



# NRC Advanced Reactor Construction Oversight Process (ARCOP)

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## Stakeholder Workshop Series





# Welcome



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# Meeting Introductions and Guidelines



# Purpose and Desired Outcome

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## Purposes of Workshops

- Discuss the objectives and draft conceptual framework of the proposed NRC Advanced Reactor Construction Oversight Process (ARCOP).
- Initiate dialogue with the public stakeholders about advanced reactor construction oversight options.
- Gain understanding of various perspectives on options being considered.

\*Please note that NRC guidance discussions are preliminary and are not meant to convey a final regulatory position.



# Planned Workshop Sessions

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Session 1, February 28, 2024, and March 20, 2024:

Introduction to NRC Advanced Reactor Construction Oversight,  
and the ARCOP Framework.

Session 2, April 3, 2024:

Inspection Scoping

Session 3, Date:

Enforcement and Assessment

Session 4, Date:

Feedback/Wrap Up



# ARCOP Terms - Review

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**Quality of Reactor Plant Construction or Construction Quality** refers to quality assurance during the design, fabrication, manufacture, construction, and testing of plant structures, systems, and components (SSCs). Adequate quality of construction of nuclear power plants means that SSCs are built according to their approved licensing basis.

## **On-Site:**

The site of the reactor plant's final installation. (i.e., the site where the reactor is licensed to be installed and ultimately operated).

## **Manufacturer:**

An entity that fabricates or assembles a complete, or nearly complete, reactor plant in an off-site location (i.e., a factory).

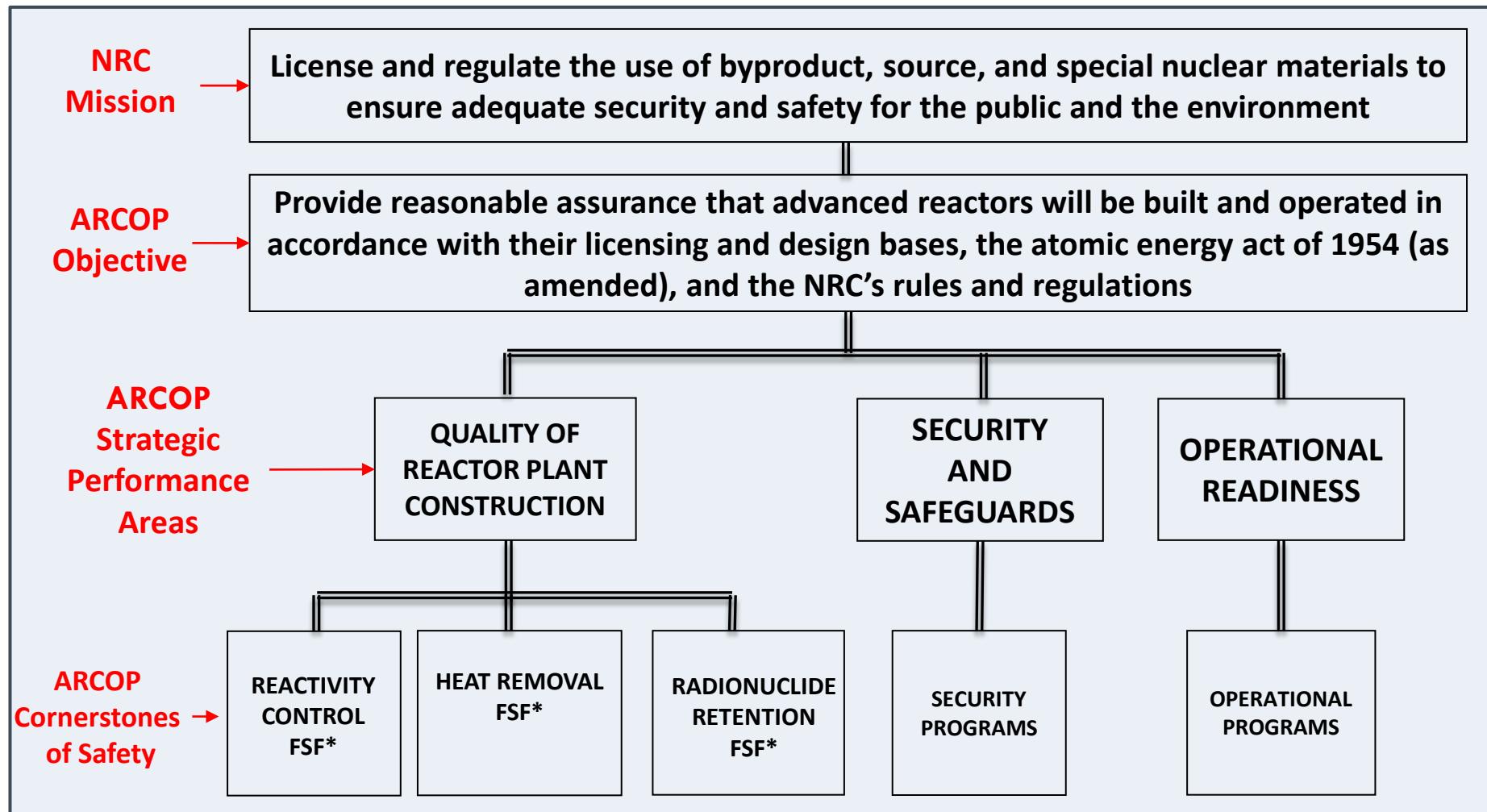
## **Vendors:**

Suppliers of components and services (to manufacturers or on-site). Vendors remain in the existing NRC vendor inspection program.



