Statement of Admiral H. G. Rickover, USN

Before the Subcommittee on Energy Research and Production of the Committee on Science and Technology U.S. House of Representatives

May 24, 1979

You have asked me to appear before your subcommittee in order to discuss my own perspective on nuclear safety and to describe the philosophy and approach of the naval reactor safety program. The views I will express are my own based on 60 years of government service. They do not necessarily reflect those of my superiors of any government agency.

Naval Reactors Program

I will begin by describing the extent of the naval reactors program. Today 115 nuclear powered submarines are in operation; 41 of these are ballistic missile firing submarines and 74 are attack submarines. Twenty-three additional attack submarines and seven trident submarines are authorized for construction. We also have one nuclear powered deep submergence research and ocean engineering vehicle. Three nuclear powered aircraft carriers are in operation, and one more is being built. Eight nuclear powered cruisers are in operation, and one more is being built together, 127 nuclear powered ships are in operation. In addition, I am responsible for the shippingport atomic power station. Including nuclear ships, the naval prototype reactors, and the shippingport station, I am responsible for the operation of 153 reactors.

There are two Department of Energy laboratories devoted to the support of the naval reactors program: one is the Betts Atomic Power Laboratory in Pittsburgh, Pennsylvania which is operated by Westinghouse; the other is the Knolls Atomic Power Laboratory located in Schenectady, New York, which is operated by the General Electric company.

Since the USS Nautilus first put to sea in 1955, naval nuclear powered ships have steamed over 40 million miles and have accumulated over 1800 reactor-years of operation. We have procured 508 nuclear cores, and have performed 166 refueling. Some 300 large businesses and over 1000 small businesses produce equipment for the naval reactors program.

Environmental Record

In the twenty-six years since the Nautilus land prototype first operated there has never been an accident involving a naval reactor, nor has there been any release of radioactivity which has had a significant effect on the environment. For example, in each of the last eight years, the total gamma radioactivity in liquids, less tritium, discharged within 12 miles of shore from all our nuclear powered ships, supporting tenders, naval bases and nine shipyards, was less than two thousandths of a curie. If one person were able to drink the entire amount of radioactivity discharged into any harbor in 1978, he would not exceed the annual radiation exposure permitted by the Nuclear Regulatory Commission for an individual worker.

Each year I issue a report which describes in detail the record of discharges of radioactivity to the environment from naval ship operations and describes our methods of control and environmental monitoring. With your permission I will provide the subcommittee with a copy of this report for 1978 for the record.

Occupational Radiation Exposure

For the past two years there has been increased public and congressional interest in the health effects due to low level radiation. I am neither an expert on radiation health effects nor am I responsible for setting the national occupational exposure limits. But I am responsible for the use of these standards in conducting radioactive work in the naval reactors program thus I have considerable experience in what it takes to perform work with radioactive material in a manner that protects the workers.

A second document I would like to provide for the record provides the occupational radiation exposure record for civilian and military people involved in navy nuclear propulsion and their support facilities. On page 2 of this report, there is a graph which shows the total occupational radiation exposures to personnel operating ships and to employees in the shipyards. In 1978 the total operator and worker exposure was about one quarter the amount in the peak year 1966, even though the number of nuclear-powered ships nearly doubled.

As identified in the document, since 1967 no civilian or military personnel in the navy's nuclear propulsion program have exceeded the quarterly federal limit of 3 rem or an annual radiation exposure limit of 5 rem. The average annual exposure of shipyard workers in 1978 was one quarter of a rem. The average annual exposure of ship operators in 1978 was one tenth of a rem. This document also outlines many of the measures implemented to achieve the record of occupational radiation exposure we have attained.

I believe both reports will be of value to the purpose of this hearing, because they convey something of the kind of care and attention to detail we have taken in order to maintain a level of assurance that both the public and the people in the program are protected.

Three Mile Island Incident

Since the incident at the Three Mile Island site, I have been asked by many people to comment, there are several reasons why I have not done this. First, all the facts are not in, and it would be presumptuous on my part to make judgments on such a highly complex subject when I do not have the facts. Second, there are significant differences between the design and operation of naval reactors and plants such as the Three Mile Island plant. I want to weigh all aspects of the incident and see if there is anything from it I can learn and incorporate into the naval program. That is the way I have always operated.

Another important aspect is the legal issue involved. It is yet to be decided who will pay all the various costs for the incident. It would not be appropriate for a government employee such as myself to be issuing pronouncements on the incident when there may be litigation.

Basic Principles Of Naval Reactors Program

There are, however, a number of facts which have been released by the Nuclear Regulatory Commission regarding Three Mile Island. These facts seem to me to reinforce many of the underlying basic principles of the naval reactors program.

Over the years, many people have asked me how I run the naval reactors program, so that they might find some benefit for their own work. I am always chagrined at the tendency of people to expect that I have a simple, easy gimmick that makes my program function. They are disappointed when they find out there is none. Any successful program functions as an integrated whole of many factors. Trying to select one aspect as the key one will not work. Each element depends on all the other elements.

I recall once several years ago an admiral, whose conventionally powered ships were suffering serious engineering problems, asked me for a copy or one specific procedure I used to identify equipment which was not operating properly. He believed that would solve his problem, but it did not. That admiral did not have the vaguest understanding of the problem or how to solve it, he was merely searching for a simple answer, a check off list, that he hoped would magically solve his problem.

I can not overemphasize the importance of this thought in your current deliberations. The problems you face can not be solved by specifying compliance with one or two simple procedures. Reactor safety requires adherence to a total concept wherein all elements are recognized as important and each is constantly reinforced.

Technical Competence

One of the elements needed in solving a complex technical problem is to have the individuals who make the decisions trained in the technology involved. A concept widely accepted in some circles is that all you need is to get a college degree in management and then, regardless of the technical subject, you can apply your management techniques to run any program; including the Presidency, Congress, or the Vatican. This has become a tenet of our modern society, but it is as valid as the once widely held precept that the world is flat. Properly running a sophisticated technical program requires a fundamental understanding of and commitment to the technical aspects of the job and a willingness to pay infinite attention to the technical details. This can only be done by one who understands the details and their implications. The phrase “the devil is in the details” is especially true for technical work, if you ignore those details and attempt to rely on management techniques or gimmicks you will surely end up with a system that is unmanageable, and problems will be immensely more difficult to solve. At naval reactors, I take individuals who are good engineers and make them into managers. They do not manage by gimmicks but rather by knowledge, logic, common sense, and hard work.

Responsibility

Another essential element is that of responsibility. In the beginning of the naval program it was apparent to me that due to the uniqueness of nuclear power and its potential effect on public safety, a new concept of total responsibility had to be established both within the navy and the then atomic energy commission (AEC). It would not work if one person was responsible for nuclear power plants in the navy, and a different person responsible in the AEC. Similarly, it would not work if there was one person in the the AEC responsible for the naval program with a different person responsible for the AEC laboratories doing the work for the naval reactor program. It would not work in the navy if five or six different admirals all had charge of different pieces of the program, as is often the case in other areas. Iit would not work if there was one person responsible for research and development, someone else responsible for construction, and another responsible for training and operation, and still another for repair work.

This kind of compartmentalization of responsibility is typical in government work, but the practice of having shared responsibility really means that no one is responsible. It reminds me of the figure in nest's cartoon of the tweed ring, where all of the characters stand in a circle, each one pointing his thumb at his neighbor as the responsible person. Unless you can point your finger at the one person who is responsible when something goes wrong, then you have never had anyone really responsible.

For these reasons, I did all I could to gain support for my concept of total responsibility. It required that a single position be established to handle both the navy and the AEC parts of the job. I think it might be of value to this subcommittee to outline how this designation of responsibility was derived from the Atomic Energy Act of 1954, and how it is carried out all the way down to the ships, whether in construction operation, or overhaul. I have such an outline and with your permission I would like to include it in the record with my statement.

I can assure you that having only one individual responsible for a total program is a unique concept within the Department of Defense. I want to emphasize that throughout this entire period of over thirty years I have had full support from the Congress, mainly through the former joint committee on Atomic Energy and the Armed Services and Appropriations Committees, and from the Atomic Energy Commission and its successors, the Energy Research and Development Administration and now the Department of Energy, I have not had such consistent support from the navy or the department of defense.

Facing The Facts

Another principle for successful application of a sophisticated technology is to resist the human inclination to hope that things will work out, despite evidence or suspicions to the contrary, This may seem obvious, but it is a human factor you must be conscious of and actively guard against. It can affect you in subtle ways, particularly when you have spent a lot of time and energy on a project and feel personally responsible for it, and thus somewhat possessive. It is a common human problem and it is not easy to admit what you thought was correct did not turn out that way.

If conditions require it, you must face the facts and brutally make needed changes despite significant costs and schedule delays. There have been a number of times during the course of my work that I have made decisions to stop work and redesign or rebuild equipment to provide the needed high degree of assurance or satisfactory performance. The person in charge must personally set the example in this area and require his subordinates to do likewise.

I will now discuss in greater detail the underlying basic principles of the naval reactors program.

Principles Of Design And Engineering

From the very beginning of the naval nuclear propulsion program I recognized that there were a large number of engineering problems in putting a naval reactor into a submarine, some problems were unique to submarine application, and some to the general problem of making a reactor plant work. I realized at the time that the use of nuclear power, as with any new sophisticated technology, would require the institution of novel requirements and standards. I realized that these requirements would necessarily be difficult to meet, and the standards would need to be more stringent than those which had been used in power plants up to that time. But when you are at the frontiers of science you must be prepared to accept the discipline this requires in order to proceed. The fact that the application of nuclear power was almost entirely an engineering problem – not a problem of nuclear physics, as nearly all of the “experts” then believed – was clear to me. The emphasis I have placed on sound, conservative engineering has been a major factor in the performance of our plants.

I should point out that in the late 1940's and early 1950's, when the original naval nuclear propulsion plant design studies began there were no standards, design guides, or codes available. They had to be developed. Due to the military application, these design criteria included considerations of reliability, battle damage, high shock and the close proximity of the crew to the reactor plant. The propulsion plant design had to be readily maintainable so possible equipment failures at sea could be repaired. The fact that major maintenance operations would be infrequent and refueling possibly / seldom as once in a ship's lifetime, required that standards for materials and systems be very rigorous and that only premium products which had a proven pedigree could be considered for use. My design objective is and has been to provide a warship that can be relied upon to perform its mission, and return.

Conservatism Of Design

I will explain some of the elements of good engineering as I have applied them to the reactor plants for which I am responsible. First, in any engineering endeavor, and particularly in an advanced field such as nuclear power, conservatism is necessary, so as to allow for possible unknown and unforeseen effects. This conservatism must be built into the design from the very beginning. If the basic design is not conservative, it quickly becomes impracticable to provide the needed conservatism. It then becomes necessary to add complexities to the system in an attempt to compensate for the inadequacies of the basic design. These complexities, in turn, serve to reduce conservatism and reliability.

I must make it clear that the military requirements which must be met by naval propulsion reactors are far more exacting than those which central station plants must endure. For example, the shock loadings for which naval plants are designed are far greater than the earthquake shock loadings for civilian plants. In addition, naval plants must be able to accommodate power transients much more rapidly than civilian plants. Each naval vessel depends entirely on its own reactor plant for the capability to perform its mission. For a ship there is no inter-connected grid to pick up the load and allow the ship to continue functioning. The stringent requirements of operating a ship at sea are reflected in a conservative design with a large overall design margin in almost every element of the plant.

Some specific examples of the conservatism in design which I have used are:

- use of ordinary water of high purity as the reactor coolant. Water has been widely used in industrial applications; its properties are well-known, and when irradiated, has short-lived radioactivity.
- Use of conservative limits for systems and equipment. Design is based on the worst credible set of circumstances, rather than relying on a statistical approach which deals in average or probable conditions.
- Provision in the design for redundancy so that failure of one component, or one portion of a system, will not result in shutting the plant down, or in damage to the reactor.
- Design of the reactor plant to enable it to accommodate expected transients, without the need for immediate operator action. This means the plant is inherently stable, and helps the operator when there is an unusual transient.
- Simple system design, so that minimum reliance need be placed on automatic control. Reliance is primarily placed on direct operator control.
- Selection of materials with which there is known experience for the type of application intended, and which, insofar as practicable, do not require special controls for

procurement, fabrication, and maintenance which could lead to problems if not properly accomplished.

