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1968

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Technical Memorandum No. DS-27

CRITERIA FOR THE SELECTION,
TRAINING AND QUALIFICATION
OF PILOTS FOR THE DEEP SUBMERGENCE ENGINEERING
AND OPERATIONS SECTION

For WHOI

Edward L. Bland

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WOODS HOLE OCEANOGRAPHIC INSTITUTION
DEPARTMENT OF OCEAN ENGINEERING
WOODS HOLE, MASSACHUSETTS

TECHNICAL MEMORANDUM #DS-27

CRITERIA FOR THE SELECTION, TRAINING AND QUALIFICATION OF PILOTS
FOR THE DEEP SUBMERGENCE ENGINEERING
AND OPERATIONS SECTION

by

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February 1968

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This work has been carried out under Contract Nonr-3484(00), NR 260-107
with the Office of Naval Research.

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I. INTRODUCTION

Because of the comparative newness of the deep submergence vehicle and the business of selecting and training new operators, a standard set of procedures do not exist. A firm program will only resolve itself after a number of operators have been successfully trained and qualified. Subsequent additions, deletions and revisions to the system will be made as the experience level increases. Background and experience requirements are not firm at this point - they will be flexible to fit the abilities and background of the particular individual and organization. Minimum selection requirements such as physical and psychological fitness, integrity, maturity and judgment must, of necessity, be defined however. Other selection requirements may be altered to fit the individual.

Training and final qualification procedures should be firm and, after actual selection, the candidate will participate in an established training program. The initial portion will include lecture periods, indoctrination tours of the vehicle, and on-the-job training with each maintenance group (instrument, mechanical, electrical, photo). This phase of the candidate's training will parallel the submarine technician's training course which will be required of Deep Submergence Engineering and Operations Section (DSE&OS) support personnel. The Pilot-in-Training must also take part in SCUBA training, will study basic first aid, seamanship, small boat handling, and Morse code.

It is strongly recommended that the candidate participate in the construction or a major overhaul of the vehicle and thus attain an intimate knowledge of the vehicle's internal construction, overhaul and maintenance procedures, test operations, etc.

An indoctrination dive will have been made by the pilot candidate by the time his classroom work has been completed. He will be carefully observed by the Pilot-in-Command during this dive for physical or psychological reaction to the stresses of diving a submarine.

The second phase of the program, the operational training phase, will consist of a number of hours actually operating the vehicle under the supervision of the Pilot-in-Command. This phase will consist of mid-water and bottom maneuvering, gradually increasing in difficulty and complexity, until the trainee exhibits ^{adequate} complete proficiency under almost all foreseeable conditions. This phase will also include launch and recovery, actual mission work with tools, arm, cameras and instrumentation, plus complete training and drill in emergency and safety procedures.

Upon completion of the co-pilot training aspect (to the satisfaction of the Chief Pilot and the Senior Pilots), the trainee will embark on the solo phase. This will consist of a series of dives as Pilot-in-Command (PIC). This is a most critical phase. As PIC, the trainee has complete responsibility for his passengers and the vehicle; he does not have the judgment of a qualified pilot to fall back on. The decision as to when the trainee is actually "ready" to take this big step must be carefully considered by all

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concerned including the candidate who without prejudice, may elect to defer it for a reasonable period.

Throughout the operational training phase, the Pilot-in-Training will stand watches as Assistant Surface Controller under the supervision of the Surface Controller, who is also a qualified pilot. He will learn every facet of tracking the submerged vehicle, navigation and control of the support ship, emergency procedures, safety considerations, etc.

After a series of "solo" type dives and actual "working" dives have been completed, adequate time spent as surface controller, and all other training requirements completed, and when, in the opinion of a qualifying committee, the candidate is in all respects ready to become a qualified pilot, the Chief Pilot will recommend to the Department Chairman that the WHOI qualification board be convened for the purpose of examining the candidate, and approving or disapproving the recommendation. Normally this board will be comprised of at least five persons, a minimum of two of whom shall be qualified pilots, the Department of Ocean Engineering Chairman, and two others from the Scientific Staff of WHOI.

II. SELECTION

A. GENERAL

The selection of personnel to participate in the pilot's training program should be made only after extensive review of the candidate's past experience and background. It has been practice and experience that candidates generally should be selected as other than Pilots-in-Training as their first exposure to DSRV's. However, this general rule will have exceptions depending upon the candidate's qualifications. If selected as other than a Pilot-in-Training but with this goal as a possibility after he has proved himself capable of meeting the required standards of self assurance, maturity, integrity, motivation, sincerity and definite ability to learn, he will then be so designated. The final selection will be based on these qualities after he has actually been observed for a period of time and only after it has been determined that he has had sufficient background training and experience. Certain physical requirements are considered mandatory and will be detailed later. Psychological parameters, in addition, must be met. These will also be detailed later.

