

## Engine Room Simulator Training Plan And Evaluation Method At Istanbul Technical University Maritime Faculty

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### ABSTRACT

Evaluation is an important aspect of Engine Room Simulator (ERS) training. It provides the means to determine the student's abilities. The evaluation method is used to monitor and evaluate the results of a training session. Evaluation method must be as easy as possible and objective evaluation should be performed.

We have created a new evaluation method that has different sheets, curves and etc. The evaluation sheet represents the degree of achievement of operation and the time to the degree of achievement. It is important to divide all operation procedures into suitable steps and to decide necessary time pertinently for the operation. These steps are made into the scale of the degree of achievement.

This paper describes the training method and the evaluation method, which are applied for different types of ERS training. Also, the authors discuss the feasibility of the use of the ERS to establish higher level skills of trainee, such as plant operation management, risk management, team management, and "internal" and "external" communication.

### 1. Introduction

Maritime training institutions all over the world started to recognize the value of simulation systems as a training tool. The International Maritime Organization (IMO), the highest international maritime body, has now officially promoted the utilization of simulators.

Engine Room Simulator is designed to simulate various types of machinery and equipment as used in the engine room of an actual ship. The main objective of ERS training is that the training be carried out efficiently, reliably and with cost-effective configuration by simulating a realistic environment. The biggest advantage of using ERS as a training tool is the possibility of creating malfunctions repeatedly, and in that way, increasing the troubleshooting skills of trainees.

Our ERS consists of two types of ERS. One is CBT type ERS; the other one is full mission type ERS. We have six units of CBT type ERS and one full mission type ERS. CBT type ERS is called WS. The trainee is able to practice the operation of the engine plant in individual or a small number of trainees on the Work Station (WS). The trainee can view mimic pictures representing the various simulated systems on the monitor. These graphic mimic process diagrams are interactive so that the process can be both monitored and controlled. And then, by full mission type ERS, the trainee is able to practice more realistic operation than WS in suitable size of group. The full missions type ERS consists of the large-sized mimic panel which imitates an engine room, a control console which imitates a control room, an

Subject	Objective	Method	Evaluation
Simulator I	Fundamental plant operation	WS checklists	Training report I
	Machinery operation	ERS scenario I	Evaluation sheet I
	Watchkeeping	Log book & Oil record book	Log book, Oil record book, Training report II
	Emergency operation	ERS scenario II	Evaluation sheet II
Simulator II	Plant operation management	ERS checklists	Training report III
	Team management	ERS scenario III	Evaluation sheet III
	Risk management	ERS scenario IV	Evaluation sheet IV
	Maritime communication Internal & external communication	Communication phrases	Evaluation sheet V

**Table 1.** The ERS training plan

instructor console which imitates a bridge of an actual ship and a main switchboard which has same function as monitoring system and remote control system.

Each composition apparatus has the function of the almost same grade as the apparatus in a ship. Almost all the main machineries, equipment and associated system are represented on the mimic panel and it makes a realistic operation available.

## 2. Engine Room Simulator Training Plan

An efficient training plan is necessary to realize effective ERS training. Sophisticated equipment and an efficient training plan result in outstanding training performance. The following basic concepts should be taken into consideration when an ERS training plan is created:

- It should be verified what training can be carried out by utilizing ERS.
- It should be clarified what is wanted to teach through ERS training.
- It should be considered that ERS training is completed in a true meaning by combining the training objective, the training method and the evaluation method.
- It should be confirmed what competence is required for ERS training in STCW convention.

We have created the ERS training plan, which is shown in table 1 depending on abovementioned concepts. The training plan indicates training subject, objectives, training method and evaluation type. The training plan contains simulator I and simulator II as training subject. Simulator I is realized as capability of the operational level depend on the competence of STCW convention. Simulator II is realized as capability of the management level depends on the competence of STCW convention. The aim of Simulator I training is that the trainee learns basic plant operation procedures such as normal start and stop each plant composition machinery, correct order of starting up the engine plant, the duty of the watchkeeping and recovery emergency situation. For this purpose we have prepared four objectives shown in Table 1. The aim of Simulator II training is that the trainee learns higher skills concerning plant operation such as plant management and team management. We have prepared four objectives for Simulator II training.

## 3. Training Objective

An objective expresses the skill that should be acquired by the training. It is taken the following concepts into consideration when training objective is set up.