- Use of a land-based prototype of the same design as the shipboard plant. This prototype plant can be tested and subjected to the potential transients a shipboard plant will experience, prior to operation of the shipboard plant.
- Use of extensive analyses, full scale mock-ups, and tests to confirm the design.
- Strict control of manufacture of all equipment, including extensive inspections by specially trained inspectors during the course of manufacture and on the finished equipment. This means that at many points during the manufacture an independent check is required, with signed certification that the step has been completed properly.
- Providing extensive detailed operating procedures and manuals, prepared and approved by technical people knowledgeable of the plant design. These manuals are constantly updated as we learn from the operations of the many other reactors. What we learn on one plant is incorporated into all our plants.
- Placing particular attention on designing, building and operating the plant so as to prevent accidents, and thus avoid undue reliance on the systems and procedures provided to cope with accidents which could occur.
- Use of frequent, thorough, and detailed audits of all aspects of the program by individuals who are specifically selected and trained, use of formal documentation for design decisions, manufacturing procedures, inspection requirements, and inspection results.
- In addition to the detailed technical review and approval by my office, the safety aspects

of operation of naval nuclear powered ships are independently reviewed by the Nuclear Regulatory Commission and the Advisory Committee on Reactor Safeguards.

Approach To New Reactors

The kind of engineering approach I have just outlined is, in my opinion, why the naval reactors program has resulted in safe, reliable nuclear power. To the casual reader much of what I have said may appear obvious, but I assure you it is not when you try to carry out these concepts in everyday work. I have encountered many cases where these ideas are ignored or not understood. I have, on many occasions, reviewed proposals for smaller, lighter, and cheaper reactors. While such proposals have covered a wide variety of reactor concepts, they have been completely consistent in one respect; they have all involved the sacrifice of sound, conservative engineering to achieve a design theoretically having better performance. They each violated most, if not all of the engineering principles I have just discussed. They would all have been, in my opinion, unsafe and unsatisfactory for naval warship application. How often have you known of cases where in the fervor of winning contracts, firms will promise all kinds of performance, only to be found incapable of delivering it when they try to make the equipment work. By this, I do not mean we should not make improvements, we have. But at all stages you must proceed in accordance with sound, conservative engineering practices if you are to produce something that will work, vice something that is just an expensive piece of unusable and unsafe junk.

As an example, I have often been pressed to reduce radiation shielding to make new ships smaller and lighter. However, if I removed 100 tons of radiation shielding from a typical submarine, the ship would be only two percent lighter. But the radiation exposures to ship personnel would increase to, ten times the current levels. I have not agreed to reducing shielding because I believe radiation exposure to personnel should be as low as I can reasonably obtain.

Naval Nuclear Training

Another element in my approach to safe operation of naval reactor plants involves the selection and training of the operators. In brief, I consider the training of officers and men to be at least as important as any other element of the navy nuclear power program. I consider it of the greatest importance that the mental abilities, qualities of judgment, and level of training, be commensurate with the responsibility involved in operating a nuclear reactor. The selection of personnel and their training in the naval nuclear power program are carried out with these considerations in mind.

Academic ability, personal character as demonstrated by any acts reflecting unreliability, and honest desire for the nuclear program are all taken into account in selection of personnel. Once selected for the naval nuclear power program, the individual is continually subject to review.

To accomplish these objectives, I require a one year training period prior to an operator going on board his first nuclear ship. The first six months of nuclear power training are spent at Nuclear Power School in Orlando, Florida, where the curriculum concentrates on the theoretical basis for shipboard systems. Upon graduation from Nuclear Power School the student reports to one of our land-based prototype plants where he learns to actually operate the propulsion plant. There the student must demonstrate that he can operate the plant under normal and casualty conditions, and is taught to operate in strict compliance with detailed operating and casualty procedures.

I established the naval nuclear power training program on a base of rigid high standards. My staff at naval reactors approves the curriculum at Nuclear Power School and the qualification guides used to develop the prototype and shipboard operator qualification programs. This ensures that the standards are not reduced by someone who does not understand the overall goals of the program, and that the individuals responsible for the design and construction of the reactor plant systems are involved in the training considerations on that system.

The methods we use in training involve lectures, seminars, homework assignments and both oral and written examinations. We also require operators to be able to demonstrate their practical knowledge in order to become qualified at the land-based prototype. These individuals must subsequently qualify on board ship. I am not satisfied with bringing an operator to a qualified level once, and then forgetting about him. Therefore, we continually reinforce theoretical and practical training with a continuing training program. This includes frequent practice in plant evolution and casualty drills.

The examinations given must be tough, and must be approved by a competent person in authority. Instructors are trained so that they are capable of correctly instructing the student. Instructors, as well as students, are monitored.

Inspections of personnel in the fleet are conducted by members of my staff, both those in the field and from headquarters; by the Fleet Nuclear Propulsion Examining Boards established by the Chief of Naval Operations; and by nuclear trained personnel on various other naval staffs. I review the results of all their inspections.

I have established a formal system of reporting propulsion plant problems which identifies areas which need improvement in the training program. I also require the Commanding Officer of each nuclear powered ship to write me periodically concerning propulsion plant problems. These letters contain a summary of the training he has conducted and allow me to personally check the adequacy.

These are just the main elements of the training efforts in my program. Because training is so important, I want to provide a much more detailed description of what we do for your record. I know you do not have time for me to read this description now, but I strongly recommend that all the committee members read it because it may be of value in your review.

Mistakes Must Be Taken Into Account

What I have presented at this point represents the main substance of my statement. In it I have outlined what I do in running the naval reactors program. Even when these measures are carried out it is important to recognize that mistakes will be made, because we are dealing with machines and they can not be made perfect. The human body is god's finest creation and yet we get sick. If we can not have perfect human beings then why should we expect, philosophically, that machines designed by human beings will be more perfect than their creators? That is what many unthinking people demand even though the Lord himself did not reach this height. I believe if you follow the practices of conservative engineering and personnel training I have outlined and if you carry them out with steadfast commitment, nuclear power can be safely used, even taking into account mistakes that will inevitably occur. That is the basis on which I have conducted all my work in this field and I believe it true just as strongly today as I ever have.

Decision on Nuclear Power

As well as anyone in this room, I recognize that nuclear power is a very difficult subject for anyone to deal with. It involves energy - a vital element in our nation's future. It involves individuals ' concerns for themselves and their families, and it is a highly technical, sophisticated technology. Ultimately, the decision as to whether we will have nuclear power is a political one – in the true sense of the word – that is, one made by the people through their elected representatives. It is vital that the decision be made on the basis of fact, not rhetoric, not conjecture or hope, or as a result of the widespread tendency to sensationalize the current topic and ignore the real limits or risks of the alternative.

I am not an expert or even particularly knowledgeable in the areas of environmental effects of other forms of power generation. However, I am aware that a good many knowledgeable people conclude that the total risk involved in the use of nuclear power is no greater than is involved in the use of any alternate source which can be tapped in the next 50 years.

I also remember the optimistic projections made for nuclear power when it was first being developed. These sprang from hope and from ignorance of the real engineering problems that would be encountered in using nuclear power. There is no reason to believe that current projections for alternate means of providing large amounts of power are any more precise. Any large scale generation of power involves major engineering difficulties and potential environmental impacts.

The job of this committee and the congress in the days ahead will not be easy. I hope and pray you will find the strength and wisdom to make the right decisions. I also hope that my testimony will in some way contribute to your difficult deliberations.

Naval Nuclear Propulsion Operator Training Program

I will now discuss in greater depth the personnel aspects of the naval nuclear propulsion program. I will describe what is involved in the selection, training, qualification, and requalification of the operators; and I will describe the methods and procedures used to ensure that policies and directives of the nuclear program are carried out, as I have previously stated, all of these elements must mesh for the system to work. You can not separate out and use the pieces which you like, and discard those which are "too hard".

By the same token, it is impossible to separate training from the technical side of the nuclear program. Within the naval reactors headquarters organization, all of the engineers are very much aware of the impact of engineering decisions on the operating personnel and of the requirements for training on new equipment or procedures. This is also true for the engineers who work at our two laboratories. Also, many of the more experienced engineers in Naval Reactors Headquarters assist in certain phases of the personnel selection process for operators and are directly involved in the training conducted at naval reactors.

You should also note the longevity of experience at naval reactors, not just as it relates to me but as it is manifested in the large majority of people in my headquarters organization. Approximately one-fourth of my headquarters engineers have been in the naval reactors program for more than twenty years. This experience and stability is important not just in training but in all aspects of the program.

When the nuclear propulsion program started, more than thirty years ago, I realized it was necessary to have excellence in operating personnel. In view of the possible serious consequences of a reactor accident I considered it of utmost importance that the operation of nuclear powered ships be entrusted only to those whose mental abilities, qualities of judgment and degree of training were commensurate with the public responsibility involved. The personnel selection and training procedures for the naval nuclear propulsion program were developed with these considerations in mind. They have evolved with experience over the last twenty-five years and are still changing. I do not say that use of these methods is the only way, but this is the way it has been found to work in the naval program, and I do not know of a better way to do it. If I did, I would use it.

Earlier in my statement I discussed the general principles I have used to form the basis of the naval nuclear propulsion program. I will state those which relate to personnel and training, and then attempt to show how these are achieved.

1. Careful selection of personnel.
2. Extensive initial training for personnel (prior to shipboard assignment), including the use of actual operating prototype plants.
3. A thorough qualification and requalification program for all personnel,.
4. Constant reinforcement of principles and procedures by a formal continuing training program for all operators. This program strives to continually upgrade the knowledge and understanding of operators at all qualification levels.
5. Frequent practice of casualty drills and plant evolutions in all operating ships and prototypes.

6. Continuing review of personnel performance and removal from the program of those who do not meet standards.
7. Frequent inspections of plants and plant operations by personnel assigned to the plant and by higher authority with systematic follow up on deficiencies.
8. A feedback system in which design, material, personnel and procedural problems are brought promptly to my personal attention together with the corrective action required in each case.
9. A common base of high standards of personnel performance in all areas including strict compliance with detailed operating and casualty procedures.

Selection of Personnel

The responsibilities involved in operating naval nuclear powered ships and the requirements of the nuclear plants themselves make it essential that individuals in the program have a high degree of intelligence and capacity to learn. Early in the program I recognized that normal procedures of personnel selection and assignment used by the navy could not be counted on to provide this program with the proper type of individual. In order to select candidates of the necessary intellectual capacity and motivation, a number of special measures had to be taken. However, I could not just follow typical civilian procedures. Recognition had to be given to the fact that I was dealing with a body of military people, this meant we would be faced with the inevitable high turnover rate, the problems typical of young, inexperienced enlisted men, and the antiquated navy training methods.

Requirements for Officers

Officers for assignment to the engineering crews of the first nuclear-powered ships were, by necessity, drawn from those having had previous shipboard experience. While I knew this was not the best way, I had no choice. As the number of nuclear-powered ships grew, the source of sea- experienced officers became insufficient to support the needs. Therefore, beginning in 1960, a number of top ranking students graduating from the Naval Academy, NROTC colleges, and from the Navy's Officer Candidate School were selected to enter nuclear power training following graduation. In 1969 the Nuclear Power Officer Candidate (NUPOC) program was added through which top graduates of all colleges are given the opportunity to apply for nuclear power training. Today, these programs which take officers directly from the naval academy or civilian colleges account for more than 95 % of the officers entering the nuclear training program. To date, some 7,000 officers have been trained in the nuclear power program.

Officers who apply for nuclear training must be college graduates meeting minimum requirements for courses in mathematics and science. The college records are screened to determine scholastic aptitude, and performance. For those officers with sea experience, naval records are also reviewed to determine effectiveness as naval officers, experience level (particularly in engineering), and their Commanding Officer's evaluation of them as candidates for the nuclear program. This screening is performed by the Bureau of Naval Personnel with the advice and assistance of naval reactors personnel.

In order to further ensure that only officers with the necessary potential and motivation are selected for the naval nuclear propulsion program, the candidates are each called to Washington and interviewed by several senior members of my staff and finally by me. In addition to providing information over and above that available in an officer's service record on his intelligence and ability, these interviews are useful in determining the willingness of the officer to undertake the difficult training program for nuclear propulsion assignment and his interest in professional advancement as evidenced by his work and study habits.

This process of interviewing has been criticized for years by many senior naval officers. I am continually asked to abolish this procedure with the suggestion that all I need to do is set down some standards on academic requirements and all those who meet them can be ordered into training. If they pass the rigorous training program then they are acceptable. There are a number of reasons why I do not agree with this suggestion. First of all, the interviews are able to detect an individual who may have good school grades but who is really incapable of passing the course.

