40 years of Operation, Nuclear Safety Upgrade and Extension of the Operating Life; Long-Term Operation of the NPP Krško

Peter Jan, GEN-WEC event, March 06, 2024

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Contents

NPP Krško in Brief

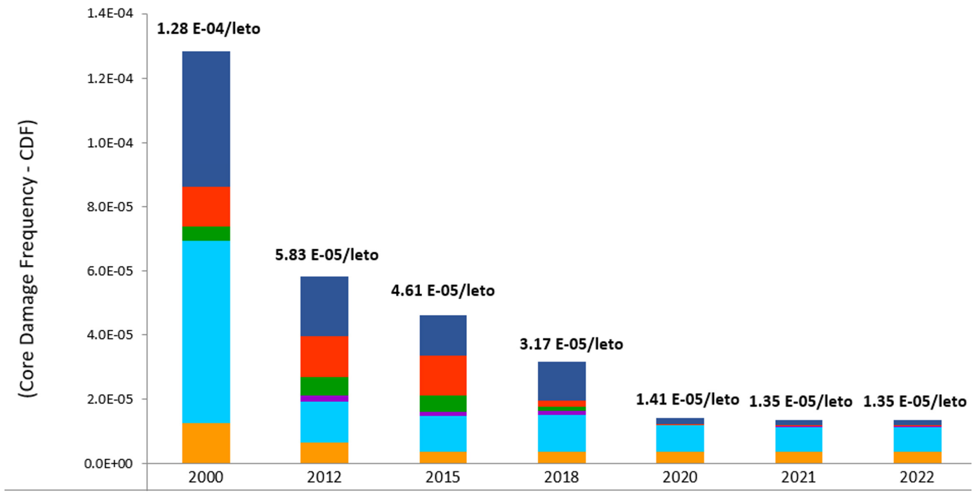
Operational performance, high operating and environmental standards. Compliance with the conditions for continued safe, reliable and long-term operation.

- Owners: **GEN-energija 50%, HEP 50%**
- Operator: **Krško Nuclear Power Plant**
- NSSS Supplier: **Westinghouse**
- Reactor Type: **PWR, 2-loop**
- Engineering: **Gilbert Architect Engineer**
- Construction Permit: **1975**
- First Criticality: **1981**
- Commercial Operation: **1983**
- Operating Life Time: **40+10+10+... years**
- No. of Employees: **~659**
- Gross Plant Output: **~734 MW**

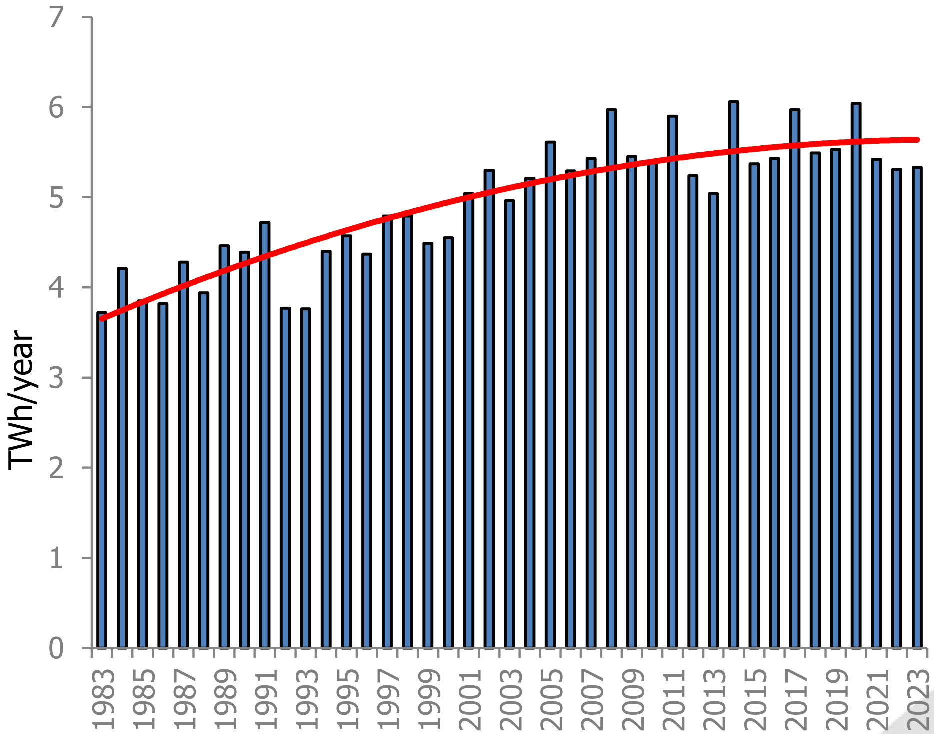
Our Vision & Mission

Biti zgled jedrske varnosti
in odličnosti na globalni ravni
(World-wide leader in nuclear safety and excellence)

Core Damage Frequency (CDF)



Positive Production Trend



NEK construction

- **Contract signed on the 1st of December, 1973, Work at site started in 1975**

CONTRACT

FOR

KRŠKO

NUCLEAR POWER PLANT

BETWEEN
SAVSKE ELEKTRARNE LJUBLJANA
AND ELEKTROPRIVREDA ZAGREB

AND

WESTINGHOUSE ELECTRIC CORPORATION

CONFORMED COPY

ARTICLE IV—CONTRACT PRICE

The Contract Price shall comprise the U.S. Dollar portion and the Yugoslav Dinar portion, which prices shall be subject to escalation and adjustment as provided for and defined in the Contract, and which will be for the supply of the Nuclear Power Plant on a Turnkey basis at the Krsko site in accordance with the Contract.

a) *Warranty*

WESTINGHOUSE warrants that the date of Plant Completion is scheduled for the latest of the following dates:

1. November 28, 1978
2. Fifty-three (53) months after Effective Contract Date in accordance with Article XXXV.

consisting of suppliers and subcontractors from the Republics of Croatia and Slovenia nominated by the OWNER to provide Yugoslav goods and services for the Krsko Plant consisting of:

Rade Koncar	Hidromontaza
Jugoturbina	Litostroj
Hidroelektra	Gradis
Djuro Djakovic	Metalna
Elektroprojekt-Zagreb	I. B. Elektroprojekt

NEK construction

- Cca 40% of work and material contributed by domestic industry.

