ESSEX®

Bondable Magnet Wire

SAVE YOU TIME, MONEY

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CAN BONDABLE MAGNET WIRE SPEED PROCESSES, IMPROVE BOTTOM LINE?

Magnet wire is an old technology and as such many decision makers simply make the same purchasing selections that they have for years on end. That has become a line of thinking that is likely to be costing your project money through additional needs — bobbins, varnish, storage — as well as the time associated with all of those additions to the manufacturing process. The purpose of this paper is to articulate the research findings of Essex Solutions in an effort to determine the best uses for bondable magnet wire. Furthermore, it is an attempt to share those findings as a way to help decision makers effectively solve bottomline problems for their organizations when faced with the choice between bondable or non-bondable wire.

Background

Bondable magnet wire is used in a variety of applications such as transformers, lift magnets, solenoids, bobbinless coils, clutch coils, voice coils, and motor stator and armature windings. Bondable wire consists of standard magnet wire insulations overcoated with a thermoplastic polymer that can be temporarily softened by either heat or solvent, or both. When the bond coat hardens, adjacent wires in direct contact with each other will be bonded together.

Potential Advantages

Use of bondable wire allows coils to be self-supporting, so bobbins or secondary varnishing may not be necessary. This can create greater throughput, less work in process (WIP), and a reduction in materials to handle, store and dispose of in the manufacturing process. It also tends to provide more uniform and consistent bonding than secondary varnish.

Application Limitations

Intimate wire-to-wire contact is necessary for bonding to occur, so any spots in the wound coil where adjacent wires are not touching will not bond.

Since the bondcoat will be softened and displaced during bonding it should be stressed that the bondcoat will not contribute to the electrical integrity of the film coating on the wire. The base insulation alone will determine the electrical properties of the wire. However, the additional build of bondcoat must be taken into account for winding and the size of the final coil. The turns density of the coil will be adversely affected with the addition of the bondcoat.

Additionally, the removal of a secondary bondcoat and vacuum impregnation, eliminates the additional dielectric strength that the bond holding the coil will add.

It must also be taken into account that the bond strength of the thermoplastic polymers decrease with temperature, until bond strength is no longer present. The minimum bond strength required to consistently maintain wire-to-wire bonding is 3 lbs. Bond strength needs at elevated temperatures will dictate which bond coat material should be used. This same characteristic is true of secondary varnishes, as seen in Charts 1 and 2 on Pages 4 and 5, respectively.

Three Common Methods of Bonding

1. ***Solvent Bonding***

   Some bondcoats can be activated by the application of certain solvents during or after coil winding. The solvent may be applied to the wire via a wick during the winding operation or the finished coils may be dipped in a bath of solvent after winding. In either case, the unit should be heated again to drive off residual solvent and to complete the bonding of the coils.

2. ***Heat - Oven Bonding***

   After the coils are formed, the unit is heated in an oven, causing the bondcoat to flow, bonding the adjacent turns of wire together.

3. ***Heat - Resistance Bonding***

   Resistance heating is similar to oven heating, except that passing current through the formed coils supplies heat. Time, voltage, and current are all unique to each application. Several coil winding equipment manufacturers offer machines with built-in resistance heating functionality. There are also white papers available on their websites if more detail on this method of bonding wires is desired.

Film Builds for Bondable Wire

Type 0 (#0):

Overall single build; less than single build base insulation plus bondcoat - available in AWG 31 and larger. This custom film build is not recommended, and is only offered for applications involving unalterable size constraints in which minimal dielectric and abrasion resistance is acceptable. Please refer specific questions to Essex marketing and engineering personnel.

Type 1 (#1):

Overall heavy build; single build base insulation plus bondcoat.

Type 2 (#2):

Overall triple build; heavy build base insulation plus bondcoat.

Type 3 (#3):

Overall quad build; triple build base insulation plus bondcoat.

See Tables 2 and 3 on pages 6 and 7, respectively for Essex Solutions standard dimensions of Types 1 and 2 bondable wire.