# Workshop Session #1 Review: Conceptual ARCOP Framework

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\*FSF = Fundamental Safety Function

Draft Concept



# Workshop Session #1 Review: ARCOP Discussion Topics

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- Inspection:
  - How is inspection scope determined?
  - How do we scope activities occurring at manufacturing facilities?
- Enforcement:
  - How can we best structure significance determination to reflect risk during construction?
  - How should we treat findings at manufacturing facilities?
- Assessment:
  - How can we best assess licensee and manufacturer performance while appropriately focusing on project quality and safety?



# Workshop Session #2

## Discussion Topics

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### Inspection:

- How is inspection scope determined?
- How do we scope activities occurring at manufacturing facilities?



# Key Decision #1: Inspection Scoping

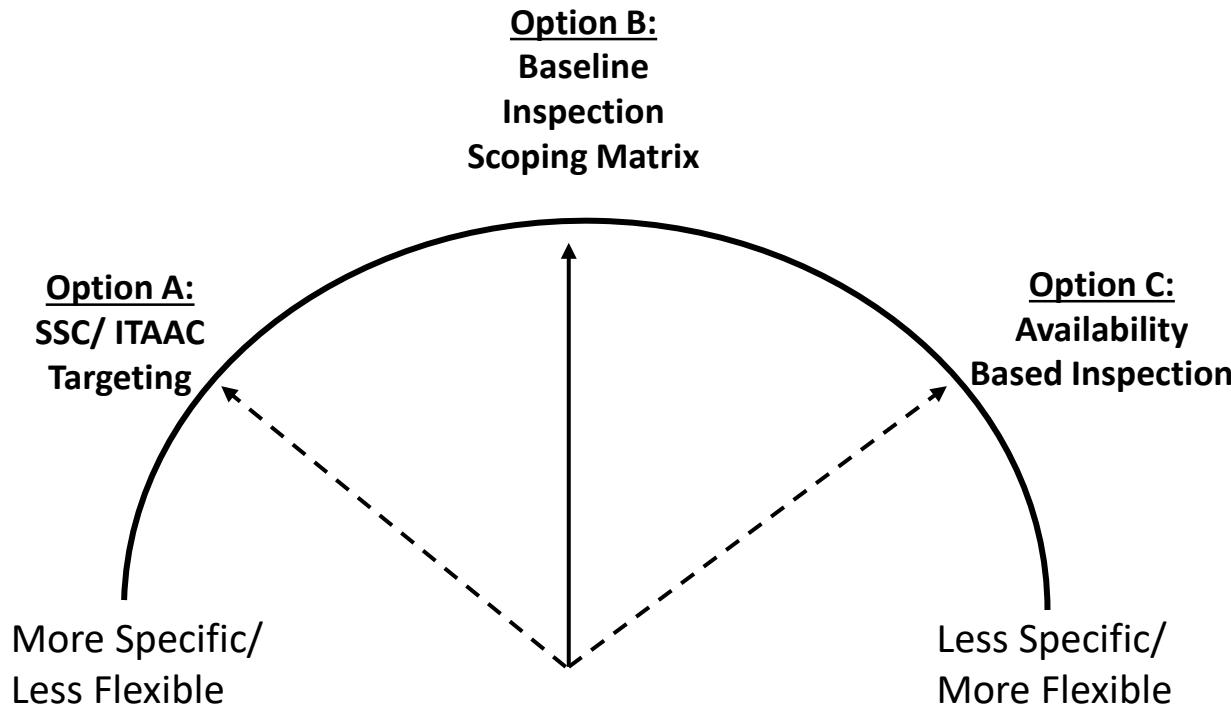
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## Options Considered:

- A. Specific SSCs and ITAAC targeted for inspection (AP1000)
- B. Baseline “Inspection Scoping Matrices”:  
Project-specific sampling of inspection areas.
- C. Availability Based Inspection:  
Periodic site inspections throughout construction

