Impact of Service Engineer Development to Improve Quality of Technical Service Information Report of Heavy Equipment Failure

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Abstract*—Heavy equipment is a capital good, high performance and reasonable costs are highly demanded. Repetitive technical problem as equipment failure will decrease performance and increase cost. It is not only fixed but needs to be analyzed and reported to get a final solution. Main problem of low-quality score of Technical Service Information (TSI) report cannot provide data and information for failure analysis to find root causes, determining conclusions, and recommending the final solution. This study aims to improve the quality score of Technical Service Information report. Standardization of documents to capture and record failure data in the field and TSI report guidance was developed referred to problems existed and manufacture standardization. Transfer of learning on standardization and guidance used a learning framework 70:20:10. Comparative analysis of the TSI quality score before and after this study became a measure of the impact on this development. The result of this study is the development of Service Engineers with a 70:20:10 pattern, on standardization of TSI Report and capturing field failure data has a good impact in increased quality score of the TSI report Service Engineer. The quantity of qualified report was also significantly improved from 32% to 92%.

***Keywords*—component, formatting, style, styling, insert.**

I. Introduction

Heavy equipment is capital goods to produce certain products. Therefore, for the production target to be achieved, the heavy equipment must always be in good performance so that it can be operated continuously (high availability) with reasonable cost.

Repetitive technical issues will result in high downtime, low availability, and increased costs. Technical problems not only need to be fixed but also need to be analyzed and reported by distributor or customer to manufacture, which provide accurate and timely failure information to initiate quality improvement to obtain a solution or final solution.

A. Background

Finding the underlying cause of the damage is a key approach and is an important step in the improvement process [1]. Necessity data of maintenance, application, and operation, physical evidence, failed parts, or components of equipment should be provided and reported to analyze failure.

Sometimes not all failure required comprehensive data, but sometimes gathering data were not adequate to clearly identify the possibility of failure mechanism to explain why it has happened. The data should be relevant, and accurate data must be collected. Information from the data is a big contribution to make recommendations and conclusions [2] [3]. Conclusion recommendation without proper analysis of collected data end evidence should be avoided.

The data quality control process is used to identify and or help reduce errors or gaps in data prior to analysis. Proactive steps to control the data quality are important very important and very necessary [4]. Distributors and manufacturers must implement data quality standards for equipment failures, supported by competent service engineers who are competent in presenting data according to established quality standards reported in the Technical Service Information.

B. Research Problem

1. TSI report of equipment failure was low-quality (score <80) as required by manufacture.
2. The 70:20:10 learning framework that was announced by the company has never been researched and implemented in the formation of reporting competency of equipment failures.

C. Objectives

1. Determine the root cause of low-quality score TSI report and take actions by factors that influence to improving the quality score.
2. Perform development service engineer with a 70:20:10 learning framework to achieve TSI quality score >80.

II. LITERATUR REVIEW

A. *Failure Analysis for Quality Improvement.*

Industrial oorganization's produce with predetermined quality standards. However product in the market having some failure after used. It is a major challenge to identify any failures and control them appropriately to prevent prolonged failure. In accordance with the importance of preventing recurrence of failures, analysis of the causes of failure has become a vital [5].

B. *Data Collection of Failure Analysis for Quality Improvement*

Failure report which come from investigation consisting detail of failure data, time of occurrence and confirming the failure, place where the failure is occurs, failure characteristic, and effect to the customers or manufacturer are the first stages of Root Cause Failure Analysis. The second stages are analysis of the failure. The third stages are determining the factor which related to the failure and determining the main cause or root cost of failure, and the last stages by determining conclusion recommendation to the failure [1]. Several reference of data collections was discussed in many book and publication journal for equipment failure [2] into several groups:

1. Failure reports that contain of data the failure parts.
2. Physical evidence or the photographs of the evidence
2. Document/records from maintenance history,
3. Operation Records
4. Environmental factors and Field Information (location, equipment, parts).

