

**TB 9-2300-247-40**  
**This bulletin supersedes TB 9-2300-247-40, 23 February 1971**

**TECHNICAL BULLETIN**

**TACTICAL WHEELED VEHICLES:**

**REPAIR OF FRAMES**

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**HEADQUARTERS, DEPARTMENT OF THE ARMY**

**4 December 1990**

## DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

TACTICAL WHEELED VEHICLES  
REPAIR OF FRAMES

Department of the Army, Washington, D.C.

4 December 1990

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## CHAPTER 1. GENERAL

### SECTION I. GENERAL

**1. Purpose.** This bulletin provides information to field maintenance personnel in the various methods of tactical wheeled vehicle frame repair.

**2. Scope.**

- a. This bulletin contains descriptions, methods and procedures for the inspection and the repair of cracked vehicle side rails, vehicle frame members, broken welds, bolts, and rivets and the fabrication of vehicle frame reinforcement members.
- b. The following family of wheeled vehicles are included as a part of this bulletin: CUCV Series Vehicles, 3/4 to 1/4 Ton HMMMV Series Vehicles, 1-1/4 Ton 2-1/2-Ton Series Vehicles 5-Ton Truck Series Vehicles.
- c. Vehicle frame repair is restricted to the criteria specified in Section IV. Any proposed repair which is not specifically specified in Sections IV and V, or not included as part of a work procedure in a specific vehicle maintenance manual, is not authorized and will not be considered.
- d. Frame repairs are allocated to General Support (GS) and depot level maintenance activities. However, vehicles will not be evacuated to a maintenance depot solely

for the purpose of frame repair. See Section IV, paragraph 10.

- e. Procedures for frame repair vary with the different types and locations of frame defect of failure. The methods and success of vehicle frame repair is dependent to a great degree on the skill and experience of the technician performing the work.. Many frame repair procedures begin with very simple steps. Often, removal and replacement procedures in the area where the frame requires repair are left to the experience of the mechanic. Other component removal and replacement procedures are strictly governed by the procedures in the specific maintenance manual for the vehicle frame under repair. Most types of cracked frames may be repaired provided the crack is located in an accessible position allowing the repair to be performed without complete disassembly of the vehicle. All vehicle frame repairs must, at a minimum be equal in strength to that of the original frame.

**3. Reporting of Errors.** The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to: Commander, U.S. Army Tank-Automotive Command, ATTN.: AMSTA-MB, Warren MI 48397-5000.

### SECTION II. DESCRIPTION OF VEHICLE FRAMES

**4. Truck Frames.** Truck frames are generally constructed of pressed steel channel side members and steel crossmembers reinforced and stiffened with gusset plates and braces. In general, frames are assembled by bolting, riveting, and with welded joints, or with a combination of all these methods.

**5. Heat-Treated Steel Frames.** Heat-treated steel frames, such as those used in 5-ton trucks are

assembled using bolts and rivets. Most welding processes destroy the heat treatment properties of the vehicle framing members, causing the metal adjacent to the weld to be weakened. As a result of the destructive properties of welding on heat-treated steel, welding of heat-treated 5-ton truck framing members is prohibited except as otherwise specified in Chapter 5.

**NOTE**

**For illustrations of specific vehicle frames, refer to the maintenance manual for the vehicle frame proposed for repair.**

All frames used in 3/4-ton, 1-1/4-ton to 2-1/2-ton series vehicles are fabricated of medium or low carbon steel. The various steel framing members are frequently joined together by welding during initial vehicle production. Future repairs to these frames by welding is permitted if the procedures specified in this manual are strictly and carefully followed.

**6. 3/4 to 1-1/4 Ton Series Vehicle Frames.**

**SECTION III. GENERAL INSPECTION OF VEHICLE FRAMES**

**7. Riveted Frame Connections.** Perform the following inspection of rivet-assembled vehicle framing members:

- a. Using a .001 inch thick feeler gage, check for space between rivet head and the riveted frame members. Penetration of the feeler gage between the rivet head and the riveted member is reason to suspect that the riveted connection and/or rivet should be replaced.
- b. Thoroughly clean rivet and riveted connection of all dirt, grease and oil. Using an oil can, apply lubricating oil around the suspect rivet and riveted connection. Allow approximately 10 to 20 seconds for the oil to penetrate. Wipe rivet and riveted connection free of oil. Tap rivet with an eight pound hammer. Any indication of oil around the rivet indicates a loose rivet. Replace all loose rivets. Check all riveted connections for signs of movement, such

as bare or shiny spots, or other indications of movement between rivet and framing member. If movement is indicated, rivet and connection are loose. Repair all loose connections.

**8. Bolted Frame Connections.** Perform the following inspection of frame bolted connections:

- a. Check bolts and nuts for tightness and proper mating with frame surfaces.
- b. Check the torque of all bolts not scheduled to be removed in accordance with appendix E of the appropriate vehicle TM.

**9. Welded Frame Connections.** Perform the following inspection of frame welded connections:

Where welds are found on the vehicle, check welds for integrity, deterioration and flaking.

**SECTION IV. CRITERIA FOR FRAME REPAIR**

**10. Frame Deficiencies.** Frame deficiencies will only be considered for repair under the following conditions: Costs. Total estimated cost of any proposed frame repair, including the frame deficiency and all other miscellaneous repairs fall within the maximum repair expenditure limits specified in TB 43-0001. Frame damage will be carefully evaluated to determine the

extent of repair required, including all operations incidental to the repair, and those costs, combined with all other costs required to provide a completely serviceable frame. If there is any doubt that the frame is non-repairable, the final decision will be made by the local Logistics Assistance Representative (LAR).

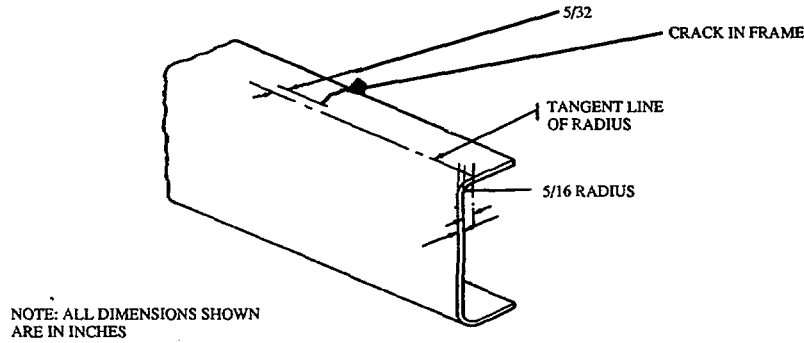


Figure 1. Cracked Frame Repair Limits.

**11. Serviceability Standards.** The proposed repair will return the vehicle frame to a condition where frame strength and serviceability, after repair, is equivalent to that of the original frame. An example of this condition would be where welding a crack in a frame side rail without space for displating; This will not restore the frame to its comparable original strength, therefore the repair would not be authorized.

**12. Repair Facilities, Equipment and Personnel.** Where there exists at the proposed repair facility the suitable equipment and skilled personnel to adequately perform the required work. This is important since poor frame repair can result in related additional failures and possible danger to personnel and damage to equipment.

**13. Frame Alinement Tolerances.** Measurements to determine acceptable frame alinement must fall within the tolerances specified in the vehicle technical manual (TM) for frame to be repaired. If a vehicle frame proposed for repair meets the required tolerances, it may be considered repairable. However, a cost estimate must still be prepared to determine if the proposed repairs are economically justified.

**14. Cracked Frame Repair Limits.** Cracks in frames progressing to within 5/32-inch of a tangent line or radius (Figure 1) can be repaired by a reinforcing technique described in Chapter 4.

**15. Frame Defects**

- a. **Not Repairable.** Defects in frames of 5-Ton series trucks and larger, showing the following defects, will not be repair.
- b. Cracks across the frame top rail flange extending beyond 1-1/2 inches down the

face of the rail (see Figure 2, crack limit gage fabrication).

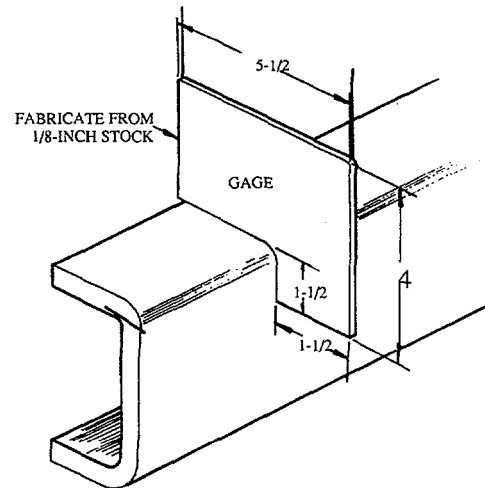


Figure 2. Crack Limit Gage

- c. Cracks in frame lower rail flange with a radius extending past the lowest rivet hole of the bogie support casting, 2-1/2-inches or more in (Figure 3).
- d. When three or more cracks in a single frame rail member are found.
- e. When two or more cracks are found in a 48-inch proximity of one another and in the same frame rail, including two cracks in the same frame rail which are diametrically opposite one another.

**16. Vehicle Component Removal.** Under normal conditions, removal, of vehicle components to provide

accessibility for frame repair is limited to the following:

- Miscellaneous brackets; riveted or bolted.
- Axle assemblies and related components.
- Crossmembers; riveted or bolted.
- Fifth wheels.
- Miscellaneous service lines and other minor interferences.
- Vehicle cabs.
- Crossmembers, gussets or brackets directly welded to vehicle frames will not be removed to gain accessibility for vehicle frame repair.

**NOTE**

**Anchor bolts used to secure components listed above may be removed for access to repair frame defects.**

**17. Riveted Connection Repair.**

- a. Rivet hole preparation.** Rivet holes shall be prepared to receive new No. 8-UNF bolts. Holes shall be reamed to provide a tight fit for the new bolt. No clearances or looseness will be allowed in the new installation. In the event that the holes must be enlarged or reamed for alignment, or for other reasons, caution should be taken during the process to insure that the diameter of the original rivet hole is not exceeded by more than 1/16-inch.
- b. Bolted frame connections.** Bolted frame connections are normally accomplished to replace rivets removed, to reinforce weld repairs, replace defective bolted connections, and to provide new bolted connections (new framing members or components). When bolted connections are used to complete vehicle frame repair, new bolts, new washers and new locknuts must be used. Under no conditions will bolted frame repairs be made with used hardware. Unless otherwise specified in the appropriate vehicle TM or other governing document, Grade 8, United National Fine (UNF) bolts will be used in all bolted frame repair or new component additions to framing members. No United National Course (UNC) or TB 9-2300-247-

40 other cold-rolled are acceptable for vehicle structural frame repair.

**c. Bolt/Rivet hole connections.**

Where new bolts are to be installed in prepared rivet holes, the rivet holes shall be prepared as specified in paragraph above. Bolts installed in prepared rivet holes shall, in all cases, be new No. 8, UNF with new washers and UNF locknuts. Installed bolts shall make a tight fit. No clearances or looseness is permitted. Reamed or enlarged holes to accept the new bolts, shall in no case, exceed the diameter of the original unprepared hole by more than 1/16-inch.

**d. Bolted reinforced plate connections.**

Repairs using bolted connections usually require reinforcement this is accomplished by the addition of steel reinforcing members across the area of the repair. These reinforcing members usually require more area surrounding the defect than similar welded or riveted connections. This additional area is required because bolt diameter and bolt spacing are critical to the strength and rigidity of the repair. For most reinforced plate connections used in frame repair, the recommended maximum bolt diameter to be used is 1/2-inch. Larger bolt diameters are not recommended because of the size of standard side rail cross section and the loss of strength of the side rail member which may result from larger bolt mounting holes. Minimum bolt spacing for repair of the types of vehicle frames and framing members specified in the manual will not be less than 3 inches measured center-to-center from each bolt. For deviations from these restrictions, and for other bolted frame repair applications not covered in this manual, refer to the specific vehicle TM for the frame proposed for repair. In cases where larger bolts or rivets were used by the manufacturer of the vehicle frame, these bolts or rivets must be replaced with larger sizes after being removed. Refer to the vehicle TM for acceptable limits. Where welded/reinforced

plate repair methods are used (paragraph ), 5/8 inch diameter drilled holes may be required for the bolted connections.

#### 18. Bolting Materials.

- a. **Bolts.** No. 8, carbon steel, UNF, conforming to SAE (TBD)
- b. **Nuts.** Steel, self-locking, UNF, MS51922.

- c. **Washers.** Washers shall be new, case hardened steel type. Washers shall be provided under all bolt heads and under all locknuts to adequately distribute over the maximum bearing surface area of the connection.

### SECTION V. WELDED REPAIRS

#### CAUTION

**Welding is not an approved or acceptable alternate method of repair for any riveted or bolted attachment (e.g., crossmember, spring hanger, etc.) on the frame assembly of the CUCV series vehicles.**

#### 19. 3/4 Ton to 2-1/2 Ton Series Vehicles.

The electric arc welding method is recommended when welding is used to repair frames of in the 3/4, 1-1/4 to 2-1/2-ton series classification. With this welding method, heat generated during welding is localized and burning of the materials is kept to a minimum. Finished welds may be ground, filed, and drilled as necessary. When available, welding electrodes conforming to MIL-E-7018, Class 1 should be used with the electric arc welding during repair of these frames. When these electrodes are not available, refer to TM 9-237 for an acceptable substitute. Prepare sketches of the proposed repair, in accordance with standard shop practices, in accordance with sketches from the appropriate vehicle TM or as shown in Chapter 3 of this manual. When the reinforcement has been shaped as shown in the sketches and clamped into position, apply welds only at the points shown on the sketches. Generally, welding is not recommended at the extreme corners of a channel framing member or its flanges. Welding at these locations tend to encourage the development of new cracks in these locations. For specific welding repairs for 3/4, 1-1/4 to 2-1/2 ton vehicle frames, refer to the

specific vehicle TM for the vehicle frame proposed for repair.

**20. 5-Ton Series Vehicle.** Welding of 5-ton series vehicle heat-treated steel frames shall be by the electric arc method and shall be limited to the use electrodes conforming to MIL-312 of the American Welding Society (AWS), AWS-A5 in sizes of 3/32 -in., 1/8- in., and 5/32-in, diameters as applicable. In cases where it becomes necessary to weld two reinforcing members which are adjacent to a heat-treated member, a small spacer will be positioned and secured between the members to prevent the transfer of heat generated by welding to and from penetrating into the heat-treated members. Specific welding instructions for 5-ton series vehicle frames are contained in paragraph.

**21. Flaseplating.** Unless otherwise stated herein, only hot or cold-rolled steel plate will be used for flaseplating. Material used for flaseplating shall, in all cases, be equal to the thickness of the plate or vehicle framing member requiring repair. Where necessary, a tolerance of plus or minus 1/16-inch of the required thickness will be acceptable. The length of the material used for flaseplating will be determined by the type and location of the break to be repaired. In all cases however, a flaseplate reinforcing member should extend far enough on all sides of the break in the framing member to reflect standard acceptable mechanical practices and that strength of the reinforcement is, at a minimum, equal to the original strength and serviceability of the frame.

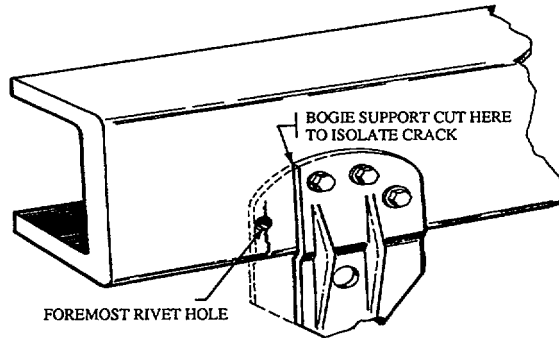


Figure 3. Unrepairable Frame Rail

## CHAPTER 2

### EQUIPMENT AND TOOLS

#### SECTION I. EQUIPMENT AND TOOLS

##### 22. Equipment.

The necessary equipment to accomplish frame repairs described in this manual are available at all field maintenance level activities.

**23. Tools.** The tools necessary to perform vehicle frame repairs described in this manual are available at all field maintenance level activities which is described under fabricated tools below.

#### SECTION II. FABRICATED TOOLS

**24. Fabricated Tools.** The rivet buster tool (NSN 5100-00-293-0556), shown in Figure 4, may also, be fabricated from a 7/8-inch or 1-inch cold chisel. The chisel is ground to the shape indicated with a suitable grinding tool. The point should be ground with one flat side to rest against the base metal and the cutting edge ground to an angle of  $50^{\circ}$  to  $55^{\circ}$ . The point may be narrowed down to approximately 5/8-inch. An air hammer used with the rivet buster is recommended to simplify rivet removal.

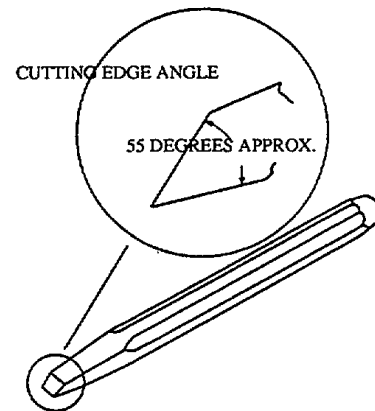


Figure 4. Rivet Buster



CHAPTER 3

FRAME ALINEMENT INSPECTION

SECTION I. 3/4, AND 1-1/4 TON TO 2-1/2 TON SERIES VEHICLE REQUIREMENTS

Tools: Light:

- Extension, 25 ft. length
- Jack, Hydraulic, 12-ton capacity
- Jack, Hydraulic, 30-ton capacity
- Plumb Bob, 10 oz.
- Square, 24 in.
- Tape Measure, 25 ft. long

Applicable Vehicle Models/Series: M966, M996, M997, M998, M1008, M1008A1, M1009, M1010, M1025, M1026, M1028, M1028A1, M1028A2, M1035, M1036, M1037, M1038, M1042, M1043, M1044, M1045, M1046.

Reference Publications: TM 9-2320-289-34

Expendable Supplies:

- Paper, white, 8 x 10-1/2 sheets
- Fitting, Grease
- Pencil
- String, 12-ply, 25 ft. long
- Tape, Masking, 1 in. wide

(1) Perform Frame Leveling in accordance with paragraphs 27a. thru 27g. and figures 5 and 6.

(2) Perform all other frame alinement checks as described in paragraphs 27 thru 31.

**25. Shop Conditions:** Floor level with slope not more than 3 inches in 24 feet in any direction, Floor surface must be flat within 1 inch in 24 feet. Floor clean of dirt, grease, oil, or debris.

b. HMMMMV Series Vehicle Frame Alinement Inspection.

Applicable Vehicle Models/Series: M998, M966, M1036, M1045, M1046, M1025, M1026, M1043, M1044, M1037, M1042,

**26. Equipment Condition:** Vehicle empty and vehicle undercarriage clean and completely free of mud, dirt, and debris.

Reference Publications: TM 9-2320-280-34

**27. 3/4, 1-1/4 and To 2-1/2 Ton Vehicle Series Frames.**

a. CUCV Series Vehicle Frame Alinement Inspection.

(1) Perform frame leveling as described in paragraphs 27a. thru 27g. and figures 5 and 6.

(2) Perform all other frame alinement checks in accordance with paragraphs 27 thru 31.

SECTION II. 5-TON SERIES VEHICLES REQUIREMENTS

Applicable Vehicle Models/Series: M39, M39A1, M39A2, M809 and M939 Series

Expendable Supplies:

Tools: Light:

- Extension, 25 ft. length
- Jack, Hydraulic, 12-ton capacity
- Jack, Hydraulic, 30-ton capacity
- Plumb Bob, 10 oz.
- Square, 24 in.
- Tape Measure, 25 ft. Long

- Paper, white, 8 x 10-1/2 sheets
- Fitting, Grease
- Pencil
- String, 12-ply, 25 ft. long
- Tape, Masking, 1 in. wide

**28. Shop Conditions:** Floor level with slope not more than 3 inches in 24 feet in any direction. Floor surface must be flat within 1 inch in 24 feet. Floor clean of dirt, grease, oil, or debris.

**29. Equipment Conditions:** Vehicle empty and vehicle undercarriage clean and completely free of mud, dirt, and debris.

Reference Publications:

- TM 9-2320-211-34-22
- TM 9-2320-260-34-2-3
- TM 9-2320-272-34-1
- TM 9-2320-272-34-2

**30. Undercarriage Preliminary Inspection.**

**NOTE**

If damage is found during the undercarriage preliminary inspection, this damage must be corrected before vehicle frame alignment can be completed.

- a. Perform the following checks:
  - (1) Check for loose or missing crossmember rivets.

- (2) Check for loose or broken crossmembers.
- (3) Check for damaged frame rails.

- b. Drive vehicle into inspection position from a 12 foot straight line of travel.

**31. Frame leveling (Figure 5).**

- a. Apply handbrake and chock wheels to prevent vehicle movement.
- b. Using tape measure, measure distance from shop floor to bottom of two front frame rails (1) at front of crossmember (2) as shown.
- c. If either frame rail (1) is lower than the other, use jack and raise lower side at axle (3) to adjust frame rails (1) to within 1-inch equal height.
- d. Record measurements on DA Form 2404.

