



QUALITY EVALUATION OF THE MODIFIED DIESEL-ELECTRIC TRAIN (KRDE)

Taufik Hidayat*, Hilman Syaeful Alam

Technical Implementation Unit for Instrumentation Development - LIPI
Jl. Sangkuriang Komplek LIPI Gedung 30, Bandung 40135, Indonesia

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Abstract

Quality of the diesel-electric train (KRDE) modified from the electric train (A and B types) which were used in three operating regions in the Indonesian Railway Company has been evaluated by analyzing the cause of the KRDE damages in terms of some aspects including: design, components quality, maintenance (method, finance, human resources), environment and way of operation. Based on the evaluation, it was found that the modification of the both types of KRDE provided a very low reliability and availability due to design and technical problems, as well as unoptimal maintenance. In KRDE type A, damage occurs in the cabling system, compressor, radiator fan system, and the braking system. While in type B, damage occurs in the traction motors, static inverter, and radiator fan. It is predicted that their life span can not reach the design life of 25 years, and even they are expected to be grounded. Many improvement is required to lengthen their service life including: repair, modification, human resource competence, facilities, spare parts, maintenance and management.

Keywords: quality improvement, diesel-electric train, damage, maintenance, operation.

I. INTRODUCTION

One of effective ground transportation modes in terms of speed, capacity and flexibility of transport is train [1]. Transportation cars and other motor vehicles contribute highest energy consumption and emissions when compared to trains in the aspects of vehicle production, maintenance, operations, infrastructure and production materials [2]. In the point of view of effectiveness and cost benefit, railroad is more profitable than conventional bus [3].

PT. KAI is a leading provider of public transportation using railways in Indonesia. To address the problems of urban commuter transport, it has been operating rail diesel electric trains (KRDE). In the operation area 2, 6, and 8 it also operates KRDE modified from two types of electric trains (KRL). However, there are some problems that occur both technically and commercially, such as reduced reliability whether caused by technical aspects (design and manufacturing) as well maintenance (availability of spare parts, machinery, equipment, human resources and financing). These problems result

in the cancellation of the scheduled departure, train delays and break downs. Moreover, high operating cost and maintenance cost will probably lead the trains to be grounded.

The study in this paper focuses on analyzing the causes of the KRDE damage in terms of design, components quality, maintenance (methods, financing, human resources), environment and way of operation.

II. MATERIALS AND METHODS

A rail diesel train (KRD) has its own drive train whose power is provided by its diesel power source. A diesel electric train (KRDE) is one type of KRD that uses electric power transmission (generator, electric power control and electric motor) [4, 5]. In 2005, modification of electric trains (KRL) into diesel electric trains (KRDE) has been conducted. Figure 1 (a) shows a modified version KRDE from KRL type A, and (b) shows a push-pull KRDE modified from KRL type B. The configuration difference between both types of KRDE can be seen in Figure 2 [6, 7], while the captions are TeC: Car Trailer with diesel generator sets and cab driver, M: Motor

* Corresponding Author. Tel: +62-813-94297528
E-mail: taufiklipi@yahoo.co.id



Figure 1. (a) Modified version KRDE from KRL type A (b) push-pull KRDE modified from KRL type B

Car with inverters and traction motors, T: Car Trailer, and TC: Car Trailer with cab driver.

Table 1 shows the name and operational areas of the modified KRDE in three operation regions (Daop) of PT. KAI. To facilitate evaluation, the problems are classified into five categories, namely: (1) human resources (HR), (2) facilities and equipment, (3) method or procedure of maintenance including materials or spare parts, (4) maintenance execution, and (5) operational facilities including Graph Train Journey (GAPEKA). Common technical problems concerning maintenance which reflect real conditions that exist in the operation areas are obtained through interviews, field observations, and supporting data observations.

