INCH-POUND

MIL-STD-981B
31 January 1992
SUPERSEDING
MIL-STD-981A
27 August 1990

MILITARY STANDARD

Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications

AMSC N/A FSC 5950

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to:

   Manager, NASA Parts Project Office
   Mail Code 310.A
   NASA/Goddard Space Flight Center
   Greenbelt, Maryland 20771

   Use the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or a standard business letter.

3. This standard is the technical baseline for the design, manufacturing, and quality standards of custom electromagnetic devices. The intent of this standard is to provide uniform requirements for devices that are used in critical space applications and mission-essential ground equipment. This standard also covers devices used in noncritical flight and non-mission-essential ground support applications.

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APPENDICES

1. SCOPE

1.1 **Scope.** This standard establishes the requirements for acceptable design, manufacturing, and quality control criteria for custom electromagnetic devices for space applications.

1.2 **Classification.**

1.2.1 **Families.** Table I shows the numerical designations that are used in this standard to indicate various device types:

TABLE I. Device types.

Device Type	Family	Applicable Military Specification
Transformer, power	03	MIL-T-27
Inductor, power	04	MIL-T-27
Transformer, R.F., fixed	11	MIL-T-55631
Transformer, R.F., variable	12	MIL-T-55631
Coil, R.F., fixed	13	MIL-C-15305
Coil, R.F., variable	14	MIL-C-15305
Inductor, audio	20	MIL-T-27
Transformer, audio	21	MIL-T-27
Transformer, pulse, low power	31	MIL-T-21038
Transformer, pulse, high power	36	MIL-T-27
Inductor, charging	37	MIL-T-27
Transformer, saturable	40	MIL-T-27
Inductor, saturable	41	MIL-T-27
Coil, R.F. chip, fixed	50	MIL-C-83446
Coil, R.F. chip, variable	51	MIL-C-83446

1.2.2 **Classes.** Two classes of requirements are defined in this standard. Class S parts are intended for critical flight and mission-essential ground support applications and any application that is critical to safety. Class B parts are for use in noncritical flight and non-mission-essential ground support applications.

2. APPLICABLE DOCUMENTS

2.1 **Government documents.**

2.1.1 **Specifications, standards, and handbooks.** The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

J-W-1177	-	Wire, Magnet, Electrical
QQ-S-571	-	Solder, Tin Alloy; Tin-Lead Alloy and Lead Alloy

MILITARY

MIL-T-27	-	Transformers and Inductors (Audio, Power, and High-Power Pulse), General Specification For.
MIL-F-14256	-	Flux, Soldering, Liquid (Rosin Bath).
MIL-C-15305	-	Coils, Fixed and Variable, Radio Frequency, General Specification For.
MIL-T-21038	-	Transformers, Pulse, Low Power, General Specification For.
MIL-S-22473	-	Sealing, Locking and Retaining Compounds, Single Component.
MIL-W-22759	-	Wire, Electric Fluorocarbon Insulated, Copper or Copper Alloy.
MIL-T-55631	-	Transformers, Intermediate Frequency, Radio Frequency and Discriminator, General Specification For.
MIL-C-83446	-	Coils, Radio Frequency, Chip, Fixed or Variable, General Specification For.

STANDARDS

MILITARY

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202	-	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-975	-	Standard Parts List for Flight and Mission Essential Ground Support Equipment.
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.
MIL-STD-45662	-	Calibration System Requirements.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 **Non-government publications.** The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM-E-595	-	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Material from Outgassing in a Vacuum Environment.
ASTM-D-2240	-	Standard Test Method for Rubber Property-Durometer Hardness

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NHB 5300.4(3A)	-	Requirements for Soldered Electrical Connections
NHB 5300.4(3H)	-	Requirements for Crimping and Wire Wrap

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents . These documents also may be available in or through libraries or other informational services.)

2.3 **Order of precedence.** In the event of a conflict between the text of this document and the references cited herein, (except for associated detail specifications or specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 **Definitions.** The meaning of terms used in this standard are in accordance with MIL-T-27, MIL-C-15305, MIL-T-21038, MIL-T-55631, and MIL-C-83446.

4. GENERAL REQUIREMENTS

4.1 **Procurement documents.** Electromagnetic devices shall meet the requirements specified herein and in the applicable procurement document for the individual part type. In the event of conflict between this standard and the procurement document, the latter shall govern.

4.2 **Power transformers, power inductors, audio inductors, audio transformers, high power pulse transformers, charging inductors, saturable transformers and saturable inductors (families 03, 04, 20, 21, 36, 37, 40, and 41, respectively).** These devices shall meet the applicable requirements of MIL-T-27 for grade 4 or 5 and class Q, R, S, V, T, or U devices and as specified herein.

4.3. **Radio frequency, fixed and variable transformers (families 11 and 12, respectively).** These devices shall meet the applicable requirements of MIL-T-55631 for grade 1, class A or B devices and as specified herein.

4.4 **Radio frequency, fixed and variable coils (families 13, 14).** These devices shall meet the applicable requirements of MIL-C-15305 for grade 1, class A or B devices and as specified herein.

4.5 **Low power pulse transformers (family 31).** These devices shall meet the applicable requirements of MIL-T-21038 for grade 4, 5, 6, or 7, class Q, R, S, T, U, or V devices and as specified herein.

4.6 **Radio frequency, chip, fixed and variable coils (families 50 and 51, respectively).** These devices shall meet the applicable requirements of MIL-C-83446 and as specified herein.

5. DETAILED REQUIREMENTS

5.1 **Materials.**

5.1.1 **Outgassing.** Materials used in nonhermetic sealed devices for spaceflight application must not exceed a maximum total mass loss (TML) of 1.0 percent and a maximum collected volatile condensable material (CVCM) of 0.1 percent when tested in accordance with ASTM-E-595.

5.1.2 **Hydrolytic stability.** Hydrolytic stability of any polymeric materials used must be verified by test data. In the absence of hard data, samples of any polymeric material used shall be cast into blocks approximately 2 inches square by 1/2 inch thick. The shore hardness shall be measured in accordance with ASTM-D-2240. The samples shall be exposed to an atmosphere of 71°C, 95 percent relative humidity for 1,000 hours. The shore hardness shall again be measured and the samples examined for liquid reversion. Materials shall show no visible reversion to the liquid state and any decrease in hardness shall not exceed 30 percent.

5.1.3 **Tapes, films and insulating materials.** Insulating materials or combinations of insulating materials shall have a minimum RMS dielectric strength of at least twice the maximum peak operating voltage to be induced between coil winding layers, or twice the RMS dielectric withstanding voltage to be applied between the coil winding and ground, or twice the dielectric withstanding voltage to be applied between the coil winding and other coil windings to be insulated from it. These requirements shall be met at the maximum operating temperature. Devices with materials stressed greater than 100 volts/mil due to the maximum operating voltage shall be tested for corona discharge in accordance with MIL-T-27.

5.1.4 **Wire.**

5.1.4.1 **Magnet wire.** Magnet wire shall conform to and be of the types and sizes specified in J-W-1177 and shall be of the appropriate class for the maximum temperature within the winding. Magnet wire used for coil winding shall conform to the size limits of Table II as absolute limits. Temperature rise limits must also be observed in selecting wire sizes. Procuring activity approval shall be required when other types and sizes of magnet wire are used.

5.1.4.2 **Insulated wire.** When insulated wire is used as wire terminals, the wire shall be of the types and sizes covered in MIL-W-22759. Wire size shall conform to the limits of Table III. Procuring activity approval shall be required when other types and sizes of insulated wire are used as terminals.

5.1.4.3 **Termination limitations.** Internal wire leads shall be attached to the coils and other internal components and terminals or case by soldering (see 5.5.10), welding, brazing, crimping or other method (e.g., lead-sweating of nylon-coated wires) in such a manner as to provide adequate electrical connection and mechanical strength. Where soft solder is used to provide the electrical connection, wire leads shall be anchored mechanically. Wire sizes shall conform to the limits of Table III. Terminations shall be such that adequate stress relief is provided for all leads. Procuring activity approval shall be required when other terminations are used.

5.1.5 **Solder and soldering flux.** Solder, when used, shall be in accordance with QQ-S-571, except that pure tin shall not be used. Soldering flux shall be in accordance with MIL-F-14256, type R for class S and type R or RMA for class B.

5.1.6 **Screws, nuts, and washers.** All mounting and terminal screws, nuts, and washers shall be protected against corrosion. Cadmium or Zinc plating shall not be used on any surface exposed to space

environment. Tin plating shall be fused if such plating is used externally. All materials shall be compatible and not support galvanic corrosion.

5.2 **Internal elements.** Packaged or unpackaged parts (other than the wound magnetic elements) used within these devices shall be selected from MIL-STD-975. Parts selected shall be of the same class as the device in which they are used. Use of any other part shall require approval of the procuring activity. The request for approval must justify the need for the part and provide sufficient data to substantiate the suitability of the part in the application. Procurement documentation for the part shall be submitted to the procuring activity for approval.

TABLE II. **Wire limitations for magnet wire (see 5.1.4.1).**

Family	Minimum Wire Size (AWG) (1)	
	Class S	Class B
03, 04, 36, 37, 40, and 41	38	44
11, 12, 13, 14, 20, 21, 31, 50, and 51	44	50

(1) Procuring activity approval shall be required when other sizes of magnet wire are used.

TABLE III. **Termination limitations (see 5.1.4.3).**

Type of Termination	Minimum Terminal/Self Lead Wire Size (AWG)	
	Class S	Class B
Interconnected lead	29	32
External terminal/self lead (1)	26	28

(1) Spliced internal lead diameter ratios shall not exceed 5 to 1 for magnet wire sizes larger than # 44.

5.3 **Radiographic inspection (when applicable).** Devices shall be inspected in accordance with appendix C.

5.4 **Marking.** Devices shall be marked as specified in the procurement document on the part and shall, as a minimum, include the procurement document number, manufacturer's part number and CAGE, trademark or symbol, terminal identification, and lot date code in accordance with Method I of MIL-STD-1285.

5.5 **Manufacturing practices.** The contractor shall provide to the procuring activity for review and approval a copy of the contractor's written procedures covering manufacturing practices. Proprietary documents shall be reviewed, approved, and maintained at the manufacturer's facility. These procedures shall, as a minimum, conform to the requirements specified herein. Any change from the approved procedures shall require approval of the procuring activity in writing. The contractor may, at his option, provide separate sets of procedures for classes S and B.

5.5.1 **Clean handling.** Operators shall have clean hands (free from handcream, etc.) while handling these devices. The use of clean, lint-free gloves or finger cot is recommended whenever practical. Magnet wire spools shall be handled by the rims of the spools only. Materials and piece parts stored, or being transferred to or between work stations shall be kept in covered containers to maintain a dust-free seal.

5.5.2 **Work areas.** Work and inspection areas must be cleared of all foreign materials before parts or materials for these devices are placed thereon. While working on these devices, the work areas shall not be used to store any parts, materials, or devices used on any other devices.

5.5.3 **Foreign material.** Care must be exercised to prevent introduction of foreign materials into the component. At each in-process inspection, the operator shall examine the device under 3X to 10X magnification to assure that no foreign materials are present. Special attention should be given to loose wire-ends, solder splashes, wire scrapings, or residues.

5.5.4 **Tools.** Except for cutting pliers, the tools used shall not be capable of cutting, nicking, or damaging the wire insulation in any manner. All tools used in the handling of magnet wire shall be free of sharp or rough surfaces or edges. This may be accomplished by the application of an epoxy or by filing any of the sharp surfaces or edges.

5.5.5 **Carriers.** Wound cores, coils or bobbins shall not be carried or stored on pegboards with nails or other sharp pegs that may cause damage to wire or insulation. All sharp or abrasive pegs shall be sufficiently covered to insure against damaging wire. The carriers shall be covered with a material that will prevent contamination by foreign materials during transport and storage.

5.5.6 **Damaged material.** Material that exhibits evidence of damage shall not be used in the fabrication of the devices.

5.5.7 **Travelers.** A lot traveler specifying each operation in the proper sequence shall be provided with each lot. Initialing or stamping of the individual traveler by the operator or inspector prior to moving to the next work station shall be required for each operation in the manufacturing process.

5.5.8 **In-process inspection.** All critical in-process operations used in the manufacturing of these devices shall be inspected by an adequately trained inspector. If circumstances preclude inspections after the process is complete, the inspection shall occur during the process. These inspection stations shall be as defined in the manufacturing process.

