DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TECHNICAL MANUAL

DIRECT SUPPORT, GENERAL SUPPORT

QUALITY CONTROL INSPECTOR'S

INSPECTION CRITERIA

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Direct Support and General Support

QUALITY CONTROL INSPECTOR'S INSPECTION CRITERIA

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CHAPTER 1

INTRODUCTION

1-1. General

This technical manual covers the inspection criteria for use by quality assurance/quality control (QA/QC) inspection personnel at the direct (DS) and general support (GS) maintenance levels. In cases of conflict between this manual and the system documentation, the system documentation will take precedence.

1-2. Purpose

The purpose of this manual is to provide information as well as a check list for use by QC inspection personnel. Some of the information is taken from other sources and included to provide the QC inspection personnel with an all inclusive document. The purpose for information on repair procedures being included is to help QC inspection personnel during in-process inspection which must be made. Reference to appendix A along with the information in this manual should provide the QC inspection personnel with all the required information he needs to perform his required duties.

1-3. Report of Equipment Publication Improvements

Report 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 DA Publications) and forwarded direct to Commanding General, U.S. Army Missile Command, ATTN: AMSMI-SMPT(NMP), Redstone Arsenal, Alabama 35809.

1-4. References

The reference documents included as Appendix A are for the inspector's use. He should consult these references for more detailed information and operational procedures. Use of these references will increase the inspector's knowledge, experience, and effectiveness.

1-5. Glossary

The glossary included as Appendix B carries a complete listing of definitions, tables, charts, and other references of benefit to the inspector.

1-6. Quality Control Inspector's Role

a. The mark of a good inspector is his ability to inspect just enough to assure compliance with all requirements and no more. To do less results in a below-standard product; to do more results in production loss and an unnecessary expenditure of funds. The more knowledge and experience, the more capable is the inspector and the more definite becomes the fine line between over and under inspection.

b. Each inspector must utilize all the technical data and tools to assist him in defining and stopping on this fine line. In the final analysis, an inspector, must depend on his own opinion for many decisions. This opinion must be as accurate as possible. The successful accomplishment of the mission and the safety of its personnel depend on such decisions.

c. In accomplishing the mission, each inspector accepts a very important role during in-process and final acceptance inspection. Inspection of materiel during process helps to assure that those subassemblies which will be used in major assemblies or items are being repaired to be as near the original as possible and as reliable as possible. Final acceptance inspection must be a guarantee to the customer that the items received are the best available.

d. Inspectors are the final link in the DS and GS maintenance chain. This chain can be the weak link or the strong link. The successful completion of tactical missions are based to a great extent on the strength of this link.

e. This document is intended to further assist every inspector in making the correct decision every time. It will be revised from time to time, as required, to make it a more useful inspection tool.

1-7. Inspector's Authority

a. To aid every inspector in performing his duties, there exists adequate written authority from higher headquarters. Such authority should be maintained for each inspector to thoroughly read and remember.

b. Basically the stamp and signature of an inspector is final. It is not subject to contradiction by anyone except his immediate supervisor. Decisions of in-process inspectors are equally as valid for both operating personnel and other inspection personnel. Simply, if an item is defective, that is the unchallenged decision. It is not to be used until repaired to the satisfaction of this same inspector and until it is acceptable, this decision must also not be challenged.

c. This authority places a heavy responsibility on the shoulders of every inspector. By his action he can either cause the expenditure of funds for unnecessary rework or can cause a malfunction of an item in the hands of its user by accepting a defective item. This responsibility requires a thoroughly competent, well trained individual.

1-8. QC Inspector's Standards

This document itself is essentially a set of quality oriented standards. "There is no substitute for quality, and quality is proportional to the inspector's workmanship." The extra care for superior workmanship spells the difference between superior quality and average quality.

a. Objective. To achieve the necessary inspection training, depth of experience, and proficiency for excellence in workmanship.

b. Responsibility. The responsibility for good workmanship lies with the commander. The inspector insures compliance with that policy and his success depends upon his qualifications, attitude, cooperation, orderliness, and coordination with other activities. Working facilities and conditions are seldom ideal, but thought, team work, and adherence to rules and procedures will produce optimum safety, neatness, efficiency, and job satisfaction for the circumstances prevailing.

c. Personnel. Quality of inspection personnel is proportional to education, training, skill, adaptability and personal characteristics. Special training is required and must be as thorough as practicable, whenever new systems are fielded, or new items are introduced, additional training is required. The most relevant characteristics for inspection personnel are listed in table 1-1. This depicts a suggested rating sheet to insure the best possible workmanship level. The inspection program will succeed in direct proportion to the degree to which personnel aspire to gaining and conforming to these qualities.

d. Factors Required for a Successful Workmanship Standards Program. There are many factors which will determine the success of a QC inspection program. The following is not all inclusive but will give the inspector a broad view of factors required:

(1) Satisfactory working conditions: proper lighting, quietness, temperature, space, clean air, etc.

(2) Standard Inspection Procedures (SIP's) for all inspection operations.

(3) Advance planning and scheduling.

(4) Carefulness.

(5) Conscientious, qualified, and cooperative personnel.

(6) Consistent and systematic policies.

(7) Reliable inspection procedures.

(8) Close adherence to procedures.

(9) Division of work into elements.

(10) Work simplification and improvement.

(11) Neatness, cleanliness, orderliness.

(12) Following safety regulations.

(13) Understanding job requirements.

(14) Knowing where to, and getting, technical help when required.

(15) Locating and correcting causes of substandard performance beyond the control of individual workers.

(16) Keeping close control over the number and kinds of inspection stations.

(17) Having ready information regarding output, possibilities, and goals.

(18) Adequate auditing of operations.

Table 1-1. Personal Qualifications

	Fair	Average	Above average
a. Education			
b. Attitude			
c. Judgment			
d. Self control			
e. Experience			
f. Skill			
g. Reliability			
h. Responsibility			
i. Quality consciousness			
j. Safety consciousness			
k. Economy consciousness			

CHAPTER 2

CLEANING, PAINTING, AND FINISHING

Section I. INTRODUCTION

2-1. General

This chapter covers the inspection requirements for cleaning, painting, and finishing. These three requirements are grouped into this chapter because of their applicability to all components.

2-2. Safety

The safety aspects of cleaning, painting, and finishing are well-defined in existing maintenance instructions and regulations and are not discussed here. The inspector is cautioned, however, to be aware of these requirements to insure that noncompliance does not cause poor quality performance.

Section II. CLEANING

2-3. General

a. The QC inspector must insure that all items on which maintenance has been performed are clean. This will require in-process inspections as well as final inspection.

b. The objective of cleaning is the removal of contaminants which would impair equipment operation. An item is satisfactorily clean that has been cleaned by one of the specified processes and no smudge appears when inspected by wiping with a clean, lint-free tissue paper. Stains caused by fungus or corrosion are acceptable as long as the parts are functionally satisfactory.

2-4. Facility

Random inspections of equipment should be performed by the quality control inspector. These inspections will determine that the equipment and cleaning facilities are adequate. Any equipment which is not in full accord with applicable cleaning standards should be regarded as defective. Corrective measures must be taken immediately to insure proper cleaning of applicable components.

2-5. Processes

Each cleaning process in use should be inspected periodically to insure conformance to applicable specifications and maintenance standards. This inspection should also include inspection of cleaning materials to insure that the proper materials are being used.

2-6. Cleaning Inspection

These inspections insure that the equipment is clean and ready to be returned to service. The QC inspector should reject any equipment which shows the following defects:

a. Loose, spattered, or excess solder; metal chips, dust, filings, dirt, sand, carbon; wire ends and insulation; phenolic or ceramic chips; foreign material, of any kind, including any particles that could loosen or become dislodged during the normal life of the equipment.

b. Fungus, mold, or any other organic growth on any item.

c. Oil, grease, cooling compound, wax, or other residue on items not requiring lubricants or protective coatings.

d. Rust, scale, powder, or other corrosion products.

e. Paint on rubber gaskets, seals, plastic or ceramic items, glass and mechanical surfaces.

f. Alkaline or acid residues. (Checked with litmus paper.)

Section III. PAINTING AND FINISHING

2-7. General

a. Painting and finishing are covered in the same section because of their interrelationship. The purpose of painting and finishing of material is to improve its general appearance, prolong its life, and keep corrosion factors to an absolute minimum.

b. Thorough cleaning by an approved technique is the first essential procedure in any effective painting or finishing method. No painting or finishing method will protect a part if contaminants or contaminating residues which accelerate corrosion or interface with adhesion or continuity of the preservatives are present on the surface of the part prior to application of the paint or finish. Improper cleaning makes all subsequent painting and finishing operations ineffective.

c. Metal items which are to be given chemical protective finishes or coatings must be cleaned so that their surfaces are completely free of dust, grit, grease, oil, acid, alkaline, and salt residues, corrosion, and other contaminants. The presence of contaminants may cause the fissures, or other surface defects that are points of entry for corrosive substances and thus make the coating ineffective. The cleaning method chosen must be most suitable for the material of which the part is made and the service requirements of the finished item.

2-8. Facilities

a. Painting. Painting shall be done in a clean, dry, well-ventilated space. It is preferred that the air temperature be between 60 to 90 degrees and the relative humidity not over 65 percent. Painting should not be done when the temperature is below 50 degrees Fahrenheit or when the humidity is above 85 percent. Materials shall be thoroughly mixed and there shall be no settling or separation of ingredients during painting operations. Unless otherwise specified, coatings may be applied by any method that will insure the application of a smooth, uniform, continuous film, free from direct overspray, runs, sags, blisters, orange peel, or other imperfection. Unless otherwise specified, baking of coats of paint shall be done at a temperature of 250 degrees Fahrenheit for 45 minutes. Freshly painted material shall not be exposed to conditions that will harm the paint. Pretreatment coating (primer wash, pretreatment blue, formula 117-B for metals) shall be applied by spraying, brushing, roller coating or swabbing. However, in the case of magnesium, this coating shall not be applied unless the magnesium has an adequate protective film and conforms to the appropriate system documentation.

b. Finishing. The finish facilities are usually separate from other work areas. The requirements are generally the same as for the painting area above, with the exception of temperature. Application of finish coats does not require temperature control as does painting.

2-9. In-Process Inspection

a. Painting. The inspector should perform an in-process inspection periodically. He should also perform an in-process inspection anytime painted items are not meeting the final painting inspection requirements. In-process inspections are made to determine that all procedures are being properly performed. The inspector should halt all painting operations found defective and insure that corrective action is taken. The inspector will generally inspect:

(1) Equipment after proper cleaning is accomplished for evidence of scale, dirt, paint peel, blisters, etc.

(2) Proper painting in accordance with the applicable requirements of the particular item. Refer to existing system documentation for these requirements.

(3) To insure that moving parts and machined surfaces, unless otherwise specified, are protected from paint.

(4) To insure that exposed bearings, glass, rubber gaskets, canvas, and gears will not be exposed to paint.

(5) Condition of surface prior to painting to insure that all moisture, soil, and contamination has been removed.

b. Finishing. The inspector should perform an in-process inspection, periodically, to insure that finishing requirements are being met. He should also perform an in-process inspection anytime items are not meeting the final finish requirements. All defects should be corrected before permitting additional finishing of items. The inspector's in process inspection should generally insure that:

(1) Contaminants which absorb moisture or accelerate corrosion, are removed as soon as possible. Oil, grease, and adherent nonporous oxide coatings may afford some protection against corrosion, but in most cases, must be removed before corrosion-preventive compounds, chemical protective finishes, electroplated metal, or paint finishes are applied.

(2) Materials used for finishing, which have not been accepted previously, are inspected and sample tested to determine compliance with the requirements as specified in the system documentation.

(3) Items to be painted after finishing are clean and that the finish meets the required standard.

(4) The inspector may, at his discretion, have test specimens made from the same type metal, coated identically, and processed concurrent with the processed items. These specimens should be checked for proper thickness (generally 4 to 5 mils), and final finish to insure proper processing.

2-10. Final Inspection

a. Painting. The inspector should inspect all painted items. These inspections will insure that the item meets required standards and is ready for use.

Criteria are:

(1) Major items must be the correct color in accordance with applicable system documentation.

(2) The correct color of items disassembled from major items shall be recorded on the inspection tag.

(3) There shall be no dried overspray, runs, sags, blisters, dirt, grit, orange peel, or other imperfections. The imperfection shall be removed and the local area repainted.

(4) There shall be no peeling, flaking, or other evidence of poor adhesion. When poor adhesion is indicated, the paint on the entire surface must be removed and the surface cleaned and repainted.

(5) The painted items shall be examined for adhesion after the coated items have dried for a minimum of 24 hours for quick-drying and baking systems, and for a minimum of 72 hours for all other systems. Water-resistant, pressure-sensitive adhesive tape (3/4-inch wide) shall be used. Press a 2-inch length of a somewhat longer piece firmly onto a flat or cylindrical surface of the item, rubbing out all air bubbles under the tape. Allow approximately 10 seconds for the test area to return to room temperature. Grasp a free end of the tape and at a rapid speed, strip it from the item by pulling the tape back upon itself at 180 degrees (in such a manner that the tape is folded back-to-back during the procedure). Observe for bare spots where the paint is removed. Disregard flecks of paint on tape where the underlying metal or phosphate coating is not visibly exposed.

(6) Paint shall have uniformity and satisfactory hiding power, color, gloss, and smoothness. If the surface does not meet these requirements, it should be repainted. Removing the existing paint may not be necessary.

(7) Exterior surfaces or trailers, vans, antennas, interior walls and ceiling of vans, and surfaces of cabinets and consoles shall be smooth, continuous and like new. Touch up or spot painting will be allowed for areas of up to 1/2-square foot.

b. Finishing. The inspector should inspect the items requiring a finish. Items requiring painting after a finish coat should be inspected in accordance with paragraph a above. The inspector will ascertain that the item meets the required standards and is ready to be returned to the using organization.

(1) shall be smooth, fine grained, adherent and free from visible blisters, pits, nodules, porosity, indications of burning, excessive edge build-up and other detrimental defects. Superficial staining shall not be cause for rejection.

(2) Slight discoloration from baking will not be cause for rejection.

(3) Cadmium plating should have no white corrosion products on the surface. Bright or dull finish is acceptable.

(4) Presence of black-silver oxide or silver sulphide (tarnish) shall not be cause for rejection of silver-plated items.

(5) All coatings shall be visually checked for continuity and uniformity.

(6) Any items which reveal bare spots due to some contamination must be completely reworked.

Section IV. SPECIAL PROCEDURES FOR MAGNESIUM

2-11. General

a. The cleaning, finishing, and painting of magnesium is covered in this section because of its unusual characteristics.

b. Magnesium is a silver-white, light, malleable ductile, bivalent, metallic element that occurs abundantly in nature. It is used in metallurgical and chemical processes, photography and signaling equipment. It is highly flammable, and is a good pyrotechnic because of the intense light it produces on burning. Structurally, it is used as an alloy.

c. The material must be treated with certain finishes to prevent excessive corrosion, indicated by a powdery substance. Special and cautious techniques must be utilized while machining or cleaning this metal due to its highly flammable composition. It is often used in design, when weight limitations are imperative.

2-12. Facilities

All treatment equipment should be inspected at random by the quality control inspector. The inspections are made to determine that the equipment and facilities for cleaning, treating, and painting of magnesium are adequate. He also should insure that proper safety equipment is available. If samples of treatment solution are taken which reveal inadequate solutions or safety hazards, corrective action must be taken immediately by the inspector.

2-13. Magnesium Cleaning

a. Acid is used to clean magnesium by pickling or to remove oxide layers of old chemical finishes, burned on drawing and forming lubricants and other water-insoluble or non-emulsifiable substances.

b. Generally, magnesium castings which have been formerly sandblasted, are pickled or treated with a sulfuric or nitric-acid solution. Treatment should continue until 0.002-inch surface is removed, if dimensional requirements permit.

c. Old paint coatings are usually removed by use of (caustic) liquid paint remover. This operation should be followed by a wash or rinse to thoroughly remove and neutralize the alkaline.

d. Insure proper treatment is used as required. The following can be used for magnesium treatments:

(1) Chrome pickle treatment.

(2) Dichromate treatment.

(3) Galvanic anodizing treatment.

(4) Chromic acid brush-on treatment.

(5) Fluoride anodizing process plus corrosion preventive treatment.

(6) Chromate treatment.

e. Random sampling for visual examination and workmanship shall be conducted.

f. All items exposed, to weather shall be examined very closely for any evidence of corrosion or deterioration of finish. If there is any evidence of corrosion, the finish must be removed to bare metal and cleaned of any corrosion or corrosion products and finished using procedures provided.

2-14. In-Process Inspection

a. Product Examination. Samples of treated parts shall be visually examined to determine conformance to workmanship standards, quality of the treated surface, and any other requirements specified by the system documentation. A visual examination of the processed surface shall be made for complete and uniform coverage. Surfaces shall be examined for coloring and general characteristics, described herein, particular to the type treatment being examined, which shall be an indication of satisfactory time of treatment and condition of solution.

b. Dimension Change Determination. The thickness of each piece selected prior to treatment shall be determined by measuring with a micrometer which reads accurately to 0.0001 inch. The pieces shall then be processed concurrently with the remainder of the lot. The pieces shall be distributed throughout the various bitches during processing so as to be representative of the entire lot. The thickness of each piece shall be determined after treatment by measuring the same location as before. The dimensional changes of each piece shall be determined from the difference of the two measurements.

c. Other Tests. Treated pieces shall be tested for conformance with any special requirements specified in the drawing. The tests shall be performed according to the methods specified therein.

d. Rejection.

(1) In the event unsatisfactory quality is detected in the processing treatment being used, the inspector will promptly notify processing personnel to take necessary corrective action. All work which was processed under doubtful conditions of the solution utilized will be rejected and reprocessed to the satisfaction of the inspector.

(2) If a sample fails to conform to the requirements of this document, all items being processed as represented by the sample will be rejected. Rejected items may be submitted for acceptance after the items have been reprocessed. Reprocessed items are subject to 100 percent inspection in order to determine if defects still remain.

2-15. Magnesium-Final Inspection

a. All equipment fabricated of magnesium will be inspected for the proper smoothness and finish.

b. Any detected bare spots will be refinished as required.

c. Any signs of apparent contamination such as dirt, grease, and pits will be removed and any necessary actions required will be taken to correct the problem.

d. Check those areas that specify special painting, etc.

e. Scratches which must be removed and reworked and / or finished.

f. Coatings shall be visually examined for continuity and uniformity.

g. Coatings shall be checked for dry film thickness as required by this document and / or the applicable system documentation. Small steel panels prepared with films should be used as comparators to the item being inspected.

h. The thickness requirement generally shall be considered met when the coating is of sufficient thickness to completely cover and impart characteristic color of the coating to the surface. Generally, four mils thickness is sufficient if a surface is completely stripped; otherwise, a five mil thickness is acceptable and adequate.

CHAPTER 3

ELECTRICAL AND ELECTRONIC EQUIPMENT

Section I. INTRODUCTION

3-1. General

This chapter covers the inspection criteria for electrical and electronic equipment. The chapter is arranged in a normal inspection manner; chassis, electrical wiring, plugs and jacks, switches and controls, motors, power sources, and assembly components. Soldering, because of its extensive coverage and importance, is included separately as chapter 7.

3-2. Definitions, Abbreviations, and Terms

The inspector should refer to Appendix B for the definitions, abbreviations, and terms applicable to electrical and electronic equipment.

3-3. Types of Inspection

a. Initial or Receiving Inspection. This type of inspection is not normally accomplished by the QC inspector. The QC inspector may perform an initial or receiving inspection when he determines that it is necessary. The inspection is performed to determine the repairs required, proper identification of equipment, MWO application, and inventory to insure that there are no missing items.

b. In-Process Inspection. This inspection is performed to insure that procedures, processes, adjustments required during assembly, parts conform to the prescribed standards, and that workmanship is in accordance with approved methods and procedures. Inspections are made to protect product quality and integrity of processing. Evidence of unacceptable workmanship or materials is cause for rejection of the item and much closer inspection of the defects and causes.

c. Final Inspection. This inspection is performed to insure that all deficiencies have been corrected, workmanship meets the standards, final configuration is correct, and that the item is operational within the tolerances and limits established for the item. Those items requiring maintenance calibration checks will have a DA Label 80 attached to indicate accomplishment of the required checks.

Section II. CHASSIS ASSEMBLIES

3-4. General

This section covers the inspections required on the chassis assemblies with respect to attaching hardware, dents, scratches, weldments, finish and identification.

3-5. Attaching Hardware

a. Attaching hardware is basically divided into two broad categories: threaded and nonthreaded. Threaded types include nuts, screws, bolts, studs, etc. Nonthreaded types include rivets, springloaded clamps, and pins.

b. Visual inspection will verify that the attaching hardware is not scarred, battered or deformed by the tools used in installation; that protective coatings remain intact and that there is no apparent deficiency in the hardware used.

3-6. Dents and Scratches

a. The location and effect of dents and scratches upon item operation determines the critical importance and possible repair or rejection. The inspector should consult the system maintenance manuals for guidance before rejecting an item because of dents and scratches.

b. The inspector must determine, with the aid of depth gages and other suitable equipment, whether to reject or repair. In the majority of cases, repair can be accomplished. Any defect which would impair safety of personnel or equipment must be rejected.

3-7. Weldments

The inspector should insure that all weldment repairs meet the inspection requirements as specified in chapter 8.

3-8. Finish

After repair, the chassis should be capable of meeting the inspection requirements for finish as specified in chapter 2.

3-9. Identification

In accordance with the method of identification (identification plate, stencil marking, etc.) inspect for clarity, legibility, and secure attachment.

Section III . ELECTRICAL WIRING

3-10. General

This section covers the inspection of electrical wiring, cables and wiring harness assemblies. Cable assemblies are identified as interconnecting cables between two assemblies. Wiring harness assemblies are identified as internal wiring which connects chassis internal components. A discussion of electrical cable and wiring harness repair is covered to give the inspector a better understanding of what he is to look for during inspection.

a. Insulation of electrical wiring is done to prevent failures, grounding, and to keep out moisture which could cause shorts. Insulation in many cases is used to prevent electrical shock to personnel and to prolong the life of the electrical equipment.

b. All splices and connector terminals should be insulated and in most cases preshrunk in place. The insulation should extend 1/4 inch beyond the connector pin or wire which it insulates. It should not be cracked, torn, checked, or rotted.

c. Insulation covering cable assemblies and connector ends of wiring harnesses are generally of two types; nonshrinkable and heat-shrinkable. Cable assemblies are usually completely covered by an outer insulation material; vulcanized rubber or neoprene. Wiring harness assemblies usually have a "spaghetti" type insulation which can be slid over the wire assemblies to cover the bare connections.

3-11. Cable Assemblies

A cable assembly consists of two or more electrical wires enclosed in a rubber or plastic cover or jacket. The ends usually terminate in pin type connectors. To assure a good quality cable repair, in-process inspection is necessary.

a. Splicing.

(1) Cables may be spliced and used provided the length is not reduced beyond 90 percent of the original length. (See paragraph 3-11 *b* for splicing procedure.) If the cable is to be returned to the using unit, the minimum length is determined by operating conditions. Conductor splices will be soldered unless .specifically prohibited. Missile cables are normally not spliced.

(2) Splices will not be made at flexing points. Splice in a new piece of conductor with joints on either side of the flexing point. Spliced joints will be strengthened by additional sleeving or lacing.

(3) For a stranded wire splice, the strands shall be combed out, interlaced, compressed, and soldered. For a nonsolder splice, twist the strands, trim and use a splice connector ("Sta-Kon, two way, butt end.

(4) For a solid wire splice, cut back the minimum of insulation, place ends of wire in stakon splice connector, solder and crimp.

b. Insulation.

(1) An appropriate cable test set or megger can be used to determine the insulation resistance. If insulation requirements for the subject cable are unavailable, reject on values less than 100 megohms.

(2) Check cable shielding to insure proper grounding of the shield.

(3) Small holes in vinyl sleeving may be patched by cementing on a patch of similar material, using vyna-kote cement. Larger holes may be repaired by slipping on a length of solid sleeving, or by using split sleeving large enough to lap 180 degrees. In both methods, cement with vyna-kote.

(4) Rubber cable jackets may be repaired by patching and vulcanizing.

(5) Plastic cable jackets may be repaired with epoxy cement with or without a patch, as necessary.

(6) Conductor splices should be coated with liquid vyna-kote and then covered with vinyl covered braided glass.

c. Connectors. The connectors used on cables are of many configurations and no attempt is made here to describe them in detail. Solderless wire wrap connections are permitted in certain instances of communication and control circuits where terminal pins are designed for this type connections. When repairing or replacing connectors, care must be taken to observe the order of disassembly of the parts so that they may be reassembled in the same order. On multi-conductor cables a template should be used to identify the conductors while the connectors are being changed. Care must be taken to orient or polarize the terminals to assure proper mating of the connectors.

(1) Ends of conductors will be sold-red to the pins and sockets using a noncorrosive flux. The quality of soldering is described in chapter 7. Clean the connector by immersing in trichloroethylene and brushing between wires, pins, and other components. Fill backshells, or hoods with sealing compound or epoxy resin if required.

(2) In the event that the jacket has shrunk away from the connector, disassemble the connector, pull the jacket into place against the connector and secure by winding the linen thread.

(3) Damaged or dirty threads on the connectors may be made serviceable by chasing the threads with a die or tap.

3-12. Wiring Harness Assemblies

Wiring harness assemblies are normally used internally in chassis assemblies. They do not require weather proofing protection and only in some cases require potting of plug and jack assemblies. The inspector should inspect for proper stripping, splices, lacing, wire color, and proper wire size of replaced wiring.

a. Stripping. Proper stripping is important to accomplish a good solid and electrical connection. If stripping is not properly done, arcing and burning may result. The inspector will have to perform an in-process inspection to insure that proper stripping is being accomplished.

(1) Stripping is usually accomplished by a mechanical stripping tool or a thermal stripper. Generally, nonadjustable type mechanical strippers are used because of the nonavailability of thermal-type strippers. These mechanical strippers should never be used on wire sizes 22 or smaller if there is a tendency to stretch the wire. Also, care should be taken to prevent nicking or cutting of the wire strands. Nicked or cut wire strands requires replacement of the wire if enough length for restripping is not available.

(2) Figures 3-1 through 3-3 show proper stripping, depending on the termination method. Figure 3-1, dimension A, is the length of the crimp bowel added to the conductor plus 1/ 16 inch. Figure 3-2 illustrates a ferrule or dead-end shield termination. Dimension C is the length of the bowel to be crimped plus 1/16 inch. For dead-ending, keep shield braid flush, within 1/8 inch of the shield jacket. Figure 3-3 shows the pigtailing of shields for grounding. Dimension C is determined by the application.

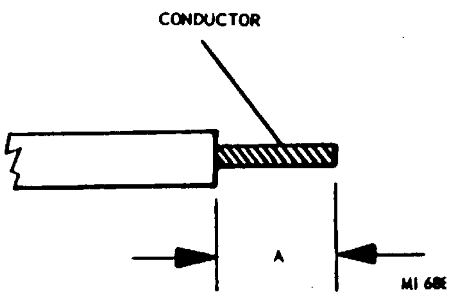


Figure 3-1. Stripping single conductor.

b. Splicing. The splicing of wiring harness assemblies is not recommended and should only be accomplished as specified in the system documentation. If splicing is to be accomplished tile following figures 3-4 through 3-8 are included to assist the inspector in determining that the splice is properly done.

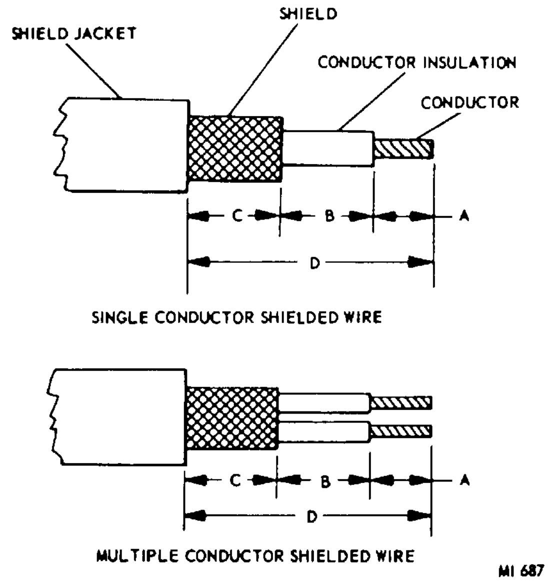


Figure 3-2. Stripping shielded conductor.

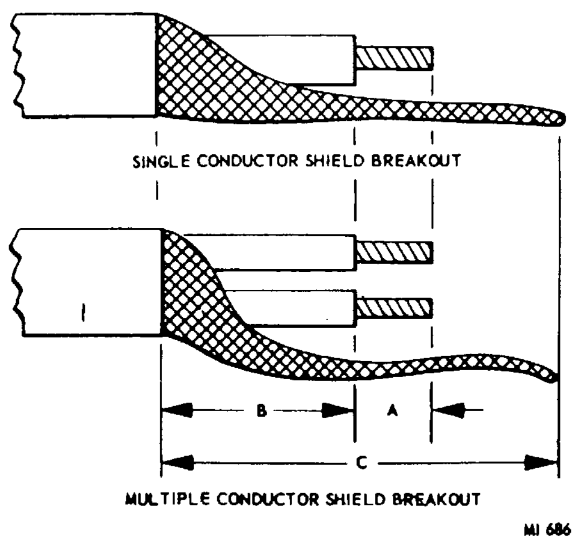


Figure 3-3. Single and multiple conductor shield breakout

c. Crimping. All crimping should be accomplished with properly qualified and calibrated tools. The inspector should inspect in-process to insure that the proper tools are being used. Figures 3-9 through 3-16 are included to assist the inspector in determining that the crimping is properly done.

d. *Lacing*. To prevent damage to insulation and breaking of conductors caused by vibration and other movements, the wires must be tied, together in

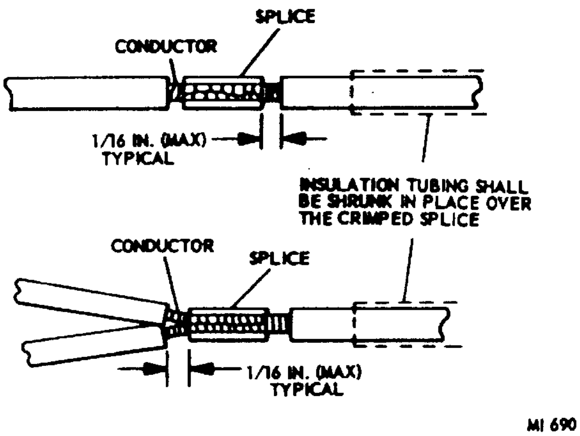


Figure 3-4. Single splice in line.

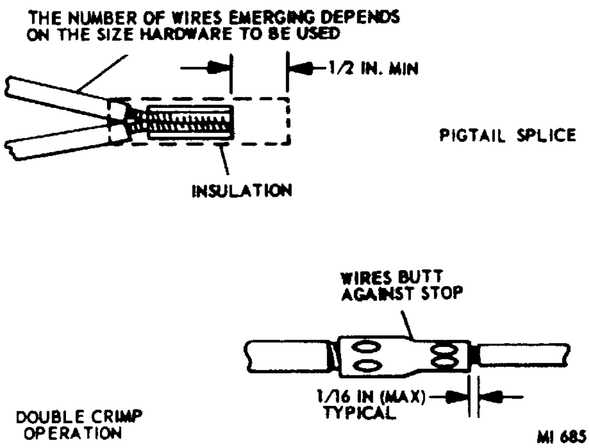


Figure 3-5. Single splice - pigtail.

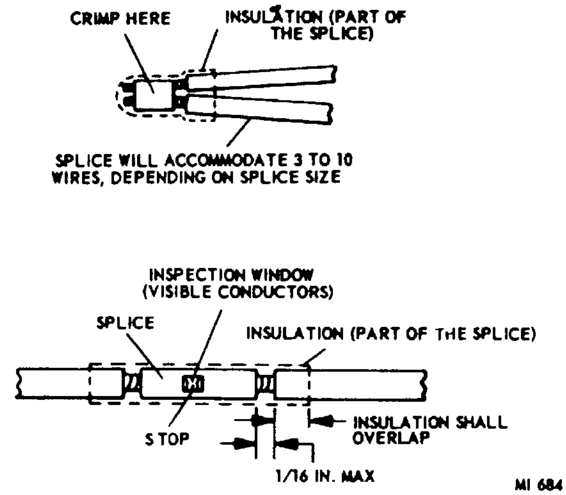


Figure 3-6. Single splice - preinsulated.

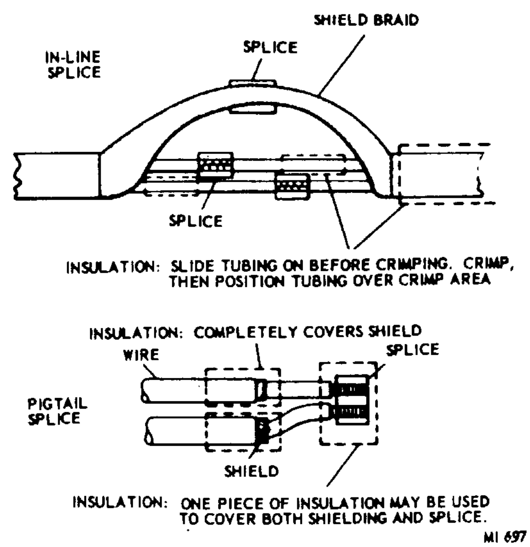


Figure 3-7. Multiwire splices

bundles or harnesses and secured to the structure or to a tiebar. Various methods such as continuous lacing, spot ties, plastic cable ties, plastic tubing, and spiral-wrapped plastic tape are commonly used for lacing the cable trunk. Excessive tension, visible as a deformation of the outside diameter of the cable trunk, will promote cold flow of the insulation under the tie. This condition can result in low insulation value or short circuits. Preferred methods of lacing and the use of plastic ties will be discussed in the following paragraphs.

(1) *Continuous lacing* (figures 3-17 and 3-18). The materials commonly used for continuous lacing are lacing tape, cord, or small diameter tubing. The stitching should be equally spaced up to the point of branching or other termination. Where the harness ending consists of a single wire or a pair of wires, a clove hitch secured by a square knot is sufficient. In component assemblies where wires break from the cable trunk to a termination, the tie should be made a distance from the branch to provide a sufficient vibration bend.

(2) *Terminating stitches and spot ties*. A clove hitch and a square knot are generally used for terminating stitches and spot ties (figure 3-19).

(3) *Running or single stitches* (figure 3-20). Running or single stitches are successfully used on insulation that has high potential cold flow characteristics. It is made by passing the free end of

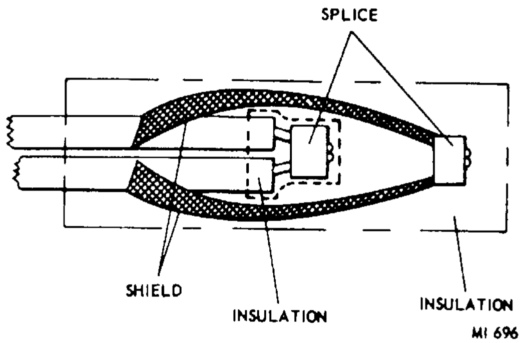


Figure 3-8. Pigtail splice with shield carried through.

the lacing material around the bundle, over the standing part, and through the loop.

(4) *Single lock stitch* (figures 3-21 and 3-22). The single lock stitch is commonly used for continuous lacing. It is made by making a single stitch, then passing the free end under the lacing between the two stitches and through the loop.

(5) *Double lock stitch* (figures 3-23 and 3-24). The double lock stitch is used primarily to prevent lacing from loosening but is frequently used for complete lacing. It is made by making two single stitches around the bundle and securing with a lock stitch.

(6) *Spacing of stitches*. The wires in a finished cable trunk should have a minimum number of crossovers. Crossovers, if necessary, should be at least 8 inches from the termination. Terminating stitches should be made at the end of each lacing. The type of stitch is determined mainly by the type of insulation and diameter of the bundle. The most commonly used stitch spacing is indicated in table 3-1.

(7) *Serve* (figures 3-25 and 3-26). The length of the serve or endless tie should be equal to approximately the outside diameter of the wire bundle and should not exceed 3/4 inch. To prevent the lacing from loosening, it should be served at the point of origin and at the point of termination of the lacing. The serve is used at bundle branches or breakouts and at all bundle end terminations. The serve is made by forming a loop along the bundle with the lacing tape, the ends of the tape toward the bundle end. Wrap the lacing end of the tape around the bundle and over the loop. Upon reaching the desired length of serve, pass the lacing end through the loop and pull the ends away from each other. Adjust by pulling until the cross is under the serve. Cut this excess tape from each end of the serve.

(8) Spot ties (figure 3-27). Spot ties are frequently used in place of continuous lacing. They are made exactly like the termination ties.

CAUTION

Cut the end of nylon straps off flush with the boss to avoid cuts to hands from the sharp edges. The plastic ties may also be used as cable clamps. Care should be taken that no cable clamp be placed over a cable tie.

(9) *Service loop* (figure 3-28). Where a loop must be provided to allow opening of an access door, the harness should be served at the start and end of the loop. The loop should not be laced, but should be secured by spot ties or plastic cable ties.

3-13. Inspection Cables and Wiring Harness Assemblies

a. After repair of cable and wiring harness, test for electrical continuity and insulation resistance.

b. Visual inspection may be made according to the following checklist:

(1) There shall be no fungus growth, oil, grease, corrosion, or foreign materials (especially around pins and terminals).

(2) Insulation shall have no cracks, tears, cuts, fraying, abrasion, burns, or other deterioration throughout entire length with particular emphasis at splices and terminations.

(3) Connectors, when required, shall have proper application of potting.

(4) Terminals and connectors shall not be twisted, bent, broken, or missing.

(5) Insulator inserts shall not be burned, cracked, chipped, broken, or contaminated with any foreign material.

(6) Mounting and connector hardware, dust covers, and caps, shall not be loose, damaged, or missing.

(7) Identification markings shall not be illegible, incorrect, or missing.

(8) Color or number code of wire shall be in accordance with system documentation or have a suitable marker indicating correct code on each end.

(9) Pin and socket terminal contacts shall be securely seated in connector inserts.

(10) Insulator blocks must not be free to be pulled or pushed out.

(11) Minimum radii of bend for power wires and cables shall be 10 x od.

(12) Minimum radii of bend for power wires and cables at terminals or support shall be 3 x od.

(13) Minimum radii of bend for RF cables enclosed in sleeving shall be 2 x od.

