Sleeving selected should be non-flammable. Sleeving specifications should be carefully evaluated for flammability ratings since a specification may cover both flammable and non-flammable materials.

One disadvantage of sleeving is that it normally cannot be easily replaced after the conductors are terminated with components such as terminal lugs or connectors unless the sleeving is cut and subsequently tied back together after installation; or unless an alternate type of sleeving such as ''zipper'' or ''spiral'' sleeving is used.

Heat-shrink sleeving can also be an issue in event it is damaged via a nick or tear since in time, the damage can eventually cause the sleeving to completely tear and separate from the conductors due to the internal stresses from the heat shrink process.

Both ends of protective sleeving should be secured with tape, tie-wrap or similar material to prevent sleeving from loosening.

13.8.26 Straps/Clamps Various types of straps and/or clamps are normally used to restrain and/or route cable and wire harness assemblies. Their primary function is to preclude damage during a shock and vibration environment and to facilitate routing in an organized fashion. They also preclude interference with moving components such as cooling fan blades, etc.

Straps and clamps that include a non-metal insert should be non-flammable. The applicable specifications should be carefully evaluated for flammability ratings since a specification may cover both flammable and non-flammable materials. The materials of the inserts should be verified for chemical compatibility with the conductor insulation since some materials may interact chemically and leave a residue on the conductor insulation or sleeving.

It is also recommended that insert materials have an unlimited shelf-life (i.e., 20 years) whenever possible and appropriate for the end-item application.

See SAEAS23190 and SAEAS21919 as examples.

13.8.27 Lacing Cord Lacing cord and/or lacing tape should be selected based on the maximum operating/environmental temperature range since some materials are restricted to 105 °C whereas other materials are available for 200 °C [392 °F] or greater temperature rating.

Materials selected should not have a wax coating.

Typical materials include; MIL-T-713, MIL-I-3158, MIL-Y-1140 and A-A-52080 through A-A-52084.

13.9 Fiber Optic Cables An optical fiber cable is a cable containing one or more optical fibers, (see Figure 13-39). The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed.

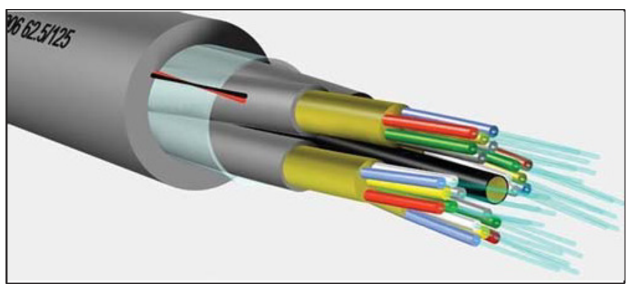

Figure 13-39 An Optical Fiber Breakout Cable

13.9.1 Design In practical fibers, the cladding is usually coated with a layer of acrylate polymer or polyimide. This coating protects the fiber from damage but does not contribute to its optical waveguide properties. Individual coated fibers (or fibers formed into ribbons or bundles) then have a tough resin buffer layer and/or core tube(s) extruded around them to form the cable core. Several layers of protective sheathing, depending on the application, are added to form the cable. Rigid fiber assemblies sometimes put light-absorbing (''dark'') glass between the fibers, to prevent light that leaks out of one fiber from entering another. This reduces cross-talk between the fibers, or reduces flare in fiber bundle imaging applications. For indoor applications, the jacketed fiber is generally enclosed, with a bundle of flexible fibrous polymer strength members like Aramid (e.g., Twaron or Kevlar), in a lightweight plastic cover to form a simple cable. Each end of the cable may be terminated with a specialized optical fiber connector to allow it to be easily connected and is connected from transmitting and receiving equipment.

For use in more strenuous environments, a much more robust cable construction is should be used. In loose-tube construction the fiber is laid helically into semi-rigid tubes, allowing the cable to stretch without stretching the fiber itself. This protects the fiber from tension during laying and due to temperature changes. Loose-tube fiber may be ''dry block'' or gel-filled. Dry block offers less protection to the fibers than gel-filled, but costs considerably less. Instead of a loose tube, the fiber may be embedded in a heavy polymer jacket, commonly called ''tight buffer'' construction. Tight buffer cables are offered for a variety of applications, but the two most common are ‘‘Breakout’’ and ‘‘Distribution.’’ Breakout cables normally contain a ripcord, two non-conductive dielectric strengthening members (normally a glass rod epoxy), an aramid yarn and 3 mm [0.118 in] buffer tubing with an additional layer of Kevlar surrounding each fiber. The ripcord is a parallel cord of strong yarn that is situated under the jacket(s) of the cable for jacket removal. Distribution cables have an overall Kevlar wrapping, a ripcord and a 900 micrometer [0.035 in] buffer coating surrounding each fiber. These fiber units are commonly bundled with additional steel strength members, again with a helical twist to allow for stretching.