- The knowledge and the skill of training objective mastered may be limited to the range of the function of ERS.

- Set up training objective individually for each subject as much as possible.
- In order to utilize the simulator training as effectively as possible, it is necessary to grasp its function enough.
- It is required for the trainee to be conscious of what he is performing now for what purpose during training implementation.

### 3.1 Fundamental Plant Operation

The aim of this training objective is that trainee learns fundamental plant operation by performing WS with making use of WS checklists. In an actual ship, it is required to have several operation methods of the plant composition machineries. But here, trainee is required to obtain only basic knowledge and skill through this training. Therefore, fundamental plant operation methods in correct order are described in WS checklists. Fundamental operation means usual or normal operation. Unusual operations are not included.

### 3.2 Machinery Operation

The aim of the machinery operation is familiarization of the operation for selected machineries by utilizing full mission ERS. We have selected main engine, diesel generator system, turbo generator, oil fired boiler and oil purifiers etc. as training target depending on the function of ERS. The trainee can learn unusual operation methods such as manual operation and emergency operation etc. about the selected machineries through this training.

### 3.3 Watchkeeping

The aim of the watchkeeping is that trainee learns how to take over the duty of the watch by using full mission ERS and how to fill Log Book, Oil Record Book up. Under the state of navigation in ERS, a trainee performs the publication to the required documents of Log Book etc. based on the state. Then, the training which duty of watch keeping is taken over to the other trainees is performed.

### 3.4 Emergency Operation

The aim of the emergency operation is that trainee learns how to recover emergency situations such as black out, ME shut down, ME auto slow down, Oil fired boiler burner trip, etc. Mainly, under the state of navigation, making an emergency malfunction intentionally, a trainee performs operation for recovering it to a normal state.

### 3.5 Plant Operation Management

The objective of the plant operation management is that trainee learns how to obtain the engine characteristic such as thermal efficiency, heat balance and fuel oil consumption rate by collecting running data and calculating these data at the suitable engine condition.

### 3.6 Team Management

In a crisis, a leaderless group will achieve nothing. A simulator is a valuable tool for demonstrating how good leadership is vital for establishing and motivating team effort. The highest priority of a team is to accomplish team goals. If those qualifications are lacking or missing effective machinery space management will break down and the ship will be thrown into risk. Achieving those qualifications is very important, that's why this objective is set up. For this purpose, a trainee learns team play under proceeding plant operation such as start up of the engine plant, stand-by station for entering/leaving port and emergency operation.

### 3.7 Risk Management

To reduce human error, training for troubleshooting repeatedly with good communication and teamwork is needed and therefore utilization of ERS for this purpose is proposed. This part of the course is about increasing the ability of trainees to manage risk.

The objective of this risk management training is to teach the trainee how to take counter measures by predicting an emergency state from the running data that is out of the normal range. Mainly, under the state of navigation, for example, it is performed by taking necessary

counter measures after detecting high temperature of scavenging air caused by fouled surface of the airside of air cooler.

### 3.8 Maritime Communication

Although Standard Communication Phrases (SMCP) is in force, there is not yet any clear identification for marine engineering terminology. IMO Model Course 3.17 Maritime English defines only the basic engine room preparations and the planning of activities in cooperation with the deck department. However, communication in the engine room is so important in terms of eradicating marine accidents based on communication failures

The maritime communication is to learn how to communicate with other staff members in the engine room and how to communicate with the bridge, further more to learn technical terms. It goes without saying that communication, both in an upward and downward direction, is vital for good management in day-to-day routines and in crisis. ERS can be utilized to demonstrate that, without good communication, tasks are made much harder due to lack of direction and misunderstanding.

### 4. Training Method

The other important matter is training method. When it is determined suitable training method, some important points should be taken into consideration. These points are the following:

- Training method should correspond to the training objective.
- The objective can be recognized by a trainee
- Training method should be more effective and steady progress.
- Training environment in training method should be more realistic so that effective training can be realized.

