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COMPUTER – BASED TRAINING FOR SEA – GOING ENGINEERS

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ABSTRACT

Importance of the safety at sea and preserving the sea environment has been increased in the operations of the ships during last decades. To achieve a safe navigation and preserve the environment, ships are equipped according to the International regulations and standards.

On the other hand, sea personnel are the people who fulfill these tasks by using the equipment. Therefore, the training of the seafarers for updated information and for better skills also became a very crucial issue. Even though there are new regulations and guidelines, this still does not reduce the accidents which 80% of still caused by human mistakes. The tasks expected from the sea personnel to provide a safe navigation are:

- *To perform their duties without risking the safety of the ship,*
- *To be able to take action fastly and reliably when any unexpected event occur.*

Successes of achieving these tasks are based on the level of the personnel's knowledge and skills. The lack of these causes the personnel not being able to use the equipments appropriately and effectively that also increases the risk in an abnormal situation resulting more harm at the incident. This paper discusses the application of Computer-Assisted Training programs in the teaching and learning process at Istanbul Technical University Maritime Faculty.

Keywords: *Computer-Based Training, Simulator, Engine Room, Fuel Management, Maritime training,Team Management*

1. INTRODUCTION

Ships are highly automated systems that can be operated by a limited number of operators. The demands of modern ship operations require that engineering officers be taught more than the standard technical skills of their ship. Factors as the cause of 80% of all investigated commercial marine casualties are virtually identical to the human error rate in aviation. In the late nineteen seventies, researchers began to explore methods

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of understanding the root causes of those human errors and reducing the incident rate. Ship casualties appeared to be the result of a weakness in human factors or "people" skills and not a lack of technical knowledge [1]. A good working understanding of plant operation and fault finding. The Engineer must have qualification as follows:

- A thorough understanding of plant operation and fault finding.
- An ability to deal with developing scenarios and to communicate problems, in a timely and effective manner.
- A thorough understanding of pro-active plant management and risk assessment.
- A thorough understanding of team concepts and the ability to establish and motivate a team.
- An ability to establish pro-active plant management and risk assessment.

The above training requirements can be summarized into five criteria:

- Knowledge
- Awareness
- Planning
- Communication
- Leadership

2. How is Engine Room Simulator used to develop the above criteria?

Knowledge

Knowledge, of varying degree, may be imparted at any point in a person's career. Engine Room Simulator use to improve a trainee's understanding of plant operations, the interactions between various items of machinery and the way in which faults may occur and accumulate leading, eventually, to plant failure.

Awareness

Situational Awareness is an accurate perception of the factors and conditions that affect the ship and the crew during a specific period of time. Elements of Good ERM (Engine Room Management) situational awareness include knowing the ship, machinery, and systems; knowing normal operating parameters; being alert to safety hazards; knowing the crew's condition.

Engineers must use their senses to be constantly aware of the state of the plant and of any discrepancies. By using visual and sound stimulus, Engine Room Simulator use to develop this awareness and, by introducing subtle faults into the system, train engineers to sense and react to problems before they have a chance to develop [2]. Awareness of the implications of decision-making also needs to be acquired.

Planning

Knowledge and awareness are useless without planning. This aspect of training really brings out the best in the simulator. By implanting dormant faults into the simulator program, to demonstrate the necessity for forward planning.

Communication

Effective communications is the exchange of information in a clear and understood manner. Effective communications is also when the intended message of the sender and the perceived meaning of the receiver lead to the desired feedback It goes without saying that communication both in an upward and downward direction is vital for good management, both in day to day routines and in crisis. The simulator can be used to demonstrate that, without good communication, tasks are made much harder due to lack of direction and misunderstanding. The elements of good communications which include clarity, brevity, accuracy and feedback are explained. Good communicators will usually be good leaders.

Leadership and Group Decision Making

In a crisis a leaderless group will mill around and achieve nothing. The simulator is a valuable tool for demonstrating how good leadership is vital for establishing and motivating team effort [3]. The highest priority of a team is to accomplish team goals. The Engine Department must be a successful team which accomplishes team goals.

If any of the above are lacking or missing then effective machinery space management will break down and the vessel will be put at risk [1]. Achieving those qualifications are very important and Engine Room Simulator can be used for this purpose.

3. Purpose of Engine Room Simulator

The main purpose of the training with engine room simulator is that the training is made efficiently, reliable with cost-effective configuration by simulating the real environment [4].