# Reasonable (and Efficient) Assurance

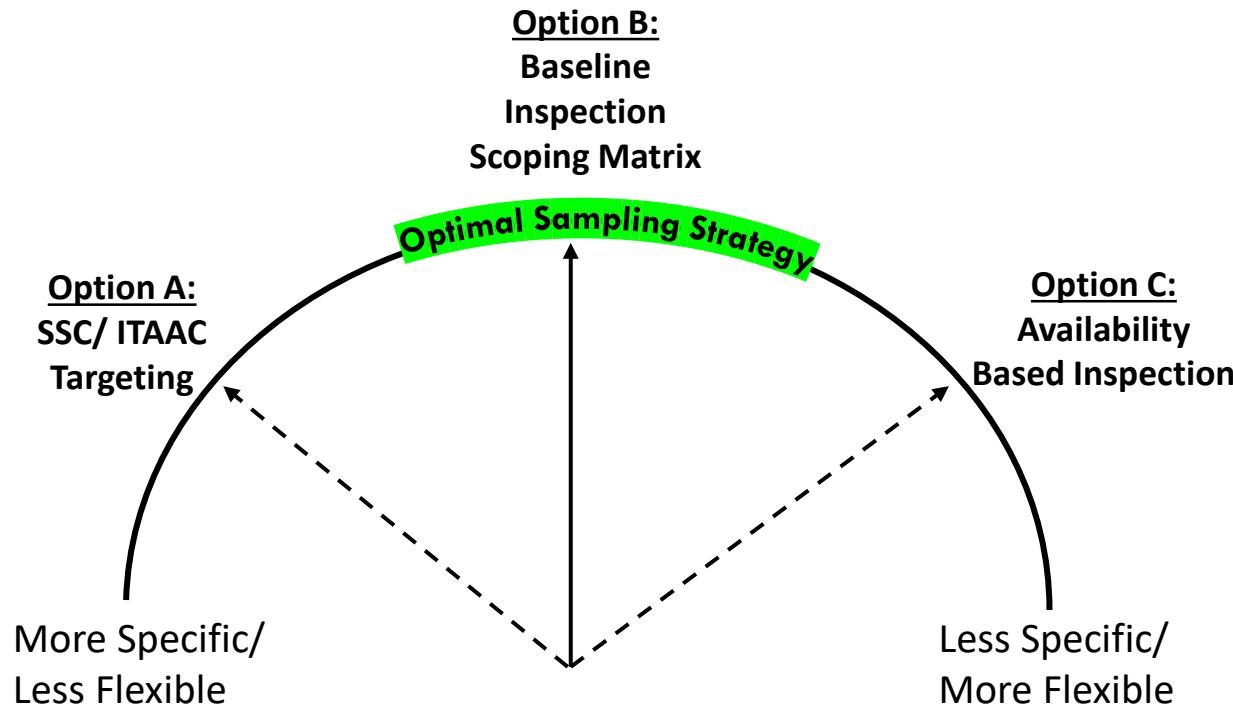
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Inspection Scoping Spectrum: Specific SSC Scoping vs. Flexibility

# Reasonable (and Efficient) Assurance

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Option B provides flexibility by allowing inspectors greater freedom in choosing SSCs that are representative of inspection area quality. Minimum and maximum samples within inspection areas are specified in the baseline inspection plan.



# Advantages of Option B: Inspection Scoping Matrices

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1. Provides reasonable assurance of inspection area quality through a combination of SSC and QAP inspections.
2. Efficiency maximized with the goal of reaching reasonable assurance with a well-defined baseline inspection program.
3. Quantifies cumulative inspection effort.



# Advantages of Option B: Inspection Scoping Matrices (cont.)

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4. Provides a tool for inspection staff to efficiently manage and plan baseline inspections
  
5. Provides a basis for reasonable assurance that the facility is built in accordance with its licensing and design bases. This is an input into the OL issuance (Part 50) and the fuel load (Part 52) decisions.



# Inspection Scoping Matrix (Draft Concept)

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# Inspection Scoping Matrix

## Draft Concept

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- Each inspection area (matrix column) is associated with an Inspection Procedure (IP).
  - IPs will verify implementation of the QAP, as it is applied to that inspection area.
- This type of inspection gives reasonable assurance that a specific SSC is of adequate quality and builds confidence that SSCs not inspected in the inspection area are also of adequate quality.
- This type of inspection is referred to as a “vertical slice” inspection – an SSC is chosen from an inspection area and each applicable QAP attribute is inspected.



# Stakeholder Engagement Point



## Building an Inspection Scoping Matrix: Inspection Areas

- Inspection areas:
  - Represented by the inspection scoping matrix columns
  - Represent different technical areas with similar implementation of QAP requirements.
  - May also represent programmatic aspects for efficiency gains (e.g., equipment qualification requirements)
- Inspection of one SSC in an inspection area provides information about the application of the QAP for other SSCs in the inspection area.



# Building an Inspection Scoping Matrix: SSCs

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SSCs populate the rows of the inspection scoping matrix.

- Only SSCs that are important to fulfilling fundamental safety functions (FSFs) are included in the matrix.
- Operational program inspections (FFD, security, in-service inspection, radiation protection, operator training, etc.) are scoped separately.



# Building the Inspection Scoping Matrix

- Step 1a: Identify SSCs important to fulfilling the FSFs
  - b: List the FSF that each SSC supports (may be multiple FSFs)
  - c: List the safety classification of each SSC
  - d: Identify Inspection Areas based on SSC commonalities
  - e: Indicate which SSC apply to which Inspection Areas ("X" or ITAAC No.)

System, Structures, and Components	FSF	Safety Class.	Foundations and Buildings	Reactor Vessel and Internals	Mechanical Components	Instrumentation and Control
SSC #1	DK	SR		X	02.03.09	X
SSC #2	HR	NSRRS		X		X
SSC #3	HR, RR	SR	02.01.06.i			



# Building the Inspection Scoping Matrix

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- Designate relative Risk Importance- Design ( $RI_D$ ) to aid inspectors in sample selection (H, M, L).
- Designate relative Risk Importance- Construction ( $RI_C$ ) to aid inspectors in sample selection (H, M, L).
- Include additional information/bases for the risk rankings for inspectors' information.



