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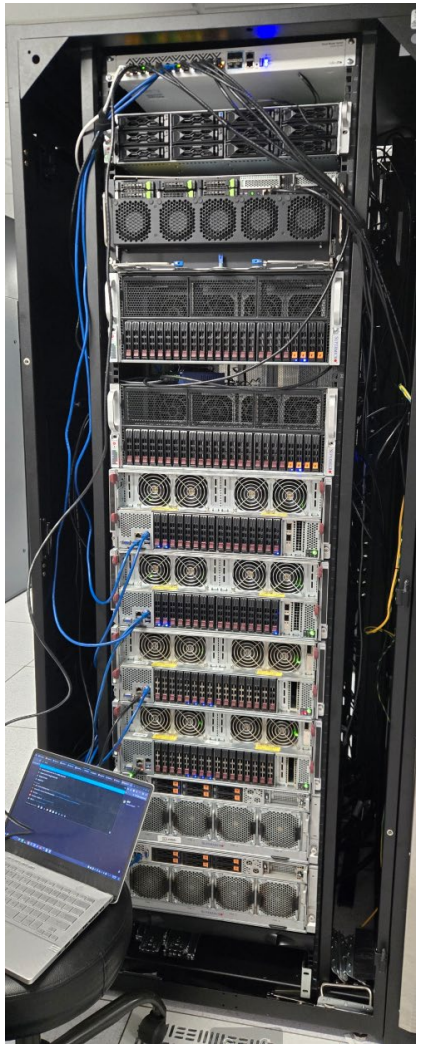
Automating 50.59s with AI

(and some other Engineering tasks too)

Nuclearn Quick Intro



- Nuclear Specific AI - Founded 2021 in Phoenix, AZ
- Deployed in 65 + reactors worldwide
- Develop the Nuclearn Platform (Agentic AI Platform with data mgmt, document search/intelligence, hybrid RAG, etc), train our own models, & run our own physical GPU clusters
- GammaLLM Series- Nuclear LLM & plant specific LLMs
- 80 + years of nuclear power engineering, operations, maintenance experience
- Automating the issue discovery and resolution cycle

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50.59, 50.65, 50.72/3

How we are thinking about using AI in Engineering, Licensing, et al

- 50.65 - Determine MRFF status, complete comments.
- 50.72/3 - Determine reportability and complete form, assist staff determinations
- **50.59** - Can it be entirely automated? Can the research be automated? Is it good enough for use?

Same tech applies to any complex document workflow

(ODMI, Design Eval, etc)

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50.59 - Prior NRC Approval?

I want to change my equipment/procedure/anything, do I need to ask first?

Following stages in NEI 96 -07 to determine

Applicability Determination	Screening	Evaluation
100x	10x	1x
AI - Moderate	AI - Easier	AI - Difficult
Human - Easy	Human - Moderate	Human - Difficult

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Simple Workflow, Seems Easy Enough?!

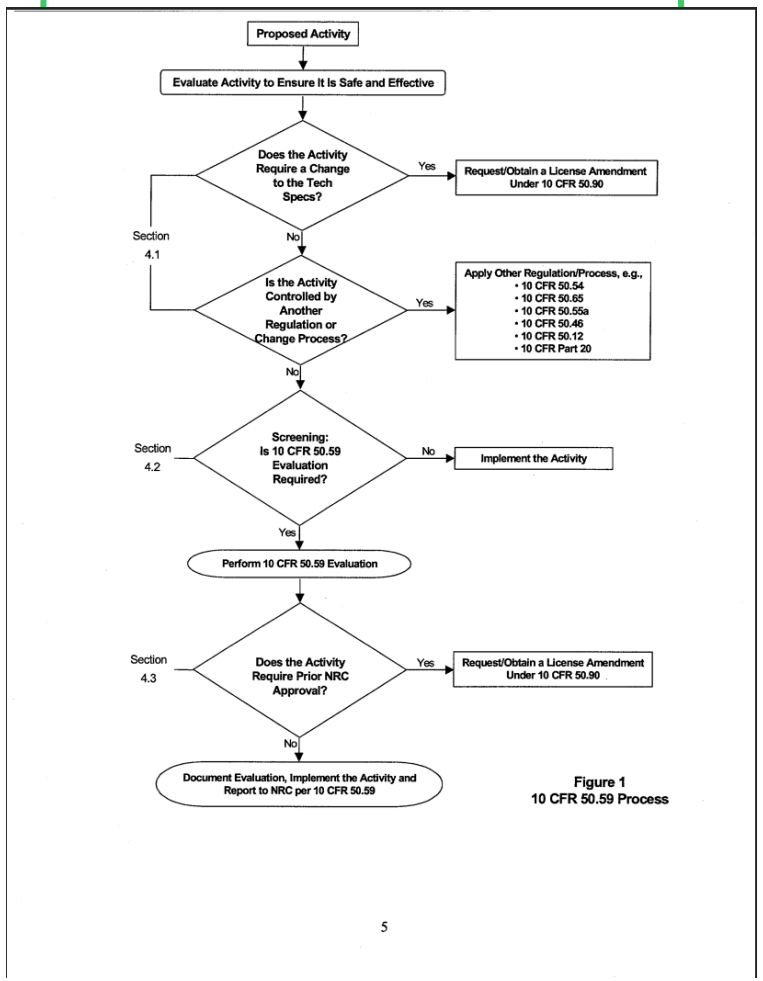

Figure 1
10 CFR 50.59 Process

Maybe just RAG it? With Claude?

