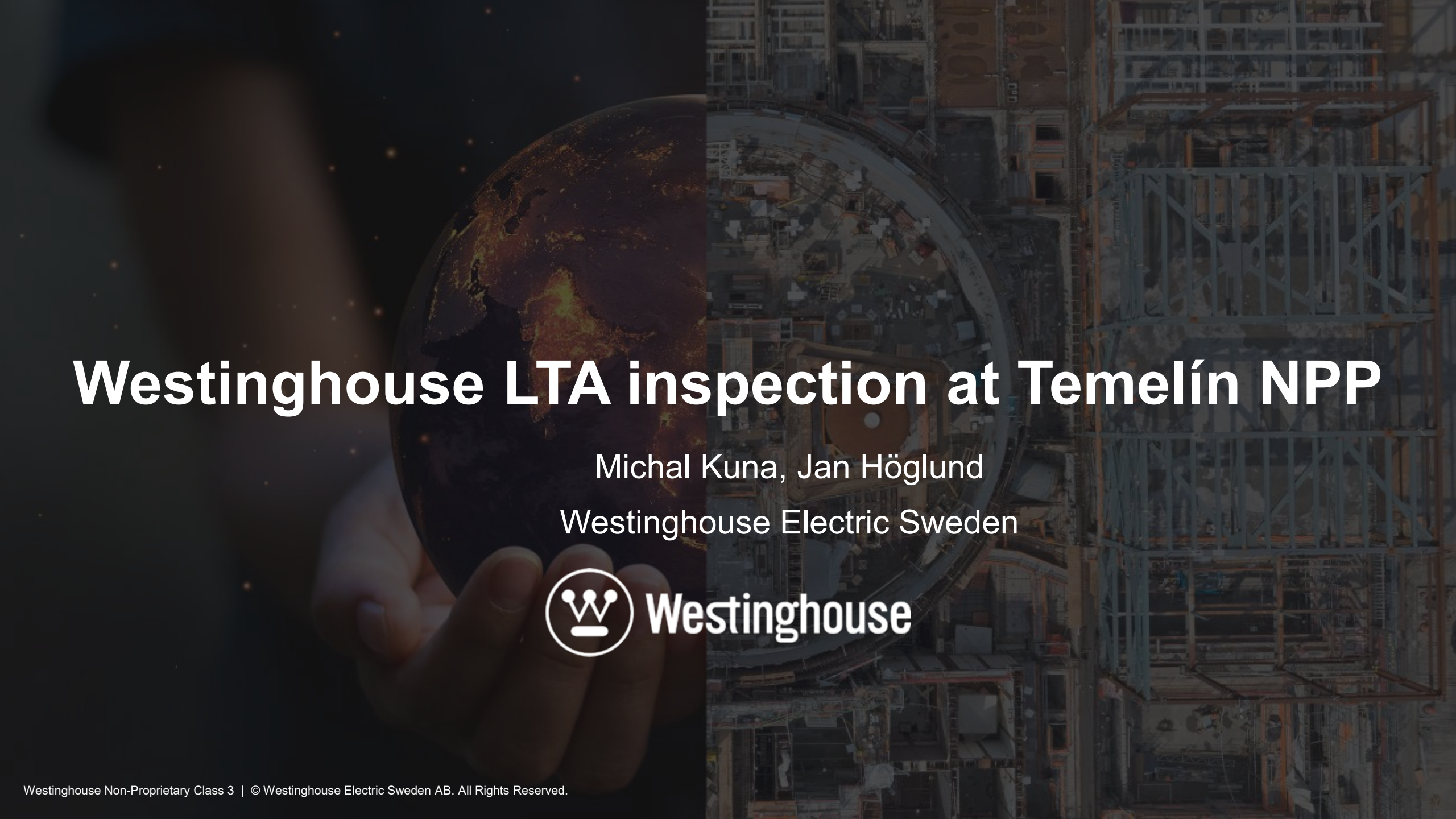
1st International Conference on LWR Fuel Performance, Modelling and Experimental Support