5.5.9 **Coil windings.**

5.5.9.1 **Tension.** A suitable device shall be used to provide near uniform tension during the machine winding process of any coil of wire size number 18 AWG or finer. For coils wound on square forms, special provision must be made to prevent excessive tension on the corners. This device and the winding machine used shall be inspected for proper operation a minimum of twice daily or once each lot whichever is more frequent. Tension control on larger wire is preferred but not mandatory. For machines which cannot accommodate any tension device, other criteria shall be established. Any

portion of the device which contacts the magnet wire (pulleys, sliders, etc) shall be free of nicks, burrs, rough spots, or any other anomalies that could cause damage to the coil wire.

5.5.9.2 **Wire breaks.** There shall be no wire breaks for any winding within the coil. The winding operation can be considered complete only when the coil has been made with an unbroken winding. Should the magnet wire break during winding operations, the magnet wire may be unwound and rewound. In no case may a broken coil wire be repaired. If magnet wire opens after assembly, the entire device shall be rejected. Those devices that are designed as multi-series connected windings are not to be identified as wire breaks within the definition of this paragraph.

5.5.9.3 **Crossed wires.** Winding shall be even and smooth. In insulation interleaved layer-wound coils, no uninsulated turns shall cross over other turns. In toroidal and cylindrical or random wound bobbin coils wound in segments, there shall be no uninsulated cross-over of any one turn to the adjacent winding segment. All situations where the voltage stress exceeds the ability of the magnet wire insulation to withstand it shall be avoided.

5.5.9.4 **Kinks, nicks, and damaged insulation.** The winding process shall not introduce any kinks, nicks, and insulation damage.

5.5.9.5 **Tapes.** The use of pressure sensitive adhesive tapes shall be kept to a minimum. The adhesive system must meet the outgassing requirements of 5.1.1.

5.5.9.6 **Terminations.** The recommended method to anchor the lead is shown. The lead anchor should be performed with minimum use of tape wrap to keep the outgassing low. See 5.5.9.5.

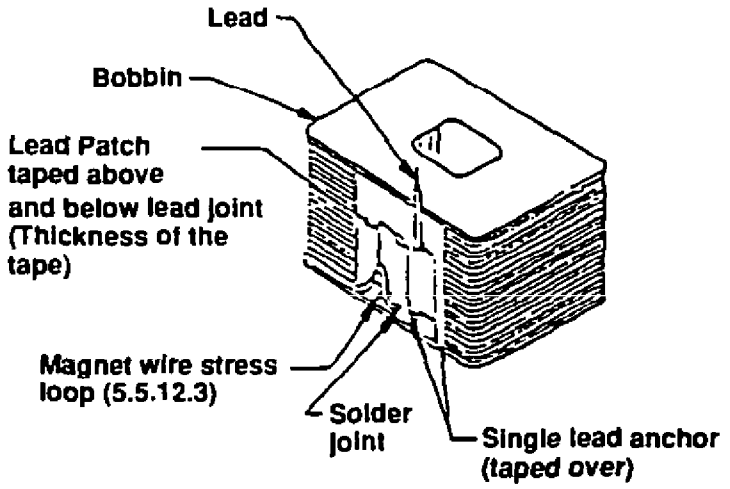
5.5.9.7 **Magnet wire to terminal post connections.** Recommended magnet wire (wire or coil) to terminal post connections are depicted in figures 3a-h, j, k, m, n, and p. For high voltage, corona-free connections, no protruding wires are allowed and balling of the joint is recommended. Care shall be exercised when using the heat shrink tubing to avoid the concentration of heat at the soldered joint. Heat shall be controlled in accordance with the tube manufacturer's stated recommended conditions.

5.5.9.8 **Antirotation feature.** Each terminal lead shall be internally constructed as illustrated on figure 4 or equivalent. Flattened or dimpled area thickness shall be no less than one-half the lead diameter and shall not exhibit sharp edges. The radius, R, shall be no greater than twice, or less than one times the diameter of the terminal lead. This radius shall be formed prior to soldering. The antirotation feature shall be completely contained within the magnetic device package.

5.5.9.9 **Terminal twist.** Finished devices with solid wire terminals shall be capable of passing the terminal twist test in accordance with method 211, test condition D of MIL-STD-202 without causing discontinuity in the winding. When the bending of the terminal leads, as specified in MIL-STD-202, is impractical, the device shall be held stationary. The lead shall be clamped in a hand chuck and the chuck rotated as required. During the twist test, the winding shall be monitored for open circuit of 100 microseconds or longer duration.

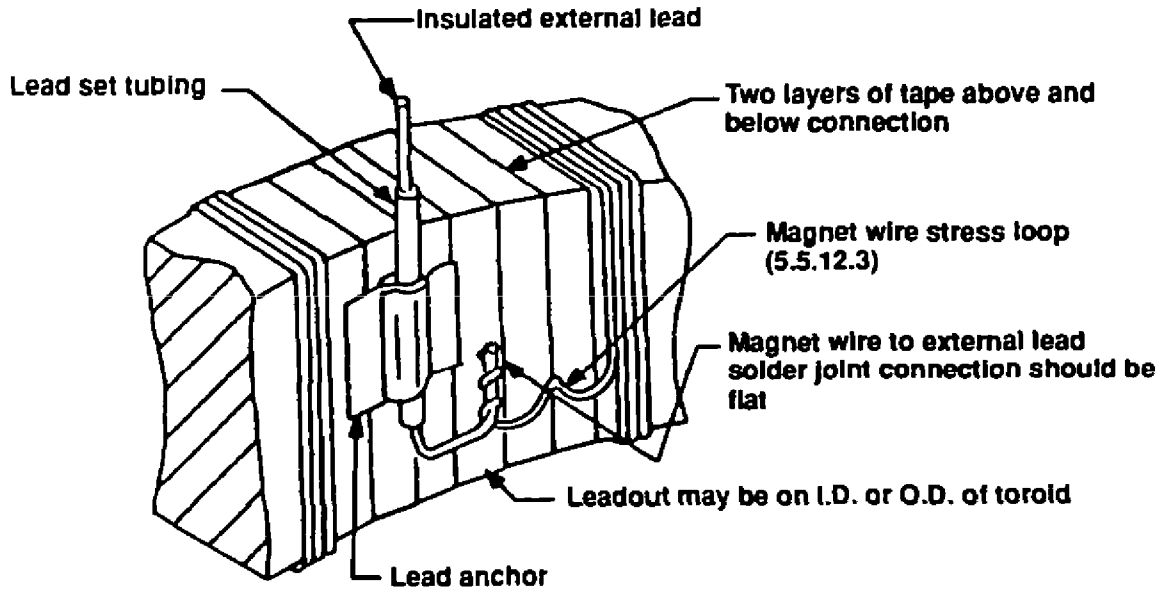
5.5.9.10 **Toroidal winders.** Shuttle rings and sliders must be inspected for nicks, burrs and rough spots. Inspect the toroid for physical damage after removal from the shuttle.

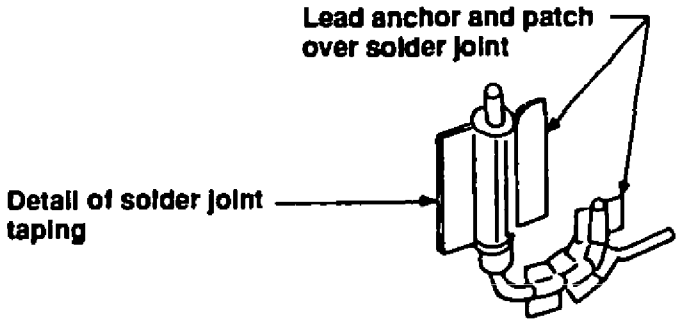
5.5.9.11 **De-reeling.** De-reeling (de-spooling) devices shall be such that they do not cause variations in tension beyond the control of the tension device (see 5.5.9.1). All portions of the device which contact the magnet wire (pulleys, sliders, spool flange, etc) shall be free of nicks, burrs, and rough spots.



Note: The recommended method to anchor the lead is shown. The lead anchor should be performed with minimum use of tape wrap to keep the outgassing low.

FIGURE 1. Recommended bobbin coil termination anchoring (see 5.5.9.6).





Note: The recommended method to anchor the lead is shown. The lead anchor should be performed with minimum use of tape wrap to keep the outgassing low.

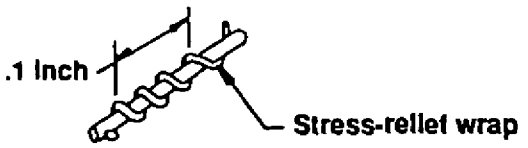
FIGURE 2. A recommended toroidal coil termination (see 5.5.9.6).

(a) Not acceptable (overlapping)

(b) Preferred (Secure, evenly spaced wraps)

(c) Acceptable (Secure wraps)

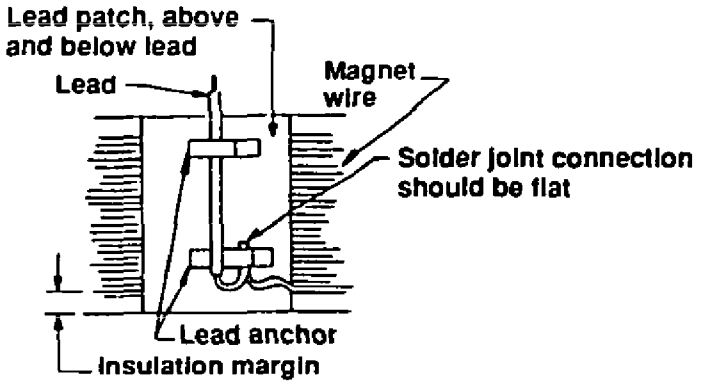
NOTE: There shall be a minimum of three (3) full wraps of wire on each lead terminal. Wires shall be mechanically secured prior to soldering. In no case shall wires be overlapped onto each other.



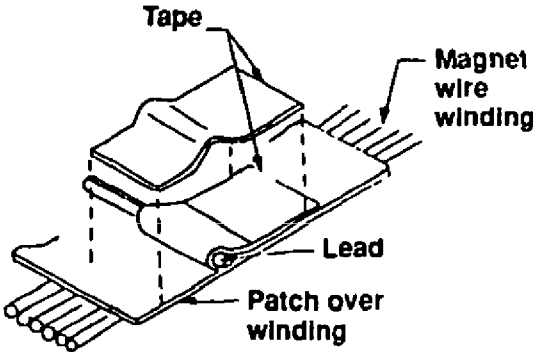
(d) Acceptable

NOTE: For magnet wires of AWG number 42 and smaller, four (4) wraps evenly distributed on terminal lead over 0.1 inch length maximum, with stress relief wraps not counted, are acceptable.

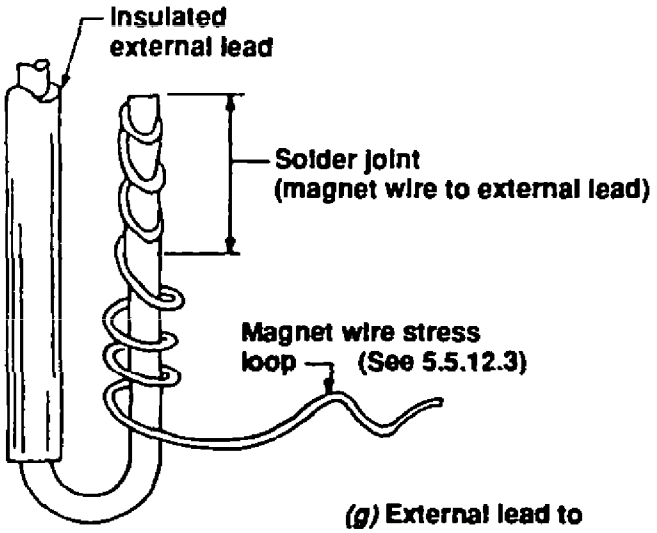
FIGURE 3 (1 of 4). Recommended magnet wire-to-post terminations (see 5.5.9.7).