Crimping procedure is the same for pin and socket contacts:

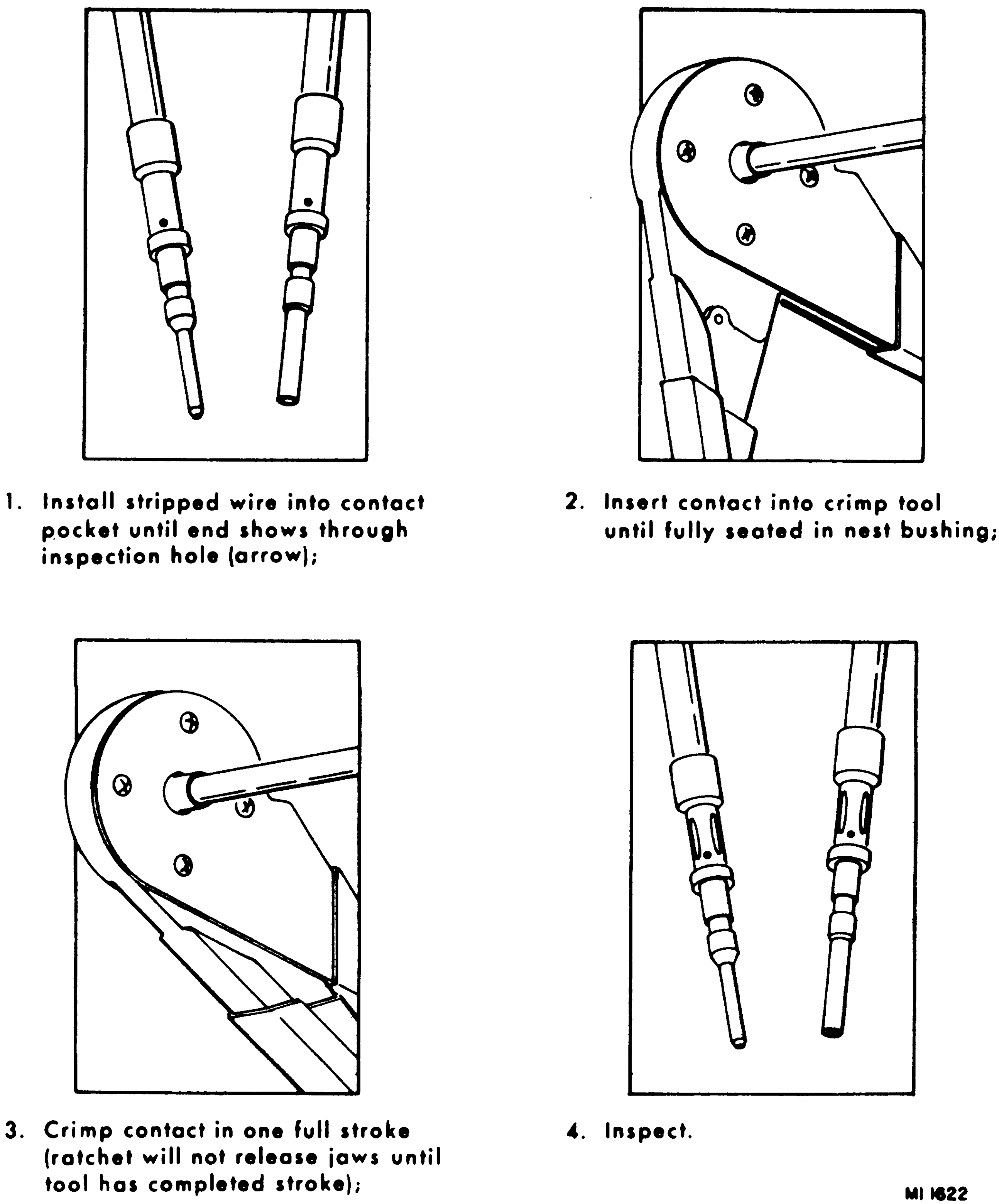


Figure 3-9. Typical crimping procedure.

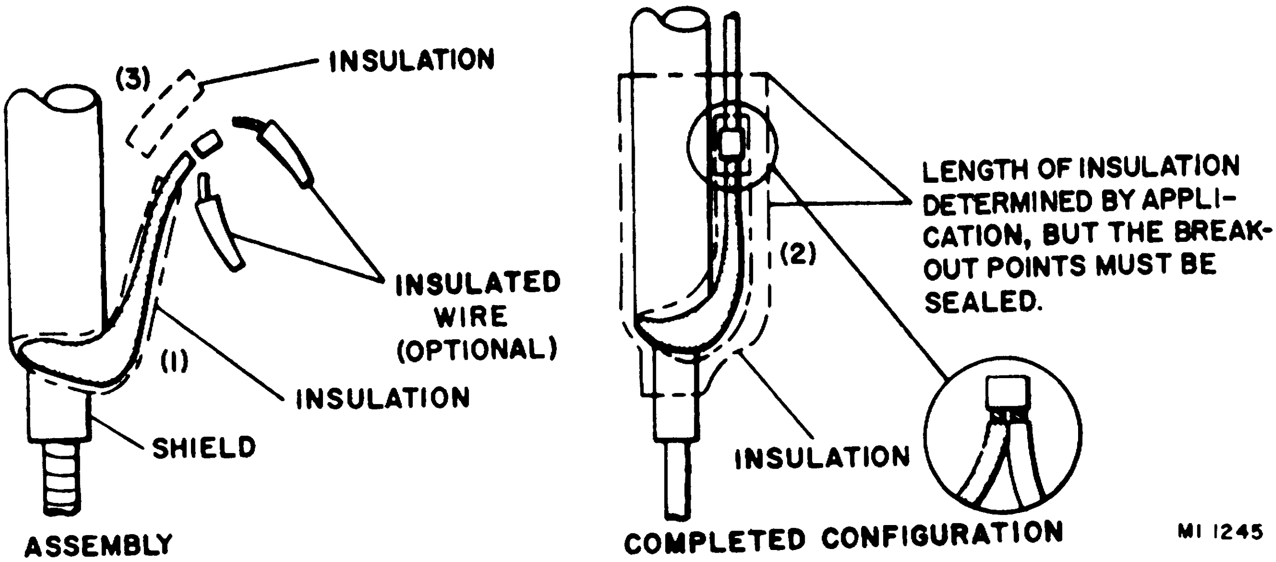


Figure 3-10. Crimping individual shield termination.

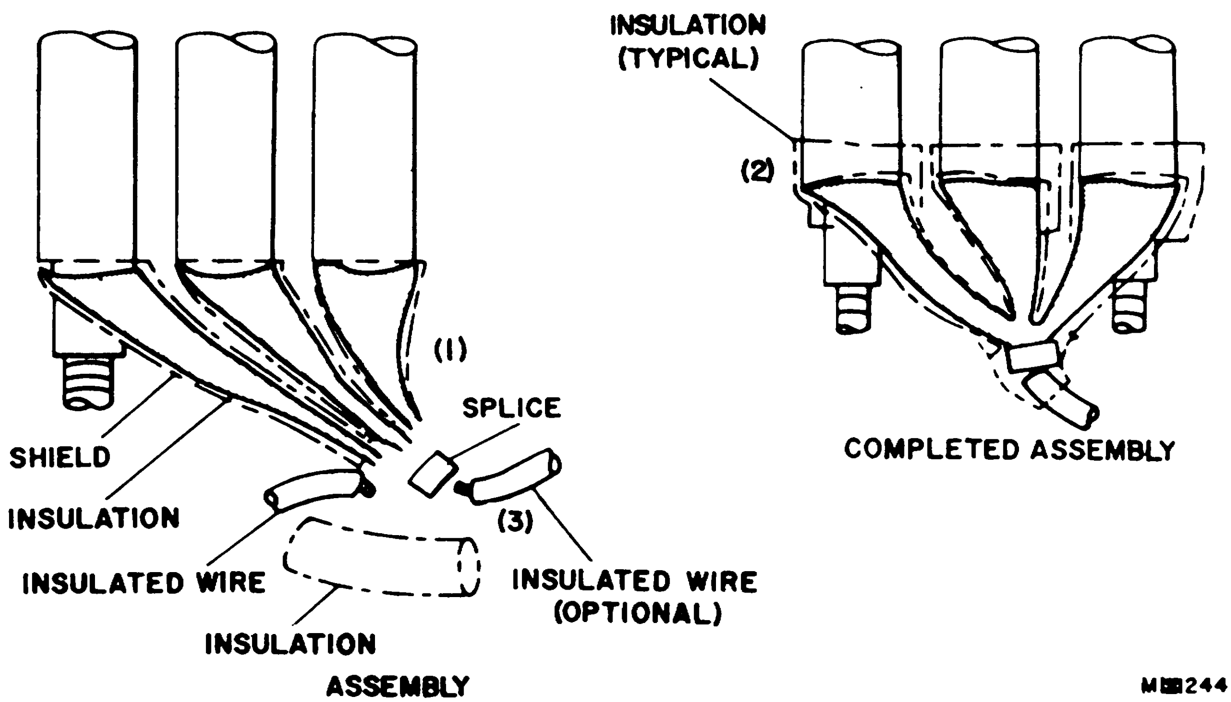


Figure 3-11. Crimping group shield termination.

(14) Minimum radii of bend for RF cables formed from straight sections of cable shall be 5 x od.

(15) Soldering of wire ends. Refer to chapter 7 on soldering.

(16) Wire ends shall be securely attached to connectors, and shall be equipped with the correct type of undamaged sleeving, where required.

(17) Lacing should be as specified in paragraph 3-12.

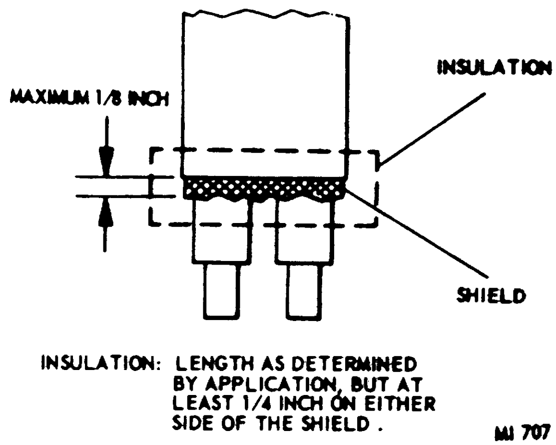


Figure 3-12. Crimping floated shield termination.

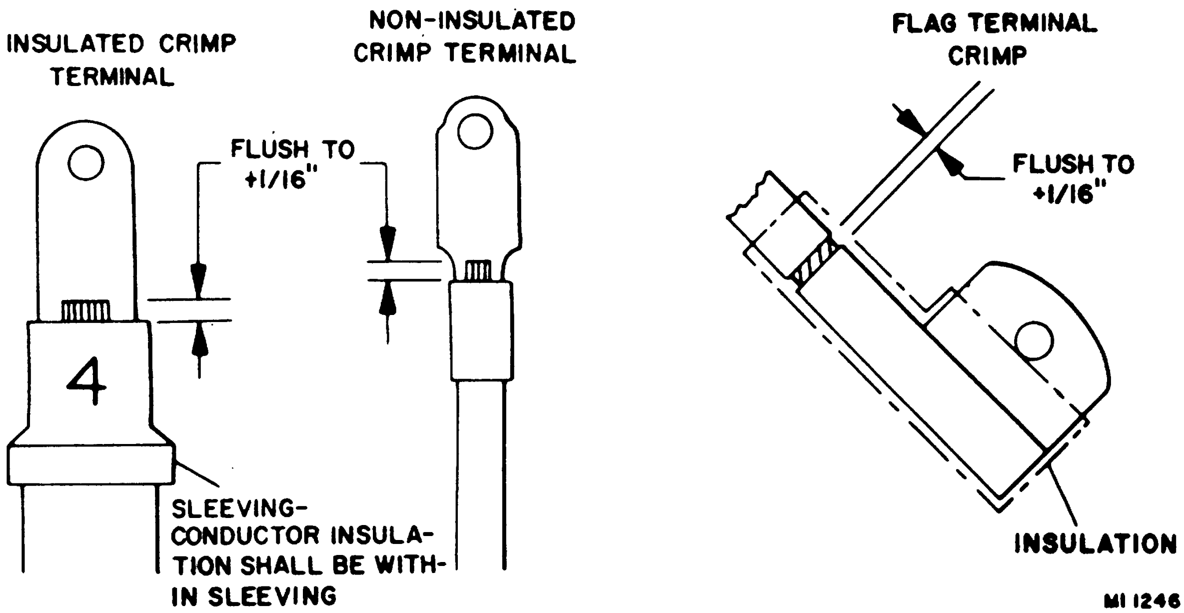


Figure 3-13. Insulated, non-insulated, and flag terminal crimps.

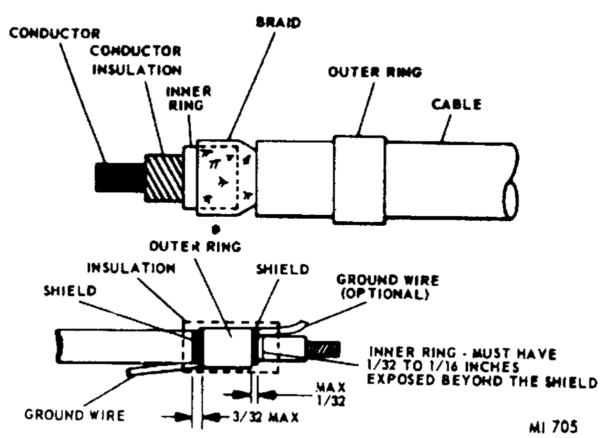
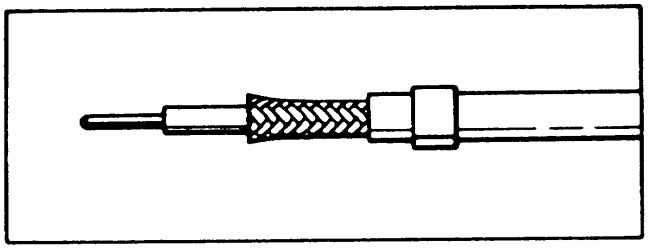
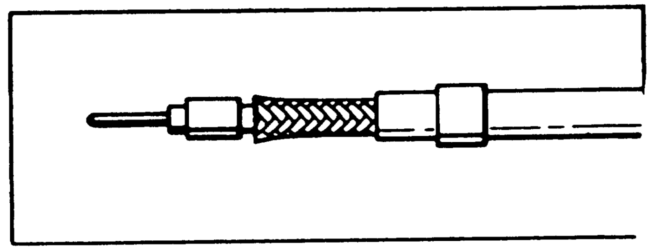


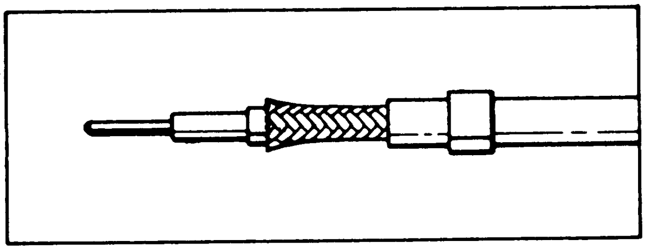
Figure 3-14. Crimping completed ferrule assembly.



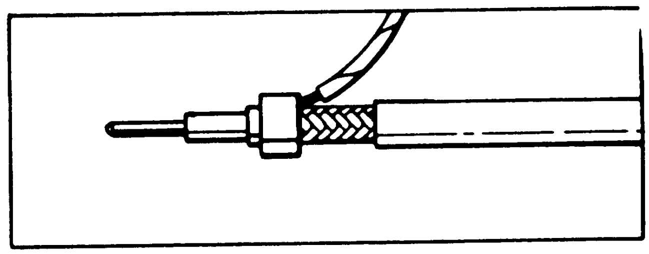
1. Strip shield, exposing conductor(s). Slip outer HYRING over conductor(s) and over shield.



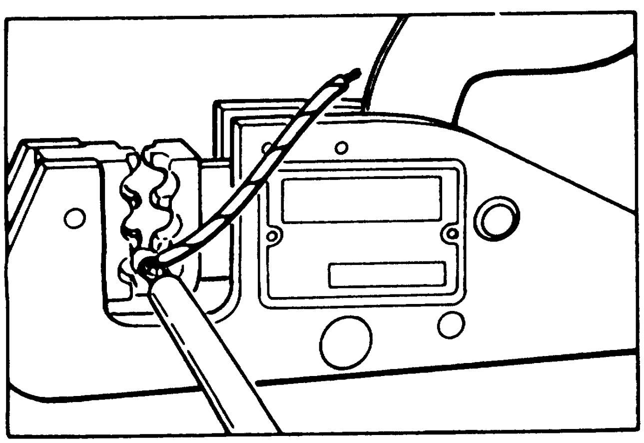
2. Fan braid slightly and slide inner HYRING under the shield.



3. The inner HYRING should extend approximately 1/16 inch beyond the end of the shield.



4. Insert the ground lead under the outer HYRING and align over the inner HYRING. There should be no exposed strands.



5. Crimp.

Note

Braid is shown exposed in these pictures to clarify procedure. In actual practice, HYRING is installed flush against insulation.

MI 1623

Figure 3-15. HYRING crimping procedure.

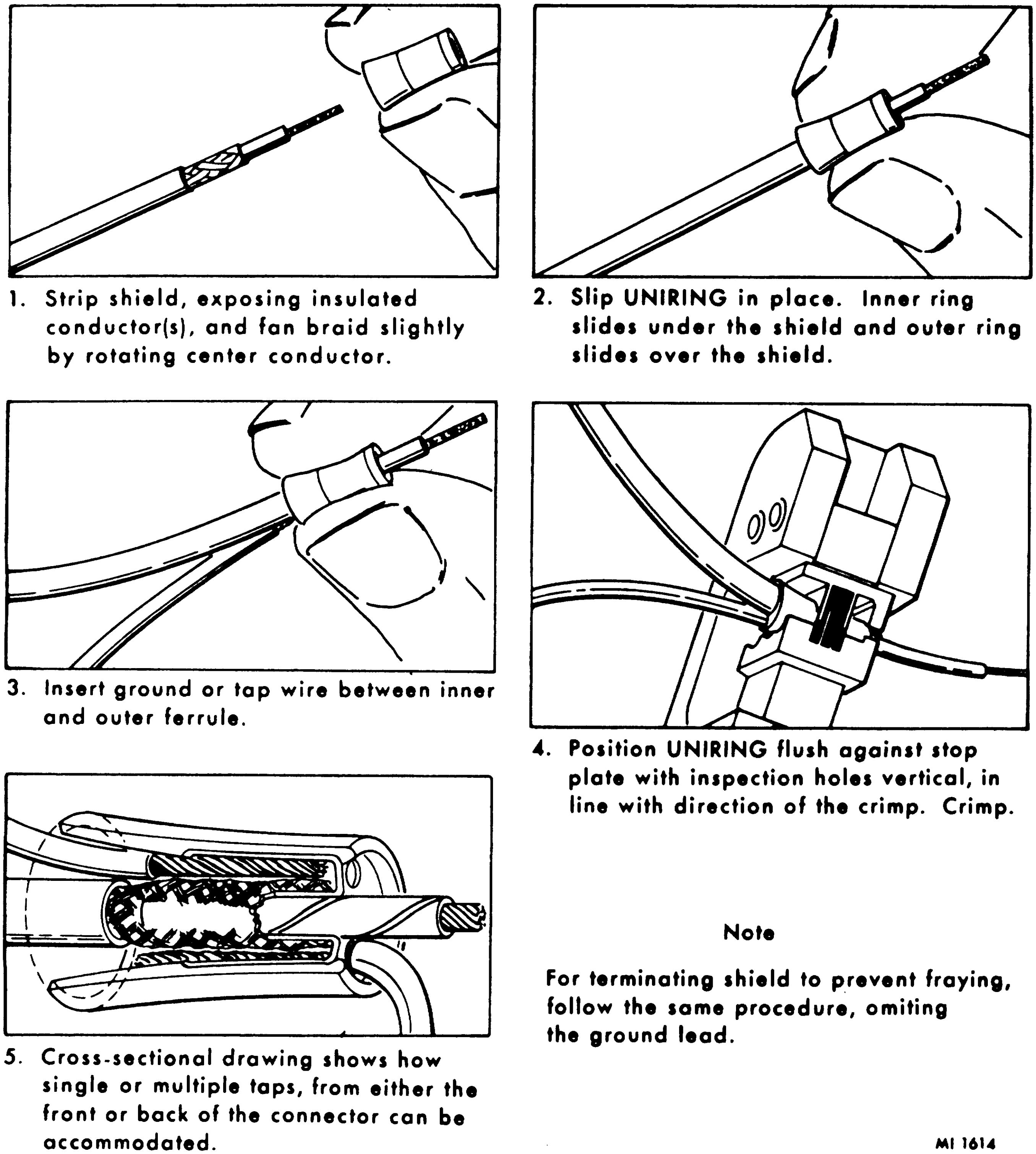


Figure 3-16. Crimping insulated conductors.

Figure 3-17. Equal spacing.

Figure 3-18. Vibration bend.

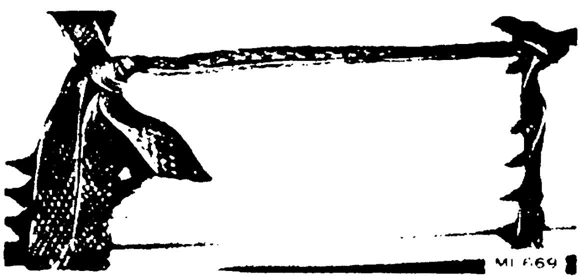


Figure 3-19. Clove hitch and square knot.

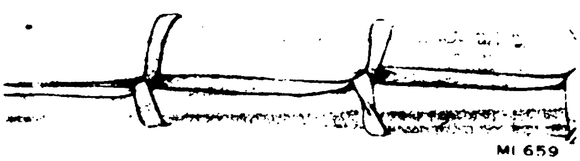


Figure 3-20. Running stitch.

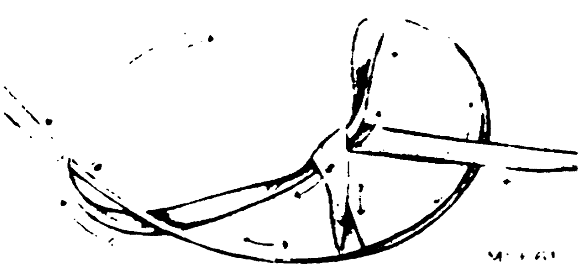


Figure 3-21. Single lock stitch method.

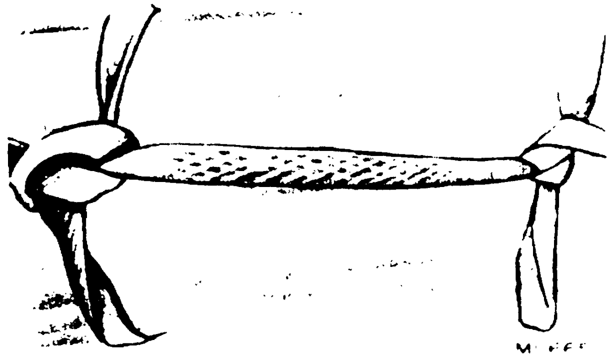


Figure 3-22. Single lock stitch completed.

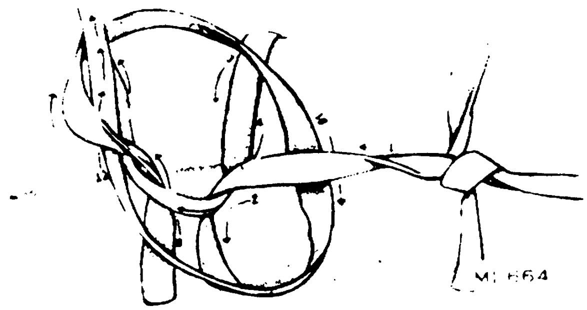


Figure 3-23. Double lock stitch.

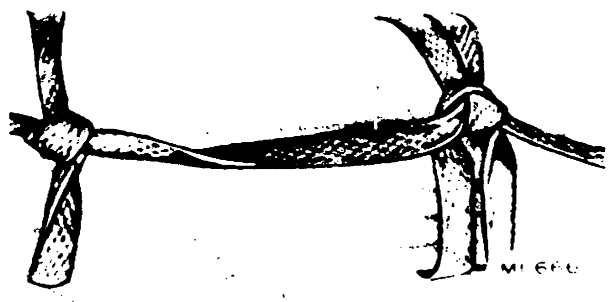


Figure 3-24. Double lock stitch completed.

Table 3-1. Stitch Spacing

Lacing intervals inches, approximate	Cable or harness diameter
1/2 inch or less	3/4 to 1 1/2
1 inch	2
Larger diameter	3

Figure 3-25. Serve at point of origin.

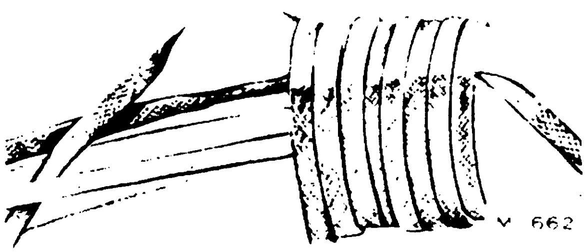


Figure 3-26. Serve method of tying.

Figure 3-27. Spot tie.

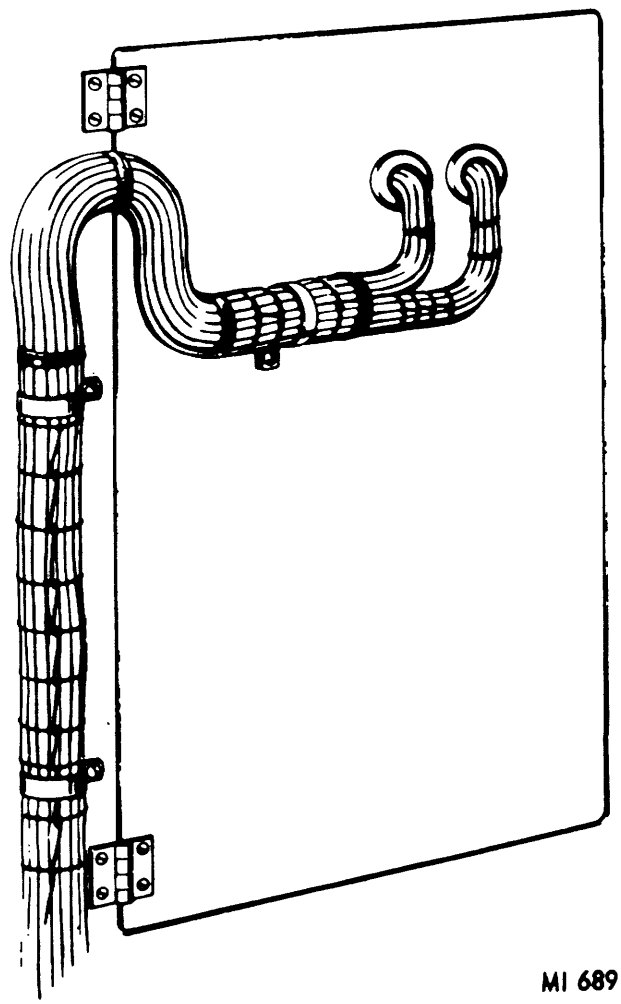


Figure 3-28. Service loop.

Section IV. RF CABLES AND WAVE GUIDES

3-14. General

The inspection of rf cables and wave guides is of the utmost importance. The inspector should become familiar with the complete repair procedures of rf cables before he can properly inspect. The repair of wave guides is restricted and usually requires only inspection and cleaning.

3-15. RF Cables

The inspector should perform in-process inspections of rf cable repairs. Figures 3-29 through 3-32 are included to show proper repair procedures. During a final inspection the inspector can remove the locknut or clamp nut securing the connector body. He can then remove the body and determine if the repair has been done properly.

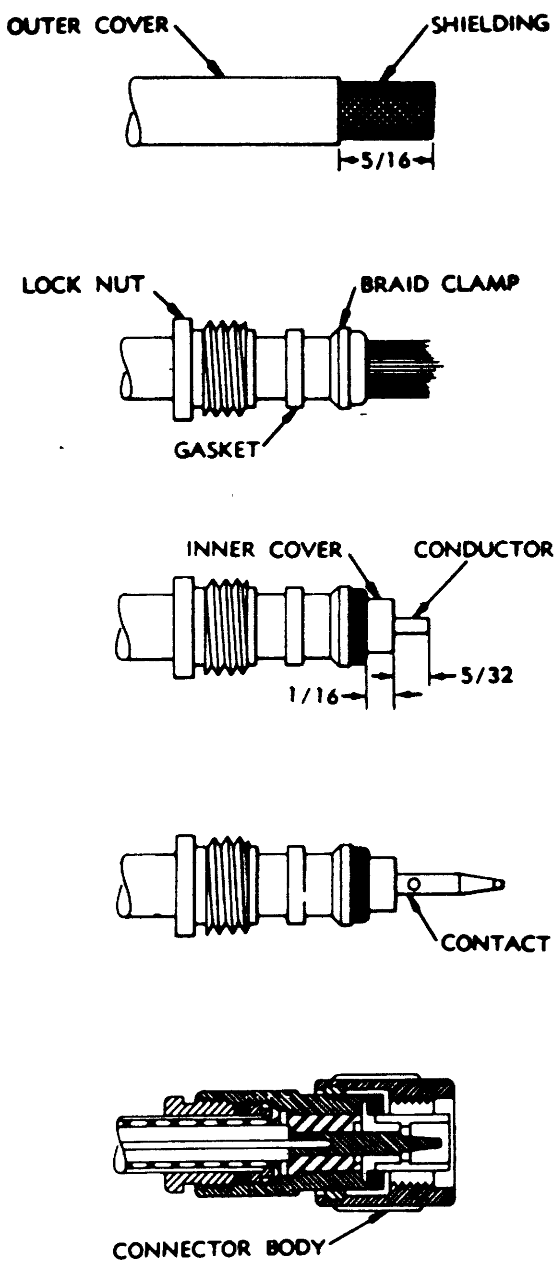
3-16. Wave Guides

Wave guides are fabricated of tubular or rectangular metal. Dimensions are critical. Damage to the interior surface can effect the electrical characteristics and make the part unserviceable. Flexible wave guides should be handled carefully to prevent bending beyond the required limit. Final inspection of wave guides should accomplish the following.

a. Rigid Wave Guides. Dimensions are critical. Inspect the interior as well as the exterior surfaces for dents, corrosion, dirt or moisture. Do not handle interior, as moisture from the skin may deposit acid on the surface which will cause corrosion. If surfaces are found to be satisfactory, cover the wave guide opening with a moisture proof cover and store in a safe, dry place.

b. Flexible Wave Guides. Handle carefully during inspection. Do not bend beyond usual extension. Do not twist. Inspect interior surfaces for chips, dents, corrosion, dirt, or moisture. Examine the exterior surfaces for blisters, tears, cracks, or any areas of nonadherence to the jacket. Cover open area with a moisture proof cover and place in a safe, dry area in a relaxed position.

ILLUSTRATION



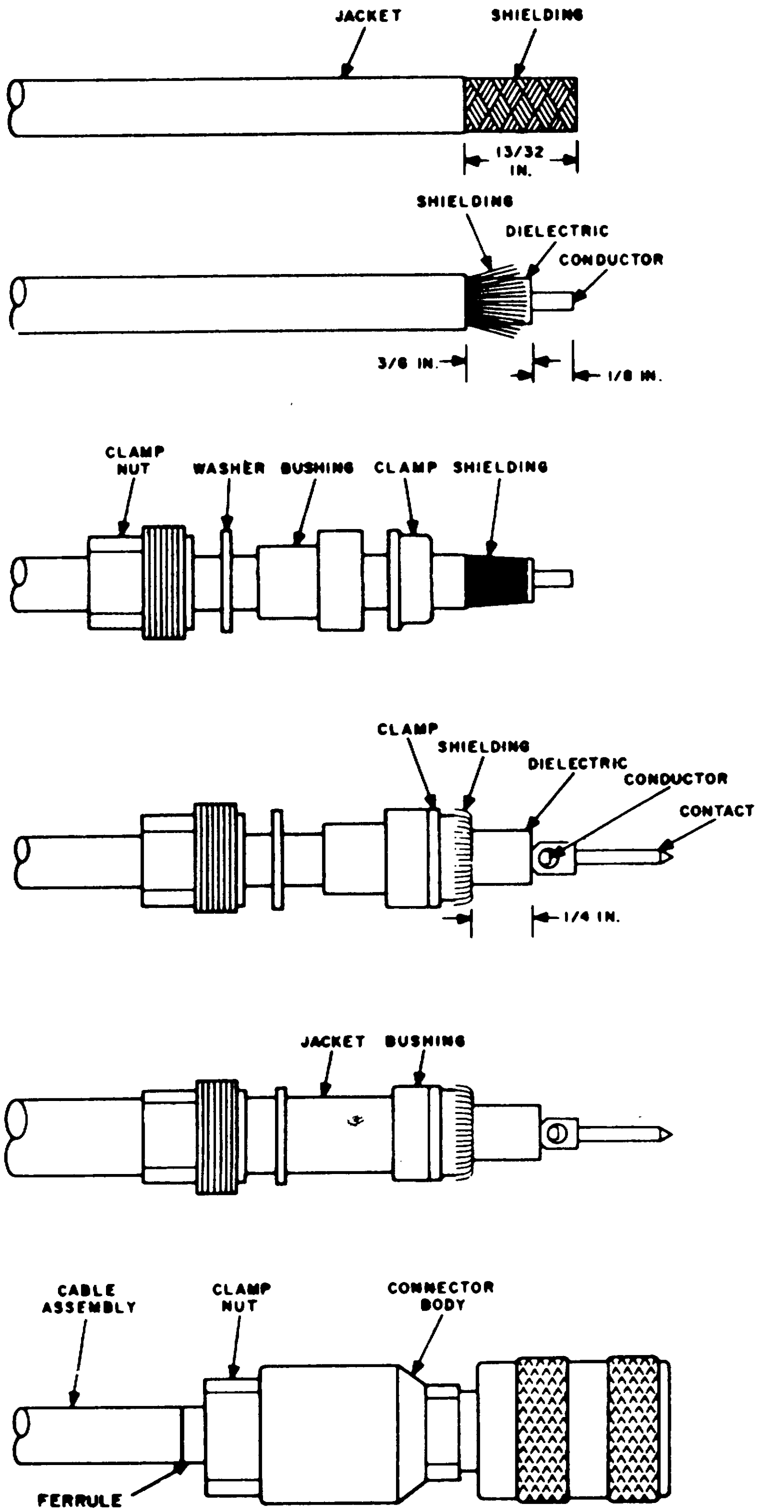
PROCEDURE

1. CUT CABLE TO PROPER LENGTH AND REMOVE 5/16 INCH OF OUTER COVER.
2. COMB OUT SHIELDING
3. SLIDE LOCK NUT, GASKET, AND BRAID CLAMP ON CABLE.
4. FOLD SHIELDING OVER BRAID CLAMP AND TRIM EXCESS.
5. CUT INNER COVER TO 1/16 INCH AND CONDUCTOR TO 5/32 INCH AS SHOWN.
6. TIN CONDUCTOR AND REMOVE EXCESS SOLDER.
7. SOLDER CONTACT TO CONDUCTOR.
8. INSERT CONTACT INTO CONNECTOR BODY, SLIDE GASKET FORWARD AND TIGHTEN LOCK NUT SECURELY.

ORD G1606

Figure 3-29. Termination procedures coaxial cable, using series N connectors.

ILLUSTRATION	PROCEDURE

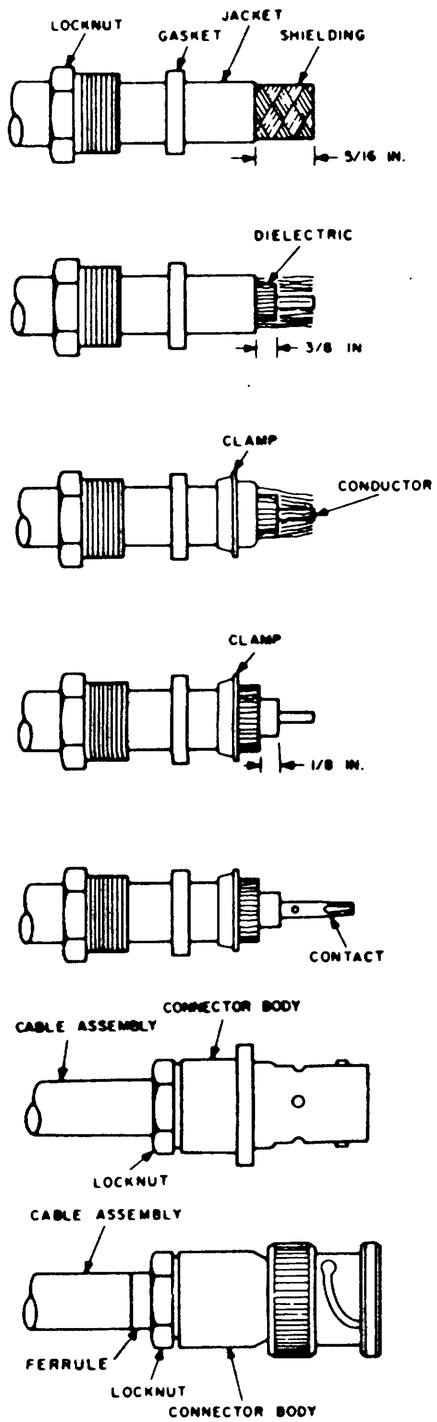


1. PREPARE CABLE TO DIMENSION SHOWN. BE CAREFUL NOT TO NICK SHIELDING.
2. COMB OUT SHIELDING AND CUT DIELECTRIC AND CONDUCTOR TO DIMENSIONS SHOWN. TIN EXPOSED CONDUCTOR AND REMOVE EXCESS SOLDER.
3. TAPER SHIELDING INWARD TOWARD CONDUCTOR. SLIP CLAMP NUT, WASHER, BUSHING AND CLAMP OVER CABLE.
4. FOLD BACK SHIELDING, TRIM TO LENGTH AND FORM BACK OVER CLAMP AS SHOWN. SOLDER CONTACT TO CONDUCTOR AND REMOVE EXCESS SOLDER. CONTACT MUST SEAT FIRMLY AGAINST DIELECTRIC.
5. WHEN USING RG-59,62 OR 71/U CABLE, CUT OFF AND DISCARD NARROW PORTION OF BUSHING CABLE JACKET WILL BUTT AGAINST REMAINING PART OF BUSHING IN IN BOTH PLUG AND RECEPTACLE ASSEMBLIES.
6. INSERT CABLE ASSEMBLY INTO CONNECTOR BODY AND TIGHTEN CLAMP NUT SECURELY. CRIMP THE FERRULE.

ORD G 4002

Figure 3-30. Coaxial termination using RG and 71/U connectors.

ILLUSTRATION



PROCEDURE

1. PREPARE CABLE TO DIMENSION SHOWN. BE CAREFUL NOT TO NICK SHIELDING. SLIP LOCKNUT AND GASKET, WITH "V" GROOVE TOWARD CLAMP, OVER JACKET.

2. COMB OUT SHIELDING AND FAN OUT FROM DIELECTRIC. CUT OFF DIELECTRIC TO DIMENSION SHOWN. BE CAREFUL NOT TO NICK CONDUCTOR.

3. COMB SHIELDING FORWARD, AND TAPER TOWARDS CONDUCTOR. PLACE CLAMP OVER SHIELDING AND PUSH BACK AGAINST CABLE JACKET.

4. FOLD BACK SHIELDING, TRIM TO LENGTH, AND FORM BACK OVER CLAMP AS SHOWN. TIN EXPOSED CONDUCTOR USING MINIMUM AMOUNT OF HEAT. DO NOT DISTORT DIELECTRIC SO AS TO PREVENT PROPER MATING WITH BUSHING, AND REAR INSULATOR.

5. SOLDER CONTACT TO CONDUCTOR AND REMOVE EXCESS SOLDER.

6. INSERT CABLE ASSEMBLY INTO CONNECTOR BODY. MAKE SURE SHARP EDGE OF CLAMP SEATS PROPERLY IN GASKET. TIGHTEN LOCKNUT SECURELY. CRIMP THE FERRULE.

ORD G 4001

Figure 3-31. Coaxial termination procedure using improved series BNC connectors.