B. BACKGROUND AND EXPERIENCE

Background and experience requirements, as such, are not considered to be absolutely rigid. A desirable requisite may be waived in favor of an equally qualifying trait or ability. For example, a candidate may not have trained in the Navy Submarine Escape Tank (a desirable background item) but has perhaps been a working diver for many years. These requirements are necessarily flexible to meet the qualifications of the individual.

The following experience and background levels are desirable in a candidate selected for training as pilot:

1. Sea Experience

It is most desirable that the candidate possess an extensive background of sea-going experience for the reason that diving operations take place at sea; often far from shore. He who is at home on the sea, who knows and understands the wind, swell and tide, who is aware of the dangers and who is accustomed to long periods of operating independent of land is most valuable. This background characteristic also provides a natural familiarity with boats, ships, buoyancy, stability, etc. It is also true that submersibles, like ALVIN, depend as much for their survival on knowledge of surface conditions as on the submerged environment.

2. Engineering or Science Background

A formal education, or extensive training and/or experience in engineering or in one of the sciences is desirable. A candidate need not possess a degree in electrical engineering or geology but should have had some higher or advanced education or equivalent experience in an applicable area.

3. Navy Submarine Training

A graduate of the Navy Submarine School, with subsequent duty, psychological testing, and qualification in Navy submarines is most desirable but not mandatory. Although our deep submergence vehicles lack the complexity and sophistication of modern Navy submarines, the engineering principles are the same and the qualified ex-Navy submariner has the advantage of already understanding the details of submarine construction and operation. However, certain other backgrounds, such as aircraft pilot training, may be just as rigorous and useful in establishing qualifications.

4. SCUBA Experience

Training or previous experience as a SCUBA diver is also mandatory for a pilot candidate. An experienced SCUBA diver has already established his independence from the world above. He has proved himself at home in the sea and reliant on his own devices. He is acquainted with the pressure environment and its effects and has acquired an understanding of the dangers involved in survival in an artificial atmosphere. Although training in submarine escape procedures (free and buoyant ascent) in the Navy Submarine Escape Tank is most desirable, it is not considered a rigid requirement.

5. Vehicle Control Experience

Experience in maneuvering and control techniques such as flying an airplane or small boat handling are valuable in that delicate and precise

adjustments are required and outside forces such as wind and currents must be anticipated and compensated for. The submersible pilot's reliance on his own judgment and the ability to make correct, instantaneous decisions regarding the control of his craft are characteristic of a successful operator. A race car driver would probably develop into a good DSV pilot in this respect, other things considered.

6. General Education

A good general education, either formally or through equivalent experience, is considered necessary. Since a pilot must be able to adequately express himself in terms of his work and vehicle, a technical background and education in electricity, physics, mechanics, hydraulics, electronics or other related technical field is most valuable. The Naval Officer and enlisted technical submarine schools provide excellent educational background and subsequent practical working experience. It is strongly felt that the candidate should have had some technical schooling either in submarines or other related field. It is difficult to understand the electrical or hydraulic details of a system when the fundamentals are not understood. Both submarine and aircraft training provide this; however, other sources may be considered.

As previously noted, the above itemized "desirable" prerequisites are not all mandatory. Selection of trainees, with respect to their background and experience, must necessarily depend on the particular individual's training, experience, and motivations.

C. PHYSICAL REQUIREMENTS

Definite

~~Definite~~ physical standards for pilot trainees are quite firm. The following conditions must be adhered to and the candidate not able to meet them should not be considered.

1. The candidate must have no contagious disease.
2. He must have had no malignant disease even though cured.
3. He must have had no record of organic heart disease in any form or excessively high or low blood pressure.
4. The candidate must have no incapacitating respiratory disease such as bronchitis, emphysema, tuberculosis or asthma.
5. He must have no history of serious back problems, arthritis, varicose veins or muscular cramps which could cause problems during prolonged dives under cold cramped conditions.
6. He must not be obese or excessively thin if serious enough to markedly interfere with the performance of his duties. A history

of malnutrition and susceptibility to infection should be cause for rejection.

7. The candidate must have no record of epilepsy.
8. He must have no neurological problems or history of significant emotional or psychiatric deviation.
9. He must not have, or had, diabetes to any degree.
10. He must not have a recurrent peptic ulcer.
11. Eyesight and hearing must be normal with glasses permitted for marginal eyesight correction. At least 20/40 in both eyes, corrected, is considered minimum.
- 12.. The pilot candidate must have no other organic defect which would prevent him from carrying out his duties nor any condition that could require surgical or other corrective treatment.

The candidate will have a thorough physical examination of the type recommended for divers including complete full-scale X-ray and thorough examination for adequate cardio-vascular health. A current electrocardiogram is required. This examination will be conducted annually by a qualified physician. As previously mentioned, training and pressuration in the Submarine Training Tank, or a similar device, is not considered necessary although desirable. The ability of the candidate to take at least two atmospheres of pressure without ill effect is necessary. This fact will be realized when he commences his SCUBA training. SCUBA training is required of all candidates for Pilot-in-Training.