Not so fast…

Examples look good on the surface, but the best models still make mistakes

Input: "Do a 5059 screening of: CR-WF3-2016-4009 identified that the Technical Requirements Manual (TRM) 4.3.4.2.a turbine valve testing, scheduled for 6/17/2016, was not performed due to a MISO conservative operations notice..."

Even with the best LLMs, Opus 4.1 Output:

```
SCREENING QUESTIONS:
1. Does the proposed activity result in a change to an SSC that adversely affects an
UFSAR-described design function?
2. Does the proposed activity result in a change to a procedure that adversely affects
how UFSAR-described SSC design functions are performed or controlled?
3. Does the proposed activity result in revising or replacing an UFSAR-described
evaluation methodology...
4. Does the proposed activity involve a test or experiment not described in the
UFSAR...
```

4.2 SCREENING

Once it has been determined that 10 CFR 50.59 is applicable to a proposed activity, screening is performed to determine if the activity should be evaluated against the evaluation criteria of 10 CFR 50.59(c)(2).

4.2.1 Is the Activity a Change to the Facility or Procedures as Described in the UFSAR?

4.2.2 Is the Activity a Test or Experiment Not Described in the UFSAR?

Problem: This is NOT aligned with NEI 96-07

- Actual NEI 96-07 Screening: Only 2 questions, not 4
- Wrong Questions: These are not the correct NEI 96-07 screening questions
- Mixing Phases: Confusing applicability criteria with screening questions

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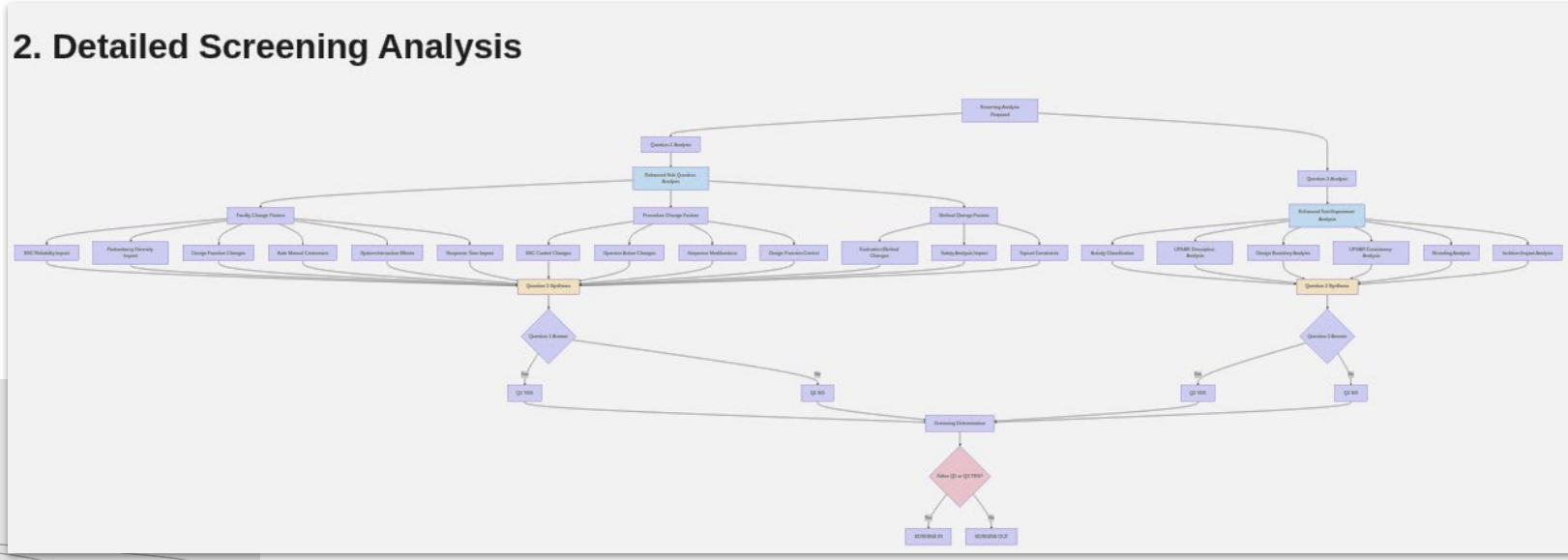
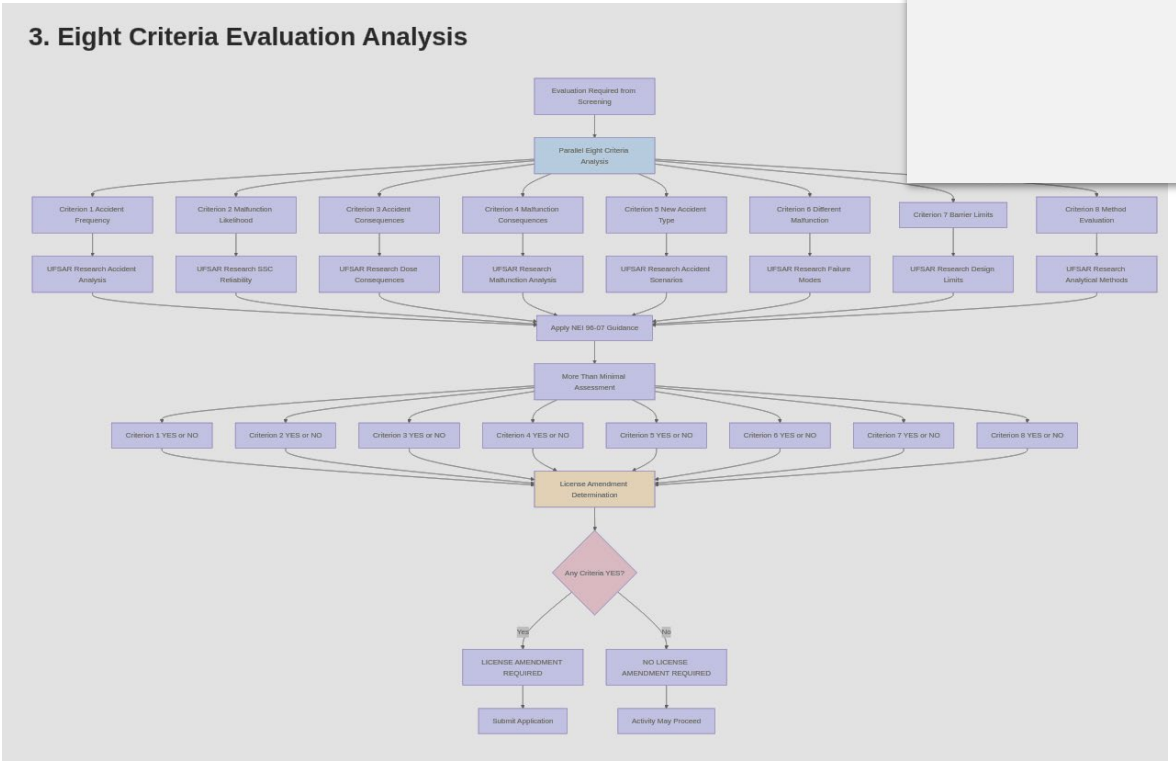
Digging deeper into NEI 96 -07… Breaking it all out

