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

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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**.**

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[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[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[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

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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 θ which is called the scale parameter and β which is called the shape parameter. The parameter β is useful for determining the level of damage from the formed data pattern and the scale parameter (θ) affects the mean value of the data pattern. The probability density function of the Weibull distribution model is provided in Eq. 1[14].

$$f(t) = \frac{\beta}{\theta} t^{\beta\text{-}1} e^{\frac{t^{\beta}}{\theta}} \quad t > 0 \tag{1}$$

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].

$$h(t) = \frac{\beta}{\theta}\left(\frac{t}{\theta}\right)^{\beta-1} \tag{2}$$

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

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^{\beta}} \tag{3}$$

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)

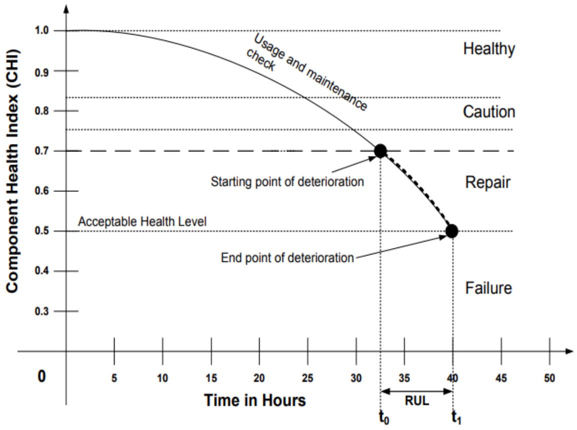

Fig 1. Component Health Index

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

$$m(t) = \frac{\int_t^{\infty} t\,f(t)dt}{R(t)} - t \tag{4}$$

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.

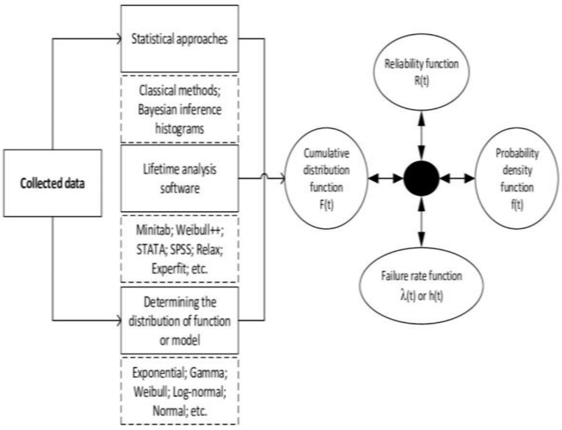

Fig 2. Data Processing Diagram on reliability analysis[6]

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.

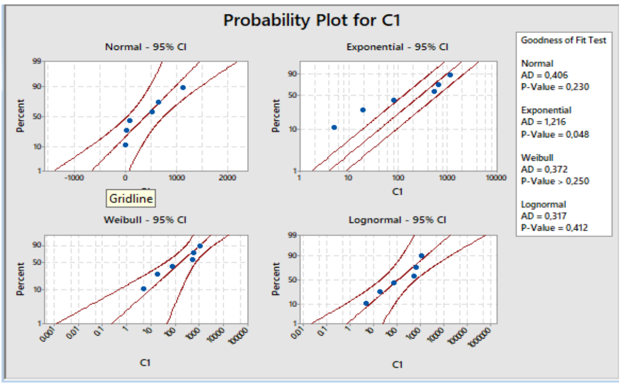

Fig. 3. Results of Component Distribution Conformity Test Electrical power supply (BRV10)

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

Component	Scale (θ)	Shape (β)	T (day)	h(t)	R(t)
Electrical power supply, B (BRV 10) Component: Emergency diesel aggregates	305.61	0.643	100	0.0031	0.8100
			250	0.0023	0.5906
			500	0.0018	0.3488
			750	0.0015	0.2060
			1000	0.0014	0.1216
			1250	0.0013	0.0718
Electrical power supply, BRV 20 Component Emergency diesel aggregates	432.63	1.547	50	0.0011	0.8362
			100	0.0016	0.6993
			200	0.0023	0.4889
			400	0.0034	0.2391
			600	0.0043	0.1169
			800	0.0050	0.0572
Reactor system, JA Reactor pool (Al-Lining) JAA01	390.42	0.979	100	0.0026	0.7781
			200	0.0025	0.6054
			400	0.0025	0.3666
			600	0.0025	0.2219
			800	0.0025	0.1344
			1000	0.0025	0.0814
Measuring point of the process systems: Reactor pool purification KBE01	139.08	0.694	50	0.0068	0.7790
			250	0.0042	0.2868
			500	0.0034	0.0823
			750	0.0030	0.0236
			1000	0.0027	0.0068
			1250	0.0026	0.0019
Experimentation system reactor pool, Rabbit systems (inside the reactor pool) (JBB)	309.36	1.250	50	0.0026	0.8170
			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