The engine room simulator is designed to simulate various types of machinery and equipment as used in the engine room of a ship using a diesel engine as propulsion system [5]. The simulated machinery and equipment are made up of the main diesel engine, diesel generators, turbo generator, auxiliary boiler, exhaust gas economizer, general auxiliary machines, heat exchangers, tanks and other major machinery components etc., and they are also interconnected by using the piping system. Their operations are simulated as close as possible to their actual conditions in service. The simulator can be split into two main parts:

- The simulated Engine Room
- The Instructor System

The simulated engine room is arranged as subsystems identical to those found onboard a real ship. The simulation is performed by a dispersed digital computer system that accepts signals from the switch, push button and handles provided on the simulator components as input data for data processing [6]. This data processing provides the output for the indication on the instruments (pressure gauges, thermometers, tachometers, etc.) with the indicator light on the simulator components. The data processing includes the event processing such as starting and stopping of the main diesel engine, generators, auxiliary boiler and pumps, and the condition change processing for the machinery and equipment such as opening and shutting of the valves. The operating sounds of the machinery and equipment can be also generated if t is necessary. The simulator is fitted with an automatic alarm system that monitors the output of the computer system.

Parts of the engines as well as engine room equipment can be simulated in normal operating condition or in faulty/deteriorated conditions. The engine room models are connected to a malfunction library controlled by the Instructor System. Figure 1 shows the arrangement of the simulator [6].

The Instructor System, denoted the TEC System (Training and Evaluation Control), comprises the facilities and features needed for the instructor to prepare, control and evaluate the simulator training.

4. Configuration of Engine Room Simulator

The PPT2000 Simulator is implemented on a network of UNIX workstations with an Instructor Station used as a common server. The network is an Ethernet and the server is equipped with a hard disk storage 1Gb. Data Tape Station is provided for taking back-up of the System Software.

The mathematical models and the man-machine interface are run as separate programs. The communication between them is established by UNIX sockets. The program running the mathematical models of the simulated process is called OTISS. The Man Machine Interface program, EMULA, is driving the graphic pictures, and installed individually on each workstation. The OTISS/EMULA - environment is very flexible. The OTISS- program can run on any of the involved computers [6].

When more than one EMULA station is connected to one OTISS program, the actions taken at one station will influence the shared process and the changes are observed on all the workstations. This way of running the simulator is controlled by the instructor to avoid chaos if different operators take inconsistent actions. In the full simulation mode, the OTISS-program is run on the server. Figure 2 shows the configration of the simulator [6]. Engine Room Simulator configures to include the following:

- Workstation
- Local (Mimic) Panel
- Engine Control Console and Room
- Instructor's Console and Room
- Sound system

4.1 Workstation

The instructor workstation is the server for all
The instructor workstation is the server for all
other computers. Together with the color graphic workstations and the distributed microprocessors it forms a complete simulator computer system. The consoles are intelligently interfaced to the instructor station through microprocessors and

serial lines to an Ethernet distribution unit. The server manages the mathematical model software and provides all the necessary capacity for the following activities [8]:

- Operation of instructor's station
- Control of the simulated models
- Control of all communication to/from workstations and consoles
- Exercise data recording and reply

On the operator stations, the operator/student(s) can view mimic pictures representing the various simulated systems. These graphic mimic process diagrams are interactive, i.e., the process can be both monitored and controlled. The instructor station has all of the functions of the operator station in addition to the specific instructor functions.

In principle, all the graphic workstations are configured as instructor stations. Whenever a workstation is going to be used in Part task mode, the student using it will act as his own instructor, meaning that he will have the instructor's privilege to start/freeze/stop the simulation. Each individual can run the exercise at his own pace. Workstation has the following specifications [6]:

Name	Type 715	Description
Processor	68030	
CPU Clock	64 Mhz	
Memory	64 MB	ECC RAM (Error Control Correction)
Monitor	20" Colour monitor	Resolution 1024 * 768,75 Hz, colour grapic interface
Interface	SCSI LAN RS-232 Parallel	High Density Connector IEEE 802,3 Ethernet Serial Interface Centronics compatible
Harddisk DAT	4.0 GB 2.0 GB	SCSI Disk Digital Audio Tape

4.2 Local (Mimic) Panel

This panel represents the engine room. The graphic symbols for the main engine, shafting, generators, auxiliary boiler and various auxiliary machines are arranged on this panel and interconnected by lines representing the various piping system.

4.3 Engine Control Console and Room

This is a full-size engine control console as used in the engine control room of an actual ship, and permits remote, manual and automatic control of the machinery and equipment in the engine room [7]. This console also contains a switchboard and a group starter panel. This console also contains power chief data chief and auto chief.

The Main Engine Remote Control Console is based on Auto Chief. This section includes Indicator Panel, ME Control Panel.

The alarm and monitoring console is the second section of the engine control console. This section is called Data Chief, and consists of a high resolution graphical workstation with a dedicated functional keyboard.

An alarm is announced by a buzzer and a flashing alarm group signal in the upper corner of the display. Alarm log, alarm acknowledgment and general alarm handling are described in a separate section in the document.

This station can also act as a control station. All functions that the general workstation can handle, like: mimic drawings, trend system, PID Controllers, general numeric indicators, status signal, alarms limit, are also available at the Alarm Monitoring System [6].

