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INTEGRATED SURVEILLANCE SPECIMEN PROGRAM FOR WWER-1000/V-320 REACTOR PRESSURE VESSELS

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OBJECTIVES OF SURVEILLANCE PROGRAMMES

Main goal of any RPV material surveillance programme is a monitoring of RPV material properties and determination of neutron fluence on RPV wall.

Results from testing surveillance specimens serve to the assessment of degradation level of RPV properties – thus they serve as inputs for RPV integrity and lifetime.

GENERAL REQUIREMENTS

In principle, all surveillance specimen programmes should, with maximum possible reliability, to monitor changes in RPV materials properties in dependence of operation time and history.

Different types of reactors used different designs and schemes of surveillance specimen programmes but all should fulfil the requirements.

REQUIREMENTS FOR WWER

Principal requirements are given in the "Rules for design and safe operation of components and piping of nuclear power facilities, PN AE G-7-008-89, Moscow, 1990" that are pratically identical with the "Rules for design and safe operation of components of NPPs and research reactors and nuclear facilities, Moscow, 1973"

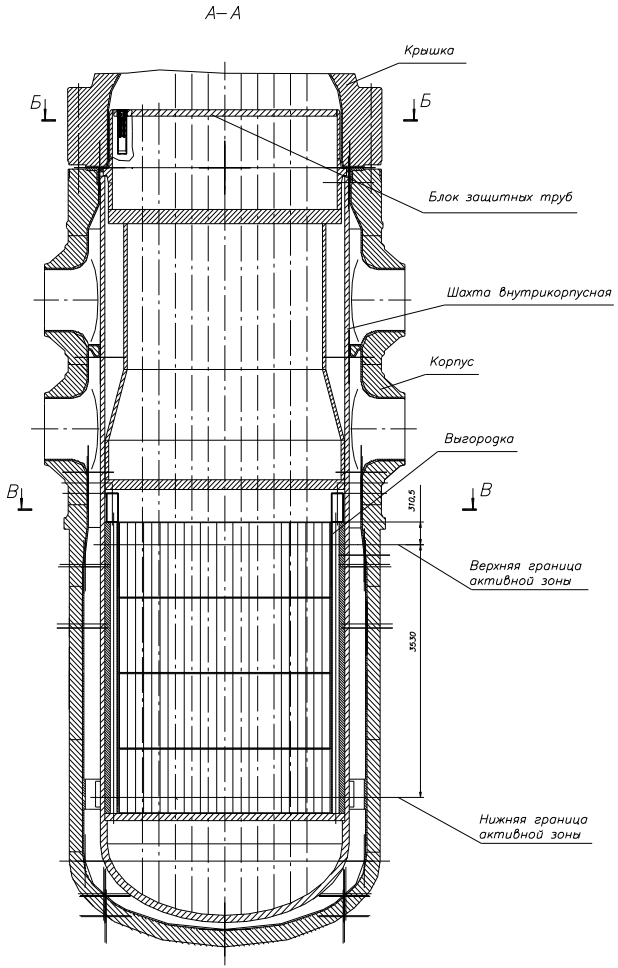
REQUIREMENTS FOR WWER

7.7.3. Surveillance specimens for monitoring changes in mechanical properties and fracture mechanics parameters should be located - in the vicinity of beltline region in front of the reactor active core…

7.7.7. In location of surveillance specimens in reactor pressure vessels and in technological channels it is required that containers with specimens contain also monitors of neutron fluence and irradiation temperature (with uncertainty no more that± 10 °C).

