JSC Rusatom Service

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REPORT

on Third Medium Repair of Unit No. 1 of the Bushehr NPP in 2018

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1. Repair Duration

1.1. Expected Repair Duration

Table No. 1

Schedule Name	Duration (start – end)
2018 Medium Repair Schedule – Unit No. 1 of the *Bushehr* NPP (MRS-1510-198/18-Rev 0 dd 14.11.2017)	12.02.2018 – 01.05.2018 79 days

Contract No. PPM/T-4100 stipulates that the 2018 PPM shall not last for more than 60 days.

In January 2018, the Principal unofficially informed *JSC Rusatom Service* about extension of the duration due to an integrity test of all 163 fuel assemblies (including integrity testing of 115 fuel assemblies (FAs) located on the PPM critical path), which increased the planned PPM duration to 79 days.

Unit No. 1 of the *Bushehr* NPP was disconnected from the grid at 12^{29} on 12.02.2018.

Having agreed it with *JSC TVEL*, *JSC Gidropress*, and *NITS KI*, during nuclear fuel handling the Principal decided to shorten the FA integrity testing (74 instead of 115); nuclear fuel handling was completed on 30.03.2018 instead of 07.04.2018 as planned initially.

1.2. Actual Repair Duration

Table No. 2

Duration (start – end)	Repair category/duration Days	Reduction (-), extension (+) of repair duration, Days
12.02.2018 – 02.05.2018	MR / 78.7 days	-0.3 days

2. Main Problems Revealed During Repair Planning, Preparation, and Performance

Planning of System and Equipment Repair

- There were several revisions of the Bill of Quantities, as was the case during previous PPMs. The Contractor drew up and initialed the final revision of it three month prior to the commencement of *PPM-2018*. The scope of repairs for certain items (that listed such objectives as, for example, "defect remediation") remained unclear until the very beginning of the work due to it being practically impossible to obtain full and accurate information about non-conformances. However, the final revision of the Bill of Quantities contained enough information for *JSC RusAS* to prepare for the planned scope of repair.
- Whenever Principals fail to provide fully-fledged terms of reference containing scopes of work for complex equipment and lists of existing defects it results in the final scope of repair being clarified only during PPMs, which leads to failure to perform some of the previously planned works; money for such works are not paid.
- Necessary connections between the repair schedule of the main equipment of systems and its (the schedule's) auxiliary equipment were lacking. As a result, this forced downtime on personnel responsible for turbine and turbine generator (TG) works. This was especially the case for oil systems and generator cooling systems.
- After the PPM began, there were no turbine set (TS) balancing operations in the schedule after the vibration measurement.

Preparation for Unit Repair

Work Organization by Principal

- The *BNPP*/*TAPNA* repair subdivision structure has not changed since previous Unit PPMs.
- A repair team responsible for the steam turbine (ST) and its equipment was not created; this is why the said equipment is still divided between two repair subdivision, namely:
  - Static Equipment Repair Subdivision (SERS) responsible for repair of equipment of systems for steam distribution, adjustment and protection, as well as for locking foundation vibration absorbers
  - Rotating Machines Repair Subdivision (RMRS) responsible for repair of turbine cylinders, bearings, and shaft rotating devices

  An engineer supervising equipment repair is assigned to every repair area. Moreover, subject matter Iranian specialists invited from IRI thermal power plants supervised all repairs of the turbine and the equipment of systems of steam distribution, adjustment, and protection.

- Prior to PPMs, the *TAPNA* RMRS and SERS heads decide what subdivision will be responsible for certain equipment listed in a Bill of Quantities. This results in the same equipment being assigned to different repair teams from one PPM to another. This is not a sound approach to preparation for repairs and work performance; this is why assignment of specific equipment to certain subdivisions is to be appropriately documented.
- Two *JSC TEM* specialists responsible for organization and performance of the below listed works were assigned to the *TAPNA* RMRS and SERS for provision of consulting services to Iranian repair personnel (Appendix No. 7 to the Contract) during preparation for and performance of the Unit PPM:
  - Preparation of lists of spare parts to be procured
  - Ensuring availability of spare parts at the warehouses of the *BNPP* Procurement and Supply Department
  - Preparation of specialized repair tooling and accessories (drawing up lists and terms of reference for manufacturing, pre-repair maintenance, supply to the turbine hall (or "ZF"), and arranging them there according to the Turbine Hall (TH) Equipment Arrangement Plan)
  - Preparation of sets of original equipment manufacturer (OEM) documentation necessary to complete planned scopes of repair
  - provision of consulting services and technical supervision of activities of *TAPNA* RMRS and SERS specialists at their work places
- The *Bushehr* NPP still has not begun working on creation of subdivision for engineering support of M&R activities analogous to Repair Preparations and Performance Departments at Russian NPPs. However, two subdivision – the Comprehensive Design Department (CDD) and the Welding Group (WD) – were created at *TAPNA*; they deal with such issues of engineering support of repairs as development and support of design documentation, method statements, and process documentation for welding performance. The two are manned; this includes Russian subject matter specialists who are the leading specialists at these repair areas.
- The Electrical Installation Section (EIS) lacks a group responsible for engineering support and logistics support (drawing up long-term and annual requests and issuing spare parts to contractors) As of today, different approaches to the organization of repair are used when working with different types of equipment; these approaches depend on personnel responsible for maintenance of specific equipment. For example, personnel responsible for TG maintenance ensure spare part supply, while there have been issues with supply of spare parts for the generator air-operated circuit breaker repair.
- There are no workshops for specific equipment repair operations. Lack of workshops for electric engine (EE) rewinding is one such example.
- There have been instances of EIS repair tooling not being inspected during interrepair periods; this leads to loss of time during PPMs. For example, the repair of the shaft barring gear of the (reactor coolant pump set) RCPS EEs

