Department of Transportation
UNITED STATES COAST GUARD

NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 7-68

Subj: Notes on Inspection and Repair of Steel Hulls

1. Purpose. The attached "Notes on Inspection and Repair of Steel Hulls" is intended to disseminated to Coast Guard Marine Inspectors, Vessel Owners, and Shipyards general information relating to good practice in the inspection and repair of steel hulled vessels. This information is furnished for guidance purposes. Where specifies are given it should be understood that mandatory application is not necessarily intended. Nothing herein shall be taken as amending applicable regulations, or as prescribing or limiting the authority and responsibility of the Officer in Charge, Marine Inspection in the exercise of his good judgment.

2. Discussion. These actors were first issued in 1960 to fulfill a need for guidance material on the inspection and repair of steel merchant vessels. Experience in their use since that time has suggested certain charges which have been included in this revision. It is believed that these notes cover the more important aspects of hull structural inspection and repair. However, constructive comments and suggestions are solicited and will be the basis for such future revision of these notes as may be necessary.

3. Cancellation. Navigation and Vessel Inspection Circulars Nos. 7-62 and 4-60 are hereby cancelled.

4. Effective Data. Upon Receipt.

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Encl: (1) Notes on Inspection and Repair of Steel Hulls

ENCLOSURE (1) TO NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 7-68

NOTES ON INSPECTION AND REPAIR OF STEEL HULLS

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NOTES ON INSPECTION AND REPAIR OF STEEL HULLS

I. Purpose

(A) These notes are intended to summarize, in a general way, technical data and background information pertaining to the inspection and repair of steel vessels. They are not intended to specify the degree of thoroughness of any inspection which, of course, must be lift to the inspector. Nor are they designed to be a substitute for the exercise of good judgment in the solution of any particular repair problems. They are intended to serve the following purposes:

(1) Summarize and consolidate technical information pertaining to the inspection and repair of steel vessels.
(2) Promote uniformity in the approach to hull repair requirements among the various marine inspection offices.

II. General

(A) The performance of an adequate inspection requires a knowledge of where to look and what to look for. With respect to hull structure, the inspector is looking for deficiencies which may affect the strength of integrity of the hull to an extent which would make it unseaworthy. The major categories of these deficiencies are as follows:

(1) Deterioration
General or local
(2) Hull Defects
Fractures, buckling or other deformation, cracking or tearing, weakening or failure of fastenings
(3) Hull Damage
Such as caused by grounding, collision, the employment of the vessel, etc.

(B) While it is logical to expect more of the difficulties on the older vessels and on vessels which have seen rough service, inspection of the newer vessels is also required, because some of these defects can occur even after relatively short services. These notes detail, in Section III, some of the particular points which have been the source of trouble in the past and to which special attention should be given in carrying out a hull examination.

(C) When in the course of such an inspection, one or more of these deficiencies are encountered, the inspector must first evaluate if seaworthiness is compromised or not. This is calls for considerable discretion because the line of demarcation subject to some range of interpretation. The following factors must be weighed in making this determination:

(1) The extent and degree of deterioration.

(2) Whether the whole or in part by protective action.

(3) The period of time involved before the next scheduled inspection of the area in question. Certain areas are accessible to inspection at every dry-docking whereas other areas are only exposed during the surveys required by the classification societies. A progressing condition which may be acceptable in one area would not be acceptable in another without repair or, at least, without a pending requirement for further inspection at a prescribed future date.

(4) Whether the repair work contemplated is necessary to restore seaworthiness or is a maintenance measure to insure prolonged utilization of the vessel. In the first case, repair must be required. In the second case, the details of the condition should be reconsidered at a future inspection and, possibly, called to the attention of the owner so that he may exercise his own good judgment.

(D) Once a decision has been reached byt he inspector that repair is necessary, the specific requirement detailing the nature and extent of the work should be written. The general rule is to "renew as original", i.e., to replace the defective structure so as to restore its original design and condition. However, in cases where the necessity for repairs apparently stems from an unsatisfactory structural feature, this feature should be corrected in making the repairs. As an example, following unsatisfactory service experience, square hatch corners have been required to be modified by provision of radiused insert plates. Where such a need for design modification exists, plans covering the change should normally be prepared and approved before the work is undertaken, insofar as practicable.

(E) In some instances, the owner may desire to reduce the structural work corresponding to renewal in kind by provision o supplementary structural reinforcement. When one considers the complicated and costly nature of repairs involving extensive renewals, it is evident that consideration should be given to such alternate means of repair proposed by the owner, or by the shipyard in his behalf I they are generally in line with the procedures and methods set forth in Section IV of these notes.

(F) If the vessel is in class, and/or is assigned a load line, the nature and extent of the repairs as determined by the classification society surveyor is to be given full consideration. However, if there is a difference of opinion as to what should be required, the inspector cannot discharge his responsibility by deferring to anyone else's judgment. In such cases, he should refer the matter to his superior officer for assistance and/or decision before the final requirements are written. A working liaison between the Officer in Charge, Marine Inspection and the local representative of the classification society will generally serve to iron out such difficulties. The repair measures set forth in Section IV of these notes are to be considered as general principles rather than specific "rules" to be rightly enforced in all cases. They should be employed as a guide taking into account the interests of the ship owner while, at the same time, fulfilling the Coast Guard's statutory responsibility with respect to seaworthiness and safety of life.

III. NOTES ON INSPECTION

(A) DETERIORATION:

(1) Deterioration of the metal structure is probably the most common, single defect in steel vessels. It can be due to a number of different causes or combinations thereof including age, inadequate maintenance, working of the hull structure, chemical or erosive action of the cargoes carried, electrolysis, local wear, some improper feature of design, etc. In some cases, such as deep pitting and external grooving, deterioration is easy to detect. In other cases, such as the general erosion of age or incipient joint or member failure, it is impossible to ascertain the deterioration without actually gaging or very careful examination. In any case judgment is required to evaluate and determine if and to what extent repair is necessary.

(B) Gaging:

(1) The only practical way of Determining the degree of deterioration is to measure the thickness of the member in question and compare

it with the original thickness. This comparison is usually expressed in terms of percentage of wastage from the original scantling. Since this determination usually requires drilling of the hull or other expensive preparation, it should not, in general, be undertaken unless there is a reasonable basis for doubt as tp- the present scantlings.

(2) Thickness measurements can be made by drilling and gaging or by ultrasonic measurement. In the following remarks, the term "gaging" is meant to include both methods of measurement; however, the acceptance of ultrasonic measurement in lieu of drilling and gaging is subject to the approval of the OMCI. See (8) below for remarks specifically pertaining to ultrasonic measurements.

