ELECTRO-MOTIVE

M.I. 549
*Rev. B

MAINTENANCE INSTRUCTION

WATER COOLING RADIATORS

INTRODUCTION

These instructions describe the cleaning, inspection, and repair of solder bonded and mechanically bonded radiator cores, Fig. 1.

Solder bonded radiator cores have a brass header plate where the tubes are bonded to the header plate with silver alloy solder and then a second puddle of lead-tin solder. See Fig. 2.

Mechanically bonded radiator cores have a steel header plate where the tubes are bonded to the header plate by roller expansion of the tube. See Fig. 3.

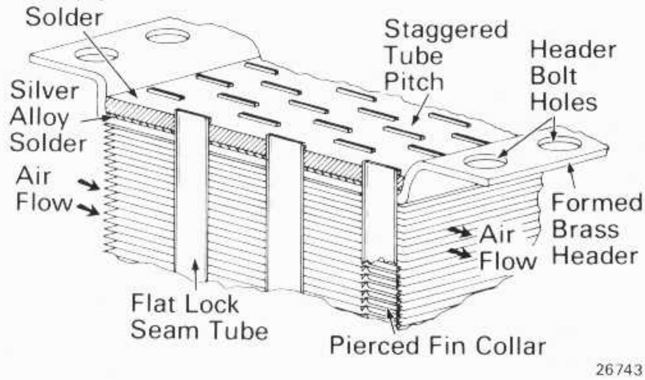
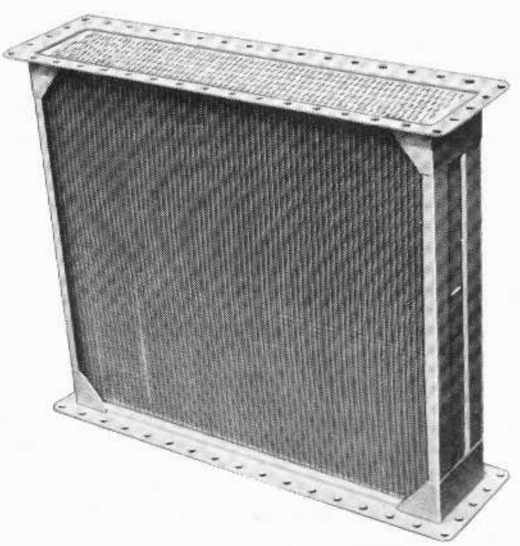


