

Pridobivanje dovoljenj za zamenjavo uparjalnikov in povečanje moči JE Krško

Integrated Licensing of the Steam Generators' Replacement and Upgrading at the Krško Nuclear Power Plant

Jože Špiler - Tadej Plestenjak

Namen prispevka je predstaviti poglobitve značilnosti postopka pridobivanja dovoljenj za posege, ki potekajo zadnja tri leta in vplivajo na jedrsko varnost. Sedanja slovenska zakonodaja temelji predvsem na zakonih in pravilnikih, ki jih je v osemdesetih letih izdala nekdanja Jugoslavija in ki so po osamosvojitvi leta 1991 ostali veljavni v Republiki Sloveniji. V prispevku je pregled zakonov in pravilnikov, ki zadevajo postopke pridobivanja dovoljenj za JE Krško. Celoten postopek pridobivanja dovoljenj za projekt zamenjave uparjalnikov in povečanje moči lahko razdelimo na dve skupini:

- postopki pridobivanja dovoljenj za posege, ki vplivajo na jedrsko varnost ter
- postopki pridobivanja dovoljenj za posege, ki ne vplivajo na jedrsko varnost.

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(Ključne besede: pridobivanje dovoljenj, specifikacije tehnične, poročila varnostna, okna obratovalna)

The aim of this paper is to outline the most important parts of the nuclear safety licensing process, which has been pursued continuously during the last three years. The present Slovenian regulatory system is essentially based on the laws and regulations which were passed in the 1980s by the former Yugoslavia and have remained in force in the Republic of Slovenia following its independence in 1991. The paper reviews the laws and regulations applicable to the licensing of Krško nuclear power plant (NPP). The integrated licensing process of the steam generators' replacement and the upgrading at Krško NPP can be divided into two groups:

- nuclear-safety-related licensing process,
- non-nuclear licensing process.

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(Keywords: licensing procedure, technical specifications, safety analysis reports, operating windows)

0 UVOD

JE Krško je ena izmed zadnjih tlačnovodnih jedrskih elektrarn v Evropi, zgrajenih po zahodni tehnologiji, ki se je odločila za zamenjavo sedanjih uparjalnikov ter dvig povečanje moči hkrati. Elektrarna ima dovoljenje za delovanje pri polni moči z največ 18% začepjenih cevi v obeh uparjalnikih. Vendar pa se je v zadnjih desetih letih pokazalo, da je vzdrževanje začepjenosti cevi znotraj navedenih omejitev drag ter tudi časovno potraten postopek. Zaradi tega se je JEK odločila za zamenjavo sedanjih uparjalnikov. Novi, tehnično izboljšani uparjalniki, omogočajo dvig povečanje moči za 6,3%: od 1882 MW_t do 2000 MW_t. Najpomembnejši parametri sistema NSSS (jedrski uparjalni sistem) pred povečanjem in po povečanju moči so prikazani v preglednici 1.

0 INTRODUCTION

Krško NPP is one of the last European pressurized-water reactor NPPs of western design that has decided to replace the existing SGs and perform the power upgrading at the same time. Currently, the plant is licensed to operate at nominal power with up to 18% of the tubes plugged in both steam generators. However, maintaining the plugging level below this limit during the last ten years has proved to be a very expensive and time-consuming process. As a result, it was decided to replace the present steam generators. Better performance of the new steam generators enables an increase in the plant's nominal power of 6.3%: from 1882 MW_t to 2000 MW_t. The most important parameters of the NSSS, before and after the power upgrading are summarized in Table 1.

Projektne izračuni ter varnostne analize, ki so bile izvedene, dokazujejo da:

- so novi uparjalniki združljivi s sedanjo opremo elektrarne in
- da elektrarna lahko varno deluje pri večji moči z enakovrednimi delovnimi ter varnostnimi omejitvami.

Omenjene analize prav tako razpoznavajo vse potrebne spremembe v elektrarni in/ali delovne omejitve, ki bi se lahko pokazale pri delovanju na večji moči. Analize so zbrane v obsežnem paketu poročil, ki je bil uporabljen kot temelj za spremembo licenčne dokumentacije; ta je bila posredovana URSJV (Upravi za jedrsko varnost R Slovenije) z namenom, da bi pridobili obratovalno dovoljenje elektrarne z novimi uparjalniki ter pri večji moči.

Namen prispevka je predstaviti poglobljene značilnosti postopka pridobivanja dovoljenj za posege, ki potekajo zadnja tri leta in vplivajo na jedrsko varnost. Glede na posebnost zamenjave uparjalnikov in povečanja moči, je opisan upravni

Appropriate design and safety analyses were performed to demonstrate that:

- the new steam generators are compatible with the existing plant,
- that the plant can safely operate at higher power with adequate operating and safety margins.

These analyses also identified all the required modifications of the plant and/or operating limitations that might be imposed at uprated power conditions. They are documented in a comprehensive set of reports which were used as the basis for the changes in the licensing documentation and were submitted to the SNSA in order to obtain an operational permit for the plant with the new steam generators and uprated power.