(3) There are two approaches to gaging. In the first, gaging is used to provide a quantitative basis for evaluating a questionable local condition. Even though this involves only limited gaging, it sould not be undertaken unless there is sufficient cause. Deep pitting over an area, holes, fractures, excessively thin edges on structural shapes, bands or belts of corrosion across bottom plating which may indicate heavy working, are all justifiable bases for requiring gaging in the affected area. However, care must be exercised not to extend the gaging so as to have it become a "fishing expedition." The ship owner should be forewarned that requirements based on a local survey of this kind may have to be extended when the plate edges in way of the renewals are examined by the inspector.

(4) Belt gaging goes far beyond the investigation of a local condition as described in the previous paragraph. It involves taking readings around several complete transverse sections of the hull including deck, sides and bottom. It is intended to furnish information which may be used to assess the average wastage of the hull envelope and its consequent effect on the longitudinal strength of the vessel. Belt gaging is a major undertaking, costly to the ship in both time and money. It should be required only for good and sufficient cause; as for example, in the following cases:

(a) A vessel coming under Coast Guard certification for the first time.

(b) A Vessel upgrading her services to a more exposed route.

(c) a vessel undergoing a major conversion.

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(d) A vessel which has had a structural failure which could be attributable to age or general deterioration.

(e) A vessel in which the general condition, as evidenced by the parameters described in paragraph (3) above, is such that there is a serious question concerning her seaworthiness.

(5) In the addition to the above, it should be noted that Section 43 of the American Bureau of Shipping Rules for Building and Classing Steel Vessels also provides guidance in the matter of gaging. At the special survey occurring approximately 8 years after build, and thereafter, surveyors may require gaging where considered necessary. At the special survey occurring approximately 12-15 years after build for tankers and 15-20 years after build for ordinary vessels, general gaging to determine the thickness of shell, deck, and other main scantlings is required. The results of these gagings are submitted to the American Bureau technical office for evaluation. The foregoing provisions apply to vessels on salt water. The American Bureau Rules contain apply to vessels, the necessity for gaging being left entirely discretionary with the surveyor. Where possible, to minimize expense to the owner, the inspector should witness such periodic surveys and make use of the results obtained.

(6) Belt gaging may clearly indicate that extensive replacements are required. In this event, a requirement to renew as original with the associated plan approval may or may not be appropriate. Frequently in lieu of removals, strapping or partial renewal to heavier scantlings may serve to restore the required strength. This should **not** be resolved locally. The record of the gagings and the proposal for repair should be submitted for approval to the Commandant (MMT) branch. It is especially important in such cases that the inspector validate the gagings and clearly indicate he considers them to be representative of the general condition of the ship. The technical staff can evaluate the readings which are provided; but only the inspector, who has seen the vessel, can state that the readings are representative.

(7) For belt gaging to be of value in determining the average condition of the vessel, the location of the belts on the vessel and the points to be gaged within the belts should be selected by the inspector. Experience is required to make sound judgments in this regards. The following are some of the important factors which must be considered:

(a) The belts should be located in sections of the hull wherein the seaworthiness is most in question. For example, in a light products tanker, a belt gaged in way of the machinery space or a cofferdam would probably not be representative of the condition prevailing in the cargo tanks. Similarly, in a dry cargo vessel, a belt across the double bottom in way of a salt water tank would be more meaningful than a belt in way of a fuel oil tank.

(b) The locations of the individual readings within the belts should be chosen with a view towards determining the average remaining place thickness not towards finding the unique spots of minimum thickness. However, the worst single spots should be sought out first to determine whether or not more extensive gaging is justified. In many instances, it may be necessary to obtain more than one reading to determine the average remaining plate thickness. In such cases, the inspector, based on his personal observation, should record only one figure which he feels to be truly representative of the plate concerned.

(c) Inconsistencies should be explained in the records of gaging whenever possible. For example, a previously installed local renewal in the belt is not representative of the general condition of that strake. The reason for the anomalous reading should be noted or, preferably, the belt should be shifted to provide a reading which is representative of the strake. Similarly, if a reading local strength, the extent of the renewal should be indicated. Credit towards longitudinal strength could be given to extensive renewal of the strake, but not to a localized replacement.

(d) In the case of longitudinally framed vessels, the belt gagings should include readings on all deck, side and bottom longitudinal and on the plating of the longitudinal bulkheads. Readings on internal should be taken on both the webs and the flanges and should be so identified. These gagings may be taken with a caliper.

(8) Ultrasonic thickness measurement may be used in lieu of drilling and gaging when authorized by the local Officer in Charge, Marine Inspection. When this method is used to comply with a specific requirement for gaging, the inspector should approve the choice of locations and witness the reading. Also, he should satisfy himself as to the accuracy and adjustment of the instrument by comparing results wih the actual gaging of test holes. Test pieces may be used to check the calibration of the instrument; however, care must be taken that the relative ease of taking accurate readings on a prepared test piece does not result in unwarranted confidence in the accuracy of readings taken on the vessel. Surface preparation to receive the probe, operator technique and competency, and condition of the "opposite" side are among the many variables which can affect readings. Therefore, comparing preferable to complete reliance on test pieces for instrument calibration.

(9) After the gaging have been recorded, comparison with the original scantlings can be made only by referring to the vessel's construction plans. The "Shell Expansion" is the most useful plan for this purpose; however, the "Midship Section" is also useful. To facilitate evaluation of results, a "Percentage of Wastage" nowograph is appended to these notes.

(C) CORROSION LIMITS - GENERAL

Service experience of the classification society, which forms the basis for their rules on the construction of ships, indicates that for most portions of a vessel, without other weakening factors, a local thickness deterioration of up to about 25 percent may be accepted before replacement is necessary. This is based in part on the condition usually found aboard ship that all structural members do not deteriorate uniformly. This means, in the application of the percentage, considerable judgment is called for depending upon the location and extent of wasted material. Localized wastage of some portions of plates or structural members in excess of 25 percent may be accepted in many cases, if the condition of the adjacent material is sufficiently good to maintain an adequate margin of strength. In these instances, careful attention should be given that a local deterioration does not result in a radical change in section or general weakening which could act as a notch. On the other hand, there may be instances where either general or localized wastages of less than 25 percent would call for replacement of material. These exceptions are dealt with in paragraphs (D) through (G) and in the discussions of the individual major hull components.

