Damage Control Training Booklet

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Purpose of Damage Control

"The objective of Damage Control is the maintenance of the maximum offensive power of the ship"

Effective Damage Control:

(a) Preserves Watertight Integrity.
(b) Preserves Buoyancy and Stability.
(c) Preserves Maneuverability, Mobility and Seaworthiness.
(d) Controls List and Trim.
(e) Effects Rapid Repairs.
(f) Provides adequate Protection from Fire, and reduction of fire and smoke hazards.
(g) Facilitates care of Wounded Personnel.
(h) Provides for dispersal of Stores, Equipment , and Personnel.

Accomplishment of the above will result in keeping the ship afloat in its best possible condition; minimizing; or even nullifying, the enemy's most destructive efforts, and maintaining the ship's maximum offensive power.

Damage Control is an Offensive function, as well as defensive.

Fundamental Elements

Four fundamental elements to be observed in obtaining a successful Damage Control program on board any ship are:

1. Organization
2. Education
3. Training
4. Maintenance

These are not listed in the order of their importance. Each is necessary to complete the program, and must be used on even the smallest of ships. A conscientious consideration and observance of the principles embodied in these four elements will enable any ship to put forth its maximum possible offensive effort.

A very brief description of what each of the four fundamental elements entails follows:

O[illegible]zation

Organization of the ship for the purpose of controlling damage involves the setting up of:

(a) A Battle Damage Control Organization.
(b) A War Cruising Damage Control Organization.
(c) A Damage Control Board and a General Policy.
(d) Departmental and Divisional Organizations for maintenance of the "XY" and "Z" conditions of closure.
(e) Departmental organizations for the proper maintenance of material equipment vital to Damage Control procedure.
(f) Training and educational programs (for officers, men, and all battle station groups).
(g) Chain of control for Damage Control organization during battle.

Education

Provide regularly scheduled programs for educating the entire ship's personnel, both as one unit, and as noted in the preceeding paragraph, in:

(a) Necessity for and desirability of thorough application of Damage Control principles.
(b) Ability of ship to resist damage and remain afloat.
(c) Methods for attaining Damage Control efficiency.
(d) Methods used by other ships in successfully overcoming war damage.
(e) Mistakes made by other ships in combatting war damage which should not be repeated by own ship.
(f) Responsibility for maintenance of material conditions of closure, watertight integrity, damage control material and equipment, etc.
(g) Their individual Damage Control duties and responsibilities.
(h) Their ship's organization for attaining the objectives of Damage Control.
(i) Knowing their ship and its systems as thoroughly as possible.

Training

Provide regularly scheduled training for the entire ship's personnel in:

(a) Proper setting of material conditions of closure.
(b) Maintenance of highest possible degree of watertight integrity.
(c) Interior battle communications.

(d) Proper operation, use and maintenance for damage control purposes, of electrical and engineering systems.
(e) Proper operation, use and maintenance of vital damage control material and equipment.
(f) Making emergency repairs.
(g) Making way about ship under adverse conditions.
(h) Locating damage, leaks, etc., under adverse conditions.
(i) Fighting fire.
(j) Working out Damage Control problems.
(k) Overcoming attack by chemical agents.
(l) First Aid.

In providing this training, it will be found necessary to provide separate programs for officers, men, departments, divisions, war cruising groups, battle station personnel, repair party organizations, and such other groups which stem from the general organization of the ship. These programs must be further adapted to "in port" and "at sea" (war cruising) operating periods.

Maintenance

Provide and enforce regular schedules of inspection, maintenance and replacement whereby: (a) watertight integrity, (b) proper operation of electrical and engineering systems for damage control purposes, and (c) proper operation of all material and equipment necessary to the attainment of damage control objectives, is insured.

Sources of Information

There is a large amount of information and data available which is essential to the development and operation of an effective Damage Control program on board ship. A list of publications to have aboard ship is appended herewith. They may all be obtained upon request to the proper authority. Most important among these are:

(a) Handbook of Damage Control (C.B. 4198)
(b) Stability of Ships (B.R. 298/42)
(c) Machinery Information book.
(d) Hydrostatic and Stability curves, and Inclining Data.
(e) Naval Monthly Orders.
(f) Admaralty Fleet Orders.

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D A M A G E C O N T R O L

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Damage Control School

Halifax, N.S.

Accumulating war experience emphasizes that the entire ship's company must be thoroughly educated in damage control principles and methods and must be properly trained to act in accordance with them.

All Hands Involved

Action reports continue to illustrate how a ship can be lost by the failure of personnel outside of the main damage control organization to employ proper damage control methods and procedures. It cannot be emphasized too strongly, therefore, that all hands from the Commanding Officer down, must be made thoroughly conversant with all phases of damage control which apply to their own ship.

Regular Programs Needed

This cannot be accomplished in any haphazard manner. Regularly scheduled educational and training programs are necessary. These should be provided for officers and men; for departmental, divisional and war cruising groups and for battle station personnel. Such programs should be adapted to "in port" and "at sea" (war cruising) operating periods.

The necessity for developing well planned damage control educational and training programs cannot be stressed too strongly. The Damage Control Officer, should be responsible for the development, supervision, and effectuation of these programs. He shall see that educational and training activities are regularly scheduled, and inserted in the ship's daily schedules in accordance with the Executive Officer's orders.

Sustained Interest Necessary

In planning and carrying through educational and training programs, every opportunity to arouse widespread interest in them throughout the ship's company should be embraced. A competitive spirit should be fostered between shipboard groups. War damage reports should be discussed freely. Questions and suggestions from all personnel should be welcomed. Questions of a general damage control nature shall be included in examinations for promotion to various petty officer ratings. Many other plans for arousing such interest will be found practicable.

It is recognized that there never will be enough time available during a ship's day for the many activities considered essential and desirable by responsible officers who are trying to get or keep the ship in its best fighting condition. It is extremely important, therefore, that the most efficient possible use be made of any time available for damage control education and training. On at least one large ship all gunnery education and training is scheduled for the morning. The afternoon is given over to damage control educational and training activities. Some similar arrangement can and should be made on every ship.

Use All Available Time

Supplementing the use of regularly designated periods, the Damage Control Officer and his assistants can utilize "dead" time throughout any 24 hour day to as great a degree as their energy and ingenuities will permit. Well and thoroughly planned educational and training programs will schedule such activities for individuals and groups required to be at certain places during specified periods of time for purposes of readiness only. Further, there frequently occur "gaps" in any ship's program of the day, because "the best laid plans .... etc." Into such gaps, on the very shortest notice should be inserted educational or training activities for personnel who would otherwise be "standing by". But this may be done only if a well planned program exists and is in operation.

Apart from this, however, there are other times available, viz:

1. During Action Stations at dawn or dusk, target practices and similar "all hands" evolutions. (For battle station groups, repair parties, etc.)
2. During War Condition cruising watches. (For individuals on watches at inactive stations).

Obtaining Good Instructors

Successful educational and training programs call for an adequate supply of good instructors. A valuable reservoir of instructional ability is found in the ship's officers, and petty officers. Most instructors will come from the Engineering and Chiefs' and Executive departments, but all departments should provide qualified personnel as needed.

Instructors should be detailed to concentrate on a certain subject, or subjects. They should be encouraged and assisted in preparing and giving their instructional work. They should be scheduled to work with suitable individuals or groups at appropriate times.

Incidentally, personnel selected instructors are thus given opportunities for exercising certain qualities of leadership which might otherwise be dormant. Inevitably, a conscientious instructor learns more than his pupils. Furthermore, the instructor's fitness for increased responsibilities may, in part, be demonstrated by his ability to educate and train others. The requirements of a rapidly expanding Navy demand that officers and men become ready for promotion or advancement, and become proficient in supervising less experienced personnel, as rapidly as possible. Acting as instructors in subjects relative to Damage Control is one mean to this end.

Classification Of Personnel

As noted in a preceeding lecture on organization, the ship's personnel may be classified in several different ways for education and training purposes.

1. The entire ship's company as one unit.
2. The ship's officers, grouped as to rank and experience.
3. The ship's crew, grouped by ratings (CPO's, PO's, etc.)