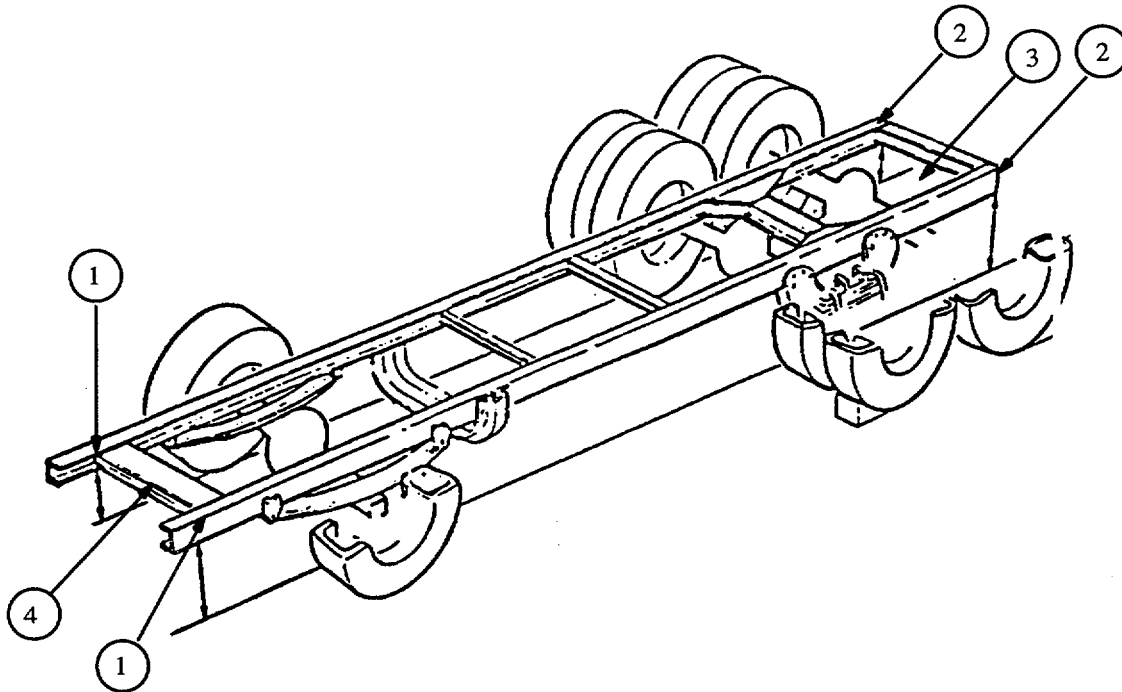


Figure 5. Frame Leveling

- e. Using tape, measure distance from shop floor to bottom of two rear frame rails (4) at crossmember (5) as shown.
- f. If either frame rail (4) is lower than the other, use hydraulic jack and raise lower

side at rear axle (6) to adjust frame rails to within 1/8-inch equal height.

- g. Record measurements on DA Form 2404.

**32. Horizontal Bow Measurements - 20 Foot Vehicle Frame Sections (Figure 6)**

- a. Refer to Figure 6. Securely tape sheets of white paper (5) to shop floor under each end of three crossmembers (6), in front of crossmember (7) and crossmember (8). Also secure sheets of white paper (5) in

front of crossmember (7) where it attaches to two frame side rails (4), except at crossmember (9) between two rear axles (10).

- b. Securely tape sheets of white paper (5) to shop floor under two bogie brackets (11).

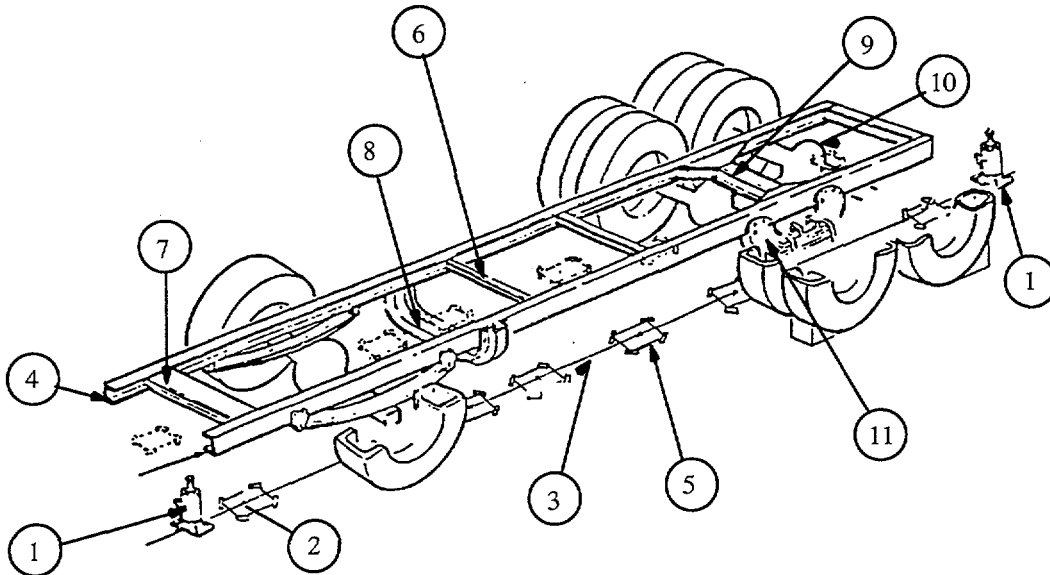


Figure 6. Stretching String On Floor

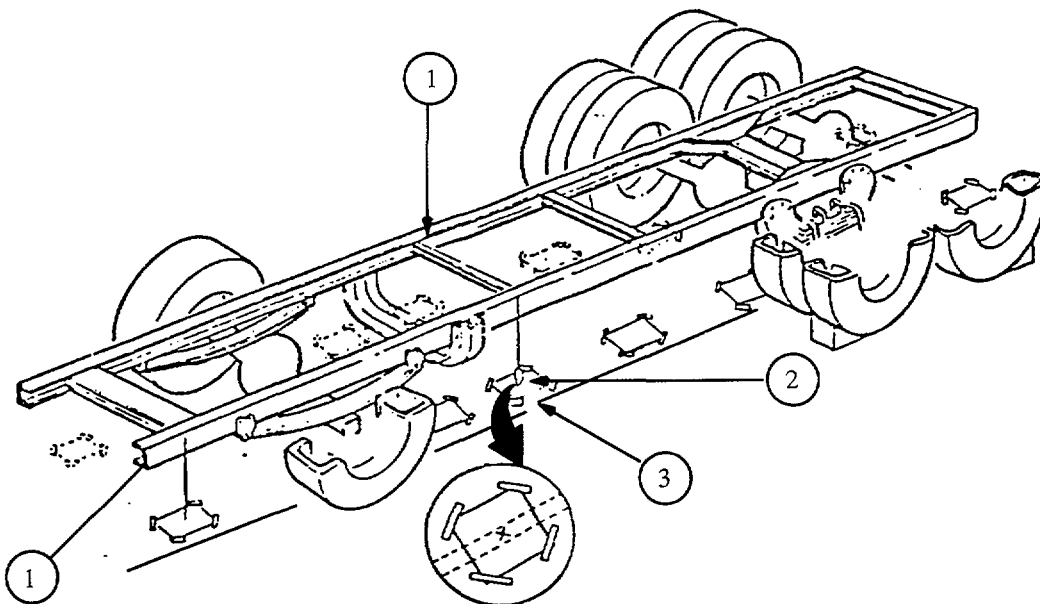


Figure 7. Marking Paper Using Plumb Bob

**NOTE**

To ensure accurate measurements, check that plumb bob string is placed flat against frame rails, is free of obstructions such as bolts, nuts, rivets, brackets, and rear springs.

- c. Refer to Figure 7. Hold string of plumb bob (2) above paper (3) to outside of frame rail (1) making sure that plumb bob string is placed flat and unobstructed against frame rails.
- d. Adjust plumb bob (2) to hang above paper (3), 4 inches from bottom of frame rail (1).
- e. Carefully locate a fixed point on paper (3) directly below plumb bob (2).
- f. Using pencil, carefully mark fixed point on paper (3) directly below plumb bob (2) point.
- g. Leave papers (3) with fixed point marks in place for next procedure.
- h. Repeat steps a thru g above for other frame rail (1).

- i. Leave papers (3) with fixed point (5) marks in place for next procedure.
- j. Refer to Figure 6. Stretch string (3) tightly on the shop floor between the front and rear plumb bob fixed point marks (2) under each frame rail (4). Place hydraulic jacks (1) on string (3) to keep string tight.

**NOTE**

Strings used for horizontal bow measurements will remain in place until the frame squareness task is completed. On vehicle frames longer than 20 feet, the two front to rear strings will be used.

**33. Measuring Marks (Figure 8).**

- a. Measure the distance between string (3) and each plumb bob mark (2). If the distance is more than 1/2-inch at bow measurement (A) or 1/2-inch at bow measurement (B), frame rails (1) are out of tolerance.

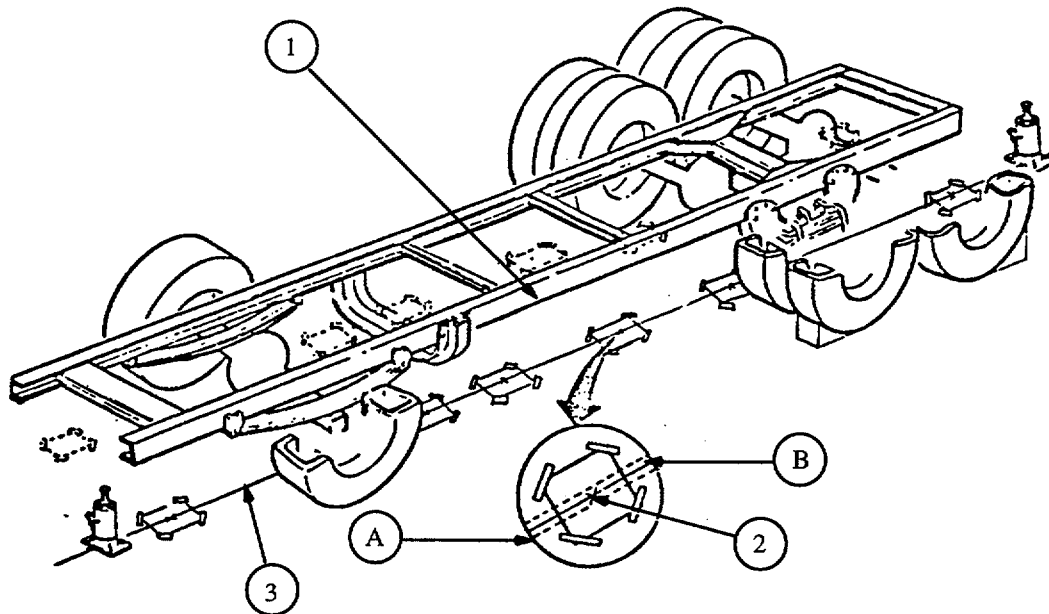


Figure 8. Measuring Marks

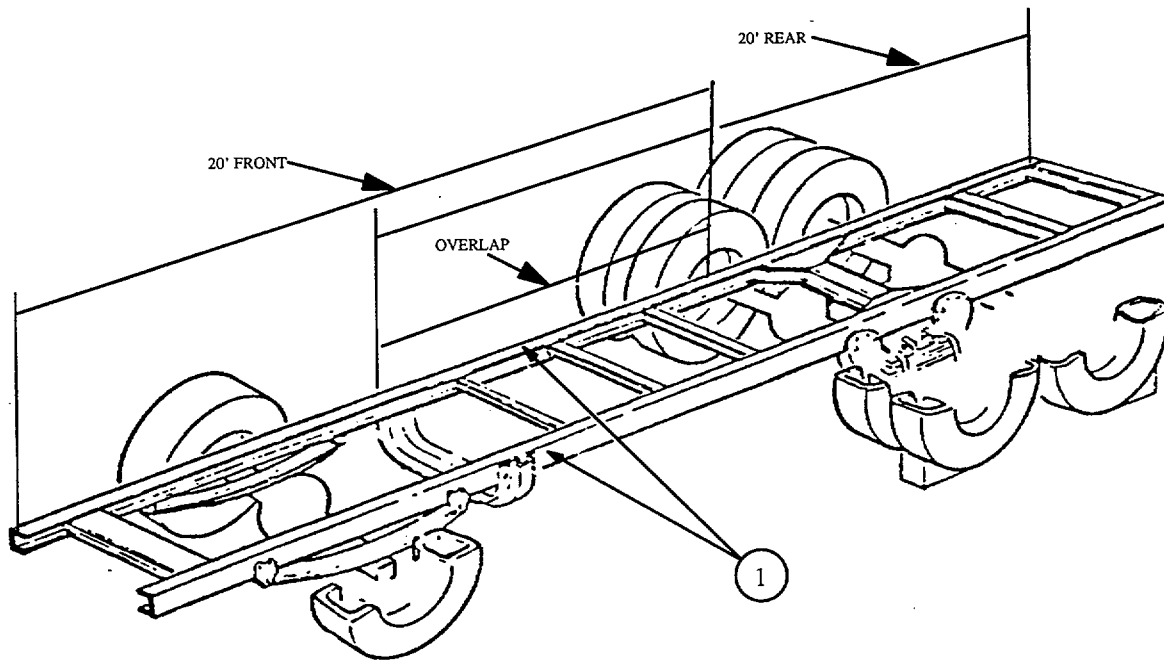


Figure 9. Measuring Frames Longer Than 20 Feet

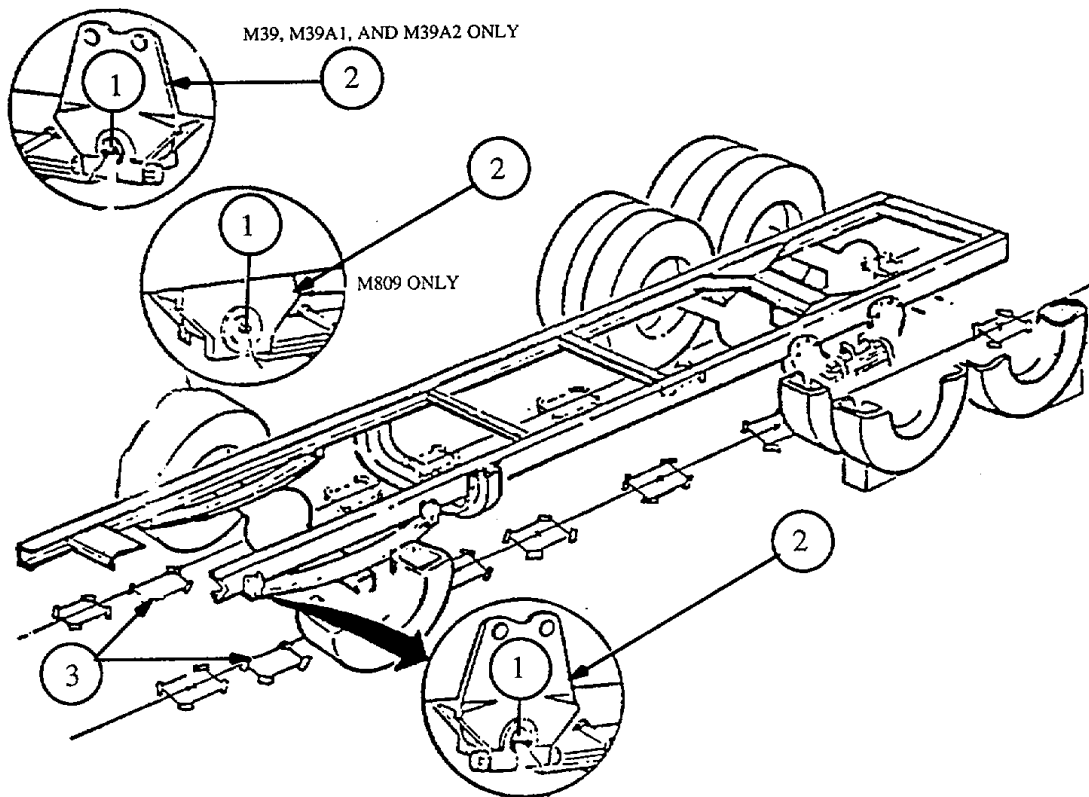


Figure 10. Front Spring Shackles and Grease Fittings Location

**NOTE**

For frame rail sections with added flaseplate, subtract 5/16-in. from plumb bob mark to compensate for the flaseplate added to the frame rail.

- b. Record measurements (A) and (B) on DA Form 2404.

**NOTE**

To verify frame rail tolerance measurement, have another qualified shop technician repeat mark measurement steps a and b. If second measurements verify frame rail out of tolerance condition, vehicle will be classified as unserviceable.

- c. Record second measurements (A) and (B).

**34. Horizontal Bow Measurements -Vehicle Frames Over 20 Feet (Figure 9).**

**NOTE**

On vehicles with frames over 20 feet in length, the forward (front) 20 feet of frames rail is measured separately from the rear (back) 20 feet of frame rail. The front 20 feet of frame rail will be measured from front to rear and the rear 20 feet of frame rail will be measured from rear to front. This will cause an overlap in measurements.

- a. Perform steps a thru c of paragraph 33 above for each 20 foot section of frame rail. If frame rail exceeds the tolerances specified, the vehicle will be classified unserviceable.

**35. Frame Squareness - All Vehicle Frames (Figure 10).**

**NOTE**

This procedure requires that the vehicle right and left front spring shackles be equipped with straight type grease fittings.

M39 series vehicles modified with M809 vehicle power steering conversion kit will have a grease fitting installed on the in- side of the right front spring shackle (re- fer to Figure 10).

- a. Locate and clean the two front grease fittings (1) on right and left front spring front shackles (2).
- b. Check that grease fittings (1) are straight type. If not, replace with straight type grease fittings.
- c. Using tape, securely attach sheet paper (3) to shop floor directly under right and left front spring front shackles (2)

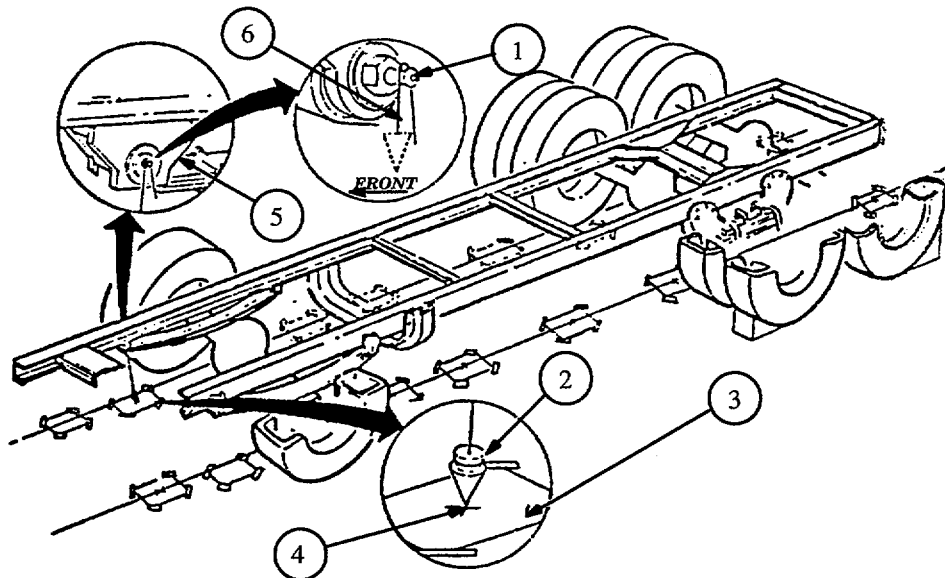


Figure 11. Marking Paper Under Right Spring Shackle

**NOTE**

If plumb bob is not placed towards the front of the vehicle on both the right and the left grease fittings (1), inaccurate frame squareness measurement will result.

- d. Refer to Figure 11. Place string (6) over grease fitting (1) on inner right front spring shackle (5). Make sure that plumb bob (2) is to front of vehicle.
- e. Lower plumb bob (2) and locate a point on paper (3) below spring shackle (5).

**NOTE**

For accuracy, do not make mark on paper until plumb bob has stopped swinging and is as close to the paper as possible without actually touching the paper.

- f. Refer to Figure 11. Carefully mark spot (4) on paper (3) directly below plumb bob (2).
- g. Refer to Figure 12. Place one edge of square (1) along horizontal line (4) used to measure horizontal bow on right side of vehicle. Make sure that the other edge of square (1) is touching plumb bob mark (5) on paper.
- h. Stretch string (2) along edge of square (1) to the left side of the vehicle.
- i. Allow string (2) to extend 6 inches beyond left horizontal (3).
- j. Using tape, secure string (2) securely to the shop floor.