Fig.2 – Flat Tube Solder-Construction Radiator



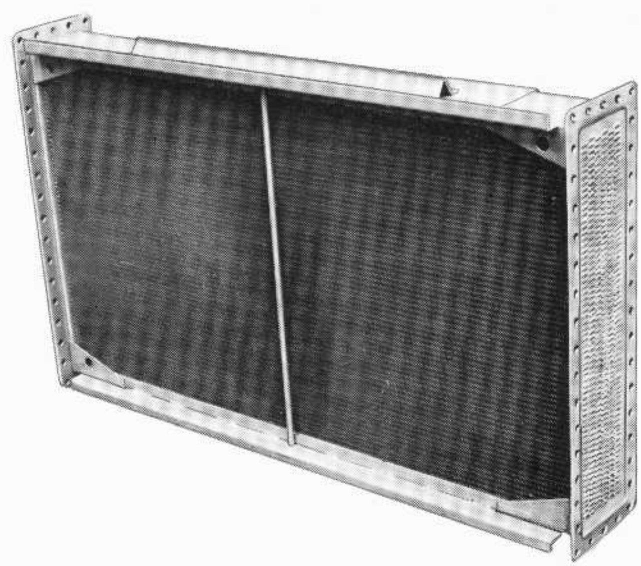


Fig.1 – Typical Radiators

*This bulletin is revised and supersedes previous issues of this number

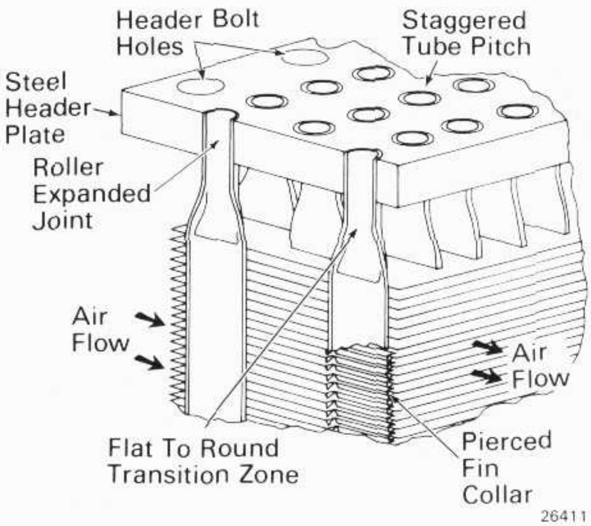


Fig.3 – Flat-To-Round Mechanical Construction Radiator

CLEANING

The radiator should be cleaned prior to repair using the following procedure:

1. Mark any areas on the air sides of the core that show signs of water treatment color. Discolored areas indicate leaks that will have to be repaired.

2. Remove debris from the fins with compressed air.

3. Straighten bent header plate flanges and comb flattened fins. Flattened fins reduce the air flow through the radiator.

4. Clean the header plate gasket surfaces being careful not to scratch the surfaces. Deep scratches in the gasket area should be removed with emery cloth.

5. Fill a soak tank with suitable cleaner. See Service Data. The radiator should be completely submerged in the cleaning solution.

CAUTION

Use of caustic cleaners is not recommended for either solder or mechanically bonded radiators. Caustic cleaners will deteriorate the solder bond between the fins and tubes and cause poor heat transfer.

6. Soak the radiator core in the cleaning solution with the tubes lying horizontally.

NOTE

The soaking time is dependent on the amount and type of soil. An agitator-type tank is more effective and will reduce cleaning time.

7. Rinse radiator using a steam-water mixture.

NOTE

Rinse radiator as soon as possible to prevent residue from hardening.

RADIATOR CORE INSPECTION

Radiator core failures, other than damage, can be categorized as: tube-to-fin bond failures, tube failures, or tube-to-header bond failures. Repair limits for tube-to-fin bond and tube failures are specified under Service Data.

If the radiator is within the repair limits described in the Service Data, the core can be repaired. If not, repair is not recommended and the core should be scrapped.

TUBE-TO-FIN BOND CHECK

Loose fins will hinder cooling and allow the tube to expand with water pressure. The expansion-contraction cycle will eventually cause the tube to crack. Check for tube-to-fin bond as follows:

1. Using a needle nose pliers or probe, check tube-to-fin bond by gently trying to move the fin collar on the tube. See Fig. 3.

2. Check sample areas of both sides of the core for loose tube-to-fin bond. The radiator should be scrapped if the loose fin area exceeds the limits specified under Service Data.

NOTE

If a tube has loose fins for more than 25.4 mm (1″) of its length, that tube should be closed by the repair method appropriate to solder or mechanical radiators.

PUDDLE SOLDER CHECK

With time, the puddle solder will oxidize and loose its strength. Solder in this condition will form slag after it is melted for repair and will not produce a reliable bond. Oxidized solder will be gray and brittle. It will not appear shiny when scraped with an awl or screwdriver blade.

Examine the header puddle solder as follows:

1. Use an awl or pick to probe the surface of the header puddle solder in various places.

2. If only a thin coating of oxidized solder is on the puddle surface, and the underlying solder is shiny, and looks like new solder, the header puddle need not be completely removed for repair of any tube-to-header leak.

3. If the puddle solder is oxidized for more than 50% of its depth anywhere on the puddle or more than 25% of its depth on most of the header, the entire solder puddle should be replaced regardless of whether tube-to-header leaks are found during the leak test.