September 14–19, 2025

Nessebar, Bulgaria



Westinghouse LTA inspection at Temelín NPP

Michal Kuna, Jan Höglund

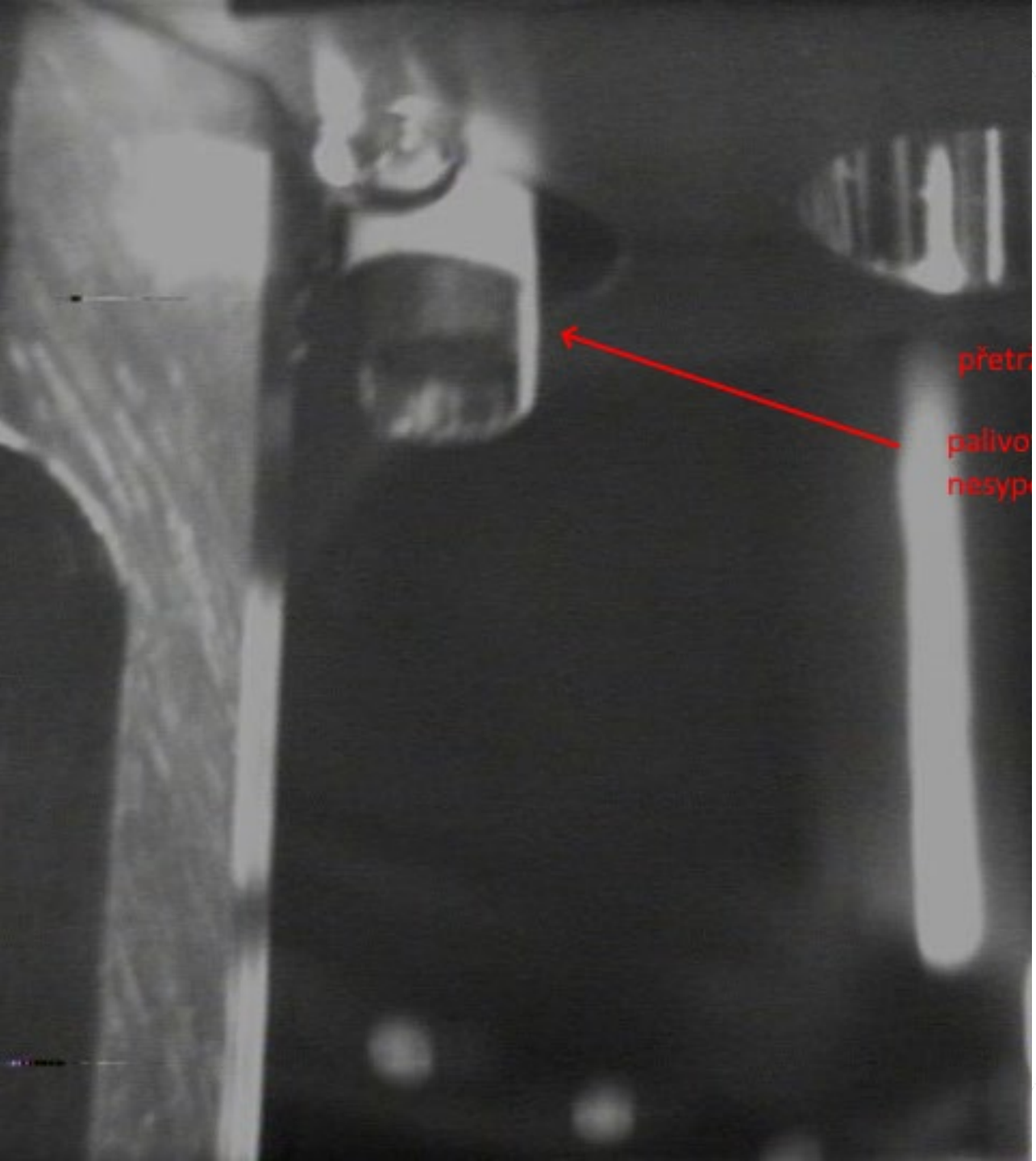
Westinghouse Electric Sweden

Westinghouse

Outline

- History
- Motivation
- Preparation
- Inspection
- Results

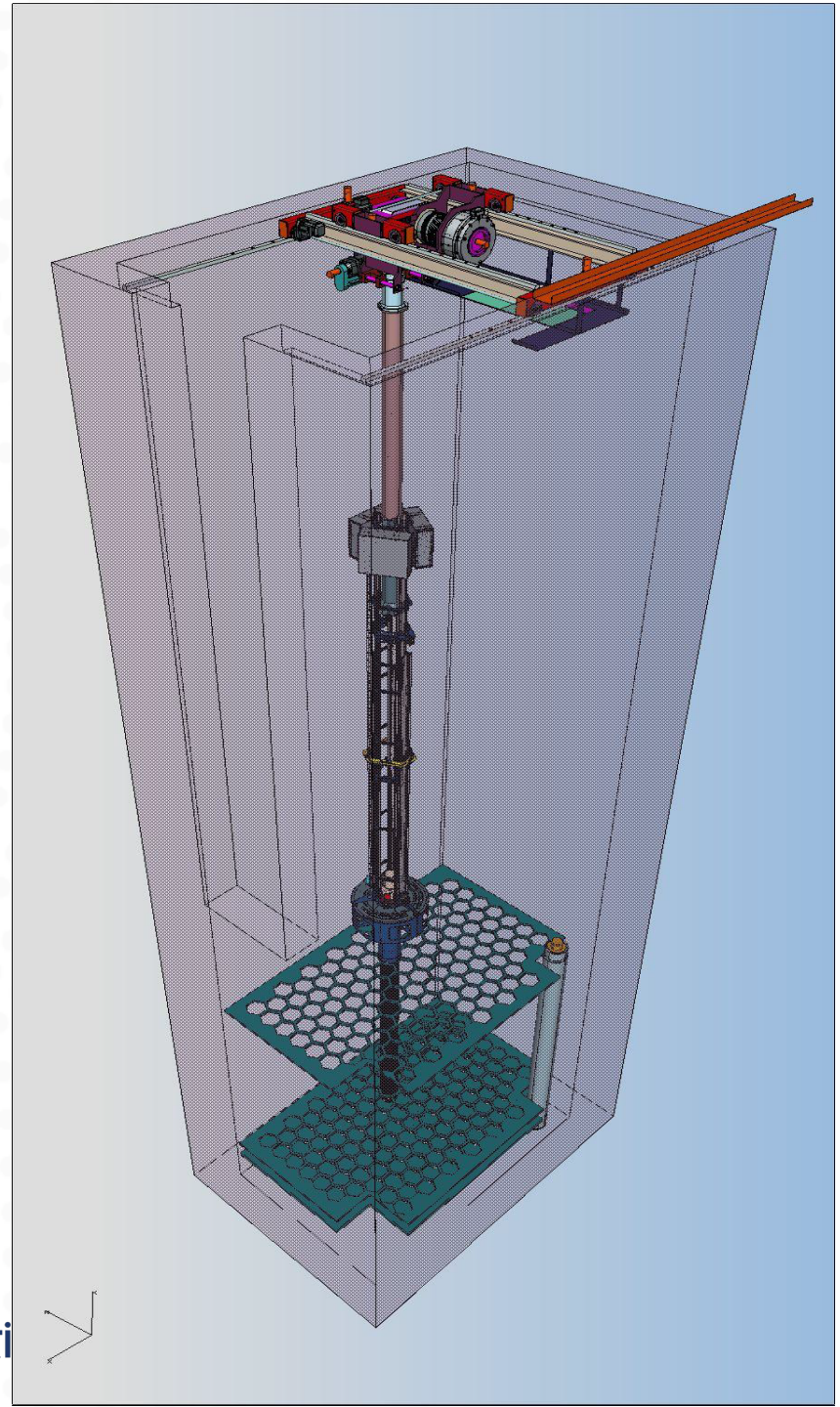
Westinghouse



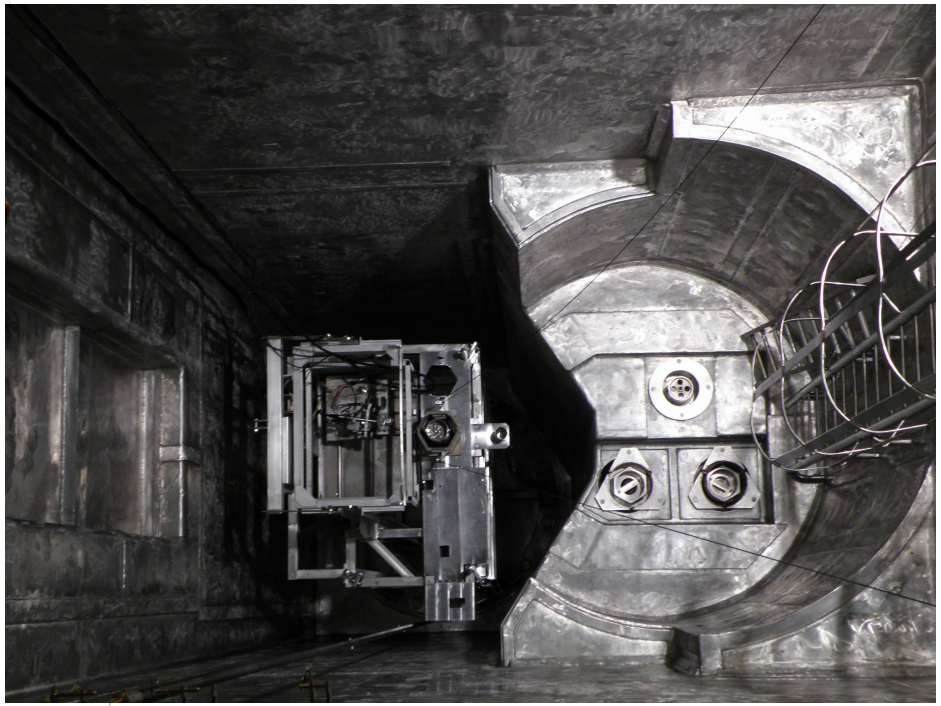
History

- Fuel inspection and repair from 2002 to 2009
- 61 rods removed from VV-6 (half leaking, half tight)
- Fuel Rod (FR) from Fuel Assembly (FA) BE24 broken in 2009
  - => FR manipulation stopped at Temelín

- In 2020 SIPS introduced at Temelín
  - Solely for visuals + geometry measurement
- Westinghouse FRIE (MSIO) still available at Temelín
  - Able to remove TN, FR and FR inspection
  - Highly modular



History



- In 2020 **SIPS** introduced at Temelín
  - Solely for visuals + geometry measurement
- Westinghouse **FRIE** (MSIO) still available at Temelín
  - Able to remove TN, FR and FR inspection
  - Highly modular
  - Some maintenance needed in 2024

Motivation for inspection

Pro&Cons

- **Leaking LTA after 3y of operation** – unknown reason, normal appearance
- ČEZ sign a contract with WSE for region deliveries
- Westinghouse support
  - FRIE maintenance and upgrade