Essex Bondable Magnet Wire Insulations

Essex Soderbond® N/155 is solderable, as well as bondable. This is Soderon/155® with a polyvinyl butyral bondcoat.

Essex Polybondex® family of bondable wires are described by the base insulation and bondcoat materials. For example, Polybondex® T indicates that the base insulation is Thermalex 200®. Polybondex® G indicates that the base insulation is GP/MR-200®. The bondcoat type is designated by the letters M, E or S for epoxy, polyester or polyamide, respectively.

Table 1
Essex Bondable Magnet Wire Constructions

Essex Solutions Trade Name	Basecoat Polymer	Topcoat Polymer	Bondcoat Polymer	Thermal Rating °C	Bonding Temperature °C	NEMA
Soderbond® N/155	Polyurethane	Polyamide	Polyvinyl Butyral	105	110 – 150	MW 136
Polybondex® G Bond M	Polyester	Polyamideimide	Epoxy	180	150 – 200	
Polybondex® G Bond E	Polyester	Polyamideimide	Polyester	180	180 – 200	MW 102
Polybondex® G Bond S	Polyester	Polyamideimide	Aromatic Polyamide	180	210 – 230	MW 102
Polybondex® T Bond M	Polyester	N/A	Epoxy	180	150 – 200	
Polybondex® T Bond E	Polyester	N/A	Polyester	180	180 – 200	
Polybondex® T Bond S	Polyester	N/A	Aromatic Polyamide	180	210 – 230	
Ultrashield® Plus Bond E	Polyester	Polyamideimide	Polyester	180	180 – 200	MW 102
Amide-Imide Bond S	Polyamideimide	-	Aromatic Polyamide	180	210 – 230	

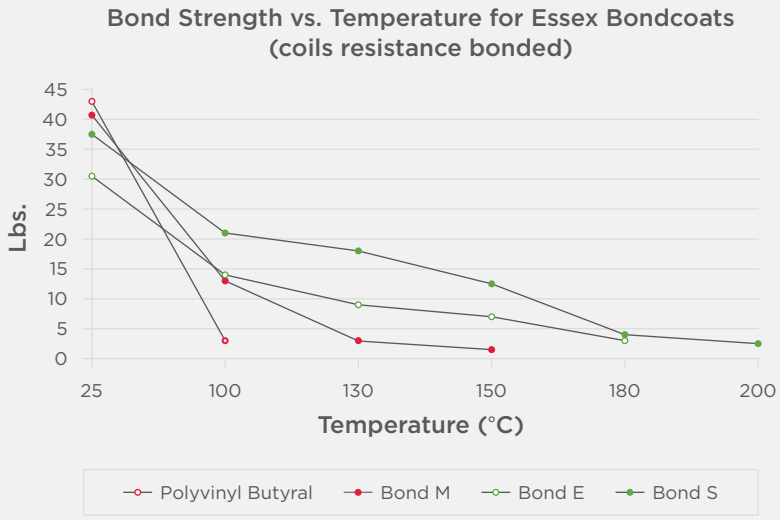
Polyvinyl Butyral is a bond intended for lower temperature solderable applications. It may be activated with denatured or isopropyl alcohol or by heating.

Bond M is an epoxy designed for use at temperatures not to exceed approximately 130°C. Solvents such as methyl ethyl ketone (MEK) can activate Bond M, but heat bonding is recommended.

Bond E is a polyester that maintains bond strength up to 180°C. Solvents such as dioxolane and dichloromethane can activate Bond E, but heat bonding is recommended.

Bond S is an aromatic polyamide that has higher bond strength at elevated temperatures than other bondcoats. It maintains bond strength to approximately 200°C. It cannot be activated by conventional solvents and must be heat activated.

