# FTA AND FMECA ANALYSIS FOR DETERMINE CRITICAL COMPONENTS OF DIESEL GENERATOR CUMMINS KTA 38D

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**ABSTRACT**

A diesel Generator is equipment has functions as a power generator and electricity supply. Tanker warship is one of the navy warships applying diesel generator Cummins KTA 38D for electricity supply when going on mission area or at basecamp. On diesel generator system consists of 7 (seven) sub-system are coolant sub-system, seawater cooling sub-system, fuel oil sub-system, air intake and exhaust sub-system, Lub oil sub-system, Electric starter sub-system and controlling sub-system. Due high operating hours, the potential for damage is increasing, because damage a component diesel generator. According ship damage report data, the percentage damage of diesel generator reach until 38.5% from total equipment damage that occurred during 2016-2022 year. Based on that phenomena, this research will identifcation factors that cause damage and determine the components have high criticality in the diesel generator using the FTA (Fault Tree Analysis) to systematically explain unexpected causal factors that lead to failure, and the FMECA (Failure Mode Effect And Criticality Analysis) method to identify critical components according factors have the highest critical point with calculation of the Risk Priority Number (RPN). The results of calculations and analysis using the FTA and FMECA methods, there are 6 (six) critical components with the highest RPN value in the diesel generator system, that Tube sea water component (375,4) with the risk of leaking, Impeller components (377,1) with a risk of corrosion/crack, Body Cover SW (372,0) with a risk of corrosion, Mechanical Seals (369,8) with a risk of leaking/damage, strainer (369,1) component with a risk of corrosion, Rectangular seal HE (367,9) a risk leakage and Battery (371,0) with a risk no power electric for start engine.

**Keywords:** Diesel generator, FTA, FMECA, Critical components

## 1. INTRODUCTION

A tanker type of warship is designed for fuel distribution and liquid logistics supplies at sea (fleet on replenishment at sea). To support the vital role carried out by the ship, the readiness of the ship's technical condition is an absolute requirement that must be properly maintained. One of the pieces of equipment that have a vital role on the ship is a diesel generator. Due to the high age and operating hours of the diesel generator, the potential for damage will increase. Damage to diesel generators caused by the damage of a component cannot be known with certainty because each component has different reliability and rate of damage.

According to ship damage report data, the percentage of damage for Cummins KTA 38D diesel generator is highest reached at 38.5% of total equipment damage that occurred during 2016 – 2022. The graphic of equipment damage shown in figure 1.

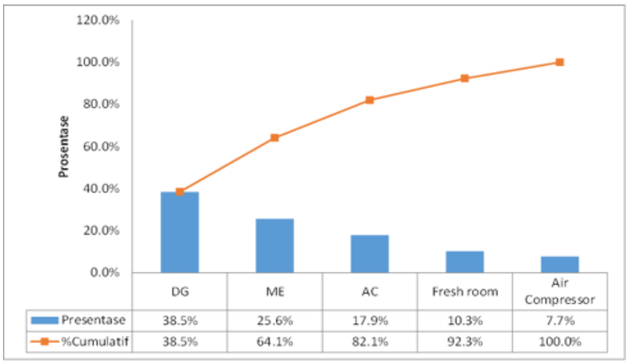



**Figure 1.** Graphics of equipment damage

There were several weaknesses in the maintenance of the diesel generator system carried out by ship personnel, these weaknesses is:

a. Incomplete equipment manual handbook.

b. Spare parts and tools maintenance equipment not available.

c. Lack of understanding of maintenance by operators,

d. Operators are still having trouble finding the root cause of equipment damage,

e. The equipment operated continuously until breakdown occurs.

Based on these references, the purpose of this study is identify critical components based on the factors have the highest critical point on the diesel generator. So that it is expected to provide a solution for equipment maintenance along with the maintenance mechanism has been implemented until now.

## 2. MATERIAL AND METHODE

### 2.1 Diesel Genartor

The diesel generator is a ship's equipment useful for supply electricity needs of the ship. Diesel generator is a combination of diesel engine and generator. A diesel engine is a combustion engine with a combustion process that occurs within the engine itself (internal combustion engine) and combustion occurs because pure air is compressed (compressed) in a combustion chamber (cylinder) so that high pressure air and high heat are obtained, along with being sprayed. the fuel is atomized so that combustion occurs.