This has been particularly true over the past fifteen years when college grades have generally lost meaning. It is a waste of money and effort to allow a person to enter training who then fails, particularly if you can predict the failure ahead of time. The other reason I insist on the interviews is more basic. Some candidates may have perfectly fine grades and could undoubtedly pass the academic portion of the course, however, they may have absolutely no capability to be put in charge of the operation of a reactor plant. If I can not be convinced in my own mind that that officer can be taught to carry out his duties responsibly with regard to the safe operation of the reactor plant at sea under trying conditions, then I can not and will not accept him. To me this is a very important part of the program.

Requirements for Enlisted Personnel

As in the case of officers, in the early years of the nuclear program enlisted candidates came from the fleet and had shipboard engineering experience. Those who applied were interviewed and screened by their Commanding Officers before being recommended as candidates. Eligibility criteria were established by the Chief of Naval Personnel with the advice and assistance of naval reactors. Assignment to the nuclear program was made by the bureau of naval personnel from among those recommended.

The manning requirements for the expanding nuclear submarine program and the nuclear surface ship program required a new source of people for training. In 1957 direct input of enlisted men for nuclear propulsion training was provided by a program of recruiting promising young high school graduates into the navy, specifically for ultimate duty in nuclear ship engineering departments. Today this program is the primary source of enlisted personnel for nuclear power training. Approximately 40,000 enlisted operators have completed the naval nuclear propulsion training program to date.

The supervision, operation, and maintenance of naval nuclear propulsion plants require a high level of competence, reliability, and expertise. For these reasons high selection criteria were established early in the program. Later, as the number of personnel in the program increased, we experienced higher attrition in the training cycle. To reduce this attrition, the educational selection criteria were made more restrictive.

Today, all enlisted applicants for nuclear training must be high school graduates who have completed one year of algebra in high school or college, and have achieved at least a “C”' or equivalent grade in that course. Additionally, all candidates must demonstrate high academic ability in the areas of math and science as measured by the Armed Services Vocational Aptitude Battery Tests and the Nuclear Field Qualification est. These are administered by the Navy Recruiting Command prior to an applicant's selection for nuclear training. These tests give an indication of the applicant's ability to handle the study of mathematics and physics , subjects which form the basis of the nuclear power training curriculum.

Selection of nuclear personnel, officer or enlisted, must necessarily require an in-depth review of a candidate's character in addition to his academic capability. For this reason, any person who has been convicted of, or who is identified as having committed, a serious offense will not be accepted. A single minor offense involving moral turpitude or which evidences unreliability may be considered disqualifying. Frequent traffic violations or accidents that indicate unreliability, recklessness of character, or basic disregard for authority may also be cause for denying entry into the nuclear program.

Any individual who has been convicted of, or is identified as, having illegally, wrongfully, or otherwise improperly used, possessed or sold marijuana or other drugs will be denied entry into or continuation in the nuclear program. Anyone showing signs of being or becoming addicted to alcohol is also excluded from entry into the program. Waivers for entry into the nuclear power program may be granted in the case of pre-service use of marijuana where it can be established that the usage was of an infrequent experimental nature and further use has been stopped. A waiver of this type may only be granted by the Commander, Navy Recruiting Command with the concurrence of the Chief of Naval Personnel. Personnel on my staff at naval reactors review and concur in each case in which a waiver is granted.

It should be noted here that these waivers may be granted only for pre-service use of marijuana. The illegal use of any drug, including marijuana, after entry into the service is not tolerated. This comes to light from time to time and all individuals involved are immediately removed from further duty involving nuclear power. No matter how exemplary their subsequent performance may be, they are not allowed to return as nuclear propulsion plant operators.

Nuclear trained personnel are subject to a continuing reliability screening process from the moment they are approved for entry into the program. All disciplinary infractions, whether civilian or military in nature, are reviewed to determine an individual's eligibility for continuation in the nuclear power program. Reviews of records are conducted in order to identify disqualifying professional performance, as well as disqualifying medical or psychological factors.

Pre-Nuclear Program Training

Initial naval training of enlisted personnel selected for nuclear training is conducted at several training sites throughout the country. During basic recruit training, the candidate is screened and classified into one of the program ratings (machinist's mate, electrician's mate, interior communications, or electronics technician) according to his capabilities and the needs of the program. The trainee then attends appropriate navy class “A” school training, which varies in length from two to five months. The curricula are basic to the ratings and are not specialized for nuclear power, these class “A” schools are operated by the Chief of Naval Education and Training, and are not controlled by Naval Reactors. Nuclear program trainees completing class “A” school training will normally be ordered directly to Nuclear Power School at Orlando, Florida.

It should be noted here, that until a nuclear program enlistee commences specialized nuclear power training at Orlando, he has attended General Navy Schools and trained in his rating alongside his conventional engineering counterpar. If he is unable to satisfy the demanding academic requirements in the Nuclear Schools, then he is immediately available to be assigned to a conventional engineering billet of his rating. Those men who leave the Nuclear Program for academic failure are therefore able to continue their naval service and make a valuable contribution to the at-sea manning of the conventional navy in technical fields. In addition, nearly all of the navy's requirements for nuclear trained personnel are for sea duty, therefore, it is important that nuclear trained personnel are able to fill general navy rating billets because the few nuclear shore billets would not provide reasonable sea-shore rotation. This would adversely affect the retention of our nuclear trained personnel.

Objectives And Phases Of Naval Nuclear Propulsion Training

The objective of the Naval Nuclear Propulsion Training Program is to prepare officers and enlisted engineering personnel to discharge their responsibility for safe and effective operation of propulsion plants of nuclear-powered ships. This is accomplished by teaching them: (1) the principles of science and engineering which are fundamental to the design, construction, and operation of naval nuclear propulsion plants; and (2) the details and practical knowledge required to operate and maintain these plants.

The programs to train personnel for engineering duty aboard naval nuclear-powered ships are centered around four major phases – formal academic instruction, operational training at one of the Department of Energy land-based naval reactor prototypes, training and qualification as a watchstander aboard an operating naval nuclear-powered ship, and continuing shipboard training. Each of these four phases is essential in the satisfactory training of an operator and providing assurance that only those who are mentally and emotionally capable, and who have demonstrated ability as a competent nuclear propulsion plant operator are assigned duty aboard nuclear-powered ships.

Formal Academic Instruction

The nuclear propulsion training program began in 1951 with the engineering officers and crew of the Nautilus. The initial theoretical training was given at the Atomic Energy Commission's aval reactors laboratory in Pittsburgh, Pennsylvania. When construction of the Nautilus prototype in Idaho was sufficiently advanced, the trainees were transferred to the prototype where they continued both theoretical and operational training. Upon reporting to the Nautilus at the building yard, detailed shipboard training was conducted throughout the construction, test, and trial period, under supervision of Naval Reactors and contractor personnel. A similar program was commenced in 1953 for the Seawolf engineering officers and men at the Atomic Energy Commission naval reactors laboratory and prototype site in West Milton, New York. As the number of nuclear-powered ships authorized for construction increased, it was recognized that a program capable of training large numbers of officers and enlisted men should be established. The Naval Nuclear Power School was established at New London, Connecticut in January, 1956 and graduated its first class of nuclear submarine officers in June, 1956. This school was subsequently relocated to Bainbridge, Maryland.

Academic training for surface ship officers was continued at the Idaho prototype site until 1959 when a second naval Nuclear Power School was established at Mare Island, California, for both surface and submarine personnel. From 1959 until 1976 all formal academic training for officers and enlisted personnel in the Naval Nuclear Program was carried out at one of these two naval Nuclear Power Schools. In 1976, the school at Bainbridge, Maryland was moved to Orlando, Florida and in 1977 the school at Mare Island, California merged with the Nuclear Power School, Orlando, where all formal academic training is presently conducted.

Purpose of Nuclear Power School

The purpose of Naval Nuclear Power School, Orlando is to teach officer and enlisted students those principles of science and engineering fundamentals necessary for the understanding of the operation of naval nuclear propulsion plants, and to prepare them for future assignment to prototype training and eventual responsibilities relating to the safe and effective operation of propulsion plants of nuclear powered ships.

In pursuit of this purpose we set high standards and we stick to them. We stress that the operator must be trained in basic principles, so that he knows not only what he is doing, but why. We teach basic theory, principles of the basic components and systems, and application of these systems and theory to watchstation duties. The students are tested with frequent and demanding examinations to be sure their knowledge can be applied, not just their memory exercised. We motivate them to perform, and do not allow them to proceed at their own pace, if is too slow. Classroom instruction takes priority over everything else at Nuclear Power School.

Nuclear Power School Organization

Nuclear power school is comprised of four departments under a Commanding Officer and executive officer. A Pre-School Department, Enlisted Department, Officer Department, and Administrative Department make up this organization.

The Commanding Officer is responsible for the academic program. He certifies that instructors are technically prepared to teach, approves the examinations, monitors the performance of the instructors and recommends student disenrollments.

Department heads are responsible for the course content specified in approved topical guides. They are responsible for instructor training, review of proposed examinations, and monitoring the performance of instructors in their respective departments.

The Commanding Officer of Nuclear Power School has already served as Commanding Officer of a nuclear powered ship. The executive officer is nuclear trained and has served as the executive officer of a ship. The academic department heads have all served as Engineer Officers of nuclear powered ships.

The instructors at Nuclear Power School come from two sources:

1. Direct input officers recruited specifically to serve as instructors. They and selected by Naval Reactors in the same manner as officer students but must meet higher academic criteria in their educational field. After a six week navy indoctrination course at Newport, Rhode Island, they report to Nuclear Power School to teach for their four year tour of duty in the navy. Many of these officers have advanced degrees in their academic specialty.

2. Officer and enlisted instructors who have already completed a tour of sea duty on a nuclear powered ship. Typically these sea returned instructors have graduated in the top fifty percent of their Nuclear Power School and prototype classes. They also have an excellent fleet performance record. Officer instructors so assigned have already qualified to serve as Engineer Officer of a nuclear powered ship.

Pre-School Department

The purpose of Pre-Nuclear Power School is to bring all enlisted students to a common acceptable level in mathematics and physics; to prepare students medically and administratively for enrollment; and to teach students how to study. The length of Pre-School is either six or three weeks depending upon the indicated academic ability of the student based on the nuclear field qualification test score and previous navy school performance. The Pre-School curriculum is not part of the Nuclear Power School curriculum for training the individual to be a nuclear propulsion plant operator. Pre-School gives students with weak high school academic backgrounds a better opportunity to pass the rigorous Nuclear Power School course; it also facilitates assignment of personnel so that less time is wasted between completion of Navy Rating School and commencement of Nuclear Power School.

Enlisted Department

The Enlisted Department is made up of seven academic divisions each headed by a division director. The division director is responsible for the subject content of the course in accordance with approved topical guides; for training his instructors; and for preparing all of his examinations. The academic divisions concentrate on the quality of their teaching, the quality of their group extra instruction and individual tutoring which is given to the weaker students.

The enlisted department is also organized militarily to provide advisors who counsel the students.

Officer Department

The Officer Department is organized in a similar manner to the enlisted department, with the exception that the instructors also fill a military role as advisors and counselors.

Civilian Support, Betts Technical Consultants

Two experienced civilian scientists from the Betts Atomic Power Laboratory are in residence at Nuclear Power School as technical consultants.

The role of the Betts Technical Consultants is to act as a technical advisor to Nuclear Power School staff, maintain liaison between Nuclear Power School and the betts atomic power laboratory, and monitor Nuclear Power School effectiveness, they also assist the instructors in preparing and presenting the course material.

Nuclear Power School curriculum

The Nuclear Power School curriculum is prepared under my direction by the Naval Reactors staff in Washington. The assistance of the Naval Reactors Laboratories is utilized in developing the curriculum. The course at Nuclear Power School lasts six months and consists of approximately 700 hours of classroom instruction.

The officer student curriculum includes mathematics, physics, heat transfer and fluid flow, electrical engineering, reactor dynamics, chemistry, aspects of reactor plant operations, materials, radiological fundamentals, core characteristics and reactor plant systems, which is an overview of all mechanical and electrical systems. Officers receive instruction up to and including the graduate level.

The enlisted curriculum includes reactor plant systems, mathematics, physics, heat transfer and fluid flow, reactor principles, chemistry, radiological fundamentals, materials, specialized in-rate instruction on plant systems and reactor plant operations. Enlisted personnel receive instruction at the undergraduate college level.