The consumption of and demand for electric power is constantly monitored and compared to the present possible power production. When deviation from preset limits arises, the system will act in order to normalize the situation. Thereby the possibility for black-out is reduced and a more economical use of the auxiliary engines is achieved. The system also performs continuous control of the frequency and load-sharing.

An alarm is announced by an acoustic buzzer signal, a flashing light in the group alarm lamp at the alarm console and logging of the alarm at the printer. Power Chief generates alarms when automatic actions fail, i.e. the result of the action is not obtained within the normal period of time.

A message is announced by logging of the message. Power Chief generates important messages when manual actions, initiated from the Data Safe panel fail, and when manual and automatic actions are successfully executed.

4.4 Instructor's Console and Room

The instructor's console has a bridge maneuvering panel for remote control of the main engine, a start switch for start-stop control of the simulator, an initial start condition setting panel for simulation start conditioning, and an abnormal condition setting panel for simulation condition changing.

4.5 Sound System

The purpose of the Sound System is to create a more realistic training environment. The Sound System is realized by using three stereo amplifiers, a number of loudspeakers and an ordinary PC that communicates with the server over a Local Area Network.

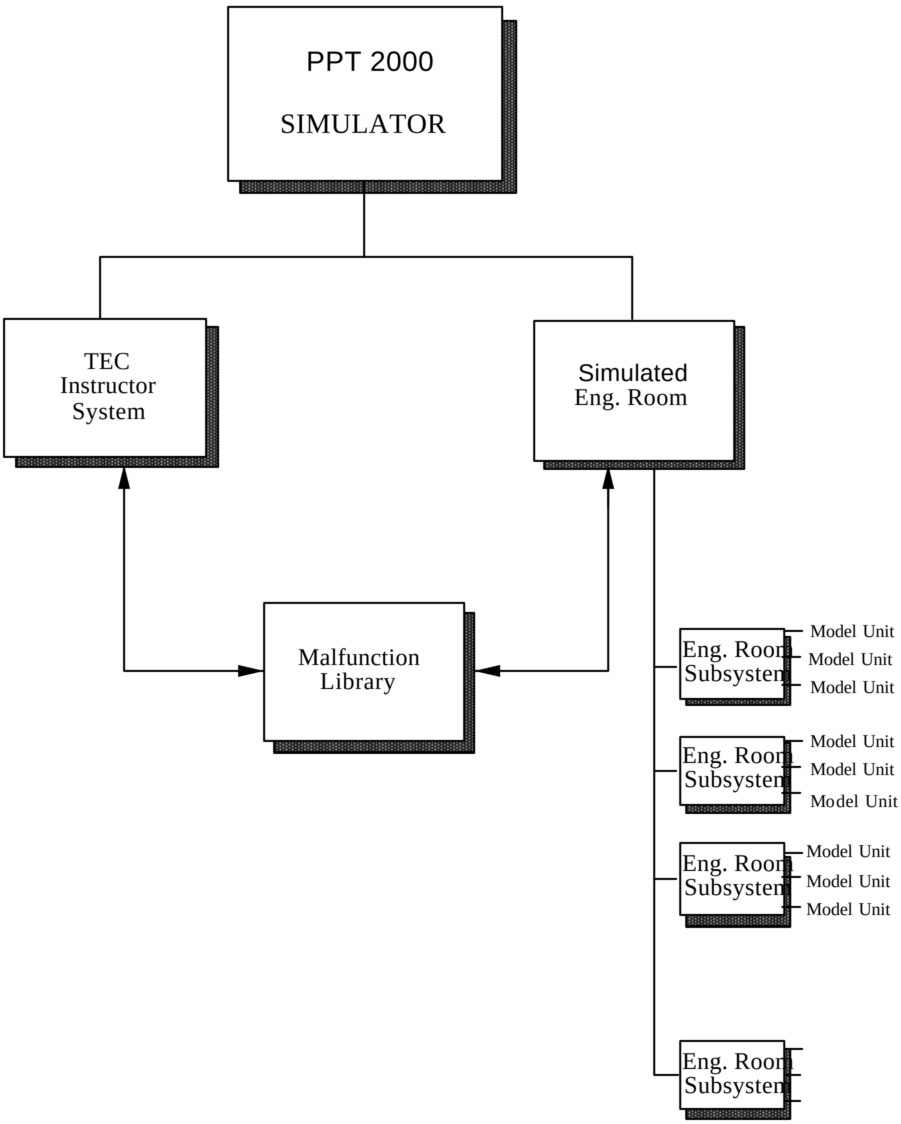

Figure 1. Overall System Architecture