was performed during the repair of the engines due to the fact that it (the shaft barring gear) was left in the containment of the ZA building.

- The Unit shutdown date was communicated to the Contractor less than 2 (two) months prior to the PPM commencement. There was risk of missing deadlines for repair commencement due to the lack of time for preparatory measures. The Contract stipulates that it is necessary to officially communicate PPM commencement dates and PPM duration to the Contractor 3 (three) months prior to PPM commencement.

Repair and OEM Documentation

- Lack of repair documentation for the Unit main equipment (ST and its systems and critical equipment of the primary and secondary circuits (pressurizer pulse safety devices (PSDs), emergency core cooling system (ECCS) PSDs, steam generator (SG) PSDs, steam-dump valves to the atmosphere, etc.) is an ongoing serious problem. It is also worth mentioning that the lacking repair process documentation cannot be substituted with the OEM documentation contained in the Unit Dossier. Lack of repair documentation makes it extremely difficult for Russian specialists to ensure necessary repair quality, while making it absolutely impossible for specialists of IRI contractors to perform repairs.
  The sets of OEM supply documentation available at the *Bushehr* NPP and Repair Manuals developed by *JSC ASE* contain information allowing to dismantle and assemble items; however, they do not contain information necessary to ensure quality of flaw detection and repair of parts and assemblies, spare part ordering, process tooling and accessories preparation, M&R planning, etc.
- Lists of equipment requiring availability of repair documentation (technical specifications for repair, etc.) were handed over to *JSC RusAS* subject matter specialists following a request of the SERS and RMRS heads. This shows that the *Bushehr* NPP understands the importance of and need for availability of repair documentation and has begun taking steps in this direction.
- Lack of repair documentation for pumping equipment continues negatively affecting its repair. Below is the list of TH pumps negatively affected by it during *PPM-2018*: Jacking oil pump SN91D001 and generator shaft sealing oil pump SU13D001. It is not clear what spare parts to order due to the lack of documentation; the lack of spare parts results in inability to repair equipment properly. It forces personnel to try and find similar spare parts (e.g. sealing rings) among available spare parts for other equipment. This causes defects (leaks during trials) that reveal themselves once repairs and equipment testing are completed. The *Bushehr* NPP needs to actively continue developing repair documentation for all equipment installed at the *Bushehr* NPP.

Spare Parts and Materials

- Availability of the necessary spare parts and materials at the *Bushehr* NPP warehouses was checked at the preparatory stage; necessary supply requests were drawn up after that. However, there were instances when wrong spare parts were issued due to spare part database errors. Personnel of the Contractor should be given access to warehouses so they could verify availability of spare parts and incoming control certificates and other certificates to prevent spare part database errors.
- The procedure for spare part and material supply used during *PPM-2018* had been perfected during previous PPMs: spare parts were quickly issued at the warehouses and then handed to individuals responsible for completion of work orders based on requests drawn up by the Principal. There were no problems in this regard.
- Yet another instance of lacking certain spare parts at the *Bushehr* NPP resulted in the need to urgently supply them to the site. This was the case for the pressurizer hatch fasteners; the same almost happened with the reactor pressure vessel head (RPVH) flange, although it was possible to solve the problem by means of thread cutting. As for the SG header studs, the lack of spare parts left no other choice but to delay the SG No. 3 overhaul until the next PPM.