The aim of this paper is to outline the most important parts of the nuclear safety licensing process, which has been pursued continuously during the last three years. The regulatory framework and practice for nuclear-safety-related objects in Slovenia

Preglednica 1. Obratovalni parametri NSSS pri večji moči in po zamenjavi uparjalnikov

Table 1. NSSS operating parameters related to the power uprating and SGs' replacement

Parametri Parameters	Parametri 16. gorivnega obdobja Original Design Cycle 16	Parametri 17. gorivnega obdobja (po zamenjavi SG ter povečanju moči) SGs' Replacement and Power Uprating Cycle 17
Skupna moč NSSS v MW _t	1882	2000
NSSS Total Power in MW _t		
Reaktorska moč v MW _t	1876	1994
Reactor Power in MW _t		
Pretok za toplotni projekt sredice v m ³ /s	12,011	12,013
Thermal Design Flow in m ³ /s		
Tlak reaktorskega hladila v MPa	15,5	15,5
Reactor-Coolant Pressure in MPa		
Temperatura reaktorskega hladila v °C		
Reactor-Coolant Temperature in °C		
Temp. na ničelni moči v °C	291,7	291,7
Zero-Load Temperature in °C		
Temp. izstopa iz sredice v °C	325,9	327,4
Core Outlet Temperature in °C		
Temp. izstopa iz posode v °C	324,3	325,1
Vessel Outlet Temperature in °C		
Povprečna temp. sredice v °C	307,8	308,1
Core Average Temperature in °C		
Povprečna temp. posode v °C	305,9	305,7
Vessel Average Temperature in °C		
Temp. vstopa v posodo/sredico v °C	287,5	286,2
Vessel/Core Inlet Temperature in °C		
Temperatura pare v °C	279,2	279,3
Steam Temperature in °C		
Tlak pare v MPa	6,34	6,48
Steam Pressure in MPa		
Pretok pare v t/s	1,029	1,0896
Steam Flow in t/s		
Temperatura napajalne vode v °C	221,1	219,4
Feedwater Temperature in °C		
Skupna električna moč v MW _e	664,4	706,8
Gross Electrical Output in MW _e		

okvir in praksa v Sloveniji pri objektih, ki so pomembni za jedrsko varnost.

1 PREGLED ZAKONODAJE PRIDOBIVANJA DOVOLJENJ ZA POSEGE, KI VPLIVAJO NA JEDRSKO VARNOST

Sedanja slovenska zakonodaja temelji predvsem na zakonih in pravilnikih, ki jih je v osemdesetih letih izdala nekdanja Jugoslavija in ki so po osamosvojitvi leta 1991 ostali veljavni v Republiki Sloveniji. Naslednji zakoni in pravilniki so uporabljeni pri procesu pridobivanja dovoljenj za delovanje, izvajanje projektnih sprememb in zato tudi sprememb SAR:

1. *Zakon o varstvu pred ionizirajočimi sevanji in o posebnih varnostnih ukrepih pri uporabi jedrske energije (Uradni list SFRJ 62/84)*

Zakon zahteva izdelavo preliminarne varnostnega poročila SAR za pridobitev gradbenega dovoljenja objekta ter izdelavo končnega SAR za pridobitev obratovalnega dovoljenja. Omenjeni zakon podaja temeljna načela varnega obratovanja jedrskih elektrarn. Med drugim zakon opredeljuje uporabo domače zakonodaje ter tehničnih standardov. V primeru, da domača zakonodaja ni sprejeta, se sme uporabiti tudi zakonodaja ter tehnični standardi države, od koder izvirajo, če so potrjeni od domačega upravnega organa (URSJV).

2. *Pravilnik o izdelavi in vsebini varnostnega poročila in druge dokumentacije, potrebne za ugotavljanje varnosti jedrskih objektov (Uradni list SFRJ 68/88)*

Pravilnik podaja razlago vsebine SAR kot osnovne dokumentacije, potrebne za ugotavljanje varnosti jedrskega objekta. Varnostno poročilo mora biti med obratovanjem dopolnjevano s podatki in analizami o vseh spremembah, ki so nastale na jedrskem objektu. Pravilnik načrtuje tri kategorije sprememb in dopolnitev končnega SAR. Prva kategorija predvideva obveščanje URSJV o izvedenih spremembah po njihovi izvedbi. Druga kategorija sprememb predvideva obveščanje URSJV pred njihovo izvedbo. V tretjo kategorijo pa spadajo spremembe, za katere je treba pri URSJV vložiti prošnjo za dovoljenje za izvedbo. Natančnejši kriteriji ter navodila glede kategorizacije sprememb v elektrarni in SAR sprememb pa niso podani.

3. *Pravilnik o pogojih za lokacijo, graditev, poskusno obratovanje, zagon in uporabo jedrskih objektov (Uradni list SFRJ 52/88)*

Pravilnik zahteva, da mora med obratovanjem jedrskega objekta njegov uporabnik stalno spremljati in analizirati stanje varnosti jedrskega objekta, pri čemer mora upoštevati izkušnje drugih jedrskih objektov in tehnološkega razvoja. Pravilnik med drugim zahteva, da je pri izvedbah sprememb tehničnih specifikacij TS, obvezna izdelava

are outlined, followed by the specifics of the steam generator replacement and the plant's uprating.

