Prediction of Remaining Useful Life for Components in SSC of RSG-GAS Based on Reliability Analysis

Entin Hartini\textsuperscript{1}, Endiah Puji Hastuti\textsuperscript{1}, Geni Rina Sunaryo\textsuperscript{1}, Aep Saepudin\textsuperscript{2}, Sri Sudadiyo\textsuperscript{1}, Amir Hamzah\textsuperscript{1}, Mike Susmikanti\textsuperscript{1}

\textsuperscript{1}Research Center for Nuclear Reactor Technology and Safety, BRIN, Kawasan Paspiptek, Tangerang Selatan, 15310, Indonesia
\textsuperscript{2}Center For Multipurpose Reactor, Kawasan Paspiptek, BRIN, Tangerang Selatan, 15310, Indonesia

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\textbf{ABSTRACT}

In the maintenance system, efforts are needed to improve the effectiveness of the maintenance system and organization. For effective maintenance planning, it is necessary to have a good understanding of component availability and the reliability of the system. For this reason, it is crucial to determine the remaining component life using Remaining Useful Life (RUL), so that maintenance tasks can be planned effectively. The purpose of this study is to determine the remaining life of the safety category A component from SSC RSG-GAS based on reliability analysis. The method used in this paper is a statistical approach to estimate the RUL. The Weibull hazard model was selected for modeling the hazard function to be integrated into reliability analysis. The model was verified using data from components with safety category A on SSC from RSG-GAS. The results obtained from the analysis are beneficial for estimating the remaining useful lives of these components which can then be used to plan for effective maintenance and help control unplanned outages. The results obtained can be used for maintenance development and preventive repair planning.

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1. INTRODUCTION

The process of operating a nuclear reactor is determined by the SSC conditions to carry out its functions. In this case, the maintenance process plays a vital role in ensuring the availability of SSC. Therefore, an operation management system requires good SSC reliability. Its management is expected to be able to plan appropriate treatment for all SSCs, to support the operation and aging management system of RSG-GAS\textsuperscript{1}. It is necessary to develop a Computerized Maintenance Management System (CMMS) or a computer-based maintenance management system used to store and retrieve maintenance data. CMMS can handle data related to the frequency and duration of maintenance breakdowns and component costs\textsuperscript{2}. Reliability management is an activity to ensure that there are no SSC failures while the reactor is operating. Furthermore, it can optimize costs and minimize or eliminate failures and their causes\textsuperscript{3}.

Maintenance components are needed to improve the maintenance support system along with replacing traditional strategies with new ones such as RUL (Remaining Useful Life), which can estimate failure times for one or more existing components and failure modes in the future. Prediction of component/system life is aimed to predict RUL before failure, by looking at the current system conditions. Therefore, estimation of
component reliability and RUL are needed and crucial in maintenance optimization[4].

In recent years, the prediction of RUL has received more attention. It is vital to assess the RUL of an asset when it is used as it impacts the operational performance and profitability of an asset. Once an indication of failure has been detected, it is necessary to estimate the accuracy of the RUL to make timely maintenance decisions to avoid failure. Likewise, its reliability and estimation accuracy tends to result in accurate determination of the optimal inspection interval, thereby minimizing the overall cost of the system[5, 6].

RUL, which is the service life (remaining life) of a component or system at a certain time in the life cycle, is incredibly important for management integrity at a particular time[7–9]. Therefore, the ability to estimate the RUL of components and systems is beneficial for being able to employ different maintenance management strategies to optimize the life cycle phases of a component or system. In absolute terms, proactive management of the system that can be improved depends on the optimal estimation of the RUL and the reliability at various stages of degradation in the life cycle phases of components and systems[10, 11]. For this reason, many reliability estimation techniques, ranging from empirical to stochastic methodologies, have been proposed by researchers in the literature. To date, risk-based and reliability-centered maintenance techniques that incorporate predictive and condition-based maintenance strategies have been incorporated into the integrity of industrial asset management frameworks to maintain operating efficiency and enhance integrity [12].

Currently, Mean Residual Life (MRL) or RUL is recognized as a key feature in maintenance strategy, while true prognostic systems are rarely found in the industry. However, in estimating useful life, variations are found depending on the actual operating conditions and environmental characteristics, such as temperature and pressure, humidity conditions, and corrosion rates. Therefore, it is obvious that there exist many uncertainties that may lead to inaccuracy of the RUL estimation with its ability to predict and predict equipment degradation[13].