C. *Data Qualification for Quality Improvement*

Data quality can be maximized if the database or data qualification are well designed. Standard and qualification data transforming to standard data collection forms should be developed. Each data item has a clear written definition, using widely accepted definitions for easy understanding. Work instructions on how to use them to collect data should also be made so that they can be understood and used as a reference by engineers in various places. Lack of guidance can result in incorrect data collection. This work instruction is essential for training staff [4].

D. *Data Quality Control Process*

The data quality control process is used to identify and or help reduce errors or gaps in data prior to analysis. Definition data quality can have universal meaning, it will depend on several aspects. To ensure accurate measure of the data quality, it must be choosing to determine what attributes are taken into consideration and how much each item of these attributes contributes to the whole [6] emphasizes that it is not easy to manage data quality (DQ) without understanding the meaning of the data, that determines its quality. The following attributes are the most important identifiers in the data:

a. Accuracy: "The recorded value is in conformity with the actual value."
b. Completeness: "All values for a certain variable are recorded."
c. Consistency: "The representation of the data value is the same in all cases."
d. Timelines: "The recorded value is not out of date.

Japan worldwide manufacturer of heavy equipment make a standardization point of each data element of TSI report.

E. *Service Engineer Development Program.*

The development of human resource capabilities can be realized when the learning process occurs. This can be measured if there are new abilities and things applied in the workplace because of the learning process, and are applied consistently [7].

The 70:20:10 learning framework is based on a study of 200 executive employees from six well-known companies [8]. Based on the results of recording, 70 percent of the increase in ability was obtained from their work history on challenging tasks, while 20 percent occurred due to relationships and communication with fellow workers, older colleagues and with superiors. A 10 percent increase in ability was obtained from the formal training process in which he participated [8].

This study applies the 70:20:10 learning framework in improving the ability of Service Engineers to solve quality problems in TSI reports that have not reached the standard.

F. *Product Failure Problem Escalation and Final Solution.*

The flow chart in Fig. 1 shows how process stages and organizational levels play a role in obtaining the final solution for equipment failure.

When failure occurs, the technician repairs and creates a Technical Service Report (TSR) which is inputted into the Equipment Monitoring Report (EMR). TSI reports are generated based on EMR data and sent to manufacturer representatives and factory engineers. In some critical problems, it is followed up with Electronic TSI.

There is a follow-up meeting called the ICauCa (Identification Cause and Corrective Action) and QA (Quality Meeting) meeting between distributors and manufacturers. Follow-up meeting namely the JUHIN meeting, to follow up on high level equipment failures at the factory level to find out solution.

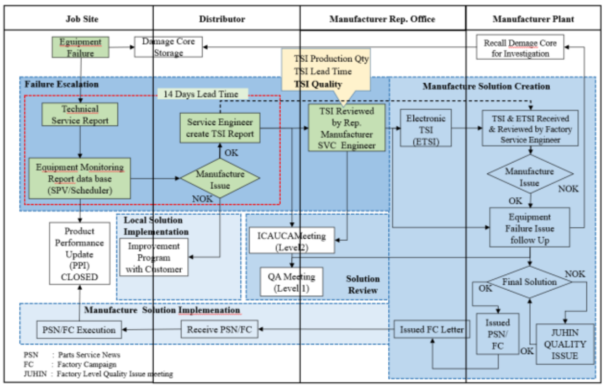


Fig. 1. Equipment failure information and solution process between distributor land manufacturers

III. RESEARCH METHODS

A. Scope of study

The scope of this evaluation research (Fig.2) is to increase Quality Score and Level of TSI reports of Service Engineer in the leading heavy equipment distributor in Indonesia. Following figure shown the flow chart of heavy equipment failure improvement and scope of this study:

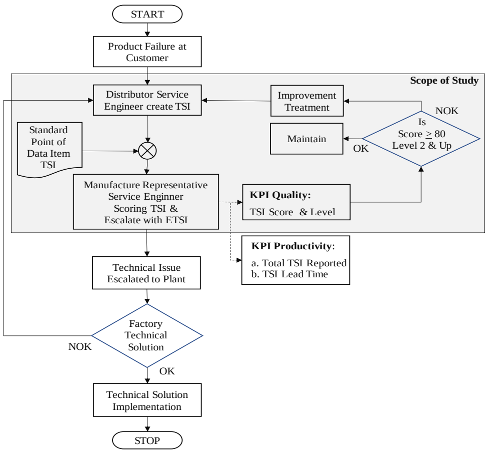


Fig. 2. Heavy equipment failure solution chart

B. Research Framework

Following diagram is the sequence of research was carried out as shown in Fig. 3.