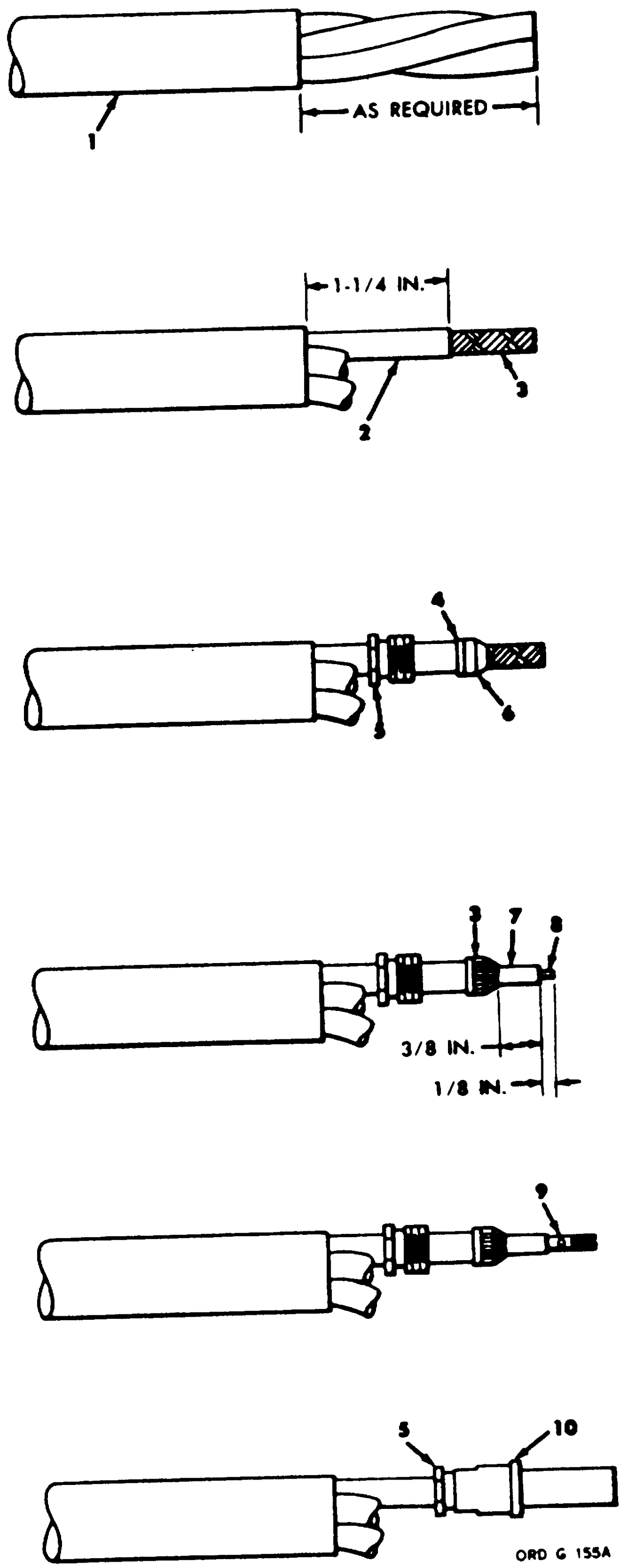


Figure 3-32. Finishing and termination of coaxial connector to coaxial fitting.

Section V. PLUGS AND JACK ASSEMBLIES

3-17. General
Plugs and jack assemblies are the beginning and end of electrical and electronic chassis. Proper input and output signals or voltages are of the utmost importance in equipment operation.

3-18. Inspection Criteria
The inspector should inspect all plugs and jacks for the following:

a. Bent, Broken, or misalinement of pins and contacts.

b. Warped outer shells.

c. Bent and broken keys.

d. Moisture, corrosion, or any other contamination which would affect equipment operation.

e. Potting to insure a firm smooth texture is evidence of moisture.

f. Broken or defective attaching hardware securing plugs and jacks to chassis.

g. Proper identification, stenciling, labeling, etc., as required.

Section VI. SERVO MECHANISMS

3-19. General
A servo mechanism is a power driven mechanism that supplements a primary control. It tends to position an object in accordance with the command given by an arbitrarily varying position indicator capable of supplying only a small amount of power. Its operation is dependent upon the difference between the actual position of the object and the desired position.

3-20. In-Process Inspection (Visual)
Visually inspect the servo for obvious damage and defects such as missing parts, loose wiring, broken connectors, broken, chipped, or burned gear teeth, and corrosion on machined surfaces.

3-21. Final Inspection
a. Machined Surfaces.
(1) Smooth
(2) Unmarked

b. Painted Surfaces.
(1) Smooth
(2) Without scratches
(3) Chipped surfaces

c. Gear Teeth. Coated lightly with grease.

d. Gear Train.
(1) Binding of the gears
(2) Excessive play

e. Gear Stops and Dials. For correct alinement.

f. Spur Gears. To insure that all mating spur gears are alined.

g. Loose wiring, bad solder joints, damaged parts.

h. Variable Resistor. Insure that resistor is filled with oil. when required.

3-22. Identification
Insure that all markings and stampings are legible. Touch up and restore all markings and stampings.

Section VII. BATTERIES

3-23. General
The types of batteries presently in the Army inventory are lead acid storage, nickel cadmium storage, dry and thermal. The lead acid battery has an electrolyte of sulfuric acid whose specific gravity varies with the amount of charge in the battery. The nickel cadmium type has an electrolyte of sodium hydroxide whose specific gravity does not vary. Dry batteries and thermal batteries are both sealed and require no maintenance other than cleaning. Repair is authorized only on nickel cadmium batteries. Inspection will cover general condition and serviceability.

3-24. Electrolyte
The surface of the liquid should be up to indicated level. Add only distilled water and do not overfill. Filler caps should be replaced.

3-25. Terminals
Terminals should be free of corrosion. Storage battery terminals may be cleaned with an alkaline solution or water. Corroded terminals of dry and thermal batteries may indicate leakage. Check for broken cases.

3-26. Shelf Life
The permissible shelf life of dry and thermal batteries should be indicated. Check for expiration.

3-27. Test

A test should be performed in accordance with applicable TM's. Batteries must be under load when testing. Do not test thermal batteries.

3-28. Inspection

Batteries shall be of the correct voltage and current. The case shall not be cracked, leaking, or otherwise damaged. Terminals shall not be corroded or loose. Batteries must be shipped dry with a tag for activation.

Section VIII. MISCELLANEOUS ITEMS

3-29. General

This section covers inspection of miscellaneous items not covered by other sections of this chapter.

3-30. Electrical Motors

Inspect all motors for the following:

a. The armature shaft should be straight and not undersized.

b. The armature lamination and iron stakes should not be loose.

c. Shaft splines should be free of cracks and splinting and firmly installed.

d. Conductors should have no cuts, cracks, abraded areas, fraying, corrosion, or evidence of overheating.

e. Winding should be suitably impregnated with varnish unless otherwise specified and there shall be no flowing, cracking, or burnt odors.

f. There should be no evidence of motor running hot or overheating.

g. Brushes securely installed and not broken, cracked, or chipped, or worn beyond useable limits.

h. Motor should operate without excessive noise and vibration.

i. If shock mounted, the mounts should be serviceable.

3-31. Electronic Tubes

Inspect all tube assemblies for the following:

a. Radioactive electron tubes should be handled in respective drawing.

b. Envelopes should not be cracked, broken, or loose in base.

c. Pins should not be corroded, bent, or broken.

d. Tubes must be of the correct type, securely seated, and firmly clamped in sockets.

e. Cathode ray tubes should have no burn spots, or clusters of small burn spots greater than 1/4 inch in diameter where normal presentation is obscured.

f. Keys should not be broken.

g. Tube clips should not be loose, cracked, chipped, or broken.

h. Tube sockets should not be cracked, chipped, broken, loose, or have any broken terminals.

i. Tube shields, clamps, retainers should not be bent, broken, loose, or missing.

j. Assure that tube shields are the heat dissipating type where applicable.

3-32. Switches and Controls

Inspect all switches and controls for the following:

a. Selector switch operation should be correct at all positions.

b. Switches should be securely installed

c. Knobs or levers should be securely attached to shafts.

d. Seating should be positive in all detent positions.

e. Terminal connections should be properly soldered or secured with terminal screws.

f. Contacts should not be dirty, burned, pitted, welded, carbonized, or have contact resistance.

g. Micro-switch actuators should not bind.

h. Push switches should depress easily and return to original position when released.

i. Push-pull switch (interlock) plungers should depress easily and return to original position when released.

j. Plunger should pull out and remain but return easily to original position when depressed.

k. Insulators, wafers, and separators should not be dirty, chipped, cracked, or broken.

l. Knob pointer should aline with position index.

m. Switch should turn easily to all positions.

n. Check that thermostatic switch operates properly and cycles at specified temperature per respective drawing.

o. Toggle switch boot should not be cracked, torn, ripped, or rotted.

p. Toggle switch should be mounted in proper position.

q. Momentary contact switches should return to the original position when released.

3-33. Transformers

Inspect all transformers for the following:

a. Transformers should be securely installed.

b. There should be no indications of overheating.

c. Windings should not be rough, loose, or broken.

d. Brushes (variable transformers) should be securely installed and not broken, cracked, chipped, or excessively worn.

e. Brushes (variable transformers) should bear firmly on windings along entire brush path and not extend off ends of winding.

f. Markings should be clear and legible.

3-34. Assembly Components and Circuit Boards

Inspect capacitors, resistors, transistors, diodes, coils, relays, miniature modules, circuit boards, etc., for proper installation, broken or damaged leads, legible identification, proper color codes, missing parts, damage, overheating, proper insulation, dirty or burned contacts, contamination and possible shorting condition.

3-35. Fuses

Inspect fuses to insure that they are of the correct voltage, current, and characteristic rating as shown in table B-8 located in appendix B.

CHAPTER 4

MECHANICAL EQUIPMENT

4-1. Introduction

This discussion of mechanical equipment is necessarily limited. The basic information and theory required by the inspector is presented; however, the breadth of the subject does not permit a detailed listing of all attaching hardware and attendant inspection procedures. Mechanical equipment is designed to perform a function at the least cost and with a minimum of required maintenance during the life cycle of the item. The best reliability and operation must be built into the item. Missile equipment must have as near 100 percent reliability as possible. Therefore, the best inspection obtainable is required.

4-2. Attaching Hardware

Attaching hardware for the equipment is subjected to:

a. Sever stresses
b. Shock
c. Corrosion
d. Contraction and expansion of metals
e. Warpage
f. Temperature changes
g. Atmospheric conditions
h. Shelf life

4-3. Tapping and Thread Cutting - General

Tapping troubles are often caused by using tap drills that are too small in diameter. For ordinary manufacturing, not more than 75 or 80 percent of the standard thread depth is necessary, and for some classes of work, not more than 50 percent is required. Tap drill sizes, especially for machine screws, should be varied according to the material to be tapped and the depth of the tapped hole.

4-4. Types of Holes (Tapping)

Soft material, such as copper, soft iron, drawn aluminum, etc., should have a larger hole for the tap than hard crystalline materials such as cast metals. When tapping soft materials, if the hole is too small, the threads will be torn off to some extent, thus actually decreasing the effective thread depth as compared to what it would be if the tap drill had been of larger diameter, but if the hole is drilled rather large, -when tapping tenacious materials, the metal at the top of the thread is drawn somewhat, thereby increasing the depths of the threads. This is more likely to occur after the keen edge of the tap has been slightly dulled by use.

4-5. Unknown Tap Drill Diameters

The diameters of tap drills can be found by the formula D= T-0.75x2d in which D = drill diameter, T = diameter of tap or thread, and d = depth of thread. The depth of thread for various numbers of threads per inch and thread forms, are given in various tables in appropriate mechanical handbooks. The diameter obtained by the above formula allows for a thread having 75 percent of the standard depth which is sufficient for general work. The formula applies to the American (National) thread form. The diameter of the tap drill should not be smaller than is necessary to give the required strength of thread, as every decrease of even 0.001 inch in diameter of the tap drill materially increases the power required for tapping and the percentage of broken taps.

4-6. Simplified Rule for Tap Drill Diameter

If a table of tap drill sizes is not at hand, the following rule may be used: Rule-To find the tap drill diameter in inches, subtract from the outside diameter of the tap an amount equal to one divided by the number of threads per inch. In the practical application of this rule, the nearest commercial drill size is always used.

4-7. Thread Gage Tolerances

Gage tolerances for the four classes of American Standard screw thread fits are designated as W, X, and Y tolerances (table 4-1 and 4-2). These tolerances are applicable to the National Coarse (NC) and National Fine (NF) Series, and to comparable diameters and pitches. The recommended uses for W, X, and Y gage tolerances are as follows:

a. Working Gages. For classes 1 and 2 fits, use Y tolerances; for class 3, use X tolerances; for class 4, use W tolerances.

b. Inspection Gages. Recommended uses are the same as given under working gages.

c. Setting Gages. These thread-plug gages are used in adjusting thread-ring gages, thread-snap gages, or other thread comparators. For classes 1 and 2 fits, use X tolerances; for class 3 fit, use W or X tolerances; for class 4, use W tolerances.

4-8. "GO" Gages for Screw Threads (Fig. 4-1)

A "Go" gage should check simultaneously as many elements as possible, whereas a "Not Go" gage usually checks one element only. A "Go" gage

Table 4-1. American Standard Thread Gage Tolerances

Threads per inch	Pitch diameter tolerances				Major or minor diam. tolerances		Lead* tolerances	
	W gages	X gages	Y gages					
			From	To	W	X and Y	W	X and Y
80	....	.0002	.0001	.0003	....	.0003	....	.0002
72	....	.0002	.0001	.0003	....	.0003	....	.0002
64	....	.0002	.0001	.0003	....	.0003	....	.0002
56	....	.0002	.0001	.0004	....	.0004	....	.0002
48	....	.0002	.0001	.0004	....	.0004	....	.0002
44	....	.0002	.0001	.0004	....	.0004	....	.0002
40	....	.0002	.0001	.0004	....	.0004	....	.0002
36	....	.0002	.0001	.0004	....	.0004	....	.0002
32	....	.0003	.0001	.0004	....	.0004	....	.0003
28	.0001	.0003	.0002	.0005	.0005	.0005	.00015	.0003
24	.0001	.0003	.0002	.0005	.0005	.0005	.00015	.0003
20	.0001	.0003	.0002	.0005	.0005	.0005	.00015	.0003
18	.0001	.0003	.0002	.0005	.0005	.0005	.00015	.0003
16	.0001	.0003	.0002	.0006	.0006	.0006	.00015	.0003
14	.00015	.0003	.0002	.0006	.0006	.0006	.0002	.0003
13	.00015	.0003	.0002	.0006	.0006	.0006	.0002	.0003
12	.00015	.0003	.0002	.0006	.0006	.0006	.0002	.0003
11	.00015	.0003	.0002	.0006	.0006	.0006	.0002	.0003
10	.0002	.0003	.0002	.0006	.0006	.0006	.00025	.0003
9	.0002	.0003	.0002	.0007	.0007	.0007	.00025	.0003
8	.0002	.0004	.0002	.0007	.0007	.0007	.00025	.0004
7	.00025	.0004	.0002	.0007	.0007	.0007	.0003	.0004
6	.00025	.0004	.0003	.0008	.0008	.0008	.0003	.0004
5	.00025	.0004	.0003	.0008	.0008	.0008	.0003	.0004
4 1/2	.0003	.0004	.0003	.0008	.0008	.0008	.0003	.0004
4	.0003	.0004	.0003	.0009	.0009	.0009	.0003	.0004

*Allowable variation in lead between any two threads not farther apart than the standard length of engagement, which is equal to the basic major diameter.

Table 4-2. Tolerances on Half Angle of Thread, Minutes

Threads per inch	W gage	X gage	Y gage	Threads per inch	W gage	X gage	Y gage
80	....	30'	45'	16	8'	10'	15'
72	....	30'	45'	14	6'	10'	15'
64	....	30'	45'	13	6'	10'	15'
56	....	30'	45'	12	6'	10'	10'
48	....	30'	45'	11	6'	10'	10'
44	....	20'	30'	10	5'	10'	10'
40	....	20'	30'	9	5'	10'	10'
36	....	20'	30'	8	5'	5'	5'
32	....	15'	20'	7	4'	5'	5'
28	8'	15'	20'	6	4'	5'	5'
24	8'	15'	20'	5	4'	5'	5'
20	8'	15'	15'	4 1/2	4'	5'	5'
18	8'	10'	15'	4	4'	5'	5'

checks the maximum limit of a threaded plug and the minimum limit of the threaded hole.

a. Pitch Diameter. The pitch diameter of W and X "Go" plug gages is the same as the minimum pitch diameter of the threaded hole or nut. The Tolerance is plus for plugs. The pitch diameter of the W and X "Go" ring gages is the same as the maximum pitch diameter of the screw. The tolerance is minus for rings.

b. Major and Minor Diameters. The major diameter of the "Go" plug gage is the same as the basic major diameter, with a plus tolerance. The minor diameter of the "Go" ring gage is the same as the minimum minor diameter of the nut or tapped hole, with a minus tolerance.

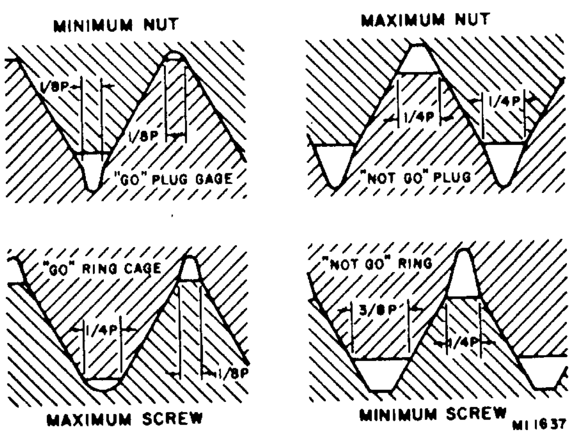


Figure 4-1. Screw thread check.

4-9. "Not Go" Gages for Screw Threads (Fig. 4-1)

A "Not Go" thread gage which checks the pitch diameter only, usually meets practical requirements. The "Not Go" gage checks the minimum limit of a threaded plug and the maximum limit of a threaded hole.

a. Pitch Diameter Plug Gage. The pitch diameter of a "Not Go" plug gage equals the maximum pitch diameter of the threaded hole or nut. The tolerance is minus but may be plus. All gages used for the production of screw threads, and "Go" gages for inspection, should be within the extreme limits of the product. However, to avoid needless controversy about parts close to "Not Go" limits because of possible small differences in gage sizes, the pitch diameter tolerances on all "Not Go" gages used for final inspection and for inspection of purchased products, may be outside of the product limits is specially authorized.

b. Pitch Diameter Ring Gage. The pitch diameter of the "Not Go" thread-ring gage is the same as the minimum pitch diameter of the screw. The tolerance is plus but may be minus for the reason given in the preceding subparagraph.

4-10. Thread Form on Gages

Figure 4-1 shows approved thread forms for both plug and ring gages. The crest of the thread on "Not Go" plug and ring gages is partly removed to insure proper contact. There is also a clearance groove at the root of "Not Go" plug and ring gages to insure pitch diameter contact. The "Go" plug and ring gages may have clearance grooves at the roots to facilitate grinding and lapping.

4-11. Truncated Setting Plugs

a. The major diameter of the full portion of the "Go" setting plug is that of a full American National form, based on maximum pitch diameter of the screw. The tolerance is plus. The major diameter of the Truncated portion of the "Go" setting plug is that of a full American National form minus one-third the basic thread depth with a minus tolerance.

b. The major diameter of the full portion of the "Not Go" setting plug is the same as that of the "Go" plug of the same nominal size, except that the truncation from a theoretical vee should not be less than 0.058 times pitch. The latter condition might arise in the case of fine pitches and especially wide tolerances. The tolerance is minus. The major diameter of the truncated portion of the "Not Go" setting plug is that of a full American National form minus one-third the basic thread depth, with a minus tolerance.

4-12. Inserts

a. The inspector should familiarize himself with the repair procedures, as in-process inspection should be performed to insure a good insert installation. Refer to the system documentation to determine if such repairs are authorized and the number of times the insert can be replaced.

b. There are various types of inserts which can be used to repair components which have attaching hole threads stripped. New hole preparation as shown in figure 4-2 is primarily the same for all types of insert installation.

4-13. Swaging Type Insert Installation (fig. 4-3)

The installation of swaging type inserts requires special tools. A drive wrench is used to install the insert into the tapped hole. After the insert is installed to the proper depth a swage tool is then used to lock the insert in place.

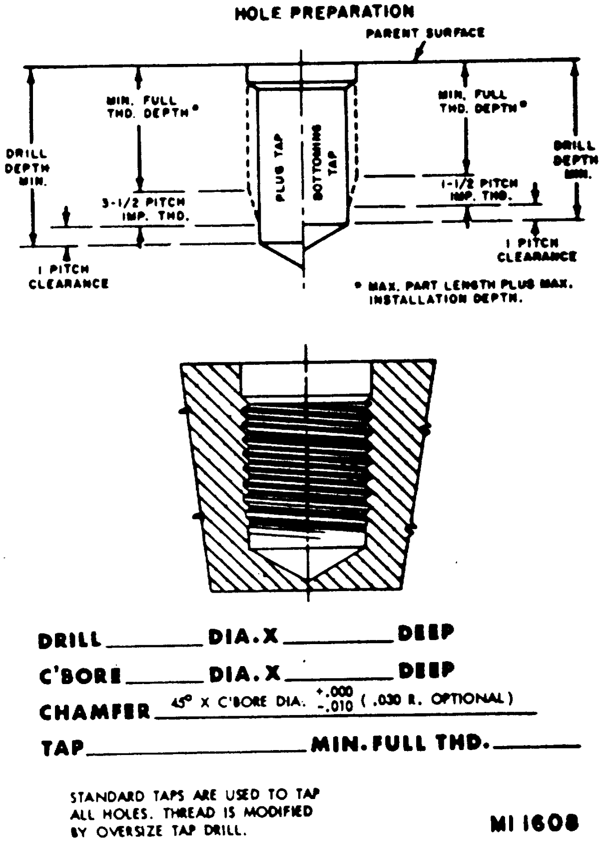


Figure 4-2. New hole preparation.

4-14. Key Type Insert Installation

The installation of key type inserts is very simple and can be accomplished without special tools. After hole preparation (fig. 4-2) or old key insert removal (fig. 4-4) screw the new key insert (fig. 4-5) to a depth of 0.010 to 0.030 below the surface. Drive the keys down (fig. 4-6) to set and lock the insert.

4-15. Blind Nut Assemblies (Fig. 4-6)

The inspector will have to perform an in-process inspection of blind nut installations because in most cases they cannot be inspected after repair. Refer to figure 4-6 which shows the proper procedure for installation of blind nuts.

4-16. Hardware Inspection

All hardware shall be of the proper size, type, shape, length, and thread. There shall be no burrs, corrosion or physical damage. Washers shall have correct pileup. Screws shall protrude at least one complete thread from the surface of the hex or clinch nut. Screws shall not protrude more than two complete threads from the surface of the hex or clinch nut when there is a possibility of shorting, mechanical interference, or safety hazard.

a. Threaded Components (Bolts, Screws, and Nuts).

(1) Threads shall not be crossed or stripped.

(2) Bolt shanks shall not be galled.

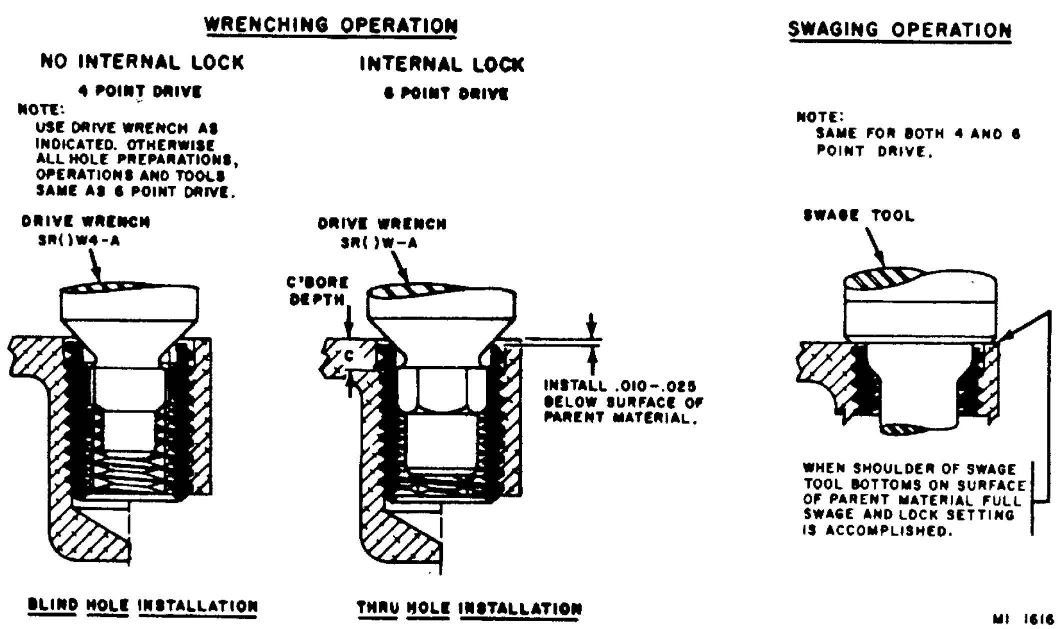


Figure 4-3. Swaging type insert installation.

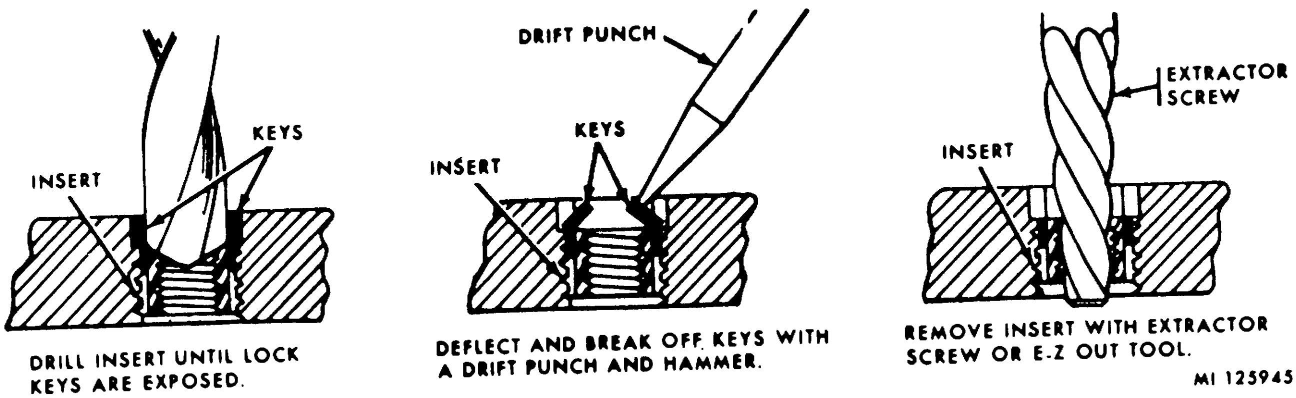


Figure 4-4. Removal of key type insert.

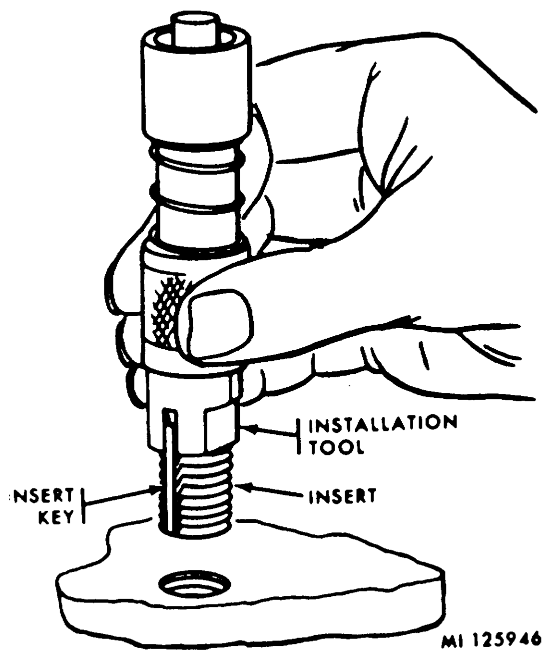


Figure 4-5. Key type insert installation

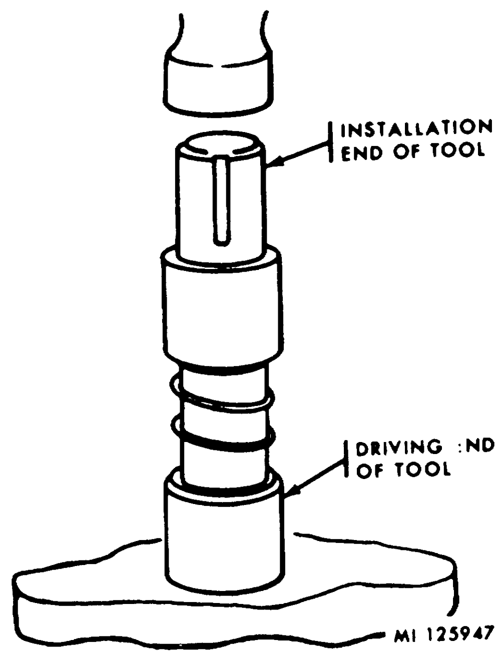


Figure 4-6. Driving the keys down.

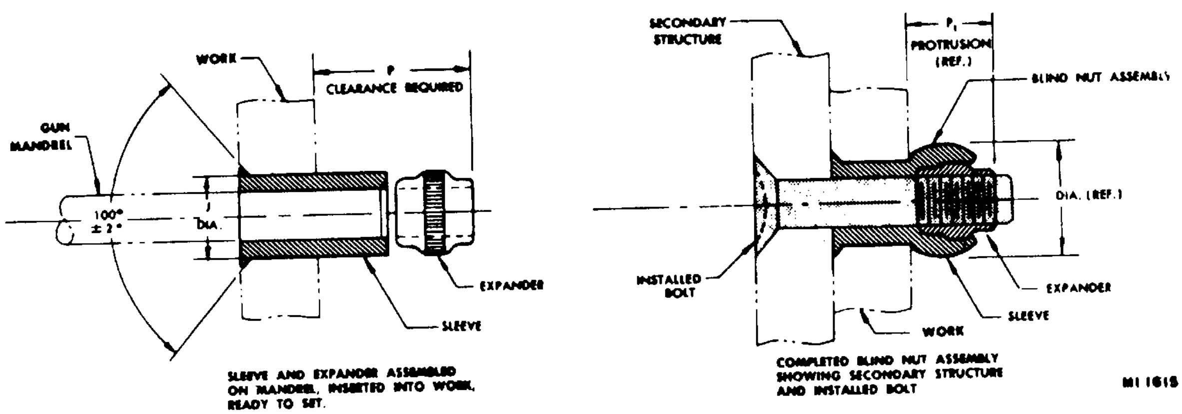


Figure 4-7. Blind nut assembly installation.

(3) Bolt heads shall not be worn or damaged.

(4) Threads shall be properly lubricated, if required.

b. Inserts (Helicoil or Kelox).

(1) Inserts or base metal shall not be corroded.

(2) Inserts shall not be cracked, have proper application, and be installed properly.

(3) Inspect keys of key type inserts to insure that they are in place and below the surface of the parent material.

c. Blind Nuts.

(1) Inspect sleeve assembly to insure that the expander has been set properly as shown in figure 4-6.

(2) Inspect final assembly to insure that bolt can be tightened without rotation of the expander which should be set into the sleeve.

d. Quick Acting Fasteners.

(1) Mechanical operation and alinement shall be correct.

(2) Hardware shall not be loose, missing, or damaged.

(3) Lubrication shall be of correct type and quantity.

e. *Rivets*.

(1) Assure correct size rivet is used.

(2) Assure that head is flush against metal and that rivet is tight.

f. Safety Wiring.

(1) Assure that safety wiring is accomplished in accordance with requirements contained on pertinent drawing or technical manual.

(2) Assure that only new wire is used.

g. Shims.

(1) Assure that shims are only used where authorized.

(2) Assure that shims are installed securely.

h. Bearings.

(1) Running surfaces shall be characteristic of a lapping or polishing process and free of tool marks, chatter, waves, scratches, gouges, nicks, pits, soft spots, scoring, galling, and other surface imperfections visible to the normal unaided eye.

(2) All bearings shall be of proper type and size, properly lubricated, and properly installed.

i. Gears, Belts, and Pulleys.

(1) Gears

(*a*) Teeth shall not be burred, chipped, cracked, galled, deformed, or broken.

(*b*) Lubrication shall be of the proper type and quantity.

(*c*) Nylon gears shall be replaced when required. Repair shall not be attempted.

(*d*) Disassembled gears (not mounted on shafts) shall be checked for proper pitch diameter, total composite error, and tooth-to-tooth error using a rolling fixture, master gear set, and super micrometer.

(*e*) Gears shall be in alinement and mesh properly.

(*f*) Shielded bearings shall be replaced when required. No repair shall be attempted..

(*g*) There shall be no excessive noise or rough motion.

(*h*) Teeth of antibacklash gears shall be properly alined.

(*i*) When disassembled, gears shall be coded for replacement in same assembly.

(2) Belts

(*a*) Shall not be cut or cracked.

(*b*) Must be pliable.

(*c*) No visible tears at joining seam.

(*d*) Installed belts must be taut but not tight.

(*e*) Installed as pairs when required.

(3) Pulleys

(*a*) Shall not be burred, chipped, cracked, galled, deformed, or broken.

(*b*) Groove shall be free of all foreign matter.

CHAPTER 5

HYDRAULIC AND PNEUMATIC EQUIPMENT

Section I. INTRODUCTION

5-1. General

This chapter orients the inspector to varied inspection requirements of hydraulic and pneumatic assemblies and piece parts. Certain items such as o-rings, gaskets, and flarings require in-process inspection. These items normally cannot be inspected during final inspection.

5-2. Precautions During Testing

a. Generally, pneumatics involve the use of high pressure air. Therefore, the testing of any component which is subjected to high-pressure must be pressure tested in an approved barricaded area following all established safety precautions.

b. Hands, or other parts of the body, should never be used in high-pressure testing to "feel" for pressure leaks, especially in hoses. These type leaks may cause serious injury to the operating personnel. Leaks of this type should be checked by the use of a soap and water solution or submerged bath.

c. When testing high-pressure hoses, insure that the hose is adequately "anchored" to prevent whiplash in the event of failure.

d. Equipment used in cleaning and testing processes shall be free from grease, lint, dust, and other foreign matter. Fluid containers and test equipment should be tested regularly for excessive contamination.

5-3. Inspection or Test

a. During final inspection, insure that all parts are properly assembled and functioning according to technical manual requirements. This includes pumps, gages, reservoirs, and valves.

b. All air and gas receivers subject to a working pressure in excess of 500 psi will be hydrostatically tested to a pressure at least 1.5 times the maximum working pressure. All receivers in use will be given a hydrostatic test every 24 months or at anytime a receiver shows any evidence of bad dents, corroded area, leakage, or other conditions that indicate weakness which might render the receiver unsafe.

Section II. HYDRAULIC COMPONENTS

5-4. General

Hydraulics is the science of applied pressure to a fluid for emission of a working force in a closed system. Six basic components make a complete working system (reservoir, fluid, pump, pressure valve, directional valve, and working component).

5-5. In-Process Inspection

a. Assemblies and parts shall be free from dirt, corrosion, oil, grease, and similar foreign residues.

b. Whenever practicable, internal parts of assemblies shall be thoroughly cleaned prior to assembly.

c. Hand tools and other equipment used in cleaning and testing processes shall be free from grease, lint, dust, and other foreign matter. Fluid containers and test equipment shall be tested regularly for excessive contamination.

d. Insure that o-rings, gaskets, and seals have no paint on any surface. Insure adequate shelf-life where necessary. Also, insure that o-rings are properly installed and that back-up rings are used where needed.

5-6. Final Inspection

a. *Operational Test.*

(1) Component under test will be connected as prescribed in the hydraulic test stand procedures and subjected to tests specified in the technical manual for the item being tested.

(2) Surfaces must pass a wipe test to supplement visual inspection. Surfaces shall be free, in addition to the above, from fingerprints, perspiration, or other acid or alkaline residues.

(3) During operation, inspection shall be made to determine that various functions are accomplished satisfactorily, the movement of all components is 'smooth, and all tubing, fitting joints, and external seals are free from leaks.

b. *Visual Inspection*.

(1) Lines and hoses.

(*a*) Cracks

(*b*) Dents

(*c*) Scratches

(*d*) Leaks

(*e*) Contamination

(*f*) Corrosion

(2) Coupling nuts.

(*a*) Torqued

(*b*) Torque stripped

(3) Reservoirs.

(*a*) Fluid leakage

(*b*) Proper fluid level

(4) Flares for correct angle.

(5) B-nuts.

(*a*) Not cracked

(*b*) Damaged hex-heads

(6) Lines.

(*a*) Properly routed

(*b*) Secured

(7) Lines, units, and supports.

(*a*) Pits

(*b*) Corrosion

(*c*) Sharp corners

(*d*) Vibration

(*e*) Leaks

(8) Fitting joints and seals for leaks.

5-7. Identification

Component must be properly identified by stamping or nameplate and, if possible, placed in a sealed plastic container for on-the-shelf storage.

Section III. PNEUMATIC COMPONENTS

5-8. General

Pneumatics is a branch of mechanics that deals with the mechanical properties of gases.

5-9. In-Process Inspection

Insure that only new precleaned o-rings and gaskets are used. Cure dates shall be within specified tolerances.

5-10. Final Inspection

a. Operation Test.

(1) *Hoses*. High-pressure hoses must withstand 125 percent of the rated operating pressure for a minimum of one minute without showing defects (i.e., leaks, unequal expansion, cuts, or breaks).

(2) *Receivers*. All air receivers subject to a working pressure in excess of 500 psi must be subjected to hydrostatic test at least equal to one-and-one half times the working pressure.

b. Visual Inspection.

(1) *Hoses and covers*.

(*a*) Cuts

(*b*) Cracks

(*c*) Checked

(*d*) Hardened

(*e*) Rotted

(*f*) Contaminated with dirt, grease, and foreign objects.

(2) *Fittings and clamps*.

(*a*) Securely mounted

(*b*) Machined surfaces free of burrs and longitudinal marks

(*c*) Sealing surfaces-smooth

(*d*) Unmachined surfaces-cracks, laps, seams

(3) *Castings*.

(*a*) Blow holes

(*b*) Porosity

(*c*) Cracks

(4) *Welds*.

(*a*) Pits

(*b*) Blisters

(*c*) Slivers

(*d*) Corrosion

(*e*) Excess flux

(5) *Coupling nuts*.

(*a*) Properly torqued

(*b*) Torque stripped

(6) *Gages, safety valves, and unloaders*. Check for proper operation. Gages will not vary more than two percent from normal operating pressure.

5-11. Identification

Markings, warnings, and identifications shall be correct and legible.

CHAPTER 6

OPTICAL EQUIPMENT

6-1. Introduction

Optical equipment used with missile systems normally has a specific function and is separately identifiable, such as theodolites and optical trackers. Due to this specificity, detailed maintenance and inspection instructions are usually included in system documentation. Accordingly, this chapter will treat the inspection procedures in a general manner. Only visual inspection procedures are presented. It is assumed that the inspector has some knowledge of the optical equipment applications and is properly aware of the delicacy of the items and the importance of accuracy.

