Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
ARDC SFR-DC 26	*Reactivity control systems.* ~~Reactivity control systems shall include the following capabilities:~~ A ~~means~~minimum of ~~shutting down the reactor shall be provided to ensure that, under conditions of normal operation, including anticipated operational occurrences, and~~ two reactivity control systems or means shall provide: (1) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the design limits for fission product barriers are not exceeded~~.~~ and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences. (2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the design limits fission product barriers are not exceeded. (3) A means of shutting down the reactor and maintaining, at a minimum, a safe shutdown ~~under design-basis event conditions~~condition following an AOO or postulated accident, with appropriate margin for malfunctions, shall be provided. ~~A second means of reactivity control shall be provided that is independent, diverse, and capable of achieving and maintaining safe shutdown under design-basis event conditions.~~	Recent licensing activity, associated with the application of GDC 26 and GDC 27 to new reactor designs ~~"Response to Gap Analysis Summary Report for Reactor System Issues," (Ref. 26)~~(ADAMS Accession Nos. ML16116A083 and ~~"Response to NuScale Gap Analysis Summary Report for Reactivity Control Systems, Addressing Gap 11, General Design Criteria 26," (Ref. 27~~ML16292A589), revealed that additional clarity could be provided in the area of reactivity control requirements. ARDC 26 combines the scope of GDC 26 and GDC 27. The development of ARDC 26 is informed by the proposed general design criteria of 1965~~,~~ (AEC-R 2/49~~ and~~, November 5~~,~~), 1967 (32 FR 10216~~) (Ref. 28); the~~), current GDC 26 and 27~~;~~, the definition of safety-related SSC in 10 CFR 50.2~~; and~~, SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. 29~~);~~), and the prior application of reactivity control requirements. ~~Current GDC 26, first sentence, states that two reactivity control systems of different design principles shall be provided. In addition, the NRC has not licensed a power reactor that did not provide two independent means of shutting down the reactor.~~ ~~(1) Current GDC 26, second sentence, states~~(1) Currently the second sentence of GDC 26 states, that one of the reactivity control systems shall use control rods and shall be capable of reliably controlling reactivity changes to ensure that, under conditions of normal operation, including AOOs, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The staff recognizes that specifying control rods may not be suitable for advanced reactors. Additionally, reliably controlling reactivity, as ~~required by~~applied to GDC 26, has been interpreted as ensuring the control rods are capable of rapidly (i.e., within a few seconds) shutting down the reactor (~~Ref.~~

Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
	(4) A system for holding the reactor ~~subcritical~~shutdown under ~~cold~~ conditions which allow for interventions such as fuel loading, inspection and repair shall be provided.	~~27).~~ADAMS Accession No. ML16292A589). The staff changed control rods to "means" in recognition that advanced reactor designs may not rely on control rods to rapidly shut down the reactor (e.g., alternative system designs or inherent feedback mechanisms may be relied upon to perform this function). ~~Additionally,~~The wording of "reliability controlling reactivity" in GDC 26 has been replaced with "inserting negative reactivity at a sufficient rate and amount" to more clearly define the requirement. For a non-LWR design the rate of negative reactivity insertion may not necessitate rapid (within seconds) insertion but should occur in a time frame such that the fission product barrier design limits are not exceeded. The term "specified acceptable fuel design limits" is replaced with "design limits for fission product barriers" to be consistent with the AOO acceptance criteria~~. MHTGR-DC~~ while also addressing liquid fueled reactors which do not have SAFDLs. ARDC 10 and ~~MHTGR-DC~~ARDC 15 provide the appropriate design limits for the fuel and reactor ~~helium pressure~~ coolant boundary, respectively~~. A non-LWR may not necessarily shut down rapidly (within seconds) but the shutdown should occur in a time frame such that the fission product barrier design limits are not exceeded. In regards to safety class, the capability to shut down the reactor is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs~~. ~~(2) Current GDC 27 states that~~The wording "safe shutdown is achieved and maintained…" has been added again to more clearly define the ~~reactivity control systems shall be designed to have a combined capability of~~ requirements associated with reliably controlling reactivity ~~changes to assure that, under postulated~~

Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		~~accident conditions and with appropriate margin for stuck rods, the capability to cool the core is maintained. Reliably controlling reactivity, as required by GDC 27, requires that the reactor achieve and maintain safe, stable conditions, including subcriticality, using only safety related equipment with margin for stuck rods (Ref.~~ in GDC 26~~). The first sentence of ARDC 26 (2) refers to the safety-related means (systems and/or mechanisms) to achieve and maintain safe shutdown. "Maintain safe shutdown" indicates subcriticality in the long term or an equilibrium condition naturally achieved by the design.~~ ~~The staff changed "reactivity control systems" to "means" in recognition that advanced reactor designs may rely on a system, inherent feedback mechanism, or some combination thereof to shut down the reactor and maintain a safe shutdown under design-basis event conditions.~~. SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. ~~29~~24), describes the characteristics of a safe shutdown condition as reactor subcriticality, decay heat removal, and radioactive materials containment. ~~The staff replaced "postulated accident conditions" with "design-basis event conditions," to emphasize that plants are required to maintain a safe shutdown following AOOs as well as postulated accidents.~~ ARDC 26 (1) clearly defines that reactor shutdown at any time during the transient is the performance requirement. The distinction between during and following the transient is discussed in (2) below. ~~The second sentence of ARDC 26(2) refers to a means of achieving and maintaining shutdown that is important to safety but not necessarily safety related. The second means of reactivity control serves as a backup to the safety-related means and, as such, margins for malfunctions are not required but the second means shall be highly reliable and robust (e.g., meet ARDC 1–5). "Independent"~~

Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		~~indicates no shared systems or components with the safety-related means and "diverse" indicates a different design than the safety-related means. The purpose of an independent and diverse means of controlling reactivity is to preclude a potential common cause failure affecting both means of reactivity control, which would lead to the inability to shut down the reactor. The second means of reactivity control does not have to demonstrate that design limits for fission product barriers are met.~~ ~~Additionally, the current GDC 26, third sentence~~In regards to safety class, the capability to insert negative reactivity at a rate and amount to preserve the fission product barrier(s) and to shut down the reactor during an AOO is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs. (2) The first sentence of GDC 26, states that two independent reactivity control systems of different design principles shall be provided. The third sentence of GDC 26, states that the second reactivity control system shall be capable of reliably controlling the rate of changes resulting from planned, normal power changes (including xenon burnout) to assure ~~acceptable fuel design limits are not exceeded. Staff has identified this as an operational requirement that is not necessary to ensure reactor safety provided a design complies with ARDC 26(1). Therefore, this sentence is not retained in ARDC 26.~~ specified acceptable fuel design limits are not exceeded. ARDC 26 (2) is consistent with the current requirements of the second reactivity control system specified in GDC 26. The words "including xenon burnout" have been deleted as this may not be as important for some non-LWR reactor designs. Also, "of different design principles" from the first sentence of GDC 26 has been replaced with "independent and diverse" to clarify the requirement. The reactivity means given by ARDC 26

Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		(2) is a system important to safety but not necessarily safety-related as it does not mitigate an AOO or accident but is used to control planned, normal reactivity changes such that SAFDLs are preserved thereby minimizing challenges to the safety-related reactivity control means or protection system. ~~(3) This is retained from the current GDC 26, fourth sentence. The reactivity control system(s) functions together with the heat removal systems to obtain a cold shutdown.~~The term "independent and diverse" indicates no shared systems or components and a design which is different enough such that no common failure modes exist between the system or means in ARDC 26 (2) and safety-related systems in ARDC 26 (1) and (3). (3) Current GDC 27 states that the reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained. Reliably controlling reactivity, as applied to GDC 27 requires that the reactor achieve and maintain a safe, stable condition, including subcriticality, using only safety related equipment with margin for stuck rods (ADAMS Accession No. ML16116A083). ARDC 26 (3) is written to clarify that shut down following an AOO or postulated accident using safety-related equipment or means is required. The term "following an AOO or postulated accident" refers to the time when plant parameters are relatively stable, no additional means of mitigation are needed and margins to acceptance criteria are constant or increasing. ARDC 26 allows for a return to power during a postulated accident consistent with the current licensing basis of some existing PWRs if sufficient heat removal capability exists (e.g., PWR main steam line break

Criterion	ARDC, SFR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		accident), but ARDC 26 (1) precludes a return to power during an AOO. (4) The fourth sentence of GDC 26 regarding the capability to reach cold shutdown has been generalized in ARDC 26 (4) to refer to activities which are performed at conditions below (less limiting than) those normally associated with safe shutdown. SECY-94-084 describes staff positions on obtaining a cold shutdown and explains that the requirement to bring the plant to cold shutdown is driven by the need to inspect and repair a plant following an accident. In regards to safety class, the capability to bring the plant to a cold shutdown is not covered by the definition of safety-related SSCs in 10 CFR 50.2, and most operating pressurized-water reactors have not credited safety-related SSCs to satisfy this requirement of GDC 26. Based on the information provided above, the system credited for holding the reactor subcritical under ~~cold~~ conditions necessary for activities such as refueling, inspection and repair is identified as an important to safety ~~but does not need to be classified as safety related.~~ system.