80 + independent LLM calls to perform AD

Humans are able to simplify complex process, process Complexity jumps to make AI work for real





20 + steps to perform an AD
80 + independent LLM calls
At least as many for Screening + Evaluation

Actual 5059 is challenging - evaluations are complex.

Complex change at WF3 involving neutron fluence code;
Responses to evaluation questions require complicated context

I. OVERVIEW / SIGNATURES[1]

Facility: Waterford 3 **Evaluation # / Rev. #:** 17-01 / 0

Proposed Change / Document: EC 68581, Evaluation of Reactor Vessel Surveillance and Current License Basis

Description of Change: CR-WF3-2016-6358 identified that the WF3 surveillance capsule W-83 neutron fluence was analyzed using the Westinghouse RAPTOR-M3G code, which is not a fluence analysis method in the current Waterford 3 licensing basis. The analysis results from capsule W-83 were used in the Reactor Vessel Integrity Time-Limited Aging Analysis (TLAA), WF3-EP-16-00001 (WCAP-18002-NP), to predict the adjusted reference temperature (ART), upper shelf energy (USE), and pressurized thermal shock reference temperature (RT_{PTS}) for the end of the current license period (32 effective full power years of operation). Since the analysis of capsule W-83 was required by 10CFR50 Appendix H for the current license period, the ART, USE, and RT_{PTS} derived from it should be incorporated into the current license basis.

The purpose of the reactor vessel fluence calculation method is to calculate cumulative neutron irradiation levels to which the reactor vessel materials are subjected. The calculated fluence is used as an input for calculating Pressure-Temperature limit curves and predicting pressurized thermal shock (RT_{PTS}) and Upper Shelf Energy (USE) fracture toughness-related screening criteria as required in 10CFR50.61 and 10CFR50 Appendix G. The neutron fluence calculation methodology described in the NRC Waterford 3 Amendment 196 Safety Evaluation Report [Reference 12] for WCAP-16002-NP [Reference 13] and WCAP-16088-NP [Reference 14] was DORT (Discrete Ordinates Code). WCAP-16002-NP describes the DORT code. WCAP-16088-NP references WCAP-14040-NP-A [Reference 15] which describes the DORT code. WCAP-14040-NP-A is the Westinghouse methodology used to develop overpressure system setpoints and reactor coolant system heatup and cooldown limit curves. WCAP-14040-NP-A has been generically approved by the NRC for Westinghouse use.

