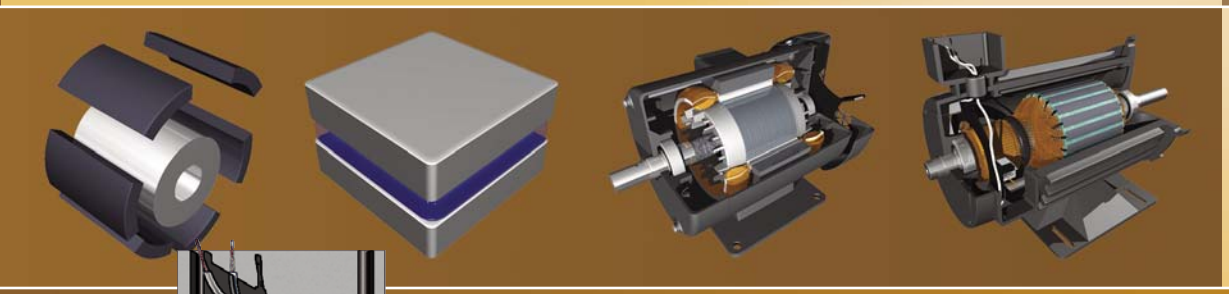
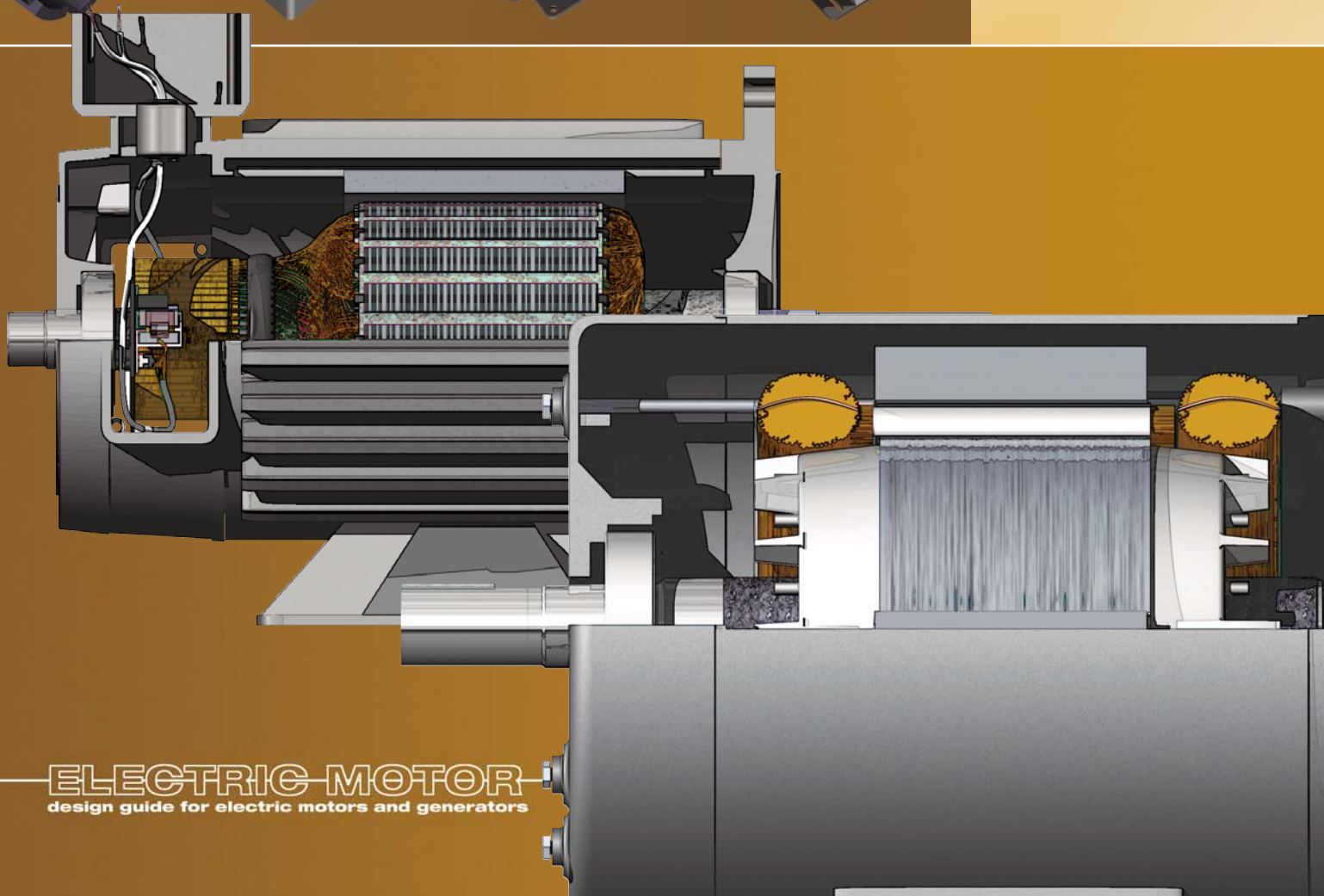
LOCTITE®

