
Maintenance Reference Based Learning Objectives

Technical Bases

Revision 0

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Introduction

This document sets forth Maintenance Reference Based Learning Objectives (MRBO) for training of nuclear plant maintenance personnel. Industry documents establish the minimum standards associated with the content of training programs for each of the maintenance disciplines. This bases document in no way compromises or supplants these industry standards or any individual company procedure, policy, or guide.

Instructional material developers should refer to this document for guidance on the development of advanced system and component training materials used to transfer the cognitive skills required by the Nuclear Maintenance Department. The MRBO are intended to reinforce and build on the cognitive skills delivered in orientation, fundamental and basic systems training. Basic systems training for Maintenance Department personnel is conducted using the applicable Operations Training materials for systems and is limited to content for the objectives listed in Table 2, System Operations RBO to ACAD 92-008 (MTCE) Cross Reference.

When mastery of the MRBO is evaluated using written evaluation, incumbents have access to all approved plant-reference documents. Initial candidates demonstrate competence at the “memory” level unless otherwise specified. In local documents, this may be expressed using a *conditional statement of evaluation* similar to “Initial candidates demonstrate from memory or using specifically authorized references and incumbents demonstrate using approved plant- reference documents ...”

This document serves as a reference guide only. Specific requirements for the development of training and examination materials including written and performance tests, are per NMP-TR (or senior) series procedures.

Minimum Level of Competence (MLC) v. Standards of Performance

The minimum performance required on initial candidate and incumbent examinations in various (cited) source documents as “80%”. This document presumes this to be minimum level of competence (MLC) throughout maintenance training programs.

In this document the term “standard” refers to the acknowledged measure of comparison for quantitative or qualitative value or the criterion¹ – in other words, the application and performance expectation is the “standard” while the regulatory (or governing) document that establishes the need or requirement for the knowledge or skill is the “reference criterion”. This differs from the frequently accepted “standard of performance” being “...successful completion of a written examination with a minimum score of 80%.”

The approach used herein views the standard of performance as the ability to apply the required knowledge to the degree specified for the position under consideration.

Performance Criterion

In the RBO approach, plant-reference documents establish the performance criterion or job performance standard. These include design and licensing documents, technical specifications, plant procedures, vendor manuals, and standards for Conduct of Maintenance (GAP-MAI-01 or Constellation (CGG) equivalent).

¹ A standard, rule, or test on which a judgment or decision can be based. (In the RBO use of “criterion,” the critical word is “rule.”)

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Providing the student with the specific performance criteria for each of the reference-based objectives ensures awareness of the standard of evaluation and establishes the relevance of the objective (and its content) to the student's position. These "application performance standards" also support criteria for acceptable performance during Task Performance Evaluations.

Consistent application of the knowledge required by the (job) position under study is the "standard of performance" associated with these Reference Based Learning Objectives. The "application performance standard" provides both student and instructor the boundaries or expectations of performance and behavior the knowledge engenders. This permits the establishment of a direct relationship between the learning objective and actual job performance.

The MLC is often and incorrectly associated with specific learning objectives. Consulting regulatory (or governing) documents, it is apparent that the intent is to deem a technician's knowledge as "competent" IF some nominal percentage (typically 80%) of the questions on an examination are answered correctly. There is a significant difference between this determination and the assessments made during a performance examination. The evaluator or examiner has the authority to refuse to pass a candidate or revoke the qualification of an incumbent based on the failure of any one of the criteria set forth in the regulatory (or governing) documents. The actual "standard of performance" is 100%, not 80%. Therefore, the correct "standard" for any of the reference-based objectives is one of demonstration. The Application Performance Standard identifies the attributes of competence assessed and the mechanisms the candidate or incumbent uses (either in the assessment or on the job) to convert knowledge into ability.