  - Experienced staff to perform all manipulation
  - Emergency scenarios and countermeasures prepared
- Good experience with inspections from Ukraine

‼ Perceived risks of pulling leaking FR due to historical experience

‼ VVER-1000 SPF and water purification system aren't design for broken FR scenario

‼ **Time during the outage** - FRIE takes longer to raise and tear down than SIPS

‼ Any problem has huge impact on the outage

Framatome and Westinghouse to supply fuel to Temelín

13 April 2022

Share

Westinghouse of the USA and Framatome of France have been awarded a long-term contract by Czech utility ČEZ for the supply of nuclear fuel assemblies to the Temelín nuclear power plant.

Temelín units 1 and 2 - both VVER-1000 reactors - have been in operation since 2000 and 2003, respectively (Image: ČEZ)

ČEZ said three bidders - Framatome, Westinghouse and Russia's TVEL - participated in the tender, which was launched in April 2020.

Decision to perform the inspection

On conditions:

- **Only tight FR**, 112 hours in the outage
- Contingency plans and equipment in place

Main inspection Goal:

- Assess **Grid To Rod Fretting (GTRF)** performance

Secondary inspection goal:

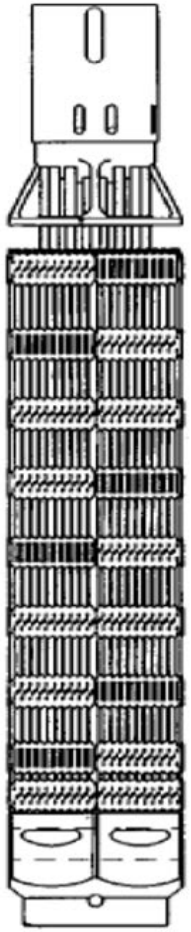
- Perform leak search of WTA2 with UT methods (AFIS)