# Building the Inspection Scoping Matrix (Draft Concept)

- Step 2a: Assign design risk and basis to each SSC
- Step 2b: Assign manufacturing and construction risk and basis to each SSC

System, Structures, and Components	FSF	Safety Class.	RI <sub>D</sub>	RI <sub>D</sub> Basis	RI <sub>C</sub>	RI <sub>C</sub> Basis	IA #1	IA #2	IA #3	Additional IAs as necessary
SSC #1	DK	SR	H	Primary FSF success path	L	Preop ITP		X		
SSC #2	HR	SR	M	FSF DID	M	ConE OE	X		X	
SSC #3	HR, RR	SR	H	Primary FSF success path	H	Complex Process	02.01.06.i			
SSC #4	RR	SR	L	SR supports FSF	H	Complex Process		07.06.03		



# Building the Inspection Scoping Matrix

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- Assign minimum and maximum sample sizes to each inspection area. These will define the project “baseline inspection plan” in the Quality of Reactor Construction strategic performance area.
- The minimum number of samples is an estimate of the number of samples required to gain reasonable assurance in that inspection area, based on complexity of design, design construction experience, etc.
- The maximum number of samples is a threshold that would indicate that something out of the ordinary is present in that inspection area.



# Building the Inspection Scoping Matrix

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- The minimum and maximum sample sizes for a reactor design are estimates that will be refined as the NRC gains inspection experience with new designs.
- The minimum sample sizes are estimates and may be adjusted for a project, or for nth-of-a-kind reactors, if warranted.
- Inspections beyond the minimum are performed if reasonable assurance is not yet obtained.
- Inspections beyond the maximum number of samples for an inspection area may only be exceeded when something out of the ordinary exists (e.g., unresolved findings, unresolved allegations, or new ConE/OE), and with NRC management approval.



# Building the Inspection Scoping Matrix

## Step 3: Assign maximum and minimum samples sizes

System, Structures, and Components	FSF	Safety Class.	RI <sub>D</sub>	RI <sub>D</sub> Basis	RI <sub>C</sub>	RI <sub>C</sub> Basis	IA #1	IA #2	IA #3	Additional IAs as necessary
Minimum Inspection Area Inspection Samples							4	8	10	
Maximum Inspection Area Inspection Samples							8	11	14	
SSC #1	DK	SR	H	Primary FSF success path	L	Preop ITP		X		
SSC #2	HR	SR	M	FSF DID	M	ConE OE	X		X	
SSC #3	HR, RR	SR	H	Primary FSF success path	H	Complex Process	02.01.06.i			
SSC #4	RR	SR	L	SR supports FSF	H	Complex Process		07.06.03		



