RIVETED. STEEL CONSTRUCTION.

Over the last ten years riveting, which has and is still being used on heritage locomotives and boilers, has become more acceptable for the repairing, restoring and reconstructing ships, including those intended to carry passengers. Ten years ago the M.C.A. just accepted rivets above the waterline, today they look like accepting all riveted replicas, built to original scantlings, to carry passengers.

Today we are in a state of transition, setting up schemes for relearning old skills, and looking at new technology to see how it can improve the quality, and reduce the costs of what used to be very labour intensive operations. While this article tries to define the current situation, it is expected to be updated soon, and frequently, through the rapid evolution of skills, and techniques. While we wish to preserve the old skills and technology, of this work, we also wish to take advantage of modern technology to find more cost effective ways of doing the same jobs, which were done in the past, but with lower labour costs.

The traditional method of preparing the shell plating of a ship was very labour intensive. It involved laying off the lines of the ship on the Mould Loft floor, developing the shape and making wooden templates for each plate, and marking the position of all the rivet holes in the “outer” edges of the plate. A steel plate was marked off from the template, cut to shape, and all the marked rivet holes punched, under the “punching and shearing machine”. The plate would then be rolled to shape, and after it had been bolted up in place the holes in the “inner” plate edges would be drilled, with a hand held “Windy” drill.

Today the shape of the ship, in the form of “the lines”, and the size of the plates, in the form of a Shell Expansion, can be given digitally to a “plate supplier”, who will cut the steel plates to size, and put in all the rivet holes with a laser cutter, to within 1 mm, and then roll the plates to shape, again to within 1 m.m.. This has been the established practice for welded ships, for many years, but it has only been used successfully on a few riveted ships, and has not been adequately advertised, and would benefit from scientific development.

Similarly, for repairs to an existing vessel, instead of lifting the lines mechanically, with straight edges, tapes and levels, and making templates off the ship, for each individual plate, it can all be done electronically. The shape of the hull, together with outlines of the plates, and the positions of the existing rivet holes can be lifted with a laser or scatter scanner, from which the data can be given the “plate supplier”, as for a new build to supply which ever plates have to be replaced. This would also apply to inside framing as well as to the shell plates.

It has not yet been established whether holes can be cut, with a laser, sufficiently accurately, so that they will not require reaming, after the plates have been bolted up together, before riveting. If they do not have to be reamed, they will not have to be dismantled, deburred, degreased, and reassembled and bolted, before they can be riveted. This could save four operations in fixing and fitting the shell plating. It is not certain that a laser could form the countersink in exterior shell plates. Reaming would remove any material compromised by the hole cutting process.

Another area which could be profitably developed is that of “bolting up” the plates in position for riveting. Traditionally this has been done with simple nuts and bolts, and requires one man inside, and another inside. In the aircraft industry this operation is carried out with Climo spring, or Advel thumb screw operated pin clamps, which are operated by one man from one side only. Development in this area could reduce the overall cost of riveted construction.

Currently steel rivets are being driven hot, by many different groups of people, in three different situations, and probably, to three different standards:-

1. Structural building work, such as bridges, railway stations, and aircraft hangers.
2. Watertight work, such as ships hulls and superstructures.
3. Pressure tight work such as boilers.

The following are some of the organisations who are currently working in the above fields:-

1. Pridhams. Riveting boilers.
2. Chatham Steam. Riveting boilers, and Cutty Sark’s Mizzen mast.
3. Company associated with Longmore Military Railway. Riveting boilers.
4. Mike Williams. Repairing and building ships and boats, and boilers
5. Tim Leach. Dutton Dry Dock. Self taught repairing narrow boats.
6. Brinklow Boat Services. Builds Narrow Boats and Dutch barges.
7. Chris Jones and others at Chatham Historic Dockyard.
8. Ian Clarke. Repairing steel structures.
9. Dorothea Restoration.
10. Tommy Nielsen.

In addition, the following organisations have worked, fairly recently in the above fields:-

1. Spencer Thetis Wharf. Cutty Sark’s Foremast
2. George Priors.”Waverley’s” sheerstrakes, sponsons, and deckhouse.
3. A boiler maker at Strood. “Kingswear Castle’s fiddley.
4. “Cutty Sark’s” maintenance crew. Foremast partners, by hand.

In addition a number of groups of older riveters, including those from Chatham Dockyard, and others in Great Yarmouth, from George Prior’s yard, who have experience, which should be recorded, and taken note of, even though not all of them may be prepared to take up a gun again today.

A properly driven rivet should fulfil the following requirements:-

1. There should be no detectable gaps between the underside of the head, and the plate, which it is driven through and no flash on the rim. If the plate under the head is not flat, the head should be reformed to fit the plate.

2. The head of the rivet should have a slight radius, where it joins the shank, filling a slight countersink in the edge of the hole.

3. There should be no detectable gaps between the shank of the rivet, and the sides of the holes in all the plates it passes through.

