# TECHNICAL SPECIFICATIONS BASES

FOR THE

# DIABLO CANYON

# INDEPENDENT SPENT FUEL STORAGE INSTALLATION

**Docket No. 72-26**

**Materials License No. SNM-2511**

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B 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

BASES

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| LCO | LCO 3.0.1, 3.0.2, and 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated. |
| LCO 3.0.1 | LCO 3.0.1 establishes the Applicability statement within each individual Specification as the requirement for when the LCO is required to be met (i.e., when the facility is in the specified conditions of the Applicability statement of each Specification.) |
| LCO 3.0.2 | LCO 3.0.2 establishes that upon discovery of a failure to meet an LCO, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS condition is applicable from the point in time that an ACTIONS condition is entered. The Required Actions establish those remedial measures that must be taken within specified Completion Times when the requirements of an LCO are not met. This Specification establishes that:<br>a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a Specification; and<br>b. Completion of the Required Actions is not required when an LCO is met within the specified Completion Time, unless otherwise specified.<br>There are two basic types of Required Actions. The first type of Required Action specifies a time limit in which the LCO must be met. This time limit is the Completion Time to restore a system or component or to restore variables to within specified limits. Whether stated as a Required Action or not, correction of the entered condition is an action that may always be considered upon entering ACTIONS. The second type of Required Action specifies the remedial measures that permit continued operation that is not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.<br>Completing the Required Actions is not required when an LCO is met or is no longer applicable, unless otherwise stated in the individual Specifications.<br>The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillances, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience. |

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BASES (continued)

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| LCO 3.0.3 | This specification is not applicable to the Diablo Canyon ISFSI because it describes conditions under which a power reactor must be shut down when an LCO is not met and an associated ACTION is not met or provided. The placeholder is retained for consistency with the power reactor technical specifications. |
| LCO 3.0.4 | LCO 3.0.4 establishes limitations on changes in specified conditions in the Applicability when an LCO is not met. It precludes placing the facility in a specified condition stated in that Applicability (e.g., Applicability desired to be entered) when the following exist:<br><br>a. Facility conditions are such that the requirements of the LCO would not be met in the Applicability desired to be entered; and<br><br>b. Continued noncompliance with the LCO requirements, if the Applicability were entered, would result in being required to exit the Applicability desired to be entered to comply with the Required Actions.<br><br>Compliance with Required Actions that permit continued operation of the facility for an unlimited period of time in a specified condition provides an acceptable level of safety for continued operation. This is without regard to the status of the facility. Therefore, in such cases, entry into a specified condition in the Applicability may be made in accordance with the provisions of the Required Actions. The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.<br><br>The provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS, or that are related to the unloading of an SFSC<br><br>Exceptions to LCO 3.0.4 are stated in the individual Specifications. Exceptions may apply to all the ACTIONS or to a specific Required Action of a Specification. |

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BASES (continued)

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| LCO 3.0.5 | This specification is not applicable to the Diablo Canyon ISFSI because it describes conditions under which a power reactor must be shut down when an LCO is not met and an associated ACTION is not met or provided. The placeholder is retained for consistency with the power reactor technical specifications. |

B 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

BASES

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**SRs**

SR 3.0.1 through SR 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

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**SR 3.0.1**

SR 3.0.1 establishes the requirement that SRs must be met during the specified conditions in the Applicability for which the requirements of the LCO apply, unless otherwise specified in the individual SRs. This Specification is to ensure that Surveillances are performed to verify that systems and components meet the LCO and variables are within specified limits. Failure to complete a Surveillance within the specified Frequency, in accordance with SR 3.0.2, constitutes a failure to meet an LCO.

Systems and components are assumed to meet the LCO when the associated SRs have been met. Nothing in this Specification, however, is to be construed as implying that systems or components meet the associated LCO when:

a. The systems or components are known to not meet the LCO, although still meeting the SRs; or

b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

Surveillances do not have to be performed when the facility is in a specified condition for which the requirements of the associated LCO are not applicable, unless otherwise specified.

Surveillances including Surveillances invoked by Required Actions, do not have to be performed on equipment that has been determined to not meet the LCO because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with SR 3.0.2, prior to returning equipment to service. Upon completion of maintenance, appropriate post-maintenance testing is required. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with SR 3.0.2.

Post-maintenance testing may not be possible in the current specified conditions in the Applicability due to the necessary facility parameters not having been established. In these situations, the equipment may be considered to meet the LCO provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow operation to proceed to a specified condition where other necessary post-maintenance tests can be completed.

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BASES (continued)

SR 3.0.2

SR 3.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a "once per....." interval.

SR 3.0.2 permits a 25% extension of the interval specified in the Frequency. This extension facilitates Surveillance scheduling and considers facility conditions that may be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities).

The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with SRs. The exceptions to SR 3.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual Specifications as a Note in the Frequency stating, "SR 3.0.2 is not applicable."

As stated in SR 3.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a "once per ...." basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion Time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the affected equipment in an alternative manner.

The provisions of SR 3.0.2 are not intended to be used repeatedly merely as an operational convenience to extend Surveillance intervals or periodic Completion Time intervals beyond those specified.

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BASES (continued)

SR 3.0.3

SR 3.0.3 establishes the flexibility to defer declaring affected equipment as not meeting the LCO or an affected variable outside the specified limits when a Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is less, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with SR 3.0.2, and not at the time that the specified frequency was not met.

This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of a Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

The basis for this delay period includes consideration of facility conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements. When a Surveillance with a Frequency based not on time intervals, but upon specified facility conditions, is discovered not to have been performed when specified, SR 3.0.3 allows the full delay period of 24 hours to perform the Surveillance.

SR 3.0.3 also provides a time limit for completion of Surveillances that become applicable as a consequence of changes in the specified conditions in the Applicability imposed by the Required Actions.