(e) Internal view

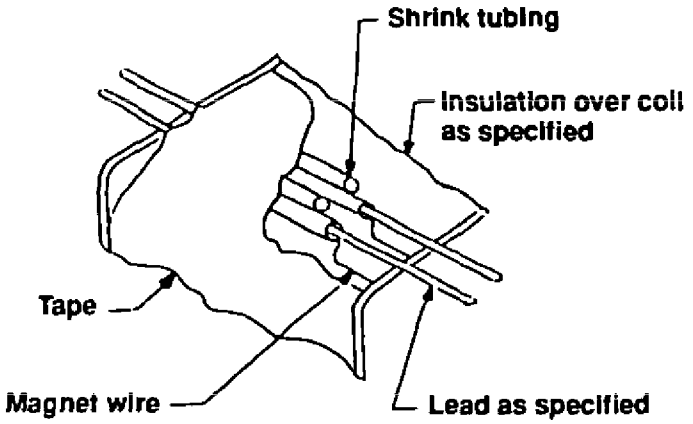


(f) Lead anchor

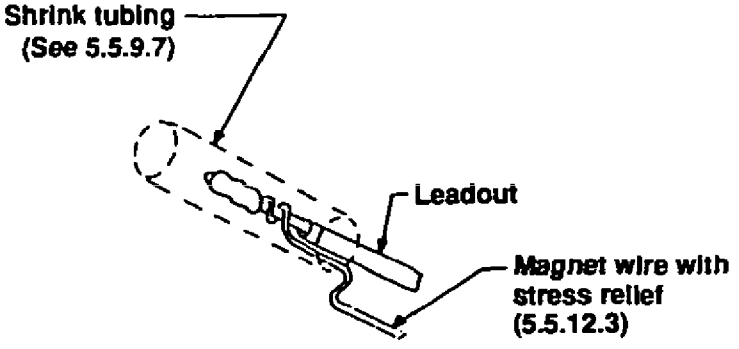


(g) External lead to magnet wire joint

FIGURE 3 (2 of 4). **Recommended magnet wire-to-post terminations (see 5.5.9.7).**

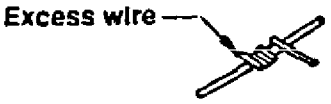


(h)

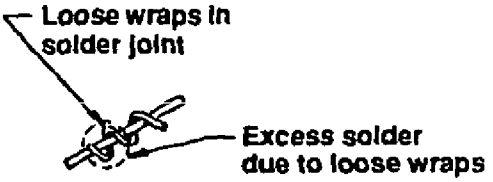


(J)

FIGURE 3 (3 of 4). **Recommended magnet wire-to-post terminations (see 5.5.9.7).**



(k) Not acceptable



(m) Not acceptable

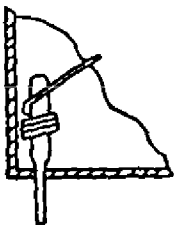
Note: There shall be no evidence of wire "pigtails" protruding more than 2 wire diameters from a wrapped terminal, nor shall there be loose wraps secured by excess solder.

(n) Sleeving - acceptable on AWG 18 or smaller diameter wire. Crimp necessary.

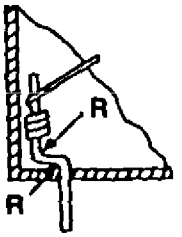
(p) "Third wire" - acceptable on AWG 30 or smaller diameter wire. Third wire must be uninsulated.

Note: Other acceptable termination methods shall exhibit adequate mechanical strength prior to soldering.

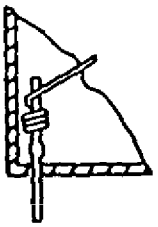
FIGURE 3 (4 of 4). **Recommended magnet wire-to-post terminations (see 5.5.9.7).**



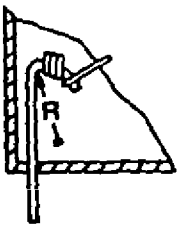
Flattened



Z-bend



Dimpled



Radius (R) *of* bend

FIGURE 4. **Antirotation features (see *5.5.9.8*).**

5.5.10 **Soldering.** Soldering and preparation for soldering shall conform to NHB 5300.4(3A). Use of any other soldering standard in lieu of or in addition to NHB 5300.4(3A) shall require the approval of the procuring activity.

5.5.11 **Soldering equipment and tools.** Shall conform to NHB 5300.4(3A). Use of any other soldering standard in lieu of or in addition to NHB 5300.4(3A) shall require the approval of the procuring activity.

5.5.12 **Prepot visual inspection.**

5.5.12.1 **Examination.** The device examination shall include, but not be limited to, inspection for conformance to the construction and workmanship criteria specified below.

5.5.12.2 **Solder joints.** All solder joints shall be well formed and positioned and shall not show any of the following characteristics when inspected under 3X to 10X magnification:

a. Sharp solder joints (tips, peaks).

b. Excessive solder which obscures the connection configuration, except connections of AWG 38 or smaller magnet wires.

c. Swelling of stranded leads due to excessive wicking.

d. Loose wire (except stress relief wraps), leads and core bands (if applicable).

e. Foreign or extraneous material embedded in the solder.

f. Fractures, cracks, or pinholes.

g. Bare conductor or dewetting within the solder joint area.

h. Protrusion of the bare wire end of strand out of solder joint.

i. Necking down of the magnet wire at the joint.

j. Pitting or voids in corona free ball connections.

5.5.12.3 **Lead wires.** Lead wires shall have stress relief of at least three times the insulated wire diameter whenever practical. Stress relief loops shall not interfere with other conductive paths. For any bend, the radius of the bend shall not be less than three times the insulated wire diameter. In addition, the magnet wire shall also have adequate stress relief at the solder joint, and shall be anchored to the coil. A device that displays a sharp bend of any lead wire (solid or stranded) at the solder joint, or peeling out from the solder fillet, shall be rejected, even if the solder joint otherwise appears to be well formed.

5.5.12.4 **Coils.** Coils of "C" cores and laminations shall be wound either on bobbins or core tubes of appropriate material size.

5.5.12.5 **Crossover of turns.** There shall be no uninsulated crossover of any one turn in any one layer of insulated interleaved layer-wound coils, nor crossover to the adjacent winding segment of toroidal or cylindrical coils wound in segments.

5.5.12.6 **Splices.** There shall be no splicing of magnet wires of the same winding or lead wires of the same size. The solder connection of the magnet wires between windings or series connection of designed multi-wound series windings or to the lead wire shall not be regarded as a splice within the definition of this section.

5.5.12.7 **Extraneous material.** There shall be no evidence of extraneous material:

a. In the path of leakage currents, such as: terminal-to-terminal, terminal-to-adjacent winding, terminal-to metallic case, and winding-to-core. (See Figure 7.)

b. In coil margins, in layer-to-layer or winding-to-winding insulation. (See Figure 11a.)

5.5.12.8 **Cores.**

a. Laminated cores ("C" cores, laminations, etc.) shall not show excessive distortion, misalignment of pole faces, foreign material, or excessive spacing in the gap, loose or bent laminations, or any other anomaly.

b. Ferrite and powder cores shall be free of cracks and chips. Chip-outs, as a result of manufacturing, smaller than 0.02 inch in the largest dimension that do not reduce the cross section of the magnetic path by more than 5 percent shall be acceptable.

c. All molypermalloy powder cores (MPP) shall be coated by phenolic resin or epoxy impregnation to provide a minimum breakdown of 500 V rms.

d. Toroidal cores encased in sealed protective boxes shall show no evidence of damage or defect that may allow leakage of the damping medium or introduction of foreign material.

5.5.12.8.1 **Protective coating.** When possible ferrite and powder toroidal cores shall be of epoxy or parylene coated type or shall be tape wrapped prior to winding. Wire shall be protected from possible abrasion in areas of contact with core.

5.5.12.9 **Rejection criteria.** Devices which fail to meet one or more of the requirements specified shall be removed from the lot and shall not be shipped.

5.5.13 **Impregnation and potting.**

5.5.13.1 **Drying.** Prior to impregnation and potting, all devices shall be dried at sufficient temperatures and for a sufficient length of time to remove all moisture and to cure all tapes. The vacuum drying of devices is preferred. The devices shall be impregnated within 20 minutes after being removed from the drying oven or vacuum chamber. If this is impractical, the devices shall be stored in controlled dry atmosphere. If the devices were exposed to a relative humidity in excess of 30 percent for 30 minutes or more, they shall be redried at sufficient temperature and for a sufficient length of time to remove all moisture.

5.5.13.2 **Impregnation.** Each device shall be impregnated in an appropriate chamber to assure thorough, void-free impregnation "when practical".

5.5.13.3 **Curing.** The cure schedule shall be sufficient to assure the complete cure of the impregnation and potting compound throughout the device. Impregnation, potting and bonding materials shall be cured in accordance with manufacturers recommendations or product bulletin.

5.5.13.4 **Preparation of cups or molds.** Cups or molds shall be prepared for potting or impregnation as follows:

a. Clean plastic or metal cups with solvents that will not contribute to the degradation of the part; such as commercial grades of isopropyl alcohol, acetone, stoddard solvent, 1,1,1-trichloroethane, or equivalent. Plastic cups shall be sandblasted or otherwise etched on the inside surface to assure good adhesion of the resin compound to the cups.

NOTE: Cleaned inner surfaces shall not be touched with bare hands or fingers and cups or molds shall be stored in such a manner as to preclude atmospheric contamination.

b. Wipe molds with the same solvents, or equivalent, for removal of visible dust, dirt, and other undesirable matter.

c. Final rinse cups and molds with the same solvent used in b. above.

5.5.13.5 **Impregnating and potting compounds.** All impregnating and potting compounds must be degassed. Pot life of materials shall be controlled and shall be in accordance with manufacturer's recommendations. In addition, all potting materials shall be dated for expiration of shelf life, and shall not be used after this date.

5.5.13.6 **Equipment.** Vacuum chambers and other equipment shall have adequate automatic controls and shall be capable of maintaining the required pressure and temperature for the time period specified by the applicable specification or source control drawing or by the product bulletin of the compound manufacturer. The inside of the chamber, chamber lid seal, resin containers and device holding fixtures shall be maintained free of dirt and other foreign materials that may inhibit proper operation of the equipment.

5.5.13.7 **Voids.** Units shall be potted or encapsulated in such a manner as to prevent voids, bubbles, and cracks.

5.5.13.7.1 **Internal voids.** There shall be no internal voids greater than 0.015 inch in the largest dimension located within 0.005 inch of any conductor, solder joint, or terminal. The total volume all voids, and the volume of any one void shall not exceed 10 and 5 percent respectively of the total volume of encapsulant within the device, and shall in no way jeopardize the mechanical or functional integrity of the device.

5.5.13.7.2 **Surface voids and depressions.** Surface voids and depressions shall not reduce the thickness of the covering over internal parts to less than what is shown in Figure 8.

5.5.13.7.3 **Extraneous material.** Care shall be taken to ensure that extraneous material is not introduced during the potting process.

5.6 **Quality assurance provisions.** Quality assurance provisions shall be in accordance with the following paragraphs. Test and inspection methods and criteria shall be in accordance with MIL-T-27, MIL-C-15305, MIL-T-21038, MIL-T-55631 or MIL-C-83446 as applicable, unless otherwise specified.

5.6.1 **Product assurance program.** A product assurance program shall be established by the contractor to meet the requirements of appendix A. The contractor shall obtain procuring activity approval of the product assurance program in accordance with appendix A. Approval shall include a product and quality audit by the procuring activity or their designated representative. This audit will cover

verification of the implementation of the product assurance program, conformance of design standard and manufacturing techniques of the requirements of this document and test and inspection capabilities.

5.6.1.1 **Documentation.** Documents shall be maintained, in accordance with appendix A, which specify materials, calibration techniques, processing, test and measurements controls and procedures. These documents shall cover all process steps to be controlled. The documentation shall be available to the operating personnel at all times. It shall be made available to the procuring agency for the purpose of verifying its existence, coverage, implementation and adequacy.

5.6.1.1.1 **Lot control.**

5.6.1.1.1.1 **Class B.** A lot control shall be used for each lot. The lot control shall include as a minimum: lot identification, operation, quantity, date of operation, and operator identification.

5.6.1.1.1.2 **Class S.** Lot control for class S devices shall be required for each part design. As a minimum requirement, the lot control shall constrain the inspection lot to consist of a single part number representing one design and processed as a single lot through all manufacturing steps on the same equipment to the same product assurance program and procurement document and identified with the same date and lot code designation. In addition, the lot shall conform to the following:

a. Each element, such as cores, magnet wire, finished cases, wire lugs and terminals, potting or molding compound used in the manufacture of the part shall be from a single lot and traceable to the lot.

b. Solder for each application shall be of a uniform composition and traceable to the source.

c. In general, all single process operations shall not be changed during processing of the lot.

d. A lot identifying number shall be assigned at the time the lot is assembled. This unique lot identifying number shall be maintained through acceptance and shall be traceable to the production lot and to the lot date code.

e. The manufacturer shall maintain traceability and test records for a minimum of 10 years on each lot date code. The manufacturer shall record when in-process controls and quality conformance inspections start and when they have been completed.

f. All requirements specified in 5.6.1.1.1.1.

5.6.1.1.2 **Process control charts.** Process control charts shall be maintained during manufacture. The charts shall contain information such as: process step, lot number and/or date, action limits and absolute limits, and range. Where absolute limits are exceeded, the manufacturer shall document the corrective action taken.

5.6.2 **Incoming inspection.** Methods and procedures which are used to control inspection, storage, and handling of incoming materials shall be documented. Records shall be provided which verify that materials used in production meet the requirements of the manufacturer's specifications and of the general and detail specifications. As a minimum the following items shall be covered.