Chart 1
Bond Strength of Essex Bondcoats

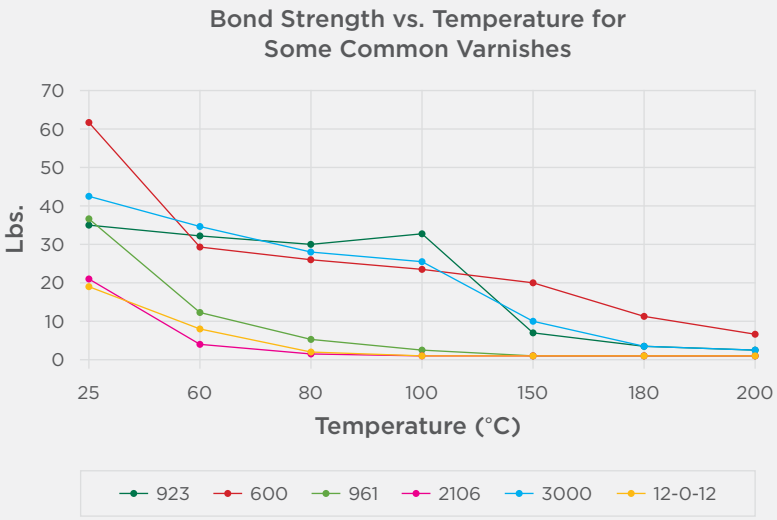


Note: Helical coil bond strength per NEMA MW 1000

Analysis

Bond coat materials have decreasing bond strength with increasing temperature, until they eventually lose the ability to maintain bonding. Each material has a different curve, so thermal and bonding requirements will determine which one is best for that particular application.

Chart 2
Bond Strength of Common Varnishes



Note: Helical coil bond strength per NEMA MW 1000

Analysis

Secondary varnishes have decreasing bond strength with increasing temperature, similar to the bond coat materials used on bondable magnet wire.

TABLE 2
Standard Dimensions of Essex Bondable Wire (in inches)
TYPE 1

	Bare Wire			Build w/o Bond	OD w/o Bond	Bond Build	Overall OD
AWG	Minimum	Nominal	Maximum	Minimum	Maximum	Minimum	Maximum
8	0.1272	0.1285	0.1294	0.0017	0.1314	0.0009	0.1332
8 ½	0.1201	0.1213	0.1221	0.0017	0.1241	0.0009	0.1258
9	0.1133	0.1144	0.1153	0.0017	0.1173	0.0009	0.1190
9 ½	0.1069	0.1080	0.1088	0.0017	0.1108	0.0009	0.1125
10	0.1009	0.1019	0.1027	0.0017	0.1047	0.0009	0.1064
10 ½	0.0952	0.0962	0.0971	0.0017	0.0991	0.0009	0.1007
11	0.0898	0.0907	0.0916	0.0017	0.0936	0.0009	0.0952
11 ½	0.0847	0.0856	0.0864	0.0016	0.0883	0.0009	0.0900
12	0.0800	0.0808	0.0816	0.0016	0.0835	0.0009	0.0851
12 ½	0.0755	0.0763	0.0770	0.0016	0.0789	0.0009	0.0805
13	0.0713	0.0720	0.0727	0.0016	0.0746	0.0009	0.0762
13 ½	0.0672	0.0679	0.0685	0.0016	0.0704	0.0009	0.0720
14	0.0635	0.0641	0.0647	0.0016	0.0666	0.0009	0.0682
14 ½	0.0599	0.0605	0.0611	0.0016	0.0629	0.0009	0.0645
15	0.0565	0.0571	0.0576	0.0015	0.0594	0.0009	0.0610
15 ½	0.0534	0.0539	0.0544	0.0015	0.0563	0.0009	0.0578