DESIGN GUIDE FOR

ELECTRIC MOTORS AND GENERATORS



Henkel



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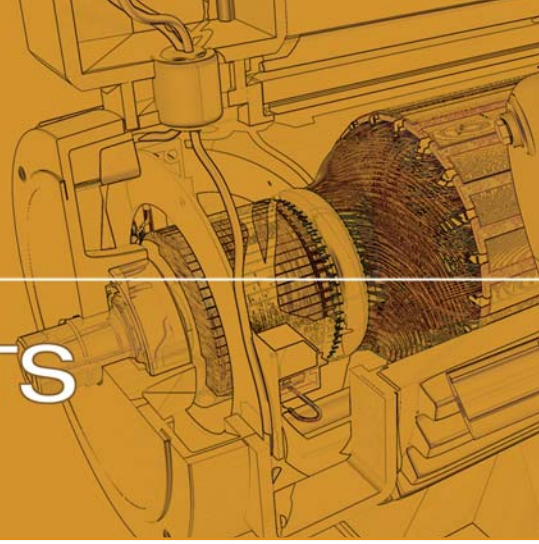

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INTRODUCTION

INTRODUCTION

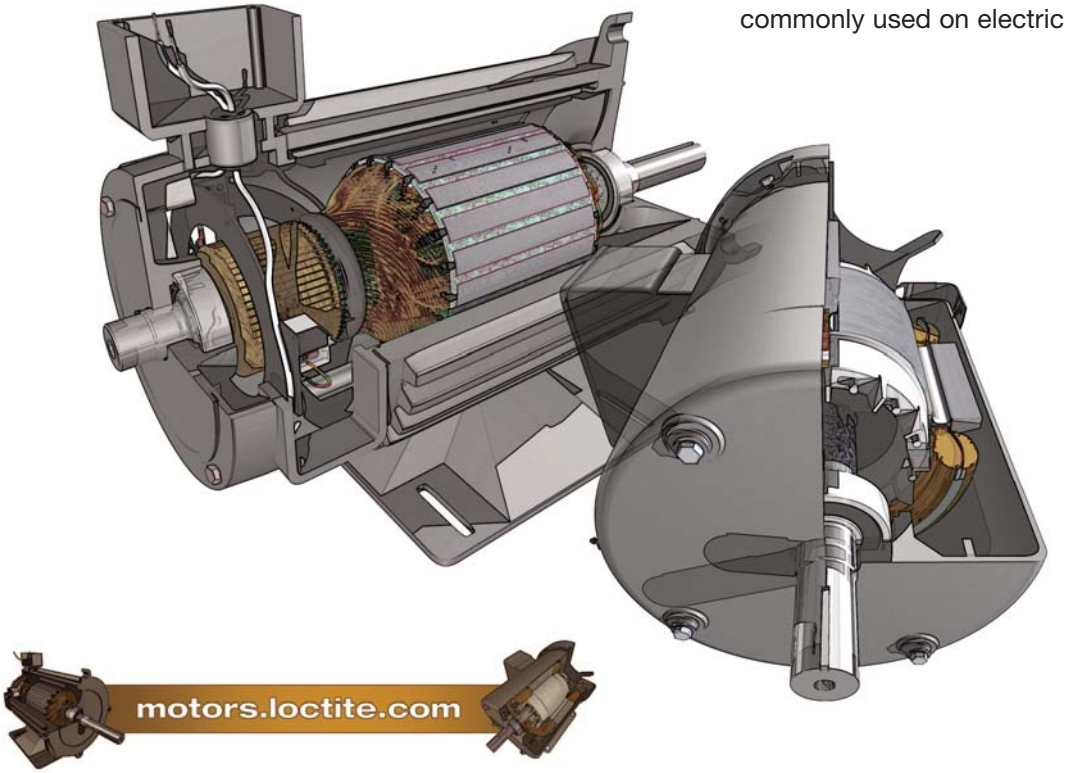
Electric motor and generator manufacturers have used Loctite® brand products to improve performance, to facilitate manufacturing processes and to reduce costs for more than 40 years. While almost all manufacturers use adhesives and sealants in some assembly operations, very few manufacturers have developed the experience to fully take advantage of the benefits that adhesives and sealants can offer. The objective of this design guide is to educate design, manufacturing and quality engineers on where and why adhesives and sealants are commonly used on motors and generators to help them recognize their full potential.

To accomplish this, the following key areas are reviewed in this design guide:

Typical Applications A detailed review of the common applications of adhesives and sealants on motors and generators. This includes illustrations, an overview, a comparison of the adhesive technologies suitable for that application, and a product selector chart.