Evaluating an efficient component/system depends on classical limitations that limit, for example, the knowledge of available data, dynamics, and implementation requirements (precision, computation time, etc.). Therefore, implementing the RUL estimation method needs to be done on the safety component data A for RSG-GAS SSC to predict its remaining component life. These results can be used to optimize the maintenance system.

This research aims to estimate the expected value of the remaining life (RUL) of a component or system before failure from any time \( t \) based on the analysis of the reliability and the level of risk to optimize the life cycle phase of the component or system.

In this paper, the reliability method is used to estimate the RUL at a certain time \( t \). First, several theoretical points are explained, then followed by a case study and the use of the reliability method in determining the RUL. It is necessary to consider the following assumptions: (a) The most suitable distribution for the failure time of a mechanical component is the Weibull distribution. The Assumptions of Independence and Identical Distribution (iid) of the data must be ensured so that a process model such as Weibull can be used; (b) in reliability analysis, hazard level function is needed to estimate RUL of components with safety category A on SSC from RSG-GAS.

2. THEORY

Analysis of Reliability, Risk Level and Estimation of The Remaining Useful Life Of Components using Statistics

The Weibull distribution is the most widely used empirical distribution and appears in almost all products of failure characteristics because it includes all three phases of damage that may occur in the damage distribution. The Weibull distribution is used in special cases, assuming the baseline hazard has a two-parameter Weibull form. The parameters used in this Weibull distribution are \( \theta \) which is called the scale parameter and \( \beta \) which is called the shape parameter. The parameter \( \beta \) is useful for determining the level of damage from the formed data pattern and the scale parameter \( (\theta) \) affects the mean value of the data pattern. The probability density function of the Weibull distribution model is provided in Eq. 1[14].

\[
f(t) = \frac{\beta}{\theta} t^{\beta - 1} e^{-\left(\frac{t}{\theta}\right)^{\beta}} \quad t > 0
\]  

(1)

In the parameter estimation stage, the distribution parameter values will be determined, which is by the time data between component damage (TTF) with the least square method and Maximum Likelihood Estimation (MLE). Furthermore, the parameter values were substituted
into the formula for the level of risk, component reliability, and RUL.

Different types of failures were considered in the reliability analysis. Failure is defined as the inability of a component to timely perform the expected activities. In the reliability analysis, this data is collected in the form of time between failures (TTF), the time between maintenance (TBM), and for the topic of reparability in the form of repair time (TTR), time for corrective maintenance (TCM), time to perform preventive maintenance (TPM) and procurement and management downtime (TTD).

Four different functions are statistically defined to describe failures as follows: (1) the failure distribution is known as the probability density function (PDF) with the symbol f(t), (2) the cumulative distribution function (CDF) with the symbol F(t), (3) the joint function of F(t) is called the reliability function with the symbol R(t), and (4) the failure rate function or the hazard function with the h(t) symbol. The hazard level is considered as the rate at which failure occurs over a certain time \([t_1, t_2]\). This level is defined as the probability of occurrence of failure per unit time interval \([t_1, t_2]\) so that failure has not occurred before \(t_1\) (initial interval)\[6\].

The risk level is calculated to determine the intensity of the probability that the product will fail at a certain time with the hazard function model. The level of risk for the Weibull distribution is provided in Eq. 2\[7\].

\[
h(t) = \frac{\beta}{\alpha} \left(\frac{t}{\alpha}\right)^{\beta-1} \exp\left(-\left(\frac{t}{\alpha}\right)^\beta\right)
\]

System reliability is defined as the ability of a component or system to perform and maintain the required functions under certain conditions without failure for a specified time\[9\]. Equation (1) is applied to determine mathematically the reliability of the system \((R(x))\), where \(R(x)\) shows the reliability of the system (%) at time \(t\). Weibull reliability is expressed as

\[
R(x) = e^{-x^{\beta}/\alpha}
\]

### Remaining Useful Life (RUL)

Remaining Useful Life (RUL) or Mean Residual Life (MRL) is the time left for components to carry out their functional abilities before failure occurs. RUL can also be defined as the duration from the current time to the end of its useful life for a component (Figure 1).