WWER-1000/V-320

STANDARD SURVEILLANCE PROGRAMME



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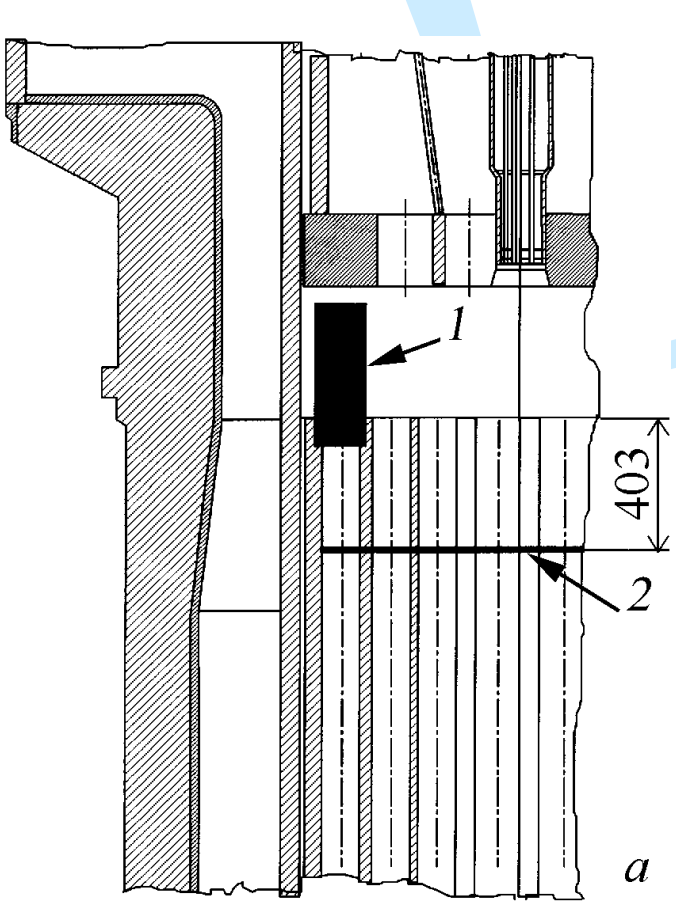
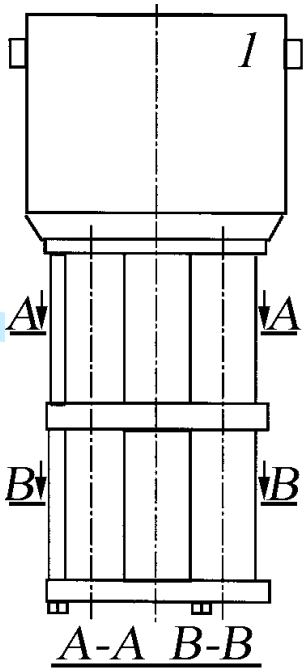
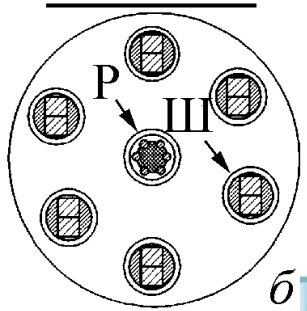
STANDARD SURVEILLANCE PROGRAMME







WWER-1000/V-320

STANDARD SURVEILLANCE PROGRAMME

DISADVANTAGES OF THE STANDARD PROGRAMME:

- **Irradiation conditions of surveillance specimens are not homogenous, thus, it is difficult to find necessary number of specimens with the same/similar fluence for the determination of transition temperature shifts**
- **Number of fluence monitors (3 sets) are not sufficient for determination of neutron fluence in assemblies and individual specimens**
- **Temperature monitoring by diamond powder monitors does not give reliable data**

WWER-1000/V-320

STANDARD SURVEILLANCE PROGRAMME

- **Lead factor for some specimens is lower than 1, thus it is not possible to use them for forecast**
- **Design of assemblies and location of specimens do not allow the orientation of specimens with respect to the reactor active core**
- **Groups of specimens are not sufficient for determination of temperature dependences of fracture toughness - K_{IC}**

WWER-1000/V-320Č

MODIFIED SURVEILLANCE PROGRAMME

SKODA NUCLEAR MACHINERY MODIFIED THE STANDARD SURVEILLANCE PROGRAMME FROM THE BEGINNING OF THE DESIGN OF THE REACTOR – IT WAS LATER APPROVED BY THE GENERAL DESIGNER – OKB GIDROPRESS

and similar design is now used by OKB Gidropress for new RPVs – China etc.