Criterion	ARDC, SFR-DC 26 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
ARDC SFR-DC 26	*Reactivity control systems.* A minimum of two reactivity control systems or means shall provide: (1) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the design limits for fission product barriers are not exceeded and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences. (2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the design limits fission product barriers are not exceeded. (3) A means of shutting down the reactor and maintaining, at a minimum, a safe shutdown condition following an AOO or postulated accident, with appropriate margin for malfunctions, shall be provided. (4) A system for holding the reactor shutdown under conditions which allow for interventions such as fuel loading, inspection and repair shall be provided.	Recent licensing activity, associated with the application of GDC 26 and GDC 27 to new reactor designs (ADAMS Accession Nos. ML16116A083 and ML16292A589), revealed that additional clarity could be provided in the area of reactivity control requirements. ARDC 26 combines the scope of GDC 26 and GDC 27. The development of ARDC 26 is informed by the proposed general design criteria of 1965 (AEC-R 2/49, November 5), 1967 (32 FR 10216), current GDC 26 and 27, the definition of safety-related SSC in 10 CFR 50.2, SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. 29), and the prior application of reactivity control requirements. (1) Currently the second sentence of GDC 26 states, that one of the reactivity control systems shall use control rods and shall be capable of reliably controlling reactivity changes to ensure that, under conditions of normal operation, including AOOs, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The staff recognizes that specifying control rods may not be suitable for advanced reactors. Additionally, reliably controlling reactivity, as applied to GDC 26, has been interpreted as ensuring the control rods are capable of rapidly (i.e., within a few seconds) shutting down the reactor (ADAMS Accession No. ML16292A589). The staff changed control rods to "means" in recognition that advanced reactor designs may not rely on control rods to rapidly shut down the reactor (e.g., alternative system designs or inherent feedback mechanisms may be relied upon to perform this function). The wording of "reliability controlling reactivity" in GDC 26 has been replaced with "inserting negative reactivity at a sufficient rate and amount" to more clearly define the requirement. For a non-LWR design the rate of negative reactivity insertion may not

Criterion	ARDC, SFR-DC 26 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
		necessitate rapid (within seconds) insertion but should occur in a time frame such that the fission product barrier design limits are not exceeded. The term “specified acceptable fuel design limits” is replaced with “design limits for fission product barriers” to be consistent with the AOO acceptance criteria while also addressing liquid fueled reactors which do not have SAFDLs. ARDC 10 and ARDC 15 provide the appropriate design limits for the fuel and reactor coolant boundary, respectively. The wording “safe shutdown is achieved and maintained…” has been added again to more clearly define the requirements associated with reliably controlling reactivity in GDC 26. SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs” (Ref. 24), describes the characteristics of a safe shutdown condition as reactor subcriticality, decay heat removal, and radioactive materials containment. ARDC 26 (1) clearly defines that reactor shutdown at any time during the transient is the performance requirement. The distinction between during and following the transient is discussed in (2) below. In regards to safety class, the capability to insert negative reactivity at a rate and amount to preserve the fission product barrier(s) and to shut down the reactor during an AOO is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs. (2) The first sentence of GDC 26, states that two independent reactivity control systems of different design principles shall be provided. The third sentence of GDC 26, states that the second reactivity control system shall be capable of reliably controlling the

Criterion	ARDC, SFR-DC 26 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
		rate of changes resulting from planned, normal power changes (including xenon burnout) to assure specified acceptable fuel design limits are not exceeded. ARDC 26 (2) is consistent with the current requirements of the second reactivity control system specified in GDC 26. The words "including xenon burnout" have been deleted as this may not be as important for some non-LWR reactor designs. Also, "of different design principles" from the first sentence of GDC 26 has been replaced with "independent and diverse" to clarify the requirement. The reactivity means given by ARDC 26 (2) is a system important to safety but not necessarily safety-related as it does not mitigate an AOO or accident but is used to control planned, normal reactivity changes such that SAFDLs are preserved thereby minimizing challenges to the safety-related reactivity control means or protection system. The term "independent and diverse" indicates no shared systems or components and a design which is different enough such that no common failure modes exist between the system or means in ARDC 26 (2) and safety-related systems in ARDC 26 (1) and (3). (3) Current GDC 27 states that the reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained. Reliably controlling reactivity, as applied to GDC 27 requires that the reactor achieve and maintain a safe, stable condition, including subcriticality, using only safety related equipment with margin for stuck rods (ADAMS Accession No. ML16116A083). ARDC 26 (3) is written to clarify that shut down following an AOO or postulated accident using safety-related equipment or means is required. The term "following an AOO or postulated accident"