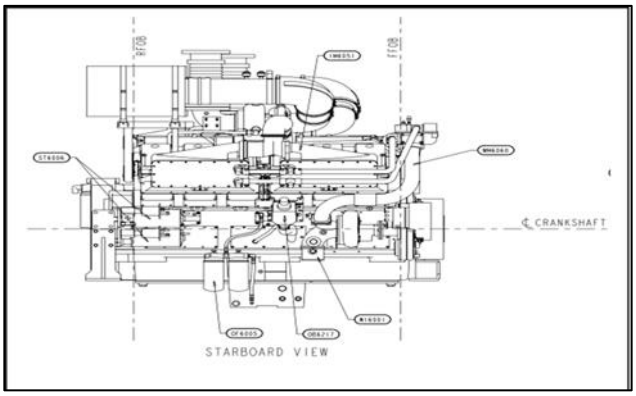



**Figure 2.** Engine Cummins KTA 38D

Specification engine data of the diesel generator Cummins KTA 38D can be seen in the description below:

| **Diesel** | | **Generator** | |
|---|---|---|---|
| Merk | : CUMMIN | Merk | : STAMFORD |
| Engine No | : 41183836 | Type | : LVM634G1 |
| Model | : KTA38-D(M) | AVR | : MX321 |
| SO No | : S060179 | Volt | : 400 |
| Advert | : 880 kw | Phase | : 3 |
| Max. | : 970kw | KVA | : 1100 |
| Idle speed | : 650~750 | Rpm | : 1500 |
| Rpm | : 1500r/min | Ampere | : 1587.8 |
| Produck | : 2013 | Freq | : 50Hz |
| Manufacture | : Chongqing Cummins China | ID No | : X13A021703 |

### 2.2 Raliability Diagram Block

Evaluate for reliability of a component or system, the first is make model the component or system into a reliability block diagram. The composition of the reliability block diagram of the system consists of structural forms, namely:

a. Series Structure

Series structure is a system structure where the system is said to be damaged if one of its components is damaged.

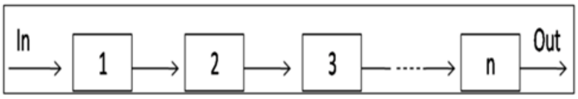



**Figure 3.** Series structure

b. Parallel structure

Parallel structure is a system structure where the system still functioning if at least one component functioning or it can be said that the system is damaged if all components are damaged.

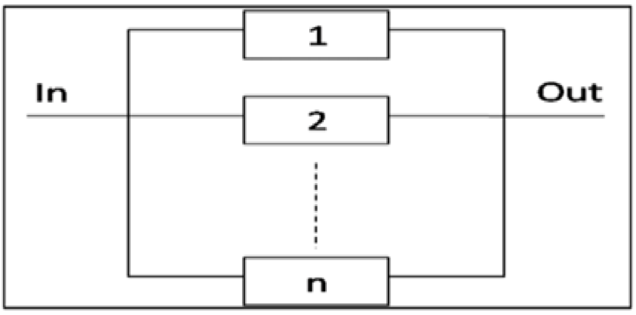



**Figure 4.** Parallel structure

### 2.3 Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is a method of deductive analysis by describing numerical graphs and analyzing how damage can occur and what are the chances of damage (Blanchard, 2004). The FTA steps in a system are as follows:

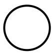
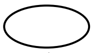
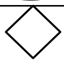
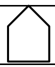
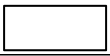
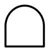
a. Identify the most important events in the system (top level events).

b. Create a fault tree (fault tree).

c. Analyze the fault tree (fault tree)

The symbols used in fault tree analysis are as follows:

**Tabel 1.** Symbol of Fault Tree Analysis

| Symbols | Description |
|---|---|
|  | Basic Event |
|  | Intermediate Fault Event |
|  | Undeveloped Event |
|  | External Event |
|  | Top Event |
|  | Logic event End gate |
|  | Logic event Or gate |
|  | Exclusife Event |

### 2.4 Failure Mode Effects and Criticality Analysis (FMECA)

FMECA is a development of FMEA by considering the level of criticality associated with the impact of the component failure mode. This criticality level is analyzed based on a combination severity and probability of occurrence The analysis may be performed according to the following scheme.

a. Definition and delimitation of the system (which components are within the boundaries of the system and which are outside).

b. Definition of the main functions (missions) of the system.

c. Description of the operational modes of the system.

d. System breakdown into subsystems that can be handled effectively.

e. Review of system functional diagrams and drawings to determine interrelation- ships between the various subsystems. These interrelations may be illustrated by drawing functional block diagrams where each block corresponds to a sub-system.

f. Preparation of a complete component list for each subsystem.

g. Description of the operational and environmental stresses that may affect the system and its operation. These are reviewed to determine the adverse effects that they could generate on the system and its components.