This Modified Surveillance Programme is loaded in 2 units in NPP Temelin (Czech Republic) and was prepared for 1 unit in NPP Belene (Bulgaria) – this programme is in agreement with requirements for LWR type reactors

WWER-1000/V-320Č

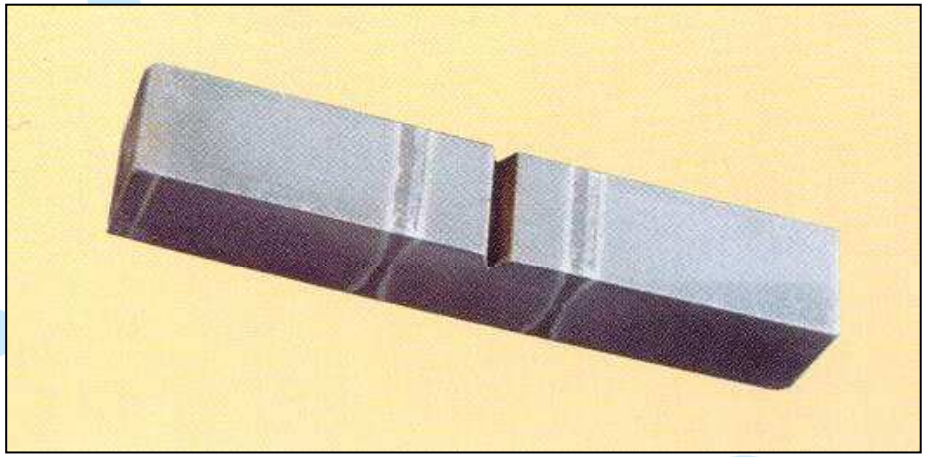
MODIFIED SURVEILLANCE PROGRAMME

- **Only archive materials are used, i.e. from RPVs in accordance with requirements of Technical Specifications – materials of beltline rings with the maximum of elements - P, Cu, As, Sb, Sn,**
- **Specimens for determination of tensile properties, notch impact properties and static and dynamic fracture toughness are in every container**

WWER-1000/V-320Č

MODIFIED SURVEILLANCE PROGRAMME
Main principles:

- „Insert“ are used instead of full ¨Charpy size specimens



- Flat containers contain all specimens for one withdrawal, thus all specimens will obtain the same fluence
- **LEAD FACTOR OF SPECIMENS IS BETWEEN 2 AND 3**

WWER-1000/V-320Č

MODIFIED SURVEILLANCE PROGRAMME

Monitors of neutron fluence are located in all containers – activated and fission (U, Np), and also wires on the cover

- Neutron fluence on outer RPV wall (in the cavity) is continously measured to determine neutron fluence and spectrum in the beltline region (in angle 30? and in the height of active core)

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MODIFIED SURVEILLANCE PROGRAMME

- Determination of neutron fluence and spectrum is correlated with the measurements in the benchmark on critical assembly in LR-0 reactor in NRI
- All containers have melting temperature monitor located in five places within the container