6-2. Care and Handling of Optical Instruments

a. The useful life and continued accuracy of optical instruments and accessories depends upon the extent to which they are properly cared for and handled. An instrument inspector must realize this fact and acquaint himself with recommended practices pertaining to each instrument and accessory he uses.

b. When transporting optical instruments, extreme caution should be exercised to prevent damage. If a mobile unit is used, it should be especially equipped for that purpose. Upon arrival at a destination, if optical instruments are not be used immediately, they should be stored in such a manner as to prevent their falling, bumping, or jarring accidentally. They should remain in their cases until needed.

c. Always be sure that an instrument is properly mounted and secured but never overtighten a clamping screw as this could damage the instrument. Be sure the proper clamping screw is loose before the instrument is to be revolved about an axis. It should also be noted that leveling screws need not be overtightened. Snug tension is sufficient.

d. Always remove an instrument from its stand before moving the instrument or the instrument stand to a new location. Failure to adhere to this procedure could result in serious damage to the instruments due to excessive bumps and vibrations. Protection should be provided for instruments set up in aisles or where traffic is excessive by setting up barricades or guard rails. Instruments mounted on stands should be protected with plastic covers when not in use. Never leave an optical instrument with a lens pointing upward without a protective cover over the objective end of the telescope as foreign matter could collect and damage the lens.

e. After optical instruments have been used in the shop, return them to their proper place. This is done not only to provide a safer storage place for the instruments, but to provide a central distribution point from which to supply the instruments. Always be sure that an instrument is placed in its case in the proper position.

6-3. Visual Inspection

a. Optical Surfaces.
- (1) Smears
- (2) Fingerprints
- (3) Chips
- (4) Fractures
- (5) Grayness
- (6) Stains
- (7) Coating

b. Paint.
- (1) Chipped
- (2) Loose
- (3) Corrosion present
- (4) Bare spots

c. Rubber Eyeshield.
- (1) Securely molded
- (2) Cracks
- (3) Damage
- (4) Deterioration
- (5) Mounted properly

d. Data Plates.
- (1) Clearly defined
- (2) Mounting adequate
- (3) Condition good
- (4) Legible

e. Eyepiece.
- (1) Dirt
- (2) Scratches
- (3) Smears
- (4) Gouges
- (5) Condensation
- (6) Fungus
- (7) Chips
- (8) Fractures
- (9) Cement separation

f. Sealing.
- (1) Leaks
- (2) Openings

g. Illuminating Windows.
- (1) Broken windows
- (2) Cracked

h. Machined Surfaces.
(1) Free of nicks
(2) Burrs

i. Housings.
(1) Damage
(2) Cracks
(3) Dents

j. Knobs and Handles.
(1) Binding
(2) Roughness

k. Graduations and Numbers.
(1) Clear
(2) Distinct

l. Level Vials.
(1) Cracked
(2) Broken
(3) Loose
(4) Cover missing or broken
(5) Bubble appears properly

m. Instrument Lights.
(1) Case intact and undamaged
(2) Switch functions properly
(3) Lamp operates
(4) Lucite windows undamaged and clear

CHAPTER 7

SOLDERING

Section I. INTRODUCTION

7-1. General

a. This chapter contains requirements for soldering of electrical and electronic equipment.

This information has been developed to increase the reliability of equipment undergoing repairs at direct support and general support shops. These concepts have proven to be adequate for all fielded equipment. Harness layout, lacing, crimping of solderless connectors, and terminations are contained in chapter 3, electrical and electronic equipment.

b. This chapter presents the instructions for inspections of soldering to obtain high reliability electrical connections. Material requirements and tools are provided in system TM's.

7-2. Inspection Requirements

Inspection requirements will hold true only if the inspector has a knowledge of proper soldering techniques. He must also have a knowledge of proper tools and materials available. The following sections should provide him with adequate inspection procedures and acceptance criteria to evaluate and determine if proper soldering repairs have been accomplished.

Section II. INSPECTION PROCEDURE

7-3. General

Many electrical chassis in the field were produced under standards that are no longer used for missile system production. The inspector must know and recognize these differences to preclude unnecessary rejection and rework of chassis. These differences are:

a. Wraps of conductor 270 degrees to 360 degrees around turret terminal were permitted, present requirements are 180 degrees, but not more than 360 degrees except multiple adjacent terminals.

b. Bare copper ends were permitted; now conductor ends must be covered by solder.

c. Nicks on leads were permitted; padded tools must now be used to form leads.

d. Slack in leads and vibration bends for mounting of components were not required; these are now required.

e. Insulation clearance from the solder joint was not specified; see paragraph 7-10*f*.

7-4. Visual Inspection

All soldered connections shall be inspected for:

a. Adequate mechanical and solder application.

b. Cleanliness.

(1) Removal of rosin flux.

(2) Removal of solder splatter from adjacent areas.

NOTE

Solder connections other than those made by the DS/GS repairman should be inspected in accordance with paragraph 7-3.

7-5. Mechanical

Mechanical check of a solder point is acceptable only when required to supplement a visual inspection. This must be limited to a minor movement of component leads using only padded pliers or wooden soldering aid. Care must be taken not to fracture delicate solder joints or to break the component leads.

7-6. Surveillance

A surveillance program should be initiated jointly by the repair shop and QC inspection units. The primary purpose of the surveillance program is to establish the standard operating procedures and standard inspection procedures to assure that repaired materials will meet the designated purpose for tactical operations. The following areas should be included in the surveillance program, but may vary depending upon: DS/ GS mission assignments, tactical situation, and geographical location.

a. Housekeeping.

(1) Cleanliness of work area.

(2) Lighting of work area.

(3) Arrangement of work benches to test equipment.

b. Control of Tools.

(1) Correct tools to perform the specific soldering function.

(2) Proper use of soldering tools.

(3) Periodic inspection of tools for proper maintenance.

(4) Replacement of tools when worn beyond established limits.

c. Control of Materials Used During Repair Procedures.

(1) Only qualified products are to be used.

(2) Disposal of excess or unqualified materials.

7-7. Workmanship Standards

Workmanship standards for soldering operations encompass two areas:

a. The repairman should be trained in soldering techniques.

b. Workmanship for the inspector is based upon the inspector's knowledge of the equipment he is inspecting and knowledge of inspection requirements.

7-8. Thoroughness of Inspections

Thoroughness of inspections will prevent unsatisfactory equipment from being released from the maintenance shop. The inspector must initiate the inspection at a common point for soldering operations. The following is offered to attain a standard level of workmanship:

a. Review the job order (DA Form 2407) to determine which components were repaired or replaced. Connections should meet the requirements of this chapter.

b. All other solder connections should be examined to determine adequacy.

7-9. Mechanical Connections

Table 7-1 lists some of the approved methods of making mechanical connections prior to soldering.

Table 7-1. Mechanical Connections

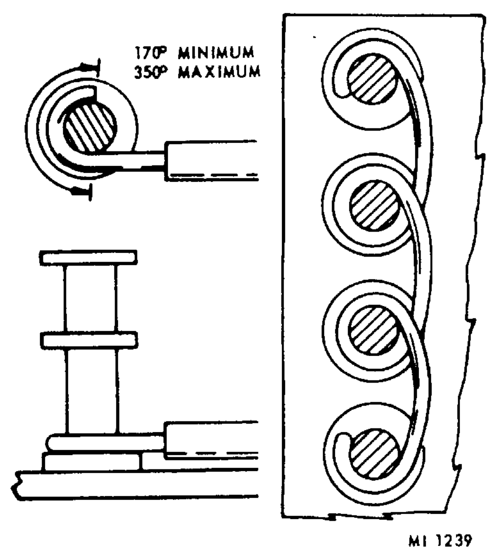
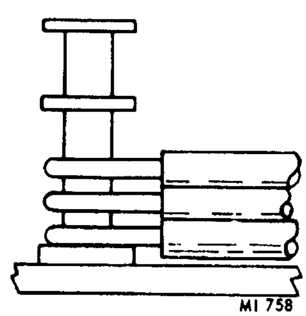
Connector type	Illustration
Turret terminal wrap	
Turret terminal multi-connection	

Table 7-1. Mechanical Connections - Continued

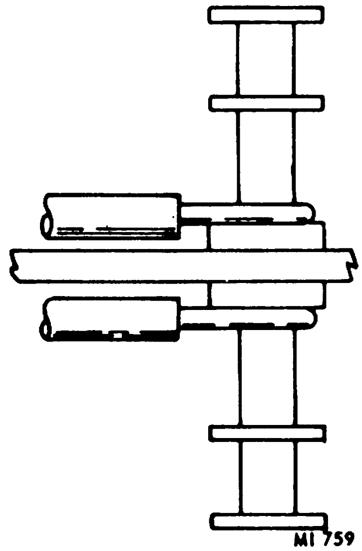
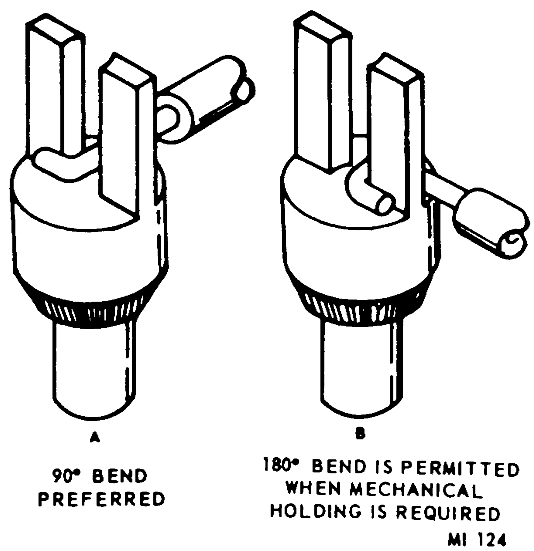
Connector type	Illustration
Double ended terminal	
Bifurcated terminal side route single connection	

Table 7-1. Mechanical Connections - Continued

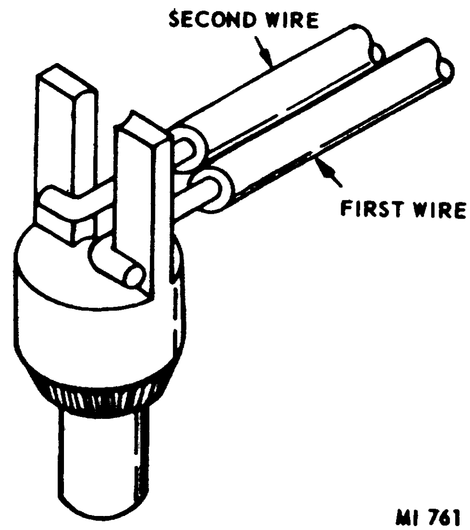
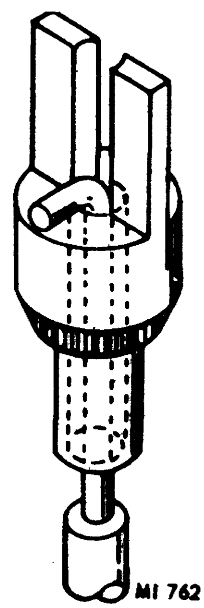
Connector type	Illustration
Bifurcated terminal multiple side route connections	
Bifurcated terminal bottom route connection	

Table 7-1. Mechanical Connections - Continued

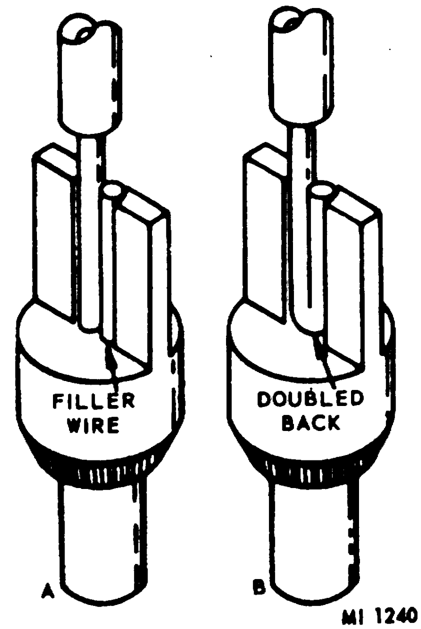
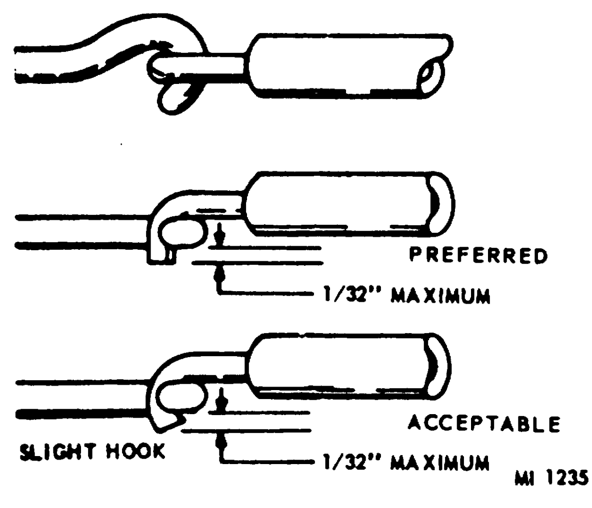
Connector type	Illustration
Bifurcated terminal top route connection.	
Hook terminals	

Table 7-1. Mechanical Connections - Continued

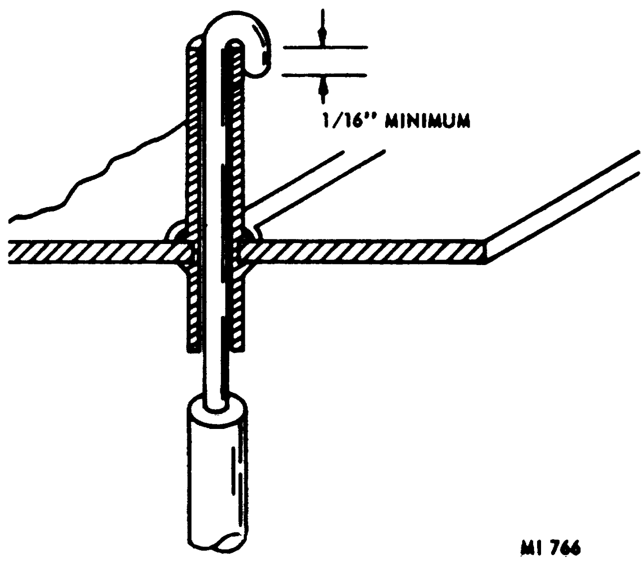
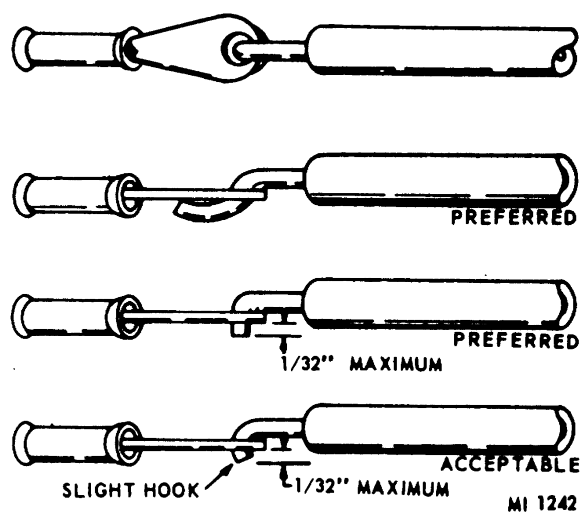
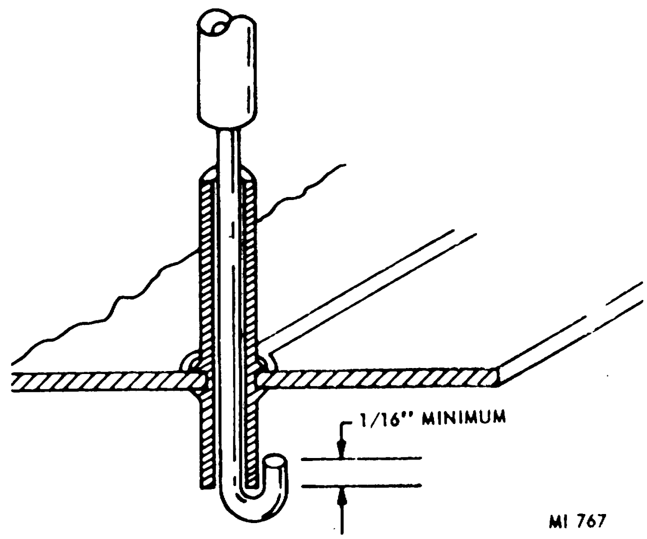
Connector type	Illustration
Eye terminals	
Feedthru terminal top termination	

Table 7-1. Mechanical Connections - Continued

Connector type	Illustration
Feedthru terminal bottom termination	

Section III. ACCEPTANCE AND REJECTION CRITERIA

7-10. Acceptance Criteria

All soldered connections shall be inspected for conformance to the following conditions:

a. Solder Connection. The solder connection shall have a smooth, bright appearance, without porosity, cracks, pits that bottom out, or surface strain lines. Solder shall cover the top of the conductor wire and concave fillet should be observed between the lower half of the conductor wire and the terminal. There shall be no foreign material or threads of insulation embedded in the solder.

b. Residual Flux. Each soldered connection shall be inspected to determine that all flux has been removed.

c. Excessive Solder. Beads or peaks of solder shall not project from the terminal and no solder shall exist as runs on the outside of the terminal. There shall be no solder splatter on the adjacent components or surfaces.

d. Cold Solder Joint. The solder shall adhere firmly and smoothly to the parts joined. The joint shall not be chalky in appearance, laking metallic luster, nor shall it have a rough, gritty, piled-up surface.

e. Rosin Joint. Flux shall not be trapped in the solder joint. The conductor wire in the joint shall not move under light probing pressure.

f. Insulation. The insulation shall not be charred, frayed, split, or pinched through exposing the conductor wire. Slight discoloration of insulation shall not be considered cause for rejection. Insulation clearance from the solder joint shall be as shown in table 7-2.

g. Capillary Action (Wicking). Wick length of solder on the wire strands shall be visible and shall not extend into the insulation.

h. Conductor Wire and Component Lead Tension. All conductor wires and component leads going to a soldered connection shall have a slack in the form of an arc or gradual bend. Solder(d components shall not be in electrical contact with adjacent circuitry; or other components.

i. Excessive Heat. Components and insulation shall not show evidence of excessive heat caused by improper soldering or electrical shorts.

j. Multiple Terminations. The number of connections per terminal shall be in accordance with system requirements. Each conductor wire shall be adjacent to the surface of the terminal, not overlapping another. Multiple connections on terminals shall be as follows:

(1) *Turret terminals*. The wire shall I)e in contact with the terminal for the full curvature of the wrap and in no case wrapped less than 180

Table 7-2. Insulation Clearance for Solder Joints

Wire diameter	Insulation Minimum	Clearance maximum
32 to 24	1/32	3 x OD
22 to 12	1/32	2 x OD
10 or larger	1/32	1 x OD

degrees or more than 360 degrees. Where three or more terminals in a row require a continuous jumper, a solid bus may be wrapped 360 degrees, and continued from terminal to terminal. The first wire on each terminal shall be placed parallel to the header nearest the terminal mounting surface. Each additional wire shall be placed next thereto, continuing outward from the terminal mounting surface. Maximum spacing between wires and between wire and header is recommended. There shall be no overlapping of wires. Wrap may be clockwise or counter-clockwise; however, on multiple connections all wraps must be in the same direction, unless required by design limitations. When soldering the second joint on double ended terminals, precaution shall be taken to prevent remelt and fracture of the first joint.

(2) *Slotted or bifurcated terminals*. Order of preferred terminations:

(a) Side route connection. The wire shall enter the mounting slot at a right angle and be terminated with a 90-120 degree bend. A bend of 180 degrees is permitted when design requires mechanical holding prior to soldering. In no instance shall the conductor extend beyond the outside diameter of the terminal, except for the point of entry. The direction of the 90-degree bend on each additional wire shall alternate. Maximum space between wires is recommended.

(b) Bottom route connection. The wire shall terminate with a 90-degree bend.

(c) Top route connection. The wire shall extend the full length of the terminal forks. When the ratio of slot size to wire size is greater than 1: 1, the wire should be accompanied by a tinned filler wire during the soldering operation to help hold the wire in position, or the wire can be doubled back. A large wire which fills the slot will require only solder fillets for retention. Multiple top route connections shall not be used unless specified in Department of the Army publications.

(3) Hook or perforated terminals. The wire shall be attached to the hook or perforated terminal by forming the tinned wire to at least 90-degrees angle. Perforated terminals to which wire sizes ACG 16 or larger are to be attached may be connected straight through.

(4) *Feed-through terminals.* The terminating end of a wire inserted through a feed-through terminal shall be hooked over the lip of the terminal not less than one-sixteenth inch. Not less than one-sixteenth inch of the connection hook shall be soldered tangent to the terminal.

(5) *Printed circuit terminating.* Components shall be installed opposite to the side to be soldered. Leads shall be bent flat to the pad and along the conductor surface. Components having pin type connections shall be mounted with pins extending straight through the printed circuit board. When component lead wire diameter, length, or composition prevent bending, or when specified in Department of the Army publications, the lead shall be treated as a pin type. "Double sided printed circuit boards employing eyelets for the interfacial circuit connections shall have the eyelets soldered to the pad on both sides of the board as well as the usual mechanical bradding. Double sided printed circuit boards employing plated through holes for interfacial circuit connections shall have a continuous plug of solder through the hole. The hole pads on both sides of the board shall be completely wetted by the solder 360 degrees around the periphery of the hole."

7-11. Rejection Criteria

Evidence of any defects, including, but not limited to the following, shall be cause for rejection:

a. Charring, burning, or other damage to insulation.

b. Splattering of fluz or solder on adjacent connections or components.

c. Solder points (peaks).

d. Pits, scars, or holes.

e. Excessive solder which obscures the connection configuration.

f. Excessive wicking.

g. Loose leads or wires.

h. Cold solder connections.

i. Rosin solder connection.

j. Fractured solder connection.

k. Cut, nicked, stretched, scraped leads, or wires.

l. Unclean connection (e.g., lint, residue, flux, solder, splash, dirt, etc.).

m. Dewetting. (Separation of printed circuit from circuit board.)

n. Insufficient solder.

o. Visible bare primary conductor within the solder joint area.

p. Clinched leads resulting in a reduction of the required spacing between conductors.

q. Splicing of conductors is prohibited, except as allowed on system drawings and as permitted by Department of the Army publications for system material.

r. Plated through holes not filled with continuous solder plug.

s. Pads connected by plated-through holes and eyelets connecting pads on multi-layer boards or double sided printed circuit boards show evidence of failure to wet the metallic surfaces.

Section IV. COMPARISON STANDARDS

7-12. General

This section provides a visual guide for inspection of solder connectors. These show the acceptable, minimum acceptable, and reject inspection criteria. Table 7-3 shows a simulated comparison between good and bad workmanship. The remaining tables show actual repair procedures with applicable inspection criteria.

Table 7-3. Workmanship

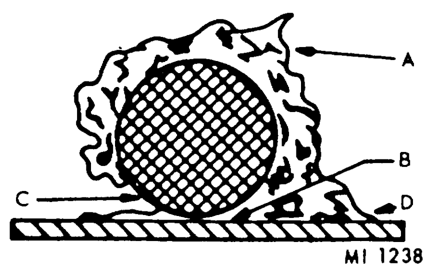
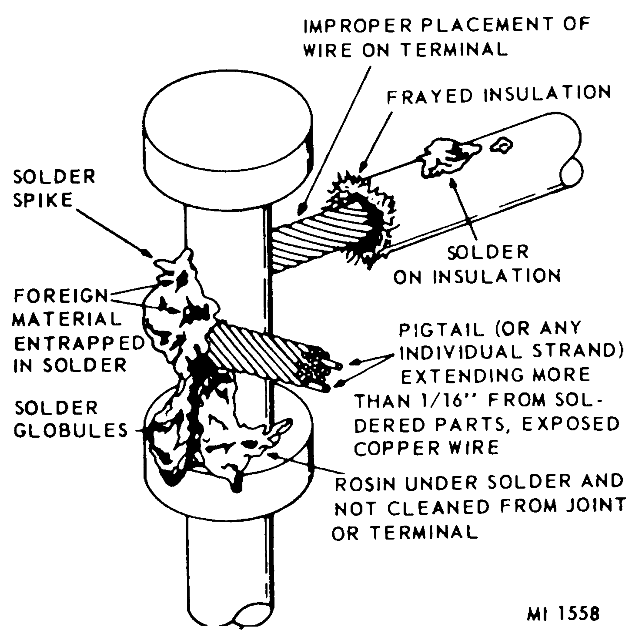
Indicator	Illustration
Cold or underheated solder joint A. Solder has a chalky appearance, lacks metallic luster, generally presents a rough, piled-up appearance. B. Solder has not bonded terminal and wire together. C. Solder coverage not complete. D. Improper filleting indicating insufficient flowing and watting action.	
Improper soldering	

Table 7-3. Workmanship - Continued

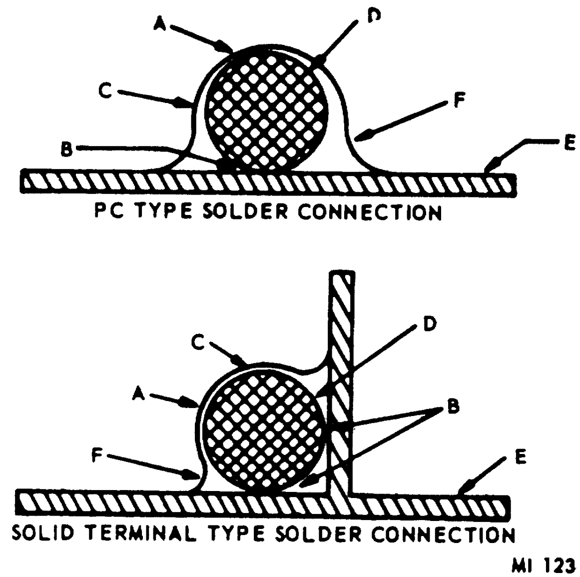
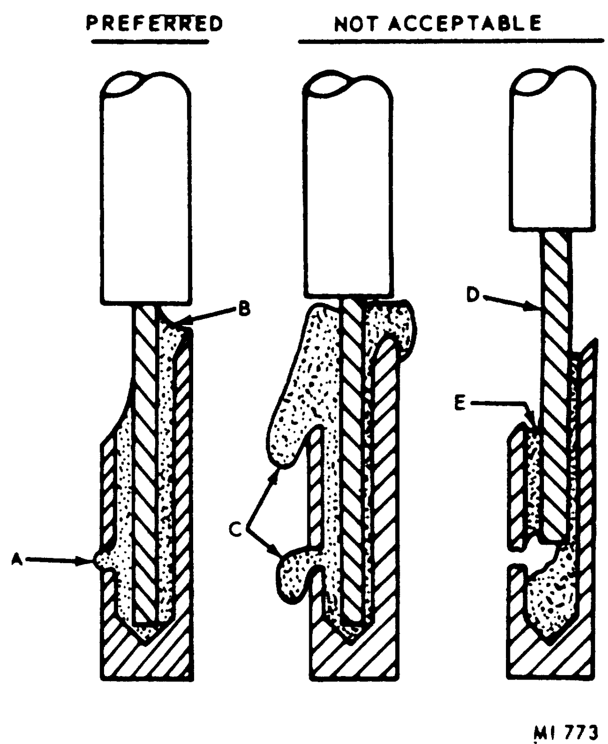
Indicator	Illustration
Cross-section good solder joint A. A minimum amount of solder shall cover the top of the conductor. B. Wire, solder and terminal must be completely fused at this point and wire must be adjacent to terminal. C. Entire mass consisting of terminal, wire and solder must be free of all foreign substances. D. Conductor wire (copper). E. Terminal or printed circuit (PC) pad. F. Smooth solder contour and proper filleting action indicating required flowing and wetting action.	
Cross-section tubular connection A. Slight protrusion is acceptable at weep hole. B. Fillet from all sides of the solder cup. C. Excess solder. Any solder on the outside surface should be a thin film only. D. Excess insulation gap, conductor not to bottom of cup. E. No fillet.	

Table 7-3. Workmanship - Continued

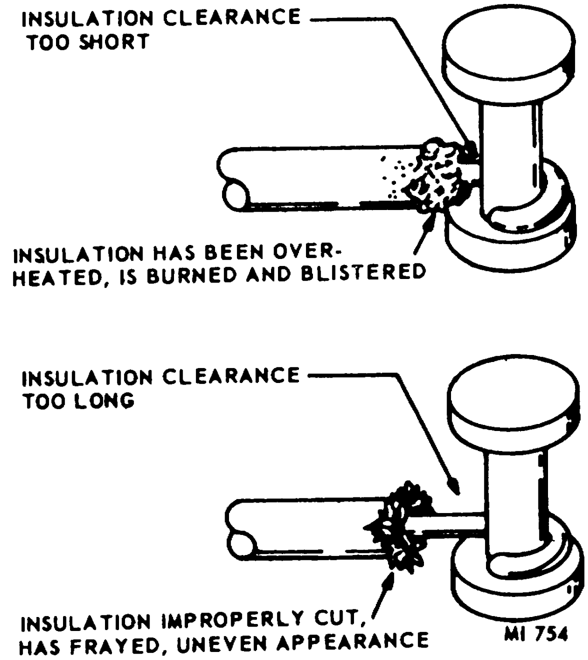
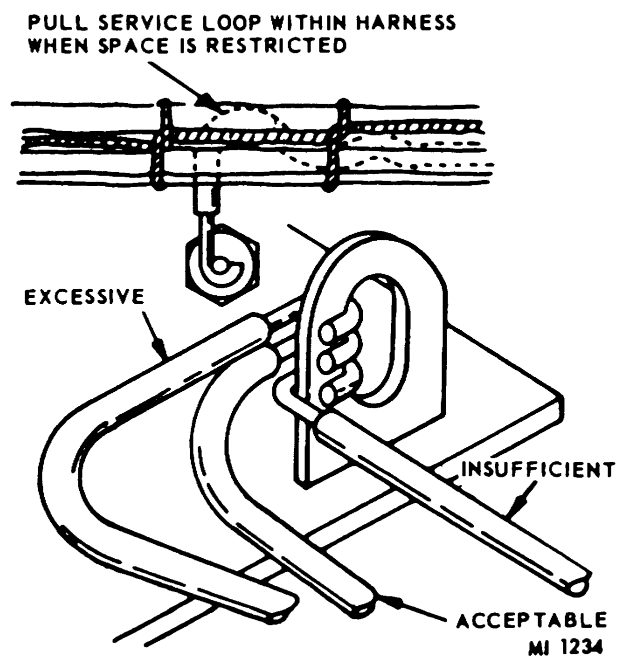
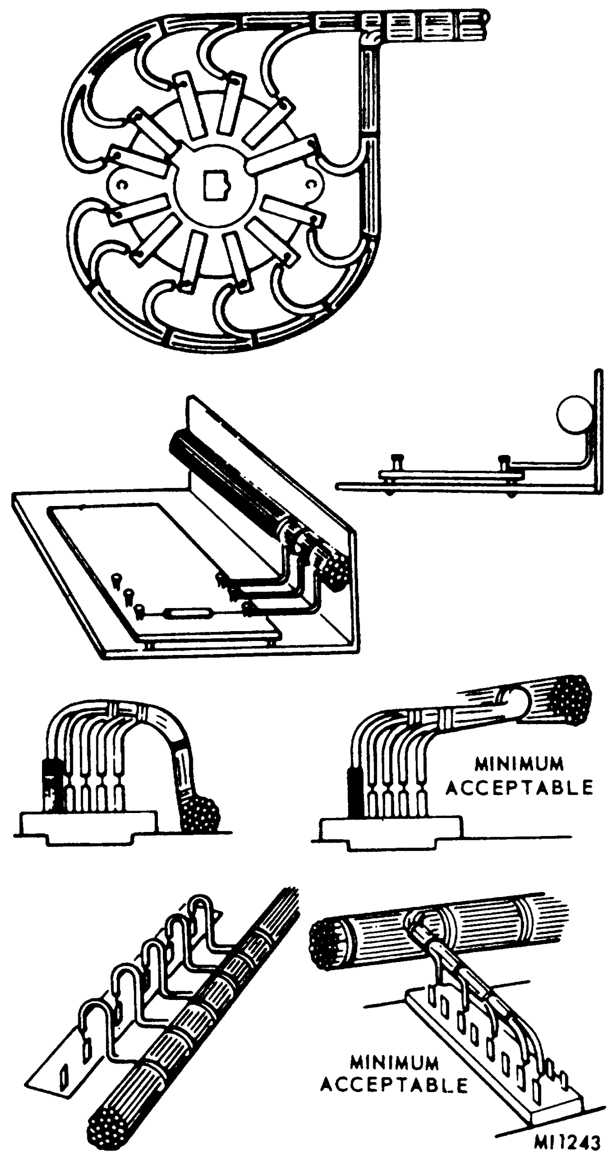
Indicator	Illustration
Improper insulation	
Vibration bends	

Table 7-3. Workmanship - Continued

Indicator	Illustration
Vibration bends	

7-13. Insulation
Table 7-4 presents inspection criteria and references to illustrations of insulation.

7-14. Stranded Conductors
Table 7-5 presents inspection criteria and reference to illustrations covering stranded conductors.

7-15. Cup Connectors
Table 7-6 presents inspection criteria for all types of cup connectors, the referenced illustrations show only one type of cup connector. The criteria is applicable to all cup type connectors.

7-16. Solder Coverage-Printed Circuit
Table 7-7 presents inspection criteria for solder coverage on printed circuit boards.

7-17. Solder Coverage-Connector Pin
Table 7-8 presents inspection criteria for solder coverage of pin type connection when used on printed circuit boards.

7-18. Solder Coverage-Turret Terminals
Table 7-9 presents in-operation criteria for turret type terminals.

7-19. Solder Coverage-Bifurcated Terminals
Table 7-10 presents inspection criteria for soldering bifurcated terminals, only side route connections are shown, solder coverage should be the same regardless of routing.

7-20. Soldering of Components
Table 7-11 presents proper mounting, spacing an soldering for installation of components in electronic equipment.