**Classification of RUL Prediction Techniques**

There are several prognostic prediction methods used to determine the RUL of a subsystem or component. For Model-Based Prediction Methodology, RUL prediction can be applied to the Statistics and Computational Intelligence (CI) approach. This model is derived from configuration, usage, and historical failure data and applies to maintenance decision-making. Model-based methodologies are often used to estimate RUL thereby informing maintenance decisions based on failure thresholds, where the time-frequency feature allows more precise results than using only the time feature. Similarly, failure-derived methods and historical data can be used to predict the RUL of a component's assets\[8\].

**Estimated RUL**

RUL is widely used in reliability-based research \[3\]. The RUL is a component/system that is considered as the correct operating time remaining before the failure. RUL estimation is recognized as an important factor for condition-based maintenance (CBM) \[3\]. The remaining component life is the length of time that the component remains functional after a certain time. The mean residual life (L) is the meantime expected for failure to occur. RUL = MRL = \(m(t)\) expressed as

\[
m(t) = \frac{\int_0^t \beta t e^{\beta t/\alpha} dt}{\int_0^\infty \beta t e^{\beta t/\alpha} dt} - t
\]
3. METHODOLOGY

After entering the data, the relevant software is selected in the first step of the appropriate statistical approach, followed by the selection of an appropriate function or model of one of the main functions, for example, f(t) with the Weibull function. Furthermore, the cumulative distribution function F(t), reliability function R(t), the level of risk h(t), and then the remaining life of the component m(t) can be calculated using the available functions[6]. Data Processing Diagram on reliability analysis is shown in Figure 2[6]. Calculation of reliability and RUL were performed using Matlab code.

![Data Processing Diagram on reliability analysis](image)

Fig 2. Data Processing Diagram on reliability analysis[6]

4. RESULTS AND DISCUSSION

The evaluated data is component damage with Safety A category on SSC of RSG-GAS reactor for core configuration number (CCN) from 72 to 94 between the years 2010 to 2018. Damage data for the SSC component is presented in Appendix A.

Determination of the distribution of component damage data and estimated data distribution parameters (Weibull distribution). Furthermore, the Goodness of Fit Test for the TTF distribution for the selected distribution, namely Normal, Exponential, Log-Normal, and Weibull, The Anderson Darling test was used. From the parameter value estimation, the shape and scale parameter values are obtained.

The plot of the probability function to determine the goodness of fit test of the exponential, normal, lognormal, and Weibull distribution functions for the BRV10 component is shown in Figure 3.

![Probability Plot for C1](image)

Fig. 3. Results of Component Distribution Conformity

Test Electrical power supply (BRV10)

The value of the scale, shape, level of failure risk/damage rate h(t), and the reliability value of the component R(t) are presented in Table 1.

![Table 1: Level of Risk and Reliability for Components of Safety Category A on SSC from RSG-GAS](image)

Table 1. Level of Risk and Reliability for Components of Safety Category A on SSC from RSG-GAS

| Component                        | Scale (θ) | Shape (β) | T (day) | h(t)  | R(t)  |
|----------------------------------|-----------|-----------|---------|-------|-------|
| Electrical power supply, BRV 10  | 305.61    | 0.643     | 100     | 0.0031| 0.8100|
| Component                        | 250       | 0.0023    | 0.5906  |
| Diesel aggregates                | 500       | 0.0018    | 0.3488  |
| Emergency diesel aggregates      | 750       | 0.0015    | 0.2060  |
| Reactor system, JA               | 1000      | 0.0014    | 0.1216  |
| Reactor pool (Al-Lining)         | 400       | 0.0034    | 0.2391  |
| JAA01                            | 600       | 0.0043    | 0.1169  |
| Measuring point of the process   | 800       | 0.0050    | 0.0572  |
| Reactor pool purification        | 1000      | 0.0025    | 0.1344  |
| KBE01                            | 390.42    | 0.979     | 0.0026  | 0.7781|
| Experimentation on system         | 250       | 0.0042    | 0.2868  |
| Reactor pool, Rabbit             | 500       | 0.0034    | 0.0823  |
| systems:                         | 750       | 0.0030    | 0.0236  |
| KBE01                            | 1000      | 0.0027    | 0.0068  |
| Experimentation on system         | 309.36    | 1.250     | 0.0026  | 0.0019|
| reactor pool, Rabbit             | 1250      | 0.0013    | 0.0718  |
| systems:                         | 800       | 0.0025    | 0.1344  |
| JBB                              | 139.08    | 0.694     | 0.0026  | 0.7790|
|                                  | 90       | 0.0068    | 0.7790  |
|                                  | 250       | 0.0042    | 0.2868  |
|                                  | 500       | 0.0034    | 0.0823  |
|                                  | 750       | 0.0030    | 0.0236  |
|                                  | 1000      | 0.0027    | 0.0068  |
|                                  | 300       | 0.0040    | 0.2973  |
|                                  | 450       | 0.0044    | 0.1621  |
|                                  | 600       | 0.0048    | 0.0884  |
|                                  | 150       | 0.0034    | 0.5452  |
|                                  | 300       | 0.0040    | 0.2973  |
|                                  | 450       | 0.0044    | 0.1621  |
|                                  | 600       | 0.0048    | 0.0884  |
|                                  | 750       | 0.0051    | 0.0482  |
From Table 1, the remaining useful life is calculated for components with safety category A on SSC from RSG-GAS can be observed. The calculation results of the RUL values are shown in Table 2 and Figure 4.