Aggregate price by the original contract:
- **Part of price fixed and firm,**
- **Part of price with pre-defined price escalation.**

NEK construction

- Cca 40% of work and material contributed by domestic industry.

NUKLEARNA ELEKTRARNA KRŠKO
v ustanavljanju
KRŠKO, Ulica 4. julija št. 38

DESIGN, MATERIAL AND EQUIPMENT SUPPLY AND ERECTION

ITEM	DESIGN CRITERIA	DETAIL DESIGN	MATERIAL AND EQUIPMENT SUPPLY	ERECTION
REACTOR COOLANT SYSTEM				
1.0 Reactor Vessel (shop fabricated) including:				
1.1 Vessel shell (1)	W	W	W	W
1.2 Vessel head with control drive mechanism adapters	W	W	W	W
1.3 Control rod drive mechanism adapter plugs	W	W	W	W
1.4 Integral support pads abd brackets	W	W	W	W
1.5 Support shoes and shims	W	W	W	W
1.6 Closure studs, nuts and washers	W	W	W	W
1.7 Flange leak-off stud	W	W	W	W
1.8 Control rod drive mechanism ventilation shroud	W	W	W	W
1.9 Control rod drive mechanism baffle cans	W	W	W	W
1.10 Closure gaskets	W	W	W	W
1.11 Vessel lifting beam (loan basis)	W	W	W	W
1.12 Shipping covers (loan basis)	W	W	W	W
1.13 Vessel shipping skid (loan basis)	W	W	W	W
1.14 Vessel head shipping skid (loan basis)	W	W	W	W

DESIGN, MATERIAL AND EQUIPMENT SUPPLY AND ERECTION

ITEM	DESIGN CRITERIA	DETAIL DESIGN	MATERIAL AND EQUIPMENT SUPPLY	ERECTION
219 Miscellaneous Buildings and Structures (Complete, including all necessary building services) (1)				
1. Gatehouse and guardhouse if separate (in-plant use only)	OW	O	O	O
2. Office Building (in-plant use only)	OW	O	O	O
3. Garage (in-plant use only)	OW	O	O	O
4. Warehouse (storage) (in-plant use only)	OW	O	O	O
5. Mess Hall (in-plant feeding only)	OW	O	O	O
6. First-Aid Post (in-plant use only)	OW	O	O	O
7. Raw & Potable Water Treatment Station Bldg.	O	O	O	O
8. Raw & Potable Water Pump Station Bldg.	O	O	O	O
9. Fire Water Pump Station *	W	W	W	W *
10. Construction Bldgs. facilities and offices	W	W	W	W
10a School facilities for children of personnel	W	O	O	O
10b Housing* (2)	W	O	O	O
220 Equipment and Fixtures (3)				
1. Gatehouse	O	O	O	O
2. Office (incl. those in primary aux. bldg.)	O	O	O	O
3. Garage	O	O	O	O
4. Warehouses	O	O	O	O
5. Kitchen and Mess Hall	O	O	O	O
6. First-Aid Post	O	O	O	O

NEK construction

Standards, regulatory requirements clearly defined in contract

B. U.S. DESIGN AND QUALITY LEVEL CODES

—ASME Boiler and Pressure Vessel Code

Section II—Material Specifications

Section III—Nuclear Power Plant Components

Section VIII—Unfired Pressure Vessels

Section IX—Welding Qualifications

Section XI—In-Service Inspection of Nuclear Reactor

—ASME Code for Pumps and Valves for Nuclear Power

—American National Standard B 31.7, Nuclear Power Piping

—American National Standard B 31.1, Power Piping

—American National Standard, Efficiency Testing for Air Cleaning Systems containing devices for removal of particulates

—Institute of Electrical and Electronic Engineers—Nuclear Power Plant Protection Systems IEEE-279 and Criteria for Class IE Electrical Systems for Nuclear Power Generating Stations IEEE-308

—Heat Exchange Institute

—National Electrical Manufacturers Association

—Institute of Electrical and Electronic Engineers

—Insulated Power Cable Engineers Association

—Illuminating Engineering Society

NUKLEARNA ELEKTRARNA KRŠKO
v ustanavljanju
KRŠKO, Ulica 4. julija št. 38

Reflection in USAR.

Commitment to U.S. standards

NEK construction (1975-1981 – from ground breaking to first criticality - <u>in 6 (six years)</u>

NEK construction (1975-1981 – from groundbreaking to first criticality - 6 (six years)

70's CIRCUMSTANCES and FACTS

1. **NO PCs,**
2. **NO internet→different meaning of communication,**
3. **NO 3D models.**

AND

1. **Clear responsibilities,**
2. **Books, tabels,**
3. **Calculator.**

TRIBAL KNOWLEDGE of U.S. Nuclear Industry

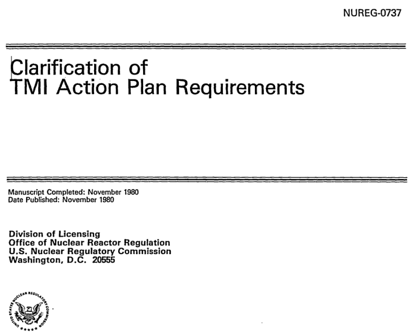
Resonable people come to resonable solutions!