The curriculum is carefully organized to provide the principles of science and engineering necessary for understanding the operation of naval nuclear propulsion plants. Each subject serves as a building block supporting the student's further training. For example: the reactor plant systems subject matter supports the heat transfer and fluid flow subject. Mathematics supports all subjects, physics supports reactor principles, chemistry, and radiological fundamentals subjects. All courses use shipboard examples when explaining concepts. For example, in mathematics the instructor avoids using abstract equations and uses the formulas from the subjects that will be studied at the school.

Control of the curriculum starts with topical guides. There is a topical guide for every subject taught at Nuclear Power School. The topical guide is originated by the Nuclear Power School staff, reviewed by the Betts Laboratory, and approved by Naval Reactors. The purpose of a topical guide is to regulate the subject by specifying what must be covered, the order in which the topics must be covered, the time allotted for each topic, and when examinations must be given. Lesson plans are developed from these topical guides for use in teaching a class. In addition, student learning objectives are developed from the topical guides. These objectives tell the students what they should be getting out of the course.

The basis for textbook and other document selection is that they will directly support nuclear power subjects, as well as include additional information to challenge even the best student. Manuals are prepared for Nuclear Power School for use by the school, the prototypes, and the ships in the fleet. These manuals are prepared by the Betts or Karl Laboratories and approved by Naval Reactors prior to issue. Use of commercial texts for some subjects are approved by naval reactors. Reactor plant manuals and other technical manuals are used for instructor reference. Books containing practice problems for each subject are prepared by the Nuclear Power School and given to students to be used throughout the course.

Instructor quality control

The initial training of a new instructor takes about three months. During this initial training the new instructor is first required to take the subject he will teach. He will give practice lectures and become familiar with related Nuclear Power School subjects. The new instructor must pass oral boards on the technical content of the course, and present a certification lecture for the division director, the department head, and the Commanding Officer. He must also pass an oral certification board by the division director, the department head, and the Commanding Officer. After qualification, the training continues so that the instructor will remain current and knowledgeable. An annual written examination is administered to all instructors to determine any weak areas. The instructor's classroom presentation is audited at least twice during each period he teaches a subject. The Commanding Officer, the executive officer and the department heads are required to audit one instructor each week. Also Betts technical consultants randomly monitor the instructors. Evaluation reports are filled out by the auditors and discussed with the instructor. These reports are forwarded up the chain of command and filed in the instructor training folder after any necessary corrective action has been taken.

Examinations

Both officer and enlisted students are required to pass a four hour written comprehensive examination prior to graduation. In addition, there are weekly quizzes and a two hour examination about every ten days, no multiple choice or true and false questions are used on any examinations at Nuclear Power School. Questions involve single and multiple concepts which require essay answers, definitions, statements of facts, or calculations. The philosophy of questioning is to examine the student in basic theory and the application of this theory to the principles of operation of the basic plant components and systems.

Careful quality control is exercised in the preparation and administration of examinations. Each examination is written and reviewed by two members of the academic division. A trial examination is given to another member as a check on any problems which may arise with the questions on the examination or the time allotted for the examination. The examination is then reviewed and approved by the academic division director, the department head, the Betts technical consultant and finally the Commanding Officer. Examinations are reviewed to ensure that they meet the objectives of the subject topical guides, are technically accurate, and have acceptable answers on the answer keys. They must meet the standards of difficulty for the individual questions and for the total examination.

After the examination has been given and graded, it is reviewed by the instructor with all of his students during the next class period. At this time the instructor discusses the concepts that gave the students the most difficulty. If a student fails an examination, the instructor interviews him to analyze his performance on the examination, so that corrective action can be effective.

Student control

Student performance is continuously monitored. Instructors monitor student performance by grading daily homework, giving frequent quizzes and a 2 to 3 hour examination about every 10 days. Advisors monitor the students' performance by interviewing students who have academic problems weekly, and every student at least every two weeks. The advisor reviews records of student study hours for correlation with the student's academic performance. If the student's grades are below average he is required to sign in whenever he studies at the school so that his study hours can be checked. The advisor also monitors the student by attending the lectures and observing the student's participation. In addition, the advisor meets with all his student's instructors at least every two weeks to discuss individual or group student performance. The class director meets weekly with the advisors and the advisors report weekly by memorandum to the Commanding Officer via the chain of command. This weekly memo discusses academic, military or personal problems that the students may have.

The senior staff, the Commanding Officer, Executive Officer, and Academic Department Heads, observe one section weekly. These observations coupled with grade reports and section advisor memos, insure that the chain of command is current on the quality of student performance and on student problems.

Various actions are available to assist students who are having difficulties. The actions designed to correct deficiencies include a mandatory study program in which students are assigned a certain number of hours to study on a weekly basis based on their grades. Some weak students are assigned weekend review packages containing additional homework questions to be answered and reviewed. In addition, students are assigned Saturday morning makeup work if they have not devoted reasonable effort on their homework. Weak students are assigned instructor assistance by their section advisor or an instructor for personalized help. There are mandatory extra instruction sessions weekly for poor students in every section.

If required, a student is given exam failure counseling. The instructors and section advisors review the student's examination to determine the reasons for his failure, including a check of his study habits and classroom notes. They then develop a corrective study program for the student.

If a student has continually failed exams he goes before an academic board. These academic boards give oral examinations to determine a particular student's current level of knowledge and his potential to successfully complete the course. The board can recommend retention on academic probation or that the student be dropped, depending on the knowledge the student shows at the board.

I approve all officer student disenrollments from Nuclear Power School. A member of my staff approves all enlisted student disenrollments.

Student Records

Complete records are maintained on each student's work at Nuclear Power School. This includes all of the results of his examinations, his progress and every personal counseling session he is given. His comment folder which contains summaries of all counseling sessions while at Nuclear Power School is retained for five years while his class standing and course average is maintained permanently on file.

Prototype operational training

Operational training is conducted at eight land-based Vaval Reactors prototypes. Three are located at the Naval Reactors facility, Idaho Falls, Idaho: four at West Milton, New York: and one at Windsor, Connecticut. These proto-types are owned and operated by the Department of Energy (DOE) primarily to provide research and test facilities for the DOE naval reactors laboratories. Instruction is provided by naval personnel and by civilian personnel from the naval reactors laboratories. The navy provides some of the classroom and administrative facilities together with most of the operating crew for the prototype plant. The DOE in turn makes the plant available for training when it is not otherwise required for developmental testing.

At these prototypes, the navy personnel in training receive lectures and on-the-job instruction in the practical aspects of reactor plant operation. They operate all of the equipment associated with the reactor plant under the supervision of qualified instructors. Officers qualify as Engineering Officer of the Watch. They must demonstrate a thorough knowledge of all the reactor plant and steam plant systems as well as the detailed operating criteria and procedures, and demonstrate the ability to perform operations on all watch stations in the prototype plant; they must demonstrate that they can take charge of the plant and put it through normal and casualty maneuvers. Enlisted men qualify as operators of equipment connected with their particular rating. This qualification consists of demonstrating general knowledge of all reactor plant systems and detailed knowledge of those associated with their own rating. They must qualify on the watch stations they would normally stand aboard ship, and they must be able to handle normal maintenance problems on their equipment.

I want to make it clear that this training is all carried out on an operating prototype propulsion plant, <u>not</u> on a reactor simulator. As far as I am concerned, you can not take an inexperienced person and train him on a reactor simulator, every time he makes a mistake on a simulator, the instructor stops and merely moves some switch back to its proper position and then goes on. On a submarine if you make a mistake, the reactor could shut down when the ship is submerged. If there is an enemy right there, you can not come to the surface and regroup. It is imperative that the type of training be geared to this increased level of responsibility. You have to train people to react to the real situation at all times; but if they are trained with a simulator, they tend to expect there will be no consequences as a result of their actions. This simply won't work in real life.

Some companies have tried ro get into the business of building real or simulators for us claiming it will allow us to train our people fast. Then they can grant a certificate that the navy people operated a simulator. But I want to know that they can operate a real honest- to-goodness reactor plant.

I would say that for anyone dealing with nuclear power, it is too complex a technology to have people just get an idea how to operate a reactor by learning how to throw a few switches that can be immediately changed to correct an error. The fact that you will be operating a reactor in a ship in combat where peoples' lives depend on your performance gives you an entirely different feeling about the importance of proper training.

I go out on the initial sea trials of every nuclear ship. More than half the crew have never been to sea before, I am talking about a brand new ship, yet I put them through their paces. I require them to exercise the ship and the propulsion plant to its fullest. Now, this is a new crew, and they must do all these things when they have had little or no experience at sea. They have no outsiders to advise them, and they must be able to operate the ship correctly for me to be satisfied. The only way they can do this is if they have been properly trained under circumstances identical to what they encounter at sea. You can not do this with simulators.

Introduction to prototype training

Training at any one of the eight prototypes is conducted the same way, and is based on a four-phase program covering a 26 week training period. A classroom phase, transition phase, in-hull phase and proficiency phase make up the basic prototype training plan.

The students are assigned to one of the prototypes upon completion of Nuclear Power School. When the class arrives, it starts classroom training which is primarily conducted in spaces outside the prototype hull. After five weeks, the student starts making the transition into the hull and he then begins watchstanding training under instruction. This is what prototype training is all about: to give the man in-hull experience operating the reactor plant, operating equipment very much like that he will be operating at sea, using procedures like those he will be using at sea. The major objective of prototype training is to make the best use of the training that is done in the hull within the constraints of reactor safety. At the conclusion of the watchstanding training under instruction, the man qualifies by passing written and oral exams. This allows him to stand the watch and to operate the equipment on his own – without the presence of an instructor. After he has qualified, and in the period before his class graduates, he stands watches to gain proficiency as a watchstander.

There are two reasons why the program is based on these four phases. First, this is a systematic approach to prepare the man to stand watches by getting him to learn the systems and components he will be operating, and then actually operating them. It is a repetitive process which goes from theory, to hardware familiarity, to operation. The preparation enables a more efficient use of the prototype reactor plant when the man enters the watchstanding phase.

Second, with this four-phase program, two classes from Nuclear Power School can be accommodated at the plant at the same time. Again, this makes for the best use of the prototype equipment, the time one class starts into watchstanding training coincides with the time the previous class qualified, and the time it ends watchstanding training coincides with the time the next class starts its watchstanding training,

Prototype classroom phase

The classroom phase is of five weeks duration. This phase consists primarily of lectures, coupled with some practical training.

In the classroom phase, the student spends 12 hours a day at the site, Monday through Friday. During this time an officer gets about 7 hours a day of lectures and examinations, and an enlisted man about 6 hours per day. The remaining five to six hours is spent in study at the site.

The lectures cover the mechanical, electrical, and reactor systems that are specific to the plant to which the trainee is assigned. In addition, he receives lectures in chemistry and radiological controls. In mechanical systems, for example, the officer gets three weeks of classroom instruction. About half of these lectures cover primary plant reactor mechanical systems and the other half cover the secondary steam plant mechanical systems.

You may ask why the student must get so much classroom instruction, since he has just finished Nuclear Power School. At Nuclear Power School he was taught the theoretical basis for the systems: for example, heat transfer and fluid flow. In teaching theory at Nuclear Power School, an S5W submarine plant was used as the primary example as it is the most numerous of the various types of propulsion plants in use in the fleet. At the prototype, the student must learn the systems of the specific plant (S1W, for example, is the prototype of the Nautilus propulsion plant and A1W is an aircraft carrier prototype) – to which he is assigned rather than S5W systems. Although the overall system layouts are similar on all the plants, the student must learn the details about the specific plant he will operate during his training at the prototype.

The mechanical, electrical, and reactor lectures are all oriented to the specific prototype. Each man gets these lectures from the viewpoint of his job. For example, the officer gets these lectures from the viewpoint of his job as a supervisor with regard to these systems.

As he goes through these lectures, the student has study assignments to complete. We call these homework but since all this is classified material, the student has to complete it at the site rather than at home. One part of these study assignments requires the student to get into the hull and trace out the plant systems – hand over hand – finding out what they look like and where they go.

In addition to the mechanical, electrical and reactor systems, the student gets chemistry and radiological controls lectures. The lectures in chemistry and radiological controls are not specific to each plant – since these areas are common to all reactor plants. The officer student gets much more in this area than the enlisted student. This is because we do not train most enlisted personnel to do much in chemistry and radiological controls, other than what is needed for their own personal safety and to do their jobs. Later, enlisted specialists called engineering laboratory technicians are trained in chemistry and radiological controls. We have found that it takes three additional months to train enlisted personnel to become specialists in this area. The officer, however, must get more at this point because he will be supervising this area.