5.6.2.1 **Magnet wire:** Magnet wire used in the design and construction of parts specified in accordance with this standard shall meet the following requirements:

a. Verification from the magnet wire supplier that the groups A, B and C inspections of J-W-1177 have been performed for the class and type of magnet wire being used.

b. Each spool of magnet wire prior to being used shall be subjected to the following tests of J-W-1177:

(l) Dielectric test.

(2) Visual and dimensional examination.

(3) Check of bare wire size of the magnet wire by a dc resistance measurement.

c. Provision shall be made to procure and utilize magnet wire not older than two years from the date of its manufacture. Each spool of wire exceeding the two year life shall be subjected to evaluation to verify its performance. Each performance evaluation shall be valid for a period of one year. Wire older than five years from the date of its manufacture shall not be used. Wire shall pass the following evaluation tests in accordance with J-W-1177:

(1) Visual and dimension

(2) Adhesion and flexibility including mandrel test

(3) Elongation

(4) Springback

(5) DWV at rated temperature

(6) Bend (rectangular wire only)

(7) Heat shock

d. Magnet wire shall be stored in protective resealable containers to protect against dust.

e. Magnet wire shall be stored in a clean controlled environment, at a temperature of +25°C (±7°C), a pressure of no less than one Standard Atmosphere, and a relative humidity of between 30 and 70 percent.

5.6.2.2 **Layer insulation.** Dielectric strength, tensile strength, volume resistivity and flexibility.

5.6.3 **Calibration.** Calibration shall be in accordance with MIL-STD-45662.

5.6.4 **Classification of inspections.** The inspections specified herein are classified as follows:

a. Materials inspection.

b. First article inspection.

c. Quality conformance inspection.

5.6.5 **Materials inspection.** Materials inspection shall be as specified in MIL-T-27, MIL-C-15305, MIL-T-21038, MIL-T-55631 or MIL-C-83446 as applicable.

5.6.6 **First article inspection.** First article inspection shall be performed in lieu of the qualification inspection specified in MIL-T-27, MIL-C-15305, or MIL-T-55631 as applicable. Requirements pertaining to First Article inspection shall be as specified in MIL-T-27, MIL-C-15305, or MIL-T-55631. Qualification inspection specified under MIL-T-21038 and MIL-C-83446 shall serve as First Article inspection requirements and shall be performed for the applicable part type under MIL-T-21038 or MIL-C-83446. First Article approval is valid only on the contract under which it is granted, unless extended by the government to another contract.

5.6.7 **Quality conformance inspection.**

5.6.7.1 **Inspection of product for delivery.**

5.6.7.1.1 **Class S devices.** Inspection of product for delivery shall consist of the applicable group A screening tests in appendix B and the applicable group B tests (see tables IV through VII). Sample size for group B tests shall be as specified under the sampling plan (see 5.6.7.4.1).

5.6.7.1.2 **Class B devices.** Inspection of product for delivery shall consist of the applicable group A screening tests in appendix B.

5.6.7.2 **Inspection lot.**

5.6.7.2.1 **Class B.** An inspection lot shall include completely assembled devices of the same grade, construction, class, family, and electrical characteristics, manufactured under essentially the same conditions and having similar construction and materials. (Similar construction and materials shall be construed to include differences that will not affect test results.) Sample units shall be so selected as to be, as far as practicable, representative of the volt-ampere range of electrical values and physical dimensions included in the lot.

5.6.7.2.2 **Class S.** An inspection lot shall consist of completely assembled devices of a single grade, construction, class, family, and part number from one procurement document. Each lot shall meet all the lot controls specified in 5.6.1.1.1.2 for class S devices.

5.6.7.3 **Group A screening inspection.** Screening inspections shall consist of the examinations and tests specified in appendix B.

5.6.7.3.1 **Lot acceptance.** If, during the 100-percent inspection of subgroup I, screening requires that over 5 percent or (1) device whichever is greater be discarded, the lot shall be rejected.

5.6.7.3.2 **Rejected lots.** If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units and resubmit for reinspection. Resubmitted lots shall be 100 percent inspected. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots. Rework of class S devices shall not be permitted unless approved by the procuring activity.

5.6.7.4 **Group B inspection.** Group B inspection shall consist of the applicable group B tests (see tables IV through VII). For Class S devices, the group B inspection shall be performed on sample units selected at random from each inspection lot that passed the group A inspection. Group B inspection for Class B devices shall be performed when specified by the procurement document. The group B inspection, when specified for Class B devices, shall be performed on sample units selected at random from inspection lots which have passed the group A inspection.

5.6.7.4.1 **Sampling plan.**

5.6.7.4.1.1 **Class B.** The sampling plan shall be specified in the procurement document.

5.6.7.4.1.2 **Class S.** Four sample units shall be subjected to the applicable group B tests. Two sample units shall be subjected to the tests of subgroup 1 and two sample units to the tests of subgroup 2.

5.6.7.4.2 **Failures.**

5.6.7.4.2.1 **Class S.** If the number of failures exceed the number allowed in Tables IV through VII, the sample shall be considered to have failed. (See 5.6.7.4.4.)

5.6.7.4.2.2 **Class B.** The number of allowable failures shall be specified in the procurement document.

5.6.7.4.3 **Disposition of sample units.** Disposition of sample units which have been subjected to the group B inspection shall be as specified in the procurement document.

5.6.7.4.4 **Noncompliance.**

5.6.7.4.4.1 **Class B devices.** If a sample fails to pass group B inspection, the manufacturer shall notify the procuring activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action acceptable to the procuring activity has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed, at the option of the qualifying activity). Group A inspection may be reinstituted; however, final acceptance and shipment shall be withheld until the group B inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the procuring activity.

5.6.7.4.4.2 **Class S devices.** If an inspection lot fails to pass group B inspection, the inspection lot shall not be delivered on the contract or purchase order. The manufacturer shall notify the procuring activity and cognizant inspection activity of the failure and take corrective action on the material or processes, or both as warranted. A failure analysis (see 5.6.7.4.4.2.1) shall be performed on the failing product and forwarded to the procuring activity. A copy of the results shall be maintained by the manufacturer.

5.6.7.4.4.2.1 **Failure analysis.** If any of the sample units subjected to the group B tests fail during testing, a detailed failure analysis shall be conducted to establish the cause of failure and the corrective actions that would eliminate subsequent failures of a similar type. A failure is categorized as lot oriented if its occurrence is apparently related to an identified lot or lots. A failure is categorized as not lot oriented if its occurrence is random and it cannot be related to a specific lot or lots. Each failure is further identified as screenable or not screenable from the completed production items. If the failure analysis shows that the failure mechanism is screenable, the entire failed lot may be screened and the group B test in which the failure occurred shall be repeated. If a failure occurs during the second group B test, the entire production lot shall be rejected. If the failure mechanism is screenable, all prior and subsequent production lots that may contain the identified failure mechanism shall also be screened. Except as may be stated otherwise in the detailed requirements for the specific part type. If the failure mechanism is lot oriented and not screenable, all production lots that contain the identified failure mechanism shall be rejected unless other disposition is directed by the contracting officer and procuring activity.

5.6.7.5 **Inspection of packaging.** Inspection of packaging for delivery shall be as specified in MIL-T-27, MIL-C-15305, MIL-T-21038, MIL-T-55631 or MIL-C-83446 as applicable.

TABLE IV. Group B tests for power transformers, power inductors, audio inductors audio transformers, high power pulse transformers, charging inductors, saturable transformers, and saturable inductors (families 03, 04, 20, 21, 36, 37, 40, and 41 respectively) and low power pulse transformers (family 31) (see 5.6.7.4).

Test (1)	Class S	
	Sample Size	Defective Units Allowed
Subgroup 1 Resistance to soldering heat Terminal strength Induced voltage (2) (3) Dielectric withstanding voltage (2) (at atmospheric pressure) Electrical characteristics Visual and mechanical examination (internal)	2	0
Subgroup 2 Vibration Shock Resistance to solvents Solderability Life (4) Dielectric withstanding voltage (at reduced voltage) Insulation resistance (5) Electrical characteristics Visual and mechanical examination (external) Visual and mechanical examination (internal) (one sample unit)	2	0

(1) Specified tests shall be performed in accordance with MIL-T-27, except tests for family 31 shall be performed in accordance with MIL-T-21038.
(2) At maximum temperature for the class.
(3) Applicable when any winding has a rated voltage in excess of 25 volts rms.
(4) Raise temperature one class, for 500 hrs.
(5) At specified voltage with IR of 7,500 megohms minimum.

TABLE V. Group B tests for RF coils (families 13 and 14) (see 5.6.7.4).

Test (1)	Class S	
	Sample Size	Defective Units Allowed
Subgroup 1 Electrical characteristics (initial) Resistance to soldering heat Terminal strength Temperature rise Vibration Shock (specified pulse) Electrical characteristics (final) Visual and mechanical examination (external) Visual and mechanical examination (internal)	2	0
Subgroup 2 Resistance to solvents Solderability Electrical characteristics (initial) Life Electrical characteristics (final)	2	0

(1) Specified tests shall be performed in accordance with MIL-C-15305.

TABLE VI. Group B tests for RF transformers (families 11 and 12) (see 5.6.7.4).

Test (1)	Class S	
	Sample Size	Defective Units Allowed
Subgroup 1		
Resistance to soldering heat		
Terminal strength		
Operating torque (when applicable)		
Temperature rise		
Dielectric withstanding voltage (2 x working voltage) (2)	2	0
Electrical characteristics		
Vibration, winding continuity		
Shock, winding continuity		
Visual and mechanical examination (external)		
Visual and mechanical examination (internal)		
Subgroup 2		
Resistance to solvents		
Solderability		
Life (3)		
Dielectric withstanding voltage (at reduced voltage)	2	0
Insulation resistance (4)		
Electrical characteristics (final)		
Visual and mechanical examination (external)		

(1) Specified tests shall be performed in accordance with MIL-T-55631.
(2) At maximum temperature for the class.
(3) Raise temperature one class, for 500 hrs.
(4) Full voltage with IR of 1.5 times the specified value.

TABLE VII. Group B tests for RF chip coils (families 50 and 51) (see 5.6.7.4).

Test (1)	Class S	
	Sample Size	Defective Units Allowed
Subgroup 1		
Electrical characteristics (initial)		
Low-temperature operation		
Temperature rise		
Overload		
Moisture resistance	2	0
Electrical characteristics		
Inductance		
Q		
High-temperature exposure		
Electrical characteristics (final)		
Turning torque (when applicable)		
Bond strength		
Subgroup 2		
Solderability		
Electrical characteristics (initial)	2	0
Life		
Electrical characteristics (final)		

(1) Specified tests shall be performed in accordance with MIL-C-83446

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Subject term (key word) listings.

Cores
Families
Impregnation and potting
Internal elements
Materials
Solder joints
Splices
Voids

6.2 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

PRODUCT ASSURANCE PROGRAM

10. SCOPE

This appendix contains details of the product assurance program requirements which serve as the basis for product line verification and constitute a pre-condition for supplying devices in accordance with this standard. This appendix is a mandatory part of the standard. The information contained herein is intended for compliance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. PRODUCT ASSURANCE PROGRAM

30.1 **Manufacturer certification.** The manufacturer shall establish, implement, and maintain a product assurance program in accordance with 30.1 through 30.1.3.6 in order to become an approved manufacturer of electromagnetic devices. The manufacturer's product assurance program shall demonstrate and assure that design, manufacture, inspection, and testing are adequate to assure compliance with the applicable requirements and quality standards of this standard and the procurement document. Where the manufacture or any portion of the manufacturing and testing operation is done at other than the manufacturer's facility, it shall be the responsibility of the manufacturer to secure and approve the documentation and control of the product assurance program as described herein. The program shall be documented in these ways:

a. Design, processing, manufacturing, and testing instructions (see 30.1.1)

b. Records to be maintained (see 30.1.2)

c. Program plan (see 30.1.3).

The program shall indicate which documentation applies to Class S and which to Class B.

All required documentation shall be available at, and continually effective in, the plant of the manufacturer producing devices which are intended to be offered for first article and quality conformance inspections under this standard.

All required program documentation shall be available for review by the procuring agency upon request, and the procuring agency shall have access to nonproprietary areas of the manufacturer's plant for the purpose of verifying its implementation.

The implementation of all proprietary documentation shall be certified by a responsible official of the manufacturer upon request by the procuring agency.

