caused by uneven schedule loading or brief periods of high emergent work.
- Trends rather than absolute numbers may, at times, provide the best indicator of performance.
- The indicator includes an analysis explaining deviations, including the reason for the movement or trend.
- Based on analysis, actions to correct unacceptable deviations from performance will be addressed in the corrective action process.
- Station level indicators are calculated in aggregate for multi-unit stations. The same value is entered in Industry Reporting and Information Sharing (IRIS) application for each unit.
- Unit level indicators are calculated independently for each unit in a multi-unit station.

V.2. CRITICAL SCOPE SURVIVAL

This indicator will measure the percentage of critical work orders identified for inclusion in the workweek at scope freeze and completed by end of execution week. Critical work orders include all surveillance, preventative maintenance, equipment qualification (EQ), and maintenance work (CM/DM) orders performed on a critical component.

Calculation:

[SC/SF] x 100

Where:

SF = total number of critical work orders at scope freeze

SC = number of completed critical work orders that were in scope at scope freeze

This is used as a unit level of KPI.

Example:

Original 100 critical work orders at scope freeze minus 5 that did not complete in the schedule. Results will be expressed as a percentage. ((100 – 5)/100) x 100 = 95% scope survival.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Critical work orders at scope freeze;
- Critical work orders survived T-0;

— Applicable work orders may be excluded from reporting if the following exceptions apply:

- Natural disaster or declared state of emergency;
- Threat to generation or grid stability based on load dispatcher (ISO) restriction;
- Station procedures restrict work due to severe weather;
- Restriction due to regulatory commitment (i.e., Tech Specs, Environmental Permit, local governmental limitations);
- Equipment failure that results in a single point vulnerability/redundant train, and original planned scope is on the remaining single point/redundant train;
- Equipment failure, where coincident execution of planned scope would result in unplanned PRA Risk colour of Orange or Red.

V.3. ONLINE CRITICAL PM OPEN IN SECOND HALF OF GRACE

This indicator measures Online Critical PM orders that are in the second half of grace. Excludes PMs performed monthly or more often.

Note: Common Critical PMs should be divided by the number of operating units and added to each unit's number.

Calculation:

Number of Online Critical PMs in Second Half of Grace = Unit's PMs in second half of grace + common share of PMs in second half of grace

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- On-line critical;
- PMs in 2nd Half of Grace.

V.4. ONLINE DEFERRED CRITICAL PM WORK ORDERS

This indicator measures the sum of Online Critical PM orders that have been deferred to exceed their late dates with an approved engineering evaluation. This metric does not include late PM. This indicator excludes PMs performed monthly or more often. Each additional deferral counts as a new deferral.

Note: Common PM should be divided by the number of operating units and added to each unit's number. Deferrals are counted when the engineering evaluation is approved.

Calculation:

Number of Online Critical PMs deferred = Unit's PMs deferred + common share of deferred PMs

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- On-line Critical;
- PM Deferred.

V.5. ONLINE DEFICIENT CRITICAL BACKLOG

The Online deficient critical (DC) maintenance backlog will provide a partial measure of overall equipment reliability and a portion of the station material condition assessment.

Note: All DCs are counted, including minor maintenance, work requests and fix-it-now work.

The common backlog is divided by the number of operating units and added to each unit's backlog. The sum of each unit's backlog needs to be equal the total backlog for the station.

A work order is considered part of the backlog until the field work and testing are complete.

Calculation:

DC: total number of open DCs by unit + (station common value /unit)

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Deficient critical maintenance backlog.

V.6. ONLINE LATE PM WORK ORDERS

This indicator measures the total number of PM that exceed their late date during the period. Includes only Critical and Noncritical PM.

Note: Common PMs should be divided by the number of operating units and added to each unit's number. Does not include PM on equipment that is out of service.

Calculation:

Number of late PMs = Unit's late PMs + common share of late PMs

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Online total PMs that are late.

V.7. ONLINE NON-CRITICAL PM OPEN IN SECOND HALF OF GRACE

This indicator measures Online Non-Critical PM orders that are in the second half of grace. Excludes PM performed monthly or more often.

Note: Common PMs should be divided by the number of operating units and added to each unit's number.

Calculation:

Number of Online Non-Critical PMs in the second half of grace = Unit's Non-Critical PMs in the second half of grace + common share of Non-Critical PMs in the second half of grace

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- On-line Non-Critical;
- PM in 2nd Half of Grace.

V.8. ONLINE CORRECTIVE CRITICAL BACKLOG

The corrective critical (CC) maintenance backlog will provide a partial measure of overall equipment reliability and a portion of the station material condition assessment.

Note: All CCs are counted, including minor maintenance, work requests and FIN work.

The common backlog is divided by the number of operating units and added to each unit's backlog. The sum of each unit's backlog needs to be equal the total backlog for the station.

A work order is considered part of the backlog until the field work and testing are complete.

Calculation:

CC: Number of open Online CCs by unit + (station common value /unit)

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Corrective critical maintenance backlog.

V.9. ONLINE CORRECTIVE NONCRITICAL BACKLOG

The corrective noncritical (CN) maintenance backlog will provide a partial measure of overall equipment reliability and a portion of the station material condition assessment.

Note: All CNs are counted, including minor maintenance, work requests and FIN work.

The common backlog is divided by the number of operating units and added to each unit's backlog. The sum of each unit's backlog needs to be equal the total backlog for the station.

A work order is considered part of the backlog until the field work and testing are complete.

Calculation:

CN: number of open Online CNs by unit + (station common value /unit)

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Corrective non-critical maintenance backlog.

V.10. ONLINE DEFICIENT NONCRITICAL BACKLOG

The deficient noncritical (DN) maintenance backlog will provide a partial measure of overall equipment reliability and a portion of the station material condition assessment.

Note: All DNs are counted, including minor maintenance, work requests and FIN work.

The common backlog is divided by the number of operating units and added to each unit's backlog. The sum of each unit's backlog needs to be equal the total backlog for the station.

A work order is considered part of the backlog until the field work and testing are complete.

Calculation:

DN: Number of open Online DNs by unit + (station common value /unit)

This is used as a unit level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Deficient noncritical maintenance backlog.

V.11. ONLINE SCHEDULE COMPLETION

This indicator measures the percentage of work completed as scheduled from the beginning of week (T-0) to the end of the week.

V.11.1. Schedule completion during an outage

Online schedule completion would not count for the unit that is in a refuel outage or planned outage. However, it would be in effect for a unit that enters a forced outage (scheduled work for that week was not performed or was not finished). It would not count for subsequent weeks of the forced outage for the affected unit, including the week of breaker closure. Online completion would continue to be in effect for the operating unit in all cases.

Calculation:

Schedule Completion = total scheduled activities completed / total scheduled activities at the start of execution week

Example:

— In this method, if 200 tasks were scheduled at the beginning of the execution week, and 150 of those tasks were completed by the end of the week, the completion rate would be 75%, regardless of when in the week the work was scheduled to be completed.

This is used as a station level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- On-line work at T-0;
- Completed work during T-0.

Applicable work activities may be excluded from reporting if the following exceptions apply:

— Natural disaster or declared state of emergency;
— Threat to generation or grid stability based on load dispatcher (ISO) restriction;
— Station procedures restrict work due to severe weather;
— Restriction due to regulatory commitment (i.e., Tech Specs, Environmental Permit, local governmental limitations);
— Equipment failure that results in a single point vulnerability/redundant train, and original planned scope is on the remaining single point/redundant train;
— Equipment failure, where coincident execution of planned scope would result in unplanned PRA Risk color of Orange or Red.

V.12. LCO EXECUTION

This indicator measures performance of planned LCO safety system outages by comparing scheduled LCO duration versus actual LCO duration. This is intended for tracking major safety system outages. This indicator should measure all LCO windows that were included in the frozen scope and meet the following criteria:

— Scheduled for >12 hours duration, and

- The allowed LCO time is:

  – ≤ 31 days for stations that have implemented Risk Informed Tech Specs; or
  – ≤ 14 days for all other stations.

Calculation:

LCO Execution = LCO deviation (in hours) / Scheduled duration (in hours)

Where:

LCO deviation = Absolute value of the Total LCO Hours Deviation from scheduled duration for all tracked windows during the reporting period.

Scheduled duration = Total LCO Hours Scheduled for all tracked windows during the reporting period.

Example:

Two LCO windows were completed during the month, and both were originally scheduled for 50 hours. The actual duration was 45 hours for window 1, and 52 hours for window 2.

LCO Execution = (5 +2) hours / (50 + 50) hours = 7%

This is used as a station level of KPI.

Reporting:

— Monthly Data/Data Entry/Work Management:

- Total LCO Hours Scheduled for all tracked windows;
- Total LCO Hours Deviation from scheduled duration for all tracked windows.

Exceptions to reporting:

— A component breaks that is unrelated to any work from the original scope, or unrelated to extent of condition of components in the original scope. The new issue not have been previously identified.

V.13. LCO EXECUTION (CONTINUED)

Applications that apply to LCO deviation:

— Contingency Work:

- If a contingency is used, the estimated actual hours that were staged for that contingency are added to the baseline of the schedule. (e.g., A 20 hr. LCO that had a 5-hr. contingency that had to be used would then show a new baseline schedule duration of 25 hrs. for the KPI calculation).
- If the contingency took 10 hrs. but was estimated at 5, the 5 hours would be used in the new baseline and 5 hours would be counted against the execution as an LCO deviation. (LL can be applied to future LCOs when re-establishing the next forecast duration).

— Emergent Unrelated Work:

- If an emergent condition (unrelated to the maintenance performed) arises during the performance of the LCO that causes additional time/scope to be added to the LCO, that impact should be scheduled and an impact to the baseline hours should be determined. That emergent work would not count negatively toward the performance of the LCO.
- The following would not be an exception:
  - The condition was caused by damage or impact to a component that occurred during the LCO window.
  - The condition was identified before the LCO started.

V.14. EMERGENT WORK

Emergent Work is the ratio of emergent work to scheduled work for all work items added to the schedule during execution week. Carryover is not included in emergent work. This indicator reflects the effectiveness of the PM programme, the rigor and effectiveness of the prioritization process, and the effectiveness of the FIN team to protect the schedule.

Note: Work that the FIN team takes is not emergent work.

Calculation:

Emergent Work = [T0] / [ES] x 100

Where:

ES = number of tasks at execution start

T0 = number of tasks added during execution week

Reporting:

— Monthly Data/Data Entry/Work Management:

- Emergent Work Online;
- On-line work at T-0.