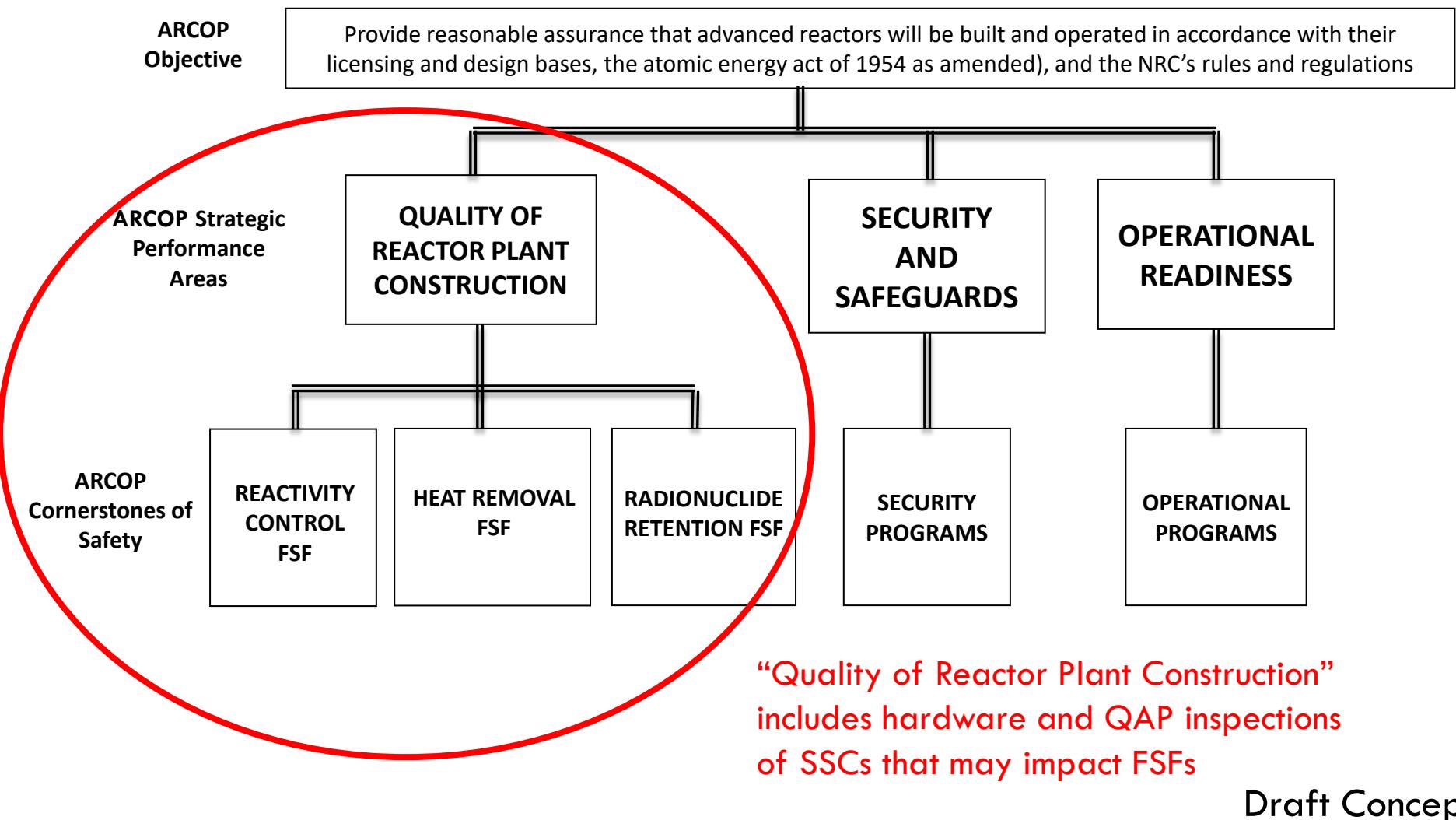
# ARCOP Inspection Scoping Matrix

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- Applies to the “Quality of Reactor Plant Construction” Strategic Performance Area.
- Safeguards & Security and Operational Readiness Strategic Performance Area will be scoped separately.

# Conceptual ARCOP Framework

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# Using the Inspection Scoping Matrix/Baseline Inspection Plan

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- Reasonable Assurance of Inspection Area Quality
- Minimum Inspection Area sample sizes
- Maximum Inspection Area sample sizes
- Adjusting min/max samples



# Executing the Inspection Scoping Matrix/Baseline Inspection Plan

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**Reasonable assurance of quality (in each inspection area) =**

confidence that the SSCs in an inspection area are being (and will continue to be) manufactured/constructed in accordance with quality standards specified in the license (LWA, CP, COL, etc.)

Each inspection area will be assessed for **“reasonable assurance of quality”** after inspections (referred to as the “continuous assessment” process).

Each inspection area is assessed separately but will consider QAP overlaps where applicable.



# Executing the Inspection Scoping Matrix/Baseline Inspection Plan

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**Minimum sample sizes** are specified for each inspection area.

Sample sizes are assigned based on risk-insights, design complexity, and construction experience.

Represents an NRC assessment hold point for each inspection area.



# Executing the Inspection Scoping Matrix/Baseline Inspection Plan

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**Maximum sample sizes** are specified for each inspection area.

Sample sizes are assigned based on risk insights, design complexity, and construction experience.

Refers to the maximum number of samples needed to make a reasonable assurance determination.

Requires review/approval by NRC management prior to exceeding maximum.



# Executing the Inspection Scoping Matrix/Baseline Inspection Plan

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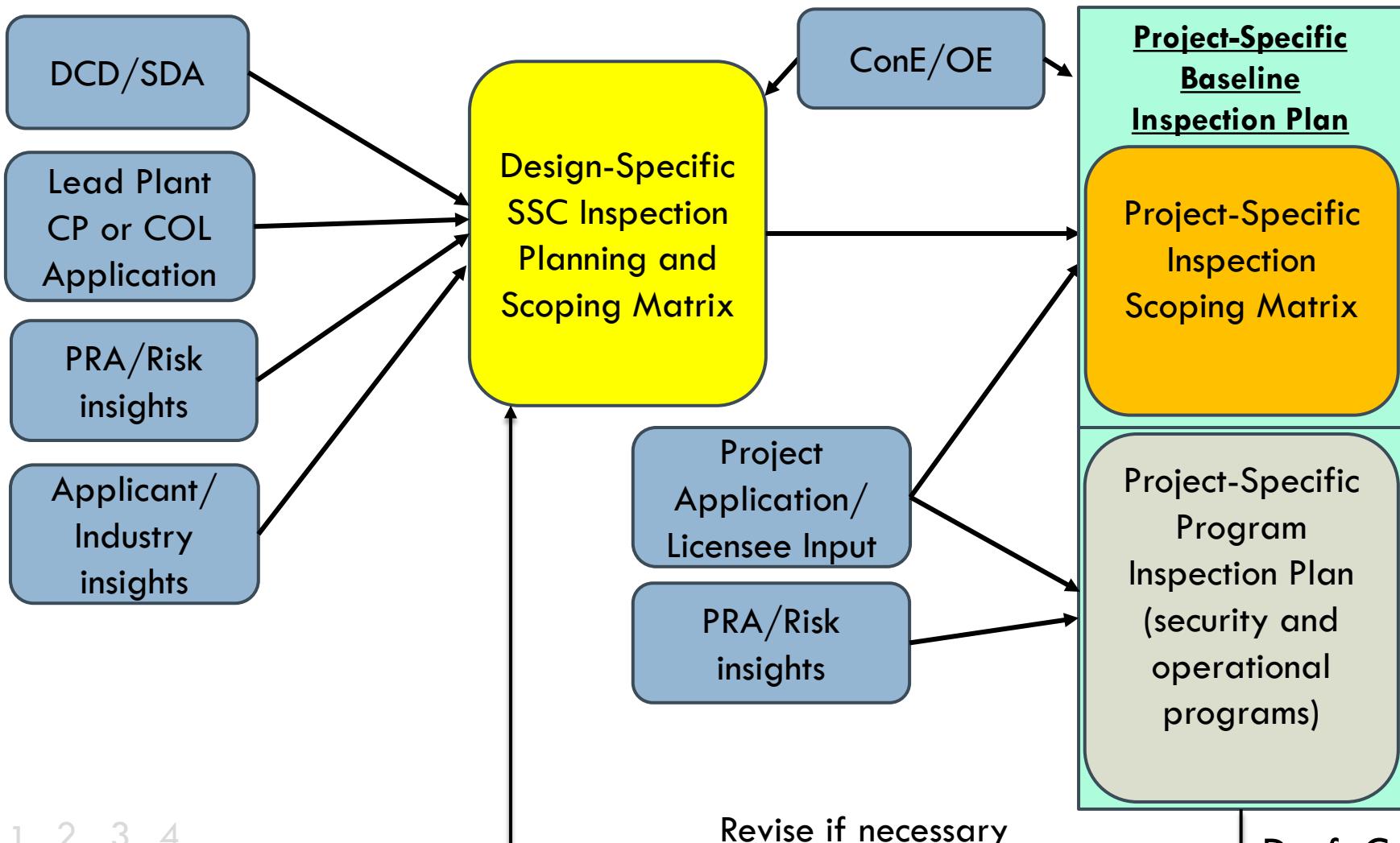
## Project-specific sample sizes:

- **less than minimum** may be approved by NRC management with sufficient justification of reasonable assurance.
- **more than maximum** may be approved by NRC management in cases where:
  - ◆ New ConE/OE becomes available
  - ◆ Previous findings not closed due to an ongoing performance/quality issue
  - ◆ Maximum samples reached without sufficient information to make a reasonable assurance determination (rare)
  - ◆ Significant QAP revision that changes previous information supporting the reasonable assurance determination



# Building a Project-Specific Baseline Inspection Plan

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# Stakeholder Engagement Point



# Inspection Scoping Exercise

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## Exercise: Building an Inspection Scoping Matrix

### Hypothetical Reactor 1 (HR1)

Note: For this exercise, HR1 has submitted a construction permit (CP) application in accordance with 10 CFR Part 50.



# Step 1a: Identify SSCs

Note: this is a partial list of hypothetical SSCs for this exercise

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<u>Reactor Cavity Cooling System (RCCS)</u>	<u>Reactor Vessel System</u>	<u>Reactor Protection System</u>	<u>Primary Coolant Loop</u>	<u>Refueling System</u>	<u>Reactor Building</u>	<u>Fire Protection System</u>
Water storage tanks	Rx vessel	Software Lifecycle	Piping	Fuel/Salt Mix tank	Foundation	Alarm system
Steam separators	Graphite reflector blocks	Field sensors	Heat exchanger	Salt purification subsystem	Core support structure	Manual fire fighting equip
Float valves	Anti-siphon	Instrumentation circuitry/ cabinets	Primary Coolant Pump	Fuel prep tank	Geometrically safe floor drains	Reactor cavity fire suppression
Evaporator tubes/thimbles	Core barrel	Signal cables	Flow control valves	Isolation valves	Biological shield	Control room fire suppression
Leak detection instruments	Salt Level instruments	Power supply	Spill isolation valves	Piping	Tank supports	
Piping		Dump Valves		Misc. maintenance isolation valves	Structural steel supports	
Water level control system		Geometrically safe dump tanks (4)		Instrumentation system	Walls, floors, and ceilings	
Isolation valves		Refueling isolation valves (inboard)		Control system		
Power Supply				Circulation pump		



# Steps 1b and 1c: Supported FSFs and Safety Classifications

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SSCs*	FSF	Safety Class.
RCCS water tanks	HR	SR
RCCS Water level control system	HR	SR
RCCS Float valves	HR	SR
RCCS Evaporator tubes/thimbles	HR	SR
RCCS Piping	HR	SR
Rx vessel	HR, RR, DK	SR
Graphite reflectors	DK	SR
Rx vessel level instruments	RR, DK	SR
RPS Software Lifecycle	DK	SR
RPS Field sensors	DK	SR
RPS Instrumentation circuitry/ cabinets	DK	SR
RPS Dump Valves	DK, RR	SR
Rx Bldg Foundation	HR, RR, DK	SR
Rx Bldg Steel supports	HR, RR, DK	SR
Rx Building walls, floors, and ceilings	HR, RR	SR