III. RESULTS AND DISCUSSION

The first aspect of KRDE quality improvement evaluation is human resources. Based on the results of a survey conducted through questionnaires to 21 maintenance personnels spread across the area of KRDE operations, the following finding is obtained: training has been rarely done related to electronics technology which is applied to KRDE; ability of the technicians is still lacking in operation of electrical measuring devices such as Avo-meter, oscilloscope and Megger.

The level of knowledge of KRDE technicians concerning basic electronics and power electronics maintenance is obtained by giving 10

Table 1.
Name and operational areas of KRDE

No.	Operation regions (Daop)	Name of KRDE
1	Daop 8 Surabaya	KRDE Arek Surokerto 1 KRDE Arek Surokerto 2
2.	Daop 2 Bandung	KRDE Baraya Geulis KRDE Rencang Geulis
3.	Daop 6 Yogyakarta	KRDE Prameks-1 KRDE Prameks-2 KRDE Prameks-3

basic questions. Figure 3 shows graphically the level of their knowledge. Yogyakarta's operational area was the highest at 70%, and no one was able to answer all questions correctly even if only a basic question. The graph shows that the competency of KRDE technicians stills less. Improvement is needed by providing continuing training. Other problems associated with human resources are: inadequate number of maintenance personal; and rapid rotation of employees.

The second aspects in the evaluation are the facilities and equipment. The facilities that exist in almost every area of operations, such as supporting building, workshops, track, pit gauge, servicing horizontal ladder, overhead cranes, lifting jacks, etc., are designed for locomotive maintenance, so that they are not suitable for KRDE maintenance. The length of gauge of servicing horizontal ladder is not enough (minimum requirement is 80 meters). There is less or no lifting jack to lift at once a set of KRDE. Special equipment to repair KRDE is still incomplete (for example: software for communication and diagnostic of the traction converter for KRDE).

The third aspects of evaluation are related to maintenance methods and procedures. In general, every region already has a clear organizational structure of running maintenance, and has been carrying out the scope of work in accordance

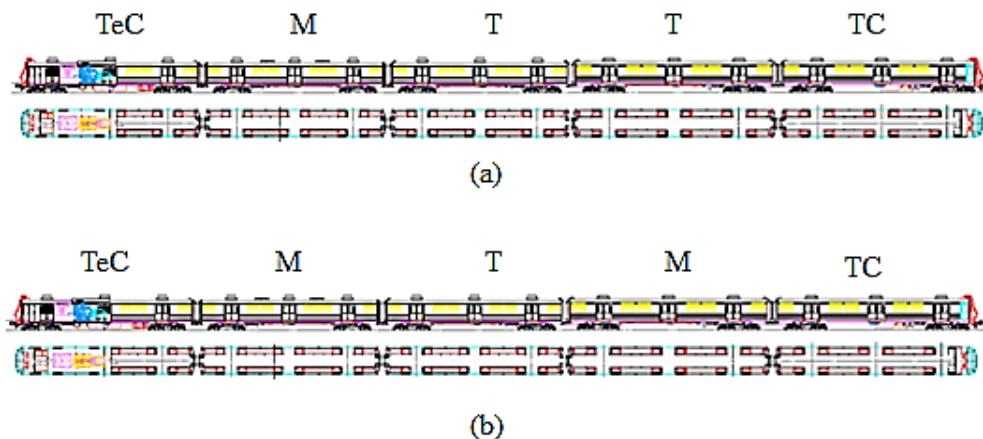


Figure 2. Configuration difference between both types of KRDE

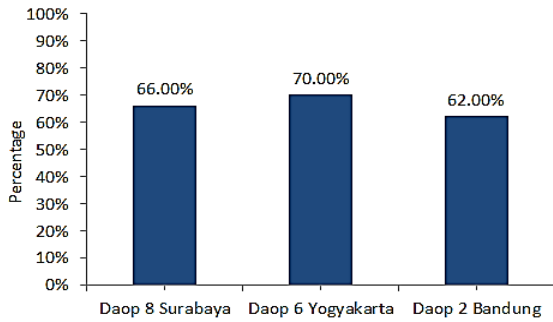


Figure 3. Charts of basic electronics and power electronics knowledge level of KRDE technicians