1 LEGISLATION FRAMEWORK FOR NUCLEAR SAFETY LICENSING

The present Slovenian regulatory system is essentially based on the laws and regulations which were issued in the 1980s by the former Yugoslavia and have remained in force in the Republic of Slovenia following its independence in 1991. The following laws and regulations are applicable to the licensing of the NPP's operation, modifications of its design and consequently the changes of the SAR:

1. *The law on Radiation Protection and the Safe Use of Nuclear Energy (Off. Gaz. SFRJ, 62/84)*

The law requires submission and acceptance of the Preliminary SAR before the construction permit is issued and submission and acceptance of the final SAR to obtain an operating permit. The law provides the general framework for the safe operation of nuclear power plants. Among other points, it states that national regulations and technical standards shall be applied and, when not available, the regulations and technical standards of the country of origin can be applied, if approved by the domestic regulatory organization (SNSA).

2. *Regulation on Safety Analysis Reports (Off. Gaz. SFRJ, 68/88)*

This regulation defines the SAR as the basic licensing document for nuclear installation with respect to nuclear safety. The SAR shall be continually supplemented to appropriately address all changes which have been implemented in the nuclear power plant. Three categories of plant changes, resulting in changes to the final SAR, are established. The first category allows immediate implementation of the change, followed by notification to the SNSA. The second category requires a notification to the SNSA before the implementation of the change. The third category requires an approval by the SNSA before the change is implemented. However, detailed criteria or guidance about the categorization of plant and SAR changes are not given.

3. *Regulation on Siting and Construction and Operation of Nuclear Facilities (Off. Gaz. SFRJ, 52/88)*

This regulation requires that the licensee continuously monitors and analyzes the level of nuclear safety, with the experience of other nuclear facilities and new technological developments to be taken into account. This regulation requires, among other things, a mandatory independent third-party evaluation of the proposed changes to the TS. The TS is the most important chapter

neodvisnega vrednotenja pooblaščen organizacije. TS so najpomembnejši del SAR, saj definirajo dovoljena območja vseh parametrov, pomembnih za varnost elektrarne. Neodvisno vrednotenje lahko izvede organizacija, ki je pooblaščen od URSJV. Za organizacijo izvedbe neodvisnega vrednotenja je skladno z dogovorom z URSJV hkrati odgovoren upravljalec jedrskega objekta.

2 POSTOPKI PRIDOBIVANJA DOVOLJENJ ZA POSEGE, KI VPLIVAJO NA JEDRSKO VARNOST TER NJHOVO IZVAJANJE V SLOVENIJI

Podrobnejša navodila glede postopkov pridobivanja dovoljenj za izvajanje sprememb SAR ter sprememb na jedrskem objektu (npr. glede kriterija razvrstitve, vsebine dokumentacije, neodvisnega pregleda) še niso izdelane niti pri upravnem organu niti pri upravljalcu. Zaradi tega postopki pridobivanja dovoljenj v NEK temeljijo na prej omenjeni zakonodaji, hkrati pa so skladni z zakonodajo države prodajalca (ZDA, npr. 10 CFR 50.59), JEK pa o vseh projektnih spremembah obvešča tudi URSJV. Takšen postopek je v skladu z Zakonom o varstvu pred ionizirajočimi sevanji in o posebnih ukrepih pri uporabi jedrske energije, v praksi pa se kaže v dnevnem sporočanju med URSJV ter JE Krško. V nadaljevanju je opisan pomembnejši del običajnega postopka.

Tehnične specifikacije določajo, da je elektrarna dolžna podati poročilo URSJV o načrtovanih spremembah, testih in poskusih vsaj 45 dni pred njihovo izvedbo.

JEK podaja URSJV v odobritev vsako načrtovano spremembo Tehničnih specifikacij. Elektrarna je prav tako dolžna sporočiti neodvisno strokovno oceno spremembe, ki jo izdelajo neodvisne organizacije. Neodvisne organizacije so pooblaščen od URSJV. Tako je v odobritveni postopek URSJV vedno vključena tretja, neodvisna oseba.

Pooblaščen neodvisne strokovne organizacije imajo izdelane QA postopke zagotovitve kakovosti za izdelavo strokovnih ocen za področja, za katera so pooblaščen. Preglede postopkov QA opravita skupaj URSJV ter JEK približno vsaki dve leti.

Podane načrtovane spremembe, ki imajo vpliv na SAR, so vedno podprte z varnostnim vrednotenjem, ki ga izdela osebje JEK. Če URSJV izrazi zahtevo, pa ji JEK sporoča tudi varnostno presojanje sprememb, ki kažejo, da ni vpliva na SAR. Omeniti je treba, da so varnostna vrednotenja načrtovanih sprememb namenjena predvsem ocenitvi možnega vpliva na varnost. Preden se načrtovana sprememba izvede ali pa poda v pregled URSJV, mora biti varnostno vrednotenje potrjeno od KOC (komisija, sestavljena iz osebja - strokovnjakov JE Krško) ter KSC (komisija zunanjih strokovnih sodelavcev).

of the SAR and defines the allowable range of all the parameters which are important for the safe operation of the plant. The independent evaluation shall be performed by organizations authorized by the SNSA. The arrangements to perform this independent evaluation are an implicit responsibility of the licensee, which is in practice accomplished in an agreement with the SNSA.