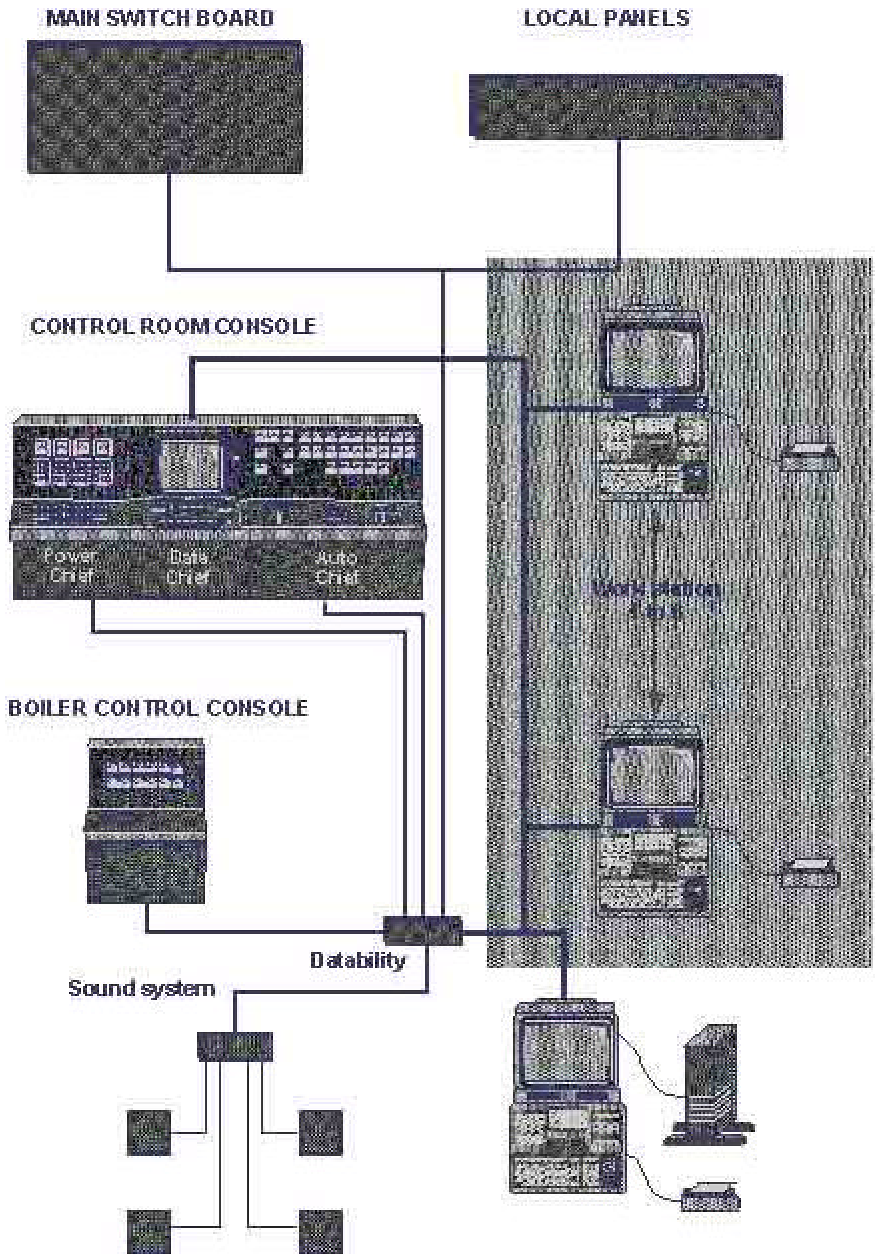

Figure 2. System Configuration

5. Fuel Oil System on Engine Room Simulator

Fuel and fuel systems knowledge is very important. If engineer makes mistake using this system it can occurs big problems which effect ship safety. The total fuel management process on a ship must be of prime concer to the engineers. It is essential that the engineers must know fuel tehnology with respect to the storag, handling treatment and burning of fuel oil [9].

The Engine Room Simulator is to simulate the functions of fuel oil system of main engine and generator engine for a marine power plant simulator, which is based on the mathematical models of fuel oil systems [7]. All main parts of the system have been simulated, for example, heavy oil tank, diesel oil tank ,drain tank, booster pumps ,supply oil pumps, circulating pumps, filters, flow meters, viscosimeter, all kinds of valves and their control panels. The software can be used to train the engineers to start and manage the fuel oil system and the abilities to diagnose faults of the system. There are many fault settings to the fuel oil system in the software, and it also has many alarm points and model parameters of the fuel oil system.

5.1 Fuel Oil Transfer System Description

The heavy fuel oil transfer system includes bunker tanks, one spill oil tank, a transfer pump and necessary piping. The transfer pump can suck oil from any of the bunker tanks or the spill oil tank and discharge it to the settling tanks or back to the bunker tanks [8]. Figure 3 shows the fuel oil transfer system [6].