  Lack of spare parts for pump SU13D001 resulted in the need to try and find sealing rings with similar dimensions and fit out the pump with those that were available at the site despite them not having any quality documents. However, the pump began leaking during trial operations – forcing personnel to cover sealing surfaces with sealant to remedy the leaks – due to the fact that installed sealing rings did not fully match OEM dimensions. A full set of spare parts for the equipment to be repaired should be supplied to the *Bushehr* NPP site prior to the *PPM-2019* commencement. This is especially the case for the main equipment since the post-repair unit start-up depends on whether the main equipment (reactors, RCPSs, SGs, pressurizers, turbines, and generators) is operational.
- A lot of spare parts and materials procured at the IRI market are not certified for use with NPP equipment. Technical decisions for use of substitute materials are not developed and approved when changing materials. Use of materials of unknown origin makes it impossible to ensure reliable equipment performance over the entire warranty period; this forces *JSC Rusatom Service* to incur higher-than-usual risks when assuming warranty obligations. The repair of the RCPS EEs is one such example, and a shining one at that. Uncertified materials were used to seal the cable penetrations of the temperature sensors of the bearings; the aggressive *Fyrquel* fluid stained the paintwork of the engine stator winding and destroyed it as the result. *JSC Rusatom Service* has to annually pay for labor intensive renewal of the stator winding paintwork out of its own pocket due to the *Bushehr* NPP using inappropriate sealing materials.

- There are certain instances when the nomenclature of the available welding materials is not sufficient to allow for quality repair of equipment due to the lack of necessary electrodes or wires. Failure to perform a quality repair of the valving sealing surfaces due to the lack of the necessary welding materials that ensure high surface hardness and durability is one such example. It is worth mentioning that requests for necessary welding materials are filled out by the *JSC ATEX* Directorate consulting specialist working for the *TAPNA* welding group in advance and prior to PPM commencement; however, almost nothing is ever supplied by the time of PPM commencement.

Special Repair Equipment

- Availability of the necessary process tooling and materials at the *Bushehr* NPP warehouses was checked at the preparatory stage; terms of reference for manufacturing of the lacking tooling were drawn up following the check.
- The practices for interrepair storing of OEM and special tooling for TS repair are unsatisfactory; all the items are stored at an unsheltered storage area. Tooling ages faster due to such storage conditions; additional work is required to get it in a working order.
  OEM and specialized tooling should be stored in warehouses between repairs; such warehouses should be able to ensure appropriate storage and preservation.
- The Principal failed to procure straps for lifting and moving around the turbine low-pressure cylinder (LPC) inner casing prior to the 2018 Medium Repair commencement despite the *TAPNA* rotating machine group having sent requests for them in advance. They were finally procured only after *JSC RusAS* repeatedly demanded they be procured during daily briefings and requested *Bushehr* NPP and *TAPNA* technical managers to do so right before the LPC disassembly.
  Hoisting machinery should be equipped with all straps necessary for upcoming repairs prior to PPM commencement.
- The lack of transportable lathes for lathing sealing surfaces in the field is dealt with through hiring an Iranian company that has such equipment. Moreover, the *TAPNA* SERS submitted a request for procurement of a transportable lathe for lathing surfaces with the diameter of up to 400 mm at the IRI market.
- The Principal still has not decided to procure a lathe for repair of RCPS sealing surfaces despite *JSC Rusatom Service* having repeatedly recommended doing so to the *Bushehr* NPP. The OEM (*JSC TSKBM*) has already issued a warning saying that it may not agree further RCPS operation due to defects of sealing surfaces of the main joint that could be revealed during one of the future metal inspections. The *Bushehr* NPP will be the one held responsible if this happens.

- During the start-up it was revealed that rods of 2 (two) RCPS EE hydraulic snubbers were at the end position. As of now, the *Bushehr* NPP does not practice regular hydraulic snubber M&R despite them not being any different from pumps or valves in that they are plant equipment, too. Below is the list of operations that 51.BU.1 0.00.AB.WI.ATEX.001 *Technical Regulations for Safe Operation* requires be completed during PPMs:
    1. Visually inspecting hydraulic snubbers to ensure there are no damage and/or leaks.
    2. Checking whether hydraulic snubbers, tanks, connecting tubes, position sensors, level sensors, and cables are properly secured.
    3. Measuring position sensor output resistance.
    4. Checking tank liquid level using mechanical indicators.
    5. Inspecting hydraulic snubbers (including disassembling them).
- It is impossible to overhaul hydraulic snubbers without specialized equipment; it requires procuring a special bench that will allow checking operational performance of hydraulic snubbers and repair of such hydraulic snubbers (that will include changing sealing rings and hydraulic fluid). Hydraulic snubbers should be repaired and adjusted during interrepair periods to reduce Unit PPM; used up hydraulic snubbers should be replaced with inspected ones during PPM. This means there should be enough back up hydraulic snubbers at the spare part warehouses.
- The *Bushehr* NPP and *TAPNA* still do no have special benches (at the Controlled Access Area (CAA) and the Free Access Area (FAA) for adjustment and testing of safety valving. The makeshift "bench" for safety valving adjustment at the ZL3 building does not allow performing proper post-repair testing adjustment. The lack of such benches means it is impossible to follow all OEM documentation requirements for post-repair adjustment and ensuring normal operation. This means that efforts to assure the quality of safety device repairs can only be taken after such safety devices have been properly mounted at the stage of putting a system into operation.