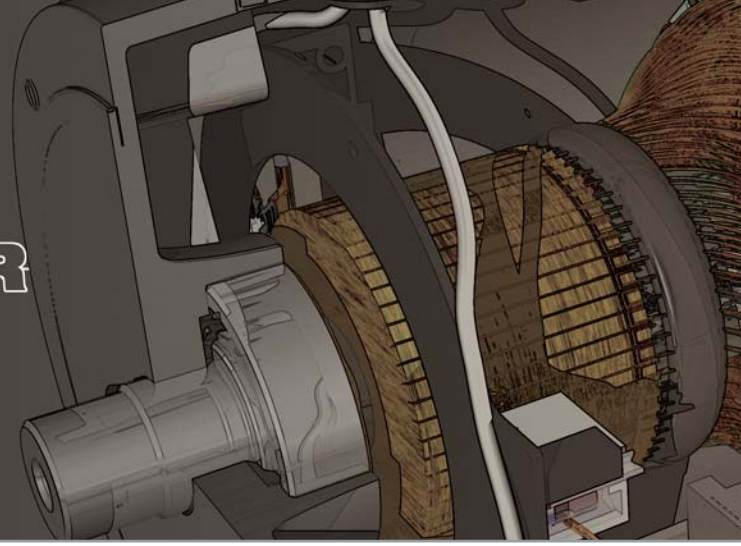
Adhesive Chemistries There are detailed descriptions of each chemistry. This includes a general description, typical applications, advantages, disadvantages, and manufacturing process considerations.

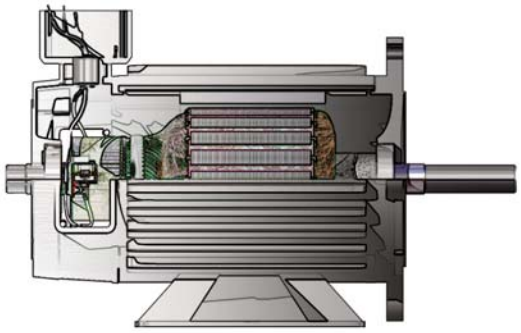
Product Selector One table that summarizes all the adhesives and sealants that are most commonly used on electric motors.