In addition, the ship's personnel may be divided into groups according to:

1. Battle Station.
2. War Cruising, or Watch.
3. Department or Division.
4. Occupation or specialty.

Despite their inter-connection, damage control education and training will be considered separately in this lecture and for the purpose of emphasizing certain fundamental differences. Knowledge must be supplemented by skill.

EDUCATION

General Educational Subjects

A damage control educational program should acquaint appropriate ship's personnel with the following general subjects:

(a) Damage Control principles, and necessity for their thorough application to own ship.

(b) Their ship's inherent resistance to damage and ability to remain afloat.

(c) Their ship's organization for attaining Damage Control objectives.

(d) Their individual damage control duties and responsibilities.

(e) Thorough knowledge of their own ship and its vital systems.

(f) Methods used by other ships in successfully controlling damage.

(g) Mistakes made by other ships in attempting to control damage and how to avoid them.

Suggested Educational Topics

Based on these general subjects, a more detailed list of topics for presentation should be made. One such list of education material is given here.

1. Necessity for Damage Control activity in own ship.
2. Knowledge of own ship- nomenclature and naming of compartments.
3. Organization of own ship for control of damage.
4. Interior communications.
5. Watertight Integrity of own ship- its importance.
6. Material Conditions of Closure, Classifications of fittings, and compartment check-off lists.
7. Individual damage control responsibilities.
8. Types of Watertight fittings.
9. Ship's Fire Fighting equipment.

10. Ship's Damage Control Equipment.
11. Gas Masks and Chemical warfare.
12. Rescue breathing apparatus; its use.
13. Ship's firemain system.
14. Ship's drainage systems and methods.
15. Ship's ventilation systems.
16. Ship's power systems, including casualty power.
17. Types of possible damage.
18. Causes of flooding; location and stopping of leaks.
19. Fuel Oil systems and stowage.
20. Gasoline systems and stowage.
21. Fire Prevention.
22. Fire Fighting methods applicable to own ship.
23. Ship's magazine sprinkling or flooding systems.
24. Ship's flushing, sanitary and fresh water systems.
25. Stability of ships, particularly as concerns own ship.
26. Individual War Damage reports.
27. Successful efforts of other ships in controlling damage.
28. Avoidable mistakes made in other ships.
29. First Aid.
30. Types of emergency repairs available to own ship.
31. When and how to abandon ship.

It will be seen, from the above list, that a large amount of information relative to damage control can be made available to the ship's personnel. Many of these suggested subjects can be further subdivided. Some may be combined. For educational purposes, short subjects may often be presented most effectively. To get the greatest value from the presentation of such material, the subject should be adapted to the group receiving it.

Methods of Presenting Educational Material

There are a number of ways in which educational material may be presented to selected groups. Some of these are:

1. Giving talks and lectures, with blackboard and illustrations.
2. Making available suitable literature.
3. Showing movies and slide films.
4. Displaying pictures, posters, diagrams, signs, etc.
5. Conducting tours, demonstrations, etc.

6. Combinations of any of the above.

Talks will probably be the most widely used method for transferring information. To be effective, they should not be too long. They may vary all the way from broadcasts over the ship's loudspeaker system to brief talks by a petty officer to his own group of men. Talks may be scheduled for any available time.

The effective use of literature pertaining to damage control can be of great value. Many publications are available. These should not only be made available to all personnel, but should literally be pressed upon them.

Within the ship, however, much pertaining to the ship's own damage control features and policies should be put on paper and made as widely available as possible. Division Officers may be provided with outlines containing information to be used in preparing divisional instruction. Current damage control information and directives may be promulgated in this way, and through insertion in ship's orders, on bulletin boards, etc. Concise information relative to damage control talks may be distributed to personnel when such talks are given.

Movies and Slide Films

More and more movies and slide films on damage control subjects are being made available. As this type of material is used for an extremely wide range of other than damage control subjects, a closely co-operative arrangement with other department heads, and with the officer supervising this type of instruction for the entire ship, is necessary. Advantage should be taken of every opportunity for using moving pictures and slide films for damage control educational purposes. This can be arranged through the Damage Control School, Halifax. To use these films properly and fully, is to employ a very compelling medium for the presentation of damage control educational material. Pictures, diagrams, and the like, may be posted on bulletin boards (or other conspicuous places) for the purpose of bringing important damage control information before the ship's company in an arresting way.

Visual Aids

One ship found that men and officers frequently consulted conspicuously posted large size compartmentation diagrams. Another ship employed local talent to create posters interestingly depicting damage control lessons. Photographs accompanied by brief descriptive sentences arouse much interest. Signs, arrows, directions and markings all may be classified as visual aids, including the conspicuous numbering of frames. Anything which can be seen, and which thereby gives information important to the attainment of damage control objectives on your ship, is worthy of consideration.

Supervised tours about the ship are recommended. Actual demonstrations, in the use of damage control methods, procedure, fittings, equipment and material, conducted by competent instructors, should be preliminary to practical training. For many of the ship's company who will not get intensive practical training these demonstrations will prove of great educational value.

Starting an Educational Program

How may the ideas heretofore discussed be co-ordinated into an organized educational program on any ship ? In simplified form, here is a suggested procedure:

1. Divide the ship's company into educational units.
2. Combine these units into a few general groups for the purpose of designating specific subjects and instructors for them.
3. Select the subjects to be presented to, and the instructor for, each general group.
4. Assign a supervisor for each general group to supervise,

   (a) Instructors.
   (b) Material presented.
   (c) Methods of presentation.
   (d) Scheduling of instruction periods and insuring that they are held.
5. Arrange for the keeping of simple records showing instruction given to each educational unit.

As with any other machinery which is expected to operate continuously, fuel must be supplied at frequent intervals. Starting equipment for unavoidable stoppages, and repair and replacement of essential parts must be provided. This is a primary duty of the Damage Control Officer, and the Damage Control Officer's assistants and associates.

Examples of educational activities, purposely simplified and condensed for this lecture, are listed here:

AT A BATTLE STATION

A regularly scheduled Action Station period, we will say, is to last for one hour. For one gun crew, thirty (30) minutes of this period will be used in drill at the gun. The last thirty (30) minutes of the period may be used for damage control instruction. An instructor is scheduled to be present at this time to explain the operation of the magazine sprinkling systems, particularly in this part of the ship. He uses pictures, diagrams, etc.

AT A CRUISING STATION

Simplified Examples of Type Educational Activities

In "war cruising" a 6" handling room is manned. The crew is required to be on station for four hours. During most of this time there will be no activity. For a period of approximately twenty-five (25) to thirty (30) minutes a designated instructor tells them about the ship's ventilation systems, using diagrams and other descriptive material, and warning of the hazards to watertight integrity inherent in these systems.

Note that in the above case the group has been taught while actually standing their watch. Instruction was given "on station", and time that otherwise would have been lost was utilized.

DURING A REGULARLY SCHEDULED PERIOD

Education of a Departmental Unit:

On a certain day the period from 1100 to 1145 is available to the engineering department to occupy a compartment with a moving picture set-up.

A moving picture presenting a damage control topic will be shown, with introductory and concluding talks by a competent instructor. The first section (or starboard watch) of the engineering department attends.

Note that the instruction need not have been in the form of a moving picture. Note also that it need not have included a whole department. A similar event might have been scheduled for "Gunnery Department Officers, port-watch" of "Communication division, starboard watch.

FOR AN "OCCUPATION OR SPECIALTY" GROUP

In port, all deck petty officers of the starboard watch are assembled and given instruction by a qualified officer in Fire Prevention.

Keep Records

Immediately after the presentation of any educational material, the instructor should see that an appropriate entry is made in the proper record. This may be in the form of a slip left in the Damage Control Office, to be entered in a master record. Any workable method may be used. The essential thing is to provide a mean of knowing who has been taught what.

The examples, here mentioned, are of a very general nature and are intended only to indicate a wide range of possible educational activity. They should not be confused with active training operations which must supplement and spring from this educational program.

TRAINING

Methods of Introducing Realism

Realism must be the key word for a damage control training program. The experience gained from simulating an operation is considerably different from that obtained from its actual performance. Further, drills held under ideal conditions do not provide the training needed for coping with actual battle damage.