Written examinations of one to two hours length are given every week. There is no comprehensive written examination at the end of the classroom phase. Instead, the weekly exam grades are used by the staff to identify weak areas where the student will need extra work. A bank of examination questions and answer keys is maintained for all written examinations given at the prototype. Each question and answer has been reviewed independently for technical accuracy, clarity, scope and depth of the question. In addition, the overall examination is reviewed and approved before use.

Requirements have been established on the reuse of questions from the examination bank in subsequent exams. There are also requirements on the types of questions that are used. For example, no true and false questions are allowed, essay questions and problems requiring calculations must make up at least 40 % of the exam. Finally, the exam questions and answers are reviewed annually for technical accuracy and content.

If a student fails an examination, he is assigned a remedial upgrading program tailored to his individual needs. Staff advisors follow the student's progress daily to ensure that the remedial assignments are completed. Student counseling is important to detect problems early before the trainee has fallen too far behind, each student receives periodic interviews from plant supervisors. Interviews are required at least every two weeks. Upon any examination failure, or for generally low grades, the frequency of these interviews increases to weekly in later phases of training

All interviews and upgrading programs are documented in the student's record. These records are essential in the event that we must disenroll the student.

The quality of lectures is assured through the use of approved lesson plans and by monitoring of the lectures. Each instructor is monitored at least once during each classroom phase by senior navy or contractor management. The monitor has a copy of the lesson plan with him, and he fills out an evaluation form which is reviewed by the instructor and his supervisor.

Prototype Transition Phase

The prototype transition phase starts at week six after completion of the classroom training. At the start of the transition phase, the students are divided into four groups and each group is assigned to a crew. They go on an eight hour rotating shift schedule, so there is always one crew operating and training on the plant, 24 hours a day and seven days a week. After their eight hour shift as the crew in the hull, the students and staff work additional hours. The students continue to work at least 60 hours a week during this period.

Two major training efforts are involved in the transition phase: systems training and the beginning of watchstanding qualification. The systems training requires more detailed study than the student was exposed to in classroom phase lectures. It is primarily a self study of each plant system, followed by a one-half to two hour oral checkout of that system. The student starts standing training watches in-hull at about the ninth week. During the transition phase some students stand watches in-hull; some study for a system checkout and some are receiving these system checkouts.

In systems training, the student first learns the individual system and its components, then the interrelationship between the systems – how they affect or interface with each other and finally how to operate all of the individual systems as an integrated plant. The document that tells the student what he needs to know about a particular subject, and tells the instructor of what he should examine the student, is called the qualification standard. The qualification standard contains a place for all the checkout signatures the student must get during his six month period at the prototype. These signatures verify that the student has completed a given portion of his training. Eventually this becomes the legal record of the students qualification. Only authorized instructors can give these signatures, and a system is used whereby certain signatures are embossed to guard against improper signing of the qualification record. Examples of the type of knowledge required by the qualification standard for a system or component are "explain the functions of the system" or, after having physically traced the system in the plant, “draw a one-line sketch of the system from memory; using appropriate symbols and nomenclature and showing the items listed below”.

The qualification standard plays an equally important role in watchstanding training and qualification. Here it indicates the practical factors and training watch requirements that the student must meet.

The second major type of training during transition phase is watchstanding. To qualify at the prototype, all students are required to stand a given minimum number of watches under the instruction of qualified staff watchstanders.

During these watches, the staff watchstander is responsible for the watch station; however, he fulfills this responsibility by using the student to carry out watchstanding duties. During these watches, the student is expected to act as if he were responsible for that watch. The staff instructor watches each move and stops and corrects the student if he starts to make a mistake. The student is graded on each watch, and must receive a satisfactory grade or he does not get credit for the watch. The student is expected to significantly improve his watchstanding capability as he gains experience of each watchstation. This factor is taken into account when assigning him a grade.

During the watch, there are prescribed things the student must do, such as starting up and shutting down a piece of equipment. These are called “practical factors”. The student does these under instruction, with the staff instructor providing direct supervision. The emphasis is on the student doing the operation himself. This is accomplished by first talking through the operation and then letting the student perform it. The staff instructor asks the student such things as: “how are you going to start up that pump?”; “show me the procedure”; “discuss each step with me”; “what is the purpose behind that step?”; “what would happen if you did not do that step?”`; “what else in the plant will be affected by it? " This sort of questioning is important because it allows the instructor to determine if the student understands why he does a particular thing, rather than the latter merely knowing that he must turn a switch or open a valve.

Prototype plant operations are scheduled to coincide with the extent the class has progressed through the training program. For the first student training watches, the plant is held in a steady-state - steaming condition. This means the reactor is at a constant power and a steady-state condition exists in the engine-room. Later on, the schedule calls for more complicated operations, such as start-ups and shutdowns of the steam plant, start-ups and shutdowns of the reactor, and casualty drills. It is important to note that in the case of the officer student qualifying as Engineering Officer of the Watch, he not only stands training watches and completes practical factors as Engineering Officer of the Watch, but also stands watch at the enlisted watch stations and does practical factors there also.

This gives the officer a better overall feel for what is happening throughout the plant. As an example, at one of our prototypes the officer student must stand a minimum of about 180 hours of training watches of which seventy per cent are devoted to watches other than Engineering Officer of the Watch.

During watchstanding training, the student is also instructed on proper communications procedures and formality in communications. He is also instructed in logkeeping and other normal duties of a watchstander.

Other training conducted during the transition phase include lectures, seminars and training exercises. A series of lectures are given which are detailed and specific for each enlisted rating, and for the officers. These lectures are given on subjects where experience has shown that more emphasis is needed to get the message through to the student. This series is about 40 hours long. For officers it covers reactor plant instruments and control, electrical equipment and control, and the main turbine.

Two other types of training are started during transition phase: seminars and training exercises. Experience has shown that training in different forms is necessary to provide a sound basis for operation and for the kinds of engineering judgment that will be needed at sea. In addition, repetition and different forms of training are required to obtain adequate retention.

In the transition phase, the student receives training through seminars, these seminars are required on watchstanding principles, such as watch relief procedures, communications, formality, procedural compliance, tactics, casualty control, logs, and plant awareness. Also, seminars are required on reactor startup and shutdown.

A seminar is not a lecture. The idea of seminar training is to get the students involved. They must participate in an active manner , and show satisfactory knowledge, otherwise they do not receive credit for participating. We have made a strong effort to enforce the idea that a seminar is not a lecture, but more like a "drill in the classroom." These seminars are designed to get the student to think his way through a problem and reach a solution. As with all other training, there are written requirements for the conduct of seminars. For example, an approved seminar guide must be followed by the instructor who is called the seminar leader and who has been formally trained and qualified to conduct seminars. In addition, the number of students is restricted to seven, as this has been shown by experience to be the maximum number of participants for an effective seminar.

The other type of training started during the transition phase is "training exercises". These are sessions of one to four hours duration in which the student participates in training outside the hull. These are limited to groups of seven or eight students with an instructor. We have found that training exercises where there is much repetition is required for the students to become reasonably proficient in certain skills.

All students participate in training exercises covering such things as damage control, where the student dons and takes off emergency breathing equipment, and use of fire fighting equipment. Also training is conducted in which the student demonstrates proper techniques for working with radiological controls. Each training exercise is conducted using a plan, each is graded and must be satisfactorily passed to get a signature. While he is at the prototype, the student will get seventeen training exercises totalling fifty-six hours. During transition phase he gets about twenty hours.

Finally, written examinations are given at the end of the transition phase. As in the classroom phase, the student is assigned a remedial program if he does not pass.

During transition phase it is important to carefully follow the progress of each student's training, several methods are used to follow progress. First, considerable effort is exerted to plan and schedule the training. This becomes particularly important at the start of the transition phase, because of the many different types of training given during this phase, the considerable self-study required, the individual's checkouts, and the watchstanding requirements.

Planning starts with a nine month activity schedule. This schedule lays out for each plant the operating time and the time the plant is scheduled to be shutdown for maintenance or conducting special testing.

Based on this nine month activity schedule, a detailed training events summary chart is developed. This summary is then broken down into weekly schedules for each crew, which are prepared and approved each week by the plant training manager. These weekly schedules list student and instructor assignments by name.

The plant evolutions are scheduled on a shift-by-shift basis for the week, in such a way as to phase in the operations and training needs, watch bills are issued for the staff instructors manning the watch, and a student watch bill is also issued for the trainees at those watch stations.

Individual student progress is followed on a daily basis. In the qualification signature book a point value is established for signatures received by the student, he is required to get a given number of points as he progresses through the training. He must stay up with his expected progress curve; if he falls too far behind, he will be assigned remedial programs which may require him to spend extra hours at the prototype. Finally, surveillance inspections and periodic audits are conducted to assure that the training program is being conducted as planned. These audits get into every phase of the training by using a pre-selected audit plan. I will discuss the audit system later.

Prototype in-hull phase

The third phase of prototype training is the in-hull phase. Early in the period, the student will finish his systems checkouts. By this time he will have spent about four hours learning and being checked out on each of about 60 systems. The student also completes his watchstanding requirements. Watches are plant controlling and can not be wasted. If students do not prepare, the full benefit of the training will not be realized. At this point the student is usually too inexperienced to grasp the complexity of the watch station and, therefore, he must be guided in his study. This is done in several ways. First, the student knows which watch he will be standing because he is assigned to it by the student watch bill. He will also know what operations are scheduled in the plant.

Second, for each watch, the student must complete pre-watch homework assignments that relate to the plant operating or casualty procedures that will be used during the watch. Third, before standing a training watch during which the watch duties are actually assumed, the student stands a number of watches as an observer, to note what is going on. In some observer watches a separate staff instructor is assigned to provide more detailed training for the student. This is to accelerate the student's acquisition of knowledge before he actually stands the watch. Finally, the student assumes the training watch under instruction.

Each watch is graded and the student must receive a satisfactory grade to get credit for the watch. A student must stand a specified minimum number of satisfactory watches in order to qualify. For example, for an officer student ten satisfactory watches are required at the Engineering Officer of the Watch (EOOW) watch station. Most students stand more than the minimum number in order to become sufficiently proficient to pass the final evaluated watch.

A standard form is used to evaluate each watch. This form requires the student to be graded in nine specific areas. If he fails a watch, he is assigned a remedial program which requires the student to do things directly related to that watch and he must complete this program before his next watch on that station.

Officers receive a final evaluated watch which must be passed in order to qualify. This is evaluated by a board composed of three people: one of my representatives from the local Naval Reactors field office, a senior representative of the plant management, and the staff Engineering Officer of the Watch on-watch instructor. This three man board is convened for the purpose of observing the student's performance during this watch. Each of the three board members independently grades the watch. The student must receive a passing grade from all three. As previously pointed out, the student must pass this watch in order to qualify.

I have certain operating philosophies that relate to student watchstanding: the plants are operated by detailed written procedures, strict compliance to these procedures is required and enforced. The shipboard plant operating manuals contain these procedures. A strong effort has been made to make the prototype manuals as much like those used on the ships as possible.

This is essential in the overall training of the student. He sees the same kinds of operating procedures. He uses the same kinds of equipment right down to the same torque wrench. For example: he is trained to the same kinds of qualification standards and use the same text books as are used throughout the naval nuclear program, insofar as this is possible.

Equipment is logged and monitored just as it is done on board ship. I require that the prototype plant be operated just as would a ship at sea, to the greatest extent possible. In this way, students get the actual live experience of knowing what to do when valves leak or equipment does not work, just as though it were happening at sea.

During the in-hull period the student finishes the seminars and training exercises that are required for qualification. These seminars and training exercises involve more complex operations and casualties. The student must show that he knows what is expected to occur during changing plant conditions, and that he can recognize the symptoms of casualties and take the proper corrective actions.

During this period, the student also participates in about 65 hours of discussions with a staff instructor during which he talks through various operating and casualty procedures. In general, these are the procedures which do not arise during watchstanding. If the student has already done any of those while he was on watch, he need not repeat them.

In the last few weeks before qualification, the student receives a detailed review of the integrated plant. He and a staff Engineering Officer of the Watch go over the entire plant operations, including how the individual systems are tied together and how they interact or interface with one another. These discussions are structured to increase the student's overall plant knowledge and to prepare him for his final oral board.