A critical concern in outdoor cabling is to protect the fiber from contamination by water. This is accomplished by use of solid barriers such as copper tubes and water-repellent jelly or water-absorbing powder surrounding the fiber. Finally, the cable may be armored to protect it from environmental hazards, such as construction work or gnawing animals. Undersea cables are more heavily armored in their near-shore portions to protect them from boat anchors, fishing gear, and even sharks, which may be attracted to the electrical power signals that are carried to power amplifiers or repeaters in the cable.

Modern fiber cables can contain up to a thousand fibers in a single cable, so the performance of optical networks easily accommodates even today’s demands for bandwidth on a point-to-point basis. However, unused point-to-point potential bandwidth does not translate to operating profits, and it is estimated that no more than 1% of the optical fiber buried in recent years is actually ’lit.’ While unused fiber may not be carrying traffic, it still has value as dark backbone fiber. Companies can lease or sell the unused fiber to other providers who are looking for service in or through an area. Many companies are ‘‘overbuilding’’ their networks for the specific purpose of having a large network of dark fiber for sale. This is a great idea as many cities are difficult to deal with when applying for permits and trenching in new ducts is very costly.

Modern cables come in a wide variety of sheathings and armor designed for applications such as direct burial in trenches, dual use as power lines, installation in conduit, lashing to aerial telephone poles, submarine installation, or insertion in paved streets. In recent years the cost of small fiber-count pole-mounted cables has greatly decreased due to the high Japanese and South Korean demand for fiber to the home (FTTH) installations.

13.9.2 Reliability and Quality Optical fibers are inherently very strong, but the strength is drastically reduced by unavoidable microscopic surface flaws inherent in the manufacturing process. The initial fiber strength, as well as its change with time, should be considered relative to the stress imposed on the fiber during handling, cabling and installation for a given set of environmental conditions. There are three basic scenarios that can lead to strength degradation and failure by inducing flaw growth: dynamic fatigue, static fatigues and zero-stress aging. Telcordia GR-20, *Generic Requirements for Optical Fiber and Optical Fiber Cable,* contains reliability and quality criteria to protect optical fiber in all operating conditions. The criteria concentrate on conditions in an outside plant (OSP) environment. For the indoor plant, similar criteria are in Telcordia GR-409, *Generic Requirements for Indoor Fiber Optic Cable.*

13.9.3 Splicing Splicing is the process of connecting two bare fibers directly without any connectors. There are two methods of fiber optic splicing: mechanical splicing and fusion splicing, see Figure 13-40.

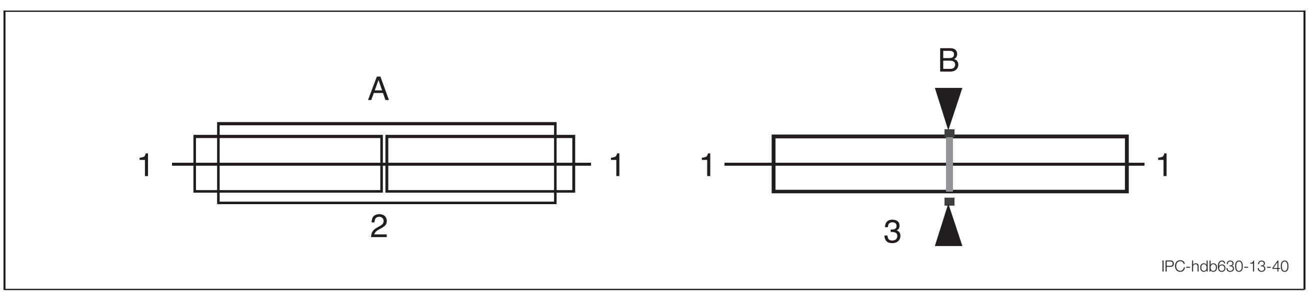

Figure 13-40 Fiber Optic Splices

13.9.3.1 Mechanical Splicing Mechanical splicing is an optical junction where two fibers are precisely aligned and held in place by a mechanical assembly, (see Figure 13-41). Mechanical splicing aligns two fiber ends to a common centerline so the light can pass from one fiber to another. Mechanical splices are best suited for multimode fiber applications. Some mechanical splices have been introduced for single mode fibers, but they usually have a higher insertion loss (typically 0.1dB).