Experimentation system reactor pool, JB Control rods drive and suspension (JDA	61.292	0.774	20	0.0163	0.7766
			100	0.0113	0.2826
			150	0.0103	0.1502
			200	0.0097	0.0799
			250	0.0092	0.0424
Cranes and hoist, SM Crane, Reactor Building	494.54	1.135	300	0.0088	0.002256
			100	0.0018	0.79486
			250	0.0021	0.56327
			500	0.0023	0.31728
			750	0.0024	0.17871
			1000	0.0025	0.10067
			1250	0.0026	0.05670
Measuring point of the process systems: Pool cooling system JNA 20	475.55	1.507	50	0.0010	0.85343
			100	0.0014	0.72835
			250	0.0023	0.45274
			500	0.0033	0.20498
			750	0.0040	0.09280
			1000	0.0046	0.04201
Out of core temperature and neutron flux measurement JKT 02	209.41	0.669	25	0.0645	0.92316
			50	0.0051	0.85222
			200	0.0032	0.52749
			400	0.0026	0.27824
			600	0.0022	0.14677
			800	0.0021	0.07742
Out of core temperature and neutron flux measurement JKT 03	57.164	0.606	10	0.0211	0.89931
			100	0.0085	0.34600
			150	0.0073	0.20352
			200	0.0065	0.11972
			250	0.0059	0.07042
			300	0.0055	0.04142

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) Component Emergency diesel aggregates	422.0292957
Electrical power supply, B (BRV 20) Component Emergency diesel aggregates	389.1657201
Reactor system, JA Reactor pool (Al-Lining) JAA01	393.9410755
Measuring point of the process systems: Reactor pool purification KBE01	177.3360699
Experimentation system reactor pool, Rabbit systems (inside the reactor pool) (JBB)	288.0915321
Experimentation system reactor pool, JB Control rods drive and suspension (JDA)	71.12416625
Cranes and hoist, SM Crane, Reactor Building	472.4362112
Measuring point of the process systems: Pool cooling system JNA 20	429.0521178
Out of core temperature and neutron flux measurement JKT02	77.951269
Out of core temperature and neutron flux measurement JKT03	77.951269

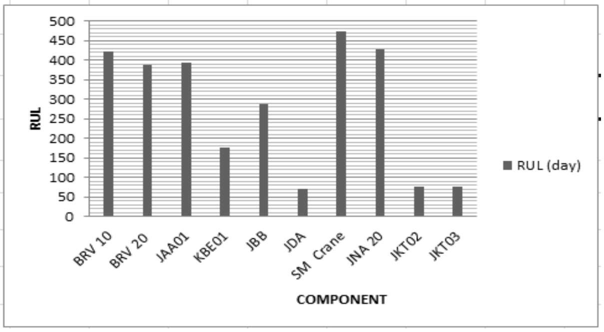

Fig 4. Remaining Component Life

The remaining component life (RUL) was calculated from the year 2010 (t_1), 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, 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 ectnessture 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 similar to the Fortran code and the Weibull distribution.

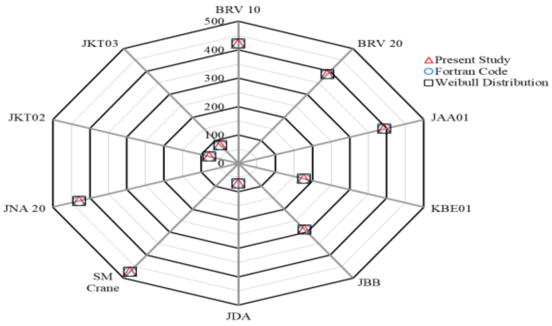

Fig 5. Comparison of RUL estimation (in days)