Failure to comply with specified Frequencies for SRs is expected to be an infrequent occurrence. Use of the delay period established by SR 3.0.3 is a flexibility, which is not intended to be used as an operational convenience to extend Surveillance intervals.

If a Surveillance is not complete within the allowed delay period, then the equipment is considered to not meet the LCO or the variable is considered outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon expiration of the delay period. If a Surveillance is failed within the delay period, then the equipment does not meet the LCO, or the variable is outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon the failure of the Surveillance.

Completion of the Surveillance within the delay period allowed by this Specification, or within the Completion Time of the ACTIONS, restores compliance with SR 3.0.1.

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BASES (continued)

**SR 3.0.4**

SR 3.0.4 establishes the requirement that all applicable SRs must be met before entry into a specified condition in the Applicability.

This Specification ensures that system and component requirements and variable limits are met before entry into specified conditions in the Applicability for which these systems and components ensure safe operation of the facility.

The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

However, in certain circumstances, failing to meet an SR will not result in SR 3.0.4 restricting a change in specified condition. When a system, subsystem, division, component, device, or variable is outside the specified limits, the associated SR(s) are not required to be performed per SR 3.0.1, which states that Surveillances do not have to be performed on equipment that has been determined to not meet the LCO. When equipment does not meet the LCO, SR 3.0.4 does not apply to the associated SR(s) since the requirement for the SR(s) to be performed is removed. Therefore, failing to perform the Surveillance(s) within the specified Frequency does not result in an SR 3.0.4 restriction to changing specified conditions of the Applicability. However, since the LCO is not met in this instance, LCO 3.0.4 will govern any restrictions that may (or may not) apply to specified condition changes.

The provisions of SR 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS.

The precise requirements of performance of SRs are specified such that exceptions to SR 3.0.4 are not necessary. The specific time frames and conditions necessary for meeting the SRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances when the prerequisite condition(s) specified in a Surveillance procedure require entry into the specified condition in the Applicability of the associated LCO prior to the performance or completion of a Surveillance. A Surveillance that could not be performed until after entering the LCO Applicability would have its Frequency specified such that it is not "due" until the specific conditions needed are met. Alternately, the Surveillance may be stated in the form of a Note as not required (to be met or performed) until a particular event, condition, or time has been reached. Further discussion of the specific formats of SRs annotation is found in Diablo Canyon ISFSI Technical Specification Section 1.4, Frequency.

# B 3.1 SPENT FUEL STORAGE CASK (SFSC) INTEGRITY

## B 3.1.1 Multi-Purpose Canister (MPC)

BASES

BACKGROUND

A TRANSFER CASK with an empty MPC is placed in the spent fuel pool and loaded with fuel assemblies meeting the requirements TS Section 2.0 Approved Contents. A lid is then placed on the MPC. An MPC lid retention device is placed over the lid and attached to the TRANSFER CASK. The TRANSFER CASK and MPC are raised to the top of the spent fuel pool surface. The TRANSFER CASK and MPC are then moved into the cask washdown area where dose rates are measured and the MPC lid is welded to the MPC shell and the welds are inspected and tested. The water is drained from the MPC cavity and moisture removal performed. The MPC cavity is backfilled with helium. Additional dose rates are measured and the MPC vent and drain cover plates and closure ring are installed and welded. Inspections are performed on the welds. TRANSFER CASK bottom pool lid is replaced with the transfer lid to allow eventual transfer of the MPC into the OVERPACK.

MPC cavity moisture removal using vacuum drying or forced helium recirculation is performed to remove residual moisture from the MPC fuel cavity after the MPC has been drained of water. If vacuum drying is used, any water that has not drained from the fuel cavity evaporates from the fuel cavity due to the vacuum. This is aided by the temperature increase due to the decay heat of the fuel.

If helium recirculation is used, the dry gas introduced to the MPC cavity through the vent and drain port absorbs the residual moisture in the MPC. This humidified gas exits the MPC via the other port and the absorbed water is removed through condensation and/or mechanical drying. The dried helium is then forced back though the MPC until the temperature acceptance limit is met.

After the completion of moisture removal, the MPC cavity is backfilled with helium meeting the backfill pressure requirements of the LCO.

Backfilling of the MPC fuel cavity with helium promotes gaseous heat dissipation and the inert atmosphere protects the fuel cladding. Providing a helium pressure in the required range at room temperature (70° F), eliminates air in-leakage over the life of the MPC because the cavity pressure rises due to heat up of the confined gas by the fuel decay heat during storage.

In-leakage of air could be harmful to the fuel. Prior to moving the SFSC to the storage pad, the MPC helium leak rate is determined to ensure that the fuel is confined.

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BASES

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| APPLICABLE SAFETY ANALYSIS | The confinement of radioactivity during the storage of spent fuel in the MPC is ensured by the multiple confinement boundaries and systems. The barriers relied on are the fuel pellet matrix, the metallic fuel cladding tubes in which the fuel pellets are contained, and the MPC in which the fuel assemblies are stored. Long-term integrity of the fuel and cladding depend on storage in an inert atmosphere. This is accomplished by removing water from the MPC and backfilling the cavity with an inert gas. The thermal analyses of the MPC assume that the MPC cavity is filled with dry helium of a minimum quality to ensure the assumptions used for convection heat transfer are preserved. Keeping the backfill pressure below the maximum value preserves the initial condition assumptions made in the MPC over-pressurization evaluation. |
| LCO | A dry, helium filled and sealed MPC establishes an inert heat removal environment necessary to ensure the integrity of the multiple confinement boundaries. Moreover, it also ensures that there will be no air in-leakage into the MPC cavity that could damage the fuel cladding over the storage period. |
| APPLICABILITY | The dry, sealed and inert atmosphere is required to be in place during TRANSPORT OPERATIONS and STORAGE OPERATIONS to ensure both the confinement barriers and heat removal mechanisms are in place during these operating periods. These conditions are not required during LOADING OPERATIONS or UNLOADING OPERATIONS as these conditions are being established or removed, respectively during these periods in support of other activities being performed with the stored fuel. |
| ACTIONS | A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each MPC. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each MPC not meeting the LCO. Subsequent MPCs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.<br><u>A.1</u><br><br>If the cavity vacuum drying pressure *or* demoisturizer exit gas temperature limit has been determined not to be met during TRANSPORT OPERATIONS or STORAGE OPERATIONS, an engineering evaluation is necessary to determine the potential quantity of moisture left within the MPC cavity. Since moisture remaining in the cavity during these modes of operation may represent a long-term degradation concern, immediate action is not necessary. The Completion Time is sufficient to complete the engineering evaluation commensurate with the safety significance of the CONDITION. |