2 THE NUCLEAR SAFETY LICENSING PROCESS AND PRACTICE IN SLOVENIA

Detailed requirements or guidance for the licensing process involving modifications to the SAR and the plant are presently not established in either the Slovene regulations or in the operating license. Such guidance could, for example, include criteria to categorize the SAR changes and plant modifications, the content of the application document and the content of the independent third-party review. Krško NPP is currently using the criteria and guidance established in the relevant legislation of the vendor country (USA, Code of Federal Regulations 10 CFR 50.59) and notifies the SNSA about all design modifications. Such an approach is consistent with the applicable Law on Radiation Protection and the Safe Use of Nuclear Energy and resulted in practices established in daily communication between the SNSA and Krško NPP. The most important practices are described below.

The Technical specifications require that a report on planned modifications, tests and experiments on the plant is to be submitted 45 days before the license is expected to be issued by the SNSA.

Further, Krško NPP submits for approval every proposed change to the plant's Technical Specifications. Every submission is supported by independent expert opinion, prepared by the so-called Technical Support Organization (TSO). TSOs are authorized by the SNSA. The decision making process within the SNSA is therefore always supported by an independent third-party assessment.

All TSOs have developed QA procedures for quality assurance for their area of expertise for which they are authorized. Joint (SNSA and Krško NPP) QA audits are carried out approximately every two years.

Submittals of proposed plant changes, which have an impact on the SAR, are also always accompanied by the safety evaluations prepared by the staff of Krško NPP. On request, Krško NPP also submits to the SNSA the safety evaluations of plant changes, which have no impact on the SAR. It should be mentioned here that the safety evaluations are aimed primarily at the assessment of potential safety consequences of the proposed modification. Before the proposed modification is implemented or submitted for approval to the SNSA, the safety evaluation has to be approved by the KOC (board of experts from the Krško NPP personnel) and the KSC (board of external experts).

V vseh primerih, ko se podaja načrtovana sprememba URSJV, se uporablja formalni postopek, predpisan z *Zakonom o splošnem upravnem postopku*. Še posebno je postopek primeren v primerih:

- pomembnejših sprememb,
- ko varnostno vrednotenje pokaže nerešeno varnostno vprašanje,
- sprememb v organizacijski strukturi (organizacijska shema, definicije odgovornosti, medsebojno sporočanje itn.),
- spremembah TS,
- spremembah pomembnejših programov ter postopkov (npr. program nadzora med uporabo (ISI), program požarne zaščite, program radiološkega nadzora itn.), ki so omenjeni v SAR, ne pomenijo pa pomembnejšega dela tega poročila.

Na koncu lahko navedemo opis tipične dokumentacije, posredovane URSJV za odobritev vloge za spremembo SAR:

- predlagano spremembo SAR (izdela jo JE Krško ali pogodbeni izvajalci),
- varnostno ovrednotenje (izdela ga JE Krško),
- varnostno analizo ali poročilo o upravičenosti (če je to treba, izdela jo JE Krško ali pogodbeni izvajalci),
- tehnično delovno poročilo (izdela ga JE Krško ali pogodbeni izvajalci),
- pozitivno neodvisno strokovno mnenje o spremembi, ki ga pripravi neodvisna pooblaščen strokovna organizacija - TSO.

Sam postopek pregleda upravnega organa ter varnostno vrednotenje uradno steče po dostavi potrebne dokumentacije URSJV. Med upravnim postopkom se opravi vsaj eno zaslišanje stranke, pri katerem sta navzoči obe strani, zastopniki elektrarne ter URSJV, in na katerem se po potrebi rešujejo odprta vprašanja. Postopek se konča s formalno odločitvijo URSJV o spremembah SAR in drugih obratovalnih razmerah.

Na koncu postopka pridobivanja dovoljenj izda URSJV odločbo.

3 PRIDOBIVANJE DOVOLJENJ ZA PROJEKT ZAMENJAVE UPARJALNIKOV IN POVEČANJE MOČI JE KRŠKO

Celoten postopek pridobivanja dovoljenj lahko razdelimo na dve skupini:

- postopki pridobivanja dovoljenj za posege, ki vplivajo na jedrsko varnost ter
- postopki pridobivanja dovoljenj za posege, ki ne vplivajo na jedrsko varnost.

Obe skupini postopkov sta na kratko predstavljeni v nadaljevanju.

3.1 Postopki pridobivanja dovoljenj za posege, ki vplivajo na jedrsko varnost

In all cases involving the submission of a modification to the SNSA, the formal administrative procedures prescribed in the *Law on Administrative Procedure* are followed. This is particularly necessary in the following cases:

- major modifications,
- when a safety assessment shows the elements of an unreviewed safety question,
- changes in the organizational structure of the plant (organizational chart, definition of responsibilities, communication lines, etc.),
- changes to the TS,
- changes of important programs and procedures (for example, the in-service inspection (ISI) Program, the Fire Protection Program, the Radiation Monitoring Program, etc.) which are referred to in the SAR, but are not a constitutive part of the SAR.