Table 7-4. Insulation

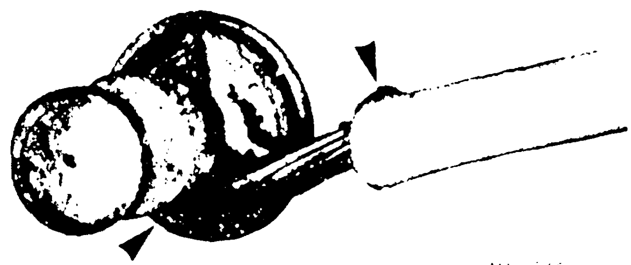
Inspection Criteria	Illustration
ACCEPTABLE Insulation is unmarked Exposed bare wire is held to a minimum Trim is neat and even	 MI 1559
MINIMUM ACCEPTABLE Minor scorch marks on insulation Trim is slightly irregular Exposed wire is within tolerance with no sign of wicking	
REJECT Insulation has been burned Excess heat and solder has caused Very bad connection - excess heat Excess solder (lead not discernible) Cold solder Rosin entrapment Lead not terminated at base of terminal Lead extends outside of terminal	 MI 1561

Table 7-5. Stranded Conductors Inspection Criteria

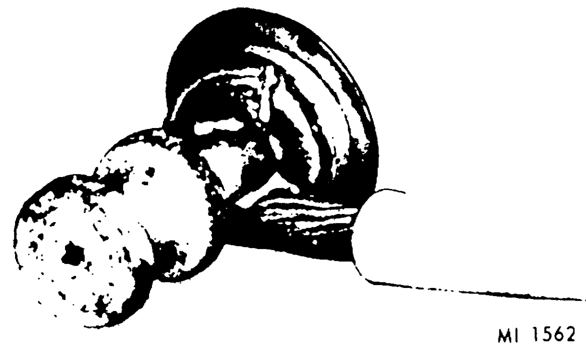
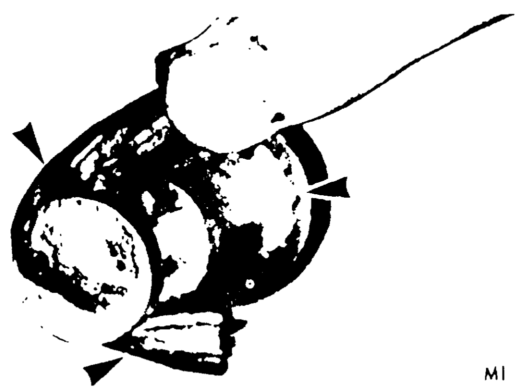
Inspection criteria	Illustration
ACCEPTABLE Joint is under no tension Original lay or twist of the wire has been maintained	 MI 1562
MINIMUM ACCEPTABLE Diameter of loop is sufficient to avoid tension on joint Original lay or twist of the wire has been maintained Insulation rough	 MI 1563
REJECT Wire has been bent in a sharp right angle bend causing strands to kink Strands have been flared on terminal Lead not terminated at base of terminal Not cleaned properly	 MI 1564

Table 7-6. Cup Connectors

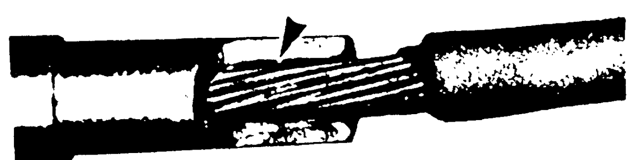
Inspection criteria	Illustration
ACCEPTABLE Conductor is correct size for cup application Solder completely fills the cup and follows the contour of the cup entry slot Strands visible	 MI 1565
MINIMUM ACCEPTABLE Conductor is maximum size for cup application All strands are within cup and fully seated Minimum solder; however, there is no evidence of wicking, nor does the solder extend beyond cup diameter	 MI 1566
REJECT Conductor is too big for cup application Connection contains loose strands and have been cut to reduce size of conductor to fit cup	 MI 1567
Conductor not in to cup bottom Solder is wicked and peaked	 MI 1568
	 MI 1569

Table 7-6. Cup Connectors - Continued

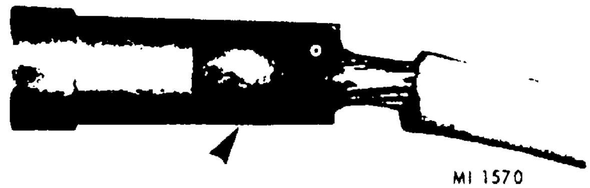
Inspection criteria	Illustration
Excessive solder	

Table 7-7. Solder Coverage - Printed Circuit

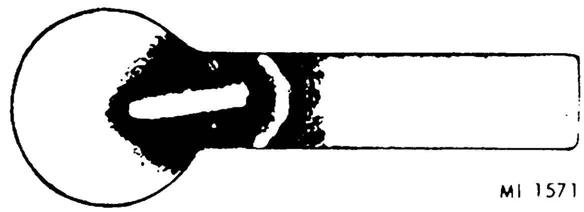
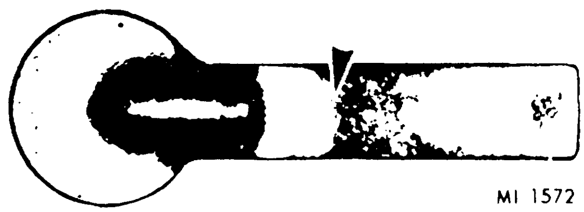
Inspection criteria	Illustration
ACCEPTABLE Lead and pad are will wetted Contour of lead is clearly defined Solder has a smooth, shiny appearance	
MINIMUM ACCEPTABLE Small imperfections in surface Smooth, metallic appearance Maximum solder but lead is discernible Minimum solder but solder is continuous over lead and pad	
REJECT Evidence of contamination. Lead is not soldered Pin hole adjacent to lead Excess solder, icicle Pad has dewetted under lead Lead not alined with conductor	

Table 7-7. Solder Coverage - Printed Circuit - Continued

Inspection criteria	Illustration
Insufficient solder	 MI 1574

Table 7-8. Solder Coverage - Connector Pins

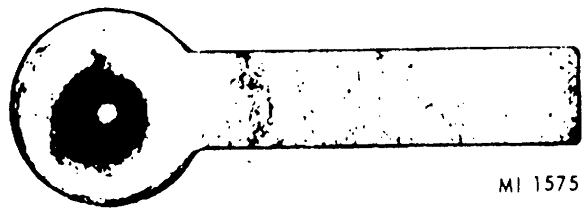
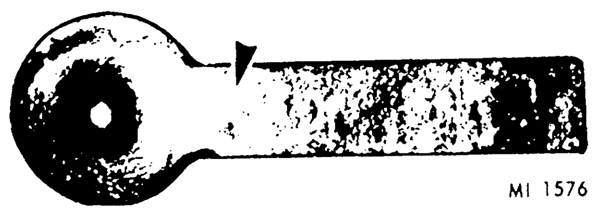
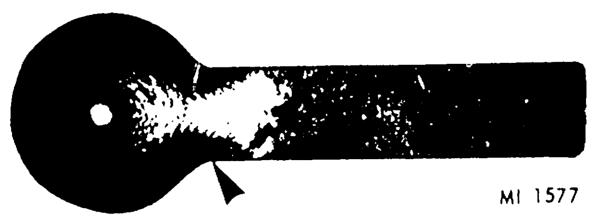
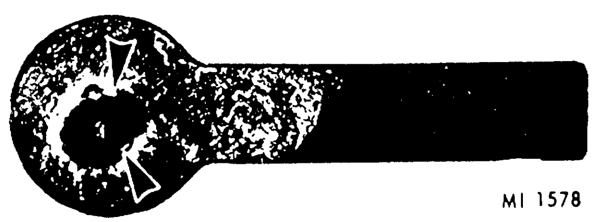
Inspection criteria	Illustration
ACCEPTABLE No surface imperfections Concave shape, heat, bright solder Good wetting of pin and pad Pin contour is well defined	 MI 1575
MINIMUM ACCEPTABLE Minor surface imperfections Visible line of demarcation between solder and pin. However, solder flow is not broken. Pin is completely tinned. Maximum solder but pin contour is discernible	 MI 1576
REJECT Excess solder	 MI 1577
Evidence of dewetting, solder does not cover pad, base metal showing Solder incomplete on tip of pin. Base metal showing. Evidence of contamination indicated by failure of pins to tin. Note definite break between pins and solder fillets.	 MI 1578

Table 7-8. Solder Coverage - Connector Pins - Continued

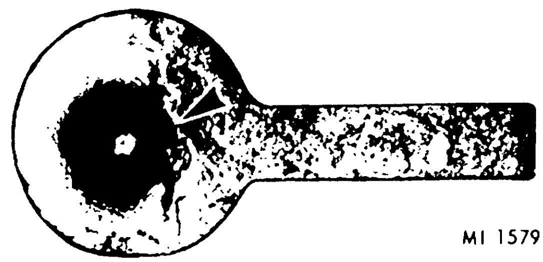
Inspection criteria	Illustration
REJECT- Continued Insufficient solder	

Table 7-9. Solder Coverage - Turret Terminals

Inspection criteria	Illustration
ACCEPTABLE Minimum wrap Only sufficient solder used to make connection Lead and terminal are well wetted and solder has feathered out to produce a smooth, bright joint	
MINIMUM ACCEPTABLE Hook of lead slightly away from terminal Joint is well wetted and lead is well defined Insulation not cut evenly	

Table 7-9. Solder Coverage - Turret Terminals - Continued

Inspection criteria	Illustration
Insufficient solder	
REJECT Hole between lead and turret Insufficient solder did not wet joint properly Too much heat Excess wrap. Extends beyond turret diameter	

Table 7-10. Solder Coverage-Bifurcated Terminals

Inspection criteria	Illustration
ACCEPTABLE Lead well formed; does not extend outside of terminal Solder bright; not wicked Insulation even; good clearance	
MINIMUM ACCEPTABLE Minimum solder Leads good Insulation clearance good	

Table 7-10. Solder Coverage - Bifurcated Terminals - Continued

Inspection criteria	Illustration
Maximum solder	
REJECT Insufficient solder	
Excess solder	

Table 7-11. Soldering of Components

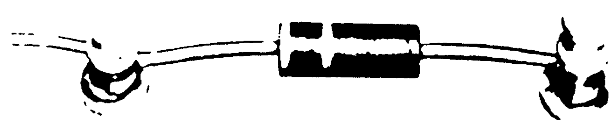
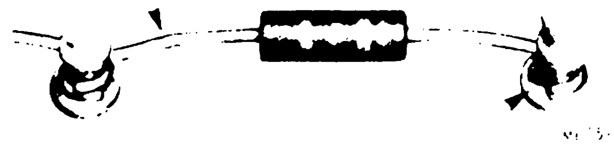
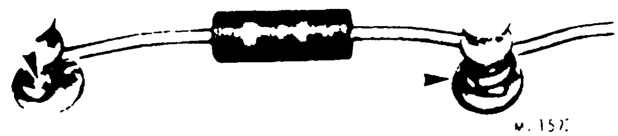
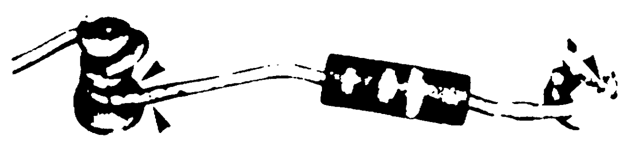
Inspection criteria	Illustration
ACCEPTABLE Component lead is clean and well tinned Solder is neat and bright and completely covers the wire	
Component centered between terminals and seated flush on boards Leads are not under tension - note offset from terminal centerline (1/16 inch) Lead bend has been made at least 1/8 inch from component body to protect component and lead weld	

Table 7-11. Soldering of Components - Continued

Inspection criteria	Illustration
MINIMUM ACCEPTABLE Component leads from a slight loop to offset component body from terminal centerline	
Slight "dimple" adjacent to lead or terminal post Solder is maximum but lead is well defined	
REJECT Lead and terminal under tension. Insufficient slack Component not flush with board Lead bent at component body	
Very poor quality throughout installation Solder has not wet terminal Hole adjacent to terminal Component lead shows evidence of contamination - solder has not wet lead	

7-21. Soldering of Hooked Leads
Table 7-12 presents proper solder coverage for hooked leads.

Table 7-12. Soldering of Hook Leads

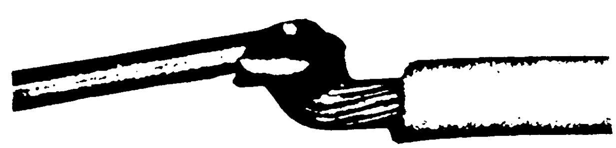
Inspection criteria	Illustration
ACCEPTABLE Leads are clean and well tinned Solder adequate, not wicked Hooks are well formed	 MI 1595

Table 7-12. Soldering of Hook Leads - Continued

Inspection criteria	Illustration
MINIMUM ACCEPTABLE Maximum solder Not wicked	 MI 1596
REJECT Excess solder Stranded conductor wicked Dimple in solder may be rosin pit	 MI 1597
Cold solder joint	 MI 1598
Insufficient solder Rosin flux entrapment	 MI 1599

CHAPTER 8

WELDING

Section I. INTRODUCTION

8-1. General

This chapter describes welding and the inspection of metal and their alloys after the welding operation. A weld is defined as a fusing of two metals by heating to suitable temperatures with or without the application of pressure of filler metal. This filler metal either has a melting point approximately the same as the base metal or below it, but above 800 degrees Fahrenheit. There are many types of welding processes which are known as arc, gas, resistance, brazing, thermit, forge, induction, and flow welding. Of these, the first five are most commonly known industrially. Some new methods such as ultrasonic and percussion are still being researched. Rockets and missiles usually employ, but are not limited to, arc and gas welding. Most of the metals and alloys used in Army materiel can be welded by one or more of the processes described in figure 8-1.

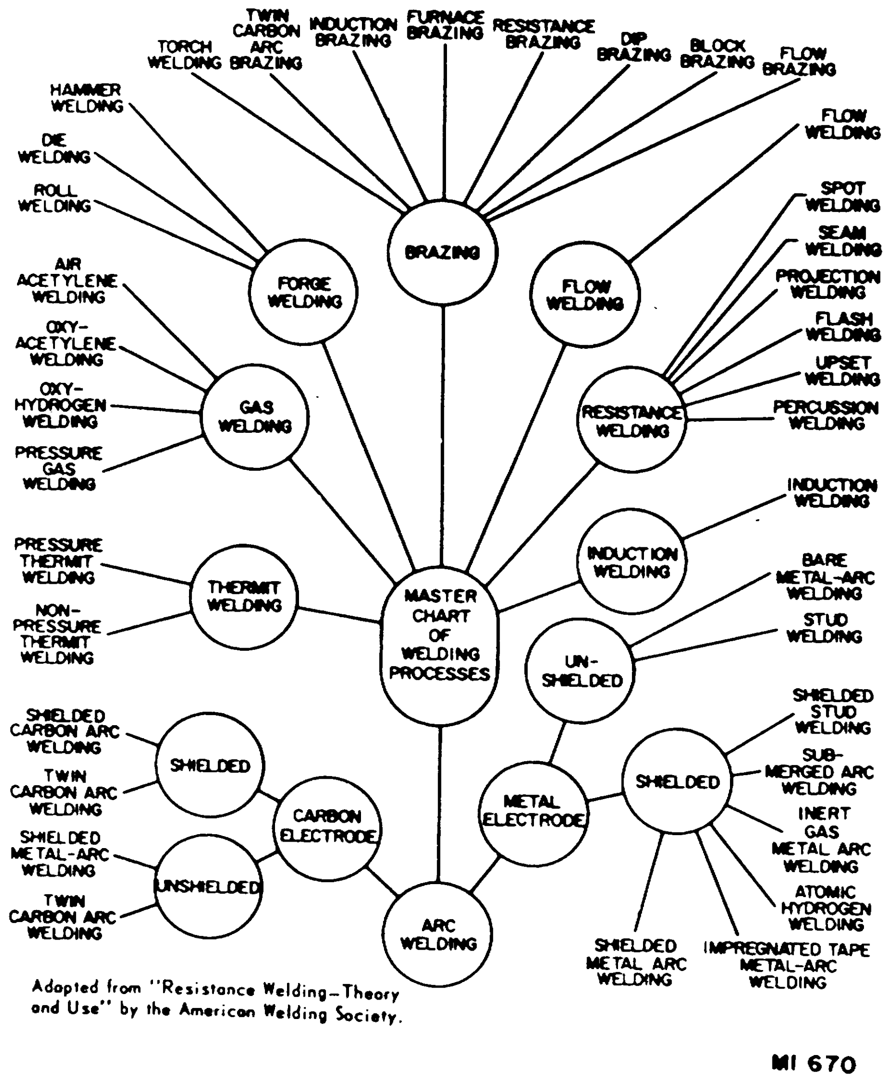


Figure 8-1. Master chart of welding processes.

8-2. Joining Mechanism

a. The joining mechanism of welding may be classified as being either a fusion or a forging action. The fundamental difference between the two mechanisms is the temperature at which the joining weld occurs. The heat generated is a function of the thermal and electrical characteristics of the materials to be welded. These characteristics govern which joining mechanism takes place.

a Fusion type weld exhibiting nugget (nickel to nickel 0.017 in ribbon)

b Forge-type weld (0.010 in x 0.047 in nickel to 0.025 in diameter dumet)

Figure 8-2. Basic types of welds.

Figure 8-2 illustrates the two basic welds.

b. Fusion occurs when the temperature is great enough to cause melting of the weld materials at the point of interface. The molten materials are confined within the weld materials and, upon cooling, solidity to a cast structure, termed a "nugget," which binds the materials together. Lighter metals and materials such as iron, steel, and nickel exhibit this type of weld.

c. The forge weld is basically a solid state one. The temperature reached is not high enough to cause melting but high enough to cause the materials to reach a plastic state. The pressure exerted by the electrodes forces the materials into intimate contact, and the proximity of the atoms of the two materials at the interface causes a solid state bond. There is no evidence of a nugget in the forge process., Copper and other metals possessing low resistivity and high thermal conductivity are joined by this type of weld, since it is difficult to localize the heat of the interface.

8-3. Preparation of Metal for Welding

a. The properties of a welded joint depend partly on the correct preparation of the edges being welded. All scale, rust, oxides, and other impurities must be removed from the joint edges or surfaces to prevent their inclusion in the weld metal. Edges should be prepared to permit fusion without excessive melting. Care should be taken to keep to a minimum the heat loss due to radiation into the base metal from the weld. Properly prepared joints will give a minimum of expansion on heating and contraction on cooling.

b. The preparation of the metal for welding is governed by form, thickness, kind of metal, the load which the weld will be required to support, and the available means for preparing the edges to be joined.

Section II. TYPES OF WELDS AND PROCESSES

8-4. General

This section is included so that you may become familiar with all types of welds and their processes. he more knowledge you possess, the better qualified you will be to inspect.

8-5. Arc Welding

In this process, the weld is produced by the extreme heat of an electric arc drawn between an electrode and the workpiece, or in some cases, between two electrodes. Welds are made with or without application of pressure and with or without filler metals.

a. Metal Electrodes.

(1) *Bare metal arc welding*. The arc is drawn between a bare or lightly coated electrode and the workpiece. Filler metal is obtained from the electrode and neither shielding nor pressure are used.

(2) *Stud welding*. The arc is drawn between a metal stud and the workpiece. The molten surfaces to

be joined are forced together under pressure. No shielding is used.

(3) *Inert-gas shielded stud welding.* This process is the same as that used for stud welding, (2) above, except that an inert-gas, such as argon or helium is used for shielding.

(4) *Submerged arc-welding*. The arc is drawn between an electrode and the workpiece, A grandular flux completely surrounds the end of the electrode and shields the entire welding action. Pressure is not used and filler metal is obtained from the electrode.

(5) *Inert-gas tungsten-arc welding (TIG).* The arc isdrawn between a nonconsumable tungsten electrode and the workpiece. Shielding is obtained from an inert-gas or gas mixture. Pressure and/or filler metal may or may not be used. Operation of typical inert-gas, shielded arc-welding machines, are explained in TM 53431-211-15 and TM 3431-213-15.

(6) *Inert-gas metal-arc welding (MIG).* The arc is drawn between a filler metal electrode and the workpiece. Shielding is obtained from an inert-gas, gas mixture, or a mixture of a gas and a flux.

(7) *Shielded metal-arc welding*. The arc is drawn between a covered metal electrode and the workpiece. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

(8) *Atomic-hydrogen welding*. The arc is maintained between two metal electrodes in an atmosphere of hydrogen. Pressure and/or filler metal may or may not be used.

(9) *Arc-spot welding*. A weld is made in one - spot by drawing the arc between an electrode and the workpiece. The weld is made without preparing a hole in either member. Filler metal, shielding gas, or flux may or may not be used.

(10) *Arc-seam welding.* A continuos weld is made along faying surfaces by drawing the arc between an electrode and the workpiece. Filler metal, shielding gas, or flux may or may not be used.

b. Carbon Electrode.

(1) *Carbon-arc welding*. The arc is drawn between a carbon electrode and the workpiece. No shielding is used. Pressure and / or filler metal may or may not be used.

(2) *Twin carbon-arc welding*. The arc is drawn between two carbon electrodes. Shielding and pressure are not used. Filler metal may or may not be used.

(3) *Inert-gas carbon-arc welding*. The arc is drawn between a carbon electrode and the workpiece. Shielding is obtained from An inert gas or gas mixture. Pressure and / or filler metal may or may not be used.

(4) *Shielded carbon-arc welding*. The arc is drawn between a carbon electrode and the workpiece. Shielding is obtained from the combustion of a solid material fed into the arc or from a blanket of flux on the work or both. Pressure and / or filler metal may or may not be used.

8-6. Thermit Welding

This is a welding process in which a weld is made by heating with superheated liquid metal and slag resulting from a chemical reaction between a metal oxide and aluminum. Filler metal, when use, is obtained from the liquid metal. Pressure may or may not be used.

a. Nonpressure Thermit Welding. In this thermit welding process, no pressure is used and the filler metal is obtained from the liquid metal.

b. Pressure Thermit Welding. In this thermit process, pressure is used and the liquid metal is not used as a filler metal.

8-7. Gas Welding

This is a group of welding processes in which a weld is made by heating with a gas flame or flames. Pressure and/ or filler metal may or may not be used.

a. *Pressure Gas Welding.* A process in which a weld is made, simultaneously over the entire area of abutting surfaces, by heating with gas flames obtained from the combustion of a fuel gas with oxygen and by the application of pressure. No filler metal is used.

b. Oxy-Hydrogen Welding. A process in which the heat is obtained from the combustion of hydrogen with oxygen. No pressure is used and filler metal may or may not be used.

c. Air-Acetylene Welding. A process in which the heat is obtained from the combustion)t) acetylene with air. No pressure is used and filled metal may or may not be used.

d. Oxy-Acetylene Welding. A process in which the heat is obtained from the combustion of acetylene with oxygen. Pressure and/or filler metal may or may not be used.

8-8. Forge Welding

This is a group of welding processes in which a weld is made by heating in a forge or other furnace and by applying pressure or blows.

a. Roll Welding. A process in which heat is obtained from a furnace and rolls are used to apply pressure.

b. Die Welding. A process in which heat is obtained from a furnace and dies are used to apply pressure.

c. Hammer Welding. A process in which heat is obtained from a forge or furnace and hammer blows are used to apply pressure.

8-9. Brazing

A group of welding processes in which the filler metal is a nonferrous metal or alloy with a melting point above 800 degrees Fahrenheit, but lower than that of the metals to be joined. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.

a. Torch Brazing. A process in which a gas flame produces the necessary heat.

b. Twin-Carbon-Arc Brazing. A process in which an arc is maintained between two carbon electrodes to produce the necessary heat.

c. Furnace Brazing. A process in which a furnace produces the necessary heat.

d. Induction Brazing. A process in which heat is obtained from resistance of the work to the flow of induced electric current.

e. Dip Brazing. A process in which heat is obtained in a molten chemical or metal bath. The bath provides the filler metal.

f. Resistance Brazing. A process in which heat is obtained from resistance to the flow of electric current in a circuit of which the work is a part.

g. Block Brazing. A process in which heat is obtained from heated blocks applied to the part to be joined.

h. Flow Brazing. A process in which heat is obtained from molten nonferrous filler metal poured over the joint until the brazing temperature is attained.

8-10. Flow Welding

This is a welding process in which molten-filler metal is poured over the surfaces to be welded until the welding temperature has been attained, and the required filler metal has been added. The filler metal is not distributed to the joint by capillary attraction.

8-11. Resistance Welding

This is a welding process in which a weld is made by heat obtained front resistance of the work to the flow of an electric current in a circuit of which the work is a part and by the application of pressure.

a. Resistance-Spot Welding. The size and shape of the individually formed welds are limited primarily by the size and contour of the electrodes. The electrodes apply pressure.

b. Resistance-Seam Welding. This weld is a series of overlapping spot welds made progressively along a joint by rotating the circular electrodes. The electrodes apply pressure.

c. Projection Welding. These welds are localized at predetermined points by the design of the parts to be welded. The localization is usually accomplished by projections, embossments, or intersections. The electrodes apply pressure.

d. Flash Welding. This weld is made simultaneously over the entire area of abutting surfaces by the application of pressure after the heating is substantially completed. Flashing is accomplished by expulsion of metal from the joint.

e. Upset Welding. This weld is made simultaneously over the entire area of abutting surfaces or progressively along a joint. Pressure is applied before heating is started and is maintained Throughout the heating period.

f. Percussion Welding. This weld is made simultaneously over the entire area of abutting surfaces by the heat obtained from an arc. The arc is produced by a rapid discharge of electrical energy. It is extinguished by pressure percussively applied during the discharge.

8-12. Induction Welding

A welding process in which a weld is made by the heat obtained from resistance of the work to the flow of induced electric current, with or without the application of pressure.

Section III. WELD INSPECTION

8-13. General

Welds must be examined to detect any condition or defect that may impair the reliability of the welded joint. Examination of the welds may be accomplished by three methods; nondestructive (visual), destructive, and metallurgical.

a. Nondestructive. This inspection is visual and requires that the inspector have a thorough knowledge of what he is inspecting.

b. Destructive. Destructive inspection of repaired items is not recommended, because so will destroy the item. The inspector may have samples made for destructive inspection. These samples should simulate the type metal and process of the item it represents.

c. Metallurgical. Metallurgical inspection is not used by the QC inspector but is included for informational purposes. At some time, the information presented may be required.

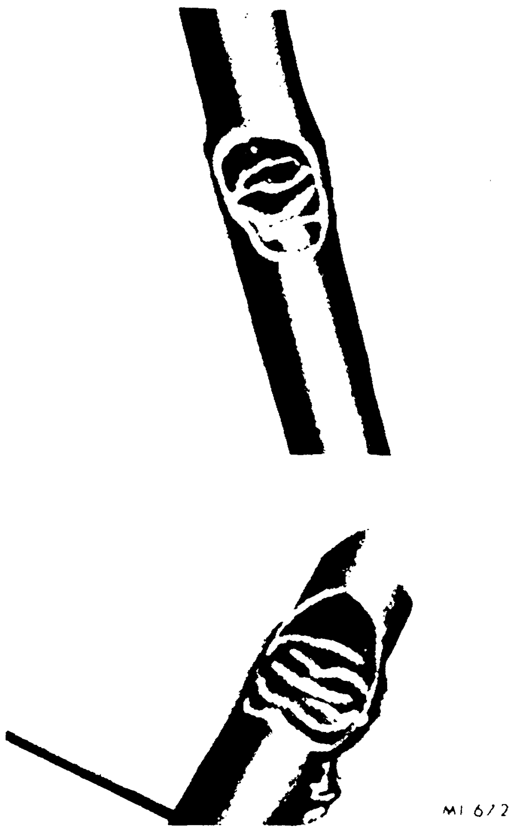


Figure 8-3. Offcenter welds.

8-14. Nondestructive Inspection (Visual Inspection)

a. The visual inspection is the only method available at the present time to nondestructively evaluate welding repairs. In some cases, a defective weld can be detected by the unaided eye, but in most cases an optical aid is required to detect minute defects. To evaluate the welds visually, illustrations are included to serve as a guide for the inspector. The inspector must also exercise his own judgement based on experience in marginal cases.

b. Every weld in a module must be visually inspected using an optical aid having a minimum magnification of 30 power. This necessitates that a module be inspected in-process at selected points during fabrication as some welds are inaccessible upon completion of the package. Upon completion of the package, all accessible welds should be reexamined to determine if any damage has resulted from handling during fabrication.

8-15. Open Weld

A point where a weld has been attempted but no fusion or forging action has occurred due to misfire of the welding machine, or a point where a weld is specified by drawing but has been overlooked by the operator. When microscopic examination leads the inspector to suspect an open weld, it is permissible to "probe" the connection. However, force to the weld must be applied with caution to avoid stressing the weld.

8-16. Offcenter Weld (Fig. 8-3)

A weld in which either or both of the materials were not centered between the electrodes. This type weld normally causes excessive metal expulsion. In some cases, if high electrode force has been used, the offcenter weld can be detected visually by the location of the indentations of the electrodes.

8-17. Cracked Weld (Fig. 8-4)

Any weld which exhibits a crack in the weldment or adjacent to it. Cracks normally appear along the fillet or across the weld area. Cracks are caused by excessive pressure and / or heat.

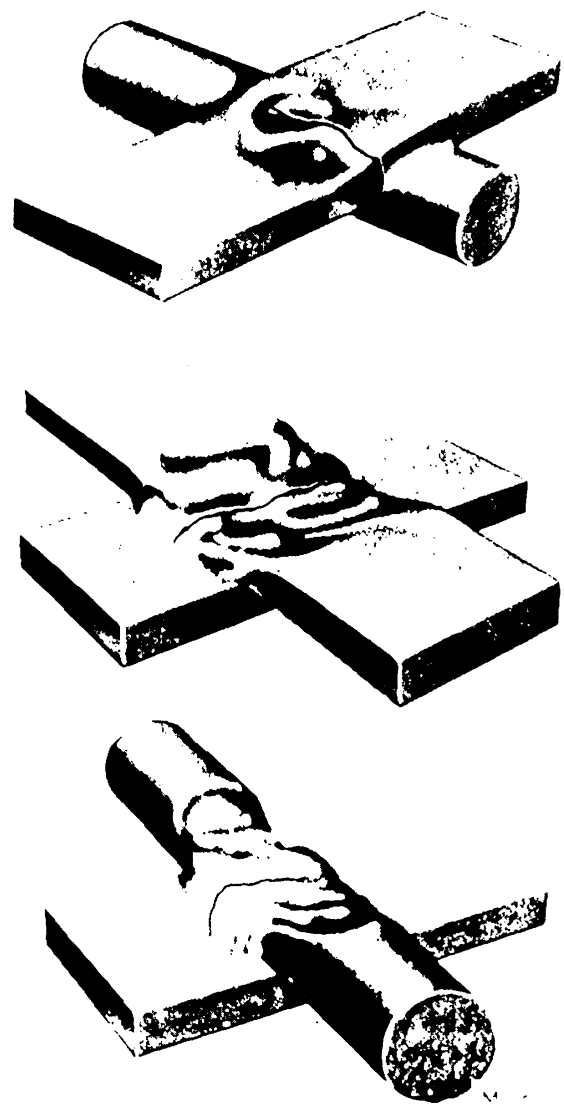


Figure 8-4. Cracked welds.

8-18. Deformed Weld (Fig. 8-5)

A deformed weld is one in which the diameter or thickness of either of the materials has been reduced by more than 50 percent or the total reduction of both materials is greater than 35 percent. Deformation is caused by excessive pressure and / or heat.

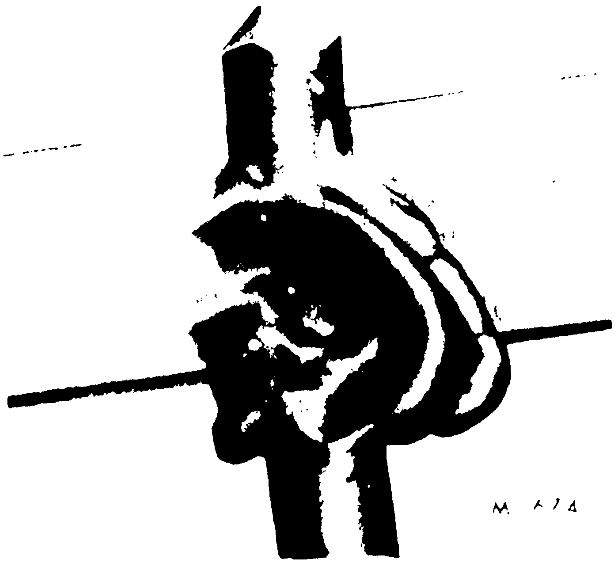


Figure 8-5. Deformed welds.

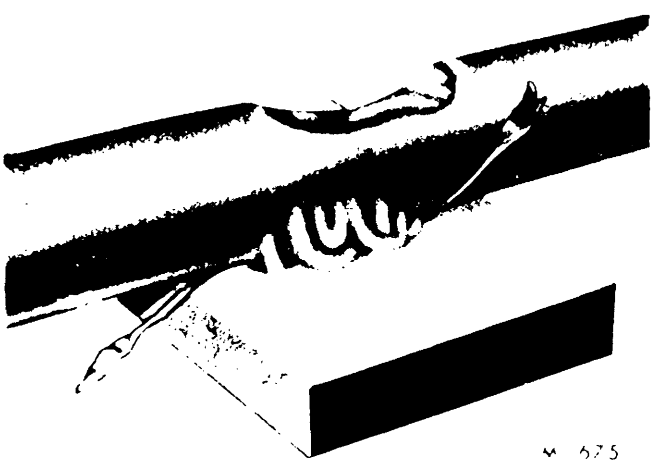


Figure 8-6. Splatter weld.

8-19. Metal Expulsion (Figs. 8-5 and 8-6)

A weld which exhibits either excessive bulging of metal at the interface, "splashed" metal deposits on the adjoining element, or fragments extending from the weld interface. Metal bulging (sometimes referred to as distortion) is not metal expulsion in the true sense of the word. It appears along the interface of the weld and is the result of too much pressure. The excessive pressure forces the material to form a bulge while it is in the plastic stage. A slight amount of bulging is not considered to be detrimental. Splattering and fragments of metal extending from the weld zone are actual cases of metal expulsion and occur because of excessive pressure and / or heat.

8-20. Blow Hole (Fig. 8-7)

A weld in which holes are evident, usually along the fillet. These holes are readily detectable under magnification. Blow holes result from the formation of a gas pocket in the weld zone which reaches such high internal pressures that metal is expelled.

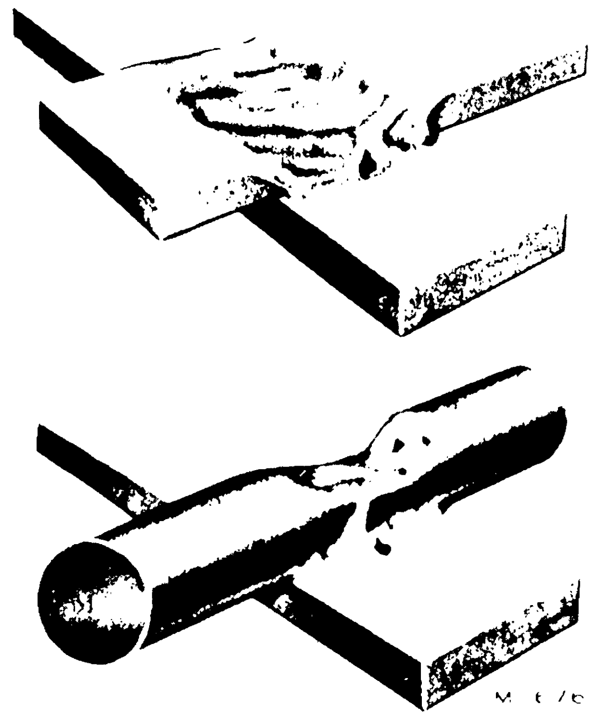


Figure 8-7. Blow hole.

8-21. Pitted Weld (Fig. 8-8)

A weld that exhibits "pits" in either or both of the materials being joined. In certain cases, when surface fusion occurs, the molten metal adheres to the electrode (termed "sticking"). As the electrode force is released, the material which as adhered to the electrode is pulled from the parent metal, resulting in a rough and pitted surface.

8-22. Excessive Surface Fusion (Fig. 8-9)

A weld in which the weld material has melted to an excessive degree at the point of interface with the electrode. A contact resistance exists at this point. If this resistance is higher than that at the weldment interface, or if proper heat balance has not been attained, the contact area will melt. In certain cases, a small amount of surface fusion cannot be avoided. However, it is desirable to keep this to a minimum, preferably below 10 percent of the lead diameter.

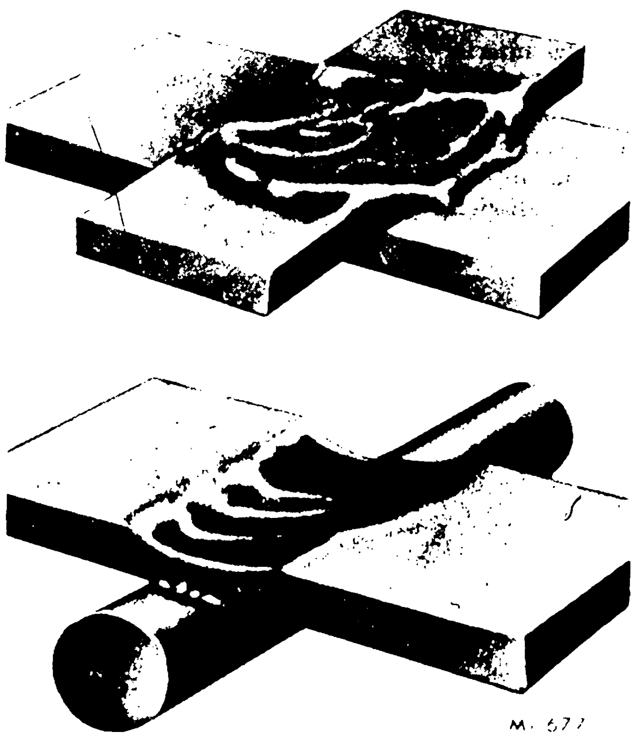


Figure 8-8. Pitted weld.

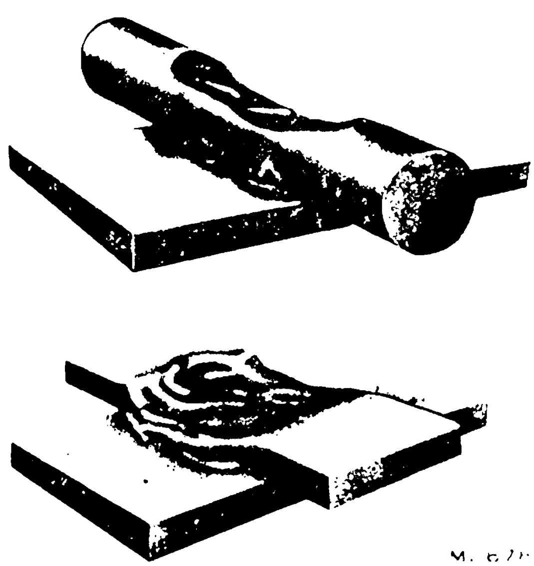


Figure 8-9. Excessive surface fusions.

8-23. Excessive Setdown (Fig. 8-10)

Setdown is the degree to which the thinner of the materials being joined is physically forced into the thicker material. It is expressed in percent, and is shown in figure 8-10. Setdown should not exceed 50 percent.

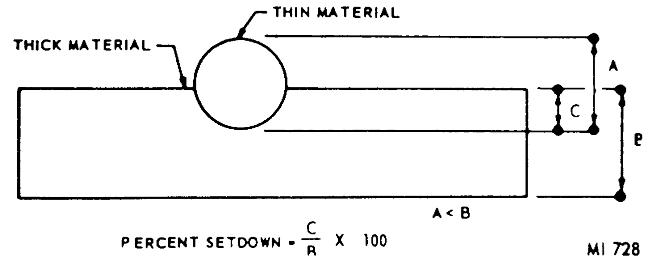


Figure 8-10. Setdown.

8-24. Insufficient Weld

An insufficient weld is one in which fusion or forging action has occurred, but not to the extent that minimum weld strength requirements can be met. It is extremely difficult to detect, and if this condition is suspected to exist, a number of samples should be obtained from the machine which produced the questionable welds and pull tests made. In certain cases, as in round materials welded to rectangular materials, it may be possible to detect insufficient welds by observing the fillet at the interface. The fillet should be evident at least along 75 percent of the interface. Normally, a defective weld will exhibit two or more of the above conditions. For example, figure 8-3 is an offset weld in which a weld splatter is evident. Figure 8-5 exhibits cracks, excess surface fusion, and excess metal bulging.

8-25. Destructive Inspection

a. Destructive inspection is made by either a pull-test or metallurgical test. Pull-testing is time consuming and expensive, and it destroys the product. Nevertheless, it is the only method available at the present time for obtaining quantitative data about the parameters of a weld. Since this method is destructive, it must be used only on a sampling basis.

b. The pull-test is commonly referred to as a tensile test of the weld. The test consists basically of pulling the weld apart by applying a tensile force of opposite direction to each lead. Besides the tensile force, there is also a shear force, and, in some instances, a torsional force applied at the weld joint. Figure 8-11 illustrates the three methods which are in use by various companies for pull-testing welds. Method A of figure 8-11 is the preferred pull-test method. This method applies an additional stress to the joint.

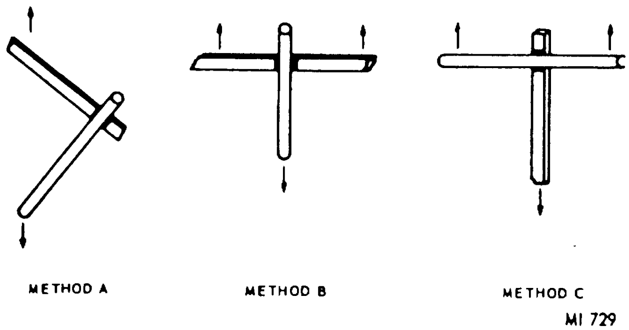


Figure 8-11. Methods of pull testing.

c. Method A is referred to as the torsion-shear method of pull-testing. This method places a torsional force in addition to a tension and shear force on the weld. In general, this method results in pull-test strengths which are much lower than the results obtained by either of the other methods. Mechanically locked interconnections are detected by the torsion-shear method, whereas they may not be detected by other methods.

d. The significance of this test is that a quantitative analysis of the weld strength may be obtained and used as a basis for determining optimum welding machine settings. Once the machine has been set, periodic pull-tests performed on samples taken from the production line can be evaluated and the results used as an in-process check.

8-26. Metallurgical Examination

a. Metallography is the only feasible analytical technique available for evaluating the quality of a weld. Metallographic examination reveals the interior of the weld, enabling the observer to determine what type of weld has been made, the amount of fusion present, and any defects present within the weld. However, it takes a trained and experienced metallographer to interpret the photomicrographs.

b. Before the interior of the weld can be observed, the sample must be encapsulated in a rigid substance and then subjected to a series of grinding and polishing operations. These operations leave a free surface and a disturbed crystalline layer above the basic metal for examination. The free surface and disturbed crystalline layers are removed by an etching process which, if done properly, will reveal the true structural characteristics of the weld.

c. Improper control or selection of welding variables can be readily determined by metallographic analysis. Such conditions as excessive or insufficient pressure or energy, heat unbalance, or combinations of these have a direct effect on the metallurgical appearance of the weld.

d. Insufficient pressure is sometimes evidenced by metal expulsion and sometimes by : he appearance of a heat affected zone (IIAZ) at the point of contact of the electrode. Metal expulsion is usually prevalent when welding heat is high and the foregoing pressure is not great enough to retain the molten metal. This condition may also be a result of poor heat inertia. The heat affected zone results because the low pressure of the electrodes creates a high -contact resistance at the electrode and material interface.

e. Excessive pressure is evidenced by metal expulsion which results in blow holes. In this case, the pressure is so great that it expels the molten material from the weld zone.

f. Insufficient heat results in the lack of fusion and, consequently, a poor weld joint (fig. 8-12).