(continued)

BASES (continued)

A.2

Once the quantity of moisture potentially left in the MPC cavity is determined, a corrective action plan shall be developed and actions initiated to the extent necessary to return the MPC to an analyzed condition. Since the quantity of moisture estimated under Required Action A.1 can range over a broad scale, different recovery strategies may be necessary. Since moisture remaining in the cavity during these modes of operation may represent a long-term degradation concern, immediate action is not necessary. The Completion Time is sufficient to develop and initiate the corrective actions commensurate with the safety significance of the CONDITION.

B.1

If the helium backfill pressure limit has been determined not to be met during TRANSPORT OPERATIONS or STORAGE OPERATIONS, an engineering evaluation is necessary to determine the quantity of helium within the MPC cavity. Since too much or too little helium in the MPC during these modes represents a potential overpressure or heat removal degradation concern, an engineering evaluation shall be performed in a timely manner. The Completion Time is sufficient to complete the engineering evaluation commensurate with the safety significance of the CONDITION.

B.2

Once the quantity of helium in the MPC cavity is determined, a corrective action plan shall be developed and initiated to the extent necessary to return the MPC to an analyzed condition. Since the quantity of helium estimated under Required Action B.1 can range over a broad scale, different recovery strategies may be necessary. Since elevated or reduced helium quantities existing in the MPC cavity represent a potential overpressure or heat removal degradation concern, corrective actions should be developed and implemented in a timely manner. The Completion Time is sufficient to develop and initiate the corrective actions commensurate with the safety significance of the CONDITION.

(continued)

C.1

If the helium leakrate limit has been determined not to be met during TRANSPORT OPERATIONS or STORAGE OPERATIONS, an engineering evaluation is necessary to determine the impact of increased helium leak rate on heat removal and off-site dose. Since the HI-STORM OVERPACK is a ventilated system, any leakage from the MPC is transported directly to the environment. Since an increased helium leak rate represents a potential challenge to MPC heat removal and the off-site doses calculated in the SAR confinement analyses, reasonably rapid action is warranted. The Completion Time is sufficient to complete the engineering evaluation commensurate with the safety significance of the CONDITION.

C.2

Once the cause and consequences of the elevated leak rate from the MPC are determined, a corrective action plan shall be developed and initiated to the extent necessary to return the MPC to an analyzed condition. Since the recovery mechanisms can range over a broad scale based on the evaluation performed under Required Action C.1, different recovery strategies may be necessary. Since an elevated helium leak rate represents a challenge to heat removal rates and off-site doses, reasonably rapid action is required. The Completion Time is sufficient to develop and initiate the corrective actions commensurate with the safety significance of the CONDITION.

D.1

If the MPC fuel cavity cannot be successfully returned to a safe, analyzed condition, the fuel must be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable based on the time required to replace the transfer lid with the pool lid, perform fuel cooldown operations, re-flood the MPC, cut the MPC lid welds, move the TRANSFER CASK into the spent fuel pool, remove the MPC lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

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SURVEILLANCE REQUIREMENTS

SR 3.1.1.1, SR 3.1.1.2, and SR 3.1.1.3

The long-term integrity of the stored fuel is dependent on storage in a dry, inert environment. For moderate burnup fuel cavity dryness may be demonstrated either by evacuating the cavity to a very low absolute pressure and verifying that the pressure is held over a specified period of time or by recirculating dry helium through the MPC cavity to absorb moisture until the demoisturizer exit temperature reaches and remains below the acceptance limit for the specified time period. A low vacuum pressure or a demoisturizer exit temperature meeting the acceptance limit is an indication that the cavity is dry.

Having the proper helium backfill pressure ensures adequate heat transfer from the fuel to the fuel basket and surrounding structure of the MPC. Meeting the helium leak rate limit ensures there is adequate helium in the MPC for long term storage and the leak rate assumed in the confinement analyses remains bounding for off-site dose.

The leakage rate acceptance limit is specified in units of atm-cc/ sec. This is a mass-like leakage rate as specified in ANSI N14.5 (1997). This is defined as the rate of change of the pressure-volume product of the leaking fluid at test conditions. This allows the leakage rate as measured by a mass spectrometer leak detector (MSLD) to be compared directly to the acceptance limit without the need for unit conversion from test conditions to standard, or reference conditions.

All three of these surveillances must be successfully performed once, prior to TRANSPORT OPERATIONS to ensure that the conditions are established for SFSC storage, which preserve the analysis basis supporting the cask design.

(continued)

REFERENCES

1. Diablo Canyon ISFSI SAR Sections 3.1.2, and 3.3.1.7
2. Diablo Canyon ISFSI SAR Section 4.2.3.3 and Table 4.5-1
3. Diablo Canyon ISFSI SAR Section 5.1.1.2 and Table 5.1-1
4. Diablo Canyon ISFSI SAR Sections 7.5.2.1 and Table 7.4-1
5. Diablo Canyon ISFSI SAR Section 8.2.7.2.2
6. Diablo Canyon ISFSI SAR Sections 10.2.2.3, 10.2.2.4, 10.2.2.5 and Figure 10.2-4.