D. PSYCHOLOGICAL REQUIREMENTS

Psychological screening of a candidate for pilot training will usually take place prior to his actual selection. After selection he will be observed by pilots and other fellow workers for a period of time to insure that he is emotionally stable and possesses sufficient maturity to be able to make intelligent decisions. In addition, the candidate must obviously be a volunteer, be strongly motivated, sincere, and have a genuine interest in the project. Prospective candidates who show interest only for self-glory and personal gain will not last long in the training program. Early in the prospective candidate's program he should be taken into the submarine, preferably in the water, and carefully observed for psychological reaction. Quite frequently claustrophobia signs will show under such circumstances where no such characteristic was even suspected. Obviously no one with any claustrophobia tendency or suspicion should be considered for further training. In addition, a calm, intelligent "cool" approach to delicate or emergency situations is mandatory and this trait in the candidate must be determined during the actual training program. This "minor crisis" type of

situation occurs daily in the normal operation and the action and/or reaction of the candidate, if involved, must be observed as an indication of his possible future handling of a genuine emergency situation in the submarine. It is felt that the value of psychological stability in a prospective pilot candidate cannot be over-stressed.

E. SELECTION SUMMARY

Based on a study of the candidate's personal record of education, background and experience, results of his medical examination and history, and careful observation of his psychological characteristics, the decision as to whether or not he will actually be selected or rejected as a Pilot-in-Training candidate will be made by the Chief Pilot and Senior Pilots. It must be recognized that not all candidates selected will necessarily meet all the requirements of qualified pilot after a period of training and observation. Those who do not, will be transferred or terminated and the Pilot-in-Training designation withdrawn.

III. TRAINING

A. BASIC INDOCTRINATION

At this point, the selectee will initiate a "Pilot's Notebook" or "Qualification Notebook." This notebook will contain copies of lectures, sketches of systems, notes and details compiled during the training phase and an accurate, dated, account of the trainee's progress. It should be kept up to date and should be available for review by the Chief Pilot, instructors or members of the Qualifying Committee at any time.

Basic indoctrination of the selected Pilot-in-Training (for training purposes) will take many forms. It will consist of lectures, familiarization tours around and in the submarine and actual "on-the-job" training with the various "groups." All phases and facets of the construction and inner workings of the vehicle must be learned and learned thoroughly. Just as important, at this stage, is the instruction in maintenance and repair procedures.

As noted before, it is strongly recommended that the Pilot-in-Training participate in a major overhaul of the vehicle, not as a casual observer, but as an active participant. He will be under the direct supervision of the Senior Pilot and will actually participate in the disassembly, repair, modification and reassembly of the vehicle as assigned. He will thus have an opportunity to be actively involved in all phases of the overhaul and to observe and to be a part of all modifications and all maintenance procedures.

In addition to learning the submarine, the Pilot-in-Training will participate in SCUBA training classes under the supervision of the WHOI Chief

Diver or authorized representative. The trainee will also be provided with reference material for self study in basic first aid, seamanship and small boat handling, rules of the road and the Morse code.

1. Lectures

Lecture periods for Pilots-in-Training and submarine technicians will be initiated and each system in the submarine will be dealt with in detail by a qualified instructor. The operation and maintenance manuals, WHOI Management Plan, applicable technical reports and data will be furnished as written reference material. Overlay type diagrams and drawings, blueprints and schematics will be employed as training aids. Pilots-in-Training will retain copies of the lectures notes for reference and incorporate them in their notebooks. Lecture sessions will generally be carried out in the following sequence:

- a. Introductory lecture explaining submarine theories, pressure, buoyancy, stability, trim, compensation, propulsion systems, life support, safety considerations, etc.
- b. Introduction to the particular DSRV.
- c. DSRV main power - source, distribution and endurance.
- d. DSRV secondary power distribution.
- e. Oil-filled, pressure-compensated boxes and enclosures.
- f. Propulsion system.
- g. Variable ballast system.
- h. Mercury trim system.
- i. Main ballast blow and vent system.
- j. DSRV safety considerations, life support and emergency procedures.
- k. DSRV cabin instrumentation and equipment.
- l. Manipulator, sample tray and tools.
- m. DSRV pre-dive, post-dive and compensation check sheets. Routine maintenance procedures.
- n. Surface support procedures, launching, tracking, navigation and recovery systems. Support craft emergency procedures.

- o. General operation and control of the DSRV missions, work, etc.
- p. General requirements of observers; i.e., geological, biological, physical, etc.

2. Familiarization Tours

Familiarization tours will be conducted for PITs and technicians around the submarine at the conclusion of lecture (b) to point out and locate outside features of the vehicle. Tours inside will be conducted by a qualified lecturer at the conclusion of lecture (1) to familiarize students with cabin instrumentation, life support equipment, vehicle control and navigation equipment, etc.