Are we able to repeat such achievement?

Operation with Continous improvements

Begining of Design changes (modifications)

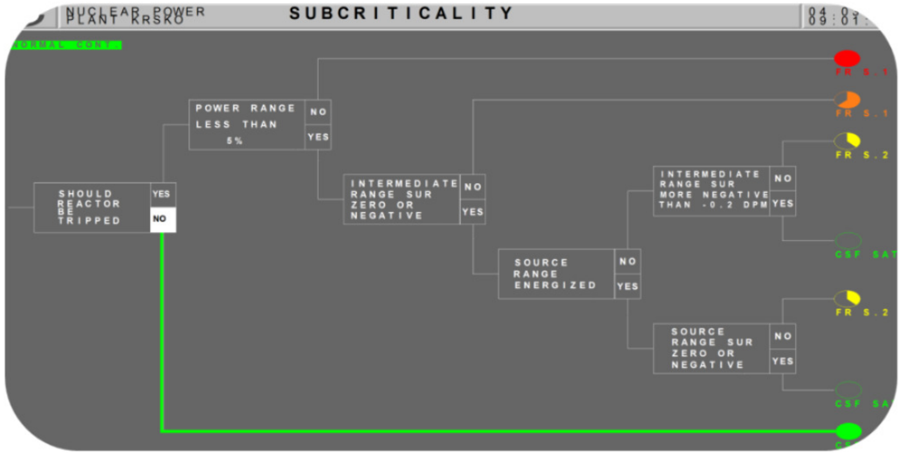
Post TMI modifications NUREG-0737


NUREG-0737

Clarification of
TMI Action Plan Requirements

Manuscript Completed: November 1980
Date Published: November 1980

Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555



1996 – 2000 Plant Modernization and power increase for 6.3%

Steam Generators Replacement

Power increase based on complete Safety analyses rerun – new Chapter 15 and part of Chapter 4

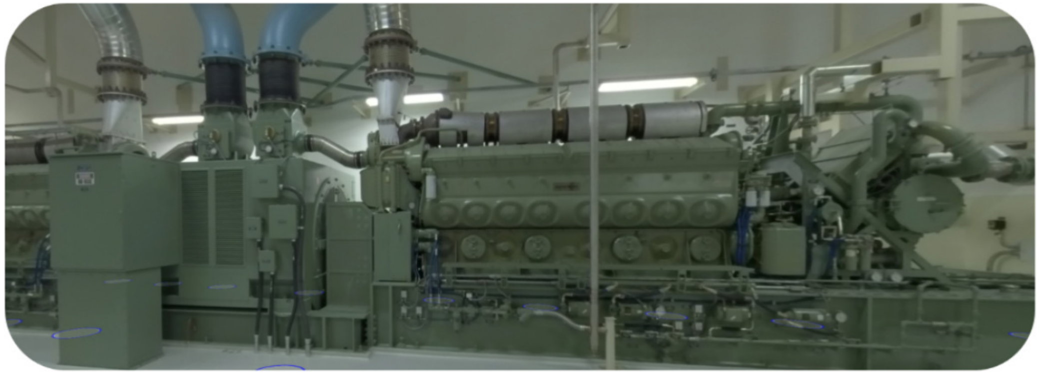
Full-scope Simulator

After 2000 – investments To increase Safety and Availability

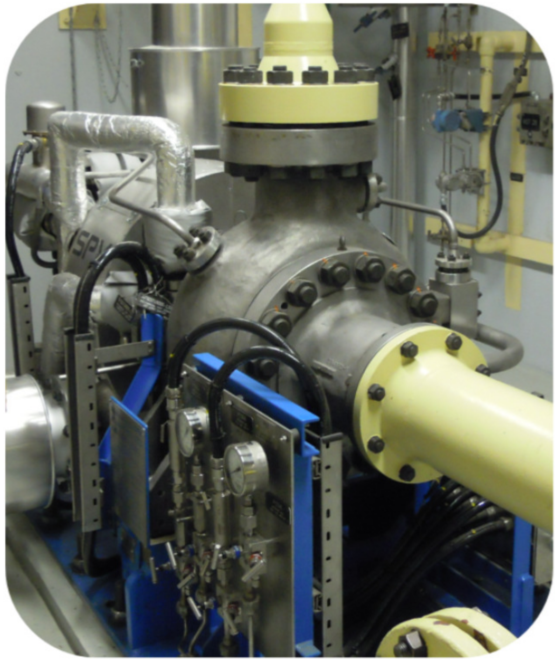
Major Investment Projects Performed

To improve Nuclear Safety

- Full-scope Simulator
- 125 V DC Supply (batteries)
- PRZR PORVs Bypass
- Radiation Monitoring System
- Emergency AC Power System (DG 3)
- Flood Safety



