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| **\*\* Note:** |  |  |
| **\*\* Station:** | Bushehr Unit 1 |  |
| **\*\* Event Date:** | 04 December 2109 |  |
| **\*\*Title:** | Actuation of reactor Emergency Protection in the Minimum Controllable power Level (MCL) due to appearance of defect in the complex.1of NFME (Neutron Flux Measuring Channels of the complex.1) |  |
| **\*\*Reference Unit:** | Unit, Year Commercial: Bushehr 1(2012)Reactor Type (size): VVER 1000 / V-446 (PWR)Plant Designer: AEPPower: 0 MW |  |
| **\*\*Station Event:** | Unit event |  |
| **Summary:** | On 04.12.2019, at 16:23, when reducing the reactor power from the power level about Nнейтр.= 2 % Nном to the power level about Nнейтр.=0.04 % Nном , due to the defect in 2 channels out of 3 neutron flux measuring channels of the complex.1 of reactor emergency protection system at the time of transition from working range 1 (WR1) to initiating range (IR), and due to formation and issuance of reactor emergency protection (EP) signal in complex.1 of reactor Emergency Protection (EP), all the reactor control rods were de-energized and dropped inside the reactor core according to the algorithm. | **Station Status -** 135 - Decreasing power – 100% to 0% |
| **Event units:** | No others |  |
| **References:** | None |  |
| **Report Description:** | On 04.12.2019, at the MCL: neutron power = 0.04 % of the NNom, 3 RCPs and main & auxiliary equipment of the reactor were operating according the schedule of switchback to backup equipment. The RCP No.2 was shut down.The start of the process of reactor power reduction from the power level about Nнейтр.= 20 % Nном to power level Nнейтр.= 2 % Nном by lowering the control rods of group 10 from the position of 182 cm from the bottom of reactor core, and at the same time injecting acid boric gradually and in multiple stages. The order for reactor power reduction has been issued by the Shift Supervisor.later on, the process of reactor power reduction from the power level about Nнейтр.= 2 % Nном  to the power level Nнейтр= 0.02 % Nном took place by lowering the control rods of group 10 from the position of 112cm from the bottom of reactor core, and injecting acid boric momentarily and in multiple stages;At 16:19:00, occurrence of defect and charging of module capacitors at the time of power changes caused the increase of the power to more than the actual value in the NFME cabinets, failure in automatic transition of the channel 3 (A) from Working Range 1 (WR1) to Initiating Range (IR) and formation of the error signal in the Complex.2 of the reactor emergency protection system.As the result of formation of the error signal, the reactor emergency protection (Logarithmic Diapason> setpoint) turned to “1” (third signal of channels A, B and C of the complex.2 of the reactor emergency protection). It should be explained that since only one signal out of three signals of each of the A, B and C channels of emergency protection has been actuated and the second signal has not been formed, therefore, the Complex.2 of the emergency protection has not been actuated.* At 16:19:00, occurrence of defect and charging of module capacitors at the time of power changes caused the increase of the power to more than the actual value in the NFME cabinets, failure in automatic transition of the channel 1 (A) from Working Range 1 (WR1) to Initiating Range (IR) and formation of the error signal in the Complex.1 of the reactor emergency protection system.

As the result of formation of the signal, the reactor emergency protection (Logarithmic Diapason> setpoint) turned to “1” (first signal of channels A, B and C of the complex.1 of the reactor emergency protection).* At 16:23:09, due to bad contact in one of working condition monitoring cards in the channel.3 (C) of the NFME cabinet, the malfunction signal was issued and the error signal in the complex.1 of the reactor emergency protection system was formed.