Criterion	ARDC, SFR-DC 26 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
		refers to the time when plant parameters are relatively stable, no additional means of mitigation are needed and margins to acceptance criteria are constant or increasing. ARDC 26 allows for a return to power during a postulated accident consistent with the current licensing basis of some existing PWRs if sufficient heat removal capability exists (e.g., PWR main steam line break accident), but ARDC 26 (1) precludes a return to power during an AOO. (4) The fourth sentence of GDC 26 regarding the capability to reach cold shutdown has been generalized in ARDC 26 (4) to refer to activities which are performed at conditions below (less limiting than) those normally associated with safe shutdown. SECY-94-084 describes staff positions on obtaining a cold shutdown and explains that the requirement to bring the plant to cold shutdown is driven by the need to inspect and repair a plant following an accident. In regards to safety class, the capability to bring the plant to a cold shutdown is not covered by the definition of safety-related SSCs in 10 CFR 50.2, and most operating pressurized-water reactors have not credited safety-related SSCs to satisfy this requirement of GDC 26. Based on the information provided above, the system credited for holding the reactor subcritical under conditions necessary for activities such as refueling, inspection and repair is identified as an important to safety system.

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
MHTGR-DC 26	*Reactivity control systems.* ~~Reactivity control systems shall include the following capabilities:~~ A ~~means~~minimum of ~~shutting down the reactor shall be provided to ensure that, under conditions of normal operation, including anticipated operational occurrences, and~~ two reactivity control systems or means shall provide: (1) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits ~~design limits for fission product barriers~~ are not exceeded.~~ –~~ and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences. (2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded. (3) A means of shutting down the reactor and maintaining, at a minimum, a safe shutdown ~~under design-basis event conditions~~condition following an AOO or postulated accident, with appropriate margin for malfunctions, shall be provided.~~ A second means of reactivity control shall be provided that is~~	Recent licensing activity, associated with the application of GDC 26 and GDC 27 to new reactor designs ~~"Response to Gap Analysis Summary Report for Reactor System Issues," (Ref. 26)~~(ADAMS Accession Nos. ML16116A083 and ~~"Response to NuScale Gap Analysis Summary Report for Reactivity Control Systems, Addressing Gap 11, General Design Criteria 26," (Ref. 27~~ML16292A589), revealed that additional clarity could be provided in the area of reactivity control requirements. ARDC 26 combines the scope of GDC 26 and GDC 27. The development of ARDC 26 is informed by the proposed general design criteria of 1965~~,~~ (AEC-R 2/49~~ and,~~ November 5~~,~~), 1967 (32 FR 10216~~) (Ref. 28); the~~), current GDC 26 and 27~~;~~, the definition of safety-related SSC in 10 CFR 50.2~~; and~~, SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. 29~~);~~), and the prior application of reactivity control requirements. ~~Current GDC 26, first sentence, states that two reactivity control systems of different design principles shall be provided. In addition, the NRC has not licensed a power reactor that did not provide two independent means of shutting down the reactor.~~ ~~(1) Current GDC 26, second sentence, states~~(1) Currently the second sentence of GDC 26 states, that one of the reactivity control systems shall use control rods and shall be capable of reliably controlling reactivity changes to ensure that, under conditions of normal operation, including AOOs, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The staff recognizes that specifying control rods may not be suitable for advanced reactors. Additionally, reliably controlling reactivity, as ~~required by~~applied to GDC 26, has been interpreted as ensuring the control rods are capable of rapidly (i.e., within a few seconds) shutting down the