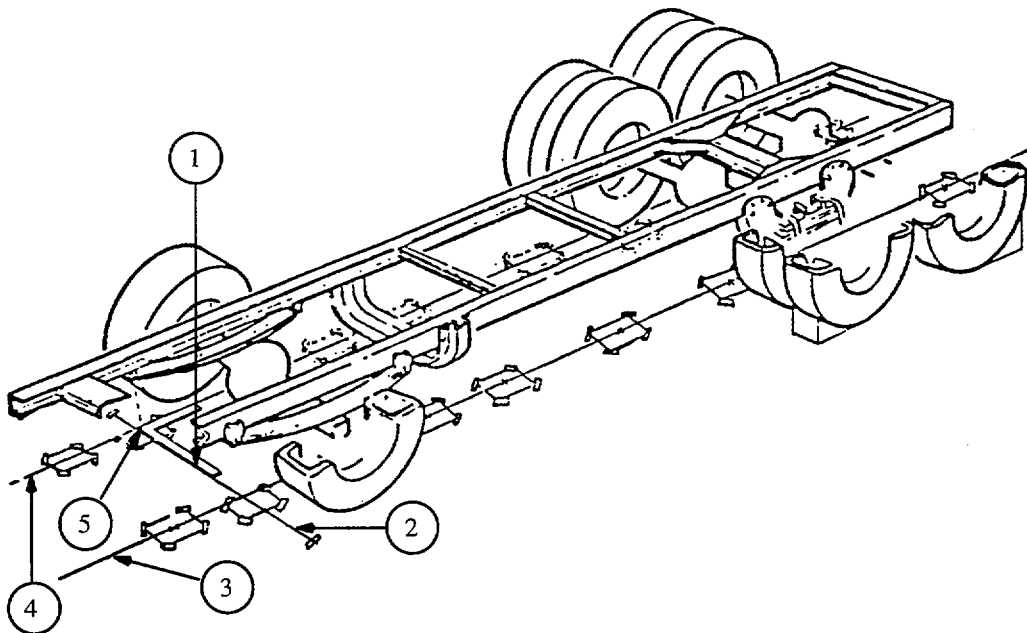


Figure 12. Establishing Reference Line (Right Side)

**NOTE**

If plumb bob is not placed towards the front of the vehicle on both the right and the left grease fittings (1), an inaccurate measurement of frame squareness will result.

- k. Refer to Figure 13. Place string (6) over grease fitting (1) on left front spring shackle (5) with plumb bob (3) to front of vehicle.
- l. Lower plumb bob (3) and locate a point on paper (4) below spring shackle (5).

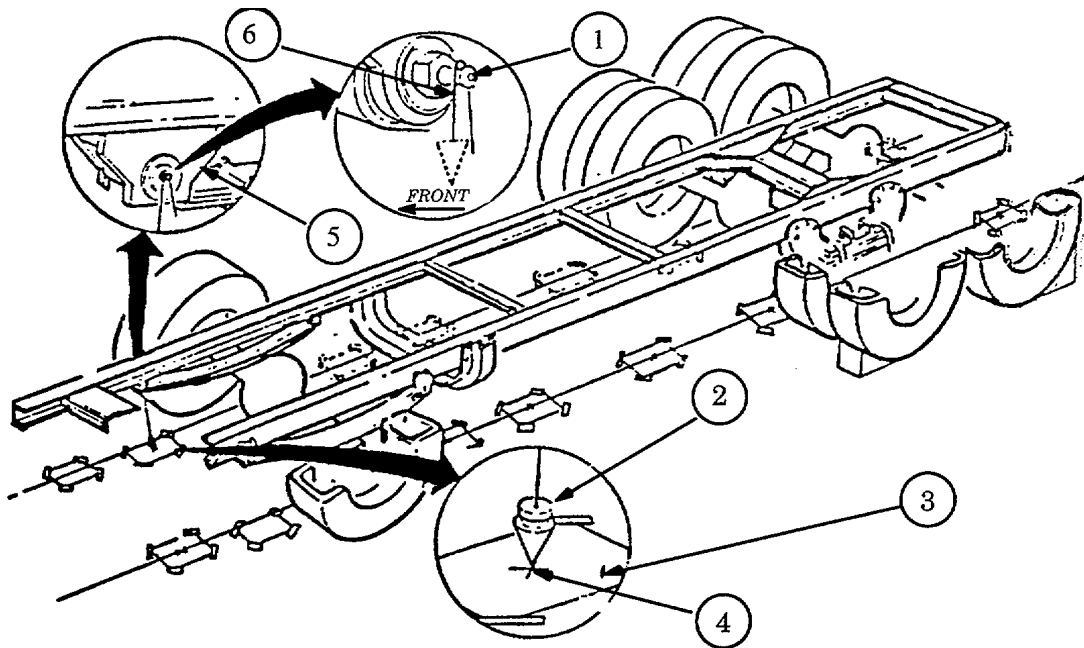


Figure 13. Marking Paper Under Left Spring Shackle

**NOTE**

For accuracy, do not make mark on paper until plumb bob has stopped swinging, is motionless, and is as close to the paper as possible without actually touching the paper.

m. Refer to Figure 13. Carefully mark a spot (5) on paper (4) directly below plumb bob point (3).

n. Refer to Figure 14. Measure the distance between the left side plumb bob mark (1) and string (2) on shop floor.

o. If the distance is more than 1/4-inch, the frame rails (3) are out of tolerance.

p. Record measurements.

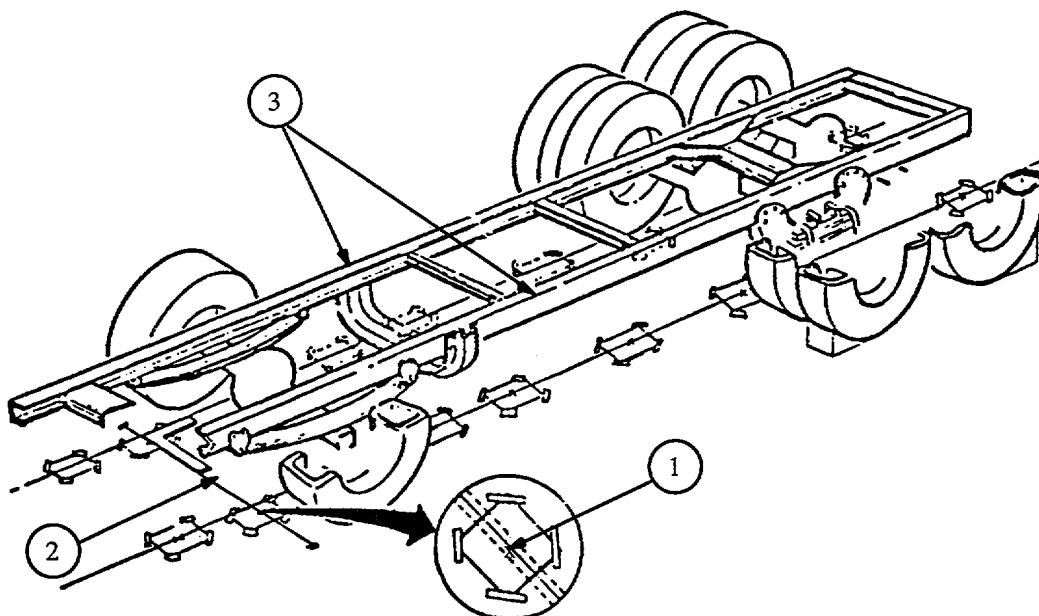


Figure 14. Measuring Frame Squareness



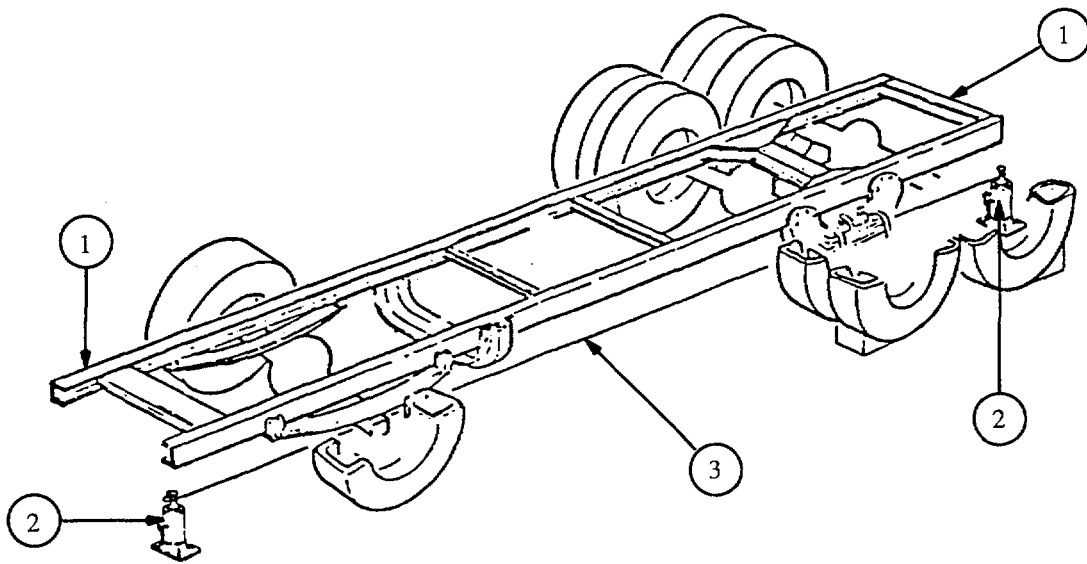


Figure 15. Establishing Line For Vertical Bow Measurement

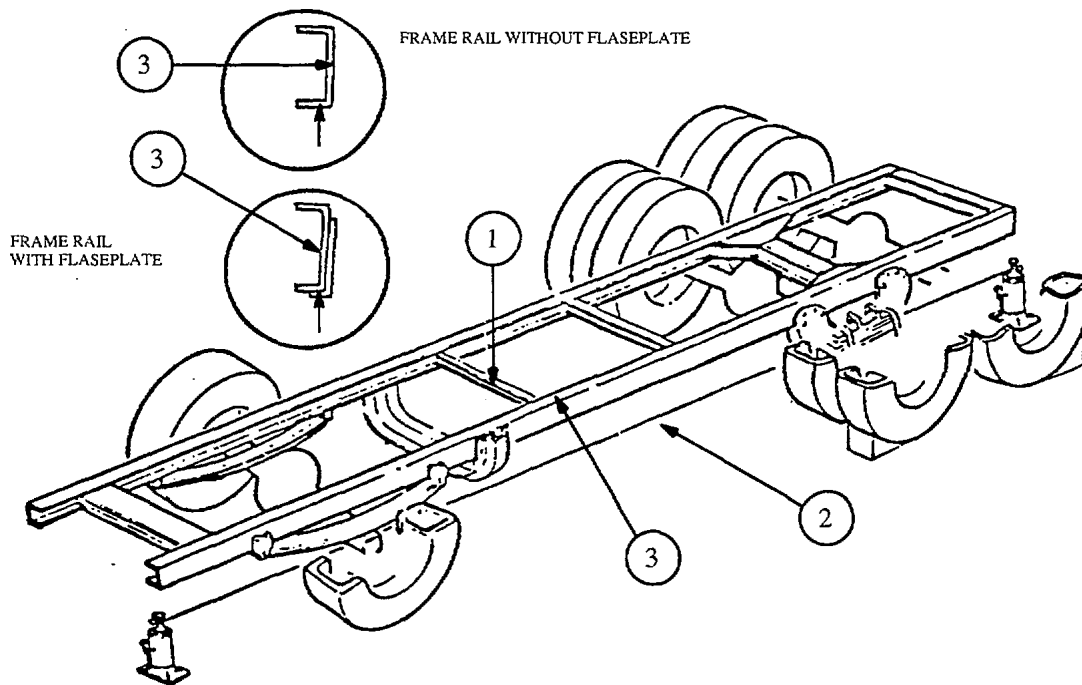


Figure 16. Measuring Vertical Bow

- q. To verify frame rail tolerance measurement, have another qualified shop technician repeat mark measurement steps n thru p. If second measurements verify frame rail out of tolerance condition, vehicle will be classified as unserviceable.
- r. Record second measurement on DA Form 2404.

**36. Vertical Bow Measurement - 20 Foot Vehicle Frame Sections (Figure 16).**

- a. Position two 30-ton capacity hydraulic jacks (2) under each end of frame rails (1). Attach string (3) to each hydraulic jack and stretch string tight until there is no visible bow or sag in string between the jacks.

- b. Refer to Figure 16. Measure the distance between string (3) and the bottom of frame rail (1) at the closest point nearest to each hydraulic jack (2). Adjust string (3) height until the measurement at each jack is the same and the entire length of string (3) is unobstructed.
- c. Refer to Figure 17. Measure the distance between string (2) and the bottom of frame rail (3) near crossmembers and as close to the frame rail centerline as possible. If frame rail (3) is bowed more than 5/16 inch,

up or down, the frame rail is out of tolerance.

- d. Record measurements.
- e. To verify frame rail tolerance measurement, have another qualified shop technician repeat mark measurement steps a thru c. If second measurements verify frame rail out of tolerance condition, vehicle will be classified as unserviceable.
- f. Record second measurement.

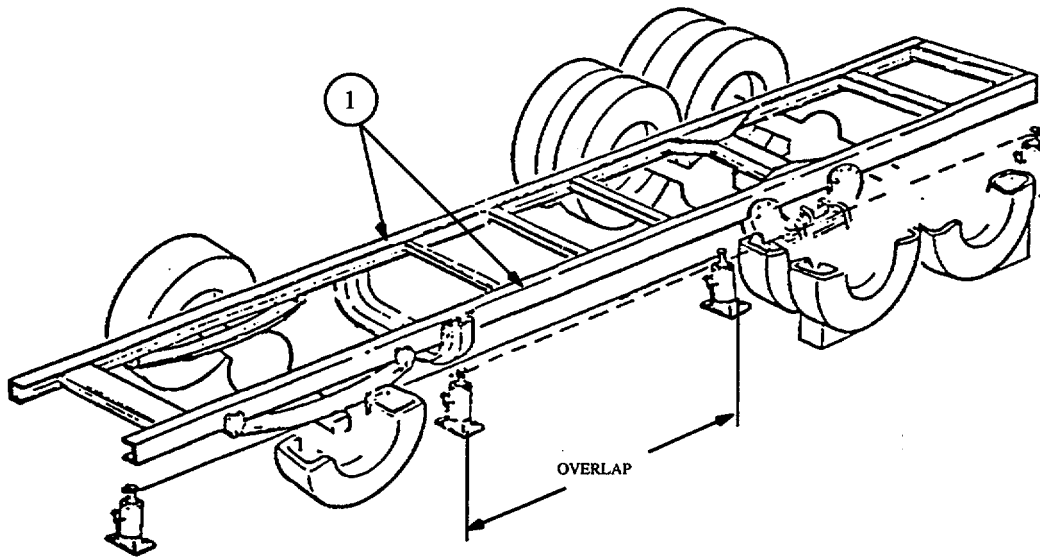


Figure 17. Measuring Vertical Bow on Frames Larger Than 20 Feet

**NOTE**

On vehicles with frames over 20 feet in length, the forward (front) 20 feet of frames rail is measured separately from the rear (back) 20 feet of frame rail. The front 20 feet of frame rail will be measured from front to rear and the rear 20 feet of frame rail will be measured from rear to front. This will cause an overlap in measurements.

**37. Vertical Bow Measurement -Vehicle Frames Over 20 Feet (Figure 18).**

- a. Refer to Figure 18 and perform steps a thru f of paragraph above for each 20 foot section of frame rail.
- b. If frame rail exceeds the tolerances specified, the vehicle will be classified unserviceable.

## CHAPTER 4

## FRAME REPAIR PROCEDURES

## SECTION I. 3/4 TO 1-1/4 TON SERIES VEHICLE FRAMES

## 38. General.

- a. Types of repairs. Common types of frame failure repairs which can be performed on the CUCV and HMMV (3/4 to 1-1/4-ton series) vehicles are; (1) Inadequate or broken welds and (2) cracked side rails, top and bottom flanges and the frame vertical web.

**CAUTION**

**Welding is not an approved or acceptable alternate method of repair for any riveted or bolted attachment (e.g. crossmember, spring hanger etc.) on the CUCV vehicle series frame assembly.**

- b. Welding Instructions. Welding instructions described in Section I will be followed to repair broken welds in the following areas of this vehicle series frame:

- (1) Front spring hanger brackets to side rail.

- (2) Rear shock absorber shaft attachment to side rail
- (3) Inner and outer side rail joints, both top and bottom, between the front engine support and the number 2 crossmember.
- (4) Steer gear bracket to the side rail frame structure.
- (5) Vertical weld between the front engine mount bracket and its support bracket, riveted to the inner side rail.
- (6) Vertical weld between the end brackets on the number 2 crossmember and the inner side rail.

39. **Cleaning and Painting.**

- a. Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- b. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

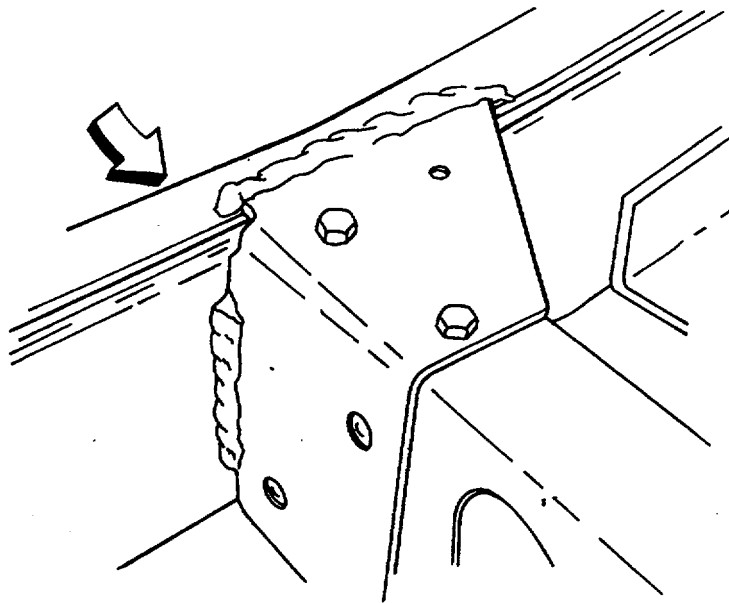


Figure 18. Cracked Side Rail Outer Flange

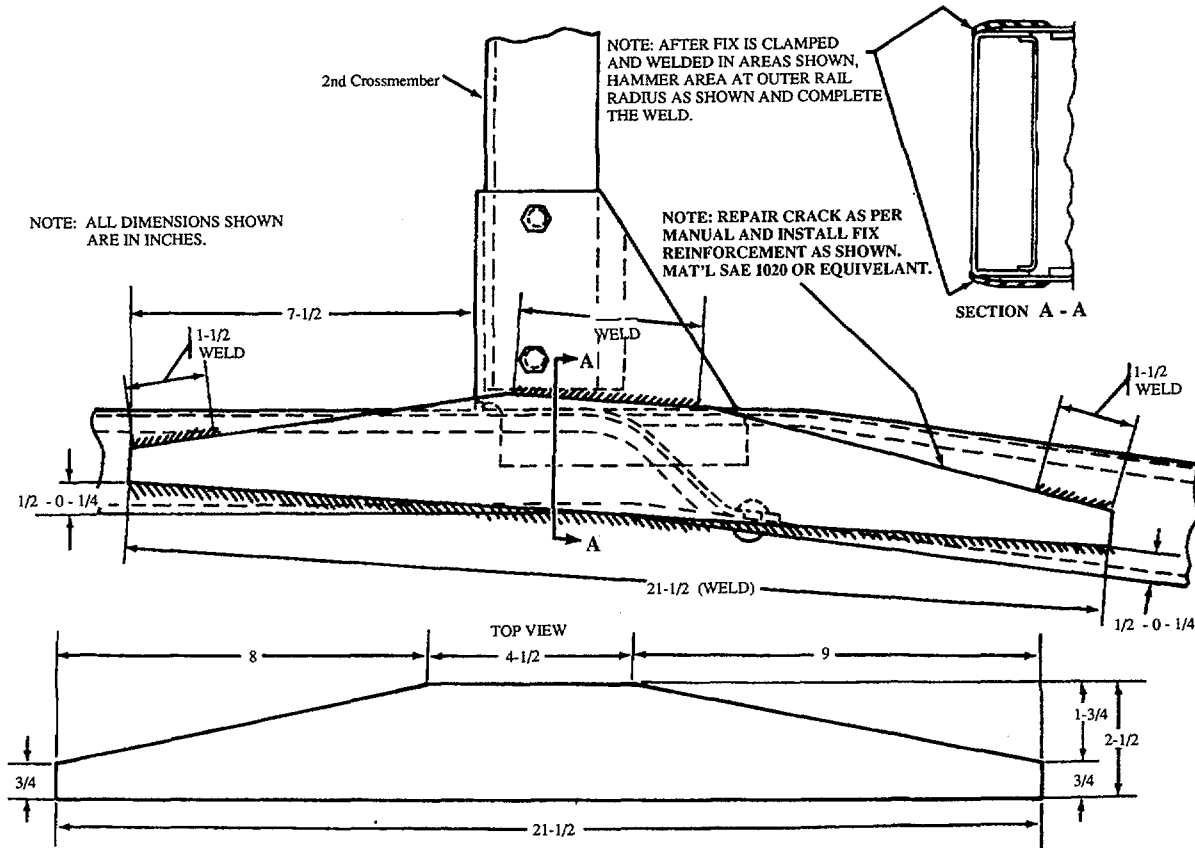


Figure 19. Reinforcement Plate

**40. Inspection.**

- a. Inspect vehicle frame for defects as described in Section I
- b. Perform vehicle frame alignment inspection for vehicles as described in Chapter 3.

**41. Sketches.** Prepare sketches to design specific repair requirements as required and/or as shown in this section.

**42. General Repair Procedures.**

- a. Thoroughly clean vehicle frame of all, oil, grease, dirt, and debris.
- b. Perform general vehicle frame inspection as specified in Section I.
- c. Perform vehicle frame alignment inspection as specified in Chapter 3.
- d. Jack up vehicle frame evenly and provide support directly under crack.

- e. Remove front wheel, splash shield, and fender to provide access as required.

**WARNING**

Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc.) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

**CAUTION**

Welding is not an approved or acceptable alternate method of repair for any riveted or bolted attachment (e.g. crossmember, spring hanger etc.) on the CUCV vehicle series frame assembly.