The Risk Priority Number (RPN) is the result of multiplying the weights of Severity, Occurance and Detection rating. These results will be able to determine the critical components of the system under study.

**RPN = Severity(S) x Occurance(O)x Detection(D)**

The Risk Priority Number is used to rank and identify failures or risks associated with operations due to design

**Tabel 2.** Severity, Occurance, and Detection rating

| Rating | Description |
|---|---|
| High | The team must either identify an appropriate action to improve prevention. |
| Medium | The team should identify appropriate actions to improve prevention and / or detection controls, |
| Low | The team could identify actions to improve prevention or detection controls |

Component criticality analysis based on failure mode/failure mode using a risk matrix according predetermined criteria. The final results obtained are items that are included in the critical components, namely components that are included in the "high" rating of risk based on the risk matrix. The overall results of the analysis of the FMECA method will be presented in the form of an FMECA Worksheet.

**Tabel 3.** Severity Level.

| ***Severity Level*** | | |
|---|---|---|
| **Kategori** | **Ranking** | **Definition** |
| ***Catastrophic*** | 8,1-10 | Cause system shutdown. |
| ***Critical*** | 6,1-8 | The system cannot function as specified. |

| | | |
|---|---|---|
| ***Marginal*** | 4,1-6 | The system has decreased function performance. |
| ***Negligible*** | 2,1-4 | The system can function with little risk. |
| ***Minor*** | 1-2 | The system can function with negligible risk. |

**Tabel 4.** Occurrence Level.

| ***Occurrence Level*** | | |
|---|---|---|
| **Frekuensi Kejadian** | ***Occurrence Rating*** | **Definition** |
| ***Frequent*** | 8,1-10 | Often occur |
| ***Probable*** | 7,1-8 | Very likely |
| ***Occasional*** | 5,1-7 | Commonly occurs |
| ***Remote*** | 3,1-5 | Rarely occurs |
| ***Improbable*** | 1-3 | Impossible to happen |

## 2.4 Research Metodhology

In order to facilitate understanding achieve expected goals in the research process, a research design made which represented in a research flow chart