30.1.1 **Design, processing, manufacturing, and testing instructions.** The manufacturer shall have in effect documented instructions covering, as a minimum, these areas:

a. Conversion of customer requirements into manufacturer's internal instructions (see 30.1.1.1)

b. Personnel training and testing (see 30.1.1.2)

c. Inspection of incoming materials, utilities and work in process (see 30.1.1.3)

d. Quality-control operations (see 30.1.1.4)

e. Quality-assurance operations (see 30.1.1.5)

f. Design, processing, manufacturing equipment, and materials instructions (see 30.1.1.6)

g. Cleanliness in work areas (see 30.1.1.7)

h. Design, material, and process change control (see 30.1.1.8)

i. Tool, and test equipment maintenance and calibration (see 30.1.1.9)

j. Failure and defect analysis and data feedback (see 30.1.1.10)

k. Corrective action and evaluation (see 30.1.1.11)

l. Incoming, in-process, and outgoing inventory control (see 30.1.1.12)

Detailed requirements for coverage of these items are stated in 30.1.1.1 through 30.1.1.12. These requirements will normally be expected to be met by the manufacturer's standard drawings, specifications, process instructions, and other established manufacturing practices. If particular requirements are not covered by the manufacturer's established practices, suitable documentation shall be added to satisfy those requirements.

30.1.1.1 **Conversion of customer requirements into manufacturer's internal instructions.** The procedure by which customer requirements, as expressed in specifications, purchase orders, etc., are converted into working instructions for the manufacturer's personnel shall be documented.

30.1.1.2 **Personnel training and testing.** The motivational and work training and testing practices employed to establish, evaluate, and maintain the skills of personnel engaged in reliability-critical work shall be documented as to form, content, and frequency of use.

30.1.1.2.1 **Certification of personnel.** The contractor shall have a written procedure covering the training of production and inspection personnel. All employees shall be instructed in proper handling of parts and materials during production, testing, and inspection operations. Only employees who have received this instruction shall be allowed to handle these materials or parts. In addition there shall be a written procedure whereby personnel performing critical tasks on class S parts are certified to perform their assigned tasks. Certification shall be determined on a continuous basis for each operator and a record maintained of each operator's performance. Any operator whose quality performance does not meet certification requirements shall receive retraining or reassignment as required. The term "critical tasks" shall, as a minimum, include coil winding, coil termination, soldering, welding, assembly, potting, encapsulation, and testing.

30.1.1.3 **Inspection of incoming materials, utilities, and work in process.** Inspection operations shall be documented as to type of inspection, sampling and test procedures, acceptance-rejection criteria, and frequency of use.

30.1.1.4 **Quality-control operations.** Quality-control operations shall be documented as to type, procedures, rating criteria, action criteria, records, and frequency of use. All critical in-process operations used in the manufacturing of these devices shall be inspected by an adequately trained inspector. If circumstances preclude inspections after the process is complete, the inspection shall occur during the process.

30.1.1.5 *Quality-assurance operations*. Quality-assurance operations shall be documented as to type, procedures, equipment, judgment and action criteria, records, and frequency of use.

30.1.1.6 **Design, processing, manufacturing equipment, and materials instructions.** Device design, processing, manufacturing equipment and materials shall be documented in drawings, standards, specifications, or other appropriate media which shall cover the requirements and tolerances for all aspects of design and manufacture including equipment test, materials procurement, and handling, design-verification testing, and processing steps. As a minimum requirement, detailed documentation must exist for the following items and must be adequate to assure that quantitative controls are exercised, that tolerances or limits of control are sufficiently tight to assure a reproducible high quality product and that process and inspection records reflect the results actually achieved:

a. Incoming materials control

b. Winding machine setup

c. Winding uniformity

d. Layer insulation

e. Winding finishing and termination

f. Soldering and/or welding

g. Core assembly

h. Rework

i. Potting and encapsulation

j. Sealing.

30.1.1.7 **Cleanliness in work areas.** The requirements for cleanliness in each work area in which unsealed devices, or parts thereof, are processed or assembled shall be documented.

30.1.1.8 **Design, material, and process change control.** The methods and procedures for implementation and control of changes in device design, material, and processing, and for making change information available to the procuring activity, when applicable, shall be documented.

30.1.1.9 **Tool and test equipment maintenance and calibration.** The maintenance and calibration procedures and the frequency of scheduled actions for tools, gauges, and test equipment shall be documented and in accordance with the requirements of MIL-STD-45662.

30.1.1.10 **Failure and defect analysis and data feedback.** The procedures for identification, handling, and analysis of failed or defective devices and for dissemination of analysis data shall be documented, including the procedure for informing the procuring agency of analysis results, when applicable.

30.1.1.11 **Corrective action and evaluation.** The procedure and responsibility for decisions regarding the necessity for corrective action as a result of failure or defect analysis, and for evaluation and approval of proposed corrective actions, shall be documented. If the procedure for evaluation and approval of changes proposed for other reasons, such as cost reduction or product improvement, differs from the above, it shall also be documented.

30.1.1.12 **Incoming, in-process, and outgoing inventory control.** The methods and procedures shall be documented which are used to control storage and handling of incoming materials, work in process, and warehoused and outgoing product in order to (a) achieve such factors as age control of limited-life materials, work, or finished and (b) prevent inadvertent mixing of conforming and nonconforming materials, work, or finished product. In addition, for class S devices, tests and inspections performed by the manufacturers on procured materials and supplies shall include verification of chemical, physical, and functional characteristics required by manufacturer drawings and specifications. Procedures shall be prepared and maintained for controlling the receipt of procured materials and supplies. The procedures shall provide the following:

a. Withholding received materials or supplies from use pending completion of the required inspections or tests, or the receipt of necessary reports.

b. Segregation and identification of nonconforming materials and supplies from conforming materials and supplies and removal of nonconforming subassemblies and parts for grade lines.

c. Identification and control of limited-life materials and supplies.

d. Identification and control of raw materials.

e. Assurance that the required test reports, certifications, etc., have been received.

f. Correct identification of materials released from receiving inspection and test to clearly indicate acceptance or rejection status of material pending review action.

g. Traceability of materials throughout the production process to the accepted product. Completed parts shall be identified to permit positive correlation to the production lot.

30.1.2 **Records to be maintained.** The records required by this section shall be continuously maintained during the manufacture of devices which are intended to be submitted for quality conformance inspection under this specification. The records pertaining to incoming and in-process inspections and those pertaining to quality conformance inspection shall be retained for a minimum of 3 years after performance of the inspections. Records shall be maintained as a minimum for:

a. Personnel training and testing (30.1.2.1)

b. Inspection operations (30.1.2.2)

c. Failure and defect reports and analyses (30.1.2.3)

d. Initial documentation and subsequent changes in designs, materials or processing (30.1.2.4)

e. Equipment calibrations (30.1.2.5)

f. Process, utility, and material controls (30.1.2.6)

g. Product lot identification (30.1.2.7)

Detail requirements for records are stated in 30.1.2.1 through 30.1.2.7.

30.1.2.1 **Personnel training and testing.** Records shall cover the nature of training or testing given, the date thereof by week and length in hours, and the group(s) of personnel given work training and testing.

The records need not indicate occasional specialized training, retraining, or testing of individuals, and are required only for motivational and product-related training and testing as distinguished from safety, first aid, etc.

30.1.2.1.1 **Training of operators and inspectors for class S.** All critical processes and production inspections shall be performed by personnel who have been trained by the manufacturer to perform their assigned task in accordance with manufacturer's in-house standards, including a formal training and test procedure to assure the proficiency of each individual. Each individual shall be retested and/or retrained at the end of a designated period or when personnel performance indicates poor proficiency. Personnel shall not be used in critical processes or inspections until the required level of proficiency has been demonstrated.

30.1.2.2 **Inspection operations.** Records of inspection operations shall cover the tests or inspections made, the materials group (lot, batch, etc.) inspected, the controlling documentation, the date of completion of inspection, the amount of material tested, and acceptance, rejection, or other final disposition of the material.

30.1.2.3 **Failure and defect reports and analyses.** Records of failed or defective devices shall cover the source from which each device was received, the test or operation during which failure occurred or defects were observed, and prior testing or screening history of the device, the date of receipt, and the disposition of the device. Records of failure and defect analyses shall cover the nature of the reported failure or defect (failure or defect mode), verification of the failure or defect, the nature of any device discrepancies which were found during analysis (failure or defect mechanism), assignment of the failure-activating cause if possible, the date of completion of the analysis, identification of the group performing the analysis, disposition of the device after analysis, and the distribution of the record. The record shall also treat the relationship of observed failure or defect modes in related lots or devices and, where applicable, corrective action taken as a result of the findings.

30.1.2.4 **Changes in design, materials, or processing.** Records shall cover the initial documentation and all changes, with the date upon which each change in design, materials, or processing becomes effective. For devices intended to be submitted for quality conformance inspection under this specification, the documents authorizing and implementing the change, and identification of the first production and/or quality conformance inspection lot(s) (as applicable) within which product incorporating the change is included, shall be maintained.

30.1.2.5 **Equipment calibrations.** Records shall cover the scheduled calibration intervals for each equipment item, the dates of completion of actual calibration, identification of the group performing the calibration, and certification of the compliance of the equipment with documented requirements after calibration, in accordance with MIL-STD-45662.

30.1.2.6 **Process, utility, and material controls.** Records shall cover the implementation of devices such as control charts (e.g., X and R charts) or other means of indication of the degree of control achieved at the points in the material, utility, and assembly process flow documented in the manufacturing instructions. Records shall also indicate the action taken when each out-of-control condition is observed, and the disposition of product processed during the period of out-of-control operation.

30.1.2.7 **Product lot identification.** Records shall be capable of identifying in each production and/or acceptance-inspection lot (as applicable) of product, these items as a minimum:

a. The acceptance-inspection tests performed on the lot, and their results.

b. The serial numbers (when applicable) of all devices in the lot.

c. The date of completion of acceptance inspection of the lot.

d. Identification of the lot.

e. The pertinent detail specification under which inspection was performed.

f. Final disposition of the lot (withdrawn, not accepted, accepted).

g. Procuring activity source inspection disposition of the lot.

h. Traceability of all materials used in the production process back to the manufacturer and his lot or batch identification.

30.1.3 **Program plan.** The program plan shall be established and maintained on a current basis by the manufacturer, and shall be delivered to the procuring agency for review (prior to survey, when applicable). It shall consist of a volume or portfolio, or series of same, which will serve to demonstrate to the procuring agency that the manufacturer's understanding of a complete product assurance program, as exemplified by his documentation system, is adequate to assure compliance of his product with the applicable specifications and quality standards. If the product assurance program exemplified is applied consistently to all product lines intended to be submitted for acceptance inspection under this specification, only one program plan is required for each manufacturing plant; any difference in treatment of different product lines within a plant shall be stated and explained in the program plan, or separate program plans prepared for such different lines. The program plan shall contain as a minimum, these items:

a. Functional block organization chart (30.1.3.1)

b. Manufacturing flow chart (30.1.3.2)

c. Proprietary-documents (30.1.3.3)

d. Examples of design, material, equipment, visual standard, and process instructions (30.1.3.4)

e. Examples of records (30.1.3.5)

f. Examples of design, material and process change control documents (30.1.1.8)

g. Examples of failure and defect analysis and feedback documents (30.1.1.10)

h. Examples of corrective action and evaluation documents (30.1.1.11)

i. Manufacturer's internal instructions for internal visual inspection (30.1.3.6)

J. Manufacturing practices (see 5.5).

Detail requirements for these items are described in 30.1.3.1 through 30.1.3.6, 30.1.1.8, 30.1.1.10, and 30.1.1.11.

30.1.3.1 **Functional block organization chart.** This chart shall show, in functional block-diagram form, the lines of authority and responsibility (both line and staff) for origination, approval, and implementation of the several aspects of the product assurance program. Names of incumbents are not required in this chart.

30.1.3.2 **Manufacturing flow chart.** This chart shall show, in flow-chart form, the manufacturing sequence typical of the product line under consideration, including inspection and process-control stations. If desired, a separate chart may be used for quality-assurance operations. Insofar as practical, each manufacturing flow chart station shall be keyed (by document number and the step(s) it controls) to the pertinent exemplary documents (see 30.1.3.3 through 30.1.3.5) included in the program plan, to facilitate understanding of the interrelationships of the various documents.

30.1.3.2.1 **Manufacturing baseline for class S devices.**
The flow chart for class S devices will show all manufacturing, inspection, testing, and quality verification points and the points where all materials or subassemblies enter the flow. The chart will identify all documents pertaining to the procurement and inspection of materials, the production processes, the production environments and production controls which were used. The documents will be identified by name, number, and revision in effect at the time of manufacturer certification, or changes approved thereafter. The manufacturer shall maintain a file/book of all referenced documents noted on the flow chart, including in-house documents referenced there for use by the qualification/certification teams and the designated procurement agency representative(s).

30.1.3.3 **Proprietary-documents.** A listing of proprietary documents shall be included in the program plan and maintained on a current basis (see 30.1).

