NCEES

advancing licensure for engineers and surveyors

NCEES Principles and Practice of Engineering Examination
NUCLEAR CBT Exam Specifications

Effective beginning October 1, 2021

- The PE Nuclear exam is computer-based. It is closed book with an electronic reference.
- Examinees have 9.5 hours to complete the exam, which contains 85 questions. The 9.5-hour time includes a tutorial and an optional scheduled break. Examinee works all questions.
- The exam uses both the International System of units (SI) and the U.S. Customary System (USCS).
- The exam is developed with questions that will require a variety of approaches and methodologies, including design, analysis, and application.
- The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.
- The **codes and standards** applicable to the Nuclear exam are shown on the last page.

	Number of Questions
1. Radiological Analysis and Consequences	**18–27**
A. Radiation Principles	6–9
1. Radioactive decay (e.g., half-lives, chains, branching)	
2. Nuclear reactions (e.g., fission yield, charged particles, transformations)	
3. Energy release from nuclear processes (e.g., binding energy, prompt gamma, fusion)	
4. Radioactive materials (e.g., fission products, activation products, spent fuel, naturally occurring radioactive material)	
B. Interaction of Radiation with Matter	6–9
1. Interaction of photons with matter (e.g., interaction coefficients, Compton scattering, pair production, photoelectric effect)	
2. Energy deposition (e.g., local, distributed, thermal analysis of shields)	
3. Shield design (e.g., buildup factors, high-Z vs. low-Z materials, neutron absorbers, streaming)	
4. Radiation effects on materials (e.g., swelling, creep, embrittlement)	
5. Neutron activation and interaction with matter	
6. Radiological imaging and therapy (e.g., PET, gamma/proton knives, industrial radiography)	
C. Radiation Detection and Protection	6–9
1. Radiation detection and measurement (e.g., types, detector sensitivity, counting statistics)	
2. Dose assessment (e.g., source geometry, biological effects, quality factors)	
3. Dosimetry (e.g., calibration, dosimeter, bioassay)	
4. Emergency preparedness (e.g., evacuation, exclusion zone, emergency declarations)	
5. Occupational and public safety (e.g., dose limits, ALARA)	

2. Nuclear Fuel Cycle **9–14**

A. Fuel Cycle Front and Back End 4–6

1. Fuel cycle analysis (e.g., enrichment processes, material balance, economics)
2. Nuclear material accountability and control (e.g., inventory and accountability, special nuclear material regulations, proliferation-resistant design)
3. Transportation and package design (e.g., Safety Analysis Report for Packaging, criticality, shielding)
4. Storage and disposition (e.g., spent fuel pool, interim storage, geologic disposal, fuel cycle policy)

B. Fuel Design and Performance 5–8

1. Fuel design (e.g., fissile enrichment, materials behavior, thermal performance)
2. Cladding design (e.g., integrity, corrosion, strength, neutron cross section)
3. Depletion, burnup, and transmutation

3. Nuclear Systems and Components **13–20**

A. System and Component Design 7–11

1. Reactor concepts (e.g., PWR, BWR, LMR, HTGR, CANDU, MSR, SMR, space reactors, accelerator-driven systems, fusion reactors)
2. Power conversion systems (e.g., turbines, heat exchangers, steam generator, condenser)
3. Emergency core cooling system (ECCS) (e.g., high-pressure injection, low-pressure injection, accumulators, emergency power)
4. Materials (e.g., thermophysical and neutronic properties, performance characteristics)
5. Mechanical and hydraulic systems (e.g., pump and turbomachinery performance, fluid-structure interactions)
6. Instrumentation and control (e.g., pressure and temperature sensors, flow meters, interlocks and permissives, nuclear instrumentation)
7. Containment systems (e.g., pressure suppression, containment spray, control of radionuclides, hydrogen control)
8. Nuclear steam supply system (NSSS) (e.g., water chemistry, corrosion control, soluble poison)
9. Safety-related software (e.g., verification and validation, software QA, cyber security)
10. Codes and standards (e.g., interpretation of excerpts of ANSI/ANS standards, general design criteria)

B. System and Component Performance 6–9

1. Energy generation and conversion (e.g., Carnot and Rankine cycles, reactor-type specific)
2. Reactor coolant system performance (e.g., heat balance, natural circulation, decay heat removal)

3. Reactor core performance (e.g., peaking factors, critical heat flux, flow oscillations)
4. Systems interactions (e.g., integrated plant behavior, coupling and feedback)
5. Reliability analysis (e.g., failure modes and effects analysis, parts count analysis, stress margin analysis)
6. Engineered safety feature analysis (e.g., uncertainty, setpoints)
7. Engineering decision-making (e.g., cost-benefit analysis, environmental impact, economics)