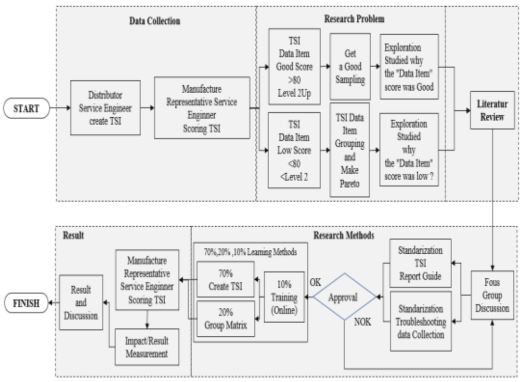


Fig. 3. Research flow process

C. Methods of Analysis

Base on the first semester 2020 TSI score point as shown on Fig. 4. TSI report quality score did not achieve the standard minimum 80 required by manufacturer.

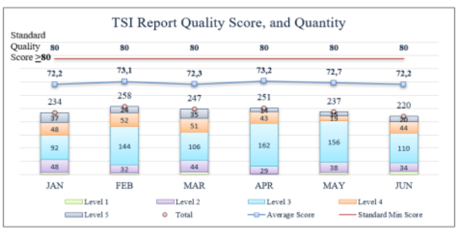


Fig. 4. Technical service information report quality score January-June 2020

Further study of 612 TSI reported which produce by 20 persons service engineers from June to August, founded that Level 1 and Level 2 Score proportion only 32%, as shown in the following Table 1.

TABLE I
TSI REPORT QUALITY SCORE LEVEL PRODUCED BY 20 SERVICE ENGINEER AT JUNE-AUGUST 2020

Level	Quantity Report	% to total	Score		
			Average	Min	Max
Level 1	11	2%	92	88	95
Level 2	182	30%	80	76	85
Level 3	265	43%	71	66	75
Level 4	152	25%	60	51	65
Level 5	2	0%	50	50	50
Total	612	100%	71		

Further data analysis by exploring each data item to find out which data items contributed to the low score, also compared with the score for each level to see the trend. The results of the analysis are as shown in the Table 2.