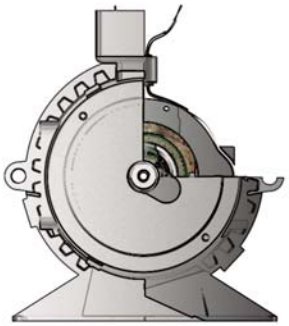


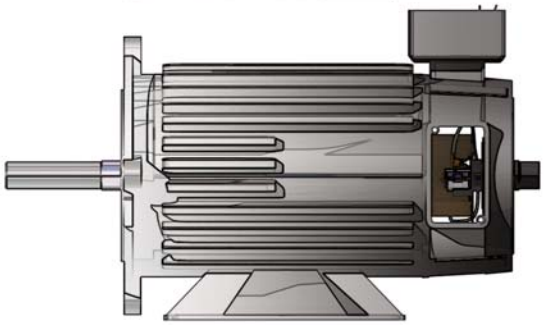
ELECTRIC MOTOR

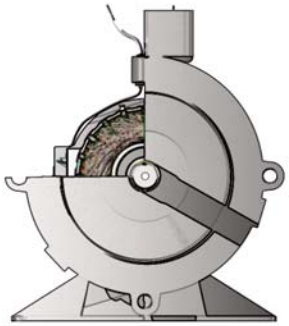
dc motor cutaway











CONDUIT OR JUNCTION BOX

WIRE CONNECTOR

END PLATE

COMMUTATOR

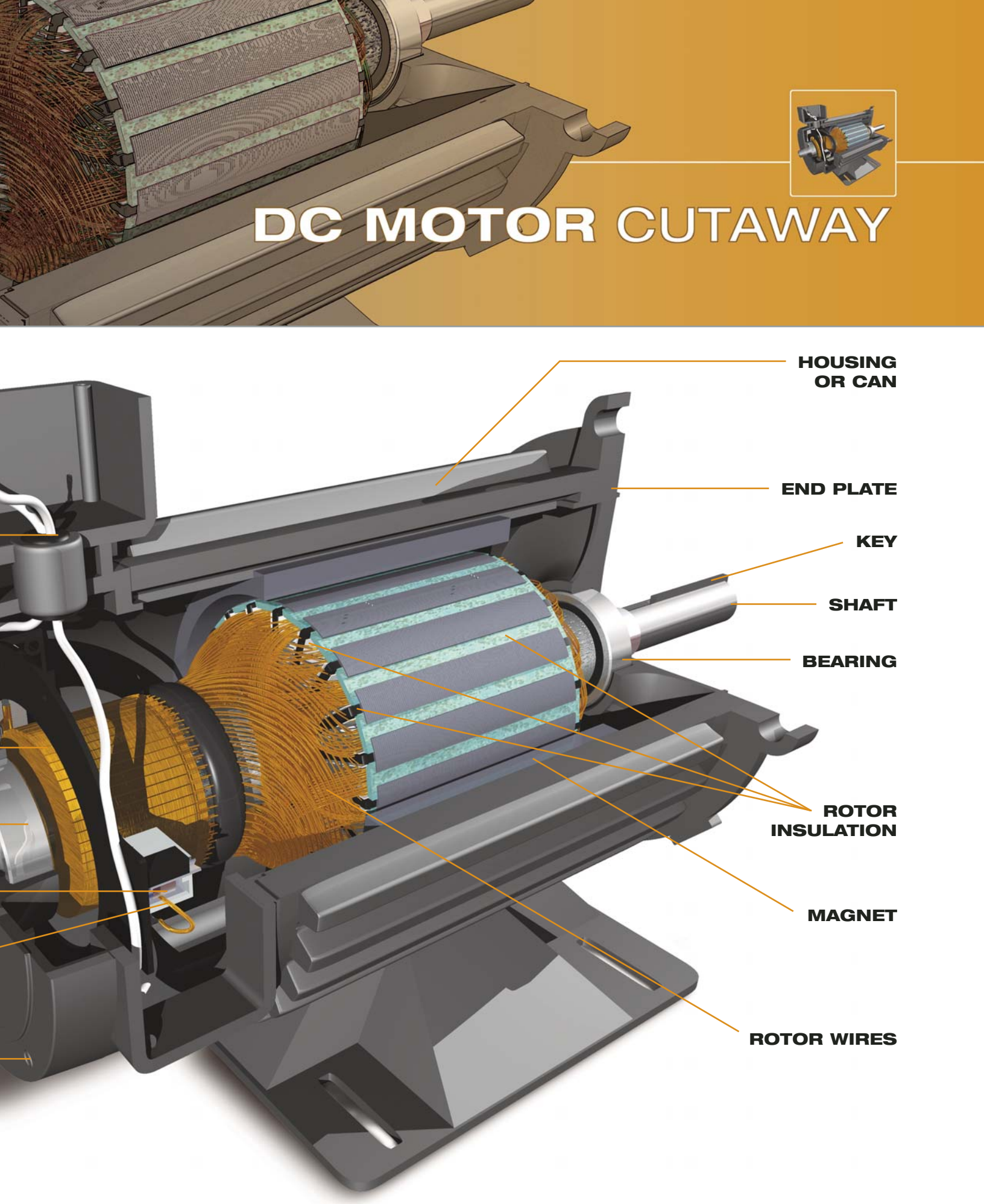
BEARING

BRUSH

BRUSH HOLDER

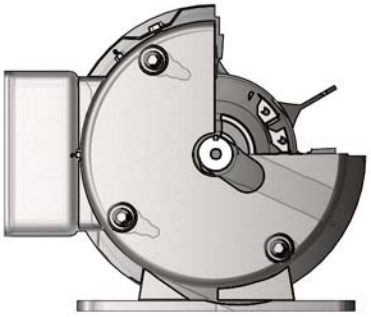
THROUGH BOLT

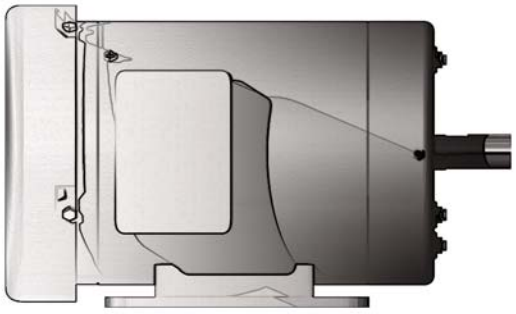
DC MOTOR CUTAWAY

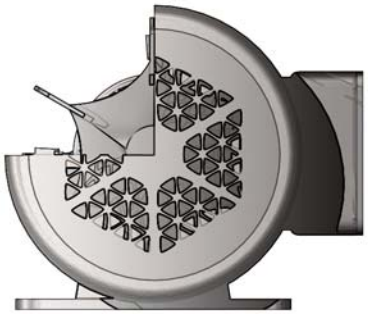


ELECTRIC MOTOR

ac motor cutaway







STATOR WINDING

STATOR WIRE INSULATION

THROUGH BOLT

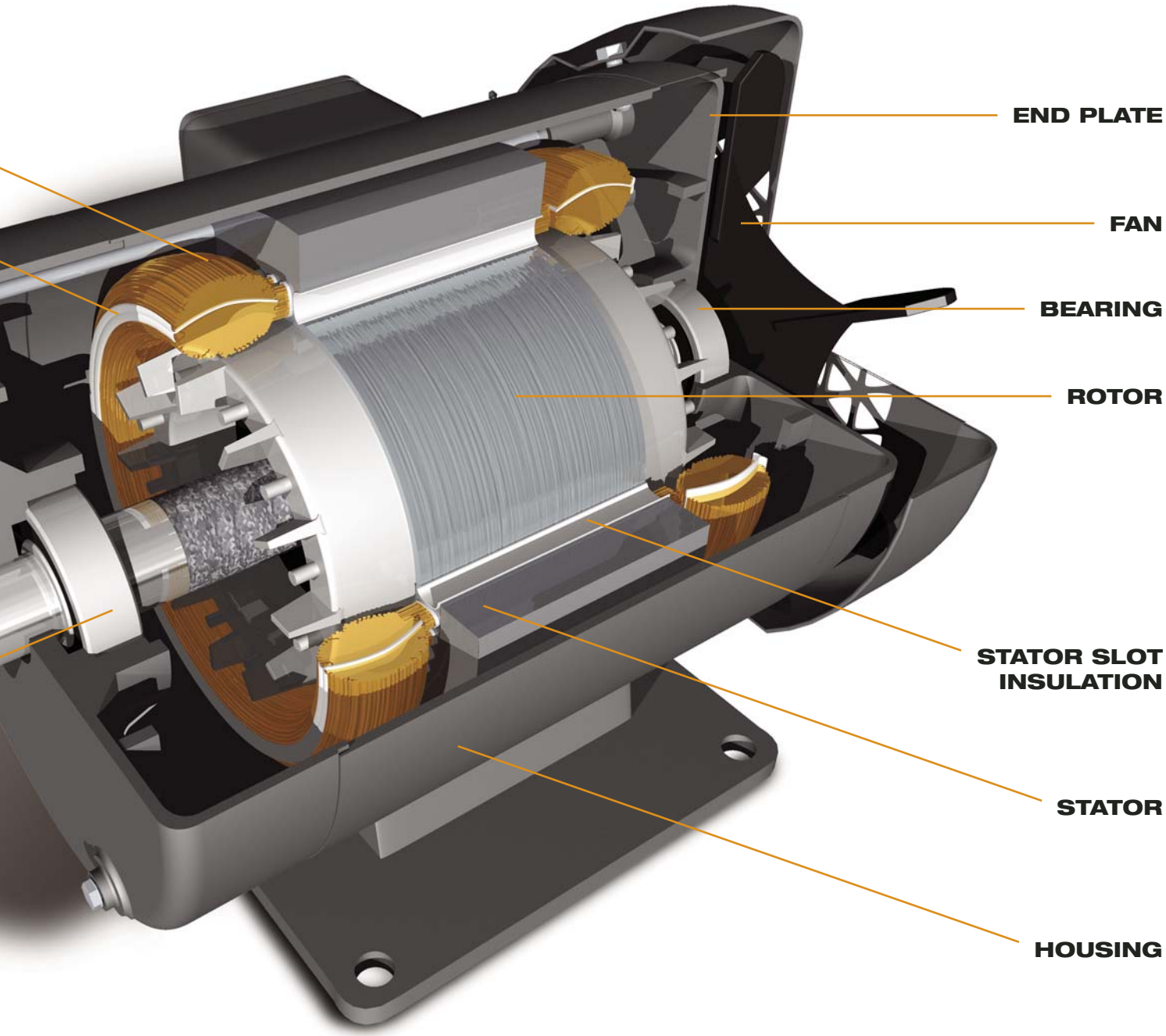
END PLATE

KEY

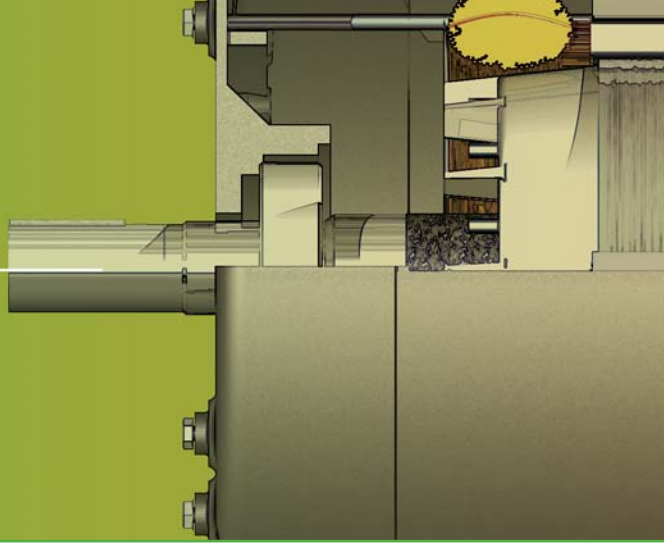
