introduction

Only a decade ago, it was common to use spring steel clips or bolts to fix magnet segments into position. Both materials were costly, difficult to automate, and required maintaining large inventories. In addition, they involved highly complex parts handling systems and intricate insertion methods. Neither method prevented noise from mechanical vibration, and both could loosen or shift, allowing corrosion to occur between the magnet and assembly.

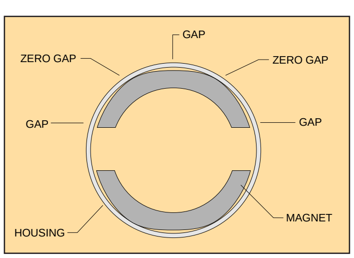
Today structural acrylic, cyanoacrylate, and epoxy adhesives are available, providing tough, durable, environmentally-resistant joints and quick processing. Adhesives first found acceptance in motor magnet bonding, where the severest environments may be encountered. Now they are widely used to bond the magnet assembly in a wide range of applications, including loudspeakers, headphones, appliances, lifting equipment, power generators, disc drives, microphones, telephones, motors (starter, micro-, electro-, and servo-motors), and measuring instruments (volt, amp, speed-meters, watt-hour-meters). Adhesive-bonded magnets provide a wealth of benefits, including:

- **High shear strength and impact resistant joints**
- **Room temperature and heat cure versions for easy processing**
- **Ultra-fast fixture times for increased throughput**
- **Easily automated assemblies to increase production efficiencies**
- **Solvent-free formulations for worker and environmental safety**
- **Excellent durability for improved product quality**
- **Prevents magnet movement and absorbs shock and impact**

considerations in Magnet Bonding

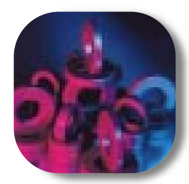
Factors relating to the magnet and the opposing substrate play a critical role in successful magnet bonding. To achieve consistent bonding performance, mating surfaces must be clean and free from contamination, such as plating residues or lubricants. Magnets must be dust-free and formed or machined to ensure that gaps between the magnet and the mating substrate remain small, preferably less than .010 inches. Generally, minimizing the gap insures faster fixturing, stronger joints, and in the case of loudspeakers, minimizes magnetic energy losses.

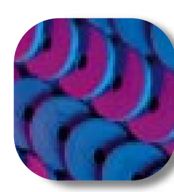
For curved magnet segments, some motor manufacturers have moved from single radius segments to tri-arc configuration. This design helps reduce magnet movement in the fixture, and can help reduce the gap due to tolerance differences between the housing and the magnet. Examination of the tri-arc bond joints shows that the adhesive fixtures or solidifies quickly at the two points of contact on the magnet surface.



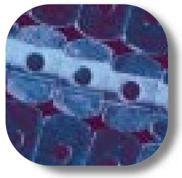
The surface of the housing, which is typically made of a steel base material, is also critical to the success of the bonding design. Housing surfaces are often fabricated to resist corrosion and may be painted or coated. Conversion coating processes such as chromating, phosphating, galvanizing and anodizing are commonly used. In most cases, “prior to paint” coatings such as zinc phosphate or chromic acid anodizing are best for adhesive bonds. Coating processes such as galvanizing or yellow zinc dichromating leave weak surface layers and can be problematic. For these challenging surfaces, heat cure epoxies may provide the best solution. On in-active surfaces, structural acrylics are used with primers to enhance cure speed. Solventless primers for dichromated surfaces are available, as well.

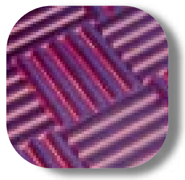
For motor manufacturers, the method used to fabricate the housing often affects its ultimate dimensional tolerance. Tighter control of housing dimensions can be used to ensure small bondline gaps. Drawn or extruded housings are typically the most stable from a dimensional standpoint. Magnet bonded housings are commonly roll-formed housings, and are more difficult to control dimensionally. When rolled housings are used, it is important that the seam is smooth and properly fitted. Misalignment or tabs that cause large gaps are unacceptable.