Purpose with outside regulation context

Outside technical detail

Reference chain of endorsed tech docs

appropriate for the intended application, the terms and conditions for its use as specified in the SER have been satisfied, and the method has been approved by the NRC.

Catawba precedent

Knowledge of Catawba licensing basis

Catawba Nuclear Station license amendment Safety Evaluation Report (SER) Section 3.2.6 describes the NRC review and approval of the neutron fluence calculation method. The NRC staff evaluated the RAPTOR-M3G neutron fluence method in accordance with Regulatory Guide 1.190 [Reference 6]. The Catawba SER provided criteria associated with Regulatory Guide 1.190 stating that an acceptable neutron fluence calculation has the following attributes:

- Criteria 1 - Performed using an acceptable methodology
- Criteria 2 - Contains an analytic uncertainty analysis identifying possible sources of uncertainty
- Criteria 3 - Contains a benchmark comparison to approved results of a test facility
- Criteria 4 - Demonstrates plant-specific qualification by comparison to measured fluence values

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How Humans Do 50.59 Analysis vs. How AI Should Do It

Human Process Pattern Recognition

Observable Human Patterns in 50.59 Analysis:

- Systematic Approach: Humans follow the same basic pattern across evaluations
- Training Consistency: Many people trained similarly in NEI 96-07 methodology
- Author Consistency: Evaluations often authored by the same experienced professionals
- Progressive Refinement: Multiple review cycles with peer checking

Human Tools That Work For AI too:

- Self-Check: Individual review of analysis completeness
- Peer Check: Colleague review for technical accuracy
- Independent Verification (IV): Independent technical review
- Management Review: Senior oversight and approval

AI Replication Strategy

Specificity of the Ask:

- Break Down High-Level Tasks: Decompose complex regulatory questions into specific sub-tasks
- Assign Focused Sub-Tasks: Each AI agent gets narrow, specific assignments
- Reduce Distraction: Broad asks add noise to AI model performance
- Higher Probability of Success: Simple, specific questions have higher accuracy rates