SHAFT

BEARING

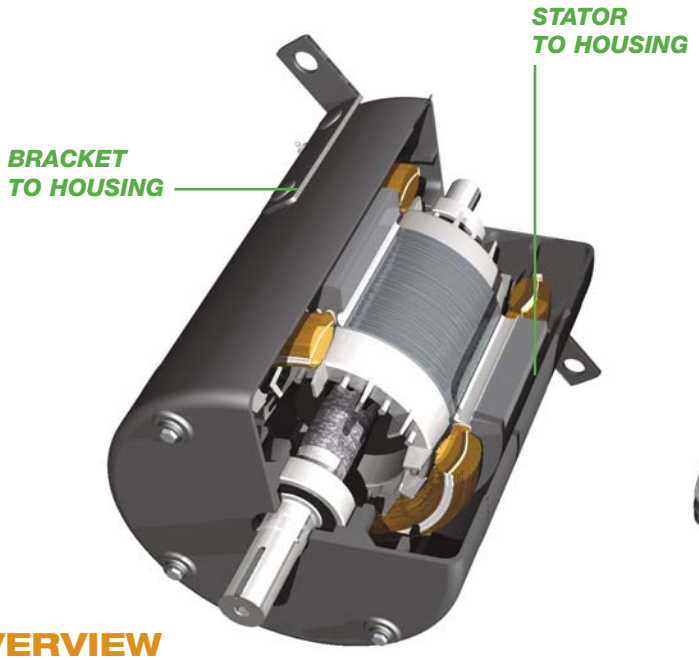
AC MOTOR CUTAWAY

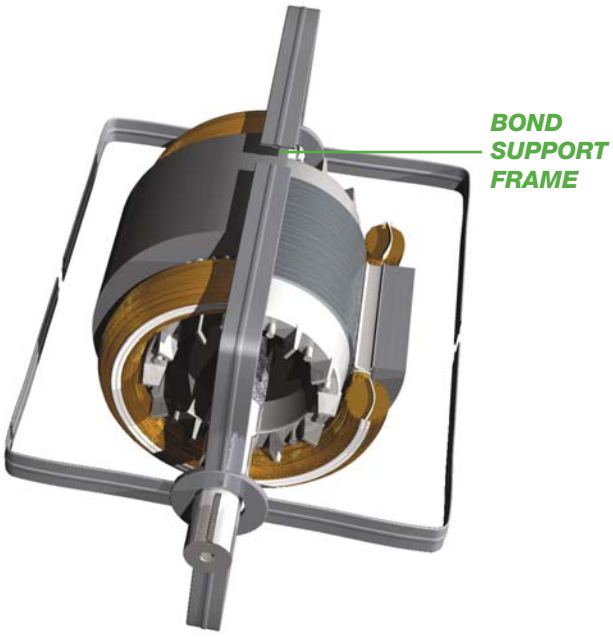


ELECTRIC MOTOR
general bonding applications



TYPICAL APPLICATIONS





OVERVIEW

General bonding applications are usually characterized by the use of an adhesive as the sole means of structurally joining two parts that have a relatively small gap between them, typically 0.002" to 0.10". Adhesives are widely used for bonding applications instead of welding, soldering, ultrasonic welding, riveting, mechanical fasteners, and tapes.

The key benefits of adhesives over these alternative methods are:

- Lower cost
- Easily automated
- Distribute stresses evenly
- Better cosmetic appearance
- Bond dissimilar substrates

ADHESIVE TYPE COMPARISON

There are a wide variety of adhesives that can be used for general bonding applications. The key selection criteria involves, but is not limited to, the following adhesive properties:

- Cure speed
- Temperature/environmental resistance
- Cost
- Adhesion to substrates
- Processing requirements (dispensing and curing)

Table 1 compares and contrasts the five most commonly used types of adhesives for bonding.

Table 11 on page 26 gives a more complete comparison of all ten adhesive types.