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B 3.1 SPENT FUEL STORAGE CASK (SFSC) INTEGRITY

B 3.1.2 Spent Fuel Storage Cask (SFSC) Heat Removal System

BASES

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| BACKGROUND | The SFSC heat removal system is a passive, air-cooled, convective heat transfer system that ensures heat from the MULTI-PURPOSE CANISTER (MPC) is transferred to the environs by the chimney effect. Relatively cool air is drawn into the annulus between the OVERPACK and the MPC through the four inlet air ducts at the bottom of the OVERPACK. The MPC transfers its heat from the canister surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect and the air is forced back into the environs through the four outlet air ducts at the top of the OVERPACK. |
| APPLICABLE SAFETY ANALYSIS | The thermal analyses of the SFSC take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the SFSC. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and other SFSC component temperatures do not exceed applicable limits. Under normal storage conditions, the four inlet and four outlet air ducts are unobstructed and full air flow (i.e., maximum heat transfer for the given ambient temperature) occurs.<br><br>Analyses have been performed for the complete obstruction of two, three, and four inlet air ducts. Blockage of two inlet air ducts reduces airflow through the OVERPACK annulus and decreases heat transfer from the MPC. Under this off-normal condition, no SFSC components exceed the short-term temperature limits.<br><br>Blockage of three inlet air ducts further reduces airflow through the OVERPACK annulus and decreases heat transfer from the MPC. Under this accident condition, no SFSC components exceed the short-term temperature limits.<br><br>The complete blockage of all four inlet air ducts stops air-cooling of the MPC. The MPC will continue to radiate heat to the relatively cooler inner shell of the OVERPACK. With the loss of air-cooling, the SFSC component temperatures will increase toward their respective short-term temperature limits. None of the components reach their temperature limits over the 72-hour duration of the analyzed event. Therefore, the limiting component is assumed to be the fuel cladding. |

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BASES (continued)

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| LCO | The SFSC heat removal system must be verified to be operable to preserve the assumptions of the thermal analyses. The operability of the heat removal system ensures that the decay heat generated by the stored fuel assemblies is transferred to the environs at a sufficient rate to maintain fuel cladding and other SFSC component temperatures within design limits. |
| APPLICABILITY | The LCO is applicable during STORAGE OPERATIONS. Once an OVERPACK containing an MPC loaded with approved contents has been placed in storage, the heat removal system must be operable to ensure adequate heat transfer of the decay heat away from the fuel assemblies. |
| ACTIONS | A note has been added to the ACTIONS, which states that for this LCO, separate condition entry is allowed for each SFSC. This is acceptable since the Required Actions for each condition provide appropriate compensatory measures for each SFSC not meeting the LCO. Subsequent SFSCs that don't meet the LCO are governed by subsequent condition entry and application of associated Required Actions.<br><br><u>A.1</u><br><br>If the heat removal system has been determined to be inoperable, it must be restored to operable status within 8 hours. Eight hours is reasonable period of time (typically, one operating shift) to take action to remove the obstructions in the air flow path.<br><br><u>A.2.1</u><br><br>As an alternative to meeting A.1, adequate heat removal capability must be verified to exist to prevent exceeding the short-term fuel cladding temperature limit. This verification must be performed immediately.<br><br>Thermal analysis of a fully blocked SFSC shows that without adequate heat removal the fuel cladding short-term temperature limit could be exceeded over time. As a result, requiring immediate verification of adequate heat removal capability will ensure that the SFSC components and the fuel cladding do not exceed their short-term temperature limits.<br><br>The thermal analysis also shows that only complete blockage of all four vents results in the potential for exceeding short-term fuel cladding or other SFSC component limits. As a result, verifying that there is at least one vent operable or the equivalent cooling of one operable vent will ensure that the short-term limits are not exceeded while the remainder of the inlet vents are returned to operable status under Action A.2.2. |

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BASES

ACTIONS (continued)

A.2.2

In addition to Required Action A.2.1, efforts must continue to restore the heat removal system to operable status.

As long as the adequate heat removal capability that was verified in A.2.1 exists, restoring the SFSC heat removal system to complete operability is not an immediate concern. Therefore, restoring it within 30 days is considered a reasonable period of time.

B.1

If the A.1, A.2.1 and A.2.2 actions cannot be met then the affected MPC must be placed in a safe condition. Transferring the affected MPC from the inoperable SFSC to the TRANSFER CASK will place the MPC in an analyzed condition. The TRANSFER CASK has adequate heat removal capability to ensure that the short-term fuel cladding temperature limit is not exceeded.

Transfer of the MPC into a TRANSFER CASK removes the SFSC from the LCO applicability. STORAGE OPERATIONS does not include time restrictions when the MPC resides in the TRANSFER CASK because of adequate heat transfer in this configuration to maintain peak fuel cladding temperature well below the short term limit.