4. The plates should be in such close contact, and coated or bedded, so that no water, or water vapour can get between the plates

5. In the case of a raised countersunk Point, which is the normal point on the outside of a ship' hull, the countersink should be completely filled, and the edge of the rivet point should absolutely flush with the edge of the countersink, effectively caulked in place. The spare metal should form an even cone, centred on the longitudinal centre of the rivet, its height can vary, to accommodate the spare metal.

6. If the point is Snap or Pan, there should be no detectable gaps between the underside of the point, and the plate, and there should be no flash around the edge of the point on the plate.

There are three methods of closing or forming the point of a rivet:-

1. By hand, usually on reasonable sized rivets this would need the riveter to hold a swage, which would be hit by a striker, wielding an appropriate sized hammer. The last time I know this was done was when "Cutty Sark's" ships staff rebuilt the Foremast Partners, when they shipped the new Foremast. I would not recommend it for production work.

2. With a pneumatic gun. In our yard, in the '50's, we only used pneumatic guns, and with one or two exceptions, normally for special operations, all the people who are riveting today are using pneumatic guns for the majority of their work.

3. Hydraulic squeeze riveting. This was used extensively on big ship riveting, as shown in an extract from a book written, in the early 1900's, when the only alternative was hand or a steam hammer. I know several people use hydraulic squeeze riveting today, for boiler work, normally only for thick, non steam tight base rings, or for non watertight fabrications, such as the shell and reverse bar connections to the floor plate; in these cases they use hydraulic squeezers with small throat depths.

   When they built the Titanic they were probably using rivets up to 2" diameter, and the points on the outside were snaps: I could well see the difficulties of hand or steam hammers on rivets of this size. In addition, the size, and weight of the riveter with a throat depth to span the width of a plate was massive, I have seen an illustration of one at least ten feet high.

One of the problems with squeeze riveting is that it does not drive the underside of the head hard up against the plate as gun, or an active jam-back would.

There are three methods of "holding up" the head of a rivet, while the point is being closed with a gun or a hammer:-

1. A solid "Dolly", a large lump of metal, normally round, with a shaped head, or a snap, to fit over the head of the rivet. The Holder Up hits the head of the hot rivet, with the dolly to drive it home, and then holds it up hard while the riveter forms the point. This was the method we used in the yard in the 50's.

2. The problems are that the dolly is heavy, so today I think that there should be some sort of counterbalance system to take the weight of the dolly. It would also probably come under the vibration regulations, so there should some sort of vibration absorbing holder for the dolly. The advantage is that it is very quick to come off one rivet, and go straight onto the next, which has been inserted by the "Rivet Boy"

3. A "Jam Back", which is a pneumatic jack, with a snap to fit the rivet head in one end. This has to have an abutment behind it, against which it can push. The hot rivet is inserted, the snap of the "Jam Back" is put over the head of the rivet, the rear end is lined up with the abutment, and the air turned on; The "Jam Back" extends and holds the rivet in place while the point is being formed. There is also an "Active" version which has a hammer action in the head end, which can be used to shape the head to fit onto a curved surface. This is a very efficient device, which does not expose the operator to vibration, but it required abutments, which have to be moved, and is obviously slower to reset onto the next rivet.

4. Another rivet gun. George Priors did all their steel riveting with two guns. I know others, who use this method also. This is very quick, as it is lighter to handle than a dolly, and does not need abutments, which have to be moved, but it is not accepted by many who rivet, as there is some doubt as to what happens if the guns are firing out of step, in addition it exposes a second operator to vibration. I am not entirely happy with this, and would like to see a lot of sectioned test pieces, before accepting it.

While some small rivets can be driven cold, almost all shipbuilding rivets should be driven hot, especially as in cooling they will contract and make the connection even tighter. There are four different methods of heating rivets:-

1. A coke forge, with a compressed air feed. The traditional method of heating rivets, which does require an experienced operator, but can supply a good flow of rivets to more than one pairs or riveters.

2. A muffle furnace is smaller and lighter than a forge, but will require a good supply of bottled gas. Unless it is a big furnace it will probably only supply a relatively small number or rivets

3. A gas torch. Only really suitable for small runs f rivets, though small it will use a relatively large quantity of gas, rather inefficiently.

4. Electric resistance heating. Using the same principle as electro forging, this was used in the past with machines holding up to 15 or 20 rivets at a time. I do not know if the equipment is still available

5. Electric induction heating. This uses the same equipment as is used to seal plastic bags. I know a setup which heats a 5/8" rivet in 30 seconds, and can be used to place in in the hole. While this appears to work well, there is a limit to the temperature, to which you can heat the rivet, and the cost of the equipment, though one set can run two heaters, and it can be used to heat sections and angles for hot-working.

There are two different areas in which testing routines should be established, firstly testing the riveters, to ensure that they are adequately skilled to rivet historic ships, and secondly testing random rivets, which have been driven in the ship, to ensure that the standard, of the test pieces, is being maintained on the ship.