Multi-Agent Implementation:

```
Instead of asking one AI agent to do everything
"Perform 50.59 screening"

Break into specific persona research assignments:
License Analyst: "Identify tech spec requirements"
Research Agent: "Research UFSAR for XYZ"
Technical Agent: "Assess technical adequacy"
IV Agent: "Challenge analysis for oversights"
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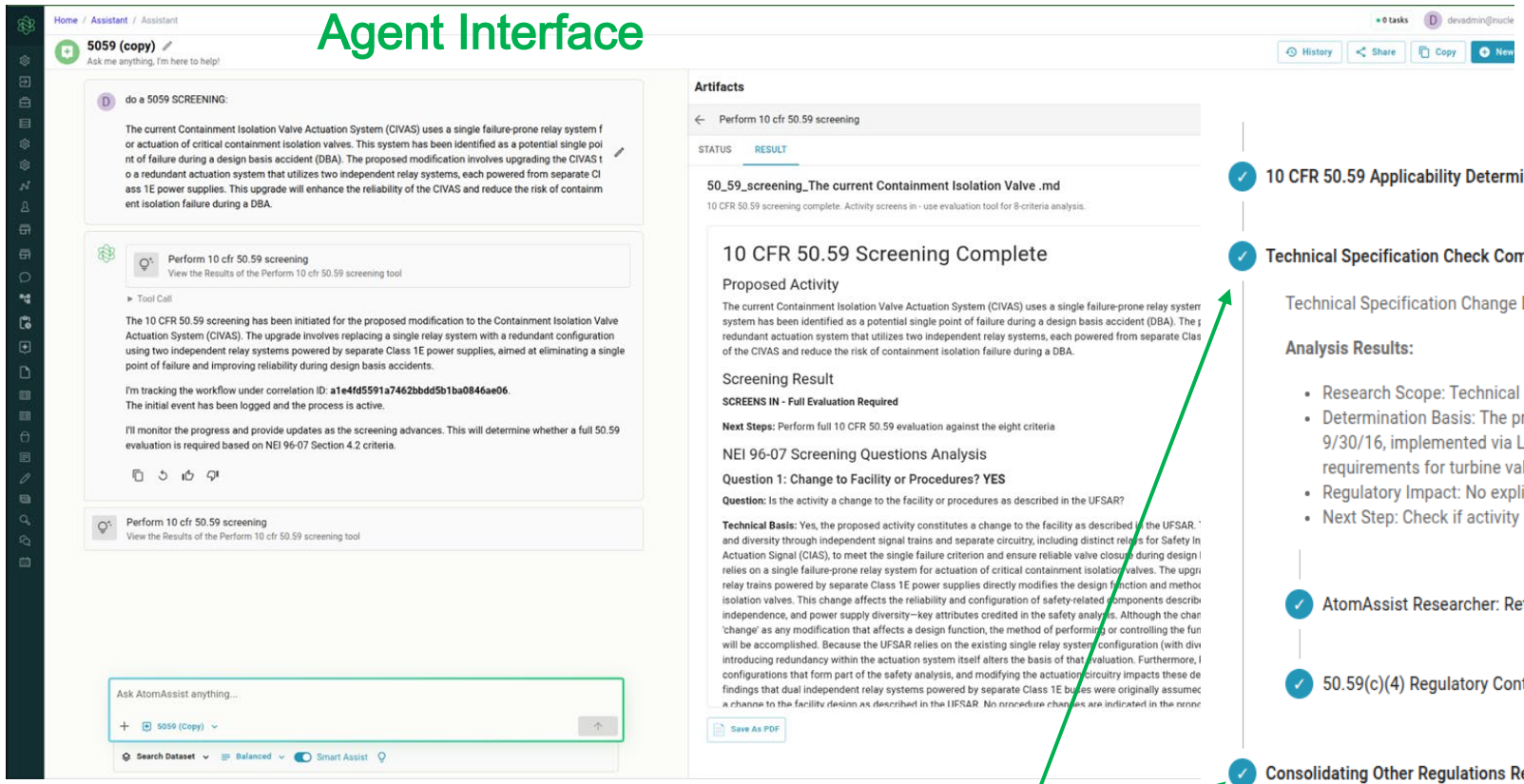
Multi -Agent Implementation - Interface



Agent Progress
Step -by -Step
Research -Evaluate -Compose

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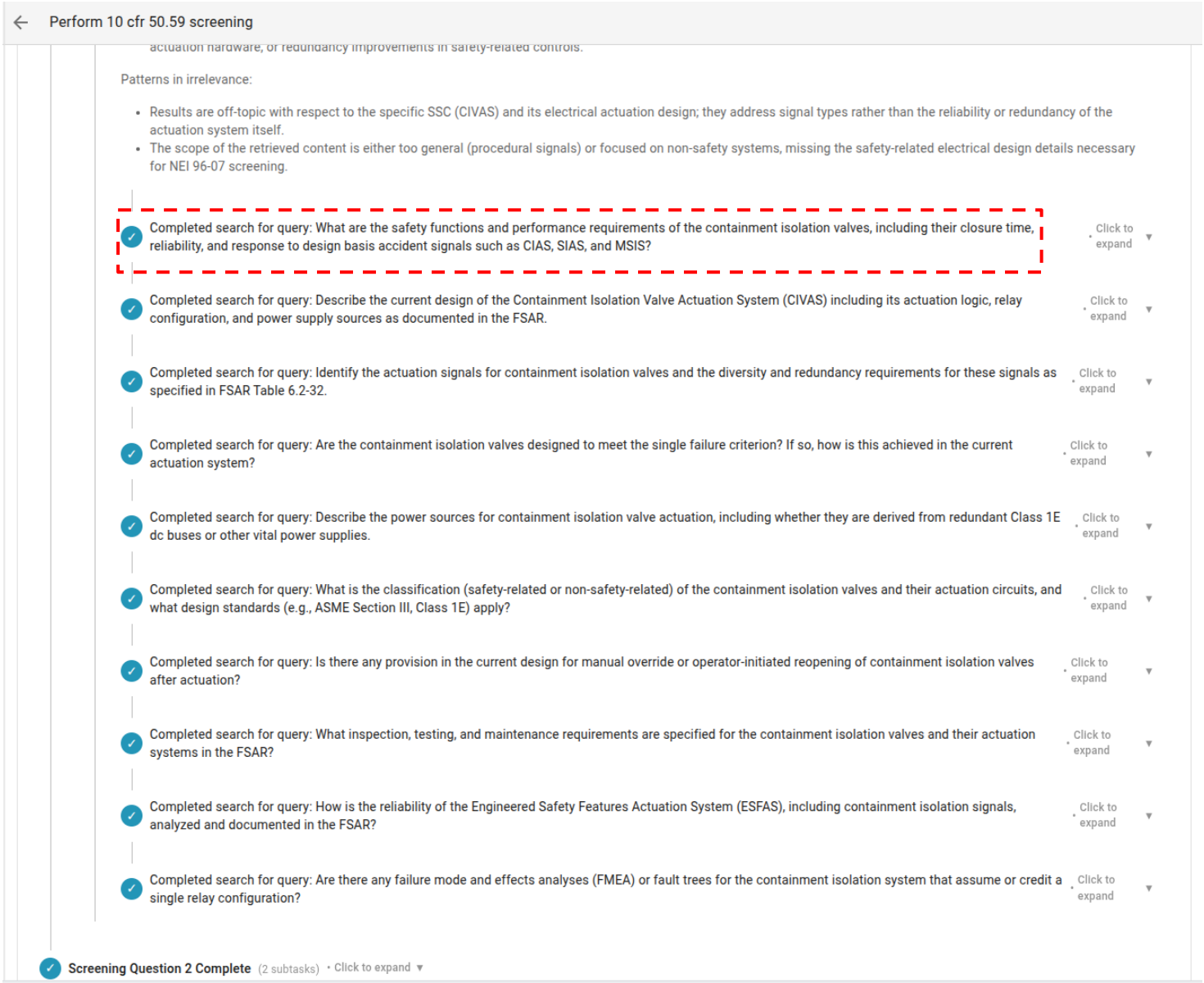
Multi -Agent Implementation - Search/Query

Dynamic, Human Like Queries issued to RAG Engine by Agent

Agent uses a combination of:

- High Performance General LLM
- Gamma2 NuclearLLM

Agent DOES NOT use cloud OpenAI, etc



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Multi -Agent Implementation - Workflow Adherence

NEI 96 -07 Workflow Adherence

Task has completed successfully.

- **10 CFR 50.59 Screening** • Click to expand ▾
- **Does the activity change the facility or procedures as described in the UFSAR?** (1 subtask) • Click to expand ▾
- **Screening Question 2 Complete** (2 subtasks) • Click to expand ▾
- **Independent Screening Review: Challenge Analysis Complete** • Click to expand ▾
- **Final Screening Report Generation Complete** • Click to expand ▾
- **Result** • Click to expand ▾

Human Perf. tools applied to AI Self -Check IV/Challenge Analysis

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Perform 10 cfr 50.59 screening

- Next Step: Challenge analysis and final screening report

Screening Summary: The activity SCREENS IN and requires a full 10 CFR 50.59 evaluation per NEI 96-07 Section 4.2.

Screening Questions Answered YES:

- Question 1 (Change to Facility/Procedures): Yes, the proposed activity constitutes a change to the facility as described in the UFSAR. The UFSAR describes the CIVAS as employing redundancy and diversity through independent signal trains and separate circuitry, including distinct relays for Safety Injection Actuation Signal (SIAS) and Containment Isolation Actuat...

Independent Screening Review: Challenge Analysis Complete • Click to collapse ▲

Challenge analysis complete with 3 issues identified.

Challenges Identified: • The original screening determination seems overly conservative by treating the proposed activity as a facility change rather than an enhancement that aligns with existing design principles. The UFSAR already credits redundancy, independence, and Class 1E power supplies in other safety-related systems, suggesting that the concept of redundancy is not entirely foreign to the facility design. The proposed modification introduces a level of redundancy that is consistent with the existing design basis. • The basis for answering Question 1 as 'Yes' is strong, but the