Work Performance

- It stands to reason for the *Bushehr* NPP and *TAPNA* to put together their own repair crews/groups specializing in repair of specific equipment to ensure quality and timeliness of repairs of unique, sophisticated, and critical equipment of the Unit.
- It is necessary to improve the quality of the repair personnel training and develop and reward self studying since it is the main component of the professional development. It is also necessary to identify the most knowledgeable, self-sufficient, pro-active, diligent, and responsible employees to make sure they stay with the plant and to grow the employee pool.

- Local repair schedules do not always factor in technological connections between equipment of different systems; this leads to expected dates of repair completion not agreeing with schedules of start-up operations. As was the case with the previous repairs, certain process systems were not ready for finishing repair operations. For example, it was necessary to bring the lubrication system into operation to perform the turbine shaft line repair (rotor alignment, half-coupling pairing, etc.); however, the said system turned out to not be ready due to the fact that the repair of the turbine main oil tank and the generator shaft oil seal both began. The plant ran into the same problem with oil pouring into the generator shaft oil seal – newly poured turbine oil did not meet the requirements for the content of mechanical admixtures and moisture; it took a lot more time to bleed the SC and SU systems than expected, causing a delay in the assembly of the TS bearings and installation of the TS onto the shaft barring gear. Downtime was forced onto the *JSC TEM* repair personnel – whose deputation was about to end at this point – due to the VC, SC, and SU systems not being ready. This resulted in forced delays at the final stage of the repair that delayed completion of the overall TS repair despite the turbine and TG repairs being performed according to the schedule.
  Repair of TS auxiliary systems should begin during the first part of repairs, not the third one.
  Readiness of turbine and flame resistant oils for being poured into oil tanks should be ensured at least a week prior to the completion of repair of equipment of respective oil systems.
- The 2018 PPM revealed impurities inside the tubes during eddy-current inspection of the heat-exchange tubes (HETs) of SG No. 2. There had been impurities inside the SG No. 2 HETs during the previous inspection back in 2014, according to *JSC NIKIMT-Atomstroy* representatives. The amount of impurities grew, according to the latest inspection results. This is why it is **necessary to plan for washing of SG No. 2 tubing during unit overhauls**. Impurities inside HETs negatively affect SG operational performance and cause tubes to corrode; this can lead to premature SG replacement, a very expensive ordeal.
- Recurrent problems with fasteners and seals of SG flange joints forces modifications involving switching to extended graphite gaskets. Use of graphite gaskets decreases load on studs, washers, and nuts, thus helping increase their service life and making sealing operations slightly easier since graphite is a less "demanding" material than nickel.
- The footage of the TV inspection of the weld joints between the HETs and SG No. 2 revealed that a large piece of work-hardened surface. Comparing this footage with the one from the previous inspection of SG No. 2 that was completed in 2014 helped determine that header surface damage grew since then. This suggests that there was a foreign object inside the main coolant pipeline (MCP) area spanning from the reactor to SG No. 2. **It is necessary**

to inspect the pipeline using a special TV system to confirm or disprove this hypothesis. However, there were attempts to use available equipment not specifically designed for this purpose to inspect it due to the fact that there is no such special TV system at the *Bushehr* NPP; these attempts yielded no results. No foreign objects are allowed inside the primary circuit due to safety concerns. All Russian NPPs use systems designed for visual inspection and removal of foreign objects from inside MCPs during repairs involving primary circuit equipment decompression; the *Bushehr* NPP does need such a system, too.