**Table 2. Remaining Use Life (RUL)**

| Component                                      | RUL (day)   |
|------------------------------------------------|-------------|
| Electrical power supply, B (BRV 10)            | 422,029,257 |
| Component Emergency diesel aggregates          | 389,165,201 |
| Reactor system, JA Reactor pool (Al-Lining)    | 393,941,075 |
| Measuring point of the process systems:        | 177,336,069 |
| Reactor pool purification KBE01                |             |
| Experimentation system reactor pool, Rabbit    | 288,091,532 |
| systems (inside the reactor pool) (JBB)        |             |
| Experimentation system reactor pool, JB        | 71,124,6625 |
| Control rods drive and suspension (JDA)        | 472,436,212 |
| Cranes and hoist, SM Crane, Reactor Building  |             |
| Measuring point of the process systems: Pool   | 429,052,117 |
| cooling system JNA 20                           |             |
| Out of core temperature and neutron flux       | 77,951,269  |
| measurement JKT 02                             |             |
| Out of core temperature and neutron flux       | 77,951,269  |
| measurement JKT 03                             |             |

The remaining component life (RUL) was calculated from the year 2010 (t1), namely the time of the last year’s component failure data, until the year 2018. The remaining component life for the electrical power supply component, B (BRV10) Component emergency diesel aggregates, electrical power supply, B (BRV20) Component emergency diesel aggregates, reactor system, JA reactor pool (Al-Lining) JAA01, measuring point of the following process systems: reactor pool purification KBE01, experimentation system reactor pool reactor, rabbit systems inside the reactor pool (JBB), experimentation system reactor pool, JB control rods drive and suspension (JDA), cranes and hoist, SM crane, reactor building, measuring point of the process systems: pool cooling system JNA 20, out-of-core temperature and neutron flux measurement JKT 02 and JKT 03, are consecutive: 422.029, 389.165, 393.941, 177.336, 288.091, 71.124, 472.436, 429.052, 77.951, and 77.951 days.

RUL estimation can provide information and data input for maintenance management to determine the appropriate and efficient treatment strategy. Strategy determination is the process of selecting components from the system with the lowest RUL value, so that replacement can be carried out before more serious damage occurs.

As seen in calculation results in Table 2, the estimation of RUL of RSG-GAS components is derived by projecting out the failure prediction during operation. This prediction assists to improve the operating conditions and protective measures, and hence avoid serious failures. Consequently, data in Table 2 should be compared with adequate litera for course estnensure of the methodology used in the present study. As in the cases studies inspected herein, the failure model of RUL was simulated using Fortran code-based on the estimation method of Ref.[14] and by applying Weibull distribution predicated on Ref.[6]. The results of the comparison for the RUL simulations are plotted in Fig. 5. It can be noticed in Figure 5 that the present study has the RUL estimation.
The effective prediction of RUL encourages fast maintenance, repair, and overhaul (MRO) decision making and increases the availability of reliable SSC RSG-GAS components for use. The results presented can be used for preventive maintenance planning based on failure probability or RUL. This can reduce regular maintenance costs and increase operational efficiency, as well as a guide for care management to make fast maintenance and better decisions. In the future, there will be more focus on estimating RUL based on the context of which parameters are more influential to be considered to achieve a more realistic approach and outcome. Prediction techniques by mapping techniques against data types can enable the selection of relevant modeling methodologies.