In addition to requiring that training exercises be actual operations carried through to a logical conclusion, realism should be increased by:

1. Turning off lights.
2. Using smoke.
3. Killing power circuits.
4. Closing normal access routes.
5. Disrupting communications.
6. Closing valves to isolate sections of piping.
7. Requiring the wearing, or use, of personal emergency gear, such as hose masks, gas masks, and Salvus gear.
8. Removing key personnel unexpectedly.
9. Stopping vital auxiliary machinery unexpectedly.
10. Removal of tools, equipment, etc., from usual locations.
11. Introducing water into drill areas.
12. Putting a list on the ship.

Casualties Should be Imposed

Commanding Officers should provide **every** opportunity for the imposition of planned casualties consistent with their ship's employment schedules and the ship's safety. Training in the handling of imposed casualties will insure quick and efficient action when real casualties are encountered. This type of training is of the utmost importance.

Objects of Damage Control Training Program

A damage control training program must prepare appropriate ship's personnel and groups to:

(a) Properly set material conditions of readiness.
(b) Maintain strict watertight integrity discipline.
(c) Use interior battle communication systems to best advantage.
(d) Make way about ship under adverse conditions involving heavy list, smoke, fire, flooding, wreckage, etc.
(e) Fight Fires of every type.
(f) Make emergency repairs.
(g) Properly operate, use and maintain:
    1. Hull and engineering systems.
    2. Damage Control equipment and material.
(h) Locate leaks and control flooding.
(i) Determine extent of damage under adverse conditions.
(j) Render first aid.
(k) Prepare food from alternate cooking locations.

Training in damage control operations, methods and procedures must be one of any ship's most important and necessary activities. Such training must be given to each officer and man whatever his assignment or station. The type, amount and intensity will, however, have to be adapted to each individual's shipboard station and duties. The training program on board ship should be directed, first, toward individuals, and second, toward organized groups.

Individuals should be considered under three headings:

(1) Primary - Engineering, Shipwright and Electrical personnel, whose regular employment and battle stations are directly concerned with damage control objectives.

(2) Secondary - Other personnel, from whatever department, who have battle damage control stations.

(3) Auxiliary - All other ship's personnel.

Specific Damage Control Training Objectives

Individuals, to the extent required by their classification as noted in the preceeding paragraph, must be trained to:

A - Properly Operate:

1- Watertight closures and fittings.
2- Ship's firefighting equipment (all types)
3- Portable electric pumps and air compressors.
4- Interior communication devices.
5- Emergency cutting and welding equipment.
6- Tools (those normally used as well as those specially supplied for Damage Control)
7- Screw and hydraulic jacks, chain falls, etc.
8- Air and electric tools.
9- Remote control valve operating systems.
10- Essential valves and fittings in hull and engineering systems.
11- Fixed pumps (all types).
12- Ventilation systems and portable blowers.
13- Steering machinery.
14- Deck machinery (winches, cranes, hoists, anchor gear, etc.)
15- Power and lighting systems.
16- Emergency leads.

Classification Of Damage Control Training Activities

B- Use properly:

1. Gas Masks.
2. Rescue breathing apparatus.
3. Hose masks.
4. Shallow water diving equipment (Salvus).
5. Indicator test plugs.
6. Sound power phones (regular and emergency rig).
7. Decontamination gear.
8. Asbestos suits, protective clothing, helmets, etc.
9. First aid equipment.
10. Stability Data.
11. Damage Control diagrams, including liquid loading and flooding effect charts.
12. Essential instruments and devices in the Damage Control Station, repair stations and other related stations.
13. Life jackets of all types, and all other material or equipment which may become available for personnel rescue purposes.

C- Do these things properly:

1. Set material conditions of closure.
2. Travel to or from any part of the ship via as many different routes as possible.
3. Act as competent damage control messengers under unusual conditions.
4. Shore bulkheads, doors, hatches, patches, etc.
5. Sound tanks and voids.
6. Test compartments for possible flooding.
7. Locate leaks or other causes of flooding.
8. Apply patches, plugs, etc., to stop flooding.
9. Recognize and eliminate fire hazards.
10. Use proper methods in extinguishing fires.
11. Make emergency repairs to piping, wiring, run jumpers, etc.
12. Remove wounded personnel from difficult locations.
13. Assist in rescue operations.
14. Clear away wreckage.
15. Organize, and assist in the operation of bucket brigades for controlling flooding or fighting fire.
16. Recognize and report defects in the ship's watertight integrity.

17. Find essential damage control equipment and material when needed.
18. Drain liquids from compartments.
19. Transfer liquids from one tank to another, or overboard, as necessary.
20. Remove smoke, gases or other fumes from working areas.

Use to Which Classification May be Put

These preceeding tabulations show one way of classifying damage control training activities. These lists are not necessarily complete and the peculiar characteristics of any one type of ship will suggest additional activities. Such a tabulation for any ship will, however, provide a basis for:

(a) Choosing instructors and assigning specific subjects to them.
(b) Designating suitable activities for certain groups.
(c) Planning a master schedule of training for all groups.

Such lists also provide a base from which progress check-off lists for "primary" damage control personnel may be made.

Training Methods Recommended

There are numerous methods of training men to perform individual tasks. These may be condensed into one time-saving master method outlined as follows:

1. Explain the purpose of the task. This is guaranteed to arouse the interest of the "trainee".
2. Tell and show how the task may best be performed. It is better if the instructor performs the task as the "trainee" watches.
3. Require the "trainee" to perform the task himself, not once, but a number of times.
4. Finally, require the "trainee" to demonstrate to the instructor how the task should be performed.

Keep Records Of Training Activities

This method of training calls for planning, for good instructors, and for the analyzing and breaking down of complicated tasks into their simple components. It is recommended for the training of individuals in damage control methods and procedures on board ship. It is further recommended for training of "primary" damage control personnel (as classified hereinbefore) in their own professional skills. Their training in these skills must be given much consideration, for it is an extremely important part of their particular damage control training.

The keeping of simple records listing the training activities given to individuals, and to groups, and further, listing activities in which individuals have been certified as "qualified" by competent judges, will be found necessary.

Any of the foregoing detailed training activities may be combined for the purpose of holding realistic damage control drills for battle station groups. When these are held, and, indeed, when any of the individual activities are engaged in, the introduction of the various obstacles and handicaps previously enumerated should be considered a necessary part of the drill.

In addition to the employment of every means or device calculated to make damage control training realistic, the encouragement of a competitive spirit is recommended between:

(a) Individuals.
(b) Repair Parties.
(c) Groups within repair parties.
(d) Other shipboard groups (Divisions, gun crews, etc.)

Arouse Interest

Such ideas as:

(a) Holding competitive inspections.
(b) Competitions covering time and accuracy of accomplishing certain training activities.
(c) Holding a competitive examination.
(d) Giving of suitable awards would be benificial.

Appropriate and ample publicity can also be a very potent factor in arousing a lively and widespread interest throughout the ship. The Damage Control Board can be very effective in furthering such interest.

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T R A I N I N G

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Damage Control School

Halifax, N.S.

TRAINING THE REPAIR PARTY

Training a repair party is a problem which can be solved by applying certain principles. It must be understood that the training problem never is completely solved. It is a continuous one to be worked on day after day.

One principle is that the officer in charge of a repair party must be made responsible (to the Damage Control Officer) for the training of his own group. On a small ship the Damage Control Officer may very properly direct the training of all repair parties personally. Nevertheless, when going into action, and immediately after damage is sustained, the officer (or key Petty Officer) in direct charge of a repair party will have to supervise its first activities. It is good policy, therefore, to require that this officer conduct, and be responsible to the greatest extent practicable, for his own party's training.

On a large ship a repair party's personnel are sufficiently numerous to create a more complex training problem. A repair party officer's ablest and most industrious efforts are needed to bring his own group to an efficient state of readiness to control damage. These parties contain both primary and secondary damage control personnel as outlined previously. Secondary personnel will not be available for as many training periods as the regular damage control "specialists", and consequently have a correspondingly less responsible battle station. The training of secondary personnel, however, must not be neglected.

Individual Training Comes First

As with any "team", training must begin with the individual, and should stress fundamentals. One suggested method of imparting these follows: Separate check-off lists, for primary and secondary personnel, may be made. These can list individual operations in which the men are to be trained. The repair party officer sees that a man received suitable preliminary educational material before undergoing training in any one of the operations.