## Acronyms

SSC: Structures, Systems, and Components

FSF: Fundamental Safety Function

HR: Heat Removal FSF

DK: Reactivity and Power Control FSF

RR: Radionuclide Retention FSF

SR: Safety Related

NSRRS: Non-Safety Related, Risk Significant

\*Associated with hypothetical plant shown on previous slide



# Steps 1b and 1c: Supported FSFs and Safety Classifications (continued)

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SSCs	FSF	Safety Class.
Primary salt loop piping	HR	SR
Primary salt heat exchanger	HR	SR
Primary Salt Pump	HR	SR
Primary salt loop flow control valves	HR	SR
Fuel/Salt Mix tank	DK	NSRRS
Salt purification loop	DK	NSRRS
Fuel prep tank	DK	NSRRS
Fueling system isolation valves	DK	SR
Fueling system piping	DK	NSRRS
Fueling system maintenance isolation valves	DK	NSRRS
Fueling system circulation pump	DK	NSRRS
Fire alarm system	?	Not SR or NSRRS
Control room fire suppression	?	Not SR or NSRRS

Fire protection SSCs, like other program-related SSCs (security, emergency planning, radiation protection, etc.) are not included in the Quality of Reactor Plant Construction strategic performance area

They should not be on this inspection scoping matrix.

Instead, fire protection and other SSCs not directly related to reactor safety may be included in safeguards/security or operational program inspections.



## Steps 1d and 1e: Identify Inspection Areas and Assign SSCs to Inspection Areas ("X" or ITAAC No.)

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SSCs	FSF	Safety Class.	Structural concrete	Mechanical Components	I & C	ASME Quals.	Reactor Internals	Piping	Seismic Quals
RCCS water tanks	HR	SR		X					X
RCCS Water level control system	HR	SR							
RCCS Float valves	HR	SR							
RCCS Evaporator tubes	HR	SR							
RCCS Piping	HR	SR							
Rx vessel	HR, RR, DK	SR							
Graphite reflectors	DK	SR							
Rx vessel level instruments	RR, DK	SR							
RPS Software Lifecycle	DK	SR							
RPS Field sensors	DK	SR							
RPS Dump Valves	DK, RR	SR							
Walls, floors, and ceilings	HR, RR	SR							
Primary salt piping	HR	SR							
Tank supports	HR	SR							

Inspection areas are selected based on technical and QAP commonalities.

Some inspection areas, such as "ASME or Seismic Qualifications" may be created for greater inspection efficiency.



## Steps 1d and 1e: Identify Inspection Areas and Assign SSCs to Inspection Areas ("X" or ITAAC No.)

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SSCs	FSF	Safety Class.	Structural concrete	Mechanical Components	I & C	ASME Quals.	Reactor Internals	Piping	Seismic Quals
RCCS water tanks	HR	SR		X					X
RCCS Water level control system	HR	SR			X				
RCCS Float valves	HR	SR		X					
RCCS Evaporator tubes	HR	SR		X					X
RCCS Piping	HR	SR				X		X	X
Rx vessel	HR, RR, DK	SR				X			
Graphite reflectors	DK	SR							
Rx vessel level instruments	RR, DK	SR							
RPS Software Lifecycle	DK	SR							
RPS Field sensors	DK	SR							
RPS Dump Valves	DK, RR	SR							
Walls, floors, and ceilings	HR, RR	SR							
Primary salt piping	HR	SR							
Tank supports	HR	SR							

X's indicate that the SSC (row) is an inspection sample opportunity in the associated inspection areas (columns).

Note: Most SSCs are expected to be included in multiple inspection areas.



## Steps 1d and 1e: Identify Inspection Areas and Assign SSCs to Inspection Areas ("X" or ITAAC No.)

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SSCs	FSF	Safety Class.	Structural concrete	Mechanical Components	I & C	ASME Quals.	Reactor Internals	Piping	Seismic Quals
RCCS water tanks	HR	SR							
RCCS Water level control system	HR	SR							
RCCS Float valves	HR	SR							
RCCS Evaporator tubes	HR	SR							
RCCS Piping	HR	SR							
Rx vessel	HR, RR, DK	SR							
Graphite reflectors	DK	SR							
Rx vessel level instruments	RR, DK	SR							
RPS Software Lifecycle	DK	SR				X			
RPS Field sensors	DK	SR				X			
RPS Dump Valves	DK, RR	SR		2.2.1.03.a		X			
Walls, floors, and ceilings	HR, RR	SR	X						X
Primary salt piping	HR	SR				X		X	
Tank supports	HR	SR	X						X

If there are ITAAC associated with the SSC, then the ITAAC number is used to indicate an inspection opportunity for that SSC in the appropriate inspection area.

2.2.1.03.a



## Steps 2a and 2b: Assign a relative design risk, design risk basis, manufacturing and construction risk and basis to each SSC

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SSCs	FSF	Safety Class.	RI <sub>D</sub>	RI <sub>D</sub> Basis
RCCS water tanks	HR	SR	H	PRA HR FSF
RCCS Water level control system	HR	SR	H	PRA HR FSF
RCCS Float valves	HR	SR	H	PRA HR FSF
RCCS Evaporator tubes	HR	SR	H	PRA HR FSF
RCCS Piping	HR	SR	H	PRA HR FSF
Rx vessel	HR, RR, DK	SR	H	
Graphite reflectors	DK	SR	L	
Rx vessel level instruments	RR, DK	SR	M	
RPS Software Lifecycle	DK	SR	H	
RPS Field sensors	DK	SR	H	
RPS Dump Valves	DK, RR	SR	H	Primary DK path
Walls, floors, and ceilings	HR, RR	SR	H	
Primary salt piping	HR, RR	SR	M	
Tank supports	RR	SR	M	

Risk Importance- Design (RI<sub>D</sub>) is an SSCs importance relative to the other SSCs in matrix.

