Classification of Components for the Aurora

August 5, 2020

Online public meeting

In summary

- The fundamental building blocks of the Aurora COLA are the regulations
  - Although Oklo reviewed many guidance documents for contents of a COLA, there is no guidance that is a “one size fits all” – this is okay because the regulations are clear for what is needed
- The regulations do not require a classification of components to be submitted with the COLA and previous safety classification is technology-depends on LWRs
- Oklo is the only company to pilot the LMP process (now RG 1.233) with the NRC and the only available reference for implementation of the defense-in-depth process, and found a similar result regarding classification as described here, although it is important to note guidance is not regulation.
- Oklo proposed a holistic framework for assurance of as-analyzed, as-built performance, built off the regulations and the Commission’s Policy Statement on advanced reactors
  - Focusing on functionality of certain components both through the design and operations

Regulatory requirements for a COLA

- Contents of a combined license application (COLA) are in the Code of Federal Regulations (CFR), specifically:
  - 10 CFR 52.77 – generally company and financial information
  - 10 CFR 52.79 – technical information
  - 10 CFR 52.80 – additional technical information
- 10 CFR 52.79 is of interest to this topic

10 CFR 52.79 requirements

- This section has many requirements to analyze the safety of the reactor and the facility, for example:
  - Describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components of the facility as a whole
  - Analysis and evaluation of the design and performance of structures, systems, and components with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents
- There is no regulatory requirement to submit component classification information
- Terms such as “safety-related” are present in the CFR

Background on “safety-related” in the CFR

- Very few places in the CFR the term is used
- “Safety classification” is **not required** for a COLA and is **not used or described** in the CFR
- Ultimately, “safety-related” is only used in the CFR in the context of a safety-related SSC

“Safety-related” definitions and use

- 10 CFR 50.2 **defines safety-related SSCs**:
  - Safety-related structures, systems and components means those structures, systems and components that are relied upon to remain functional during and following design basis events to assure:
    - (1) The integrity of the reactor coolant pressure boundary
    - (2) The capability to shut down the reactor and maintain it in a safe shutdown condition; or
    - (3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in § 50.34(a)(1) or § 100.11 of this chapter, as applicable.
- In addition, “safety-related” is used, but not defined, in the context of the definition of a basic component, as follows:
  - In all cases, *basic component* includes **safety related design, analysis, inspection, testing, fabrication, replacement parts, or consulting services** that are associated with the component hardware, whether these services are performed by the component supplier or other supplier.
- Finally, 10 CFR 50.2 uses, but does not define, “safety-related” in the context of construction, as follows:
  - Construction or constructing means, for the purposes of § 50.55(e), the analysis, design, manufacture, fabrication, quality assurance, placement, erection, installation, modification, inspection, or testing of a facility or activity which is subject to the regulations in this part and consulting services related to the **facility or activity that are safety related**.
- The footnote in 10 CFR 50.49(b)(1) is of importance and states the following:
  - **Safety-related** electric equipment is referred to as "Class 1E" equipment in IEEE 323–1974. Copies of this standard may be obtained from the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017.
  - (It’s important to note that the regulation references an IEEE standard that is written in the context of large LWRs and has not been historically used by smaller reactor designs.)
- The term “safety-related” is used, but not defined, in the context of in-service testing requirements for pre-1971 plants (10 CFR 50.55a(f)(1)).
- Applicability of Appendix B to 10 CFR Part states the following:
  - The pertinent requirements of this appendix apply to all activities affecting the **safety-related** functions of those structures, systems, and components;

