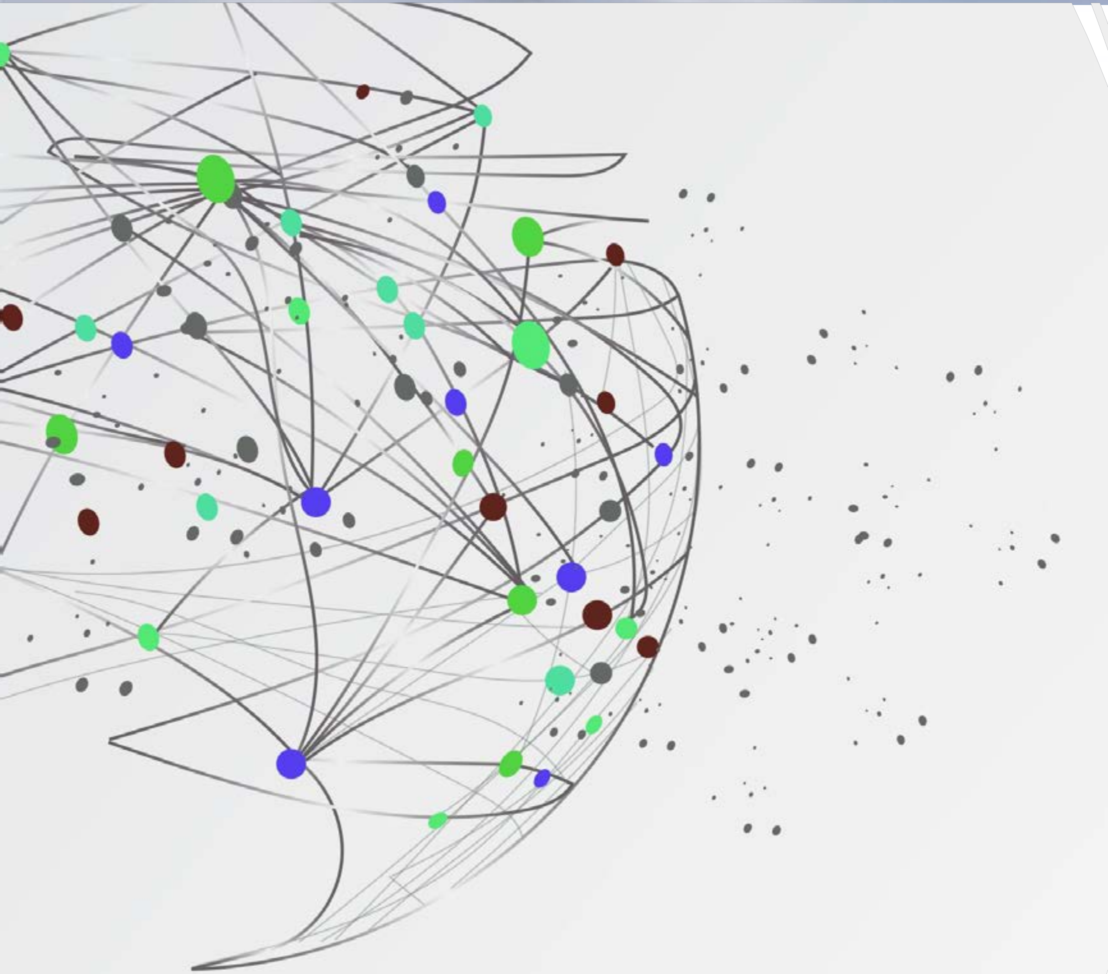


Structured Retrieval in Document-Centric Engineering

Knowledge Graphs for Traceable Nuclear Information

What is TerraPower

Nuclear Innovation Company

- Natrium® Reactor
- Early construction phase
- 100k+ documents including, technical, process management, and knowledge workspaces