At end-of-card checkout the student is conducted by a staff instructor for two hours in each of six areas. By “end-of- card” I mean that the student has completed all of the required training in the qualification standard. These checkouts are done just prior to final oral boards. They cover mechanical, electrical, and reactor operations; the steam plant, the chemistry and radiological control areas, and integrated plant operations.

Finally, during the in-hull watchstanding period, each student gets what is called a progress oral board when he is about 50 % and 80 % of the way through qualification. These boards are one to two hours long and are conducted in the same manner as a final qualification board.

Progress of the class and of each student is again carefully monitored during in-hull training. Here we look for how well he is progressing in his watchestanding, training areas, discussions, etc. If a student falls behind he will be assigned remedial programs.

Prototype Qualification Criteria

Up to this point in the training program the student's progress has been measured almost entirely by written examinations. As he moves into the actual process of qualifying on the prototype reactor plant, the methods of measuring his knowledge and ability change. He is now required to demonstrate his performance by three different means: watchstanding ability, knowledge as demonstrated on a comprehensive written examination, and knowledge demonstrated on an oral board. Different people at the prototype are involved in making these evaluations. They are not based on an individual decision. Each watch is usually graded by different people, while the final evaluated watch requires a unanimous group decision for qualification.

The written comprehensive exam consists of questions selected so that each written examination is different. Additionally, the three members of the final oral board must unanimously agree that the individual is qualified.

This brings me to the meaning of qualification. It is a pass/fail grade for the student if he passes. It means that the plant staff, both navy and the contractor, are willing to let him stand the watch on his own. It means that the plant manager is willing to assume responsibility for safety of the plant when it is being operated by this qualified student. The contractor is thus saying that from a reactor safety viewpoint he is willing to let the man operate the plant. If the contractor can not say this, then obviously we should not let him go on to operate a submarine or surface ship in the fleet.

There are four performance areas that the student must pass to become qualified:

First, the student must have a satisfactory final watchstanding grade. I have mentioned that each watch was graded. This grade is the average received for the watches he stood under instruction. The grading becomes more severe for later watches as more is expected of the student and the plant operations become more complex.

Second, for officer students a final evaluated watch must be passed. This is done by a board of three members as noted previously. If the student fails this watch, he completes remedial training and tries again, after being upgraded in his weak areas. Typically, he will not be given more than two to three chances before a decision is made on whether he should be disenrolled.

Third, the student must pass a final comprehensive written examination. These are drawn from an examination bank and cover each of the areas of mechanical, electrical, reactor, chemistry, radiological controls, and the overall plant. The exam is four hours in length for enlisted personnel and eight hours for officers. These examinations are graded and reviewed with the student prior to his final oral board. If the student fails in any area, he is reexamined after an upgrading program. If he fails a re-examination, he will normally be disenrolled from the school.

Lastly, each student receives a final oral board. This is a good technique for probing his knowledge in depth. It is much easier, in this way, to assess what the student actually knows, since every flaw in his answers can be noted. Any significant knowledge weakness in reactor safety will cause the student to fail the board.

Members of the oral board are alerted to the student's weak areas by having reviewed his record. They can therefore probe areas in sufficient depth. Only specific personnel are authorized to participate as board members. For officer students, for example, the final board is composed of four members: a member of the contractor plant management; a member of my Naval Reactors field office staff or the nuclear power training unit staff; a commissioned officer from the plant staff; and an Engineering Officer of the Watch. A failing grade assigned in any area by any board member causes the student to fail the board.

In the event of failure, he will be given a re-board after remedial training. For the re-board, the members required are higher level managers. For example, for the re-board of an officer student, usually the plant manager, one of my representatives from the local Naval Reactors field office, the Commanding Officer of the nuclear power training unit and another commissioned officer will be the board members. If a student fails his second board, he will usually be disenrolled. In some cases I may approve a third board.

The oral boards are conducted formally, there is a chairman of the board. The board examines the student's record. Each member asks questions. All members grade the answer. The questioning continues until all are satisfied. For an officer, this usually takes two to three hours.

Prototype Proficiency Phase

Once he has qualified, the student enters the fourth and last phase of training at the prototype, this is the proficiency phase. The primary purpose of this phase is to become proficient as a watchstander. In this phase the student gets watchstanding experience as the man on watch at the station. He takes the watch by himself, and there is no staff watchstander present to help him.

Lectures are also scheduled to increase the student's knowledge in various areas. In addition the qualified student has an opportunity to participate in various maintenance tasks.

For this part of the program, the lectures and tasks are scheduled on a case basis. The object is to give students as much additional training as we can while he is gaining watchstanding experience. Obviously, not all students get the same amount of proficiency training, since they qualify at different times.

The entire class graduates at the same time and are transferred to the fleet. A small number of those who have demonstrated above average performance at the Nuclear Power School and the prototype are retained on the staff to qualify as instructors.

I have described the path a student takes to complete his prototype qualifications.There are some other areas related to the prototype and the training there that I will discuss.

Control Of The Prototype Training Program

The primary control of prototype training program is the prototype training manual. Both Betts and Karl laboratories participated in preparation of this document before Naval Reactors approved and issued it. This administrative manual covers all the basic requirements for running the program. It ranges from the organization and titles of people involved, to detailed descriptions of how the program is conducted. It covers preparation and control of all the materials used: including, for example, what must be in a lesson plan, how it is organized, who approves it, and so on. It covers the primary academic standards and policies.

Based on the Naval Reactors prototype training manual, approved local prototype training manuals have been developed for each prototype site. This allows some flexibility to take account of site differences. However, any significant deviation requires the approval of naval reactors.

Student Records

As in the case of the Nuclear Power School, complete and detailed records are kept on each student for all of his work at the prototypes. Sample examinations used for qualification, his qualification standard, results of oral examinations, and his counseling records, are all maintained for five years while a summary of his record is maintained for 20 years. As an example of the records maintained, each student must obtain some one thousand instructor signatures attesting to being watchstation qualification throughout his six months training at the prototype. These records are retained for five years as part of the student's record.

Qualification Guides

I have discussed qualification standards, which are local documents issued by each prototype plant. These standards are based upon qualification guides which are also approved by Naval Reactors for use at all prototypes. The local standard is exactly the same as the Naval Reactors guides except for deviations to allow for a given plant's design differences. Any deviations from the naval reactors issued guide requires naval reactors approval.

Prototype Organization

The prototype sites are operated by a contractor site manager, and the individual prototype plants are supervised by a contractor plant manager. He has training, maintenance, and administrative groups under him that operate and maintain the plants, and train the students. These groups are a mixture of civilian and navy personnel. The Windsor, Connecticut site is slightly different in that there is no civilian plant manager. The prototype is operated by the navy with a naval officer in charge who has had command of a nuclear ship.

As I have mentioned, the prototype plants are operated on a four crew basis around the clock. Both navy and contractor personnel are assigned to crew and staff watches. The contractor shift supervisor on each crew is the on-shift senior contractor watch, and supervises overall operation of the plant. Again, the Windsor organization has a naval officer in a similar capacity.

I have mentioned the Nuclear Power Training Unit (NPTU). This is the navy military organization at each prototype site that militarily controls the naval personnel, the Commanding Officer of the NPTU has previously served as the Commanding Officer of a nuclear powered ship. He is responsible for the military performance of the navy personnel at the site. He is also responsible to me to see that training is being properly conducted.

In the case of the Windsor prototype, the Commanding Officer NPTU is also Commanding Officer of the prototype for operating the plant. A contractor organization is there with a site manager, but the civilian organization does not operate the plant. Both the Commanding Officer of each NPTU and his executive officer monitor the plant, act as members of various qualification boards, and conduct watchstanding evaluations of officers.

Navy Prototype Staff Personnel

The selection of naval officers for assignment to the prototype staff is made by the Chief of Naval Personnel with the assistance of my staff at naval reactors. Because of the operational nature of their assignment at the prototype, heavy weight in selection is given to the officer's performance in the fleet. The officer should have stood in the upper fifty percent of his Nuclear Power School and prototype classes. An exception to this is sometimes made based on above average performance in attaining Engineer Officer qualification as well as outstanding fleet performance. Similar criteria are applied to selection of enlisted staff instructors. We also place heavy weight on their demonstrated performance on a nuclear ship.

Instructor Training

We have established an extensive instructor training program. Each instructor first completes watch qualification then he is trained as an instructor over a six week period after qualification.

He must specifically qualify for each type of training he will be involved in, whether it is presenting classroom lectures, conducting systems checkouts, providing watchstanding training, or participating as an oral board member. The record of his qualification is documented in a qualification standard.

In control quality, the staff personnel are periodically evaluated by a training officer or a contractor manager.

The best staff instructors are eventually assigned as classroom instructors. They qualify by giving “dry run” lectures to senior personnel. The first time they give the classroom lecture, they are monitored 100% of the time and are critiqued by senior instructors or management personnel. The civilian contractor personnel who are involved in the operation of the plant qualify to the same standards as officers. They also must go through a training program in order to become instructors.

Monitoring and Audits

An extensive audit and monitoring program has been set up to confirm that the program is run the way the government and the contractor wants it to be run.

This involves routine and special audits by contractor management, by the Naval Reactors field office, and by the navy nuclear power training unit. In some cases the auditors stand watches for extended period of time in-hull or in training areas to learn what is going on in depth.

In addition, a separate group of sea-experienced naval officers, called the Plant Performance Evaluation Activity (PPEA), whose daily job is to do in-depth evaluations of operations and training at each prototype.

Finally there are periodic audits by the contractor laboratories and by Naval Reactors headquarters personnel.

I require my Naval Reactors field office personnel, certain civilian contractor managers, plant performance evaluation activity personnel, and the senior naval officer assigned to the prototypes to write me weekly and advise me of problems they have observed in any area, and what corrective action is being taken. Many of these letters address training issues and provide me a good insight as to how training is being conducted. Members of my staff at Naval Reactors in Washington periodically visit the Nuclear Power School and the prototypes and report to me, in writing, their observations in all areas including the training program.

There is assigned, at each Naval Reactors field office, a sea-experienced nuclear trained officer whose primary function is to review all aspects of the training program at that site. He conducts frequent and detailed audits. He also reports in writing to me each week.

As is evidenced from what I have said, during the periods of formal academic instruction at Nuclear Power School and prototype training, a process of weeding out those personnel not suitable to become nuclear plant operators takes place. Only those officers and enlisted men who have demonstrated that they have the academic and practical abilities required of a safe and competent operator are graduated from the training program. I consider this process essential to insure that only those who have proved themselves to be safe and competent operators are assigned to nuclear-powered ships. In this way I attempt to maintain uniform high standards throughout the program. You should note that, even with the careful selection of personnel I have described, and a training program that involves a significant amount of counseling, the academic failure rate over the one year course is about twelve per cent for officers and about twenty per cent for enlisted personnel.

Once the officer or enlisted man has satisfactorily completed Nuclear Power School and prototype training he is considered to be “nuclear qualified”. In the case of an officer, he is assigned nuclear designator code which identifies him as having qualified for assignment to jobs involving the supervision, operation and maintenance of a naval nuclear propulsion plant. Enlisted personnel receive a navy enlisted classification code (NECC) which likewise identifies the individual as being assignable to a nuclear billet. These designator codes are immediately removed if the individual becomes unassignable to a nuclear job because of poor performance, unreliability, or for other causes.

These nuclear designators, both for officer and enlisted personnel, are assigned by the Chief of Naval Personnel based on Naval Reactors recommendation. Removal of an officer's nuclear designator can only be done with my approval, removal of enlisted nuclear designation requires Naval Reactors concurrence.

Fleet Nuclear Propulsion Plant Training

All personnel who operate any equipment directly associated with the nuclear propulsion plant aboard ship must have received the one year course, including the formal academic training and the operational training at one of the prototypes. This requirement is explicitly stated in the navy's instruction on operation of nuclear-powered ships. This states that key propulsion plant watches may be stood only by graduates of this one year combined course. This requirement ensures that all nuclear propulsion plant operators have received training supervised by the Department of Energy, and are familiar with the theoretical and practical aspects of safe reactor operation.

Following completion of training at a prototype, the newly qualified officer or enlisted personnel is assigned to billets in nuclear-powered ships. They then learn the systems and procedures pertaining to their particular ship. The enlisted personnel complete qualification on all watch stations pertinent to their rating, and the officers qualify as Engineering Officers of the Watch on the nuclear propulsion plant of that ship. The qualification program in each ship is actually a continuous training and retraining process. I will now describe how this fleet nuclear propulsion plant training is conducted.