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AUTHOR CONTRIBUTION

All authors contribute together as the main contributors to this paper. All authors read and approved the final version of the paper.

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APPENDIX

Damage Data for Components with safety category A on SSC from RSG-GAS

| Component | Date of Damage | TTF | Type of Damage |
|-----------|----------------|-----|----------------|
| Diesel BRV 10 CW heater fault cannot be reset | 24/11/2010 | 0 | Electrical power supply, B (BRV 10) Component: Emergency diesel aggregates |
| Day tank brv10 over scale danosilasi | 08/05/2012 | 531 | |
| Fuse BRV10 break | 07/02/2014 | 640 | |
| BRV10 cannot be operated | 26/02/2014 | 19 | |
| BRV10 fault mechanic at RKU in local is not fuel | 15/05/2014 | 78 | |
| BRV10 electrical fault occurs repeatedly | 20/05/2014 | 5 | |
| Diesel BRV 10 water pump water line is leaking | 16/06/2017 | 1123 | Electrical power supply, B (BRV 20) Component: Emergency diesel aggregates |
| The flexible radiator hose for diesel generator no.2 (BRV20) is leaking | 21/05/2011 | 0 | |
| BRV20 water pump water line is leaking | 28/06/2013 | 769 | |
| The flexible radiator hose for diesel generator no.2 (BRV20) is leaking | 03/12/2014 | 523 | |
| Charger BRV20 tidak berfungsi/rusak | 26/03/2015 | 636 | |
| BLV20 charger does not work/is damaged | 01/06/2015 | 67 | |

| Component | Date of Damage | TTF | Type of Damage |
|-----------|----------------|-----|----------------|
| JAA Reactor pool (Al-Lining) | 29/09/2015 | 100 | Reactor system, JAA Reactor pool (Al-Lining) JAA01 |
| BRV20 fault | 09/05/2016 | 343 | |
| BRV20 fault | 09/05/2016 | 343 | |
| BR V 20 | 27/02/2017 | 294 | |
| Operates without anyone knowing | 03/04/2011 | 0 | |
| The JAA01 CL001 indicator points to 0 m | 27/08/2011 | 146 | |
| The JAA01 CL811/821/831 designation <12.41 m | 13/09/2011 | 17 | |
| The JAA01 CL811 reading level is below the minimum limit | 17/01/2012 | 126 | |
| A noise is heard on KBE 01 AP 001 KBE01 | 01/04/2010 | 0 | |
| The KBE01 AP001 pump is inoperable | 08/08/2013 | 1225 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 16/01/2014 | 161 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 28/01/2014 | 12 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 06/02/2014 | 9 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 24/02/2014 | 18 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 01/04/2014 | 36 | |
| The KBE01 pump designation CP001 at RKU shows the maximum KBE01 AP001 blink/fault (off) | 25/04/2014 | 24 | |
| No. | Date       | Description                                                                 |
|-----|------------|-----------------------------------------------------------------------------|
| 1   | 13/05/2014 | The system is dead, there is no power supply                                 |
| 2   | 21/07/2014 | There is a water leak dripping in the pump seal of the reactor purification system (KBE01 AP001) |
| 3   | 03/02/2015 | The KBE01 AP001 pump sounds rough                                             |
| 4   | 01/04/2016 | KBE01 AP001 sounds harsh                                                     |
| 5   | 22/03/2017 | The indicator is below the limit/drop                                        |
| 6   | 14/05/2017 | KBE01AA01 0 valve cannot be opened/closed from RKU                         |
| 7   | 22/10/2017 | Experimentation system reactor pool, JBB                                       |
| 8   | 30/03/2010 | Experimentation system reactor pool, JBB                                       |
| 9   | 26/07/2010 | The JDA01 spindle is broken                                                   |
| 10  | 14/05/2011 | The radiation timer counter is abnormal (sometimes runs doesn’t)             |
| 11  | 07/05/2013 | MCB 4A on bit system JBB03 line 3 is broken                                 |
| 12  | 25/06/2013 | The solenoid valve cannot be turned on when the capsule returns to the drum |
| 13  | 04/03/2014 | The radiation timer counter is abnormal (sometimes runs doesn’t)             |
| 14  | 09/06/2011 | JDA07 control rod overload insert indicator light cannot turn on (off)       |