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BASES

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| ACTIONS (continued) | B.1 (continued)<br><br>If actions A.1, A.2.1 and A.2.2 are not met the Completion Time for this Required Action is immediate. Thermal analysis of a fully blocked SFSC shows that without adequate heat removal the fuel cladding short-term temperature limit could be exceeded over time. The analysis shows that without heat removal for the first 72 hours the SFSC components and the fuel cladding do not exceed their short-term temperature limits. However at that time, the temperatures are continuing to increase. By requiring immediate action, this should allow adequate time to transfer the MPC to the TRANSFER CASK as not to exceed the 72 hours. |
| SURVEILLANCE REQUIREMENTS | SR 3.1.1<br><br>The long-term integrity of the stored fuel is dependent on the ability of the SFSC to reject heat from the MPC to the environment. Visual observation that all four inlet and outlet air ducts are unobstructed and intact ensures that airflow past the MPC is occurring and heat transfer is taking place. Complete blockage of any one or more inlet or outlet air ducts renders the heat removal system inoperable and this LCO not met. Partial blockage of one or more inlet or outlet air ducts does not constitute inoperability of the heat removal system. However, corrective actions should be taken promptly to remove the obstruction and restore full flow through the affected duct(s).<br><br>The Frequency of 24 hours is reasonable based on the time necessary for SFSC components to heat up to unacceptable temperatures assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of blockage of air ducts. |
| REFERENCES | 7. Diablo Canyon ISFSI SAR Section 3.4, Table 3.4-2<br>8. Diablo Canyon ISFSI SAR Section 4.4<br>9. Diablo Canyon ISFSI SAR Sections 7.1, 7.2, and 7.3<br>10. Diablo Canyon ISFSI SAR Section 8.1<br>11. Diablo Canyon ISFSI SAR Sections 8.2.11, 8.2.12, and 8.2.15 |

B 3.1 SPENT FUEL STORAGE CASK (SFSC) INTEGRITY

B 3.1.3 Fuel Cool-Down

BASES

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| BACKGROUND | In the event that an MPC must be unloaded, the TRANSFER CASK with its enclosed MPC is returned to the cask preparation area to begin the process of fuel unloading. The MPC closure ring, and vent and drain port cover plates are removed. The MPC gas is sampled to determine the integrity of the spent fuel cladding. The MPC is attached to the Cool-Down System. The Cool-Down System is a closed-loop forced ventilation gas cooling system that cools the fuel assemblies by cooling the surrounding helium gas.<br><br>Following fuel cool-down, the MPC is then re-flooded with water and the MPC lid weld is removed leaving the MPC lid in place. The transfer cask and MPC are placed in the spent fuel pool and the MPC lid is removed. The fuel assemblies are removed from the MPC and the MPC and transfer cask are removed from the spent fuel pool and decontaminated.<br><br>Reducing the fuel cladding temperatures significantly reduces the temperature gradients across the cladding thus minimizing thermally-induced stresses on the cladding during MPC re-flooding. Reducing the MPC internal temperatures eliminates the risk of high MPC pressure due to sudden generation of steam during re-flooding. |
| APPLICABLE SAFETY ANALYSIS | The confinement of radioactivity during the storage of spent fuel in the MPC is ensured by the multiple confinement boundaries and systems. The barriers relied on are the fuel pellet matrix, the metallic fuel cladding tubes in which the fuel pellets are contained, and the MPC in which the fuel assemblies are stored. Long-term integrity of the fuel and cladding depend on minimizing thermally induced stresses to the cladding.<br><br>This is accomplished during the unloading operations by lowering the MPC internal temperatures prior to MPC re-flooding. The Integrity of the MPC depends on maintaining the internal cavity pressures within design limits. This is accomplished by reducing the MPC internal temperatures such that there is no sudden formation of steam during MPC re-flooding. |

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BASES (continued)

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| LCO | Monitoring the circulating MPC gas exit temperature ensures that there will be no large thermal gradient across the fuel assembly cladding during re-flooding which could be potentially harmful to the cladding. The temperature limit specified in the LCO was selected to ensure that the MPC gas exit temperature will closely match the desired fuel cladding temperature prior to re-flooding the MPC. The temperature was selected to be lower than the boiling temperature of water with an additional margin. |
| APPLICABILITY | The MPC helium gas exit temperature is measured during UNLOADING OPERATIONS after the transfer cask and integral MPC are back in the fuel building and are no longer suspended from, or secured in, the transporter. Therefore, the Fuel Cool-Down LCO does not apply during TRANSPORT OPERATIONS and STORAGE OPERATIONS.<br><br>A note has been added to the APPLICABILITY for LCO 3.1.3 which states that the Applicability is only applicable during wet UNLOADING OPERATIONS. This is acceptable since the intent of the LCO is to avoid uncontrolled MPC pressurization due to water flashing during re-flooding operations. This is not a concern for dry UNLOADING OPERATIONS. |
| ACTIONS | A note has been added to the ACTIONS which states that, for this LCO, separate Condition entry is allowed for each MPC. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each MPC not meeting the LCO. Subsequent MPCs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.<br><br><u>A.1</u><br>If the MPC helium gas exit temperature limit is not met, actions must be taken to restore the parameters to within the limits before re-flooding the MPC. Failure to successfully complete fuel cool-down could have several causes, such as failure of the cool down system, inadequate cool down, or clogging of the piping lines. The Completion Time is sufficient to determine and correct most failure mechanisms and proceeding with activities to flood the MPC cavity with water are prohibited. |

(continued)

BASES (continued)

A.2

If the LCO is not met, in addition to performing Required Action A.1 to restore the gas temperature to within the limit, the user must ensure that the proper conditions exist for the transfer of heat from the MPC to the surrounding environs to ensure the fuel cladding remains below the short term temperature limit.

Ensure the annulus between the MPC and the TRANSFER CASK is filled with water. This places the system in a heat removal configuration which is bounded by the FSAR thermal evaluation of the system considering a vacuum in the MPC. The system is open to the ambient environment which limits the temperature of the ultimate heat sink (the water in the annulus) and, therefore, the MPC shell to 212°F.

Twenty-two (22) hours is an acceptable time frame to allow for completion of Required Action A.2 and is conservatively based on a thermal evaluation of a TRANSFER CASK located in a pit or vault. In such a configuration, passive cooling mechanisms will be largely diminished. Eliminating 90 percent of the passive cooling mechanisms with the cask emplaced in the vault, the thermal inertia of the cask (approximately 20,000 Btu/ºF) will limit the rate of temperature rise with design basis maximum heat load to approximately 4.5°F per hour. Thus, the fuel cladding temperature rise in 22 hours will be less than 100ºF. Large short term temperature margins exist to preclude any cladding integrity concerns under this temperature rise.