Each training objective has different training method in the training plan in our simulator-

training plan. There is relationship between the training objective and the training method. The training method includes some documents such as checklists, scenarios and records. These documents are follows:

- WS checklists
- ERS scenario I
- Log book & Oil record book
- ERS scenario II
- ERS checklists
- ERS scenario III
- ERS scenario IV
- Communication phrases

### 4.1 WS Checklists

WS checklists have been developed to standardize training and operations procedure and ensure the avoidance of faults due to wrong operating procedures. The procedures for the operation from the state of cold ship to the state of ship's navigation are described in the WS checklists. The checklists contain mainly the following items:

- Start up procedures from cold ship to running diesel generators for ME preparations
- Fire up oil fired boiler
- Starting purifiers
- Main engine preparations
- Starting main engine
- Maneuvering operations
- Normal procedures and keeping the systems under normal operating conditions

WS checklists have been implemented in such a way that the whole engine room operation has been divided into many smaller, typical tasks. The checklists give clear instruction what to do and how to do.

INSTRUCTOR	STUDENT	
	STEP	PROCEDURES
<p>Make the initial condition in generator single run. Announce the subject &lt;Commence the operation of changing DG from DG1 to DG2&gt;</p>	1. Preparation	Check LO level of LO sump Tank and supply with LO if necessary → Check FW level of Exp. Tank and supply with FW if necessary → Set LO pump to AUTO → Open LO valves concerned → Open SW valves concerned → Open FO valves concerned
	2. Starting DG2	Open starting air valves concerned and confirm air pressure Reset control system if necessary and set control position to LOCAL → Start DG2 and set its speed to 720 rpm → Set FW Temp controller to 70 degree → Set control position to REMO
	3. MSB Operation	Adjust and confirm volt and frequency of DG2 → Turn synchronize indicator to on → Turn ACB of DG2 to on
	4. Stopping DG1	Adjust electrical load of DG1 and DG2 to even → Adjust electrical load of DG1 to 0 → Turn ACB of DG1 to off Set control position to LOCAL → Stop DG1 → Set LO pump to MAN and close LO valves concerned → Close FO valves concerned → Close SW valves concerned

Table 2. Extract of ERS Scenario I for Diesel Generator Operation

INSTRUCTOR	STUDENT	
	STEP	PROCEDURES
<p>Choose the state of full ahead engine as an initial condition. Make trainees watch and confirm the present condition in the engine room. ME: Running under navigation full (102rpm) TG: Running DG: State of standby Auxiliaries: The number of auxiliaries etc. Announce the subject. &lt;Start the excise of emergency operation. Black out will happen. After that, recover the plant condition into the same as before. Set Emergency shut off valve of TG to 10%. Black out occurred</p>	ME restart	<p>Confirm TG trip and Emergency G and DG start up Confirm ACB of DG "IN" Set control position of ME to ECR Set ME control mode to "maneuvering mode" Set maneuvering lever to "0" Reset ME shut down indication Set ME Maneuvering Lever to 100% &lt;later&gt; Confirm ME revolution 77rpm and set ME control mode to "at sea"</p>

Table 3. Extract of ERS scenario II for black out

#### 4.2 Log book & Oil record book

The Logbook and Oil record book are used for the objective of watch keeping implementation. We have prepared ordinary logbook and oil record book depend on the function of ERS.

#### 4.3 ERS Scenario I

The ERS scenario I indicates steps to be followed and what to do to attain the step for trainee. The ERS scenario I contains the following items:

- Main engine operation
- Diesel generator operation
- Purifier operation
- Oil fired boiler operation
- Fresh water generator operation

#### 4.4 ERS Scenario II

ERS scenario II (Table 3) shows steps and indicates what to do to recover emergency situations such as black out and ME shut down in the same format as ERS scenario I.

#### 4.5 ERS Check List

ERS checklists means data measurement sheet and it is used for collecting data which is necessary to calculate the thermal efficiency and to draw engine characteristic curve and heat balance diagram. The trainee can collect the necessary running data by filling this measurement sheet up.

#### 4.6 ERS scenario III

ERS scenario III (Table 4) has been prepared for team management. For example, five trainees as one team may process the procedures for plant operation by using scenario III under the leadership of the trainee who was appointed as chief engineer.

#### 4.7 ERS scenario IV

ERS scenario IV is used for Risk management. ERS scenario IV shows steps and indicates what to do to avoid serious situation of engine plant in the same format as ERS scenario I.

#### 4.8 Communication Phrases

The communication phrase, which contains typical conversation pattern and technical terms for this training, has been prepared.