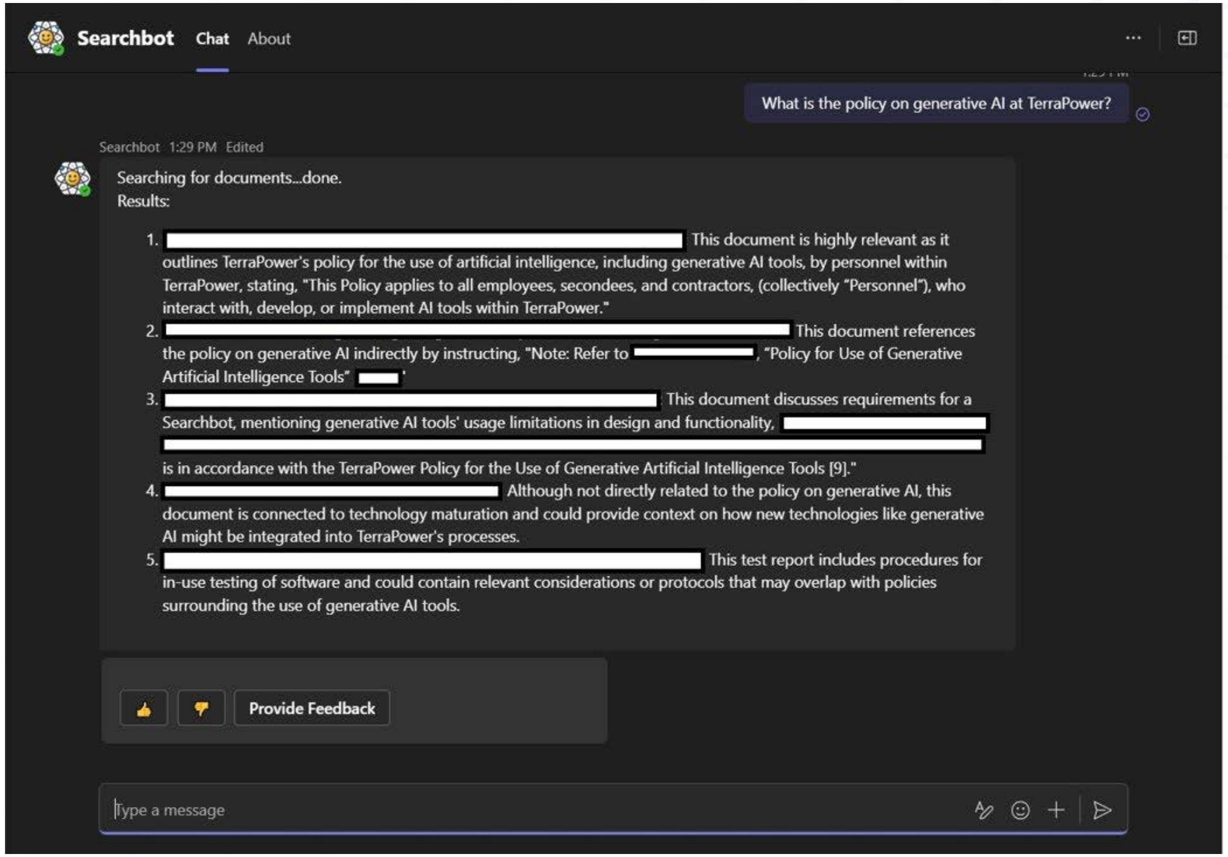
Early AI

SearchBot (Retrieval)

- Finding knowledge across a growing corpus
- Exposing engineers to early AI capability
- Build the foundation for future AI applications

<u>**Limitations:**</u>

- Not a conversational tool
- No multi-hop reasoning
- No agentic orchestrations



Introducing Thermo

- Home grown AI framework
- Conversational AI tool
- Uses state of the art AI methodologies
- Users can upload and interact with their own documents
- Expanded index to other sources of data
- Leverages source system permissions in responses

Thermo's limitations

- Could only do semantic matching
- Need deterministic connections to reduce reliance on stochasticity
- Can't ask double negatives: "don't include documents about fuel rods"
- Can't reliably ask about references and logical connections

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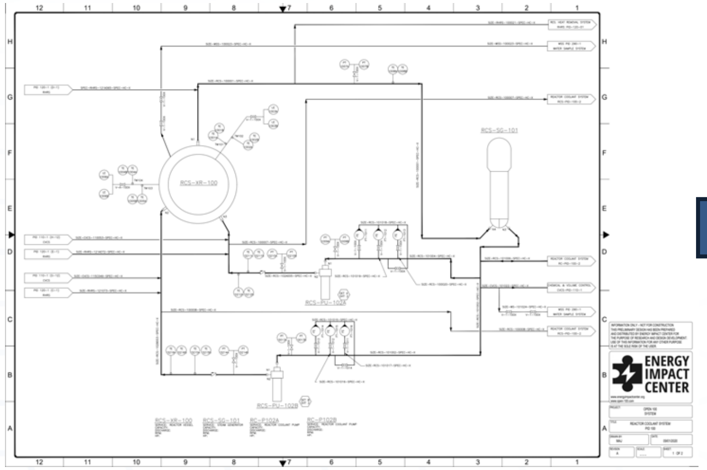
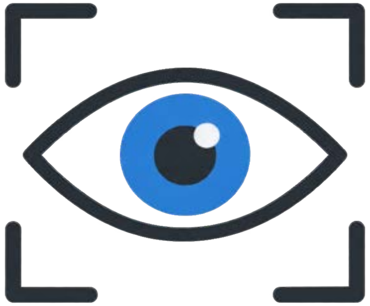
We need relationships: knowledge graph

