1200 PSI PROPULSION PLANT TRAINER DEVICE 19E22

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ABSTRACT

The ability of today's surface Navy to carry out its mission depends not only on advanced weapons systems and highly sophisticated electronics countermeasures, but also on the reliability of the steam propulsion plants which generate electrical power and propel the ships around the world. Reliability of a propulsion plant depends upon a crew, both enlisted men and officers, who are well trained in equipment maintenance and the ability to operate the plant safely both under normal and casualty conditions. To achieve this required expertise through training is the function of the 1200 PSI Propulsion Plant Trainer, Device 19E22.

This paper will discuss how the 1200 PSI Propulsion Plant Trainer executes its training mission through the following major elements:

1. A full-scale mockup of the engineering spaces including:
   (a) Engineer Room
   (b) Fire Room and Forced Draft Blower Room
   (c) Auxiliary Machinery Spaces, consisting of Auxiliary Machinery Room No. 1, Auxiliary Machinery Room No. 2, and Electrical Central.
2. A high-speed digital computer and associated Real Time Interface and peripheral equipment.
3. Computer programs including:
   (a) Executive program
   (b) Math Model programs
   (c) Input/Output programs
4. Instructor Station

BACKGROUND

The days of the World War II stick shift destroyer are long gone. Technological advances and changes in mission requirements during the post World War II period have brought about a new breed of ships to the fleet. Today's surface Navy requires the use of advanced weapons systems and sophisticated electronics to carry out its mission. Larger ships with higher power generation and propulsion capabilities are needed to accomodate and support these complex systems and today's possible tactical situations. The 1200 PSI steam propulsion and power generation plant is one of the high capacity systems in use today on many classes of ships. This plant has a far greater steam generating capability, increased flow rates, and generates steam pressures nearly twice that used on World War II ships. As a result, human responses were no longer adequate to control and regulate these plants and had to give way to sophisticated automated control systems. In turn, this high capacity and complexity of the 1200 PSI plant necessitated the generation of new and improved maintenance and repair techniques, as well as the development of skilled and properly trained personnel to operate and maintain it.

Initially the 1200 PSI plant had poor reliability record, with numerous equipment failures, casualties, personnel injuries and, regretfully, deaths, thus severely affecting the ability of the ships with these plants to perform this mission. A study revealed that much of the problem was due the lack of proper training in plant maintenance and operational procedures. To correct this situation, a 1200 PSI "Hot Plant" was constructed at the Service Schools Command in Great Lakes, Illinois to enhance the training capabilities of the basic machinist mate and boiler technician schools. A second "Hot Plant" was to be constructed at the Surface Warfare Officers School Command in Newport, Rhode Island to support that school's officer and enlisted engineering courses. However, for economic reasons it was decided that the second training plant should be a simulator 1200 PSI Propulsion Plant Trainer. There was considerable opposition to the simulator trainer approach versus a "Hot Plant", but the safety and economic factors, plus manpower savings, were overwhelmingly in favor of the simulator.

DEVICE 19E22 TRAINING OBJECTIVES

The 1200 PSI Propulsion Plant Trainer student training programs designed to meet the trainer's mission, which is to provide the student with the prerequisite knowledge and skills necessary to competently commence conventional steam propulsion plant qualifications, are structured to meet the following five training objectives:

1. Develop the ability to properly start, operate, and secure the plant under normal conditions.

2. Develop the ability to recognize abnormal conditions and/or symptoms which signal an impending casualty.

3. Develop the ability to take timely and appropriate corrective action which would prevent such an impending casualty from occurring.

4. Develop the ability to timely place the plant in a safe and stabilized condition when a casualty does occur to prevent cascading effects.

5. Develop the ability to restore the plant to normal operating conditions.

Training in the basic skills required to meet these training objectives is provided by the various officer and enlisted personnel service schools. The prime mission of the 1200 PSI trainer is then to provide the necessary "hands-on" training to shape and hone those skills to the required proficiency and concerted operation levels. Specifically, Device 19E22 was to support the following training courses:

1. Department Head Course

   - *Hands-on training prior to ship billet*

2. 1200 PSI Main Propulsion Assistant (MPA) Course

   - System tracing
   - EOSS operational indoctrination
   - Casualty control procedures
   - Maintenance and inspection
   - Watch standing
   - Automatic boiler control operation

3. 1200 PSI Supervisor's Course

   - Indoctrinate junior officers and SCPO's into 1200 PSI operation and supervision of maintenance

To meet these training requirements, a simulator training device based on the engineering spaces of an FF-1078 class frigate was decided upon by the Navy.

THE TRAINER AND ITS MISSION

In general the trainer specification required a full scale reproduction of the engineering spaces, and the simulation of all operational equipment which directly support the generation of electrical power and the propulsion of the ship. In addition, the equipment simulation should include visual and aural effects associated with both normal and casualty conditions.

Figure 1 shows the configuration of the trainer in the building as compared to the relative locations of respective engineering spaces aboard the design basis ship. As can be seen, the relative space locations are the same, except that the Auxiliary Machinery Room No. 2 and Electrical Central have been moved in order to accomodate the trainer within a more reasonably sized building. The basic overall trainer dimensions are 133' long, 41' high, and 47' wide. Although direct maintenance access through the simulated bulkheads is provided, they are hidden from direct view and are locked when training is in progress. As a *result, the trainees must move about during training* exercises in the same manner as they would on board ship.

Operational equipment simulation within the engineering spaces uses a great amount of detail to ensure easy recognition, and to facilitate familiarization with the locations of the various indicators and controls. Figures 2 through 4 illustrate this high degree of realism of the simulated equipments. Of note is the considerable amount of piping that provides system tracing capability to the trainer. Essentially all of the equipments and machinery are simulated. In a few cases, however, real shipboard equipments such as alarm panels and ship communications equipment are used. Equipment simulation includes dynamic characteristics such as start-up, running, shutdown, casualty modes of operation, and are categorized into the following sub-system groups:

- Main Steam System
- 1200 PSI and 150 PSI Desuperheated Steam Systems
- Condensate and Feed Systems
- Main and Auxiliary Condenser Air Removal Systems
- *Main Turbine Lube Oil Service Systems*
- Main and Auxiliary Sea Water Circulating System
- Fresh Water Drain System
- Fuel Oil System
- Auxiliary Exhaust and Escape Steam Systems
- Lube Oil Systems
- Drain Vent and Drain Collecting Systems
- Compressed Air System
- Automatic Boiler Control Systems
- Electrical Systems
- Communications Systems
- Twin Agent (AFFF and PKP) Fire Extinguishing System

To further enhance the equipment simulations, dynamic aural cues are extensively used. These aural cues are electronically produced, and are under math model driven computer control so that full operating range and casualty sounds are realistically generated. Over two hundred speakers and four sound systems are used which

