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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 “TVS-2M” type 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**: |
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| Reasons for making technical decisions: Programs of 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 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, show 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, is 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;
* Effective specific consumption of natural uranium in the conditions of approximately similar length of the operation cycle (content of 235U with enrichment 0.3%) is reduced by ~5-7%;
* No BARs are needed and U-Gd fuel rods are used;
* Average burn-up fraction of irradiated FAs increases on ~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.

2. List of documentation which justify the necessity of activities under current technical decision based on calculations and examinations are as follows:1. Based on conclusion of calculations
* "Feasibility study report on TVS-2M implementation at Bushehr NPP" with code No.446-Pr-176 (See Appendix No.2);
* "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" 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.3);
* 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.4);
* 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.5).

3. 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 is 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 are deleted from refueling program;
* The rigidity skeleton of TVS-2M makes operator able to increase movement speed of fuel handling machine (FHM) working mast for TVS-2M handling.

4. TVS-2M implementation at BNPP-1 effects on safety. The relevant topical reports are developed and confirmed by means of legal framework of Appendix No.2 (See Appendix No.6 to the current technical decision) to the Supplement No.10 to the BNPP-1 fuel contract that are used for updating Final Safety Analysis Reports (FSARs) of BNPP-1, especially under AOO, DBA and BDBA5. TVS-2M implementation at BNPP-1 complies with requirements of updated document 49.BU.1 0.0.OO.FSAR.RDR0016. Following list of documents is developed or modified because of implementation of TVS-2M at BNPP-1:1. Justification topical reports are developed according to Appendix No.2 to the Supplement No.10;
2. Relevant FSAR of BNPP-1 such as chapters No.4, 5, 6, 9, 11, 12 and 15 are updated;