Let us summarize the above discussion with a description of typical documentation submitted to the SNSA to approve a change in the SAR:

- proposed change to the SAR (prepared by Krško NPP or its contractors),
- safety evaluation (prepared by Krško NPP),
- safety analysis or safety analysis justification report (if necessary, prepared by Krško NPP or its contractors),
- technical report packages (prepared by Krško NPP or its contractors),
- positive independent expert opinion about the proposed change prepared by an independent reviewer - TSO.

After the documentation package is submitted, the process of regulatory review, safety evaluation and decision making is officially started by the SNSA. During this process, at least one hearing takes place to give Krško NPP and the SNSA an opportunity to consider and discuss the application and open issues, if any. The process formally concludes with the SNSA's formal decision about the proposed change to the SAR and other licensing conditions.

At the end of licensing process, the SNSA issues the Licensing Amendment.

3 INTEGRATED LICENSING OF THE STEAM GENERATORS' REPLACEMENT AND UPDATING AT THE KRŠKO NPP

The whole licensing process can be divided into two groups:

- nuclear-safety-related licensing process,
- non-nuclear licensing process.

Both are discussed in some detail below.

3.1 Nuclear-safety-related licensing process

The manpower involved in the preparation of the steam generator replacement and power uprating AT Krško NPP exceeded 80 man-years. Therefore, the SNSA suggested that the licensing

Celotna priprava zamenjave uparjalnikov in dviga povečanja moči je zahtevala prek 80 človeških let. Zaradi tega je URSJV predlagala, da se postopek pridobivanja dovoljenj razdeli na naslednje vzporedne prostopke pridobivanja dovoljenj:

- projektiranje, izdelava in testiranje uparjalnikov JE Krško,
- analize ob zamenjavi uparjalnikov in analize za povečanje moči,
- skladiščenje starih uparjalnikov in radioaktivnih odpadkov, nastalih zaradi zamenjave.

JEK je tako na predlog URSJV dne 31. julija 1997 podala vlogo za projektiranje in izdelavo uparjalnikov JE Krško in dne 8. septembra 1997 še vlogo za vgradnjo novih uparjalnikov ter varnostne analize za povečanje moči ob zamenjavi uparjalnikov. Postopek pridobivanja dovoljenj stavbe za skladiščenje starih uparjalnikov in radioaktivnih odpadkov, nastalih zaradi zamenjave pa je že končan.

Projektiranje, izdelava in testiranje uparjalnikov JE Krško

Dela projektiranja, izdelave in zamenjave uparjalnikov JE Krško so zaupana konzorciju Siemens-Framatome in se izvajajo v skladu s standardom ASME vrelnih in tlačnih posod. Kot neodvisni ocenjevalci so pri nadzoru, zagotovitvi kakovosti in nadzoru kakovosti sodelovale naslednje pooblašene organizacije iz Ljubljane:

- Fakulteta za strojništvo,
- Inštitut za varilstvo,
- Inštitut za metalne konstrukcije,
- Inštitut za kovinske materiale in tehnologije.

Njihova opažanja potrjujejo visoko tehnološko raven in kakovost novih uparjalnikov. Ugotovitve so zbrane v strokovnih ocenah, ki jih izdela vsaka izmed pooblaščenih organizacij. Strokovne ocene se skupaj z dokumentacijo projektanta oziroma izvajalca del konzorcija Siemens-Framatome podajo URSJV v odobritev.

Analize ob zamenjavi uparjalnikov JE Krško in analize za povečanje moči

Leta 1991 je bila izvedena študija izvedljivosti povečanja moči WENX 91-42. Omenjena študija je pokazala, da je mogoče **povečanje moči za 6,3%** (do 2000 MW) brez izvedbe pomembnejših posegov. Sama zamenjava uparjalnikov ter povečanje moči elektrarne je tako podprto z ugotovitvami več analiz.

Rezultati analiz dokazujejo zmožnost delovanja elektrarne v danem **delovnem oknu** ter zmožnost varnega delovanja z novimi uparjalniki pri večji moči. Osnutek delovnega okna zagotavlja večjo prožnost delovanja elektrarne kakor pa sedanja licencirana delovna točka (npr. ni treba izvajati

process should be systematic and divided into the following parallel licensing processes:

- design, manufacturing and testing of the Krško NPP steam generators,
- steam-generator replacement and power uprating safety analyses,
- storage of old steam generators and radioactive waste as a result of the replacement.

Following the above suggestion of the SNSA, the Krško NPP filed the application for the commencement of the licensing process for the steam generators' design, manufacture and testing on July 31, 1997. This was followed by the application for the commencement of the licensing process for the replacement of both steam generators and power uprating safety analyses on September 8, 1997. The licensing process for the storage of the old steam generators and the radioactive waste resulting from the replacement has been completed.