“Safety-related” definitions and use

- Generally, Appendix R to 10 CFR Part 50 does not apply to new plants. Interestingly, the regulation makes the assertion that some of these terms are used interchangeably, stating the following, “…The phrases ‘important to safety,’ or ‘**safety-related**,’ will be used throughout this Appendix R as applying to all safety functions. The phrase ‘safe shutdown’ will be used throughout this appendix as applying to both hot and cold shutdown functions.”
- This regulation uses, but does not define, the term “safety-related,” in the context of what is commonly referred to as “critical digital assets” (not defined in 10 CFR 73.54), as follows:
  - (a) Each licensee subject to the requirements of this section shall provide high assurance that digital computer and communication systems and networks are adequately protected against cyber attacks, up to and including the design basis threat as described in § 73.1.
    - (1) The licensee shall protect digital computer and communication systems and networks associated with:
      - (i) **Safety-related** and important-to-safety functions…
- In the context of remote “safety-related building” siting, this regulation uses, but does not define the term, as follows:
  - Determination of siting factors for other design conditions. Siting factors for other design conditions that must be evaluated include soil and rock stability, liquefaction potential, natural and artificial slope stability, cooling water supply, and remote **safety-related** structure siting…
- In the context of what the ACRS is expected to review under 10 CFR 1.13:
  - The Committee, on its own initiative, may conduct reviews of specific generic matters or nuclear facility **safety-related** items.
- As defined in 10 CFR 21.3:
  - *Constructing* or *construction* means the analysis, design, manufacture, fabrication, placement, erection, installation, modification, inspection, or testing of a facility or activity which is subject to the regulations in this part and consulting services related to the facility or activity that are **safety related**.

Aurora and the NRC Commission's Policy statement on advanced reactors

The design of the Aurora follows the NRC Commission's Policy statement on advanced reactors, for example:

- ✓ Takes advantage of inherent safety characteristics
- ✓ Incorporated security in design to limit threat possibilities

Ultimately reduces the reliance on system functionality to ensure the protection of public and environmental health and safety, as well as domestic security

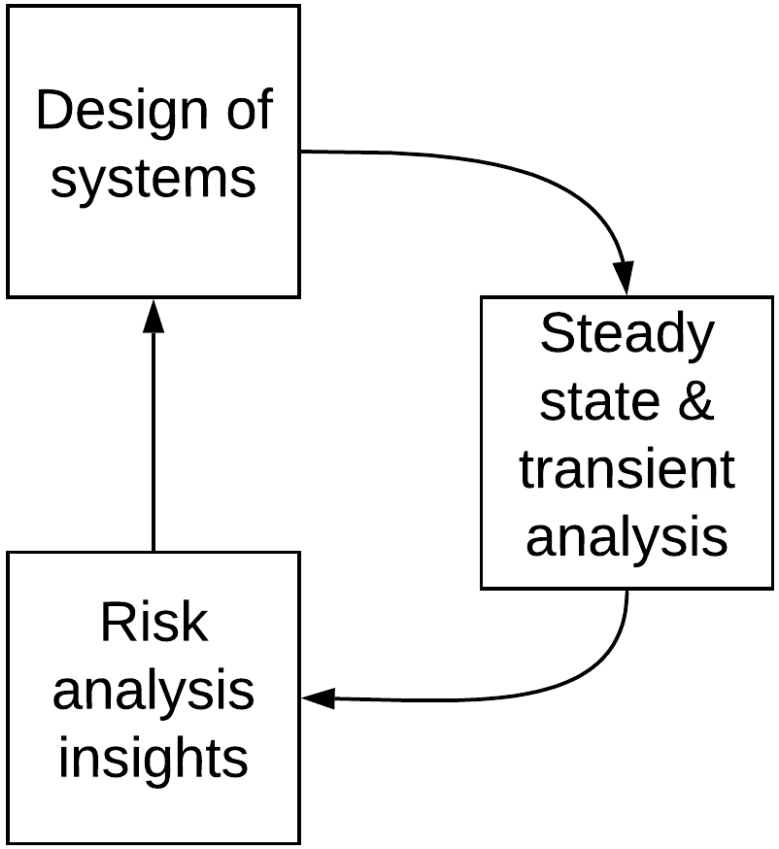
Aurora and “safety-related” (per the CFR)

- **No good fit for a plant that is not cooled by a circulating coolant and is 1000x smaller than a commercial operating plant**
- Fundamentally, the Aurora-INL COLA structure is **built from the regulations**
  - This was developed in conversations with the NRC in early 2018 and demonstrated in the DG-1353 structure in late 2018
- Oklo proposed a framework for licensing the Aurora that focuses on maintaining components:
  - Applies both during design and operation of the facility
  - **Focuses on requirements for systems, not on an arbitrary system classification**