4. Reactor Physics and Criticality Safety **19–29**

A. Neutronics Principles 6–9

1. Cross sections (e.g., macroscopic and microscopic, scattering, absorption/capture, Doppler broadening)
2. Neutron transport (e.g., neutron balance, deterministic methods, Monte Carlo methods, multigroup, flux, streaming)
3. Nuclear reaction rates (e.g., capture, scattering, fission, neutron sources and production)
4. Diffusion theory (e.g., Fick's law, diffusion approximation, diffusion coefficients)
5. Slowing down and thermalization (e.g., lethargy, scattering kernels, 1/v)
6. Delayed neutrons (e.g., precursor concentration (ß), energy spectra)
7. Fission product poisoning (e.g., xenon, samarium)

B. Steady-State Systems 4–6

1. Thermal reactor analysis (e.g., four- and six-factor formulas, homogeneous/heterogeneous effects, moderator effectiveness, spectral shift)
2. Fast reactor analysis (e.g., breeding ratio, fuel types, fast nonleakage probability, fuel utilization factor, reproduction factor)
3. Neutron absorbers (e.g., differential and integral control rod worth, shutdown margin, burnable poisons, self-shielding, chemical shim)
4. Subcritical systems (e.g., accelerator-driven, spallation sources)

C. Critical System Dynamics 5–8

1. Reactor kinetics (e.g., doubling time, approach to criticality, one-group delayed neutron approximation)
2. Point kinetics (e.g., k-effective, delayed neutron fraction, fission spectrum, reactivity, neutron lifetime, Inhour equation)
3. Reactivity coefficients (e.g., moderator/coolant temperature, void, Doppler, power)
4. Spatially dependent kinetics (e.g., xenon oscillations, local control rod effects, impact on local detectors)
5. Reactivity-initiated accident neutronics (e.g., rod drop/ejection)

D. Criticality Safety 4–6

1. Subcritical system analysis (e.g., neutron sources, neutron reflection, leakage, subcritical margin, process analysis)
2. Minimum critical mass (e.g., different fissile materials, bare and reflected, H/U ratio)
3. Criticality safety regulations and standards
4. Lessons learned from case histories (e.g., SL-1, Tokai-mura)

5. Safety Analysis 11–17

A. Design Basis Analysis 6–9

1. Application and interpretation of experimental data and software results (e.g., biases and uncertainties in data, conservatism)
2. Fuel behavior (performance) analysis (e.g., pellet-clad interaction)
3. Core thermal-hydraulic analysis (e.g., critical heat flux, departure from nucleate boiling ratio)
4. Non-LOCA transient analysis (e.g., overcooling, loss of flow, steam line break)
5. LOCA transient analysis (e.g., acceptance criteria, long-term cooling)
6. Core protection setpoint analysis
7. Containment performance (e.g., ECCS performance, containment pressure and temperature, containment sumps)
8. Licensing and regulations (e.g., technical specifications, safety analysis report, environmental impact statement, regulatory compliance)

B. Probabilistic Risk Assessment and Severe Accident Analysis 5–8

1. Fault and event trees, cut-set analysis, and reliability block diagrams
2. Quantitative risk assessments
3. Risk metrics (e.g., large early release frequency [LERF] and core damage frequency [CDF], importance measures)
4. Beyond design basis events (e.g., station blackout, unprotected events, FLEX)
5. Risk mitigation systems (e.g., alternate ac power generator, alternate feedwater flow path)
6. Severe accident phenomena (e.g., degraded core, zirconium-water reaction, atmospheric dispersion, lessons learned)
7. Safety goal policy statement (e.g., uncertainty, risk-based assessment, defense in depth)

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NUCLEAR Codes and Standards

Effective Beginning with the October 2021 Exam

The following codes and standards will be supplied to examinees on exam day as an electronic pdf file in the exam. Solutions to exam questions that reference a standard of practice are scored based on this list. Solutions based on other standards will not receive credit.

CODE/STANDARD	TITLE
	Chart of the Nuclides
10 CFR 20	Standards for Protection Against Radiation
10 CFR 21	Reporting of Defects and Noncompliance
10 CFR 50	Domestic Licensing of Production and Utilization Facilities
10 CFR 51	Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions
10 CFR 52	Licenses, Certifications, and Approvals for Nuclear Power Plants
10 CFR 54	Requirements for Renewal of Operating Licenses for Nuclear Power Plants
10 CFR 70	Domestic Licensing of Special Nuclear Material
10 CFR 71	Packaging and Transportation of Radioactive Material
10 CFR 72	Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste
10 CFR 835	Appendix D, Surface Contamination Values
10 CFR 835	Appendix E, Values for Establishing Sealed Radioactive Source Accountability and Radioactive Material Posting and Labeling Requirements
40 CFR 261	Subpart C, Characteristics of Hazardous Waste
NUREG 1571	Information Handbook on Independent Spent Fuel Storage Installations
Reg. Guide 1.3	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors
Reg. Guide 1.7	Control of Combustible Gas Concentrations in Containment
Reg. Guide 1.28	Quality Assurance Program Criteria (Design and Construction)
Reg. Guide 1.105	Setpoints for Safety-Related Instrumentation
Reg. Guide 1.174	An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis
Reg. Guide 1.183	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors
Reg. Guide 1.203	Transient and Accident Analysis Method