(D) OVERSITE OR UNDERSIZE SCANTLINGS

There are some vessels in existence which were built to scantlings differing from those required by the current American Bureau of Shipping Rules. In evaluating the necessity for replacing deteriorated structure in such vessels, allowance needs to be made for the fact that the vessel was built to scantlings differing from the current requirements. Where the original scantlings are known to be in excess of requirements, a corresponding increased corrosion allowance is acceptable. Conversely, where original scantlings are below requirements, the maximum acceptable deterioration is reduced. As an example, for converted LST's , originally built to less than commercial scantlings, ¼" deck plasting, 3/8" stringer and sheer strakes, and 3/8" bottom plating including the bilge strakes should generally be replaced when wasted more than 15 percent. In dealing with ex-LCI's and other lightly built vessels converted to merchant service similar reduced corrosion allowances are in order. Also, individual members may sometimes be made oversize to compensate for some other feature of the overall design. In such a case, an extra corrosion allowance would not be justified. Because of these ramifications, it may not be practical for inspectors to determine whether a vessel's original scantlings are under or over requirements. When it is believed that the original scantlings may have been light, the matter should be referred to the field (mmt) office or to the Commandant (MMT) before a full corrosion allowance is permitted. On the other hand, if the owner requests an increased corrosion allowance because of oversized scantlings, he should offer suitable verification. Proper notation on the original plans of the vessel or documentary evidence from the classification society would be acceptable for this purpose.

(E) SPECIAL COATINGS

Recent advances in protective coasting technology have given promise that corrosion in ship steel may be virtually eliminated. Based on this, ships constructed since 1965 have had the option of building the scantlings which are, in general, 10% below the scantlings tabulated in the American Bureau of Shipping "Rules for Building and Classing Steel Vessels", provided acceptable special coatings have been applied. In all such cases, the approved hull structural plans clearly indicate such reduction by showing, for each plate and structural shape, both the required tabular scantling and the permitted reduced scantling. For example, a structural shape would be indicated on the plan as follows:

16" x 4" x 20.4# FLG PL

16" x 4" x 17.85# FLG PL

Normally, painting of the hull structure has not been the subject of Coast Guard requirements. However, in the case of vessels which have been allowed to have reduced scantlings on the basis of special coatings, it is a valid concern of the Coast Guard inspector to insure that such coatings are maintained. If corrosion has occurred, evaluation of the degree should be referred to the required tabular scantling and not to the as-built scantling.

(F) HIGH STRENGTH STEELS

(1) The use of high strength steels in some recently built ships introduces new problems which must be carefully considered when evaluating structural renewals or repairs. These steels offer significant advantages in saved weight and their use permits thinner sections to be used in highly stressed areas which would otherwise require excessively thick sections of conventional ship steel. However, the thinner plating and sections of high strength steel are not as forgiving of poor design as the heavier sections of mild steel. Special attention must be paid to the possibility of buckling and detailing in the design and careful fabrication becomes a must. Also special procedures are required for welding. These are discussed in Section V.

(2) Structural renewals in areas where high strength steels have been used must be made with the same high strength steel. In some cases, an equivalent grade may be substituted. Also, repairs to high strength steels must be made in accordance with the specified procedures. A problem arises because high strength steels are not visually distinguishable from ordinary ship steel. The use of such steels should be indicated on the vessel's Certificate of Inspection and by the entry "special material" in column (4) in the "RECORD" of the American Bureau of Shipping. Further, both the American Bureau and the Coast Guard have requested that vessels utilizing high strength steels in their construction shall retain on board structural drawings identifying the special steel, indicating where it is used and specifying, in detail, the required welding and fabrication procedures.

(3) In any larger vessel built since 1964, renewal or repair in way of the main hull girder should not be undertaken without first examining the vessel's approved structural plans to confirm if high strength steels were used. If so, every care must be exercised to use the correct steel for renewals and to adhere to the specified procedures for both renewals and repairs. It is well to note that there is no such thing as a "minor" repair where high strength steels are involved. Further information on the uses of high strength steels is available from Commandant (MMT) or field (mmt) office.

(G) ALTERNATIVES

In some instances, owners may desire to install supplemental structural reinforcement rather than replace deteriorated material. This may be feasible, but since it constitutes a modification of design, plans detailing the proposed changes should be approved before the work is carried out.

(H) DECK PLATING

Deck plating comprises a highly stressed portion of the hull girder and is of critical importance to the longitudinal strength of the vessel. Accelerated corrosion may be expected in the deck because it is subject to mechanical abuse from deck cargo, hatch beams and repeated scaling. Also, it is always exposed and frequently awash. Because of this, the deck plating, especially in the midship's half length, should be carefully examined for cracks, leaks, or signs of excessive wear. The corners of hatch or other deck opening, the corners of deck erections, pads, or other items producing discontinuities or hard spots should be examined for evidence of cracking Whenever practicable, the detail concerned should be eased and made less abrupt when repairs are made. In the case of riveted construction, special attention should be paid to the riveting of butts. Discovery of working or loose riveted butts calls for prompt corrective action. This may be evidence of cracking at the rivet holes not yet sufficiently extensive to extend beyond the rivet head. Cracking of the plate will, in general, call for replacement of that portion of the plating. Buckling of deck plating is uncommon; however, the use of thinner high strength plating increases the likelihood. Any such buckling can seriously impair the strength of the vessel and calls for corrective action.

(I) DECK LONGITUDINALS

In tank vessels the corrosive deterioration of deck longitudinals may be much more rapid than that of deck plating. These longitudinals are necessary to support the deck plating so that it can carry local hydrostatic loading, to provide panel stiffness to the deck plating so that, as a part of the hull girder, it can carry compressive loading without buckling, and also to directly contribute to the hull girder stiffness and strength. Because the relative importance of these factors may be different when dealing with different designs, it is very difficult to lay down any generally applicable wastage limits. However, for the usual proportions of longitudinals to plating and usual spans of a tanker of about T2 size, deterioration of some deck longitudinals up to a maximum of about 40 percent or about .18" wastage, whichever is the lesser, may be accepted provided the average deterioration is not more that about 30 percent or about .14" wastage, whichever is the lesser. For a single voyage, maximum deterioration of some longitudinals as high as about 50 percent or about .22" wastage has been accepted. The above applies to longitudinals fabricated from structural shapes such as inverted angles or T bars. In the case of flat bar longitudinals, the critical in compression. Consequently, not more than about a 20 percent corrosion allowance should be permitted. Additionally, flat bar longitudinals should be faired or replaced if they are distorted or buckled to any degree. In the case of river tank barges not carrying any deck cargo, general deterioration of deck longitudinals up to about 40 percent may be accepted. Since the obvious necessity for maintaining oiltightness does not apply to the rake ends, they tend to be neglected. This should not be permitted since the rake ends provide the major buoyancy of the vessel and are, therefore, vital to seaworthiness.