TABLE II
LOW SCORE OF TSI DATA ITEM

No	Technical Service Information (TSI) Data Item *	Point /Item**	Total TSI	Total Point TSI Data Item of 612 TSI	Average Score per TSI Data Item *#	Score TSI Data Item per Level *)				
						1	2	3	4	5
1	TSI No.	1	612	612	100	100.0	100.0	100.0	100.0	100.0
2	Distributor Name	1	612	612	100	100.0	100.0	100.0	100.0	100.0
3	Country	1	612	612	100	100.0	100.0	100.0	100.0	100.0
4	Category	1	612	612	100	100.0	100.0	100.0	100.0	100.0
5	Saved Date	1	612	612	100	100.0	100.0	100.0	100.0	100.0
6	Sent Date	1	612	612	100	100.0	100.0	100.0	100.0	100.0
7	Working Country	1	612	612	100	100.0	100.0	100.0	100.0	100.0
8	Info. Category	1	612	612	100	100.0	100.0	100.0	100.0	100.0
9	Subject	1	612	611	100	100.0	100.0	99.6	100.0	100.0
10	How was problem?	1	612	474	***77.8***	83.3	87.4	***65.8***	85.2	100.0
11	Model-Type	1	612	612	100	100.0	100.0	100.0	100.0	100.0
12	Machine S.M.R.	1	612	612	100	100.0	100.0	100.0	100.0	100.0
13	Engine Model	1	612	612	100	100.0	100.0	100.0	100.0	100.0
14	Serial Number	1	612	612	100	100.0	100.0	100.0	100.0	100.0
15	Hours on Parts	1	612	611	100	100.0	100.0	99.6	100.0	100.0
16	Odometer	1	612	181	***29.9***	***50.0***	***30.2***	***24.8***	***37.4***	***0.0***
17	Engine Serial Number	1	612	612	100	100.0	100.0	100.0	100.0	100.0
18	Delivery Date	1	612	611	99.8	100.0	99.5	100.0	100.0	100.0
19	Failure Date	1	612	612	100.0	100.0	100.0	100.0	100.0	100.0
20	Failure Confirmation Date	1	612	140	***23.1***	***58.3***	***37.2***	***14.7***	***16.1***	***0.0***
21	Contact Date by Customer	1	612	193	***31.1***	91.7	***43.3***	***20.5***	***28.4***	***50.0***
22	Customer Name	1	612	612	100.0	100.0	100.0	100.0	100.0	100.0
23	Application	1	612	608	99.4	100.0	100.0	99.6	98.1	100.0
24	Working Condition	1	612	603	98.5	100.0	98.1	98.9	98.1	100.0
25	Repair Date	1	612	174	***27.9***	***41.7***	***28.4***	***22.7***	***36.1***	***0.0***
26	Machine Location	1	612	602	98.5	100.0	98.1	97.8	100.0	100.0
27	Ground Condition	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
28	Environment	1	612	600	98.2	100.0	97.2	98.2	99.4	100.0
29	Speciality of Machine Usage	1	612	322	***54.8***	100.0	***76.3***	***41.0***	***47.1***	***0.0***
30	Option/Attachment	1	612	416	***69.3***	100.0	83.3	***64.4***	***56.8***	***50.0***
31	Local Modification	1	612	276	***47.9***	***58.3***	***73.5***	***38.8***	***28.4***	***0.0***
32	Fuel	1	612	590	96.7	100.0	100.0	93.2	98.1	100.0
33	Major Component Name	1	612	301	***50.5***	100.0	***75.8***	***37.4***	***35.5***	***0.0***
34	Critical Part Number	2	612	432	***70.9***	95.8	86.5	***72.5***	***44.8***	***50.0***
35	Critical Part Name	2	612	425	***70.0***	95.8	87.7	***70.9***	***42.6***	***25.0***
36	Major Component Serial Number	1	612	209	***36.4***	***50.0***	***67.9***	***24.5***	***13.5***	***0.0***
37	Error Code	1	612	208	***37.3***	***41.7***	***61.4***	***24.8***	***25.8***	***50.0***
38	Work Type	1	612	609	99.5	100.0	100.0	100.0	98.1	100.0
39	Component Code	1	612	605	98.9	100.0	100.0	99.6	96.1	100.0
40	Phenomenon Code	1	612	611	99.8	100.0	100.0	100.0	99.4	100.0
41	Send To	1	612	611	99.8	100.0	100.0	100.0	99.4	100.0
42	Office Name	1	612	604	98.8	100.0	99.5	99.6	96.1	100.0
43	Dealer Name	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
44	TEL No.	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
45	Applicant	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
46	E-Mail Address	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
47	Service Manager	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
48	Failed Parts Returnable	1	612	610	99.7	100.0	99.5	100.0	99.4	100.0
49	Phenomenon/symthom of problem (low power, noisy, exhaust white gas, etc)	2	612	536	88.4	100.0	97.0	90.5	***72.6***	***50.0***
50	Customer complaint (safety issue, high repair cost, long downtime, etc)	3	612	186	***31.1***	97.2	***39.7***	***25.4***	***24.3***	***16.7***
51	Condition of damage part (leak, worn, rusty, broken)	3	612	422	***69.0***	100.0	***75.8***	***79.7***	***38.7***	***16.7***
52	Kind of machine work (load, light, heavy, etc)	2	612	179	***29.3***	91.7	***36.3***	***20.1***	***31.0***	***50.0***
53	Site condition (dusty, chemical, high altitude, etc)	2	612	151	***24.2***	91.7	***23.7***	***18.5***	***29.7***	***50.0***
54	Maintenance of machine (Air Cleaner cleaning interval, hyd oil replacement interval, etc)	2	612	172	***28.7***	100.0	***32.8***	***21.6***	***30.3***	***25.0***
55	Inspection & measurement data result (check sheet)	4	612	412	***67.9***	100.0	80.8	***69.8***	***44.5***	***25.0***
56	Action taken or planned (when, what, how, etc)	5	612	467	***77.7***	100.0	91.4	80.4	***52.8***	***20.0***
57	Similar problem in Indonesia	1	612	47	***7.6***	***75.0***	***7.9***	***7.2***	***2.6***	***0.0***
58	Competitor problem information	1	612	31	***4.7***	***75.0***	***0.9***	***6.5***	***1.3***	***0.0***
59	Request plant to recall or investigate damage part	1	612	398	***64.8***	100.0	***76.7***	***60.1***	***54.8***	***0.0***
60	Request plant to inform similar problem in other country	1	612	40	***6.0***	83.3	***2.3***	***6.8***	***3.9***	***0.0***
61	Environment & working condition (working area, machine work condition)	2	612	474	***77.6***	***62.5***	89.1	***78.2***	***61.9***	***50.0***
62	Maintanance condition (Air cleaner, Oil filter, Fuel storage,	2	612	468	***76.1***	***25.0***	82.3	87.1	***52.3***	***50.0***
63	Identification of machine & component (Whole photo, front/rear/side photo, SMR, Serial no)	4	612	362	***59.1***	***58.3***	***70.1***	***58.7***	***44.8***	***37.5***
64	Location abnormal part (overall, close up, capture of part book, electric/hyd line diagram)	4	612	460	***75.9***	100.0	92.3	***77.7***	***48.7***	***25.0***
65	Abnormality description (measurement data result, leak, worn, rusty, broken)	8	612	447	***73.5***	100.0	89.1	***77.0***	***44.4***	***6.3***
66	Damage core (component serial/stamping, hose brand, etc)	2	612	356	***58.2***	100.0	***77.9***	***56.5***	***30.6***	***50.0***
67	Outcome repair (repair, replace new part)	1	612	360	***59.4***	100.0	***72.6***	***52.9***	***49.7***	***50.0***

