



TECHNICAL SPECIFICATION

for

Supply of the Thermal Performance and DVR Application

Augmented Quality

Specification Number
SP-ES1474
Rev. 0

KRŠKO NUCLEAR POWER PLANT

Written by:


Aljoša Šumlaj / Robi Jačovec

Date: 7/1/2025

Written by:


Gordan Janković

Date: 8/1/2025

Reviewed by:


Aleksandra Antolovič

Date: 8/1/2025

Reviewed by:


Peter Jan

Date: 08/01/2025

Reviewed by:


Marko Turalija

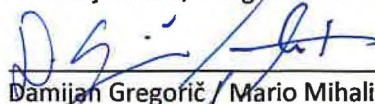
Date: 8/1/2025

Reviewed by:


Andrej Kavčič / Gregor Škorc

Date: 9/1/2025

Reviewed by:


Damijan Gregorič / Mario Mihalina

Date: 9/1/2025

Approved by:


Božidar Krajnc

Date: 9/1/2025

CONTENTS

1	BACKGROUND	3
2	SCOPE OF WORK.....	4
2.1	Development of Thermal Performance application.....	4
2.2	Development of DVR model.....	5
2.3	Thermal Performance and DVR software long-term support	6
3	SAFETY CLASSIFICATION OF WORK	6
4	DESIGN INPUT.....	6
5	APPLICABLE DESIGN CONTROL PROGRAM	6
6	APPLICABLE CODES, STANDARDS, AND DESIGN CRITERIA FOR THE WORK.....	7
7	AFFECTED SYSTEMS.....	7
8	IDENTIFICATION OF AFFECTED EQUIPMENT.....	7
9	REVIEW AND/OR VERIFICATION OF WORK	7
10	SCHEDULE REQUIREMENTS.....	8
11	STATUS REPORTING REQUIREMENTS	9
12	WORK TO BE PERFORMED OR INFORMATION TO BE PROVIDED BY NEK.....	9
13	CHANGES OF WORK SCOPE.....	9
14	DELIVERABLES TO BE PROVIDED BY THE CONTRACTOR	10
15	RECORDS.....	11
16	ORGANIZATIONAL CONTACT	11
17	CONTRACTOR TECHNICAL APPROACH TO THE WORK	11
18	ACCESS TO CONTRACTOR FACILITY AND DOCUMENTS	12
19	SUBCONTRACTED WORK.....	12
20	QUALITY ASSURANCE REQUIREMENTS	12
21	NEK PROPRIETARY DATA	12
22	ATTACHMENTS	12

1 BACKGROUND

NEK is a Westinghouse design 2-loop PWR NPP with 2000 MW NSSS thermal output and a maximum gross power of 736 MW. The original steam generators were replaced with Siemens type 72W/D4-2 in 1999 by the consortium Siemens-Framatome. The low-pressure turbines were replaced by MHI in 2006, the main generator was replaced by Siemens in 2010 and the high-pressure turbine was replaced by Siemens in 2022. The principal scheme of the secondary cycle is presented in the heat balance diagram below (see Figure 1). The heat from the secondary cycle is dissipated into river Sava and the atmosphere through the tertiary system which includes condenser and cooling towers.

NEK uses secondary power calorimetric calculation (i.e. secondary power calculation of the two steam generators) for reactor power calculation and control. The biggest contributor for calorimetric power is feedwater flow measurement. NEK has two venturi elements, one in each main feedwater line to the steam generators. Delta-p measurement across this venturi, corrected by temperature and pressure effects, is then used as feedwater flow input to the calorimetric power calculation. NEK does NOT have ultrasonic feedwater flow measurement equipment.

The goal of this specification is to:

- Procure a software platform enabling NEK to optimize the operation of secondary and tertiary cycle to obtain maximum plant thermal efficiency.
- Procure a software platform for DVR (data validation and reconciliation, as defined in EPRI Topical Report 3002018337, and according to VDI2048 standard) with the purpose of providing accurate indication of calorimetric parameters to improve thermal core power accuracy.