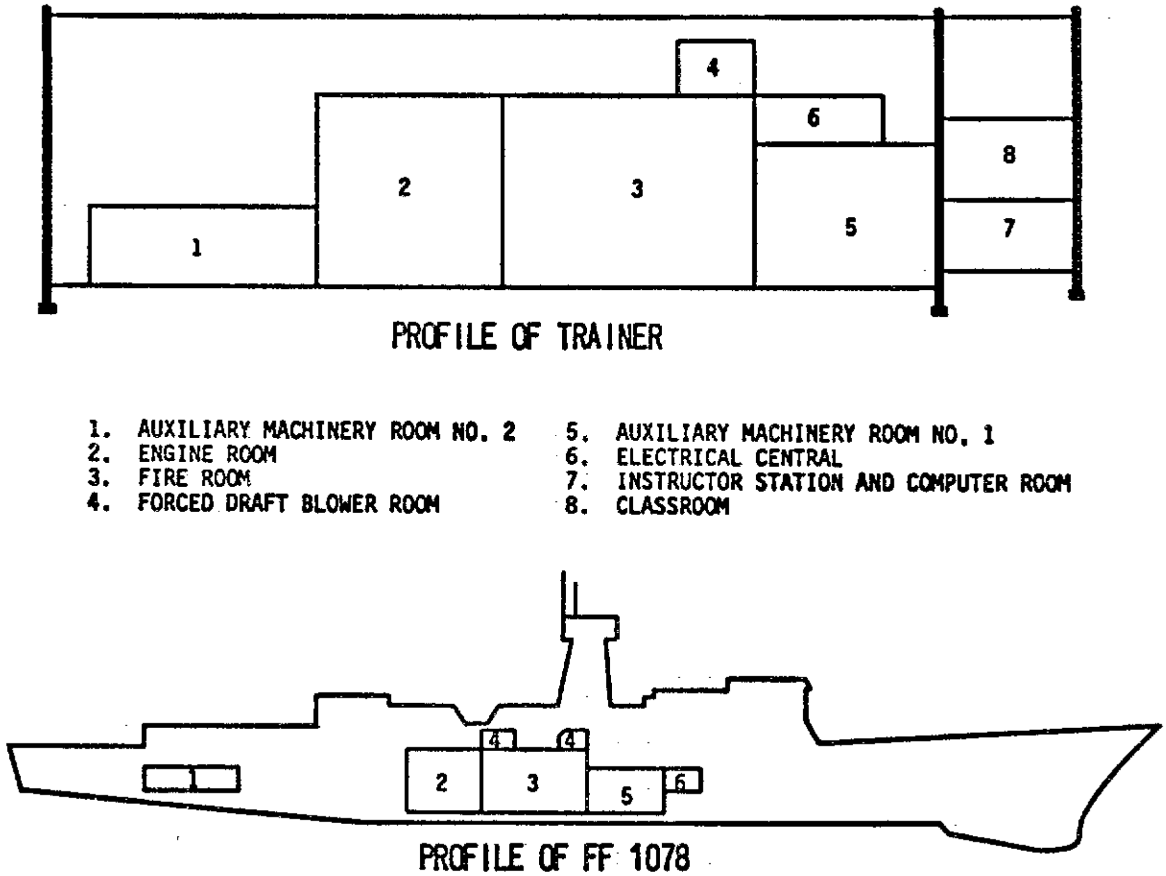

Figure 1. Trainer Configuration

are mounted in single or multiple quantities inside the equipments, thereby approximating very closely the sound pattern of their operational ship counterparts.

Visual effects are also used in many instances in order to produce the level of simulation necessary to meet the training objectives. These effects include such as rotating shafts on pumps, variable water levels in sight glasses, variable speed and direction of the main shaft, burner flame color, stack smoke density, and conflagration in the Fire Room. As in the case of the aural cues, the visual effects are also under math model driven computer control to assure their fidelity to the operational conditions being simulated.

All electronic equipment necessary to control the various functionally replicated machinery is located within the major machinery units in each room and the maintenance accesses to these are made inconspicuous so as not to detract from the realism of the replication. Cabling too, is either hidden from view or forms a part of some simulated ship's piping and/or cabling. In general, therefore, the internal arrangement of the trainer areas resembles very closely the configuration of the corresponding areas on the design basis ship, and any deviations necessitated by practical considerations are inconspicuous.

This attention to replication detail, comprehensive system simulation, and the extensive use of aural and visual effects creates a very realistic training environment. Consequently, not only can a broad spectrum of training in normal plant operation and casualty controls be achieved, but, in addition, such training is conducted under the constraints and limitations of a shipboard environment without the dangers inherent in that environment.

As important as a realistic training environment is to meeting the training objectives of Device 19E22, the essence of this trainer, or any trainer as a matter of fact, are the math models which drive it. Due to the uniqueness of the 1200 PSI Propulsion Plant Trainer, the contractor exercized considerable freedom in the design and development of the trainer, so as to take full advantage of innovative use of state-of-the-art simulation techniques. Consequently, it was essentially up to the contractor to decide upon the best math modeling approach to meet the training objectives.

Basically the operational requirements were that the trainer would be capable of supporting training in the Engineering Operational Sequencing System (EOSS), which includes Engineering Operational Procedures (EOP) and the Engineering Operational Casuality Control (EOCC) procedures,