Other Events:
- Fault system, in the CXB02 Marshalling Kiosk the system is dead, there is no power supply on 13/05/2014.
- The KBE01 AP001 pump sounds rough on 03/02/2015.
- KBE01 AP001 sounds harsh on 01/04/2016.
- KBE01 AP001 Pump On Blink indicator cannot be reset on 22/03/2017.
- KBE01 AP001 sounds harsh on 14/05/2011.
- JDA06 faults frequently on 24/02/2013.
- JDA06 power supply module cannot be closed on 05/02/2014.
- JDA01 control rod overload insert indicator light cannot turn on (off) on 19/03/2014.
- Armatur Drop JDA02 Blink, cannot be reset on 20/03/2014.
- JDA06 when rod drop test, not responding to indicator on 28/04/2014.
JDA07 + 14 (Regard) cannot be downgraded manually. 

15/07/2014  26

JDA07 + 14 (Reg. Rod) cannot be lowered and triggered a blink fault. 

12/08/2014  28

JDA03 - 05 if compensated rise/fall a fault occurs. 

09/09/2014  28

During the rod-drop time test, the counter does not stop. 

87  05/01/2015  118

JDA03 + 10/12 oscillation analog indicator. 

89  27/08/2015  234

The control rod fell off on its own. 

28/09/2015  32

Self-falling. 

05/10/2015  7

The control rod fell off on its own. 

08/10/2015  3

The control rod falls by itself. 

27/10/2015  19

The regulating rod (JDA07) control rod does not move automatically. 

30/10/2015  3

JDA07 does not respond down when compensation is done, the control rod does not respond. 

02/11/2015  3

Control rod not responding JDA 08 + 12 is damaged. 

05/11/2015  3

After a scram event, the adjustment control rod (JDA07) cannot be automatic. 

05/02/2016  29

JDA04 at start-up crashed. 

91  25/07/2016  171

The designation JDA05 + 11 is defective, does not turn on. 

92  08/03/2017  226

JDA03 cannot go up / down JDA07 is not a couple. 

93  21/05/2017  74

Out of core temperature and neutron flux measurement JKT 03. 

94  01/12/2017  194

Control rod. 

95  07/03/2018  96

Cranes and hoist, SM Crane, Reactor Building. 

76  08/10/2011  0

Cranes and hoist, SMK 10 (13 m floor) electric power does not reach the hanging panel. 

77  10/01/2012  94

The SMJ 10 crane descends on its own (out of control). 

81  12/03/2013  427

Close the operation button on the 13th-floor crane partially off. 

91  10/05/2016  1155

The trolley cannot be operated left or right. 

95  02/01/2018  602

Cranes SMJ10 cannot be operated to the left (left) at a slow speed. 

95  26/03/2018  83

Temporary drop. 

78  14/05/2012  0

The JNA20 CP001 / 002 pipe always drops. 

80  26/09/2012  135

The JNA20 blower is off. 

85  19/05/2014  600

JNA20 CT001 temperature control indicator on the RKD stand-up panel does not point. 

96  16/01/2013  194

JKT02 CX821, there is no response. 

86  05/11/2014  170

JNA20 AN001 rough bearing sound JKA20 rough motor sound. 

93  13/05/2017  920

JKT02 CX #11, there is no response. 

95  15/03/2018  306

JKT02 CX #12 oscillation. 

79  06/07/2012  0

At the time of the scram reactor at a power of 1.84 MW, the JKT02 CX811 oscillation. 

85  24/04/2014  463

The appointment of the JKT02 CX821 neutron.
The JKT02 CX821 neutron detector did not respond when the reactor started up. The JKT02 CX821 detector showed no response when the reactor started up.

81 18/01/2013 0
JKT03 CX841 HV fault
JKT03 CX831 response is unstable
The meter does not show the true value, even though the detector position is upper.

09/02/2013 14
JKT03 CX841 oscillation occurs
JKT03 CX821 cannot measure
JKT03 CX811 up.

25/08/2014 110
Unbalanced load alarm JKT03 CX811 with JKT03 CX821 is different
Oscillation system (JKT03 CX811)
JKT03 CX811 oscillation meter designation JKT03 CX821 oscillating neutron detector designation The JKT03 CX821 neutron detector designation oscillates momentarily causing an unbalanced load alarm JKT03 CX821 slow response neutron detector indicates that it raises an unbalanced load alarm. The response of the JKT03 CX821 Detector was too fast, causing an unbalanced alarm.