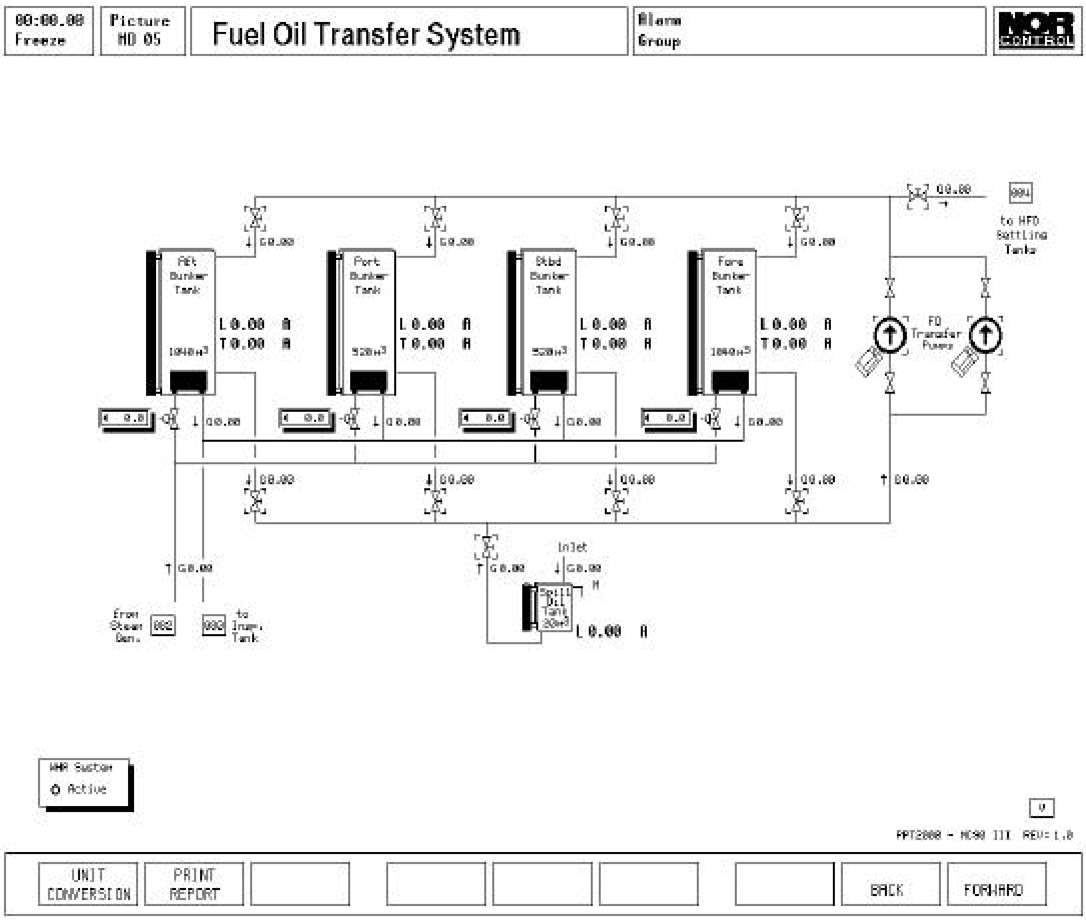

Figure 3. Fuel Oil Transfer System

The bunker tanks are heated by steam. The heat transfer is proportional to the steam pressure which is set by manually controlled throttle valves. If the heating is turned off, the bunker tank temperature will slowly cool down towards ambient temperature. The flow resistance in the heavy fuel oil lines is dependent on temperature. The resistance increases at temperatures below 60°C; below 20°C no flow is possible.

5.2 Fuel Oil Settling Tanks Description

A HFO transfer pump transports the fuel oil from the bunker tanks to settling tanks. The transfer pump should be started locally at low settling tank level or high spill oil tank level. Figure 4 shows the fuel oil settling tanks [6].

The heating of the settling tanks is handled by automatic thermostatic control valves with an adjustable proportional band and set point.

By means of flexible piping system the HFO separators can suck oil from one or both settling tanks, separate it and discharge it back to either of the settling tanks, or to the HFO service tank.

If the temperature of the oil in the settling tank cools below a certain limit, it will be difficult for the separators' feed pump to transport the oil.

The process of water precipitation in the settling tanks is properly modelled so that the water in the oil from the bunker tank will gradually fall towards the tank bottom by force of gravity.

If the collected water is not discharged regularly, HFO separators' problems will finally be experienced.