Evaluation Instruments

Two targets exist for developed content – both equally important and addressed in the RBO method. The performance criterion (PC), evaluated during task performance evaluations, laboratory evaluations, performance examinations, job or task walkdowns, and management observation; and the MLC as expressed through successful completion of written or scripted oral evaluation. In the SAT process, definition of these "targets" occurs before content development. Use of the RBO assists the developer by clearly defining the evaluation criteria (MLC and PC) and, to some extent, evaluation instruments for consideration.

Content Development

Content development requires access to and inclusion of plant-specific information and requirements. Senior or experienced line management should identify their expectations for position specific requirements prior to development and approval of training materials. The role of experienced incumbents and supervisory personnel in defining the scope of learning content is of particular importance when task analysis to the skills level has not been performed or validated against the target population. Additionally, ensuring that the required training is delivered to the correct audience when needed is a fundamental of effective ownership of training and plant performance improvement.

Developers using the RBO Basis Document consult the associated sections of the facility job and task analysis and industry, regulatory (or governing) documents to identify the topics required, then retrieve the supporting site information from approved plant-reference documents.

The Application Performance Standard associated with each objective determines the level of detail provided in developed content. No universal "rules" exist to guide developers therefore; task analyses, position descriptions, developer competence, and use of templates with some boilerplate all serve important roles in supporting consistent development **and** implementation of material.

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MRBO-1, Effect of Maintenance

Objective Statement: **Explain** the effect of maintenance activities on XXX [system] [equipment] [component] to plant or system operations.

Application Performance Standard: Demonstrate the ability to:

- **Recall** the general function of the system, equipment or component and its purpose with regard to overall plant or system operation,
- **Identify** alarms, indications, interlocks, and automatic features affected by specified maintenance activities,
- **Describe** system or equipment alignments and flow path for specified maintenance activities,
- **Predict** the effect of specified system, equipment or component maintenance activities on the ability of the system or equipment to fulfill its purpose and design function and,
- **Predict** overall plant or system response to equipment or component malfunctions or loss as a result of a maintenance activity.

The content for this objective is generally found in the FSAR, System Design Basis Document, System Design Description, equipment technical manuals, and vendor documents. It builds on cognitive skills transferred during basic systems training surrounding plant system purpose and function. For this reason, advanced maintenance topics should consider completion of the associated basic systems training as a prerequisite to any qualification award. The standard of performance for this objective is to **explain** the general effect that maintenance activities will have on plant or system operation. At the initial level, this infers that the candidate is able to identify the system components affected by maintenance activities and any alarms or indications operators may observe as the result of a specific maintenance action. For the incumbent, the standard includes the ability to **relate** the effect of component, system or equipment function to overall plant operation and **identify** the effect maintenance outcomes may have on the system or plant operability.

Learning content developed to support this objective should include a discussion of the effect maintenance activities have on systems with respect to Technical Specification applicability including Limiting Conditions for Operation. This does **not** imply that maintenance technicians are expected to demonstrate a thorough understanding of Technical Specifications, a basic recognition that maintenance on a given system (or component) has Technical Specification applicability is sufficient.

Learning content should also address the effect of maintenance on reactivity control², nuclear safety and those systems that serve a role in the implementation of Emergency Operating Procedures.

Development of initial level questions for this objective should consider how maintenance activities affect the system or equipment with respect to operability to assess trainee mastery. In the continuing training setting, questions should also consider how the system or equipment is used to accomplish specific plant operations and how the role of maintenance affects the ability of the system to accomplish these operations.

² See GAP-MAI-01, Conduct of Maintenance

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MRBO-2, Function, Relationship and Construction of Components

Objective Statement: With respect to [system] [equipment] maintenance activities, **describe** the function, relationship and construction of affected components.

Application Performance Standard: Demonstrate the ability, for an identified maintenance activity, to:

- **State** the purpose and function of system components or equipment parts,
- **Describe** the geographic location of components within the system or equipment,
- **Describe** the construction of system components or equipment parts,
- **Discriminate** and **distinguish** between variations of component models in terms of their construction, application and the performance of maintenance activities and,
- **Determine** the effect on the plant, system or equipment status, or radiological and other environmental conditions resulting from component maintenance.