30.1.3.4 **Examples of design, material, equipment, visual standard and process instructions.** An example of each type of design, material, equipment, visual standard, and process instruction used in the manufacture of devices intended to be submitted for acceptance inspection under this standard shall be included in the program plan. These may be either dummies or actual working documents, but shall in either event show the form of the pertinent document; blank forms shall not be included.

30.1.3.5 **Examples of records.** Examples of records, complying with the requirements of 30.1.3.4 for instructions, shall be included in the program plan.

30.1.3.6 **Manufacturer's internal instructions for internal visual inspection.** The manufacturer's internal instructions for visual inspection before potting shall be included in the program plan.

SCREENING TESTS

10. SCOPE.

This appendix contains details for performance of group A screening tests for devices specified in accordance with this standard. This appendix is a mandatory part of this standard. The information contained herein is intended for compliance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. SCREENING TESTS

30.1 **Power transformers, power inductors, audio transformers, audio inductors, high power pulse transformers, charging inductors, saturable transformers, and saturable inductors (families 03, 04, 20, 21, 36, 37, 40 and 41 respectively).** These devices shall be subjected to the group A screening tests of table VIII.

30.1.1 **Thermal shock.** Thermal shock screening shall be in accordance with MIL-T-27, and as follows:

a. Number of cycles: The number of cycles shall be as specified in the procurement document but shall not be less than 10 cycles minimum for class B parts and 25 cycles minimum for class S parts.

b. Continually monitor continuity during the entire final cycle to verify no intermittent conditions. Continuity monitoring current shall not exceed 3 microamperes. Equipment shall be capable of detecting intermittent opens exceeding 100 microseconds.

c. Class S parts using magnet wire smaller than AWG 38 shall have dc resistance measured before and after the thermal shock screen. The change in resistance shall not exceed ±3 percent.

30.1.2 **Burn-in.** (Applicable to class S and class B parts)

30.1.2.1 **Transformers.**

30.1.2.1.1 **Power burn-in (applicable for transformers with an output greater than 0.8 watts).** Devices shall be tested as follows:

a. Test duration: 96 hours minimum.

b. Test temperature: Maximum rated ambient temperature.

c. Test voltages and currents: Rated input voltage and current at minimum rated frequency and at maximum rated load.

TABLE VIII. Group A screening tests for families 03, 04, 11, 12, 20, 21, 31, 36, 37, 40, and 41, respectively (see 30.1, 30.2 and 30.4).

Examination/Test	Class S	Class B	Applicable Military Specification	Inspection
Subgroup I				
Thermal shock	X	X	See 30.1.1	
Burn-in	X	X	See 30.1.2	
Seal (when applicable)	X	X	MIL-T-27	
Dielectric withstanding voltage	X	X	MIL-T-27	100 percent
Induced voltage	X	X	MIL-T-27	
Insulation resistance	X	X	MIL-T-27	
Electrical characteristics	X	X	MIL-T-27	
Radiographic inspection	X		See appendix C	
Subgroup II				
Visual and dimensional examination (external)	X	X	MIL-T-27	100 percent

30.1.2.1.2 **No load burn-in (applicable for transformers with an output equal to or less than 0.8 watts).** Devices shall be tested as follows:

a. Test duration: 96 hours minimum

b. Test temperature: Maximum rated ambient temperature

c. Test voltages and current: Rated input voltage and current at minimum rated frequency with no load.

30.1.2.2 **No-load burn-in for inductors.** Devices shall be tested as follows:

a. Test duration: 96 hours minimum

b. Test temperature: Maximum operating temperature

c. Test voltages and currents: Not applicable.

30.2 **Radio frequency, fixed, and variable transformers (families 11 and 12, respectively).** These devices shall be subjected to the group A screening tests in table VIII except tests shall be performed in accordance with MIL-T-55631 in lieu of MIL-T-27.

30.3 **Radio frequency fixed and variable coils (families 13 and 14).** These devices shall be subjected to the group A screening tests in table IX.

TABLE IX. Group A screening tests for families 13 and 14 (30.3).

Examination/Test	Class		Applicable Military Specification	Inspection
	S	B		
Subgroup I				
Thermal shock	X	X	See 30.3.1	
No-load burn-in	X	X	See 30.3.2	
Dielectric withstanding	X	X	MIL-C-15305	
Insulation resistance	X	X	MIL-C-15305	
Inductance	X	X	MIL-C-15305	100 percent
Q	X	X	MIL-C-15305	
Self resonant frequency	X	X	MIL-C-15305	
DC resistance	X	X	MIL-C-15305	
Radiographic inspection	X		MIL-C-15305	
Subgroup II				
Visual and mechanical examination	X	X	MIL-C-15305	100 percent

30.3.1 **Thermal shock.** Thermal shock screening shall be in accordance with MIL-C-15305 and as follows: (Note: End point measurements per MIL-C-15305 shall not apply).

a. Number of cycles: 25.

b. Continually monitor continuity during the entire final cycle to verify no intermittent conditions. Continuity monitoring current shall not exceed 100 microamperes. Equipment shall be capable of detecting intermittent opens exceeding 100 microseconds.

c. Class S parts using magnet wire smaller than AWG 38 shall have dc resistance measured before and after the thermal shock screen. The change in resistance shall not exceed ±3 percent.

30.3.2 **No load burn-in.** Devices shall be tested as follows:

a. Test duration: 96 hours minimum

b. Test temperature: Maximum rated operating temperature

c. Test voltage: Not applicable

30.4 **Low power pulse transformers (family 31).** These devices shall be subjected to the group A screening tests in table VIII except tests shall be performed in accordance with MIL-T-21038 in lieu of MIL-T-27.

TABLE X. Group A screening tests for families 50 and 51 (see 30.5).

Examination/Test	Class		Applicable Military Specification	Inspection
	S	B		
Subgroup I				
Thermal shock	X	X	See 30.5.1	
No-load burn-in	X	X	See 30.5.2	
Dielectric withstanding voltage	X	X	MIL-C-83446	
Insulation resistance	X	X	MIL-C-83446	
Inductance	X	X	MIL-C-83446	100 percent
Q	X	X	MIL-C-83446	
Self resonant frequency	X	X	MIL-C-83446	
DC resistance	X	X	MIL-C-83446	
Radiographic inspection	X		MIL-C-83446	
Subgroup II				
Visual and mechanical examination (external)	X	X	MIL-C-83446	100 percent

30.5 **Radio frequency, fixed and variable, chip coils (families 50 and 51, respectively).** These devices shall be subjected to the group A screening tests in table X.

30.5.1 **Thermal shock.** Thermal shock screening shall be in accordance with MIL-C-83446 and as follows:

a. Number of cycles: 25

b. Continually monitor continuity during the entire final cycle to verify no intermittent conditions. Continuity monitoring current shall not exceed 3 microamperes. Equipment shall be capable of detecting intermittent opens exceeding 100 microseconds.

c. Class S parts using magnet wire smaller than AWG 38 shall have dc resistance measured before and after the thermal shock screen. The change in resistance shall not exceed ±3 percent.

30.5.2 **No-load burn-in.**

a. Test duration: 96 hours minimum.

b. Test temperature: Maximum rated operating temperature.

c. Test voltage: Not applicable.

RADIOGRAPHIC INSPECTION

10. SCOPE

This appendix contains details for performance of the radiographic inspection for devices specified in accordance with this standard. This appendix is a mandatory part of this standard. The information contained herein is intended for compliance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. RADIOGRAPHIC INSPECTION

30.1 **Radiographic inspection.** Devices shall be tested in accordance with Method 209 of MIL-STD-202. The following details and exceptions shall apply:

a. Radiographic quality: The radiograph shall render a clear sharp image of the penetrameter.

b. Image quality indicator: A radiograph of the penetrameter shall be included on each radiograph film. The penetrameter may be made from a sample of the same type as that being radiographed, with an AWG number 48 tungsten wire mounted across the body.

30.1.1 **Transformers and inductors.** Examples of typical construction and terminology are shown on figure 5.

30.1.1.1 **Views.** Radiographs shall be taken of each device in each of three axes; X, Y, and Z. When inadequate coverage is provided, additional views shall be taken as deemed necessary to satisfy the criteria defined herein. Axial orientation is shown on figure 6.

30.1.1.2 **Examination.** The radiographic examination shall include, but not be limited to, inspection for extraneous materials, alignment, clearance and processing damage.

30.1.1.2.1 **Extraneous material.** There shall be no visible extraneous materials that can cause damage to insulation or electrical short circuit between conductors or connections. Loose or excessive bonding material such as weld or solder splash, solder balls and short lengths of unattached wire shall be considered extraneous material. See figure 7.

30.1.1.2.2 **Alignment and clearances.** Acceptable parts shall exhibit adequate internal electrical and mechanical clearances. Criteria for determining adequate clearance by inspection of radiographs shall be established by each manufacturer and must be approved by the qualifying activity, except as specified otherwise herein. Unacceptable alignment and clearances include the following:

a. Insufficient clearance between wires and metallic case, other conductive support, or external surfaces. See figure 8.

b. Lead wire under tension that can be subjected to further stress under thermal expansion. See figure 8(g).

c. Inadequate clearance of wires and installation holes, wherein the wires can be damaged in installation.

d. Inadequate clearance between adjacent terminals due to pigtails of the wires, or wire alignment.

e. Inadequate clearance between wires. See figure 8(b).

30.1.1.2.3. **Processing damage.** Unacceptable processing includes the following:

a. Raveled or frayed wire ends that can separate or pierce insulation, other wires or parts. See figures 9(a) and 10(a).

b. Partially broken wire strands. Multiple strand wire in which one or more strands have separated. See figure 9(b).

c. Missing or incomplete soldering or welding of connections. See figures 9(c) and 10(d).

d. Excess lengths of wires that are unsupported and can move freely under mechanical or thermal stress. See figure 9(d).

e. Unauthorized splices or repair of broken wires or terminals. See figures 9(e) and 10(c).

f. Voids in encapsulant in contact with the lead between the coil and external surface that completely surround the wire or, although not surrounding the wire, extend greater than 20 percent of the distance from the coil to the external surface. See figures 9(f) and (g).

g. Cracked or damaged core. see figure 10(f).

30.1.1.2.4 **Miscellaneous.** Cracked, broken or improperly assembled core, deformed or bent parts, and voids in the seal shall be cause to reject a part.

30.1.2 **Radio frequency coils.**

30.1.2.1 **Views.** Two views, normal to the major axis of the part shall be taken. One view shall be 90 degrees from the other.

30.1.2.2 **Examination.** The coil examination shall include, but not be limited to, inspection for extraneous material on the windings or within the enclosure, misaligned or mispositioned core, misaligned electrodes and physical damage to the windings of the coil.

30.1.2.2.1 **Cracked or damaged core.** The core shall show no evidence of being cracked or otherwise damaged. See figure 11(a).

30.1.2.2.2 **Extraneous material.** There shall be no loose or attached extraneous material 0.002 inches (.0508 mm) or larger in size on the windings or within the enclosure. See figure 11(b).

30.1.2.2.3 **Misaligned leads.** The center line of the leads shall not form an angle greater than 5 degrees. See figure 11(c).

30.1.2.2.4 **Windings.** There shall be no excessively loose turns visible on the coil. A separation of 0.010 inches or more between a winding and the next inner layer of winding shall be considered excessive. See figure 11(d).

30.1.2.2.5 **Misaligned core.** The core shall be aligned with 5 degrees of a line connecting the centers of the two electrical connections. See figure 11(e).

30.1.2.2.6 **Damaged magnet wire.** The magnet wire shall show no evidence of being chipped, nicked, or otherwise damaged. See figure 11(f).

