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| **APPROVED BY** | Shirazi M. | BNPP Chief Engineer | \_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| **УТВЕРЖДАЮ** | Ширази М. | Главный инженер BNPP |
| **AGREED BY** | Sepanloo K. | NNSD Director General | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| **СОГЛАСОВАНО** | Сепанлу К. | Генеральный директор NNSD |
| **AGREED BY** | Derakhshandeh H. | NPPD deputy managing director for technical and engineering | \_\_\_\_\_\_\_\_\_ signatureподпись | \_\_\_\_\_\_\_\_dateдата  |
| **СОГЛАСОВАНО** | Деракхшандэ Х. | Зам. директора NPPD по инженерно-технической поддержки |

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| **TECHNICAL DECISION code: 67.BU.1 0.YM.ABA.RT.FNSM17572** |
| **ТЕХНИЧЕСКОЕ РЕШЕНИЕ код: 67.BU.1 0.YM.ABA.RT.FNSM17572** |
| **TITLE**: On implementation and loading of new generation fuel assembly type “TVS-2M” instead of UTVS type in 7th fuel cycle of BNPP-1 and thereafter. |
| **НАЗВАНИЕ**: О внедрении и загрузке нового поколения тепловыделяющей сборки ТВС-2М вместо УТВС, в 7-ом и последующих топливных циклах BNPP-1. |
| **FACILITY**: Bushehr Nuclear Power Plant-Unit №1 (BNPP-1). Buildings 1ZA and 2ZK.0 |
| **ОБЪЕКТ**: Бушер АЭС Блок №1. Здания 1ZA и 2ZK.0 |
| **STRUCTURAL ELEMENT**: Fuel Assembly (FA) |
| **КОНСТРУКТИВНЫЙ ЭЛЕМЕНТ**: Тепловыделяющая Сборка (ТВС) |
| **SAFETY CLASS** (as per OPB-88/97):1N  |
| **КЛАСС БЕЗОПАСНОСТИ** (по ОПБ-88/97): 1Н |
| **EQUIPMENT GROUP:** (as per PNAE G-7-008-89): No |
| **ГРУППА ОБОРУДОВАНИЯ:** (по ПНАЭ Г-7-008-89): Нет |
| **SEISMIC STABILITY CLASS**: (as per PNAE G-5-006-87): I |
| **КАТЕГОРИЯ СЕЙСМОСТОЙКОСТИ**: (по ПНАЭ Г-5-006-87): I |
| **TYPE OF ACTIVITY**: Modernization/Implementation of new generation fuel assemblies |
| **ВИД РАБОТЫ**: Модернизация/Внедрение нового поколения тепловыделяющей Сборки |

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| **ОБОСНОВАНИЕ**: | **REASON**: |
| Reasons for making technical decisions: Programs for improvement of safety and efficiency1. Regarding the calculation results obtained from the report of "Calculation of thermal-mechanical behavior of UTVS in the core of "Bushehr" NPP, Unit 1, selection of the optimal strategy of introduction of rigid skeleton FA and taking into account the results of operation of Russian and foreign NPPs" with code No.446-Pr-186 (See Appendix No.1), from the viewpoint of assurance of design time of scram for Unit 1 of "Bushehr" NPP, transition to the FAs with welded skeleton (TVS-2M) is necessary.