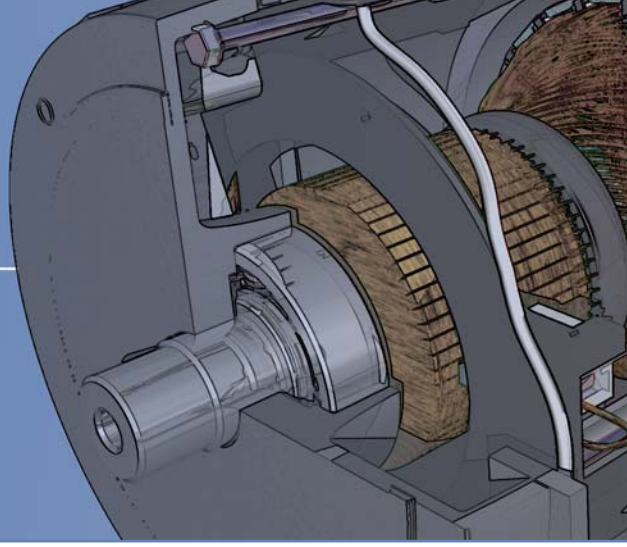
GENERAL BONDING

TABLE 1. COMPARISON OF ADHESIVE TYPES FOR GENERAL BONDING

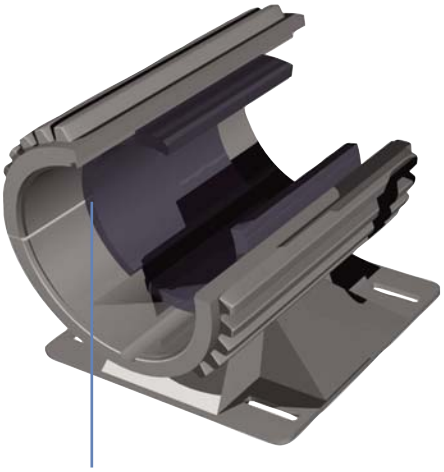
ATTRIBUTE		ACRYLIC, TWO-STEP	ACRYLIC, TWO-PART	CYANOACRYLATE	EPOXY, TWO-PART	HOT MELT
OVERVIEW						
Key Benefits		• Fast fixture speed • No mixing • Good adhesion to metals and ceramics • Excellent toughness • Light cure available	• High gap fill • Structural strengths • High impact strength • Able to cut through surface contaminants	• Fast fixture speed • High adhesion to most materials • Light cure available	• Room temperature cure • High gap fill • Excellent temperature resistance • Wide variety of formulations	• Fast fixture speed • Low volumetric cost • Many types of hot melts offer a wide range of performance
Key Limitations		• Limited gap fill • Exposed adhesive may remain tacky • Separate dispensing of activator	• Long cure time • Will cure in mix tip during idle times • May have strong odor • May have flammable vapors	• Limited gap fill • Low temperature resistance • Durability may be affected by substrate corrosion	• Long cure times • Adhesive cures in mix tip • Limited adhesion to plastics and elastomers • Equipment needed for bulk dispensing	• May have poor adhesion to metals • Dispensing equipment required • Hot dispense point can be a safety concern
PERFORMANCE						
Adhesive to Substrates	Metals	Excellent	Excellent	Very Good	Excellent	Good
	Plastics	Fair	Very Good	Excellent	Fair	Very Good
	Paper	Excellent	Excellent	Excellent	Excellent	Excellent
Gap Fill	Ideal	0.002 - 0.004"	0.004 - 0.006"	0.001 - 0.003"	0.004 - 0.006"	0.002 - 0.005"
	Maximum	0.040"	>0.50"	0.010"	>0.50"	0.25"
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 180°F	-65 to 300°F	-65 to 250°F
	Maximum	400°F	400°F	250°F	400°F	330°F
PROCESSING						
Fixture Time	Average	1 - 2 min	15 - 30 min	20 - 30 sec	20 - 30 min	30 sec
	Fastest	15 - 30 sec	3 -5 min	5 - 10 sec	3 - 5 min	5 - 10 sec
Full Cure		24 hours	24 hours	24 hours	24 hours	24 hours
Equipment Required		No	Two-Part Dispensing	No	Two-Part Dispensing	Hot Melt Dispenser
LOCTITE® BRAND PRODUCTS						
		• 392™ – Gen. purpose • 326™ – Fast fixture • 334™ – High temp. & impact • 332™ – Severe environment • 3920™ – Light cure	• H3000™ – Gen. purpose • H4500™ – Metal bonding • H8000™ – High impact • H8500™ – Ultra high impact • H8600™ - Severe Env.	• 380™ – Gen. purpose • 4500™ – Fast cure • 4205™ – High temp. • 4307™ – Light cure	• E-20NS™ – Gen. purpose • E-40FL™ – Flexible • E-20HP™ – High impact	• 7804FRM-HV™ – Gen. purpose • 3631™ – High adh. to metals • 0450™ – Long open time • 7901™ – High temp.

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
magnet bonding applications



TYPICAL APPLICATIONS



MAGNET SEGMENTS TO HOUSING

RING MAGNETS TO ROTOR

MAGNET SEGMENTS TO ROTOR

OVERVIEW

Magnets in electric motors are almost exclusively assembled today using adhesives. While a handful of different adhesive technologies are employed to meet the unique challenges of each specific motor's performance and processing requirements, it is widely accepted that adhesives create a higher quality joint at a lower cost than mechanical fasteners such as clips and bolts.

The key benefits of adhesives over clips and bolts are:

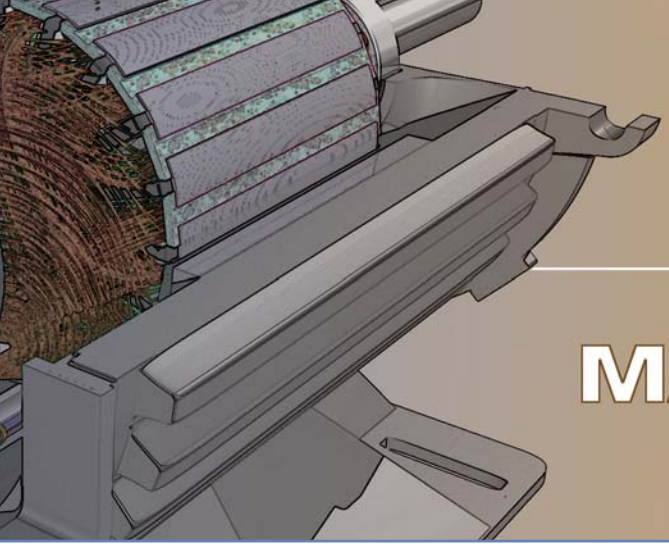
- Lower cost components
- Decreased inventory cost
- Easier to automate
- Will not chip magnets
- Prevent vibrational noise
- Prevent corrosion

ADHESIVE TYPE COMPARISON

In general, any of these adhesives can achieve bond strengths that exceed the tensile or compressive strength of the magnet. As a result, the key performance attributes that typically differentiate these adhesive types are:

- Cure speed
- Gap fill
- Temperature resistance
- Impact strength

Table 2 compares and contrasts the four most commonly used types of adhesives for magnet bonding.