- f. Drill a 3/16-inch hole at the extreme edge of the crack and bevel the edges of the crack with a chisel or grinding tool as shown in Figure 23

- g. Apply weld as required and ground flush with surrounding metal.
- h. Fabricate reinforcement plate of 1/4-inch cold-rolled steel plate as detailed in Figure 20.
- i. Position fabricated steel plate over crack flush with side member.

- d. Jack up and evenly support the vehicle frame to gain access to the area to be repaired. Provide firm support directly under the area to be repaired.
- e. Perform the necessary removal of components, service lines, electrical wiring, etc., as required to gain access to the proposed repair.

- 43. Defect. Crack In Upper Flange of Main Side Rail.** Figure 19 illustrates a crack in the outer flange of the frame main side rail at the junction with the forward crossmember. The crack originated at the back end of the fillet weld indicating a slight weakening at that point.

**NOTE**

**Uneven contact of fabricated steel plate at the edges of side member or between the mating surfaces will result in a poor and undependable weld.**

- a. Shape fabricated plate according to prepared sketches or to suit conditions.
- b. Clamp fabricated plate securely to side rail member.
- c. Weld edges of fabricated plate to side rail member being careful not to disturb the metal at the edge of the upper flange, wherever possible.
- d. Thoroughly clean repaired surfaces and surrounding area of repair.
- e. Prime and paint repaired area and surrounding surfaces as specified in TM-43-0139.

- 44. Defect. Cracked Side Rail Outer Flange.** Figure 21 illustrates a cracked side rail outer flange in the area of the number 2 crossmember.

- a. Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- b. Perform general vehicle frame inspection as specified in Chapter 1.
- c. Perform vehicle frame alignment inspection as specified in Chapter 3.

**WARNING**

**Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc.) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- f. Drill 1/8-inch hole at end of crack and v-notch crack using portable grinding tool..
- g. Apply weld to crack and grind flush.
- h. Refer to figure 22 and fabricate "L" reinforcement plate using .180-inch SAE steel plate or equivalent.
- i. Apply reinforcement plate to both outer flanges of side rails, both top and bottom as shown.
- j. Thoroughly clean repaired surfaces and surrounding area of repair.
- k. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

- 45. Defect. Cracked Outer Flange at Body Mount Bracket.** Figure 21 illustrates a cracked side rail outer flange at the body mounting bracket forward of the number 2 crossmember. The crack occurs in the top or bottom flange as a result of an inadequate weld below the inner and outer side rail top or bottom joint.

- a. Cleaning. Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- b. General Inspection. Perform general vehicle frame inspection as specified in Chapter 1.
- c. Perform vehicle frame alignment inspection as specified in Chapter 3.

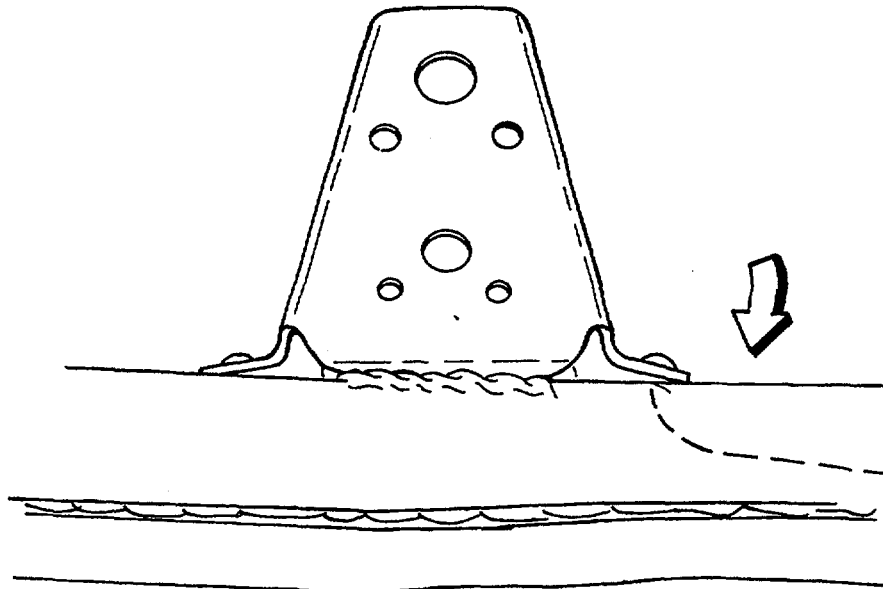


Figure 20. Cracked Rail Forward of No. 2 Crossmember

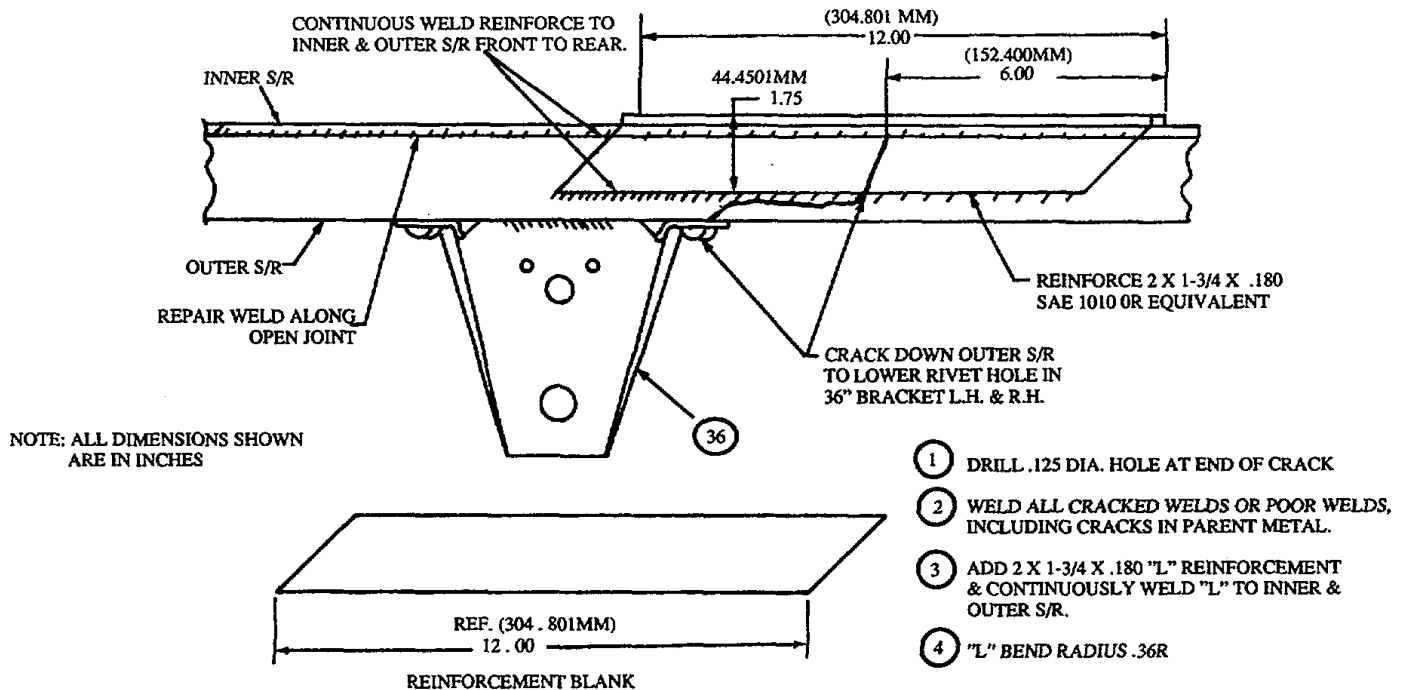


Figure 21. Weld Reinforcement

- d. Jack up and evenly support the vehicle frame to gain access to the area to be repaired. Provide firm support directly under the area to be repaired or as shown.
- e. Perform the necessary removal of components, service lines, electrical wiring, etc., as required to gain access to the proposed repair.
- f. Refer to figure 22 and fabricate "L" shaped reinforcement plate using .180-inch 1010 SAE steel plate or equivalent.
- g. Apply reinforcement plate as shown.
- h. Thoroughly clean and paint repaired surfaces and surrounding area of repair.

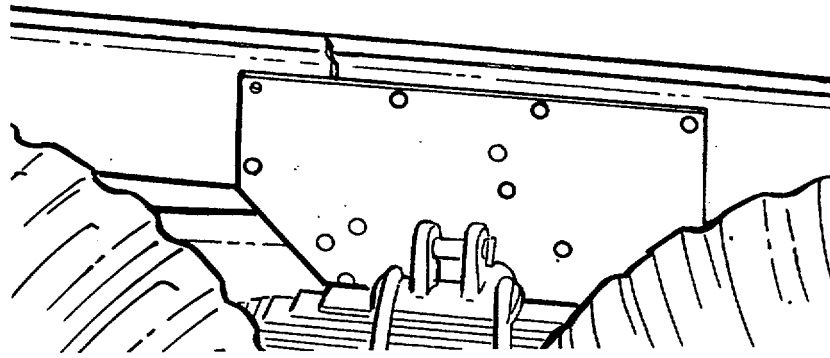


Figure 22. Cracked Frame Near Rear Axle (outside view)

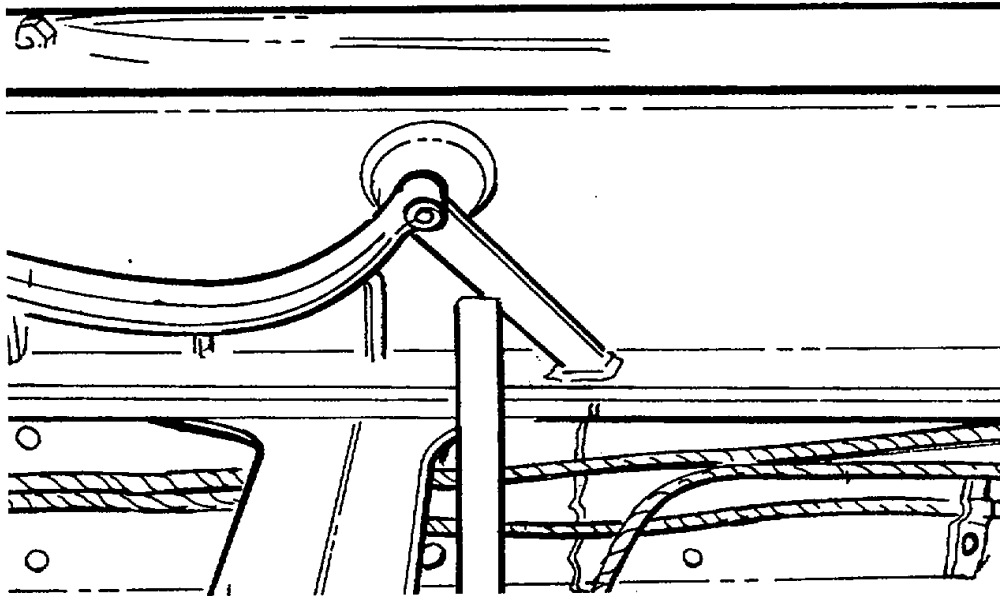


Figure 23. Cracked Frame Near Rear Axle (inside view)

## SECTION II. 2-1/2 TON VEHICLE SERIES FRAMES

**46. Defect. Cracked Side Rail.** Figures 23 and 24 illustrate cracked side rails which are near the rear axle, starting at a rivet hole in the lower flange and continuing through the entire rail.

- Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- Perform general vehicle frame inspection as specified in Section I.
- Perform vehicle frame alignment inspection as specified in Chapter 3.

### NOTE

**When supporting vehicle, four supports are necessary to maintain a minimum stress condition during stress operation,**

### Tools:

Light:  
 Extension, 25 ft. length  
 Jack, Hydraulic, 12-ton capacity  
 Jack, Hydraulic, 30-ton capacity  
 Plumb Bob, 10 oz.  
 Square, 24 in.  
 Tape Measure, 25 ft. long

### Expendable Supplies:

Paper, white, 8 x 10-1/2 sheets  
 Fitting, Grease  
 Pencil  
 String, 12-ply, 25 ft. long  
 Tape, Masking, 1 in. wide

Shop Condition: Floor level with slope not more than 3 inches in 24 feet in any direction.

Floor surface must be flat within 1-inch in 24 feet. Floor clean of dirt, grease, oil, or debris.

Equipment Condition: Vehicle empty and vehicle undercarriage clean and completely free of mud, dirt, and debris.

d. Perform the necessary removal of components, service lines, electrical wiring, etc., as required to gain access to the proposed repair.

e. Carefully jack up and evenly support the vehicle frame to gain access to the area to be repaired as shown in Figure 25. Provide firm support directly under the area to be repaired and as shown.

f. Remove hold down bolts securing cargo area and raise cargo area approximately 4 to 6 inches of clearance above side rails to gain access to for working space.

g. Lower or remove rear axle assembly, side plate, and frame bracket.

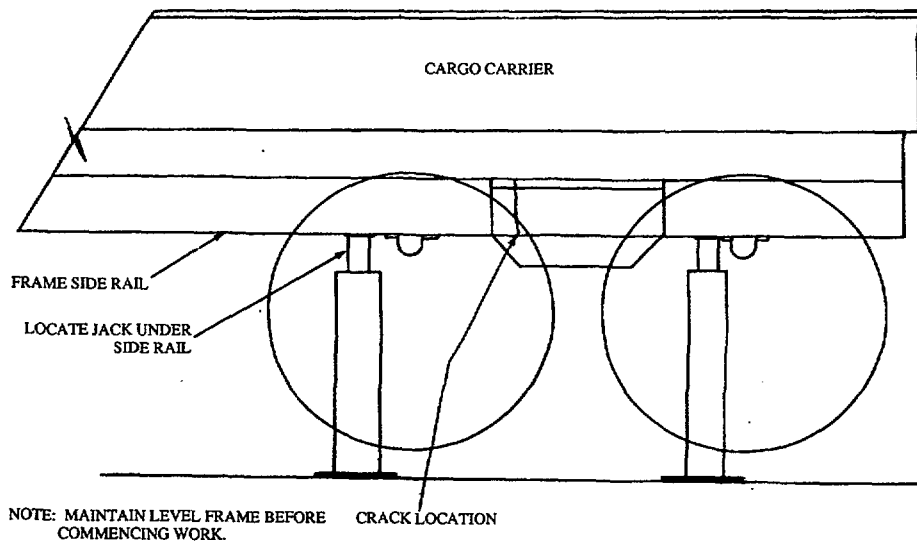


Figure 24. Location of Jacks or Supports

**WARNING**

Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc.) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

**CAUTION**

When cutting at the edges of frame rail break, care should be taken not to remove excessive metal and create the need for an unnecessarily large welded area.

h. Remove rivets and bolts as required and as described in Chapter 1.

i. If the break (crack) does not extend through the entire cross section of the rail, a 3/16-inch diameter hole may be drilled at the extreme edges of the crack. This will reduce the concentration of the defect at the tip of the break.

j. Using a suitable grinder, bevel the edges of the break and follow the repair procedures indicated in paragraphs m thru y.

k. Separate the vehicle frame at the break to be repaired and scarf or bevel the edges of the broken sections and cut a V-shaped groove at both sides of the break.

l. To assure accuracy of alinement, butt the two broken sections together and clamp with C-clamps, a straight edge or angle iron as shown in figure 28.



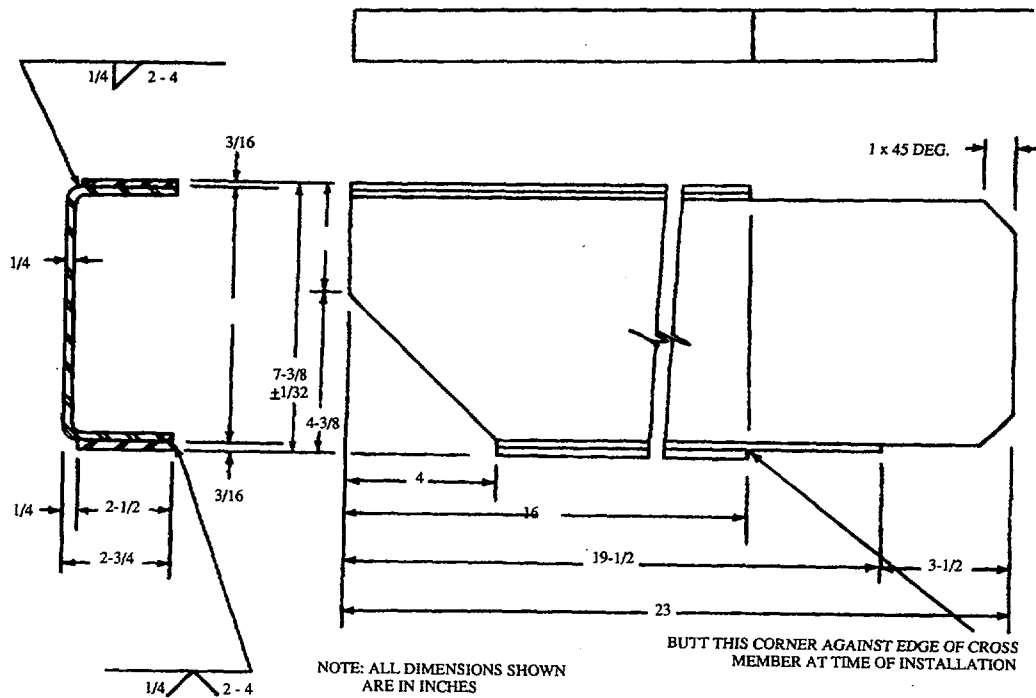
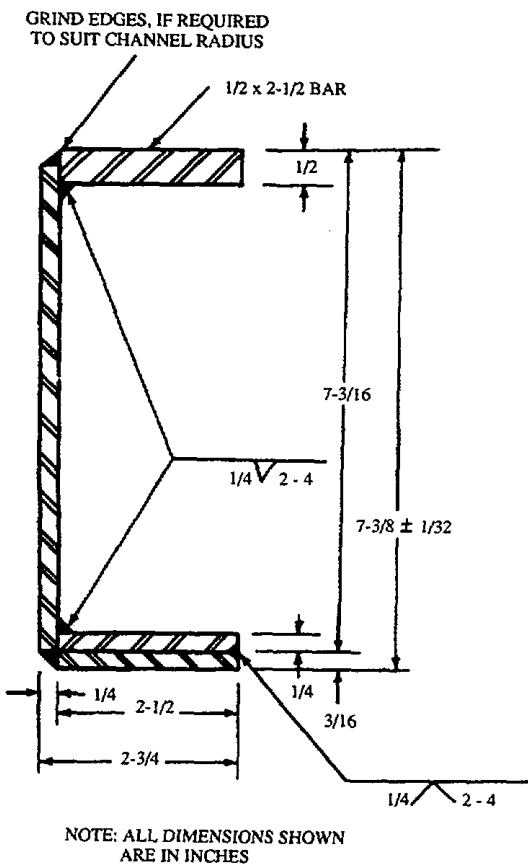


Figure 25. Reinforcing Plate Fabrication Details



**NOTE**

If forming equipment is not available for fabricating reinforcements under this task, the sketches for fabrication shown in Figure 27 are recommended for use..

- m. Using forming equipment, fabricate reinforcements as shown in Figure 26 and/or Figure 27, as applicable.
- n. After bolts and rivets have been removed, fit the fabricated reinforcement inside the side rail, tightly butted up to the framing crossmember as shown in Figure 28.
- o. Using grinding tool, slightly grind the reinforcing member as necessary to provide an accurate fit.
- p. Locate and drill new center-to-center holes for connection of the framing and reinforcing members, size holes no larger than the existing holes. Where new holes cannot be drilled with reinforcing plate in position, locate holes, center-to-center, remove reinforcing plate, drill new holes and reinstall plate.

Figure 26. Reinforcing Channel Fabrication Details

- q. Select UNF Grade 8 bolts of sizes to fit the new and existing holes, as required, and of lengths to accommodate the added reinforcement plate, washers and locknuts.

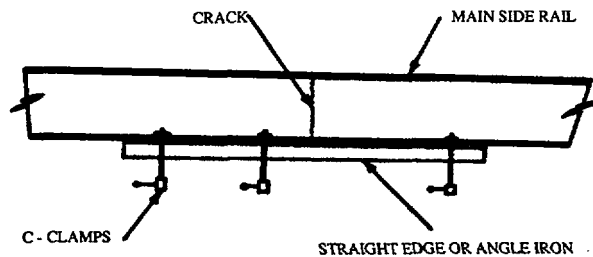
**NOTE**

**When shoulder bolts are used in fastening reinforcement plates in the new work, the length of the new shoulder bolt shall depend on the total thickness of the framing member and the reinforcing plate.**

- r. Where holes are slightly mislined because of warpage or shrinkage caused by the welding process, aline holes by reaming. In no case, however, shall any new bolt

installed exceed the size of the original bolt or rivet removed by more than 1/16-inch.

- s. Thoroughly clean repaired surfaces and surrounding area of repair.
- t. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.
- u. With the reinforcement plate in place, ream holes, where accessible and as required, to the exact size of the new bolt to be installed. Since welding is a suitable method of repair for this type of frame defect, bolting of the reinforcement plate is a secondary means of increasing the strength of the repair.



CROSS SECTIONAL VIEW SHOWING METHOD OF USING C - CLAMPS



*Figure 27. Method of Maintaining Alinement of Side Rail Before Tack Welding*

- v. Install correct size bolts, washers and locknuts in all bolt and rivet holes. Torque all bolted connections as specified in paragraph q.
- w. Weld reinforcing plate to side rail as indicated in Figure 29.