(J) KEEL PLATING

In recognition of local strength factors and also the additional corrosion to which keel plates are subject as a result of being unavailable for painting when sitting on keel blocks in dry-dock, keel plating is normally of greater thickness than the balance of the bottom plating. Taking account of the fact that a large part of this extra thickness may be regarded as an additional corrosion allowance, it is generally satisfactory to defer the

replacement of keel plating until the wastage is somewhat more than would otherwise be considered acceptable. In determining that amount of such extension, consideration should be given to the condition of adjacent "A" strake (s). If the adjacent plating is in good condition and does not require replacement, the keel plating may be accepted provided the effective remaining thickness is not less than approximately 75 percent of the original thickness of the adjacent strakes and provided it is not buckled or otherwise damaged. If the adjacent plating is wasted so as to, itself, require replacement, it is generally wise to replace the keel plating even though it may be wasted no more than about 25 percent of its thickness.

(K) BOTTOM PLATING, INNER BOTTOM PLATING AND BOTTOM INTERNALS

(1) The bottom plating complements the deck plating as the lower flange of the hull girder. As well as sustaining a major portion of the hull bending moment, it is subject to increased stress due to water pressure. Its strength may be reduced either by general or localized corrosion and by buckling. In view of the prime importance of this plating, the maximum average reduction in thickness to be permitted in about the midships half-length is about 20 percent. If the wastage exceeds this amount the plating should be renewed. Alternate measures or means of reinforcement can be considered but since they would constitute a major change in the design of the vessel, plans for same should be submitted for approval to the field (mmt) office or to the Commandant (MMT). If after consideration of the bottom shell plating with regard areas or plates requiring attention, these may be dealt with on the basis of a maximum average wastage of about 25 percent from original, provided the plates and supporting structure are otherwise in satisfactory condition. Welded butts which exhibit excessive wastage (grooving) as compared to the balance of the plate should be rewelded after excavation to sound metal.

(2) Joggled lapped seams and butts are particularly prone to excessive local deterioration because of the flexing which may take place at such joints and because they provide a pocket in which corrosion may develop. Accordingly, when inspection plating containing joggled lapped joints, it is important to check the condition of the joint itself and particularly the plating thickness in way of the joggle. Renewals should be in accordance with Section IV (B) of these notes.

(3) Unfair or set-in plating is common forward. A fair degree of deformation of the hull plates in the forward portion of a vessel ordinarily may be accepted without resulting in serious impairment of structural strength. However, for transversely framed ships, severe buckling or set-in condition of bottom plating within approximately the midships half length can seriously impair strength. In general, the greater the athwartship extent of buckling the greater the impairment in hull strength. Any appreciable buckle of sufficient athwartship extent to cross a center vertical keel or inner bottom girders is serious. Such a buckle should be corrected by replacement of plating and the buckled portions of girders. If there is no evidence to indicate the buckle was caused by grounding or other excessive locl loading, or is associated with excessive wastage, it may be an indication of need for providing additional stiffening. In such instances, the Commandant (MMT) or field (mmt) office should be advised of the circumstances and proposed corrective measures. Buckles of shorter athwartship extent may also require correction, depending upon the depth or height of buckles the number of buckles, and their relative locations. For instance several bottom buckles within the same frame space are more serious than the same number of the same size buckles distributed in the random manner. Localized transverse bands of accelerated corrosion or grooving may be found in association with buckles. These are indicative of localized excessive stress which experience indicates may lead to cracking. Consequently, plating replacement may be called for even though the deterioration may be less than 25 percent. In such case it is usually sufficient to replace less than a full plate.

(4) In the case of riveted construction, bands of stress corrosion may be observed, mostly immediately adjacent to the riveted lapped butts, even where the plating surface is generally quite fair. Experience has shown that cracking develops in these areas. Since such cracks are in primary hull girder material, their occurrence must be regarded as a very serious matter. Where zones of serious corrosion are noted, appropriate preventive action in the form of plating replacement should be taken before any actual cracking develops. In making such replacements, as in the case of welded construction, renewal of less than a complete plate is acceptable if the condition of the balance of the plate is satisfactory. The butts of such renewal inserts should be flush welded, care being taken to insure 100 percent penetration. Originally riveted seams should be riveted, with sufficient existing riveting adjacent to welds released and re-driven to insure 100 percent sound riveting.

(5) Tank tops are considered in the computation of scantlings for load line assignment both by ABS and the Coast Guard and must of necessity be maintained

in reasonable condition consistent with their inclusion in the section modulus, there are two other structural functions which are equally important. First, without support by the bottom transverses and longitudinals, the bottom plating has insufficient rigidity to carry compressive loading and tends to buckle when the vessel is subjected to a hogging bending moment. Secondly, the entire bottom structure has the function of resisting water pressure when the vessel is in ballast and of bearing the weight of cargo when loaded. It must be maintained in efficient condition to safely perform these functions.

(6) A moderate amount of buckling of tank tops is acceptable provided buckling is confined to the plating between transverse and longitudinal girders. Fairness of transverses and girders may be checked by sighting or use or a taut line along the frame and girder lines. If floors of girders are found to be appreciably deformed or cracked they should be repaired or replaced. In doing such work, obvious defects such as sharp cornered or raggedly cut lightening holes or other cut-outs should be made fair. Buckling of floors or girders not associated with grounding or other external damage may be an indication of structural weakness and need for structural modification or reinforcement, in addition to repair. In riveted construction, loosening and failure of the riveting within the double bottom may be observed. It is apparent that once the fastening begin to fail, the stress levels and corrosion rates in adjoining structure increase rapidly. The practical solution to this problem is the early detection of these fastening in order that the existing material in the vessel can be made to perform to its capacity. The old adage that "a stitch in time serves nine" is certainly applicable here.

(L) **SIDE PLATING**

In the side plating the strake "between wind and water" is an area which is highly susceptible to corrosion. The maximum general wastage is to be expected in the area. Also, serious localized corrosion may often be encountered in way of overboard discharges and scupper openings. The latter may usually be repaired by the use of insert plates rather than by plate renewals. Suitably attached wastage doublers may be used on sound plating as a means of protection.