According to the obtained results, a quick transfer to UTVS with optimized spring unit (with spring wire diameter of 5.1 mm), beginning from the fourth cycle, and subsequent transfer to TVS-2M, beginning from the seventh cycle, is an optimal version of transfer from UTVS to FA with rigid skeleton (TVS-2M) from the point of view of thermal-mechanical behavior of FA in the core of Unit 1, "Bushehr" NPP. Analysis of the results of operation experience of WWER-1000 Units, wherein the transition was accomplished from UTVS to the FAs with welded skeleton, shows a quick decrease in jamming forces of RCCAs in guiding tubes (GTs) when implementing FAs with welded skeleton and thus the results of the performed calculations are confirmed. Therefore, the results of calculation modeling of transient loadings at Unit 1 of "Bushehr" NPP obtained in the a.m. report, with regard for the analysis of available operation experience of transient loadings at WWER-1000 type Units, led to selection of the optimal strategy of TVS-2M implementation at Unit 1 of "Bushehr" NPP.TVS-2M in comparison with UTVS has more rigid skeleton (welded skeleton) fuel assembly and fuel mass in each fuel assembly increases by ~7.5% that leads to the following results:* Maximum burn-up fraction increases;
* No BARs are needed and U-Gd fuel rods are used;
* Average burn-up fraction of irradiated FAs increases about 20%;
* Increase in flexibility of arrangement of fresh FAs;
* Average core enrichment is maintained or increases;
* Duration of fuel operation cycle increases up to ~ 45 EFPD.
1. According to the results of the report "Calculation of neutron-physical characteristics of transitive fuel cycles starting from the 7th loading, with outlet to equilibrium fuel cycle of Unit 1 of Bushehr NPP" (See Appendix No.2), transition of uranium-gadolinium fuel cycle of VVER-1000 reactor NPP Bushehr-1 to TVS-2M fuel will begin from the 7th fuel loading. Fuel loadings from 7th to 9th will consist of UTVS and TVS-2M. Fuel loadings from 10th and further will consist of TVS-2M. The variant of transition to the fuel TVS-2M with 16 spacing grids (SG) will be used in loadings 7th and 8th, and loading 9th and further will continue to use TVS-2M with 13 SG.
2. List of documentation which justifies the necessity of activities under current technical decision based on calculations and examinations is as follows:
3. Based on conclusion of calculations
* "Feasibility study report on TVS-2M implementation at Bushehr NPP" with code No.446-Pr-176 (See Appendix No.3);
* "Calculation of thermal-mechanical behavior of UTVS in the core of «Bushehr» NPP, Unit 1. Selection of the optimal strategy for introduction of rigid skeleton FA taking into account, the results of operation of Russian and foreign NPPs" with code No.446-Pr-186.
1. Based on conclusion of examinations
* "Technical support, consultation and analysis of fuel operation during the third fuel loading at NPP «Bushehr», Unit 1" with code No.446-Pr-192 (See Appendix No.4);
* Analysis of Fuel Operation during the 4th Fuel Loadings at NPP «Bushehr», Unit 1 with code No.BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.004.01-2 (See Appendix No.5);
* Analysis of Fuel Operation during the 5th Fuel Loadings at NPP «Bushehr», Unit 1 with code NO.BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.011.00-0 (See Appendix No.6).
1. Regarding reliability analysis based on statistical experience, the leakage of rigid skeleton FA such as TVS-2 and TVS-2M is significantly less than UTVS without rigid skeleton. According to the document "Feasibility study report on TVS-2M implementation at Bushehr NPP" with code No.446-Пр-176, as of 2015 during 13 years from the beginning of operation of the first TVS-2, it was manufactured and put into operation totally 3585 TVS-2 and TVS-2M fuel assemblies with the rigid zirconium skeleton out of which only 22 fuel assemblies were recognized as leaky ones by the operating results. The total level of the fuel rod failures of the TVS-2 and TVS-2M fuel assemblies with rigid skeleton is 1.97×10-5 as of 2015. Among 2296 TVS-2Ms manufactured and installed for operation from 2006 to 2015, 11 (eleven) TVS-2Ms were recognized leaky and 3 (three) of them were withdrawn in the planned order. By 2015 the level of failures of TVS-2M fuel rods was 1.54×10-5.

Since operation cycles of TVS-2M is equal to ~ 341 EFPD, the time of refueling is improved and shortened because of following reasons:* Decrease of 12% in fresh fuel loading of each cycle (42 fresh FAs is loaded);
* No BAR bundle is used in operation cycles. Thus, transfer of 18 BAR bundles is deleted from refueling program. So the benefits of this elimination are less radioactive waste production and reduction of refueling period;
* The rigidity skeleton of TVS-2M makes operator able to increase movement speed of fuel handling machine (FHM) working mast for TVS-2M handling.
1. TVS-2M implementation at BNPP-1 impacts safety. The relevant topical reports are developed and confirmed by means of legal framework of Appendix No.2 to the Supplement No.10 (See Appendix No.7 to the current technical decision) to the BNPP-1 fuel contract that are used for updating Final Safety Analysis Reports (FSARs) of BNPP-1, especially under AOO, DBA and BDBA
2. TVS-2M implementation at BNPP-1 complies with requirements of updated document 49.BU.1 0.0.OO.FSAR.RDR001
3. Following list of documents is developed or modified because of implementation of TVS-2M at BNPP-1:
4. Justification topical reports are developed according to Appendix No.2 to the Supplement No.10 (The List of documents is developed based on TVS-2M implementation at BNPP-1 -See Appendix No.11).
5. Relevant FSAR of BNPP-1 such as chapters No.4, 5, 6, 9, 11, 12 and 15 are updated;
6. Operational documents are revised according to the "Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1" (See Appendix No.8).
7. Activities related to this technical decision are nuclear hazardous activities. The List of safety analysis reports, which are included in Appendix No.9 and 11 (See Appendix No.9 and 11).
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| **РЕШИЛИ:** | **DECISION:** |
| 1. Implement activities related to applying of new generation fuel assembly type “TVS-2M” instead of UTVS type in 7th fuel cycle of BNPP-1 and thereafter.

