SHIELDING MATERIALS

In order to maximize design effectiveness, Vermillion has used a large number of shielding materials in conjunction with Vermalloy®. Some of these are listed below with basic application information.

Vermalloy® 622 -- A high permeability mumetal type alloy in standard stranded form. Used in critical shielding applications, especially in audio frequency ranges and high magnetic fields.

Vermalloy® 3946 -- A high permeability mumetal type alloy in flattened ribbon form. Provides up to 75% shield weight savings for critical airborne or satellite applications.

Tinned Copper (T/C) -- Most common and least expensive shielding material. Commonly used where magnetic shielding is not a requirement.

Ribbon Copper -- Flattened form of T/C providing for weight savings.

NOTE: Other coatings such as nickel and silver are also used over copper in shielding applications. These are primarily utilized for special applications where high temperature and/or severe environmental requirements may be encountered.

Mylar Wraps -- Usually used in conjunction with copper or aluminum coating to provide an additional shielding layer. Uncoated mylar wrap can provide isolation as well as act as a binder to hold cable together during the manufacturing operation. Aluminum mylar generally provides cost, environmental and weight advantages while copper mylar provides flexibility, conductivity and higher frequency response advantages.

NOTE: A drain wire is usually included in the design of multiple layer shielded cable applications. It is used to reduce the effect of the inductance created by the weave of the braid and the spiral wrap of the foil tape. The drain wire provides a convenient method of terminating foil tape wrapped cable layers. When utilized with Vermalloy® shielding, the drain wire is used to reduce the DC resistance of the shield and to drain currents generated by the collapse of magnetic fields in high permeability material.

THE VERMALLOY® ADVANTAGE

The principal objective of any cable shielding material is to eliminate interference caused by both electrical and magnetic fields, regardless of where they are generated -- externally to the cable or internally. Electrical field shielding is generally accomplished by low resistance materials, usually copper based, since the shielding is required to bleed off the currents induced by the field. Effective magnetic field shielding, on the other hand, is a direct function of the absorption loss of the shielding materials. High permeability magnetic material such as Vermalloy® is very effective in increasing this absorption loss and thereby producing a more effective magnetic shield.

The cables described in this manual generally contain combinations of materials to enhance both the electric and magnetic shielding properties of the cables. Additional shielding layers can also be utilized to overcome saturation effects in high magnetic field strength applications.

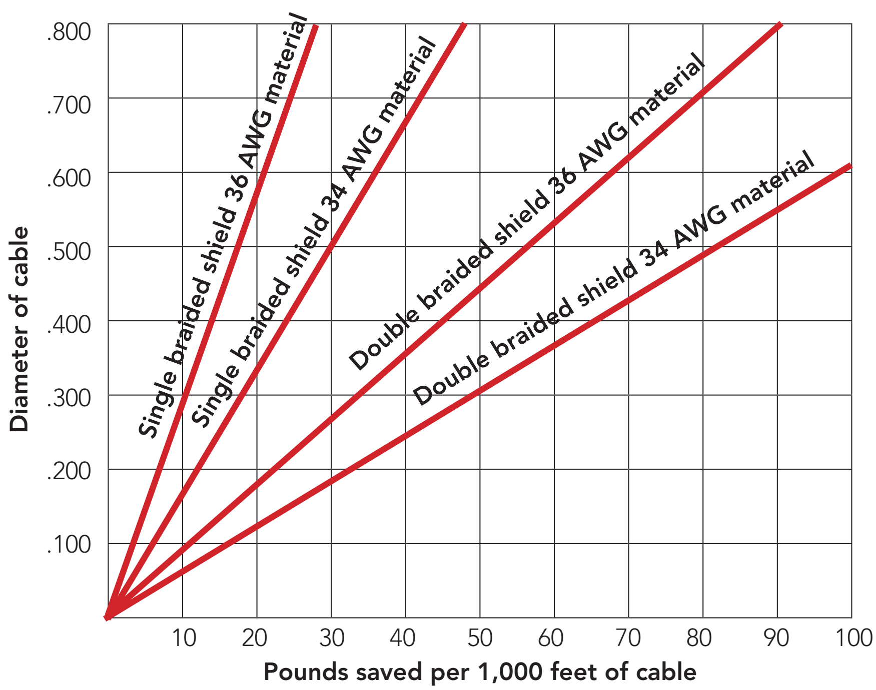
Performance curves contained in this section illustrate the effectiveness of various materials in shielding against both electrical fields and magnetic fields.

VERMALLOY® EFFECTIVENESS TEST DATA MAGNETIC (H-FIELD)

Vermillion engaged D.L.S. Electronic Systems, Inc., Glenview, Illinois, to run tests on various shielding configurations to determine the Magnetic Shield Effectiveness, expressed as "Effective Loop Area," of these different designs. The Test Frequency Range was 300 Hz - 100 KHz. This complete test will be made available upon request.

Following are excerpts from their report on these tests.

	AVERAGE EFFECTIVE LOOP AREA
Twisted pair with copper mylar wrap, tinned copper braided shield, drain wire, tinned copper braided shield, and heat shrink jacket. Braided shielding was 95% coverage	.0233
Twisted pair with Vermalloy® 3948 braided shield (95% coverage) and heat shrink jacket	.0035
Twisted pair with Vermalloy® 622 braided shield (95% coverage) and heat shrink jacket	.0022
Twisted pair with Vermalloy® 622 braided shield, clear mylar wrap, tinned copper braided shield, and a heat shrink jacket. Shielding was 95% coverage	.0009



Weight savings realized by using Vermalloy® 3948 or ribbon copper shielding materials versus round shielding materials

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DESIGN CONSIDERATIONS

Effective design of shielded cable assemblies involves careful attention to tradeoffs to optimize specific characteristics of the end design. In addition to flexibility, primary design consideration areas include performance in both electrical and magnetic fields, weight and cost.

Performance -- Electrical (E-Field)
Usually expressed in terms of shielding effectiveness (dB) and specified band width over which shielding requirements are to be met. Primary tradeoffs include:

- Number of layers of shielding used
- Types of shielding used in each layer
- Percent coverage of each shielding layer

E-Field performance test data is included in this section for the main types of shielding used by Vermillion. Use of this test data will allow the designer to maximize performance in his critical area of interest (i.e., voice range, high frequency, etc.). Test samples can then be built up and evaluated to verify performance characteristics.

Performance -- Magnetic (H-Field)
Also expressed in terms of shielding effectiveness but using "effective loop area" (square inches) instead of attenuation (dB). Primary tradeoffs are similar to those discussed for E-Field above, although permeability of the shielding material is more of a factor in designing an effective shield for a given frequency band coverage.

Weight
Data for the unit weights of various type and size shielded cables made by Vermillion is also contained in this section. This data can be used to obtain total cable weight by knowing the length of cable used. As previously noted, the Vermalloy® 3948 ribbon-type shielding reduces the weight of conventional woven shielding by 70-80%. Another way of reducing the cable weight is by decreasing the percent coverage of a shielding layer on a given cable. The tables also contain information for calculating the effect of reduced shielding coverage.

Cost
Generally most directly related to performance criteria; such as type of shielding used and number of layers. To a lesser extent weight factors such as use of ribbon shielding also affect cost.

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	FREQUENCY											
	DC - 30 Hz	30 Hz - 300 Hz	300 Hz - 3KHz	3 KHz - 30 KHz	30 KHz - 300 KHz	300 KHz - 3 MHz	3 MHz - 30 MHz	30 MHz 300 MHz	300 MHz - 3 GHz	3 GHz - 30 GHz	30 GHz - 300 GHz	
		RF										
	LF			HF						EHF		
SHIELDING MATERIALS	H FIELD PREDOMINANT			E FIELD PREDOMINANT					MICROWAVE FIELD PREDOMINANT			FEATURES
VERMALLOY® 622	X	X	X	X	X							High Permeability, Standard Weight; MIL-N-144111
VERMALLOY® 3948	X	X	X	X	X							High Permeability, Light Weight; M27500 Style I
NICKEL COATED COPPER ASTM B 255		X	X	X	X	X						Low Permeability, Medium Conductivity; Standard Weight, M27500 Style P
TIN COATED COPPER ASTM B 33			X	X	X	X	X					High Conductivity, Standard Weight; M27500 Style T
RIBBON COPPER (FLAT) ASTM B 272			X	X	X	X	X					High Conductivity, Light Weight; M27500 Style J
SILVER COATED COPPER ASTM B 298				X	X	X	X	X				Extra High conductivity, Standard weight; M27500 Style H
ARACON®			X	X	X	X	X	X	X	X		High Conductivity, Extremely flexible and lightweight
TIN COATED COPPER VERMALLOY® 622	X	X	X	X	X	X	X					Small Loop Area, Standard Weight, Increased Bandwidth
SILVER COATED COPPER VERMALLOY® 622	X	X	X	X	X	X	X	X				Small Loop Area, Standard Weight, Increased Bandwidth
ARACON® VERMALLOY®622	X	X	X	X	X	X	X	X	X	X		Small Loop Area, Standard Weight & Flexible, Increased Bandwidth
RIBBON COPPER (FLAT) VERMALLOY® 3948	X	X	X	X	X	X	X					Light Weight, Increased Bandwidth
FERRITE TUBING							X	X	X	X		Low Permeability, Light Weight, Microwave Suppressor
RIBBON COPPER (FLAT) VERMALLOY® 3948 FERRITE LOADED DIELECTRIC	X	X	X	X	X	X	X	X	X	X		Light Weight, Broad Bandwidth