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
	~~independent, diverse, and capable of achieving and maintaining safe shutdown under design-basis event conditions.~~ (4) A system for holding the reactor ~~subcritical~~shutdown under ~~cold~~ conditions which allow for interventions such as fuel loading, inspection and repair shall be provided.	reactor (~~Ref. 27).~~ADAMS Accession No. ML16292A589). The staff changed control rods to “means” in recognition that advanced reactor designs may not rely on control rods to rapidly shut down the reactor (e.g., alternative system designs or inherent feedback mechanisms may be relied upon to perform this function). ~~Additionally,~~The wording of “reliability controlling reactivity” in GDC 26 has been replaced with “inserting negative reactivity at a sufficient rate and amount” to more clearly define the requirement. For a non-LWR design the rate of negative reactivity insertion may not necessitate rapid (within seconds) insertion but should occur in a time frame such that the fission product barrier design limits are not exceeded. The term ~~“specified acceptable fuel design limits” is replaced with~~ “design limits for fission product barriers” is replaced with “specified acceptable system radionuclide release design limits (SARRDLs)” to be consistent with the AOO acceptance criteria associated with MHTGR-DC 10 (SARRDL) and MHTGR-DC 15 (helium pressure boundary)~~. MHTGR-DC 10 and MHTGR-DC 15 provide the appropriate design limits for the fuel and reactor helium pressure boundary, respectively. A non-LWR may not necessarily shut down rapidly (within seconds) but the shutdown should occur in a time frame such that the fission product barrier design limits are not exceeded. In regards to safety class, the capability to shut down the reactor is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs~~. ~~(2) Current GDC 27 states that~~The wording “safe shutdown is achieved and maintained…” has been added again to more clearly define the ~~reactivity control systems shall be designed to have a~~

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		~~combined capability of~~ requirements associated with reliably controlling reactivity ~~changes to assure that, under postulated accident conditions and with appropriate margin for stuck rods, the capability to cool the core is maintained. Reliably controlling reactivity, as required by GDC 27, requires that the reactor achieve and maintain safe, stable conditions, including subcriticality, using only safety related equipment with margin for stuck rods (Ref.~~ in GDC 26~~). The first sentence of ARDC 26 (2) refers to the safety-related means (systems and/or mechanisms) to achieve and maintain safe shutdown. "Maintain safe shutdown" indicates subcriticality in the long term or an equilibrium condition naturally achieved by the design.~~ ~~The staff changed "reactivity control systems" to "means" in recognition that advanced reactor designs may rely on a system, inherent feedback mechanism, or some combination thereof to shut down the reactor and maintain a safe shutdown under design-basis event conditions.~~. SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. ~~29~~24), describes the characteristics of a safe shutdown condition as reactor subcriticality, decay heat removal, and radioactive materials containment. ~~The staff replaced "postulated accident conditions" with "design-basis event conditions," to emphasize that plants are required to maintain a safe shutdown following AOOs as well as postulated accidents.~~ ARDC 26 (1) clearly defines that reactor shutdown at any time during the transient is the performance requirement. The distinction between during and following the transient is discussed in (2) below. ~~The second sentence of ARDC 26(2) refers to a means of achieving and maintaining shutdown that is important to safety but not necessarily safety related. The second means of reactivity control serves as a backup to the safety-related means and, as such,~~

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		~~margins for malfunctions are not required but the second means shall be highly reliable and robust (e.g., meet ARDC 1 -5). "Independent" indicates no shared systems or components with the safety-related means and "diverse" indicates a different design than the safety-related means. The purpose of an independent and diverse means of controlling reactivity is to preclude a potential common cause failure affecting both means of reactivity control, which would lead to the inability to shut down the reactor. The second means of reactivity control does not have to demonstrate that design limits for fission product barriers are met.~~ ~~Additionally, the current GDC 26, third sentence~~In regards to safety class, the capability to insert negative reactivity at a rate and amount to preserve the fission product barrier(s) and to shut down the reactor during an AOO is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs. (2) The first sentence of GDC 26, states that two independent reactivity control systems of different design principles shall be provided. The third sentence of GDC 26, states that the second reactivity control system shall be capable of reliably controlling the rate of changes resulting from planned, normal power changes (including xenon burnout) to assure ~~acceptable fuel design limits are not exceeded. Staff has identified this as an operational requirement that is not necessary to ensure reactor safety provided a design complies with ARDC 26(1). Therefore, this sentence is not retained in ARDC 26.~~ specified acceptable fuel design limits are not exceeded. ARDC 26 (2) is consistent with the current requirements of the second reactivity control system specified in GDC 26. The words "including xenon burnout" have been deleted as this may not be as important for some non-LWR reactor designs. Also, "of different design principles" from the first sentence of

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		GDC 26 has been replaced with "independent and diverse" to clarify the requirement. The reactivity means given by ARDC 26 (2) is a system important to safety but not necessarily safety-related as it does not mitigate an AOO or accident but is used to control planned, normal reactivity changes such that SAFDLs are preserved thereby minimizing challenges to the safety-related reactivity control means or protection system. ~~(3) This is retained from the current GDC 26, fourth sentence. The reactivity control system(s) functions together with the heat removal systems to obtain a cold shutdown.~~The term "independent and diverse" indicates no shared systems or components and a design which is different enough such that no common failure modes exist between the system or means in ARDC 26 (2) and safety-related systems in ARDC 26 (1) and (3). (3) Current GDC 27 states that the reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained. Reliably controlling reactivity, as applied to GDC 27 requires that the reactor achieve and maintain a safe, stable condition, including subcriticality, using only safety related equipment with margin for stuck rods (ADAMS Accession No. ML16116A083). ARDC 26 (3) is written to clarify that shut down following an AOO or postulated accident using safety-related equipment or means is required. The term "following an AOO or postulated accident" refers to the time when plant parameters are relatively stable, no additional means of mitigation are needed and margins to acceptance criteria are constant or increasing. ARDC 26 allows for a return to power during a postulated accident consistent with the

Criterion	MHTGR-DC 26 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		current licensing basis of some existing PWRs if sufficient heat removal capability exists (e.g., PWR main steam line break accident), but ARDC 26 (1) precludes a return to power during an AOO. (4) The fourth sentence of GDC 26 regarding the capability to reach cold shutdown has been generalized in ARDC 26 (4) to refer to activities which are performed at conditions below (less limiting than) those normally associated with safe shutdown. SECY-94-084 describes staff positions on obtaining a cold shutdown and explains that the requirement to bring the plant to cold shutdown is driven by the need to inspect and repair a plant following an accident. In regards to safety class, the capability to bring the plant to a cold shutdown is not covered by the definition of safety-related SSCs in 10 CFR 50.2, and most operating pressurized-water reactors have not credited safety-related SSCs to satisfy this requirement of GDC 26. Based on the information provided above, the system credited for holding the reactor subcritical under ~~cold~~ conditions necessary for activities such as refueling, inspection and repair is identified as an important to safety ~~but does not need to be classified as safety related.~~ system.

Criterion	**MHTGR-DC 26 Title and Content** **Clean Version**	**NRC Rationale for Adaptation to GDC** **Clean Version**
MHTGR-DC 26	*Reactivity control systems.* A minimum of two reactivity control systems or means shall provide: (1) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences. (2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded. (3) A means of shutting down the reactor and maintaining, at a minimum, a safe shutdown condition following an AOO or postulated accident, with appropriate margin for malfunctions, shall be provided. (4) A system for holding the reactor shutdown under conditions which allow for interventions such as fuel loading, inspection and repair shall be provided.	Recent licensing activity, associated with the application of GDC 26 and GDC 27 to new reactor designs (ADAMS Accession Nos. ML16116A083 and ML16292A589), revealed that additional clarity could be provided in the area of reactivity control requirements. ARDC 26 combines the scope of GDC 26 and GDC 27. The development of ARDC 26 is informed by the proposed general design criteria of 1965 (AEC-R 2/49, November 5), 1967 (32 FR 10216), current GDC 26 and 27, the definition of safety-related SSC in 10 CFR 50.2, SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs" (Ref. 29), and the prior application of reactivity control requirements. (1) Currently the second sentence of GDC 26 states, that one of the reactivity control systems shall use control rods and shall be capable of reliably controlling reactivity changes to ensure that, under conditions of normal operation, including AOOs, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded. The staff recognizes that specifying control rods may not be suitable for advanced reactors. Additionally, reliably controlling reactivity, as applied to GDC 26, has been interpreted as ensuring the control rods are capable of rapidly (i.e., within a few seconds) shutting down the reactor (ADAMS Accession No. ML16292A589). The staff changed control rods to "means" in recognition that advanced reactor designs may not rely on control rods to rapidly shut down the reactor (e.g., alternative system designs or inherent feedback mechanisms may be relied upon to perform this function). The wording of "reliability controlling reactivity" in GDC 26 has been replaced with "inserting negative reactivity at a sufficient rate and amount" to more clearly define the requirement. For a non-LWR design the rate of negative reactivity insertion may not