Legend : * **TSI Data Item** is the item data should be filled out in TSI Report
** **Point/Item** was point of each TSI Data Item, if this item data fill out correctly on the TSI
*# **Average Score per TSI Data Item** is average score from collected 612 TSI.
*) **Score TSI Data Item per Level *)** is average score achieved per data item per report (Level 1- Level 5)

To facilitate the follow-up, data items were grouped and pareto were arranged by that group as following Fig. 5.

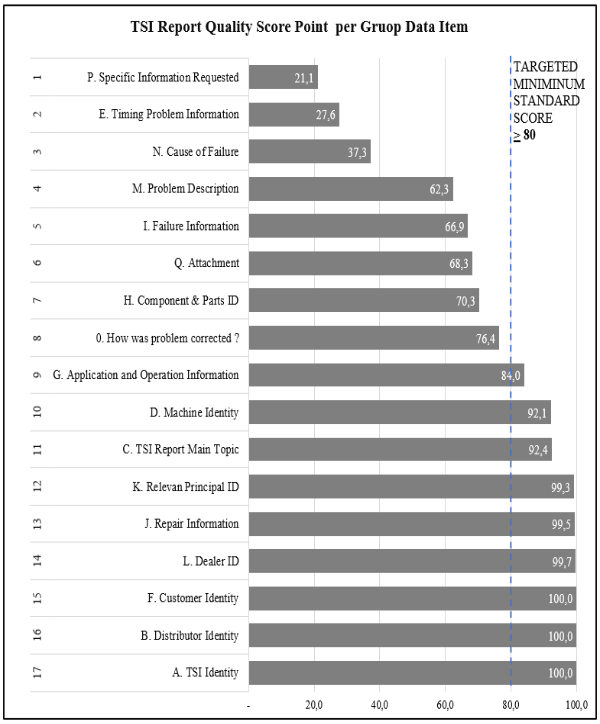


Fig. 5. Pareto of lowest score data item group.