16	0.0503	0.0508	0.0513	0.0014	0.0531	0.0009	0.0545
16 ½	0.0475	0.0480	0.0485	0.0014	0.0502	0.0009	0.0516
17	0.0448	0.0453	0.0457	0.0014	0.0475	0.0009	0.0488
17 ½	0.0423	0.0427	0.0431	0.0013	0.0449	0.0009	0.0462
18	0.0399	0.0403	0.0407	0.0013	0.0424	0.0008	0.0437
18 ½	0.0377	0.0380	0.0384	0.0013	0.0400	0.0008	0.0413
19	0.0355	0.0359	0.0362	0.0012	0.0379	0.0008	0.0391
19 ½	0.0336	0.0339	0.0342	0.0012	0.0359	0.0008	0.0371
20	0.0317	0.0320	0.0323	0.0012	0.0340	0.0007	0.0351
20 ½	0.0299	0.0302	0.0308	0.0011	0.0321	0.0007	0.0332
21	0.0282	0.0285	0.0288	0.0011	0.0303	0.0007	0.0315
21 ½	0.0266	0.0269	0.0272	0.0011	0.0287	0.0007	0.0298
22	0.0250	0.0253	0.0256	0.0011	0.0270	0.0007	0.0281
22 ½	0.0237	0.0239	0.0241	0.0010	0.0257	0.0007	0.0267
23	0.0224	0.0226	0.0228	0.0010	0.0243	0.0006	0.0253
23 ½	0.0211	0.0213	0.0215	0.0010	0.0230	0.0006	0.0240
24	0.0199	0.0201	0.0203	0.0010	0.0217	0.0006	0.0227
24 ½	0.0188	0.0190	0.0192	0.0009	0.0206	0.0006	0.0215
25	0.0177	0.0179	0.0181	0.0009	0.0194	0.0006	0.0203
25 ½	0.0167	0.0169	0.0171	0.0009	0.0184	0.0006	0.0193
26	0.0157	0.0159	0.0161	0.0009	0.0173	0.0005	0.0182
26 ½	0.0149	0.0150	0.0151	0.0008	0.0165	0.0005	0.0173
27	0.0141	0.0142	0.0143	0.0008	0.0156	0.0005	0.0165
27 ½	0.0133	0.0134	0.0135	0.0008	0.0148	0.0005	0.0156
28	0.0125	0.0126	0.0127	0.0008	0.0140	0.0005	0.0147
28 ½	0.0118	0.0119	0.0120	0.0008	0.0132	0.0005	0.0140
29	0.0112	0.0113	0.0114	0.0007	0.0126	0.0004	0.0133
29 ½	0.0105	0.0106	0.0107	0.0007	0.0118	0.0004	0.0126
30	0.0099	0.0100	0.0101	0.0007	0.0112	0.0004	0.0121
30 ½	0.0094	0.0095	0.0096	0.0006	0.0106	0.0004	0.0114
31	0.0088	0.0089	0.0090	0.0006	0.0100	0.0004	0.0108
31 ½	0.0083	0.0084	0.0085	0.0006	0.0095	0.0004	0.0103
32	0.0079	0.0080	0.0081	0.0006	0.0090	0.0004	0.0097