3. On-The-Job-Training

The trainee, during the indoctrination training phase, will be assigned by the senior pilot to each of the specific maintenance groups for a period of at least four diving days, actually working with the groups and concentrating primarily on pre-and post-dive check-outs and routine maintenance. This is an "at-sea" type operation, under actual operating conditions. It is not expected that the PIT will become an expert electronic technician or mechanic during this phase but he will rather thoroughly familiarize himself with the operation of each group, especially with regard to the "what" and "why" of the pre-and post-dive check-outs. At the conclusion of this phase, the trainee should be able to supervise any group in the checks and in routine maintenance on the vehicle. Specific groups to be worked with are the instrument, mechanical, electrical and photo.

4. SCUBA Training

SCUBA training for the prospective pilot is mandatory, not necessarily as a life saving device, but rather, basically, to teach the trainee self-reliance and confidence in his ability to live in an alien environment. If he can acquire complete confidence in the fact that he is able to actually live underwater, even for a short period of time, the goal of the SCUBA training has been achieved. It is desirable, of course, that the trainee has already had some SCUBA training or experience, in which case, this training will serve as a refresher.

SCUBA training will be conducted under the instruction of the WHOI Chief Diver, as practicable, during appropriate periods. It will consist of a standard course in general "water" abilities, followed by actual training with SCUBA equipment. The eventual goal will be full qualification in the sea at established depths - minimum two atmospheres - 33 feet. During the SCUBA training the PIT will be carefully observed by the instructor for signs of panic or lack of confidence. The trainee must be completely "at

home" in the underwater environment and confident that he can meet any emergency or situation with intelligent decisions.

The by-product of the SCUBA training, of course, is the knowledge that it is possible to escape from the disabled submarine at depths up to approximately 200 feet with SCUBA gear. In addition, the training is valuable in that underwater repair or salvage may be necessary and a pool of qualified SCUBA divers in the project is a definite asset. His knowledge will enable him to supervise, if not actually participate, in the direction of SCUBA divers in normal or emergency operations.

5. First Aid

It is expected that a short, concise lecture or discussion period in the fundamentals of first aid will be conducted. Emphasis will be placed on artificial respiration, minor injuries, etc. A suitable first aid manual will be provided for study.

6. Small Boat Handling and General Seamanship

All Pilots-in-Training are expected to be familiar with the handling of small boats, rules of the road and general seamanship. It is expected that, in the near future, the Coast Guard will require every DSV pilot to pass a written examination on these subjects.

The manner and method of controlling the vehicle on the surface is quite similar to the handling of a single screw small craft. However, a knowledge of the rudder and screw action against the current and the wind, tide, and sea effects on the craft are necessary. Practice will be gained in these skills by use of the support craft's tenders, and later, by actually driving the submarine on the surface. General seamanship such as basic knots, method of making up towing bridles, rigging a sea anchor, etc., are invaluable.

Rules of the road are considered necessary. It is quite conceivable that the submarine may lose contact with the support craft and find itself on the surface in the midst of a fleet of fishing craft. Who has the right-of-way? Knight's Modern Seamanship is an excellent reference for this training requirement, although it is not the only one.

The PIT is expected to become familiar with rules of the road and general seamanship through self-study.

7. Morse Code

As an emergency provision, all pilots are expected to have a working knowledge of the Morse code. In the event of a failure of the "voice" mode on the underwater phone, CW keying, using the microphone press-to-talk button, could be used for communications to the surface. In the

event of a complete failure of the underwater telephone equipment, communications with the surface support craft could be maintained by banging on the hull (two taps for a dash; one for a dot), over short ranges and under good conditions.

8. Emergency Procedures

At this time the PIT must review the printed material and notes taken during the lecture on emergency procedures. It is imperative that he know and understand the established procedures to be followed for every emergency before his first familiarization dive. As a trainee co-pilot he will be responsible, in event of incapacitation of the pilot, for the safety of the vehicle and its occupants. He must have memorized emergency surfacing procedures, ship's battery limitations, switching for emergency power for life support system, communications, and blow and vent systems. He must know fire fighting procedures, emergency shallow water escape procedures, and surface survival and rescue procedures. He must know, and be able to locate, in any situation, the electrical breakers, emergency power switches, dump switches, fire extinguisher, SCUBA bottle valves and mouth-pieces, sphere release wrench, etc. These locations must be learned by touch rather than sight. All of the steps and procedures were covered in a previous lecture, and the trainee must, at this time, review the lecture and memorize the locations. A beneficial drill would be to exercise the trainee inside the submarine, with lights out, by a qualified pilot.