Criterion	MHTGR-DC 26 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
		necessitate rapid (within seconds) insertion but should occur in a time frame such that the fission product barrier design limits are not exceeded. The term “design limits for fission product barriers” is replaced with “specified acceptable system radionuclide release design limits (SARRDLs)” to be consistent with the AOO acceptance criteria associated with MHTGR-DC 10 (SARRDL) and MHTGR-DC 15 (helium pressure boundary). The wording “safe shutdown is achieved and maintained…” has been added again to more clearly define the requirements associated with reliably controlling reactivity in GDC 26. SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs” (Ref. 24), describes the characteristics of a safe shutdown condition as reactor subcriticality, decay heat removal, and radioactive materials containment. ARDC 26 (1) clearly defines that reactor shutdown at any time during the transient is the performance requirement. The distinction between during and following the transient is discussed in (2) below. In regards to safety class, the capability to insert negative reactivity at a rate and amount to preserve the fission product barrier(s) and to shut down the reactor during an AOO is identified as a function performed by safety-related SSCs in the 10 CFR 50.2 definition of safety-related SSCs. (2) The first sentence of GDC 26, states that two independent reactivity control systems of different design principles shall be provided. The third sentence of GDC 26, states that the second reactivity control system shall be capable of reliably controlling the rate of changes resulting from planned, normal power changes

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		(including xenon burnout) to assure specified acceptable fuel design limits are not exceeded. ARDC 26 (2) is consistent with the current requirements of the second reactivity control system specified in GDC 26. The words "including xenon burnout" have been deleted as this may not be as important for some non-LWR reactor designs. Also, "of different design principles" from the first sentence of GDC 26 has been replaced with "independent and diverse" to clarify the requirement. The reactivity means given by ARDC 26 (2) is a system important to safety but not necessarily safety-related as it does not mitigate an AOO or accident but is used to control planned, normal reactivity changes such that SAFDLs are preserved thereby minimizing challenges to the safety-related reactivity control means or protection system. The term "independent and diverse" indicates no shared systems or components and a design which is different enough such that no common failure modes exist between the system or means in ARDC 26 (2) and safety-related systems in ARDC 26 (1) and (3). (3) Current GDC 27 states that the reactivity control systems shall be designed to have a combined capability of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained. Reliably controlling reactivity, as applied to GDC 27 requires that the reactor achieve and maintain a safe, stable condition, including subcriticality, using only safety related equipment with margin for stuck rods (ADAMS Accession No. ML16116A083). ARDC 26 (3) is written to clarify that shut down following an AOO or postulated accident using safety-related equipment or means is required. The term "following an AOO or postulated accident" refers to the time when plant parameters are relatively

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		stable, no additional means of mitigation are needed and margins to acceptance criteria are constant or increasing. ARDC 26 allows for a return to power during a postulated accident consistent with the current licensing basis of some existing PWRs if sufficient heat removal capability exists (e.g., PWR main steam line break accident), but ARDC 26 (1) precludes a return to power during an AOO. (4) The fourth sentence of GDC 26 regarding the capability to reach cold shutdown has been generalized in ARDC 26 (4) to refer to activities which are performed at conditions below (less limiting than) those normally associated with safe shutdown. SECY-94-084 describes staff positions on obtaining a cold shutdown and explains that the requirement to bring the plant to cold shutdown is driven by the need to inspect and repair a plant following an accident. In regards to safety class, the capability to bring the plant to a cold shutdown is not covered by the definition of safety-related SSCs in 10 CFR 50.2, and most operating pressurized-water reactors have not credited safety-related SSCs to satisfy this requirement of GDC 26. Based on the information provided above, the system credited for holding the reactor subcritical under conditions necessary for activities such as refueling, inspection and repair is identified as an important to safety system.