V.15. CARRYOVER WORK

Carryover work (CW) is work that was scheduled to finish in the current work week, did not finish, and rolled into the following execution week.

Note: If using a graded approach to scheduling, this only applies to levels A, B and C scheduled activities.

Calculation:

CW = (CA/ES)

Where:

ES = number of tasks at current execution start

CA = number of scheduled tasks not completed in current execution week that rolled into the following execution week

Example:

100 tasks (ES) were scheduled in execution week. 20 tasks were not finished, and five (CA) were allowed to carry over into the following week. CW = 5/100 = 5%

Reporting:

— Percentage of carryover work per station by week.

The following additional performance indicators were selected as being useful for diagnosing WMP problems at individual stations, but they may not be monitored at all stations.

V.16. ONLINE AVERAGE AGE OF BACKLOG (CC, CN, DC AND DN)

The average age (in days) of backlog is measured from when the work order is approved in screening to when the work document is closed out. This includes all online work coded CM (CC and CN) or DM (DC and DN), including open CM and DM minor maintenance, FIN-coded work, and non–unit common work CM and DM. Average age should be calculated and reported on a per-unit basis.

Calculation:

Typical for Corrective and Deficient:

- CC: total cumulative age of all CCs/total number of CCs;
- CN: total cumulative age of all CNs/total number of CNs;
- DC: total cumulative age of all DCs/total number of DCs;
- DN: total cumulative age of all DNs/total number of DNs.

Reporting:

- Corrective critical maintenance backlog (CC) ___days;
- Corrective non-critical maintenance backlog (CN)___days;
- Deficient critical maintenance backlog (DC) ___days;
- Deficient non-criticasl maintenance backlog (DN) ___days.

V.17. SCOPE STABILITY (TASK LEVEL)

This indicator measures additions and deletions from scope freeze until the start of execution week. Workweek scope includes all the scheduled activities in that week. All PM, surveillances, CM, DM, OM and other work activities on the schedule — along with scheduled support activities such as scaffold building, insulation removal and radiological protection support — would be included in scope, regardless of priority. Not included in this calculation is FIN work. All work removed from scope, whether because of completing before the week or cancelling the task, are counted as deletes in the calculation. Online scope stability will be in effect at all times for the online unit at multi-unit stations when the other unit is offline.

Calculation:

(Scope [SF] - (Losses [SF to ES] + Additions [SF to ES]))/Scope [SF]

Where:

SF = number of tasks at scope freeze

ES = number of tasks at execution start

Reporting:

- Scope Stability - % (task level) per station.

V.18. SCHEDULE STABILITY (TASK LEVEL)

Schedule stability is an indication of how static the schedule is after the station has accepted ownership at the schedule freeze meeting. It is a reflection of changing plant conditions and the organization's ability to maintain the committed plan from schedule freeze to execution. This indicator measures schedule changes, not including adds or deletes.

Calculation:

(Tasks [SF] - Date Changes [SF to ES])/Tasks [SF]

Where:

SF = schedule freeze time

ES = execution start

Date Changes = number of tasks with a different day of the week start from SF to T-1

Examples:

(1000 – 24)/1000 = 97.6% schedule stability

Reporting:

- Schedule stability percentage by station at the task level.

V.19. SELECTION STABILITY (WORK ORDER LEVEL)

Selection Stability includes all work orders included in the scope that is provided for planning staff to commence planning of work orders for a given workweek through scope freeze. This metric is to understand how static the scope is through the Planning and Engineering milestones up through Scope Freeze at a work order level. All additions and deletions are part of the calculation.

Calculation:

(Scope [SF] - (Losses [SF to SS] + Additions [SF to SS]))/Scope [SF]

Where:

SF = selection freeze time

SS = the beginning of the week the scope is frozen

Reporting:

- Selection Stability – (work order level) per station.

V.20. SCHEDULE ADHERENCE (GRADED APPROACH) (TASK LEVEL)

Schedule Adherence is reported from the beginning of execution week to the end of the week:

- With the graded approach to scheduling (see Appendix V), schedule adherence is monitored consistent with the expectations for each level. Level A activities are monitored for hourly compliance, Level B for daily or swiftly compliance, and Level C for weekly compliance. The indicator should be a composite percentage of activities completed as expected;
- Note: Measuring only Daily Schedule Adherence is an option in lieu of the graded approach (measuring levels A, B and C).

V.20.1. Schedule adherence during an outage

Online Schedule Adherence would not count for the unit that is in a refuelling outage or planned outage. However, it would be in effect for a unit that enters a forced outage. (Scheduled work for that week was not performed or was not finished.) It would not count for subsequent weeks of the forced outage for the affected unit, including the week of breaker closure. Online adherence would continue to be in effect for the operating unit in all cases.

Calculation:

SA = total number of tasks scheduled by schedule grade / total scheduled activities

- Example (Graded Approach): If you completed 1 of 2 Level A tasks as scheduled (hourly), 39 of 48 Level B tasks as scheduled (daily), and 100 of 150 Level C tasks as scheduled (weekly), your adherence would be (1 + 39 + 100)/ (2 + 48 + 150) = 140 / 200 or 70% adherence, regardless of whether all Level A and Level B tasks were eventually completed within the week.
- Example (Daily Schedule Adherence Approach): If you have 10 Level B activities or tasks scheduled for Monday and completed 8, then your daily adherence for Monday would be 80%. This would be repeated for each day.

Reporting:

Schedule adherence percentage by station at the task level either by day (Daily Schedule Adherence Approach) or weekly (Graded Approach):

- Exceptions to reporting:

• Natural disaster or declared state of emergency;
• Threat to generation or grid stability based on ISO restriction.

V.21. TOTAL SCOPE SURVIVAL (WORK ORDER METRIC)

From scope selection, some work does not survive the process through execution for various reasons. This indicator measures the percentage of work orders identified for inclusion in the workweek at scope selection that are completed in execution week.

Calculation:

[SC/SS] x 100

Where:

SS = number of work orders at scope selection

SC = number of completed work orders that were in scope at scope selection

Example:

Original 100 at scope selection execution minus 5 that did not complete in the schedule results will be expressed as percentage. ((100 – 5)/100) x 100 = 95% scope survival

Reporting:

— Total Scope Survival = percentage by station at the work order level:

- Exceptions to reporting:
  - Natural disaster or declared state of emergency;
  - Threat to generation or grid stability based on ISO restriction.

V.22. OPERATIONS CLEARANCES READY

This is the percentage of Operation's clearances ready to be implemented.

Calculation:

Total clearances ready to be hung/Total clearances required x 100

V.23. PARTS IDENTIFICATION

This is the percentage of parts requested at the planning complete milestone versus the total requested by the start of work (planning effectiveness).

V.24. PARTS AVAILABILITY

This is the percentage of work activities that have all identified parts available and on hand by the pre-stage milestone (material support effectiveness).

V.25. MAINTENANCE WALKDOWNS COMPLETED

This represents the percentage of work packages that require maintenance walkdowns for which the walkdowns are completed and accepted by the appropriate station milestone.

V.26. RESOURCE UTILIZATION

The number of personnel made available in your Scheduling and Resource tool to perform work in the plant divided by the number of personnel in your approved business plan by resource type (maintenance electrician, instrument, and control) (Nonsupervisory personnel).

Calculation:

(Persons available for work) / (Persons in business plan) x 100

V.27. COMMITTED RESOURCE STABILITY

A measure of resource utilization from scope freeze (or earlier if available) to T-0. The actual number of personnel available at the start of execution week compared against the number of personnel made available in your Scheduling and Resource tool to perform work in the plant at scope freeze. Can choose to do so by department or discipline. (Nonsupervisory personnel).

Calculation:

Final Resources per discipline provided at T-0/Committed Resources per discipline made available at Scope Freeze X 100.

APPENDIX VI. TYPICAL WORK MANAGEMENT INTERFACES ROLES AND RESPONSIBILITIES IN THE WORK PROCESS

This appendix introduces typical work management interfaces roles and responsibilities in the work process as an industry reference. It is useful for educating and engaging participants, managers, and others in WMP. It can be used as a starting point for further defining roles and resolving participation shortfalls.

VI.1. SCREENING PROCESS

The screening process is the starting point of remedying a deficient condition in the plant and is a critical part of the WMP. It is the point in the process at which the classification is assigned, and the appropriate priority is determined. The appropriate priority can only be assigned when the screening team is aware of and clearly understands the importance and urgency of returning a particular piece of equipment to service. Because of this critical point of the process, all organizations discussed in this appendix are encouraged to take an active role and to have sufficient representation in the screening process.

VI.2. SITE MANAGEMENT

Benefits to Site Management (see Table 3):

- Safe operation of the plant, minimizing risk to nuclear safety, personal safety, and radiological safety;
- Efficient bundling of work to maximize equipment availability and to maximize efficiency of available resources;
- Reduced Maintenance work backlogs and improved performance indicators.

TABLE 3. SCOPING PROCESS OF SITE MANAGEMENT

Process	Activity	Deliverables
Scoping	• Support staffing and selection of complex work plans and coordinators. • Provide management oversight at T-meetings. • Verify that site and major department meetings or training affecting department resources are identified and included in resource histograms: – All-hands meetings. – Emergency preparedness drills. – Safety meetings. • Provide management oversight at the scope validation meeting. • Commit to scope validation meeting scope.	• Prior to the scoping meeting, provide the work management organization with information for any nonroutine meetings that affect site resources. • Provide the names of individuals selected to support complex work plans. • Approve budget to support scheduled work, including modifications, overtime, and contract resources.
Planning	• Review milestone status, including planning and reviews.	• Hold site accountable to work management milestones.

TABLE 3. SCOPING PROCESS OF SITE MANAGEMENT

Process	Activity	Deliverables
	• Review all work determined to be at risk and assign a management sponsor for all work carried forward.	• Identify management sponsors for all at-risk work.
Scheduling/ Coordination	• Review status of complex work plans and at-risk work by responsible department. • Review aggregate risk assessment. • Verify department resources have met or will meet required work management milestones. • Support rescheduling of work for missed milestones or initiating of recovery plan for those needed to be carried at risk. • Commit to schedule freeze meeting scope or schedule. • Review schedules for LCOs, complex work, mitigating system performance indices and maintenance rule (MR) activities. • Verify the department resources have met or will meet required work management milestones. • Support rescheduling of work for missed milestones or initiating recovery plan for those needed to be carried at risk.	• Hold site accountable to work management milestones. • Provide management oversight for the schedule freeze meeting.
Execution	• Verify department status on actual work performance. • Verify department resources have met or are on track to meet scheduled hourly and daily scheduled work compliance and are on track for work assigned to workweek. • Facilitate accountability and ownership of schedule, and scope implementation as committed to at scope freeze.	• Resolve issues that prevent, or delay scheduled work from starting or being completed as scheduled.
Post Workweek Analysis	• Effectively use information provided by performance indicators through the following: – Ensuring that the indicators are comprehensive by gauging process health as well as overall process effectiveness. – Understanding the aggregate effect of all indicators. – Challenging owners of indicators with declining trends. • Provide management representation or support at work critique meetings, including department managers, the plant manager, and senior leadership. • Verify lessons learned are captured with actions in place to correct going forward. • Provide management expectation feedback to group.	• Ensure each department provides accountable representation at workweek critique meeting.