- The *Bushehr* NPP metal laboratory quality control group employees and *TAPNA* engineers are to be present during inspections in the course of unit repairs; the quality control group employees worked around the clock while *TAPNA* personnel worked only day shifts thus often forcing downtime on repair personnel forced to wait for engineers to come to work. To help bring down repair duration, *TAPNA* personnel need to be present – around the clock, if need be – during inspections.
- The *Bushehr* NPP metal laboratory issued metal inspection reports with significant delays (up to one week), slowing down the decision making process and the overall work performance. The Principal's managers claimed they could do nothing about the delays quoting the extreme workload of the metal laboratory personnel as the reason.
- Insufficient flexibility and speed of machining station operations at mechanical shops during repair of parts and manufacturing of repair tooling and accessories. Equipment repair was dragged out during the 2018 PPM due to requests for machining station operations being processed unacceptably slowly. The available nomenclature of steel grades for manufacturing of parts and accessory does not allow to fully comply with design documentation requirements. When preparing for repairs, it is necessary to supplement the nomenclature of materials to be procured for the mechanical shop.
- Many repair supervisors only organized communications between subdivisions and did not control the technological order of repair operations due to the lack of experience. It is possible to arrange training and on-the-job training of repair supervisors at Russian NPPs to deal with their lack of experience.
- Iranian specialists of the *TAPNA* CDD lacking experience developing repair documentation results in the need for continuous supervision of their work. Specialists of the *TAPNA* CDD need to go through training and long on-the-job training at Russian NPPs to be able to work without supervision.
- Special clothes and footwear were exposed to additional radiation exposure and contamination due to subpar decontamination of Reactor Compartment (RC) equipment and rooms – particularly of the floors of room No. 801 of the ZA building central hall (CH) – by personnel of the Principal.

- The completed PPM showed that the *Bushehr* NPP needs to procure equipment and devices that help bring down unit repair duration. This means, first and foremost, SG shutoff devices; they allow inspecting metal regardless of the primary circuit coolant level. The *PPM-2018* refueling took a month; 2 (two) SGs could be inspected during this time had shutoff device been available. Shutoff devices are necessary to make sure unit repair deadlines are met since 2-3 (two to three) SGs will be scheduled for metal inspection during the next PPM.
- It became obvious that a SG tubing draining device needs to be procured to bring down the time required to prepare for SG metal inspection. The equipment that the *Bushehr* NPP currently uses for this purpose is bulky, requires a lot of time to install/dismantle, and is not efficient enough. Russian NPPs have switched to equipment that allows them to drain tubing of one SG in 6-8 (six to eight) hours, while it takes the *Bushehr* NPP 2-3 (two to three) days to do the same job.
- One of the problems associated with automatic process control system-related works is the lack of rooms for storage of tools, accessories, and equipment (that was prepared for installation/dismantling). For example, the *JSC TEM* room was used in the Turbine Compartment (TC); additional crates with tools stored in this very small room inconvenienced the personnel working there. Another example is that in the CAA, tools were stored inside the RCP EE repair stand in the CH; anyone could use them at any time. The Principal was not able to allocate dedicated rooms quoting the lack of such rooms as the reason.

Documentation

- The procedure for handover of additional scopes of work to the Contractor still has not been formalized (despite *JSC RusAS* having handed the draft procedure to the *Bushehr* NPP/*TAPNA* as far back as during the 2015 Overhaul No. 1). The lack of the said procedure still results in documents justifying additional scopes of work – both newly handed over for repair and arising during repairs following flaw detection – taking a long time to agree. It is worth mentioning that the process of gathering agreeing signatures is often complicated by conflicting opinions of various Iranian specialists on specific additional works; this can result in failure to sign documents, among another things.
- During preparation for PPMs, requests for regulatory technical documentation necessary for equipment repair under Bills of Quantities for Iranian specialists are not filled out and sent to the *TAPNA* technical archive. This means that repairs are performed in partial violation of regulatory documentation. It is necessary to issue technical documentation for work places for IRI repair companies prior to PPM commencement so repair personnel can read through it.

3. Commendable Practices Observed During Repair Preparation and Performance

- In order to fulfill their obligations, *TAPNA* representatives engaged *JSC TEM* specialists under Appendix No. 7 to the Contract; the said specialists provided consulting services during the repair, did actual repair work, and prepared spare parts for the TS equipment. Respective specialists of the *TAPNA* RMRS and SERS were assigned to the said consultants. Engaging *JSC TEM* specialists in the Principal's area of responsibility helped solve a lot of organizational and technical issues related to the TS repair and share experience with the *TAPNA* RMRS and SERS.
- It was possible to highly engage the plant management during the PPM; this ended up being one of the key reasons it was possible to optimize unit repair duration. *Bushehr* NPP managers and specialist were actively involved with solving problems arising during repairs.
- An efficient metal laboratory quality control group was created. The group specialists independently oversaw repair operations; this significantly improved the work quality.
- A system for supervision of repair operations was introduced at the CAA and the FAA; it involved allocation of computerized work places to supervisors and made it possible to quickly sort out work-related issues.
- Shift Chief Engineers chaired meetings at repair HQs; this made it possible to quickly make technical and organizational decisions. First, daily briefings and meetings at repair HQs were held with the Russian personnel, then with the Iranian one.
- We would like to praise the good organization of timely preparation of documents for letting people carry out work orders by the *Bushehr* NPP Workplace Safety Department and Radiation Safety Department. There were no failures to issue work orders, as there were no delays due to them.
- We would like to praise the good organization of work at the Whole Body Counter (WBC) Laboratory; the laboratory personnel worked even during weekends and holidays if it was required. All repair personnel went through the WBC evaluation in due time and was issued personal dosimeters and personal protection equipment at the CAA in due time.
- Transfer of personnel to the NPP site and back to the camp after work is well organized. Buses adhered to the schedule.
- The NPP site cafeteria and the camp restaurant work well. All repair personnel had meal tickets and the cafeterias mostly followed the schedule throughout the PPM.
- NPP specialists get more experienced and undeniably get more professional over time.