Criterion	ARDC 17 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
ARDC 17	***Electric power systems.*** Electric power systems shall be provided when required to permit functioning of structures, systems, and components ~~important to safety.~~. The safety function for ~~the systems~~each power system shall be to provide sufficient capacity~~,~~ and capability~~, and reliability~~ to ensure that (1) specified acceptable fuel design limits and design conditions of the ~~primary~~reactor coolant boundary are not exceeded as a result of anticipated operational occurrences and (2) ~~vital~~safety functions that rely on electric power are maintained in the event of postulated accidents. The ~~onsite~~ electric power systems shall be comprised of an onsite power system and an additional power system. The onsite electric power system shall have sufficient independence, redundancy, and testability to perform ~~their~~its safety functions, assuming a single failure. An additional power system shall have sufficient independence and testability to perform its safety function. If electric power is not needed for anticipated operational occurrences or postulated accidents, the design shall demonstrate that power for important to safety functions is provided.	The electric power systems are required to provide reliable power ~~system is required~~ for SSCs during anticipated operational occurrences or postulated accident conditions~~.~~ when those SSCs' safety functions require electric power. The safety functions are established by the safety analyses (i.e. design basis accidents). Where electric power is needed for anticipated operational occurrences or postulated accidents, the electric power systems shall be sufficient in capacity~~,~~ and capability~~, and reliability~~ to ensure ~~vital~~that safety functions as well as important to safety functions are maintained. ~~The~~ The electric power systems provide redundancy and defense-in-depth since there would be a minimum of two power systems. Compared to GDC 17, more emphasis is placed herein on requiring reliability of the overall power ~~sources~~supply scheme rather than fully prescribing how such reliability can be attained. For example, reference to ~~onsite vs.~~ offsite electric power systems was deleted to provide for those reactor designs that do not depend on offsite power for the functioning of SSCs important to safety~~.~~ or do not connect to a power grid. ~~he text related~~ Important to ~~"…supplies, including batteries, and the onsite distribution system," was deleted to allow increased flexibility in the design of onsite power systems for advanced reactor designs. However, such onsite systems are expected to remain capable of performing assigned~~ safety functions ~~during accidents as a condition of requisite reliability.~~ include post-accident monitoring,

Criterion	ARDC 17 Title and Content Proposed Changes Compared to DG-1330	NRC Rationale for Adaptation to GDC Proposed Changes Compared to DG-1330
		control room habitability, emergency lighting, radiation monitoring, communications and/or any others that may be deemed appropriate for the given design. The electric power system for important to safety functions could be non-Class 1E and would not be required to have redundant power sources. "Reactor coolant pressure boundary" has been relabeled as "~~primary~~reactor coolant boundary" to ~~conform to standard terms used in the LMR industry.~~ create a more broadly applicable non-LWR term that defines the boundary without giving any implication of system operating pressure. As such, the term "reactor coolant boundary" is applicable to non-LWRs that operate at either low or high pressure. ~~The existing single switchyard allowance remains available under ARDC 17. If a particular advanced design requires use of GDC single switchyard allowance wording, the designer should look to GDC 17 for guidance when developing PDC.~~ ~~If electrical power is not required to permit the functioning of SSCs important to safety, the requirements in the SFR-DC are not applicable to the design. In this case, the functionality of SSCs important to safety must be fully evaluated and documented in the design bases.~~

Criterion	ARDC 17 Title and Content Clean Version	NRC Rationale for Adaptation to GDC Clean Version
ARDC 17	***Electric power systems.*** Electric power systems shall be provided when required to permit functioning of structures, systems, and components. The safety function for each power system shall be to provide sufficient capacity and capability to ensure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant boundary are not exceeded as a result of anticipated operational occurrences and (2) safety functions that rely on electric power are maintained in the event of postulated accidents. The electric power systems shall be comprised of an onsite power system and an additional power system. The onsite electric power system shall have sufficient independence, redundancy, and testability to perform its safety functions, assuming a single failure. An additional power system shall have sufficient independence and testability to perform its safety function. If electric power is not needed for anticipated operational occurrences or postulated accidents, the design shall demonstrate that power for important to safety functions is provided.	The electric power systems are required to provide reliable power for SSCs during anticipated operational occurrences or postulated accident conditions when those SSCs' safety functions require electric power. The safety functions are established by the safety analyses (i.e. design basis accidents). Where electric power is needed for anticipated operational occurrences or postulated accidents, the electric power systems shall be sufficient in capacity and capability to ensure that safety functions as well as important to safety functions are maintained. The electric power systems provide redundancy and defense-in-depth since there would be a minimum of two power systems. Compared to GDC 17, more emphasis is placed herein on requiring reliability of the overall power supply scheme rather than fully prescribing how such reliability can be attained. For example, reference to offsite electric power systems was deleted to provide for those reactor designs that do not depend on offsite power for the functioning of SSCs important to safety or do not connect to a power grid. Important to safety functions include post-accident monitoring, control room habitability, emergency lighting, radiation monitoring, communications and/or any others that may be deemed appropriate for the given design. The electric power system for important to safety functions could be non-Class 1E and would not be required to have redundant power sources.

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		"Reactor coolant pressure boundary" has been relabeled as "reactor coolant boundary" to create a more broadly applicable non-LWR term that defines the boundary without giving any implication of system operating pressure. As such, the term "reactor coolant boundary" is applicable to non-LWRs that operate at either low or high pressure.