Westinghouse

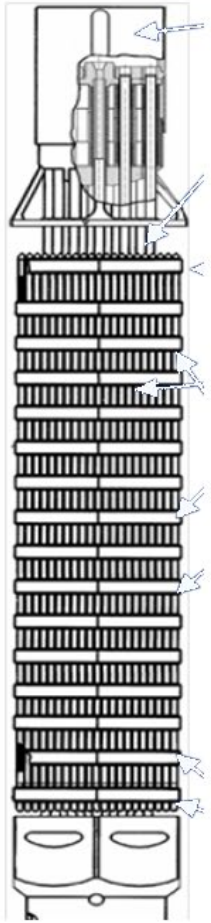
Evolution: From VVANTAGE6 to RWFA-T

2000 → 2005 → 2012 → 2015 → 2019 → 2026

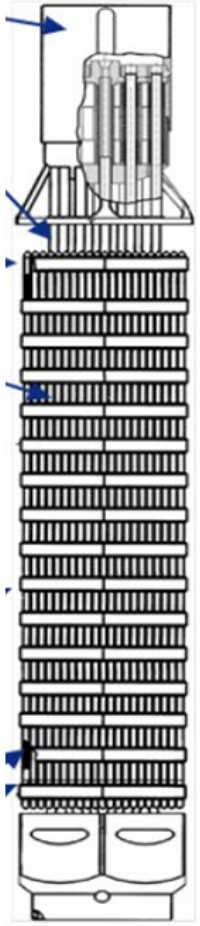
Temelín VV6 Phase 1X



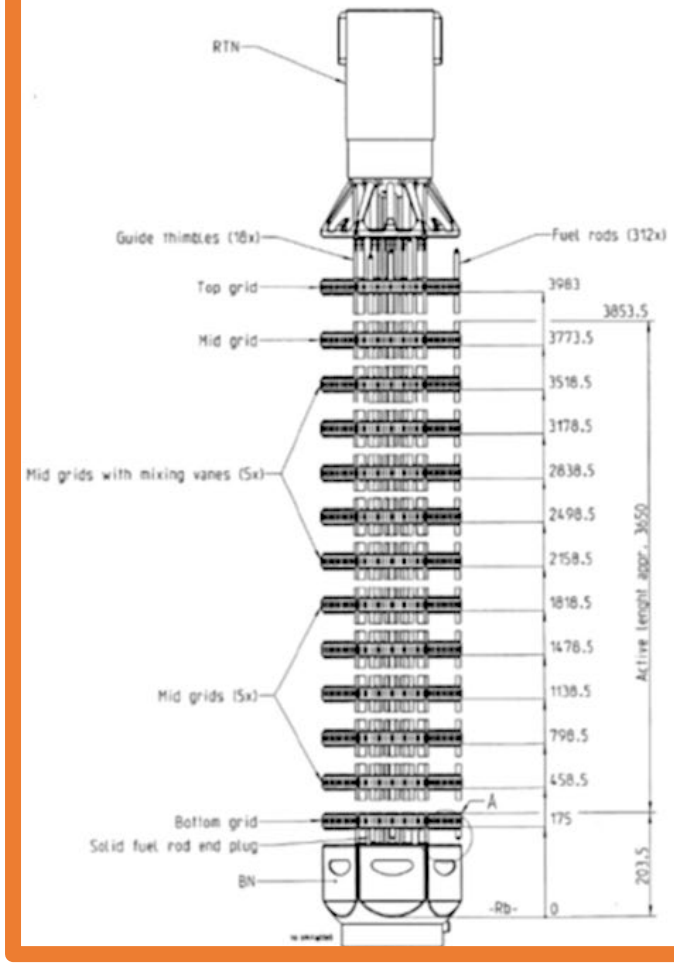
SU3 LTA



SU3 (R)WFA



Temelín LTA

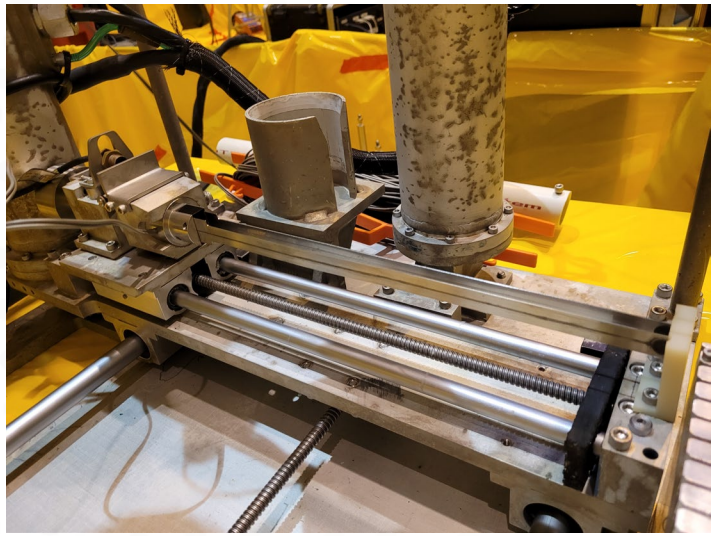


RWFA-T

Preparations

FRIE upgrade & maintenance

- Eddy Current – measure defect volume
- Cameras – high res, color
- FR handling tool – smoother FR extraction
- UT probes – find leaking FR
- Seals, bearings, etc.. maintenance



Preparations (continued)

FOSAR & Fissile material container

FOSAR

- Can collect small debris like broken pellets, pieces of cladding or other
- Vacuum to filter or collect with tweezers

Fissile material container

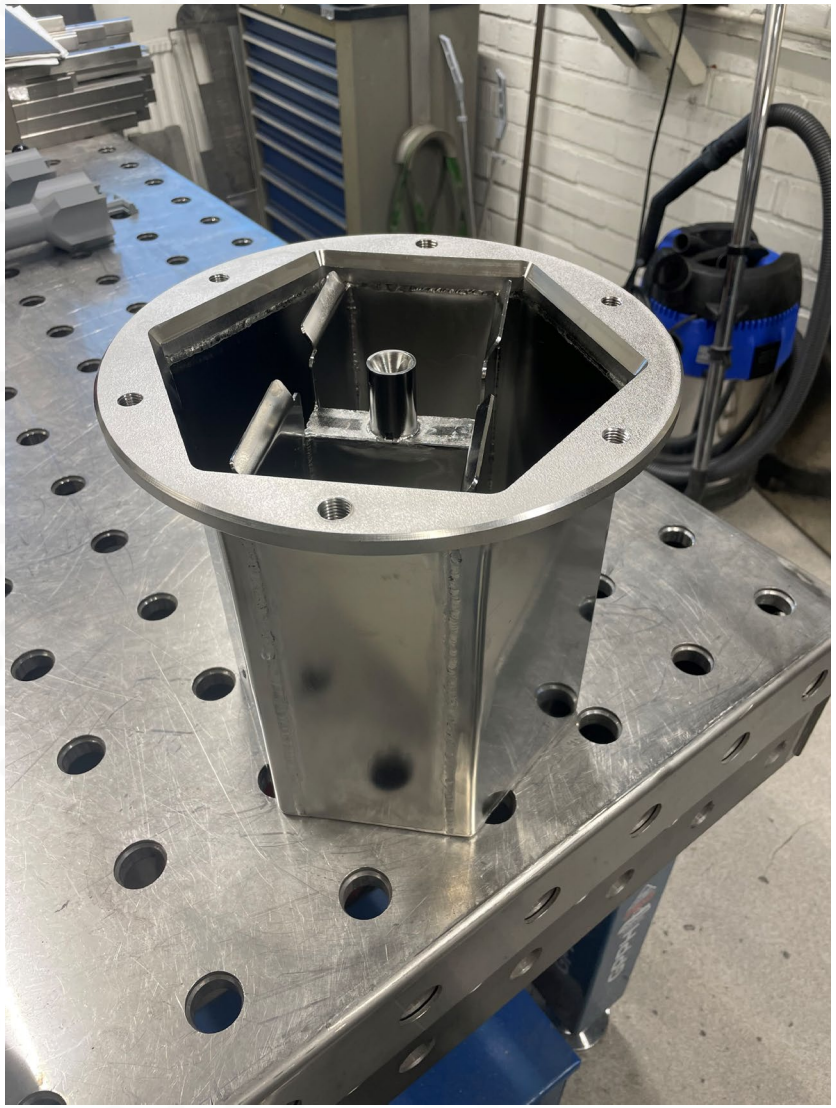
- Designed per Temelín needs
- Intermediate storage of radioactive material, even pellets in SFP cell or plant hermetic seal container
- Storage of FOSAR filters
- Remote, robust handling in SFP sections under water

Emergency procedures

- For collecting and handling broken FR, loose pellets and other debris
- Handling heavily contaminated water
- Emergency cooling of pool section with FRIE

Westinghouse

Preparations (continued)



FOSAR & Fissile material container

FOSAR

- Can collect small debris like broken pellets, pieces of cladding or other
- Vacuum to filter or collect with tweezers

Fissile material container

- Designed per Temelín needs
- Intermediate storage of radioactive material, even pellets in SFP cell or plant hermetic seal container
- Storage of FOSAR filters
- Remote, robust handling in SFP sections under water

Emergency procedures

- For collecting and handling broken FR, loose pellets and other debris
- Handling heavily contaminated water
- Emergency cooling of pool section with FRIE

Westinghouse

Inspection

Westinghouse Field Acceptance Criteria

The design is accepted in the aspect of GTRF if both bullets below are met

- ✓ Less than 44% through wall on a single individual wear depth
- ✓ Less than 10% through wall from all measurements on 95/95 basis.