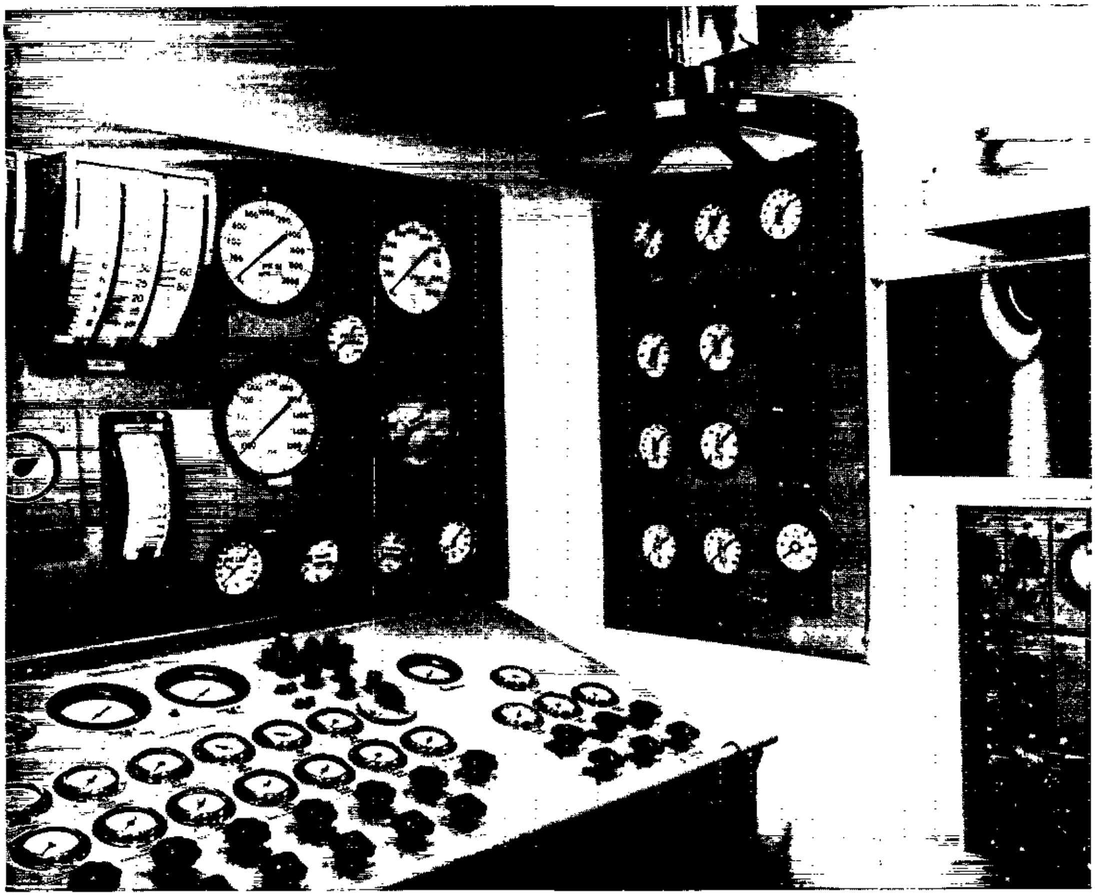

Figure 2. Fire Room Control Station

and could operate in the following four modes of operation:

Integrated Mode - Simultaneous and interactive operation of all the engineering spaces on common training problems.

Independent Mode - Separate and independent operation of three rooms - Fire Room, Engineer Room and Auxiliary Spaces (consisting of *Auxiliary Machinery Room* No. 1, Auxiliary Machinery Room No. 2 and Electrical Central).

Record/Playback Mode - On instructor command record a 30 minute history of training data, and play it back in real time.

Accelerated Mode - On instructor command move from one training situation and plant configuration to another in faster than real time.

The Record/Playback Mode is used for critique and demonstration purposes, and the Accelerated Mode is used to shorten the duration of operations such as lube oil preheating cycles. In actuality the Record/Playback and Accelerated Modes of operation are submodes, since they are active during either the Integrated or Independent Modes. Four trainer initialization conditions were also specified. They were:

Cold Iron - Dockside with shore steam and shore electrical power.

Auxiliary Steaming - Dockside on one boiler and ships electrical power.

Underway I - One boiler in automatic control, 15 knots.

Underway II - Two boilers in automatic control, 25 knots.

It should be noted that in Integrated Mode the entire trainer will be set to the selected initial condition, while in the Independent Mode each of the three rooms (Fire Room, Engineer Room, and Auxiliary Spaces) can be set to any of the four initial conditions. Also, although a large number of valves and controls are automatically resettable on computer command, some manual operations are required during trainer initialization. These involve such operations as insertion or removal of burners, rotary switches, and the like.

To provide this type of trainer operation, as well as support comprehensive training in plant operating procedures, it was decided early in the design development stage to math model the 1200 PSI plant from the physics point of view. By doing so the math models would recreate in essence the physical laws that govern the plant's operation, thus assuring accurate simulation of the plant dynamics during normal operation as well as casualty effects and their cascading. Furthermore,