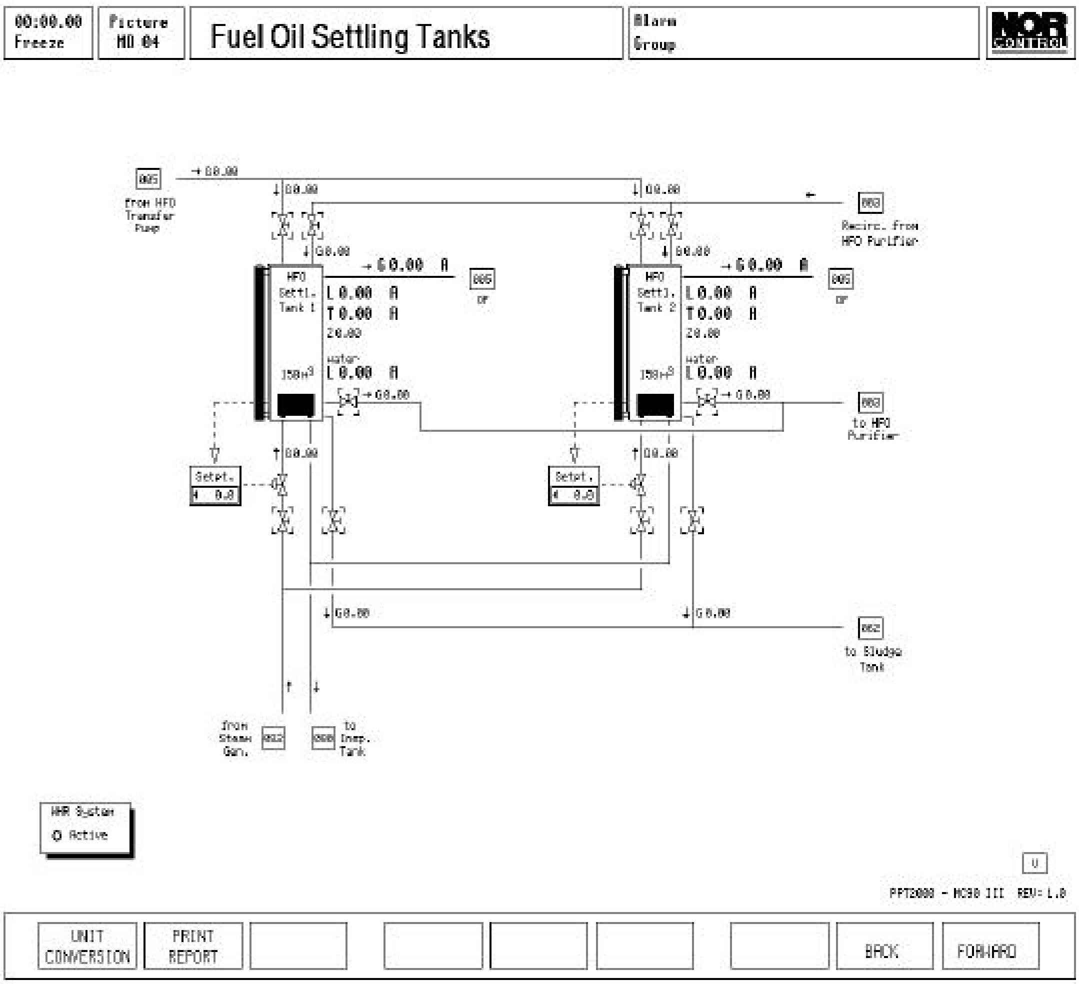

Figure 4. Fuel Oil Settling Tanks

The drain valves can be opened at the local panel. In order to simulate visual inspection of the water/oil mixture, use is made of the valve's panel light. A steady light indicates that the valve is open and water is flowing. A flashing light indicates that the valve is open and mostly oil is flowing. Note that the flashing light function is available only when Local Panel is used for operating the fuel oil settling tanks, in the engine room.

5.3 Fuel Oil Service Tanks Description

The HFO service tank supplies clean heavy fuel to the engine fuel oil system. It is filled via the HFO separators system, taking suction from the HFO settling tanks [8]. The service tanks are equipped with steam heaters. The heat effect is proportional to the steam flow, which depends on the control valve position and the steam pressure. The temperature of the service tanks depends on steam heating, loss to surroundings and temperature of inlet flow from purifier and return flows. The fuel oil viscosity in the service tanks is computed. The temperature of the fuel in the tanks is controlled by simple P-controllers, positioning the steam control valves according to tank temperature and set point. Figure 5 shows the fuel oil service tanks [6].

5.4 HFO Separator System Description

There are two HFO separators usually taken There are two HFO separators usually taken from the settling tanks and discharge it to the HFO service tank. The oil to be cleaned is continuously fed to the separator. Separated sludge and water accumulate at the periphery of the bowl. Normally a sludge discharge takes place at specific time intervals, but if the water contamination is high, an earlier discharge may be initiated. Figure 6 shows HFO separator system [6].