TABLE 3. SCOPING PROCESS OF SITE MANAGEMENT

Process	Activity	Deliverables
All	• Endorse and provide expectations for process results. • Monitor performance and enforce adherence to the process. • Verify department or group meets work management milestones. • Ensure that work is executed in adherence to established plans, schedules, and procedures in order to maintain clarity of direction, ensure high-quality performance, and establish credibility in meeting the designated schedules. • Ensure the process supports operational safety, defence-in-depth, high standards of materiel condition and equipment performance, and efficient use of resources. • Ensure at-risk work is resolved for those work activities that are critical to the site and should not be rescheduled. • Support the WMP by clearly defining expectations and exhibiting the desired behaviours. • Clearly understand, endorse, and support the process through the following: – Understanding and promoting risk awareness. – Holding the organization accountable for working within the process. – Understanding the effects of management decisions on the process. – Trusting the process to work and understanding trends in the performance indicators. – Being familiar with the interrelationships among organizations supporting the WMP. – Providing the tools and resources to achieve individual, organizational and process success as part of the strategic plan. – Challenging inappropriate work prioritization and other methods that could circumvent the WMP. • Foster an accountable culture by the following: – Being responsive in resolving the cause(s) of process or implementation problems without discouraging identification of such problems. – Enforcing uniform adherence to high standards.	• Generate corrective actions to document and address identified performance deficiencies. • Establish recovery plans to address missed milestones and shortfalls.

TABLE 3. SCOPING PROCESS OF SITE MANAGEMENT

Process	Activity	Deliverables
	– Recognizing and promoting desired individual behaviours. • Actively promote continuous improvement initiatives (self-assessments, corrective actions, lessons learned) by the following: – Periodically attending schedule development, coordination, and critique meetings to demonstrate continued support and to communicate and reinforce expectations. – Ensuring that corrective actions are effective and are completed as scheduled.	

VI.3. WORK CONTROL AND WORK MANAGEMENT

Benefits to Work Control and Work Management (see Table 4):

— Safe operation of the plant, minimizing risk to nuclear safety, personal safety, and radiological safety;
— Efficient use of station resources;
— Efficient bundling of work to maximize equipment availability and maximize efficiency of available resources.

TABLE 4. SCOPING PROCESS OF WORK CONTROL AND WORK MANAGEMENT

Process	Activity	Deliverables
Scoping	• Participate in long-range schedule meetings. • Participate in PM review and optimization meetings. • Confirm work orders to remain in workweek and their schedule dates. • Identify upcoming work for which work orders have not been generated. • Identify the need for complex work plans and coordinators. • Identify and agree on the scope of work to be assigned to the workweek. • Perform initial validation of craft resources required to perform scheduled work. • Verify redundant equipment is available for service to support the release of scheduled work. • Facilitate and chair the scope validation meeting. • Update and freeze scope.	• Update work orders in the scheduling and planning system. • Identify the complex work plan coordinators. • Develop the initial workweek schedule with required resources. • Post and distribute workweek schedules for site use. • Conduct the scope validation meeting. • Issue the scope validation meeting report.

TABLE 4. SCOPING PROCESS OF WORK CONTROL AND WORK MANAGEMENT

Process	Activity	Deliverables
Planning	• Sequence work order activities and validate logic ties. • Identify and schedule required support activities. • Track and communicate workweek scope changes to affected individuals and work groups. • Identify and reschedule work orders that will not meet work process engineering and planning milestones. • Provide planners with approved work, assigned to specific workweeks.	• Update work orders in the scheduling and planning system. • Post and distribute workweek schedules for site use.
Scheduling and Coordination	• Confirm work orders to remain in workweek and their schedule dates. • Sequence work order activities and enter logic ties into the schedule. • Review status of complex work plans and at-risk work. • Schedule work added late into the workweek. Screen scheduled work for preconditioning concerns. • Perform aggregate risk assessment (probabilistic risk assessment (PRA)). • Approve at-risk work, with responsible owner assigned. • Facilitate and chair the schedule freeze meeting. • Verify a management sponsor for all at-risk work carried forward. • Identify and reschedule work orders that will not meet applicable work process milestones (reviews, radiation work permits, clearance orders, parts). • Update and freeze schedule. • Issue detailed schedules for LCOs and complex work activities. • Verify adequate resources are available to execute scheduled work. • Identify and reschedule work orders that will not meet applicable work process milestones (walkdowns, planning, parts, and so forth). • Update risk assessments based on schedule changes. • Review the status of at-risk issues that require resolution. • Conduct turnover with the executing workweek manager, evaluating the impact of carryover work at T-1 on the work schedule and rescheduling work as necessary.	• Provide an updated workweek schedule to site organizations for resource planning. • Provide an initial PRA integrated risk assessment. • Post and distribute the workweek schedule for site use. • Prepare the schedule freeze meeting report. • Provide an updated workweek schedule to site organizations for resource planning. • Revise workweek schedules based on walkdowns and schedule reviews. • Post and distribute certified or frozen workweek schedule for site use. • Communicate workweek risk assessment to all stakeholders.

TABLE 4. SCOPING PROCESS OF WORK CONTROL AND WORK MANAGEMENT

Process	Activity	Deliverables
	• Verify each department manager's resource commitment to implement work as scheduled.	
Execution	• Facilitate and chair daily work status and end-of-shift update meetings. • Obtain and communicate status on actual work performance. • Facilitate accountability and ownership of schedule and scope implementation as committed to at scope freeze. • Expedite resolution of work completion and emergent issues. • Reschedule work orders not able to start. • Facilitate turnover of carryover work with next week's workweek manager.	• Produce the schedule and production package. • Update the daily schedule.
Post Workweek Analysis	• Facilitate and chair the T+1 workweek critique meeting. • Review activities completed late, and activities not worked. • Verify that the work orders not completed are properly dispositioned and rescheduled. • Review the effectiveness of complex work plans in achieving on-time completion of work activities.	• Issue the T+1 package with updated process metrics. • Identify process enhancements and lessons learned. • Generate corrective actions as appropriate for scheduling process and performance improvement.
All	• Verify the department or group is on track to meet work management milestones. • Attend daily work order screening meetings. • Review work status of T-16 through T-0 work order holds. • Reschedule work orders removed from the workweek for not meeting milestones. • Evaluate and recommend work orders to be carried at risk. • Resolve scheduling and execution issues. • Ensure the work order status is updated on the site schedule. • Expedite resolution of emergent issues. • Manage scope additions for all phases. • Review rescheduled work orders and their impacts on other workweek schedules.	• Generate corrective action process documents to document and address identified performance deficiencies. • Appropriately schedule and prioritize work to manage risk.

VI.4. SYSTEM AND COMPONENT ENGINEERING

Benefits to System and Component Engineering (see Table 5):

— Support system health and equipment reliability;
— Optimize the MR programme;
— Integrate engineering issues into the WMP for resolution.

TABLE 5. SCOPING PROCESS OF SYSTEM AND COMPONENT ENGINEERING

Process	Activity	Deliverables
Scoping	• System and programme engineers review the health and materiel condition of plant SSCs. • System engineers review open system work order tasks to ensure work is appropriately prioritized and scheduled, supporting MR and system reliability expectations for assigned systems. • Identify the right work scope to improve system health and to minimize equipment unavailability. • Evaluate PM frequency for deferral or relaxation based on materiel condition and maintenance feedback, taking corrective action as necessary. • Provide engineering change status and completion forecast of work tasks T-16 through T-0. • System engineers review work management reports for completion dates on related engineering support activities. • An engineering representative participates in the scope selection meeting.	• Prioritize system health- and reliability-related work list. • Revise recommendation for performance-based PM frequency changes (real-time PM optimization). • Review the report for the Scope Review meeting.
Planning	• Notify responsible workweek manager and appropriate system, programme or design engineering personnel of engineering issues that may require rescheduling of work. • Confirm that work orders on hold for engineering support have been resolved. • An engineering representative participates in the work planning process.	• Complete engineering change packages. • Resolve engineering holds or restraints.
Scheduling and Coordination	• Complete all engineering reviews of work orders (ASME, equivalency qualifications, rigging requests, fire protection, and so forth). • Identify all engineering support activities to Scheduling. • Verify all engineering procedure revisions are complete, including the identification of operations, maintenance, and RP resources required to support testing. • Make preparations for scheduled engineering activities and resources. • Representatives participate in schedule freeze meeting for engineering activities and verify that support will be provided. • Review and commit to final schedule. • Support resolution of emergent and at-risk work orders, as applicable: – Identify any engineering concerns with schedule additions and deletions, work sequences or task durations.	• Incorporate engineering support activities into the work schedule. • Complete engineering change packages. • Resolve engineering holds or restraints. • Incorporate engineering support activities into the work schedule.

TABLE 5. SCOPING PROCESS OF SYSTEM AND COMPONENT ENGINEERING

Process	Activity	Deliverables
	– Engineering representatives to support resolution of emergent and at-risk work orders, as applicable. – Complete preparations to implement complex work plans. – Make final preparations for engineering tests and support activities.	
Execution	• In the daily production meeting, report exceptions of activity starts and completions per schedule and exceptions. • Review engineering issues affecting the schedule and review their solutions. • Implement engineering tasks per the schedule. • Provide engineering field support to work groups as requested. • Provide schedule updates to the work management organization. • Participate in pre-job briefings as required.	• An engineering representative attends daily production meetings.
Post Workweek Analysis	• Identify reasons for not implementing or supporting a scheduled activity and identifying resolution. • Identify reasons for not completing an activity on schedule. • Complete post work reviews as applicable. • Provide input to the Workweek Manager (WWM) for lessons learned.	• Initiate the corrective action process for engineering issues as warranted. • An engineering representative attends the T+1 the meeting.
All	• Verify that the Engineering Department is supporting the WWM process to meet work management milestones.	• Generate corrective actions to document and address identified performance deficiencies. • An engineering representative actively participates on the Work Order Screening Team.