LEAK TEST

Tube leaks or tube-to-header bond leaks can be located using the following procedure:

1. Install a blanking cover or tank on both header plates.

2. Apply 345 kPa (50 psi) air pressure on the tube side with the radiator immersed in clean water at room temperature.

CAUTION

Avoid exceeding 345 kPa (50 psi) air pressure since higher pressure may damage the radiator tubes.

3. Mark tubes and tube-to-header bonds that emit bubbles.

4. Qualify the core by using the repair limit information given in the Service Data. The core should be scrapped if the number of tubes leaking exceeds the repair limit.

5. Refer to the repair method appropriate for the type of leak and type of radiator construction.

SOLDER BONDED RADIATOR REPAIR

The following procedure describes the repair of solder bonded radiators only.

TUBE LEAK REPAIR

Tube leaks are repaired by sealing each end of the defective tube, thus eliminating it from service. When loose fins leave more than 25.4 mm (1") of a tube unsupported, it should also be sealed using this method.

Experience has shown that up to 2% of the total tubes can be sealed without adversely affecting cooling. Use the information in the Service Data as a guide in determining whether the core is scrapped or repaired.

NOTE

The recommended heating tip for melting out old solder and applying new solder is listed under Service Data.

1. Thoroughly dry the inside of the tube(s) to be repaired.

2. Locally heat the puddle solder around the leaking tube with a medium flame and apply zinc chloride flux; see Service Data. Use a soft wire brush to scrub and clean the area.

3. When the puddle solder around the leaking tube has melted, pinch the end of the tube closed with pliers and bend the tube over, so that the tube can be covered by the puddle solder.

4. Reapply flux and heat the area with 243° C (470° F) flame. Melt 50% tin, 50% lead solder to cover the tube and blend into the original puddle solder.