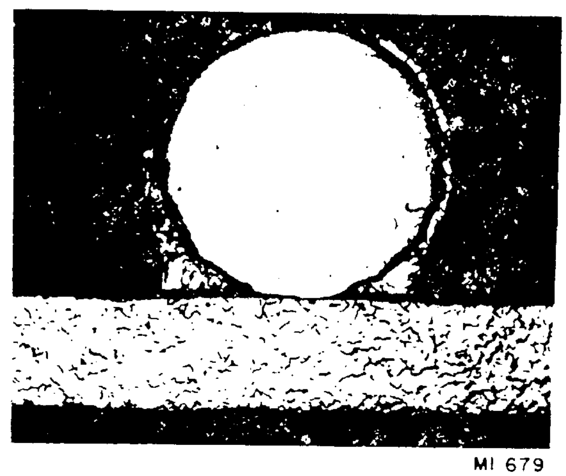


Figure 8-12. Lack of fusion caused by insufficient heat.

g. Excessive heat can cause excessively large nuggets (over penetration) which, in extreme cases, extend the full width of the material. Over penetration is undesirable since the recrystallized nugget lacks ductility. Excessive heat also contributes to metal expulsion, gas pockets, and shrinkage cavities. Figure 8-13 is a photomicrograph of a weld containing shrinkage cavities.

h. The nugget of a fusion type weld should exhibit equal penetration and be free of porosity, inclusions, blow holes, and shrinkage cavities. Penetration is defined as the depth to which the fusion extends into the material and should be at least 20 percent of the material thickness is. Figure 8-14 illustrates proper penetration.

i. Improper heat balance can, in many cases, be detected by the presence of a nugget existing within one of the materials. Figure 8-15 (top) shows a nugget that is contained within the clad of an interconnecting material. Improper heat balance can be solved by methods discussed previously.

Figure 8-13. Excessive heat and pressure resulting in shrinkage cavities.

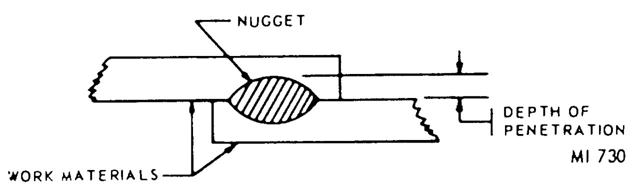


Figure 8-14. Proper penetration.

j. A sound weld is accomplished when the clad has been broken through and proper heat balance has been attained.

k. It has been found, in certain cases involving welding of solder coated leads, that resistance solder joint was produced by the weld process, rather than a true weld. A similar situation exists when welding dumet to an interconnecting material. Here, the copper sheath melts and forms a brazed joint. Both of these conditions have been detected by metallographic analysis.

Figure 8-15. Improper heat balance.

l. The value of metallographic analysis is obvious and should be performed on welds produced at machine settings to verify the adequacy of the weld parameters to produce reliable welds.

However, metallographic analysis and interpretation should be performed by a qualified metallographeror metallurgist.

CHAPTER 9

ADHESIVE BONDING, POTTING, EMBEDDING, AND SEALING

Section I. INTRODUCTION

9-1. General

WARNING

Many of the chemicals used in adhesive technology are toxic and present safety hazards to personnel. Ovens are often used to heat material. They should always be well ventilated to prevent inhaling of chemical fumes. The surrounding working area should be free of contamination of materials as they are skin irritants. Have fire fighting equipment nearby in case of emergencies as some chemicals are highly flammable. Protect the eyes from exposure. Always have first aid equipment nearby.

a. This chapter describes adhesive bonding, potting, embedding, and sealing operations employed in the maintenance of materiel.

b. In many cases, potting, embedding, and sealing compounds are identical to compounds used as adhesives; usually the only difference is in the amount of material used. Adhesive processes require very small amounts of material as compared to potting processes. Potting compounds are those resins which can be converted from liquid to solid state at room or slightly elevated temperatures and at atmospheric pressure. Potting compounds are used to protect, hold in place, and insulate mechanical and electrical parts. Potting, embedding, and sealing compounds may be broken into three general categories:

(1) Polyurethanes, epoxies, silicones, and polysulfides

(2) Sealants containing solvents and elastomers

(3) Staking sealants (Loctite)

c. Unless otherwise stated, assume that all information applies to sealants as well as to potting and embedding compounds. Applied potting compounds are relatively difficult to repair; be careful when using these materials on expensive parts.

9-2. Definitions, Abbreviations, and Terms

The inspector should refer to appendix B for the definitions, abbreviations, and terms applicable to adhesive bonding, potting, embedding, and sealing.

Section II. ADHESIVE BONDING

9-3. General

The use of adhesive bonding agents involves five phases: selection of the proper adhesive, cleaning, application, curing, and inspection of the finished joint. It is assumed that the bonding will normally consist of repair of an existing joint and does not involve the design of a new joint.

9-4. Types of Adhesives

The broad use of adhesive bonding has resulted in development of many different types of adhesives. Therefore, no discussion will be made here of the various types. The system technical manuals should be followed in selecting the proper adhesive, determining the mixture, and selecting the cure time and temperature.

9-5. Cleaning Parts

a. To achieve maximum adhesion, the adherent surface must be carefully prepared. Clean all potting areas until they are free from oil, grease, release agents, rust, moisture, or fingerprints. Skin grease or perspiration deposited on the adhesion surface may reduce adhesion by as much as 75 percent. Basically, four methods are utilized, which are brushing, flowing, spraying, and rolling.

b. Thoroughly clean the surface either mechanically or chemically, depending upon the type of material and the contaminant to be removed. To eliminate dirt, scale, rust, and similar contaminants, use wire brushing, buffing with powdered wire brushes, sandpapering, sandblasting, or other types of abrasion. Degrease by solvent cleaning before and after abrading the surfaces. Remove oils, greases, and most similar contaminants with chemical cleaning agents such as solvents and detergents. Make sure no solvent remains within the mold cavity.

9-6. Applying the Adhesive

Apply adhesives with a spatula, brush, or syringe-type extruding gun (sealant gun). Apply only enough adhesive to insure complete contact between the adhering areas. Apply two-part adhesives to one surface only (the smaller, if possible). Apply one-part adhesives to both surfaces. The solvent in one-part elastomeric adhesives must be allowed to dry until tack-free before mating the parts. Since the various types of solvents require different drying periods, observe strictly the instructions on drying time. After the parts have been firmly secured, remove excess adhesive around the glue line with MEK solvent. Do not use excessive solvent, the solvent may retard the curing of the adhesive if allowed to penetrate the glue line. Thoroughly clean the tools with MEK and wipe them dry with a clean cloth.

9-7. Using Fixtures in Bonding

a. Aline the parts to be bonded and place them in contact as instructed in the maintenance document. Hold and align the bonded part during adhesive cure with fixtures such as C-clamps, spring clamps, weights, masking tapes, molded fixtures, or combinations of these devices in accordance with the specific system documentation. Avoid damaging the assembly or extruding excess adhesive at the glue line when applying pressure with a fixture.

b. Release agents may be used on fixtures, but avoid excessive use. Excessive release agents can contaminate the operator's hands or may enter the bonded area. Make sure the release agent will have no damaging effect on the bonding operation or succeeding operations. Apply the release agent according to instructions on the container.

9-8. Curing the Adhesive

a. Cure Conditions. All adhesives require some curing period. The time required varies with the heat and pressure applied. Observe the temperature, pressure, and cure time specified by the instructions for each particular adhesive. The time and temperature of cure must be consistent with thermal limitations of the assembly to which the compound is applied to prevent damage to heat-sensitive compounds or materials.

b. Heat. To apply heat, use a forced-air-circulating oven, if possible, capable of maintaining temperatures from 100 to 500 degrees F. within ±10 degrees F. When heat lamps are used, be careful not to develop hot spots by concentrating heat in small areas. Rotate the work on a turntable or by hand to prevent these hot spots during heatlamp cure.

c. Pressure. Pressure is seldom required during the cure of most adhesives. If necessary, apply just enough pressure to insure complete contact. Elastomeric adhesives do not exude from the glue line. Do not attempt to force the parts together so hard as to cause exuding. Resinous or two-part adhesives require enough pressure on the bonded parts to exude a slight amount of adhesive at the glue line. Clean off excess adhesive from the glue line.

d. Single-Part Adhesives. Thoroughly blend single-part adhesives, such as solvent dispersions, before application. Shake the unopened container, or open the container and stir the con tents, or both.

9-9. Final Inspection

The quality of an adhesive bond can best be determined by assuring that the correct adhesive was used and then by monitoring the entire bonding process, from cleaning to curing. If samples can be taken for testing to destruction, it is obvious that such a test is the best measure of the adhesive bond. In most instances, however, inspection must be accomplished without damage to the adhesive joint. The following nondestructive tests will serve to reject most of the defective bonds:

a. Visual Examination. Check the joint for warpage and improper alinement. The edges of the joint should show some flash (extruded adhesive) to indicate that the proper amount of adhesive was used. The flash should be hard and nonporous to indicate proper curing. Soft and tacky shows undercure; burnt and bubbly shows overcure. Visual examination is the most effective test.

b. Tapping. On large bonded areas, the joint may be tapped with a hard object. Voids and blisters sound hollow compared to well-bonded areas.

c. Proof Loading. Load the joint with the same type of stress anticipated in service. The magnitude of the stress should be greater than normal but should not exceed 125 per cent of anticipated load.

Section III. POTTING, EMBEDDING, AND SEALING

9-10. General

In many cases, potting, embedding, and sealing compounds are identical to adhesive bonding compounds. More material is used in their application than in bonding. These compounds are resin which can be converted from liquids to solids at room or slightly elevated temperatures. Normally, these resins will not be used in field repair except for the potting of plugs, jacks, and material containing potting, embedding, and sealing may be damaged and will have to be inspected for defects. The defects may have originated in manufacture or they may be the result of handling and environment in service. The application of these materials is defined as follows:

a. Potting. The placing of electrical components or networks in a metal or plastic container which is then filled with casting resin. The liquid resin then hardens by cooling or chemical action and the container becomes an integral part of the finished product.

b. Embedding. A process similar to potting except that the components and liquid resin material are cast in a temporary container which is removed when the resin hardens.

c. Sealing. The placement of a small fillet of resin sealant over joints or cracks on containers. The sealant protects the container from foreign material. Sometimes sealants are used for staking (bonding) parts together in conjunction with the protection or sealing action.

9-11. Preparing Parts to be Potted

a. To achieve maximum adhesion, the adherent surface must be carefully prepared. Clean all potting areas until they are free from oil, grease, release agents, rust, moisture, or fingerprints. Skin grease or perspiration deposited on the adherent surface may reduce adhesion by as much as 75 percent.

b. Thoroughly clean the surface either mechanically or chemically, depending upon the type of material and the contaminant to be removed. To eliminate dirt, scale, rust, and similar contaminants, use wire brushing, buffing with powdered wire brushes, sandpapering, sandblasting, or other types of abrasion. Degrease by solvent cleaning before and after abrading the surfaces. Remove oils, greases, and most similar contaminants with chemical cleaning agents such as solvents and detergents. Make sure no solvent remains within the mold cavity.

c. While preparing adherent surfaces, consider which areas do or do not require adhesion. In potting, the mold or container becomes a part of the finished product; therefore, adhesion to the mold is essential. In embedding, however, a release agent must be applied to the mold before potting. Often, electrical wires with nonadherent surfaces are encountered. Do not attempt to abrade or clean electrical wires or sleeved junctions near the potted area, since the abrasion may cause short circuits.

d. Check each unit to be processed to insure that components are in place and ready for potting or encapsulating. Correct any discrepancies. Aline molds and components in the fixtures and center all wires and components protruding from a mold uniformly in the cavity.

e. When so instructed in the technical documentation, prime the molds, components, substrates, or any combination thereof, with suitable adhesion-promoting agents, or release agents, as applicable. Make sure the primer will not damage the molds, components, substrates, or the potting or encapsulating compound. Apply the primer according to the instructions on the container.

9-12. Preparing the Potting Compound

a. Almost all potting compounds require thorough mixing before combining two-part or applying one-part sealants to a substrate. If the resin or accelerator contains no filler and is transparent, it may not require extensive mixing.

b. If weighing and mixing of two-part systems are necessary, follow the instructions on the container.

c. Foaming systems, because of their short reaction time, must be quickly and thoroughly mixed. Stir the mixture until it is homogeneous, lighter in color, and more viscous. Do not overmix or the mixture will be too stiff to pour.

9-13. Applying the Potting Compound

a. Potting compounds can be poured, extruded through sealant guns, (air-pressure activated), dipped, or spread with a knife or spatula. Each potting compound or sealant has its own particular procedure for application, depending on the material's viscosity. In general, apply material as dictated by the instructions on the container. Apply only enough to insure adequate coverage.

b. Be careful not to trap air in the potting or encapsulating material while putting the material in sealant guns or other injection apparatus. Pour the material down the inside wall when loading the gun or cartridge.

c. Extrude potting material into an open mold by placing the nozzle at the bottom of the mold and retracting the nozzle as the cavity fills; keep the nozzle tip just below the level of compound in the mold. Be sure to use access holes in closed molds, if they are provided.

d. Before the potting compound solidifies, examine any wires or other movable protrusions for alinement, and realine them as necessary.

e. Special instructions or precautions which must be observed while applying potting compounds covered in (1) and (2) below:

(1) *Staking sealants.* Staking sealants are noted for the controllability of their adhesive strengths to metal substrates. These compounds remain liquid indefinitely until they are confined between closely fitting metal surfaces in the absence of air; then they change to an infusible, insoluble state. These compounds are used in sealing threaded fasteners, plugs, and threaded fittings against fluid pressure; in locking such threaded parts against working loose under shock vibration; and in retaining existing or replacement ball bearings in worn housings, thus eliminating the need for a press fit. These compounds are supplied in color coded strengths and two viscosities for each color. The metal substrate which the compound contacts is considered the catalyst.

(2) *Urethane foams*. Access holes in the mold should be no less than 1/2 inch in diameter, so that the mixed foam can be poured quickly into the part to be potted. Bleeding vent holes should be provided if possible, and if not, the excess foam may exude from the access hole when the foam rises. Make sure the mold is heated according to the foaming instructions. All foams are exothermic; the heat of reaction causes the chemicals to form gas pockets and cause foaming. If the heat from the reaction is used up in warming the mold, poor foaming action will result and the rise will be insufficient. A general rule, if mold-heating information is not provided, it to heat the mold from 100 to 120 degrees F. for one hour just before foaming.

9-14. Using Fixtures in Potting

a. Aline parts to be potted as instructed in the technical documentation. Hold and aline the potted part during the cure of the potting compound with fixtures such as molds, C clamps, spring clamps, weights, masking tapes, molded fixtures, or combinations of these devices in accordance with the specific instructions.

b. Release agents may be used on fixtures at times, but avoid excessive use. Excessive release agent can contaminate the operator's hands or can accidentally enter the adherent areas as a result of poor workmanship.

c. While preparing adherent surfaces, consider which areas do or do not require adhesion. In potting, the mold or container becomes a part of the finished product; therefore, adhesion to the mold is essential. In embedding, however, a release agent must be applied to the mold before potting. Often, electrical wires with nonadherent surfaces are encountered. Do not attempt to abrade or clean electrical wires or sleeved junctions near the potted area, since the abrasion may cause short circuits.

d. Check each unit to be processed to insure that components are in place and ready for potting or encapsulating. Correct any discrepancies. Aline molds and components in the fixtures and center all wires and components protruding from a mold uniformly in the cavity.

e. After the potting compound has cooled to room temperature, proceed carefully to remove fixtures and molds, if required. Trim flash areas as required. Store fixtures and molds are required to keep them in good operating condition.

9-15. Curing the Potting Compound

a. Cure Conditions. All potting compounds require some curing period. The time required varies with the heat applied. Observe the cure time and temperature specified by the instructions for each particular material. The time and temperature of cure must be consistent with thermal limitations of the assembly to which the compound is applied to prevent damage to heat-sensitive components or materials.

b. Heat. To apply heat, use a forced-air-circulating oven, if possible, capable of maintaining temperatures from 100 to 500 degrees F. within 3 10 degrees F. When heat lamps are used, be careful not to develop hot spots by concentrating heat in small areas. Rotate the work on a turntable or by hand to prevent these hot spots during heatlamp cure. Do not exceed curing temperatures or the potting material, the potted part, or both may be ruined.

c. Special Instructions. Special instructions or precautions which must be observed in the cure of potting compounds are covered in (1) through (3) below:

(1) *Silicones.* A minimum of 20 percent relative humidity is necessary to cure silicone materials. (Heat does not accelerate their cure.) Because of this moisture requirement, compounds applied thicker than one-eighth inch require longer to cure than do thin coatings. As a general rule, for each one-eighth inch thickness, allow 24 hours at room temperature for cure. Post cure silicones for 15 to 60 minutes at 10 degrees

Fahrenheit above the intended maximum service temperature of the cured compound.

(2) *Polysulfides*. Avoid heat curing these materials at temperatures higher than 120 degrees Fahrenheit, because the cured potting compound will gas or become foamlike in appearance. Do not use heat lamps.

(3) *Epoxies.* Allow mixed epoxies which have generated exothermic heat to return to or below cure temperature before starting the cure cycle.

9-16. Final Inspection, Cured Potting Compound

a. Inspect the potting compound to determine if it is smooth, continuous, and properly cured. Poorly potted parts may be recognized by: air voids on the surface and throughout the potted unit; potting material burned or bubbly from excessive heat or localized heat; compound soft or tacky from under-curing, discrepant shelf-life, or lack of heat; substance cracked because of thermal shock or exothermic reactions, or streaked because of inadequate mixing.

b. Avoid testing potted or sealed assemblies. Instead, if tests are required to determine that the assembly is properly potted, provide test samples of the same material. Choose standard test specimens to satisfy this requirement whenever practical, taking care to repeat the curing and potting methods employed during the original procedure. If the test specimen fails, try to determine the specific cause of failure. Some of the predominant causes of failure are listed below:

(1) Poor surface preparation of substrates.

(2) Potting compound not properly mixed.

(3) Incorrect ratio of resin to hardener (the ratio is sometimes reversed).

(4) Each unit container not premixed.

(5) Potting compound shelf-life exceeded (this can result from incorrect shelf-life markings).

(6) Potting compound not suited for the job.

(7) Substrates not suitable for potting because of configuration or type of material.

CHAPTER 10

LUBRICATION

Section I. INTRODUCTION

10-1. General

This chapter establishes the inspection criteria for items requiring lubrication after repair. These inspections require that the inspector have knowledge and special training in the lubrication of all types of equipment.

10-2. Reference

a. Refer to applicable system technical manuals (TM), technical bulletins (TB), and lubrication orders (LO) for applicable coverage of lubrication.

b. The inspector should refer to appendix B for the definitions, abbreviations, and terms applicable to lubrication.

Section II. APPLICATION

10-3. General

a. The best lubricant will fail to accomplish its purpose if not applied to the moving surfaces and in the proper amounts.

b. There are many methods of applying lubricants and new methods are being developed as new lubricants and new equipment are developed. The inspector should consult the applicable system LO's for proper lubrication interval, amount, and application.

c. Most lubricants are applied with hand grease guns, pressure grease guns, oil cans, special package applicators, brush or cloth-smearing.

10-4. Over-Lubrication

Over-lubrication can be as detrimental as under lubrication in the following ways:

a. Cause seal leakage.

b. Drip on valuable materials.

c. Damage electronic components.

d. Short electric or electronic components.

e. Drip onto hot surfaces and cause fires, smoke, or vapor.

f. Contaminate brake linings, clutches, etc.

g. Interfere with friction drives.

h. Contaminate air or gas in piping.

i. Interfere with dial or other instrument operation.

j. Discolor dials. stickers, or instruction panels.

10-5. Under-Lubrication

a. Under-lubrication can be caused by several factors, some of which are insufficient lubricant, inadequate seals, wrong lubricant, high temperatures, high pressures, and lubricant contamination.

b. Insufficient lubrication can cause noise, wearing, heat, fire, breakage, and many other types of failures and hazards.

Section III. INSPECTION PROCEDURES

10-6. General

The inspection procedures are general and should be supplemented with reference to system documentation.

10-7. Engines

Inspect for correct engine oil and oil filters. Check oil seals to insure there is no leakage. Check against lubrication order to insure that all prescribed points are adequately lubricated.

10-8. Bearings

a. In-Process. Inspection of bearings in most cases will have to be accomplished during an in-process inspection. Inspection should cover seals, bearing conditions, and alinement, lubricant contamination, and under or over-lubrication.

b. Final. During final inspection, the bearing should be operated to insure proper alinement and lubrication. In most cases, this will require an operational check of the items in which the bearing was replaced.

10-9. Gears

a. The inspector must be familiar with the operation and purpose of gears before he can determine when gears are defective and should be replaced.

b. Inspection of gears which usually are encased will have to be accomplished during an in-process inspection. The inspector should inspect, using table 10-1 as a reference, for type of gear wear and possible correction.

c. Final inspection should insure that the proper lubricants were used, the gears operate properly, and there is no leakage around seals.

10-10. Wire Rope

Inspect wire ropes to insure proper lubrication so that it will function dependably during service. Lubrication is especially critical because of exposure to weather, water washings, dust, and other contaminations. Although wire rope is lubricated when manufactured, serious damage can result through internal and external corrosion and friction if proper lubrication is not continued. Refer to lubrication order or technical manual.

10-11. Oil Seals

In any lubricating system, it is just as important to "seal in" the lubricant as it is to "seal out" contamination. The inspector can insure compliance by in-process inspection of oil seal installation and close checks for leakage.

10-12. Oil Filters

Good quality oil filters are necessary to remove contamination from oil in a circulating system. It is the inspector's responsibility to inspect to insure that proper oil filter change has been made. As a general rule, anytime maintenance is performed on any system which requires a lubricated part to be changed, the filter should also be changed. Lubrication orders should be closely followed here.

10-13. Miscellaneous

Many other items and components such as fans, motors, pumps, shafts, flexible couplings, and chains require constant lubrication, and must be inspected to assure that quality of lubricant, application methods, seals, and lubrication practices conform to standards and lubrication order requirements. A good knowledge of these components, attention to details of applicable lubrication orders, and special inspection procedures are required for adequate inspection, and assurance that components are kept in required condition.

Table 10-1. Types of Gear Wear Observed After Use

Condition	Type of gear	Probable cause	Possible correction
Abrasion	All types	Contaminants either metal or other particles	Change oil and flush out case before renewal.
Burning	All types	Lack of lubricant or overload.	Proved enough oil, decrease load if possible.
Galling	Bevel, hypoid, spiral	High surface temperature or oil film rupture.	Use means to reduce operating temperature. Check type oil being used. Change per LO.
Pitting	All types	Oil viscosity too low, rough surface, too high local pressure.	Increase oil viscosity and substitute oil, better gear surface finish. Initial pitting may cease after run-in period.
Scoring	Bevel, helical, and spur types	Too low a viscosity oil; sliding under heavy load; rough surfaces; improper tooth contact, perhaps due to misalinement; temperature low when starting.	Increase oil viscosity or use oil with EP agent, preheat before starting.

CHAPTER 11

PRESERVATION, PACKAGING, AND PACKING

11-1. General

a. This chapter contains information required for field inspection to assure that preservation, packaging, and packing conform to prescribed standards.

b. The protection of equipment from hazards of climate and transportation involves the application of packaging and packing materials. Proper cushioning (fig. 11-1) adequately prevent damage resulting from exposure to those hazards.

11-2. References

The inspector should refer to appendix A for the references applicable to preservation, packaging, and packing.

11-3. levels of Protection

a. Level A Military Pack. This is the level of packing which will afford adequate protection during shipment, handling, indeterminate storage, and worldwide redistribution.

b. Level B Limited Military Pack. This is the level of packing which will afford adequate protection against damage during multiple shipments and handling and covered storage.

c. Level C Minimum Military Pack. This is the level of packing which will afford adequate protection against damage during direct shipments from supply sources to the first receiving activity for immediate use. This level, in general, will conform to applicable carrier rules and regulations and may be the supplier's commercial pack when such meets the requirements of this level.

11-4. Application of the Levels of Packing

a. Determining Factors. Application of the levels of packing is based upon such factors as destination, use, storage conditions, and type of material to be shipped.

b. Guidelines. For the judicious establishment of requirements for levels A, B, and C, the military services have agreed upon the following guidelines:

(1) *Items for indeterminate use*. Items in this category are those for which the ultimate destination, handling, storage conditions, or storage duration is unknown and cannot be determined either at the time of procurement or when reserved, packaged, and packed at a supply activity, installation, or commercial facility.

(a) *Preservation and packaging*. Level A, military package.

(b) *Packing*. Level B, limited military pack, except when items having a probable overseas demand are individually parked in shipping containers, level A, military pack, should be used.

(2) *Items for routine overseas supply*. Items in this category are those which are to be shipped in established channels or patterns for consumption at oversea land-based destinations having favorable storage conditions.

(a) *Preservation and packaging*. Level A, military package, or level B, limited military package, as required by the nature of the item and shipping and storage experience.

(b) *Packing*. Level A, military pack, or level B, limited military pack, as required by the nature of the item and shipping and storage experience.

(3) *Items for immediate use overseas, destination known*. Items in this category are those which are to be shipped to an overseas activity for use upon receipt; for example, parts for repair of essential inoperative equipment.

(a) *Preservation and packaging*. Level B, limited military package, or level C, minimum military package, as required by the nature of the item and shipping and storage experience, except that unboxed items may require level A, military package protection.

(b) *Packing*. Level A, military pack, or level B, limited military pack, as required by the nature of the item and shipping and storage experience.

(4) Items for domestic use, redistribution expected. Items in this category are those which will be stored and redistributed in the supply system and ultimately used at a domestic activity.

(a) *Levels for known covered storage*. Preservation and packaging should be level A, military package, level B, limited military package, or level C, minimum military package, as required by the nature of the item and shipping and storage experience. Packing should be level B, limited military pack, or level C, minimum military pack, except that when water transportation is involved, packing should be in accordance with "items for routine overseas supply," above.

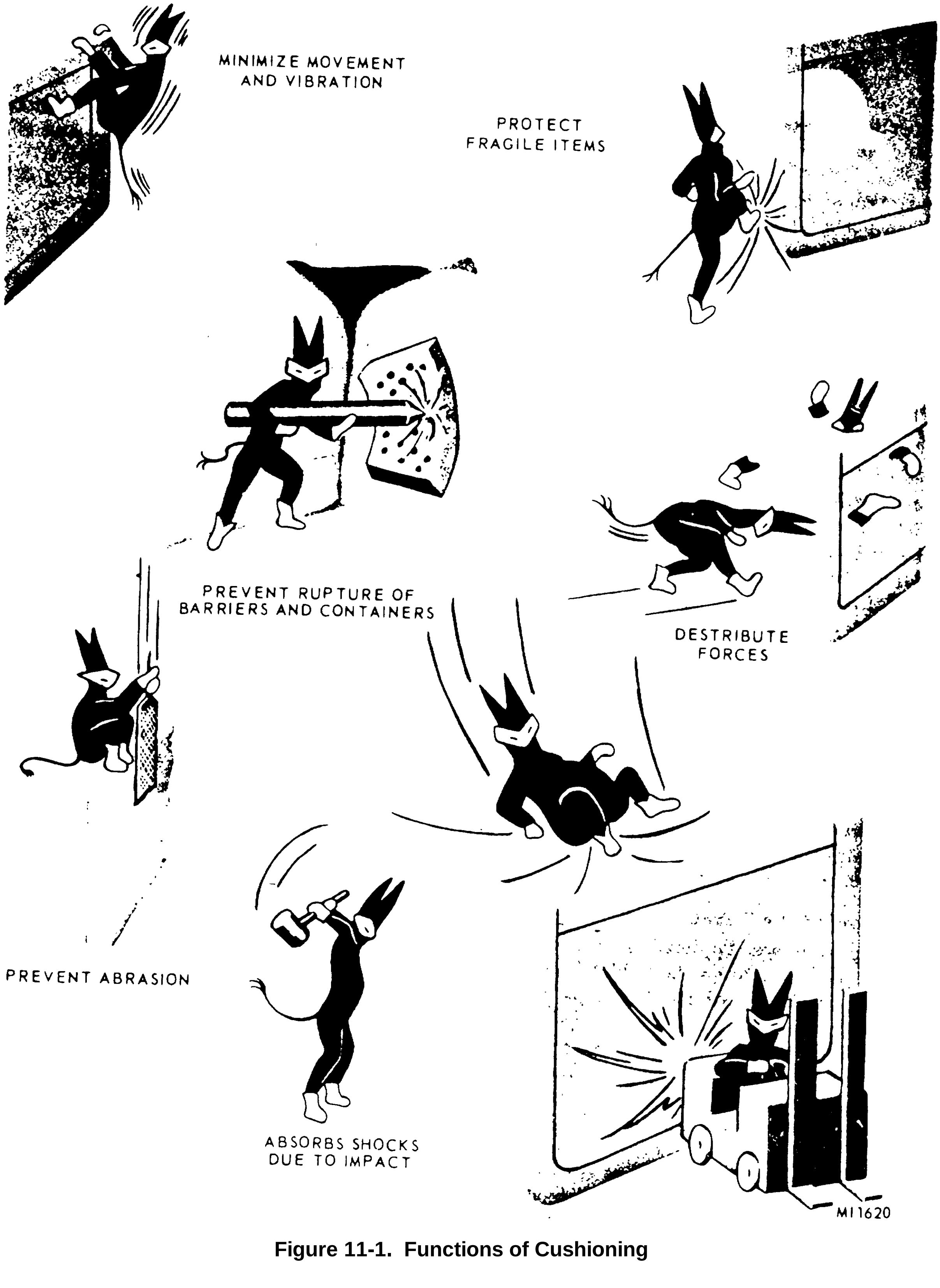


Figure 11-1. Functions of Cushioning

(b) *Levels for open storage*. Preservation and packaging should be level A, military package. Packing should be level A, military pack.

(5) *Items for immediate domestic use*. Items in this category are those which will be used upon receipt at the first domestic receiving activity.

(a) *Preservation and packaging*. Level C, minimum military package.

(b) *Packing*. Level C, minimum military pack.

c. *Packing for Domestic Shipment*. When different packaged and packed items are consolidated in a shipping container necessitating unpacking at the first receiving activity for shelf storage until selected for shipment to a second destination, level C shipping containers should be used.

11-5. Containers

a. Rigid Containers. There are at present many different containers which would fit the definition of rigid container. Examples of these are reusable metal containers, nonreusable or one-way containers, fiberboard (spirally wound) containers, glass containers, plastic containers, etc.

(1) *Reusable metal containers*. Reusable metal containers are found in two general classifications: exterior and interior.

(a) *Exterior containers*. Exterior reusable metal containers are similar to a metal drum in construction. These containers incorporate a fully removable cover with a gasket and a bolted ring closure. All parts of the container are interchangeable within each style. Exterior containers are available in seven different sizes.

(b) *Interior containers*. The interior reusable metal container is constructed of a lighter gage steel than the exterior container and is not fabricated with rolling hoops. Two styles or types of manufactured containers are procured. The first is the welded-seam construction and the second is the deep-drawn seamless style. These containers are constructed with a fully removable cover which is secured in place by means of a removable ring, bolt, and nut, Interior containers are available in eight different sizes.

(2) *Containers, metal, nonreusable*. Cans, pails, and drums. These containers are in the category generally classified as nonreusable, one-way containers and are available in a variety of types and classes and with different methods of closure.

(3) *Other rigid containers*. As already mentioned, glass, plastic, etc., can also be found in rigid container form.

(4) *Fiberboard and paperboard containers*. There are various fiberboard and paperboard containers which are acceptable.

11-6. Humidity Indicators (fig. 11-2)

Humidity indicators shall be used unless otherwise specified. As applicable, the indicator shall be located behind inspection windows or immediately within the closing edge, face, or cover of the barrier. The indicator shall be located as far as practicable from the nearest unit of desiccant. Other color change humidity indicators will be subject to approval of the procuring agency. Externally mounted indicating elements or devices, when specified, shall be installed in place, or

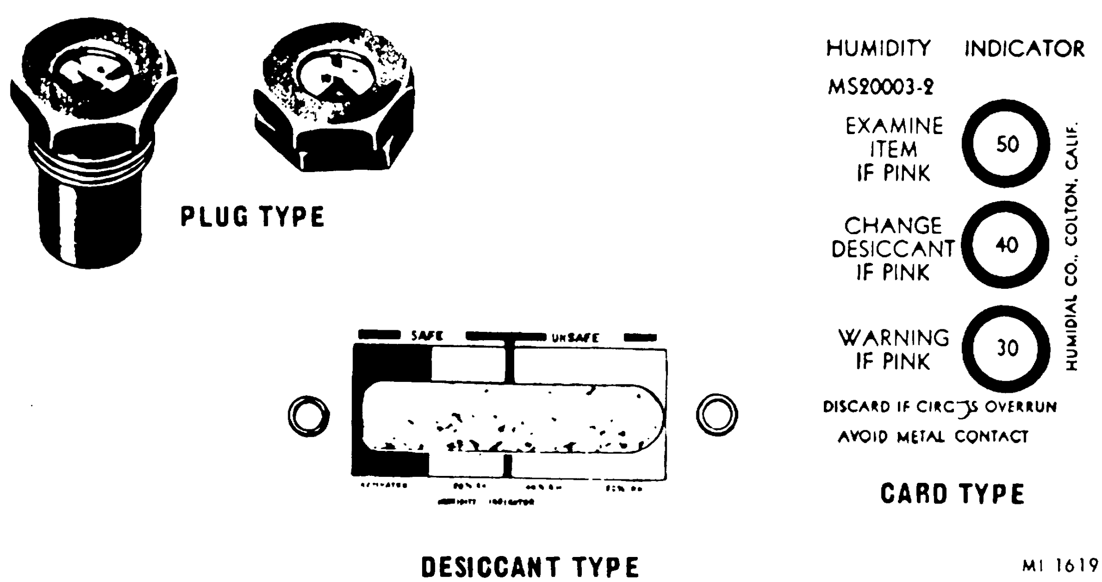


Figure 11-2. Humidity Indicators.

when required. Externally mounted color change indicators, unless otherwise specified, shall conform to specification entitled "Indicator, Humidity, Plug Color Change. This indicator is a metal, plug type which is permanently calibrated, reacts quickly to humidity change, and is used for determining relative humidity within rigid containers and flexible water-vapor-proof barriers.

Section III. INSPECTION

11-7. General

At this level, a 100 percent inspection is desirable. The procedures used may be a compilation of checklists, routing cards, inspection sheets, test procedures, or other documents normally used to define operations.

11-8. Inspection Points

The following points are based upon the assumption that the inspector will have at hand all necessary documents covering packaging and packing. These points are in addition to regular inspection procedures, such as accountability, dimensional checks, etc.

a. Are the containers or packaging materials in contact with the item chemically nonreactive to the hazardous material(s)?

b. Is movement within the container prevented or controlled by shock mount systems?

c. Does the identity of the item check with the shipping instructions and bill of lading?

d. Are the contents (if more than one item) compatible with no inert parts separately packaged?

e. Does the container qualify under the applicable requirements?

f. Is the shipping container closed in conformance with applicable requirements?

g. Are unit or intermediate container, net and gross weight, or volume within the limits allowed?

h. In addition to other required markings, is the proper shipping name shown exactly?

i. Are other required precautionary markings shown correctly?

j. Are the proper labels affixed, as required by the applicable tariff?

k. Does an empty container have obliterated explosive and hazardous markings, proper shipping names, and any explosive or hazardous label covered with the "EMPTY" label?

l. Is the classification of the material valid and correct?

m. Is the container authorized for this material correct for volume, weight, mode of transportation?

n. Is the container marked with one of the following: DOT specification, Government specification, BA number?

o. Do drums have DOT or military specification inspection schedule maintained?

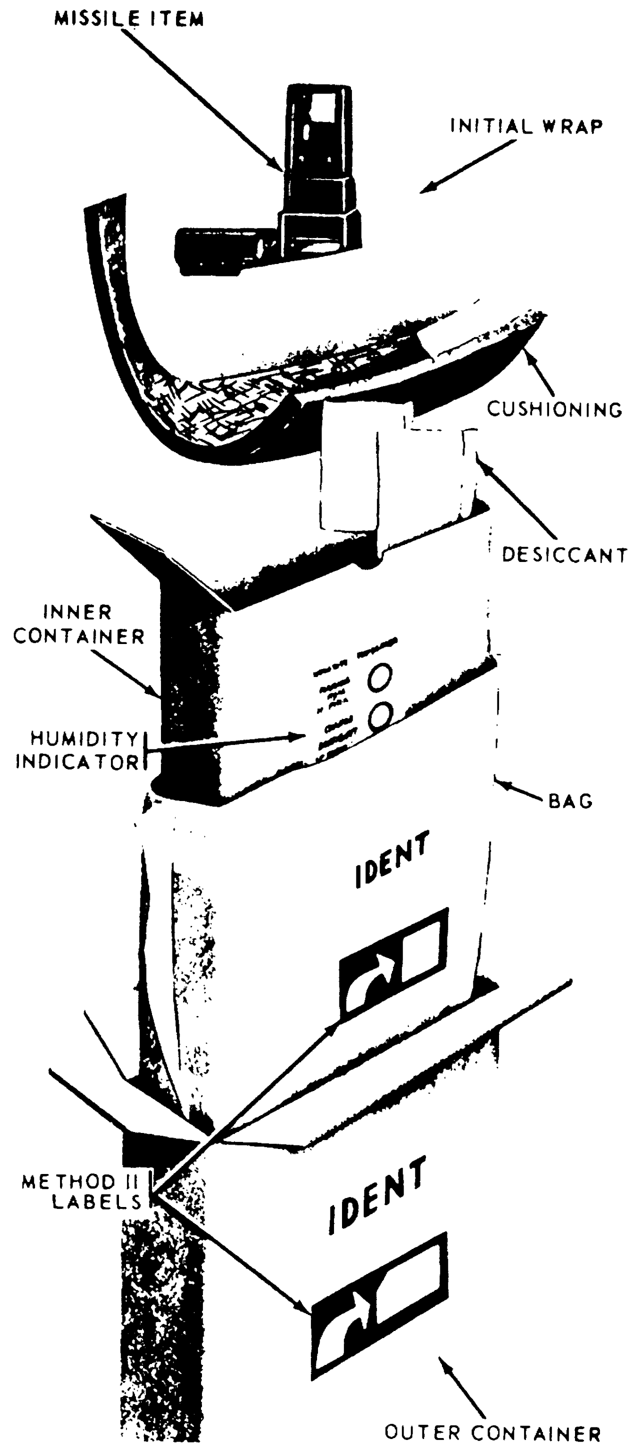


Figure 11-3. Deficiencies

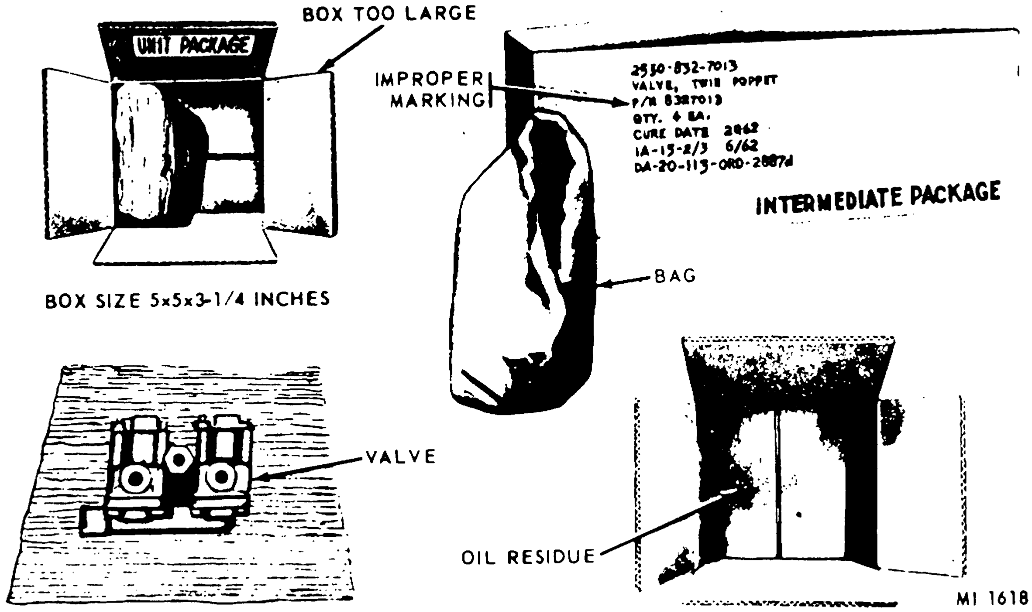


Figure 11-4. Method of Preservation, Packaging, and Packing

p. Was the DOT certification on B / L signed? (The most frequently appearing item of DD 6's.)

q. Are the nomenclature and special markings correctly shown on the container and consistent with shipping papers?

r. Was the carrier really inspected and the DD 626 filled out?

s. Are old placards removed, markings obliterated, and/or EMPTY labels affixed to empty containers (as required) before reshipment of return?