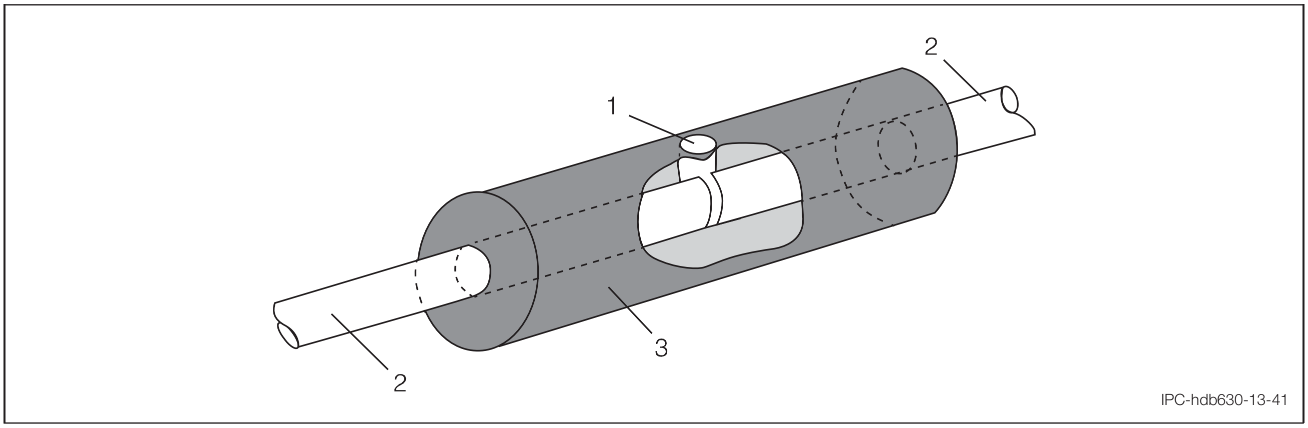

Figure 13-41 Mechanical Fiber Optic Splice
1. Transparent Adhesive Hole
2. Optical Fiber
3. Glass or Ceramic Alignment Tube

13.9.3.2 Fusion Splicing Fusion splicing is an optical junction of two optical fibers by permanently welding them together with heat generated by an electronic arc (called arc fusion), (see Figure 13-42).

The fusion splicing process begins by preparing each fiber end for fusion. Fusion splicing requires that all protective coatings be removed from the ends of each fiber. The fiber is then cleaved with high precision fiber cleavers. In fusion splicing, splice loss is a direct function of the angles and quality of the two fiber-end faces.

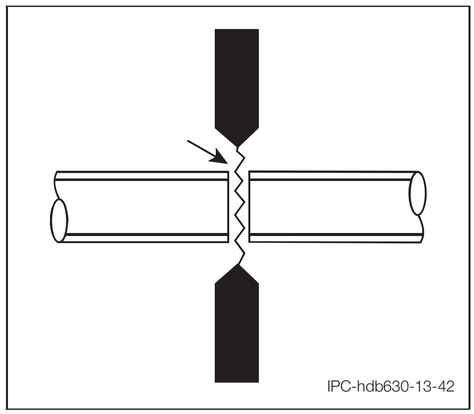

Figure 13-42 Fusion Fiber Optic Splice

13.9.3.3 Quick Termination Fiber Optic Connectors A quick termination fiber connector is actually a mini-pigtail housed in a connector body. There is a fiber stub already bonded into the ferrule in the factory, where the end face of the ferrule is polished to a PC finish. The other end of the fiber is cleaved and resides inside the connector body. The field fiber is cleaved and inserted into the connector until it ''butts up'' against the fiber stub. A mechanical clamping process keeps the fiber in place and completes the connector with no epoxy or polishing required. After strain relieving the fiber to the connector, it is ready to be mated to another connector inside an adapter, (see Figure 13-43).

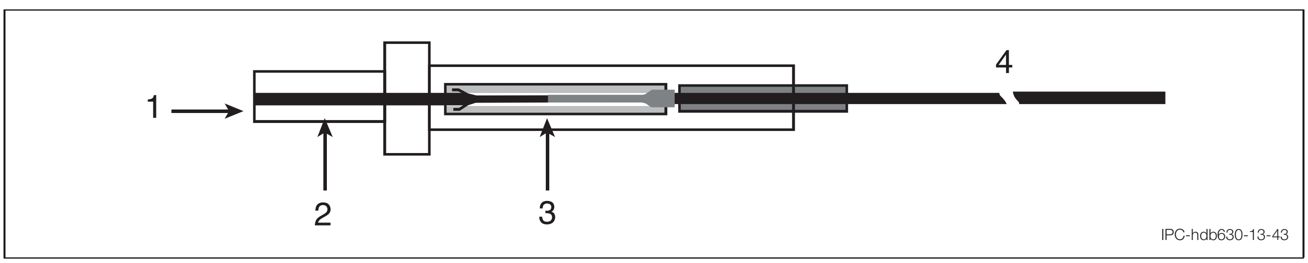

Figure 13-43 Quick Termination Fiber Optic Connector
1. Factory Polished End Face
2. Fiber Stub
3. Mechanical Splice with Index Matching Gel
4. Field Fiber

13.9.3.3.1 Applications for Quick Termination Fiber Connectors:

a. Where a smaller number of connectors are necessary.

b. Where moves, adds, changes or testing are frequently performed.

c. LAN environments where the installer is required to move from termination point to termination point (work areas, telecommunications outlets).

d. Where maintenance or restoration is required on an active network or system.

13.9.3.3.2 Applications for Traditional Epoxy and Polish Fiber Connectors:

a. Where a large number of connectors will be used.

b. Where added fiber retention is beneficial.

g. Where gel-filled cable is present.

h. Where unique buffer coatings or cable types are used.

i. Environmental conditions that are not aligned with TIA 568-B.3 (Outside Plant, Industrial, etc).