Work Scope

- Removal of Top Nozzle on the assembly to be inspected
- Visual inspection of individual fuel rods
- Eddy Current (EC) measurements on the individual fuel rods to obtain wear data
- Fuel rods are put back in the assembly
- Top Nozzle is re-installed on the inspected assembly

Program

- Given boundary condition – can't find the root cause of leaking FR =>
  - ✓ Only UT leaker search with the AFIS system on WTA2
- Focus on GTRF =>
  - ✓ Inspection of identical, leak-free WTA3
  - ✓ 40 FRs extracted, inspected and measured with EC
  - ✓ Rods were chosen based on VIPER long term wear test results

Westinghouse

Inspection

Westinghouse Field Acceptance Criteria

The design is accepted in the aspect of GTRF if both bullets below are met

- ✓ Less than 44% through wall on a single individual wear depth
- ✓ Less than 10% through wall from all measurements on 95/95 basis.

Work Scope

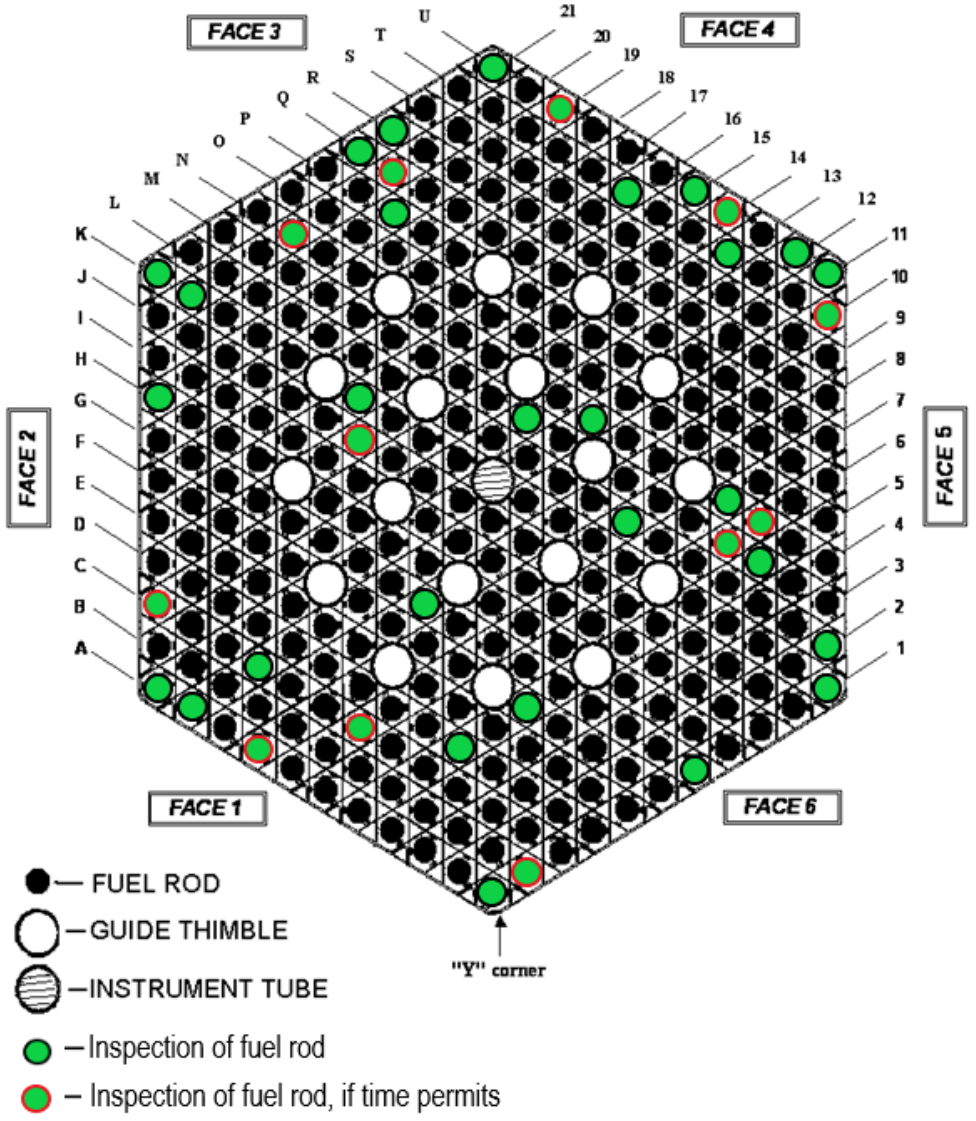
- Removal of Top Nozzle on the assembly to be inspected
- Visual inspection of individual fuel rods
- Eddy Current (EC) measurements on the individual fuel rods to obtain wear data
- Fuel rods are put back in the assembly
- Top Nozzle is re-installed on the inspected assembly

Program

- Given boundary condition – can't find the root cause of leaking FR =>
  - ✓ Only UT leaker search with the AFIS system on WTA2
- Focus on GTRF =>
  - ✓ Inspection of identical, leak-free WTA3
  - ✓ 40 FRs extracted, inspected and measured with EC
  - ✓ Rods were chosen based on VIPER long term wear test results