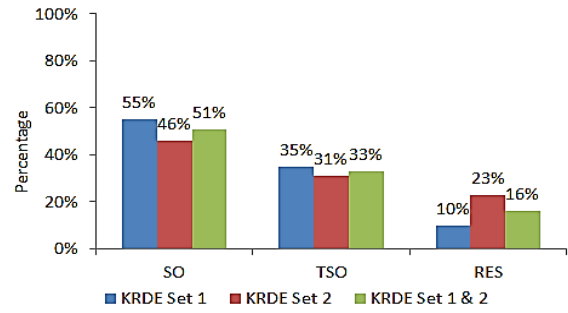


Figure 4. Operationilability of KRDE Arek Surokerto

with its function. However, the method of maintenance is still based on time, while KRDE maintenance should be based on operating time (hours of operation) and mileage (kilometers). Other problems are limitation of KRDE maintenance budget, lack of spare parts, lack of procurement mechanisms of special components so that the KRDE cannot be operated because it must wait for the materials or spare parts.

The 4th aspect of evaluation is related to maintenance execution. General maintenance of KRDE has been done at two places, Dipo and Balai Yasa in each Daop. The maintenance carried out at the Dipo is a monthly periodic of maintenance as follows: Daily Maintenance, 1-month maintenance (P1), 3-month maintenance (P3), 6-month maintenance (P6) and 12-month maintenance (P12). The maintenance done at Balai Yasa includes 2nd annual maintenance (SPA), 4-year maintenance (PA) and repair (PB). Monthly periodic maintenance of KRDE facilities has been implemented at the Dipo, but other maintenances at Balai Yasa which covers SPA, PA, and PB, has not been implemented according to the requirements because of the following reasons: insufficient competence to perform maintenance and lack of supporting equipment.

The 5th aspect is related to operational patterns of train journey (GAPEKA). This pattern is strongly influences to the effectiveness of the KRDE maintenance. Due to short time available for maintenance, in fact KRDE maintenance is not possible to be conducted. KRDE performance can be seen from the aspect of availability and operational. There are several terms that describe KRDE conditions, namely: SO, TSO and RES. SO means ready for operation, TSO means not ready for operation, and RES indicates a condition in which the train can be operated but it was decided not to operate due to routine maintenance, inspection and minor repair. RES is also associated to a condition in which the train is ready for operation (SO) but the management decided not to be operated.

In the Daop 8 Surabaya, there are 2 sets of KRDE Arek Surokerto, which started operating in October 2009 as commuter trains having route from Surabaya to Mojokerto. These KRDE are modification version of KRL type B or KRDE push-pull, namely KRDE set 1 and KRDE set 2. The KRDE has been experiencing technical problems even though improvement and modification efforts have been made by the manufacturer. It can be seen from the percentage of SO, which only reached an average of 51%,