13.10 Wire Marking Methods The following paragraphs identify the most commonly used methods for marking of cable and/or wire harness assemblies.

13.10.1 Hot Stamp Marking Hot stamp marking is still the most inexpensive method for wire or cable identification and it can be used to mark over Teflon insulation.

In order to ensure a quality marking you should have the correct air pressure, dwell time, wheel temperature and foil. The air pressure is the pressure in which the wheels make contact with the wire or cable. Control of this process is important to preclude affecting the integrity of the wire or cable insulation.

The dwell time is the length of time in which it takes to complete the whole stamping cycle. The wheel temperature and foil types are chosen together. The foil consists of a backing and a pigment color. The pigment is transferred to the wire or cable insulation via the heat from the character wheels. The backing of the foil should be able to withstand the required temperature range and can be made of different materials such as Mylar or Nylon. Certain pigments will stick to certain substrates and will require different temperatures to transfer them. For example, one cannot use a foil that will mark on PVC at 275° for Teflon that may require temperatures of 350-400°.

Hot stamp marking should not be used for some wire types; specifically, wire conforming to AS81044 and AS50881. This wire is used for aerospace application and the concern is that this marking method could sufficiently penetrate the wire insulation and result in a dielectric breakdown of the insulation.

13.10.2 Inkjet Marking Inkjet technology has improved greatly over the last few years. With less maintenance and quicker start-ups, inkjet marking systems have grown much more reliable and user friendly.

For the wire and cable industry, it is usually a dye or pigmented ink, with an MEK base. Although rare, alcohol based inks can be used; however, drying time is increased.

Depending on the interfacing wire processing equipment and software, one can mark on the fly and vary text strings throughout the length of the wire or cable. You can also vary font sizes and bold font, tower print and invert the text. Inkjets are dot matrix printers, and the ink is directed onto the wire or cable via deflector plates once it is electrically charged.

Inkjet marking, however, does have its limitations. Certain substrates (insulations) require certain ink types, and marking Teflon is not an option. In addition, if you have an automated printer with black ink, you normally cannot clearly mark on black wire. Since changing ink is normally not a possibility, one should purchase an additional printer to mark using a different color ink.

13.10.3 Dot Matrix Marking A dot matrix printer is used to apply marking information to a label. The Dot Matrix terminology refers to the method the printer uses to create the marking images. This is accomplished by several small pins, aligned in a column. These pins strike an ink ribbon positioned between the pins and the label, creating dots on the label. Characters are formed by patterns of these dots by moving the print-head laterally across the page in tiny increments.

The pins are contained in the print-head and are driven by solenoid actuated small hammers which force each pin to contact the ink ribbon and label.

A Dot Matrix printer has an advantage in being able to print letters in italics or bold by changing the way dots are arranged on the label. These printers are more economical than laser printers.

13.10.4 Laser Marking Laser wire marking provides a permanent, non-contact, permanent mark for wire and multi-core cable identification. It is the preferred, and most often specified, method of marking wire and cable today for aerospace and military applications. Equipment is available that is capable of marking wire in accordance with the AS 50881 International Standard.

Although laser marking is the commonly preferred marking method, there are certain mil-spec wire and cable that should not be laser marked. This includes Kapton insulated wire and cable. Ink Jet marking may be used for marking this type of wire and cable.

Laser marking is not a viable option for some manufacturers because of the high cost, and/or the time it takes to apply the marking.

The following different laser types are available:

a. **Vector Based Laser –** The laser uses x-y coordinates.

b. **Mask Type Laser –** The mask acts as a type of stencil.

c. **Carbon Dioxide Laser –** Destructive and not typically used for wire and cable.

d. **UV Laser –** Ideal for marking Teflon. However, the Teflon jacket should contain Titanium Dioxide in order for a color change to occur.

13.10.5 Hand Ink Pen Marking Hand marking of information using a commercially available ink marker pen is sometimes used to modify markings in fielded product. However, this marking method is not recommended for initial marking because of legibility and longevity concerns.

13.10.6 Label Marking Applying marking using a label is especially useful when hot stamp or inkjet cannot provide satisfactory results. Labels are printed and then applied automatically, or manually. Some labels can also withstand harsh environments such as gasoline and oil. Some labeling systems allow you to program the text to be printed via a PC and use a master machine to send a print signal for the label location.

Wrap-around markers, including a self-laminating marker, are an easy method for marking that does not require the termination to be removed in event a wire marker replacement is needed. These markers have a clear portion that will wrap around and laminate the marking legend. This protects the marking from damage.

The gauge (size) of the wire or cable determines the length of the self-laminating/wrap-around marker or the diameter of the sleeve to be used. Normally the length of the label should be five times the outer diameter of the wire or cable to be marked.

13.10.7 Heat Shrink Sleeve As with labeling, heat shrink sleeve can also be an effective method when hot stamp or inkjet marking is not an option. Heat shrink can be marked prior to it being applied to the wire or cable and then heated to shrink. However, once the wire is terminated, heat shrink cannot normally be used in event a marking change is needed unless the termination is removed and replaced with new heat shrink.