9. Familiarization Dive

Upon final completion of the formal classroom instruction, on-the-job type training and required reading, it is expected that the trainee will embark on his first familiarization dive. He will not be required to do any work - only observe and assist the pilot as requested. He will probably be asked to drive, if in mid-water or if in flat terrain on the bottom, if time and mission permit, in order that the Pilot-in-Command may observe his reaction to being placed in the driver's seat. He already knows the mechanics of driving the vehicle - he may now have the opportunity to put his knowledge to work. The Pilot-in-Command may also ask pointed questions of the trainee - questions concerning capabilities of the vehicle, how the trainee would handle a specific emergency, etc. The Pilot-in-Training, on the other hand, has an opportunity to become familiar with the actual operation of the vehicle during this initial familiarization dive, and to actually see how it is done.

B. OPERATIONAL TRAINING

1. General

Now that the trainee has completed his classroom training and has made his initial familiarization dive, he is ready, with the

approval of the Chief Pilot, to commence his operational training as Co-Pilot and as Assistant Surface Controller. The PIT will progress, from handling the vehicle under the least complicated condition, to the most complex, mission-oriented, operation available, under the close supervision of the Pilot-in-Command or Surface Controller. He will perform, or assist in the performance of, pre-dive and post-dive checks, navigation and control of the support vessels, tracking of the submarine and supervision of the launching and recovery operations (under the supervision of the Surface Controller). This will be the final phase of the training of the new pilot - all that he has previously learned through lectures, self study and observation, will now be applied.

2. Pre-Dive And Post-Dive Checks

These important operations have been previously covered in detail by lecture and by the trainee's on-the-job training. At this point, the Pilot-in-Training must actually perform the pre-dive and post-dive checks on the submarine, under supervision. Just as an airplane pilot performs his own pre-flight check so should the submarine pilot trainee perform his own pre-dive check in order to gain an intimate knowledge of the vehicle's material condition before the dive. All check-off items must be covered (electrical, mechanical, electronic and photo) and precise condition of each item noted. The PIT has already assisted in these checks during his on-the-job training with various groups but now he is personally concerned because he is checking for his own benefit. The value of these check lists cannot be over-stressed and each item must be understood, precisely performed or observed, and recorded.

3. Compensation

Pre-dive compensation has also been covered, but now the trainee must actually perform this important bit of paper work. Gathering all of the weight information, from all sources, he must do the actual computation for a number of dives until there is no question as to the manner in which the final "VB" or "trim" figure is arrived at. His work will be checked by the Pilot-in-Command or a Senior Pilot or the Surface Controller.

4. Environment

It is not expected that the Pilot-in-Training become an authority on geology or marine biology, but it is considered necessary that he possess a general working knowledge of the environment in which he will be working. Many books are available through which he may become acquainted with various marine life forms and their peculiarities in the geographical area in which he will be operating. A basic understanding of the characteristics of sea water is also necessary - its chemical constitution, salinity, temperature, the behavior of sound under different conditions, etc. In addition, the trainee should have a basic knowledge of the topography of the ocean bottom in the operating areas. He should be

able to recognize various types of rock outcroppings, their origination, formation, etc. This basic geological and biological knowledge will assist in the recognition of unusual or out-of-place items or occurrences. On a biology dive, for example, an unusual geological phenomena may be observed.

5. Co-Pilot Dives

No set schedule of actual duration, or sequence, of co-pilot dives can be set up for this phase of the PIT's training since the trainee will normally have to be phased into the normal operating schedule of the vehicle. In addition, the actual number of hours spent in each operation cannot be firmly fixed since each trainee will be different - some will learn the most complex maneuver in half a dozen dives while others may take two dozen. Of course, schedule and mission must also be considered - it is possible, and likely, that the trainee will "co-pilot" several dives and not be allowed to "take the stick" due to circumstances or schedule. In general, though, the trainee will proceed as follows:

a. Launching

Observe at least three launchings from inside the sphere and at least three from the sail before being allowed to handle the vehicle himself. Ideally, the trainee will "sit-out" the first few launches in the sphere carefully observing the instruments while listening to the PIC's orders to the linehandlers and following the operation of the stern prop and the rudder. On a later launch, he should observe, from the sail, the actual control of the vehicle and the linehandlers by the pilot, paying particular attention to the pilot's actions in keeping the vehicle straight and centered between the support ship's hulls, when the lines are shifted and when the swimmers are put into the water to cast off. There are many things to watch and consider and very little room for error or misjudgement in the launch and recovery operations and the trainee must watch and absorb every bit of information available.