When a man has learned to perform an individual operation satisfactorily, his list should be checked to show this. When he has been qualified in a required number of operations, it is desirable to provide him suitable recognition. This may take the form of an entry in the man's record that he is qualified as a "damage controller", or some similar designation. A certificate or letter from the Damage Control Officer, or even the Commanding Officer, would be appropriate.

Use "Damage" Control Instructors Where Practicable

Such qualification check-off lists can be prepared without undue difficulty. It may be found desirable for the repair party officer to utilize the services of various "damage control instructors" to assist in this fundamental training of individual members of his repair party. Particularly in larger ships may this be true. There have been many effective methods used in training repair parties by able and conscientious officers. All of these cannot be tabulated here. These methods have, however, been based on the principle that the individuals making up the repair party must possess certain knowledge and must be able to perform certain essential operations. For this reason the importance of training <u>individuals</u> prior to, and concurrent with, <u>group</u> training is emphasized.

Repair Party Drills

Group training for repair parties most frequently will be in the form of drills. A drill may involve the entire repair party (on small ships this will be the usual thing) or one of its parts. To be of much value, a drill must be well planned beforehand. This required that it be scheduled for a definite period. Such periods will be most easily available during regularly scheduled general quarters, and dawn and dusk alerts. Other scheduled drill periods should be provided in the week's schedule, however, so that independent repair party drills may be held then.

In planning a drill for his repair party, the officer in charge should consider the following requirements:

(a) The drill should have one main purpose. Other secondary objectives may well be included. But there must be a main purpose and the drill should be arranged so that this objective can be logically attained.

Use War Damage Reports

(b) The drill should be as realistic as possible. A careful study of War Damage Reports will be of great value. Damage done to a ship of similar type or size can be the basis for creating effective drill situations. The employment of any of the previously listed methods for increasing realism should be carefully considered by the officer planning the drill. Before holding a drill certain preparations may have to be made to "set the stage" for a realistic operation.

(c) It is desirable to plan a drill for any group so that, if at all possible, every member of the group will have some duty to perform. It is bad to have members of a party standing about with a feeling of having no part in the proceedings. Communication casualties may be introduced, men used as observers, messengers, helpers, first aid assistants, emergency material procurers, etc.

Observers May Be Used

(d) In many drills it will prove of great value to arrange for the presence of observers in the drill areas. These are for the purpose of keeping notes on action taken, tools and equipment used, number of men employed, and similar pertinent information. These notes provide material for a post-drill discussion. Observers often can be advantageously obtained from other repair parties.

Post-Drill Discussions

(e) The effectiveness of a drill can be greatly enhanced by a discussion immediately following it. Observers should be present with their notes and the repair party officer should go over the drill with his men, calling for reports from observers and pointing out what appear to be errors of omission or commission. Men should be encouraged to ask questions, volunteer information and suggestions. Properly handled by the repair party officer, this "critique" will prove interesting and will give his repair party personnel a fuller understanding of how their actions would affect the control of damage resulting from an actual battle occurrence.

In the final analysis, the success of any independent repair party drill will depend upon the repair party officer himself. He must be personally properly prepared, must plan the drill carefully and must enter into the drill energetically and enthusiastically.

A number of suggested independent repair party drills are listed here. These have all been used on various types of ships and, in some modified form, are applicable to any ship:

(1) Conduct firefighting operations in many shipboard areas. Actually use equipment as against Class "A", "B" and "C" fires.

(2) Eliminate all sources of power to many different types of equipment. Repair party must run emergency leads to equipment, hook up the cables and actually run the equipment with them.

(3) Set a prescribed watertight condition of closure in a certain area. Either the "XY" or "Z" condition. Have it inspected and checked by another repair party. A mark should be assigned to permit competitive comparison with other parties.

(4) Remove smoke from a compartment, previously filled by artificial means, without contaminating other compartments. Use both regularly installed and emergency ventilating equipment as applicable and necessary. Require use of rescue breathing apparatus, hose masks, gas masks, etc.

(5) Hold drill in cutting out sections of firemain as a result of battle damage. Re-route firemain pressure. Run jumpers. Actually operate necessary valves and have appropriate pumps operated and put on the line.

Suggested Repair Party Drills

(6) Operate drainage system to remove water from a number of different compartments. Co-ordinate activities with engineering department. Actually operate valves and line up for correct suction. Use water from the firemain , where practicable, to supply water to be pumped through the drainage piping.

(7) Drain water from previously filled compartments using more than one portable pump simultaneously. Use emergency switch boards. If necessary, supply clogging material in water to necessitate use of basket type strainers, cleaning of pumps, etc.

(8) Hold drills involving use of portable pumps, for both drainage and firefighting purposes. Actually drain compartments (or tanks); use foam with pumps in fire fighting operations.

(9) Hold drill problems based on damge control diagrams requiring actual operation of valves and other equipment depicted thereon. Record times necessary to reach successful solutions and carry out indicated procedures.

(10) Hold drills in shoring bulkheads, decks, doors or hatches at various locations throughout a repair party area. Do not actually cut shores unless scrap lumber may be obtained for this purpose. Bring necessary materials and tools to the shoring point or to the most convenient adjacent area. Describe method of shoring to be used in each case, put material in approximate required position, clamp strongbacks into place, etc. In general, carry out the work to the most complete point possible without damaging shoring material.

The 10 above listed drill suggestions may be multiplied on board ship by the variety of locations and by the different battle damage conditions which it is desired to reproduce. In this way perhaps as many as a hundred different drills could be worked up for any one repair party.

Other types of drills for repair parties will, of course, come rapidly to mind. In brief, some of these may be enumerated:

(a) Varying types of communication drills and exercises, including running emergency communication lines.

(b) Drills in repairing spare sections of piping, pre-damaged for drill repair purposes. Quick repairs to be made, water or air pressure applied to test efficiency of repair.

Additional Drill Ideas

(c) Operate various hull systems for damage control purposes to accomplish a particular objective. (Example): Fuel oil filling and transfer system. System may be operated in a different way than under normal, routine undamaged conditions. Use auxiliary or standby equipment.

(d) Conduct inspections of other repair party areas, damage control equipment, compartment check-off lists, watertight closures, etc., on a competitive basis.

(e) Hold decontamination drills, cleaning up suspected areas in vicinity of shell or bomb explosions, with particular check on ventilation openings. Use all necessary equipment; powdered soap and water may be used as drill decontaminants.

(f) Exercise in handling heavy weights, using rigging methods and equipment. Use chain falls, blocks and tackles, jacks, wire rope slings, etc. Select equipment that might be jettisoned in an emergency.

(g) Unusual ship repairs requiring use of burning and welding equipment may be handled by a repair party as an emergency damage control drill.

(h) Drill in investigation of damage and establishing flooding boundaries. This is difficult in that it is necessary to visualize, from War Damage Reports, the possible extent of damage from any type of hit at any particular point. Here the repair party officer's ability to create a logical drill situation is brought to the test.

(i) Drill in speedy de-energizing of electrical circuits to, or passing through, damaged areas. Electrical personnel should be used for this, but other responsible repair party personnel should be trained along with them.

(j) Drill in counterflooding, or liquid transfer, operations.

(k) Drill in taking over, or assisting in manning, other repair party areas.

(l) Drill in plugging holes underwater using regular diving equipment, (Salvus).

Use All Damage Control Equipment

When holding independent repair party drills fullest possible use should be made of as much damage control equipment, both fixed and portable. Hull systems should be used to the fullest practicable extent. All practicable methods for increasing realism should be introduced into the drill, consistent with the extent to which the training of the party has been advanced.

As the training of the repair party progresses, it becomes desirable to co-ordinate its training with the rest of the damage control organization and, ultimately, with all departments of the ship. This is obtained largely through the holding of damage control problems (for the damage control organization) and, finally, battle problems (involving all departments of the ship).

Short damage control problems held frequently by the Damage Control Officer serve to train the repair party in damage control procedures embodied in one or more of the independent repair party drills. Problems should be prepared to include casualties affecting engineering, gunnery and other departments. Battle damage from more than one hit is usually imposed. These are often concentrated in one general area: aft, forward or amidships. This permits the use of other repair party personnel, from the unaffected areas, as observers. They also may be used to open switches in power circuits, close valves, etc., as desired, to realistically reproduce battle damage conditions.