A more holistic assurance of as-analyzed, as-built performance

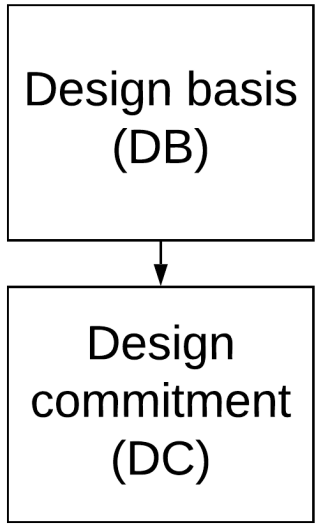
Methodology for the Aurora

- **Iterative and systematic process**
  - Systems are designed to high level safety goals
  - Their performance is evaluated under during normal and off-normal (i.e., steady state and transient) operations through an analysis of many different event types:
    - Historical event types for non-LWRs
    - Event categorization in NUREG 0800
    - External hazards
  - This performance is compared to insights gained from the PRA
- Subsequent slides explain the use of design bases, design commitments, design criteria, and programmatic controls to ensure as-designed, as-analyzed performance

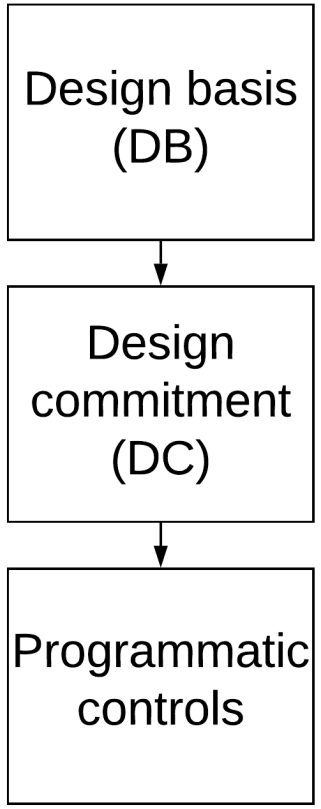


Design basis
(DB)

Design bases:
The characteristics of a system that ensure the safe operation of the reactor.



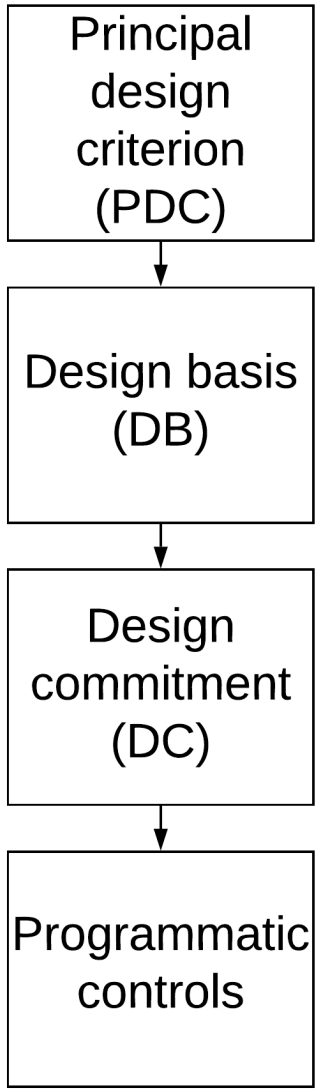
Design commitments:
The specific commitments made to ensure that a design basis is met.



Programmatic controls:

Administrative controls used to ensure that the design commitments are met.