Design, manufacture and testing of the new steam generators

The design, manufacture and testing of the new steam generators was performed by the consortium Siemens-Framatome in accordance with the ASME Boiler and Pressure Vessel Code. The TSOs from Ljubljana listed below were involved as independent reviewers supervision, quality assurance and quality control of the manufacturing process:

- The Faculty of Mechanical Engineering,
- The Welding Institute,
- The Institute for Metal Structures,
- The Institute of Metals and Technology.

Their findings support the high technological level and the quality of the new steam generators. As documented in independent evaluation reports issued independently by each TSO, they were submitted to the SNSA for approval together with a comprehensive set of documentation prepared by the designer and manufacturer - consortium Siemens-Framatome.

Steam generator replacement and power-uprating safety analyses

The plant uprating feasibility study WENX 91-42 was performed in 1991. The main conclusion of this study was that a **power increase of 6,3%** (to 2000 MW) is feasible without major modifications to the plant. The steam generator replacement and power uprating are now supported by a substantial set of adequate analyses.

The analyses verified the plant's maneuverability for a selected **operating window** and safe operation with a new steam generators at an uprated nominal power. The concept of the operating window provides more flexibility in the plant operation than the currently licensed operating point (e.g., no

dodatnih analiz po čepljenju cevi uparjalnika, če niso prekoračene omejitve delovnega okna). Izvajanje analiz z odobritvijo delovnega okna zagovarja tudi praksa v Evropi.

Drugi del analiz pa obravnava in potrjuje **osnutek LBB** za cevovode reaktorskega hladilnega sistema. Osnutek LBB dovoljuje, da se dinamične obremenitve, ki so posledica velikega zloma, pri izračunih ne upoštevajo. Uporaba osnutka LBB seveda temelji na analizah, ki kažejo, da je trdnost materiala cevovodov reaktorskega hladilnega sistema na taki stopnji, da se opazi puščanje skozi poškodbo pred zlomom cevovoda. Ena izmed mogočih prednosti takega postopka je tudi odstranitev za vzdrževanje zapletene cevne opreme (npr. cevne podpore).

Izvajalec vseh omenjenih analiz je Westinghouse Electric Systems Europe, ki je podružnica projektanta JE Krško s sedežem v Bruslju. Vse analize so zajete v delovnih poročilih (eno poročilo za posamezno analizo), zbirni oceni (zbirka vseh izvedenih analiz) in spremenjenem SAR vključno z spremenjenimi TS. Vsa ta dokumentacija je tudi poslana URSJV v odobritev.

Vsako delovno poročilo je bilo hkrati pregledano od JE Krško, pooblaščenih organizacij ter URSJV. Njihove ugotovitve lahko kategoriziramo kot komentarje, priporočila ter zahtevane spremembe (sl. 1). Po pregledu in/ali razrešitvi vseh komentarjev je pripravila pooblaščen organizacija neodvisno strokovno oceno, ki se je skupaj z drugo potrebno dokumentacijo poslala URSJ v odobritev. Z omenjenim postopkom (sl. 1) so se skupaj z URSJV pregledala in reševala vsa odprta vprašanja, ki zadevajo pridobivanje dovoljenj, tako da bodo za ponovni zagon elektrarne na večjo moč ter z zamenjanimi uparjalniki pridobljena vsa potrebna dovoljenja.

Naslednje pooblaščen organizacije so bile izbrane od JE Krško in z odobritvijo URSJV kot neodvisni ocenjevalci analiz, ki jih izvaja Westinghouse:

- Inštitut Jožef Stefan, Ljubljana,
- Fakulteta elektrotehnike in računalništva Zagreb,
- Fakulteta za gradbeništvo in geodezijo Ljubljana,
- Enconet, Dunaj.

Njihove ugotovitve dokazujejo primerno varnostno raven JE Krško po dvigu moči ter zamenjavi uparjalnikov.

Dodaten pregled dejavnosti zamenjave uparjalnikov ter preostalih remontih del bo izvajal ter nadzoroval URSJV ter pooblaščen organizacije v skladu z dosedanja prakso pregleda remontnih dejavnosti.

re-analysis of the plant operation is needed after plugging of some tubes in the steam generators, if the limits of the operating window are not violated) The analyses supporting the operating window were consistent with European practice.

Another part of the analyses also verified the applicability of the **LBB concept** for the reactor-coolant-loop piping. The LBB concept allows that the dynamic loads resulting from a large break in the piping is not taken into account. Application of the LBB concept is of course based on analyses showing that the material of the reactor-coolant piping is tough enough to allow for reliable detection of leaks through defects before the risk of a break takes place. One of the possible advantages of such an approach is the removal of the complex and difficult-to-maintain piping support hardware (e.g., snubbers).

All of the above analyses were performed by Westinghouse Electric Systems Europe, a Brussels-based subsidiary of the designer of the Krško NPP. All analyses are documented in Work reports (one per analysis), Summary reports (summarizing all analyses performed) and a revised SAR including a revised TS. These documents represent the documentation submitted to the SNSA for approval.