Damage Control Problems

Such problems are best held when all hands are manning battle stations. Gunnery, engineering and other personnel may be drawn into the drill either as observers, from undamaged areas, or as participants, within the damaged area.

Gunnery Damage Control

There are times, however, when such damage control problems can be held without having the entire ship at action stations. One such time can be when the gunnery department is conducting a drill calling for a general manning of gunnery stations. In cooperation with the Gunnery Officer, the Damage Control Officer may introduce casualties which affect the operation of gunnery equipment. This will exercise both departments in "gunnery damage control" and provide broader training for the repair party involved.

Damage Control problems will vary in the amount of time required for their preparation. The more thoroughly prepared ones will have written instructions provided, in the form of slips, for observers to hand to repair party personnel at predetermined times. Signs, tags, and other devices for indicating damage conditions will be employed. Shorter and more informal problems can be developed in which hits are reported over a communication circuit to the repair party officer who then conducts the operations of his party in accordance with his own visualization of the situation.

Advanced Training

Damage Control problems are the means by which the Damage Control Officer provides advanced training for his repair parties. The ultimate in training for the repair party, however, (and for the entire Damage Control Organization) is provided by the ship's Battle Problem in which all departments take a most active part. This Battle Problem attempts to give the ship, as a whole, training in conducting battle operations just as they would have to be conducted in an actual battle. To accomplish this result a large amount of thought and work is necessary, and this must be provided proportionately by each department on the ship.

Restricted.

W A T E R T I G H T I N T E G R I T Y

A N D

T H E R E G U L A T I O N S

F O R

W A T E R T I G H T O P E N I N G S

Damage Control School

Halifax, N.S.

Bulkheads And Decks

A warship is divided into a large number of small compartments. This is done by what are called bulkheads and decks.

The bulkheads may be compared to the walls of a house: there are two kinds, - those which run in a fore and aft direction and are called longitudinal bulkheads, and those which run across the ship and are called transverse bulkheads.

The decks may be compared to the floors of a house. In a house the floors are given numbers, but in a ship the decks are given names: the most important are upper deck, main deck, lower deck, platform deck and hold.

Like the walls and floors of a house, the bulkheads and decks of a ship make the boundaries of the various compartments and give strength to the structure.

Watertight Compartments

They have, however, one other most important function, and this is where our analogy to the house ceases. As many as possible have to be watertight: thus, a warship is made up of a large number of small watertight compartments.

Let us analyse the reason for this.

The outer skin or hull of a ship keeps the water out, and, as long as that skin is whole, the ship is safe and will float. The aim of the enemy is to pierce that skin, and he has various weapons with which to make the attempt. There are torpedoes, mines, bombs, and shells. Of these, the torpedo or mine is most likely to cause flooding; they are more deadly too, than any other weapon because little or no warning can be expected before they explode. We must therefore be always ready for them.

Watertight Integrity

If, then, one of these weapons makes a hole in a ship below or on the waterline, water will inevitably enter the hull. How far that water will go, and how serious will be the effect depends on the next line of defence - the watertight compartments which we have just described. The torpedo may shatter or pierce some of the boundaries of the watertight....

compartments, as well as the hull, but the next boundary should hold and prevent the spread of the flooding. The Army term - "Defence in depth" - describes the principle rather well. The Navy gives the subject the general description of "Maintenance of watertight integrity".

Watertight Boundaries

You can see, then, how important it is for the inner bulkheads and decks as well as the outer skin of a ship to be kept in a watertight condition. The submarine and the airplane have increased their range to such an extent that there are comparitively few places where they cannot achieve surprise: the maintenance of watertightness all the time has, therefore, become more important than ever. In this war, there are not many occasions on which a ship can relax on internal watertightness.

Once the hull of a ship has received underwater damage, it is essential to have efficient watertight boundaries to stop the water spreading. It is plain that it would be best to keep these boundaries - or - bulkhead and decks - permanently intact, which would result in our ship being made up of a large number of completely watertight compartments.

Factors Against Keeping Permanent Watertight Boundaries

There are, however, various factors in the construction of a ship and life at sea which conflict with this ideal.

In the first place, there are a large number of men to be fitted in: they have to have spaces to live and sleep in, and to work: they have to be fed, which means using compartments for store rooms, refrigerators, and so on. They have to have facilities for washing, which means opening up bathrooms.

There are, also, the numerous compartments connected with the propelling machinery and the guns: there are engine and boiler rooms, and the magazines- to mention a few - they all have to be manned. This means the opening of doors to get into them and the fitting of adequate ventilation. There are also all sorts of pipes, such as the various water systems and drains, which must pass through compartments.

Openings.

It is clear, then, that there are a large number of fittings in each watertight compartment which tend to reduce the internal watertightness or integrity of the ship. They are given the general term of opening, and here is a list of them:-

Doors
Hatches
Ventilation valves
Manholes
Scuttles
Drain cocks
Scupper valves

Obviously, if we are to maintain our watertight boundaries, it is essential to keep closed as many as possible of those openings that are below or near to the waterline of the ship. Those that we cannot keep closed must be under strict control, and there must be an organization for closing them in emergency.

Closing Of Openings In An Emergency. Red And Blue

Let us deal first with how to close these openings in emergency. By "emergency" we mean when the ship is hit by the enemy, or action is about to be joined, or submarine attack or air attack is imminent.

All those openings, which are below the waterline or close above it, are the ones through which water is likely to spread if the hull is pierced; we would like to keep them permanently closed: they are all marked red, which draws attention to the risk which they constitute. Clearly then, any red openings, which are open, must be closed in emergency with the utmost speed.

All those openings, which are above the waterline and not marked red, but which may be reached by flooding, as the ship lists or settles, are marked blue: clearly they must also be closed in emergency but there will be more time to do this and it can be done after the red ones.

The remainder of the openings, which are sufficiently high up in the ship not to be affected by flooding, have no colour marking.

The actual form that the red and blue marking takes is this:-

On a door or hatch one corner is painted red or blue.
On a valve, cock, scuttle, or manhole, a red or blue disc is painted; sometimes an arrow is added to point at the operating mechanism.

Both the corner and the disc markings have the same meaning. They tell everyone in the ship which openings to close in an emergency and the order in which to close them.

The Closed Openings. How And When To Open Them

Let us now consider a closed opening in a ship - it may be a door, a hatch, a valve, a manhole, a drain cock or a scuttle. Let us see how, or under what conditions, we may open one.

The red and blue colour markings, as we have already seen, serve a dual purpose - they tell us how dangerous openings are from the watertight point of view, and the order in which they should be closed in an emergency. It is obvious, that the more red openings that are kept permanently closed, the safer will be the ship: we must expect, then, to find closed a very large number of openings that are low down in the ship. However, as we have already seen, the ship is our house; we live in it, and we have to move about in it, so we shall certainly meet doors which we want to get through and other openings which we must open. It is evident, then, that there has to be some simple code to tell us what to do.

Here it is. Letters are used. There are four of them - X, Y, Z and O - and each has a different meaning. Every opening, whether it is a door, a hatch, a valve, a cock, or a scuttle, has marked on it, in a position where it can easily be seen, one of these letters.

X Marking

We will first take the case of a door marked with and "X". Before you can open it, you must get permission, even if it is only to pass through. In some ships, this will mean going to the Damage Control Headquarters to get permission from the officer on watch there; in other ships, the permission may be given by the O.O.W. on the quarter deck or bridge. If the door is to be kept open for any period, a sentry will have to be placed whose job it will be to close the door in an emergency.

Y Marking

The next letter is Y. "Y" on a door means that you may open it to pass through, provided you clip it up again immediately after getting through. You need not get permission for this, but, if the door has to be kept open for any length of time, then, you must get permission to do so from the D.C.H.Q. or C.O.W., in the same way as for an X door; a sentry must also be placed, or other suitable arrangement made, for closing it quickly in an emergency.

Careful Clipping Of "Y" Doors.

After passing through a "Y" door, the clips must always be put on again with care, and the door securely closed. That particular bulkhead - or in the case of a hatch, that particular deck - must be left intact and watertight. Failure to do so might even result in the loss of your ship.

Doors and hatches are given the Y marking because they lead to some compartment, or piece of machinery, that has constantly to be visited. They are usually "Red" and the fact that they have a Y marking, and not an X, does not mean that they are further away from the waterline or the ship's side. Be very careful, then, about clipping them up.