(M) **LONGITUDINAL AND TRANSVERSE BULKHEADS**

Cargo hold bulkheads are usually not troubled by excessive corrosion except along the lower boundaries and in way of bilge wells. Such corrosion is a local condition and should be repaired by the use of insert plates or well attached lapped plates of sufficient material remains for proper installation. In the case of the longitudinal and transverse bulkheads in a tankship, especially where light products have been carried, corrosion is to be expected. Wastage up to about 35 percent may be accepted provided there is no evidence of deformation when subjected to a hydrostatic test. The top strake of bulkhead plating in a tankship is usually made heavier in anticipation of the increased corrosion to be expected in this area which is usually wet but not submerged. Therefore, when referred to the originally scantling, an increased allowance for deterioration may be permitted. Applying a 35 percent wastage to the original scantling of the next to topmost strake will serve to establish the minimum thickness acceptable in the topmost strake.

(N) FRAMES, BEAMS AND STIFFENERS

Generally the flanges and portions of the webs next to the flanges are more highly stressed, more subject to mechanical damage, and corrode faster than the balance of the member. If excessive wastage has occurred but is limited to the flange and outer portion of the web, cropping of the defective section rather than complete renewal may be permitted. Details on this are included in Section IV. The use of short lengths of flat bar welded in way of deteriorated material is not an acceptable repair. Full length flat bar doublers may be satisfactory in some cases but this represents a change in design so the installation should be made in accordance with an approved plan. Notwithstanding the above, flat bar doublers are never acceptable on internals within the tanks of a tankship because of the danger of gas entrapment. Often times, projecting frames or beams are deformed due to hook pulls, damage bu cargo, etc. Such conditions, if they are scattered and not serious to the extent that the members are town or broken loose from their fastenings, may be permitted to remain until there is other work required in the area.. However, this principle would not apply to structural columns

IV. NOTES ON REPAIRS

(A) FRACTURES

(1) Fractures in hull plates, etc., usually start in localized, highly stressed areas. In the preliminary inspections, the first thing to be determined is whether or not the fracture started in a notch or sharp angle (stress raiser), and if it did, to eliminate this feature.

(2) Major fractures. When major fractures occur and where considerable material is to be removed and new plates, frames, etc., are to be inserted, the repair may involve appreciably more restraint and less favorable welding conditions than for new constructions. The type of repair to be made and welding procedure to be used should be carefully evaluated.

(3) Cracks. Cracks in the deck or in the bottom within about the admidships half length and which originate in structural discontinuities will frequently require the fitting of a suitable repair insert in order to minimize weld restraint in the local area of stress concentration. Cracks which have opened too far or are too irregular to permit satisfactory weld preparation, or which are located so that access is insufficient for producing sound, full penetration welds, also call for the fitting of inserts. Evidence of deterioration or poor quality of the fractured plate are additional reasons for plate replacement.

(4) As previously noted, localized bands of accelerated corrosion should ordinarily be taken as evidence of such deterioration and the affected portion of plating replaced. Where none of the foregoing conditions exist, the crack may be repaired by welding without replacement of plating.

(5) In repairing cracks which do not involve steel replacement, the following procedure should be followed:

(a) Locate the ends of the crack; and approximately two plate thicknesses beyond the end, drill a hole to prevent its extension. The use of dye penetrant or other NDT method is desirable to locate the ends of the crack does not extend beyond the holes. The diameter of the drilled hole should be about the

same as the plate thickness. Then, V out the crack by chipping or gouging to an accepted edge preparation for welding plates of the particular thickness involved.

(b) Gas free, remove ceiling, etc., as necessary to provide full access to both sides of the crack. Thorough inspection of both sides of the crack should always be carried out.

(c) After V-ing out, if a crack has a root opening too wide for closing with the first bead, do not draw the edge of the plate together by means of a steamboat ratchet or other means preliminary to welding. Instead, build up the groove with light beads until a groove of usual proportions is obtained or used a backing strip. Backing strips should be removed followed by back side chipping and welding.

(d) Where the crack in the plating crosses stiffeners, framing or girders, the welds connecting these members to the plating should be released. This should be done by burning through the weld for a distance af at least 6 inches on each side of the crack before welding of the crack is commenced. In way of gunwale or hatch side assemblies, it may be desirable to increase the length of release.

(e) If the crack extends into the framing member, it should be suitably prepared and welded. If the resulting butt is welded after the plating or poor accessibility exists, the butt in the frame should be smoothly scalloped out adjacent to the plating.

(f) Special care should be taken in the repair of surface cracks. Care should be taken that the defect is completely removed by grinding or other suitable means. In that such a procedure may easily mask cracks by the "peening" effect, the use of a NDT method such as magnetic particle may be useful in detecting any remaining subsurface defect.

(B) REPLACEMENT OF AND WORK ON SHELL AND DECK PLATING

(1) The following precautions apply to repairs or alternations on both riveted and welded hulls:

(a) Sheer strake. The sheer strake, insofar as practicable, should be kept clear of welded fittings. Where there is no alternative but to make attachments in this region, brackets, as applicable, and at least 150°F. preheat should be maintained during welding. However the use of preheat may ordinarily be omitted if low hydrogen electrodes are used. The upper edge of the sheer strake should be fair and smooth, i.e., free of notches, nicks, and cuts, weld craters, and any irregular edge burning. Because of the change in ship steel requirements which became effective at the time, the foregoing precautions are particularly applicable to ships built prior to 1947.

(b) Stringer plate. Insofar as practicable the stringer plate should also be kept free of welded attachments.

(c) Welding of deck fittings. Were heavy deck fittings, such as chucks, bitts and cleats, are to be welded to the strength deck, pre-heat of at least 150°F should be employed during welding of low hydrogen electrodes should be used. Such heavy fittings should only be installed in accordance with approved plans. Ends of deck fittings should be kept well clear of deck butts and seams. When a number of fittings are installed on deck, positioning them in a direct line athwartships should be avoided. Also, if they are required to be in a longitudinal line, there should be sufficient interval between each so as to avoid creating areas of high stress concentration in the plating between the fittings.

(d) Replacement of plates having joggled lapped seams and /or butts should be made, whenever possible, with flush seams and butts. A typical method is shown on the following page:

(insert graph)

(C) **INSERT PLATES**

(1) In welded construction, repairs involving less than a full plate should generally be made by means of an insert plate installed in accordance with the following principles:

(a) While less than complete plates may be replaced, the lines of cut and new welding should, as far as practicable, lie in existing lines of welding. Inserts should ordinarily cover at least one frame space.