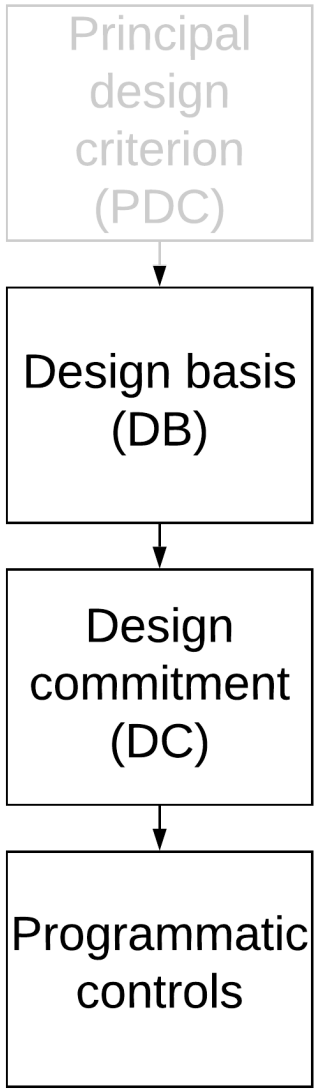
- Quality Assurance Program (QAP)
- Preoperational tests (POTs)
- Startup tests (SUTs)
- Inspections, test, and analysis acceptance criteria (ITAAC)
- Technical Specifications (TS)



Principal design criteria:

- The specific criteria that must be met to ensure adequate safety of the Aurora.

The design bases are grouped and analyzed in terms of fundamental safety functions from a high level to create the principal design criteria.



II.02 Design and Analysis of SSCs

(Part II, "FSAR," Chapter 2)

II.02 uses these abbreviations to create unique codes for each DB, DC, and programmatic control, and summarizes each DB in a gray box.

Design basis:

DB.RXS.01 Specific characteristic of the reactor system

Design evaluation summary:

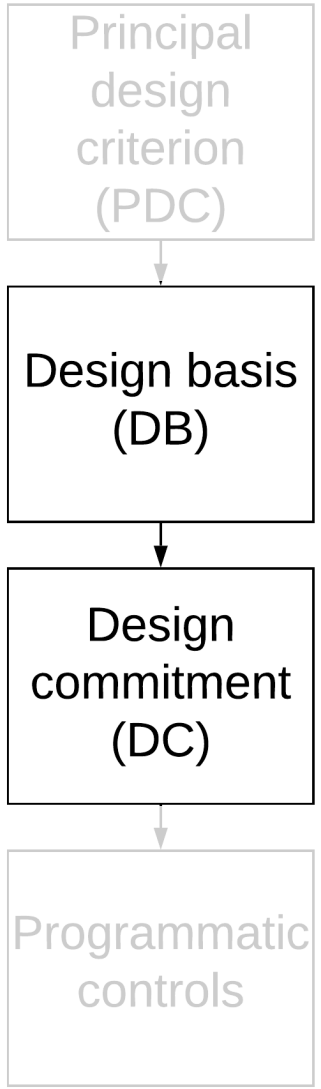
Summary of the analysis that shows the reactor system meets the DB...

Design commitments and programmatic controls:

DC.RXS.01A Specific commitment to ensure **DB.RXS.01** is met

POT.RXS.01.A Preop. test used to verify **DC.RXS.01.A**

Or: SUT, ITAAC, TS, etc.



II.05 Transient Analysis

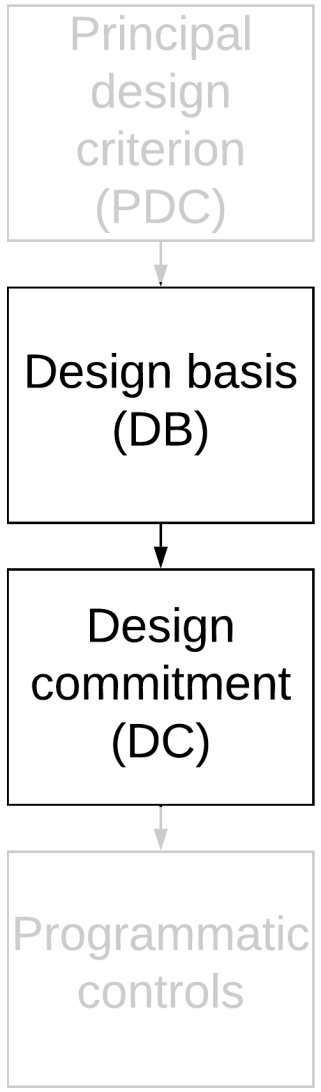
(Part II, "FSAR," Chapter 5)