VI.5. DESIGN ENGINEERING AND RAPID RESPONSE ENGINEERING

Benefits to Design Engineering and Rapid Response Engineering (see Table 6):

- Maximizes station equipment availability and reliability;
- Supports the implementation of plant improvement projects, design changes and procurement.

TABLE 6. SCOPING PROCESS OF DESIGN ENGINEERING AND RAPID RESPONSE ENGINEERING

Process	Activity	Deliverables
Scoping	• Review work management reports for assigned completion dates on related engineering support activities. • Identify approved design changes to be added to the schedule. • Identify potential long-lead-time parts and engineering change issues. • An engineering representative participates in the scope review meeting as required: – Commits to scope validation meeting scope. • Verify project work orders are scheduled into the workweek process to meet required milestones. • Complete equivalency evaluations to support obsolescence issues.	• Identify modification material lists at T-24 or earlier as required for very long lead materials. • Complete design change packages. • Engineering representatives provide input for work scope.
Planning	• Provide engineering input to job planning. • Coordinate vendor support of scheduled work. • An Engineering representative supports the work planning process as required.	• Provide support to planning. • Review planned packages. • Address technical or logistical issues associated with scheduled work.
Scheduling and Coordination	• Identify and develop detailed schedules for complex tasks as assigned. • Assign an activity coordinator, as necessary, to ensure a single point of contact for complex task completion. • Actively participate in the schedule freeze meeting. • Verify plant conditions support task execution. • Confirm that design change preparations and prefab work in previous workweeks are on schedule: – Walk down task to validate content of work planning documents as required.	• Resolve schedule conflicts with at-risk work. • Detailed schedules and activity coordinators are in place to ensure the organization supports timely execution of tasks. • Support emergent work. • Engineering products are ready to support scheduled work.
Execution	• Provide engineering coverage for activities. • Resolve task coordination and execution issues. • Identify task performance improvement opportunities. • Participate in the pre-job briefings as required.	• Participate in pre-job briefings. • Support implementation issue as required. • Participate in functional testing, and formally turn over the system to the site.

TABLE 6. SCOPING PROCESS OF DESIGN ENGINEERING AND RAPID RESPONSE ENGINEERING

Process	Activity	Deliverables
Post Workweek Analysis	• Perform post job critiques. • Identify improvement opportunities.	• Participate in the workweek critique meeting.
All	• Verify the department or group meets work management milestones. • Resolve any engineering issues.	• Generate corrective actions to document and address identified performance deficiencies.

VI.6. WORK PLANNING

Benefits to Work Planning (see Table 7):

- Predictable, manageable time frame for planning and reviewing work packages, minimizing the planning of emergent work;
- Maximized planning resources through prioritization of work;
- Timely completion of support activities such as reviews, procurement of parts, and so forth.

TABLE 7. SCOPING PROCESS OF WORK PLANNING

Process	Activity	Deliverables
Scoping	• Plan approved work packages based on scheduled start dates. • Plan forced outage work. • Attend Work Order Screening Team meetings. • Provide additional focus for major component outage work. • Provide work package planning status. • Identify potential long-lead-time parts required. • Identify potential engineering support required. • Identify work order tasks that will not meet WMP milestones. • Participate in the scope validation meeting.	• Long-term parts identification and generation of materials requests associated with those long-lead-time parts following the earliest meeting or earlier based on lead time. • Identification of vendor support needs and generation of contract requisitions as required.
Planning	• Maintenance planners identify parts, material and other support required. • Initiate procedure change request for special procedures. • Initiate engineering change request for engineering assistance. • Coordinate and develop (with the implementing organization) the final man-hour estimates for each work task. • Incorporate engineering responses in plans.	• Initiate requisitions and reserve material. • Complete work order planning by the planning milestone. • Identify and resolve any work package restraints.

TABLE 7. SCOPING PROCESS OF WORK PLANNING

Process	Activity	Deliverables
	• Identify special support activities such as vendor pre-job inspections. • Participate in complex work planning. • Coordinate with RP planners for dose estimates and walkdowns.	
Scheduling and Coordination	• Complete planning reviews with final labour (craft and time) resource estimates. • Address emergent planning issues identified during package reviews. • Continue planning for emergent and at-risk work orders. • Provide the WWM with the status on at-risk work. • Resolve shop walkdown planning issues. • Resolve or implement any work package comments from the reviewing work groups.	• Revise work packages to include all walkdown and emergent issues. • Work packages are delivered for review and walkdown. • Work packages are revised to resolve all emergent issues and comments from walkdowns.
Execution	• Report the status of active scope change issues and any emergent work planning problems.	• Work packages are revised to resolve all emergent issues.
Post Workweek Analysis	• Review feedback on completed work packages as applicable. • Provide input to the WWM for lessons learned. • Participate in the T+1 meeting.	• Initiate corrective actions for work package issues.
ALL	• Resolve work package issues that do not meet the planning review milestone (at-risk work). • Planners expedite material identification and planning for emergent work or at-risk work. • Review emergent work planning issues. • Update model work orders for repetitive tasks as changes are made to the associated active work orders. • Review work history for repetitive failures.	• Work packages are revised to resolve emergent issues. • Revise model work order and templates to capture package improvements, including resource hours, work direction and coordination issues. • Generate corrective actions to document and address identified performance deficiencies and rework.

VI.7. MATERIAL SUPPLY

Benefits to Material Supply (see Table 8):

— Sufficient time for procurement and receipt of parts and services;
— Margin to support engineering reviews for parts equivalency;
— Avoidance of premium fees for expediting needed parts.

TABLE 8. SCOPING PROCESS OF MATERIAL SUPPLY

Process	Activity	Deliverables
Scoping	• Identify long-lead-time parts and parts requiring equivalency evaluations. • Determine material availability.	• Provide parts hold status. • Report on delivery dates.
Planning	• Initiate procurement as needs are identified. • Notify planners of any material issues that could affect the schedule. • Verify material availability.	• Provide parts hold status. • Report on delivery dates.
Scheduling and Coordination	• Approve parts reviews as material is received, receipts are inspected, and parts are made available to issue. • Verify all materials or parts are on site for scheduled work orders. • Actively participate in schedule freeze meeting. • Review and commit to final schedule. • Notify the WWM and planners of any materials that will not arrive in time to support scheduled work. • Arrange for weekend support of receipt inspection for late material if necessary. • Receive and pre-stage any final items of late material.	• Provide parts hold status. • Report on delivery dates. • Pre-stage material in support of work package walkdown. • Provide updates on any contract requisition issues.
Execution	• Report on any work in progress material issues as requested by the WWM. • Expedite material for emergent problems.	• Participate in daily production meeting and report the status of procurement issues.
Post Workweek Analysis	• Identify emergent issues that could have been prevented. • Provide input to the WWM for lessons learned. • Participate in the T+1 meeting.	• Initiate corrective actions for material or contract issues as required.
All	• Monitor material delivery dates and identify deliveries that will not meet the procurement milestone. • Notify planners of emergent material issues. • Support procurement of emergent or at-risk work order tasks. • Replenish supplies based on minimum inventory requirements. • Verify that the department or group meets work management milestones.	• Provide parts hold status. • Report on delivery dates. • Generate corrective actions to document and address identified performance deficiencies.

VI.8. OPERATIONS

Benefits to Operations (see Table 9):

— Improved plant safety, reliability, and availability;
— Maximum equipment operability;
— Fewer operator workarounds or burdens;
— Improved operations resource management.

TABLE 9. SCOPING PROCESS OF OPERATIONS

Process	Activity	Deliverables
Scoping	• Review all work for conflicts with protected train issues. • Ensure identified work corrects operator burdens and workarounds: – Verify identified work minimizes equipment outages by bundling work within isolation boundaries. – Participate in scope validation meetings as required. – Commit to scope validation meeting scope. • Ensure that seasonal readiness issues are identified and addressed. • Identify critical work that should not be removed from the workweek. • Identify and revise needed operations procedures as required.	• Provide input to work management for operations activity and equipment availability concerns. • Actively participate in work scoping meetings. • Provide operations resource estimates.
Planning	• Identify proposed activities that plant conditions will not support. • Identify just-in-time training (JITT) requirements. • Assign coordinators for operations activities identified as infrequently performed tests or evolutions (IPTEs). • Identify LCO's, IPTE's and other high-risk work that should be managed per the complex work process. • Assist planners in proper task sequencing and post maintenance test requirements. • Participate in the development of complex work plans. • Help resolve work order restraints as necessary.	• Provide support to planning and work management. • Initiate training requests for JITT. • Provide personnel to support IPTEs. • Complete operations work plan reviews. • Produce the work authorization, clearance and Isolation–restoration plan.
Scheduling and Coordination	• Verify that operations procedures have been revised as required. • Confirm that work sequences are satisfactory for safety and clearance. • Complete operations scheduling of workweeks per the milestone. • Complete work authorization and tagging clearance orders. • Complete the PRA. • Actively participate in the schedule freeze meeting. • Review and commit to the final schedule.	• Complete an operations review of all work order tasks. • Complete operations procedure revisions. • Complete work authorization and clearance orders. • Verify post maintenance testing activities are properly scheduled. • Provide schedule comments to the workweek manager for schedule revision.

TABLE 9. SCOPING PROCESS OF OPERATIONS

Process	Activity	Deliverables
	• Identify issues related to schedule conflicts and sequences. • Operations shift managers review and approve scheduled work. • Verify and walk down clearances. • Participate in the development of complex work plans and attend any meetings. • Affirm that the Operations Department is sufficiently staffed to support the schedule. • Confirm readiness to perform IPTE activities. • Prioritize and implement clearances to minimize out-of-service time for MR and LCO, mitigating system performance indicators for SSCs. • Prepare packages for issuance. • Ensure the risk assessment and any emergent updates are communicated to operations on-shift personnel. • Shift manager reviews the T-1 schedule for work preparations.	
Execution	• Deliver the plant status and issues update at the daily production meeting. • Report operations exceptions for activity starts and completions per the schedule and provide reason to WWM. • Hang or remove clearance sections in support of work activities. • Issue or close out work packages. • Review completed work packages and performed return-to-service operability testing. • Verify risk for equipment prior to removal from service. • Support FIN team activities. • Participate in pre-job briefings as required.	• Tag system per the work schedule. • Close out work packages and return equipment to service. • Provide schedule updates to the WWM.
Post Workweek Analysis	• Discuss reasons for not supporting a scheduled activity. • Identify any clearance issues that affected the schedule and identify the causes: – Provide input to the WWM for lessons learned. • Identify any work activity that could not be started or completed as scheduled.	• Generate corrective actions to document and address identified performance deficiencies.
All	• Verify that the department or group is on track to complete actions and to meet work management milestones. • The senior reactor operator screens new work requests for safety and operability concerns.	• Generate corrective actions to document and address identified performance deficiencies.