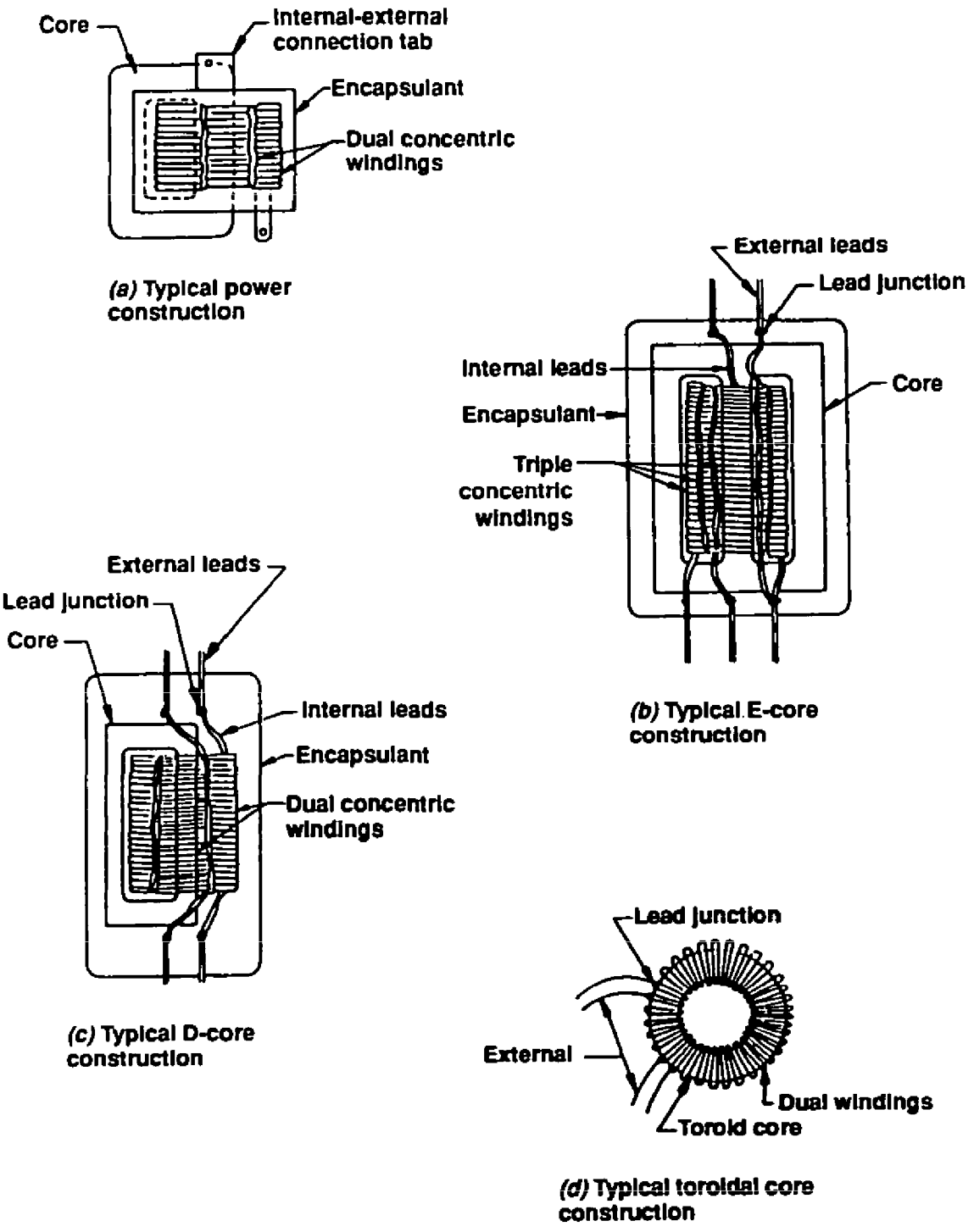


FIGURE 5 (1 of 3). **A typical transformer/inductor construction (see 30.1.1).**

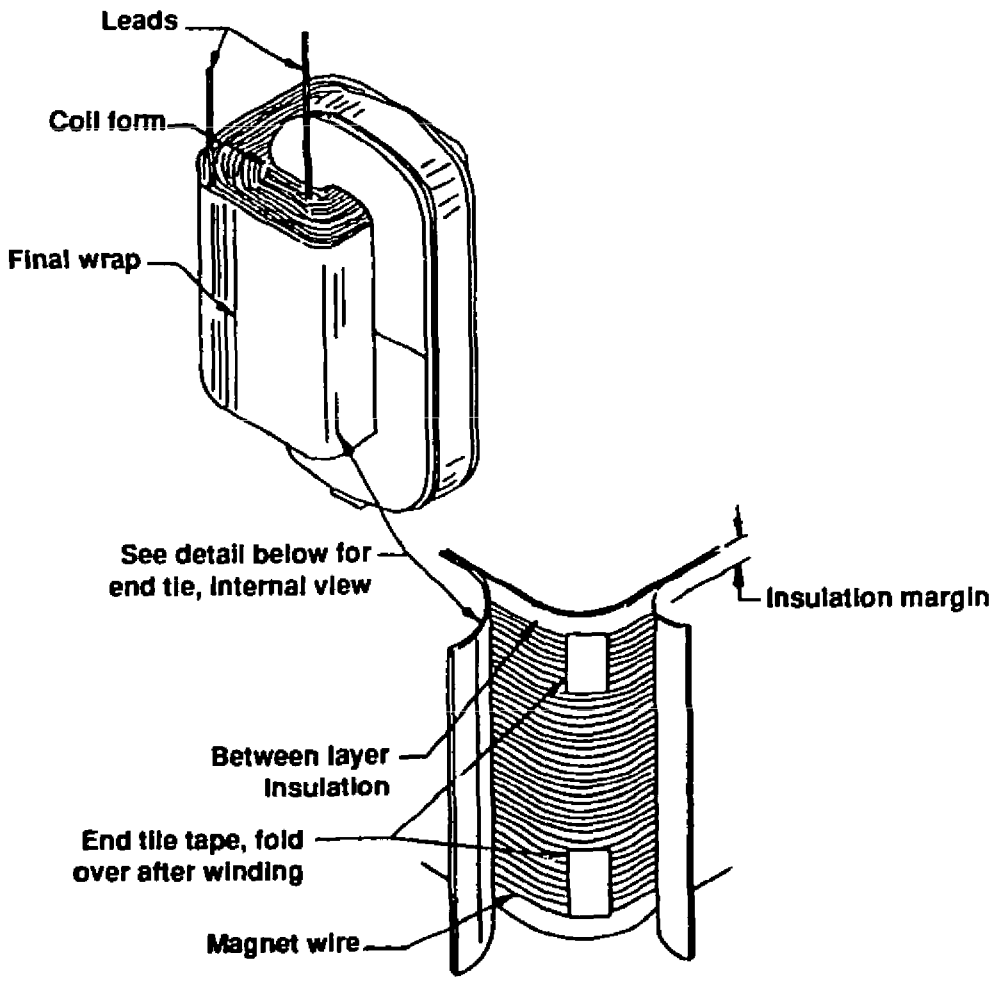


FIGURE 5 (2 of 3). A typical transformer/inductor construction (see 30.1.1).

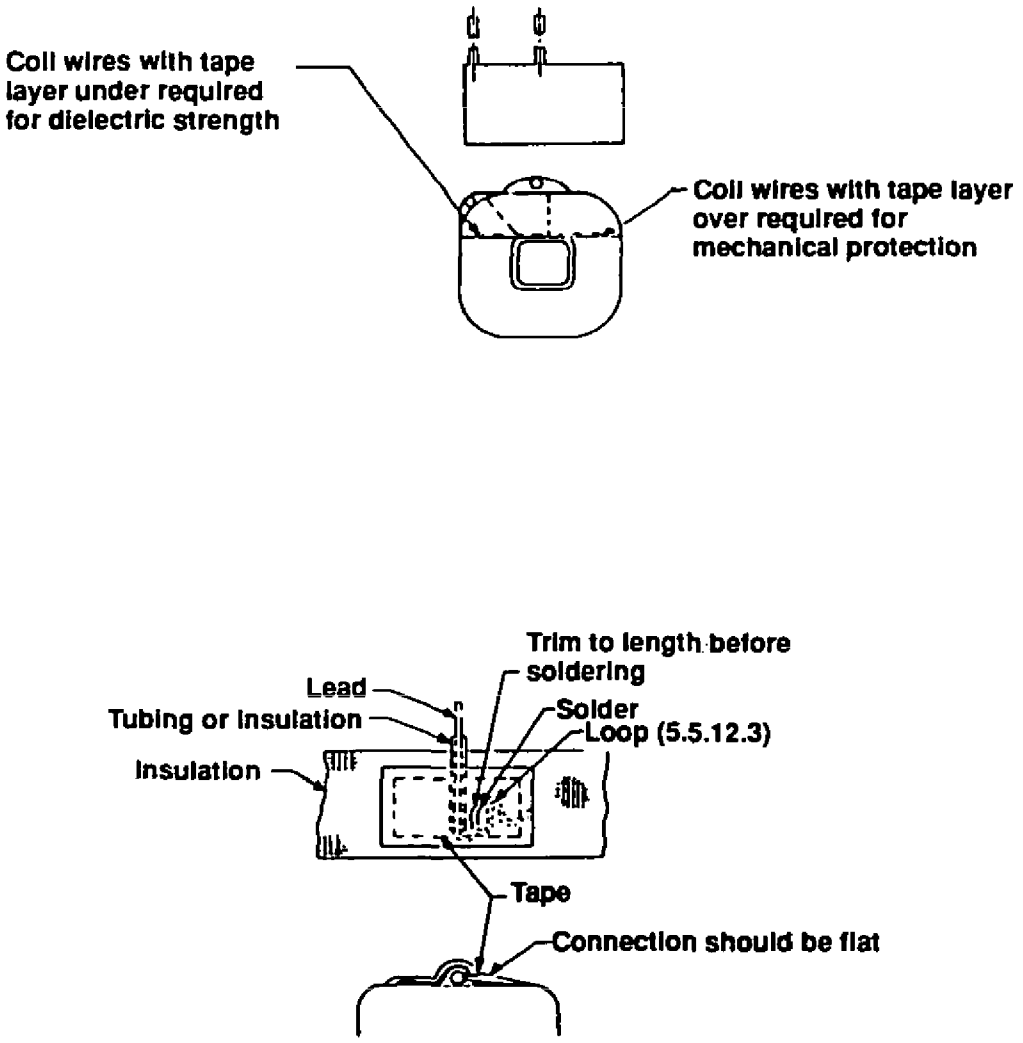


FIGURE 5 (3 of 3). **A typical transformer/inductor construction (see 30.1.1).**

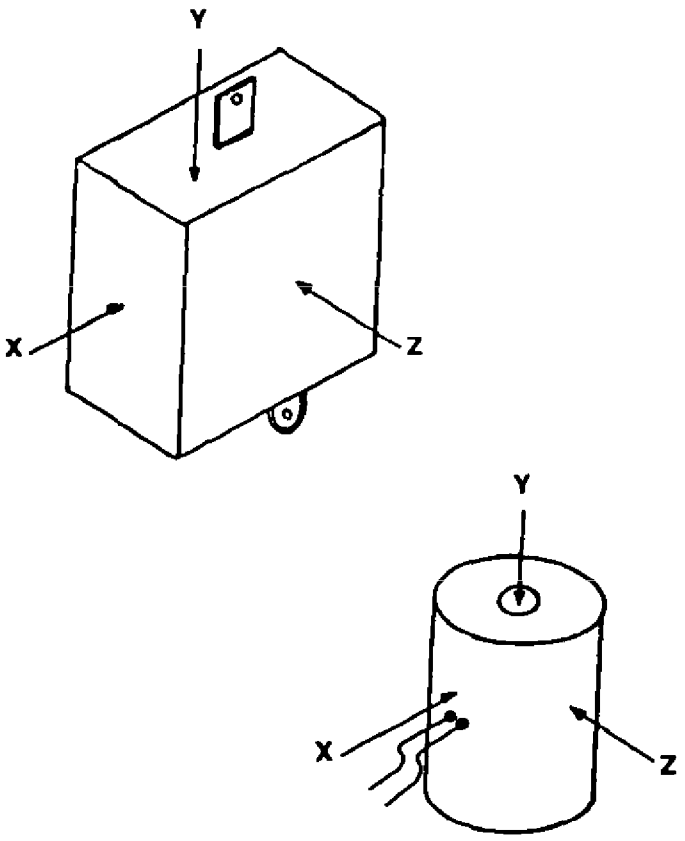


FIGURE 6. **Axial orientation (see 30.1.1.1).**

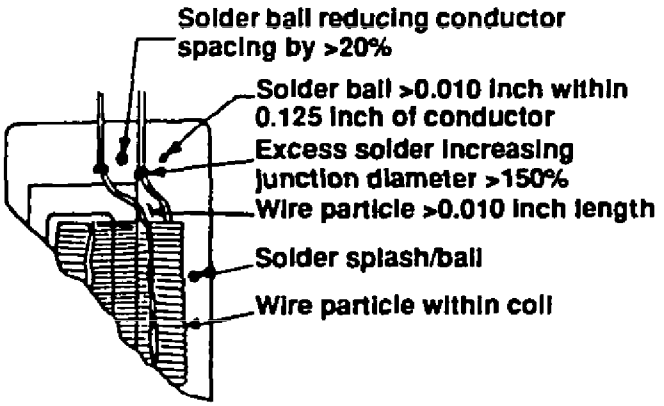


FIGURE 7. Unacceptable extraneous material (see 30.1.1.2.1).