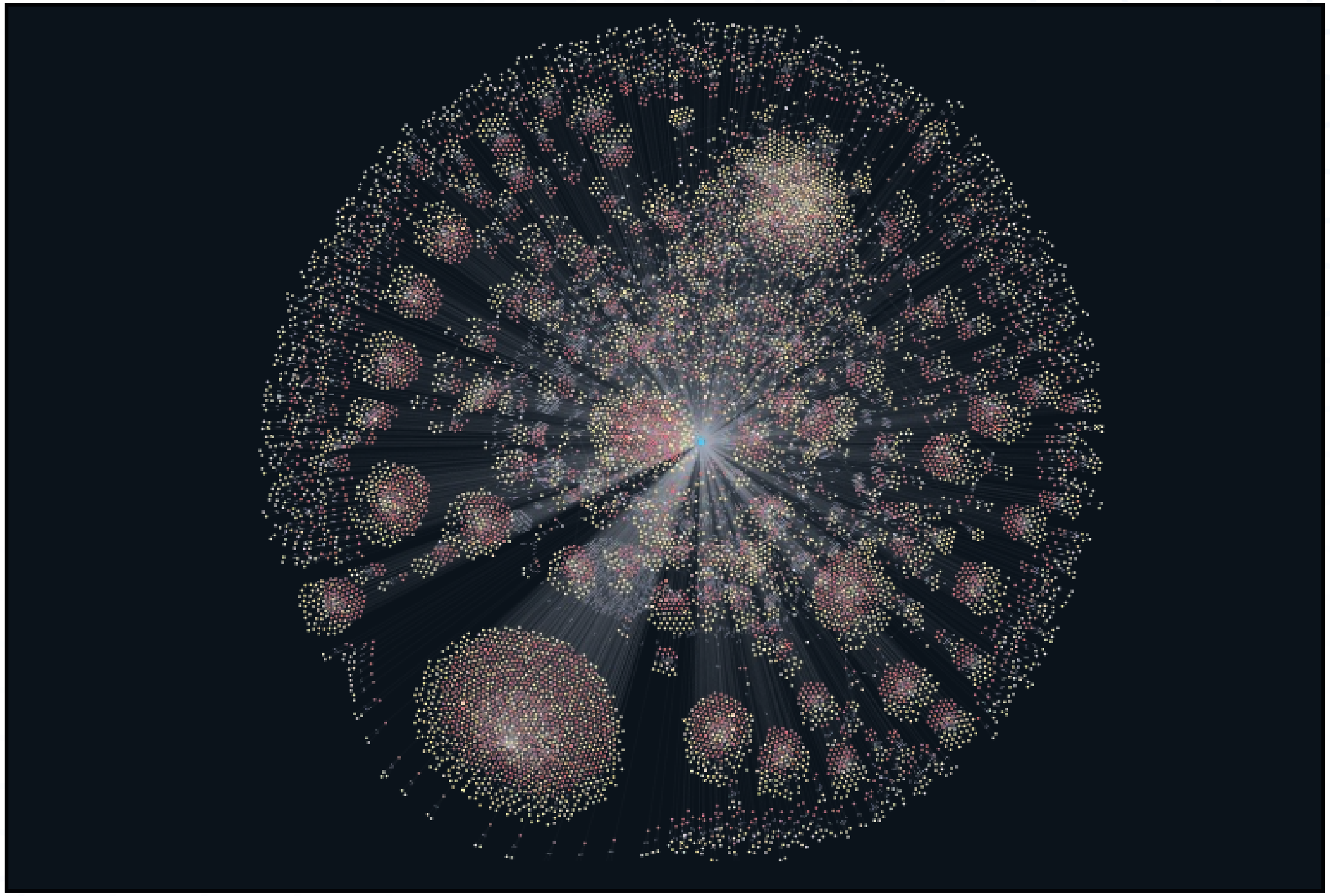


P&ID and Source Data from:
https://www.open-100.com/reactorcoolant



TerraPower Brain

- 10 million relationships mapped
- 6.5 million data points
- Ingesting in real time as new documents are minted
- Multi-hop agentic traversals governed by human derived relationships