Westinghouse

Inspection

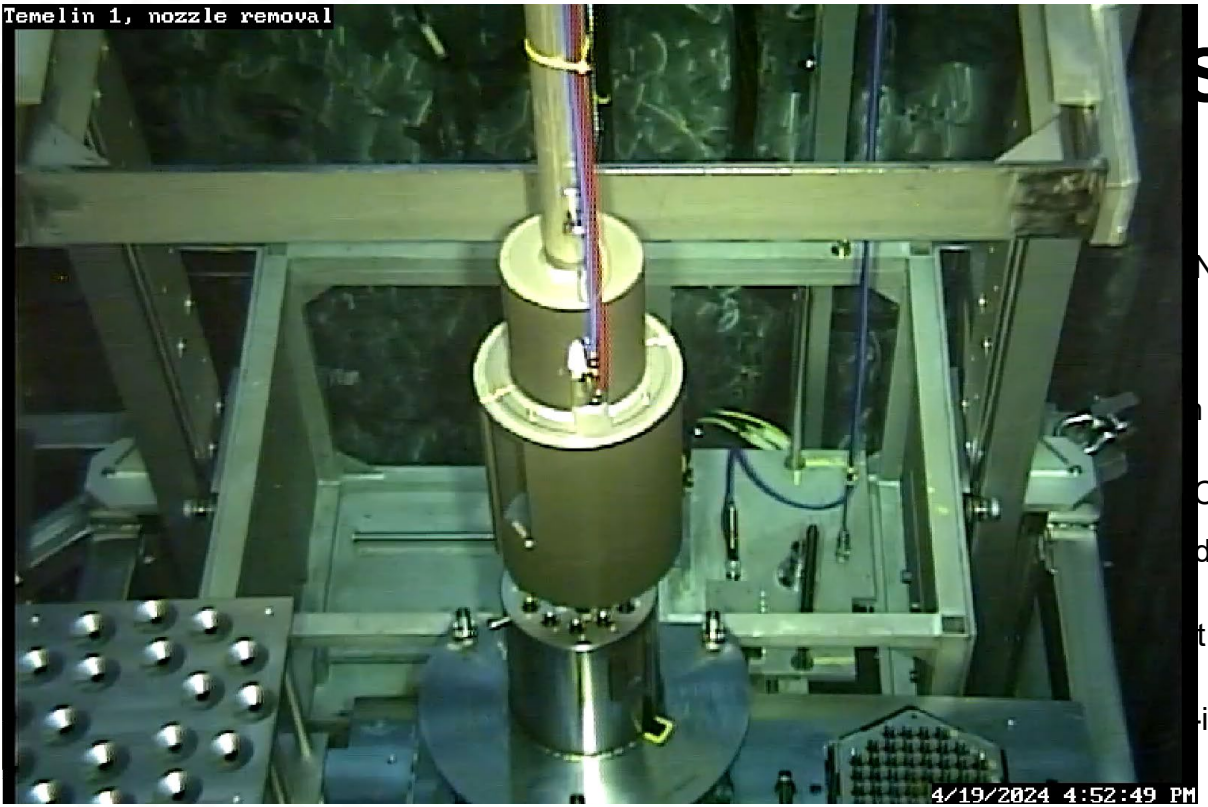


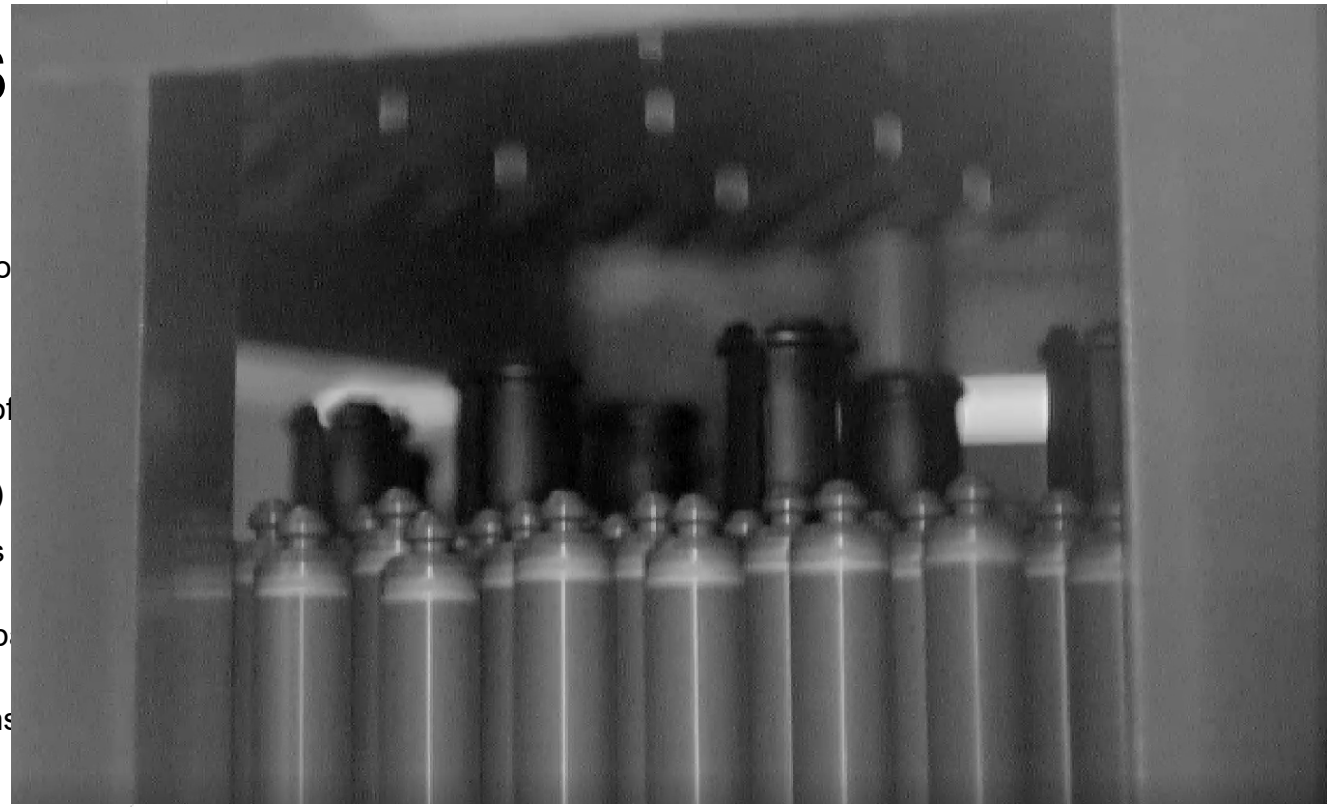
Program

- Given boundary condition – can't find the root cause of leaking FR =>
  - ✓ Only UT leaker search with the AFIS system on WTA2
- Focus on GTRF =>
  - ✓ Inspection of identical, leak-free WTA3
  - ✓ 40 FRs extracted, inspected and measured with EC
  - ✓ Rods were chosen based on VIPER long term wear test results