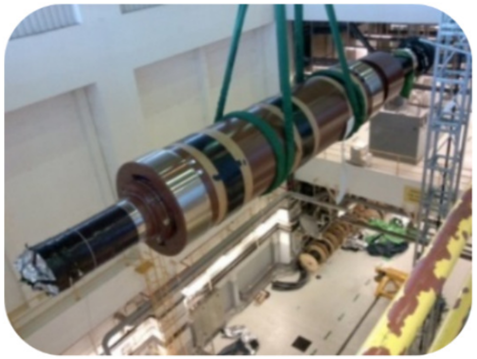
- Passive Autocatalytic Recombiners (PAR)
- Passive Containment Filtering Ventilation System
- TD Auxiliary Feedwater Pump
- Emergency Control Room
- RCP high temperature seals
- BB2– Alternative SI PMP and Alternative AF PMP with bunkered water sources



Major Investment Projects Performed

To increase Availability

- Condenser
- Process Computer
- Steam Generators
- Low-pressure Turbine Rotors
- Spent Fuel Pit Re-racking
- Cooling Tower Extension
- Reactor Coolant Pump Motors
- Secondary Heaters
- In-core Instrumentation
- Digital Turbine Control
- Moisture Separator Reheaters
- Generator Stator & Rotor & Exciter
- Reactor Head
- Main Transformers
- Switchyard
- Main transformer 500 MVA
- Renewal of 400 kV switchyard
- High-pressure Turbine



Continous Safety Improvements-Response to new Challenges

Aircraft Crash Countermeasures

Coping with Beyond Design Basis Condition

NEK developed concept based on **U.S. B.5.b** requirements.

NEK applied similar solutions as first response on Fukushima Daiichi accident.

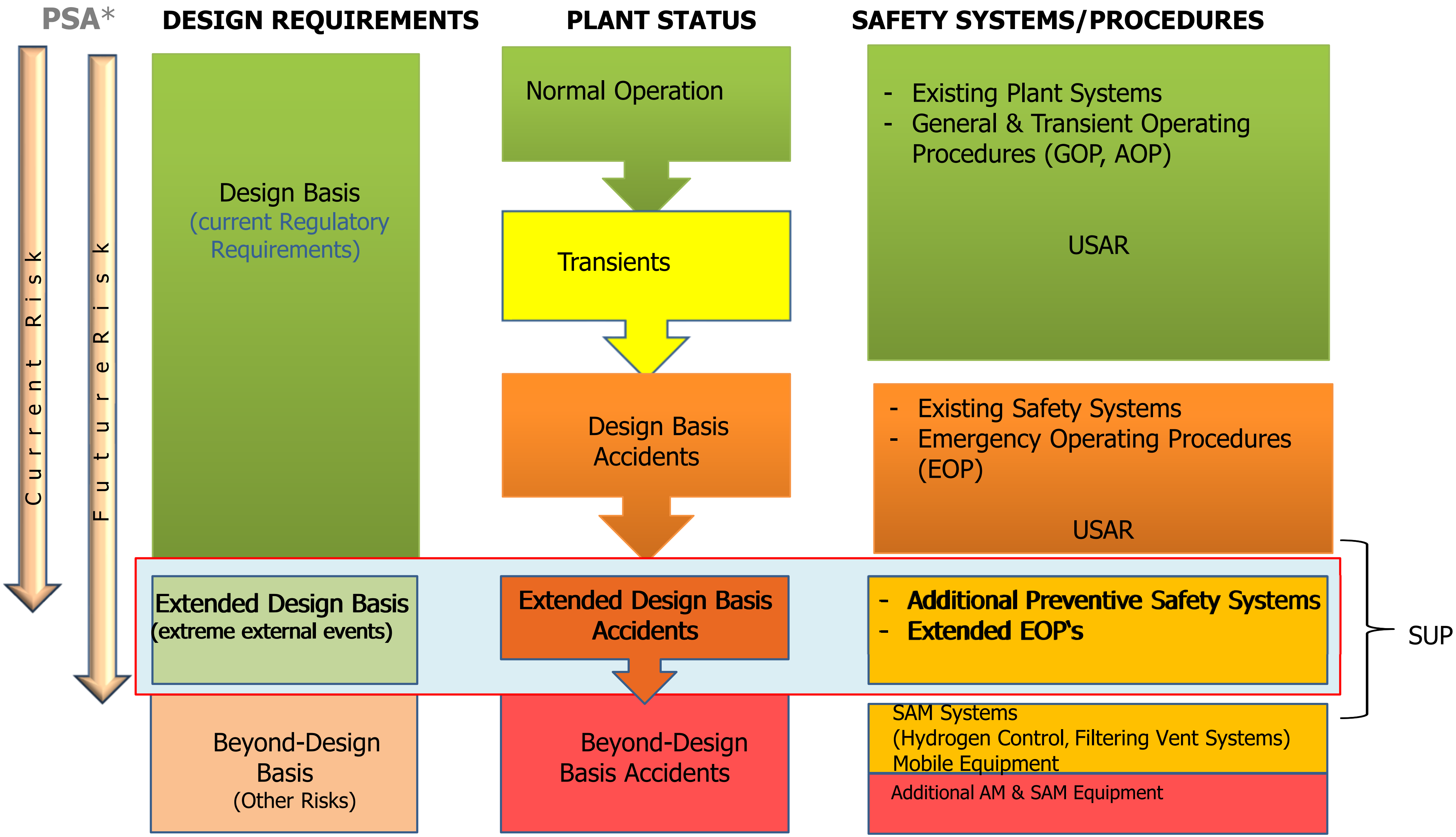
The concept of usage mobile equipment was recognized as very useful for **natural disasters-**Mobile equipment (FLEX).