That trend is further explored and discussed in the Product Matrix group to identify the root cause. Further study of low score TSI from the pareto, by group Product Matrix it was concluded that the cause of low score TSI report is:

1. Completeness of supporting data is lacking.
2. Inconsistent filling of report data.
3. Accuracy of data reported.
4. Unclear analysis and request for improvement.

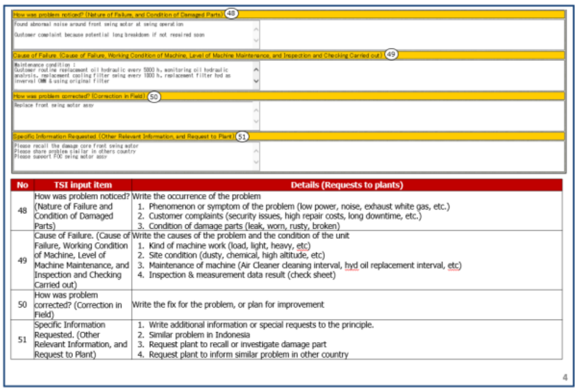
The root causes are:

1. Quality of data reports from field service technicians.
2. Inadequate data collection guidelines.
3. Collaboration and cooperation with Service Engineers that need to be improved.
4. Coordination in follow-up and handling of failure reports.

Based on this analysis, the Group Product Matrix working organization was formed by applying the 70:20:10 learning framework which resulted in:
1. Standardization of TSI report guidance.
2. Troubleshooting Documentation Guide.
3. TSI Working Team reports in the Group Product Matrix across the product team.

1. Standarization of TSI Report Guide

The Service Information guide contain of the instruction and how to fill the TSI, gives a sample of a good Technical Service Information as reference. The TSI Report Guide shown at Fig. 6.



No	TSI input item	Details (Requests to plants)
48	How was problem noticed? (Nature of Failure and Condition of Damaged Parts)	Write the occurrence of the problem 1. Phenomenon or symptom of the problem (low power, noise, exhaust white gas, etc.) 2. Customer complaints (security issues, high repair costs, long downtime, etc.) 3. Condition of damage parts (leak, worn, rusty, broken)
49	Cause of Failure. (Cause of Failure, Working Condition of Machine, Level of Machine Maintenance, and Inspection and Checking Carried out)	Write the causes of the problem and the condition of the unit 1. Kind of machine work (load, light, heavy, etc) 2. Site condition (dusty, chemical, high altitude, etc) 3. Maintenance of machine (Air Cleaner cleaning interval, hyd oil replacement interval, etc) 4. Inspection & measurement data result (check sheet)
50	How was problem corrected? (Correction in Field)	Write the fix for the problem, or plan for improvement
51	Specific Information Requested. (Other Relevant Information, and Request to Plant)	1. Write additional information or special requests to the principle. 2. Similar problem in Indonesia 3. Request plant to recall or investigate damage part 4. Request plant to inform similar problem in other country

Fig. 6. Technical service information report guide page 1

2. Problem failure/troubleshooting documentation guide.

Failure/troubleshooting documentation guide contains guidelines for recording data through photography so that failure handling data is completely documented, those photographs to be attached on the TSR and EMR. Good photo should organize documentation of troubleshooting and documented all data related to analyze and determined cause of trouble or failure, which capture of following subject:

a. Environment (working condition)

Environment/working condition (Fig.7) should well capture to show what condition of the machine was operated. Field topography gentle, steep, or bumpy; working condition: good, badly damage working area, wet, rocky, muddy; and detail area such as severity of road, many holes on the road.

Fig. 7. Photo documentation of working condition

b. Maintenance Condition

Maintenance condition could be seen from the condition of machine, filters or air cleaner, parts installation condition. It is required that photograph should record the condition to ensure evaluate maintenance condition as shown in Fig. 8.