justification could be more explicit in addressing the regulatory definition of a 'change' and how the proposed activity impacts the current design basis. The UFSAR findings indicate that the current system relies on a single relay system, and modifying it to a redundant system does indeed alter the described configuration, which should be explicitly stated in the justification. • The basis for answering Question 2 as 'No' is clear, but it might be beneficial to explicitly state that the proposed activity does not involve any new experiments or tests that are not already described in the UFSAR. This could help to avoid any ambiguity and ensure that the determination is robust.

Challenge Responses: • While the proposed activity does constitute a change to the facility, it is a change that enhances the reliability of the system and aligns with existing design principles. The introduction of a redundant relay system is a step towards improving the safety and reliability of the CIVAS, and it should be evaluated in the context of its impact on the existing design basis rather than being treated as a fundamental change. • The justification for answering Question 1 as 'Yes' is strong, but it could be enhanced by explicitly stating that the proposed activity does indeed alter the current design basis by introducing redundancy where it was not previously present. This would make the justification more robust and less open to interpretation. • The basis for answering Question 2 as 'No' is clear, but adding explicit statements about the absence of new experiments or tests would further strengthen the determination. This would ensure that the activity is clearly distinguished from tests or experiments, which would require a different evaluation process.

Key Findings:

- Original Determination: SCREENS IN
- Final Determination: SCREENS IN
- Determination Revised: No
- Confidence Level: Medium

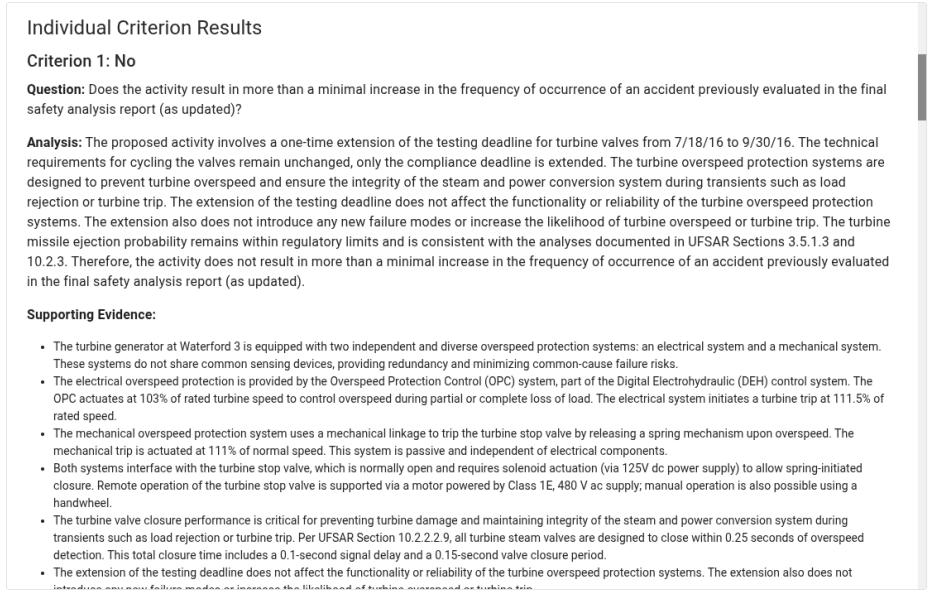
Challenge Analysis Summary: The original screening determination is generally sound, but it could benefit from more explicit justifications and a more nuanced approach to evaluating the proposed activity. The activity does constitute a change to the facility, but it is a change that enhances the system's reliability and aligns with existing design principles. The determination should be revised to more clearly articulate the regulatory rationale and to explicitly address the potential challenges identified.

Regulatory Impact: The independent review validated the original screening approach and conclusions. Final confidence assessment indicates moderate regulatory assurance with some uncertainties identified.

- **Final Screening Report Generation Complete** • Click to expand ▾
- **Result** • Click to expand ▾

Multi -Agent Implementation - Evaluation Step Complexity

Technical Rigor SAT? - Maybe
Engineering Research Accelerator - Definitely