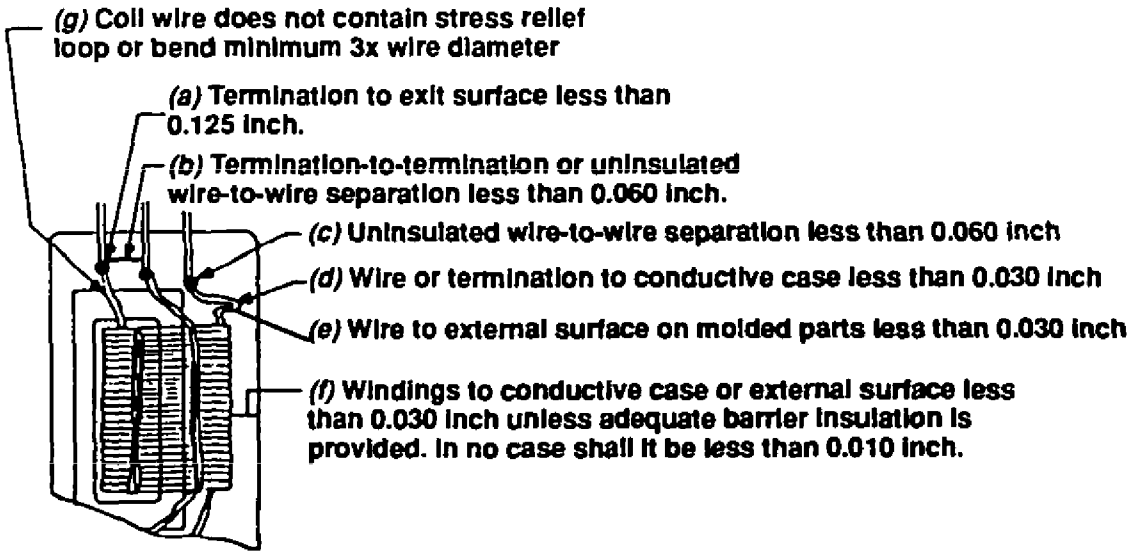


FIGURE 8. Unacceptable alignment and clearances (see 30.1.1.2.2).

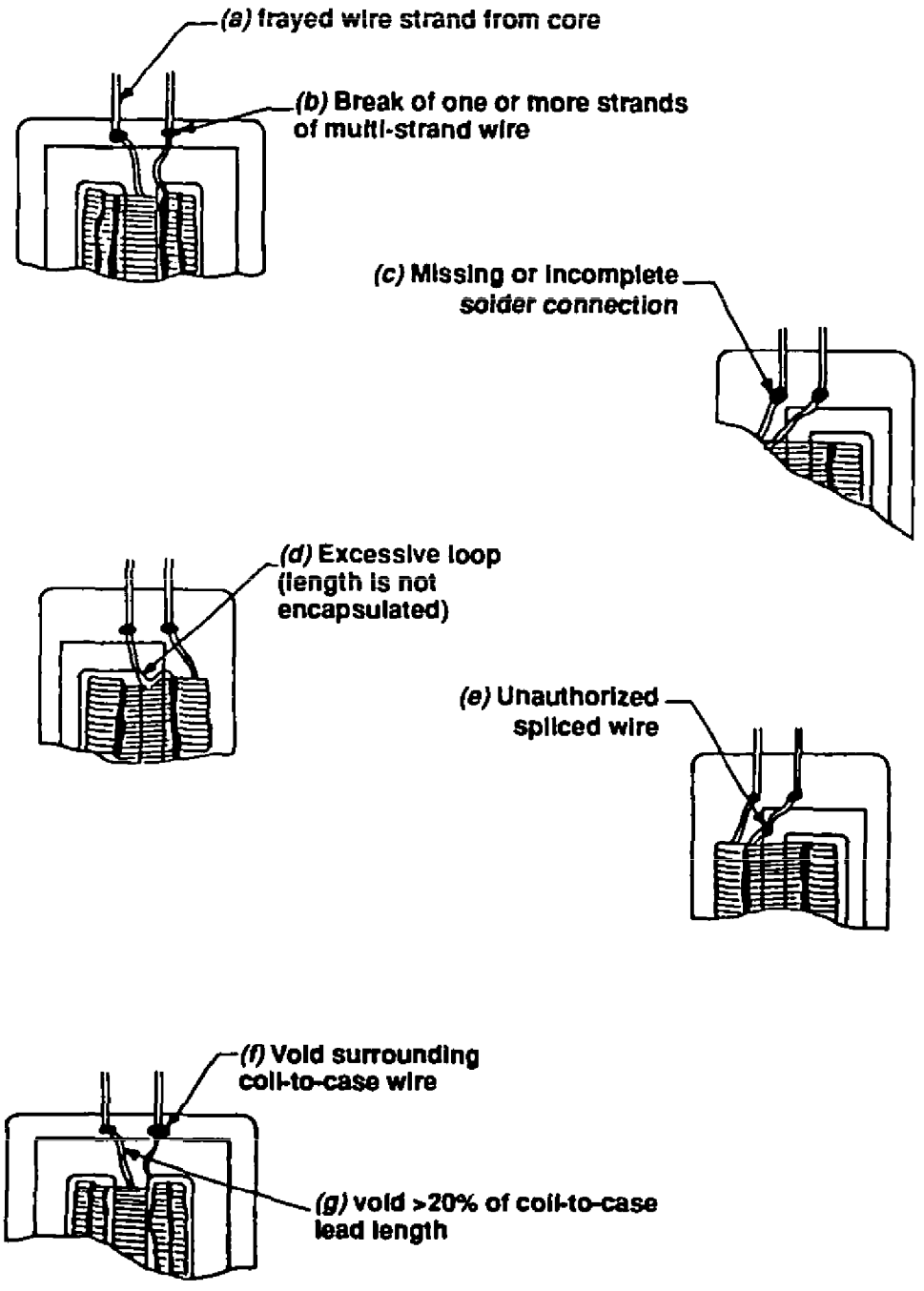


FIGURE 9. Unacceptable processing (see 30.1.1.2.3).

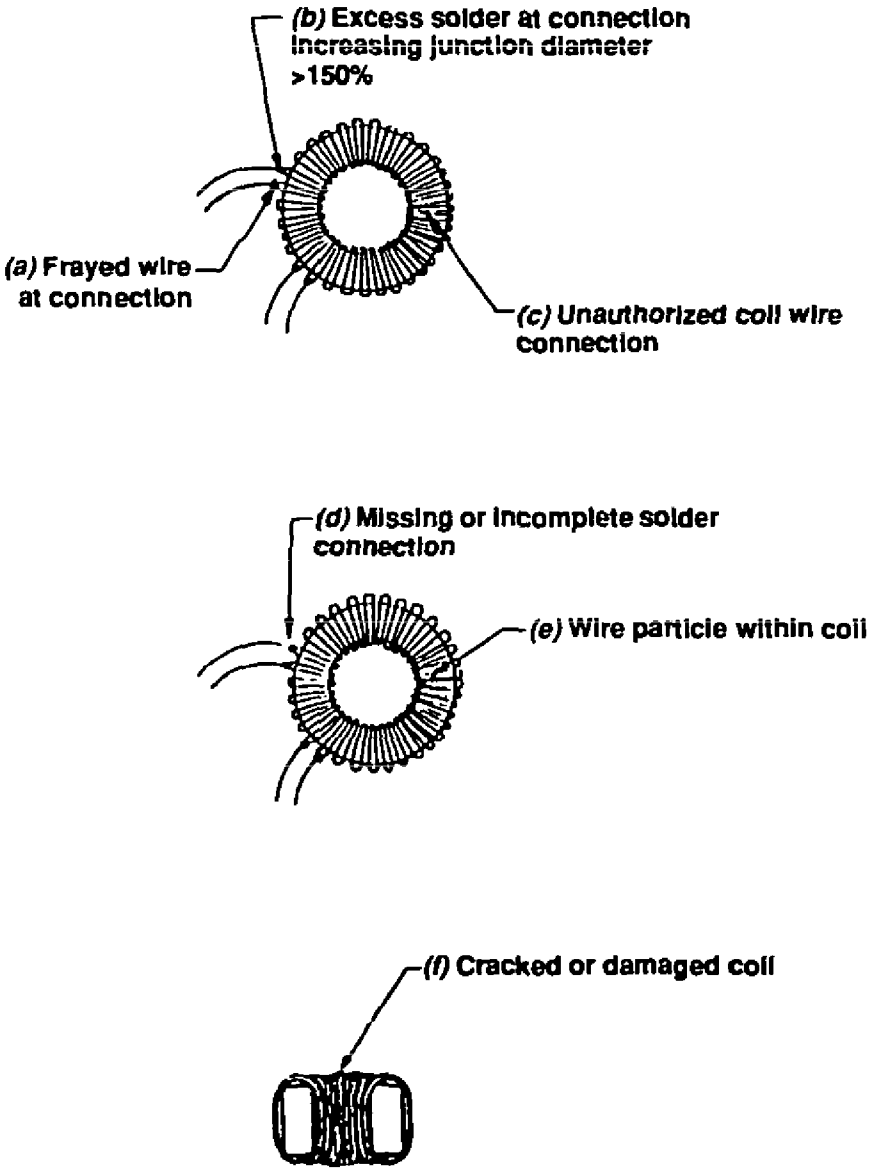
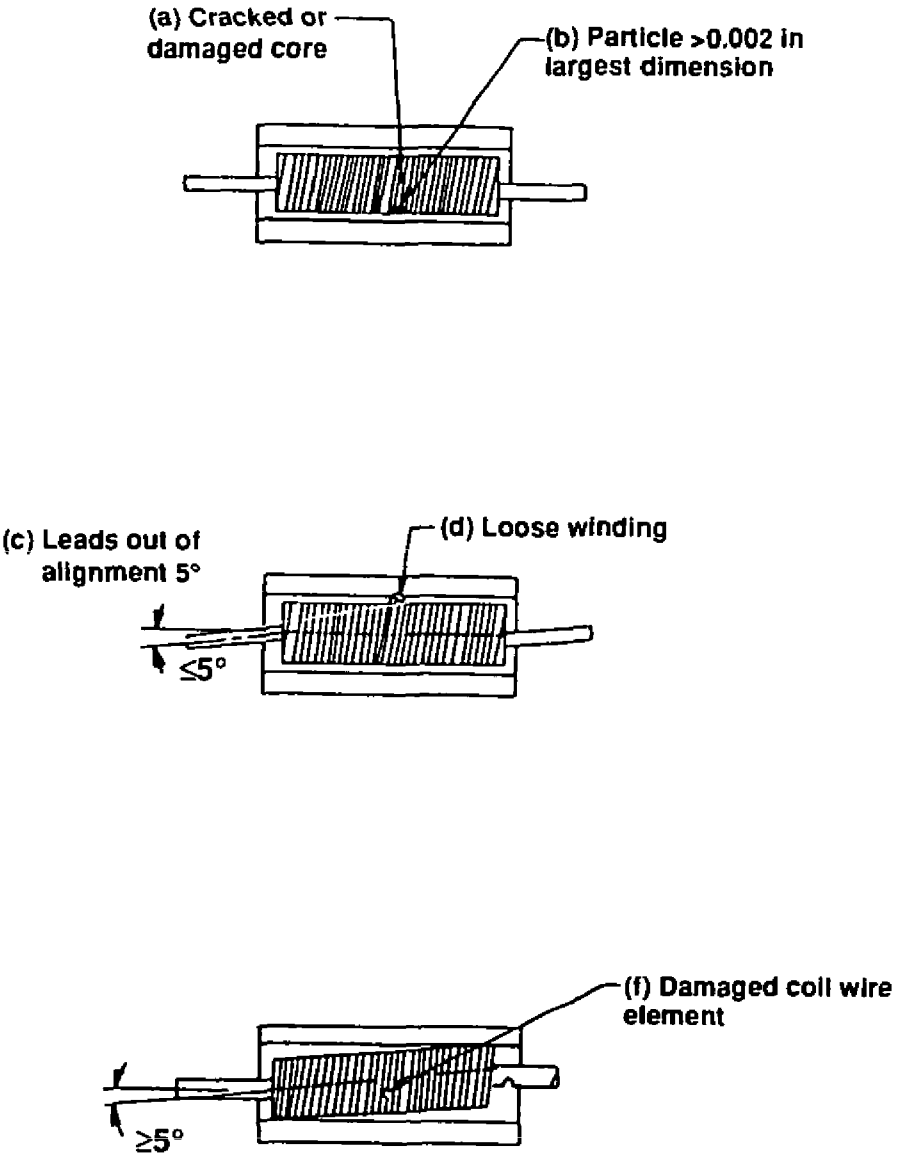


FIGURE 10. **Unacceptable processing damage - toroidal core (see 30.1.1.2.3).**



(e) Core misalignment

FIGURE 11. **Unacceptable workmanship for radio frequency coils (see 30.1.2.2).**

CONCLUDING MATERIAL

Custodians:
NASA - NA
Air Force - 19

Review activities:
DLA - ES

Preparing activity:
NASA -NA

Agent:
DLA - ES

(Project 5950-0771)

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