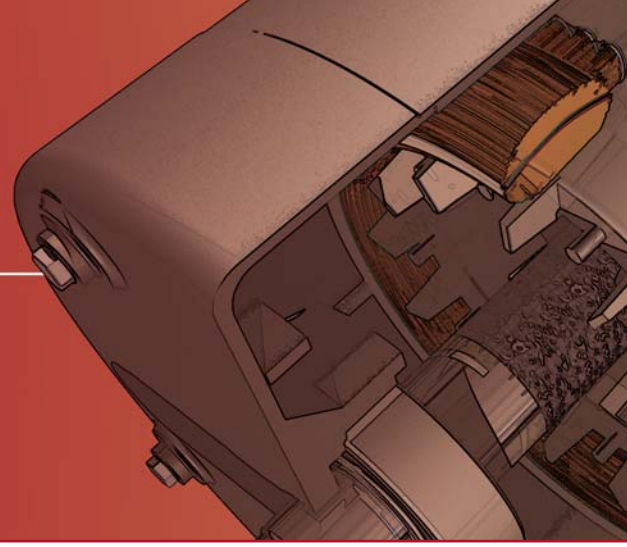
MAGNET BONDING

TABLE 2. COMPARISON OF ADHESIVE TYPES FOR BONDING MAGNETS

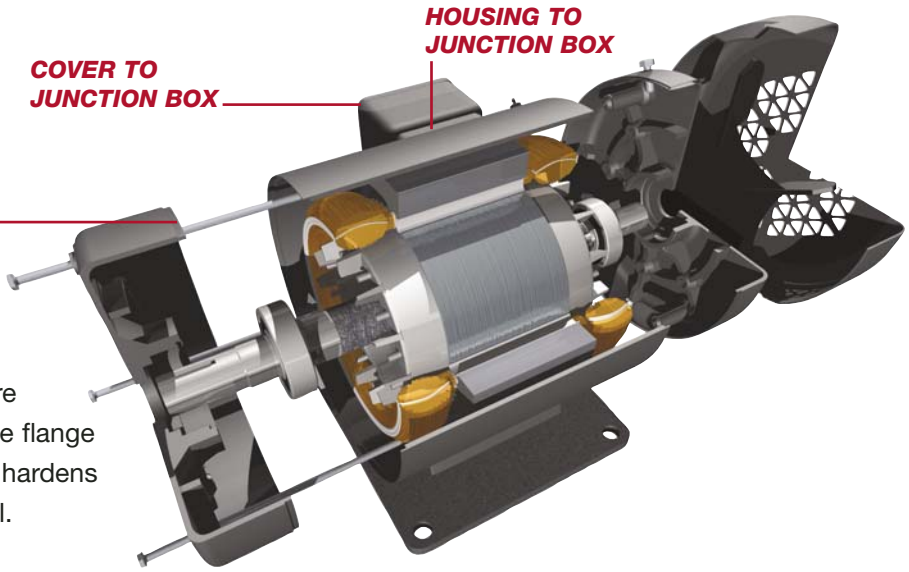
ATTRIBUTE		ACRYLIC, TWO-STEP	CYANOACRYLATE	EPOXY, ONE-PART HEAT CURE	EPOXY, TWO-PART
OVERVIEW					
Key Benefits		• Fast fixture speed • No mixing • High impact strength • Light cure available	• Fast fixture speed • High adhesion to plastics and elastomers • Light cure available	• High gap fill • Excellent temperature resistance • Fully cured in one hour	• Room temperature cure • High gap fill • Excellent temperature resistance • Wide variety of formulations
Key Limitations		• Limited gap fill • Must control activator amount precisely • Activator may contain solvents	• Limited gap fill • Low temperature resistance • Durability may be affected by substrate corrosion	• Curing equipment required • Long cure times • Must allow parts to cool	• Long cure times • Adhesive cures in mix tip • Limited adhesion to plastics and elastomers • Equipment needed for bulk dispensing
PERFORMANCE					
Gap Fill	Ideal	0.002 - 0.004"	0.001 - 0.003"	0.004 - 0.006"	0.004 - 0.006"
	Maximum	0.040"	0.010"	>0.50"	>0.50"
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 180°F	-65 to 350°F	-65 to 300°F
	Maximum	400°F	250°F	400°F	400°F
Impact Strength (steel)		Excellent	Fair	Good	Good
PROCESSING					
Fixture Time	Average	1 - 2 min	20 - 30 sec	30 - 45 min	20 - 30 min
	Fastest	15 - 30 sec	5 - 10 sec	15 - 30 min	3 - 5 min
Full Cure		24 hours	24 hours	1 hour	24 hours
LOCTITE® BRAND PRODUCTS					
		• 392™ – Gen. purpose • 326™ – Fast cure • 334™ – High temp. & impact • 332™ – Severe environment • 3920™ – Light cure	• 380™ – