Hadron Energy
with the
Nuclear Regulatory Commission

Topic: Meeting on Principal Design Criteria (PDC)
December 17, 2025

Sam Gibson
CEO

Ross Ridenoure
CNO

Chris Neal
Lead Mechanical Engineer

Ryan Mott
Director of Licensing and Operations

Hadron Energy

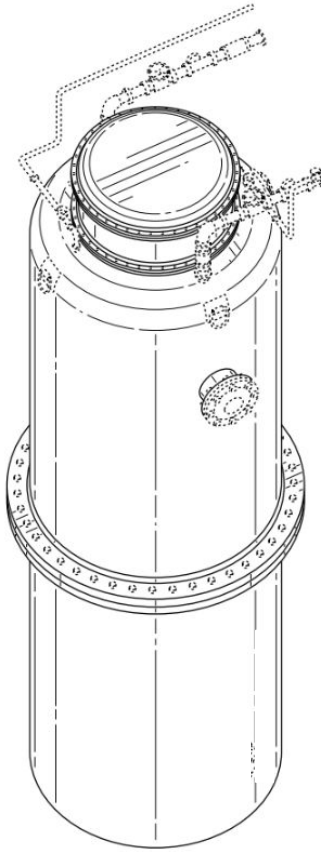
Agenda

- **Overview of the Hadron MMR**
- **Regulatory Approach**
- **Legal Framework for GDCs**
- **Identification of Key GDCs**
- **Discussion on List of Proposed PDCs**
- **Summary / Next Steps**

Overview of the Hadron MMR

An integral, passive design.

- Hadron is seeking licenses to manufacture, construct and operate its 10 MW, LWR-based micro-modular reactor (MMR)
- To date, Hadron has submitted its Regulatory Engagement Plan (REP) and its Topical Report (TR) on its Quality Assurance Program Description (QAPD)
- As Hadron works towards its goal of obtaining a Manufacturing License (ML) and a Combined License (COLA) in 2028, we seek to engage with the NRC early and often
- Today, we are looking for feedback on the proposed Principal Design Criteria (PDC), which is the subject of a TR to be submitted in January 2026.



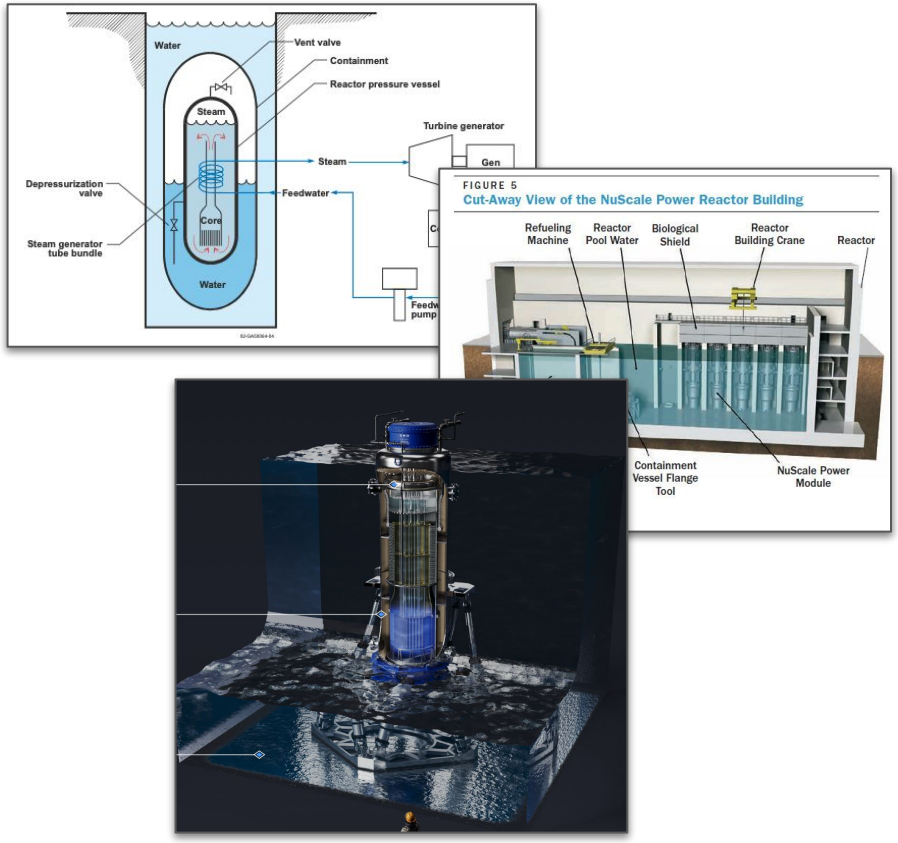
The Hadron MMR

Hadron Energy

Regulatory Approach

Both NuScale and the Hadron MMR are **"LWR-in-a-pool"** concepts. Both share safety attributes with the Multi-Application Small Light Water Reactor (MASLWR), which pioneered the concept of an integral reactor within a sealed containment vessel in a pool-based heat sink.

Our Principal Design Criteria (PDC) are therefore structured to follow the established regulatory precedent of the NuScale Power approval.



Top to Bottom: Multi-Application Small Light Water Reactor (December 2003); NuScale Power Reactor Building (© NuScale Power, LLC); the Hadron MMR

Hadron Energy

Legal Framework for GDCs / PDCs

10 CFR 50.34 requires applicants to establish Principal Design Criteria (PDC).

For LWRs like the Hadron MMR, the General Design Criteria (GDC) in Appendix A are *required*.

These General Design Criteria establish minimum requirements for the principal design criteria for water-cooled nuclear power plants similar in design and location to plants for which construction permits have been issued by the Commission

PDCs that deviate from GDCs must address the specific safety features of the design (e.g., in an *exemption*):

There will be some water-cooled nuclear power plants for which the General Design Criteria are not sufficient . . . it is expected that additional or different criteria will be needed . . . for water-cooled nuclear power units of advanced design. Also, there may be water-cooled nuclear power units for which fulfillment of some of the General Design Criteria may not be necessary or appropriate. For plants such as these, departures from the General Design Criteria must be identified and justified.

Hadron Energy

*See 10 CFR Part 52, subpart F and 10 CFR 52.157(a); 10 CFR Part 52, subpart C and 10 CFR 52.79(a)(4)(i); 10 CFR Part 50, Appx. A.

Key Exemption Topics

- **PDCs 17-18:** Electric Power Systems Applicability
- **PDC 19:** Safe Shutdown vs. Cold Shutdown
- **PDC 27:** Combined Reactivity Control Capability
- **PDC 33:** Reactor Coolant Makeup
- **PDCs 34-44:** Passive Fluid Systems & Power Requirements
- **PDC 40:** Containment Design Basis
- **PDC 52:** Containment Leakage Rate Testing
- **PDCs 55-57:** Containment Isolation

1. PDCs 17 and 18 – Electric Power Systems

Background:

- Standard GDC 17 requires onsite and offsite electric power systems to permit functioning of structures, systems, and components (SSCs) important to safety, and GDC 18 relates to the inspection of those systems.
- Hadron's safety-related systems (scram, decay heat removal, containment isolation) are passive and rely on stored energy or physical principles.
- **Regulatory Precedent:** NuScale received an exemption from GDC 17 because "The NuScale Power Plant design provides passive safety systems... without reliance on electrical power".

Does the Staff agree with Hadron's approach to request an exemption from the requirements of GDCs 17 and 18, consistent with the precedent set by NuScale, given that no safety-related SSCs rely on electrical power?

Reference: Final Safety Evaluation Report for the NuScale Standard Plant Design Certification Application, Chapter 8: Electric Power, August 2020, ADAMS Accession No. ML20205L405, at 8-10 – 8-14.

2. PDC 19 – Safe Shutdown v. Cold Shutdown

Background:

- Standard GDC 19 requires equipment outside the control room with a potential for "cold shutdown."
- "Cold shutdown" implies active cooling to low temperatures (<200° F), which is not necessary for long-term safety in Hadron's passive design (the exact parameters are still under investigation).
- **Regulatory Precedent:** NuScale received an exemption to substitute "safe shutdown" for "cold shutdown," defining it as a stable condition with k_{eff} < 0.99 and reactor coolant temperature <420° F.

Does the Staff agree that the term “safe shutdown” is the appropriate long-term safety metric for the Hadron microreactor, replacing the specific “cold shutdown” requirement in PDC 19, provided the reactor remains subcritical with adequate passive decay heat removal?

Reference: FSER for the NuScale Standard Plaint Design Certification Application, Chapter 1: Introduction and General Discussion, July 2020, ADAMS Accession No. ML20204A986, at Section 1.14.

3. PDC 27 – Combined Reactivity Control Capability

Background:

- Standard GDC 27 requires reactivity control systems to have a combined capability, *in conjunction with poison addition by the ECCS*, to reliably control reactivity changes under accident conditions.
- Although Hadron's system incorporates a chemical shim for non-safety-related purposes, Hadron's ECCS is purely passive and does not include active poison injection.
- **Regulatory Precedent:** NuScale received an exemption from GDC 27 to remove the poison addition requirement because their ECCS does not include safety-related boron injection.

Does the Staff agree that an exemption to remove the ECCS poison addition requirement is justified, given that safety-related control rods alone ensure subcriticality and the ECCS is purely passive?

Reference: FSER for the NuScale Standard Plaint Design Certification Application, Chapter 1: Introduction and General Discussion, July 2020, ADAMS Accession No. ML20204A986, at 1-50.

4. PDC 33 – Reactor Coolant Makeup

Background:

- Standard GDC 33 requires a system to supply reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary.
- Hadron's integral reactor vessel is housed within a tight, high-pressure containment and relies on containment inventory retention rather than active makeup.
- **Regulatory Precedent:** NuScale received an exemption from GDC 33 because the RPV and containment design retain sufficient inventory to ensure core cooling without reliance on a makeup system.

Does the Staff agree that a safety-related reactor coolant makeup system is not required for the Hadron design, provided that the integral containment design retains sufficient inventory to maintain core coverage and cooling?

Reference: FSER for the NuScale Standard Plant Design Certification Application, Chapter 9: Auxiliary Systems, July 2020, ADAMS Accession No. ML20205L407, at Section 9.3.6.

5. PDC 34-44 – Electric Power and Fluid Systems

Background:

- Standard GDC 34, 35, 38, 41, and 44 include requirements for systems to operate using onsite or offsite electric power.
- Hadron's fluid systems for core makeup, residual heat removal, ECCS, and containment cooling are passive.
- **Regulatory Precedent:** NuScale received exemptions from the power provisions of these GDCs because safety functions are accomplished via passive systems "without reliance on electric power".

Does the Staff agree that exempting the electric power provisions from fluid system PDCs (34, 35, 38, 41, 44) is acceptable, provided that suitable redundancy and isolation capabilities are maintained without reliance on power?

Reference: FSER for the NuScale Standard Plant Design Certification Application, Chapter 1: Introduction and General Discussion, July 2020, ADAMS Accession No. ML20204A986, at Section 1.14 (Table 1.14-1).

6. PDC 40 – Containment Heat Removal Testing

Background:

- Standard GDC 40 requires periodic functional testing of the containment heat removal system.
- Hadron's containment heat removal system includes no active components; passive heat transfer occurs through a containment pool, which acts as the ultimate heat sink. Periodic inspection of heat transfer surfaces is undertaken under GDC 39.
- **Regulatory Precedent:** NuScale's received an exemption because the containment vessel was "partially immersed in the reactor pool, which functions as an ultimate heat sink."