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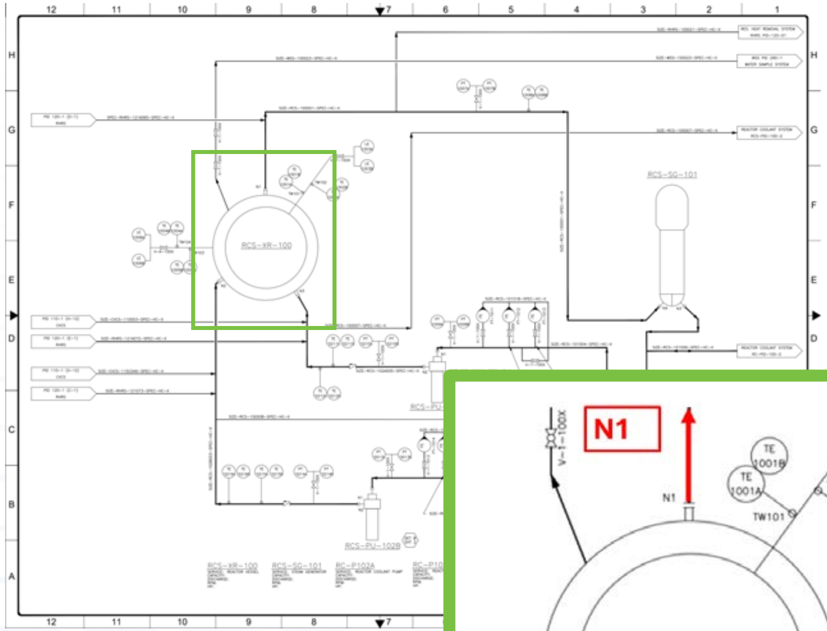
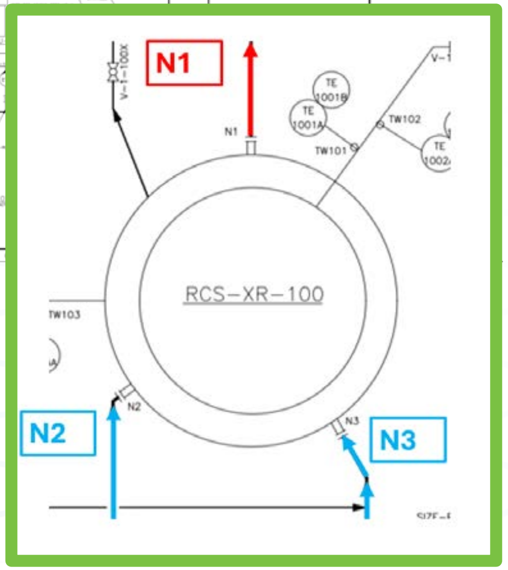
Demo Data