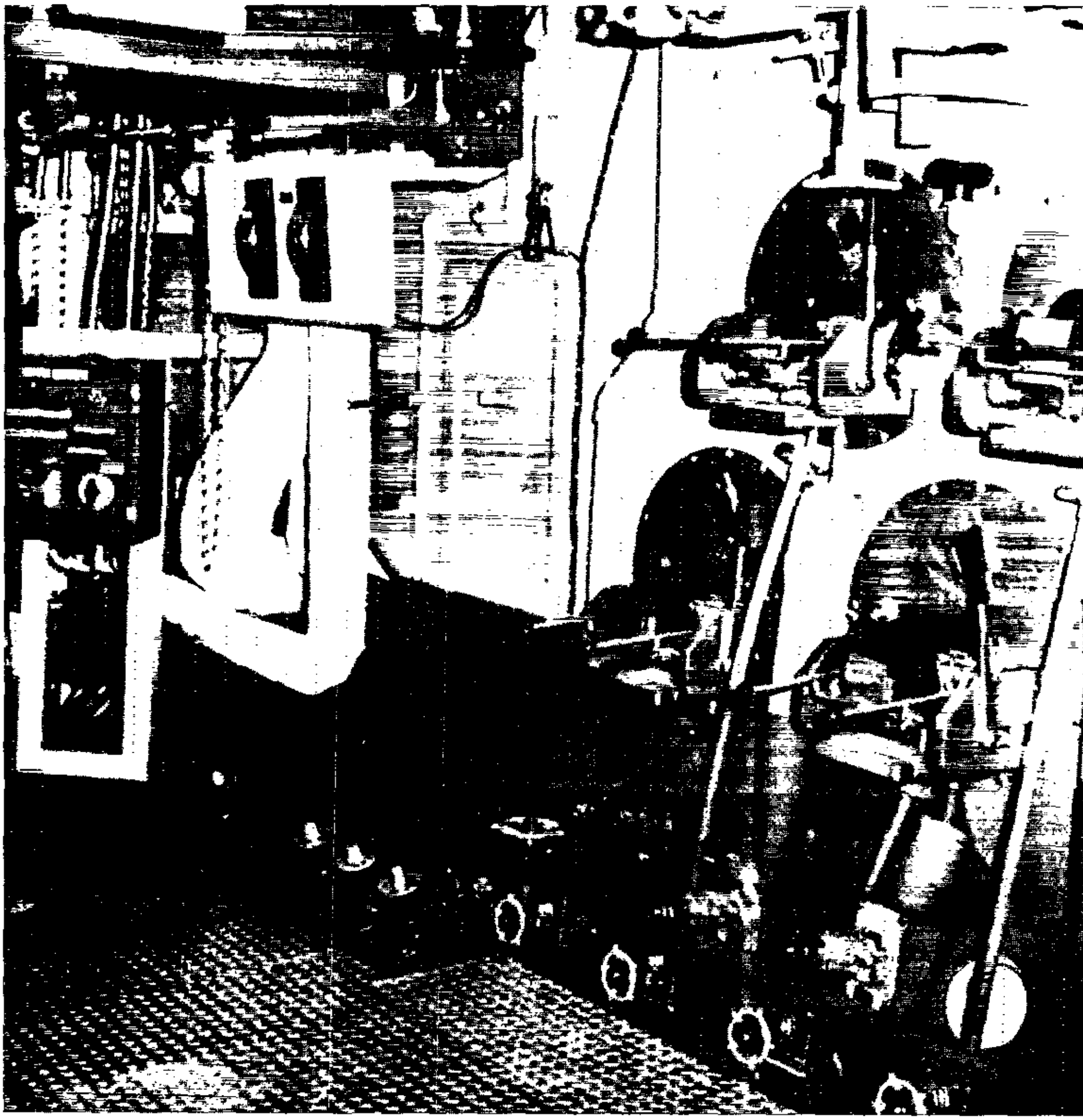

Figure 3. Fire Room - Firing Aisle

it was also decided not to model the exact detailed physical processes that take place, but rather to break down the plant into the smallest necessary system, subsystem, component, and process levels, and then use lumped parameter math modeling techniques. As a result, while the math models still recreate the physical laws at play in the plant, they are simplified considerably and have the characteristics of a black box with inputs, outputs, and a transfer function or series of equations representing the physical process. Obviously, extreme care was taken during this breakdown process to assure that all the feedback loops were accounted for and the required gage, thermometer, indicator, etc. values would be calculated.

The actual math modeling process used a bottom up approach. That is, the math models for the lowest level were developed first, then for the next higher level, and so on until the entire propulsion plant math model was developed. At each math modeling stage great emphasis was placed on making sure that all of the required input/output variables were accounted for, and that the necessary feedback loops were incorporated. One somewhat unique aspect of the math modeling process was that electrical equivalence methods were used during the analysis phase to gain in-depth understanding of the plant's operation, dynamics, and inter-relationships. Thereafter the models were written using the appropriate physics disciplines.

There were 156 casualties called out in the specification which could be inserted and removed on instructor command. They were distributed among the three trainer areas as follows:

Fire Room	-	56
Engineer Room	-	29
Auxiliary Spaces	-	71
		156

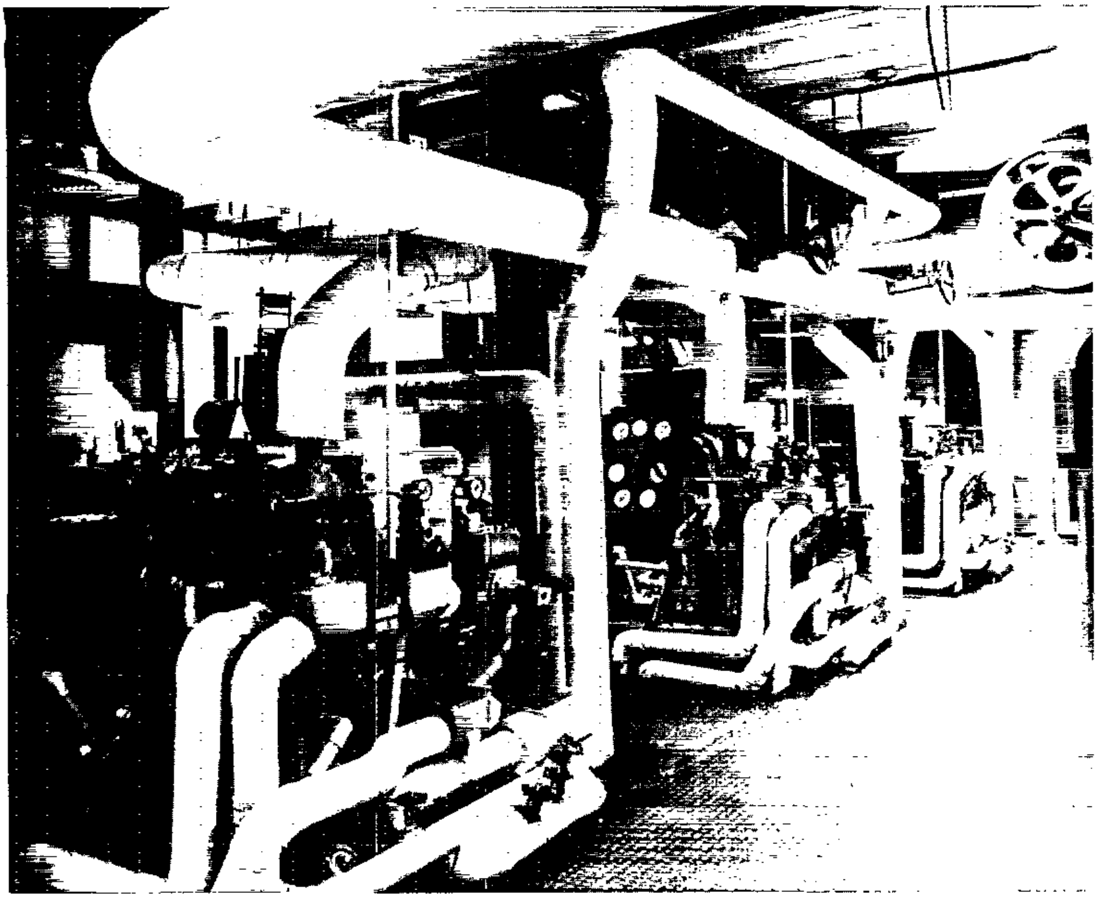

Figure 4. Auxiliary Machinery Room No. 1 Ships Service Turbo Generators (SSTG's)

Analysis of these casualties indicated that they fell into two basic categories. They were:

1. Equipment or component failures, such as "Ahead Throttle Jammed".

2. Casualties defined by symptoms, such as "Diesel Fuel Starvation".

Prior to the implementation of these casualties into the math models, the exact mode of failure had to be defined. For instance, a pump failure can be due to a broken shaft, overload, burned-out motor, etc. This is especially true in the case of the second category of casualties which are only defined via a symptom. For example, there are a relatively larger number of causes that would produce fuel starvation in a diesel engine. Furthermore, many such effects do not occur instantaneously, but rather at some rate dependent on the causing mode of failure. As a result, a specific failure mode must be defined, so that the resultant effects will be accurate both in symptoms and the time frame. Once the exact cause or failure was defined for each of the 156 casualties, the plant math models were then appropriately modified to react realistically to their insertion or removal.