- x. Thoroughly clean repaired surfaces and surrounding area of repair.
- y. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

**SECTION III. 5-TON VEHICLE SERIES FRAMES (REINFORCEMENT).**

**NOTE**

The M939 vehicle series have heat-treated frames and will not be repaired by welding.

**47. Defect. Frame Rail Reinforcement Failure.**

Figure 30 illustrates a failure in the lower flange of the reinforcement plate on the main side rail.

- a. Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- b. Perform general vehicle frame in section as specified in Section I.
- c. Perform vehicle frame alignment inspection as specified in Section III.

- d. Jack up and evenly support the vehicle frame to gain access to the area to be repaired. Provide firm support on each side of the defect or the area to be repaired to reduce any stress on framing members to a minimum.
- e. Perform the necessary removal of components, service lines, electrical wiring, etc., as required to gain access to the proposed repair.
- f. To reduce the tendency of the defect (crack) to increase, drill 3/16-inch diameter hole at the terminal point of the crack at the flange portion of the framing member.

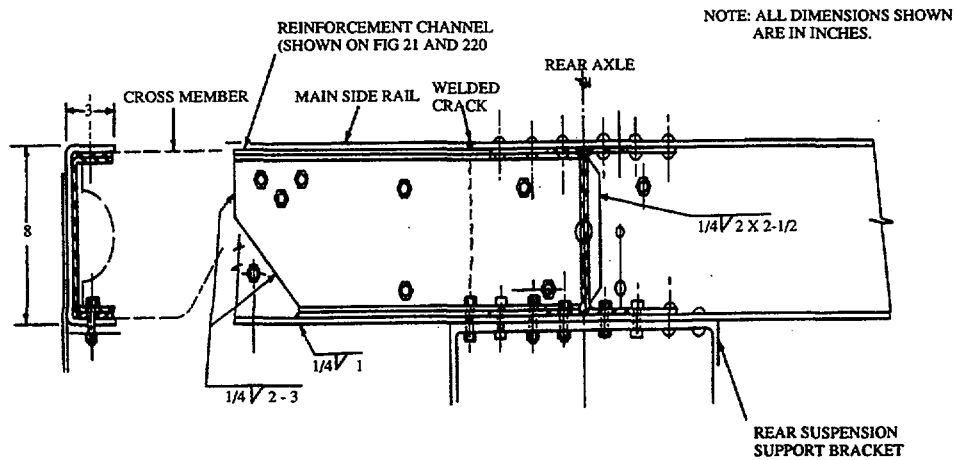


Figure 28. Reinforcement Channel in Position for 2-1/2-Ton Truck Frame

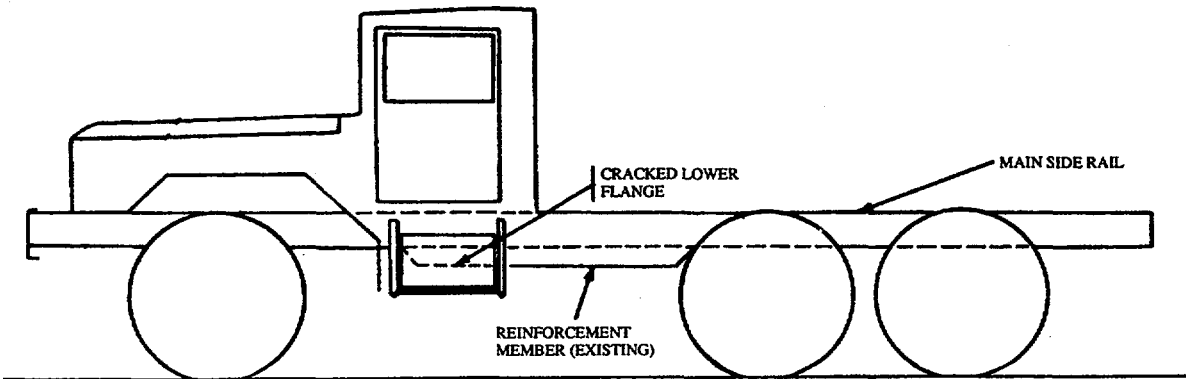


Figure 29. Crack in Lower Flange of Main Side Rail Reinforcement Member

- g. Fabricate a 3/8 x 3 x 3-inch steel angle shaped to provide an accurate fit to suit the reinforcing member under repair as shown in figure 31 h. Clamp the steel angle into position and bolt as indicated.
- i. Thoroughly clean repaired surfaces and surrounding area of repair.
- j. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.
- k. Verify frame alignment as specified in Section III.

**48. Defect. Main Side Rail Lower Flange And Reinforcing Member Failure.** Figure 31 illustrates a failure in the lower flange of the main side rail and reinforcing member approximately 12 or 13 inches forward of the centerline of the rear axle assembly.

- a. Thoroughly clean vehicle frame of all oil, grease, dirt, and debris.
- b. Perform general vehicle frame inspection as specified in Section I.

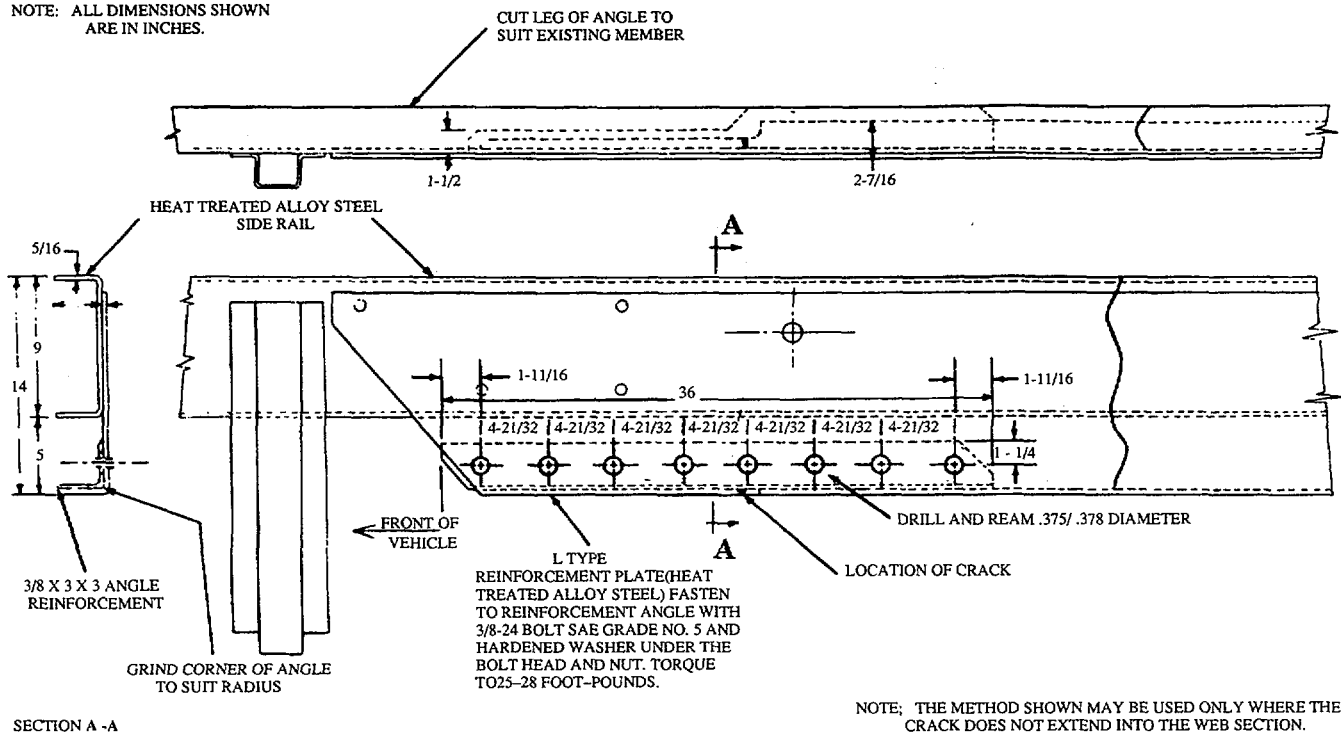
**NOTE**

**Heat-treated steel frames, such as those used in 5-ton trucks are assembled using bolts and rivets. Most welding processes destroy the heat treatment properties of the**

**vehicle framing members, causing the metal adjacent to the weld to be weakened. As a result of the destructive properties of welding on heat-treated steel, welding of heat-treated 5-ton truck framing members is prohibited except as otherwise specified. This repair can best be accomplished by plates secured with bolts, locknuts, and washers.**

- c. Remove the rear axle suspension bracket, rubber bumper bracket, and remove the crossmembers, removing all rivets and bolts as specified in Section I.
- d. Slightly deflect the side rail on the side of the cracked crossmember.
- e. Detach the cracked reinforcement member from the cracked side only.
- f. Carefully jack up the rear of the vehicle frame at four locations to evenly distribute the load and to reduce the stress at the point of the frame defect.
- g. Perform the necessary removal of components, service lines, electrical wiring, etc., as required to gain access to the proposed repair.

NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES.



SECTION A - A

Figure 30. Reinforcement Angle for 5-Ton Truck Frame

**NOTE**

The rear axle suspension bracket located below the lower flange of the main side member prevents the adding of reinforcement plates in this area. However, reinforcements may be located in the area within the channel (refer to Figure 29).

Fabricate the reinforcing member as shown in Figure 31. The metal is being added primarily to the lower flange. This is the principal area where the additional support is needed. Because metal cannot be welded to the main side rail, the full design load cannot be supported. The metal to provide design load support must be added to the reinforcing member by welding, using low carbon steel.

- h. Remove rear axle suspension bracket, bumper bracket, on the cracked side of the frame only.
- i. Remove the following components/ assemblies as required for accessibility:

**WARNING**

Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc.) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

- (1) Remove bolts and rivets securing brackets or other items to the frame as described in Chapter 1.
- (2) For tractors, remove fifth wheel anchor bolts, as required.
- (3) For cargo trucks, remove cargo body brackets, anchor bolts, and raise body for clearance.
- j. Using jack, deflect side rail member outward a distance of not more than 1/2-inch at the rear crossmember.
- k. Remove defective reinforcement member as shown in Figure 28.

- l. Drill a 3/8-inch diameter hole at the terminal of the crack in the reinforcement member to reduce the tendency of the crack to continue.
- m. Fabricate reinforcement members and angles using cold rolled steel plate as shown in Figure 31. Position and clamp reinforcements in place as shown in Figure 29. Check carefully for accurate fit.
- o. Temporarily position spacer between side rail and reinforcing member and weld reinforcement angle, stiffener, and filler plate as shown in Figure 33.
- p. Remove temporary spacer and secure reinforcement member to side rail with new No. 8 bolts, washers, and locknuts.

**NOTE**

**Do not reinstall the bottom front bolt securing the bogie bracket to the rail flange at the side. The front bolt that must be removed from all 5-ton series vehicles is identified in Figure 33 by arrow "Location of Crack". The hole is to remain unused as a bolt hole.**

- n. Locate and drill undersized mounting holes as shown on the sketches and ream to the exact size of the new bolts to be selected.
- q. Replace all crossmembers, brackets, components/assemblies, items, anchor bolts, and other materials removed for access to the repair work, using new bolts, washers and locknuts for all vehicle framing members.
- r. Thoroughly clean repaired surfaces and surrounding area of repair.

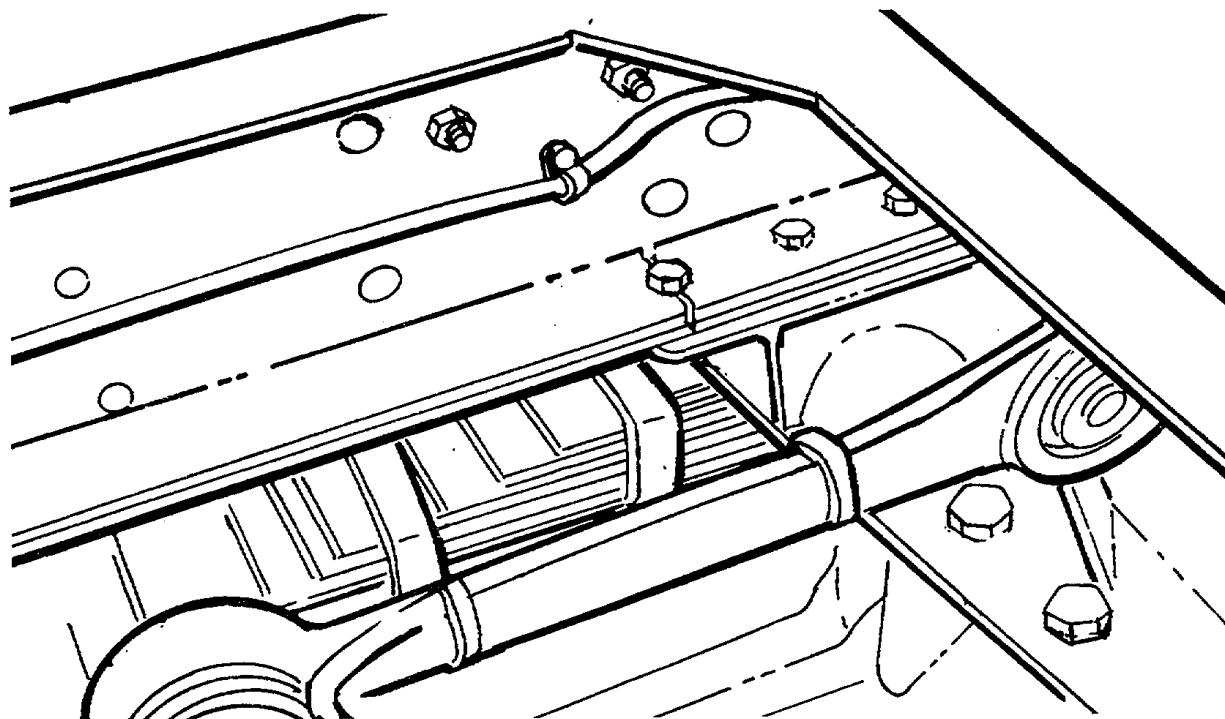


Figure 31. Crack in Lower Flange of Main Side Rail and Reinforcement Member

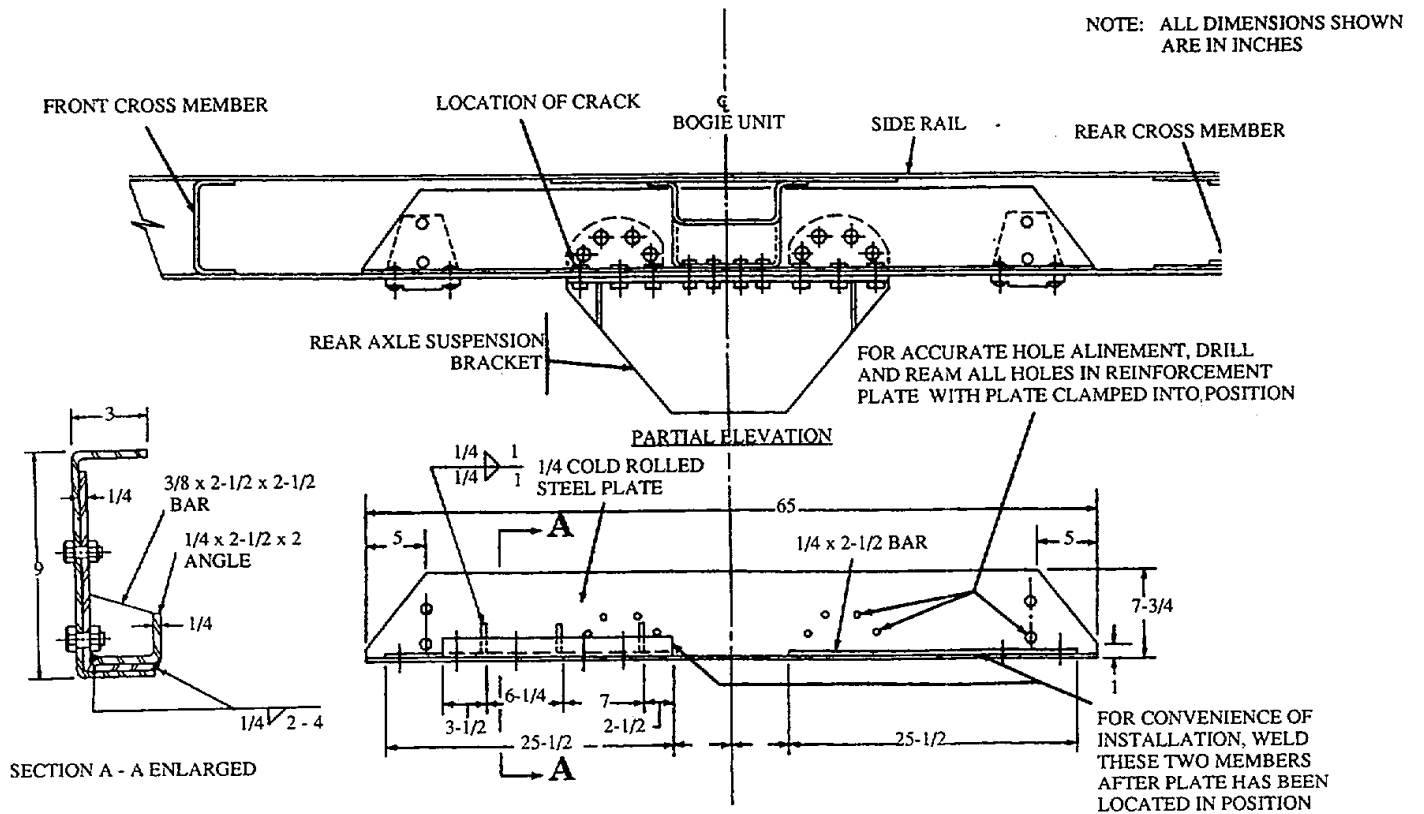


Figure 32. Installation Details for Reinforcement of Right Side Rail 5-Ton Truck Frame

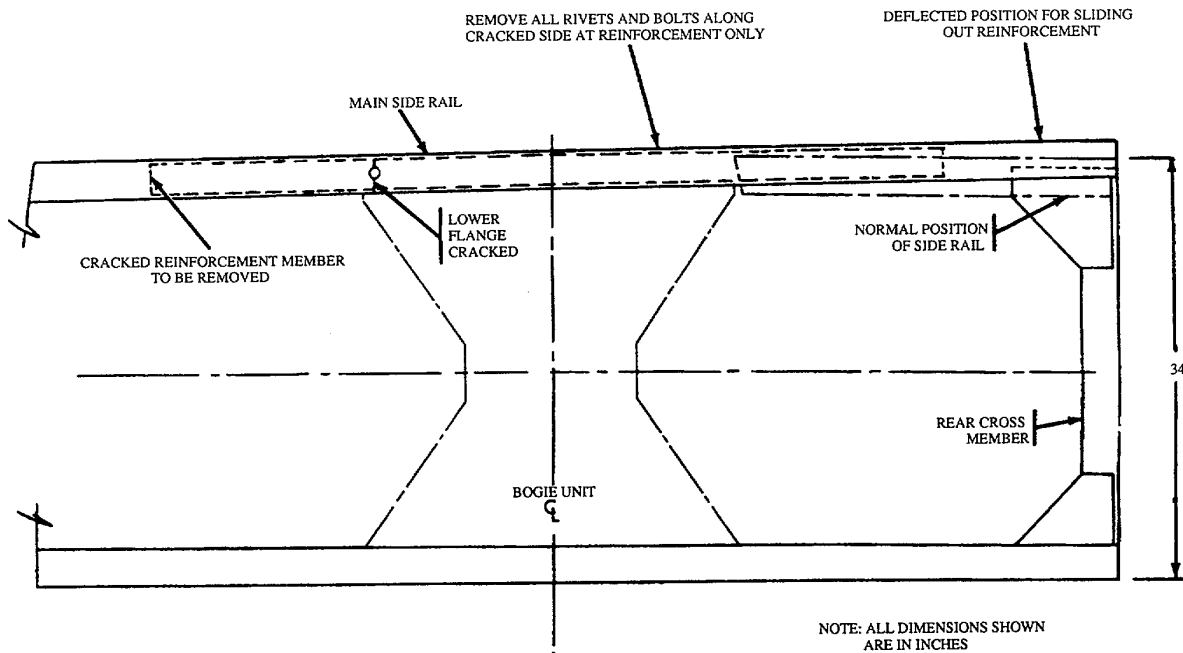


Figure 33. Plan View of 5-Ton Truck Frame

- s. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.
- t. Verify frame alinement as specified in Chapter 3.

rail. Even though no particular frame deficiencies are specifically mentioned, the advantages of each of these repair methods should be evaluated and the method of repair selected, according to the type and location of the defect, as well as, the availability of materials. The procedures to be followed in the application of the repair sketches of Figures 36 thru 38 are similar to those specified under frame repairs in paragraphs 49 thru 58 and are not repeated.