After a period of observing, and when the Senior Pilots, and the trainee himself, consider the time is right, the Pilot-in-Training will be allowed to perform the launch himself, under close scrutiny of the Pilot-in-Command. Efficiency in this delicate operation comes only after much practice - each launch is different and there is no established set of rules - only generalizations which will be passed on by the pilots or procedures to be learned by actually "doing."

b. Diving, Mid-Water Control And Maneuvering

The next, most logical, operation for the PIT will be to dive the submarine and, at a pre-selected depth, stop, get a trim and maneuver the boat. Again, no set number of hours can be assigned to this phase. The trainee must, however, become proficient in carrying out all of the prescribed procedures for diving the submarine, know instinctively how

to act if an emergency arises during the diving operation, how to stop the dive at the pre-determined depth and how to trim the vehicle for that depth. He must be constantly aware of the atmosphere in the sphere and sample, at regular intervals, the carbon dioxide and oxygen content of the cabin.

After the trim has been obtained, slight depth changes, course and speed changes are mechanical but the PIT must become familiar with reaction times of the propulsion and control systems at all speeds. How long does it take to stop at a set speed? How long does it take to turn at full rudder at a certain speed? What effect does full right or left rudder have on depth at speed? All of these events are characteristic of this vehicle only - they are not standard of all DSVs - they must be learned - and the logical place to learn the vehicle's characteristics is in mid-water, not in rough terrain on the bottom. Since "getting the feel" of the vehicle in a safe mid-water environment is considered most important, the trainee should be allowed to take over and to do what he wants - pump mercury - see how long it takes to get a 10 degree down angle, see how long it takes to start the vehicle down from a neutral trim by flooding variable ballast. Getting a good "feel" for the control of the vehicle here in mid-water will add much to the confidence and the ability of the trainee when he graduates to bottom maneuvering.

c. Landing, Bottom Maneuvering, Surfacing

The next phase of the PIT's operational training is submarine bottom work. Since perhaps 80 to 90% of all actual missions consist of bottom geological or biological sampling, bottom exploration, search, salvage, etc., proficiency in landing, "getting a trim", maneuvering, depth control and obstacle avoidance are paramount in importance.

At the onset, the Pilot-in-Training must apply the mechanics of landing the vehicle, which he has already learned, to actual practice. When to drop the descent weight (if carried), how to locate the bottom using sonar, fathometer and lights, slowing and stopping the descent, obtaining a trim before landing, actual landing or hovering just above the bottom, etc. Then, bottom maneuvering, straight line driving and course keeping, depth control, avoiding underwater hazards, determination of underwater current conditions and how to combat them, use of sonar, transponders and pingers for navigational purposes, procedures for climbing and descending hills, advantages and disadvantages of angles on the submarine, effect of temperature on the trim, etc. All of these facets must be thoroughly learned and practiced until reaction becomes "automatic."

The Pilot-in-Training must be constantly aware of the dangers and hazards of close-to-the-bottom work and must be able to recognize and to automatically react to any situation. He must constantly, at any given moment during the dive, be prepared to abort the dive and surface the submarine under any conceivable emergency situation.

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Standard surfacing procedures must be practiced and practical knowledge gained as to methods of controlling ascent speed, how to safely use MBT blow and vent systems during the ascent, conservation of power, advantages and disadvantages of pumping variable ballast during ascent, effect of "warming up" as surface is approached, use of transponder for locating the support craft, how to stop at a safe depth for a safety look at the surface before surfacing, etc.

After arrival on the surface, the PIT must become familiar with the dangers of surfacing in a rough sea and the dangers that exist just after surfacing, while the hatch is still closed and when the submarine is completely blind. In the event the support ship is out of sight, the trainee must familiarize himself with procedures for regaining contact and protecting the submarine from the sea and other hazards.

Again, no specific number of dives or number of hours can be assigned to this phase. The trainee must "do", under close supervision, until he has acquired proficiency.

d. Manipulator Operation

In conjunction with the actual operation of the vehicle, the PIT must become thoroughly familiar with the use of the mechanical manipulator. Practice controlling the "arm" with the submarine in its cradle is the logical first step. Later, when time and situation permit, actual operation of the arm on the bottom, both with the submarine at rest and while hovering, is necessary. Quite often it will be necessary for the pilot to maneuver or control the vehicle and operate the arm at the same time. The PIT must learn this difficult operation and, it can only be learned through actual experience. Attitudes of the craft to assist in the operation of the manipulator must also be learned. Quite often it will be necessary to put an angle on the boat, or to pump heavy to counter the force of the manipulator. Common practice, when picking samples or coring on the side of a sheer cliff, is to nose in with the main screw turning slowly to hold the vehicle steady against the cliff to overcome the reaction force of the arm. All of these "tricks" will come with practice and much experience with the arm is necessary to become truly efficient in its operation. The pilot must also become proficient in maneuvering the vehicle to assist the observer in doing a manipulative task.

e. Mission Oriented Dives

The Pilot-in-Training will now co-pilot on actual working dives of varying complexity. Practice will be gained in the actual usage of the submarine for its intended purpose. These missions will probably consist of bottom sampling of rocks, sediment, water, plankton and other geological or biological items and the trainee will learn to use the variety of externally mounted devices and manipulator tools. He will also learn usage of ship-installed equipment such as the temperature and current monitors, sample trays, etc.