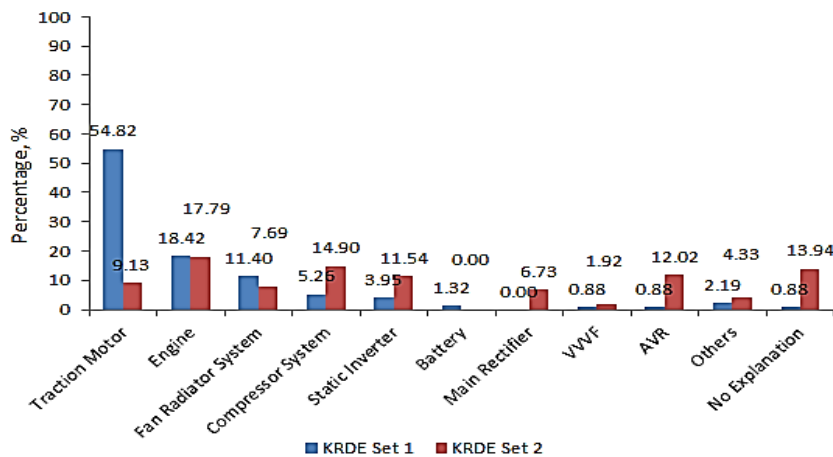


Figure 5. TSO causes of KRDE Arek Surokerto Set-1 and Set-2



Figure 6. (a) Traction Motor (TM) which has been repaired, and (b) TM position that is still attached to the system

see Figure 4. The data processing is carried out in the period from 1 October 2009 until 27 November 2011 [8].

TSO causes of KRDE Arek Surokerto can be seen in Figure 5. It impaired and damage due to the traction motors dominated the causes of TSO of KRDE set 1, while KRDE set 2 is dominated by the engine problems.

Damage to the traction motor (TM) is the most prominent case, because the damage occurred in all the units from the total of eight units of TM. Figure 6 shows the traction motor of KRDE push-pull. The majority of the damage occurred on the pinion gear that connects the rotor to the shaft that is connected to the power distributor gearbox. This damage contributes significantly to the total damage resulting in TSO.

Damage to the engine ranks second as a cause of KRDE TSO. One cause of damage to the engine was leaking oil filter. The oil filter is easily hit by hard objects (rocks, etc.) because its position is too low and it is not equipped with a safety protection. The position of air combustion intake is under floor, so it is easy for dirt or dust to enter and clog the air filter. Damage also occurred at the engine sensors, such as oil pressure sensor. It is difficult to obtain spare parts.

In the Daop 2 Bandung, there is KRDE Baraya Geulis with a round-trip route from Padalarang to Cicalengka. Maintenance and repairs of KRDE are periodically handled by locomotive Dipo Bandung. KRDE BarayaGeulis has experienced journey of 65632 km or 2216.30

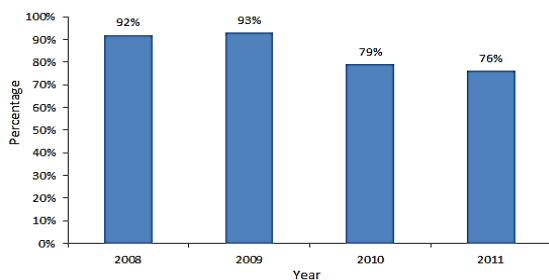


Figure 7. Operations (SO) of KRDE Baraya Geulis from 2008 to 2011

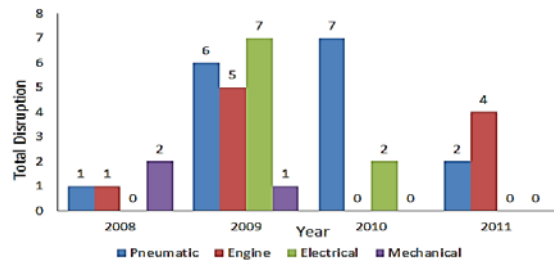


Figure 8. Total disruptions per-category of KRDE Baraya Geulis from 2008 to 2011

hours. Its average performance since the beginning of operation until September 2011 is shown in Figure 7 [9].

Disruptions and damage are categorized into four categories, namely: pneumatic, diesel, electric, and mechanical. The amounts of damage per category during 2008 to 2011 are shown in Figure 8 [9]. Based on this data, it can be concluded that the damage to the pneumatic system (compressor, air ducts) and the electrical system is the dominant factors.

Besides Baraya Geulis, KRDE operated in Daop 2 Bandung is KRDE Rencang Geulis. KRDE Rencang Geulis has own mileage of 76,064 miles or 3141.45 hours with a round-trip route from Padalarang to Cibatu. The average performance of KRDE Rencang Geulis from the beginning of operation until September 2011 was the 65% SO and 35% TSO, as shown in Figure 9 [9].