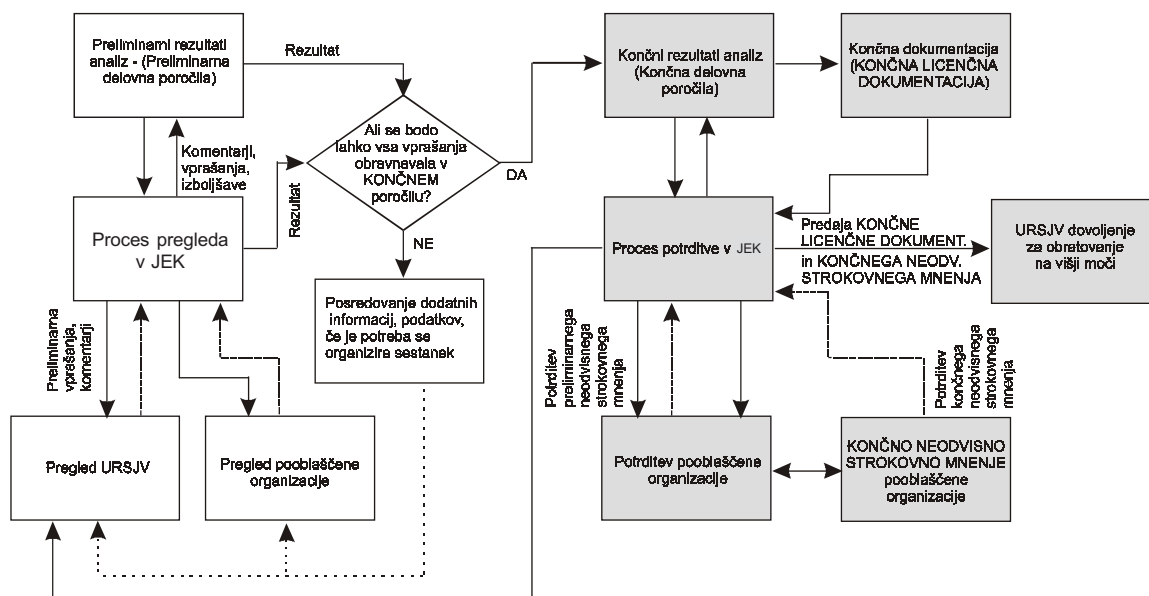
Each of the work reports was reviewed in parallel by the Krško NPP, the TSO and the SNSA, resulting in a list of comments, categorized as suggestions, recommendations and required changes (see Figure 1). After the clarification and/or resolution of all the comments, the TSO prepared Independent Evaluation Report(s), which were submitted together with other licensing documentation to the SNSA for their approval. With this approach (shown in Fig. 1) all licensing issues (questions, concerns) were addressed and resolved in due time with the SNSA and should enable the authorized restart of the plant after the power uprating and SG replacement is authorized.

The following Technical Support Organizations were selected by Krško NPP in agreement with the SNSA to act as independent reviewers for the analyses performed by Westinghouse:

- Institute Jožef Stefan, Ljubljana,
- Faculty of Electrical Engineering and Computing Department of Power Systems, Zagreb, Croatia,
- Faculty of Civil and Geodetic Engineering, Ljubljana,
- Enconet, Vienna, Austria.

Their findings support the appropriate safety level of the Krško NPP after power uprating and the SG replacement.

An additional review and evaluation will be conducted for the steam generator replacement activities and associated modifications as a regular part of the SNSA and TSO activities during each outage.



Sl. 1. Postopek pridobivanja dovoljenj varnostnih analiz za zamenjavo uparjalnikov ter povečanje moči uparjalnikov