**49. Defect. Typical Non-weldable Frame Defects.** Figures 34 and 35 illustrate typical repair methods to be used to repair heat treated vehicle frame side rails where welding is not permitted. These repair methods may be applied to cracks in the lower flange of the frame side

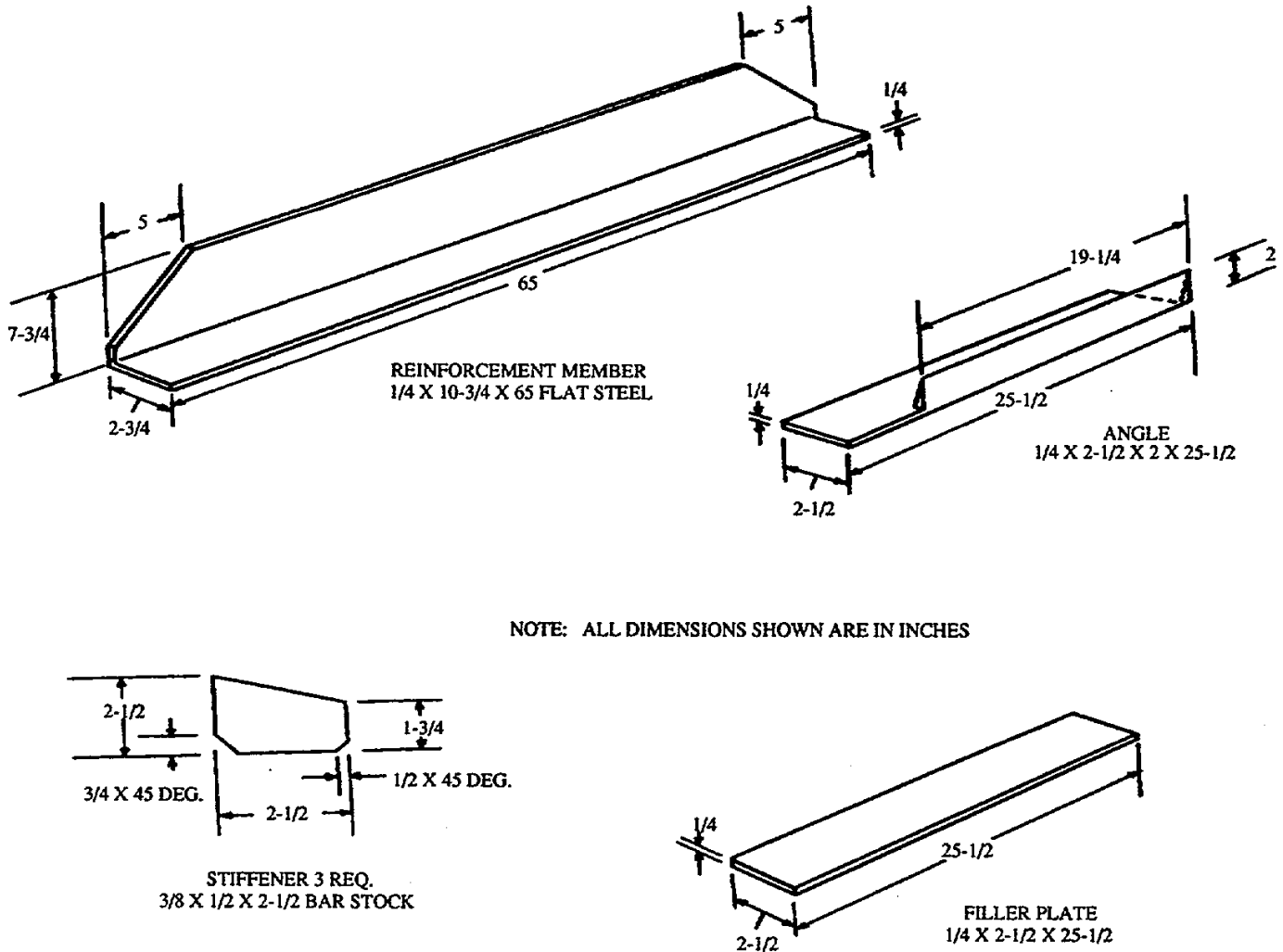


Figure 34. Fabrication Details for Reinforcements of 5-Ton Truck Frames



NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES

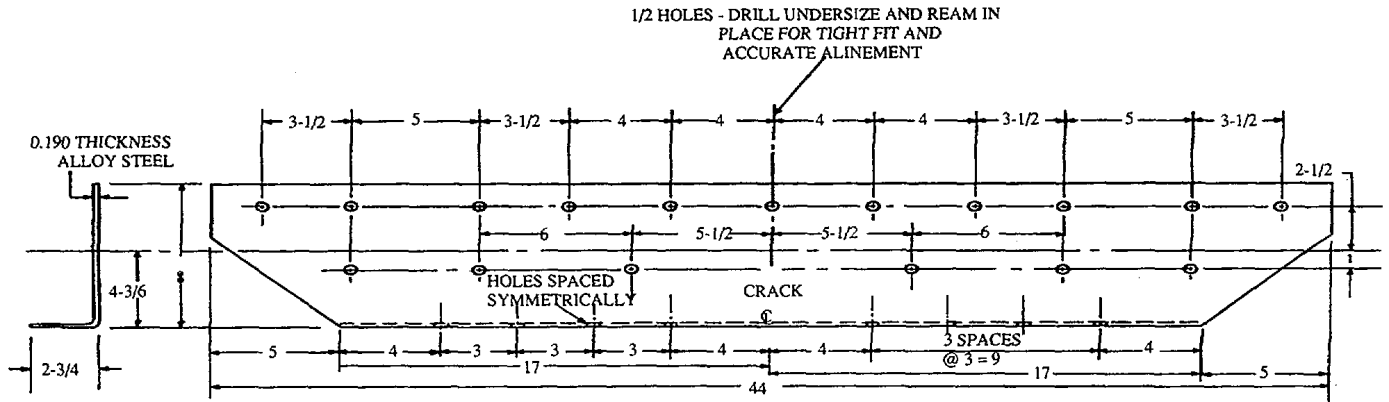
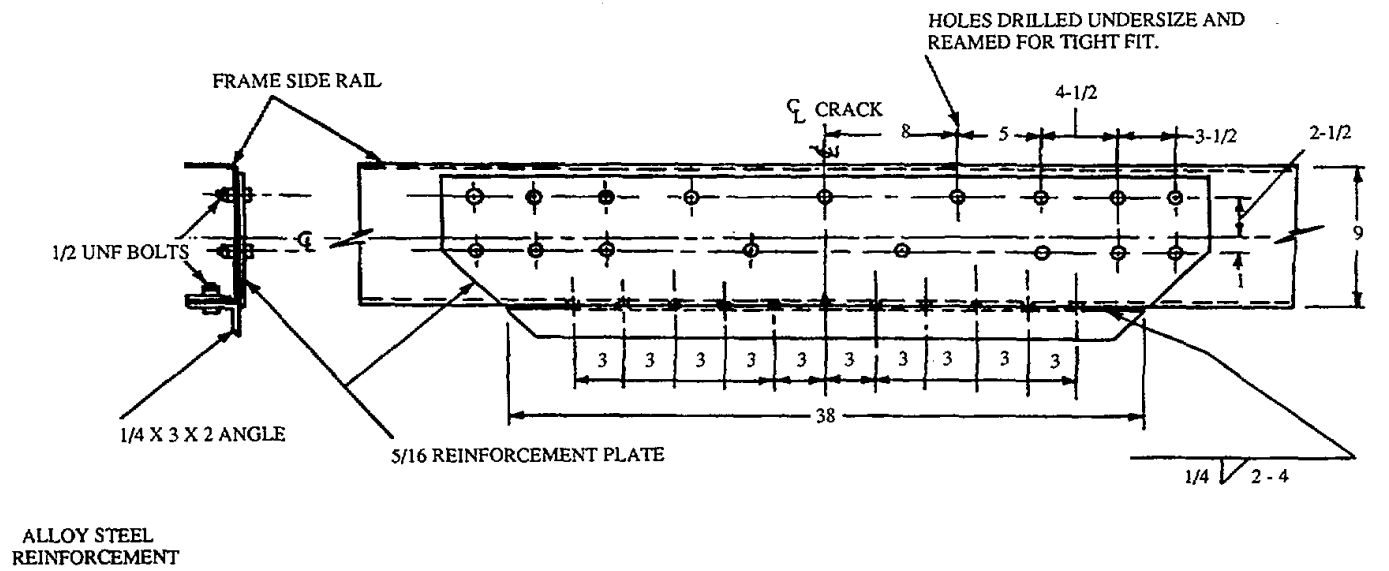


Figure 35. Reinforcement Member for 5-Ton Truck Frame



NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES.

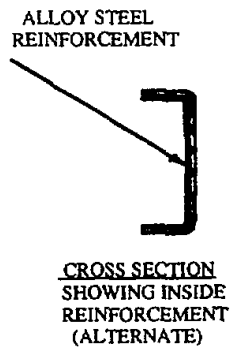


Figure 36. Reinforcement Plate in Position on 5-Ton Truck Frame

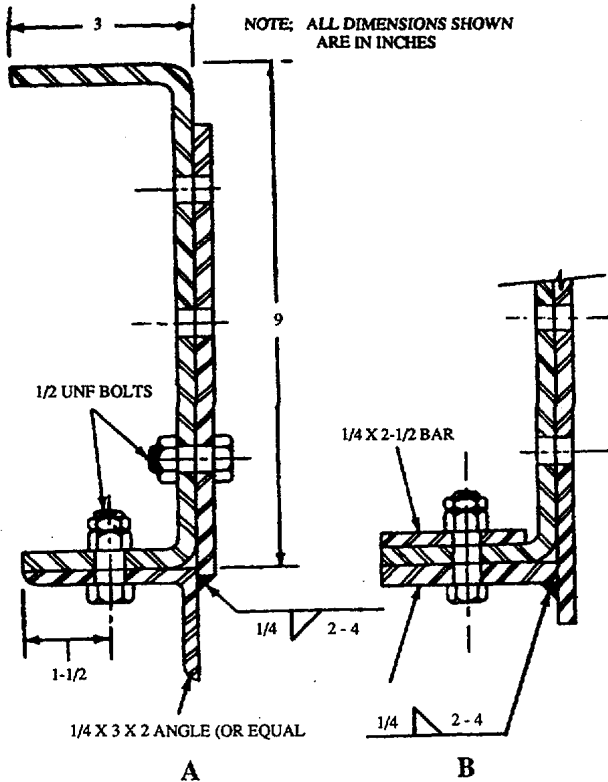


Figure 37. Cross Sections of Frame Side Rail

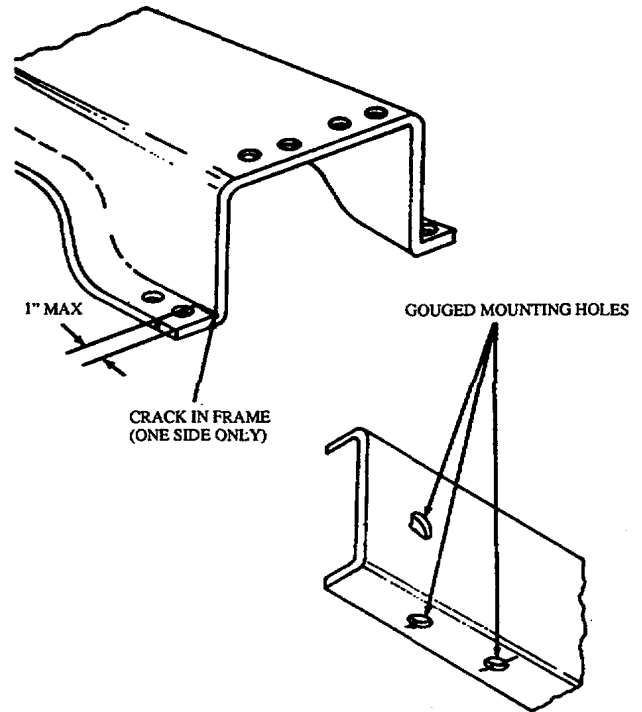


Figure 38. Crossmember Forming Cracks and Gouged Mounting Holes

- a. Figures 36 and 37. These methods are recommended where alloy steels are available and sufficient clearance is available on the inside of the channel to apply the repair.
- b. Figure 38. If the methods illustrated in sketches A and B of Figure 38 are employed, cold rolled steel will be acceptable.
- c. Option, Figure 38, Sketch A. An optional arrangement to this application would be to a wider reinforcement plate to cover the entire (as assembled) side of the 1/4 x 3 x 2 inch angle iron. The reinforcement can then be bolted to the angle iron thus eliminating the need for a weld as well as providing additional metal for support.
- d. Holes which have been flame-gouged during rivet removal under field maintenance conditions will be acceptable as is provided the following conditions exist:

- (1) There is no evidence of cracking in the metal and no effect on frame alinement due to gouging.
- (2) The gouged holes are of the size and fit to accept the new bolts specified in Section I.
- (3) All required brackets, mounting pads, washers, and other items required to be installed or replaced can be properly installed and accurately alined in the refitted, gouged areas.
- (4) Any gouged areas which exceed the criteria in thru above can be repaired only within the limits prescribed for flaseplating.
- (5) The radius of front crossmember flanges which have cracks forming on the internal side of the radius (extending longitudinally through the radius) may be repaired without removal under the following conditions:

(6) Forming cracks generate at sharp radius when originally formed are detectable only on one side.

(7) Length of crack does not exceed 1-inch. Flanges with cracks exceeding 1-inch will be removed for welding repair as shown in Figure 39.

#### SECTION IV. WELDING OF 5-TON VEHICLE FRAMES

##### NOTE

**The M939 vehicle series have heat-treated frames and will not be repaired by welding.**

**50. General.** 5-ton vehicle frames generally experience cracks at several common locations of both the left and the right frame rails, at: (1) the trapezoidal plate, (2) bogie support bracket, intermediate crossmembers, and the forward jounce brackets on the lower flange. Repairs to these areas may be accomplished by special reinforcement plates, angles, and reinforcing doubler plates of various types. The welding repairs covered here will not include all possible defects or frame conditions but relies on the experience and ingenuity of repair personnel in the use of this information.

**51. Preliminary Procedures.** Perform the following preliminary procedures:

- a. Thoroughly clean vehicle frame of all, oil, grease, dirt, paint, asphalt, and debris.
- b. Perform general vehicle frame inspection as specified in Chapter 1.
- c. Perform vehicle frame alignment inspection as specified in Chapter 3.
- d. Remove all necessary components/assemblies as required for accessibility:

##### WARNING

**Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- e. Remove bolts and rivets securing securing brackets or other items to the frame as described in Chapter 1.

- f. For tractors, remove fifth wheel, fifth wheel anchor bolts, dump bed, and hydraulic hoist, as required.
- g. For cargo trucks, remove cargo body brackets, wooden sills, as applicable, remove anchor bolts, and raise body for clearance.
- h. Remove all electrical harnesses, fuel and hydraulic lines, and related items as required for access to the area of repair. Take care to preserve the integrity of all components removed for future installation.
- i. Sketches. Prepare sketches to design specific repair requirements as required and/or as shown in this section.
- j. Where required, jack up and evenly support the vehicle frame to gain access to the area to be repaired. Provide firm support on each side of the defect or the area to be repaired to reduce any stress on framing members to a minimum.
- k. Thoroughly clean all frame rails and supporting members of dirt, asphalt, paint, etc.
- l. Once crack has been detected, measure crack with crack limit gage (Figure 2) by placing gage on top of frame over the crack. Crack should not exceed 1-1/2-inches.
- m. Using center punch, mark location of crack at the extreme end of the crack.
- n. Defect. Forming Cracks On Radius Of Front Crossmember Flanges (Figure 39).

**52. Defect Description.** The radius of front crossmember flanges which have forming cracks on the internal side of radius, which extend longitudinally through radius.

**53. Repair Procedure.**

- a. If crack extends only partly through section, drill 3/16-inch diameter at end of crack to minimize the tendency to increase.

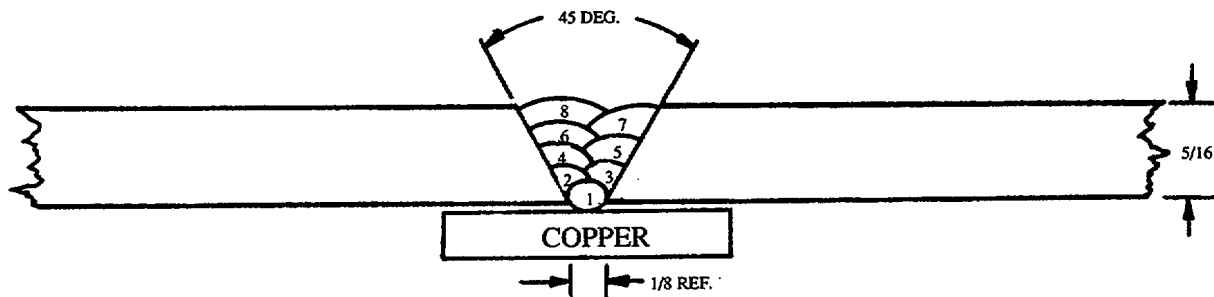
- b. Bevel edges of crack and weld to obtain complete penetration.

**WARNING**

Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

- c. Grind away excess metal of weld bead to eliminate bead acting as stress raiser.

- d. Weld additional plates on each end of crossmember as described in paragraph 6. Plates shall be welded in area of highest density; approximately 6 inches measured in from each end.
- e. Stress relieve all welded areas for one hour by heat treating at 11250 F., plus or minus 25° F.
- f. Thoroughly clean repaired surfaces and surrounding area of repair.
- g. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.



**NOTE: PEEN EACH PASS AFTER DISPOSITION WITH PNEUMATIC HAMMER.**

Figure 39. (Added) Repair of Cracked Frame Rails

- 54. Defect. Cracks and Elongated Or Gouged Mounting Holes.** Figure 40 illustrates cracks and elongated or gouged mounting holes detected forward of No. 1 crossmember or to rear of bogie.

**WARNING**

Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

- a. Drill a 2/16-inch diameter hole at the terminal point of the crack.
- b. Grind a V-shaped groove along the edges of the crack, through the thickness of the cracked section.

- c. Bevel edges of V-shaped groove.

**CAUTION**

No weaving motion will be used during the welding process. Heat and number of welding passes will be kept to a minimum to prevent excessive heating of side rails

- d. Obtain electrode type, MIL-308-MO-16, Class, sized 1/8-inch or 3/32-inch, with maximum for the welding process.
- e. Using copper back-up, apply welded stringer bead to each side of groove.
- f. Apply channel flaseplating reinforcement plates after welding as described in paragraph. Thickness of flaseplating reinforcement shall be equal to side rail thickness within 5/16-inch. Bolting instructions shall be as described in paragraph.

g. Thoroughly clean repaired surfaces and surrounding area of repair.

h. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

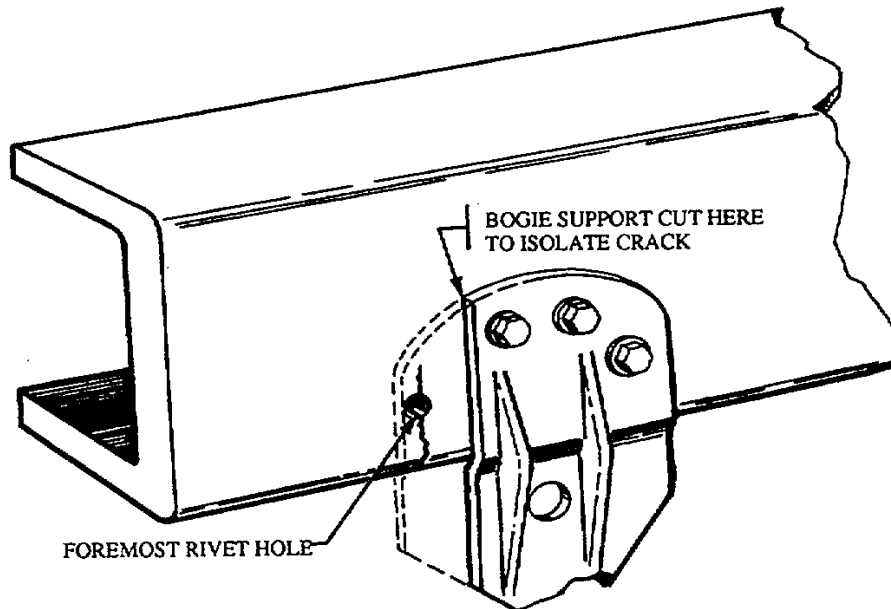


Figure 40. Isolation of Crack In Bogie Support

**55. Defect. Cracks Under Bogie Support.** Cracks located under bogie supports requiring removal of the support assembly.