All SSCs on the matrix are legitimate inspection opportunities.

RI<sub>D</sub> is based on PRA if available and other risk insights.



## Steps 2a and 2b: Assign a relative design risk, design risk basis, manufacturing and construction risk and basis to each SSC

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Risk Importance- Construction ( $RI_C$ ) is based on the relative risk of a deficiency occurring during construction and the risk of not identifying the deficiency prior to operations.

Factors impacting  $RI_C$  are:

- industry experience with the activity (FOAK)
- complexity of the activity
- Construction Experience (ConE) or Operating Experience (OE)
- other planned verification or testing activities to assure quality prior to operations

RI <sub>D</sub> Basis	RI <sub>C</sub>	RI <sub>C</sub> Basis	Structural concrete	Mechanical Components	I & C
HR	L			X	
F					X
HR	L			X	
F					X
HR	L			X	
F					X
HR	H	FOAK			
	M	ConE			
	H	FOAK			
	M	complex			X
	M	complex			X
	H	ConE/complex			X
DK	M	ConE		X	
	L		X		
	M	ConE			
	L		X		



## Step 3: Assign maximum and minimum samples sizes to each inspection area

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SSCs	FSF	Safety Class.	RI <sub>D</sub>	RI <sub>D</sub> Basis	RI <sub>C</sub>	RI <sub>C</sub> Basis	Structural concrete	Mechanical Components I & C
		Minimum Inspection Area Sample Size					8	5
		Minimum Inspection Area Sample Size					12	8
RCCS water tanks	HR	SR	H	PRA HR FSF	L		X	

Minimum sample size based on the minimum inspection information needed to come to a reasonable assurance of inspection area quality determination.

Exceeding the maximum sample size indicates that there may be problems in that inspection area that need NRC management attention, such as:

1. Quality issues resulting in NRC findings in the inspection area.
2. Unanticipated complexities in the inspection area potentially needing an adjustment in NRC resources and inspections in the inspection area.
3. Changes in a previous determination of reasonable assurance in the inspection area due to additional information such as ConE/OE, allegations, or significant changes in the construction organization (e.g., change in prime contractor).



# Tracking inspections using the project inspection scoping matrix

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SSCs	FSF	Safety Class.	RI <sub>D</sub>	RI <sub>D</sub> Basis	RI <sub>C</sub>	RI <sub>C</sub> Basis	Structural concrete	Mechanical Components	I & C
		Minimum Inspection Area Sample Size					8	5	5
		Minimum Inspection Area Sample Size					12	8	8
		Completed samples					5	6	3
Reactor Bldg sample #1	HP	SP	H	PRA IIR	I		✓		

The number of completed samples in each inspection area is tracked to ensure assessments are performed after the minimum number of samples are complete, and each inspection thereafter.



# Tracking inspections using the project inspection scoping matrix

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Cells are color coded to indicate which SSCs were sampled in the inspection area, and the results.

This aids in inspection planning and inspection  
preparation.



# Other Inspection Planning Notes

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- Using construction oversight experience, the NRC can estimate the inspection hours per sample in each inspection area.
- A range of the total number of inspection hours for the Quality of Reactor Construction portion of the baseline inspection plan can then be generated using the minimum and maximum sample sizes of each inspection area.
- Inspection plans can then be adjusted by using more or less inspection areas, or by adjusting the minimum and maximum required samples.



# Stakeholder Engagement Point



# Key Takeaways

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- Different SSC inspection scoping scales for advanced reactors (non-LWR, SMR, and microreactors) is achieved by use of an inspection scoping matrix that:
  - includes only SSCs that affect FSFs
  - organizes SSCs into “inspection areas” where general conclusions can be drawn about inspection area quality based on informed sampling
  - requires inspection area assessments after a set number of inspection samples. An affirmative assessment of quality in an inspection area would result in no additional required samples in the inspection area.
  - results in reasonable estimates of NRC oversight costs to licensees
  - increases NRC inspection efficiency and reduces indirect\* charges to licensees

\* Indirect charges include travel, inspection planning, and inspection documentation costs.



# Key Takeaways (continued)

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- Inspection scoping of Safeguards, Security and Operational Programs is not included in the matrix and will be discussed at future workshops.
- Enforcement of findings and assessment of oversight results will be discussed in the next workshop.
- Feedback during this and future workshops will help guide development of ARCP.

Thank you for attending.



# Planned Workshop Sessions

Session 1, February 28, 2024, and March 20, 2024:

Introduction to NRC Advanced Reactor Construction Oversight,  
and the ARCOP Framework.

Session 2, April 3, 2024:

Inspection Scoping

Session 3, Date:

Enforcement and Assessment

Session 4, Date:

Feedback/Wrap Up



# Feedback on this Public Meeting



<https://feedback.nrc.gov/pmts/feedback/form?meetingcode=20240424>