Because of the fact that the plant math models were written based on the physical laws of the plant, insertion of casualties not only produced all of the necessary symptoms, but also, if appropriate, cascaded even to catastrophic proportions if timely corrective action was not taken by the trainees. Also, although all of these casualties are controllable by the instructor, a number of them will also occur as a consequence of inappropriate action by the trainees. As an example, turbine rumble will result if incorrect warm-up procedures were used. In some instances proper corrective action will automatically remedy the cause thereby canceling the casualty. In the case of the turbine rumble example, the appropriate reduction in turbine speed and the following of proper subsequent heat-up procedures will terminate the casualty whether it was initiated by the instructor or trainee action. In many cases, however, the failure causing the casualty, and therefore the casualty also, will remain in effect even if proper action was taken by the trainees. A case in point is a failed fuel oil pump as a result of a broken shaft. The corrective action in this instance is to place the standby pump on line. However, even though this action returns the plant to normal and stable operating conditions, the failed pump will remain out of commission as in the real world environment. Thus training in degraded plant operation capability is also provided, since unless the casualty is removed by the instructor, the failed pump cannot be returned to service.

To provide training capability in both the correct normal operation and casualty control procedures, another type of malfunction was added to the trainer. These were called maloperations or "MALOP", and are flagged and identified to the instructor whenever the proper procedural sequence of operations was not followed by the trainees. In those cases where the maloperation affects a critical main flow system, it is fully integrated in the math models, and if not timely corrected, is capable of producing a casualty. Typically, such maloperations are associated with the fuel oil, steam, lube oil, or sea water circulating systems. On the other hand, if the maloperation impacts a noncritical system, it will only be sensed by the math models for indication to the instructor. Maloperations of this nature are associated with vent, circulation, drain, gland seal, or other such valves. In general, MALOPS will remain in effect until corrective action is taken by the trainees. In those cases where the maloperation affects a critical system, however, the maloperation produces a degrading effect in the plant math models, and if corrective action is not taken in a timely manner, will result in a casualty.

It should be noted that the purpose of the 1200 PSI Propulsion Plant Trainer is to support comprehensive training in proper plant operation under normal and casualty control conditions and not to support training in plant maintenance. As a consequence, the functionally simulated equipments, components, and systems, as well as the math models, are limited to those relevant to plant operation. Equipments, components and piping associated with plant maintenance operations are only mocked-up in order to maintain the necessary degree of realism and to provide familiarization to the trainees. The decision as to what is plant operation related and what falls into the category of maintenance was often difficult since in many cases there is no clear cut distinction in function. Thus numerous revisions took place as a result of re-analysis conferences with Navy personnel familiar with 1200 PSI plant operations.

The drivers of the Device 19E22 simulator are the computer system with the resident math models and the Real Time Interface (RTI) system which interconnects the approximately 5,000 trainer input/outputs to the computer. The Device 19E22 computer system consists of a Harris Slash 4 computer system with 120K bytes of core memory, two 800 bpi tape drives, a 2150K byte fixed head disk, and the RTI Adapter (RTIA) whose purpose is to make the RTI system compatible with the I/O data transfer formats of the computer. Of interest also is the configuration of the simulated Twin Agent Fire Extinguishing System. It is completely independent of the main computer system is is totally microprocessor controlled, requiring only that the trainer room lights be on to operate. As a result, it is, in effect, a trainer within a trainer, and permits fire control training in conjunction with, or independent of, propulsion plant training. This, in conjunction with the Independent Mode capability, enhances the trainer up time through the availability of several modes of degraded operation.

With the exception of the Twin Agent Fire Extinguishing System trainer which is self-starting and self-contained, total control of trainer operation is provided by the Instructor Station shown in Figure 5. It is divided into three sections, as follows, from left to right:

1. Fire Room Console
2. Engine Room Console
3. Auxiliary Spaces Console

Each console consists of an interactive CRT/Keyboard terminal, communications controls, and a special purpose control panel. The interactive CRT/Keyboard terminal is used not only to display pertinent trainer room data, but also to initialize and control the trainer through the use of simple alphanumeric data entries. The only discrete controls and indicators are those that are not readily or conveniently adapted to CRT/Keyboard operation and are located on the special purpose control panel to the right of the CRT. Typically, these consists of Independent Mode controls representing outside of the room system demands and/or supplies, and instruments such as Engine Order Indicator/Transmitter. As a result, instructor workload is greatly minimized, permitting him to devote the majority of his time to training and instruction.

Communications controls for each instructor are located to the right of the CRT. These controls permit the instructors access to all of the simulated ships communications circuits for both monitoring and two-way communications purposes, as deemed necessary. In order to support Integrated and Independent Mode trainer operation, the communications system is under computer control. Thus if the Integrated Mode is selected, normal inter-space communications are possible, with the Instructor Station assuming the role of all areas outside those simulated in the trainer. In the Independent Mode, each Instructor Station console takes command of its respective counterpart. That is, the Engine Room console will assume the role of all areas outside the Engine Room. Additionally, a wireless instructor communications system is also provided. This system enables roving instructors inside the trainer to communicate with the Instructor Station to coordinate training exercises without prewarning the trainees of upcoming situations.

In addition to the critical parameter displays on the CRT's and the monitoring capability of area communications, a closed circuit TV system is used to further enhance the instructor's ability to observe and evaluate trainee performance during training exercises. This system has nine strategically located TV cameras inside the trainer area, four TV monitors on the Instructor Station, a video switcher, and a video recorder. Thus not only can trainee activity be monitored during a training exercise, but also a recording of a selected exercise segment can be made for post-training debriefing and critique which also will include all of the communications that transpired during that segment.

This then was a general description of Device 19E22, 1200 PSI Propulsion Plant Trainer, its capabilities, and the rationale behind the hardware and software design approaches that were used to ensure that the trainer could meet the requirements of its training objectives, and thus its mission. Since Device 19E22 represents a new approach to U.S. Navy engineering training, that