Before Safety Upgrade Program Concept

PSA*	DESIGN REQUIREMENTS	PLANT STATUS	SAFETY SYSTEMS/PROCEDURES
Current Risk	Design Basis (current Regulatory Requirements)	Normal Operation	- Existing Plant Systems - General & Transient Operating Procedures (GOP, AOP) USAR
		Transients	
		Design Basis Accidents	- Existing Safety Systems - Emergency Operating Procedures (EOP) USAR
	Beyond-Design Basis (Other Risks)	Beyond-Design Basis Accidents	Additional AM & SAM Equipment

***PSA** – Probabilistic Safety Assessment

Safety Upgrade Program Concept
Extended Design Basis



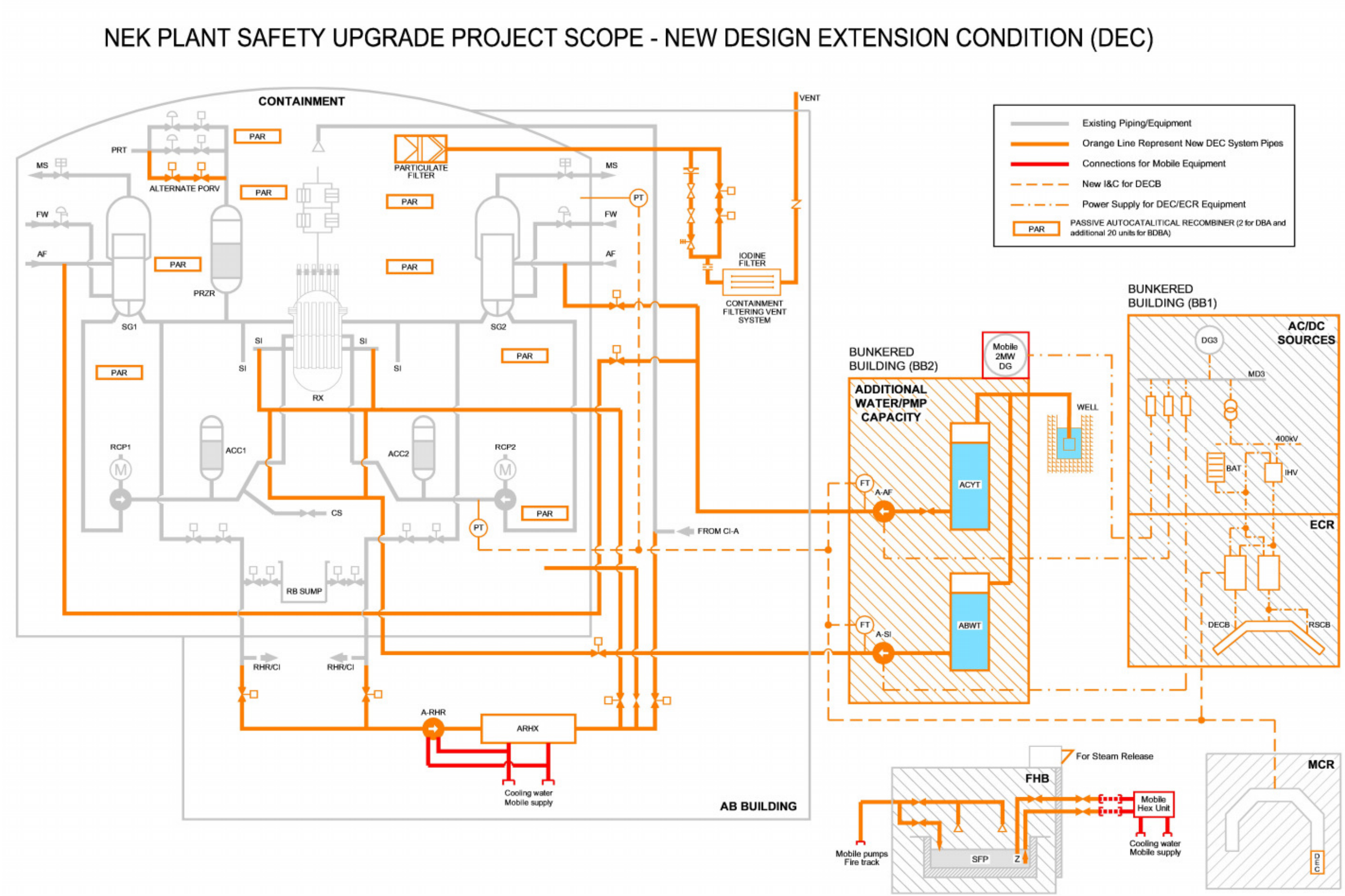
***PSA** – Probabilistic Safety Assessment

Safety Upgrade program to meet new regulatory requirements

Overview – without SFDS

Major technical precondition for Safety Upgrade

NEK Original Design Margins of original plant systems



AP1000 vs **WENRA requirements?**
(severe natural disasters-combinations of events and BDBA, DEC-B conditions)