Individual Criterion Results

Criterion 1: No

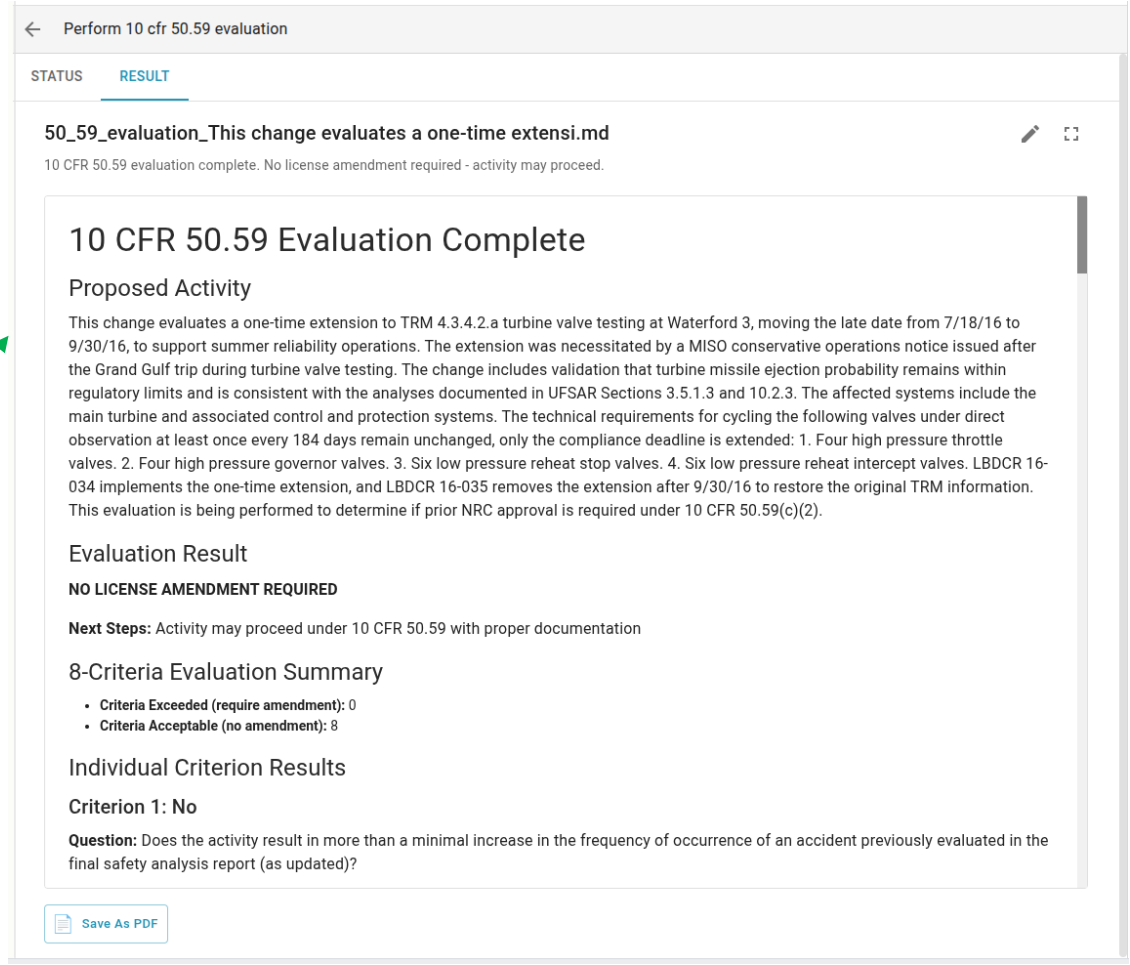
Question: Does the activity result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final safety analysis report (as updated)?

Analysis: The proposed activity involves a one-time extension of the testing deadline for turbine valves from 7/18/16 to 9/30/16. The technical requirements for cycling the valves remain unchanged, only the compliance deadline is extended. The turbine overspeed protection systems are designed to prevent turbine overspeed and ensure the integrity of the steam and power conversion system during transients such as load rejection or turbine trip. The extension of the testing deadline does not affect the functionality or reliability of the turbine overspeed protection systems. The extension also does not introduce any new failure modes or increase the likelihood of turbine overspeed or turbine trip. The turbine missile ejection probability remains within regulatory limits and is consistent with the analyses documented in UFSAR Sections 3.5.1.3 and 10.2.3. Therefore, the activity does not result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final safety analysis report (as updated).

Supporting Evidence:

- The turbine generator at Waterford 3 is equipped with two independent and diverse overspeed protection systems: an electrical system and a mechanical system. These systems do not share common sensing devices, providing redundancy and minimizing common-cause failure risks.
- The electrical overspeed protection is provided by the Overspeed Protection Control (OPC) system, part of the Digital Electrohydraulic (DEH) control system. The OPC actuates at 103% of rated turbine speed to control overspeed during partial or complete loss of load. The electrical system initiates a turbine trip at 111.5% of rated speed.
- The mechanical overspeed protection system uses a mechanical linkage to trip the turbine stop valve by releasing a spring mechanism upon overspeed. The mechanical trip is actuated at 111% of normal speed. This system is passive and independent of electrical components.
- Both systems interface with the turbine stop valve, which is normally open and requires solenoid actuation (via 125V dc power supply) to allow spring-initiated closure. Remote operation of the turbine stop valve is supported via a motor powered by Class 1E, 480 V ac supply; manual operation is also possible using a handwheel.
- The turbine valve closure performance is critical for preventing turbine damage and maintaining integrity of the steam and power conversion system during transients such as load rejection or turbine trip. Per UFSAR Section 10.2.2.2.9, all turbine steam valves are designed to close within 0.25 seconds of overspeed detection. This total closure time includes a 0.1-second signal delay and a 0.15-second valve closure period.