As the result of formation of the signal, the reactor emergency protection (Logarithmic Diapason> setpoint) turned to “1” (third signal of channels A, B and C of the complex.2 of the reactor emergency protection).the recorded values of the reactor neutron power before the actuation of the reactor emergency protection for the channels 1, 2 and 3 of the complex.1 were 0.008%Nном, 0.012%Nном and 0.032%Nном, respectively, and after the actuation, 0.009%Nном, 0.01%Nном and 0.14%Nном, respectively.considering the fact that in each of channels A, B and C of the Complex.1 of the reactor emergency protection, 2 out of 3 signals were actuated, therefore, all three channels A, B and C of the aforementioned complex were actuated and the emergency protection signal was formed.Generally, the defect signal of NFME is formed and issued in the form of the power emergency protection signal, and because the power range was within the initiating range (IR), emergency protection signal was issued from NFME cabinets to the SLPE cabinet. Therefore, at this time, due to these signals being issued by the NFME cabinets to SLPE cabinet of complex.1 of reactor emergency protection system, the “2 out of 3” signal was formed.At 16:23:09:997, after forming and issuing the emergency protection signal from the SLPE cabinets of complex.1 of reactor emergency protection system, consequently, the command for implementing this signal via related ECC cabinets was issued that caused the opening of 380V D.C. and 110V A.C. contactors in the cabinets and finally the drop of all control rods into the reactor core. Increase of boric acid concentration of the primary circuit up to 8.34 gr/dm3 and announcing the reactor “hot shutdown” state. | **Station Activity -** 03- Reactivity manipulations or reactivity management**System(s)-** 735-In-core and ex-core neutron monitoring |
| **\*\*Consequences:** | duration of plant shutdown due to occurrence of event: 0 hourloss of electric energy production: 0 MWh |  |
| **Report Analysis and Comments:** | Based on the analysis performed on the equipment and neutron powers measured by NFME sensors in the logarithm working measuring ranges (WR-1) and initiating ranges (IR) in two complexes of reactor emergency protection system in the time interval of 16:18:44 ÷ 16:23:09, it was specified that at the time of reduction of neutron power and transition of the NFME channels from working range 1 (WR1) to initiating range (IR) , the failure of the module in the cabinet and the existence of bad contact in the NFME card and the formation of error signals in the channels A and C in complex.1 of reactor emergency protection system resulted in actuation of reactor emergency protection and reactor shutdown at 16:23:09.Direct causes: * Failure and charging of capacitors of the current to frequency converter module (PPN-111R1) in the cabinet at the time of power changes that caused the incorrect display of power value more than actual value.
* The existence of bad contact in working condition monitoring card (PUM-451R) of channel C of complex.1 of emergency protection system in the cabinet at the time of power changes that caused the incorrect display of power value more than actual value.

Root causes: * Hidden factory defect in the current to frequency converter module (PPN-111R1) in the NFME cabinet and existence of bad contact in the working condition monitoring card
 | **Component(s(-**110- Neutron flux (detectors, ion chambers, associated components)**Consequence(s)-** 02- Station transient**Category-** 7- Deficiencies of design, installation, operation, maintenance**Group(s)-** 210-Shift – control room operators**Direct cause** –0502 - False response, loss of signal, spurious signal 0206- Bad contact, disconnection**Root cause(s)-** 2102-Manufacturer fabrication /construction inadequate |
| **Corrective Actions:** | 1. conducting thorough Investigation and technical services of current to frequency modules (PPN-111R1 and PPN-111R) of BPH cabinets during the outage and replacing modules in case of detecting any appearance and technical defect in their capacitors.
2. replacing the current to frequency converter modules (PPN-111R1) in the working condition monitoring cabinets (BPH-63R)
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| **Note:**  |  |  |
| **INES Level:** | 0 |  |
| **Station Status:** | 135 - Decreasing power – 100% to 0% |  |
| **Station Activity:** | 03- Reactivity manipulations or reactivity management |  |
| **Direct cause:** | 0502 - False response, loss of signal, spurious signal 0206- Bad contact, disconnection |  |
| **Category:** | 7- Deficiencies of design, installation, operation, maintenance, |  |
| **Consequence(s)\*:** | 02- Station transient |  |
| **System(s)\*:** | 735-In-core and ex-core neutron monitoring |  |
| **Component(s)\*:** | 110- Neutron flux (detectors, ion chambers, associated components) |  |
| **Group(s)\*:** | 210-Shift – control room operators  |  |
| **Root cause(s)\*:** | 2102-Manufacturer fabrication/construction inadequate |  |
| **Causal factor(s)\*:** | ***-*** |  |
| **List Attachments:** | \_ |  |
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