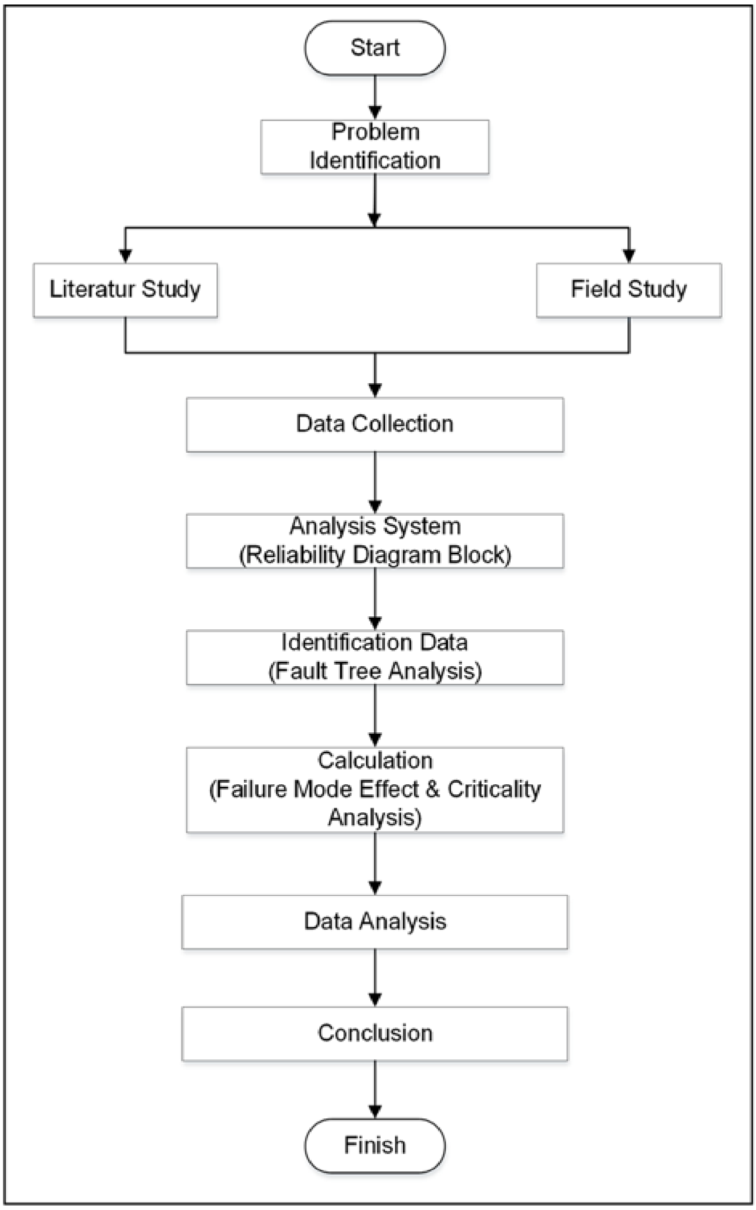



**Figure 5.** Flow Chart Diagram

## 3. RESULTS AND DISCUSSION

Based on direct observation, guidance from the Cummins KTA 38D engine manual book and interviews with respondents and experts, there are 7 (seven) systems that support the operation of diesel generators arranged in the series structure

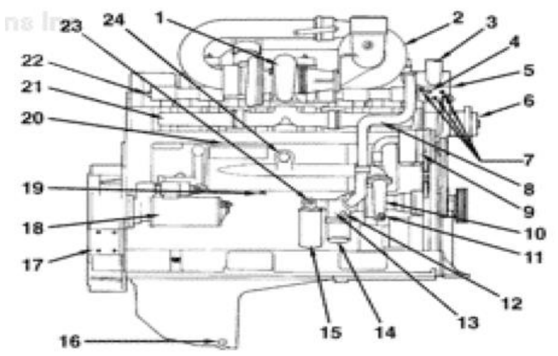



**Figure 8.** Layout of diesel generator

Generality of the supporting components of a diesel generator are as follows:

**Table 5.** Components of Diesel

| | |
|---|---|
| 1. High pressure Turbocahrger | 13. Water Pump inlet housing |
| 2. Low pressure Turbocahrger | 14. Water inlet connection |
| 3. Water outlet | 15. Coolant Filter |
| 4. Water Press. Pickup | 16. Oil Drain |
| 5. Thermostat housing | 17. Flywheel housing |
| 6. Gear Driven | 18. Starter |
| 7. Water press/temp | 19. Petcock for water drain |
| 8. Water bypass tube | 20. oil cooler |
| 9. Alternator | 21. Exhaust manifold |
| 10. Water pump | 22. Heater supply |
| 11. Petcock for water drain | 23. Water shutoff valve |
| 12. Heater retuen port | 24. Coolant Heater |

Acccording to the block diagram of diesel generator system has a

series structure, where the system is said to be damaged if one of its components is damaged and the system is said to be good if all components are in good condition.

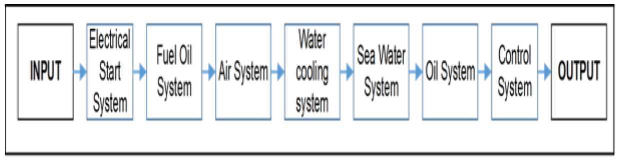



**Figure 9.** Block Diagram of Diesel Generator

### 3.1 Fault Tree Analysis of Diesel Generator

In the FTA method, the failure of the diesel generator is a top event, the diesel generator operational support systems are developed into a fault tree to find the factors that cause the diesel generator to fail. Factor analysis diesel generator failure can be caused by one of the existing systems. The relationship/logic event of the diesel generator failure factors is to use an OR gate. This shows that the failure of the diesel generator can be caused by one of the failure factors. For detail of factor cause diesel generator fail on figure 10.