5. Repeat as necessary for all other leaking tubes on that end of the radiator.

6. Flush the header and all tubes with water to remove unused flux.

7. Dry the tubes with compressed air.

8. Turn the core over and repeat the process on the other ends of the tubes to be sealed.

9. Flush both headers and all tubes again to remove unused flux.

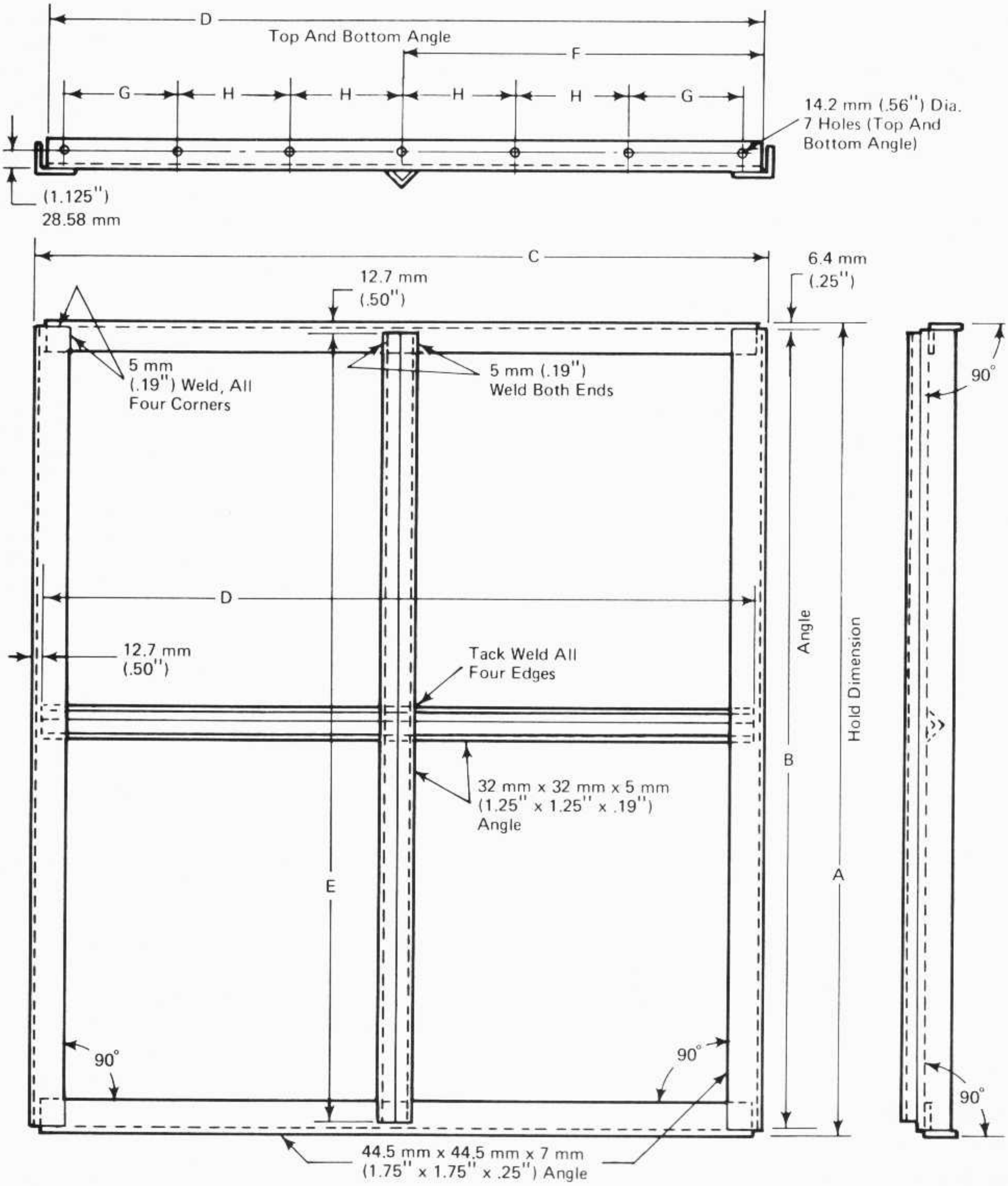
NOTE

Flux is corrosive and will damage the core if it is not thoroughly rinsed off the headers, out of the tubes and off the fins.

10. Repeat the Leak Test procedure to assure that all leaks have been eliminated.

11. If necessary comb out and straighten any bent fins.

12. Spray all external surfaces with one coat of black radiator paint. See Service Data. Avoid spraying gasket and water swept surfaces.



DIMENSION CHART								
CORE	A	B	C	D	E	F	G	H
8-Row	1162 mm ± .3 (45.75" ± .01)	1149.4 mm (45.25")	990.6 mm (39")	965.2 mm (38")	1136.7 mm (44.75")	482.6 mm (19")	154.8 mm (6.093")	154.8 mm (6.093")
6-Row (double length)	1400.2 mm ± .3 (55.125" ± .01)	1387.5 mm (54.625")	889 mm (35")	863.6 mm (34")	1374.8 mm (54.125")	431.8 mm (17")	103.2 mm (4.062")	154.8 mm (6.093")
6-Row (single length)	697.2 mm ± .3 (27.45" ± .01)	684.5 mm (26.95")	889 mm (35")	863.6 mm (34")	671.8 mm (26.45")	431.8 mm (17")	103.2 mm (4.062")	154.8 mm (6.093")

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Fig.4 – Header Clamping Fixture

NOTE

Mix equal parts of radiator paint and V.M. and P. naptha.

TUBE-TO-HEADER LEAK REPAIR

The majority of tube-to-header bond leaks occur in the outer two tube rows along the long side of the header. Although less common, leaks at the middle rows also occur.

Repair of the two outer tube rows can be accomplished by melting out the puddle solder on the two outer tube rows only. If the solder puddle on the two outer rows is removed, it is not necessary to put the core in a frame or fixture since the unmelted solder in the other tube rows will maintain header alignment.

If the leaks are both in the middle and outer tube rows, or the puddle solder is oxidized, it is recommended that all the puddle solder in the header be removed. In that case, a frame or fixture, Fig. 4, is required to hold the header in correct alignment with the core.