13.10.8 Thermal Marking Thermal marking requires a foil and heat, but unlike hot stamp marking, it does not require ''impacting the insulation.'' This method uses heat to transfer the pigment from the foil to the wire while it is rolled on. It can mark on both flat and round cables with either black or white markings. Color foil changeover is quick and it can mark logos and other bitmaps.

13.10.9 Fundamental Marking Principals The process(s) involved in the marking of cable and/or wire harness assemblies should be robust and under process control to the extent necessary to assure that the following marking principals are met to achieve compliance with the accept/reject criteria of Section 12 of IPC/WHMA-A-620.

13.10.9.1 Correctness of Required Marking The manufacturer should ensure that all applied marking contains the correct information (text, numbers, color, font size, etc.) specified in the contract/documentation, and that the marking was provided in the correct location, using the specified materials (e.g., shrink sleeve, labels, ink, etc.).

13.10.9.2 Marking Process(s) The manufacturer should ensure that the contractually specified marking process(s), and/or applicable process(s) specified by the manufacturer were used to apply the marking and are under acceptable process control.

13.10.9.3 Marking Robustness Completed marking should be permanent and free from damage, including any evidence of damage that may have occurred from use of the incorrect marking process(s).

13.11 Content of Engineering Drawings for Cable and/or Wire Harnesses Engineering drawings, of one or more of the drawing types described in x.1, should include the following information, if applicable to the type of cable or wire harness being designed, and the end-use of the product (e.g., Class 1, 2 3, or Space). This information is in addition to any information specified in ASME Y14.100 and the documents referenced therein. If the information is readily available from an industry recognized current standard, or from a current military specification, it need not be duplicated on the engineering drawings unless otherwise specified by the user. Additional detailed information may be required for the specific application and this information should be provided on the engineering drawings.

1. Physical and electrical properties of the wire and cable.
2. Physical and electrical properties of the cable and harness assembly.
3. Material properties.
4. Application issues.
5. Requirements pertaining to non-metallic components.
6. Special handling, storage and processing requirements.
7. Foreign Object Debris (FOD).
8. Parts, materials and processes.
9. Flammability, including any required flammability testing.
10. Outgassing requirements.
11. Time-critical or limited-life requirements.
12. Flourine attack requirements (white plague).
13. Identification of circuit categories.
14. Shielding requirements.
15. Method of shield termination and shield grounding.
16. Reliability requirements.
17. Interchangeability requirements.
18. Service life requirements.
19. Requirements pertaining to cable and harness length.
20. Requirements pertaining to accessibility for maintenance.
21. Requirements pertaining to cable and harness management (routing).
22. Bend radius requirements.
23. Breakout requirements.
24. Requirements pertaining to protection and support of installed wiring harnesses and cable assemblies.
25. Requirements pertaining to forming wires into cables and harnesses.
26. Requirements pertaining to separation of redundant systems.
27. Requirements pertaining to corona suppression.
28. Electrical design requirements.
29. Wire and cable requirements.
30. Requirements for connectors.
31. Requirements pertaining to protection of severed electrical circuits.
32. Requirements pertaining to wire terminations.
33. Requirements pertaining to insulation compatibility with sealing and servicing.
34. Identification and marking requirements (see 6.20). Identify the location of labels, orientation, size of markings, etc.
35. Design details for form layout fixture; scale drawing should be provided for large comples cable and wire harness assemblies.
36. Wire lay requirements.
37. Requirements pertaining to etching of fluorocarbon-insulated electrical wire.
38. Maximum current, voltage and temperature specified for the application.
39. Identify the type of terminal lugs (e.g., ring, spade), part number and specification, size (i.e., AWG wire size the lug is designed for, color code, type of tooling required for crimping, type of base material and plating.