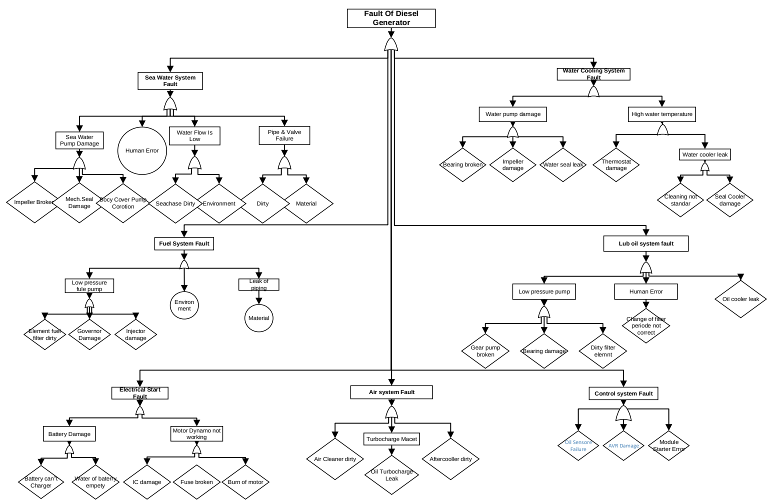



**Figure 10.** Fault Tree Diagram of Diesel Generator

### 3.2 FMECA of Diesel Generator

The diagram in figure 3.1 shows which components are the cause of the sub-system on the diesel generator that affects engine performance. To find out the failure in detail using the Failure Mode Effect and Citical analysis which is applied to the diesel genartor system. The diesel generator system is divided into 7 (seven) sub-systems, namely fresh water sub-system, seawater sub-system, air sub-system, fuel sub-system, lubricant sub-system, electric start sub-system and control sub-system.

a. Sea water sub-system, function each component are of tube coole for heat absorber coolant, impeller for make faster in and out fluid, gasket pump for body casing insulator, Casing cover for protective rotary component pump, Mechanical seal for obratction fluid leakage, strainer for filtering sea water waste, shaft SW pump for pass on rotary moment from driver, and bearing SW pump for keep friction between shaft rotary and body casing.

b. Coolant water sub-system, function each component are, bearing for keep friction between shaft rotary and body casing, seal oil and water for prohibit oil and water get involved, thermostate for keep stability water temperature, rectanguler seal HE for obstauction fluid leakage, and heat excahanger tube for heat absorber coolant.

c. Fuel oil sub-system, function each component are, element fuel filter for filtering fuel sludge, main shaft fuel pump for pass on rotary moment from driver, o-seal drive shaft and seal wire for obstuction fuel leakage, and injector for fuel spraying to combution chamber.

d. Lub oil sub-system, function each component are bushing oil pump for vibration muffle, element oil filter for filtering oil sludge, and seal oil heat exchanger for leakage oil inhibitor.

e. Air intake and exhaust Sub-system, funtion each component are air cleaner for filtering air waste, aftercooler for absorb heat of air intake, seal rectanguler ring for air leakage inhibitor and bushing turbocharger for vibration muffle and oil leak inhibitor

f. Elelctricaly starter sub-system, function each component are, battery for electric power storage, and modul starter for regulating starting engine process

g. Control sub-system, function ecah component are, AVR for electrically controlling fuel and Engine oil sensor for read oil temperature.

For detail cause and effect each component in the sub system diesel generator show on FMECA worksheet tabel 7.

The FMECA process included components failure mode, failure cause, effects of the failure on the transformer/network and recommendations were formulated to curb future failure. The criticality analysis of each failure mode was performed by assigning to each failure mode a Risk Priority Numbers (RPN), and the results of the entire FMECA process is represented in table 7. Table 7, summarizes the failure modes of diesel geneator components each sub system, failure causes, effects of component failure of the diesel genator units or the entire grid and the Risk Priority Numbers based on how severe the effects of a failure are, how frequent a fault occurs and how easy is it to detect the failure before it occurs. Risk Priority Numbers assignments to failure modes are referred to as criticality analysis and specify the critical nature of each component failure. Sample calculation RPN on Tube cooler sea water is ; ***RPN = S*** (8) x O (8) x D (6) = 375

The highest RPN shows the components on which much attention should be tilted. From table 7, any seven component have the highest RPN values their are impeller, tube cooler sea water, casing cover, battery accu, mechanical seal, strainer and seal rectanguler heat excahanger.

**Tabel 7.** Causes and Effect failure worksheet

| No | Item | Function | Failure Mode | Failure Causes | Failure Effect | Detection Method |
|---|---|---|---|---|---|---|
| W1 | Tube Cooler Sea Water | Heat absorber coolant | Mechanical | Tube cooler corrosion | Coolant and sea water mixed | Visual inspection |
| W2 | Impeller | Make Faster in/0ut fluid from pump | Mechanical | Impeller corrosion and crack | Suction and press pump can"t work perfection | No detection equipment |