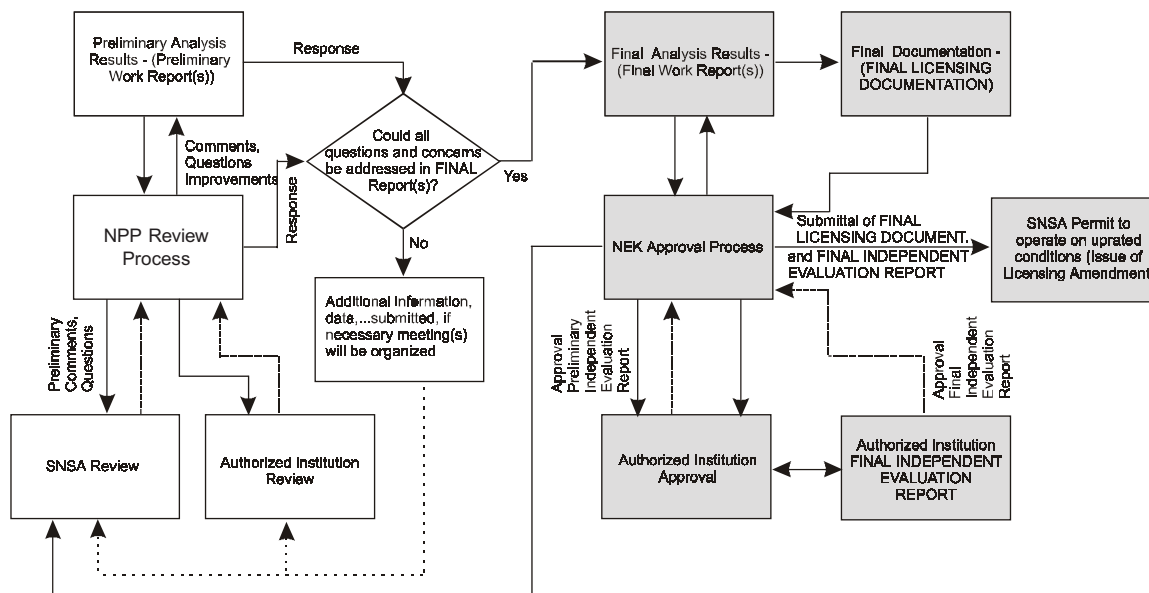


Fig. 1. Licensing process for safety analysis for the SGs' replacement and power uprating

3.2 Postopki pridobivanja dovoljenj za posege, ki ne vplivajo na jedrsko varnost

Pridobivanje dovoljenj za posege, ki ne vplivajo na jedrsko varnost, je prav tako del celotnega postopka pridobivanja dovoljenj. Sem spadajo naslednje dejavnosti v skladu z Zakonom o graditvi objektov:

- spremembe dokumentacije elektrarne, ki jih potrjuje občinska uprava,
- spremembe na transportni poti za omogočanje prevoza nadomestnih uparjalnikov,
- gradbeno dovoljenje za simulatorsko zgradbo,
- gradbeno dovoljenje poslopja za shranjevanje starih uparjalnikov,

3.2 Non-nuclear licensing process

The non-nuclear licensing process is also part of whole licensing process regarding the Krško steam-generator replacement and power uprating project. It covers the following licensing activities in accordance with Civil construction law:

- changes to site documents approved by local authorities,
- modifications of the roads to accommodate transportation of the replacement steam generators,
- building permit for the simulator building,
- building permit for old steam generators' building,

- remontna dela ter povečanje moči, ki so opredeljeni kot rekonstrukcija.

- replacement activities and power increase defined as reconstruction.

4 SKLEPI

Poglavitni namen projekta modernizacije JE Krško - analiz ter postopka pridobivanja dovoljenj je izvedba vseh potrebnih analiz, ki dokazujejo združljivost nadomestnih uparjalnikov s sistemi elektrarne ter zagotavljajo, da bodo parametri normalnega obratovanja in nevarnih stanj znotraj področja sprejemljivosti tudi po zamenjavi uparjalnikov. Hkrati pa naj bi analize pokazale tudi vse spremembe, potrebne za zadovoljitev omenjenega kriterija.

Vse analize so hkrati pregledane od JE Krško, pooblaščenih organizacij ter URSJV. Njihove ugotovitve lahko kategoriziramo kot komentarje, priporočila ter zahtevane spremembe. Po pregledu in/ali razrešitvi vseh komentarjev, pripravi pooblaščen organizacija neodvisno strokovno oceno, ki se skupaj s preostalo potrebno dokumentacijo pošlje URSJ v odobritev. Z omenjenim postopkom se skupaj z URSJV pregledujejo in rešujejo vsa odprta vprašanja, sam postopek pa je voden tako, da omogoča uspešen konec procesa pridobivanja dovoljenj.

KRATICE

JEK - Jedrska elektrarna Krško, SG - uparjalnik, NSSS - jedrski sistem za proizvodnjo pare, URSJV - Uprava Republike Slovenije za jedrsko varnost, SAR - varnostno poročilo, TS - Tehnične specifikacije, QA - zagotovitev kakovosti, KOC - Strokovni svet pogona, KSC - Varnostni komite Krško, LBB - puščanje pred zlomom.

Naslov avtorjev: Jože Špiler
Tadej Plestenjak
Nuklearna elektrarna Krško
Vrbina 12
8270 Krško, Slovenija

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4 CONCLUSIONS

The main purpose of the Krško Modernization - Analysis and Licensing project is to perform all the analyses needed to prove compatibility of the replacement SGs' with the plant systems and to prove that all normal operation and accident conditions after replacement the SGs' installation and power uprating remain within the acceptance criteria. Identification of all the changes needed to satisfy the above criteria was included.

All analysis and work was reviewed in parallel by the Krško NPP, the TSO and the SNSA, resulting in a list of comments, categorized as suggestions, recommendations and required changes. After the clarification and/or resolution of all comments, the TSO prepared Independent Evaluation Report(s), which were submitted together with other licensing documentation to the SNSA for their approval. With this approach, all licensing issues (questions, concerns) were addressed and the whole process was performed in such a way as to enable the successful completion of the licensing process.

ABBREVIATIONS

NPP - Nuclear Power Plant, SG - Steam Generator, NSSS - Nuclear Steam Supply System, SNSA - Slovene Nuclear Safety Administration, SAR - Safety Analysis Report, TS - Technical Specification, TSO - Technical Support Organization, QA - Quality Assurance, KOC - Krško Operating Committee, KSC - Krško Safety Committee, LBB - Leak before break.

Authors' Address: Jože Špiler
Tadej Plestenjak
Nuclear Power Plant Krško
Vrbina 12
8270 Krško, Slovenia

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