SURVEILLANCE REQUIREMENTS

SR 3.1.3.1

The long-term integrity of the stored fuel is dependent on the material condition of the fuel assembly cladding. By minimizing thermally-induced stresses across the cladding the integrity of the fuel assembly cladding is maintained. The integrity of the MPC is dependent on controlling the internal MPC pressure. By controlling the MPC internal temperature prior to re-flooding the MPC there is no formation of steam during MPC re-flooding.

The MPC helium exit gas temperature limit ensures that there will be no large thermal gradients across the fuel assembly cladding during MPC re-flooding and no formation of steam which could potentially overpressurize the MPC.

Fuel cool down must be performed successfully on each SFSC before the initiation of MPC re-flooding operations to ensure the design and analysis basis are preserved.

(continued)

BASES (continued)

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| REFERENCES | 12. Diablo Canyon ISFSI SAR Sections 4.2.3.3.3, 4.4.1, and 4.4.1.2.6 |
| | 13. Diablo Canyon ISFSI SAR Table 5.1-1 |
| | 14. Diablo Canyon ISFSI Sections 9.4.1.1.2 and 9.4.1.1.4 |
| | 15. Diablo Canyon ISFSI SAR Sections 10.2.3, 10.2.3.1 and 10.2.3.6 |

B 3.1 FUEL INTEGRITY

B 3.1.4 Spent Fuel Storage Case (SFSC) Time Limitation in Cask Transfer Facility (CTF)

BASES

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| BACKGROUND | The SFSC heat removal system is a passive, air-cooled, convective heat transfer system that ensures heat from the MULTI-PURPOSE CANISTER (MPC) is transferred to the environs by the chimney effect. Relatively cool air is drawn into the annulus between the OVERPACK and the MPC through the four inlet air ducts at the bottom of the OVERPACK. The MPC transfers its heat from the canister surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect and the air is forced back into the environs through the four outlet air ducts at the top of the OVERPACK. However, while the SFSC is in the CTF there is a reduced cooling capability over this normal storage configuration because of ambient air access restrictions. As a result, over time the decay heat produced by the spent fuel may cause exceedance of the short term temperature limit of the fuel cladding or damage the shielding material. To ensure that this does not take place the time that a SFSC, with a loaded MPC, is allowed to be in the CTF shall be limited to 22 hours.<br><br>Lifting mechanisms and equipment used at the CTF for SFSC handling shall be designed per NUREG-0612. |
| APPLICABLE SAFETY ANALYSIS | The thermal analyses of the SFSC take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the SFSC. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and other SFSC component temperatures do not exceed applicable limits. Under normal storage conditions, the four inlet and four outlet air ducts are unobstructed and full airflow (i.e., maximum heat transfer for the given ambient temperature) occurs.<br><br>However while the SFSC is in the CTF the restricted airflow around the SFSC decreases heat transfer capability. This case has been bounded by an analysis of a loaded TRANSFER CASK being in a loading pit with no external ventilation capability and is provided in the HI-STORM 100 System FSAR, Section 4.5.2. In that analysis, there is assumed to be only 10 percent of the normal heat transfer capability. Based on this, the temperature inside the MPC is shown not to reach the short-term limit of the fuel cladding within the first 22 hours. This analysis is considered bounding of the SFSC because the thermal inertia of the SFSC is greater then that of the TRANSFER CASK, therefore the heat-up is much slower. As a result, providing a time limitation of 22 hours for the SFSC to be in the CTF is conservative and adequate to ensure that the short-term temperature limits will not be met or exceeded. |

(continued)

BASES (continued)

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| LCO | The SFSC must not remain in the CTF for greater than 22 hours. This time limitation ensures that the decay heat generated by the approved content in a loaded MPC does not reach or exceed the approved content or other SFSC component temperature design limits. |
| APPLICABILITY | The LCO is applicable during TRANSPORT OPERATIONS while a SFSC is in its lowered position in the CTF. If an OVERPACK in the CTF does not contain an MPC, which contains approve contents, then this LCO does not apply. |
| ACTIONS | A note has been added to the ACTIONS, which states that for this LCO, separate condition entry is allowed for each SFSC. This is acceptable since the Required Actions for each condition provide appropriate compensatory measures for each SFSC not meeting the LCO. Subsequent SFSCs that don't meet the LCO are governed by subsequent condition entry and application of associated Required Actions.<br><br><u>A.1</u><br><br>If the LCO cannot be met the SFSC must be removed from the CTF immediately to ensure adequate heat removal capability exists to prevent exceeding the short-term fuel cladding and SFSC component temperature limit. NUREG-0612 qualified lifting mechanisms and equipment shall be used to remove the SFSC from the CTF.<br><br>While the SFSC is in the CTF the restricted airflow around the SFSC decreases heat transfer capability. This case has been bounded by an analysis of a loaded TRANSFER CASK being in a loading pit with no external ventilation capability. In that analysis, there is assumed to be only 10 percent of the normal heat transfer capability. Based on this, the temperature inside the MPC is shown not to reach the short-term temperature limit of the fuel cladding within the first 22 hours. This analysis is considered bounding because the thermal inertia of the SFSC is greater when compared to the TRANSFER CASK, therefore the heat-up is much slower. As a result, providing a time limitation of 22 hours for the SFSC to be in the CTF is conservative and adequate to ensure that the short-term temperature limits will not be met or exceeded. |

(continued)