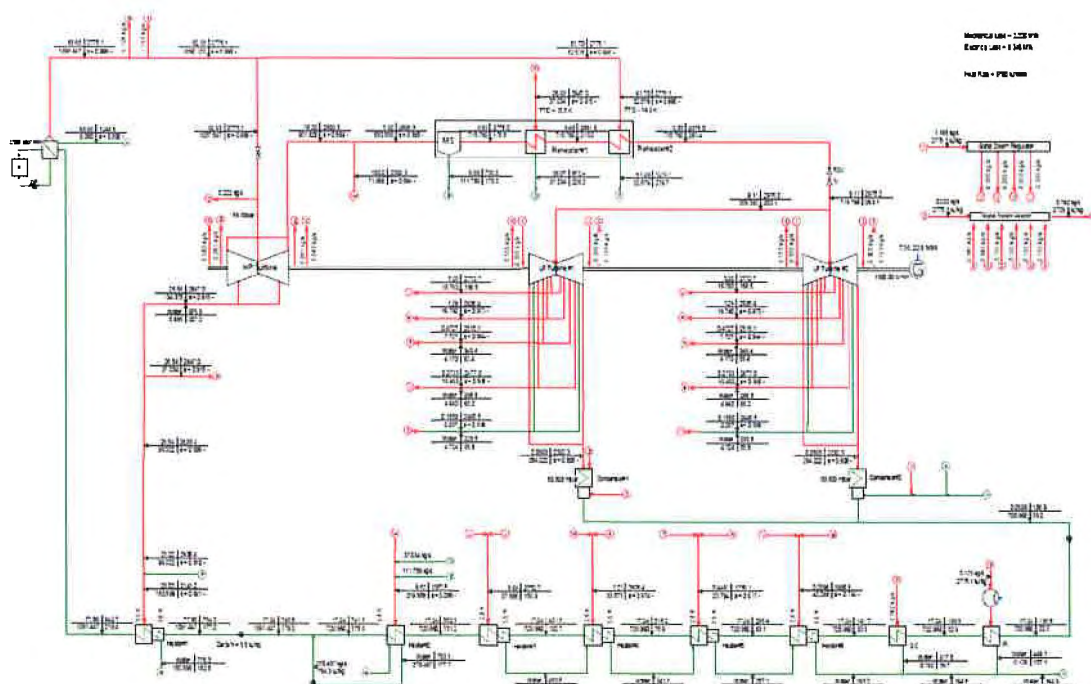


Figure 1: NEK Heat Balance Diagram

2 SCOPE OF WORK

2.1 Development of Thermal Performance application

2.1.1 Phase 1a - Development of steady-state PEPSE model

Scope of Phase 1a is development of steady-state energy balance PEPSE (Performance Evaluation of Power System Efficiencies) model of the plant (including primary, secondary and tertiary cycle) based on thermal kit and real measured data from Plant Information System (PIS). Contractor will provide the data list for PEPSE model development considering thermal kit and measured data from PIS.

List of measuring data at NEK are as follows:

- Water flows: Feedwater (FW) flow into steam generator (SG), water flow on FW pumps. Steam flow and blowdown flow from SG. Water flow of MSR, extraction steam and heater drain system – all secondary system.
- Temperatures: FW temp. and redundant FW temp, steam header temp, temperatures on the secondary site – condensate, heater drain, extraction systems. Additionally, RCS temperatures.
- Pressures: SG pressure, steam line header pressure, extraction, heater drain pressures. Turbine impulse pressure, condenser vacuum.
- Power: Neutron flux indications, RCS temperature rise (dT), Gross electricity output.
- Secondary system leakage.

Contractor shall define the list of any additionally required inputs needed for performing the described scope of work.

2.1.2 Phase 2a - Development of On-line Thermal Performance Application

Scope of Phase 2a is development of on-line thermal performance application based on PEPSE model from Phase 1a for monitoring, analysis, optimization of plant performance and operational decision support. Application shall be able to receive on-line Plant Computer data sent from NEK.

To obtain maximum plant thermal efficiency application shall include at least following features:

- on-line monitoring taking data from PIS on an hourly basis for any potential loss of efficiency and generation including leakage detection
- “what-if” and sensitivity analysis
- predictive pattern recognition in order to detect abnormal operating conditions
- production forecasting

2.1.3 Phase 3a - DVR integration into Thermal Performance Application

Scope of Phase 3a is integration of Data Validation Reconciliation (DVR) values (see chapter 2.2) into on-line thermal performance application to potentially replace raw measurements that drift or is out of accurate calibration, with reconciled DVR values.

2.1.4 Phase 4a - Installation at NEK and Commissioning

Thermal performance application has to be installed on plant computer. Preferably, application shall be installed on a virtual machine in NEK Plant Computer (PIS) environment. Full functionality test of the application shall be performed as Site Acceptance Testing (SAT) according to the SAT procedure, which shall be drafted by the Contractor and approved by NEK. SAT procedure shall include Thermal Performance model verification and validation as recommended by Contractor from similar projects.