NOTE

If all the header puddle solder is removed, a fixture must be used to hold the header in correct alignment. If the header is not square with the core, the repaired core will be strained when bolted to other cores and will fail prematurely.

OUTER TUBE ROW REPAIR

If the radiator has tube-to-header leaks in the outer two tube rows, use the following procedure:

1. Rest core on work surface so that core rests on both header plate flanges with the tubes horizontal.

   a. Melt the puddle solder from the first two outer tube rows nearest to the surface that the core is resting on. The shaded area in Fig. 5 indicates the area from which solder is removed. Melt solder out by playing a 327° C (620° F) flame over the area. The melted solder will run out of the dish, over the header flange and out.

   b. Turn the core over so that the two unmelted rows which were at the top are now nearest the surface the core is resting on. Repeat Step a.

   c. Clean all surfaces that are to be resoldered with zinc chloride flux. See Service Data. Use syringe to ensure that all cracks, tubes, and header surfaces have been cleaned by flux.

NOTE

When using flux, play a medium flame on the fluxed surfaces. The heating will boil the flux, thus improving its cleaning ability. Use a soft wire brush to scrub and clean the areas which are being prepared for soldering.

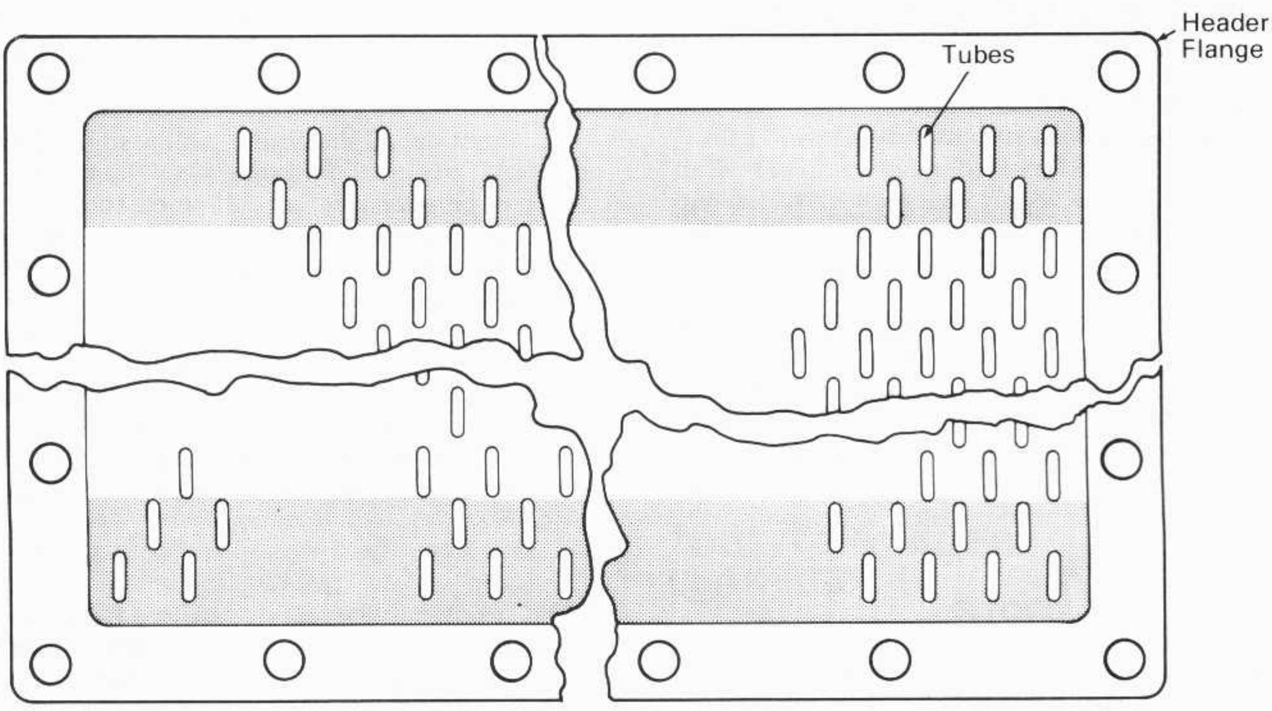

Fig.5 – Radiator Core Schematic

d. Repeat Step c using clean flux.