Valves And Drain Cocks

In each example we have discussed the case of a door, but the same rules apply, whatever is the type of opening; except, of course, we cannot pass through ventilation valves and clip them up after us. A "Y" marking on a valve means open if necessary while using that particular compartment, but must be closed on vacating it. The "Z" marking is usually used for ventilation valves to mess deck spaces etc. A "Y" on a drain cock - from a bathroom, for example: this means that the cock can be opened for draining purposes, but must be closed afterwards. Usually only a "Y" or "Z" marking is necessary on a ventilation valve.

The XY Condition

X and Y openings, then, are always closed except when they are opened with permission, as has been just explained. When opened for any reason, they are under strict control, and special arrangements have to be made for quick closing, should an emergency arise. This state of having X and Y openings closed is called "being in the XY condition" and is the normal condition of ships, both at sea and in harbour, in wartime.

Z Marking

We now come to Z openings: they are usually left open, both in harbour and at sea - they are closed in very dangerous waters or when action is imminent, and, of course, at action stations. The order to close them is passed by the pipe "Close Z openings"; whether you have heard this pipe or not, does not matter; if you come to a "Z" door which is closed and you wish to to open it, you can do so to pass through, but must clip it up again immediately afterwards. If Z openings are piped closed, the "Y" rule applies, and you still have to get permission to leave it open.

The Z Condition

When all the Z openings are closed - The X and Y, as we have already seen, are always closed - the ship is said to be in the "Z" condition, and she is in a high state of watertightness and ready for battle. In the "Z" condition all ventilation valves should be closed and fans shut off. Naval engagements are usually of fairly short duration, but if it should be necessary to ventilate any particular compartment, the repair party can do so for ten or fifteen minutes, and then close everything up tight again. The man that opens a valve for this purpose should stand by said valve until the area is ventilated, and close it again.

O Marking

It will not be easy to move about in a ship in the Z condition, and the ventilation will not be good because nearly every opening will be closed. There may, however, be a few openings, which are not marked with a Z and are, therefore, still open. They are marked with an O, the fourth and last of the letters in our code of rules. Such openings are nearly always open - even at action stations: they might be closed for some special reason, such as a gas attack or after the ship has been damaged: this may be done by pipe by their letter; they may also have a gas marking which is explained later.

Routine Marking

Another marking which you may meet in some ships, is the "Routine" marking. Certain openings which cannot be marked with one of the four letters are given the marking "Routine".
This means that the door, hatch, or valve so marked, is worked to a special routine. The routine which governs the operation of this type of opening is posted up close to it, so, before doing anything, ...

you must read the routine to learn what you may or may not do to that opening. But as a rule a "Y" marking is more suitable than "Routine" on the average small ships. Finally, in our code, there is another qualifying symbol, "X ACTION", which is of course an X opening, but means that it may be opened in action, such as an ammunition hatch in a ship that has no ammunition hoist.

Summary Of The XYZ Red And Blue System.

Let us now sum up how the opening and closing of openings is regulated in ships.

In the first place, there are the red and blue colours which tell us what openings we must close so as to stop water spreading inside the ship, once a hole has been made in the hull. The red openings are the lowest down in the ship, or closest to the ship's side, and must be closed first; the blue are higher up, and there should be time to close them before they become a danger and water reaches them. The pipe "Close Red and Blue openings" means that something has happened or is likely to happen which affects the watertightness of the ship. This is a pipe which is only used in emergency and it is the signal for every man in the ship, whatever his job, to close any red or blue openings near to him.

In the second place, there are rules which tell us when and how we can open a closed opening. They are indicated by one of four letter:

X- Permission required to open and to keep open.
Y- Can be opened for passage or use, but must be reclosed at once. Permission required to keep open.
Z- When closed the Y rule applies.
O- Closed only when ordered.

There is one other special marking - "Routine". This means that a special routine governs that opening. Read the routine which is posted near to it.

Qualifying Symbols

There are a few other markings which are put on some openings, in addition to those we have already described. They are called "Qualifying Symbols", because they qualify the basic X, Y, and Z meanings. There are two which you ought to know and which are fairly common.

2 Clips

Certain "Y" doors and hatches are in such constant use that, although they are red or blue and we would like to keep them fully clipped, it is not practicable. They are marked with the words 2 clips under their letter. This means that two clips only need be used to secure them; the clips that have to be used are indicated by two parallel black lines painted on the door or hatch. At the emergency pipe "Close red and blue openings", these doors or hatches should be secured with all the clips.

Gas

Certain openings must not be opened while a gas attack is going on - they are marked with a yellow circle or disc. As a rule your ship will have an order that no X,Y or Z openings are to be opened without permission during a gas attack, so it will not be necessary to paint a yellow disc on an opening that carries an X,Y or Z marking.

Action

"Action" On an opening means open in action.

The Irresponsible Or The Careless

That completes our description of the regulations for watertight openings. It is obvious that everyone in a ship must know and obey these regulations. As you can now realize the careless clipping up of a door or the irresponsible opening of a valve might very easily result in the failure of a watertight boundary: this, in turn, might very easily result in the loss of the ship.

In a modern ship, particularly a large one, it is rather easy to forget the sea. It may appear to be a long way from us but this is a delusion. The sea is an element with which no one can afford to take liberties: those who do will regret it sooner or later. Experience has shown that the flooding resulting from underwater explosions may be fifty per cent, or more in excess of that estimated from the results of scale experiments.

This increase in flooding, which may result in increased loss of life and make all the difference between saving or losing a ship, is due largely to structures, supposedly watertight, not being so, and to doors, hatches, valves etc., being left open.

Watertight integrity is of prime importance in restricting flooding and thus ensuring that loss of buoyancy and increase in free surface are kept to a minimum. It is important to appreciate that any deficiency in watertight integrity prior to damage will add to the difficulties of Damage Control afterwards.

Ideal Condition

The steps necessary to ensure that a ship is always in the best possible state to withstand damage are as follows:-

(a) A high state of training and organization must be maintained at all times.

(b) A log of watertight openings should be maintained.

(c) There should be a strict routine for ventilating compartments below the waterline and for ensuring that all valves are closed when ventilation is shut down.

(d) It is essential that routine air-tests of watertight compartments are carried out and any defects made good.

(e) "X" and "Y" rules should be strictly enforced both at sea and in harbour.

Note: More ships have been lost through failure of watertight integrity than from lack of subdivision. There is one case on record of a ship sunk in action and subsequently raised. It was merely necessary to send divers down, close the watertight openings, pump out, and the ship came to the surface. The answer to that one is quite obvious.

Repair Parties To Check Watertight Openings

It is the first duty of Damage Repair Parties to check on all watertight openings on closing up to action stations. A list of openings in each compartment, posted up on bulkhead near access, is a very good visual aid and reminder for repair parties.

Escaping From A Compartment

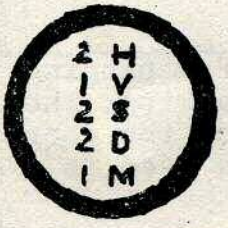
And now for one final word of warning. Should any of you find yourselves in a ship that has been hit and you have to evacuate a compartment, it is your bounden duty to close up properly the hatch, door, or manhole by which you escape. Neither does your duty cease here- you must then see whether there are any other openings that can be closed, such as cocks or valves. The red and blue colour markings will help you to find them.

The Poster

In conclusion let me draw attention to the poster of the Regulations for watertight openings. It is your job, as a sailor, to know and obey these regulations. C.A.F.O. 813/43 refers.

DETAILS OF MARKINGS USED IN CONNECTION WITH WATERTIGHT INTEGRITY

EXAMPLE	COLOUR & SIZE	APPLICATION
Red or Blue Markings 	Red or Blue Equal sides of 10"	Upper corner of a door, opposite side to hinge. Similar position on a hatch.
Red or Blue Discs. 	Red or Blue 2" Diameter	On or near to the operating mechanism of a valve.
Letter markings X, Y, Z & O.	Black. On a door or hatch, 3"block letters. On a valve etc, 1½" block letters.	Upper centre of a door or hatch. As requisite on a valve etc. "Eye" level where possible.
Routine Marking. "ROUTINE"	Black. 2" block letters.	Similar to letter marking.
May be left open Discs. 	Red. A disc of 6" diam. The word "Open", 1½" letters.	Slotted screw-hole for hanging disc over existing marking. The identification mark of the door for which disc may be used is to be on the disc.
Gas Symbol. 	Yellow. 2" diameter.	In a conspicuous position on gas flaps and some "O" doors.
Qualifying Symbols. "ACTION" and "2 CLIPS"	Black. On a door or hatch, 1½" block letters. On a valve etc, 1" block letters.	Under the letter marking.