Training of NEK personnel with all documents and information relating to the system to enable the NEK staff to use the application correctly have to be provided at the end of project.

2.2 Development of DVR model

2.2.1 Phase 1b - Development of detailed offline DVR model

Contractor shall create a data reconciliation model of the plant by a system of equation, which shall include all applicable components and measurements available on NEK Plant Computer for primary, secondary and tertiary cycle to the extent practicable for the benefit of the DVR model. Information will be provided from the plant documents such piping and instrumentation diagrams. In the model, mass and energy balances will be encompassed by the system of equations. The recommendations of the EPRI document (Reference 6.4) should be taken into account when creating the model.

The basic goal of reconciled data is to find indication of measurement drifts, leakages and errors to optimize the power operation. At least following should be calculated as reconciled data (parameters used in power calorimetric calculation):

- feedwater flow,
- feedwater temperature,
- steam pressure,
- blowdown flow and
- blowdown temperature,

with assessment of systematic and random error for each parameter. The final DVR model should have uncertainty equal or better than assumed in Revised thermal design procedure uncertainty analysis (Reference 6.5) for all above mentioned parameters.

In case that main feedwater flow uncertainty as estimated by the DVR model cannot be achieved to be better than 0.5% span with 95% confidence level, Contractor shall perform Phase 5b below.

2.2.2 Phase 2b - development of on-line DVR model

After DVR model is completed, model shall be upgraded to receive on-line Plant Computer data sent from NEK.

2.2.3 Phase 3b - Thermal Performance-DVR integration

See Chapter 2.1.3

2.2.4 Phase 4b - Installation at NEK and Commissioning

Contractor shall install DVR software with NEK model locally on NEK computer/server. Preferably, DVR software shall be installed on a virtual machine in NEK Plant Computer (PIS) environment. Full functionality test of the local DVR software shall be performed as Site Acceptance Testing (SAT) according to the SAT procedure, which shall be drafted by the Contractor and approved by NEK. SAT procedure shall include DVR model verification and validation as defined in Reference 6.4 and as recommended by Contractor from similar projects.

Contractor shall also organize training for up to 6 people for the use and maintenance of the DVR software.

2.2.5 Phase 5b - Additional instrumentation installation – if required

In case DVR model cannot estimate the main feedwater flow to uncertainty better than 0.5% of span, as stated in chapter 2.2.1, Contractor shall identify improvements in existing instrumentation (e.g. replacement of primary measurement elements, transmitters etc) or identify new measurements which needs to be installed to improve the uncertainty to below 0.5%.

The engineering and procurement specifications for the additional instrumentation as defined above shall be in scope of the Contractor. Material and installation cost shall be NEK scope.

2.3 Thermal Performance and DVR software long-term support

Contractor shall assure full support including periodic updates and maintenance of the Thermal Performance and DVR software if required for the period of at least 5 years.

3 SAFETY CLASSIFICATION OF WORK

This work is classified as Augmented Quality.

4 DESIGN INPUT

Design input consists of data, drawings, NEK procedures and documents, vendor documents, and other documents pertinent to the modelling of the primary, secondary and tertiary cycle. Due to the volume of the input data, these documents will be made available to the contractor upon request after contract approval.

5 APPLICABLE DESIGN CONTROL PROGRAM

Applicable NEK procedures for performing engineering services:

5.1 ED-1, Design Modification Control Program

- 5.2 ED-2, Document Control Program
- 5.3 ED-11 Process Computers Configuration Control Program
- 5.4 ADP-1.2.116, Program nadzora dokumentov v NEK
- 5.5 ADP-1.2.003, Plant Design Modification and Control Process
- 5.6 ADP-1.2.009 Process Computers Software Configuration Control
- 5.7 ESP-2.605, Design Analysis and Calculations
- 5.8 ESP-2.606, Peer Reviews
- 5.9 ADP-1.2.116, "Program nadzora dokumentov v NEK (Documents Control at NEK)" or Contractor equivalent procedure
- 5.10 ADP-1 .2.127: "Quality records management" or Contractor equivalent procedure
- 5.11 ADP-1 .2.010: "Technical Report" or Contractor equivalent program
- 5.12 QS-600 : "Generic software quality assurance program requirements"

6 APPLICABLE CODES, STANDARDS, AND DESIGN CRITERIA FOR THE WORK

- 6.1 VDI 2048 edition 2017- Uncertainties of measurement during acceptance tests on energy conversion and power plants Fundamental, ICS 17.0206.2
- 6.2 EPRI, Thermal Performance Engineering Handbook
- 6.3 IAEA-TECDOC-1971, Thermal Performance Monitoring and Optimization in Nuclear Power Plants
- 6.4 EPRI Topical Report no. 3002018337: Use of Data Validation and Reconciliation Methods for Measurement Uncertainty Recapture, Revision 0-A, September 2023
- 6.5 SSR-NEK-3.0 Revised thermal design procedure uncertainty analysis

7 AFFECTED SYSTEMS

Primary, secondary and tertiary systems, Plant Computer.