(b) The existing plate should be cut back to good material. (No less than ¾ thickness of plate being inserted.) The existing plate edge and the internals in way of the cut-out should always be examined before the insert is installed.

(c) The shipfitting and plate edge preparation should be such that welding grooves of proper proportions are provided so that acceptable welds can be made.

(d) The weld metal of intermediate passes on butts and seams of restrained insert plates may be peened. The finish pass should not be peened but may advantageously be made using low hydrogen electrodes.

(e) To minimize locked-in stresses when installing an insert plate, it is necessary to ease the restraint impose by the surrounding structure. First, holes should be drilled as shown below to reduce the likelihood of cracks occurring at the ends of the slots. The adjacent plating should then be slotted as shown below. Butts 1 and 2 can be welded first rather than concentrating it at the immediate boundaries of the insert plate. Rounding the corners of the insert plate, not in way of existing seams or butts, is an acceptable alternative.

(insert graph)

(f) In certain cases, a welded lapped patch plate may be used in lieu of an insert plate for the permanent repair of small damaged areas which lie wholly within an individual panel of plate. However, except for temporary repairs, their use should not be permitted in the strength deck, bottom or shell plating. Patch plates are also inadvisable in areas of high corrosion. In making the installation, the old plate should be cut away to a sufficient thickness of sound metal so that the existing metal at the edge of the patch is at least as good as would be required if an insert were used. If the opening required to achieve this exceeds that appropriate to the use of a patch should be used. Patch plates should be continuously fillet welded both inside and outside. In order to reduce heavy stress concentrations in the vicinity of path plates, such plates and the holes which they cover should have their corners rounded to a radius at least equal to one eighth of their transverse dimension or three inches whichever is the greater.

(insert graph)

(D) WELDED DOUBLER PLATES

(1) A welded doubler plate is not, in general, considered suitable as a permanent repair measure for the main hull girder. Its use does not insure continuity of strength which is achieved by the installation of insert plate in the same location. Also, when a doubler is attached to deficient plating, its very presence creates a discontinuity which may induce rather than prevent a structural failure. Additionally, where doublers have been used, they tend to proliferate as randomly-placed patches which often serve only to cover up the deficiencies which would otherwise indicate the true condition of the hull.

(2) Doublers may properly be used to provide local reinforcement at hatch corners, overboard discharges, seachests, mast or kingpost foundations, etc. They may also be used in accordance with approved plans, in the form of strapping fitted to increase the hull girder strength and stiffness. Where so used the plating to which they are attached should be in good condition to insure efficient attachment, bu fillet welding along the edges. Plug welding, in the body of the doubler, can be used. The corners of the doubler should be tapered and well rounded.

(3) Doublers may be accepted in non-strength areas where their purpose is essentially to restore waterlight integrity and local strength. Such areas include:

(a) deck plating well inboard between cargo hatches

(b) house tops and superstructure decks except the first deck above the main deck in vessels with long superstructures

(c) forecastle decks and poop decks limited to approximately the forward or after one-tenth length of the vessel

(d) platform decks

(4) Even in these locations, doublers should not be permitted where special local strength is required. For example, the plating forming the house top of a small deck house is not involved in basic hull strength. Repair by doubler would be perfectly acceptable if the deck house served as a bosn's locker or the plenum of a ventilation system. However, if the house top plating tied together the framing intended to fix the position of a mast or kingpost, a doubler patch would not be permissible. Another example in the same category is the superstructure deck plating in way of a lifeboat installation.

(5) When a doubler is deemed appropriate and is installed over a crack, the ends of the crack should be drilled and, if possible, the crack should be veed and welded.

(6) On vessels without double bottoms operating on protected waters or in other similar circumstances on such vessels, doublers may be accepted for repairs in way of engine or boiler rooms where it would be necessary to remove heavy equipment, etc. in order to provide access for plating replacement. However, in such cases, care should be taken that existing plating has enough thickness for efficient attachment.

(7) Doublers on tank vessels in way of cargo or fuel tanks are a special problem. The interface between a doubler and the plate beneath can constitute a gas pocket which is hazardous and completely inaccessible to gas-freeing procedures. Doublers should not be permitted in such locations except as detailed on approval plans.

(8) Plan approval is usually not necessary for installations made in accordance with paragraphs (3) and (4) above. However, a record of each installation, including its size and location, should be maintained in the vessel's inspection file.

(E) CROPPING AND RENEWING

(1) In the case of structural members such as frames, beams, stiffeners, etc., it is a practical repair measure to crop out the distorted or wasted section of the member, the outer flange for example, and replace with new material. Where this method is used, the following conditions should prevail:

(a) There should be sufficient material in the remaining portion of the member to permit should attachment of the new metal.

(b) The new portion should be in good alignment with the adjoining old portion. Particular care should be exercised in this regard in way of flanges.

(c) There should be sufficient clearance to permit the making of good welds. If this is not the case, the member should be renewed.

(d) If the attachment of the member to the adjoining plating is by riveting, the joint will have to be checked for tightness and corrected as necessary after completion of welding.

V. WELDING

(A) GENERAL

Section 26, Parts I and III of the American Bureau of Shipping Rules for Building and Classing Steel Vessels contains the requirements and instructions for the production of acceptable hull welds and the qualifications of welders. These rules are not repeated here because they are available to and should be used by inspectors engaged in construction or repair work. Some points which require special not are discussed in the following paragraphs.

(B) WELDERS

In view of the importance of obtaining sound welds in repair work, normally only welders qualified by the Coast Guard, the American Bureau of Shipping or the Naval Ships Systems Command (Navy Department) should be employed. In some cases, qualifications by other government agencies or fabricators may be acceptable. Cases of this nature should be referred to the Commandant (MMT) for resolution.

(C) STEEL

(1) Steel plate and shapes which are to be welded should meet the applicable requirements for structural steel for hulls as set forth in Section 39 of the American Bureau of Shipping Rules for Building and Classing Steel Vessels. Half rounds, rounds and bulb bars are frequently produced from Bessemer steel which is not permitted by American Bureau of Shipping Rules due to the likelihood that such steel may be very notch sensitive at ordinary operating temperatures.