40. Identify the type and size of cable clamps, part number and specification, type of clamp material and plating (if plating applies); part number, specification and material type for lacing cord or wire ties. Include a note identifying that one size smaller or larger cable clamp may be used to accommodate wire or cable harness overall diameter tolerances; if build-up of the cable/harness diameter to fit the clamp size is allowed, specify the material used.
41. Identify applicable workmanship standards (e.g., IPC/WHMA-A-620, IPC/WHMA-A-620 with the Space Addendum, when required). Include any other accept/reject criteria required for the application, and/or specified by the user.
42. Identify the type of inspection and testing required and the point in the manufacturing cycle the inspections and testing should be performed at (if important); identify whether inspection and testing should be performed on a 100% basis, or otherwise on a sample basis; specify sample size, if sampling is allowed.
43. Identify the test procedure numbers (multiple test procedures may apply depending on whether the testing is performed at the cable or wire harness level, or in conjunction with testing performed at a higher level assembly; for example, if the wire or cable harness is installed in a drawer or cabinet prior to shipment, the supplier may elect to perform certain testing at the drawer or cabinet level).
44. Identify the IPC product class designation (Class 1, 2 or 3) specified by, and/or agreed to by the user.
45. Identify the Space Addendum, if invoked by the user.
46. Identify any exceptions to and/or tailoring of specified requirements, subject to justification by the supplier, and user approval.
47. Dimensioning and tolerancing should be unambiguous and appropriate for the type of cable and wire harness assembly; if not otherwise specified, tolerances should conform to IPC/WHMA-A-620. Breakout dimensions should be shown unless the drawing is scaled 1 to 1; if a 1-1 scale drawing, the drawing should have a scale bar on the horizontal and vertical planes for verification. Display the units of measure on the drawing; use numeric value only and identify the unit of measure adjacent to each dimension or otherwise in the drawing title block. If the dimension is an interface controlled dimension, identify it with the standard interface dimension symbol (i.e., draw a rectangle around the dimension).The same dimension units of measure should be used consistently throughout the drawing. Baseline dimensioning should be used to reduce cumulative form tolerances.
48. Symbols that define items on a drawing should be consistently used. Recommended symbols include; a circle for an item number, a square for a note reference and a triangle to reflect an operation.
49. The amount of information provided on the drawing should only include that information needed to design manufacture, inspect and test the product; excess details may add complexity and/or cost.
50. Manufacturer's connector pin-out should not be deviated from.
51. Dimensions chosen should not conflict with the production equipment used; for example, requiring a cable jacket to be stripped too short to crimp individual wires in a press with guard.
52. The drawing should identify any needed torque range for electrical and mechanical threaded items (e.g., fasteners for installation, backshells, connector clamps, coupling nuts, etc.) that may be required to prevent loosing of the items in the specified shock and/or vibration environment, or otherwise to preclude component damage,
53. Drawings of large and complex wire harnesses and cables should include isometric views, or preferably, a photograph of the completed assembly that was verified to conform, to the drawing requirements. If a photograph is embedded in the drawing it should be of the image quality necessary to ensure legibility when reproduced.
54. Drawings should not be proprietary in nature, unless otherwise approved by the user in the contract.
55. Drawings should be structured such that the product may be manufactured, inspected and tested by organizations other than the original supplier, without requiring any additional information and/or documents from the supplier.
56. Whenever possible, drawing notes should be generic in nature, without referencing to a supplier procedure such that the notes can be complied with by other organizations. However, supplier procedures may be referenced if the supplier has provided the procedure to the user and has authorized unlimited distribution of the procedure to other suppliers, unless otherwise the proprietary criteria of bbb is applicable.
57. When required by the user, all drawings for manufacture, inspection and testing of cable and wire harness assemblies; including harness board drawings and test fixture drawings should be provided to the user.
58. Identify the installation of temporary ESD type protective covers for all un-mated connectors.

14 GASKETS

Gaskets come in a variety of profiles to meet many different needs. Gaskets are commonly used to slow or stop flow from one side of the box to the other. This can include scenarios such as keeping water out and radio frequency (RF) in. The material selected for the gasket will be driven by the end use environment and design criteria. See MIL-DTL-83528 with its associated detail slash sheets for an example of EMI gaskets.

14.1 Conductive Elastomer EMI Gaskets Conductive elastomer gaskets are highly electrically conductive, mechanically resilient and conformable vulcanized gaskets which provide low interface resistance between mating electronic enclosure flanges or covers while simultaneously providing moisture, pressure, or environmental sealing. These gaskets are intended for use in electromagnetic interference/radio frequency interference suppression applications. See Table 14-1 for EMI gasket material characteristics and Figure 14-1 for typical EMI gasket profiles.

They are available in the following types:

a. Flat gaskets (die cut from sheets).

b. Molded seals (such as O-rings or other profiles).

c. Extruded or molded strips (which may be spliced into rings or other fabricated shapes).

d. Waveguide gaskets.

All EMI gasket materials (metal and elastomer) to varying degrees are incompatible with certain flange surfaces. Design of the joint, therefore, plays a central role in determining the electrical stability and corrosion resistance of the joint. Design variables include: Flange material and finish, gasket filler and form (i.e., sheet, O-ring in a groove, etc.), use of parallel non-conductive environmental gaskets, mechanical design and use of insulating coatings. Choice of the design options should depend on: Environment of the application, levels of shielding effectiveness required versus frequency, and expected life of the equipment. When designing for salt spray environments, all of the preceding factors should be considered.