| No | Item | Function | Failure Mode | Failure Causes | Failure Effect | Detection Method |
|---|---|---|---|---|---|---|
| W3 | Gasket pump | Body casing insulator | Mechanical, thermal | Gasket damage | Permeate water from pump | Visual inspection |
| W4 | Casing Cover | Protective rotary componen pump | Material, Mechanical | Material corrosion | Pump can't vaccum | Visual inspection |
| W5 | Mechanical Seal | Obstruction fluid leakage | Mechanical | Mech.Seal damage | Pump suction not perfection | Visual inspection |
| W6 | Strainer | Filtering sea water waste | Mechanical, material | Material corrosion | Sludge go into cooling water | Visual inspection |
| W7 | Shaft SW Pump | Pass on rotary moment from driver | Mechanical | Wear out and corrosion of shaft | impeller not balance occure of vibration | No detection equipment |
| W8 | Bearing SW pump | Fiction keeping between shaft rotary and body casing | Mechanical | Bearing broken and worn out | Pump suction not perfection | No detection equipment |
| W9 | Bearing Coolant Pump | Fiction keeping between shaft rotary and body casing | Mechanical | Bearing broken and worn out | Pump suction not perfection | No detection equipment |
| W10 | Seal Water Coolant Pump | Prohibit oil and water get involved | Mechanical, thermal | Solidify of seal or damage | less of pump suction | Visual inspection |
| W11 | Seal oil Coolant Pump | Prohibit oil and water get involved | Mechanical, thermal | Solidify of seal or damage | Pump suction not perfection | Visual inspection |
| W12 | Thermostat | Keep Stability water temperature | Mechanical, thermal | Termostate can"t work | Coolant temperature Overheating | Visual inspection |
| W13 | Rectanguler Seal HE | Obstruction fluid leakage | Mechanical, thermal | Solidify of seal or damage | Leakage coolant | Visual inspection |
| W14 | Heat Exchanger Tube | Heat absorber coolant | Mechanical, thermal | Tube HE corrosion | Coolant and sea water mixed | Visual inspection |
| W15 | Element Fuel Filter | Filtering Fuel Sludge | Mechanical | Element filter clogged | Less of fuel pressure | Pressure sensor |
| W16 | Main Shaft Fuel Pump | Pass on rotary moment from driver | Mechanical | Shaft worn out | Gear pump can"t rotatri occure vibration | No detection equipment |
| W17 | O-Seal Drive Shaft | Obstruction fuel leakage | Mechanical, thermal | Solidify of seal or damage | Pump suction not perfection | Visual inspection |
| W18 | Seal Wire | Obstruction fuel leakage | Mechanical, thermal | Solidify of seal or damage | Pump suction not perfection | Visual inspection |
| W19 | Injector | Fuel spraying to chamber | Mechanical | Injector Shim worn out | High of exhaust temperatur | Visual inspection |
| W20 | Bushing Oil pump | Vibration muffle | Mechanical | Bushing worn out | Crude noise and oil leak | No detection equipment |
| W21 | Element oil Filter | Filtering oil Sludge | Mechanical | Element filter clogged | Less of oil pressure | Pressure sensor |
| W22 | Seal oil Heat Exchanger | Leakage oil inhibitor | Mechanical, thermal | Solidify of seal or damage | Oil Leakage | Visual inspection |
| W23 | Battery Accu | Electric Power Storage | Mechanical, thermal, Electrical | Less of accu water or element damage | No electrik power to starting engin | Voltage indicator |
| W24 | Gear pinion motor | Pass on rotary power of starter | Mechanical | Knocked gear or fault | Flywheel can<t turning | No detection equipment |
| W25 | Air Cleaner | Filtering air waste | Mechanical | Element filter clogged | Decreasing volume of air | Pressure sensor |
| W26 | Aftercooler | Absorb heat of air intake | Mechanical, thermal | Aftercooler corrosion | Air intake temperatur high | Visual inspection |
| W27 | Seal Rectanguler ring | Air Leakage inhibitor | Mechanical, thermal | Solidify of seal or damage | Air leakage | Visual inspection |

| No | Item | Function | Failure Mode | Failure Causes | Failure Effect | Detection Method |
|---|---|---|---|---|---|---|
| W28 | Bushing TC | Vibration muffle and oil leakage inhibitor | Mechanical | Bhusing worn out | Crude noise and oil leak | No detection equipment |
| W29 | AVR | Electricaly Controlling fuel | Thermal, Electrical | Short Circuit | Engine rotation unstable | Rpm engine Indicator |
| W30 | Engine oil sensor Temperatur | Read oil temperature | Thermal, Electrical | Short Circuit | Engine can"t start | Alarm sensor |
| W31 | Modul Starter | Regulating starting engine process | Thermal, Electrical | Short Circuit | Engine can"t start | Alarm monitoring |