The content for this objective will be derived from system or equipment technical documentation including the FSAR for certain high value safety systems and components. System Design Basis Documents, equipment technical manuals, vendor documents, maintenance procedures and standing work orders offer specific details not otherwise available.

The intent of this objective is, through either a constructive or de-constructive process, to permit the trainee to grasp the component functional interrelationships within the system or equipment and the physical (geographic) relationship of equipment to the plant, components to the system and parts to the component or equipment. Initial candidates state the purpose of identified components within the system or equipment, explain the relationships that exist between components, controls and component parts, to system or equipment performance. Additionally, trainees should demonstrate the ability to predict system or equipment behavior based on the normal function of each of the components identified. Satisfactory knowledge is evaluated by the trainee's ability to discriminate and distinguish one component from another in terms of operational effect on the system or equipment including automatic operation of the individual components. This objective introduces the foundation for **analysis** of system interactions including troubleshooting.

Questions that assess the trainee's ability to relate one component to another from an operational perspective or apply rules (considering interlocks, permissive or restrictive and controls) are appropriate at the initial level and above.

Mastery of this objective (incumbent level) is demonstrated by the ability of the trainee to analyze a maintenance activity with respect to its affect on component, equipment or system operability (e.g., given a maintenance activity with improperly performed steps, explain why a given outcome was obtained.)

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MRBO-3, Maintenance Methods and Techniques

Objective Statement: **Discuss** methods and techniques applied during the performance of maintenance activities on XXX [system] [equipment] [component]

Application Performance Standard: Demonstrate the ability to:

- **Describe** methods for breaching systems, including:
 - Applicable radiological exposure and contamination controls,
 - Considerations for the containment of leakage, and
 - Maintenance of safe work boundaries.
- **Describe** disassembly and assembly methods including removal, replacement, repair and torque techniques,
- **Describe** the foreign material exclusion controls required,
- **Explain** cleaning and inspection techniques,
- **Discuss** methods for performing adjustments and calibrations,
- **Identify** rigging and lifting techniques,
- **Describe** the use of required special tools or equipment (e.g. cranes, scaffolding, breaker grounding devices and etc.)
- **Explain** the objective of preventive maintenance techniques and the consequence of improper performance including:
 - Component lubrication,
 - Cleaning and inspection, and
 - Inservice Testing and Inspection
- **Discriminate** between post-maintenance testing methods (e.g. inspections, leak tests, component operation, functional test, valve operation) and,
- **Identify** the handling and disposal requirements for wastes or hazardous materials generated by a specific maintenance activity.

This objective will be applied differently depending on the maintenance discipline and activity under consideration. For example, the activities performed by mechanical maintenance technicians on large contaminated components (i.e., Reactor Recirculation Pump replacement) will require that rigging and lifting be addressed. The calibration of installed instrumentation by instrument technicians may require that only the performance of adjustments and calibration be addressed.

The intent of this objective is to provide trainees with the knowledge and skills required to safely and correctly perform a variety of maintenance activities. Inclusion of this objective is not appropriate for all topics or systems. When developing the cognitive learning content for performance exercises, dynamic learning activities, or for specific maintenance activities this objective is used to reinforce specific methods and techniques required by the activity. For the fundamental (Level 100) training phase, this objective is presented in its entirety as a topic. Continuing training and advanced qualification training should draw on specific attributes of this objective as required for reinforcement or the acquisition of advanced skills.

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The content for this objective will be derived from system or equipment technical documentation including System Design Basis Documents, equipment technical manuals, vendor documents, maintenance procedures and standing work orders.

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MRBO-4, Events and Human Performance

Objective Statement: **Describe** the application of error prevention techniques associated with XXX maintenance activities, a related event or operating experience report

Application Performance Standard: Demonstrate the ability to:

- **Analyze** the event and **determine** the contributing error precursors, latent organizational weaknesses and failed or ineffective barriers
- **Identify** the specific concern of an operating experience report to the system, equipment or component and specified maintenance activity and,
- **Determine** the organizational processes, job-site, and worker behaviors used to prevent or mitigate future occurrence of the event.