When separated water reaches the disk stack, some water escapes with the cleaned oil. The increase in water content is sensed by a water transducer installed in the clean oil outlet. On the control panel there are indications of the following alarms:

-Water Transducer Failure
-Sludge Discharge Failure
-High Oil Pressure
-Low Oil Pressure
-High/Low Oil Temperature
-No Displ. Water
-High Vibration

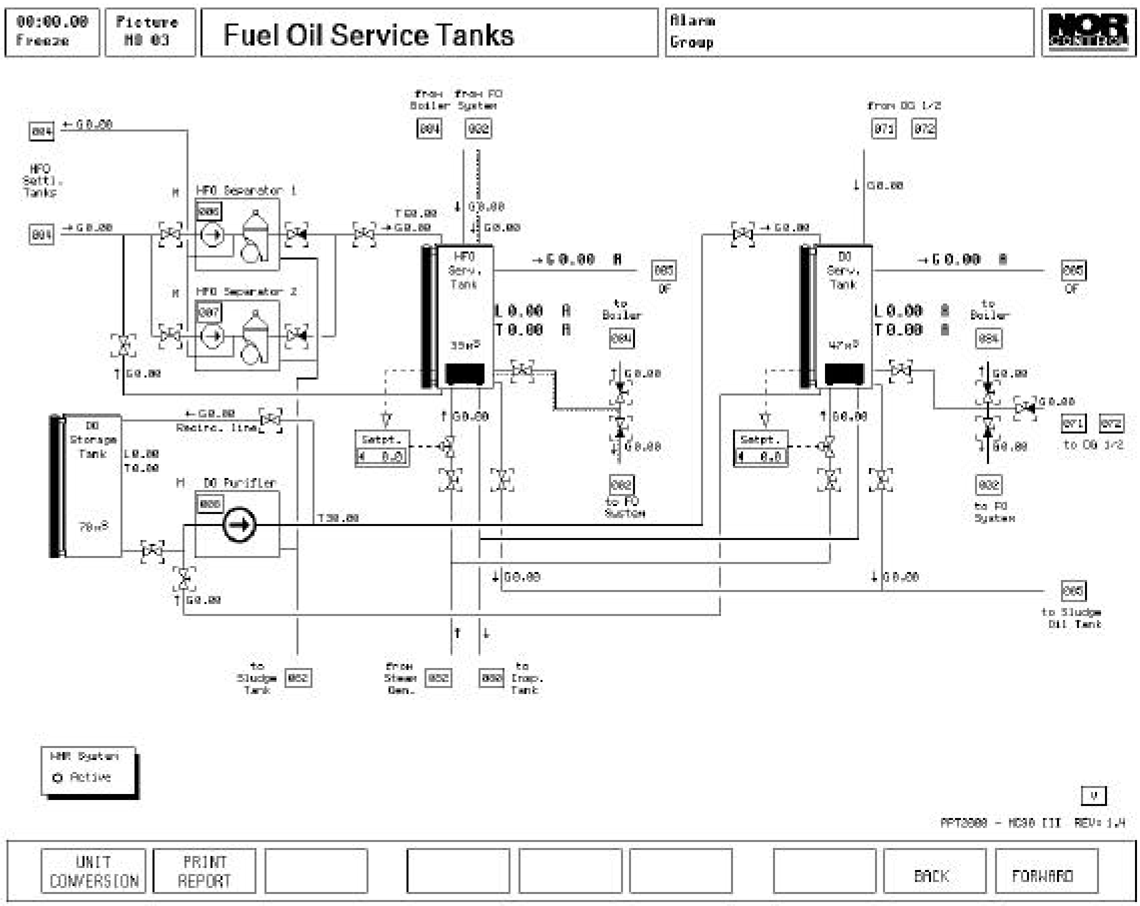

Figure 5. Fuel Oil Service Tanks

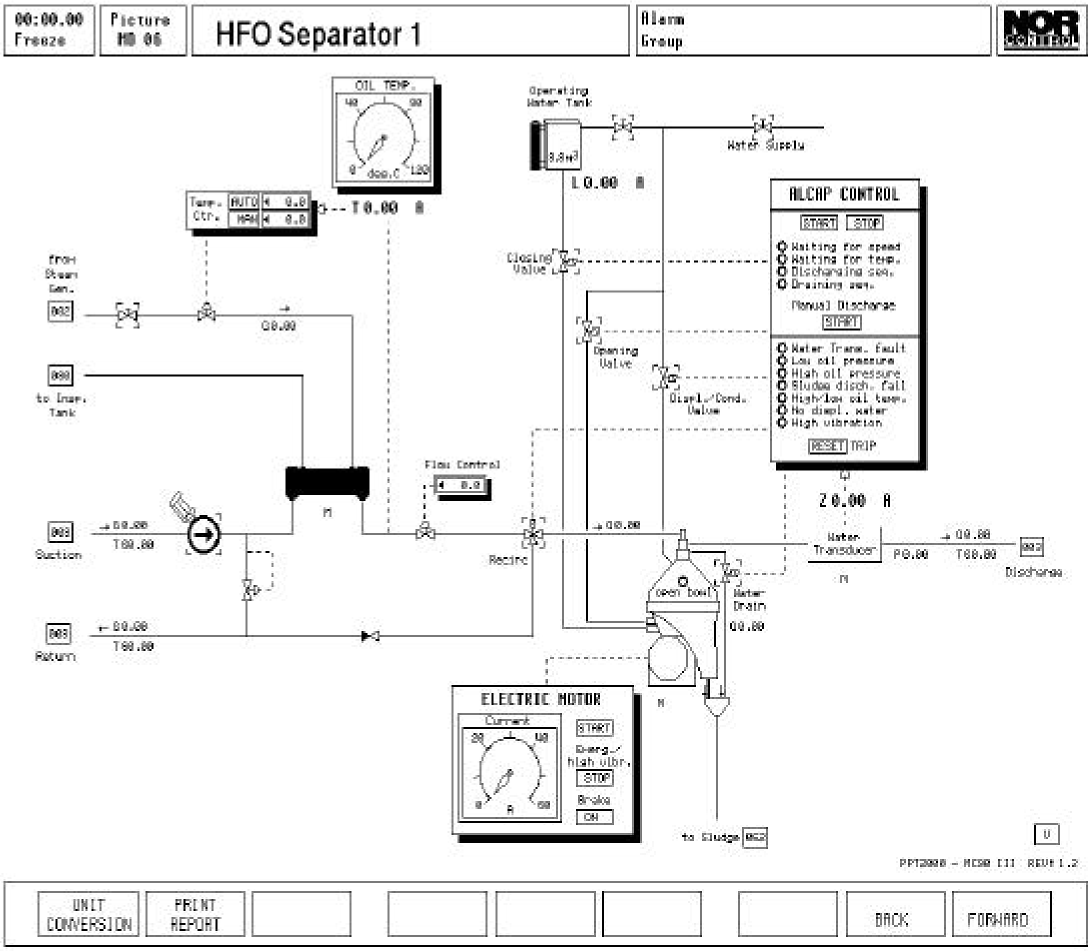

Figure 6. HFO Separator System

Water transducer failure alarm is activated if the transducer is measuring less than 0.05% water content in the outlet oil. Since it is not possible to measure a water content below this value in this separator system, this limit is used to indicate a fault condition of the transducer. Onboard, this failure could be loose connections, faulty oscillator unit, etc.

5.5 Related systems required to be in operation

The start-up procedure of fuel oil systems and the subsystems describe in the following

Heavy fuel oil transferring from bunker tanks to settling tanks

Open inlet to selected tank from HFO transfer pump. Open outlet from selected bunker tank. Start transfer pump after opening of outlet valve. Observe that transfer of oil between bunker tanks is possible. Ensure that valves going to bunker tanks are closed when transferring to settling tanks.

Fuel Oil Settling Tanks

Steam system for heating of oil.
Sufficient oil level in tanks.
Select one tank to be in service. From this tank open outlet valve to HFO Separator. Open recirculation into tank from HFO Separator. Open heating valves to and from heating coils and set desired temp on controller. HFO requires above 40°C to be pumped. Drain water from tanks periodically, or when alarms activate.

Transferring of HFO

Main bus bar active.
Boiler running with normal steam pressure.
HFO Separator running.

HFO Purifier System

Main bus bar active and boiler running with normal steam pressure.