Operational documents are revised according to the "Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1" (See Appendix No.7).7. Activities related to this technical decision aren’t nuclear hazardous activities. safety analysis is attached to technical decision. (See Appendix No.8).  |
| **РЕШИЛИ:** | **DECISION:** |
| 1. Develop justification topical reports according to Appendix No.2 to the Supplement No.10.Resp.: JSC TVEL Deadline: December 20192. Updated Final Safety Analysis Report (FSAR) of BNPP-1 because of TVS-2M specifications and its effects. Resp.: JSC TVEL Deadline: December 20193. 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 Deadline: Before beginning of 7th cycle of BNPP-14. Issue «permit for manufacturing of nuclear fuel and reactor core component» along with relevant validity conditions in order for loading of TVS-2M in reactor core of BNPP-1 according to INRA/NNSD regulations.Resp.: INRA / NNSD Deadline: Before beginning of PM-20205. Upgrade software of the software-hardware complex (SHC) in a set of the control and protection system (CPS) electrical equipment complex according to item 6.7 of Appendix No.2 to the Supplement No.10.Resp.: JSC TVEL (OKB GP, VNIIM) Deadline: in PM-20206. Modify FHM control system by a change in the FA shuffling velocities and mass according to item 10.1.2.7.1 of Appendix No.2 to the Supplement No.10.Resp.: JSC TVEL (OKB GP, Comtech) Deadline: in PM-20207. Develop technical assignments for "Upgrading software of the software-hardware complex (SHC) in a set of the control and protection system (CPS) electrical equipment complex" and "Modify FHM control system by a change in the FA shuffling velocities and mass" 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, VNIIM, Comtech) Deadline: before beginning of PM-20208. 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 10th cycle of BNPP-19. Modify documentation provided under the Supplement No.10 (See Appendix No.9) 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-110. Implementing the new generation of fuel assembly of the TVS-2M type replacing the UTVS type in 7th fuel cycle of BNPP-1 and thereafter.Resp.: NPPD, BNPP Deadline: PPM-202011. Performing incoming control of technical documents of the project for transition to the new generation of the fuel assembly of the TVS-2M type and in case of existence of any comments, arranging the elimination of them by the contractor.and final approval of the documents Resp.: NPPD,TAVANA Co., BNPP Deadline: Before the start of PPM-202012. Performing supporting activities for all issues pertaining to the project during its implementation.Resp.: TAVANA co. Deadline: Continuous13. Submitting the operational information related to using new generation of fuel assembly of TVS-2M type in the reactor core to the NPPD, for submission to the contracting organization.Resp.: BNPP Deadline: After end of 7th fuel cycle of BNPP-1 |
| **КОРРЕКТИРОВКА ДОКУМЕНТАЦИИ**: | **UPDATING OF DOCUMENTS**: |
| Updated Final Safety Analysis Report (FSAR) of BNPP-1 because of TVS-2M specifications and its effects. Resp.: OKB GP, JSC TVEL Deadline: December 2019Revise 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: Deadline: Before the start of 7th cycle of BNPP-1Modify 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 №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.Приложение №1 –« Расчет термомеханического поведения УТВС в активной зоне» первого блока BNPP. Выбор оптимальной стратегии для внедрения жесткой конструкцией ТВС на основе результатов полученных в Российских и иностранных АЭС»; код: 446-Pr-186 – в 1 экз. на 63 листах.2. Appendix №2 – «Feasibility study report on TVS-2M implementation at Bushehr NPP»; code No.446-Pr-176 – 1 copy on 80 sheets.Приложение №2 – «Отчет по рассмотрению осуществимости внедрения ТВС-2М на BNPP» код: 446-Pr-176 – в 1 экз. на 80 листах.3. Appendix №3 – «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.Приложение №3 – «Техническая поддержка, консультация и анализ управления топливом во время третьей загрузки первого блока BNPP; код:446--Pr-192 - в 1 экз. на 88 листах.4. Appendix №4 – «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.Приложение №4 – «Анализ управления топливом во время четвертой загрузки первого блока BNPP »; код: BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.004.01-2 - в 1 экз. на 79 листах.5. Appendix №5 – «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.Приложение №5 – «Анализ управления топливом во время пятой загрузки первого блока BNPP»; код: BU1- GEN.TVN-FM.TS.RPT-ANA.0-0.011.00-0 - в 1 экз. на 66 листах.6. Appendix №6 –« 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.Приложение №6 – «» - в 1 экз. на 38 листах.7. Appendix №7 - «Assigned Operational Documentation List for Modification because of TVS-2M implementation at BNPP-1» - 1 copy on 10 sheets.Приложение №7 – «» - в 1 экз. на 10 листах8. Appendix №8 – List of documentation Justification of safetyПриложение №8 – Перечень документов обоснование безопасности9. Appendix №9 - «Supplement No.10 to the Fuel Contract No.08843672/50293-09D» - 1 copy on 7 sheets.Приложение №9 – «10-ое дополнение контракта топлива, № 08843672 / 50293-09D» - в 1 экз. на 7 листах |
| **VALIDITY PERIOD**: Until fulfillment of certain conditions |
| **СРОК ДЕЙСТВИЯ**: До завершения определенных условий |
| **RESPONSIBLE FOR IMPLEMENTATION**: Saeed Gol, FNSM Manager of BNPP, 07731112511 |
| **ОТВЕТСТВЕННЫЙ ЗА ВНЕДРЕНИЕ**: Саид Голь, Начальник СЯБиТ BNPP, 07731112511 |
| **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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| --- | --- | --- | --- | --- |
| Developed by | Saadatpour M. | Head of Nuclear Fuel Control and Safeguard group | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Разработал | Саадатпур М. | Руководитель Группы КЯТиГ |
| Agreed by | Gol S. | Manager of FNSM | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Голь С. | Начальник СЯБиТ |
| Agreed by | M. Hojati | Manager of TDPM | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Ходжати М. | Начальник ОПиТД |
| Agreed by | Khezri K. | Manager of MSIM | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Хезри К. | Начальник ОСМиН |
| Agreed by | Shamani Y. | ВNPP Deputy Chief Engineer for engineering and technical support | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Шамани Я. | ЗГИИП |
| Agreed by | Farzi B. | ВNPP Deputy Chief Engineer for operation | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Фарзи Б. | ЗГИЭ |
| Agreed by | Moazzen M. | BNPP Deputy Managing Director for Safety | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Моазен М. | ЗДБ |
| 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 |  | JSC TVEL Representative | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано |  | Представитель АО ТВЭЛ |
| Agreed by | Lapin A. | OKB “Gidropress” Representative | \_\_\_\_\_\_\_\_\_signatureподпись | \_\_\_\_\_\_\_\_\_dateдата  |
| Согласовано | Лапин А. | Представитель ОКБ «Гидропресс» |