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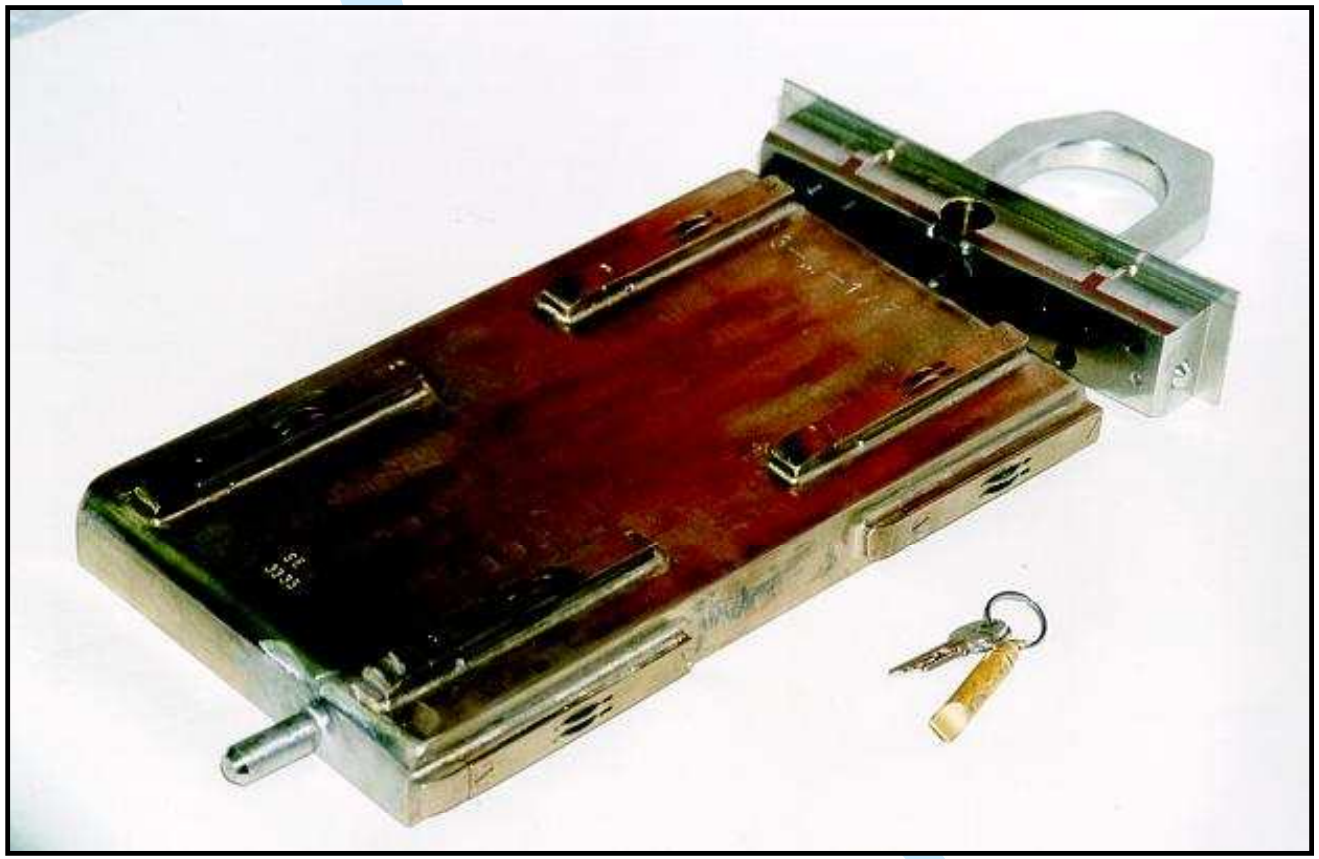
MODIFIED SURVEILLANCE PROGRAMME