There are five obvious known means of testing a rivet:-

1. Visual. If it looks right, it probably is all right; if it looks wrong, it is almost certainly wring.

2. Mechanical probing of the driven rivet. A feeler gauge, or a dentist's probe should detect any gaps or crevices, but might not detect a water vapour entry path, which is the ultimate, which should be avoided if possible..

3. Tapping a rivet, like the "Wheel Tapper" on the old railways. Will only pick up looseness, and is not prove that the rivet is watertight.

4. A destructive test of taking off the head of a driven rivet, and determining the force required to drive out the shank and point. One would like to avoid this on an actual ship, it is the old traditional test, which on one ship, was started at one in a hundred rivets driven, and the proportion reduced as mutual confidence increased. There should be an agreed method of replacing such a rivet in a ship, which should be agreed, before work starts.

5. Cutting through the driven rivet longitudinally, and grinding and etching the surface to differentiate between the metals of the plates and the rivet. This can only be done on test pieces as a test of the riveters.

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There are a range of X-Ray, and sonic testing devices, like the ”Lizard”, which are used in a range of fields, which may be of assistance for non-destructive testing of rivets. It would be very helpful if a device like the “Lizard” which can detect surface cracks in castings could be developed to detect voids between rivet and the plates it was driven through.

This whole area requires further investigation, in a range of fields; it may also be worth looking in the aeronautical field, where a lot or riveting is still going on, though I appreciate it carried out in an entirely different manner, but it has to be inspected to a much higher standard.

Today we wish to establish if it is necessary to set up a measurable standard of riveting for the repair and restoration of historic ships and building replicas. Today the situation is different from that when the ships were built. Then they were expected to earn a profit, in a relatively short life span, today they are expected to have a longer life, and be operated and maintained for posterity; an indication of this is the H.L.F. contracts, which specify that a ship shall be maintained, “as restored” for at least 50 years.

In order to meet these requirements, it may be necessary for work like riveting to be carried out to a higher standard closer to that of boiler making than the old traditional shipbuilding. The recent programme on the “Titanic” suggested that the riveting in those days may not have to been as good as it might.

The requirement for a longer life will not only involve the expertise of closing of the rivet, but also a range of possible steps to prevent any water, or even water vapour entering the interfaces between any of the faying surfaces. This would start corrosion, which might, as old hands say “make the joint watertight”, in the short term, but in the long term will produce “rust binding”, which will lower the breaking strain of the connection, and will eventually burst the rivets, and the connection.

When riveting was in general use in shipyards, there was a clear “tree” of supervision, from the individuals in the “Rivet Squad” to the Shipyard Manager, which ensured the quality of the finished work. They all knew if a rivet looked, sounded and was right.

Today we do not have the body of experience of riveting in shipyard management chains, though there must be such a chain in the boiler building field. It will be necessary therefore to take advice from those who are riveting to standards, and the organisations, who will be certifying the finished vessel. In addition the present litigatious society may make an audit trail on paper an advisable precaution.

There are regulations under the Health and Safety, and Noise Pollution regulations, which will have to be complied with. The Control of Vibration at Work Regulations 2005, specify the time that an operator may be subjected to any combination of vibrations of differing frequencies, and magnitudes, per day.

The variables of this requirement should be investigated, to establish the least hazardous combination, and how this can be reduced even further by devices, which are currently available. In addition steps should be taken to develop new more effective vibration damping, and absorbing devices. One way to comply with the regulations is to rotate jobs within the rivet squad. An additional advantage of this is that every man will know every job in the squad, and it will improve the quality and output of the squad.

When a shipyard in Lowestoft carried out sound tests on riveting, they showed that the sounds of riveting, in the yard were within the acceptable limits. The yard also produced special screens to reduce noise. Care should be taken to avoid a yard, who wanted a job, but did not want to rivet, might quote for it and, and then try to use these regulations as an excuse not to rivet it.

Since the feasibility of carrying out riveted repairs, to ships, which were originally riveted, has now been established, and has been accepted by the M.C.A. it is very important to establish the best methods, and record them and the actual costs of the different elements of the whole job. In view of the frequent diverse statements which have been made about the cost of riveting being either eight times as expensive, or only 10% more expensive, compared with welding, it is very important that accurate descriptions of the methods for both the riveting, and the preparation of the plate work, ready to rivet, are recorded, together with the accurate figures for each operation.

When looking for a quotation for a riveted ship, it should be remembered that a shipyard building welded ships today is unlikely to be interested in taking on, or even quoting for a riveted ship. This would be purely commercial decision, because, if they got the order an appreciable proportion of their workforce, and their plant, would not have any work; in practice, they might quote a stupidly high price, in the off chance that they might have been the only tenderer.

Now that riveting has been re-established as feasible, and is accepted by certifying authorities, there is no reason why the principles laid down in the American Green Book, “of replacing like with like, using the same method of connection” can not be carried out, and grants should not be given for restorations which do not conform with this principle.

This information is available, with the latest updates, on the N.H.S. website, in the “Conservation Manual”. Advice on this subject should be available from our “Shipshape Network”.

M.R.C.Parr.

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