There is a wide variety of materials available with new ones being added as technologies evolve. Some typical materials are listed below to provide some general guidelines for the typical trade off between temperature, shielding effectiveness and base material that will be important considering the environment it will be used in. EMI Gasket Material types:

a. Silver-plated, copper-filled silicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of range of -55 °C to +125 °C [-67 °F to 257 °F].

b. Silver-plated, aluminum-filled silicone capable of 100 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +160 °C [-67 °F to 320 °F].

c. Silver-plated, copper-filled fluorosilicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +125 °C [-67 °F to 257 °F] and resistant to solvents and jet fuels.

d. Silver-plated, aluminum-filled fluorosilicone capable of 90 dB of plane wave shielding effectiveness at 10 GHz, with, a continuous use temperature range of -55 °C to +160 °C [-67 °F to 320 °F], and resistant to solvents and jet fuels.

e. A medium durometer, pure silver-filled silicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +160 °C [-67 °F to 320 °F].

f. Pure silver-filled fluorosilicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -65 °C to +160 °C [-85 °F to 320 °F]and resistant to solvents and jet fuels.

g. Silver-plated, copper-filled silicone, expanded copper foil reinforced, capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -45 °C to +125 °C [-49 °F to 257 °F].

h. A high durometer, pure silver-filled silicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +160 °C [-67 °F to 320 °F].

i. A low durometer, pure silver-filled silicone, capable of 80 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +160 °C [-67 °F to 320 °F].

j. A high durometer silver-plated, copper-filled silicone capable of 110 dB of plane wave shielding effectiveness at 10 GHz with a continuous temperature range of -45 °C to +125 °C [-49 °F to 257 °F].

k. Silver-plated, nickel-filled silicone capable of 100 dB of plane wave shielding effectiveness at 10 GHz with a continuous use temperature range of -55 °C to +125 °C [-67 °F to 257 °F].

l. Silver plated glass-filled silicone capable of 100 dB of plane wave shielding effectiveness at 10 GHz with a continuous temperature range of -55 °C to +160 °C [-67 °F to 257 °F].

Table 14-1 EMI Gasket Material Characteristics[5,6]

Item No.	Inspection		Units	Tol.	A	B	C	D	E	F	G	H	I	J	K	L
					Material Type											
1.	Operating temperature range		°C [°F]	N/A	-55 [-67]	-55 [-67]	-55 [-67]	-55 [-67]	-55 [-67]	-65 [-85]	-45 [-49]	-55 [-67]	-55 [-67]	-45 [-49]	-55 [-67]	-55 [-67]
					125 [257]	160 [320]	125 [257]	160 [320]	160 [320]	160 [320]	125 [257]	160 [320]	160 [320]	125 [257]	125 [257]	160 [320]
2.	Specific gravity		Sp gr 23/23 °C	±13%	3.5	2.0	4.0	2.0	3.5	4.0	4.751	4.0	1.7	3.5	4.0	1.9
3.	Hardness		Shore A units	±7	65	65	75	70	65	75	80	80	45	85	75	65
4.	Compression/deflection		Percent	Min	3.5	3.5	3.5	3.5	2.5	3.5	2.5	2.5	8.0	2.5	3.5	3.5
5.	Tensile strength		Pounds per square inch	Min	200	200	180	180	300	250	600	400	150	400	200	200
6.	Elongation		Percent	Min	100	100	100	60	200	100	20	90	50	100	100	100
				Max	300	300	300	260	500	300	N/A	290	250	300	300	300
7.	Compression set		Percent	Max	32.0	32.0	35.0	30.0	45.0	60.0	N/A	60.0	35.0	35.0	32.0	30.0
8.	Tear strength		Pounds per inch	Min	25	30	35	35	50	40	70	60	20	40	30	30
9.	Volume resistivity (as received)		Ohm-cm	Max	0.004	0.008	0.010	0.012	0.002	0.002	0.007	0.005	0.010	0.005	0.005	0.006
10.	Shielding effectiveness 20 MHz - 10 GHz (E-Field)		dB	Min	110	100	110	90	110	110	110	110	80	110	100	100
11.	Electrical stability during vibration	During	Ohm-cm	Max	0.006	0.012	0.015	0.015	0.010	0.010	0.010	0.006	0.015	0.010	0.010	0.009
		After			0.004	0.008	0.010	0.012	0.002	0.002	0.007	0.005	0.010	0.005	0.005	0.006
12.	Electrical stability after break		Ohm-cm	Max	0.008	0.015	0.015	0.015	0.010	0.010	N/A	0.006	0.020	0.010	0.010	0.009
13.	Low temperature flex	TR10	°C [°F]	Max	-55 [-67]	-55 [-67]	-55 [-67]	-55 [-67]	-55 [-67]	-65 [-85]	N/A	-55 [-67]	-55 [-67]	-45 [-49]	-55 [-67]	-55 [-67]
		TR70			-55 [-67]	-55 [-67]	-40 [-40]	-40 [-40]	-40 [-40]	-40 [-40]	N/A	-40 [-40]	-55 [-67]	-35 [-31]	-55 [-67]	-55 [-67]
14.	Volume resistivity (after life testing)		Ohm-cm	Max	0.010	0.010	0.015	0.015	0.010	0.010	0.010	0.008	0.015	0.010	0.010	0.015
15.	Volume resistivity after electro-magnetic pulse (EMP) exposure[2]		Ohm-cm	Max	0.010	0.010	0.015	0.015	0.010	0.010	0.010	0.008	0.015	0.010	0.010	0.015
16.	Fluid immersion [3,4]		–	–	N/S	N/S	SUR	SUR	N/S	SUR	N/S	N/S	N/S	N/S	N/S	N/S

1. Tolerance on material G only is ±0.75 sp gr 23/23 °C.
2. 0.9 kA per linear inch of perimeter.
3. N/S = Not survivable; SUR = Survivable.
4. Maximum volume swell of 25 percent and maximum change in hardness of 15 shore A units.
5. Galvanic compatibility between the metal loaded gasket and the contacting surface materials should be considered (e.g., use of silver loaded EMI gaskets in contact with chemical filmed aluminum may require the use of silver epoxy paint on the aluminum surfaces in contact with the gasket).
6. Gasket materials should be "closed-cell" (to minimize moisture absorption) and fungus inert.