11-9. Storage Inspection

a. Preservation or Packaging (Figs. 11-3, 11-4, 11-5 and 11-6).

(1) No preservative
(2) Improper preservative
(3) Preservative improperly applied
(4) Corrosion
(5) Contamination
(6) Package improperly sealed (Fig. 11-7)
(7) Inadequate blocking or cushioning
(8) Nonspecification materials used
(9) Excessive preservation or packaging

b. Packing (Figs. 11-3, 11-4, and 11-5).

(1) Container overloaded
(2) Container crushed
(3) Container wracked
(4) Container punctured
(5) Wire or strap broken or loose
(6) Straps inadequate or inadequately fastened
(7) Frame members failed
(8) Inadequate blocking, bracing or cushioning
(9) Cleats broken
(10) Ends knocked out
(11) Sheathing broken
(12) Boards split
(13) Nails pulled
(14) Fiberboard panels torn
(15) Improper type container used
(16) Container not waterproof
(17) Nonspecification materials used
(18) Case liner damaged or unsealed
(19) Excessive packing or waste space
(20) Container came open

c. Marking.

(1) Old marking not obliterated
(2) Marking not legible
(3) Tags or labels not waterproofed
(4) Inadequate packing list protector
(5) Incorrect or incomplete marking
(6) Markings improperly applied
(7) Incorrect service markings

d. Loading, Sowage, or Handling.

(1) Load improperly trimmed
(2) Center of gravity not considered
(3) Sling damage
(4) Improper stowing

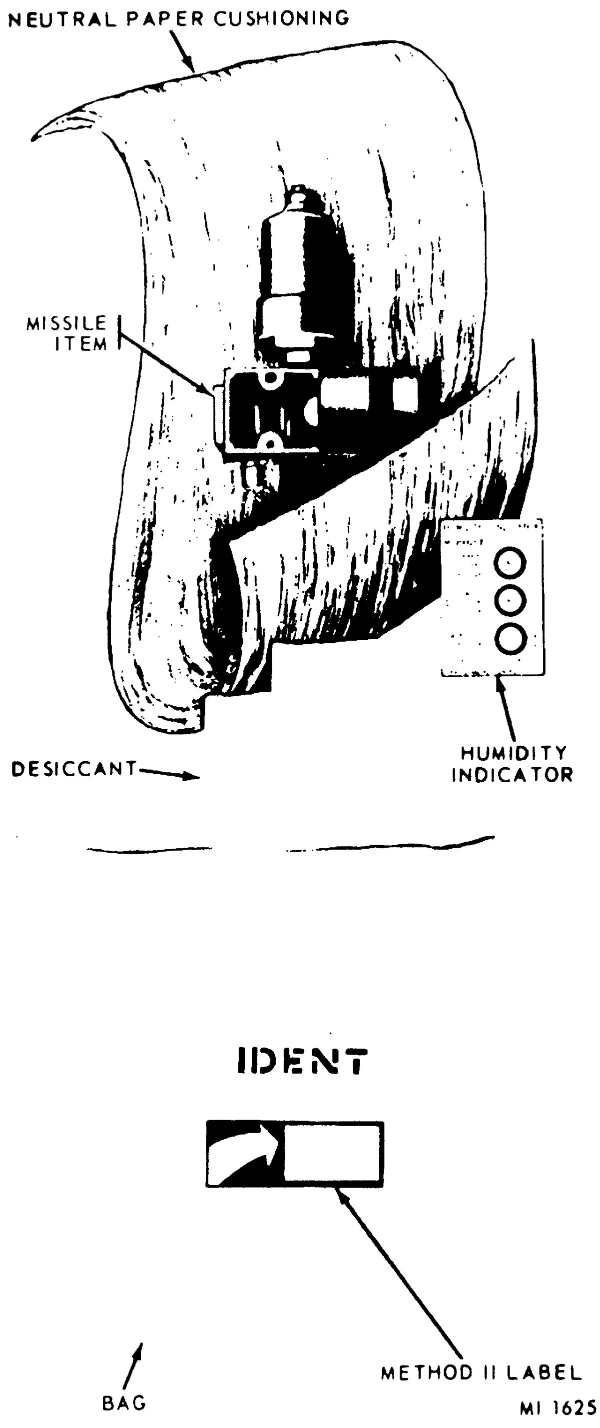


Figure 11-5. Method of Preservation and Packaging.

(5) Improperly arranged load
(6) Improper dunnaging
(7) Load not properly nested
(8) Inadequate tiedown or lashing
(9) Steel strapping failure
(10) Improper blocking or bracing
(11) Inadequate bulkhead or gate
(12) Inadequate doorway protection
(13) Rough handling
(14) Regulations violated

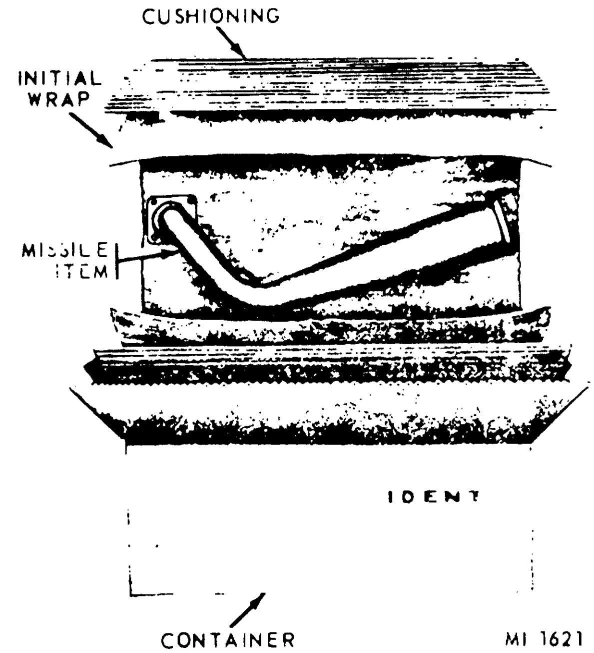


Figure 11-6. Method of Packaging and Packing Missile Items

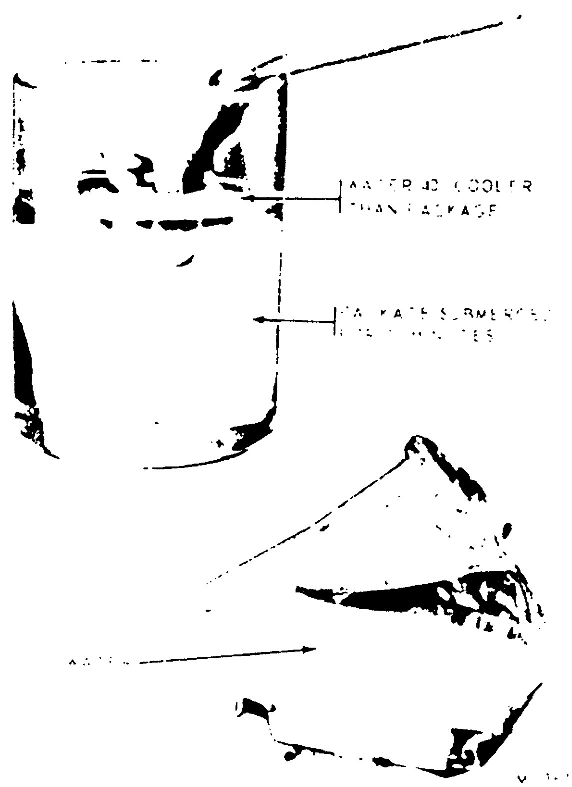


Figure 11-7. Package Failure.

APPENDIX A

REFERENCES

A-1 GENERAL

All the documents referenced in this appendix are not used in this TM, but are included as an aid to the inspector. He should obtain and familiarize himself with these documents; by doing so he will increase his knowledge and be more capable of inspecting properly.

A-2 PUBLICATION INDEXES

DA Pamphlets of the 310series and PAM 108-1 should be consulted frequently for the latest changes or revision of the references given in this Appendix and for new publications relative to the material covered in this technical manual.

A-3 OTHER PUBLICATIONS

Adhesives: Description, use, bonding techniques; properties .... TB ORD 1032
Batteries, Dry .... TB 34-9-171
Batteries, Dry, Shelf life inspection .... TB 9-6135-200-20/1
Bearings, Antifriction: Inspection; care; maintenance .... TM 9-214
Chassis, Miscellaneous (electrical equipment)
  Capacitance & resistance check .... TB 9-4900-250-50/2
  Circuit continuity check .... TB 9-4900-250-50/1
  Resistance .... TB 9-4900-250-50/8
Chassis coating compound: Description; application; etc. .... TB ORD 401
Chemical products: Storage; handling; fire precautions; safety .... TB CML 50
Chemicals, Hazardous: Storage, shipment and handling .... TM 3-250
Circuit breakers: Hand operated .... TB 34-9-182
Compressed air characteristics: Supply pressure & hoses .... TB 34-9-244
Corrosion control: Guided missile systems .... TB 9-337
Electrical communications systems: Definitions and abbreviations .... TM 11-486-11
Electrical indicating instruments, Repaired:
  Inspection requirements .... TB 11-6625-666-50
Electrical wiring .... TM 5-760
Electricity: Fundamentals .... TM 11-661
Electronic communication equipment: Military Handbook .... TM 11-487A
Frequency Techniques: Electronic .... TM 11-667
Fungus-resistant treatment: Signal equipment .... TB SIG 355-3
Gaskets: Description; application .... TB 9-225
Gaskets: Types; uses, etc. .... TB FNG 346
Glossaries: Welding terms and definitions .... TB 34-9-7
Guided missile systems: Corrosion control and treatment .... TB 9-337
Guided missiles & rockets: Painting & marking .... TB 746-92-1
Hose assemblies: Hydraulic (general) .... TB 9-1440-250-50/ 10
Hose assembly handbooks: Cross reference data .... TB 700-4720-1
Identification plates: Communication equipment .... SB 11-263
Launcher material, Rocket: Color and marking .... TB 746-95-2
Lubrication: Ordnance material .... TM 9-273
Magnesium products: Welding, joining and finishing .... TB ORD 638
Materials testing: Equipment, methods .... TM 5-530
Materiel, Pre-positioned: Inspection, care & preservation .... TM 38-450
Name plates: Communication equipment .... SB 11-263

Oil seals: Description; application .... TB 9-255
Optics: Handbook for the laboratory specialist .... TM 9-237
Ordnance materiel:
Calibration of test equipment .... TB ORD-1026 / series
Cleaning: methods, materials, etc .... TM 9-208-1
Cleaning, preserving, abrading, etc., materials .... TM 9-247
Inspection: radiographic method .... TB ORD 1034
Lubrication .... TM 9-273
Packaging: Army general supplies .... SB 9-156
Packing: Supplies and equipment .... SB 38-100
Packing (for sealing joints):
Description; application .... TB 9-255
Types; uses; etc. .... TB ENG 346
Painting: Field use, instructions .... TM 9-213
Painting and marking: Guided missiles and rockets .... TB 746-92-1
Pneumatic equipment: Maintenance & repair .... TB ENG 28
Preservative materials: Rubber preservative coaring .... TB 9-248
Radar: Pulse system performance: Theory; measurement T .... TM 11-759
Radio equipment: Trouble shooting and repair .... TM 11-4000
Rocket launcher materiel: Color and marking .... TB 746-95-2
Servo systems: Electronic .... TM 11-674
Solder & soldering: Materials; methods, equipment .... TB SIG 222
Supplies & equipment, Military: Preservation, packaging,
packing .... TM 38-230-1
Terms and definitions .... TB 34-9-256
Threads: Line pipe, valves, fittings and flanges .... TB 34-9-71
Tires, Pneumatic: Care; maintenance .... TM 9-1870-1
Tires, Solid-rubber: Identification; inspection;
classification; maintenance; disposition .... TM 9-2630-200-14
Tires & tubes, Pneumatic: Repair and rebuild .... TM 9-1871
Training: Radio repair personnel .... TM 11-477
Transistors: Basic theory; applications .... TM 11-690
Transmission lines: Radio frequency .... TM 11-675
Transmission lines: Theory; practice .... TM 11-679
Tubes, Electron: Basic theory & application .... TM 11-662
Welding: Design, procedures & inspection .... TM 5-805-7
Welding Machine, Arc: General and inert gas shielded
Transformer-Rectifier type, ac and dc; 300 Ampere rating
at 60 percent duty cycle .... TM 5-3431-213-15
Welding set, arc inert gas shielded consumable metal electrode
for 3/64 in. wire, dc, 115 v .... TM 5-3431-311-15
Welding terms and definitions: Glossary .... TB 34-9-67
Wire rope: Standardization .... TB 34-9-125

APPENDIX B

GLOSSARY

B-1. GENERAL

This appendix is used by the inspector to find abbreviations, symbols, definitions of terms, color code tables, temperature charts, and other general information which will assist during inspection.

B-2. ABBREVIATIONS

The abbreviations listed below are those authorized. These abbreviations may appear in the system documentations, inspection forms, or other applicable documents.

AA............................... two hundred fifty
ABEC........................... Annular Bearing Engineering Committee
AC .... alternating current
ADPT .... adapter
AL .... aluminum
AL-ALLOY.................... aluminum alloy
AL-BZ .... aluminum bronze
ALLOY-S...................... alloy steel
AMP............................ ampere(s)
ANLD .... annealed
ANODIC-FIN................ anodic finish
ANPT .... Aeronautical National Taper Pipe Thread
AR .... as required
ASB .... asbestos
AV............................... twenty five
AWG........................... American Wire Gage
AX............................... twenty
BA............................... bale
BAY .... bayonet (lamp base)
B-HD........................... button head
BDG-HD...................... binding head
BG .... bag
BK............................... book
BL .... barrel
BLK............................. Color Coding (electric cable identification) black
BLU............................. Color Coding (electric cable identification) blue
BLUNT-PT .... blunt point
BR .... brass
BRGT.......................... bright
BRN............................ Color Coding (electric cable identification) brown
BT............................... bottle
BX............................... box (es)
BZ............................... bronze
C.................................. centigrade, cycle(s), hundred
CA .... can, cartridge
CAND .... candelabra
CAND-BAY-BASE........ candelabra bayonet base
CARB.......................... carbon
CARB-S .... carbon steel
CD .... cadmium
CD- OR ZN-PLTD .... cadmium- or zinc-plated
CD-PLTD .... cadmium-plated
CFM............................ cubic feet per minute
CHAM .... chamfered)
CHG............................ change
CI................................. cast iron
CK .... countersunk
CK-HD .... countersunk head
C / L............................ center line
CL................................ coil
CN .... can
CNTR OR CR .... container
C / O .... consists of
CO .... container
COAX .... coaxial
COLD-FIN-S .... cold-finished steel
CONE-PT.................... cone point
COND .... conductor(s)
COP............................ copper
COP-PLTD.................. copper plated
CORR-RES-S .... corrosion-resistant steel
COT .... cotton
CP .... concrete piercing, candle power
CPS .... cycles per second
CROSS-RECESS-RD-HD .... cross recess round head
CROSS-RECESS-TR-HD .... cross recess truss head
CR-PLTD .... chromium plated
CT............................... carton
CTD .... coated
C TO C .... center to center
CUP-PT .... cup point
CUR............................ current
CY .... cylinder(s)
DBLE .... double
DBLE-CONTACT .... double contact
DC .... direct current
DEG............................ degree(s)
DIA .... diameter
DIM............................. dimension(s) (al)

DLD	drilled
DLD-F / C-PIN	drilled for cotter pin
DLD-F / LKG-WIRE	drilled for locking wire
DOG-PT	dog point
DP	double-pole
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DR	double-row, drum
DT	double-throw
DZ	dozen
EA	each
ENMLD	enameled
EN	envelope
ENV	envelope
ETC	et cetera (and so forth)
EXTER	external
EXT-TEETH	external teeth (lock washer)
F	Fahrenheit
FASTNR	fastener
FBR	fiber
FC	fire control
FED SPEC	Federal Specification
FIGS	figures
FIL	filament(s)
FIL-HD	fillister head
FIN	finish(ing)
FL	flat
FL-CK-HD	flat countersunk head
FL-FIL-HD	flat fillister head
FL-HD	flat head
FL-PT	flat point
FLGD	flanged
G	Color Coding (electric cable identification) gold
GA	gage, gallon(s)
GL	gallon(s)
GLVD	galvanized
GM	gram (s)
GR	grain(s), gross
GRN	Color Coding (electric cable identification) green
GY	Color Coding (electric cable identification) gray
H	height, high
HALF-RD	half round
HD	head, hundred
HDL	handle(d)
HDLS	headless
HEX	hexagon(al)
HEX-HD	hexagon head
HEX-SOCKET	hexagon socket
HEX-SOCKET-HD	hexagon socket head
HF	hundred feet
HP	horsepower
HY	henry(ies)
I	iron
ID	inside diameter(s) (dimension)
INCAND	incandescent
IND	inductance, induction
INS	insulated, insulating, insulator
INST	instantaneous
INT	internal
INT-TEETH	internal teeth (lock washer)
JT	joint
KC	kilocycle(s)
KG	keg
KNURLED-HD	knurled head
KT	kit
KV	kilovolt(s)
KW	kilowatt(s)
LACQD	lacquered
LEA	leather
LG	long (length)
LH	left hand
LIN	linear
LKG	locking
LL	fifty
LUBR	lubricator, lubricating, lubrication
MA	milliampere(s)
MACHST	machinist
MC	megacycle(s)
MED	medium
MEG	megohm(s)
MF	thousand ft
MH	millihenry(ies)
MI	malleable iron
MIN	miniature
MIN-BAY-BASE	miniature bayonet base
MM	millimeter(s)
MTG	mounting(s)
MTL	metal
MX	thousand
NC	American National Coarse Thread
NEF	American National Extra Fine Thread
NF	American National Fine Thread
NI	nickel
NI-PLTD	nickel plated
NI-SIL	nickel silver
NOM	nominal
NPT	American Standard Taper Pipe Threads
NPTF	American Standard Taper Pipe Threads (Dryseal)
NS	American National Special Thread
OD	outside diameter (dimension), olive drab
OPNG	opening

ORN	Color Coding (electric cable identification) orange
OVAL-HD	oval head
OZ	ounce(s)
PAN-HD	pan head
PAPR	paper
PASS-FIN	passivated-finish
P-BZ	phosphor bronze
PC	piece(s)
PG	package
PHOS-C'D	phosphate coated
PKG	package
PL	plate, pail
PLTD	plated
POS	positive
PR	Color Coding (electric cable identification) purple, pair
PRI	primary
PT	pint
PTF	pipe thread fine
PY	pyramid
QT	quart(s)
RAD	radial, radius
RD-END	round end
RD-HD	round head
RE	reel
RECEP	receptacle
RECT	rectangular
RH	right hand
RL OR RO	roll
RMS	root mean square
RPM	revolutions per minute
RU	rubber
S	steel
SE	set
SEC	second(s) (time interval)
SECS	sections
SF OR SQ FT	square foot
SGLE	single
SGLE-COND	single conductor
SGLE-CONTACT	single contact
SGLE-PH	single phase
SGLE-TUN-FIL	single tungsten filament
SH	sheet
SHK	shank
SIL-PLTD	silver plated
SL	spool
SLTD	slotted
SM	smooth
SOCKET-HD	socket head
SP	single-pole, spool
SPDT	single-pole, double-throw
SPG	spring
SPG-S	spring steel
SPST	single-pole, single-throw
SQ	square
SQ-DRIVE	square drive
SQ-END	square end
SQ-HD	square head
SR	single-row
ST	single-throw, set
STABIL	stabilotron
STGHT	straight
STLS-S	stainless steel
SV	sleeve
SW	switch
SY OR SQ YD	square yard
SYN	synthetic
SYN-RU	synthetic rubber
TEMP	temperature
TERM	terminal(s)
THD	thread(ed) (s)
THK	thick(ness)
TND	tinned
TND-COP	tinned copper
TN-PLTD	tin plated
TOL	tolerance
TR	tracer(s), transmit-receive
TU	tube
TUBR	tubular
TUN-FIL	tungsten filament
UA	microampere(s)
UF	microfarad(s)
UH	microhenry(ies)
UNC	Unified Coarse Thread
UNEF	Unified Extra Fine Thread
UNF	Unified Fine Thread
UNIV-JT	universal joint
U / 0	used on
USEC	microsecond(s)
UUF	micromicrofarad(s)
U/W	used with
V	volt(s)
VAR	variable
VIO	Color Coding (electric cable identification) violet
VUL	vulcanize(d)
VX	five
W	watt(s), wide, width
W /	with
W / E	with equipment
WH	watt-hour(s)
WHT	Color Coding (electric cable identification) white
W / O	without
W TR PRF	waterproofed
X	by (as in 2 x 4)
XX	ten
YD	yard(s)
YEL	Color Coding (electric cable identification) yellow
ZN	zinc
ZN-CTD	zinc-coated
ZN-PLTD	zinc-plated

B-3. DEFINITIONS AND TERMS

A

ABRASIVES: Emery cloth or aluminum oxide cloth grit size 300 to 400 shall be used for cleaning cold, surface treated soldering iron tips and resistance heating electrode tips. The use of abrasives for cleaning plated soldering iron tips should be limited to only experienced maintenance personnel. This type of cleaning is rarely required where soldering iron holders are utilized.

ABRASIVE WEAR: Wear due to hard particles such as sand, metal, etc., between the surfaces.

ACETONE: A flammable, volatile liquid used in acetylene cylinders to dissolve and stabilize acetylene under high pressure.

ACETYLENE: A highly combustible gas composed of carbon and hydrogen. Used as a fuel gas in the oxy-acetylene welding process.

ACTUAL THROAT: See throat of fillet weld.

ADHESIVE WEAR (GALLING WEAR): High surface temperature or oil film rupture wear.

AIR ACETYLENE: A low temperature flame produced by burning acetylene with air instead of oxygen.

ALLOY: A mixture with metallic properties composed of two or more elements of which at least one is a metal.

ALLOY: A mixture with metallic properties composed of two or more elements of which at least one is a metal.

ANILINE POINT: The critical solution temperature of a 50-50 mixture of the oil in question with aniline.

ANTI-WICKING TOOL: Special shaped holding type tweezers, designed to stop capillary flow of liquid solder to prevent wicking of stranded conductors. These are manufactured to fit the different wire sizes. These may be used as thermal shunts during the soldering operation.

ARC BLOW: The swerving of an electric arc from its normal path because of magnetic forces.

ARC BRAZING: An electric brazing process wherein the heat is obtained from an electric arc formed between the base metal and an electrode, or between two electrodes.

ARC CUTTING: A group of cutting processes in which the severing of metals is accomplished by melting with the heat of an arc between an electrode and the base metal. See carbon-arc cutting, metal-arc cutting and oxy-arc cutting, and air-arc cutting.

ARC WELDING: A group of welding processes in which a fusion is produced by heating with an electric arc of arcs, with or without the use of filler metal.

AS WELDED: The condition of weld metal, welded joints, and weldments after welding and prior to any subsequent thermal or mechanical treatment.

ATOMIC HYDROGEN WELDING: An arc welding process in which a fusion is produced by heating with an electric arc maintained between two metal electrodes in an atmosphere of hydrogen. Pressure and / or filler metal may or may not be used.

AXIS OF A WELD: A line through the length of a weld, perpendicular to a cross section at its center of gravity.

B

BACK PASS: A pass made to deposit a back weld.

BACK STEP: A sequence in which weld bead increments are deposited in a direction opposite to the direction of progress.

BACK WELD: A weld deposited at the back of a single groove weld.

BACK FIRE: The momentary burning back of a flame into the tip, followed by a snap or pop, then immediate reappearance or burning out of the flame.

BACKHAND WELDING: A welding technique in which the flame is directed towards the completed weld.

BACKING STRIP: A piece of material used to retain molten metal at the root of the weld and / or increase the thermal capacity of the joint so as to , prevent excessive warping of the base metal.

BACKING WELD: Backing in the form of a weld.

BACK UP: In flash and upset welding, a locator used to transmit all or a portion of the upsetting force to the work pieces.

BARE ELECTRODE: An arc welding electrode that has no coating other than that incidental to the drawing of the wire.

BARE METAL-ARC WELDING: An arc welding process in which fusion is produced by placing an unshielded arc between a bare or lightly coated electrode and the work. Pressure is not used and filler metal is obtained from the electrode.

BASE METAL: The metal to be welded or cut. In alloys it is the metal present in the largest proportion.

BEAD WELD: A type of weld composed of one or more string or weave beads deposited on an unbroken surface.

BEADING: See string bead and weave bead.

BEVEL ANGLE: The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member.

BLACKSMITH WELDING: See forge welding.

BLOCK BRAZING: A brazing process in which fusion is produced by the heat obtained from heated blocks applied to the parts to be joined and by a nonferrous filler metal having a melting point above 800 deg F, but below that of the base metal. The filler metal is distributed in the joint by capillary attraction.

BLOCK SEQUENCE: A building up sequence of continuous multipass welds in which separated lengths of the weld are completely or partially built up before intervening lengths and deposited. See buildup sequence.

BLOW HOLE: See gas pocket.

BOND: The junction of the welding metal and the base metal.

BOXING: The operation of continuing a fillet weld around a corner of a member as an extension of the principal weld.

BRAZE WELDING: A method of welding in which a groove, fillet, plug or slot weld is made by using a nonferrous fillet metal having a melting point below that of the base metals but above 800 deg F. The filler metal is not distributed in the joint by capillary attraction.

BRAZING: A group of welding processes in which fusion is produced by heating to a suitable temperature above 800 deg F, and by using a nonferrous filler metal having a melting point below that of the base metals. Filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.

BRIDGING: A welding defect caused by poor penetration. A void at the root of the weld is spanned by weld metal.

BUCKLING: Distortion caused by the heat of a welding process.

BUILDUP SEQUENCE: The order in which the weld beads of a multipass weld are deposited with respect to the cross section of a joint. See block sequence.

BUTT JOINT: A joint between two base metals in such a manner that the weld joining the parts is between the surface planes of both the parts joined.

BUTT WELD: A weld in a butt joint.

C

CAPILLARY ATTRACTION: The phenomenon by which adhesion between the molten filler metal and the base metals, together with surface tension of the molten filler metal, causes distribution of the filler metal between the properly fitted surfaces of the joint to be brazed.

CARBON ARC CUTTING: A process of severing metals with the heat of a carbon arc.

CARBON ARC WELDING: A welding process in which fusion is produced by placing an arc between a carbon electrode and the work. Pressure and / or filler metal and / or shielding may or may not be used.

CARBON RESIDUE: The carbon deposit left after subjecting an oil to high temperatures.

CARBURIZING FLAME: An oxy-acetylene 'flame in which there is an excess of acetylene. Also called excess acetylene or reducing flame.

CASCADE SEQUENCE: Subsequent beads are stopped short of a previous bead giving a cascade effect.

CHAIN INTERMITTENT FILLET WELDS: Two lines of intermittent filler welds in a T or lap joint in which the welds in one line are approximately opposite those in the other line.

CHAMFERING: The preparation of a contour, other than for a square groove weld for welding on the edge of a member.

CLEANING MATERIAL: Clean, white, lint-free cloth or tissue used with approved solvents to clean soldered joints.

CLEANING SOLVENTS: Tetrachloroethylene, Perchloroethylene, Trichloroethane and Isopropy Alcohol are the approved cleaning solvents for cleaning solder connections.

COATED ELECTRODE: An electrode having a flux applied externally by dipping, spraying, painting or other similar methods. Upon burning the coat produces a gas around the arc.

COLD SOLDER JOINT: A cold solder joint is the result of insufficient heat to enable the solder to flow. Quite recognizable, this joint has a piled up, rough surface, chalky, without metallic luster.

COMMUTATORY CONTROLLED WELDING: The making of a number of spot or projection welds in which several electrodes, in simultaneous contact with the work, progressively function under the control of an electrical commutating device.

COMPOSITE ELECTRODE: A filler metal electrode used in arc welding, consisting of more than one metal component combined mechanically. It may or may not include materials that improve the properties of the weld, or stabilize the arc.

COMPOSITE JOINT: A joint in which a thermal and mechanical process is used to unite the base metal parts.

CONCAVITY: The maximum distance from the face of a concave fillet weld perpendicular to a line joining the toes.

CONCURRENT HEATING: Supplemental heat applied to a structure during the course of welding.

CONE: The conical part of a gas flame next to the orifice of the tip.

CONVEXITY: The maximum distance from the face of a convex fillet weld perpendicular to a line joining the toes.

CORNER JOINT: A joint between two members located approximately at right angles to each other in the form of an L.

CORROSIVE WEAR: Wear due to atmospheric or chemical corrosion.

COVER GLASS: A clear glass used in goggles, hand shields, and helmets to protect the filter glass from splattering material.

COVERED ELECTRODE : A metal electrode with a covering material which stabilizes the arc and improves the properties of the welding metal. The material may be an external wrapping of paper, asbestos and other materials or flux covering.

CRATER: A depression at the termination of an arc weld.

CURRENT DENSITY: Amperes per square inch of the electrode sectional area.

CUTTING TIP: A gas torch tip especially adapted for cutting.

CUTTING TORCH: A device used in gas cutting for controlling the gases used for preheating and the oxygen used for cutting the metal.

CYLINDER: A portable cylindrical container used for transportation and storage of a compressed gas.

D

DENT: A slight hollow in a surface, generally circular in shape and having a low point near the center of the circular area. The surface is not cut.

DEPOSITED METAL: Filler metal that has been added during a welding operation.

DEPOSITION EFFICIENCY: The ratio of the weight of deposited metal to the net weight of electrodes consumed exclusive of stubs.

DEPTH OF FUSION: The distance from the original surface of the base metal to that point at which the fusion ceases in a welding operation.

DEWETTING. Separation of printed or plated circuits from the circuit board. This is usually the result of excessive heat being applied during soldering operations. Also, failure of solder to flow when reworking a solder joint due to contamination.

DIE: a. Resistance Welding. A member, usually shaped to the work contour, used to clamp the parts being welded and conduct the welding current.

b. Forge Welding. A device used in forge welding primarily to form the work while hot and apply the necessary pressure.

DIE WELDING: A forge welding process in which fusion is produced by heating in a furnace and by applying pressure by means of dies.

DIP BRAZING: A brazing process in which fusion is produced by heating in a molten chemical or metal bath and by using a nonferrous filler metal having a melting point above 800 F, but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.
When a metal bath is used the bath provides the filler metal.

DRAG: The horizontal distance between the entrance and the point of exit of a cutting oxygen stream.

DROPPING POINT: The temperature at which a grease will pass from a semisolid to a fluid state.

E

EDGE JOINT: A joint between the edges of two or more parallel or nearly parallel members.

EDGE PREPARATION: The contour prepared on the edge of a member for welding.

EFFECTIVE LENGTH OF WELD: The length of a weld throughout which the correctly proportioned cross section exists.

ELECTRODE: a. Metal Arc - Filler metal in the form of a wire or rod, whether bare or covered, through which current is conducted between the electrode holder and the arc.

b. Carbon Arc - A carbon or graphite rod through which current is conducted between the electrode holder and the arc.

c. Atomic Hydrogen - One of the two tungsten rods between the points of which the arc is maintained.

d. Electrolytic Oxygen-Hydrogen Generation The conductors by which current enters and leaves the water, which is decomposed by the passage of the current.

e. Resistance Welding The part or parts of a resistance welding machine through which the welding current and the pressure are applied directly to the work.

ELECTRODE FORCE: a. Dynamic In spot, seam, and projection welding, the force (pounds) between the electrodes during the actual welding cycle.

b. Theoretical In spot, seam, and projection welding, the force, neglecting friction and inertia, available at the electrodes of a resistance welding machine by virtue of the initial force application and the theoretical mechanical advantage of the system.

c. Static In spot, seam, and projection welding, the force between the electrodes under welding conditions, but with no current flowing and no movement in the welding machine.

ELECTRODE HOLDER: A device used for mechanically holding the electrode and conducting current to it.

ELECTRODE SKID: The sliding of an electrode among the surface of the work during spot, seam, or projection welding.

EMULSIFICATION: The tendency of an oil to mix with water.

ETCHING: A process of preparing metallic specimens and welds for macrographic or micrographic examination.

F

FACE OF WELD: The exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done.

FACE SHIELD: A protective device to be worn on the head for shielding the face and neck.

FATIGUE WEAR: Wear due to excessive use, surface irregularities, and other defects. Often not due to lubricant failure.

FAYING SURFACE: That surface of a member that is in contact with another member to which it is joined.

FILLER METAL: Metal to be added in making a weld.

FILLET WELD: A weld of approximately triangular cross section, as used in a lap joint, tie joint or corner joint, joining two surfaces at approximately right angles to each other.

FILM FAILURE: Failure of a lubricating film when the load is so extreme at the point of maximum pressure as to squeeze the film down to the point of boundary lubrication.

FILTER GLASS: A colored glass used in goggles, helmets, and shields to exclude harmful light rays.

FIRE POINT: The temperature at which the vapors continue to burn when mixed with air and ignited.

FLAME CUTTING: See oxygen cutting.

FLAME GOUGING: See oxygen gouging.

FLAME HARDENING: A method for hardening a steel surface by heating followed by a rapid quench.

FLAME SOFTENING: A method for softening steel by heating with a gas flame followed by slow cooling.

FLASH: Metal and oxide expelled from a joint made by a resistance welding process.

FLASH POINT: The temperature at which the vapors will ignite momentarily when mixed with air and exposed to an open (open cup) or closed cup.

FLASH WELDING: A resistance welding process in which fusion is produced, simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to the flow of current between two surfaces and by the application of pressure after heating is substantially completed. Flashing is accompanied by expulsion of metal from the joint.

FLASHBACK: The burning of gases within the torch or beyond the torch in the hose, usually with a shrill, hissing sound.

FLAT POSITION: The position in which welding is performed from the upper side of the joint and the face of the weld is approximately horizontal.

FLOC POINT: The floc point is the point (temperature) at which wax crystals precipitate from a mixture of the oil to be tested and a refrigerant.

FLOW BRAZING: A process in which fusion is produced by heating with a molten nonferrous filler metal poured over the joint until the brazing temperature is attained. See brazing.

FLOW WELDING: A process in which fusion is produced by heating with molten filler metal poured over the surfaces to be welded until the welding temperature is attained and the required filler metal has been added. The filler metal is not distributed in the joint by capillary attraction.

FLUX: A cleaning agent used to dissolve oxides, release trapped gases and slag and to cleanse metals for welding, soldering and brazing.

FOREHAND WELDING: A gas welding technique in which the flame is directed against the base metal ahead of the completed weld.

FORGE WELDING: A group of welding processes in which fusion is produced by heating in a forge or furnace and by applying pressure or blows.

FREE BEND TEST: A method of testing weld specimens without the use of a guide.

FRETTING CORROSION: Corrosion caused by vibration, high pressure, and oxidation. This results when parts hold a load for a considerable period without moving.

FRACTURED SOLDER JOINT: This is the result of allowing soldered components to move, while the solder is in a plastic state. Looks similar to a cold solder joint, however, close examination will show fatigue-like cracks 90 degrees to direction of movement.

FULL FILLET WELD: A fillet weld whose size is equal to the thickness of the thinner member joined.

FURNACE BRAZING: A process in which fusion is produced by the furnace heat and a nonferrous filler metal having a melting point above 800 deg F, but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

FUSION: A thorough and complete mixing between the two edges of the base metal to be joined or between the base metal and the filler metal added during welding.

FUSION ZONE (FILLER PENETRATION): The area of base metal melted as determined on the cross section of a weld.

G

GAS POCKET: A weld cavity caused by the trapping of gases released by the metal when cooling.

GAS WELDING: A process in which the welding heat is obtained from a gas flame.

GOGGLES: A device with colored lenses which protect the eyes from harmful radiation during welding and cutting operations.

GRAVITY: Weight per volume. The petroleum industry uses the specific gravity or the API scales "Gravity is of little significance as an index of the quality of oil."

GROOVE: The opening provided between two members to be joined by a groove weld.

GROOVE ANGLE: The total included angle of the groove between parts to be joined by a groove weld.

GROOVE FACE: That surface of a member included in the groove.

GROOVE RADIUS: The radius of a JF or UF groove.

GROOVE WELD: A weld made by depositing filler metal in a groove between two members to be joined.

GROUND CONNECTION: The connection of the work lead to the work.

GROUND LEAD: See work lead.

GUIDED BEND TEST: A bending test in which the test specimen is bent to a definite shape by means of a jig.

H

HAMMER WELDING: A forge welding process.

HAND SHIELD: A device used in arc welding to protect the face and neck. It is equipped with a filter glass lens and is designed to be held by hand.

HARD SURFACING: The application of a hard, wear resistant alloy to the surface of a softer metal.

HEAT AFFECTED ZONE: That portion of the base metal whose structure or properties have been changed by the heat of welding or cutting.

HEAT TIME: The duration of each current impulse in pulsation welding.

HEATING GATE: The opening in a thermal mold through which the parts to be welded are preheated.

HELMET: A device used in arc welding to protect the face and neck. It is equipped with a filter glass and is designed to be worn on the head.

HOLDER SOLDERING IRON: A cage-like device to dissipate heat from a soldering iron when not in actual use for soldering operations. The holder prevents overheating of soldering irons, thus preventing buildup of oxides on the tips. This extends the life of the tip and provides easier soldering iron maintenance.

HOLD TIME: The time that pressure is maintained at the electrodes after the welding current has stopped.

HORIZONTAL WELD: A bead or butt welding process with its linear direction horizontal or inclined at an angle less than 45 degrees to the horizontal, and the parts welded being vertically or approximately vertically disposed.

HORN: The electrode holding arm of a resistance spot welding machine.

HORN SPACING: In a resistance welding machine, the unobstructed work clearance between horns or platens at right angles to the throat depth. This distance is measured with the horns parallel and horizontal at the end of the downstroke.

HOT SHORT: A condition which occurs when a metal is heated to that point, prior to melting, where all strength is lost but the shape is still maintained.

HYDROGEN BRAZING: A method of furnace brazing in a hydrogen atmosphere.

HYDROMATIC WELDING: See pressure controlled welding.

I

IMPREGNATED-TAPE METAL-ARC WELDING: An arc welding process in which fusion is produced by heating with an electric arc between a metal electrode and the work. Shielding is obtained from decomposition of an impregnated tape wrapped around the electrode as it is fed to the arc. Pressure is not used, and filler metal is obtained from the electrode.

INDUCTION BRAZING: A process in which fusion is produced by the heat obtained from resistance of the work to the flow of induced electric current and by using a nonferrous filler metal, having a melting point above 800 degrees F, but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

INDUCTION WELDING: A process in which fusion is produced by heat obtained from resistance of the work to the flow of induced electric current, with or without the application of pressure.

INERT-GAS CARBON-ARC WELDING: An arc welding process in which fusion is produced by heating with an electric arc between a carbon electrode and the work. Shielding is obtained from an inert gas such as helium or argon. Pressure and / or filler metal may or may not be used.