DETAILS OF MARKINGS USED IN CONNECTION WITH WATERTIGHT INTEGRITY		
EXAMPLE	COLOUR & SIZE	APPLICATION
2 Clips. 	Black. 2 parallel black lines, 5" long and ¼" wide ½" apart.	On "2 Clip" doors or hatches opposite to the clips that are to be used. The angle of the lines as requisite to show direction for putting on the clips.
Bulkhead numbers 17	Black. 3" block letters.	As requisite in conspicuous position on bulkheads.
Other side Marking "SPIRIT ROOM OS"	Black. 2" or 1" block letters.	On bulkhead to mark what is on the other side. The name of the compartment followed by the letters "OS" underlined.
Black Circles 	Black. ½" in width. Internal diameter. 6". Letters and numbers of appropriate size.	Indicates number and type of openings in that compartment. H= Hatch. D= Door. S= Scuttle. V= Valve. M= Miscellaneous other opening.
Green Arrows 	Green. 1" wide. About 12"long.	As requisite high up on bulkheads to point at position of strainers.
Internal Waterline Marking -DWL-	Black. 3" block letters. 1½" wide line.	On bulkheads of compartments to indicate the height of the normal deep water line: in such a position that it can be seen from hatchway.

Restricted

THE USE OF CONCRETE IN REPAIRING HULL DAMAGE

Damage Control School

Halifax, N.S.

THE USE OF CONCRETE FOR REPAIRS OF DAMAGED HULL

Use of Concrete

With the aid of wood or steel cofferdams, concrete can often be used to great advantage in stopping leaky boundaries, such as ruptured bulkheads, damaged hatches, warped doors, leaky bounding bars, deck ruptures around pipe lines, shell or bomb holes in decks or hull plating, and leaky deck or bulkhead seams. To a limited extent, concrete may also be used to restore strength in damaged machinery supports.

Principles

The fundamental principles to be observed in using concrete include:

(a) Suitable materials.
(b) Accurate measurement of materials.
(c) Thorough mixing.
(d) A workable mix.
(e) Proper application.
(f) Prompt placing after mixing.

Materials

The materials which should be available on board ship for use in making concrete are coarse sand, high early strength Portland cement, calcium chloride, aggregate (gravel) and fresh water.

Gravel

The gravel should not exceed one inch in maximum diameter, and about 30% of it should be small pebbles. It should be as rough as possible, crushed rock being an excellent aggregate. In an emergency, small pieces of hard coral or broken firebrick may be used. The aggregate serves as a re-inforcing material, the larger pieces tending to hold the mass together even after cracking has occurred.

There is some question as to the necessity for aggregate in concrete. If strength is a factor, aggregate must definitely be used. Builders and salvage personnel also state that it must be used. On the other hand, leaks have been stopped on naval vessels with a mixture of cement and sand only.

Sand

The sand should be coarse, clear and sharp, and should be free of vegetable matter and oil. It should be a true sand- not powdered coral. It should be washed in fresh water before being stowed away.

Mixing

The materials should be mixed in approximately the following proportions (by volume):

1 High Early Strength Portland Cement
1½ Sand
2 Aggregate

Various authorities recommend different formulas, with slightly higher proportions of sand and aggregate. If mere bulk is required, less cement may be used. Four cubic feet of the separate materials will make about three cubic feet of concrete when mixed, although the concrete will tend to swell when deposited under water.

The materials may be mixed in tubs, in a wooden box, or on the deck of a washroom. In the latter case, cover drains to keep from fouling them.

The best procedure is to lay the sand first, and to pour the cement over it. The two are mixed dry by turning them over with a shovel or a garden hoe until the mass has a uniform color. The aggregate is then added and the mixture again turned over.

Water

Fresh water at or above 70o should be used. It should be clean and free of oil and vegetable matter. In an emergency, salt water may be used. The amount of water should be just enough to make a sticky plastic mass of mud that will hang together, but which can still be poured through a large tube. Too much water reduces the strength and watertightness of concrete, and encourages washing away. About 4½ gallons of water for each 100 pounds of cement will make a satisfactory concrete.

Calcium Chloride

Calcium chloride generates heat upon contact with water, and thereby facilitates the setting of concrete under water. Use two pounds of calcium chloride for each 4½ gallons of water, dissolving the calcium chloride in the water before the latter is poured into the dry ingredients.

Prompt Application

Concrete should be deposited promptly after it is mixed. For a large job it may be advisable to have two mixing boxes, staggering the batches so as to have a steady flow of fresh concrete.

Depositing Above Water

In depositing concrete above water it is usually necessary to build a form or cofferdam to retain the concrete while it is setting. Frames, bulkheads and other parts of the ship's structure may be used as part of the form. Place the concrete in the form with a shovel or a bucket. Do not drop or throw the material in loosely, as that would tend to entrap air pockets. Press or tamp the concrete tightly into the form. If the concrete settles rapidly, without air pockets, it is a sign that you have used too much water. If time and conditions permit, it is advisable to scrape and to clean metal surfaces against which concrete is to be deposited.

Depositing Under Water

Concrete is usually deposited under water by the use of a chute made of watertight pipe or waterproofed canvas. It may also be made of ½" lumber. The chute, or tube, should be large enough to allow a free flow of the concrete. An inside diameter between four and six inches should suffice. The upper end may be made much larger, to serve as a sort of hopper. The tube is used to avoid dropping the concrete loosely through the water and thereby wasting much of it. The lower end of the tube should be right down in the mass of deposited concrete.

Restrict Leaks

At best, using concrete for under water leak stopping is difficult. The heavier materials will sink to the bottom, but the finer particles tend to wash away--especially the cement. Therefore, every effort must be made to prevent the flow of water through or across the mixture while it is being poured and after it is in place. As a preliminary measure, try to stop or to restrict the flow of water through cracks or holes that are to be patched. Mattresses, pillows, oakum, wedges, plugs and similar materials may be used for this purpose.

Forms

After the leaks have been restricted as much as possible, erect a form or cofferdam around the damaged area. Steel plates or lumber (preferably tongue and groove) may be used for this purpose. The form itself should be tight, and it should fit snugly against decks and bulkheads. This is to reduce the washing effect of water. The form is necessarily left open at the top for depositing concrete.

Put the chute well down into the form, with the lower end practically buried in concrete. Fill the chute to a height above the water level, and move the chute along the bottom, gradually depositing concrete as you move along. Continue shoveling concrete into the tube. Do not let the concrete pile up at any one point and then try to relocate it with a shovel or a hoe.

In several cases it has been found advisable to install a pipe running from a point near the leaky seam or hole to a point outside the form. The pipe carries away harmful water while the concrete is setting, after which the pipe can be plugged.

Use of Bags

Concrete may also be deposited under water by means of bags of about one cubic foot capacity. The bags may be made of a coarse cloth, such as burlap-- the common gunny sack. After filling a bag about two-thirds full, tie it securely. The bags of concrete are laid in a criss-cross manner, so that the whole structure is interlocked.

Bagged concrete can be used to great advantage in stopping deck ruptures in flooded compartments, after which you can pump out the water. It may be necessary to provide some support in the form of angle irons, steel plate or timbers, to keep the bags from falling through before the concrete sets.

Setting Time

The average initial setting time of most High Early Strength Portland Cement under water at a temperature of 50o Farenheit, and in depths up to fifteen feet, is between 30 and 45 minutes. However, the concrete will not have any appreciable strength until it has set for several days, maximum strength being attained when it is about four weeks old.

Seawater

Sea water may be used in mixing concrete when fresh water is not available. It speeds the initial set. It is important to remember that if a smaller amount of water is used, the time of setting will be reduced. This, however, results in a stiffer mix, which is more difficult to handle.