**WARNING**

**Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

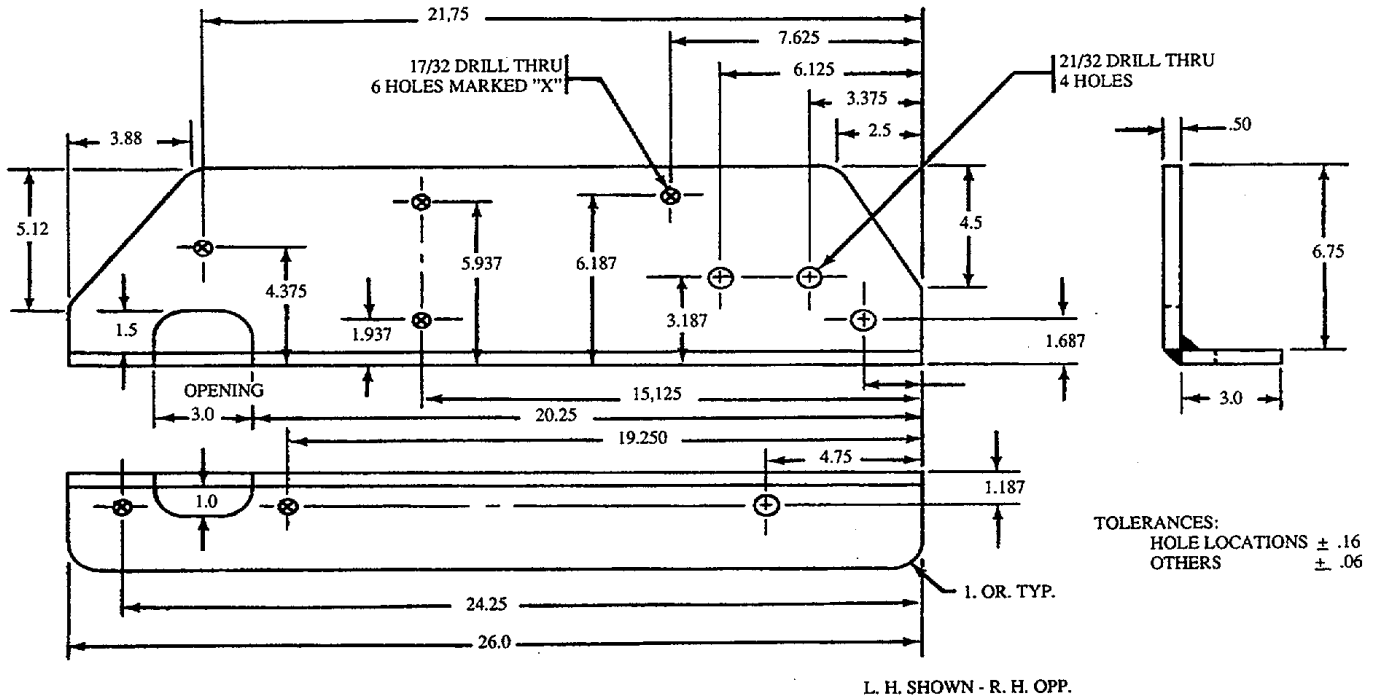
- Cut bogie support to provide space around the area of the vehicle frame to be welded.
- Cut the support by drilling a series of holes at the proposed welding point as shown in figure 41. Chisel through holes, and grind separated surfaces to a smooth finish with a portable grinding tool.
- Sketches. Prepare sketches to design specific repair requirements as required and/or as shown in this section.
- Fabricate and install doubler plate from prepared sketches and as shown in figure 42.

e. Thoroughly clean repaired surfaces and surrounding area of repair.

f. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

**56. Defect. Cracks In Lower Flange of Frame Rail.** Cracks in lower flange of frame rail at the bogie support.

- Sketches. Prepare sketches to design specific repair requirements as required and/or as shown in this section.
- Fabricate doubler plate from prepared sketches and as shown in Figure 42.
- Using C- clamps, insure that frame rails are in alignment and in close contact with the doubler.
- Grove the side rail and weld into the liner with the doubler plate in place.
- Thoroughly clean repaired surfaces and surrounding area of repair.
- Prime and paint repair area and surrounding surfaces as specified in TM-3-01 39.



NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES

Figure 41. Construction of Doubler

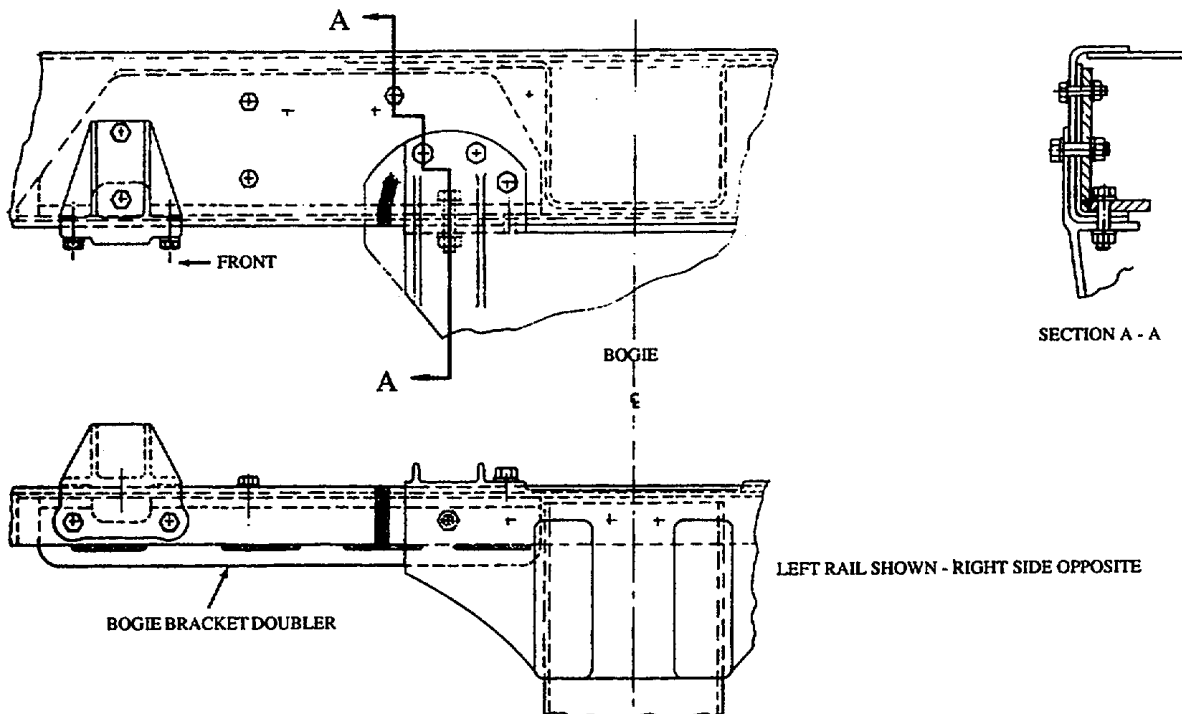


Figure 42. Repair at Crossmember (Upper Flange)

**57. Defect. Cracks in lower flange of frame rail and liner at the bogie support.**

- a. Sketches. Prepare sketches to design specific repair requirements as require and/or as shown in this section.

**WARNING**

**Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- b. Cut outside edge 1/2-inch from the outer edge and parallel to the bogie support rib.
- c. Grind the entire edge to a rounded finish in order to reduce crack sensitive conditions.
- d. Fabricate doubler plate as shown in Figures 42 and 43, and as described in paragraph.
- e. Using C-clamps, insure that frame rails are in alinement and in close contact with the doublers and repair as shown in Figures 42 and 43.
- f. Thoroughly clean repaired surfaces and surrounding area of repair.
- g. Prime and paint repair area and surrounding surfaces as specified in T-43-0139.

**58. Defect. Cracks in crossmembers at the rear of vehicle cab.**

- a. Sketches. Prepare sketches to design specific repair requirements as requires and/or as shown in this section.

**WARNING**

**Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- b. Remove rivets attaching the rail at the cracked end as described in Chapter 1. Leave the

opposite end of the crossmember attached as shown in Figure 44.

- c. Fabricate doubler plate as shown in Figures 42, 45, 47, and 49, as applicable.

**NOTE**

**In all cases where crossmembers are removed for repair of a crack, a portion of the crack in the crossmember must be cut at the end where the crack appears in the rail as shown in Figure 40. This will allow the crossmember to be reinstalled and joined to the doubler plate.**

- d. Cut the cracked end of the crossmember to fit the doubler plate.
- e. Weld the crossmember to the doubler plate in the ground out groove as shown in Figures 44, 45 and 46 which describe the subscribed methods of doubler construction and repairs to the defective areas of the crossmember.
- f. Place doubler inside rail and locate centrally in relationship to the crossmember.
- g. Clamp doubler securely to member with C-clamps and drill the necessary bolt holes in the rail face.
- h. Bolt doubler plate securely with new No. 8 bolts, washers, and locknuts. Torque bolts in accordance with appendix E of the appropriate vehicle TM.
- i. Bevel the doubler edge which is directly opposite the crossmember to a 45° angle.
- j. Weld the doubler to the frame in the ground out groove created during doubler fabrication as shown.
- k. Thoroughly clean repaired surfaces and surrounding area of repair.
- l. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

**59. Defect. Cracks in the rear bogie area top flange rail that require cutouts of portions of the trapezoid plate to accept the doubler flange**

- a. Sketches. Prepare sketches to design specific repair requirements as required and/or as shown in this section.

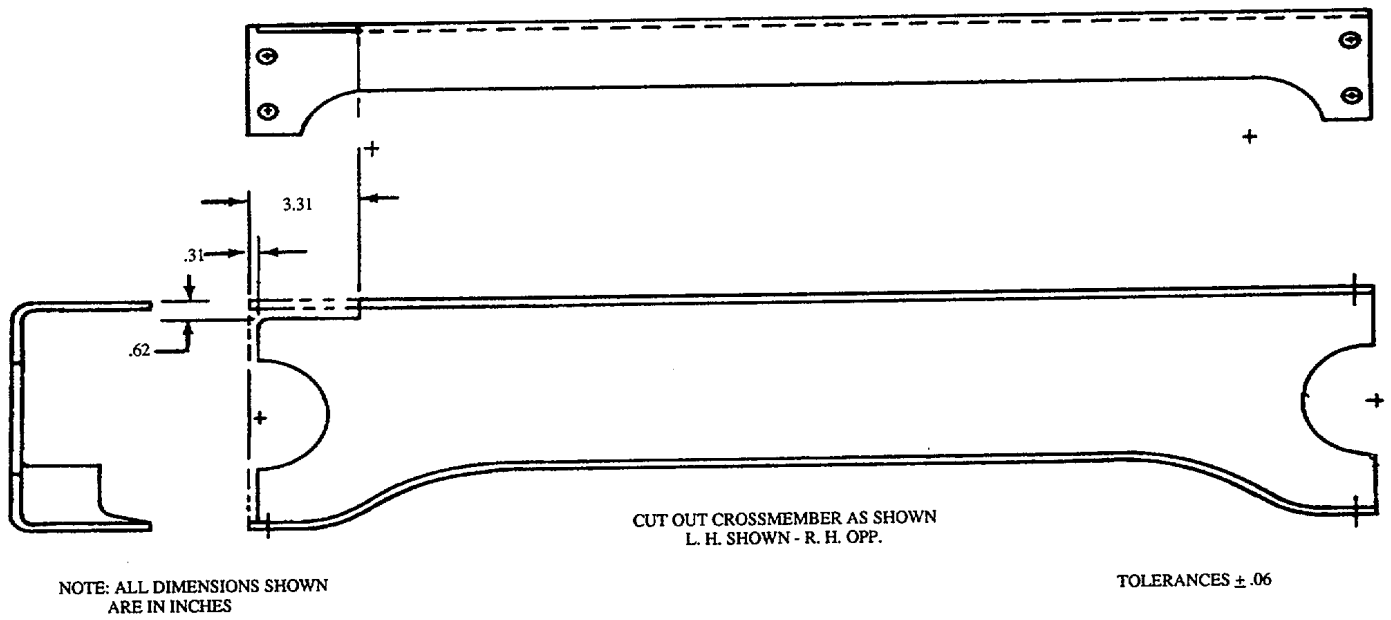


Figure 43. Crossmember Modification

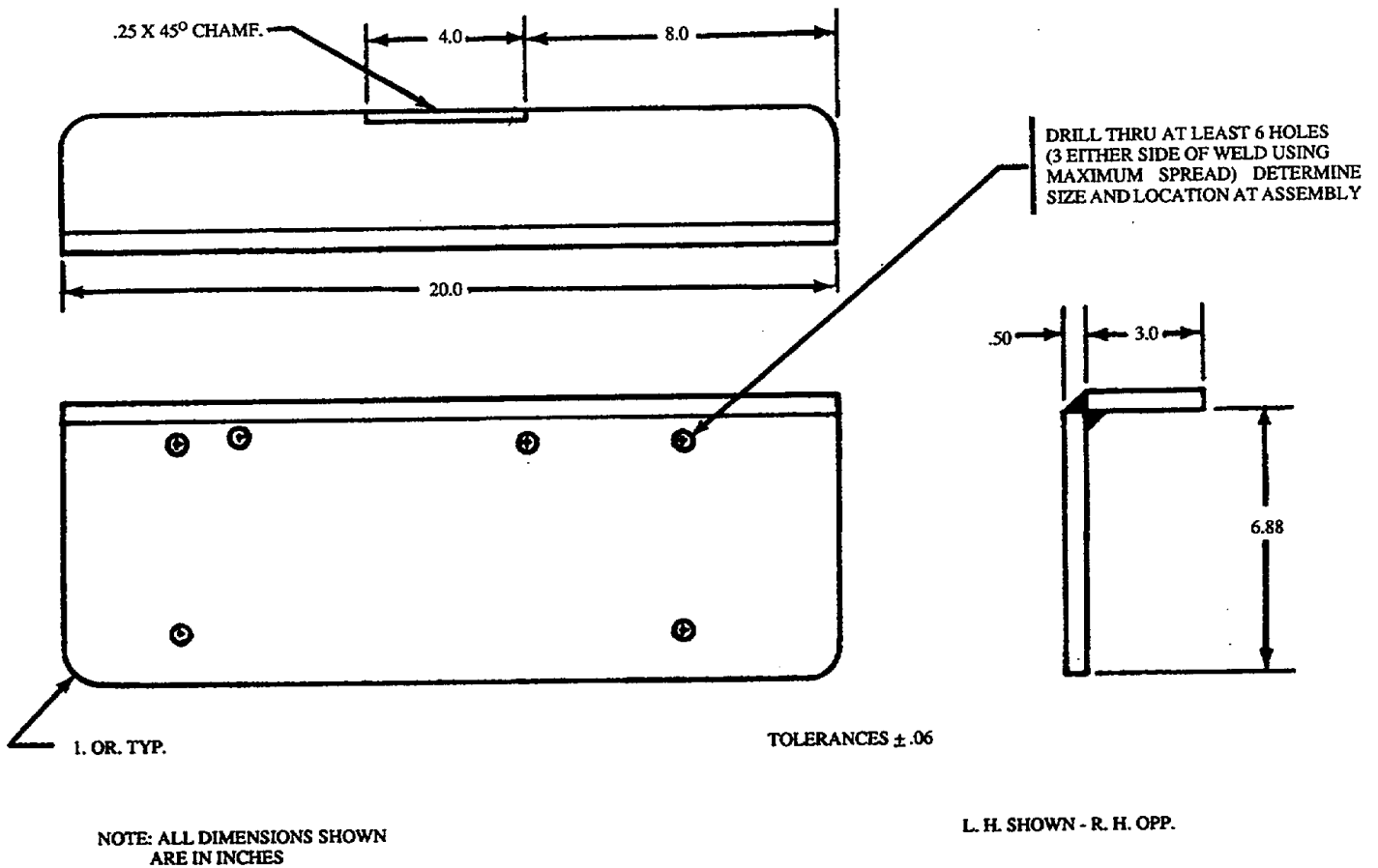


Figure 44. Doubler at Crossmember



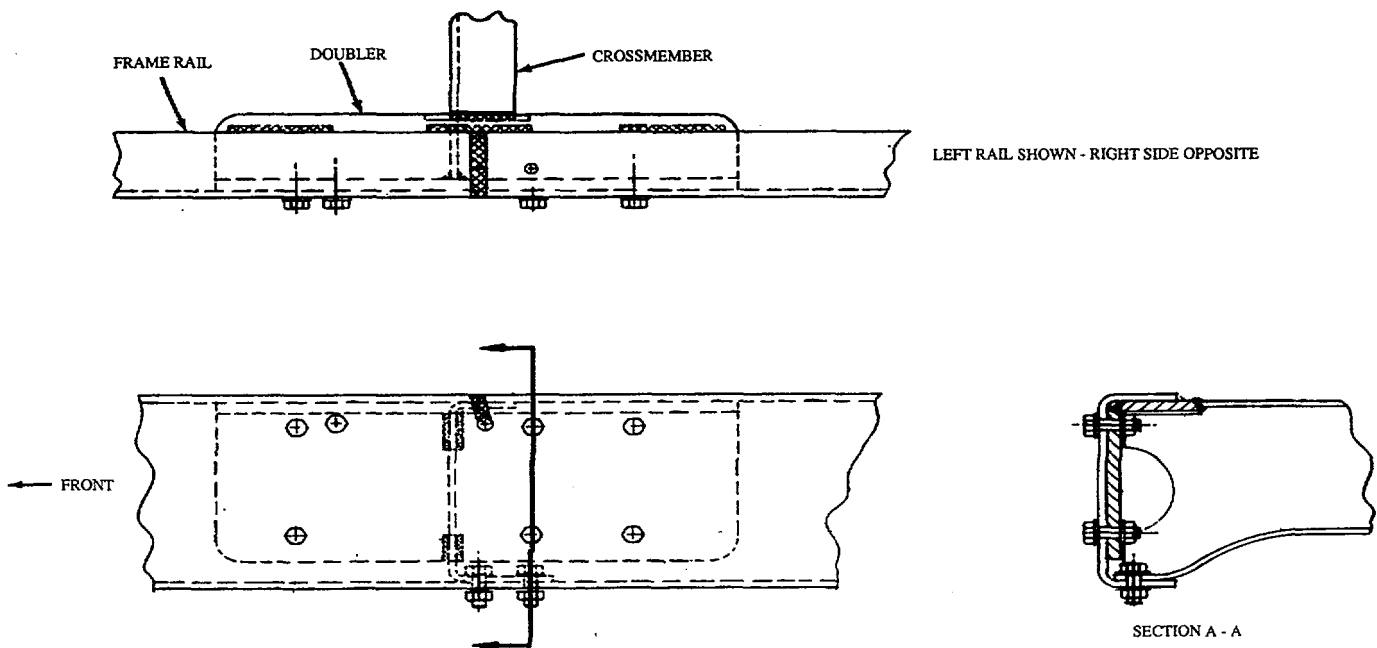


Figure 45. Repair at Crossmember (Upper Flange)

**NOTE**

The exact doubler location determines the length of the cutout in the trapezoid plate.

**60. Repair Procedure**

**WARNING**

Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

- a. Using an oxyacetylene torch, provide cutouts in the trapezoid plate with a maximum 5/32-inch gap as shown in Figures 47, 48, and 49 which specify the fabrication of doubler plates and repairs to defective trapezoidal areas.

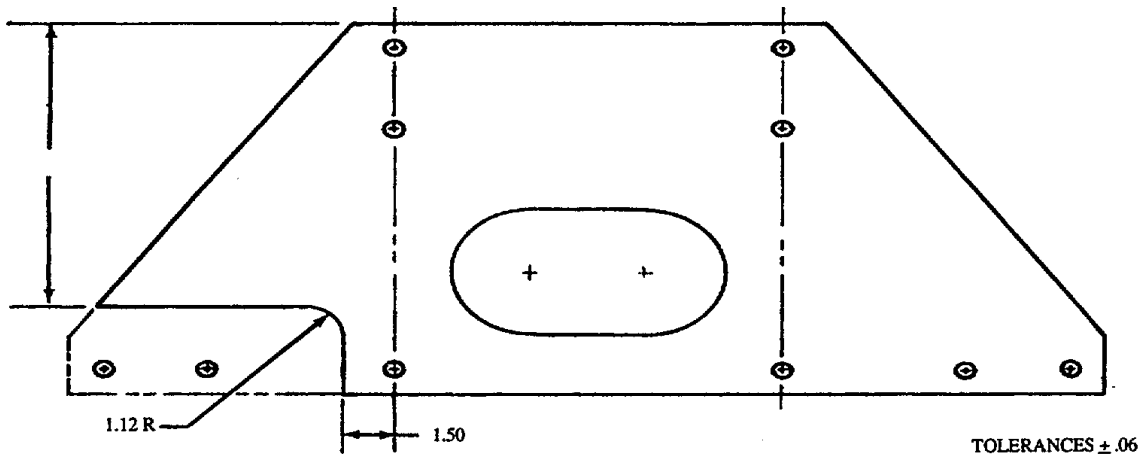
- b. Fabricate doubler plate as shown in Figures 42, 45, 48 and 50.
- c. Bevel the doubler at the gap to a 450 angle.
- d. Securely bolt the doubler to the plate using new No. 8 UNF bolts, washers, and locknuts. Torque bolts in accordance with appendix E of the appropriate vehicle TM.
- e. Secure doubler to the rail and repair as shown in Figure 46..
- f. Thoroughly clean repaired surfaces and surrounding area of repair.
- g. Prime and paint repair area and surrounding surfaces as specified in TM-43-0139.

- 61. Defect.** Cracks at jounce bracket requiring cutouts of portions of the trapezoid plate to accept the doubler flange and the addition of spacer.

**NOTE**

Since most cracks at the jounce bracket start under the bracket, removal may be necessary to complete repairs.