2. With the core resting on one header and the tubes in a vertical position:

   a. Run a length of No. 7, 3.2 mm (1/8″) diameter silver wire solder along each tube row. See Service Data for alloy. Then use a 327° C (620° F) flame to sweat this silver solder into the tube to header joints. See Fig. 6.

NOTE

Most of the tube-to-header joint strength is produced by the silver alloy solder. Omitting the silver alloy solder will reduce the reliability of the repaired radiator.

CAUTION

Use only as much heat as necessary to melt the silver solder. Too much heat will cause the solder in the tube seams to melt out and the tubes will leak. Keep the torch moving over the header so that the temperature comes up evenly and gradually.

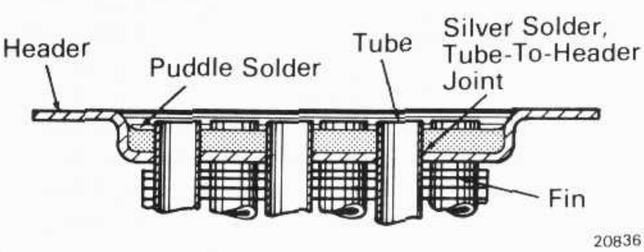

Fig.6 – Radiator Core Cross-Section

   b. After the silver solder has melted and formed a fillet around each tube, use a small amount of flux and a wire brush to reclean the area. Reapply silver solder to the gap between the header and the first tube row.

   c. Using 9.5 mm (3/8″) TRIBAR solder, see Service Data, and a 260° C (500° F) flame, build up a puddle with a minimum depth of 4 mm (5/32″). Blend the new puddle solder with the existing puddle solder increasing the puddle depth to 6.4 mm (1/4″) at the edge of the header dish.

NOTE

The old puddle solder should not be reused for radiator repair. Reusing the old puddle solder will reduce the reliability of the repaired radiator.

   d. Solder space between rows using a 3.2 mm (1/8″) wire puddle solder and a 260° C (500° F) flame. See Service Data.

   e. Blend excess solder with 260° C (500° F) flame carefully so that it runs and levels out. Make certain that the old and new puddle solder is well blended.

   f. Remove all traces of flux by immersing core several times in room temperature water.

3. Repeat the Leak Test to assure that all leaks have been eliminated.

4. Spray all external surfaces with one coat of black radiator paint. See Service Data. Avoid spraying gasket and water swept surfaces.

NOTE

Mix equal parts of radiator paint and V.M. and P. naptha.

5. Stamp the month and year of repair in one corner of the header puddle solder.

COMPLETE HEADER REPAIR

If the radiator has leaks at both middle and outer tube rows or the header solder puddle is oxidized, use the following procedure:

1. Bolt a clamping fixture as shown in Fig. 4 between the header flanges on both sides of the radiator.

2. With the core resting flat and the tubes in a horizontal position.

   a. Melt out all the header puddle solder. Use a 327° C (620° F) flame. Keep flame moving over entire header surface to raise its temperature evenly and gradually. The melted solder will run out of the dish, over the header flange and out.

   b. When all solder has been removed, clean all surfaces that will be resoldered with zinc chloride flux. See Service Data. Use a syringe to ensure that all cracks, tubes, and header surfaces have been cleaned with flux.

NOTE

When applying flux, play a medium flame on the fluxed surfaces. The heating will boil the flux, thus improving its cleaning ability. Use a soft wire brush to scrub and clean the areas which are being prepared for soldering.

c. Repeat Step b using clean flux. This will remove any remaining dirty flux.