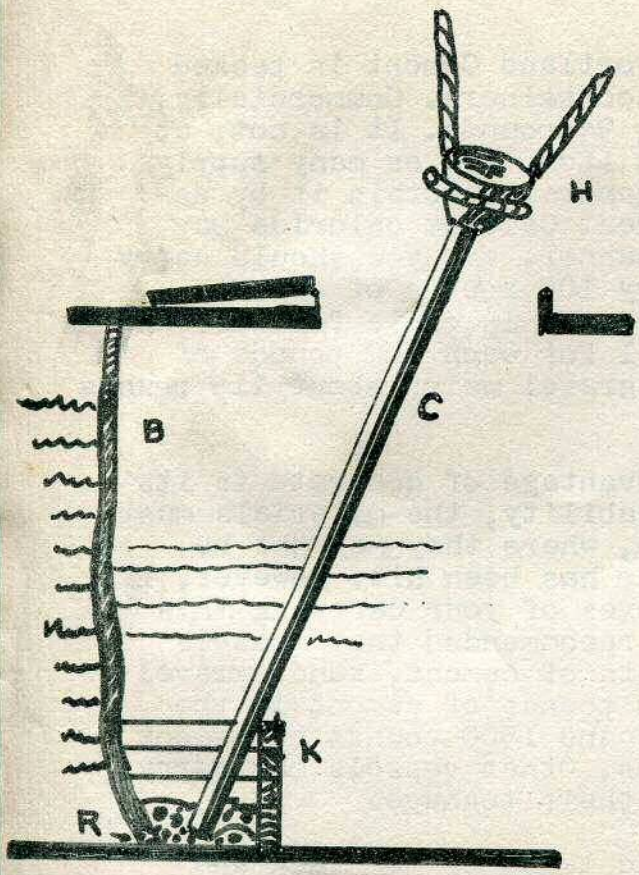
Obtaining Materials High Early Strength Portland Cement is packed in 25 or 50 pound sealed containers. Commercially, it comes in bags weighing 94 pounds. It is not, at present, a standard stock item, but as many supply firms carry it, you can generally obtain it by demand through Central Stores. Calcium chloride may be obtained in the same manner, and you should carry two pounds of it for every 100 pounds of cement carried. You should also carry 1½ cubic feet of sand and 2 cubic feet of gravel for each 100 pounds of cement carried. Sand and gravel weigh about 115 pounds per cubic foot.

Disadvantages The outstanding disadvantage of concrete is its weight. For reasons of stability, the materials must be stowed low in the ship, where they may not be accessible after your ship has been hit. However, if your type commander approves of your carrying this additional weight, it is recommended that vessels carry proportionate amounts of cement, sand, gravel and calcium chloride, 200 pounds of cement in the case of destroyer escorts and 1500 pounds of cement in the case of battleships. Other vessels may carry amounts proportionate to their tonnage.

Reinforcing Dry concrete has a bad tendency to crack and fracture under stress, especially if the mixture is not rich enough in cement. Unsupported, it may break away from the place where you have laid it.

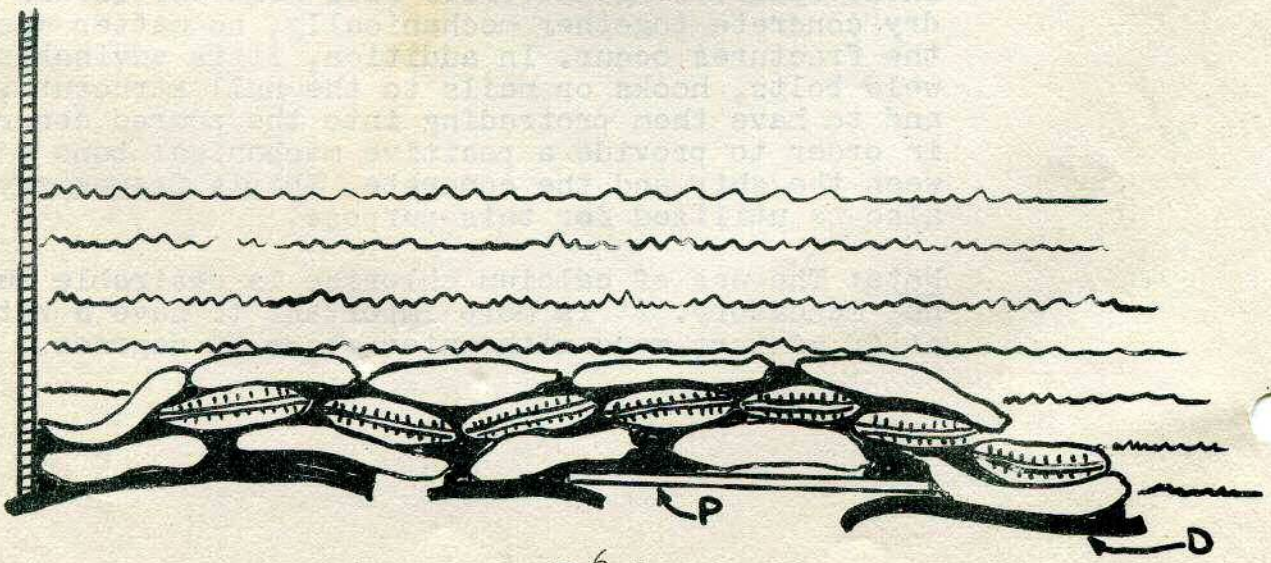
It is therefore desirable to bury metal rods or heavy wire mesh in the concrete as it is poured. These reinforcing materials will hold the blocks of dry concrete together mechanically, no matter where the fractures occur. In addition, it is advisable to weld bolts, hooks or nails to the hull structure, and to have them protruding into the poured concrete, in order to provide a positive mechanical bond between the ship and the concrete. Ship's frames may also be utilized for this purpose.

Note: The use of calcium chloride is desirable but not mandatory. It is more important to have a rather stiff mixture made with water above 70 degrees.

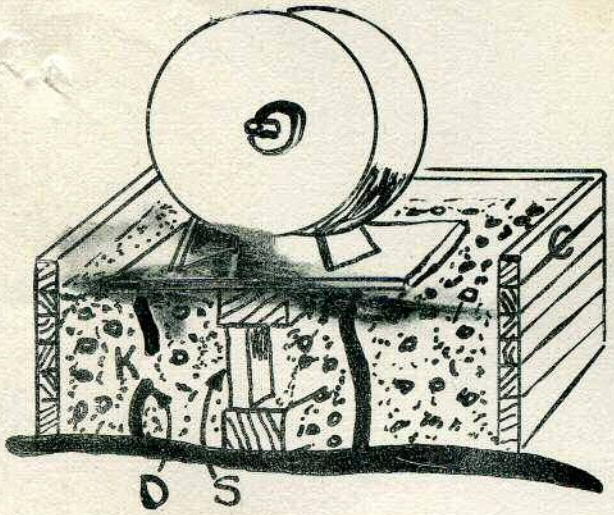


Bulkhead "B" is ruptured at "R". A cofferdam "K" is built around the damaged area. Concrete poured into hopper "H" flows down through chute "C" and fills the cofferdam. It may be necessary to put wedges or pillows into rupture "R" to keep the concrete from walking through the hole, or to restrict the flow of water which would wash out cement. Keep end of tube well down into the laid concrete, as if rupture was small and being filled with tooth paste from a tube.

This sketch illustrates the use of bagged concrete to stop leaks in a ruptured deck "D". Note the use of steel plate "P" to support the bags, and how the bags are laid criss-cross.

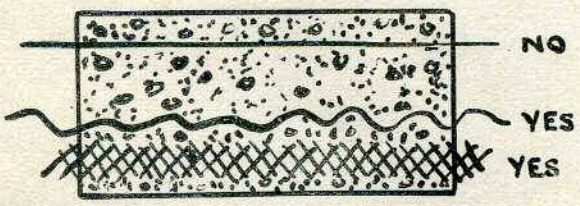


Advantage may sometimes be taken of the ship's framing or stringers to support concrete while it is setting.



Illustrating how concrete may be used to make a support for a machinery unit.

(c)= Cofferdam.
(s)= Shores.
(k)= Concrete.
(d)= Damaged support.



Smooth wire is practically useless for reinforcing concrete notched or jagged rods or expanded metal, should be used to give mechanical holding power in case the concrete fractures.