II.05 explicitly states key modeling assumptions, and summarizes accompanying DB and DC with a similar gray box.

e.g.:

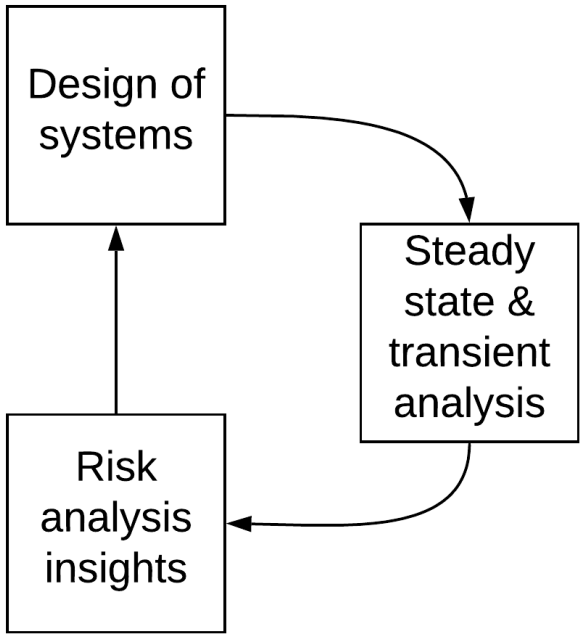
An X second delay is assumed for shutdown rod insertion would look like:

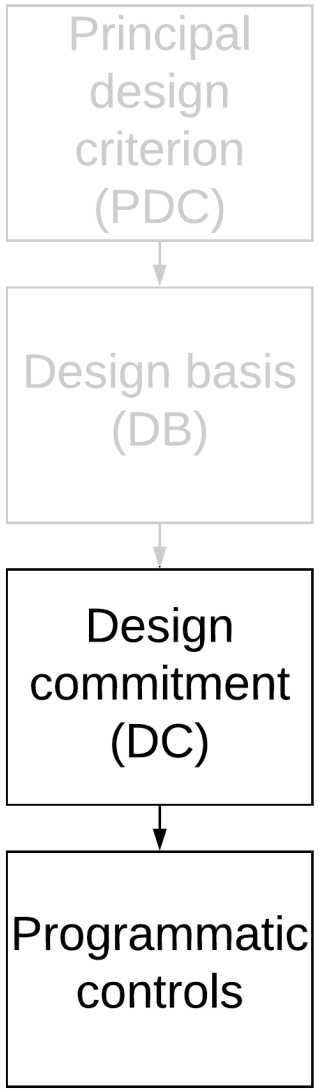
DB.SRS.02	The shutdown rod system fully inserts the shutdown rods within a sufficient time after receiving a trip signal to prevent damage to the reactor.
DC.SRS.02.A	The shutdown rod system fully inserts shutdown rods within X seconds of receiving a trip signal.
	POT.SRS.02.A (see Chapter 14)
	SUT.SRS.02.A
	TS.LCO.01 (see Part IV)



Iterative Process

- During the design process for the Aurora an iterative process of design of systems (**II.02**) and safety analysis of those systems (**II.05**) was used.
- The design phase determined the required DBs, the safety analysis confirmed the sufficiency of the DBs, and through iteration a final set of DBs was selected.