Safety Upgrade Program

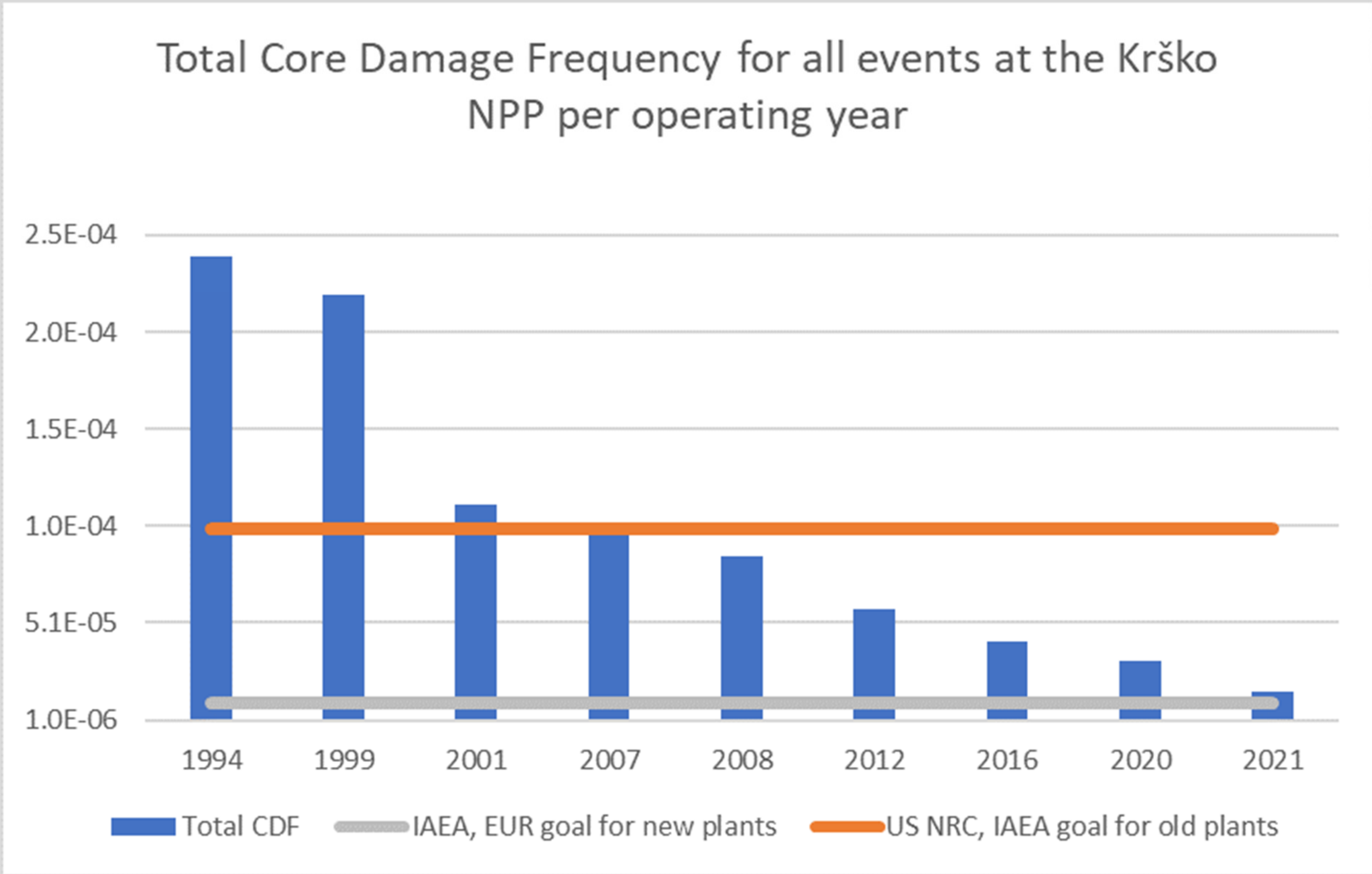




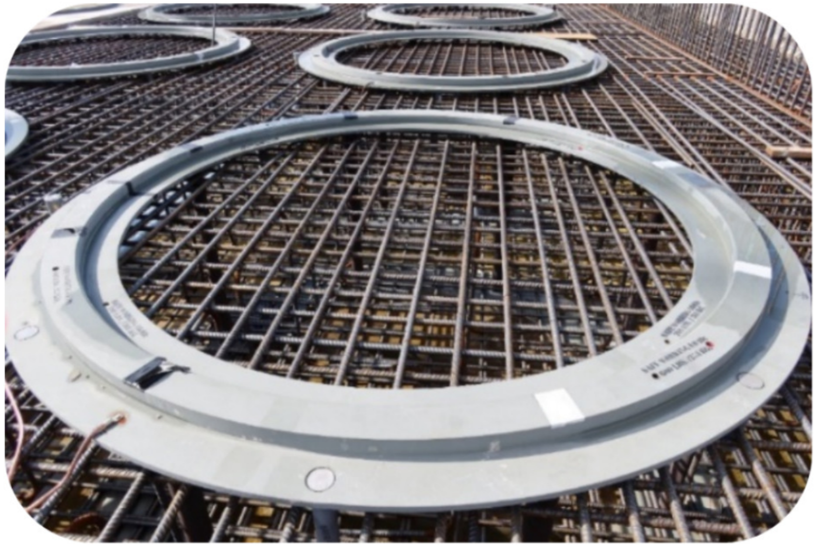


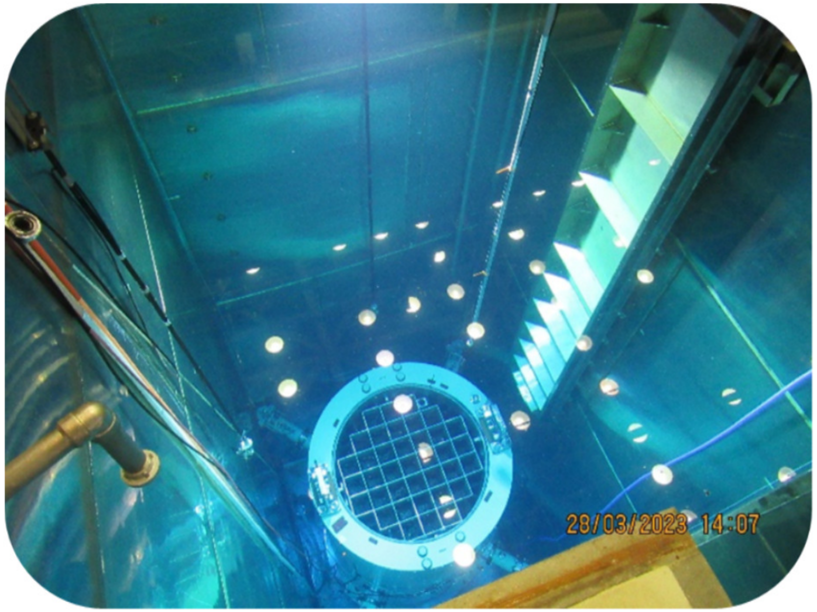
Implementation of the Safety Upgrade Program