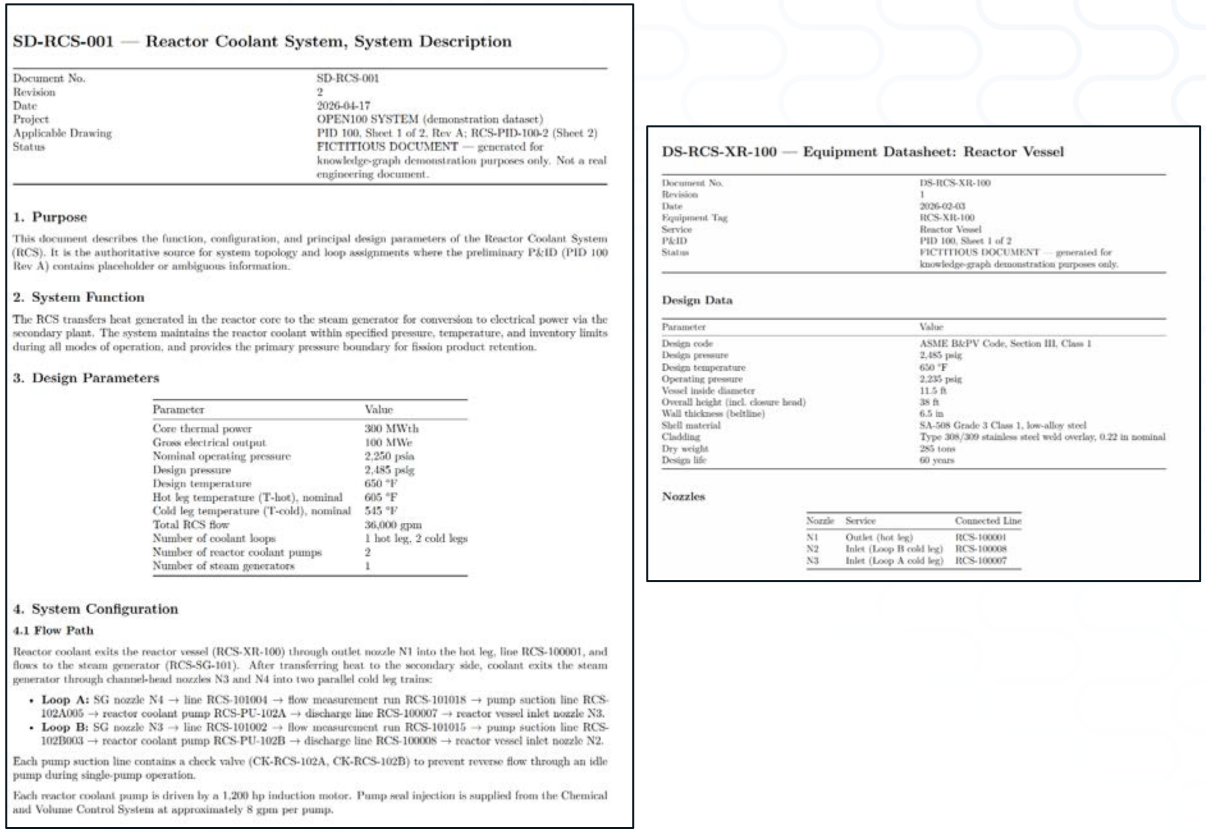
Piping and Instrumentation Diagram





P&ID and Source Data from:
https://www.open-100.com/reactorcoolant

Fictitious Engineering Documentation



SD-RCS-001 — Reactor Coolant System, System Description

Document No.	SD-RCS-001
Revision	2
Date	2026-04-17
Project	OPEN100 SYSTEM (demonstration dataset)
Applicable Drawing	PID 100, Sheet 1 of 2, Rev A; RCS-PID-100-2 (Sheet 2)
Status	FICTITIOUS DOCUMENT — generated for knowledge-graph demonstration purposes only. Not a real engineering document.

1. Purpose

This document describes the function, configuration, and principal design parameters of the Reactor Coolant System (RCS). It is the authoritative source for system topology and loop assignments where the preliminary P&ID (PID 100 Rev A) contains placeholder or ambiguous information.

2. System Function

The RCS transfers heat generated in the reactor core to the steam generator for conversion to electrical power via the secondary plant. The system maintains the reactor coolant within specified pressure, temperature, and inventory limits during all modes of operation, and provides the primary pressure boundary for fission product retention.

3. Design Parameters

Parameter	Value
Core thermal power	300 MWth
Gross electrical output	100 MWe
Nominal operating pressure	2,250 psia
Design pressure	2,485 psig
Design temperature	650 °F
Hot leg temperature (T-hot), nominal	605 °F
Cold leg temperature (T-cold), nominal	545 °F
Total RCS flow	36,000 gpm
Number of coolant loops	1 hot leg, 2 cold legs
Number of reactor coolant pumps	2
Number of steam generators	1

4. System Configuration

4.1 Flow Path

Reactor coolant exits the reactor vessel (RCS-XR-100) through outlet nozzle N1 into the hot leg, line RCS-100001, and flows to the steam generator (RCS-SG-101). After transferring heat to the secondary side, coolant exits the steam generator through channel-head nozzles N3 and N4 into two parallel cold leg trains:

- **Loop A:** SG nozzle N4 → line RCS-101004 → flow measurement run RCS-101018 → pump suction line RCS-102A005 → reactor coolant pump RCS-PU-102A → discharge line RCS-100007 → reactor vessel inlet nozzle N3.
- **Loop B:** SG nozzle N3 → line RCS-101002 → flow measurement run RCS-101015 → pump suction line RCS-102B003 → reactor coolant pump RCS-PU-102B → discharge line RCS-100008 → reactor vessel inlet nozzle N2.