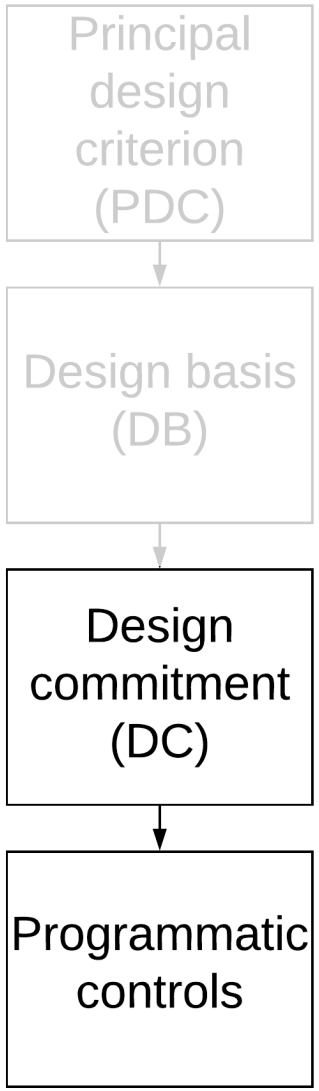




Programmatic Controls

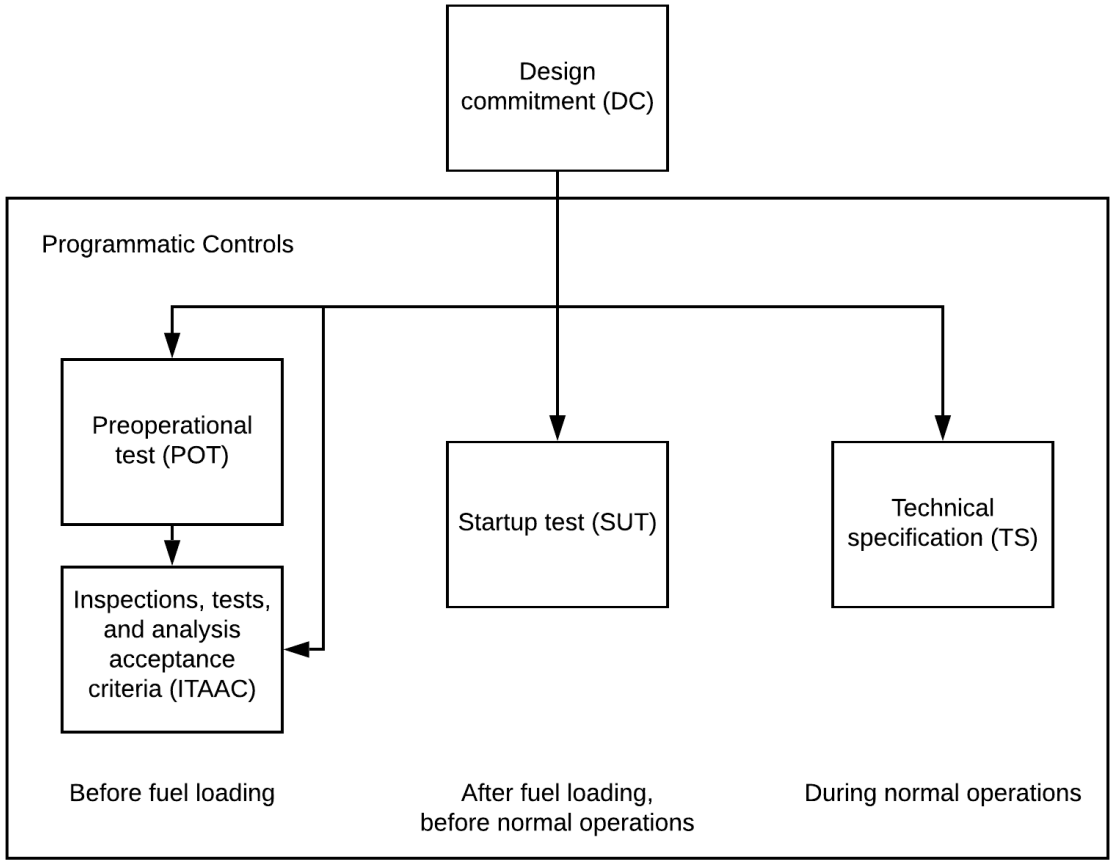
The Quality Assurance Plan, II.14 (Preoperational Testing and Initial Operations), IV (Technical Specifications), and **VI.B (Proposed License Conditions, App. B: ITAAC)** contain the programmatic controls that are used to verify design commitments are met. These include:

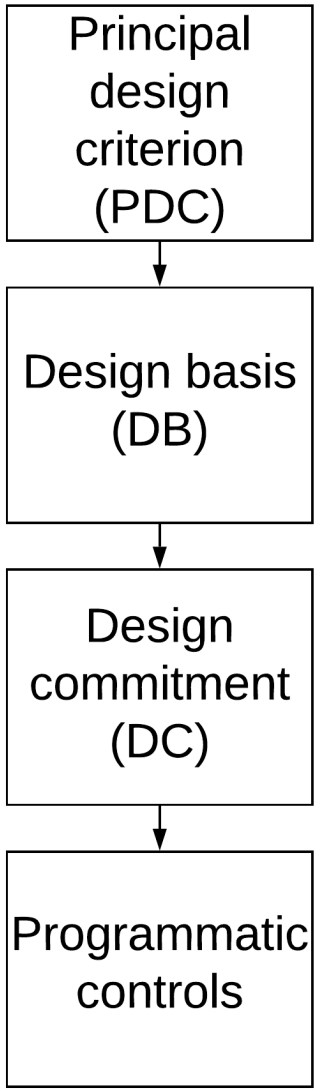
- QAPD (topical report submitted separately from COLA)
- Preoperational tests (POTs, **II.14**)
- Startup tests (SUTs, **II.14**)
- Inspection, test, analysis and acceptance criteria (ITAAC, **VI.B**)
- Technical specifications (TS, **IV.**)



Programmatic Controls

Each type of programmatic control helps assure DCs are met during a specific time period.





Summary

FSAR, description of SSCs (II.02) describes each system and provides the DBs and DCs

FSAR, transient analysis (II.05) describes assumptions and key parameters in analysis and confirms the sufficiency of the DBs and DCs in ensuring safety

FSAR, PDC (II.04) derives the principal design criteria from the FSFs with the DBs

The design process between II.02 and II.05 is iterative with insight from risk and external hazards, and PDC allow for a functional derivation of DBs.

QAPD, ITP (II.14), TS (IV), and **ITAAC (VI.B)** provide the programmatic controls that ensure the DBs and DCs are met starting from manufacturing, initial testing, and on an ongoing basis.

Ultimately, the Aurora COLA focuses on what must be maintained and in which way, not on arbitrary classification of SSCs into technology-irrelevant terms.

Conclusion

- Oklo utilized the NUREG 0800 event categories that LWRs do, *and* a range of other non-LWR events and heat pipe specific events. Oklo surveyed all external event hazard space
- Oklo structured its application based directly off existing regulations for requirements for an application
- Ultimately the Oklo Aurora plant is analyzed and safe against events that no existing (and safe) plant could withstand today, including a complete loss of everything outside the module (building, heat sink, power, etc), as well as simultaneous failure of a shutdown system
- We are proud to be working on a plant that has safety and environmental characteristics and benefits never seen before, and appreciate NRC work to ensure these plants with novel characteristics can be effectively licensed

Background slides

10 CFR 50.77 – (i.e., 10 CFR 50.33)

Section	Short description	Location in COLA
50.33(a)	**Name**	**I.01**
50.33(b)	**Address**	**I.01**
50.33(c)	**Description of business**	**I.01**
50.33(d)	**Business details**	**I.01**
50.33(e)	**Class of license**	**I.02**
50.33(f)	**Financial qualification**	**I.03**
50.33(g)	**Emergency planning governments**	**I.04**
50.33(h)	Construction or alteration	V.03
50.33(i)	Generation and distribution of electric energy	V.03
50.33(j)	Restricted Data or defense information	V.03
50.33(k)	**Decommissioning**	**I.05**

10 CFR 52.79 (part 1/4)

Section	Short description	Location in COLA
52.79(a)(1)	**Site envelope and boundary**	**II.01**
52.79(a)(2)	**Design and analysis of structures, systems, and components**	**II.02**
52.79(a)(3)	**Radioactive materials produced in operation**	**II.03**
52.79(a)(4)	**Principal design criteria**	**II.04**
52.79(a)(5)	**Transient analysis**	**II.05**
52.79(a)(6)	**Fire protection**	**II.06**
52.79(a)(7)	Pressurized thermal shock	V.03
52.79(a)(8)	Combustible gas control	V.03
52.79(a)(9)	Station blackout	V.03
52.79(a)(10)	Environmental qualification of electric equipment	V.03
52.79(a)(11)	Codes and standards	V.03
52.79(a)(12)	Primary containment leakage rate testing program	V.03