The material for developing content to this objective is extracted from Operating Experience data and should be specific to the maintenance activity, system or equipment discussed or applicable to the type of maintenance activity performed. Discussion of events should focus on the error precursors, latent organizational weaknesses and failed or ineffective barriers that resulted in the initiating event. Use of the INPO Performance Model focusing on organizational processes, job-site and worker behaviors, and plant results is also an effective tool for case study discussions surrounding plant or industry events.

Trainees are expected to recognize the significance of the event to plant and personnel safety, identify specific barriers that were violated or absent, and determine the specific actions used to prevent or mitigate future occurrence of the event. Learning content developed to support this objective **shall** use the terminology, techniques and processes established by Constellation Human Performance procedures and policies. Exercises developed to support this objective should challenge students to assure an understanding and ability to apply good human performance practices and recognize error-likely situations during (or when planning) maintenance activities.

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MRBO-5, Precautions, Limitations and Maintenance Fundamentals

Objective Statement: **Describe** the precautions, limitations, and Maintenance Department Expectations associated with the XXX maintenance procedures and activities to achieve the required maintenance outcome and management expectations.³

Standard of Performance: Demonstrate the ability, given a maintenance activity to:

- **Explain** the basis for a given precaution or limitation,
- **Recognize** when a precaution or limitation has been violated or is being enforced,
- **Illustrate** how the Maintenance Expectations are applied under various conditions and modes,
- **Discuss** potential safety hazards,
- **Identify** requirements for personal and radiological safety measures,
- **Describe** the application and use of devices to control radiological exposure,
- **Explain** the operational considerations associated with limits and requirements for environmentally qualified and safety related equipment or components.
- **Describe** administrative controls for local manual operation of components.

The content for this objective is derived from maintenance (and frequently operating) procedures, system design documents, operating experience reports (including LER, OE, SOER, etc.), and site or corporate procedures applicable to the conduct of maintenance. It is not intended for the developer to list all limits and precautions from procedures in the lesson materials. Detailed discussion of significant items that have direct effect on MRBO-6 or 7 topics, are the result of site events, specifically address system or equipment reliability, operability, safety, or containment of radioactivity should be included in training materials. Initial candidates are expected to review all precautions and limitations found in identified procedures with the learning content providing emphasis of those precautions and limitations having a direct effect on the maintenance outcomes for the system or equipment under study. The incumbent setting should review any precautions and limitations associated with infrequently performed procedures with emphasis on those that either are recent additions or have been associated with human performance events.

The expectation is that the initial candidate shall be able to explain the bases for a given precaution or limitation from procedures (maintenance or operating) and given plant condition(s), recognize when a precaution or limitation has been violated or is being enforced (in the case of interlocks preventing system response). Additionally, all student levels must demonstrate the ability to apply maintenance fundamentals associated with the system or equipment under study. The INPO “Fundamentals for Operations, Engineering, Maintenance, Radiological Protection, Chemistry and Training” document provides a valuable development resource for this topic.

Understanding and the ability to explain operational considerations associated with precautions and limitations are reinforced by material presented in the Basic Systems Course. Understanding

³ NMP does not have one source to describe the expectations of Maintenance Management. To extrapolate these, one must consult GAP-MAI-01, Conduct of Maintenance and other procedures including CG-HU series procedures.

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these concepts provides some assurance that Equipment Reliability is considered by personnel involved in the planning, supervision and execution of maintenance activities. This knowledge requirement is justified by the experience of the nuclear industry with respect to plant aging management and industry concerns of the appreciation of maintenance personnel for the effect improperly performed maintenance may have on the reliability of the station.

Knowledge of these operational considerations is a contributor toward realization of the goals of ACAD 98-006, Predictive Maintenance Activities To Improve Equipment Performance (see section 9.1).

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MRBO-6, Failure Modes and Corrective Actions

Objective Statement: **Describe** typical XXX [system] [equipment] [component] failure modes, causes and corrective actions.