INSTRUCTOR	STUDENT	
	ORDER	RESPONSE
1. 25 miles to the harbor limit. (interphone)	1. <all right> 2. 25 miles to the port limit, begin the operation for entering port. 3. Start DG 1 with HFO use. <all right> 4. Alternate electric source from TG to DG 1. <all right> 5. Stop TG. <all right> 6. Stop Condensate pump 1 and Vacuum pump 1. <all right> 7. Stop FW Generator. <all right> 8. Select MANEU MODE on ME. <all right>	2. <all right> 3. Started DG 1 with HFO USE. Running condition is good. 4. Connected DG 1 to Main Bus Bar and set it on AUTO. Disconnect TG from Main Bus Bar. 5. Stopped TG and begin to cool down. Closed valves concerned. 6. Stopped Condensate pump 1 and Vacuum pump 1. Closed valves concerned. 7. Stopped heating and closed valves concerned. Stopped Ejector pump and closed valves concerned Stopped Distilled Water pump and closed valves concerned. 8. Selected MANEU MODE on ME.

**Table 4.** Extract of ERS scenario III for Entering Port

These patterns include standard engine order, preparation main diesel machinery, arrival in port, watch keeping in the engine space of a diesel ship, fire fighting and drill.

### 5. Evaluation Method

The evaluation is the most important element of simulator training. If the reasonable training evaluation is not carried out, simulator training will lose its true meaning. Therefore, the suitable evaluation method should be established in simulator training. The evaluation method is used to monitor and evaluate the results of a training session. The concept of our evaluation methods is:

- A trainee can estimate easily accomplishment after training implementation by oneself with the result of the evaluation method.
- The evaluation method is utilized for the follow-up after training implementation.
- The evaluation method is utilized as a reference when an instructor estimates trainee's individual results.
- The evaluation method should be as easy as possible, and consider it so that a difference may not arise by evaluators and objective evaluation can be performed.

As for evaluation, the instructor as much as possible should not cause a difference. Since

it carries out through actual training, we have to make it a thing as simple as possible and effective. According to the characteristic of training equipment, as for the evaluation method, a suitable one should be prepared for each training session. Evaluation method should be grasped easily what the trainee fully understands or what the trainee scarcely understands by the evaluation result.

For the evaluation concerning operation, the specific evaluation method is preinstalled in ERS. This preinstalled evaluation method is to measure the trainee's skill level with the degree of deviation from normal value of running parameter and its importance. To define the normal value of running parameter as the standard of evaluation is caused to limited evaluation method and also it should not be practical evaluation method of realistic training.

We have created two types of evaluation method. One is report system and the other one is evaluation sheet. We have prepared fixed evaluation sheet for machinery operation, emergency operation, team management, risk management and maritime communication.

#### 5.1 Report System

The training report should evaluate the com-prehension concerning ship's propulsion plant effectively.

ITEM 1:Sea Water System ( MD 01 )	
QUIZ	YOUR COMMNTS
What is role of SW pump.?	
What is role of Filter in High Suction and Low Suction lines?	
When do you use High Suction?	
For what is SW recirculation line shut off valve installed?	
For what is Emergency Bilge suction installed?	
For what is Direct Emergency Suction installed?	
What is role of Emergency Fire Pump? Why is its Sea Suction separated from suction for Fire Pumps?	