10 CFR 52.79 (part 2/4)

Section	Short description	Location in COLA
52.79(a)(13)	Reactor vessel material surveillance program	V.03
52.79(a)(14)	**Operator training program**	**V.04**
52.79(a)(15)	Maintenance rule	V.03
52.79(a)(16)	Effluent monitoring and sampling	V.03
52.79(a)(17)	Three Mile Island requirements	V.03
52.79(a)(18)	Risk-informed treatment of SSCs	V.03
52.79(a)(19)	**Earthquake criteria**	**II.07**
52.79(a)(20)	**Unresolved and generic safety issues**	**II.08**
52.79(a)(21)	**Emergency planning**	**II.09**
52.79(a)(22)	**Emergency planning with state and local governments**	**II.17**
52.79(a)(23)	Reserved	V.03
52.79(a)(24)	**Prototype operational conditions**	**II.11**

10 CFR 52.79 (part 3/4)

Section	Short description	Location in COLA
52.79(a)(25)	**Quality Assurance Program - design**	**II.12**
52.79(a)(26)	**Organizational structure for operations**	**II.13**
52.79(a)(27)	**Quality Assurance Program - operation**	**II.12**
52.79(a)(28)	**Preoperational testing and initial operations**	**II.14**
52.79(a)(29)	**Operational plans**	**II.15**
52.79(a)(30)	Technical Specification	IV
52.79(a)(31)	Multi-unit sites	V.03
52.79(a)(32)	Technical qualifications of the applicant	II.16
52.79(a)(33)	Training Program description	II.17
52.79(a)(34)	Operator requalification	V.04
52.79(a)(35)	**Physical security plans**	**II.18**
52.79(a)(36)	**Safeguards and other security plans**	**II.18**

10 CFR 52.79 (part 4/4)

Section	Short description	Location in COLA
52.79(a)(37)	**Incorporation of operational insights**	**II.19**
52.79(a)(38)	Severe accidents	V.03
52.79(a)(39)	**Radiation Protection Program description**	**II.20**
52.79(a)(40)	**Fire Protection Program description**	**II.21**
52.79(a)(41)	Standard Review Plan evaluation	V.03
52.79(a)(42)	Anticipated transients without scram	V.03
52.79(a)(43)	**Criticality accidents**	**II.22**
52.79(a)(44)	**Fitness-for-Duty Program description**	**II.23**
52.79(a)(45)	**Minimization of contamination**	**II.20**
52.79(a)(46)	**Probabilistic risk assessment summary**	**II.24**
52.79(a)(47)	Aircraft impact assessment	V.03

10 CFR 52.80

Section	Short description	Location in COLA
52.80(a)	**Inspections, tests, analyses, and acceptance criteria**	**VI**
52.80(b)	**Environmental report**	**III**
52.80(c)	Limited work authorization	V.03
52.80(d)	Mitigation of beyond design basis events	V.03

Organization of the Environmental Report

Chapter	Chapter title	Requirement
1	Purpose	None
2	Description of the Aurora site	
	Site description	10 CFR 51.45(b)
		10 CFR 51.45(c)
	Site preparation	10 CFR 51.45(b)
		10 CFR 51.45(c)
	Operational activities	10 CFR 51.45(b)
		10 CFR 51.45(c)
	Status of compliance	10 CFR 51.45(d)
3	Projected impacts	10 CFR 51.45(b)(1)
		10 CFR 51.45(b)(2)
		10 CFR 51.45(b)(4)
		10 CFR 51.45(c)
4	Environmental impacts of alternatives	10 CFR 51.45(b)(3)
		10 CFR 51.45(c)
5	Summary of impacts	
	Irreversible and irretrievable commitments of resources	10 CFR 51.45(b)(5)
	Benefits and cost	10 CFR 51.45(c)
Appendix A	Environmental commitment set	None