All ship steel, including the above items, must be made by the open hearth, basic oxygen, electric furnace or such other process as may be specifically approved. The ends of half-rounds and bulbs should be kept clear of existing structural discontinuities. Half-round installations which disturb the smooth, unnotched edge of the sheer strake should be avoided. High strength steels require very special handling during fabrication. Great care must be exercised in adhering to care and use of the correct welding electrodes, and in the proper identification of the steel. The usual shipyard practices suitable for working with conventional ship steel are not adequate when it comes to high strength steel. Among the more important reasons for this are the following:

(a) Steels look the same, but when used in the design of a ship, much greater loads are imposed on the special steels; loads which probably could not be sustained if conventional steel was substituted by mistake.

(b) Welding electrodes which are satisfactory of conventional steel would not provide strength, in way of the welded connection, equivalent to the strength of the plates joined. In most cases, low hydrogen electrodes are recommended for welding high strength steels in order to avoid underbead tracking.

(c) In some high strength steels; for example, the quenched and tempered steels, a heat input during welding which would be acceptable for conventional steel, would drastically reduce the toughness of the special steel in the heat affected zone (HAZ).

(d) Also, in some of these steels, the installation of temporary clips or even are strikes on the plate can have a serious, detrimental effect.

(2) In view of the above, renewal or repairs involving high strength steels should not be undertaken without recourse to plans and procedures which have been approved for the specific installation. Further information on the welding of high strength steels available from the Commandant (MMT) or the field (mmt) office.

(D) FILLER METAL

(1) Electrodes should be suited to the steel to be welded. Except when special steels are involved or specific electrodes are indicated on approved plans, the welding electrodes should be among those listed in the current American Bureau of Shipping approved list, "Approved Welding Electrodes Wire-Flux and Wire-Gas Combinations."

(2) This list is distributed to all Marine Inspection Offices by the Commandant whenever new issues are published. It is to be noted that most of the approved welding electrodes are listed in Equipment Lists, CG-190, but this listing will be discontinued beginning with the 1968 edition. Electrodes should be kept dry while in storage. Where low hydrogen electrodes are used, it is especially important that they be de-hydrated before use. Otherwise, moisture picked up from the atmosphere alone without any direct wetting may result in very faulty welds.

(E) EDGE PREPARATION

The preparation of the edge of the base metal before welding depends upon the thickness of the plate and the design of the joint. The requirements are specified in Section 26 of the American bureau of Shipping Rules. The following are some points which require special attention:

(1) Rough or irregular preparation of the edge should not be accepted.

(2) The dimensions of the root opening should be within the specified tolerances. Excessive root face, insufficient root gap, or insufficient bevel angle will result in poor penetration. Too wide a root gap will result in difficulty in making a satisfactory root pass unless one face of the joint is first built up by welding or a backing strip is used. All examined deficiencies are readily apparent if the fit-up is examined before the welding is commented and all are correctable.

(3) The surface to be welded should be clean and dry. The includes both the base metal and previous beads of welding. A clean surface is one free of dirt, slag, oil, rust, scale, or paint.

(F) WELDING SEQUENCE

In most repair work locked-in welding stresses cannot be avoided. However, they can be minimized if some attention is given to working in accordance with a planned welding sequence. In general, this must be left to a welding engineer. But, when major repairs are undertaken, the inspector should as certain that a welding sequence has been prepared and he should check to see that it is followed on the job. Some of the fundamental considerations in this regard are as follows:

(1) It is poor practice to weld across an open butt.

(insert picture)

(2) Where extensive work is required on both sides of the vessel, it is better practice to have the welding progress simultaneously on both sides rather than to complete one side before starting the other.

(3) In general, the order of welding should be such as to allow the maximum freedom for contracting of the weldment. For example, it would be poor procedure to fix both shorter edges of a plate before welding the longer edges.

(4) Temperature is an important factor in welding. Where welding is done at temperatures appreciably below freezing, pre-heat and /or shelter should be provided to reduce the rate of chilling. More caution in this regard is necessary when welding on thick plating than on thinner plating.

For ordinary thicknesses and temperatures not far below freezing, work within a ship or on a ship's bottom within a graving dock may usually be considered as sufficiently sheltered.

(G) **PROCEDURE**

(1) Besides proper shipfitting and t4emperatures and edge preparation, there should be careful alignment of the structure. Local eccentricity in butts of intercostal longitudinal beams, girders, and bulkheads attached to strength deck and shells is conducive to service cracking. The webs of such members should be carefully aligned on both sides of the interrupting (transverse) structure before welding, and changes of girder depth and flanges occurring at the interrupting section should be provided with transition fairing.

(2) Tack welds which are used to position the weldment in the fit-up should be chipped out before making the final weld. Frequently, they have been overstressed and may contain sub-surface cracks. The welding machines employed should be adequate for the job, in good condition and operated at the correct setting for the work at hand. Butt welds, except in very thin plates, call for back-chipping with a round- nosed tool or by means of lame-gouging in order to insure complete penetration. The use of a backing strip, flux back-up, etc., are satisfactory alternatives.

(I) **Back Chipping**

(insert picture)

(II) **Backing Strip**
(insert picture here)

(H) WELDING DEFECTS

(1) Particular attention is called to weld deficiencies which can occur if correct procedures are not followed. These weld deficiencies can and do lend to cracking of the main hull girder of the vessel and are about the most effective crack initiators known. The destructive potential of the deficiencies often lies dormant for protracted periods while waiting the necessary conditions of temperature and/or service stress magnitude to trigger a crack which instantaneously propagates into a serious hull failure. Such failures can occur under fairly moderate stresses, arising from sea action or from cargo distribution alone, on a cold winter day.

(a) Sub-surface weld defects in butts and seams which include interpass weld bead cracks, slag inclusion, incomplete penetration and lack of fusion must be avoided.

(b) Slugged welds. Slugged welds involve laying welding rods, cable, bolts or other extraneous material in a welding groove and then welding over it. Such a procedure obviously creates a serious cavity in the heart of the weld which is not detectable from surface appearance. Supervisors and workmen who have been well informed as to the critical nature of such a condition are the best protection against slugged welds. Welders turning out very high footage should have their welding subjected to radiographic examination as a precaution against "slugging."

(c) Caulking of leaky or cracked welds. Caulking or peening in no way reduces the crack initiating properties of a defective weld nor does it reduce the liability of an existing crack to propagate further. Such an operation only serves to "conceal" and thereby "build" into the vessel a potential source of serious structural failure. Accordingly, all peening or caulking of leaky or cracked ship welds should be prohibited. Leaky or cracked molds should be chipped out and re-welded.