**Table 5.** Extract of training report I

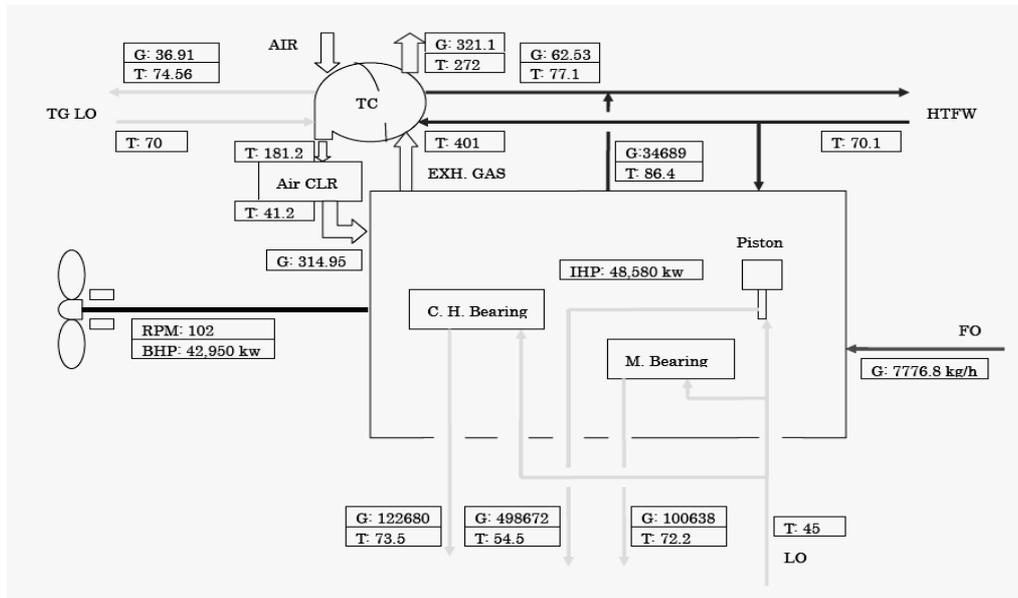


Fig.1 Heat balance diagram

There are training reports I, II, III, a log book, and an oil record book. Training reports I and II are that trainee fills the blank up with answers to a quiz in the training report I and II. It means that the trainee must proceed to their performance on WS with answering to questions at a certain period and he/she must submit the training report forms (I, II) to the instructor when he/she finishes their training performance. Table 5 shows extract of training report I. The instructor checks the submitted report forms if the answer is sufficient and judges the level of comprehension of the trainee and what knowledge is insufficient. And the instructor will follow up insufficient knowledge.

Training report III is the calculation item sheet and trainee calculates the thermal efficiency with making use of data in the ERS checklists. Trainee also draws and the heat balance diagram which is shown in figure 1 and 2, the engine characteristic curve which is shown in figure 3 by using calculation results to learn the plant operation management totally. The instructor judges the level of comprehension of the trainee on this subject according to the results of calculation and the other result.

## 5.2 Evaluation sheet

The evaluation sheet evaluates comprehension level by measuring trainee's degree of achievement about the knowledge concerning plant composition, plant composition machineries etc.

The degree of achievement can change with the comprehension level that the trainee has, and it can be represented as a function of time. That is, in the case of performing operation towards the set up objective, required time is represented with the sum of the physical time when it is required for operation including change of running parameters, and the time which trainee's judgment takes. As far as simulator training, the time needed to change running parameters is fixed. And then the physical time when it is required for operation may be thought that it is almost fixed, when the trainee with the almost same fundamental ability receives training by the same program and receives a prior briefing.

The time which trainee needs for judgment of operations will change with the trainee's comprehension level of knowledge concerning plant operation such as the plant composition,

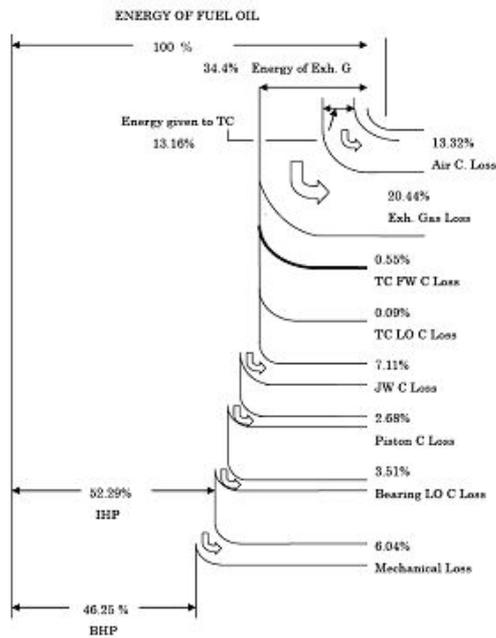


Fig. 2 Heat balance diagram II

plant composition machineries, an operation of machineries and its operation, and this comprehension level will be represented by the evaluation sheet as a function of time.

It is thought that this evaluation sheet might serve as the most suitable evaluation method of all operation training only when the all operation procedures are divided into suitable steps and these steps were made into the scales of the degree of achievement. In the evaluation sheet, the vertical axis represents the degree of achievement of operation and the horizontal axis represents the time to the degree of achievement. Each evaluations sheet has two lines. These lines are standard line, which is shown in figure 4 and 5 as black line and success line, which is shown in figure 4 and 5 as green line.