8 IDENTIFICATION OF AFFECTED EQUIPMENT

Primary, secondary and tertiary instrumentation.

9 REVIEW AND/OR VERIFICATION OF WORK

The Contractor is required to perform an internal review and verification. Contractor shall work closely with NEK representatives and organize weekly status progress meetings for NEK review of Contractor's work. Review Contractor shall maintain and track the list of open items which shall be discussed on weekly meetings.

10 SCHEDULE REQUIREMENTS

Both scopes, Thermal Performance and DVR model shall be developed and implemented in parallel. Overall Schedule Requirements for project tasks and deliverables (milestone dates) are following:

Project Phase #	Description	Milestone
Phase 1a, 1b Base PEPSE Model Development and DVR Model development	Date of contract approval	T0
	Contractor will provide the data list for PEPSE and DVR model development considering thermal kit and real measured data	T0 + 1 week
	NEK will provide required data	T0 + 3 weeks
	Contractor will provide basic training for usage of PEPSE and DVR model-software (via MS Teams)	T0 + 5 weeks
	Contractor will develop PEPSE and DVR model & submit it (including associated documentation and instrumentation uncertainty analysis) to NEK for review	T0 + 7 weeks
	NEK will review model and documentation and provide comments	T0 + 9 weeks
	Contractor will resolve NEK comments and submit final PEPSE and DVR model and associated documentation to NEK	T0 + 10 weeks
Phase 2a, 2b On-line Thermal Performance and DVR Application Development	Contractor will develop On-line thermal performance and DVR application & submit it (including associated documentation) to NEK for review	T0 + 13 weeks
	NEK will review on-line application(s) and associated documentation and provide comments to contractor	T0 + 14 weeks
	Contractor will resolve NEK comments and submit On-line application(s) and associated documentation to NEK	T0 + 15 weeks
Phase 3a, 3b Inclusion of DVR in the TP Application	Contractor will include DVR into TP application & submit it (including associated documentation) to NEK for review	T0 + 18 weeks
	NEK will review of application and documentation and provide comments to contractor	T0 + 19 weeks
	Contractor will resolve NEK comments and submit TP application with DVR included and associated documentation to NEK	T0 + 20 weeks
Phase 4a, 4b Site Acceptance Test (SAT) and Training	TP and DVR application will be Installed on Plant Computer and contractor will develop SAT procedures	T0 + 21 weeks
	NEK will review SAT procedures and submit comments to contractor	T0 + 23 weeks

Project Phase #	Description	Milestone
	Contractor will resolve comments on SAT procedure and SAT will be performed by contractor and NEK	T0 + 24 weeks
	Final SAT and all associated documentation will be sent to NEK	T0 + 25 weeks
	Contractor will perform training for NEK Personnel	T0 + 26 weeks
Phase 5b Additional instrumentation for DVR model – if required	Contractor shall identify additional measurement locations and/or improvements of the existing measurements	T0 + 27 weeks
	NEK shall review and approve new measurements	T0 + 29 weeks
	Contractor shall prepare engineering and procurement specifications for the new measurements	T0 + 30 weeks

11 STATUS REPORTING REQUIREMENTS

Status reporting shall be provided on weekly meetings – see chapter 9.

12 WORK TO BE PERFORMED OR INFORMATION TO BE PROVIDED BY NEK

NEK will supply the Contractor with the inputs that the Contractor may require for the Scope of Work. Note that some of the documents may only be available at the NEK site due to proprietary requirements.

13 CHANGES OF WORK SCOPE

The Contractor shall identify any scope changes that could impact the Contractor's cost or schedule of the project by the issuance of a Contractor Change of Work Scope Request. The Contractor shall not proceed with a change in the scope of the Work until written approval has been authorized by NEK. It is the Contractor's obligation to notify the NEK Responsible Commercial Person in writing of the noted scope change and it is the responsibility of the NEK Responsible Commercial Person to attempt to respond within 15 working days of the acceptability of the Contractor's scope change request. Unauthorized Work will not be reimbursed by NEK.