3. Resolder headers as described under Outer Tube Row Repair, and then remove the clamping fixtures.

4. Repeat Leak Test to assure that all leaks have been eliminated.

5. Spray all external surfaces with one coat of black radiator paint. Avoid spraying gasket and water swept surfaces.

NOTE

Mix equal parts of radiator paint and V.M. and P. naptha.

6. Stamp the month and year of repair in one corner of the header puddle solder.

MECHANICALLY BONDED RADIATOR REPAIR

The following procedure describes the repair of mechanically bonded radiators only. If the leak is in a tube and the tube-to-header joint is still sound, then the leak can be repaired by the method described for tube leak repair. If the location of the leak is at the tube-to-header plate joint or possibly at the tube-to-header joint, then the leak should be repaired by the method described for tube-to-header leak repair.

TUBE LEAK REPAIR

1. Thoroughly dry the inside of the tube to be repaired using compressed air.

2. Carefully clean each end of the tube to remove scale or sludge. Use fine emery cloth to remove any deep scratches on the inner diameter of the tube and to eliminate the sharp edge on the end of the tube I.D.

3. Insert the tapered phenolic repair plug into the tube as shown in Fig. 7.

NOTE

Improved design tapered phenolic plugs have been developed to replace brass plugs previously used for repairing mechanical construction radiators. Metal plugs cannot tolerate variance in the tube diameter, will not seal scratches or nicks in the tube; and may deform adjacent rolled joints. The phenolic plug, on the other hand, will undergo some compression to retain a tight interference fit, and is not degraded by hot water, steam or inhibitor chemicals. See Service Data for phenolic plug part number.

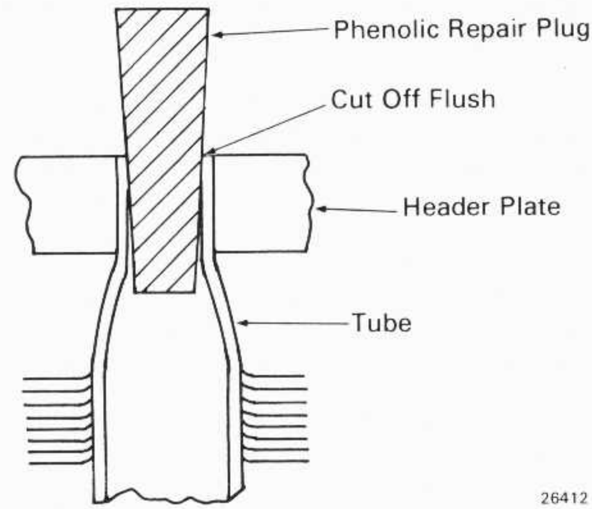

Fig.7 - Leak Repair

4. Use a small hammer to drive the phenolic plug into the end of the tube until a snug fit results. Driving the plug in too far will "shave off" the sides of the plug or crack the plug. No pipe compound or sealant is necessary to cause the plug to seal. The seal and interference fit is accomplished by the taper on the plug.

5. Use a hacksaw to cut off the exposed portion of the plug flush with the steel header plate. Trim the end of the plug with a file, if necessary, so that the plug extends no more than 0.8 mm (1/32") above the header plate.

CAUTION

Allowing the plug to protrude too far beyond the header surface will cause interference when the repaired core is bolted to another core or will block water flow in the same tube of a mating radiator core and possibly cause the water in that tube to freeze in winter.

6. Repeat Steps 3 through 5 to plug the other end of the tube.

7. Straighten or comb any bent fins.

8. Repeat the Leak Test to assure that all leaks have been eliminated.

TUBE-TO-HEADER LEAK REPAIR

If a mechanical radiator has a tube-to-header leak, driving a plug into the end of the tube will not seal the leak path between the tube and the header plate. A tube-to-header leak should be repaired as follows:

1. Use a 14 mm (9/16") drill to remove the tube from the header plate hole at both header plates. Drill to a depth of 1-1/2 times the header plate thickness to allow room for the length of the phenolic plug.