4. Suggestions for Improving Organization and Performance of Maintenance and Repair

- Create departments (groups) for engineering support of repairs for all possible areas of focus.
- Create a repair team for STs and their equipment inside the *TAPNA* repair department.
- Ensure that Main (Planned) Bills of Quantities for upcoming PPMs are ready (agreed) no later than 6 (six) months prior to an expected repair commencement date and ensure that *JSC Rusatom Service* scopes of work (labor expenses) under Main Bills of Quantities are agreed no later than 3 (three) months prior to an expected repair commencement date (as stipulated by Item 5.1 of the Contract).
- Ensure that OEM and specialized tooling are stored in warehouses between repairs and that such warehouses are able to ensure appropriate storage and preservation.
- Ensure that spare parts and materials necessary for repairs are available at the NPP warehouses, as well as that they are available no later than 1 (one) month prior to an expected repair commencement date so that they can be checked.
- Ensure that spare parts and materials are issued only upon presentation of necessary accompanying documentation (incoming control certificates and/or other certificates).
- Applications for regulatory technical documentation necessary for equipment repairs are to be submitted to the *TAPNA* technical archive 1 (one) month prior to a PPM commencement date. Documentation for work places is to be issued prior to a PPM commencement date.
- Arrange recurrent training (continuing training) for engineers and repair personnel at the training center. Arrange additional theoretical and practical training for repair personnel teaching them how to use various repair equipment (nut drivers, grinders, etc.) no later than 1 (one) month prior to commencement of all PPMs.
- Continue improving systems for management and supervision of repairs. Arrange training for supervisors, including training on NPP equipment and systems.
- Assign specialists of the design group of the *TAPNA* CDD to various equipment-related areas of focus (rotating machines, pipelines, valves, vessels, and non-standard equipment).
- To help bring down repair duration, it is necessary to ensure that *TAPNA* engineers are present – around the clock plus upon request, if need be – during inspections.
- Consider optimizing how the *Bushehr* NPP metal laboratory works during PPMs to help bring down the time it takes to issue reports.

- Consider improving and optimizing how repair and mechanical shops work during PPMs to help bring down the time of processing of applications for machining station operations.
- Create an accurate (up-to-date) universal *BNPP-1* equipment database.
- During long-term and yearly planning (e.g. repair of pumps and EEs and sensor calibration), use to the full such approach to the repair that implies repair of a given piece of equipment by only one responsible entity.
- It is necessary to ensure the use of the comprehensive approach during the development of local schedules for repair of technological systems and of schedules of power-up operations for these systems and the unit as a whole; the goal is to prevent unnecessary downtime during the final stage of repairs. The said schedules should be interconnected at the agreeing stage and followed to the letter at the repair and power-up stages. When necessary, schedules of start-up operations should be quickly adjusted based on analysis of repair progress. It is necessary to establish personal responsibility for completion of power-up operations and tests, as well as better ensure completion of schedules of start-up operations.
- It is necessary to agree local repair schedules with those tasked with completion of works (contractors).
- Include turbine set balancing into post-PPM start-up schedules.
- Present the history of defects of equipment to be repaired to the Contractor; this should be done as a part of the preparation for equipment repair.
- Develop and implement a procedure for handing additional scopes of work over to the Contractor. During repairs, additional works should be handed over to the Contractor simultaneously with filling out of appropriate handover certificates.
- It stands to reason to draw up terms of reference for sophisticated equipment (such as reactors, generators, turbines, and RCPSs); such terms of reference should detail expected scopes of works, distribute responsibility for completion of preparatory and other works, and be attached as Appendices to Bills of Quantities.
- Factor in scopes of work of related subdivisions and, if need be, make adjustments when planning equipment repair.
- It is necessary to identify the reasons behind the formation and the nature of the sediments inside the SG No. 2 HETs. Develop and implement measures for sediment removal.
- It is recommended that you remedy all revealed defects and prepare the polar crane and refueling machine equipment for long-term storage once PPMs are over.
- Overhaul the repair personnel housing (replace pipelines, equipment, furniture, etc.) to bring it up to the standards mentioned in the contact. Ensure that the living condition in the Morvarid camp are up to the the

standards mentioned in the contact no later than 2 (two) weeks prior to the arrival of Russian repair personnel.