Shipboard Qualification

Officer and enlisted personnel reporting to the fleet arrive with a solid background in the principles of operation of a nuclear propulsion plant. They have also learned "how to qualify". The shipboard qualification program consists of basic engineering qualification (BEQ) and individual watchstation qualification. Basic engineering qualification provides a cross rate background level of knowledge for all nuclear trained personnel, and allows the operator to build on the principles learned at the Nuclear Power School and the prototype. This qualification consists of various nuclear propulsion plant knowledge requirements including subjects such as reactor theory, systems design, principles of operating and casualty procedures, engineering department organization, radiological controls and chemistry. In most cases BEQ will be pursued concurrently with initial watch qualification and some portions are prerequisites for each watchstation. Advanced watch qualifications such as reactor operator require completion of be in its entirety.

The shipboard program of watch qualification for officer and enlisted personnel varies from that at the prototype in that it is less rigidly structured. The individual is expected to complete practical factors and training watch requirements concurrent with study and checkout on shipboard propulsion plant systems. Since he has just completed prototype qualification this is not an unreasonable expectation.

Each officer, upon reporting to his first nuclear ship, must qualify as Engineering Officer of the Watch (EOOW). He completes basic engineering qualification and selected theoretical and practical portions of enlisted watchstander qualification requirements as prerequisites to the advanced requirements for now. It usually takes three to six months to complete this qualification depending on the ability of the officer, the ship's operating schedule and the similarity of the shipboard plant with that of the prototype the officer attended.

The first step in shipboard qualification for an enlisted operator is to qualify rapidly on an in-rate watchstation so that he may become a useful member of the crew. The length of time required will vary depending on the watchstation, and the additional factors previously mentioned as affecting officer qualification rate. For example, an engineering laboratory technician (ELT) may be able to qualify as a shipboard ELT in only a few days because shipboard radiological controls and chemistry equipment, procedures, and associated systems are very similar to those at all prototypes. But it will usually take several weeks or months for him to qualify at other watchstations.

The submarine and surface ship force commanders have promulgated recommended qualification paths for each rate and have provided guidelines indicating the approximate length of time the average individual is expected to complete each watch qualification. Experience has shown that many operators will qualify in less time than the guideline period while a few will exceed it. Ultimately each enlisted man is required to qualify on his most advanced in-rate watchstation and, upon gaining appropriate seniority and experience, to qualify as engineering watch supervisor (EWS), the most senior enlisted watch.

Previously qualified personnel, officer and enlisted, returning from shore duty or transferring from another ship will be examined on the senior watchstation on which they were previously qualified. The results of this examination will determine the type and length of qualification required for requalification in their new ship.

The mechanics of shipboard watch qualification are similar to those already described and in use at the prototypes. The operator must study the system or other subject, physically trace out the system, locate components and, finally, receive a checkout with satisfactory knowledge level indicated by a signature on his qualification card which is similar in purpose to the protype qualification standard. He must complete practical factors and demonstrate satisfactory ability to handle his watchstation during training watches. Final comprehensive oral and written examinations complete this qualification process.

Qualification Quality Control

To assure safe and reliable propulsion plant operation, I have, through the Chief of Naval Operations, established high standards and require that these standards be maintained within the shipboard qualification program. The standards that are to be observed are spelled out in the engineering department manual for naval nuclear propulsion plants, and in qualification guides for nuclear propulsion plant watchstanders. These publications are prepared by naval reactors and form the basis for development of shipboard qualification requirements. Quality control of the qualification program is maintained by formally stated requirements. Personnel who are authorized to certify completion of the various qualification requirements are designated in writing and must demonstrate that they possess the requisite knowledge level to be a qualification petty officer. The engineering department manual defines who may approve the written examinations to be given for each watchstation and also specifies who has the authority to certify final qualification. For example, the Commanding Officer is personally required to certify the final qualification of all reactor operators, as well as certain other watchstanders. The end product of the system I have described is a trained nuclear propulsion plant watchstander who understands how the plant works, why it works, and what is required for safe operation.

Continuing Training Program

Shipboard nuclear propulsion plant training is not limited to the watch qualification program. A continuous shipboard training program is a high priority program consisting of maintenance of watchstanding proficiency, watchstander requalification, and what I will call "recurring training".

Maintenance Of Watchstanding Proficiency

An operator can be considered proficient on a given watchstation only if he stands watch at a prescribed frequency on that watchstation. In the naval nuclear program we define this requirement and maintain records so that we can be sure when we assign an operator to a watch station that he has "maintained his proficiency" on that watchstation. For example, I require an Engineering Officer of the Watch to stand at least two-four hour watches each month to maintain proficiency. If a watchstander does not meet these requirements his name is removed from the list of qualified watchstanders and he is required to complete special training specified by the ship Engineer Officer before he can be returned to the list of qualified watchstanders.

Watchstander Requalification Program

The watchstander requalification program takes into account: (1) the operator who has failed to maintain or re-establish watchstanding proficiency for more than six months, (2) the need to periodically reestablish a minimum level of watchstander knowledge since, regardless of how often the operator stands watch, his knowledge level degrades with time and (3) the need to requalify personnel when new equipment is added or alterations made to installed equipment. This program requires the complete requalification of any watchstander who has not stood a particular watch for over six months. It requires the complete requalification of all watchstanders every two years regardless of how often they stand watch.

When new equipment is added, or installed equipment altered, the Commanding Officer and Engineer Officer determine to what extent requalification is required. All watchstanders are also required to requalify on ships undergoing overhaul. This provision ensures that watchstanders who may not have stood a watch on an operating propulsion plant for several months or a longer period are qualified on those watchstations before the plant is again operated. This not only upgrades watchstanding but ensures adequacy of training on equipment new to the watchstander.

Recurring Training

A major portion of training time is spent on “recurring training”. There is a continuing need to reinforce initial training and provide training which increases the level of knowledge of all nuclear operators. I want to make it clear that, in order to maintain high standards in the navy nuclear propulsion program, ships Commanding Officers must conduct recurring training. This training is also a vehicle for improving the watchstander's ability to handle casualties, and supports more advanced watch qualification.

The methods used in conducting nuclear propulsion plant recurring training in ships are the same proven ways of accomplishing training I have described and are in use at Nuclear Power School and prototypes. Lectures and seminars are conducted on a departmental and divisional basis. In most cases a monitor, senior to the instructor or seminar leader is present to assist in keeping the training session “on track”, and to provide feedback to the command and the instructor on the quality of the lecture or seminar. Lectures are given by experienced personnel who are specifically selected to fit the topic and audience. Selection of instructors, lecturers and monitors is an important quality control measure.

A comprehensive examination program is a key factor in any formal training program. Examinations are necessary to ensure understanding and retention of the material covered in lectures and seminars. Therefore, examinations are given covering most “recurring training” sessions and are designed to be tough enough to challenge the most knowledgeable crew members.

Casualty Drill Training

In addition to classroom type training, the recurring training program is also composed of practical evolutions and casualty drills. These form an important part of the shipboard training plan, allowing the nuclear propulsion plant operator to build on his theoretical knowledge of the propulsion plant and put into practice the principles of operating and casualty procedures he has studied. The engineering department manual for naval nuclear propulsion plants lists the required drills and evolutions and indicates whether the drill should be walked-through or actually conducted. In some cases, part of the casualty action may be walked-through and part actually carried out. Within the constraints of reactor and ship safety, a conscious effort is made to carry out these casualty drills in a realistic manner.

Poorly conducted casualty drill training, which allows improper actions to occur without identification and correction, simply reinforces the wrong way to do things in the propulsion plant. In effect, we could train ourselves to operate the plant in an unsatisfactory fashion. To avoid this I insist that casualty drills be carefully planned, closely monitored, and thoroughly critiqued.

I will describe some of the considerations that are involved in the conduct of casualty drills on a nuclear ship. First, a drill guide is prepared which describes the drill, how it will be initiated, what is to be accomplished, specifies safety monitors and observers, etc. Various propulsion plant reference material and the engineering department manual are used. The Engineer Officer then submits this drill guide to the ship's Commanding Officer for his approval. A file of these approved drill guides is maintained for recurring use. The Commanding Officer must approve the actual conduct of each drill even though he has previously approved the basic drill guide. Sometimes the watch section scheduled for a particular drill will be notified well in advance of the nature of the drill in order that specific training, such as a review of the appropriate casualty procedures, may be accomplished. This may be appropriate where the section will be doing a difficult drill for the first time or where the ship has just completed a lengthy period with the plant shutdown.

Drill monitors and safety observers must be fully aware of what is expected of them and the limits to their responsibilities. This is accomplished at a briefing attended by all monitors and safety observers and normally led by the engineering officer. I consider it appropriate that the ship's Commanding Officer or executive officer be present at these briefings to the maximum extent possible. An important aspect of this session is to review in detail how the drill will be initiated and how the symptoms of the casualty will be made known to the watchstanders. In cases where the entire casualty can not be allowed to occur because of reactor or ship safety, realism in the conduct of casualty drills is important, but safety considerations dictate that some casualties should not actually be done for training. Therefore, we use techniques for presenting the symptoms of these casualties in a manner that will, as nearly as practicable, appeal to the same senses that the watchstander would normally use in the casualty situation. During this pre-drill briefing the applicable casualty procedures are also reviewed to ensure that all monitors and safety observers know the correct watchstander actions.

The actual casualty drill may be pre-announced or may be a surprise to the watch section. The Engineer Officer will normally make this determination. Some combination of both methods is appropriate to ensure that the watchstanders can properly handle unexpected plant casualties. During drills, monitors correct watchstander errors on the spot, where failure to do so would reinforce improper actions. Safety monitors are stationed to prevent incorrect watchstander action which could hazard the reactor plant. Drills are allowed to progress long enough to evaluate the section's ability to restore the plant to its normal condition. Obviously there are practical limits to drill length and in some cases the first watch section will carry out the initial casualty actions and a second section will recover the plant back to a normal condition. Upon completion of the drill, a critique involving all drill monitors is immediately held to collect comments, determine where errors were made and evaluate the overall conduct of the drill. Appropriate reference material such as the operating manuals for the ships propulsion plant are essential at this session to accurately assess all of the casualty actions taken.

After the Engineer Officer has assembled the significant comments from the monitor critique he conducts a critique of the drill for the watch section after they come off watch. If training lessons are to be learned that would benefit other engineering department personnel, the Engineer Officer will cause this information to be disseminated. Finally, where drill deficiencies show weaknesses in the ship's fundamental training program, corrective measures are taken to upgrade these areas. Similar requirements for maintaining watchstanding proficiency and conducting continuing training are also established at the prototype plants for staff personnel.

Training For New Construction

Nuclear-Powered Ships

Training of personnel assigned to a new construction nuclear-powered ship begins upon arrival of the crew at the shipyard. This arrival is timed so that the majority of the engineering department personnel are present for the entire propulsion plant test program. Two-thirds of the nuclear-trained personnel for the new crew are required to have served on an operating nuclear-powered ship and be qualified on the propulsion plant of that ship. Engineering personnel receive classroom lectures conducted by the experienced ship's engineering personnel, shipyard personnel, and manufacturers ' representatives. All personnel must complete initial shipboard watchstander qualification or requalify under procedures similar to those for initial qualification. In the case of operators who have previously qualified in another ship, the crew gains practical operating experience aboard ship by participating directly in the testing of the propulsion plant, beginning with extensive tests before the reactor core is installed. In the case of certain new design ships, special short courses for the new construction nucleus crews are taught at the prototype plant or the appropriate Naval Reactors laboratory. This better prepares the nuclear trained personnel for operation of the propulsion plant during the initial test program. The ship's crew operates the equipment during the test program, under the surveillance of qualified engineers and scientists including representatives of the Department of Energy. In this way the crew becomes thoroughly familiar with operation and maintenance of the propulsion plant, and is ready to take the ship to sea on its first trials with maximum assurance of safe operation.

Training For Nuclear Powered Ships Undergoing Overhaul

Training of nuclear propulsion plant operators on ships undergoing overhaul is accomplished using the same methods as for operating ships. There are some minor differences in that there is less opportunity for practical training, and some special training sessions may be conducted by contractor or shipyard personnel. As I have mentioned, all watchstanders must requalify under procedures similar to those for initial qualification.