the study



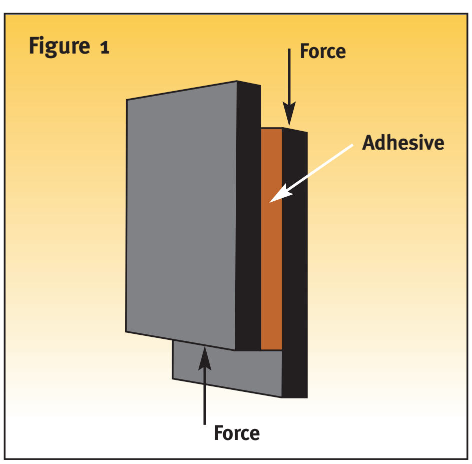


In response to frequent requests from magnet bonding manufacturers for a more consistent test method to determine the long-term durability of adhesive-bonded magnets, Loctite designed a study. Adhesion behavior was analyzed using several Loctite® structural adhesives, including acrylic, epoxy, and cyanoacrylate chemistries. Blockshear and impact strength testing was conducted, with a goal to qualitatively and quantitatively determine the adhesive durability, using standard test methods.

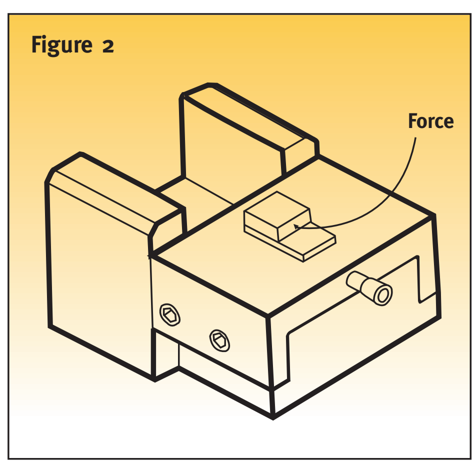
The selected base material substrates were comprised of mild steel, E-coat, and yellow zinc dichromate, and the magnet substrates included ferrite, alnico, and neodymium. All magnets were assembled and tested without magnetization. Blockshear testing was performed according to ASTM D4501 and impact testing to ASTM D950.

test method

Methods of testing adhesive-bonded magnets varies widely by manufacturers, from simple drop tests to a more elaborate slide rail apparatus fitted with a stationary striker. Blockshear values determine adhesive durability per ASTM D4501, as depicted in Figure 1. A more scientific test method exists in ASTM D950, shown in Figure 2. This method determines the comparative impact strength of adhesive bonds in shear, when tested on standard specimens under specified conditions.