Some typical profiles are shown in Figure 14-1. There are a lot of variations available.

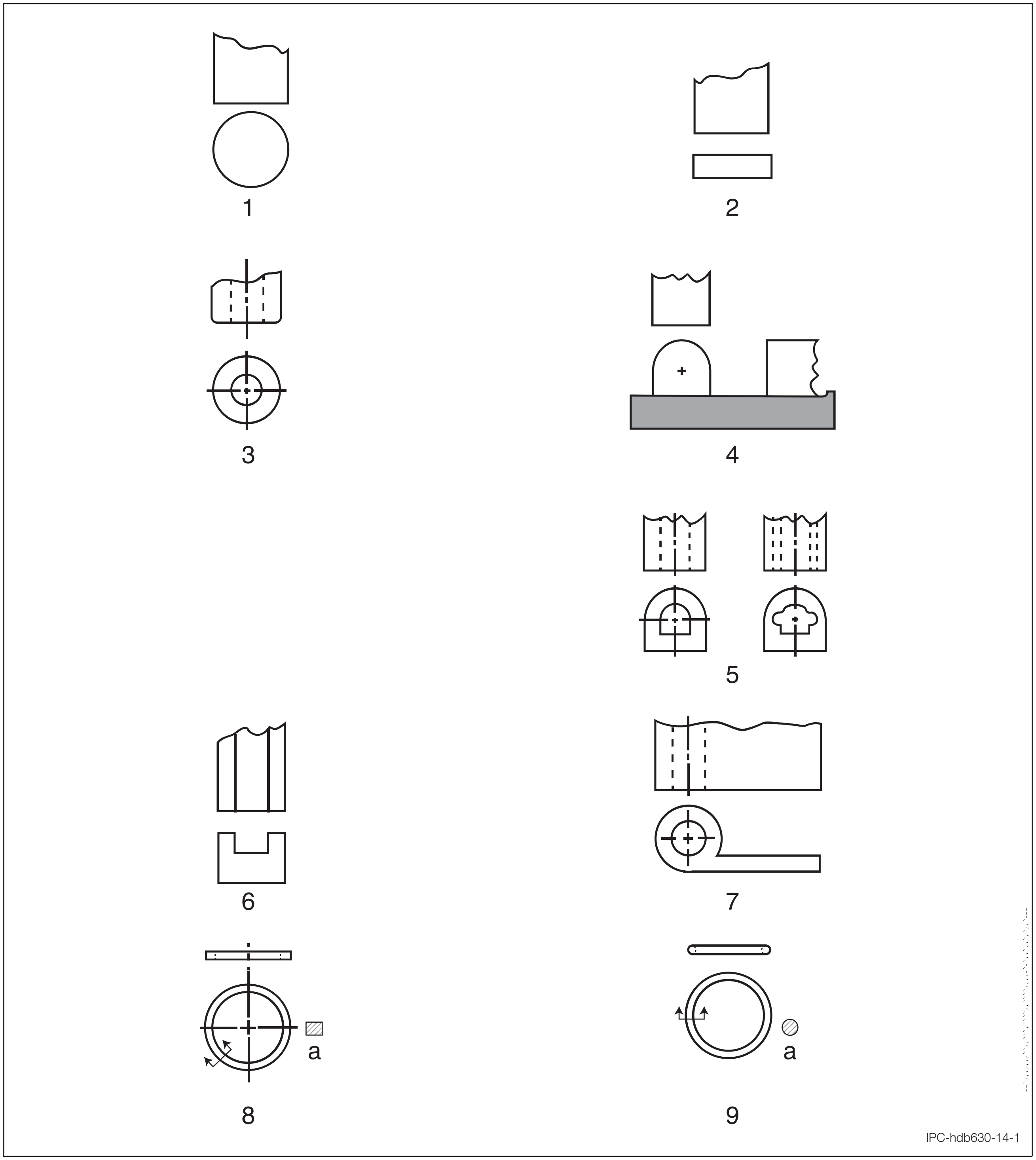

Figure 14-1 Typical EMI Gasket Cross Sectional Profiles

1. **Circular Strip**
2. **Rectangular Strip**
3. **"O" Strip (Hollow)**
4. **Solid "D" Strip**
5. **Hollow "D" Strip**
6. **Channel Strip**
7. **"P" Strip**
8. **Flat Circular Washer**
9. **"O" Ring**