Open outlet valve from selected HFO settling tank.
Open HFO SEP oil inlet valve to separator.
Open HFO SEP oil outlet valve to HFO service tank.
Open HFO SEP HEATER STEAM shut off valve.
Open valve for displacement water.
Start HFO SEP feed pump. Adjust desired flow.
Set temperature controller to AUTO and adjust set point to 98°C.
Start electric motor.

Heavy fuel oil transferring from HFO settling tanks to HFO service tank

Open fuel oil outlet valve from HFO settling tank to HFO separator.
Open fuel oil separator suction valve from HFO settling tanks. Close fuel oil separator suction valve from HFO service tank. Open fuel oil discharge valve from separator to HFO service tank. Close fuel oil discharge valve to HFO settling tanks.

6. CONCLUSIONS

Use of simulators in the education and training of sea-going engineers have become very important because of following changes in the maritime industry during the last few decades:

- Stringent environmental protection rules and regulations;
- Intense international competition which requires ships at optimum efficiency;
- Highly rated marine power plants, using very poor quality fuels;
- Qualified personnel with skills and experiences for the ship safety operation.
- Extensive use of automation and reduction of personnel;

This paper discusses the application of Computer-Assisted Training programs in the teaching and learning process of sea-going engineers and explain some principle on fuel oil system. This method of education has demonstrateda number of significant advantages, such as:

- The system has made the teaching/learning process much faster.
- There has been a significant increase in the quality of training.
- There has been an intensification of students' activity during the educational process.
- There is greater objectivity in the evaluation and assessment of student progress.
- There has been a reduction in the costs of education and training.

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