- Install protective screens between work places near RCPS EEs and pump mechanical parts.
- Fence off work places near the most critical equipment (RCPs, SGs, pressurizers, and ECCS hydraulic accumulators) with portable fences with warning tape, as well as restrict access to such areas for personnel of other companies who are not involved with ongoing works there.
- Procure 2 (two) sets of *Standard Supreme FME Cabinet* accessories manufactured by *TY-FLOT* (or analogous sets) for protection of equipment by means of foreign material exclusion.
- Ensure that measures for exclusion of foreign materials from open cavities of equipment are included into work orders, as well as ensure implementation of these measures when granting access to work places.
- Install additional portable lighting at work places at SG and RCPS compartments.
- Find a centralized place for storage of straps in the RC CH.
- Provide protective containers that can be securely closed for storage of small parts of seal units and RCPS radial axial bearings (RABs) inside RCPS compartments.
- Manufacture polymer protective pads for protection of RAB parts during temporary storage.
- Decontaminate RC rooms every day.
- Provide tested racks for washing and drying RCPS EE stators.
- Provide a container for storage of the RPVH fasteners and tools (wrenches) at the RC CH.
- Provide the Contractor with working and tested hoisting machines.
- Decontaminate the personnel lock floors (locker room for personal clothes, locker room for work clothes, and washroom) every day.
- Provide the Contractor's personnel working at the CAA with hardhats.

You can find the recommendations for the spare parts to be made available for the 2019 *Bushehr* NPP PPM in Table No. 7.

Table No. 7

Recommendations for Spare Parts to be Made Available for 2019 *Bushehr* NPP PPM

No.	Suggestions	Source of Funding
1.	Below is the list of the spare parts to be included into supply orders: - inserts and welding materials for rotor blade repair - spare part sets for the SN and SU pumps according to the OEM documentation - set of springs for spring units of pressure plates and outer rings of front parts of generator winding - spare part set for the *38-CK016M* control system according to *JSC NIKIMT* recommendations - at least 1 (one) RPVH neutron and temperature measuring channel flange	Spare part supply contract
2.	Ensure that full sets of fasteners for SG flange joints to be repaired are available at the *Bushehr* NPP site by the time PPMs begin.	Spare part supply contract

5. Suggestions for PPM Duration Optimization and Equipment Reliability Improvement

Table No. 8

No.	Activities	Possible sources of funding	Implementation deadline
1.	Develop a list of the most complex equipment that does not have repair documentation and order M&R Manuals for such equipment. Such M&R Manuals are to contain: - M&R strategy, M&R categories, and the list of machines, tools, accessories, and materials necessary for repair activities - procedures for a) the use of methods and means of supervision of equipment condition and b) defect remediation - a) flaw detection, indicator value, and guideline requirements with which items should comply after repair and b) acceptance, testing, end-to-end supply, packaging, and transportation requirements	Contract No. CNT-EST/4100-1	Before *PPM-2019*
2.	Organize agreeing of a) substitute materials and non-original spare parts and/or b) their use according to the set procedure with original equipment manufacturers.	Contract No. CNT-EST/4100-1	Before *PPM-2019*
3.	Procure a special bench for hydraulic snubber performance testing and repair. Develop a hydraulic snubber M&R schedule.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2019*
4.	Procure a bench for repair of RCPS main joint sealing surfaces.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2019*
5.	Procure a TV system for visual inspection of MCP inner surfaces and foreign material removal.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2019*
6.	Procure a device for individual blowdown and draining of SG HETs.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2019*
7.	It is necessary to modify special systems to ensure reliability of equipment of *SK-series* special systems manufactured by *JSC NIKIMT-Atomstroy*.	Contract No. PPM/T-4100 and Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2019*

No.	Activities	Possible sources of funding	Implementation deadline
8.	Analyze whether it is possible to install additional hoisting equipment in the area of the RC CH where RCPS EEs are to be repaired.	Contract No. CNT-EST/4100-1	Before *PPM-2020*
9.	Procure special equipment for adjustment and testing of safety valving at the CAA and the FAA.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2020*
10.	Manufacture roller supports for repair of low and high pressure rotors (2 pcs (at least) and 1 pce respectively). Manufacture dummy shafts for repair of linings of bearings Nos. 1-8. Procure modern equipment for control and adjustment of TS flow parts and shaft lines.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2020*
11.	Procure SG shutoff devices to enable SG repair during refueling.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2020*
12.	Design, manufacture, and install additional biological protection for protection of personnel using *SK-27* systems and recovering surveillance samples; such protection is to be installed in the inspection well or the reactor internals inspection well.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100 P	Before *PPM-2020*
13.	It is necessary to appropriately modify LPCs Nos. 1, 2, 3 with the OEM help to improve reliability of the *K 1000 60/3000 3*-series turbine and ensure the expected service life of the rotor blades of the 5th stages of the low-pressure rotors.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2020*
14.	It is necessary to perform such modification of oil control ring assemblies that includes installation of additional factory-made contact seals to prevent oil from spilling outside of turbine bearing housings.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-	Before *PPM-2020*