TABLE 9. SCOPING PROCESS OF OPERATIONS

Process	Activity	Deliverables
	• Identify and initiate work requests for equipment deficiencies. • Maintain plant configuration control to support scheduled work and emergent issues.	

VI.9. RADIATION PROTECTION

Benefits to RP (see Table 10):

— Improves radiological safety across the station;
— Improves the ability to achieve ALARA goals;
— Improves RP resource management;
— Helps the station focus on each work activity from a radiological perspective.

TABLE 10. SCOPING PROCESS OF RADIATION PROTECTION

Process	Activity	Deliverables
Scoping	• Identify and communicate changed or abnormal radiological conditions. • Identify any issues of radiological concern associated with the initial scope of the target week. • Identify dose-significant concerns that meet the station ALARA Committee approval threshold. • Review long-range schedules. Anticipate the effects of RP-intensive work windows. • Recognize activities that require RP planning support. • Identify activities that require extra or nonstandard radiological controls. • Identify support resources: decontamination, scaffold builds, operations, and so forth. • Actively participate in the scope validation meeting.	• Provide input to the cycle schedule for RP-intensive activities. • Identify dose-saving collateral work in the area or system. • Radiological protection personnel actively participate in scoping meeting. • Provide input to the long-range schedule for RP-intensive activities. • Provide baseline RP resource estimates to Scheduling to account for training, vacations, and so forth.
Planning	• Provide RP input to work planning: – Exposure or contamination controls affecting the job. – Shielding and flushing requirements. – Dose estimates for scheduled work. – Input for bundling of work to minimize overall dose. • Actively participate in the planning process.	• Establish ALARA goals. • Establish contamination controls. • Incorporate dose-saving collateral work in the ALARA plan. • Initiate radiation work permits (RWPs). • Initiate shielding requests. • Request flush procedures.

TABLE 10. SCOPING PROCESS OF RADIATION PROTECTION

Process	Activity	Deliverables
Scheduling and Coordination	• Issue RWPs. • Participate in T-week reviews. • Understand location, scope, dates, and hours of activities. • Identify conflicts with other scheduled activities. • Validate scheduling and coordination of shielding and flushing requirements. • Identify required RP resources. • Identify and resolve effects to other work: limited access, shifting radiation boundaries, and so forth. • Ensure radioactive waste shipments are identified on the schedule. • Actively participate in the schedule freeze meeting. • Review and commit to the final schedule. • Perform walkdowns or surveys per station-established dose thresholds. • Validate RWP assumptions. • Develop dose goals for the target week. • Identify shielding requirements. • Identify flushing requirements. • Verify job conditions. • Validate support requirements. • Complete micro-ALARA dose estimates.	• Complete reviews of planned work packages. • Make all RWPs complete and available for package walkdowns per milestones. • Resolve RP schedule conflicts. • Identify and resolve impacts to other work: limited access, shifting radiation boundaries, and so forth. • Provide input to WWM or scheduler to incorporate sublevel RP details into the schedule as required. • Approve RWPs for use. • Establish low dose waiting areas. • Complete walkdowns of RP work order activities.
Execution	• Actively participate in pre-job briefings. • Ensure proper dosimetry is identified and specific setpoints as required. • Monitor job performance per station-established dose thresholds. • Ensure exposure and contamination controls are in place. • Establish and verify appropriate decontamination requirements.	• Provide RP coverage for scheduled and emergent work. • Update job exposure results, tracking of exposure against job estimates, and reporting of deltas. • Generate corrective actions to document and address identified RP and work group performance deficiencies.
Post Workweek Analysis	• Report job results: – ALARA. – Contamination control. – Job coordination issues. • Compare actual dose received versus estimate. • Identify improvement opportunities.	• Actively participate in the T+1 meeting. • Issue corrective actions for RP performance improvements.
All	• Verify the department or group is on track to meet the work management milestones. • Identify broken or deficient equipment (such as radiation monitors and process leaks).	• Generate corrective actions to document and address identified RP and work group performance deficiencies.

VI.10. MAINTENANCE

Benefits to Maintenance (see Table 11):

- Sufficient time for preparation and safe execution of work;
- Reduction of work backlog;
- Minimized potential for human performance issues;
- Predictable resource scheduling;
- Incorporation of craft feedback and lessons learned in work packages and scheduling.

TABLE 11. SCOPING PROCESS OF MAINTENANCE

Process	Activity	Deliverables
Scoping	• Maintenance personnel to work with the shop coordinator or discipline scheduler to identify any work to be assigned outside of the shops, considering budget priorities. • Maintenance personnel to work with the shop coordinator or discipline scheduler to identify any significant maintenance equipment or support required and to issue request, as needed. • Maintenance personnel to work with the shop coordinator or discipline scheduler to provide initial scheduling with resource availability, taking into account training and vacations. • Maintenance personnel to work with the shop coordinator or discipline scheduler to confirm PM feedback analysis for deferral or relaxation based on material condition and maintenance feedback provided at T+1.	• Provide baseline shop resource estimates to Scheduling to account for training, vacations, and so forth. • Conduct initial scope review validating required resources, supplemental personnel, expected durations, and required qualifications.
Planning	• As requested, maintenance staff to work with the shop coordinator or discipline scheduler to help planners develop resource estimates and repair strategies for corrective maintenance (CM) work orders. • Help resolve work order restraints as necessary.	• Resolve identified work restraints or work package issues required to support planning.
Scheduling and Coordination	• Interface and work with the shop coordinator or discipline scheduler to review the schedule for resource and support needs. • Develop turnover expectations from the shop coordinator or discipline scheduler to the maintenance supervisors to ensure maintenance staff can successfully participate in the schedule freeze meeting. • Supervisors assign work packages to work crews for	• Ensure required resources are available. • Complete all workweek package walkdowns. • Provide feedback to planning personnel for any work package revisions or additional parts required. • Provide feedback to operations and RP personnel as required. • Provide feedback to work management personnel on

TABLE 11. SCOPING PROCESS OF MAINTENANCE

Process	Activity	Deliverables
	• walkdown and review of workability of the work order, including tag boundaries, RWPs and parts. • Commit required resources to implement the schedule. • Identify the need for any additional support activities. • Confirm the ability to implement any complex work plans. • Confirm work sequences and durations. • Supervisors to provide and communicate job durations, resource or other changes to the schedulers and planners. • Confirm that prefabrication work tasks identified in earlier weeks will be completed on schedule. • Review and commit to the final schedule. • Identify any resource impact caused by emergent work or other site issues. • Assemble tools and materials and make prework preparations as necessary prior to execution week. • Perform prerequisite work steps as permitted.	scheduling issues and required resources. • Participate in the schedule freeze meeting.
Execution	• The FIN team performs emergent work activities to protect site-scheduled work (within FIN capabilities). • Report exceptions to activity starts and completions per the schedule and provide reasons to WWM. • Communicate work completion and schedule impacts to work groups awaiting handoffs. • Implement work and perform post maintenance testing per the schedule. • Provide schedule updates to WWM. • Forward completed work packages to the work control and package control groups as required. • Participate in the pre-job briefings as required.	• Participate in the daily production meeting. • Complete scheduled work per the workweek schedule. • Communicate work handoffs in a timely manner. • Implement the 30-minute rule for WWM notification of schedule deviations. • Generate corrective actions to document and address identified work group performance deficiencies.
Post Workweek Analysis	• Discuss reasons for not implementing or supporting a scheduled activity. • Provide input to the WWM for lessons learned.	• Participate in the T+1 meeting. • Generate corrective actions to document and address identified work group performance deficiencies.
All	• The FIN team validates new work requests. • Verify that the department or group is on track to meet work management milestones.	• Participate in the daily production meeting. • Participate in the work order screening meeting.

TABLE 11. SCOPING PROCESS OF MAINTENANCE

Process	Activity	Deliverables
		• Generate corrective actions to document and address identified performance deficiencies.

VI.11. SECURITY

Benefits to Security (see Table 12):

- Improves the ability to achieve and maintain goals and Institute for Nuclear Power Operations (INPO) standards;
- Improves security resource management;
- Optimizes Nuclear Regulatory Commission (NRC) cornerstone performance.

TABLE 12. SCOPING PROCESS OF SECURITY

Process	Activity	Deliverables
Scoping	• Review long-range schedules. • Identify activities that require compensatory security actions or controls. • Actively participate in the scope validation meeting.	• Provide input to the cycle schedule for security-intensive activities. • Validate required resources, supplemental personnel, expected durations and required qualifications at the initial scope review meeting. • Commit to supporting the work scope.
Planning	• As requested, help planners develop resource estimates and repair strategies for corrective maintenance (CM) work orders. • Help resolve work order restraints as necessary.	• Resolve identified work restraints or work package issues required to support planning.
Scheduling and Coordination	• Identify conflicts with other scheduled activities and effects to other work: limited access, special requirements, coordination with crafts, operations, or RP. • Validate scheduling, available coordination resources, and duration. • Complete walkdowns and security reviews. • Actively participate in the schedule freeze meeting. • Review and commit to the final schedule. • Validate security controls affecting job activities. • Identify physical barrier setup and temporary security alterations. • Determine temporary post requirements or boundaries.	• Commit to supporting the final work schedule.

TABLE 12. SCOPING PROCESS OF SECURITY

Process	Activity	Deliverables
Execution	• Provide security resources for activities. • Support the effects of emergent work and compensatory measures. • Participate in the pre-job briefings as required.	• Ensure security controls and compensatory measures are taken as needed to support scheduled and FIN teamwork.
Post Workweek Analysis	• Report job results and security coordination issues and identify improvement opportunities.	• Actively participate in the T+1 meeting.
All	• Identify broken or deficient security equipment. • Identify changes to security conditions; note the effects to station activities. • Verify that security personnel are on track to meet work management milestones.	• Initiate appropriate work request and corrective actions. • Provide support details to affected work management process, WWM, scheduler, and planning. • Generate corrective actions to document and address identified performance deficiencies.

VI.12. CHEMISTRY

Benefits to Chemistry (see Table 13):

- Ensures station support of chemistry-related equipment reliability;
- Improves the ability to achieve and maintain top-quartile performance;
- Improves chemistry resource management.