Photographic missions will be the primary purpose of other "working" dives and the Pilot-in-Training will become familiar with the operation of ship-mounted and hand-held cameras and strobes, with the ship's lighting systems for photography work, mounted camera focal points, etc.

Still other dives may be orientated around a search or survey mission. Inspection of underwater scientific objects and precise recording (photographically or verbally) of the condition of the object may be necessary. Search missions involving precise search patterns using a planted transponder or pinger or some other fixed object as a reference point will probably be practiced. A recovery mission may be encountered during the PIT's operational training period whereby a lost object will be searched out and recovered, either by the submarine, or submarine attached recovery devices.

In all of this mission-orientated phase of the PIT's training he will become proficient in the use of the submarine and its equipment for its intended purpose - the accomplishment of actual underwater work. On many occasions, methods and procedures will have to be improvised on the spot to accomplish the mission. Proficiency comes with practice and experience and much of both are needed before the efficiency of the Pilot-in-Training will become apparent.

f. Recovery

Recovery of the submarine, especially in rough weather, is one of the more difficult operations. A late or erroneous order to a linehandler or a wrong rudder or speed change could easily put the submarine in a hazardous position between the support ship's hulls, even with the cooperation of the wind and the sea. The Pilot-in-Training must learn to "play" the swell and the wind and to anticipate the movements of his vehicle as a result of these forces. He must understand and intimately know the limitations of his rudder and power and pre-plan his approach accordingly. The trainee should observe a number of approaches and recoveries from the sail and the support ship before being allowed to actually perform the operation himself. When he, and his Pilot-in-Command, consider he has gained sufficient knowledge of all aspects and possible eventualities, he should be allowed to make the actual approach and recovery, complete, including driving, orders to swimmers and linehandlers and hoist operator, under the close scrutiny of the Pilot-in-Command. The first few recoveries should be in comparatively calm water so that the PIT may get the "feel" of the operation.

Safety of the swimmers and the linehandlers, during the launch and recovery operations, is of prime consideration and the trainee must understand that the Pilot-in-Command is solely responsible. Orders to the swimmers and linehandlers and operation of the vehicle must be carried out with this fact in mind. No swimmer must be allowed in the water

until the Master of the support ship has given his all clear and until the pilot has assured himself that rudder and propellers will not be moved. Linehandlers must not be put in a dangerous position of having to hold the submarine against a heavy side surge which is physically beyond the capability of the line or the linehandler. Surge and swell must be anticipated and the screw and rudder used cautiously, to assist the linehandlers. Much better to smash a lift prop than to have a linehandler slip and fall between the support ship's hull and the submarine while trying to hold the submarine against the surge. Each launch and recovery are different and each must be "played by ear." The PIT must learn by observation and by much practice.

6. Surface Controller

One of the major aspects of the Pilot-in-Training's operational training phase will consist of standing watches with, and under the supervision of, the Surface Controller. The Surface Controller's responsibility for the safety and control of the submarine and its support ships extends from the time the submarine passes clear of the support ship on launch until it returns to this point on recovery. He is responsible for the control and navigation of the support ship, its tenders and any other ships assigned to the expedition, and for the tracking and location of the submarine while it is submerged. With a constantly maintained navigational plot of the support ship and the submarine, the Surface Controller must advise the submarine pilot with respect to bottom characteristics, charted or suspected obstructions, currents and any other pertinent information available and provide recommended courses during search or survey type missions.

The Surface Controller has the authority to terminate the dive due to any factor, in his judgement, which would endanger normal or emergency surfacing and recovery of the submarine (such as deteriorating weather).

In addition to keeping an accurate plot on the submerged submarine, the Surface Controller must cause the support ship to be maneuvered to maintain proper aspect and range to the submarine without endangering the support ship itself. He must carefully observe and anticipate actions and movements of other surface craft in the vicinity and be prepared to act accordingly. In the event of loss of contact with the submarine, emergency surface or other unusual or emergency situation, the Surface Controller must immediately initiate appropriate procedures (Reference: WHOI Management Plan).

The Pilot-in-Training, in the course of his instructional watches, with and under the guidance of the Surface Controller, must become intimately acquainted with every aspect of this important phase of the submarine operation. In addition to the items and procedures already mentioned, he must learn operation of the electronic tracking equipment and the support ship's navigation equipment. His instructional watches

will commence shortly after, or during, his basic indoctrination instruction and continue throughout his training program. Many watches of many hours duration will be necessary before complete familiarity with every phase of surface controlling is attained. The Surface Controller position is filled by a qualified pilot.