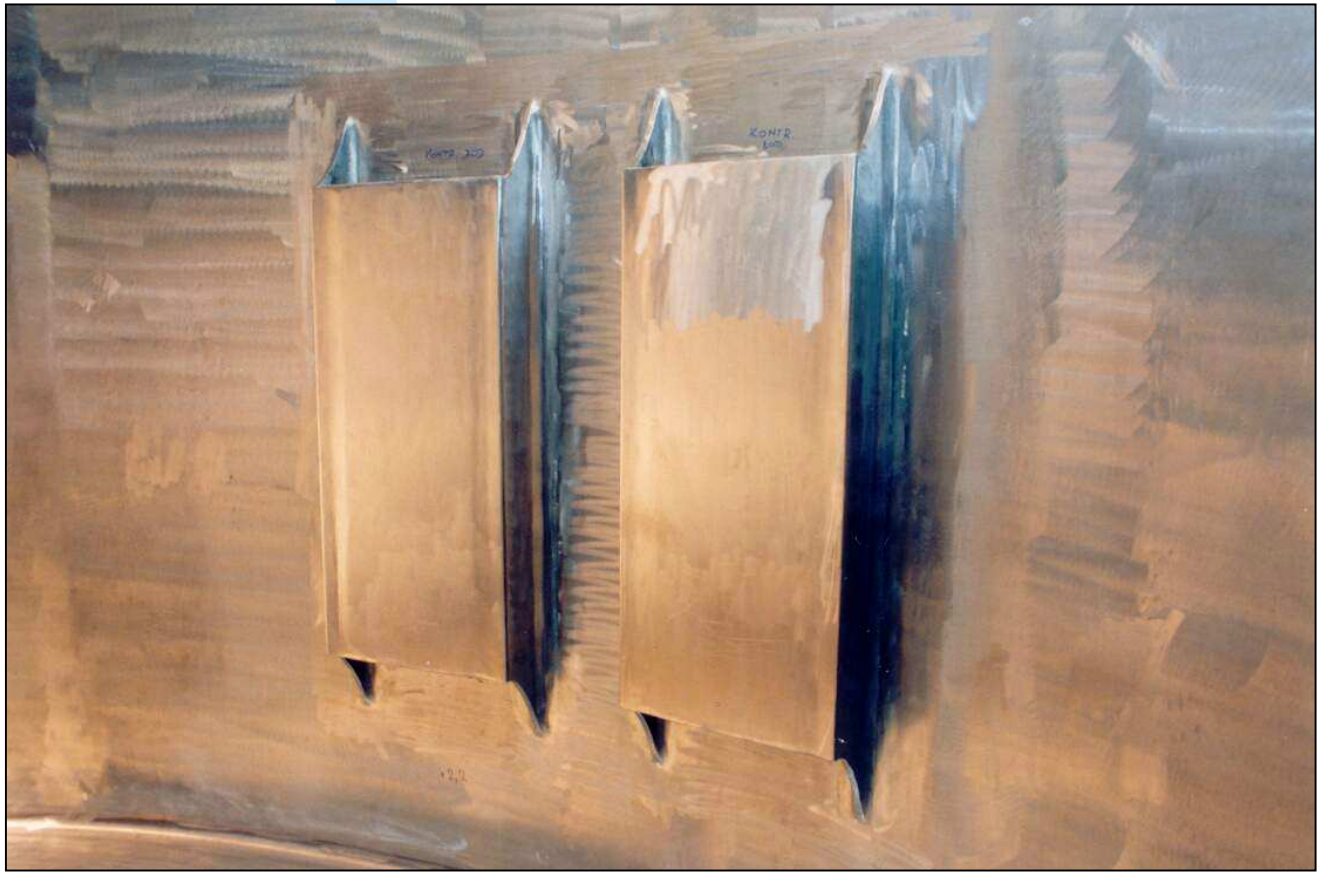
- Six containers are determined for the effect of radiation embrittlement, two for the effect of annealing and for the re-embrittlement effects, if necessary - all containers are located on inner RPV surface in the beltline region
- Two containers are determined for the effect of thermal aging – the containers are located above the core
- Design of containers and holders allow withdrawal and also re-loading of new containers – it was realised in this May 2004 in Temelin Unit 1 and in March 2005 in Temelin Unit 2

FLAT TYPE CONTAINER

200 X 300 X 25 mm



LOCATION OF CONTAINERS ON RPV WALL



SPECIMEN MATERIALS

- **base material** from the more sensitive heat and from the three rings of the beltline region chosen in accordance with the criterion
  CF = (10 % P + % Cu);
  - **weld metal** from the special prepared welding coupon used the same welding consumables as the critical weld No.3 below the core beltline;
  - **heat-affected zone** from this welding coupon using the most sensitive base material.