As for the standard line, the adequacy is important. The standard line is created with average of the operation results that the faculty's instructors made. The result of operation refers to actual time that they needed to complete the operation. Since

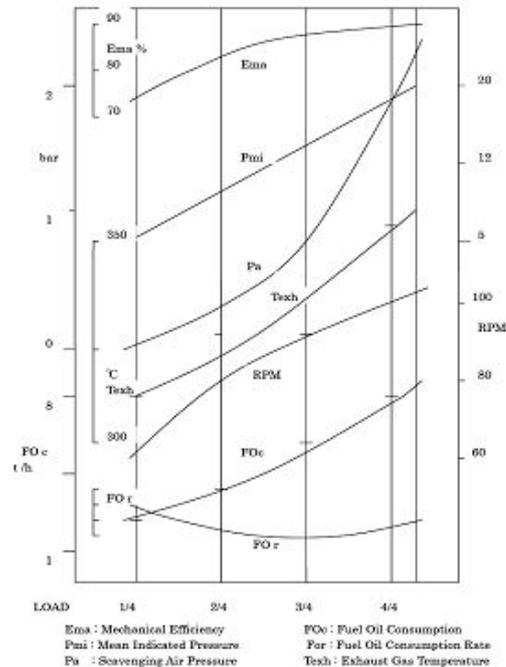


Fig.3 Engine characteristic curve

it is accepted that the general capability of these instructors concerning ship's propulsion plant is in the management level of STCW convention from the qualification and career, generally it is appropriate to consider that the results of these instructors are regarded as the standard of the evaluation.

We created the success line by multiply some coefficient to the time of standard line. Because the standard line which made of faculty's instructors, in a way, represents the best achievements and it must be hard for the trainee to attain the same level as the instructors and also it is not necessary to attain the same level through the training. Therefore, we may consider that the success line is regarded as operational level and management level of STCW convention in comparison with the standard line.

That is, if the completing point of operation is in the left-hand side of the success line, it can be recognized that the trainee completed the operation in successful and he/she has sufficient knowledge on the operation that

he/she has done. Under proceeding the operations when he/she deviates from the success line, it is thought that the knowledge on the portion from which it deviated is insufficient, and it should become the material of follow-up. Thus, the instructors evaluate the trainee's achievements by comparing their result line with the success line.

The instructor plots the time required for each step of operation on the graph by measuring actual time taken during the training implementation. And the trainee's result line (actual operation curve) is created by connecting each dot on the graph.

the operation of these three steps. Trainee B needs approximately double time of the success line about the operation to Step 1. The operation of Step 1 means the operation whereby the trainee confirms recovery of power supply after black out and then restarts the main engine after resetting the abnormal condition of main engine. Trainee B proceeds to restart auxiliaries smoothly after restart main engine and ends the operation to Step 2 at the same time as success line. And after Step 2, the trainee completes all the operation to Step 3 favorably. In this case, it can be considered as "success", however, follow-up is necessary about the operation to Step 1.