Engineer Officer Training And Qualification

In addition to the one year course of instruction and subsequent shipboard qualification already described, those officers who are assigned as Engineer Officer of nuclear-powered ships are formally examined and qualified. Each nuclear trained junior officer is expected to complete this qualification prior to the end of his first or, in the case of surface ship officers, second shipboard tour of duty. This program involves preparation by the candidate, on board his ship, and final approval by me after he successfully completes a comprehensive written and oral examination administered over a two day period at Naval Reactors in washington.

The training program for the prospective Engineer Officer is an individually established study plan formulated under the supervision of his Commanding Officer. From the practical experience standpoint the candidate must have two years experience onboard a nuclear ship and must have been an engineering department division officer for at least one year. He must, of course, have the recommendation of his Commanding Officer. When so recommended, the candidate will be ordered by the Chief of Naval Personnel to report to Naval Reactors for two days to be examined for qualification as Engineer Officer. The first day the officer will take a seven and one-half hour written examination consisting of five sections covering reactor theory, radiological controls and chemistry, fluid systems, electrical systems and overall plant operations. He must pass all sections of the examination. On the second day the candidate receives three oral interviews on propulsion plant subjects. He must pass all three oral interviews. If he successfully passes all areas of the examination he will then be designated as qualified to serve as Engineer Officer of a nuclear ship. If he fails either the written or oral examination, one re-examination is usually allowed. The officer is required to complete both an oral and written re-examination in all areas regardless of the area or areas he failed. Being successful in attaining the Engineer Officer qualification does not guarantee that the individual will serve as Engineer Officer since only the technically best people are chosen for this assignment. All officers now assigned as Engineer Officer have been qualified under this system. We have also reached the point where all nuclear-trained officers must pass this additional qualification requirement in order to be assigned as Executive Officer and Commanding Officer of a nuclear-powered ship.

Commanding Officer Training And Qualification

Clearly, the one person having the greatest overall responsibility for the safe operation of the nuclear propulsion plant is the ship's Commanding Officer. Therefore, it should not be surprising that each prospective Commanding Officer is required to attend a course of instruction at Naval Reactors and satisfactorily complete this course prior to reporting to a ship as Commanding Officer.

In the early years of the program, senior sea-experienced officers were selected as Commanding Officers of the first nuclear-powered ships. These prospective Commanding Officers received the same type of training that other officers in nuclear ships received. However, the academic instruction was given by members of the Naval Reactors staff at headquarters in washington. In addition to formal classroom training, the prospective Commanding Officers received added material on those subjects affecting the testing and operation of nuclear-powered ships which they need to know by reason of their responsibilities as Commanding Officers. Operational training of prospective Commanding Officers consisted of approximately eight weeks of concentrated instruction and qualification on all engineering watch stations at one of the Naval Reactors prototypes. They were also required to pass oral and written examinations both at the prototypes and the Naval Reactors headquarters.

Since 1961, prospective Commanding Officers of all nuclear-powered submarines have had previous duty on board a nuclear-powered ship, and have therefore undergone training at one of the Naval Nuclear Power Schools and at a prototype upon initial entry into the nuclear power program.

Upon selection as a Commanding Officer, the prospective Commanding Officer reports to Naval Reactors for a thirteen week course. This course is a concentrated training period covering the nuclear propulsion plant of the ship to which the officer is scheduled for assignment as Commanding Officer. Subjects covered include mechanical, fluid and electrical (including control and instrumentation) systems, plant materials, reactor engineering, reactor theory, reactor safety and chemistry and radiological controls. The prospective Commanding Officer is examined in all areas and must pass each one. Two oral examinations are also given covering course material. A final comprehensive written examination of similar length and composition to the prospective Engineer Officer examination is administered, and the prospective Commanding Officer must pass all sections of this examination. In addition, a final oral examination on reactor safety is given by a four member Naval Reactors board. Special briefings by senior naval officers and training in subjects that will aid the prospective Commanding Officer in running his ship are included in addition to the technical training.

I approve satisfactory course completion for each prospective Commanding Officer before he can actually go on to command a nuclear ship.

Other Naval Reactors Sponsored Training

I have directed that certain other training be conducted when it is required to meet an identified specific need. For example, two years ago it came to my attention that electronics technicians were severely lacking in the knowledge and skills to properly conduct maintenance on the electronic equipment associated with the nuclear propulsion plant. I directed the establishment of a five week course at the prototype sites in Idaho and New York to teach the necessary electronics repair techniques.

As I have mentioned, special design courses are taught for the nucleus crews of some new design ships. For example, we teach a seven week design course at West Milton, New York for the nuclear trained crew members of Trident submarines.

Aircraft carrier prospective Executive Officers and Reactor Officers are required to attend the prospective Commanding Officers course at naval reactors, and certain force commander staff personnel attend the chemistry and radiological control's section of that course. In addition, members of my staff at the various field offices who monitor prototype, shipyard and ship performance are required to demonstrate by examination that they have an adequate level of knowledge to perform those duties.

Quality Control And Feedback To Training

Throughout my comments, I have indicated various points where a measure of quality control is exercised in the training program. I will now review and further discuss the key means by which we control the standards of our shipboard training. Monitors are used both in the lecture and seminar area and in casualty drills. Officer and enlisted personnel are used as monitors, with the principal criteria for selection being the individual's knowledge of the area he is to monitor. Frequent examinations are used, not just to confirm an adequate level of knowledge but to increase knowledge as well. The nuclear trained personnel on the staff of the ship's immediate superiors in the chain of command (for example, squadron or force commander) routinely review shipboard training for its effectiveness. Often this requires that staff personnel go to sea and actually observe the training being conducted.

The pre-criticality reactor safeguards examination conducted by my staff on ships with new reactor cores provide a direct evaluation of the state of the crews training,

Reactor Safeguards Examination

The purpose of this examination is to determine if the crew of a ship with a new core is prepared to operate the nuclear propulsion plant, particularly from a reactor safety and radiation control point of view. Results of these examinations are used to suggest to the prospective Commanding Officers areas where further training is necessary.

This verification of operator knowledge level is done directly by my staff for ships which are newly constructed or being refueled. A team composed of a minimum of four members, representing four key areas of operator specialty, is assembled and headed by a senior member of my staff. They go to the new construction or overhaul facility and spend several days interviewing members of the nuclear watch sections, observing practical drills and evolutions and inspecting the material condition of the ship.

At the conclusion of the examination the team leader reports to me directly with a pass or fail recommendation. I personally approve all results of these examinations. This inspection, called a reactor safeguards examination, occurs about four to six weeks prior to initial criticality of the reactor. Immediately prior to initial criticality, the shipyard commander or the supervisor of shipbuilding, as appropriate, requests permission by naval message to conduct operations with the reactor at power. I personally authorize initial criticality and subsequent testing with the reactor at power.

The procedure I have just described is also used in the case of a land-based prototype with a new reactor core.

Following this initial safeguards examination, each crew is examined annually. In the past these annual examinations have been conducted by senior members of my staff. On March 13, 1967, the Chief of Naval Operations established Naval Nuclear Propulsion Examining Boards on the staffs of the commander-in-chief Atlantic and Pacific fleets.

Operational Reactor Safeguards Examination

The Fleet Nuclear Propulsion Examining Boards provide an outside, independent evaluation of shipboard training, along with other facets of propulsion plant operations, administration, and maintenance. These boards are headed by a senior captain who has served as Commanding Officer of a naval nuclear-powered ship. The Atlantic Fleet Nuclear Propulsion Examining Board is composed of sufficient officers to conduct operational reactor safeguards examinations on three ships simultaneously. The Pacific fleet board is manned to conduct two operating examinations simultaneously. Each team conducting an operational reactor safeguards examination is composed of four nuclear trained officers. The senior team member has previously served as Commanding Officer of a naval nuclear-powered ship, the remaining three officers have served as Engineer Officer in naval nuclear-powered ships. The nuclear propulsion examining boards conduct over 180 examinations a year of nuclear-powered ships operating at sea as well as radiological support facilities on support ships and shore bases. These examinations last from two to five days and look into every aspect of nuclear propulsion plant or radiological support facility operations, administration, and training. Casualty drills and evolutions are conducted for the board to evaluate. Operators are interviewed by board members to determine their level of knowledge. Additionally, the board conducts a detailed inspection of engineering or radiological support facility spaces to determine adequacy of material conditions and cleanliness. Upon completion of the examination a grade is assigned and a trend is determined relative to the ship's previous performance.

The operational reactor safeguards examination report provides the individual ship with immediate feedback that it can use to improve training and operation. These reports also provide Naval Reactors the opportunity for an overall look at fleet nuclear propulsion plant training as well as how individual ships are doing. The results of the examination, including the grade and trend assigned, are reported to the ship's operational commander, the Chief of Naval Operations and to me. Ships that have significant weak areas are required to submit a written report of corrective action within a specified period following the examination. Examination reports are used to upgrade the performance and training of the crews of all nuclear-powered ships and radiological support facilities and, when necessary, to initiate changes in the overall training program including Nuclear Power School and prototype training.

I discuss the results of the examination with each Commanding Officer by phone – because for the most part they are in various parts of the world. If I consider it necessary, I ask him to write me and tell me what he will do to improve the performance of his ship.

Personnel from my staff conduct annual examinations at the land-based prototypes. A written report of corrective action is required in all cases within a specified period following the examination. Again, these safeguards examinations reports provide feedback useful in improving the training program.

Incident Reports

To ensure that I am kept fully aware of problems associated with naval nuclear powered plants (both ship and prototype), I require the Commanding Officer or prototype managers to report to me directly any equipment malfunction, operational difficulty, or deviation from prescribed procedures. These written "incident reports" are in addition to other formal navy requirements and are uniquely designed to satisfy the technical requirements of nuclear power. They describe in detail what has happened, why it happened, and what has already been done locally to correct the problem and prevent a recurrence. I read every report and ensure that adequate corrective action is taken in each case. My staff reviews each report in depth in their particular area of interest. They also monitor for trends indicative of a problem common to several plants or common only to one type of plant.

This rapid feedback of design, material, personnel, or procedural problems has proven invaluable in improving the reliability, safety and performance, both of the equipment and of the operators. Many times apparently inconsequential failures, when investigated fully, have led to actions which prevented more serious incidents from occurring.

These fleet and prototype incident reports also sometimes describe cases where, had the individual been better trained, he might have avoided an error in the performance of his job. Lessons learned from these reports are periodically promulgated to the fleet in naval reactors technical bulletin articles, and changes made, if needed, to design and to the overall training program.

Monitor Watch Program

I previously indicated the importance of inspections in regard to maintaining high standards. These inspections come in many ways and forms but one of the most effective is the monitor watch. The monitor watch is a surveillance conducted by someone knowledgeable in a given area, to observe and detect deficiencies in performance that occur during the period of observation. Experience has shown that these monitor watches should be at least two hours in length so that the inspector becomes part of the background and the crew performs as they would without a monitor present. I require my representatives in the field (shipyards and prototypes) to conduct monitor watches periodically particularly during the night, and report the results directly to me. The force commanders have a similar monitor watch system in which nuclear trained staff members conduct monitor watches on the ships assigned to their command. I receive copies of the monitor watch reports that are submitted under the force commanders system. In addition, members of the Nuclear Propulsion Examining Board conduct monitor watches on ships in the area where they have just completed an examination. The monitor watch may identify problems in any propulsion plant area including training. Monitor watch reports, then, are another feedback system to the overall training program,

Commanding Officer's Letters

I require every Commanding Officer of a nuclear powered ship to write a periodic personal letter to me discussing propulsion plant problems. Included in this letter is a listing of all recurring nuclear propulsion plant training the Commanding Officer has conducted on his ship since his last letter. This listing contains the training subject, date, who attended by category, (for example all EOOW's), number of people attending each session, who monitored the training, grades on examinations given, drills and evolutions conducted for training, and schools attended by nuclear trained personnel. This training summary is evaluated by myself and members of my staff for adequacy of content and extent. If it is not considered adequate, the Commanding Officer or in some cases his boss is called and the weaknesses pointed out. My direct and personal interest in each ship's training should be obvious.

Nuclear Propulsion Plant Training – Final Comments

I have provided a detailed description of the Navy Nuclear Propulsion Plant Training Program. High standards of performance are maintained through use of proven training methods with reliable quality control checks to ensure that training is conducted properly. Both theoretical and practical training are included. The results of several different inspection and reporting systems enable me continuously to evaluate the training being conducted for its adequacy. These results are also evaluated to determine areas where Nuclear Power School and prototype training needs improvement or modification. In this manner, the operational experience of the nuclear propulsion plant operators is continuously factored back into the training program.