All these materials were heat treated by the same regimes as the whole pressure vessel

- **cladding materials**
  1st layer – crack in both directions, i.e. from the surface and to the surface
  2nd layer - crack in both directions, i.e. from the surface and to the surface
  heat affected zone in base metal - crack in both directions, i.e. from the surface and to the surface
- **IAEA reference steel JRQ of ASTM A 533 B type**

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INTEGRATED SURVEILLANCE PROGRAMME

Surveillance specimen programme should fulfil requirements given by Codes and standards.

The „Modified Surveillance Programme“ can be extended as „INTEGRATED SURVEILLANCE PROGRAMME“ using NPP Temelin as a HOST reactor for other WWER-1000 units as it fulfil condition of 10CFR50, Appendix H.

Requirements for the Integrated Surveillance Programme - 10CFR50, Appendix H:

II. Criteria for Integrated Surveillance Programme

? 3. Integrated Surveillance Programme can be applied for a group of reactors with the same design and similar operation conditions. Archive material can be irradiated in one unit if sufficient neutron dosimetry is realised in all units. The following criteria should be fulfilled:

Requirements for the Integrated Surveillance Programme - 10CFR50, Appendix H:

1. **Design and operating conditions of all units should be similar to allow comparison of radiation damage prediction as a function of the power output.**
2. **Good exchange of information should be assured between NPPs.**
3. **It is necessary to assure the „host“ reactor will operated without any decrease of output and for required time to be able to use surveillance specimens for prediction.**
4. **In the same time, other advantages in individual units should be reached, like shortening of reactor outages, decrease of dose per personnel etc.**

WWER-1000/V-320 INTEGRATED SURVEILLANCE PROGRAMME OBJECTIVES

- **The primary objective of the project is to rise and collect necessary reliable information on irradiation embrittlement of VVER-1000/V-320 type RPV materials irradiated in conditions representative to RPV ones to be able to perform reliable assessment of RPV materials degradation during NPP operation.**

WWER-1000/V-320
INTEGRATED SURVEILLANCE PROGRAMME
SPECIAL OBJECTIVES

- **Determination of exact radiation embrittlement of individual RPV materials from different reactors having only *Standard surveillance programme* in appropriate irradiation conditions close to RPV wall.**
- **Comparison of data from irradiation in *Integrated surveillance programme* in „host reactors" with those of *Standard surveillance programmes* in operating reactors.**
- **Verification of data with comparison to irradiated IAEA Reference Steel JRQ.**

WWER-1000/V-320
INTEGRATED SURVEILLANCE PROGRAMME
1st part
MATERIALS IRRADIATED IN ETE-2

NPP	ETE-2	NIIAR
2U - 8 – ROVNO – 3	WM	
5U - 18 – ROVNO – 4	WM	BM
3U - 16 – KALININ – 3	WM	
4U - 17 – KHMELNITSKY – 2	WM + BM	
6U – 19 – ZAPOROZHYE – 6	WM	WM

WITHDRAWAL SCHEDULE

The following scheme is proposed :

- **2, 6, 10, 18, 26 + x years for radiation damage containers;**
- **one container for thermal annealing effect;**
- **one container for re-embrittlement rate effect.**

CURRENTLY PLANNED WITHDRAWAL OF CONTAINERS

	ETE-1	ETE-2
1st container	2004	2005
2nd container	2008	2009
3rd container	2012	2013
4th container	2020	2021

INTEGRATED SURVEILLANCE PROGRAMME 2ND PART

ADDITIONAL MATERIALS WILL BE IRRADIATED:

–BASE METALS OF

- •UKRAINIAN NPPs: ROVNO-3,4, KHMELNITSKY-2, ZAPOROZHIE-6
- •RUSSIAN NPP: KALININ-3
- •BULGARIAN NPP: BELENE-1

–WELD METAL OF

- •BULGARIAN NPP: BELENE-1

FIRST CONTAINER WAS INSERTED IN MARCH 2005 INTO Temelin Unit 2

THANKS FOR THE ATTENTION