**Tabel 8.** RPN value of components

| No | Item | Severity (S) | Occurrence (O) | Detection (D) | RPN |
|---|---|---|---|---|---|
| W1 | Tube Cooler Sea Water | 7.8 | 7.8 | 6.3 | 375.4 |
| W2 | Impeller | 8.1 | 6.8 | 6.9 | 377.1 |
| W3 | Gasket pump | 3.9 | 7.1 | 3.8 | 103.5 |
| W4 | Casing Cover | 7.5 | 8.6 | 5.8 | 372.0 |
| W5 | Mechanical Seal | 7.3 | 8.0 | 6.4 | 369.8 |
| W6 | Strainer | 6.8 | 8.8 | 6.3 | 369.1 |
| W7 | Shaft SW Pump | 7.9 | 2.1 | 5.6 | 94.1 |
| W8 | Bearing SW pump | 3.8 | 4.5 | 3.8 | 63.3 |
| W9 | Bearing Coolant Pump | 5.3 | 4.1 | 4.3 | 92.0 |
| W10 | Seal Water Coolant Pump | 4.0 | 7.8 | 6.3 | 45.1 |
| W11 | Seal oil Coolant Pump | 6.9 | 6.8 | 6.9 | 95.7 |
| W12 | Thermostat | 5.3 | 2.4 | 4.8 | 67.3 |
| W13 | Rectanguler Seal HE | 7.9 | 3.4 | 4.1 | 367.9 |
| W14 | Heat Exchanger Tube | 7.9 | 2.5 | 5.1 | 103.4 |
| W15 | Element Fuel Filter | 6.4 | 8.1 | 5.8 | 94.8 |
| W16 | Main Shaft Fuel Pump | 7.9 | 2.5 | 5.3 | 98.4 |
| W17 | O-Seal Drive Shaft | 3.3 | 7.0 | 2.1 | 76.0 |
| W18 | Seal Wire | 4.0 | 2.5 | 5.0 | 97.5 |
| W19 | Injector | 7.5 | 4.3 | 5.5 | 88.6 |
| W20 | Bushing Oil pump | 7.8 | 4.9 | 5.0 | 80.4 |
| W21 | Element oil Filter | 8.1 | 3.4 | 3.5 | 99.9 |
| W22 | Seal oil Heat Exchanger | 7.0 | 2.5 | 6.1 | 101.5 |
| W23 | Battery Accu | 7.9 | 7.3 | 2.3 | 371.0 |
| W24 | Gear pinion motor | 7.3 | 4.0 | 3.6 | 73.4 |
| W25 | Air Cleaner | 3.3 | 8.4 | 5.6 | 51.8 |
| W26 | Aftercooler | 3.6 | 3.0 | 3.4 | 21.4 |
| W27 | Seal Rectanguler ring | 3.5 | 6.4 | 2.5 | 82.7 |
| W28 | Bushing TC | 8.1 | 2.3 | 2.6 | 75.2 |
| W29 | AVR | 8.0 | 3.5 | 6.8 | 36.8 |
| W30 | Engine oil sensor Temperatur | 3.6 | 2.0 | 4.6 | 15.0 |
| W31 | Modul Starter | 7.8 | 2.6 | 1.8 | 38.8 |
| | | **RPN Value : 366,6** | | | |

**Tabel 9.** Risk Matriks Component

| No | Item | Consequency | | Risk Level |
|---|---|---|---|---|
| | | Severity | Occurrence | |
| W1 | Tube Cooler Sea Water | Critical | Probable | High |
| W2 | Impeller | Catastrophic | Probable | High |
| W3 | Water Seal | Negligible | Probable | Medium |
| W4 | Casing Cover | Critical | Frequent | High |
| W5 | Mechanical Seal | Critical | Probable | High |
| W6 | Strainer | Critical | Frequent | High |
| W7 | Shaft SW Pump | Critical | Improbable | Low |
| W8 | Bearing SW Pump | Negligible | Remote | Medium |
| W9 | Bearing Coolant Pump | Marginal | Remote | Medium |
| W10 | Seal Water Coolant Pump | Negligible | Improbable | Low |
| W11 | Seal oil Coolant Pump | Critical | Remote | Medium |
| W12 | Thermostat | Marginal | Improbable | Low |