CAUTION

Make certain that the drill is in line with the tube to prevent the drill point from damaging adjacent tubes.

2. Use fine emery cloth to clean the inside of the hole in both header plates and remove the sharp edge of the holes so the phenolic plug will not be "shaved off" when it is driven into the hole.

3. Insert the tapered phenolic plug into the hole in the header plate as shown in Fig. 8.

4. The instructions for driving the plug into the hole in both header plates, and cutting the plugs off flush with the header are the same as those described under tube leak repair.

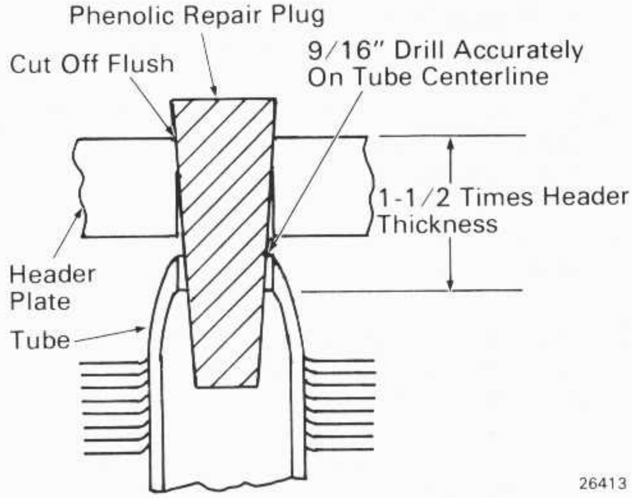

Fig.8 - Tube-To-Header Leak Repair

5. Straighten or comb any bent fins.

6. Repeat the leak test to assure that all leaks have been eliminated.

SERVICE DATA

SPECIFICATIONS

TUBE-TO-FIN BOND

Loose Tube-To-Fin Bond - Total Area Not To Exceed	9,678 mm^2 (15 sq. in.)
Loose Tube-To-Fin Bond - No Single Area To Exceed	6,452 mm^2 (10 sq. in.)

TUBE REPAIR

Maximum Number Of Adjacent Tubes Required	4
Maximum Percentage Of Total Number Of Tubes Required	2%

EQUIPMENT

	Part Number
Solder, Soft – 50% Tin, 50% Lead, 0.68 kg (1.5 lb) Bar	8225762
Solder, Tribar – 40% Tin, 60% Lead, 11.34 kg (25 lb)	8478479
Solder, Silver Wire – 2.5% Tin, 97% Lead, 0.5% Silver, 3.2 mm (1/8") dia. No. 7, 11.34 kg (25 lb) Spool	8478480
Solder, Puddle – 38% Tin, 62% Lead, 3.2 mm (1/8") dia. 11.34 kg (25 lb) Spool	8486859

Flux, Zinc Chloride

Chemical Composition:

	Min.	Max.	
Zinc Chloride	37.0	50.0	Oz/Gal.
Ammonium Chloride	7.0	13.0	Oz/Gal.
Hydrochloric Acid (As HCl)	5.1	13.0	Oz/Gal.
Water	Balance		
Specific Gravity	1.15	1.30	

Color: The color of the flux shall be water white.

Paint, Black Radiator – Use One Part Paint With One Part V.M. And P. Naptha, 3.78 Liters (1 Gal.) Can	8204764

Soldering Tip, Stainless Steel Tube – Available From National Welding Co. Division Of Variflow Corp., 7748 W. Addison St., Chicago, Il 60634
Blow Pipe Tip N3-134-00130

Repair Plug – Mechanical Radiator, Phenolic	9500388

CLEANING SOLUTION

To remove soil from exterior of radiator, use a mild alkaline cleaner.

To remove hardness salts from the water side of the tubes, use an inhibited cleaner containing sulfuric and citric acid.

NOTE

The type, concentration, and temperature of a cleaner is dependent on the type of soil on the radiator. The cleaner must not be detrimental to solder or brass. Consult local metal cleaner representative for recommended cleaning solution.