Fig. 8. Sample picture of maintenance condition

c. Identity Machine, Component or Parts

Component and parts identity number (Fig. 9) and most named Serial Number was important information of, by that number Manufacturers can be easier to track the history of its production process.

Fig. 9. Photo documentation of equipment identity, components, or parts

d. Location/position of abnormal parts

Fig.10 is documentation to show the screening position of the defective or abnormal position of component or parts, by sequenced zoom in approach from the wider position location to the narrow/special location.

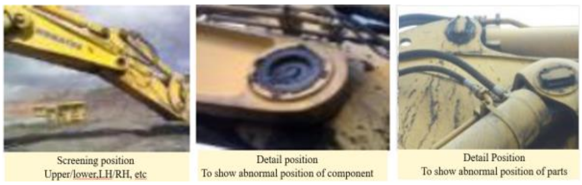


Fig. 10. Location/position of abnormal parts

e. Abnormality Description

Fig.11 is showing the abnormality description with complete identify of the machine and the hours of failure, failure or error code which displayed on the instrument panel and measured result as shown on display of the measurement tools.

Fig. 11. Documentation of abnormality

f. Damage part/component.

Documented damage parts/component from overall body, and identity number or serial number of failed part or component as shown in Fig. 12. Overall photo document should use tagging of component or parts data.

Fig. 12. Documentation of damage part/component

g. Outcome repair

Fig. 13 is showing installed parts or component repaired the failed parts to show the repair had carried out and completed.

Fig. 13. Photo documentation of outcome repair.

IV. RESULTS AND DISCUSSIONS

A. *Implementation Formal Training*

The 10 percent stage of the 70:20:10 learning framework is formal training to Service Engineers and Field Engineers as shown in Fig. 14. This process is carried out with formal online training. Quality acceptance training shown above the minimum requirements had been targeted. It is indicated that training process was accepted by participants.

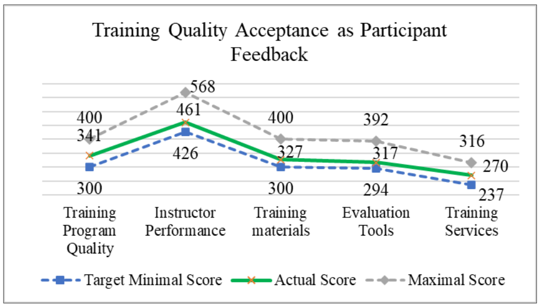


Fig. 14. Training quality acceptance by participants.

B. *Implementation Formal Training*

The 20 percent stage in this research was carried out by forming 2 matrix teams located at the Head Office and Kalimantan

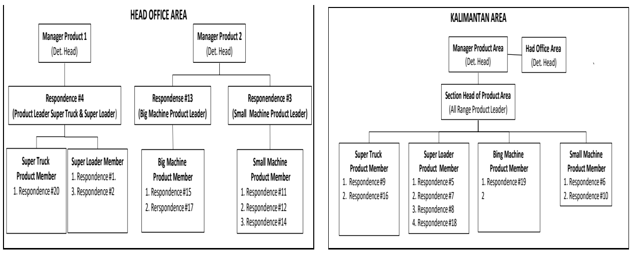


Fig. 15. Product matrix group.

The group product (Fig. 15) consisting of Engineer, Leader group and Manager of product, with following key activities:

1) Mutually discuss, mentoring and escalate obstacles and difficulties in the process of created TSI.
2) Weekly review of targeted technical report from branch and site. Review progress to control TSI production, lead time and quality.
3) Give a group feedback discussion of TSI report quality score point, to maintain spirit and consistence.

This following Fig.16 shown the impact result during research that in terp of KPI TSI production and lead time was maintained.