INERT-GAS METAL-ARC WELDING (MIG): An arc welding process in which fusion is produced by heating with an electric arc between a metal electrode and the work. Shielding is obtained from an inert gas such as helium or argon. Pressure and/ or filler metal may or may not be used.

INERT-GAS SHIELDED-ARC WELDING (TIG): An arc welding process in which fusion is produced by heating with an electric arc between a tungsten electrode and the work while an inert gas flows around the weld area to prevent oxidation. No flux is used.

INTERPASS TEMPERATURE: In a multipass weld, the lowest temperature of the deposited weld metal before the next pass is started.

J

JOINT: That portion of a structure in which separate base metal parts are joined.

JOINT PENETRATION: The maximum depth a groove weld extends from its face into a joint, exclusive of reinforcement.

K

KERF: The space from which metal has been removed by a cutting process.

L

LAP JOINT: A joint between two overlapping members.

LAYER: A stratum of weld metal, consisting of one or more weld beads.

LEG OF A FILLET WELD: The distance from the root of the joint to the toe of the fillet weld.

LOCAL PREHEATING: Preheating a specific portion of a structure.

LOCAL STRESS RELIEF HEAT TREATMENT: Stress relief heat treatment of a specific portion of a structure.

LUBRICANT BASE: The type of soap (sodium, lime, lithium, lead, aluminum, etc.) used in the manufacture of greases.

M

MAGNETIC INDUCTION: Flux per unit cross-sectional area, flux density.

MASH SEAM WELDING: A seam weld made In a lap joint in which the thickness at the lap is reduced plastically to approximately the thickness of one of the lapped joints.

MELTING POINT: The temperature at which a metal begins to liquify.

MELTING RATE: The weight or length of electrode melted in a unit of time.

METAL ARC CUTTING: The process of severing metals by melting with the heat of the metal are.

METAL ARC WELDING: An arc welding process in which a metal electrode is held so that the heat of the arc fuses both the electrode and the work to form a weld.

METALLIZING: A method of overlay or metal bonding to repair worn parts.

MIXING CHAMBER: That part of a welding or cutting torch in which the gases are mixed for combustion.

MULTI-IMPULSE WELDING: The making of spot, projection, and upset welds by more than one impulse of current. When alternating current is used each impulse may consist of a fraction of a cycle or a number of cycles.

N

NEUTRAL FLAME: A gas flame in which the portion used is neither oxidizing or reducing.

NEUTRALIZATION NUMBER: The milligrams of potassium hydroxide required to neutralize one gram (by oil).

NICK BREAK TEST: A method for testing the soundness of welds by nicking each end of the weld, then giving the test specimen a sharp hammer blow to break the weld, then giving the test specimen a sharp hammer blow to break the weld from nick to nick. Visual inspection will show any weld defects.

NONFERROUS: Metals which contain no iron. Aluminum, brass, bronze, copper and lead are nonferrous.

NUGGET: The fused metal zone of a resistance weld.

O

OPEN CIRCUIT VOLTAGE: The voltage between the terminals of the welding source when no current is flowing in the welding circuit.

OVERHEAD POSITION: The position in which welding is performed from the underside of a joint and the face of the weld is approximately horizontal.

OVERLAP: The protrusion of weld metal beyond the bond at the toe of the weld.

OXIDIZING FLAME: A flame in which the oxygen combines with all the acetylene or fuel available and then the excess oxygen oxidizes the metal.

OXY-ACETYLENE CUTTING: An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of acetylene with oxygen.

OXY-ACETYLENE WELDING: A welding process in which the required temperature is attained by flames obtained from the combustion of acetylene with oxygen.

OXY-ARC CUTTING: An oxygen cutting process in which the necessary cutting temperature is maintained by means of an arc between an electrode and the base metal.

OXY-CITY GAS CUTTING: An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of city gas with oxygen.

OXY-HYDROGEN CUTTING: an oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained by the combustion of hydrogen with oxygen.

OXY-HYDROGEN WELDING: A gas welding process in which the required welding temperature is attained by flames obtained from the combustion of hydrogen with oxygen.

OXY-NATURAL GAS CUTTING: An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of natural gas with oxygen.

OXY-PROPANE CUTTING: An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of propane with oxygen.

OXYGEN CUTTING: A process of severing ferrous metals by means of the chemical action of oxygen on elements in the base metal at elevated temperatures.

OXYGEN GOUGING: An application of oxygen cutting in which a chamfer or groove is formed.

P

PASS: The weld metal deposited in one general progression along the axis of the weld.

PEENING: The mechanical working of metals by means of hammer blows. Peening tends to stretch the surfaces of the cold metal, thereby relieving contraction stresses.

PENETRANT INSPECTION: a. Fluorescent. - A water-washable penetrant with high fluorescence and low surface tension. It is drawn into small surface openings by capillary action. When exposed to black light the dye will fluoresce.

b. Dye - A process which involves the use of three non-corrosive liquids. First, the surface cleaner solution is used. Then the penetrant is applied and allowed to stand at least 5 minutes. After standing, the penetrant is removed with the cleaner solution and the developer is applied. The dye penetrant, which has remained in the surface discontinuity, will be drawn to the surface by the developer resulting in bright red indications.

PENTRATION CONSISTENCY: The distance a standard-weight cone penetrates into a grease at a set temperature.

PERCUSSIVE WELDING: A resistance welding process in which a discharge of electrical energy and the application of high pressure occurs simultaneously or with the electrical discharge occurring slightly before the application of pressure.

PERMANENT MAGNET: usually an iron alloy having a high value of coercive force; that is, the magnetic domains are not easily rotated. Thus, after the alloy has been saturated by the application of a sufficiently large magnetizing force, the domains tend to remain aligned indefinitely, even after the magnetizing force has been removed.

PIT: A small circular indentation in a surface resulting from chemical action or corrosion.

PITCH: Center to center spacing of welds.

PLUG WELD: A weld is made in a hole in one member of a lap joint, joining that member to that portion of the surface of the other member which is exposed through the hole. The walls of the hole may or may not be parallel, and the hole may be partially or completely filled with the weld metal.

POKE WELDING: A spot welding process in which pressure is applied manually to one electrode. The other electrode is clamped to any part of the metal much in the same manner that arc welding is grounded.

POROSITY: The presence of gas pockets or inclusions in welding.

POSITIONS OF WELDING: All welding is accomplished in one of four positions: flat; horizontal; overhead or vertical. The limiting angles of the various positions depend somewhat as to whether the weld is of a fillet or groove type.

POSTWELD INTERVAL: In resistance welding, the heat time between the end of weld time, or weld interval, and the start of hold time. During this interval, the weld is subjected to mechanical and heat treatment.

POUR POINT: The temperature at which an oil just ceases to flow or pour.

PREHEATING: The application of heat to a base metal prior to a welding or cutting operation.

PRESSURE CONTROLLED WELDING: The making of a number of spot or projection welds in which several electrodes function progressively under the control of a pressure sequencing device.

PRESSURE WELDING: Any welding process or method in which pressure is used to complete the weld.

PRE WELD INTERVAL: In spot, projection, and upset welding, the time between the end of squeeze time and the start of weld time or weld interval during which the material is preheated. In flash welding, it is time during which the material is preheated.

PROJECTION WELDING: A resistance welding process between two or more surfaces or between the ends of one member and the surface of another. The welds are localized or predetermined points or projections.

PULSATION WELDING: A spot, projection, or seam welding process in which the welding current is interrupted one or more times without the release of pressure or change of location of electrodes.

PUNCTURE: A complete surface penetration, usually from a sharp object.

PUSH WELDING: The making of a spot of projection weld in which the force is applied manually to one electrode and the work or a backing bar takes the place of the other electrode.

Q

QUENCHING: The sudden cooling of heated metal with oil, water, or compressed air.

R

REACTION STRESS: The residual stress which could not otherwise exist if the members or parts being welded were isolated as free bodies without connection to other parts of the structure.

REDUCING FLAME: See carburizing flame.

REGULATOR: A device used to reduce cylinder pressure to a suitable torch working pressure.

REINFORCED WELD: The weld metal is built up above the general surface of the two abutting sheets or plates in excess of that required for the size of the weld specified.

RESIDUAL STRESS: Stress remaining in a structure or member as a result of thermal and / or mechanical treatment.

RESISTANCE BRAZING: A brazing process in which fusion is produced by the heat obtained from resistance to the flow of electric current in a circuit of which the work is a part and by using a nonferrous filler metal having a melting point above 800 degrees F, but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

RESISTANCE BUTT WELDING: A group 'f resistance welding processes in which the weld occurs simultaneously over the entire contact area of the parts being joined.

RESISTANCE WELDING: A group of welding processes in which fusion is produced by heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part and by the application or pressure.

REVERSE POLARITY: The arrangement of direct current arc welding leads in which the work is the negative pole and the electrode is the positive pole of the welding arc.

ROOT: See root of joint and root of weld.

ROOT CRACK: A crack in the weld or base metal which occurs at the root of a weld.

ROOT EDGE: The edge of a part to be welded which is adjacent to the root.

ROOT FACE: The prepared edge of a member to be joined by a groove weld which is not beveled or grooved.

ROOT OF JOINT: That position of a joint to be welded where the members approach closest to each other. In cross section, the root of a joint may be a point, a line, or an area.

ROOT OF WELD: The points, as shown in cross section, at which the bottom of the weld intersects the base metal surfaces.

ROOT OPENING: The separation between the members to be joined at the root of the joint.

ROOT PENETRATION: The depth a groove weld extends into the root of a joint measured on the centerline of the root cross section.

ROSEN JOINT: A pocket of rosen in a soldered connection. This occurs when insufficient heat is applied to perform the soldering operation.

S

SAPONIFICATION NUMBER: The milligrams of potassium hydroxide required to saponify (form soap) one gram (of oil).

SATURATION: In a magnetic material, the condition that exists when all magnetic domains are perfectly aligned with the externally applied magnetic field. The magnetic induction has reached its maximum possible value.

SCARF: The chamfered surface of a joint.

SCARFING: A process for removing defects and checks which develop in the rolling of steel billets by the use of a low velocity oxygen deseaming torch.

SCRATCH OR GOUGE: Surface skin damage in which the metal has been displaced to the sides of the scratch or gouge as a result of a sharp instrument striking or scraping the skin surface.

SEAL WELD: A weld used primarily to obtain tightness and to prevent leakage.

SEAM WELDING: Welding a lengthwise seam in sheet metal either by abutting or overlapping joints.

SELECTIVE BLOCK SEQUENCE: A block sequence in which successive blocks are completed in a certain order selected to create a predetermined stress pattern.

SERIES WELDING: A resistance welding process in which two or more welds are made simultaneously by a single welding transformer with the total current passing through each weld.

SHEET SEPARATION: In spot, seam, and projection welding, the gap surrounding the weld between fraying surfaces, after the joint has been welded.

SHIELDED WELDING: An arc welding process in which protection from the atmosphere is obtained from a flux, decomposition of the electrode covering, or an inert gas.

SHOULDER: See root face.

SHRINKAGE STRESS: See residual stress.

SINGLE-IMPLUSE WELDING: The making of spot projection and upset welds by a single impulse of current. When alternating current is used, an impulse may consist of a fraction of a cycle or a number of cycles.

SIZE OF WELD: a. Groove weld The joint penetration (depth of chamfering plus the root penetration when specified).

b. Equal leg fillet welds The leg length of the largest right triangle which can be inscribed within the fillet weld cross section.

c. Unequal leg fillet welds The leg length of the largest right triangle which can be inscribed within the fillet weld cross section.

d. Flange weld The weld metal thickness measured at the root of the weld.

SKIP SEQUENCE: See wandering sequence.

SLAG INCLUSION: Non-metallic solid material entrapped in the weld metal or between the weld metal and the base metal.

SLOT WELD: A weld made in an elongated hole in one member of a lap or tee joint joining that member to that portion of the surface of the other member which is exposed through the hole. The hole may be open at one end and may be partially or incompletely filled with weld metal. (A fillet welded slot should not be construed as conforming to this definition.) SLUGGING: Adding a separate piece of pieces of material in a joint before or during welding with a resultant welded joint that does not comply with design, drawing, or specification requirements.

SOFT SOLDER: A composition of lead and tin (60-40) that will melt within a heat range of 361 to 380 degrees. This solder is desirable for repair of electronic equipment because upon removal of heat reverts from liquid to solid state almost instantly. Higher ratios of lead to tin require more heat and remain in a plastic state longer.

SOLDER POINTS: A peak of lead on a solder connection. These result from excessive solder being applied during the soldering operation.

SPACER STRIP: A metal strip or bar inserted in the root of a joint prepared for a groove weld to serve as a backing and to maintain the root opening during welding.

SPATTER: The metal particles expelled during arc and gas welding which do not form a part of the weld.

SPOT WELDING: A resistance welding process in which fusion is produced by the heat obtained from the resistance to the flow of electric current through the work parts held together under pressure by electrodes. The size and shape of the individually formed welds are limited by the size and contour of the electrodes.

STAGGERED INTERMITTENT FILLET WELD: Two lines of intermittent welding on a joint, such as a tee joint, wherein the fillet increments in one line are staggered with respect to those in the other line.

STORED ENERGY WELDING: The making of a weld with electric energy accumulated electrostatically, electromagnetically, or electrochemically at a relatively low rate and made available at the required welding rate.

STRAIGHT POLARITY: The arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc.

STRESS RELIEF HEAT TREATMENT: Uniform heating of a structure or portion thereof to a sufficient temperature, below the critical range, to relieve the major portion of the residual stresses, followed by uniform cooling. (Terms normalizing, annealing, etc., are misnomers for this application.) STRING BAND WELDING: A method of metal arc welding on pieces 3 / 4 inch thick or heavier in which the weld metal is deposited in layers composed of strings of beads applied directly to the face of the bevel.

STUD WELDING: An arc welding process in which fusion is produced by heating with an electric arc drawn between a metal stud, or similar part, and the other work part, until the surfaces to be joined are properly heated. They are brought together under pressure.

SUBMERGED ARC WELDING: An arc welding process in which fusion is produced by heating with an electric arc or arcs between a bare metal electrode or electrodes and the work. The welding is shielded by a blanket or granular, fusible material on the work>. Pressure is not used, filler metal is obtained from the electrode, and sometimes from a supplementary welding rod.

SURFACING: The deposition of filler metal on a metal surface to obtain desired properties or dimensions.

T

TACK WELD: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

TEE JOINT: A joint between two members located approximately at right angles to each other in the form of a T.

TEMPER TIME: In resistance welding, that part of the postweld interval during which a current suitable for tempering or heat treatment flows. The current can be single or multiple impulse, with varying heat and cool intervals.

THERMAL SHUNT: Any metallic clamp device that is placed ahead between a component and area of soldering. Prevents overheating of delicate electronic components.

THERMIT CRUCIBLE: The vessel in which the thermit reaction takes place.

THERMIT MIXTURE: A mixture of metal oxide and finely divided aluminum with the addition of alloying metals as required.

THERMIT MOLD: A mold formed around the parts to be welded to receive the molten metal.

THERMIT REACTION: The chemical reaction between metal oxide and aluminum which produces superheated molten metal and aluminum oxide slag.

THERMIT WELDING: A group of welding processes in which fusion is produced by heating with superheated liquid metal and slag resulting from a chemical reaction between a metal oxide and aluminum, with or without the application of pressure. Filler metal, when used, is obtained from the liquid metal.

THROAT DEPTH: In a resistance-welding

machine, the distance from the centerline of the electrodes or platens to the nearest point of interference for flatwork or sheets. In a seam-welding machine with a universal head, the throat depth is measured with the machine arranged for transverse welding.

THROAT OF FILLET WELD: a. Theoretical - The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the filletweld cross section.

b. Actual The shortest distance from the root of a fillet weld to its face.

TOE CRACK: A crack in the base metal occurring at the toe of the weld.

TOE OF THE WELD: The junction between the face of the weld and the base metal.

TORCH: See cutting torch or welding torch.

TORCH BRAZING: A brazing process in which fusion is produced by heating with a gas flame and by using a nonferrous filler metal having a melting point above 800 degrees F, but below that of the base metal. The filler metal is distributed in the joint by capillary attraction.

TORQUE: A force that tends to set a body into rotation.

TRANSVERSE SEAM WELDING: The making of a seam weld in a direction essentially at right angles to the throat depth of a seam welding machine.

U

UNDERBEAD CRACK-: A crack in the heat affected zone not extending to the surface of the base metal.

UNDERCUTTING: An undesirable crater at the edge of the weld caused by poor weaving technique or excessive welding speed.

UPSET: A localized increase in volume in the region of a weld, resulting from the application of pressure.

UPSET WELDING: A resistance welding process in which fusion is produced simultaneously over the entire area of abutting surfaces, or progressively along a joint, by the heat obtained from resistance to the flow of electric current through the area of contact of those surfaces. Pressure is applied before heating is started and is maintained throughout the heating period.

UPSETTING FORCE: The force exerted at the welding surfaces in flash or upset welding.

V

VERTICAL POSITION: The position of welding in which the axis of the weld is approximately vertical. In pipe welding, the pipe is in a vertical position and the welding is done in a horizontal position.

VIBRATION BENDS: A turn or bend made into an electrical lead to prevent vibrations from a harness or cable being transmitted to electronic components.

VISCOSITY: The distinguishing characteristic which denotes the body or relative fluidity of a lubricating oil. The heavier the oil, the higher its viscosity.

VISCOSITY INDEX: The viscosity of a petroleum oil changes with temperature. The rate of change is indicated by its viscosity index.

W

WANDERING BLOCK SEQUENCE: A block sequence in which successive blocks are completed at random after several starting blocks have been completed.

WANDERING SEQUENCE: A longitudinal sequence in which the weld bead increments are deposited at random.

WEAVE BEAD: A type of weld bead made with transverse oscillation.

WEAVING: A technique of depositing weld metal in which the electrode is oscillated. It is usually accomplished in a semicircular motion of the arc terminal to the right and left of the direction of deposition. Weaving serves to increase the width of the deposit, decreases overlap, and assists in slag formation.

WELD: A localized fusion of metals produced by heating to suitable temperatures. The application of pressure and / or the use of filler metal may or may not be used. The filler metal has a melting point approximately the same or below that of the base metals, but always above 800 degrees F.

WELD BEAD: A weld deposit resulting from a pass.

WELD GAGE: A device designed for checking the shape and size of welds.

WELD METAL: That portion of a weld that has been melted during welding.

WELD SYMBOL: A picture used to indicate the desired type of weld.

WELDING SYMBOL: The assembled symbol consists of the following eight elements, or such of these as are necessary: reference line; arrow; basic weld symbols; dimension and other data; supplementary symbols; finish symbols; tail; specification, process, or other references.

WELDABILITY: The capability of a material to form a strong bond of adherence under pressure or when solidifying from a liquid.

WELDING LEADS: a. Electrode lead The electrical conductor between the source of the arc welding current and the electrode holder.

b. Work lead The electrical conductor between the source of the arcwelding current and the work.

WELDING PRESSURE: The pressure exerted during the welding operation on the parts being welded.

WELDING ROD: Filler metal in wire or rod form used in gas welding and brazing processes and in those arc welding processes in which the electrode does not provide the filler metal.

WELDING TECHNIQUE: The details of a manual, machine, or semiautomatic welding operation which, within the limitations of the prescribed joint welding procedure, are controlled by the welder or welding operator.

WELDING TIP: The tip of a gas torch especially adapted to welding. " WELDING TORCH: A device used in gas welding and torch brazing for mixing and controlling the flow of gases.

WELDING TRANSFORMER: A device for providing current of the desired voltage.

WELDMENT: An assembly whose component parts are formed by welding.

WICKING: Capillary action of liquid solder flowing along a standed conductor. Wicking of solder under the conductor insulation must be rejected.

WORK LEAD: The electric conductor (cable) between the source of arc-welding current and the work.

X

X-RAY: A test method used to detect internal defects in a weld.

B-4. TABLE AND CHARTS

TABLE B-1
UNITS OF MEASURE

Metric System Prefixes

Giga	=	1,000,000,000	Deci	=	0.1
Mega	=	1,000,000	Centi	=	0.01
Kilo	=	1,000	Milli	=	0.001
Hecto	=	100	Micro	=	0.000001
Deka	=	10	Nano	=	0.00000001
			Pico	=	0.00000000001

Length

1 centimeter	=	0.3937 inches	=	0.0328 feet
1 meter	=	39.37 inches	=	1.0936 yards
1 kilometer	=	0.62137 miles	=	3280 feet
1 inch	=	2.54 centimeters		
1 foot	=	0.3048 meters		
1 mil	=	0.001 inch		

Square Measure

1 sq cm	=	0.1550 sq in		
1 sq meter	=	1.196 sq yd	=	10.784 sq ft
1 sq kilometer	=	0.386 sq miles		
1 sq inch	=	6.452 sq centimeters		
1 sq foot	=	929.03 sq cm	=	0.092903 sq meters
1 sq yard	=	0.8361 sq meters		
1 sq mile	=	2.59 sq kilometers		
1 circular mil	=	0.7854 sq mils		
1 sq inch	=	1,000,000 sq mils		

TABLE B-1 (Continued}
Cubic Measure

1 cu centimeter	=	0.061 cu inch		1 cu inch	=	16.39 cu cm
1 cu meter	=	1.308 cu yds	=	35.316 cu feet		
1 gallon (U.S.)	=	231 cubic inches				
1 cu foot	=	7.48 gallons		1 liter	=	1000 cu cm

Time

1 day = 86,400 seconds   1 year = 8760 hours (approx.)

Mass

1 slug	=	32.2 pounds mass	=	14,606 kilograms
1 pound mass	=	453.6 grams		

Force

1 pound force	=	11 slug		X 1 foot / sec / sec
1 dyne	=	1 gram		X 1 centimeter / sec / sec
1 newton	=	1 kilogram		X 1 meter / sec / sec
1 pound force	=	4.452 newtons		
1 newton	=	100,000 dynes	=	0.224 pounds force
1 gram force	=	980.6 dynes		

Pressure

1 atmosphere	=	14.69 pounds/sq inch=29.92 in of Hg
1 atmosphere	=	76 cm of Hg=33.9 ft of water
1 in Hg	=	0.491 pounds/sq inch
Water pressure pounds/sq inch	=	head in ft x 0.434

Work and Energy - Mechanical

1 erg	=	1 dyne X 1 centimeter
1 joule	=	1 newton X 1 meter = 10^5 dynes x 10^2 cm = 10^7 ergs
1 ft lb	=	1 pound force X 1 foot = 1.356 joules

Work and Energy - Heat Equivalent

1 Btu raises 1 pound of water 10°F
1 gram calorie raises 1 gram of water 10°C
1 Btu = 252 gram calories = 778 ft lb = 1055 joules
1 gram calorie = 0.003964 Btu = 4.184 joules
1 horsepower hour = 2544 Btu

Work and Energy - Electrical Equivalent

1 joule = 1 watt X 1 second = 1 amp (dc) X 1 volt (dc) X 1 sec
W (joules) = ½ L (henries) X 1 $(\text{amperes})^2$
W (joules) = ½ C (farads) X E $(\text{volts})^2$
1 kilowatt hour   3,600,000 joules

Power

1 watt - 1 joule/ sec
1 horsepower - 550 ft lb/ sec - 746 watts
1 watt - 3.412 Btu / hr = 0.239 gram calorie/ sec
P (watts) -R (ohms) X 1 $(\text{amperes})^2$
R (ohms)   E $(\text{volts})^2$
P (watts)

TABLE B-1 (Continued)
Angles

1 circle = 2π radians = 360 degrees
1 radian = 57.3 degrees 1 degree = 0.01745 radians

Geometric Figures

Circle, area of = D^2 X 0.7854 = πr^2 r = radius
Circle, circumference of = πD or $2\pi r$
Sphere, area of = $\pi D^2 = 4\pi r^2$ D = diameter
Sphere, volume of = D^3 X 0.5236 = $4/3\ \pi r^3$
Triangle, area of = ½ altitude X base
Cone, volume of = area of base X 1/3 altitude
Trapezoid, area of = ½ (sum of parallel sides) X altitude
Pyramid, volume of = area of base X 1/3 altitude

TABLE B-2
TEMPERATURE CONVERSION TABLE

In left column find known temperature in degrees C. or F. Refer to corresponding C. or F. column for the equivalent.

	Cent	Fahr		Cent	Fahr		Cent	Fahr
-100	-73.3	-148	21	-6.11	69.8	52	11.1	125.6
-90	-67.8	-130	22	-5.56	71.6	53	11.7	127.4
-80	-62.2	-112	23	-5.00	73.4	54	12.2	129.2
-70	-56.7	-94	24	-4.44	75.2	55	12.8	131.0
-60	-51.1	-76	25	-3.89	77.0	56	13.3	132.8
-50	-45.6	-58	26	-3.33	78.8	57	13.9	134.6
-40	-40.0	-40	27	-2.76	80.6	58	14.4	136.4
-30	-34.4	-22	28	-2.22	82.4	59	15.0	138.2
-20	-28.9	-4	29	-1.67	84.2	60	15.6	140.0
-10	-23.3	14	30	-1.11	86.0	61	16.1	141.9
0	-17.8	32	31	-0.56	87.8	62	16.7	143.6
1	-17.2	33.8	32	0	89.6	63	17.2	145.4
2	-16.7	35.6	33	0.56	91.4	64	17.8	147.2
3	-16.1	37.4	34	1.11	93.2	65	18.3	149.0
4	-15.6	39.2	35	1.67	95.0	66	18.9	150.8
5	-15.0	41.0	36	2.22	96.8	67	19.4	152.6
6	-14.4	42.8	37	2.78	98.6	68	20.0	154.4
7	-13.9	44.6	38	3.33	100.4	69	20.6	156.2
8	-13.3	46.4	39	3.89	102.2	70	21.1	158.0
9	-12.8	48.2	40	4.44	104.0	71	21.7	159.8
100	-12.2	50.0	41	5.00	105.8	72	22.2	161.6
11	-11.7	51.8	42	5.56	107.6	73	22.8	163.4
12	-11.1	53.6	43	6.11	109.4	74	23.3	165.2
13	-10.6	55.4	44	6.67	111.2	75	23.9	167.0
14	-10.0	57.2	45	7.22	113.0	76	24.4	168.8
15	-9.44	59.0	46	7.78	114.8	77	25.0	170.6
16	-8.89	60.8	47	8.33	116.6	78	25.6	172.4
17	-8.33	62.6	48	8.89	118.4	79	26.1	174.2
18	-7.78	64.4	49	9.44	120.2	80	26.7	176.0
19	-7.22	66.2	50	10.0	122.0	81	27.2	177.8
20	-6.67	68.0	51	10.6	123.8	82	27.8	179.6

TABLE B-2 (Continued)

	Cent	Fahr		Cent	Fahr		Cent	Fahr
83	28.3	181.4	120	49	248	310	154	590
84	28.9	183.2	130	54	266	320	160	608
85	29.4	185.0	140	60	284	330	166	626
86	30.0	816.8	150	66	3-2	340	171	644
87	30.6	188.6	160	71	320	350	177	662
88	31.1	190.4	170	77	338	360	182	680
89	31.7	192.2	180	82	356	370	188	698
90	32.2	194.0	190	88	374	380	193	716
91	32.8	195.8	200	93	392	390	199	734
92	33.3	197.6	210	99	410	400	204	752
93	33.9	199.4	212	100	413	410	210	770
94	34.4	201.2	220	104	428	420	216	788
95	35.0	203.0	230	110	446	430	221	806
96	35.6	204.8	240	116	464	440	227	824
97	36.1	206.6	250	121	482	450	232	842
98	36.7	208.4	260	127	500	460	238	860
99	37.2	210.2	270	132	518	470	243	878
100	37.8	212.0	280	138	536	480	249	896
105	40.6	221.0	290	143	554	490	254	914
110	43	230	300	149	572	500	260	932

TABLE B-3
COLOR CODES

Color	Digits or No. of Zeros	Resistors RMA or JAN Multiplier	Resistors RMA or JAN Tolerance	Capacitors Molded Mica RMA and JAN Multiplier	Capacitors Molded Mica RMA and JAN Tolerance	Capacitors Molded Mica RMA and JAN Class or Characteristic	Capacitors Ceramic Multiplier	Capacitors Ceramic Tolerance	Multiplier	Tolerance C 10µµf	Tolerance C 10 µµf	PTS / Mil / °C	Color	Digit or No. of Zeros
BLACK	0	1		1	20%	A	1	20%	1	20%	2.0	0	BLACK	0
BROWN	1	10		10		B	10		10	1%		—30	BROWN	1
RED	2	100		100	2%	C	100		100	2%		—80	RED	2
ORANGE	3	1000		1000	3% (RMA)	D	1000		1000	2.5% (RMA)		—150	ORANGE	3
YELLOW	4	10^4		10^4		E	10^4	5%	10^4			—220	YELLOW	4
GREEN	5	10^5			5% (RMA)	F (JAN)				5%	0.5	—330	GREEN	5
BLUE	6	10^6				G (JAN)						—470	BLUE	6
VIOLET	7	10^7										—750	VIOLET	7
GRAY	8	10^8				I (RMA)					0.25	+30	GRAY	8
WHITE	9	10^9				J (RMA)		10%		10%	1.0	*	WHITE	9
GOLD		0.1	5%		5% (JAN)		0.1	5%					GOLD	
SILVER		0.01	10%		10			10%					SILVER	
NO COLOR			20%					20%					NO COLOR	

* —350 +500 JAN
120 —750 RMA

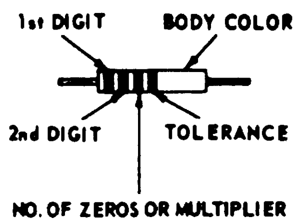
TABLE B-4

RESISTORS

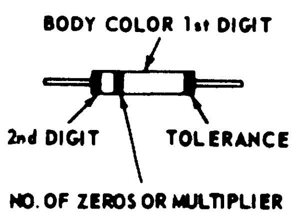
RMA AND JAN CODING FOR FIXED COMPOSITION RESISTORS ARE IDENTICAL. COLOR CODE GIVES THE RESISTANCE IN OHMS.

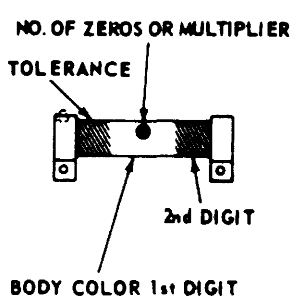
COLOR BAND SYSTEM

RESISTORS WITH BLACK BODY COLOR ARE COMPOSITION, NON-INSULATED. RESISTORS WITH COLORED BODIES ARE COMPOSITION, INSULATED. WIRE-WOUND RESISTORS HAVE THE 1st DIGIT COLOR BAND DOUBLE WIDTH.



BODY, TIP, DOT OR NARROW BAND SYSTEM



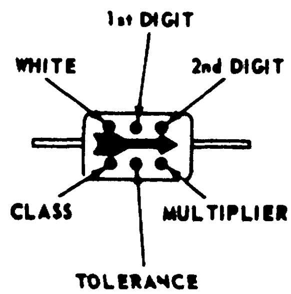


EXAMPLE
BROWN-GREEN-RED,
1500Ω - 20%

CAPACITORS, MOLDED MICA

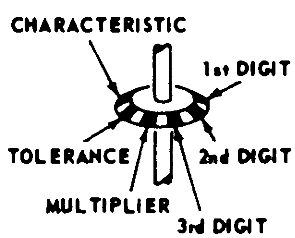
ALL AXIAL LEAD MICA CAPACITORS HAVE A VOLTAGE RATING OF 300 TO 500 VOLTS. THE MAXIMUM CAPACITY OBTAINABLE IS 10,000 uuf. THE COLOR CODE GIVES THE CAPACITY IN uuf.

RMA 6-DOT SYSTEM

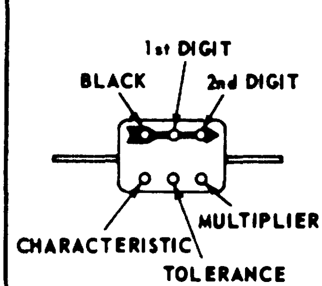


"CLASS"
WAS PREVIOUSLY
"VOLTAGE"

BUTTON SILVER MICA READ CLOCKWISE



JAN 6-DOT SYSTEM

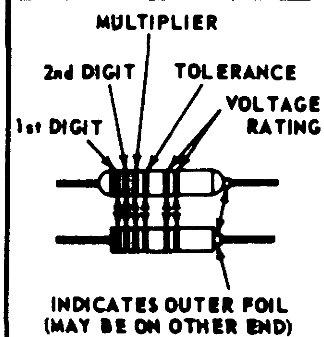


EXAMPLE-RMA 6 DOT
WHITE-ORANGE-BLUE,
360uuf, 2%
WHITE-RED-BROWN, CLASS J

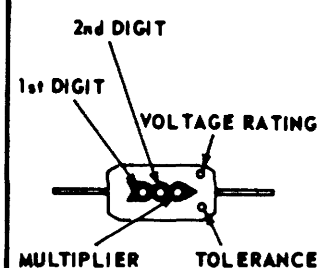
CAPACITORS, MOLDED PAPER

VOLTAGE RATINGS IN HUNDREDS OF VOLTS. ONE COLOR BAND EMPLOYED FOR RATINGS UNDER 1,000 VOLTS. THE COLOR CODE GIVES THE CAPACITY IN uuf.

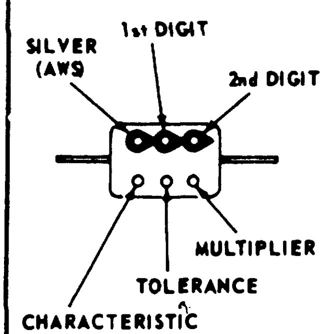
BAND SYSTEM



DOT SYSTEM



ARROW POINTS TO
OUTER FOIL END

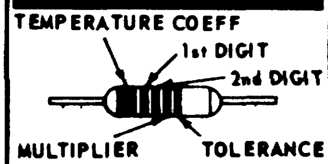


EXAMPLE
RED-GREEN-ORANGE-
BLACK-BROWN-RED,
2500 uuf, 20%, 1200 VOLTS

CAPACITORS, CERAMIC

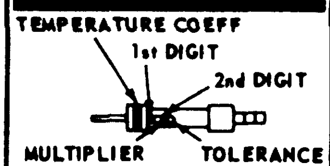
ALL TUBULAR CERAMIC CAPACITORS ARE RATED AT 500 VOLTS. THE COLOR CODE GIVES THE CAPACITY IN uuf.

MOLDED INSULATED

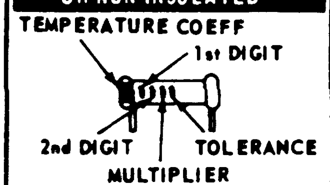


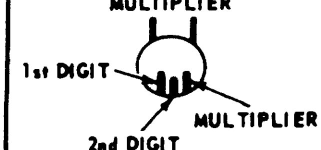
NOTE: DO NOT CONFUSE WITH RESISTORS. FIVE COLOR BANDS USED, (ONE BROAD, FOUR NARROW), WHILE RESISTORS USE FOUR BANDS.

STAND OFF CERAMIC



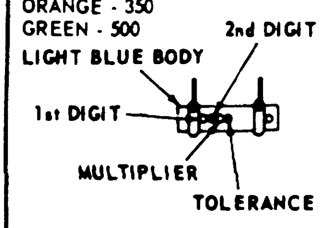
DIPPED PHENOLIC INSULATED OR NON-INSULATED





HI-CAPACITY CERAMIC TYPE (NOT TEMPERATURE COMPENSATED)

DC WORK VOLTS
BROWN - 150
ORANGE - 350
GREEN - 500



EXAMPLE
BROWN-BLACK-ORANGE,
10,000 uuf

MI 1626

TABLE B-5
SOLDER ALLOY TEMPERATURE RANGES

%Sn	%Pb	%Ag	%Sb	Temperature at which solder becomes plastic C°	F°	Temperature at which solder becomes liquid C°	F°
0	100					327	620
5	95			272	522	314	59'
10	90			224	435	302	576
15	85			183	361	290	554
20	80			183	361	280	536
25	75			183	361	268	514
30	70			183	361	257	496
35	65			183	361	247	477
38	62			183	361	242	468
40	60			183	361	238	460
45	55			183	361	225	437
48	52			183	361	218	424
50	50			183	361	212	414
55	45			183	361	200	392
60	40			183	361	188	370
63	37			Eutectic		183	361
65	35			183	361	184	364
70	30			183	361	186	367
75	25			183	361	192	378
80	20			183	361	199	390
85	15			183	361	205	403
90	10			183	361	213	415
95	5			183	361	222	432
100	0					232	450
95			5	232	450	238	460
35	63		2	187	369	237	459
27	70	3		179	354	312	594
40	57	3		179	354	289	543
50	47	3		179	354	260	500
61.5	35.5	3		179	354	248	478
62.5	36.1	1.4		Eutectic		179	354
96		4		Eutectic		221	430
95		5		221	430	240	465
	97.5	2.5		Eutectic		305	581
	95	5		305	581	365	689
0.75	97.5	1.75		Eutectic		310	590

A eutectic alloy is that composition of two or more metals that has one sharp melting point and no plastic range. Sn-Tin; Pb-Lead; Ag-Silver; Sb-Antimony.

TABLE B-6. FUSES-STYLE, VOLTAGE RATING, CURRENT RATINGS AND CHARACTERISTICS

STYLE

CODE	MATERIAL*	DIMENSIONS
F01	A	¼" X 1"
F02	A	¼" X 1¼"
F03	B	¼" X 1¼"
F04	A	¼" X 1¼"
F05	A	9/32" X 1¼"
F06	B	9/32" X 1¼"
F07	A	13/32" X 1½"
F09	C	13/32" X 1½"
F10	C	13/32" X 1½"
F11	B	13/32" X 1½"
F15	C	9/16" X 2"
F16	C	.812" X 3"
F19	C	1.312" X 5 7/8"
F20	C	1.875" X 7 1/8"
F21	C	2.406" X 8 5/8"
F22	C	2.906" X 10 3/8"
F27	C	13/32" X 3"
F28	C	13/32" X 4½"
F29	C	.812" X 5"
F30	C	.812" X 10"
F60	D	13/32" X 1½"
F61	D	.562" X 2"
F62	D	.812" X 3"
F63	D	1.312" X 5 7/8"
F64	D	1.875" X 7 1/8"
F65	D	2.405" X 8 5/8"
F66	D	2.906" X 10 3/8"
F67	D	2.000" X 10 3/8"

VOLTAGE RATING

CODE	VOLTAGE
A	31
B	52
C	90
D	125
G	250
H	500
J	1000
L	2500
N	5000
P	10000

CURRENT RATINGS

CODE	CAPACITY IN AMPS
R001 to R009	.001 to .009
R010 to R099	.010 to .099
R100 to R999	.100 to .999
1R00 to 9R99	1.00 to 9.99
10R0 to 99R9	10.0 to 99.9
100R to 999R	100. to 999.

NOTE: "R" denotes decimal point

CHARACTERISTICS

CODE	CHARACTERISTICS
A	Normal interrupting capacity
B	Time lag (Slow blow)
C	Very high interrupting capacity

EXAMPLE OF FUSE MARKING

F02	*G*	*1R50*	*A*
Style (Same code as on chart)	250 Volts	Current rating	Normal interrupting capacity

* A Glass
B Plastic or Ceramic
C Fibre
D Glass Melamine

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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	***To***	***Multiply by***	***To change***	***To***	***Multiply by***
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

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