Reducing the Risk of Core Damage Frequency (CDF)



Safety Upgrade Program – construction of Spent Fuel Dry Storage



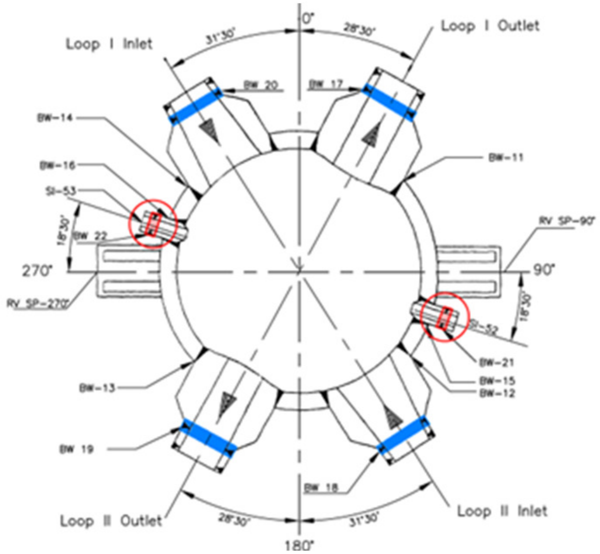


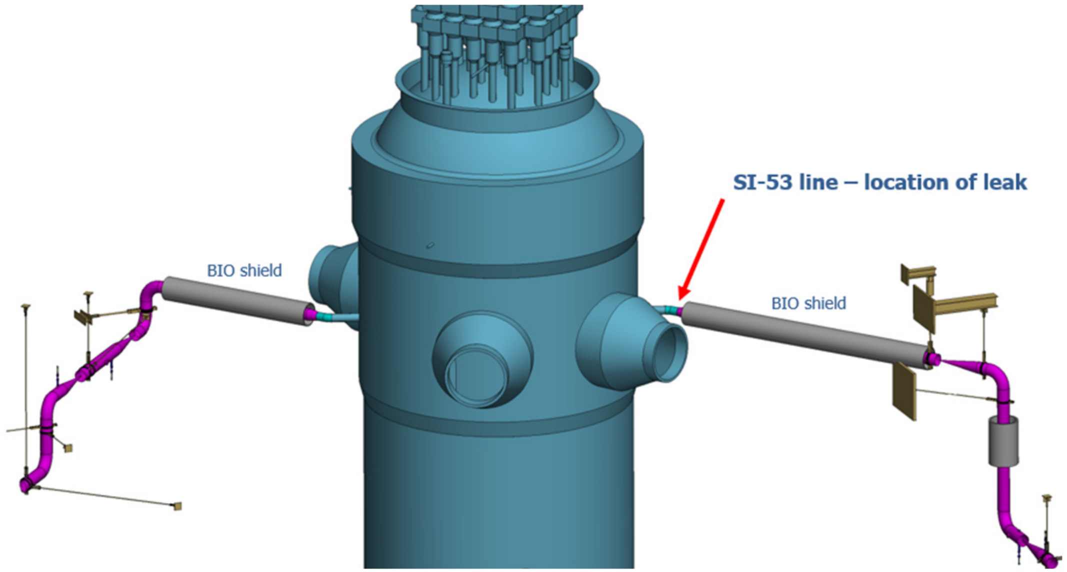
Krsko NPP SI line leakage

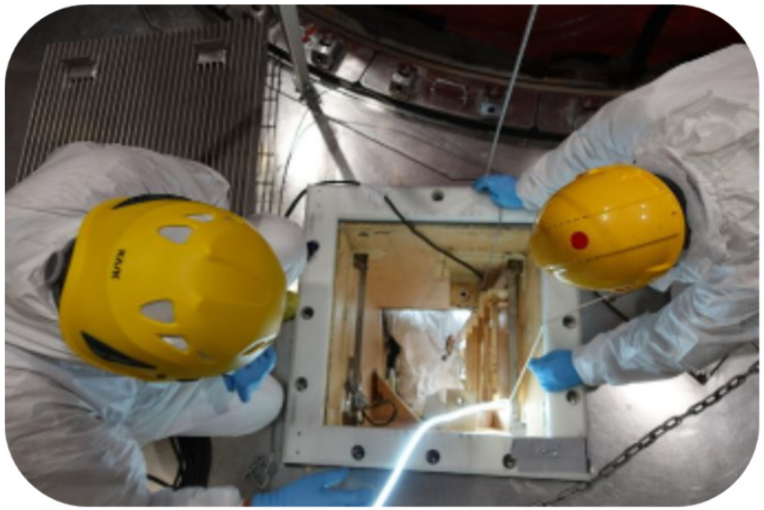
Leak on SI line – forced outage

Leakage on SI-53 line at NPP Krsko

Leak location – pipeline SI-53







Lessons Learned after SI-53 repair

What went good/excellent?