- The extension of the testing deadline does not affect the functionality or reliability of the turbine overspeed protection systems. The extension also does not

Final Report Generated
PDF/Word
Template -able



Perform 10 cfr 50.59 evaluation

STATUS RESULT

50_59_evaluation_This change evaluates a one-time extensi.md

10 CFR 50.59 evaluation complete. No license amendment required - activity may proceed.

10 CFR 50.59 Evaluation Complete

Proposed Activity

This change evaluates a one-time extension to TRM 4.3.4.2.a turbine valve testing at Waterford 3, moving the late date from 7/18/16 to 9/30/16, to support summer reliability operations. The extension was necessitated by a MISO conservative operations notice issued after the Grand Gulf trip during turbine valve testing. The change includes validation that turbine missile ejection probability remains within regulatory limits and is consistent with the analyses documented in UFSAR Sections 3.5.1.3 and 10.2.3. The affected systems include the main turbine and associated control and protection systems. The technical requirements for cycling the following valves under direct observation at least once every 184 days remain unchanged, only the compliance deadline is extended: 1. Four high pressure throttle valves. 2. Four high pressure governor valves. 3. Six low pressure reheat stop valves. 4. Six low pressure reheat intercept valves. LBDCR 16-034 implements the one-time extension, and LBDCR 16-035 removes the extension after 9/30/16 to restore the original TRM information. This evaluation is being performed to determine if prior NRC approval is required under 10 CFR 50.59(c)(2).

Evaluation Result

NO LICENSE AMENDMENT REQUIRED

Next Steps: Activity may proceed under 10 CFR 50.59 with proper documentation

8-Criteria Evaluation Summary

- **Criteria Exceeded (require amendment):** 0
- **Criteria Acceptable (no amendment):** 8

Individual Criterion Results

Criterion 1: No

Question: Does the activity result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final safety analysis report (as updated)?

Save As PDF

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5059 Workflow with AI

AD

- Achievable
- Simple Analysis
- Deployable Today
- Exception handling with outside regulations and document differentiation (TRM, TS, etc)
- External Regulation requires innate knowledge - Nuclear LLM
- Document management (Latest version control, etc)

Screening

- Achievable
- Analysis possible with agent workflows
- Deployable today

Evaluation

- Possible
- Difficult to guide LLM/AI to level of rigor of human engineers
- Requires outside context that is difficult without extensive research and tribal knowledge
- Researcher accelerant
- Engineering design/calculations sometimes required

AI TO DO COMPLEX NUCLEAR ANALYSIS IS NON-TRIVIAL

SIMPLE RAG EXAMPLES LOOK GREAT, BUT AREN'T USEABLE

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