TABLE 3
Standard Dimensions of Essex Bondable Wire (in inches)
TYPE 2

	Bare Wire			Build w/o Bond	OD w/o Bond	Bond Build	Overall OD
AWG	Minimum	Nominal	Maximum	Minimum	Maximum	Minimum	Maximum
8	0.1272	0.1285	0.1294	0.0035	0.1332	0.0009	0.1351
8 ½	0.1201	0.1213	0.1221	0.0034	0.1258	0.0009	0.1279
9	0.1133	0.1144	0.1153	0.0034	0.1190	0.0009	0.1207
9 ½	0.1069	0.1080	0.1088	0.0034	0.1125	0.0009	0.1143
10	0.1009	0.1019	0.1027	0.0034	0.1064	0.0009	0.1079
10 ½	0.0952	0.0962	0.0971	0.0033	0.1007	0.0009	0.1022
11	0.0898	0.0907	0.0916	0.0033	0.0952	0.0009	0.0965
11 ½	0.0847	0.0856	0.0864	0.0033	0.0900	0.0009	0.0914
12	0.0800	0.0808	0.0816	0.0032	0.0851	0.0009	0.0864
12 ½	0.0755	0.0763	0.0770	0.0032	0.0805	0.0009	0.0819
13	0.0713	0.0720	0.0727	0.0032	0.0762	0.0009	0.0775
13 ½	0.0672	0.0679	0.0685	0.0032	0.0720	0.0009	0.0734
14	0.0635	0.0641	0.0647	0.0032	0.0682	0.0009	0.0698
14 ½	0.0599	0.0605	0.0611	0.0031	0.0645	0.0009	0.0661
15	0.0565	0.0571	0.0576	0.0030	0.0610	0.0009	0.0625
15 ½	0.0534	0.0539	0.0544	0.0030	0.0578	0.0009	0.0592
16	0.0503	0.0508	0.0513	0.0029	0.0545	0.0009	0.0560
16 ½	0.0475	0.0480	0.0485	0.0028	0.0516	0.0009	0.0530
17	0.0448	0.0453	0.0457	0.0028	0.0488	0.0009	0.0502
17 ½	0.0423	0.0427	0.0431	0.0027	0.0462	0.0009	0.0476
18	0.0399	0.0403	0.0407	0.0026	0.0437	0.0008	0.0450
18 ½	0.0377	0.0380	0.0384	0.0025	0.0413	0.0008	0.0426
19	0.0355	0.0359	0.0362	0.0025	0.0391	0.0008	0.0404
19 ½	0.0336	0.0339	0.0342	0.0025	0.0371	0.0008	0.0383
20	0.0317	0.0320	0.0323	0.0024	0.0351	0.0007	0.0363
20 ½	0.0299	0.0302	0.0308	0.0023	0.0332	0.0007	0.0344
21	0.0282	0.0285	0.0288	0.0022	0.0315	0.0007	0.0326
21 ½	0.0266	0.0269	0.0272	0.0022	0.0298	0.0007	0.0309
22	0.0250	0.0253	0.0256	0.0021	0.0281	0.0007	0.0292
22 ½	0.0237	0.0239	0.0241	0.0021	0.0267	0.0007	0.0277
23	0.0224	0.0226	0.0228	0.0020	0.0253	0.0006	0.0263
23 ½	0.0211	0.0213	0.0215	0.0020	0.0240	0.0006	0.0249
24	0.0199	0.0201	0.0203	0.0019	0.0227	0.0006	0.0236
24 ½	0.0188	0.0190	0.0192	0.0019	0.0215	0.0006	0.0224
25	0.0177	0.0179	0.0181	0.0018	0.0203	0.0006	0.0212
25 ½	0.0167	0.0169	0.0171	0.0018	0.0193	0.0006	0.0202
26	0.0157	0.0159	0.0161	0.0017	0.0182	0.0005	0.0191
26 ½	0.0149	0.0150	0.0151	0.0017	0.0173	0.0005	0.0182
27	0.0141	0.0142	0.0143	0.0016	0.0165	0.0005	0.0173
27 ½	0.0133	0.0134	0.0135	0.0016	0.0156	0.0005	0.0164
28	0.0125	0.0126	0.0127	0.0016	0.0147	0.0005	0.0155
28 ½	0.0118	0.0119	0.0120	0.0015	0.0140	0.0005	0.0147
29	0.0112	0.0113	0.0114	0.0015	0.0133	0.0004	0.0141
29 ½	0.0105	0.0106	0.0107	0.0014	0.0126	0.0004	0.0133
30	0.0099	0.0100	0.0101	0.0013	0.0121	0.0004	0.0126
30 ½	0.0094	0.0095	0.0096	0.0013	0.0114	0.0004	0.0124
31	0.0088	0.0089	0.0090	0.0012	0.0108	0.0004	0.0114
31 ½	0.0083	0.0084	0.0085	0.0012	0.0103	0.0004	0.0110
32	0.0079	0.0080	0.0081	0.0011	0.0097	0.0004	0.0102

EXECUTIVE SUMMARY

The choice between bondable magnet wire or non-bondable wire will come down to the specific project; for many projects that decision will likely be influenced by the space needed to complete the component.

For applications that can use bondable magnet wire there are inherent savings in time and money:

- The elimination of multiple steps in the process will eliminate the cost associated with bobbins and secondary varnish or tape
- The elimination of multiple steps in the process also will eliminate the additional assembly time and drying time allowing for quicker insertion to the production line
- The elimination of the use, storage and disposal of certain volatile organic compounds (VOC's)

The analysis above are objective findings and not definitive for each, specific project. It is always best to discuss the specs and expectations of any project with an Essex solutions expert.