The number of disruption of KRDE Rencang Geulis per category can be seen in Figure 10 [9]. Major disruptions at KRDE Rencang Geulis are not much different from KRDE Baraya Geulis, which are dominated by the pneumatic system (compressor, air ducts), and electrical systems.

In the Daop 6 Yogyakarta, there are KRDE Prameks 1, 2 and 3 with a round trip route from Solo to Yogyakarta and Solo to Kutoarjo. KRDE maintenance is the responsibility of the locomotive Dipo Solo. Figure 11 shows the performance of KRDE Prameks-1, 2 and 3 from 2009 until 2011 [10].

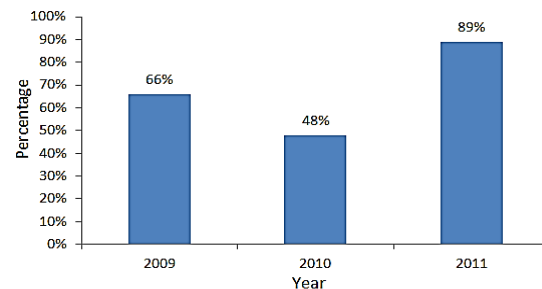


Figure 9. Operations (SO) of KRDE Rencang Geulis from 2009 to 2011

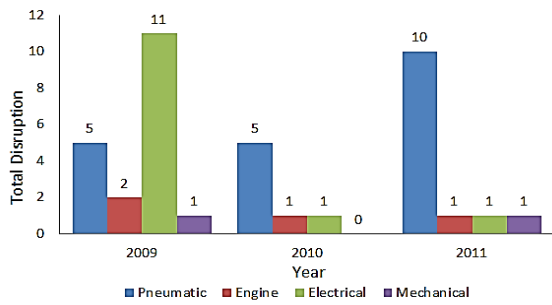


Figure 10. Total disruptions per-category of KRDE Rencang Geulis from 2008 to 2011

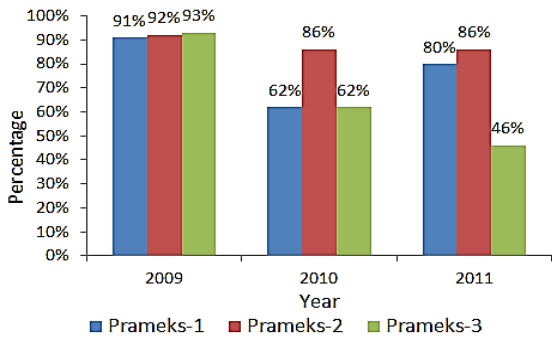


Figure 11. Operations (SO) of KRDE Prameks 1, 2 and 3 from 2008 to 2009

Figure 12, Figure 13 and Figure 14 show technical factors cause disruption or TSO beyond routine maintenance and inspection for each KRDE Prameks 1, 2 and 3. While the code of disruption causes is described in Table 2 [10].

Based on the average percentage of SO, KRDE Prameks-1 has the SO by 79% over the past three years, indicating that supply is still below from the target of 85% SO. Based on data disruption, there is a number of dominant damage, such as compressor system, braking system and control cables. There is a recurrent nature of the disorder, such as damage to the compressor, control wiring, and damage to the stairs or doors, resulting long enough of TSO. There is a non-recurring disruption that results in a long TSO due to unavailable parts, such as traction motor damage.

In KRDE Prameks-2, the average percentage of SO for three years, amounting to 89%, suggesting that the availability of KRDE Prameks-2 meet the target (minimum 85%), while the disruption is dominated by the damage in the compressor system, engine, and control systems. There is a recurrent nature of the disorder, such as impaired compressors, control cables, and disruption of the stairs or doors that lead to long TSO status.