GOOD PRACTICES/PERFORMANCES/CIRCUMSTANCES

1. **Prompt WEC response** on NEK request for Emergency call (around 25 competent participants from WEC, WEB, WER).

2. **WEC comprehensive mobilization for on-site activities** (arround 100 persons) although the high outage season in USA.

3. **Numip imediate walkdowns** for exact data to built mock-up as fast as possible and as acurrate as possible.

4. Advantages of **local contractors** and support companies (Numip, Qtechna, Elmont, Kovis,…). Availability and knowledge about the plant configuration and processes. **Understanding plant expectations** regarding field activities.

5. **Commitment and mission of persons** involved to resolve the issue and replace pipings.

6. **Centralized project management** for NEK Team, team physically together, leaded from one place, SPOC for al interferences, requirements, alignments, needs, decisions.

7. NEK coordination 24/7, including workshop and hot shop.

8. **Industrial safety:** permanent fire watch and rescue team for all 3 work places in Reactor Building.

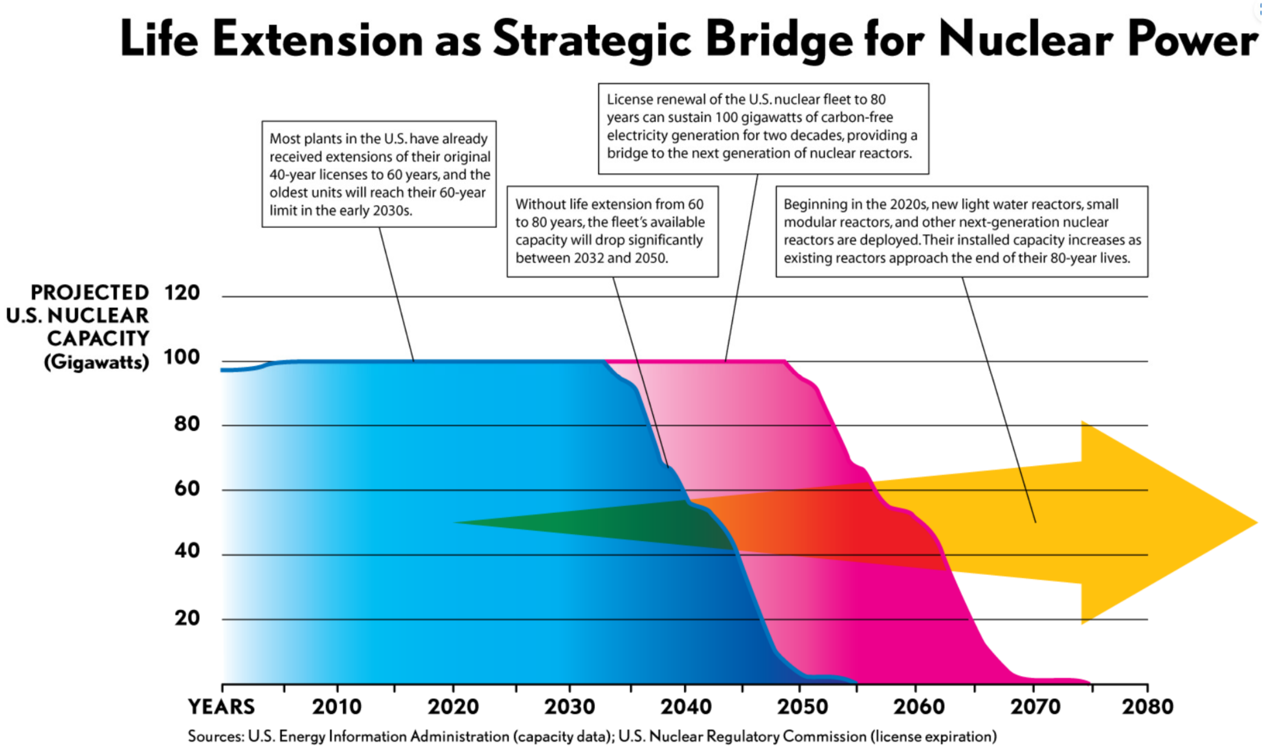
PLEX - NEK Plant Life Extension from 40-60Y; DONE (January 2023), Next challenge PLEX 60-80 years

NPP Krsko Life extension as Strategic Bridge for Nuclear Power in Slovenia?

1. **Feasibility Study**
2. **Life extension preparation cca 15 years.**

ELECTRIC POWER RESEARCH INSTITUTE

EPRI experiances with U.S. Plants



Life extended from 60-80 years:

Peach Bottom 2 & 3,

Turkey Point 3 & 4,

Surry 1 & 2

In progress:

North Anna 1 & 2,

Point Beach,

V.C: Summer and

Robinson.

EXCERCISE: Are we able to repeat such achievement?

Being proud on sucess! ≠ **Being overselfconfident**-ignoring today's circumstances, facts.

Challenges for JEK2:

1. **JEK2 NATIONAL PROJECT** to be proud on**.**
2. **Ambitious schedule for JEK2** to be defined at all levels.
3. Completion of the project within **planned budget and schedule.**
4. **Effective integration of Nuclear Safety Culture**, **knowledge and experiences from Krško UNIT 1.**

Today's **circumstances and facts** regarding **Nuclear in SLOVENIA.**

Hvala!
Welcome in Krško!

A: Vrbina 12, 8270 Krško, Slovenija
M: nek@nek.si

www.nek.si