14 DELIVERABLES TO BE PROVIDED BY THE CONTRACTOR

The contractor shall prepare and hand over the following deliverables:

Project Phase #	Deliverable	Format
Phase 1a, 1b	Preliminary PEPSE and DVR model and associated documentation	PEPSE software, TP application and DVR software, MS Word, MS Excel, MS Access, Adobe, PDF, MS Power point etc., as applicable
Base PEPSE Model Development and DVR model Development	Final PEPSE and DVR model and associated documentation	
Phase 2a, 2b	Preliminary On-line TP and DVR application with associated documentation	
On-line Thermal Performance and DVR Application Development	Final On-line TP and DVR application with associated documentation	
Phase 3a, 3b	Preliminary TP application with DVR included and associated documentation	
Inclusion of DVR in the TP Application	Final TP application with DVR included and associated documentation	
Phase 4a, 4b	TP and DVR application installation on Plant Computer and preliminary SAT procedures	
Site Acceptance Test (SAT) and Training	Final SAT Documentation	
	Training materials	
Phase 5b	Engineering design documents including: <ul style="list-style-type: none"> • Instrumentation location markups on NEK P&ID and isometric drawings • Instruments procurement specifications • Recommended vendors • Installation requirements Any other design and installation requirements so that instruments meet uncertainty goals for the DVR model	
Additional instrumentation for DVR model – if required		

15 RECORDS

Contractor shall maintain records related to the subject design engineering services in accordance with own record management procedures. Contractor's records related to the subject design engineering services are subject to NEK audit and review without limitations related to the scope or time when the audit is performed.

Contractor shall keep records of all project correspondence (memo, fax, e-mail) that has been created in correspondence with NEK and with other project partners. No matter if according to the Contractor's record management procedures above described correspondence is subject to be filed as record or not, during the project implementation above described correspondence should be processed and kept as a record.

16 ORGANIZATIONAL CONTACT

Contractor shall co-ordinate all technical and scheduling matters with the assigned NEK project manager and responsible engineer.

NEK project manager – Thermal performance software:

Robi Jalovec

Phone: ++ 386 7 4802 529

E-mail: robi.jalovec@nek.si

NEK project manager – DVR software:

Gordan Janković

Phone: ++ 386 7 4802 523

E-mail: gordan.jankovic@nek.si

The Contractor shall coordinate all technical and schedule matters with the NEK project managers. Commercial items are to be addressed with the NEK Commercial Department representative. The representative will be defined during the bidding process.

17 CONTRACTOR TECHNICAL APPROACH TO THE WORK

The bid shall contain the Contractor's interpretation of the scope of work. The bid shall also contain references to similar work performed by the Contractor in the NPP thermal performance optimization field.

18 ACCESS TO CONTRACTOR FACILITY AND DOCUMENTS

For the purpose of reviewing the quality and the amount of the work being performed, a Contractor will provide access to Contractor's or to its Authorized Sub-contractor's working process to NEK. A Contractor will introduce to NEK Contractor's/Sub-contractor's personnel assigned to contracted work.

19 SUBCONTRACTED WORK

The Contractor can subcontract any portion of the work to qualified subcontractors. The work cannot be subcontracted without the written approval of the NEK. Subcontractors will be required to be technically qualified to the satisfaction of NEK criteria.

20 QUALITY ASSURANCE REQUIREMENTS

The Contractor shall establish a Quality Assurance Program that complies with the relevant requirements of the specification QS-600 Generic Software Quality Assurance Program Requirements, rev. 1. The relevant requirements of the QS-600 are: General Requirements (req. 1.1 and 1.2), Documents for Submission (req. 5.0), Software Development Cycle (req. 6.3.8. to 6.3.11.), Instructions, Procedures, and Drawings (req. 6.5.1. to 6.5.5.), Configuration Management (req. 6.7.2. to 6.7.4.), Software Error Management (req. 6.10) and Quality Assurance Records (req. 6.11.1 and 6.11.2).

One (1) copy of the Contractor's QA program manual shall be submitted to NEK with the Bid, if not previously submitted to NEK.

21 NEK PROPRIETARY DATA

NEK has a proprietary interest in all the drawings, designs, specifications, documents, information or know-how that may be furnished pursuant contract execution. Also, NEK has a proprietary interest in any know-how, improvement, discovery, or invention that may be made, developed, or conceived in the performance of the scope of work under this specification. All such information shall be considered proprietary to the NEK. The right to use all such Information shall be transmitted to the Contractor only for its personnel use and shall be entirely restricted to the performance of the Contract and subject to the confidentiality provision.

22 ATTACHMENTS

Not applicable.