Blockshear Test Specimen, Side View, ASTM D4501



Impact Specimen Fixture with Magnet and Base Substrate Specimen, ASTM D950

Blockshear and Impact Study

Substrate (block)	Magnet	Blockshear Bond Strength, psi, per ASTM D4501		Impact Bond Strength per ASTM D950 up to 10 ft.-lb.	
		Avg.	Predominant Failure Mode	Impact Value	Predominant Failure Mode
Product 392/7387					
Mild Steel	Ferrite	2749	Adhesive Failure to Magnet	›10	Magnet
Mild Steel	Alnico	2951	Adhesive Failure to Magnet	›10	None
Mild Steel	Neodymium	2998	Adhesive Failure to Magnet	›10	Adhesive
E-coat	Ferrite	2698	Magnet Substrate Failure	›10	Magnet
E-coat	Alnico	2926	Block Substrate Failure	5.9	Adhesive
E-coat	Neodymium	2467	Block Substrate Failure	›10	Magnet
Zn. dichr.	Ferrite	1497	Adhesive Failure to Block	›2.6	Adhesive
Zn. dichr.	Alnico	1993	Block Substrate Failure	6.6	Adhesive
Zn. dichr.	Neodymium	2071	Block Substrate Failure	›7.3	Magnet
Product 332/7387					
Mild Steel	Ferrite	1440	Adhesive Failure to Magnet	›10	Magnet
Mild Steel	Alnico	2651	Adhesive Failure to Magnet	›10	None
Mild Steel	Neodymium	3183	Cohesive Failure	›10	Magnet
E-coat	Ferrite	1239	Adhesive Failure to Block	6.5	Adhesive
E-coat	Alnico	2180	Cohesive Failure	8.7	Adhesive
E-coat	Neodymium	1695	Cohesive Failure	›6.8	Mixed
Zn. dichr.	Ferrite	668	Adhesive Failure to Block	›1.1	Adhesive
Zn. dichr.	Alnico	729	Adhesive Failure to Block	5.6	Adhesive
Zn. dichr.	Neodymium	964	Adhesive Failure to Block	›6.6	Mixed
Product 326/7649					
Mild Steel	Ferrite	1455	Mixed Mode	›10	Magnet
Mild Steel	Alnico	1574	Adhesive Failure to Block	›10	None
Mild Steel	Neodymium	1418	Adhesive Failure to Block	›10	Mixed
E-coat	Ferrite	901	Adhesive Failure to Block	›7.0	Magnet
E-coat	Alnico	2643	Block Substrate Failure	8.1	Adhesive
E-coat	Neodymium	908	Adhesive Failure to Block	›9.9	Magnet/Adhesive
Zn. dichr.	Ferrite	1292	Adhesive Failure to Magnet	›10	Magnet
Zn. dichr.	Alnico	1590	Block Substrate Failure	7.0	Adhesive
Zn. dichr.	Neodymium	1590	Block Substrate Failure	›7.1	Mixed
Product E-214HP					
Mild Steel	Ferrite	4774	Magnet Substrate Failure	›10	Magnet
Mild Steel	Alnico	7775	Adhesive Failure to Block	›10	None
Mild Steel	Neodymium	5891	Adhesive Failure to Magnet	›10	Magnet
E-coat	Ferrite	4616	Block Substrate Failure	›10	Magnet
E-coat	Alnico	5930	Block Substrate Failure	›10	None
E-coat	Neodymium	4638	Block Substrate Failure	›10	Magnet
Zn. dichr.	Ferrite	4462	Block Substrate Failure	›9.8	Magnet
Zn. dichr.	Alnico	4574	Block Substrate Failure	9.3	Adhesive
Zn. dichr.	Neodymium	4918	Block Substrate Failure	›8.6	Mixed
Product 380					
Mild Steel	Ferrite	1987	Adhesive Failure to Block	›9.2	Magnet
Mild Steel	Alnico	2656	Adhesive Failure to Block	›10	None
Mild Steel	Neodymium	1515	Adhesive Failure to Block	›10	Magnet
E-coat	Ferrite	2406	Magnet Substrate Failure	›8.9	Adhesive
E-coat	Alnico	3593	Block Substrate Failure	›9.8	None
E-coat	Neodymium	3077	Block Substrate Failure	›10	Magnet
Zn. dichr.	Ferrite	1410	Adhesive Failure to Block	›8.5	Magnet
Zn. dichr.	Alnico	1615	Block Substrate Failure	4.9	Adhesive
Zn. dichr.	Neodymium	2508	Adhesive Failure to Block	›10	Magnet

Note: If only a value is given, it represents an average. If “›” and a value is given, it represents a minimum sample group value.

technical product information

Product Number/Activator		392/7387	332/7387	326/7649	E-214HP	380
Key Product Features		Ultra Fast, High Thermal Resistance	Highest Thermal, Impact & Shock Resistance	Fast Fixturing, High Strength	High Strength, Heat Cure	Low Viscosity, Small Gaps
Chemical Type		Modified Acrylic	Modified Acrylic	Urethane Methacrylate Ester	Epoxy	Cyanoacrylate
Viscosity, cP		60,000	200,000	18,000	150,000	200
Cure Speed	Fixture	30 seconds	1 minute	40 seconds	40 minutes @120°C	15 seconds
	Full	24 hours	24 hours	24 hours	24 hours	24 hours

For additional Technical Information, request Technical Data Sheets and Material Safety Data Sheets by calling 1-800-562-8483.

ordering information

Product Number	392	332	Activator 7387	326	Activator 7649	E-214HP	380
25 ml Syringe	39205	33201					
30 ml Cartridge						29339	
50 ml Bottle	39250			32629			
300 ml Cartridge	39275	33275				29340	
1 Liter Bottle	39280	33290		32685			
Pails	17507 15 liters	17601 12 liters				29341 5 gallons	
1 oz Bottle							38050
1 lb Bottle							38061
2 kg Bottle							18494
1.75 oz Bottle			18861		19269		
25 gm Aerosol Can					21347		
4.5 oz Aerosol Can			21088		21348		
1 qt Can			18862				
1 gallon Can					19266		

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0009-738/LT-3564