Westinghouse

Inspection





- ✓ Rods were chosen based on VIPER test results

RESULTS

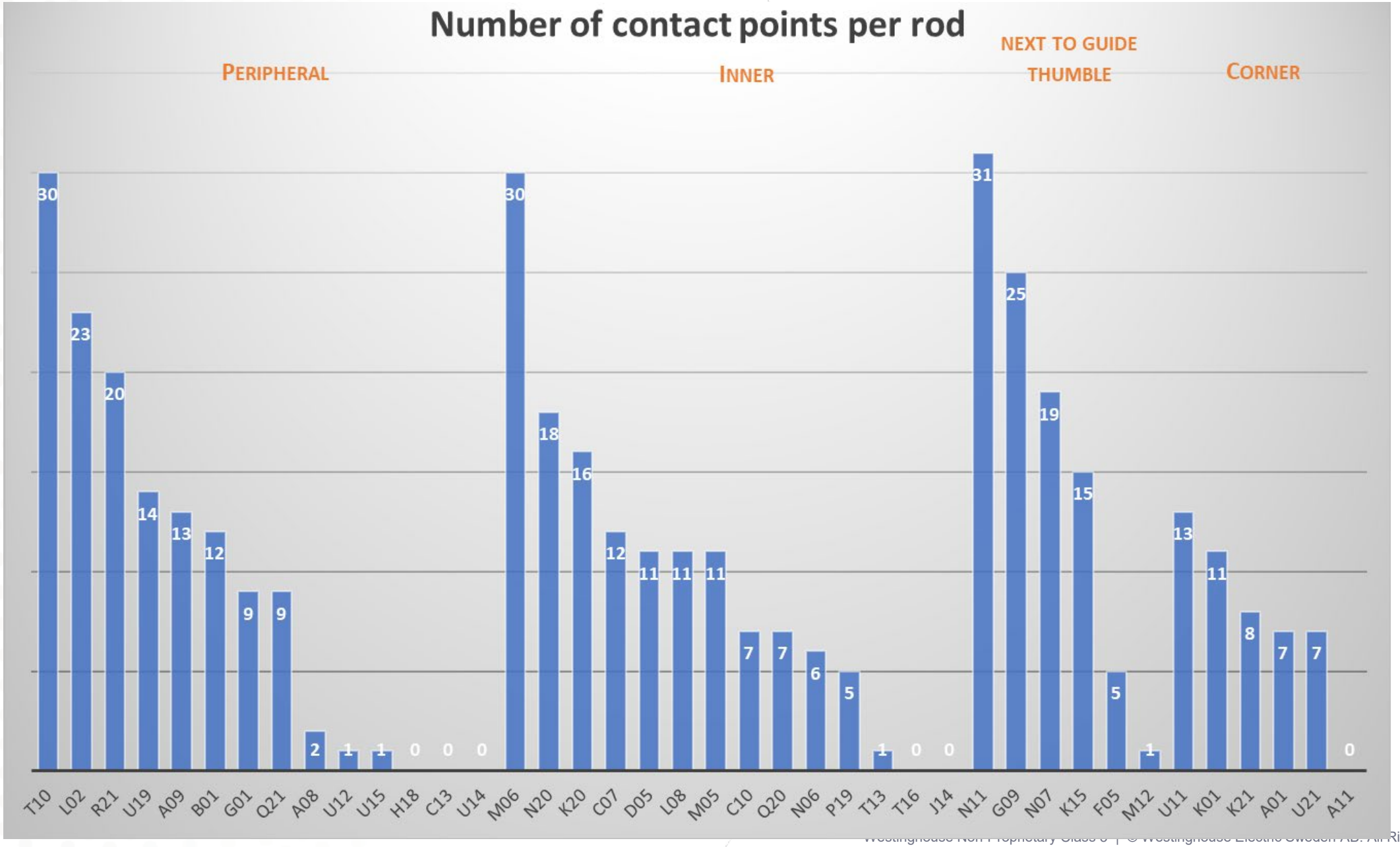
- **Visual Inspections:**
  - 40 rods, 13 grids, 1+2 spring/dimples per cell ➔ **1560 contact positions** inspected
  - **No fretting wear observed.** Only normal contact marks

- **EC-testing**
  - **No detectable mark on any rod**
  - See Table to the right: Code NDD = Not Detectible Defect

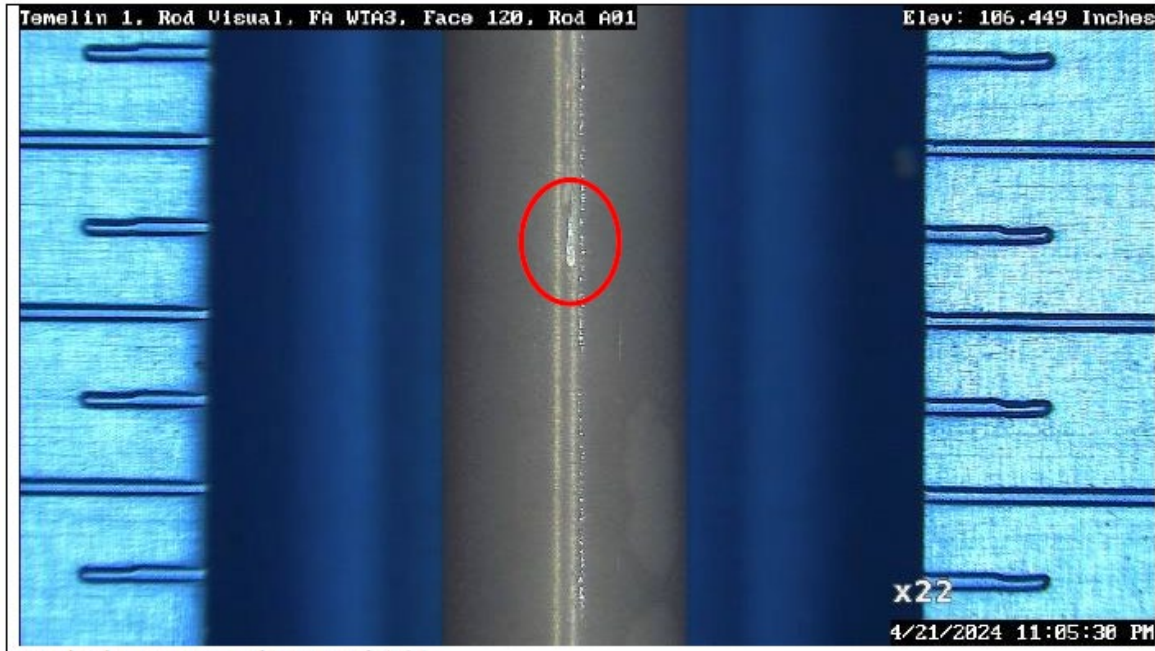
GTRF Acceptance Criteria are Fulfilled for RWFA-T