Resp.: NPPD, BNPP Deadline: PPM-20201. Develop justification topical reports according to Appendix No.2 to the Supplement No.10.

Resp.: JSC TVEL Deadline: Before the beginning of 7th cycle of BNPP-11. Update Final Safety Analysis Report (FSAR) of BNPP-1 due to TVS-2M specifications and its effects.

Resp.: JSC TVEL/NPPD/ BNPP(ETD) Deadline: Before the beginning of 7th cycle of BNPP-1  1. Revise operational documents stipulated in "Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1" according to item 10.4 of Appendix No.2 to the Supplement No.10.

Resp.: BNPP/JSC TVEL Deadline: Before the beginning of 7th cycle of BNPP-11. Issue «permit for manufacturing of nuclear fuel and reactor core component» along with relevant validity conditions in order to load TVS-2M in reactor core of BNPP-1 according to INRA/NNSD regulations.

Resp.: INRA / NNSD Deadline: Before the beginning of PM-20201. Modernize In-Core Instrumentation System (ICIS) so that it is able to measure and calculate core parameters based on TVS-2M specifications.

Resp.: NPPD/ BNPP (APCSM) Deadline: Before the end of 9th cycle of BNPP-11. Develop technical assignments for "Upgrading software of the software-hardware complex (SHC) in a set of the control and protection system (CPS) of electrical equipment complex" and "Modifying FHM control system by a change in the FA mass and shuffling velocities" according to items 6.7 and 10.1.2.7.1 of Appendix No.2 to the Supplement No.10.

Resp.: JSC TVEL (OKB GP, VNIIEM, Comtech) Deadline: Before the end of 9th cycle of BNPP-11. Upgrade software of the software-hardware complex (SHC) in a set of the control and protection system (CPS) of electrical equipment complex according to item 6.7 of Appendix No.2 to the Supplement No.10.

Resp.: JSC TVEL (OKB GP, VNIIEM) Deadline: Before the end of 9th cycle of BNPP-11. Modify FHM control system by a change in the FA mass and shuffling velocities according to item 10.1.2.7.1 of Appendix No.2 to the Supplement No.10.

Resp.: JSC TVEL (OKB GP, Comtech) Deadline: Before the beginning of 10th cycle of BNPP-11. Purchase elongated RCCA compatible with height of fuel in TVS-2M fuel rods according to topical reports of item 6 of Appendix No.2 to the Supplement No.10.

Resp.: NPPD Deadline: Before the beginning of 10th cycle of BNPP-11. Modify documentation provided under the Supplement No.10 (confidential) as a result of the first cycle operation experience of the TVS-2M at BNPP-1 (if necessary) according to item 5.1.4 of the Supplement No.10 (See Appendix No.10).

Resp.: JSC TVEL Deadline: After finishing 7th cycle of BNPP-11. Review technical documents of the project for transition to the new generation of the fuel assembly of the TVS-2M type; in case of existence of any comments, arrange to eliminate them by the Contractor and approve the final version of the documents.

Resp.: NPPD(TAVANA,BNPP,NNSD) Deadline: PPM-20201. Submit the operational information related to applying new generation of fuel assembly of TVS-2M type in 7th fuel cycle of the reactor to the NPPD in order to submit to the Contractor.

Resp.: BNPP Deadline: After the end of 7th fuel cycle of BNPP-11. Modify assigned appendices to the BNPP-1 Fuel Contract No.08843672 / 50293-09D 08.08.1995 and finalize amendment No.4.

Resp.: NPPD, JSC TVEL Deadline: 20201. Adjust and improve Full Scope Simulator (FSS) based on TVS-2M implementation at BNPP-1 in order to train BNPP-1 operators according to design change of reactor core.