Application Performance Standard: Demonstrate the ability to:

- **Identify** abnormal indications and **diagnose** the probable cause,
- **Describe** component failure modes, the symptoms associated with each and possible repair actions,
- **Discuss** methods and techniques for troubleshooting including possible diagnostic techniques,
- **Assess** the conditions and **determine** the corrective actions required to achieve the required equipment configuration or maintenance outcome,
- **Break down** a series of events, facts, conditions, indications and information regarding system, equipment or component status,
- **Prioritize** and **defend** proposed technician actions required to diagnose and troubleshoot system, equipment or component malfunctions.

A thorough understanding of the design, construction and typical failure modes of systems and components is required in order for maintenance technicians to support diagnostic and corrective actions required to support continued plant operation. Recognition of abnormal operating indications by experienced maintenance personnel has been pivotal in preventing serious plant events and personnel injury. The content of this objective is derived from plant operating experience, maintenance databases and history (e.g., EPIX), vendor equipment manuals, Industry Notifications available from the NRC website, standing work orders, and plant procedures.

It is not expected that candidates will possess or grasp the same level of mastery as experienced technicians. Therefore, this topic should be presented in a setting that lends itself for the transfer of *tacit knowledge* from more experienced personnel. Discussions pertaining to methods and techniques and the deconstruction of events should be framed using a case study approach when possible.

Substantial benefit to the overall fundamentals knowledge of the station may be achieved by the use of Dynamic Learning Activities when presenting this topic in the continuing training setting.

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MRBO-7, Maintenance Actions and Sequence

Objective Statement: **Describe** the basic maintenance actions and sequence associated with the XXX maintenance task as they apply to:

- a) Removal and installation activities,
- b) Cleaning and rebuilding activities,
- c) Post-Maintenance testing,
- d) Special testing and,
- e) Documentation requirements

Application Performance Standard: Demonstrate the ability, given a set of plant, system or equipment conditions, sequence of events or desired maintenance outcome, to:

- **Assess** the conditions and **determine** the procedural actions, equipment configuration or required maintenance activities,
- **Predict** the effects of maintenance activities on environmental conditions and plant area habitabilityⁱ,
- **Identify** when components have been properly removed from service to allow performance of maintenance activities,
- **Identify** the sequence of maintenance actions to achieve the required maintenance outcome,
- **Prioritize** technician actions required to achieve the required maintenance outcome,
- **Identify and explain**:
 - Required interdepartmental notifications,
 - Documentation of actions and component parameters,
 - Acceptance criteria determination,
 - Program commitments,
 - Component testing requirements,
 - Component visual inspection characteristics,
 - Installation activities and,
 - Operational test characteristics,

The content for this objective is generally extracted from plant procedures. It is the intent of this objective that initial candidates demonstrate the ability to **restate** (in their own words) the general sequenceⁱⁱ of maintenance activities required to achieve the desired maintenance outcome. Additionally, given a set of equipment conditions or sequence of events, the trainee is expected to **assess** the conditions and **determine** the required configuration or outcome and **prioritize** maintenance actions to achieve the desired outcome. For example, the ability to evaluate maintenance work order and determine if the sequence of activities could reasonably be expected to result in the desired outcome.

Incumbents are generally evaluated on this objective during dynamic learning activities in a field (or laboratory) setting or during management observations during actual maintenance activities. Written questions for incumbents should require the demonstration of the ability to assess

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conditions and events, differentiate between procedures based on conditions and events then prioritize technician actions to select the correct procedure and, or actions to achieve the required (desired) maintenance outcome.

This objective applies whenever training for a specific maintenance task is being developed and may be applicable to non-maintenance disciplines (i.e. Engineering or Operations). The use of this objective in multi-discipline dynamic learning activities will increase the awareness of personnel to the effect activities of one discipline has on another. Ownership of overall quality for maintenance actions and systems longevity (plant aging management) considerations should be included in the content supporting this objective.