TABLE 13. SCOPING PROCESS OF CHEMISTRY

Process	Activity	Deliverables
Scoping	• Review long-range schedules. • Identify activities that require compensatory chemistry actions or controls. • Identify support resources: – Chemical treatment application. – Waste management. – Chemical disposal. • Actively participate in the scope validation meeting.	• Provide input to cycle schedule for chemistry-intensive activities. • Commit to supporting the work scope.
Planning	• Recognize activities that require chemistry planning support. • Provide chemistry input to job planning: – Bulk chemical requirements – Cross-contamination and intrusion issues	• Identify compensatory sampling or operational requirements. • Identify personal protective equipment and engineering controls for chemical hazards.

TABLE 13. SCOPING PROCESS OF CHEMISTRY

Process	Activity	Deliverables
	– Industrial safety concerns and hazard analysis – Chemical disposal strategy	• Provide input on chemistry controls and sampling requirements for job planning.
Scheduling and Coordination	• Identify conflicts with other scheduled activities. • Validate scheduling and coordination of sampling, chemical addition, and flushing requirements. • Coordinate and assign chemistry resources to support target week activities. • Complete walkdowns and reviews. • Actively participate in the schedule freeze meeting. • Review and commit to the final schedule. • Review chemical use permits. • Validate support requirements. • Perform a job hazard analysis. • Validate the chemical disposal strategy.	• Review planned packages. • Coordinate and assign chemistry resources to support workweek activities. • Chemistry personnel commit to execution of the target week schedule. • Document the job hazard analysis.
Execution	• Provide chemistry support for activities as required. • Perform surveillance testing (ST) and sampling as scheduled. • Evaluate emergent work for effects to chemistry. • Perform chemistry sampling and addition. • Initiate chemistry compensatory actions for out-of-service equipment.	• Actively participate in the pre-job briefings. • Monitor job performance affecting system chemistry. • Ensure chemical exposure controls and personal protective equipment are used properly.
Post Workweek Analysis	• Identify job coordination issues. • Identify improvement opportunities.	• Actively participate in the T+1 meeting.
All	• Verify that the department or group is on track to meet work management milestones. • Identify broken or deficient chemistry support equipment (such as resin depletion and carbon bed exhaustion). • Identify changed or abnormal chemistry conditions.	• Generate corrective actions to document and address identified performance deficiencies.

VI.13. EMERGENCY PLANNING

Benefits to Emergency Planning (see Table 14):

— Improves the ability to meet commitments of the emergency plan (EP);
— Improves the ability to respond to events in the short and long term;
— Maintains the health and safety of plant personnel; protects and informs the general public.

TABLE 14. SCOPING PROCESS OF EMERGENCY PLANNING

Process	Activity	Deliverables
Scoping	• Identify broken or deficient EP-related equipment. • Identify any issues of EP concern associated with scheduled activities that could render EP equipment inoperable. • Recognize activities that require EP planning support; that is, compensatory measures that would be required for equipment taken out of service. • Identify EP drills and exercises to be incorporated into the site schedule. • Participate in the major scope and schedule alignment meetings as required based on the scope of work affecting EP equipment. • Participate in the scope validation meeting as required based on the scope of work affecting EP equipment.	• Initiate work requests or corrective actions as needed. • Provide support details to affected work management process, WWM, scheduler and planning. • Conduct initial scope review to validate required resources, supplemental personnel, expected durations and required qualifications. • Commit to supporting the work scope.
Planning	• Provide EP input for job planning, as noted above. • Participate in and review the planning meeting as required based on the scope of work affecting EP equipment.	• Identify compensatory sampling or operational requirements. • Maintain the integrity of the EP.
Scheduling and Coordination	• Provide input to work management on the impact and priority of scheduled work on EP-related equipment. • Understand the location, scope, and duration of activities affecting EP equipment. • Identify conflicts with other scheduled activities such as EP drills and exercises. • Participate in and review the schedule freeze meeting as required based on the scope of work affecting EP equipment. • Validate that controls and compensatory measures are in place to protect EP capabilities while scheduled activities render EP equipment inoperable.	• Maintain the integrity of the EP.
Execution	• Evaluate emergent work for impact on EP-related equipment, instituting compensatory measures as required.	• Actively participate in the pre-job briefings. • Monitor job performance affecting EP-related systems.
Post Workweek Analysis	• Identify improvement opportunities, and capture lessons learned. • Participate in and review the T+1 critique meeting as required based on the scope of work affecting EP equipment.	• Generate corrective actions to document and address identified performance deficiencies.

VI.14. SHOP COORDINATOR AND DISCIPLINE SCHEDULER

Benefits to maintenance and work management (see Table 15):

— Prepares targeted workweek;
— Develops key deliverables for the implementing team (maintenance supervisors);
— Participates in the early phases of the process;
— Develops a workable schedule that is correctly resource loaded;
— Incorporates craft feedback from work packages and scheduling;
— Establishes a single point of contact for the early phases of the process;
— Works directly with the cycle planner and workweek manager.

TABLE 15. SCOPING PROCESS OF MAINTENANCE AND WORK MANAGEMENT

Process	Activity	Deliverables
Scoping	• The shop coordinator and discipline scheduler identify any work to be assigned outside of the shops, considering budget priorities. • Identify significant maintenance equipment or support required, and issue request. • Provide initial scheduling with resource availability, taking into account training and vacations. • Actively participate in the scope validation meeting. • Attend the scope selection meeting – representing maintenance.	• Provide baseline shop resource estimates to Scheduling to account for training, vacations, and so forth. • Conduct an initial scope review validating required resources, supplemental personnel, expected durations and required qualifications.
Planning	• As requested, help planners develop resource estimates and repair strategies for corrective maintenance (CM) work orders. • Help resolve work order restraints as necessary. • Attend scope freeze meeting – representing maintenance.	• Resolve identified work restraints or work package issues required to support planning.
Scheduling and Coordination	• Review the schedule for resource and support needs. • Prepare maintenance personnel to participate successfully in the schedule freeze meeting. • The shop coordinator turns over to the maintenance shops so that the maintenance organization owns the schedule freeze meeting.	• Ensure required resources are available. • Complete all workweek package walkdowns. • Provide feedback to planning for any work package revisions or additional parts required. • Provide feedback to operations and RP as required. • Provide feedback to work management on scheduling issues or required resources.
Execution	• No expected participation.	• No expected deliverable.
Post Workweek Analysis	• Discuss and understand the reasons for maintenance staff not implementing or supporting a scheduled activity. • Provide input to the WWM for lessons learned.	• Participate in the T+1 meeting as needed. Maintenance staff should lead participation. • Generate corrective actions to document and address identified work group performance deficiencies.

TABLE 15. SCOPING PROCESS OF MAINTENANCE AND WORK MANAGEMENT

Process	Activity	Deliverables
All	• Verify that the department or group is on track to meet work management milestones.	• Assist maintenance personnel in the generation of corrective actions to document and address identified performance deficiencies.

APPENDIX VII. GOOD PRACTICE FROM JAPAN

VII.1. TEPCO’S WORK MANAGEMENT PROCESS

Tokyo Electric Power Company (TEPCO) introduced the Management Model (MM) to pursue safe and effective plant operation in 2016 and work management is one of the core function areas to support operation (see Fig. 8).

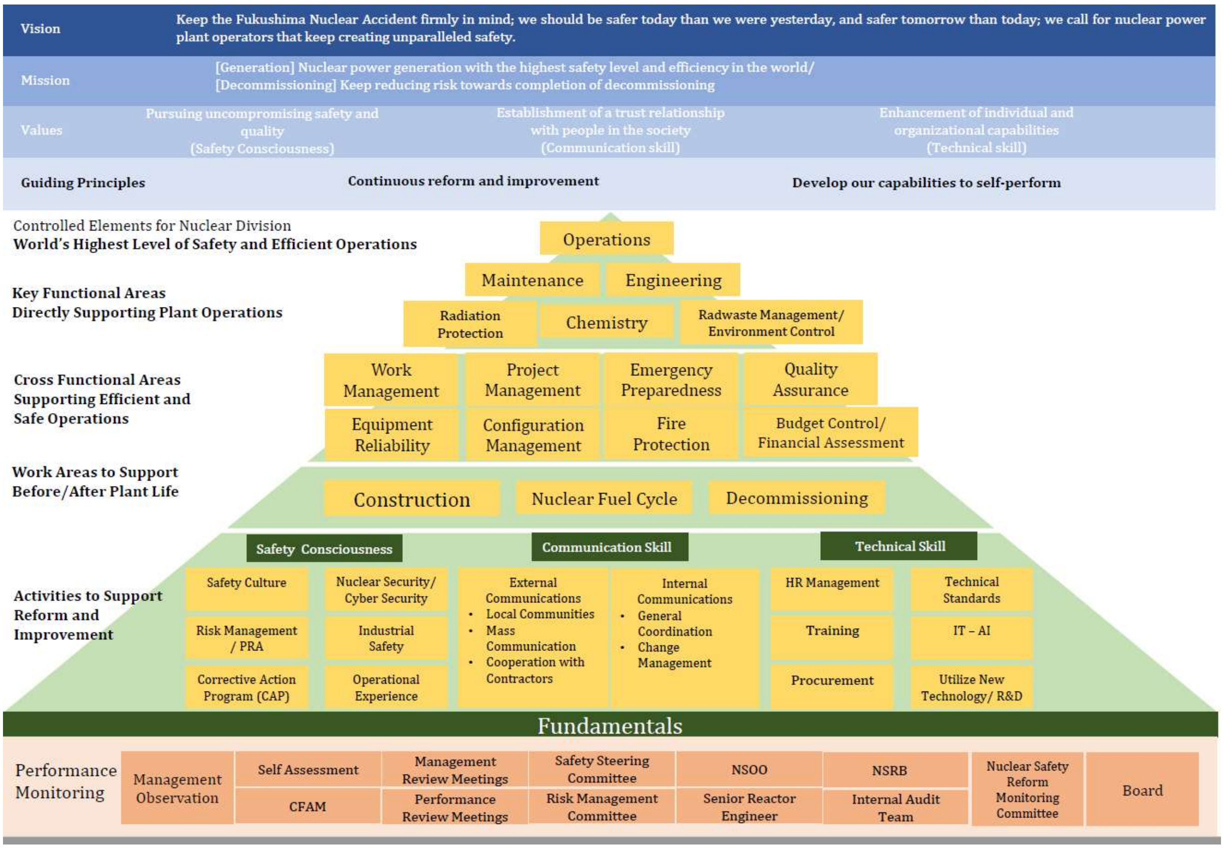

FIG. 8. TEPCO’s NPP operation management structure.