Resp.: BNPP(HRMTC) Deadline: During 7th cycle of BNPP-1 |
| **КОРРЕКТИРОВКА ДОКУМЕНТАЦИИ**: | **UPDATING OF DOCUMENTS**: |
| 1. Update Final Safety Analysis Report (FSAR) of BNPP-1 due to TVS-2M specifications and its effects. Resp.: OKB GP, JSC TVEL,NPPD/ BNPP(ETD) Deadline: The startup of BNPP-1 at 7th fuel cycle2. Revise operational documents stipulated in "Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1" according to item 10.4 of Appendix No.2 to the Supplement No.10.Resp.: BNPP-1(ETD / TDPM BNPP) Deadline: Before the start of 7th cycle of BNPP-13. Modify documentation provided under the Supplement No.10 as a result of the first cycle operation experience of the TVS-2M at BNPP-1 (if necessary) according to item 5.1.4 of the Supplement No.10. Resp.: JSC TVEL Deadline: After finishing 7th cycle of BNPP-1 |
| **Приложения**: | **Appendix**: |
| 1. Appendix No.1 – «Calculation of thermal-mechanical behavior of UTVS in the core of "Bushehr" NPP, Unit 1. Selection of the optimal strategy of introduction of rigid skeleton FA taking into account the results of operation of Russian and foreign NPPs»; code No.446-Pr-186 – 1 copy on 63 sheets.2. Appendix No.2 – «Report. Calculation of neutron-physical characteristics of transitive fuel cycles starting from the 7 loading, with outlet to equilibrium fuel cycle of Unit 1 of Bushehr NPP» - 1 copy on 566 sheets3. Appendix No.3 – «Feasibility study report on TVS-2M implementation at Bushehr NPP»; code No.446-Pr-176 – 1 copy on 80 sheets.4. Appendix No.4 – «Technical support, consultation and analysis of fuel operation during the third fuel loading at NPP «Bushehr», Unit 1»; code No.446-Pr-192 - 1 copy on 88 sheets.5. Appendix No.5 – «Analysis of Fuel Operation during the 4th Fuel Loadings at NPP «Bushehr», Unit 1»; code No.BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.004.01-2 - 1 copy on 79 sheets.6. Appendix No.6 – «Analysis of Fuel Operation during the 5th Fuel Loadings at NPP «Bushehr», Unit 1»; code NO.BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.011.00-0 - 1 copy on 66 sheets.7. Appendix No.7 –«Appendix No.2 to the Supplement No.10 to the Fuel Contract No.08843672 I 50293-09D 08.08.1995. Detailed description of the Documentation» - 1 copy on 38 sheets.8. Appendix No.8 - «Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1» - 1 copy on 10 sheets.9. Appendix No.9 – «List of update FSARs (Justification of TVS-2M implementation) of item 11 of Appendix No.1 to the Supplement No.10 of the Fuel Contract»- 1 copy on 7 sheets.10. Appendix No.10 - «Item 5.1.4 of Supplement No.10 to the Fuel Contract No.08843672/50293-09D» - 1 copy on 1 sheet.11- Appendix No.11- «List of Topical Reports of The Appendices Noes.1 And 2 to The supplement No.10 to Fuel Contract» -1 copy on 10 sheets. |
| **VALIDITY PERIOD**: Until fulfillment of certain conditions |
| **СРОК ДЕЙСТВИЯ**: До завершения определенных условий |
| **RESPONSIBLE FOR IMPLEMENTATION**: M.Saadatpour, Head of NFCG of BNPP, 07731112532 |
| **ОТВЕТСТВЕННЫЙ ЗА ВНЕДРЕНИЕ**: Саадат М., РГКЯТ BNPP, 07731112532 |
| **DISTRIBUTION**: NPPD, BNPP, TAVANA Co., JSC «TVEL», OKB «Gidropress», , INRA/NNSD. |
| **РАССЫЛКА**: NPPD, BNPP, TAVANA Co., АО «ТВЭЛ», ОКБ «Гидропресс», INRA/NNSD. |

**IMPLEMENTATION MARK**:

**ОТМЕТКА О ВНЕДРЕНИИ**:

**TECHNICAL DECISION SIGNED BY**

**ТЕХНИЧЕСКОЕ РЕШЕНИЕ ПОДПИСАЛИ**

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| Agreed by | Moazzen M. | BNPP Deputy Managing Director for Safety | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
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| Agreed by | Kapyrin P.G. | BNPP Assistant of Chief Enginner | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Капырин П.Г | Ассистент Главного Инженера BNPP |
| Agreed by | Ghods M. | TAVANA co. managing director | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Годс М. | Генеральный директор TAVANA |
| Agreed by | Ugryumov A. | JSC TVEL Vice President for R&D | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
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| Agreed by | Lapin A. | OKB “Gidropress” Representative | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Лапин А. | Представитель ОКБ «Гидропресс» |