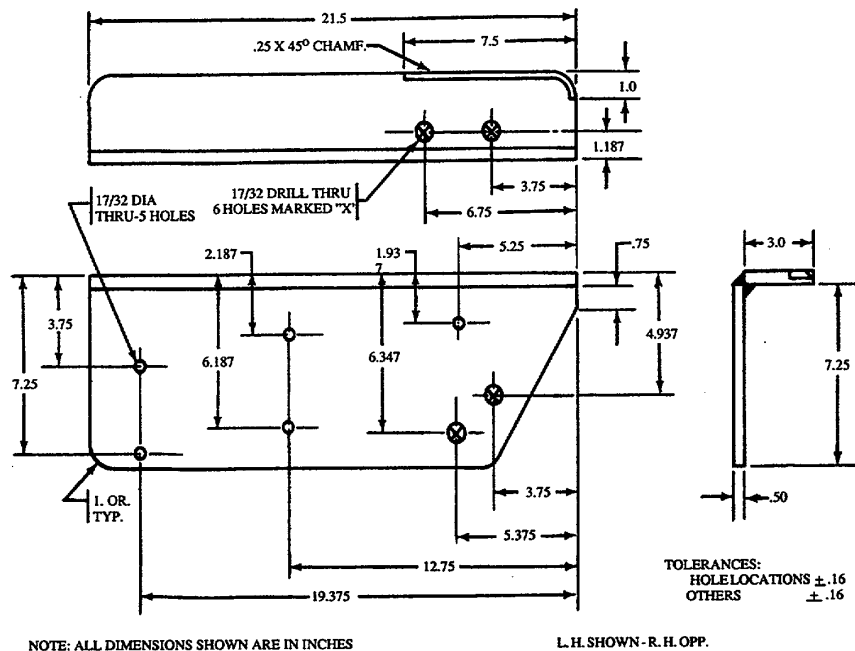
- a. Sketches. Prepare sketches to design for specific repair requirements as required and/or as shown in this section.



NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES

CUT OUT TRAPEZOIDAL PLATE AS SHOWN  
L. H. SHOWN - R. H. OPP.

Figure 46. Trapezoidal Plate Modification



NOTE: ALL DIMENSIONS SHOWN ARE IN INCHES

L. H. SHOWN - R. H. OPP.

Figure 47. Doubler at Trapezoidal Plate - Upper Flange

**NOTE**

The exact doubler location determines the length of the cutout in the jounce bracket.

**WARNING**

Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.

- b. Use an oxyacetylene torch, make cut-outs in the jounce bracket with a maximum 5/32-inch gap as shown in Figures 42, 45, 48, and 50.

**NOTE**

Due to the various locations and types of cracks which may develop in vehicle frame rails, the widths, lengths, and contours of doublers fabricated will vary with the application. Figures 42, 45, 51, and 53 indicates the types and methods recommended for doubler construction.

- c. Prepare sketches and/or templates for the conditions and locations of the proposed repair. Individual templates for each crack and location may be used as a pattern and contour cutting to fit the particular rivet and frame hole location.
- d. Join the two segments of steel plate at right angles, fitting pieces corner-to-corner longitudinally and weld inside and outside. The outer corner weld shall be a 3/8-inch fillet type conforming to MIL-STD-1261, Class I.
- e. Fabricate doubler plate as shown in Figures 42, 45, 48 and 50, and as described in paragraph 62.
- f. Bevel the doubler at the gap to a 45° angle.
- g. Securely bolt the doubler to the bracket using new No. 8 UNF bolts, washers, and locknuts. Torque bolts in accordance with
- h. Add spacer as shown and secure doubler to the rail and repair as shown in Figures 42, 45, 48, and 50.
- i. Thoroughly clean repaired surfaces and surrounding area of repair.
- j. Prime and paint repair area and surrounding surfaces as specified in TM-43-01 39.

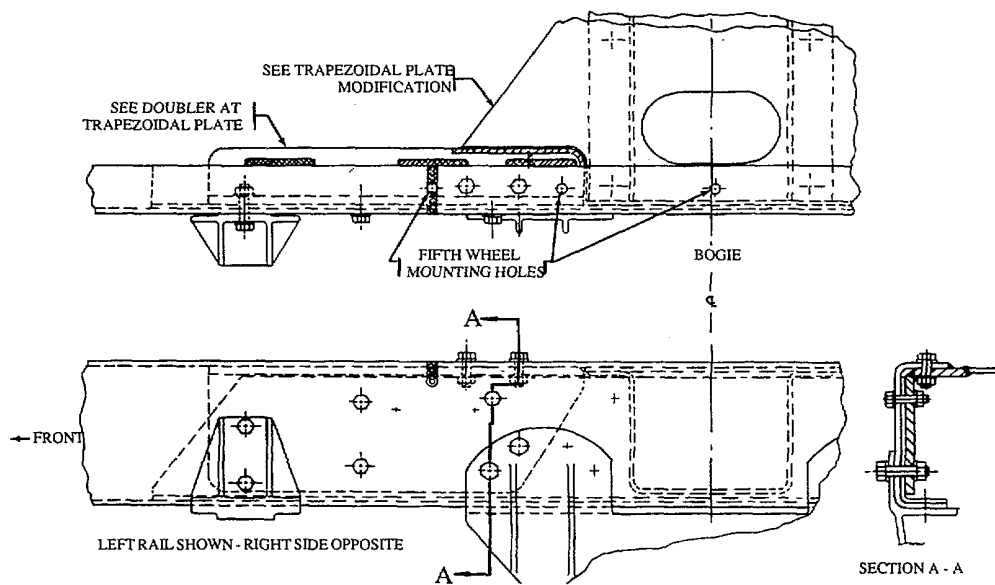


Figure 48. Repair at Trapezoidal Plate - Upper Flange

62. Doubler Plate Fabrication.

- a. Use 1/2-inch Society of Automotive Engineers (SAE) steel plate, NSN 9515-02-222-5059.

**WARNING**

**Use Only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- b. Using an oxyacetylene torch, cut and trim the fabricated doubler to the desired form. Grind all edges to a smooth finish. The outside edges shall be no closer to a bolt hole than 1/2-inch.
- c. Drill all holes in doubler to template and to location of repair area. Where required, provide

holes in frame and doubler to assure a firm and secure attachment of the repair and to meet the requirements for minimum bolt configuration on each side of the crack and to assure a tightly mated surface and proper stress distribution. Such additional holes may be drilled after doubler has been attached to the rail.

- d. Where required, grind inside fillet welds to assure positive contact between washer and doubler mating surfaces.
- e. When mating doubler to frame, ream doubler and frame rail holes as required for proper hole alignment and tight fit of attaching hardware.
- f. Where it is necessary to remove elongation in holes, holes may be enlarged to accept a larger bolt.

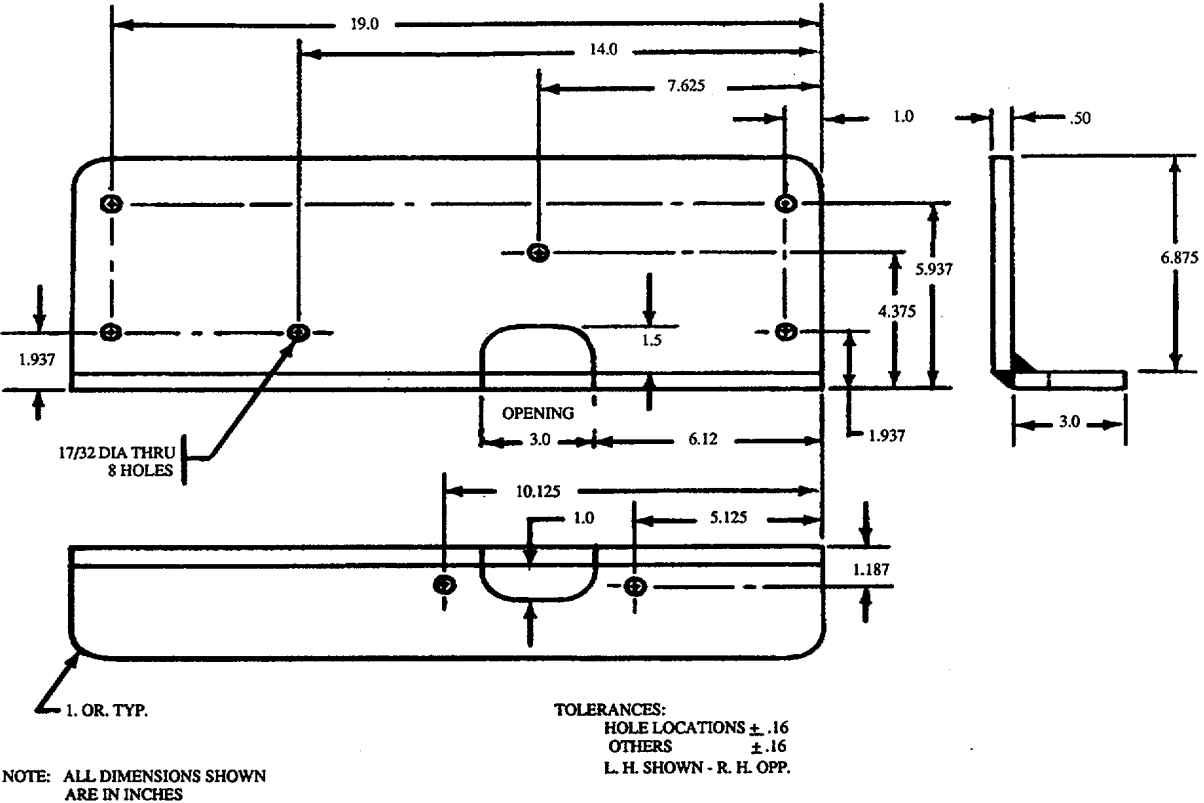
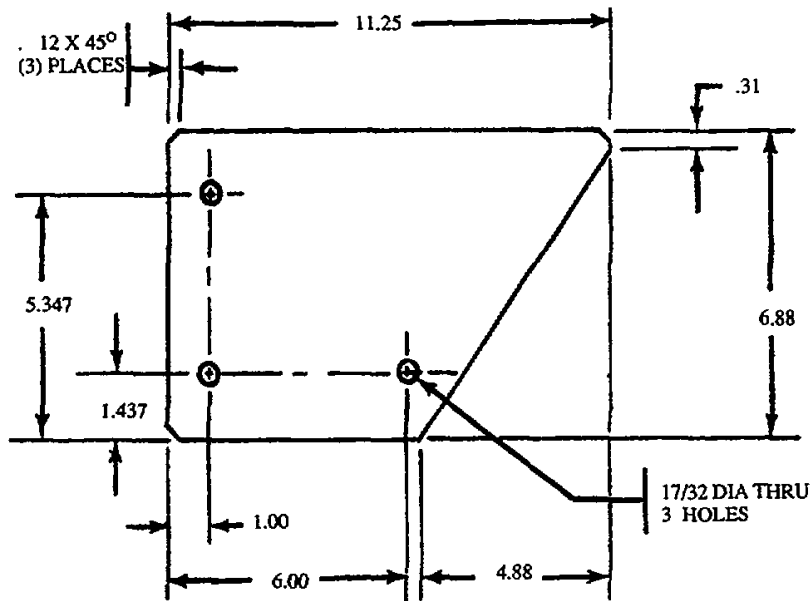


Figure 49. Doubler at Jounce Bracket



TOLERANCES:  
 HOLE LOCATIONS  $\pm .16$   
 OTHERS  $\pm .16$

NOTE: ALL DIMENSIONS SHOWN  
 ARE IN INCHES

MATERIAL:  
 STEEL - .25 STOCK  
 1020 OR EQUIV.

Figure 50. Spacer for Repair at Jounce Bracket

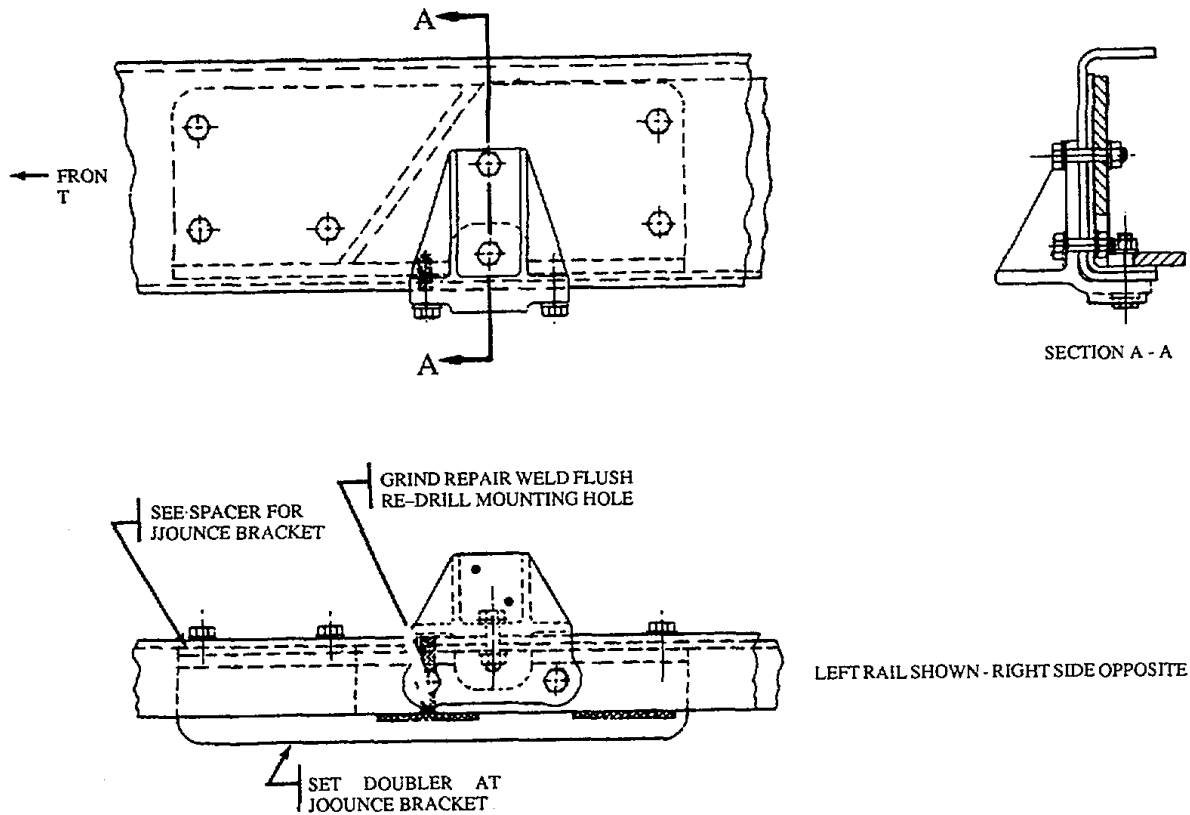


Figure 51. Repair of Jounce Bracket

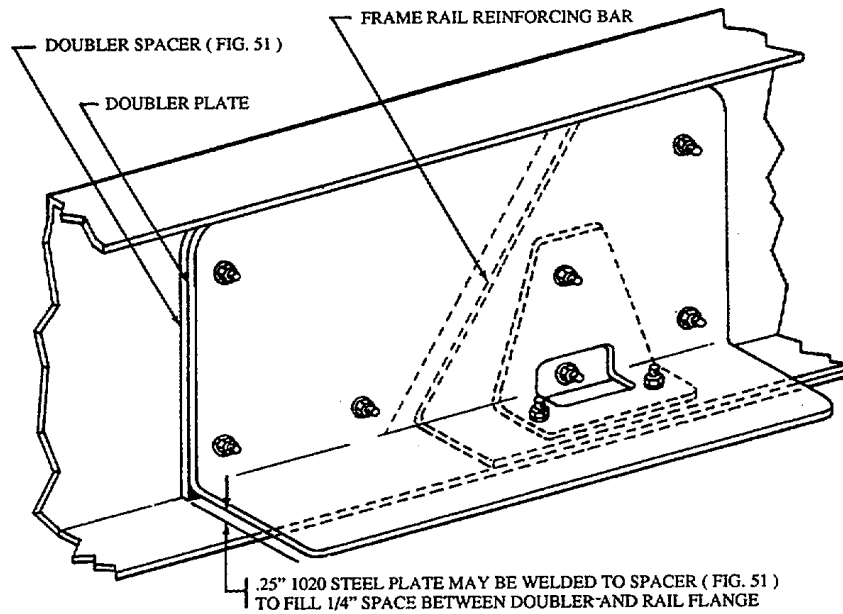


Figure 52. Inner View - Jounce Bracket

**63. Welding Frame Rails.**

- a. Cleaning. Thoroughly clean frame rail to be welded of all grease, asphalt, dirt, or other debris.
- b. Inspection. Inspect frame rail to determine

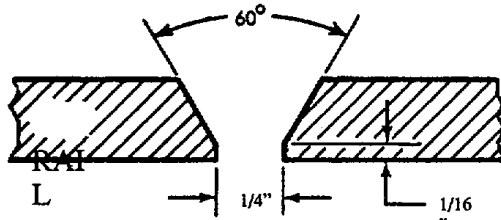


Figure 53. Typical Root Groove

**WARNING**

**Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- d. Preheating. Preheat frame rails between 4500 F and 5500 F before welding.
- e. Grooving. Groove all cracks as indicated in Figure 54.
- f. Groove Welding. Use sizes 3/32-inch and 1/8-inch electrodes for groove welding.

nature of the defect and the method of repair.

- c. Welding Electrodes. Perform all welding using electrode type MIL-312, Specification 12018-M of AWS-A5 in sizes 3/32-inch, 1/8-inch, and 5/32-inch diameters.

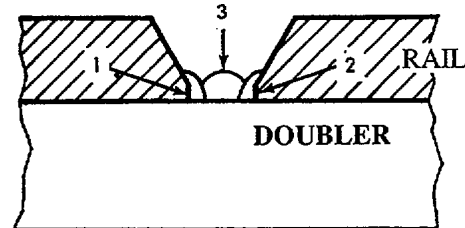


Figure 54. Groove Welding Passes

Perform initial welding passes as indicated in Figure 55.

- g. Recommended welding current for flat welding is as follows:

<u>Electrode size</u>	<u>DCRP</u>
3/32	50-75
1/8	75-95
5/32	90-135

- h. Beading. Deposit the first layer of weld metal with three passes of a 3/32-inch diameter electrode. as shown in Figure 49, using stringer beads. Where vertical welding is required, such passes may be up or down. A weave pass may be used in vertical-up pass in the rail face and

radius part of the rail. Weld the remainder of the joint with 1/8-inch diameter electrodes.

- i. Flat, Vertical and Overhead Welding. Use only stringer beads in the flange portion of the rail for flat and overhead welding. In welding the groove, the doubler and/or liner is welded into the joint. The recommended welding currents for flat welding are as follows:

(1) Use only stringer beads in the flange portion of the rail.

(2) For other positions of welding, such as vertical or overhead, adjust welding currents to suit the conditions. Use lowest currents possible to obtain sound weld deposits.

- j. Crown Welds. Completed welds shall have a crown deposit rising above the surface of the rail to a maximum of 3/16-inch and not less than 1/8-inch. There shall be no undercutting along the edge of weld deposits.

## WARNING

**Use only effective chip guarding equipment, protective equipment and protective clothing (goggles, shields, gloves aprons, etc) when doing any drilling, grinding, or welding. Failure to follow this warning could result in injury to personnel.**

- k. Grinding. Remove by grinding all excess metal and/or weld globules in either the overhead or vertical position before proceeding with further welding. All weld reinforcements shall be ground smooth.
- l. Slag Removal. Remove slag by chipping and wire brushing after each pass. Where C-clamps are used, they will not be removed until welds have been inspected and found acceptable.
- m. Heat Control. Heat control shall be maintained throughout the welding process. If temperatures reach 750° F within 1-inch in any direction from the weld, halt the welding process, cover the area affected with nylon felt cloth, and protect the area from cold drafts for controlled cooling of the metal.

By Order of the Secretary of the Army:

CARL E. VUONO  
*General, United States Army*  
*Chief of Staff*

Official:

PATRICIA P. HICKERSON  
*Colonel, United States Army*  
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# THE METRIC SYSTEM AND EQUIVALENTS

## WEIGHT MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches  
 1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches  
 1 Kilometer = 1000 Meters = 0.621 Miles

## WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces  
 1 Kilogram = 1000 Grams = 2.2 lb.  
 1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

## LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces  
 1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

## SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches  
 1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet  
 1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

## CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches  
 1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

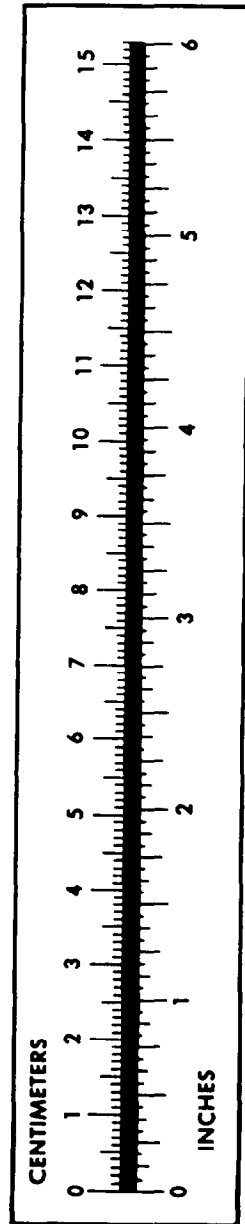
## TEMPERATURE

$5/9(^{\circ}\text{F} - 32) = ^{\circ}\text{C}$   
 212° Fahrenheit is equivalent to 100° Celsius  
 90° Fahrenheit is equivalent to 32.2° Celsius  
 32° Fahrenheit is equivalent to 0° Celsius  
 $9/5^{\circ}\text{C} + 32 = ^{\circ}\text{F}$

## APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
its	Liters	0.473
arts	Liters	0.946
allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
ers	Gallons	0.264
ms	Ounces	0.035
ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
ometers per Liter	Miles per Gallon	2.354
ometers per Hour	Miles per Hour	0.621



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