7. Solo Dives

After many months of instruction, study and practical work on the submarine and many hours under the water, the Pilot-in-Training will reach the point where he, the Chief Pilot and the Senior Pilots consider he is ready to embark on his first dive as Pilot-in-Command. Any one of the senior members of the expedition has the option of objecting. The PIT, himself, must have absolutely no doubt or qualm concerning his first solo, taking into serious consideration the fact that he will have full responsibility for the lives of his passengers, his own life and the Institution's investment, and must rely entirely on his own knowledge and devices. He will have no qualified pilot alongside to bail him out if he gets into trouble. This decision, of course, will be a very delicate one to make and everyone involved must be certain before the "go-ahead" is given. It is expected that the first "solo" will be in shallow water so that assistance will be available should it be needed. Perhaps several shallow or mid-water solos will be necessary in order for the trainee to gain sufficient confidence and efficiency and overcome all anxiety before a deep bottom dive is attempted. This will depend entirely on the individual. He will not be sent on a deep, to-the-bottom dive until he and his seniors are confident that he can safely and satisfactorily put his knowledge to work. Deeper mid-water and bottom working dives will follow. Again, no number, as to dives or hours can be placed on this phase. Careful observation by seniors, comments from passengers and observers and the comments and feelings of the trainee himself will eventually establish whether or not he has had sufficient solo time and is capable of "working" the boat efficiently, safely, intelligently and with confidence.

The agreement to proceed on this phase of the training must be mutual between the Senior Pilot, the candidate, and the observer, if one is involved. If any party involved feels that the particular mission (other than training) will be jeopardized, there will be provided adequate opportunity to proceed with the training at a more appropriate time.

IV. QUALIFICATION

A. Qualification Committee

When, in the opinion of the Chief Pilot, the Pilot-in-Training has completed all of his training requirements, he (the Chief Pilot) will call an informal meeting of the Qualification Committee consisting of Senior Pilots and instructors for the purpose of discussing the nomination

of the Pilot-in-Training to the Qualification Board. The PIT's notebook will be available for examination. Discussion will center about the following points:

1. The Candidate's observed suitability for acceptance of the responsibilities of a Pilot's position.
2. His observed intelligent, logical and "cool" competent approach to problems or situations.
3. The Candidate's consideration for safety factors and elements with respect to personnel and vehicle, and the interest of scientific observers.
4. His actual knowledge of the vehicle and its capabilities.
5. His dexterity and efficiency in the handling of the vehicle on the surface and submerged.
6. The Candidate's observed ability to handle the Surface Controller's duties intelligently and efficiently.
7. His sincerity and devotion to duty and,
8. His observed leadership ability.

All traits and characteristics of the Pilot-in-Training will be discussed openly from a professional point of view. Personal likes and dislikes should not enter into the meeting except where leadership or ability to command is directly concerned. After a thorough discussion, and, when a unanimous affirmative decision by all members of the Committee is attained, the trainee will be considered qualified in all respects as a Pilot-in-Command of DSRV ALVIN.

B. Qualification Board

As the final step, the Chief Pilot will recommend to the Department Chairman the convening of the Qualification Board for the final determination of the Candidate's qualifications. This Board will consist of the Chief Pilot and at least one other qualified Pilot, the Department Chairman and two members of the WHOI Scientific Staff. The Candidate will be present. Qualification Board members will put forth questions and hypothetical situations to the Candidate for answer or explanation. Upon satisfactory completion of this session, as determined by the Senior Board Member, the Candidate will be asked to retire and the final decision will be made by the Board. If a 2/3 affirmative decision is arrived at, the Candidate will be recommended for designation as a qualified "Pilot-in-Command" of the DRV, by the Director of WHOI. Normally, this step will result in the qualification as recommended by the Board. If other vehicles are under the operational control of WHOI, separate procedures will be carried out to accommodate these circumstances.

Applicants Name _____ Age _____

Medical Qualification for: Pilot annual examination _____
(Check one) Pilot-in-Training examination _____ *

To: Chief Pilot, DSE&O Section
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

Subj: Physical and Emotional examination for qualification of Pilot or Pilot-in-Training of a deep submersible, report of

Ref: WHOI Manual "Criteria for the Selection, Training and Qualifications of Pilots for the Deep Submergence Engineering and Operations Section

EAR-NOSE-THROAT CLEARANCE EXAMINATION-CONSULTATION

History	Naso-pharynx
Ear Canals	Pharynx and Larynx
Ear Drums	Audiometer

Nose and Sinuses

History of significant emotional or psychiatric deviation _____

GENERAL PHYSICAL EXAMINATION, incorporating above E.N.T. consultation, emotional stability, chest X-ray, and cardiogram, with emphasis on respiratory and cardio-vascular systems.

The above named man reported, was examined and (found to be physically and emotionally qualified) (found not to be physically or emotionally qualified) for piloting or participating as a Pilot-in-Training of a deep submersible.

Reason for not qualifying:

NOTE: If Pilot-in-Training, he is to be qualified as well for Self Contained Breathing Apparatus (SCUBA) training.

Examining Physician - Date