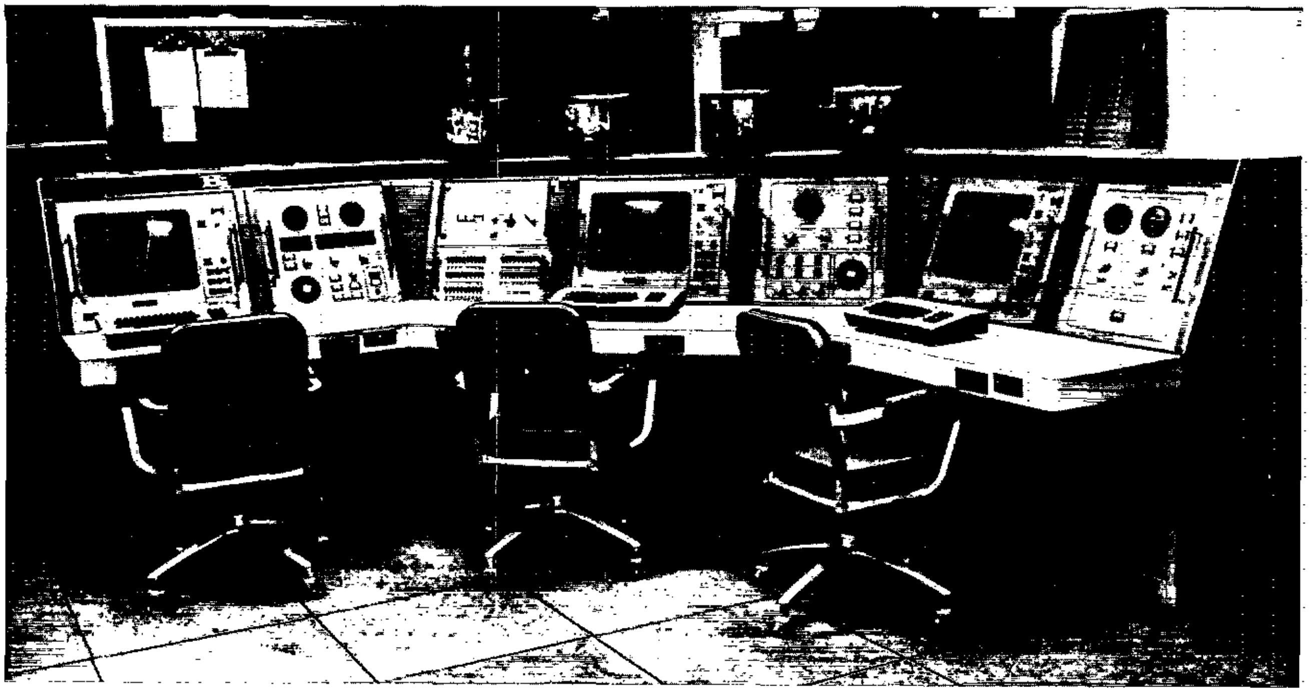

Figure 5. 19E22 Instructor Station

of marrying the traditional need for propulsion plant and power generation operator training with computer technology and simulation techniques, it is worthwhile to study the effectiveness of Device 19E22 in support of the Navy's training efforts, specifically in support of the training efforts of Surface Warfare Officers School Command.

Surface Warfare Officers School Command is a shore training activity operating under the command of the Chief of Naval Technical Training (CNTECHTRA). The mission of Surface Warfare Officers School Command is to provide the naval surface warfare forces, through a system of functional training, with officers professionally qualified to serve as effective naval leaders of surface ships with the ultimate goal of "command at sea." From Ensign to Captain, Surface Warfare Officers School Command provides a continuum of training for surface warfare officers at every level within the shipboard organization for all surface ships in the fleet. The followinq Surface Warfare Officers School Command courses emplov Device 19E22 directlv in their curriculums. Deoartment Head Course. Solit Tour Engineer Officer Course, and 1200 PSI Main Propulsion Assistant Course.

Engineering training is an integral part of these courses since surface warfare officers are required to possess comprehensive knowledge of surface ship propulsion plants and electrical power generation and distribution systems. Obtaining basic engineering qualification is a prerequisite for formal qualification and designation as a Surface Warfare Officer. Furthermore, since 1976, qualification as a shipboard Engineering Officer of the Watch is a prerequisite for qualification to command at sea. The existence of Device 19E22 at Surface Warfare Officers School Command underscores the importance of engineering training to the career path of today's Surface Warfare Officer.

As aforementioned, the mission of the 1200 PSI Propulsion Plant Trainer is to provide the student with the prerequisite knowledge and skills necessary to competently commence conventional steam propulsion plant qualifications. To meet this mission, and to accomplish the training objectives mentioned earlier, the training programs of Device 19E22 and the engineering curricula of Surface Warfare Officers School Command courses are structured around the FF-1052 Class Frigate Engineering Officer of the Watch (EOOW) Personnel Qualification Standard (PQS). The EOOW PQS system requires the student, as an EOOW trainee, to possess a detailed knowledge of the theory of 1200 PSI steam propulsion plant operations and of the many main and auxiliary systems of the propulsion plant. Engineering theory and propulsion plant systems training is presented in classroom lectures at Surface Warfare Officers School Command. Beyond requiring knowledge of theory and systems, the EOOW PQS system requires the trainee to discuss and/or perform certain evolutions at the various watchstations in the propulsion plant. Device 19E22 is the training platform on which students accomplish PQS watchstation requirements during normal and abnormal plant operating conditions.

Matching the realism of Device 19E22 is the fact that the students utilizing the device are given the actual EOOW PQS training materials that are employed on the operational ships themselves. Students perform watchstation items, such as placing into operation the main engine, lighting fires in a boiler, or performing corrective action for a low water in the boiler casualty, and earn signatures from 1200 PSI Propulsion Plant Trainer instructors in the EOOW PQS Qualification Card. These signatures certify that the student has demonstrated to a qualified operator a satisfactory ability to complete a specific watchstation action. The qualification card serves to document the actual watchstation training the student received in Device 19E22 and is forwarded as a record of training to the Commanding Officer of the student's future ship. It should be noted as a practical matter that Surface Warfare Officers School Command does not attempt to "qualify" students as EOOW's, for that formal, at-sea qualification is the prerogative and responsibility of the surface ship's Commanding Officer. Rather, it is reported to the Commanding Officer what qualification prerequisites were satisfactorily completed in the 1200 PSI Propulsion Plant Trainer. It is a significant fact, however, that Commanding Officers are "accepting" a large majority of the EOOW PQS line items performed in the 1200 PSI Propulsion Plant Trainer as valid for qualification purposes aboard their ships. Thus, one of the tangible benefits of the 1200 PSI Propulsion Plant Trainer is that the training received by the officer in the trainer ashore obviates, to a significant degree, the need to receive the same qualification training at sea. The end result is that officers are receiving their formal EOOW qualification earlier in their sea tour than previously experienced, and can dedicate more time towards meeting their other responsibilities. The readiness of the individual officers and, thus, the readiness of their ships, has been improved because of the engineering training these officers receive in Device 19E22.

In addition to using the actual FF-1052 Class Frigate EOOW PQS system, the students also utilize the Engineering Operational Sequencing System (EOSS) operational procedures and casualty control procedures that are identical to those that exist in the fleet today aboard most surface ships. Disciplined utilization of EOSS is stressed at all levels of the trainer's training programs. The 1200 PSI Propulsion Plant Trainer's EOSS is a credible, realistic, and workable document. It has been evaluated as satisfactory and technically correct by the Naval Sea Systems Command. It was utilized as a standard during acceptance testing of the device, and it was taken aboard actual frigates and employed to safely start up and prepare the propulsion plant for underway operations.