Each pump suction line contains a check valve (CK-RCS-102A, CK-RCS-102B) to prevent reverse flow through an idle pump during single-pump operation.

Each reactor coolant pump is driven by a 1,200 hp induction motor. Pump seal injection is supplied from the Chemical and Volume Control System at approximately 8 gpm per pump.

DS-RCS-XR-100 — Equipment Datasheet: Reactor Vessel

Document No.	DS-RCS-XR-100
Revision	1
Date	2026-02-03
Equipment Tag	RCS-XR-100
Service	Reactor Vessel
P&ID	PID 100, Sheet 1 of 2
Status	FICTITIOUS DOCUMENT — generated for knowledge-graph demonstration purposes only.

Design Data

Parameter	Value
Design code	ASME B&PV Code, Section III, Class 1
Design pressure	2,485 psig
Design temperature	650 °F
Operating pressure	2,235 psig
Vessel inside diameter	11.5 ft
Overall height (incl. closure head)	38 ft
Wall thickness (beltline)	6.5 in
Shell material	SA-508 Grade 3 Class 1, low-alloy steel
Cladding	Type 308/309 stainless steel weld overlay, 0.22 in nominal
Dry weight	285 tons
Design life	60 years

Nozzles

Nozzle	Service	Connected Line
N1	Outlet (hot leg)	RCS-100001
N2	Inlet (Loop B cold leg)	RCS-100008
N3	Inlet (Loop A cold leg)	RCS-100007

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Thank you

To learn more, visit **www.terrapower.com**

Examples

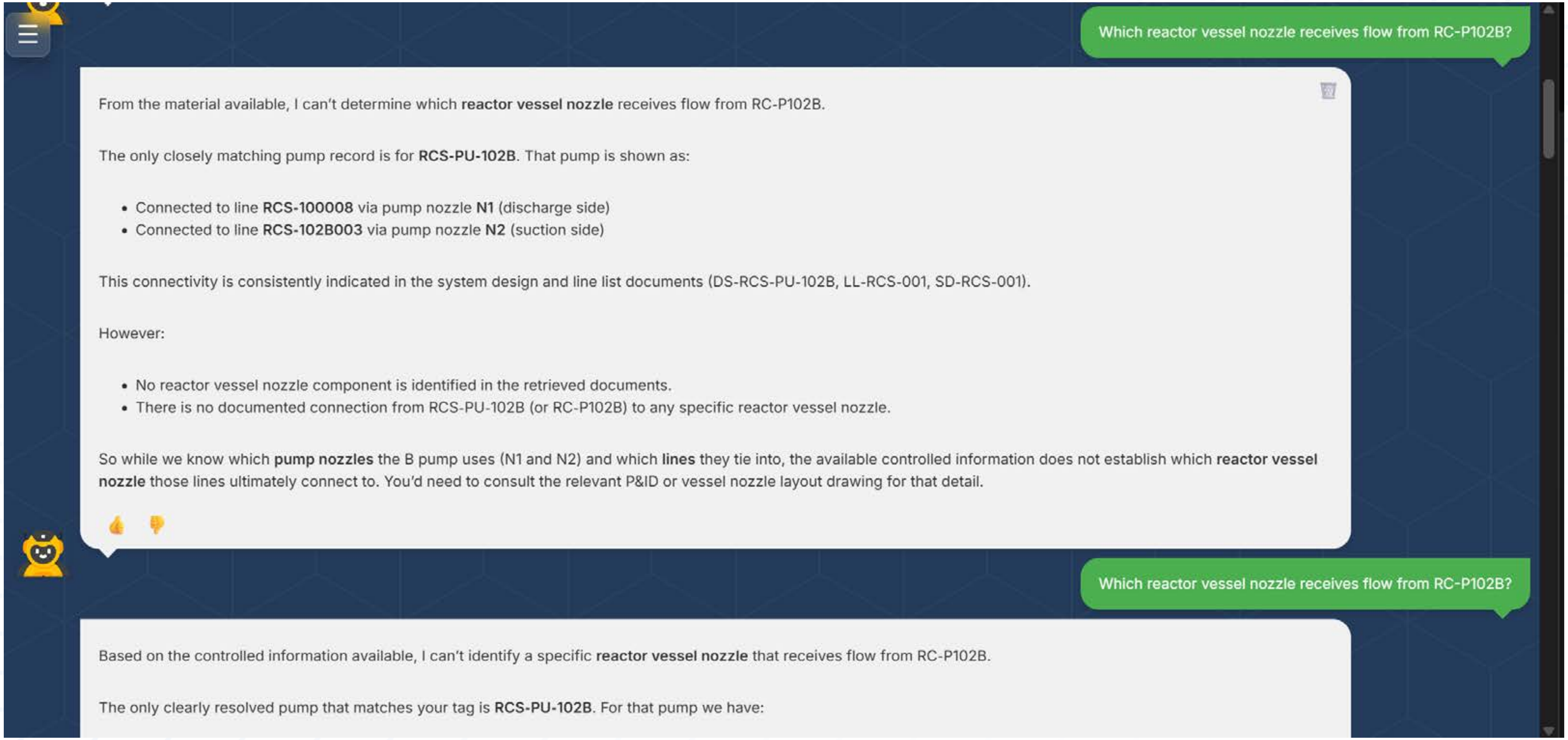
What nozzles are connected to the reactor vessel?