No.	Activities	Possible sources of funding	Implementation deadline
		2018/309/1575-D **C&A** – Contract No. PPM/T-4100	
15.	It is necessary to modify ST set equipment according to recommendations of *CJSC Power Machines* to ensure the intended mode of operation of the *SG* sealing system.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2020*
16.	Procure a TV system for distant visual inspection of the Protective Tube Unit and the Core Barrel.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2020*
17.	Introduce an in-mast fuel sipping test system that can be used during fuel assembly handling.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2020*
18.	Analyze the possibility to design and construct an additional building for CAA equipment repair.	Contract No. CNT-EST/4100-1	Before *PPM-2021*
19.	It is necessary to perform such modification of SGs that includes switching to extended graphite gaskets for sealing.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2021*
20.	Procure a group SG flange joint nut driver that does not require a polar crane.	Contract No. SP-	Before

No.	Activities	Possible sources of funding	Implementation deadline
		BNPP-1-2018/309/1575-D	*PPM-2021*
21.	It is necessary to ensure the ability to use test benches to ensure a) quality of repair of and b) performance of pressurizer PSDs and ECCS PSDs. The possibility of such activities was factored in when designing both types of PSDs. It is necessary to develop a project and install necessary pipelines and valves to perform such activities.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2021*
22.	Procure a *SIGO-1* system to help bring post-PPM containment testing time down.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2021*
23.	Consider procuring alternative devices (that proved to be worthwhile at Russian NPPs) for automatic inspection of SG metal.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2022*
24.	Procure manipulators for remote repair and control of defective SG HETs; such manipulators are to come with repair units, SG HET draining units, and SG HET integrity testing units using the bubble method.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2022*
25.	It is necessary to modify the Main Steam Isolation Valve control line by replacing the existing valves manufactured by *MK Splav* with more reliable and repairable onces to improve reliability and repairability of the Main Steam Isolation Valve.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2022*
26.	Procure nut drivers for flange joints of RPVS nozzles to improve equipment reliability and reduce	Contract No. SP-	Before

No.	Activities	Possible sources of funding	Implementation deadline
	repair time.	BNPP-1-2018/309/1575-D	*PPM-2022*
27.	Procure a water purification system for removal of impurities from the fuel pool.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2021*
28.	Modify the refueling machine control system to help bring FA handling time down.	**PD** – Contract No. CNT-EST/4100-1 **E2TES** – Contract No. SP-BNPP-1-2018/309/1575-D **C&A** – Contract No. PPM/T-4100	Before *PPM-2022*
29.	Procure a nut driver for simultaneous automatic elongation of all studs for decompression and sealing of the reactor main joint.	Contract No. SP-BNPP-1-2018/309/1575-D	Before *PPM-2022*
30.	Continue engaging OEM supervision engineers during PPMs.	Contract No. CNT-EST/4100-1	Permanently

Abbreviations:

PD (project development) – development of terms of reference, initial technical requirements, and other project documentation.

E2TES (end-to-end equipment supply) – supply of necessary equipment, spare parts, and materials for modification.

C&A (construction and assembly) – installation and adjustment of new equipment; modification of existing equipment.

Conclusions

- The results of the Third Medium Repair of Unit No. 1 of the *Bushehr* NPP show that a high level of organization of unit PPM has been reached. The NPP administration and specialists treated the preparation for and the performance of the PPM responsibility. It is necessary to continue improving the systems for M&R of the NPP equipment and systems according to the recommendations mentioned in Item 9.

- It is necessary to begin implementing the suggestions mentioned in Item 10 to improve the safety of operation and ensure safe and efficient performance of NPP equipment and systems.

- It is necessary to continue manning NPP subdivisions with highly qualified specialists.

- It is necessary to develop a system for advanced professional training and continuing training of repair personnel.

- It is necessary to develop informational systems for M&R management.

- It is necessary to continue procuring highly efficient hardware, tools, and tooling for equipment repair.

- It is necessary to ensure availability of repair documentation at the NPP.

- It is necessary to improve the system of organizational and technical measures to ensure compliance with the occupational and radiation safety requirements and the rules for work with decompressed equipment.

- It is necessary to overhaul the repair personnel housing to bring it up to the standards mentioned in the contact.