(d) Square corners. Welding into or around square corners, such as can occur in the installation of insert and doubler plates, should not be permitted for attachments to shell, strength decks or tank tops. Such square corners should be rounded to a 3 inch minimum radius. Corners of openings should be rounded to the largest practicable radius, generally not less than l/8 the transverse dimension but not ordinarily more than 24 inches. Cuts should be made either by guided burning or should be ground to a fair smooth contour. An exception to this is the welding of an entire plate section. Generally, the corners are not rounded but the seams in the adjacent plates are released as shown in the following sketch to minimize locked-in stresses and then rewelded in suitable sequence. Holes drilled as whom prior to releasing the adjacent plate will minimize the likelihood of cracks occurring at the ends of the slots.

(insert graph here)

(a) Undercut welds. Undercut butt and seam welds of shell, inner bottom and strength deck, or undercut fillet welds attaching structural members thereto, should be avoided. This is particular)y important for fillet welds near or at the end of discontinuous longitudinal members, such as bilge keels, tanker longitudinals, deck clips, or foundation members. Undercutting in these locations has contributed to complete hull girder fractures.

(f) Arc-strikes and light beads of welding. Arc-strikes and light beads of welding should be avoided on the surface of strength deck, shell or tank top plating, due to quench effect with possible subsequent crack stimulation. Arc-strikes produce hard, brittle metal locally, containing microscopic cracks. It is recommended that such areas be chipped out and re-veiled using a pre-heat of at least 150'F.

(g) Projections or cavities. Very often pads or lugs are welded to plates for the purpose of jacking the plates into alignment and afterwards are knocked loose with a sledge. Any projections resulting iron knocking off the lugs should be chipped off and ground fair if necessary. If there are any cavities these should be welded flush.

(2) Slugging, included slag, or submerged cracks cannot be determined by the surface appearance of welds. These defects, however, can seriously reduce the strength of a welded joint and can provide the starting point for serious fractures. Section 26 of the American Bureau of Shipping Rules for Building and Classing Steel Vessels provides for radiographic or equivalent inspection of hull joints at important locations. Since any joints in the hull, including the upper decks within approximately at least the middle half length may be regarded as important, this rule is considered to provide a basis for requiring random spot checking of hull welding by means of radiographic or ultrasonic techniques. Such spot checking should be accomplished to the extent determined necessary by experience in checking welding in the yard concerned. Yards should keep a record of

the work performed by each welder. Any welder found to be deliberately slugging welds should be disqualified and may be subject to criminal prosecution.

(3) When welds are checked by a non-destructive testing method, such as radiography, the question often arises as to the proper standard to apply for a rejection or acceptance criterion. Slugged welds, of course, give a gross defect indication and there is no question as to the non-suitability of such a weld. Other welding defects such as slag inclusions, porosity and subsurface cracks require algae judgment as to what constitutes an unacceptable weld. There is no simple answer. In some cases, such as a main strength highly stressed joint, a very rigid standard would be proper. In other cases, to evaluation of the design and the type of stress applied might indicate a large margin of safety exists and the acceptance criteria can safely be set lower. The following information sources offer guidance:

SSC-177 "Guide for Interpretation of NDT of Welds in Ship Hull Structures" prepared by the Ship Structures Committee

IIW Pamphlet "Radiographs of Welds"

ABS Circular No. 145, Guide for the Radiographic Inspection of Welds

ABS Circular No. 40, Magnetic Particle Inspection

SSC-177 applies only to hull welding and therefore the requirements are not as stringent as for pressure vessels.

Vl. **RIVETING**

(A) **CENERAL**

The renewal of deck and shell plating is best accomplished from an overall structural viewpoint by replacement in kind, (i.e.) riveted replacements in riveted hulls to avoid hard spots or points of high stress concentration in an otherwise less restrained hull structure. However, riveting is becoming increasingly difficult and costly. Hence, it becomes necessary to make welded repairs to riveted ships. Extensive experience and tests indicate that

the steel in the existing **riveted** ships may be more sensitive to brittle fracture initiation and propagation, when welded, than is shipbuilding steel presently being supplied under American Bureau of Shipping requirements for Classes B or C hull steel. **Because of this**, the use of welding in the repair or alteration of existing **riveted** hulls should be limited as follows:

(1) Shell and deck seams involving existing plating thicker than 1/2" should ordinarily not be welded.

(2) As previously noted, flush butts between new and existing strakes of shell and deck may be welded. Such welds must have full penetration.

(3) Lapped butts involving the use of fillet welds should not be used. Welded lapped seams may be used where plating is 1/2" or less in thickness.

(4) For greater thicknesses, replacement should be as original or the design changed so that butt welds can be employed. A typical method of doing this with in-and-out plating is shown in the sketch below. For joggled plates, see Section IV (B) of these notes.

(B) HOLE PREPARATION

Where riveting is necessary and the rivet holes are punched, the holes should be reamed in order to remove the excessively cold-worked material which can be a source of crack initiation. The holes need to be reamed between 1/16" and 1/4" depending on the thickness of plate and the diameter of the hole. In most cases a ream of 1/8" will be suitable.

(C) DETERIORATED OR MISSING RIVETS

The replacement of deteriorated or missing rivets, which were marginal in size in original construction, with undersize bolts is unsatisfactory. However, upon approval by the Officer in Charge, Marine Inspection, bolts may be used for emergency purposes if oversized and closely fitted into oversized, reamed holes. Often the ringing of rivets by means of welding is proposed as a repair measure for leaking or otherwise defective rivets. Rivets which do not completely fill and are not firm and tight in their holes fail to effectively carry their share of the load, and ringing with welding does not improve this situation. Accordingly, any ringing of rivets by welding must be regarded as a temporary measure acceptable only where not more than a few scattered frame or seam rivets are involved. Ringing of rivets by welding should not be permitted in way of lapped

or strapped butts, or for any riveting of deck plating outboard of the hatches. The use of welding in building up the deteriorated points of otherwise wound rivets is permissible, however, provided the corroded metal can be and is removed prior to the time that the building up is done.

(D) LOCK PINS

Certain types of lockpins have been accepted as a substitute for hull structural rivets. Unless lockpins are specified on an approved plan, they should not be used in repair applications without consulting the Commandant (MMT) or a field (mmt) office. See NVIC 3-68 for further information ca this subject.

VII. OTHER INFORMATION SOURCES

Several NAVICS are published or in process of preparation on related subjects. An effort has been made to avoid duplication of material; therefore, it will be necessary to consult the appropriate circular when seeking information for materials or special processes not covered by these notes. Examples of subjects covered elsewhere include:

(1) Steels for Low Temperature Service (NVIC 7-67)

(2) Tensile Fasteners (Lockpins) (NVIC 3-68)