Device 19E22 EOSS and PQS programs are the keystones of its student training programs. These documents are no different than their shipboard counterparts and match the realism of Device 19E22 itself. Utilization of EOSS and PQS enhance the capability of the trainer to provide effective training. The capability to provide training and practice by students in the disciplined utilization of the EOSS while actually performing Engineering Officer of the Watch qualification prerequisites is an important element of the engineering training offered at Surface Warfare Officers School Command and one which was not available until Device 19E22 was placed into operation.

Device 19E22 was commissioned in November 1977 and, after a series of acceptance tests and reliability and maintainability demonstrations, was placed into operation for student training in late February 1978. Through 30 June 1980, the trainer has been utilized to provide training to nearly 3000 students, totaling over 100,000 man-hours of training. During this same period, the reliability of the device itself has been exceptionally high. In 28 months of continual daily operation, only 89 of over 6100 scheduled training hours have been lost due to unscheduled maintenance or repair activity. Both Surface Warfare Officers School Command, as the custodian of this one-of-a-kind training device, and the Navy have been exceptionally pleased with and proud of the capabilities of Device 19E22, the reliability of the trainer, the efficiency of training conducted on the device, and the training effectiveness.

When Device 19E22 was placed into operation for student training, a pilot program was established for a 1200 PSI Main Propulsion Assistant Course class. Initial utilization of the device was directed for this course because the students of this course receive no other functional, "hands-on," deckplate training, enroute to their ultimate duty station, other than that available in the 1200 PSI Propulsion Plant Trainer. The pilot program was expectedly successful. The capabilities of the device, including the realistic simulation, the magnitude of casualties, and reset capability, all combined to provide a dynamic, five-week addition to the 1200 PSI Main Propulsion Assistant Course. It was clear that more operational training could be accomplished in Device 19E22 than in a shipboard style, integrated, hot plant.

The positive results of Surface Warfare Officers School Command's training program in Device 19E22 for the 1200 PSI Main Propulsion Assistant Course led to a rapid integration of trainer utilization into the Department Head Course curriculum. Other factors contributed to utilization of the trainer by this course commencing in May 1978. Heretofore "hands-on", engineering training for students enrolled in this course was accomplished at sea aboard various units of the Naval Surface Force, U.S. Atlantic Fleet. The reduction of surface units in the Atlantic Fleet, the increased operating tempo of the remaining available SURFLANT ships, the rising fuel costs for operating ships at sea, the economic costs of per diem and travel to and from the homeports of the training ships for the Department Head Course students, and the uncertain material condition of the training ships' propulsion plants which on some occasions caused loss of training, accelerated the integration of the Department Head course into the utilization schedule of Device 19E22.

With the addition of the Department Head Course, which placed an annual demand on the trainer of 12 training weeks, to the 1200 PSI Main Propulsion Assistant Course, which required access to the trainer for 50 weeks annually, scheduling conflicts developed which required continual resolution. Thus a decision to implement two training shift operations was made in the late summer of 1978, and not only resolved the scheduling conflicts due to single shift operations, but also allowed further increases in trainer utilization, thus meeting the increasing demands on the trainer by new training initiatives of Surface Warfare Officer School Command. In the interim period of increasing the instructor staff to support double shift operations, the Deputy Chief of Naval Operations (Surface Warfare), Vice Admiral James H. Doyle, Jr., USN, established the following 1200 PSI Propulsion Plant Trainer Utilization Priority Table to resolve scheduling conflicts between current and future users of the trainer:

Priority No.	*Course/Program*	Annual *Requirements*
One	1200 PSI Main Propulsion Assistant Course EOOW Training Program	45 weeks
Two	Department Head Course (CORE) Training	8 weeks
Three	Department Head Course Engineering Specialty,	4 weeks
	Split Tour Engineer Officer Course	7 weeks
Four	Department Head Course Combat Systems EOOW	12 weeks
Five	Fleet Utilization Training Program	24 weeks
		100 weeks

Single shift operations continued until March 1979 at which time partial, double shift training commenced. In June 1979 two-shift training commenced on a full time basis.

The 1200 PSI Propulsion Plant Trainer, because of its unique capabilities, provides distinct advantages to the students of the various courses and training programs described below. Responses of student watchstanders can be conditioned through repetition. The reset capability allows training evolutions to be repeated quickly with negligible loss of training time. Indeed, in comparison with a shipboard propulsion plant in which one evolution may take two hours to accomplish, the same evolution can be accomplished several times in the same time frame in Device 19E22. Because of the many, preprogramed casualties inherent in Device 19E22, a second advantage is that the students are permitted to observe, without fear of the consequences of non-action by the watchstanders, the actual casualty symptoms. Thus, in a controlled and safe environment without time constraints, the student can observe the immediate and long range symptoms and effects of, for example, a loss of sea water circulating water to the operating condition of a Ship's Service Turbogenerator and to the electrical distribution system. Coupled with this advantage to the student is the third advantage of being able to actually respond to the casualty symptoms themselves, to take the necessary corrective action, in accordance with Naval Sea System Command authorized Engineering Operational Casualty Control (EOCC) procedures, to bring the propulsion plant to a safe, stabilized condition, and then to restore the plant to its original operating condition. Now, instead of merely watching, the students are doing those watchstander actions required to properly operate and control the propulsion plant. Again, as described earlier, the propulsion plant, its components and systems will respond favorably or unfavorably to student watchstander actions. Thus the trainer, in casualty control evolutions as well as in normal operating evolutions, provides the classic teaching environment -- learning by doing.

A fourth advantage to the students made possible by the design of Device 19E22 is that students are afforded the opportunity to perform all propulsion plant evolutions at each watchstation of the 1200 PSI Propulsion Plant. Students utilizing the trainer are actually exposed to and receive training at all the watchstations that are manned in the FF-1078 propulsion plant during underway Condition One, or General Quarters. Thus, the trainer is manned, for training purposes, at a higher level than an operating surface ship would be for normal, routine training evolutions at sea. This manning level permits maximization of training for the student.

The fifth advantage to the student is closely linked to the trainer's capabilities which permit the selection of training scenarios that are commensurate with the abilities of the student. The spectrum of student expertise utilizing the 1200 PSI Propulsion Plant Trainer ranges from that possessed by a fledgling junior enlisted man stationed aboard ship, to the detailed knowledge and experience displayed by Lieutenant Commanders, Limited Duty Officers, and Warrant Officers. The flexibility of Device 19E22 is such that beneficial, basic individual training can be provided as easily as sophisticated team training, and, occasionally, widely disparate types of training are provided simultaneously. These instances demonstrate the independent and concurrent flexibility of the trainer inherent in its design characteristics and capabilities.