| No | Item | Consequency | | Risk Level |
|---|---|---|---|---|
| | | Severity | Occurrence | |
| W13 | Rectanguler Seal HE | Critical | Frequent | High |
| W14 | Heat Exchanger Tube | Critical | Improbable | Low |
| W15 | Element Fuel Filter | Critical | Occasional | Medium |
| W16 | Main Shaft Fuel Pump | Critical | Improbable | Low |
| W17 | O-Seal Drive Shaft | Negligible | Remote | Medium |
| W18 | Seal Wire | Negligible | Remote | Medium |
| W19 | Injector | Critical | Remote | Medium |
| W20 | Bushing Oil pump | Marginal | Improbable | Low |
| W21 | Element oil Filter | Marginal | Probable | Medium |
| W22 | Seal oil Heat Exchanger | Critical | Remote | Low |
| W23 | Battery Accu | Critical | Frequent | High |
| W24 | Gear pinion motor | Critical | Remote | Medium |
| W25 | Air Cleaner | Negligible | Occasional | Medium |
| W26 | Aftercooler | Negligible | Improbable | Low |
| W27 | Seal Rectanguler ring | Negligible | Remote | Medium |
| W28 | Bushing TC | Catastrophic | Improbable | Low |
| W29 | AVR | Critical | Improbable | Low |
| W30 | Engine oil sensor Temperatur | Negligible | Improbable | Low |
| W31 | Modul Starter | Critical | Improbable | Low |

**Tabel 10.** Risk matriks mapping

| | *Minor* | *Negligible* | *Marginal* | *Critical* | *Catastrophic* |
|---|---|---|---|---|---|
| ***Frequent*** | | | | **4,13,23** | |
| ***Probable*** | | **3** | **21** | **1,5,6** | **2** |
| ***Occasional*** | | **25** | | **15** | |
| ***Remote*** | | **8,14,17,18,27** | **9** | **11,19,22,24** | |
| ***Improbable*** | | **10,26,30** | **12,20** | **7,14,16,29,31** | **28** |

**Tabel 11.** Critical Components

| No | Item | Function | Failure Mode | Failure Causes | Failure Effect | Risk Level | RPN |
|---|---|---|---|---|---|---|---|
| W1 | Tube Cooler Sea Water | Heat absorber coolant | Mechanical | Tube cooler corrosion | Coolant and sea water mixed | High | **375,4** |
| W2 | Impeller | Make Faster in/0ut fluid from pump | Mechanical | Impeller corrosion and crack | Suction and press pump can"t work perfection | High | **377,1** |
| W4 | Casing Cover | Protective rotary componen pump | Material, Mechanical | Material corrosion | Pump suction not perfection | High | **372,0** |
| W5 | Mechanical Seal | Obstruction fluid leakage | Mechanical | Mech.Seal damage | Pump suction not perfection | High | **369,8** |
| W6 | Strainer | Filtering sea water waste | Mechanical, material | Material corrosion | Sludge go into cooling water | High | **369,1** |
| W13 | Rectanguler Seal HE | Obstruction fluid leakage | Mechanical, thermal | Solidify of seal or damage | Leakage coolant | High | **367,9** |
| W23 | Battery Accu | Electric Power Storage | Mechanical, thermal, Electrical | Less of accu water or element damage | No electrik power to starting engin | High | **371,0** |

RPN calculations and risk mapping for critical components of diesel generators have the effect of engine running is shutdown, which has an RPN value above the average and has a risk with a "High" rating. So that the components can be categorized as critical components of diesel generators.

## 4. CONCLUSION

System of Diesel generator Cummins KTA 38D have 7 (sevent) sub-systems that support the operation of diesel generators arranged in series structure. Fault tree to find the factors that cause the diesel generator to fail. Factor analysis diesel generator failure can be caused by one of the existing systems.

RPN calculations and risk mapping for critical components of diesel generators have the effect of engine running is shutdown, which has an RPN value above the average and has a risk with a "High" rating. The critical components are, tube cooler seawater (375,4) with failure causes tube cooler corrosion and failure effect is coolant mixed with seawater, impeller (377,1) with failure causes corrosion/crack and failure effect is suction and pressure can't work, casing cover (372,0) failure causes material corrosion failure effect pump suction not perfection, battery accu (371,0) failure causes is less of water battery failure effect no electric power , mechanical seal (369,8) failure causes damage failure effect pump suction no perfection, strainer (369,1) failure causes carrion failure effect sludge to go into cooling water and seal rectangular heat exchanger (367,9) failure causes solidify or damage failure effect is coolant leakage.

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