TEPCO introduced WMP as a part of the management model for the following purposes:

- Pursuing safety by developing and adhering to a plan that minimizes risks of nuclear safety and equipment protection for maintenance activities;
- Efficiently managing human and material resources, and enhancing productivity.

VII.1.1. Current Status of TEPCO's work management process

Due to unique features in maintenance activities in Japan, e.g. difficulty to control contractors' work, the complete process described in AP-928 [5] has not been accomplished. TEPCO is improving OP, CM, ER and LP process as well as WM (see Fig. 9).

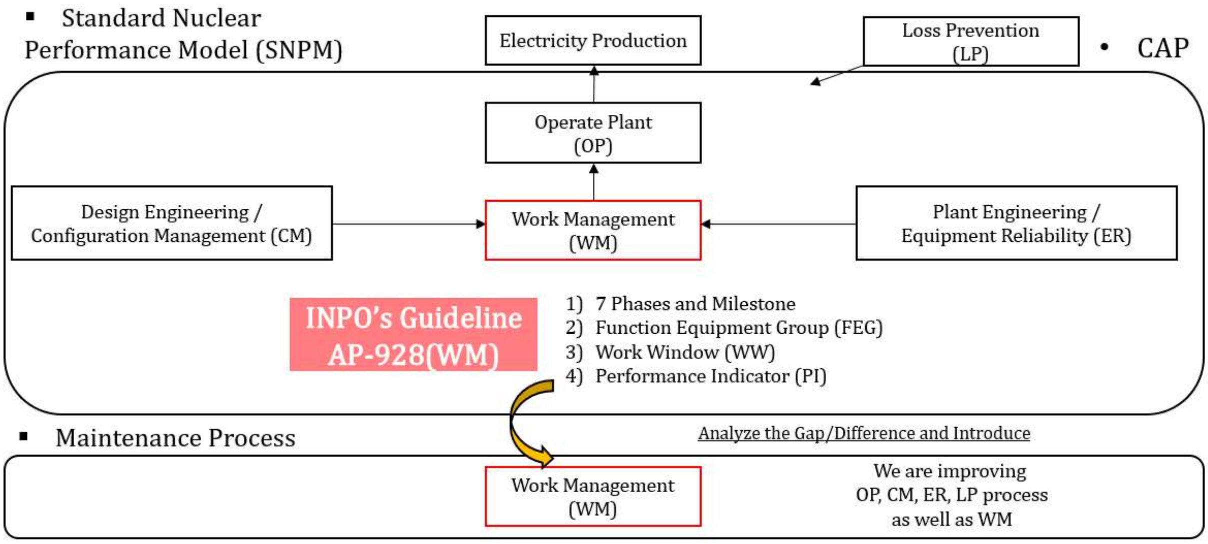

FIG. 9. Standard nuclear performance model.

VII.1.2. Fundamentals for work management

Common subject matter:

- Understand the workflow (process) of work management and execute it accordingly;
- Gain education, training, and experience to gain knowledge of the WMP;
- Seek a more effective WMP and continuously improving it;
- Express managers' expectations for the outcome of the WMP and presents it to the organization;
- Evaluated and respected good practices;
- Have an ownership regarding work preparation and implementation results.

WMP overview (TEPCO):

- Divided into seven phases, with monthly milestones set until the execution phase;
- Managed by work order (WO) using IT systems, MAXIMO and supplemental systems;
- WO is issued for PM, design change requests, equipment malfunctions, and OE information (See Fig. 10).

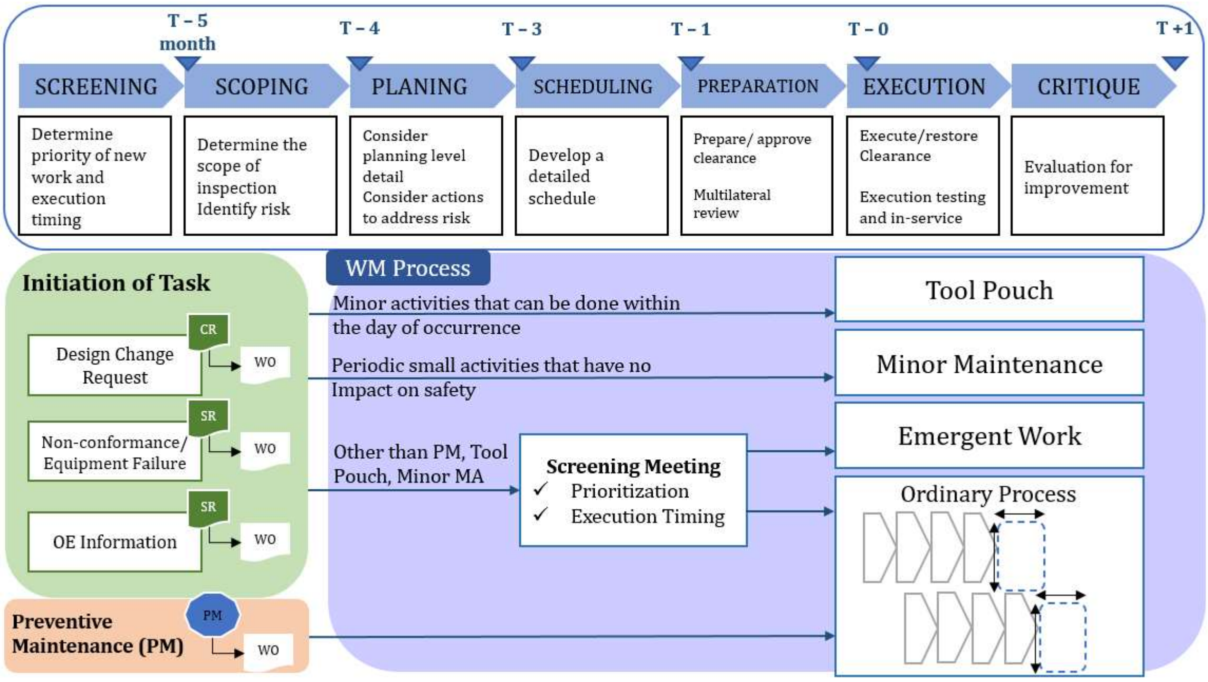

FIG. 10. Work management process.

Development of Functional Equipment Group:

- — Defined as 'a group consisting of a main component and subcomponents, within shared isolation boundary or fixed position';
- — Isolation boundaries are defined by work duration, target, function, content; all activities performed within this boundary;
- — Maintenance of all Equipment in one FEG is simultaneously performed (see Fig. 11).

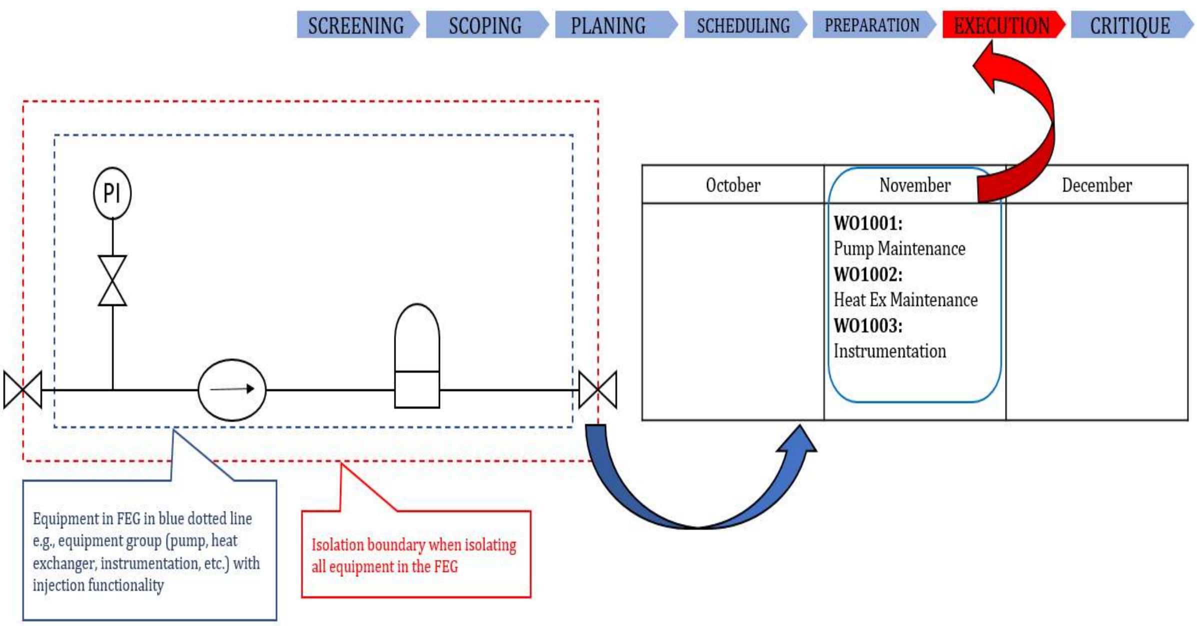

FIG. 11. Function equipment group.

Work Window (WW) establishment:

— In the work execution phase, the work period and execution timing are set as a work window (WW). Equipment is allocated to WW for each FEG. AP-928 describes a one-week WW (US standard), but TEPCO's nuclear power plants use a one-month WW due to differences such as extended outages and restrictions due to regulations (see Fig. 12).