A final advantage, and perhaps the most important one in view of its long term effects, is that the trainer and its instructors provide the vehicle by which the students are schooled in the disciplined utilization of Engineering Operational Sequencing System (EOSS) procedures and formal propulsion plant communications doctrine at all watch levels. As mentioned earlier, the trainees learn to operate the propulsion plant and all its equipment safely in accordance with formal, accurate, authorized documents. They are indoctrinated into respecting these procedures and in recognizing the need for strict adherence to them. If the students gain nothing from their experience in the 1200 PSI Propulsion Plant Trainer other than a fervent application for the correct, proper, and right way in which to operate a propulsion plant in strict accordance with EOSS, then the trainer has still provided immeasurably valuable training. Students are conditioned not to rely on the memory of the watchstander or on the unsafe, unauthorized "folklore" approach to plant operations that regrettably characterized operating doctrine in the past. This zealous emphasis on EOSS is more a function of the 1200 PSI Propulsion Plant Trainer instructor staff, but without the device as the practical and realistic platform on which to practice utilization of EOSS, then the training results in this particular area would be superficial at best.

The value of the 1200 PSI Propulsion Plant Trainer is reflected in its heavy utilization schedule. There are, in fact, more training demands on the device than the trainer and its staff can accommodate. This heavy demand underscores the appreciation of the 1200 PSI Propulsion Plant Trainer and of its capabilities by Surface Warfare Officers School Command and the Navy. Training requests which have been presented to Surface Warfare Officers School Command but which cannot be regularly and formally supported by the trainer include summer training for U.S. Naval Academy midshipmen, training for Naval Reserve Officer Training Corps (NROTC) midshipmen from civilian universities, and U.S. Naval Reserve Training. Additionally, all requests for Fleet Utilization Program Training cannot be met because of higher priority commitments.

The Fleet Utilization Training Program, which places a yearly demand on Device 19E22 of 24 weeks, represents the most varied utilization of the device, and is the one program which can be analyzed in terms of the potential for expanded application of computer simulation of propulsion plant operations for the greater training needs of the Navy. Initial second shift training in the 1200 PSI Propulsion Plant Trainer was conducted in March 1979 in support of this program. This program evolved from a proposal by Commander Destroyer Squadron Twenty-Eight to utilize Device 19E22 for training the engineering crews of the ships in that squadron. This proposal was sanctioned by Vice Admiral James H. Doyle, USN, Deputy Chief of Naval Operations (Surface Warfare) and Vice Admiral William Read, USN, Commander Naval Surface Force, U.S. Atlantic Fleet, (COMNAVSURFLANT). A pilot program was established for evaluation during March through June 1979, with scheduling the responsibility of COMNAVSURFLANT. The pilot program was successful as the trainer demonstrated its ability to provide safe, energy-saving, and beneficial training in basic steam propulsion plant operations. Since March 1979, this program has provided valuable training, with tangible results, to over 650 enlisted personnel of 16 different Atlantic Fleet surface ships. Several of these ships have utilized the 1200 PSI Propulsion Plant Trainer on multiple occasions. Through June 30, 1980 nearly 14,000 man-hours of training have been provided under this program. These ships have reported that the differences in configuration between their propulsion plants and that of the 1200 PSI propulsion plant trainer have had negligible effect on the benefits and value of the training received. Fleet Utilization of the trainer has steadily increased to its present level of 24 weeks per year. This program provides training opportunities that never existed before and now ensures that 100% utilization of the device is achieved. When scheduled to utilize the 1200 PSI Propulsion Plant Trainer, a ship preselects a training program that best meets its particular desires, based upon the ship's operating cycle and its own assessment of its watchstanders' experience levels and training needs. The five training programs available to fleet users are:

1. Basic Knowledge: Individual training keyed to enlisted watchstanders without significant steaming experience.

2. Pre-LOE (Light Off Examination): Team training for watchteams with little steaming shipboard experience.

3. Pre-LOE/Proficiency Maintenance: Team Training for match teams with adequate knowledge and steaming experience; normal start-up, operate and secure training.

4. Pre-OPPE (Operational Propulsion Plant Examination)/Proficiency Maintenance Team Training with sufficient, integrated steaming experience; normal operating training plus some casualty control training.

5. Pre-OPPE/Pre-REFTRA (Refresher Training): Team training for watch teams with sufficient steaming experience; almost exclusively casualty control training.

The flexibility of the device and its multiple modes of operation easily allow a ship's crew to transition from one training program to another as it gains proficiency in operating the propulsion plant. Scheduling, as mentioned above, is the responsibility of COMNAVSURFLANT. Of interest is that when notified of dates the trainer is available for Fleet Utilization in any given calendar quarter, COMNAVSURFLANT fills the schedule within a period of a day or two. The fleet units are eager to use Device 19E22. Some units have requested several months in advance to be placed on the 1200 PSI Propulsion Plant Trainer's Fleet Utilization Schedule.

Utilization of Surface Warfare Officers School Command's 1200 PSI Propulsion Plant Trainer is maximized, limited by necessity for maintenance and daily diagnostic tests. But the demands for the trainer continue to grow, particularly from the fleet. The track record of Device 19E22 has been most impressive. Its utilization as an integral part of several Surface Warfare Officers School Command courses has added dynamic realism and excitment to these courses. It has provided training opportunities where none existed before. It has been a significant cost-saver as students no longer travel elsewhere to receive "hands-on" operator training. And, although obvious in an era of skyrocketing energy costs, it is noted that the trainer does not consume fuel oil or lube oil. Device 19E22 provides functional engineering training at a cost substantially lower than anywhere else in the Department of Navy. The 1200 PSI Propulsion Plant Trainer freed Atlantic Fleet units from training commitments to Surface Warfare Officers School Command's Department Head Course, thus allowing them to dedicate their fuel allocations for underway activities more closely aligned to their own primary mission areas and commitments. Qualification prerequisites performed in the 1200 PSI Propulsion Plant Trainer, and accepted by students' Commanding Officers, have reduced qualification periods of the students aboard ship.

The 1200 PSI Propulsion Plant Trainer has proven itself exceedingly safe and reliable and highly capable of providing efficient and effective training. Computer technology and simulation techniques, exemplified in Device 19E22, are indeed a present and viable means to meet the ever-increasing training needs of the U.S. Navy, particularly in the surface engineering community. Surface Warfare Officers School Command could not be more pleased with the positive impact Device 19E22 has had on its training programs. This enthusiasm for the present performance and potential of the 1200 PSI Propulsion Plant Trainer has been shared by many senior Navy officials, foreign Navy visitors, and interested civilian concerns who have visited Surface Warfare Officers School Command to observe Device 19E22 in operation, and, in particular, by the fleet personnel who use the device to receive the most dynamic and 1200 PSI efficient propulsion plant operator training available in the U.S. Navy today.

ABOUT THE AUTHORS

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