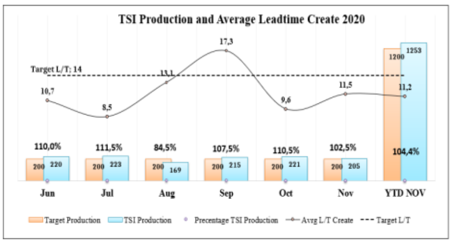


Fig. 16. TSI production and average leadtime when research

C. Result Practice Learning Process

The 70 percent learning framework in this study enriches the production capabilities of TSI, the results of this study, the quality score of September-November 2020 increased compared to data for June - August 2020 (base line) as following Fig. 17:

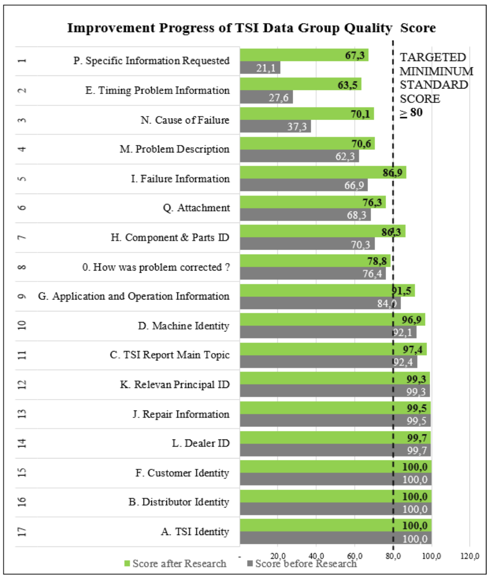


Fig. 17. Improvement progress of TSI data group quality score.

After implemented 70:20:10 learning framework improvement competencies of each service engineer measured by improvement their quality score as following table.

V. CONCLUSSION

This study was resulted impact of:

1. Increased TSI quality score from average 71 to 83.7.
2. Increased qualified TSI report > Level 2 from 31.5% to 90.2% of 641 TSI reported.
3. Average quality score Level 2 improved from 76 to 83, above minimum score 80 as requested by manufacturer.
4. TSI report quality score of 20 respondence improved above 80, from 82 to 84.9 (as shown on Table 3).

VI. RECOMENDATIONS

1. The Group Product Matrix must be maintained to achieve persistence results.
2. Data collection may use video recording, and improved infrastructure for storage and transfer data.

TABLE III
PROGRESS IMPROVEMENT TSI REPORT QUALITY SCORE PER RESPONDENCE

No	Respondence #	AVERAGE SCORE		
		BEFORE	AFTER	Progress
1	Respondence #1	80.3	82.3	Improved
2	Respondence #2	79.4	83.2	Improved
3	Respondence #3	79.2	83.9	Improved
4	Respondence #4	76.4	83.8	Improved
5	Respondence #5	73.3	84.0	Improved
6	Respondence #6	73.3	84.0	Improved
7	Respondence #7	72.5	84.9	Improved
8	Respondence #8	71.0	84.3	Improved
9	Respondence #9	70.5	82.9	Improved
10	Respondence #10	70.4	82.0	Improved
11	Respondence #11	70.4	83.2	Improved
12	Respondence #12	70.1	83.8	Improved
13	Respondence #13	68.8	84.0	Improved
14	Respondence #14	68.1	83.3	Improved
15	Respondence #15	68.1	84.5	Improved
16	Respondence #16	68.0	84.6	Improved
17	Respondence #17	67.1	83.2	Improved
18	Respondence #18	66.2	83.9	Improved
19	Respondence #19	65.3	82.6	Improved
20	Respondence #20	58.5	82.9	Improved
Grand Total		71.1	83.7	Improved
Total Report		612	641	

Following Table IV shows the progress improvement of TSI report quality Level and Score:

TABLE IV
TSI REPORT COMPARATION BEFORE RESEARCH AND AFTER RESEARCH

Level	Quantity		Percentage Qty		Average Quality Score	
	Before	After	Before	After	Before	After
Level 1	**11**	**344**	**1.8%**	**53.7%**	**88**	**88**
Level 2	**182**	**234**	**29.7%**	**36.5%**	**76**	**83**
Level 3	265	43	43.3%	6.7%	66	72
Level 4	152	20	24.8%	3.1%	51	64
Level 5	2	0	0.3%	0.0%	50	-
	612	**641**	**100%**	**100%**	**71.1**	**83.7**

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