CONCLUSION

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	CCN	Date of Damage	TTF	Type of Damage
Electrical power supply, B (BRV 10) Component: Emergency diesel aggregates	73	24/11/2010	0	Diesel BRV 10 CW heater fault cannot be reset
	78	08/05/2012	531	Day tank BRV10 over scale danosilasi
	85	07/02/2014	640	Fuse BRV10 break
		26/02/2014	19	BRV10 cannot be operated
		15/05/2014	78	BRV10 fault mechanic at RKU in local is not faul
		20/05/2014	5	BRV10 electrical fault occurs repeatedly
	86	16/06/2017	1123	BRV10 electrical fault
Electrical power supply, B (BRV 20) Component: Emergency diesel aggregates	75	21/05/2011	0	Day tank fuel level too low "fault" cannot be reset,
	83	28/06/2013	769	*The accuracy is broken*
	86	03/12/2014	523	BRV20 water pump water line is leaking
	87	26/03/2015	636	The flexible radiator hose for diesel generator no.2 (BRV20) is leaking
	88	01/06/2015	67	*Charger* BRV20 tidak berfungsi/rusak
		29/09/2015	100	BRV20 charger does not work/is damaged
	89	09/05/2016	343	BRV20 fault
	91	09/05/2016	343	BRV20 fault
		27/02/2017	294	BRV 20 Operates without anyone knowing
Reactor system, JA Reactor pool (Al-Lining) JAA01	74	03/04/2011	0	The JAA 01 floating bulkhead door is slightly curved
		27/08/2011	146	The JAA01 CL001 indicator points to 0 m
	76	13/09/2011	17	JAA 01 CL811 / 821/831 designation <12.41 m
	77	17/01/2012	126	JAA 01 CL 811/821/831 points <12.41
	85	06/01/2014	720	The JAA01 CL811 reading level is below the minimum limit
	91	22/08/2016	959	The temperature indication on the JAA01 CT001 meter is zero
	94	20/09/2017	394	JAA01 CL811 pmeter is not accurate
Measuring point of the process systems: Reactor pool purification KBE01	71	01/04/2010	0	A noise is heard on KBE 01 AP 001
	83	08/08/2013	1225	KBE01 AP002 is rough
		16/01/2014	161	The KBE01 AP001 pump is inoperable
		28/01/2014	12	The KBE01 pump designation CP001 at RKU shows the maximum
	85	06/02/2014	9	KBE01 AP001 blink/fault (off)
		24/02/2014	18	KBE01 AA068 every time the process closes, a blink fault occurs
		01/04/2014	36	KBE01 AA068 cannot be opened / closed
		25/04/2014	24	The KBE01 AP001 pump

				is operating, but there is no flow
		13/05/2014	18	Fault system, in the CXB02 Marshalling Kiosk the system is dead, there is no power supply
	86	21/07/2014	69	The KBE01 AP001 pump sounds rough
	87	03/02/2015	197	There is a water leak dripping in the pump seal of the reactor purification system (KBE01 AP001)
	90	01/04/2016	423	KBE01 AP001 sounds harsh
	92	22/03/2017	355	KBE01 AP001 Pump On Blink indicator cannot be reset
	93	14/05/2017	53	The indicator is below the limit/drop
	94	22/10/2017	161	KBE01AA010 valve cannot be opened/closed from RKU
Experimentation system reactor pool, JBB	71	30/03/2010	0	1 broken Hot Cell lighting lamp (JBB01)
	72	26/07/2010	118	The water supply tank from the JBB 01 to JBB 04 system rabbit has no known water level
	75	14/05/2011	292	JBB 01 rabbit system facility is not operating optimally
	82	07/05/2013	724	The radiation timer counter is abnormal (sometimes runs doesn't) on RS-5
	84	25/06/2013	49	MCB 4A on bit system JBB03 line 3 is broken
	85	04/03/2014	252	*The solenoid valve cannot be turned on when the capsule returns to the drum, Manipulator problem*
Experimentation system reactor pool, JB Control rods drive and suspension (JDA)	75	09/06/2011	0	JDA 07 inoperable / JDA 03 at start-up crashes itself
		17/06/2011	8	JDA 03 at start-up falls off on its own
	77	02/03/2012	259	The JDA 01 spindle is broken
	78	11/04/2012	40	Many of the JDA indicator lights on the panel do not light up
		25/04/2012	14	JDA07 + 14 has a slow response and frequent shutdown faults.
		30/04/2012	5	Reg rod JDA07 at position 353 mm, a repeated fault occurs
	79	12/06/2012	43	Position indicator display is off
		18/06/2012	6	JDA is broken (JDA 02)
	81	26/01/2013	222	JDA06 + 11 response is slow (lagging behind the others)
		08/02/2013	13	JDA06 11 response is slow (lagging behind the others)
		24/02/2013	16	JDA04 armature dropped indicator cannot be reset
	82	30/04/2013	65	JDA06 faults frequently
	85	05/02/2014	281	The JDA06 power supply module cannot be closed
		19/03/2014	42	JDA01 control rod overload insert indicator light cannot turn on (off)
		20/03/2014	1	JDA07 Armatur Drop
		28/04/2014	39	JDA02 Blink, cannot be reset
	86	19/06/2014	52	JDA06 when rod drop test, not responding to indicator