BASES

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| ACTIONS | A.1 (continued)<br><br>The Completion Time for this Required Action is immediately. The bounding analysis shows that the temperature inside the MPC does not reach the short-term temperature limit of the fuel cladding within the first 22 hours. As a result, providing a time limitation of 22 hours for the SFSC to be in the CTF is conservative and requiring immediate action to remove the SFSC will ensure that the short-term temperature limits will not be met or exceeded. |
| SURVEILLANCE REQUIREMENTS | SR 3.1.1<br><br>The integrity of the stored fuel is dependent on the ability of the SFSC to reject heat from the MPC to the environment. Verification that a SFSC does not remain in the CTF for more then 22 hours will ensure that the short-term temperature limits will not be met or exceeded.<br><br>The Frequency of once per 8 hours while a SFSC is in the CTF will ensure that the 22 hours time limitation from the initial movement of a SFSC into the CTF or from a loaded MPC being lowered into an empty OVERPACK in the CTF is not exceeded. The once every 8 hours verification is reasonable based on the time necessary for SFSC components to heat up to unacceptable temperatures assuming design basis heat loads, and allows for corrective actions to take place. This surveillance is only required if a SFSC is in the CTF. |
| REFERENCES | 1. Diablo Canyon ISFSI SAR Section 3.4, Table 3.4-2<br>2. Diablo Canyon ISFSI SAR Section 4.4<br>3. Diablo Canyon ISFSI SAR Sections 7.1, 7.2, and 7.3<br>4. Diablo Canyon ISFSI SAR Section 8.1<br>5. Diablo Canyon ISFSI SAR Sections 8.2.11, 8.2.12, 8.2.15, and 8.2.17 |

## B 3.2 SPENT FUEL STORAGE CASK (SFSC) CRITICALITY CONTROL

### B 3.2.1 Dissolved Boron Concentration

BASES

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| BACKGROUND | A TRANSFER CASK with an empty MULTI-PURPOSE CANISTER (MPC) is placed in the spent fuel pool (SFP) and loaded with fuel assemblies and associated NONFUEL HARDWARE meeting the requirements of Section 2.0, Approved Content.<br><br>After loading the MPC, an MPC lid is placed on the MPC along with a lid retention device attached to the TRANSFER CASK. The TRANSFER CASK with the MPC inside is removed from the SFP to a washdown area. In the washdown area, the MPC lid is welded in place and the MPC is leak tested, drained, dried, and backfilled with helium. The TRANSFER CASK and accessible portions of the contained MPC are also surveyed to ensure that any radioactive contamination is within administrative limits.<br><br>For those MPCs containing fuel assemblies of relatively high initial enrichment, credit is taken in the criticality analyses for boron in the water within the MPC. To preserve the analysis basis, the dissolved boron concentration of the water in the MPC must be verified to meet specified limits when there is fuel and water in the MPC. This may occur during LOADING OPERATIONS and UNLOADING OPERATIONS.<br><br>A boron dilution analysis has been performed and submitted to the NRC in PG&E Letters DCL-03-150 and DIL-03-014 to determine the time available for operator action to ensure criticality does not occur in an MPC-32 during LOADING OPERATIONS and UNLOADING OPERATIONS. The analysis results show that operators have approximately 5 hours available to identify and terminate the source of unborated water flow from the limiting boron dilution event to ensure criticality in the MPC-32 does not occur. To minimize the possibility of a dilution event, a temporary administrative control will be implemented while the MPC is in the SFP that will require, with the exception of the 1-inch line used to rinse the cask as it is removed from the SFP, at least one valve in each potential flow path of unborated water to the SFP to be closed and tagged out. During the cask rinsing process, the MPC will have a lid in place that will minimize entry of any unborated water into the MPC. The flow path with the highest potential flow rate of 494 gpm will be doubly isolated by having two valves closed and tagged out while the MPC is in the SFP. |

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| APPLICABLE SAFETY ANALYSIS | The spent nuclear fuel stored in the SFSC is required to remain subcritical ($k_{eff} \leq 0.95$) under all conditions of storage. The SFSC is analyzed to store a wide variety of spent nuclear fuel assembly types with differing initial enrichments and associated NONFUEL HARDWARE. For all allowed fuel loaded in the MPCs credit was taken in the criticality analyses for neutron poison in the form of soluble boron in the water within the MPC. Compliance with this LCO preserves the assumptions made in the criticality analyses regarding credit for soluble boron. |

(continued)

BASES

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| LCO | Compliance with this LCO ensures that the stored fuel will remain subcritical with a $k_{eff} \leq 0.95$ while water is in the MPC. The LCO provides the minimum concentration of soluble boron required in the MPC water based on type of MPC and the initial enrichment of the fuel.<br><br>LCO 3.2.1.a provides the minimum concentration of soluble boron required in any of the MPCs if one or more fuel assemblies are loaded with an initial enrichment of ≤ 4.1 wt% U-235. LCO 3.2.1.b provides the minimum concentration of soluble boron required in MPC-24/24E/24EF if one or more fuel assemblies are loaded with an initial enrichment of > 4.1 wt% and ≤ 5.0 wt% U-235. LCO 3.2.1.c provides the minimum concentration of soluble boron required in MPC-32 if one or more fuel assemblies are loaded with an initial enrichment of > 4.1 wt% and ≤ 5.0 wt% U-235.<br><br>All INTACT FUEL ASSEMBLIES loaded into the MPC-24, MPC-24E, MPC-24EF, and MPC-32 are limited by analysis to maximum enrichments of 5.0 wt% U-235.<br><br>For all INTACT FUEL ASSEMBLIES loaded into an MPC that contains DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, the maximum initial enrichment of the INTACT FUEL ASSEMBLES is limited to the maximum initial enrichment of the DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS (i.e., 4.0 wt% U-235). |
| APPLICABILITY | The dissolved boron concentration LCO is applicable whenever an MPC-24, MPC-24E, MPC-24EF, or MPC-32 has at least one fuel assembly in a storage location and water in the MPC.<br><br>During LOADING OPERATIONS, the LCO is applicable immediately upon the loading of the first fuel assembly in the MPC. It remains applicable until the MPC is drained of water.<br><br>During UNLOADING OPERATIONS, the LCO is applicable when the MPC is reflooded with water after helium cool-down operations. Note that compliance with SR 3.0.4 ensures that the water to be used to flood the MPC is of the correct dissolved boron concentration to ensure the LCO is met upon entering the Applicability. |

(continued)

BASES

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate condition entry is allowed for each MPC. This is acceptable since the Required Actions for each condition provide appropriate compensatory measures for each MPC not meeting the LCO. Subsequent MPCs that do not meet the LCO are governed by subsequent condition entry and application of associated Required Actions.