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Table 1, Maintenance RBO to ACAD 92-008 (MTCE) Cross Reference

Supporting Maintenance RBO	ACAD 93-008 Section 8.2
1,2	Identify alarms, indications, interlocks, and automatic features affected by important maintenance activities.
1,2	Identify abnormal system and component indications and diagnose the probable causes.
6	Describe component failure modes (e.g., valve thermal binding and relay failures) and discuss the possible diagnostic and repair actions that may be necessary.
3	Discuss the proper methods and practices for safe troubleshooting of defective components.
5	Explain the limitations of and requirements for maintenance activities associated with environmentally qualified and safety-related components and equipment
7	Identify when components have been removed properly from service before performing maintenance activities.
3,7	Describe proper methods for breaching systems, including applicable radiological exposure and contamination controls.
5	Discuss potential hazards (e.g., electrical shock, high-temperature or high-pressure fluid used in system) associated with performing maintenance activities on specific systems.
3,7	Describe proper disassembly and assembly methods, including removal, replacement, repair, and torque techniques.
3	Identify system cleanliness requirements and describe the methods used to prevent foreign material from entering systems and components.
3,7	Discuss the proper methods for performing adjustments and calibrations on components or systems.
5	Identify industrial safety measures necessary for performing work in the vicinity of specific operating equipment.
3	Explain acceptable cleaning and inspection techniques for system components.
3	Identify proper rigging and lifting techniques for major components such as pumps and motors.
3,7	Identify where the use of special tools or equipment (e.g., cranes, scaffolding, breaker grounding devices) will be required and describe how they will be used when working on various components.
5	Describe the application and operation of various devices (e.g., video cameras, filter removal tools, remotely operated machines) used for radiological exposure reduction.

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- 3 Explain the lubrication principles associated with components such as valves, pumps, motors, and valve actuators, including the problems associated with improper lubrication.
- 3,7 Discuss the methods to test (e.g., leakage test, component operation, loop functional test, valve operation) a component when maintenance work is completed.
- 5 Describe the administrative controls for performing local and manual operation of components during maintenance activities.
- 3 Describe the proper methods for handling and disposing of waste or hazardous materials resulting from system maintenance.
- 3,7 Explain post-maintenance testing requirements and responsibilities, including the following attributes:
- interdepartmental notifications (e.g., operations, quality control, engineering)
 - importance of documenting maintenance actions and component parameters
 - acceptance criteria determination
 - program commitments (e.g., technical specifications, industry standards, regulatory documents)
 - component testing requirements (e.g., inspection, leak test, functional test, calibration) associated with a work activity
 - visual inspection characteristics (e.g., component free of corrosion, fasteners/terminations tight)
 - installation activities (e.g., wiring checks, pressure tests, torque verifications)
 - operational test characteristics (e.g., proper rotation, temperature, voltage, pressure)

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Table 2, System Operations RBO to ACAD 92-008 (MTCE) Cross Reference

Supporting System Operations RBO	ACAD 93-008 Section 8.1 Items
2	Identify major plant equipment.
2	Explain the purpose, application, and principles of operation of key components.
3, 5.a, 5.c	Explain system flowpaths.
1, 7	Explain the importance of the system to nuclear safety.
8.a	Identify the basic interrelationships with other plant systems and units.
5	Describe normal values of important parameters.
1	Identify systems affected by the plant technical specifications.
11.b	Describe the basic effect on system operation from a selected maintenance activity.

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Change Summary

0	Initial development and issuance for use
1	
2	

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End Notes

ⁱ Environmental conditions include temperature, noise level, humidity, and radiation levels including radioactivity release. Habitability refers to those conditions required to gain access to and operate plant equipment including release of system fluids, steam, heat, radiation, hazardous materials, or other conditions that challenge the ability of personnel to operate plant components.

ⁱⁱ The phrase “general sequence” implies that the trainee, at the initial candidate level, is not expected to recall from memory exact procedure wording or component identification. For example; if a pump’s driver or gearing requires a pre-lubrication period before introducing flow through the pump, the trainee should recognize that placing this step (action) after opening both suction and discharge valves is incorrect.