		15/07/2014	26	JDA07 + 14 (Regard) cannot be downgraded manually
		12/08/2014	28	JDA07 + 14 (Reg. Rod) cannot be lowered and triggered a blink fault
		09/09/2014	28	JDA03 - 05 if compensated rise/fall a fault occurs
	87	05/01/2015	118	During the rod-drop time test, the counter does not stop
	89	27/08/2015	234	JDA03 + 10/12 oscillation analog indicator
		28/09/2015	32	The control rod fell off on its own
		05/10/2015	7	JDA03 control rod Self-falling
		08/10/2015	3	The control rod fell off on its own
		27/10/2015	19	The control rod falls by itself
		30/10/2015	3	The regulating rod (JDA07) control rod does not move automatically
		02/11/2015	3	JDA07 does not respond down when compensation is done, the control rod does not respond
		05/11/2015	3	Control rod not responding
	90	07/01/2016	94	jda 08 + 12 is damaged
		05/02/2016	29	After a scram event, the adjustment control rod (JDA07) cannot be automatic
	91	25/07/2016	171	JDA04 at start-up crashed
	92	08/03/2017	226	The designation JDA05 + 11 is defective, does not turn on
	93	21/05/2017	74	JDA03 cannot go up / down
	94	01/12/2017	194	JDA07 is not a couple
	95	07/03/2018	96	Control rod JDA07 + 12 down position stuck when pressed manually
Cranes and hoist, SM Crane, Reactor Building	76	08/10/2011	0	Crane 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	Crane SMJ10 cannot be operated to the left (left) at a slow speed
	95	02/01/2018	602	The trolley cannot be operated left or right
	95	26/03/2018	83	Crane SMJ10 console panel can not be lowered down
Measuring point of the process systems: Pool cooling system JNA 20	78	14/05/2012	0	The pressure on the JNA20 CP001 / 002 pipe always drops
	80	26/09/2012	135	*The JNA20 blower is off*
	85	19/05/2014	600	JNA20 AN001 Frequently Faults
	86	05/11/2014	170	The JNA20 CT001 temperature control indicator on the RKD stand-up panel does not point
	93	13/05/2017	920	JNA20 AN001 rough bearing sound
	95	15/03/2018	306	JNA20 rough motor sound
temperature and neutron flux measurement JKT 02	79	06/07/2012	0	JKT 02 CX 811, there is no response
	81	16/01/2013	194	JKT02 CX811 oscillation
	85	24/04/2014	463	At the time of the scram reactor at a power of 1.84 MW, the JKT 02 max
Out of core temperature and neutron flux measurement JKT 03	89	16/12/2015	601	The appointment of the JKT02 CX821 neutron

			detector did not respond
	18/12/2015	2	The JKT02 CX821 neutron detector showed no response when the reactor started up
90	18/01/2016	31	JKT02 CX821 cannot respond while operating
81	18/01/2013	0	JKT03 CX841 HV fault
	26/01/2013	8	JKT03 CX831 response is unstable
	09/02/2013	14	The meter does not show the true value, even though the detector position is upper
83	15/07/2013	156	JKT03 CX841 oscillation occurs
85	07/05/2014	296	JKT03 CX821 cannot measure
86	25/08/2014	110	JKT03 CX811 up, Unbalanced load alarm
	13/10/2014	49	JKT03 CX811 with JKT03 CX821 is different
88	12/08/2015	303	Oscillation system (JKT03 CX811)
	13/08/2015	1	JKT03 CX811 oscillation meter designation
89	28/09/2015	46	JKT03 CX821 oscillating neutron detector designation
	08/10/2015	10	The JKT03 CX821 neutron detector designation oscillates momentarily causing an unbalanced load alarm
	10/10/2015	2	JKT03 CX821 slow response neutron detector indicates that it raises an unbalanced load alarm
	12/10/2015	2	The response of the JKT03 CX 821 Detector was too fast, causing an unbalanced alarm