The reactor vessel RCS-XR-100 has three reactor coolant nozzles connected to the main loop in the current scope:

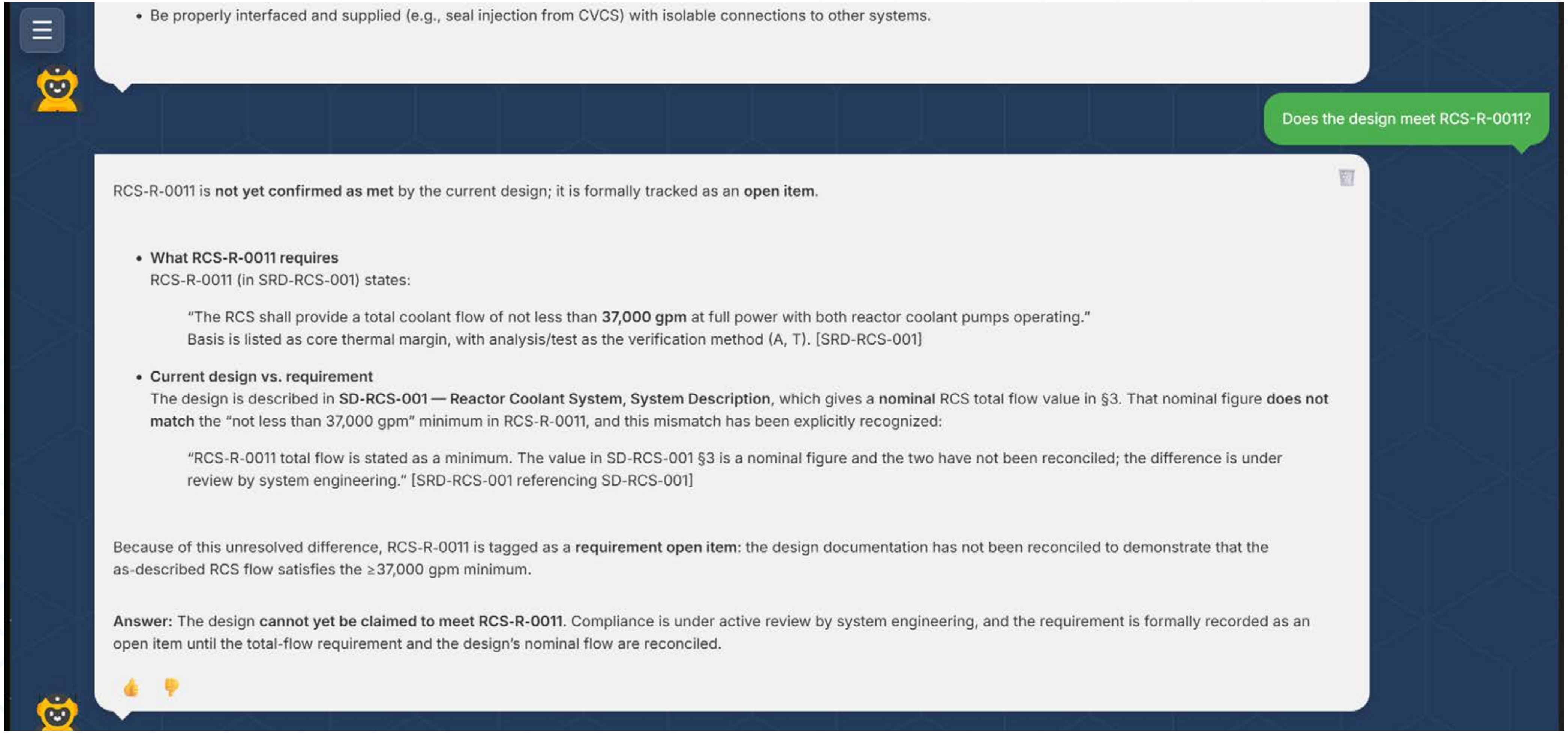
- **Nozzle N1 – Hot leg outlet**
  - Coolant exits the vessel through outlet nozzle **N1** into the hot leg, line **RCS-100001**, which then goes to the steam generator channel head.LL-RCS-001, SD-RCS-001
  - Described as: "Reactor coolant exits the reactor vessel (RCS-XR-100) through outlet nozzle N1 into the hot leg, line RCS-100001..."SD-RCS-001
- **Nozzle N2 – Loop B cold leg inlet**
  - Pump B discharge line **RCS-100008** connects to reactor vessel inlet nozzle **N2**.LL-RCS-001
  - In the flow-path description: Loop B ends at "discharge line RCS-100008 → reactor vessel inlet nozzle N2."SD-RCS-001
- **Nozzle N3 – Loop A cold leg inlet**
  - Pump A discharge line **RCS-100007** connects to reactor vessel inlet nozzle **N3**.LL-RCS-001
  - In the flow-path description: Loop A ends at "discharge line RCS-100007 → reactor vessel inlet nozzle N3."SD-RCS-001