A.1 and A2

Continuation of LOADING OPERATIONS, UNLOADING OPERATIONS or positive reactivity additions (including ACTIONS to reduce dissolved boron concentration) is contingent upon maintaining the MPC in compliance with the LCO. If the dissolved boron concentration of water in the MPC is less than its limit, LOADING OPERATIONS or UNLOADING OPERATIONS, and any positive reactivity additions must be suspended immediately. Inherent in the required action to stop these activities is the requirement to place any in progress activity, such as the movement of a fuel assembly, in a safe condition.

A.3

In addition to immediately suspending LOADING OPERATIONS or UNLOADING OPERATIONS, and any positive reactivity additions, action to restore the concentration to within the limit specified in the LCO must be initiated immediately.

One means of complying with this action is to initiate boration of the affected MPC. In determining the required combination of boration flow rate and concentration, there is no unique design bases event that must be satisfied; only that boration be initiated without delay. In order to raise the boron concentration as quickly as possible, the operator should begin boration with the best source available for existing plant conditions. The methods available for boration should include, but not be limited to, direct boration of the MPC or boration of the SFP if the MPC is located in the pool at the time.

Once boration is initiated, it must be continued until the boron concentration is restored. The restoration time depends on the amount of boron that must be injected to reach the required concentration.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS

SR 3.2.1.1

When the MPC is placed in the SFP the dissolved boron concentration in the MPC water must be verified by two independent measurements to be within the applicable limit within 8 hours prior to entering the applicability of the LCO. For LOADING OPERATIONS, this means within 8 hours prior to loading any approved content into the cask.

The use of two independent measurements provides reasonable assurance that the dissolved boron LCO limit is met and maintained. The 8 hours limitation is considered a reasonably short time period which minimizes any potential for changes in the critical dissolved boron concentration prior to loading and still allows flexibility in the operation. Once the dissolved boron concentration has been verified a change in this concentration is not credible unless there is some action specifically taken to modify it. During the period between verification and loading all changes in water volume including additions or subtractions in the SFP or MPC; recirculation of water through the MPC; or the addition or dilution of the dissolved boron concentration in the SFP or MPC to be loaded, will be administratively controlled. If any of these actions or operations takes place during the 8-hour period, the dissolved boron concentration will be re-verified to be within limits prior to loading any authorized contents in the MPC.

In addition, while the MPC is in the SFP or while water is in the MPC the boron concentration will continue to be verified to be within the applicable limits every 48 hours. This reflects the premise that normally there is no real need to re-verify the boron concentration of the water in the MPC after it is removed from the SFP unless water is to be added to, or recirculated through the MPC, because these are the only credible activities that could potentially change the dissolved boron concentration during this time. The 48-hour Completion Time for the re-verification is infrequent enough to prevent the interference of unnecessary sampling activities while lid closure welding and other MPC storage preparation activities are taking place in an elevated radiation area atop the MPC. However, it is often enough to ensure that any change in the concentration for any reason is detected in a reasonable time to take proper action. Plant procedures shall specifically ensure that any water to be added to, or recirculated through the MPC is at a dissolved boron concentration greater than or equal to the minimum boron concentration specified in the LCO.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.2

For UNLOADING OPERATIONS, this means verifying the source of borated water to be used to reflood the MPC within 8 hours prior to commencing reflooding operations. This ensures that when the LCO is applicable (upon introducing water into the MPC), the LCO will be met.

The use of two independent measurements provides reasonable assurance that the dissolved boron LCO limit is met and maintained in the source of water. The 8 hours limitation is considered a reasonably short time period which minimizes any potential for changes in the critical dissolved boron concentration in the source of water prior to introduction into the MPC and still allows flexibility in the operation. Once the dissolved boron concentration has been verified a change in this concentration is not credible unless there is some action specifically taken to modify it. During the period between verification and introducing the water into the MPC all changes in water source or volume including additions or subtractions in the source; or the addition or dilution of the dissolved boron concentration in the source will be administratively controlled. If any of these actions or operations takes place during the 8-hour period, the dissolved boron concentration in the source water will be re-verified prior to introducing any water into the MPC to be unloaded.

In addition, while the MPC to be unloaded is in the SFP or while water is in the MPC to be unloaded the dissolved boron concentration will continue to be verified to be within the applicable limits every 48 hours. This reflects the premise that normally there is no real need to re-verify the dissolved boron concentration of the water in the MPC unless water is to be added to, or recirculated through the MPC, because these are the only credible activities that could potentially change the dissolved boron concentration during this time.

The 48-hour Completion Time for the re-verification is infrequent enough to prevent the interference of unnecessary sampling activities while MPC UNLOADING OPERATIONS are taking place in an elevated radiation area atop the MPC. However, it is often enough to ensure that any change in the concentration for any reason is detected in a reasonable time to take proper action. Plant procedures shall specifically ensure that any water to be added to, or recirculated through the MPC is at a dissolved boron concentration is greater than or equal to the minimum dissolved boron concentration specified in the LCO.

REFERENCES

1. Diablo Canyon ISFSI SAR Section 4.2