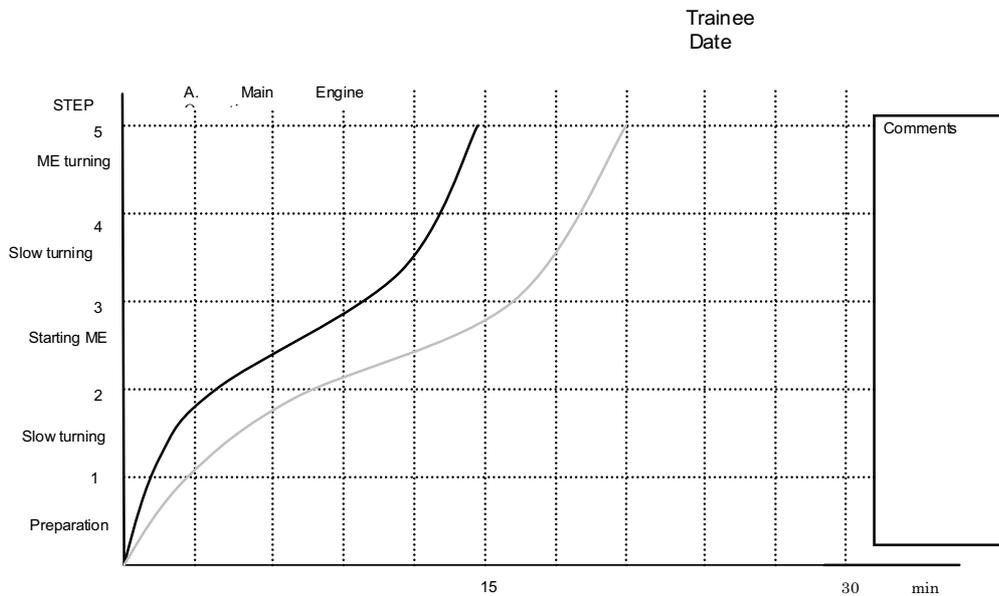


Fig. 4 Evaluation sheet for ME operation

Figure 5 shows a sample by putting three trainees' results. In this figure, step 1 means the operation from the black out to ME restart. Step 2 means the operation from ME restart to completion of restart all auxiliaries to be necessary. Step 3 means the operation from completion of restart all auxiliaries to completion of alternating power source to TG that was in service before black out. Trainee A's result is mostly located in the middle between the standard line and the success line. Therefore, it can be judged that trainee; he/she has knowledge required about

The following two points can be pointed out as a reason that he/she needed longer time than success time to reach to Step 1:

- a. It was late to have acknowledged the recovery of power supply, beside the time was required in order to judge necessary operation for main engine.
- b. The required knowledge about the operation for restart main engine after shut down is insufficient.

It is necessary to deepen understanding to

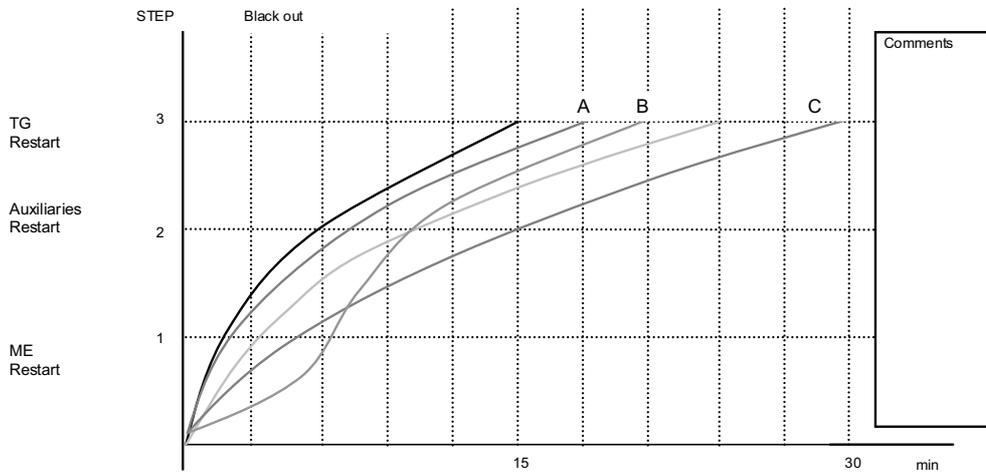


Fig. 5 Evaluation sheet for black out

the power supply system about "a", and to deepen understanding about restart conditions of main engine and the operation method after the main engine shut down about "b".

It can be judged that the trainee C is insufficient in the knowledge and understanding about this training because the result is below the success line about the all operations.

## 6. Conclusions

It is recognized that suitable training utilizing engine room simulator is effective in some specific field and limited field. In order to perform suitable simulator training, setting up the suitable objective, the suitable training and the evaluation method for the objective are indispensable. We created them in the ability of the maximum practical use of the simulator to be carried out, and it is considered that these are appropriate. However, about the training concerning the main apparatus such as main engine, diesel generator and boiler etc. since these simulation functions are lower than the function that they have individually in these individual simulators, it is considered that improvement of the simulator should be made for further substantial training.

As for the evaluation, it is necessary to verify the results of evaluation sheet to be

appropriate from general view from now on. It may be also necessary to research on the ability of the trainee who achieved "good result" in an actual ship. After that, we can declare that our evaluation method can contribute widely in the field of simulator training. The evaluation should cover all the training objectives and it should also indicate whether the training plan and the instructor are adequate.

On the other hand, an engine simulator instructor needs to find out what training is possible by the simulator, and needs to establish the training method and evaluation method as a means for the completion of training purpose. Therefore, it is required for having sufficient knowledge about general ship's propulsion plant composition, the composition apparatus, physical and mechanical characteristic, the meaning of each operation, the order of operation, etc. depending on actual on board experience and also it is required for having the knowledge about characteristic of simulated engine plant and operation of the simulator. For example, in being related with operation, it becomes the most important thing that series of operation can be divided into suitable steps in our training method and evaluation method. These become possible when it has sufficient knowledge about plant operation.

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