LINE	ASSY	ROD	ROD	VOLTS	DEG	CODE	%	CH	LOCATION		EXTENT
1					CAL	3			TEM	ACQ	
2					COMP	TEMELIN					
3					PROBE	.360					
4					ANALYST	10289			II	04/20/24	
5					OPERATOR	10289			II		
6					ACQ START	1959				04/19/24	
7											
8	WTA3	A	11			NDD					SPR TIP
9	WTA3	J	14			NDD					SPR TIP
10	WTA3	U	14			NDD					SPR TIP
11	WTA3	C	13			NDD					SPR TIP
12	WTA3	U	21			NDD					SPR TIP
13	WTA3	U	12			NDD					SPR TIP
14	WTA3	U	15			NDD					SPR TIP
15	WTA3	T	13			NDD					SPR TIP
16	WTA3	T	16			NDD					SPR TIP
17	WTA3	G	1			NDD					SPR TIP
18	WTA3	F	5			NDD					SPR TIP
19	WTA3	B	1			NDD					SPR TIP
20	WTA3	K	1			NDD					SPR TIP
21	WTA3	M	12			NDD					SPR TIP
22	WTA3	U	19			NDD					SPR TIP
23	WTA3	H	18			NDD					SPR TIP
24	WTA3	A	9			NDD					SPR TIP
25	WTA3	C	10			NDD					SPR TIP
26	WTA3	C	7			NDD					SPR TIP
27	WTA3	G	9			NDD					SPR TIP
28	WTA3	K	15			NDD					SPR TIP
29	WTA3	K	21			NDD					SPR TIP
30	WTA3	Q	21			NDD					SPR TIP
31	WTA3	P	19			NDD					SPR TIP
32	WTA3	N	7			NDD					SPR TIP
33	WTA3	M	5			NDD					SPR TIP
34	WTA3	T	10			NDD					SPR TIP
35	WTA3	L	2			NDD					SPR TIP
36	WTA3	L	8			NDD					SPR TIP
37	WTA3	N	6			NDD					SPR TIP
38	WTA3	U	11			NDD					SPR TIP
39	WTA3	N	20			NDD					SPR TIP
40	WTA3	Q	20			NDD					SPR TIP
41	WTA3	K	20			NDD					SPR TIP
42	WTA3	A	8			NDD					SPR TIP
43	WTA3	D	5			NDD					SPR TIP
44	WTA3	A	1			NDD					SPR TIP
45	WTA3	N	11			NDD					SPR TIP
46	WTA3	M	6			NDD					SPR TIP
47	WTA3	R	21			NDD					SPR TIP

Westinghouse



Contact mark and scratch from rod extraction, rod G09



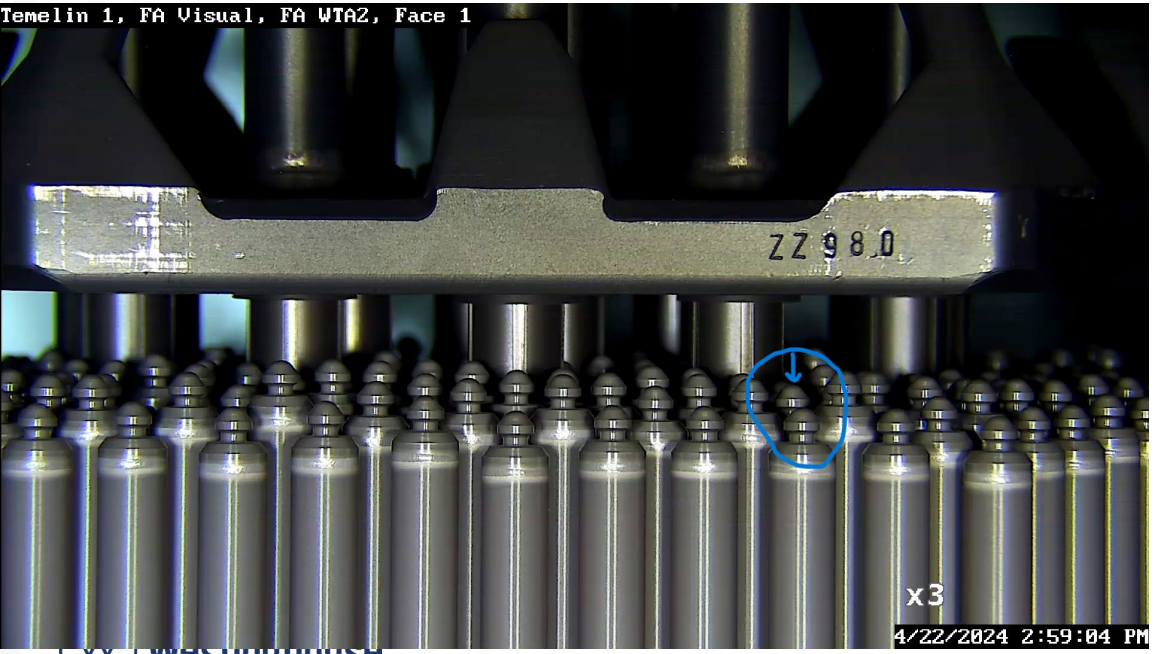
Typical contact marks on rod A01

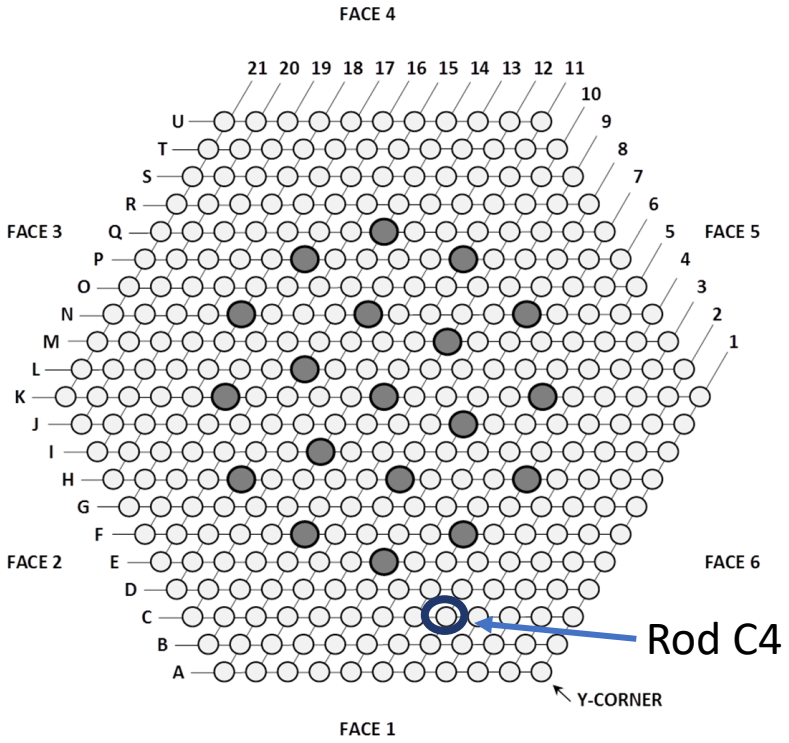
Contact mark on rod U11

Typical contact marks on rod A01

AFIS Inspection on the Leaking WTA2

- Rod C4 detected as leaking
- No excessive growth
- Difficult to visually inspect in third row





SUMMARY

Safe rod extraction and re-insertion within given time in VVER-1000 conditions.

WTA2 - leaking

- One leaking FR identified
- No excessive growth observed
- Root cause not established

WTA3 – not leaking

- Thoroughly examined for GTRF
- 1560 contact points investigated
- **No fretting wear** observed visually
- No detectable marks on EC

Overall performance

- No broken fuel rod
- Finished about 20 hours sooner
- No other major problem
- Operational „issues“ (UT probe replacement, hosing replacement, etc…)
- Foreign material from pools caused delays

Westinghouse