Instrumentation (thermowells TW101–TW104 and level elements LE-1003A/B, LE-1006A/B) are installed on the vessel, but the documents here only explicitly identify **N1, N2, and N3** as the coolant nozzles connected to RCS-XR-100 in the main loop.DS-RCS-XR-100, SD-RCS-001

Examples


Which reactor vessel nozzle receives flow from RC-P102B?
From the material available, I can't determine which reactor vessel nozzle receives flow from RC-P102B.
The only closely matching pump record is for RCS-PU-102B. That pump is shown as:
• Connected to line RCS-100008 via pump nozzle N1 (discharge side)
• Connected to line RCS-102B003 via pump nozzle N2 (suction side)
This connectivity is consistently indicated in the system design and line list documents (DS-RCS-PU-102B, LL-RCS-001, SD-RCS-001).
However:
• No reactor vessel nozzle component is identified in the retrieved documents.
• There is no documented connection from RCS-PU-102B (or RC-P102B) to any specific reactor vessel nozzle.
So while we know which pump nozzles the B pump uses (N1 and N2) and which lines they tie into, the available controlled information does not establish which reactor vessel nozzle those lines ultimately connect to. You'd need to consult the relevant P&ID or vessel nozzle layout drawing for that detail.
Which reactor vessel nozzle receives flow from RC-P102B?
Based on the controlled information available, I can't identify a specific reactor vessel nozzle that receives flow from RC-P102B.
The only clearly resolved pump that matches your tag is RCS-PU-102B. For that pump we have:

Examples



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Examples

If FE-1015 is removed for maintenance, what isolates it and what carries the flow?

FE-1015 is part of the **Loop B flow measurement run**. When it is removed for maintenance:

- **Isolation of FE-1015:** It is isolated by **valve V-1-1012**, which the valve list identifies as "FE-1015 isolation, Loop B flow run RCS-101015."
  (VL-RCS-001 — Reactor Coolant System Valve List)
- **Flow path during maintenance:** The **Loop B flow-run bypass valve V-1-1014** is opened, and flow is carried through the bypass around the measurement run rather than through FE-1015.
  The system description states that each flow element can be individually isolated (Loop B: **V-1-1011, -1012, -1013**) "with a normally-closed bypass valve around each measurement run (... Loop B: **V-1-1014**)."
  (SD-RCS-001 — Reactor Coolant System, System Description; VL-RCS-001 — Reactor Coolant System Valve List)

So: **V-1-1012 isolates FE-1015**, and **flow is carried by the Loop B bypass controlled by V-1-1014** when FE-1015 is out of service.