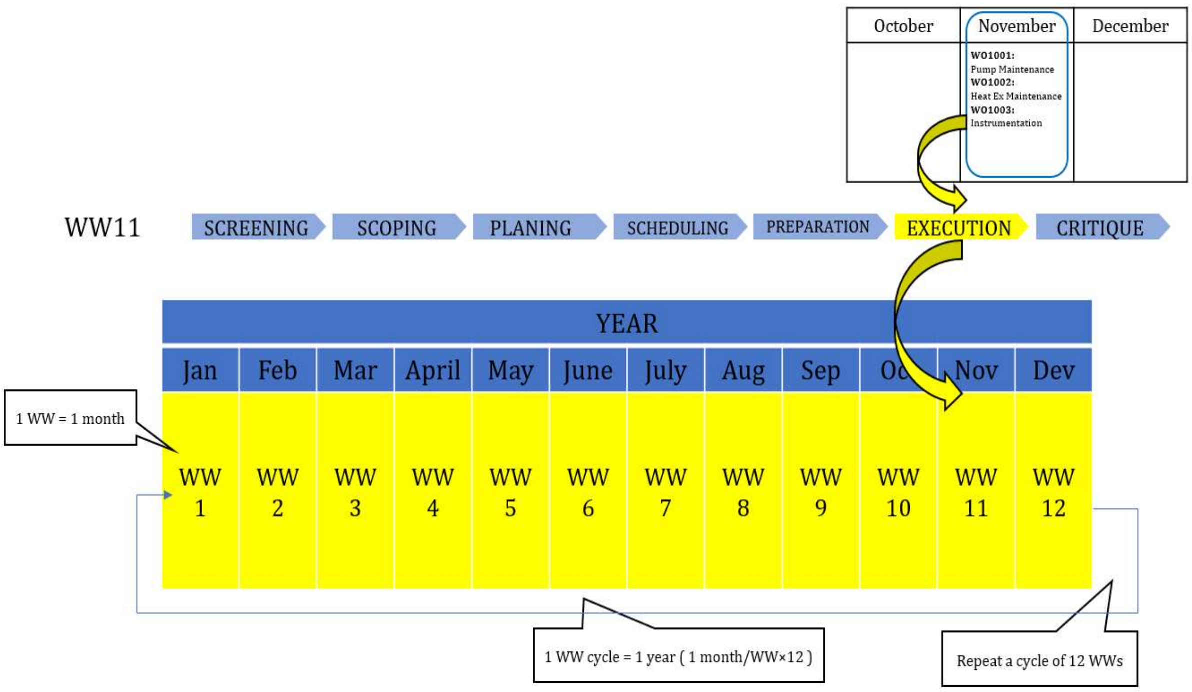

FIG. 12. Work execution schedule.

PI development/evaluation:

— At critique phase, the measure against safety risk, and the effectiveness of the process are evaluated and lessons learned for the next planning are identified. Effectiveness of the process is evaluated by the following PI's (see Table 16).

TABLE 16. PERFORMANCE INDICATORS

PI	Target values
Unplanned unavailability of safety system Days (Days of discrepancy between planned and actual unavailability period)	0 day
Schedule completion rate (% of work completed by the end of a WW duration)	95% or more
Percentage of emergent work (% of additional work after the schedule freeze)	10% or less
Scope stability (% of scope change after scope freeze)	80% or more

TABLE 16. PERFORMANCE INDICATORS

PI	Target values
Schedule stability (% of schedule change after the scheduling phase)	90% or more
Scope survival (% of CC work after Execution)	90% or more

APPENDIX VIII. KAIZEN PRINCIPLE

VIII.1. KAIZEN PRINCIPLE

Kaizen principle has developed by Toyota just after World War II. Toyota has been maintaining this concept for more than 70 years. Kaizen principle is an innovation process to establish a lean[9] work process by pursuing a real objective and value of the work.

VIII.2. BASIC APPROACH OF KAIZEN

Figure 13 describes basic principle of Kaizen, which means "continuous improvement," is to make incremental and continuous improvements in various aspects of a process or system. It originated in the manufacturing industry but has since been adopted in various fields, including business management, healthcare, and personal development. The core idea behind Kaizen is that small, incremental changes made consistently over time can lead to significant improvements in efficiency, quality, productivity, and overall performance. Rather than seeking radical or revolutionary changes, Kaizen focuses on identifying and implementing small, manageable improvements that can be easily integrated into daily work routines.

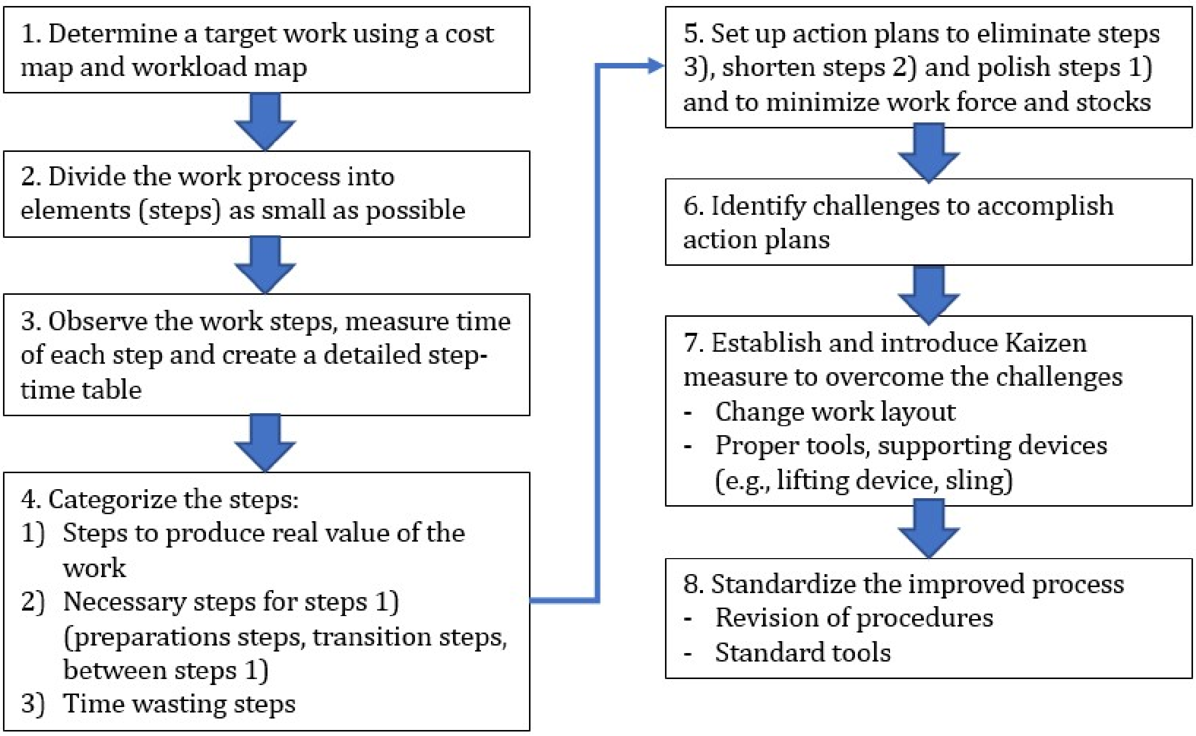

FIG. 13. Basic principle of Kaizen.

[9] Lean process requires minimum work force and time while the process itself assures safety and quality of the work.

VIII.3. HOW CAN KAIZEN CONTRIBUTE TO EFFECTIVE WMP?

Key features of the Kaizen process are as follows:

- Strong ownership of the work members cultivated through the Kaizen mind-set training, and attitude and behavior to deny the current status;
- Detailed analysis of the work steps using the step-time chart; from level of hours to level of minutes, ultimately to level of seconds;
- Two fundamental theories; Just in Time (not create any excessive products) and Autonomation (a process automatically detects a failure and stops by itself);
- Accomplish one-man work by using supporting tools.

Through the Kaizen process work time and work force of each work process (in addition to improving safety and quality of the work and reducing cost) are optimized. After performing Kaizen for many work processes, TEPCO and contractors can have flexible time and work force. Consequently, smooth and levelled out annual work plan can be accomplished (this is very strong advantage especially for TEPCO and other Japanese utilities which have many units under shutdown).

In Fiscal Year 2018, Kaizen activities performed in TEPCO Nuclear Power and NPC achieved a cost reduction of four-billion Japanese yen and allowed 12 people to be transferred to the FDEC to support other important missions. In addition, these Kaizen improvement activities contributed to safety improvements, including:

- Maintenance work on the Residual Heat Removal Sea water system safety related pump at Fukushima Daini NPP was reviewed and streamlined, with the work moved from a contractor to the in-house maintenance team. This reduced the maintenance costs and reduced the maintenance duration by 50 percent, thus improving the overall pump availability.
- Work to sort and segregate radioactive waste at Kashiwazaki Kariwa NPP was reviewed and streamlined reducing the work duration by approximately 20 percent, which reduced worker handling activities and radiation dose exposure.
- A Kaizen improvement activity replaced electronic memory devices in safety related radiation monitoring devices with commercial grade units. Prior to implementation and approval by the regulator, it was necessary to confirm the alternative commercial grade devices were suitable for nuclear operations and that the failure rate was acceptable. Use of the commercial grade devices resulted in quicker repair time for the safety related monitors, as well as a cost reduction from 250,000 yen per unit to 1000 yen per unit.
- A number of Kaizen improvement activities have generated both cost reduction and safety improvements. For example:

  - A review of the maintenance activities on safety related Ventilation Stack Sample Pumps at Kashiwazaki-Kariwa (KK) allowed the activities to be streamlined and improved the availability of critical spares, thus reducing the overall equipment downtime.
  - Fukushima Daiini (2F) maintenance teams through progressive Kaizen activities have changed the testing of HVAC dampers, thus removing the need to access high elevation areas, and reducing the number of people involved from five to one. As a result, industrial safety hazards were reduced.

- Fukushima Daiich (1F) civil engineering teams streamlined the process for installing welded treated water storage tanks reducing the installation time by 80 percent.

Support and involvement in the Kaizen process is achieved through a structured process of training, education, coaching and support. For example, all staff have received basic awareness training. In addition, one-third of all staff have received the next level of training, termed ‘Triple Kaizen’, and those responsible for training and coaching have received the highest level of training, termed ‘Total Kaizen’. This extensive training has contributed to approximately 20 percent of all activities undertaken to date being subject to Kaizen improvement activities.

Potential Kaizen improvement activities are proposed, analysed, and assessed in a structured manner, with implementation controlled by established change control and configuration control processes, governance, and approvals. Potential impacts on nuclear safety and other potential risks related to personnel and plant equipment are also considered. A review, decision, and escalation process has been defined and implemented to review potential Kaizen improvement activities. The more significant Kaizen improvement activities, such as those with large potential cost savings or applicable across the fleet, are escalated for review at the company level Study Meeting.

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ABBREVIATIONS

AI	artificial intelligence
ALARA	as low as reasonably achievable
CM	corrective maintenance
DM	deficient maintenance
EP	emergency plan
EWP	electronic work packages
FEG	functional equipment grouping
FIN	fix-it-now
INPO	Institute for Nuclear Power Operations
KPI	key performance indicator
LCO	limiting condition for operation
NPP	nuclear power plant
PM	preventive maintenance
PRA	probabilistic safety analysis
PSA	probabilistic safety assessment
RP	radiation protection
RWP	radiation work permit
RWP	radiation work permit
SCs	system and components
SSCs	systems structures and components
TEPCO	Tokyo Electric Power Company
WMP	work management process
WWM	workweek manager

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