Does the Staff agree that the inherent characteristics of the design (i.e., the passive heat transfer capability of the integral steel containment vessel) justifies an exemption from the periodic testing requirements of GDC 40?

Reference: FSER for the NuScale Standard Plant Design Certification Application, Chapter 6: Engineered Safety Features, July 2020, ADAMS Accession No. ML20205L406, at Section 6.2.2.4.

7. PDC 52 – Containment Leakage Rate Testing

Background:

- Standard GDC 52 requires periodic integrated leakage rate testing (Type A testing) at containment design pressure.
- Hadron's containment is a factory-fabricated, ASME Section III, Class 1 high-pressure vessel integral with the RPV. Its design allows for preservice and inservice inspection.
- **Regulatory Precedent:** NuScale received an exemption from GDC 52, utilizing ASME Class 1 vessel inspection and Type B/C testing (penetrations) as an alternative that meets the underlying safety purpose.

Does the Staff agree that comprehensive ASME Class 1 vessel inspection combined with Local Leak Rate Testing (LLRT) provides an acceptable alternative to Integrated Leak Rate Testing (Type A), justifying a modification to PDC 52?

Reference: FSER for the NuScale Standard Plant Design Certification Application, Chapter 6: Engineered Safety Features, July 2020, ADAMS Accession No. ML20205L406, at Section 6.2.6.

8. PDC 55-57 – Containment Isolation

Background:

- Standard GDC 55 and 56 require one isolation valve *inside* and one *outside* containment for penetrations. Standard GDC 57 requires at least one isolation valve outside containment for closed systems.
- Hadron's integral design (RPV inside Containment) makes placing valves "inside" containment physically impractical, and active valves on passive decay heat removal lines introduce unnecessary failure modes.
- **Regulatory Precedent:** NuScale requested exemptions from GDC 55, 56 and 57 to allow two valves outside containment for specific lines and permit a closed system outside containment as a redundant barrier instead of a valve.

Does the Staff agree that **alternate redundant barriers**—specifically two valves outside containment for primary lines (PDC 55/56) and a robust, closed-loop system outside containment for passive cooling lines (PDC 57)—provide an acceptable alternative to the standard valve configurations?

Reference: FSER for the NuScale Standard Plant Design Certification Application, Chapter 6: Engineered Safety Features, July 2020, ADAMS Accession No. ML20205L406, at Section 6.2.4.

9. *Summary & Next Steps*

PDCs Requiring Departure / Exemption from GDCs:

- **Electric Power (PDC 17/18):** Exempt electric power requirements; safety functions are achieved via passive means.
- **Shutdown (PDC 19):** Require "safe shutdown" (stable, subcritical, passive cooling) rather than "cold shutdown" (<200 F).
- **Reactivity (PDC 27):** Remove "poison addition" requirement; control rods alone ensure subcriticality.
- **Coolant Makeup (PDC 33):** Protection against small breaks provided by integral containment inventory retention, not active makeup.
- **Fluid Systems (PDC 34-44):** Remove requirements for onsite/offsite electric power; Residual Heat Removal, ECCS, and Containment Cooling are passive.
- **Heat Removal (PDC 40):** Exempt periodic testing; heat removal is an inherent characteristic of the submerged vessel, verified by inspection.
- **Containment Testing (PDC 52):** Replace Integrated Leak Rate Testing (Type A) with ASME Class 1 vessel inspection and Type B/C testing.
- **Isolation (PDC 55-57):** Establish alternate redundant barriers: dual valves outside containment for primary lines (PDC 55/56) and closed loops outside containment for passive cooling (PDC 57).

Does the Staff have any further questions regarding the scope or technical justification of these proposed Principa; Design Criteria?

Next Steps:

- Hadron will incorporate Staff feedback into the final PDC Topical Report.
- Formal submittal of Topical Report: **January 2026**

Additional questions?