Next on KRDE Prameks 3, the average percentage of SO for three years, which are 70%,

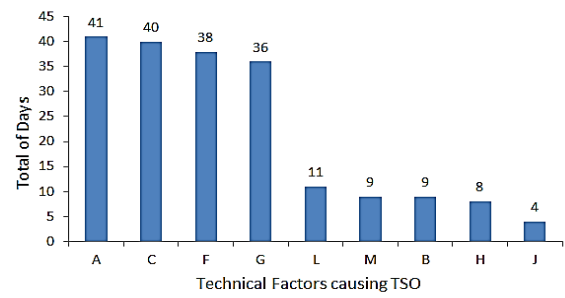


Figure 12. TSO of KDRE Prameks 1 from the year 2009 to 2011

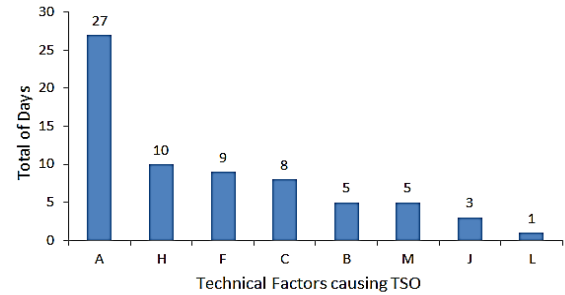


Figure 13. TSO of KDRE Prameks-2 from the year 2009 to 2011

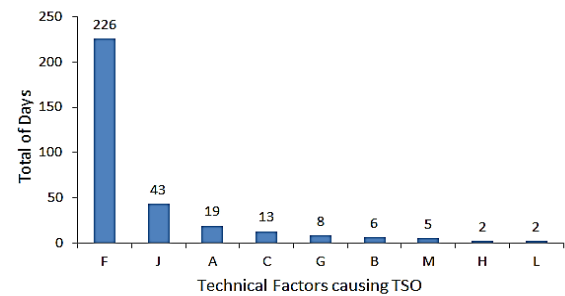


Figure 14. TSO of KDRE Prameks-3 from the year 2009 to 2011

Table 2. Code of causing TSO of KRDE Prameks

Codes	TSO Causes of KRDE Prameks
A	Compressor system.
B	Braking system: wind pipe, air tank, valve, and air dryer.
C	Doors, stairs, glass, lighting, and painting.
D	Routine maintenance (km base, time base).
E	Examination (outside routine, because visible symptoms of damage).
F	Control system, wiring, coupler, 110 VDC supply voltage, battery.
G	Alternator, main rectifier, VVVF, SIV, TM.
H	Engine, engine start system, fuel system.
J	Cooling system engine (Micromaster, cooler, etc.).
L	Bogie, spring water, leveling valve.
M	Wheels & bearings.

indicating that the availability of KRDE Prameks-3 has not met the target (minimum 85%). Damage occurs predominantly in the control system, wiring, electrical compiler, engine cooling system (Micromaster, cooler, etc.), and compressor systems. Very long TSO on the KRDE Prameks-3 was caused by revamping cabling system that takes a very long time, and the delay is due to the procurement of spare parts of Micromaster.

IV. CONCLUSIONS

The KRDEs which were modified from KRL type A and B had a very low reliability and availability due to the design and technical problems as well as un-optimal maintenance. Disruption and damage that often occur on KRDE (modification from KRL A) are the cabling system, compressor, radiator fan system, and the braking system, while KRDE Push-Pull (modification from KRL B) are the traction motors, static inverter, and radiator fan. The KRDEs maintenance is not optimal because the facilities and support equipment have not been adequate. There is no specific maintenance budget for KRDE. The competency of human resources is still lacking and there are mistakes in maintenance management system and delays in maintenance. The life span of KRDE for both type A and B is predicted that it can not reach the design life of 25 years, and even they are expected to be grounded. Many improvements are required to extend their service life including: repair, modification, human resource competence, facilities, spare parts, maintenance and management.

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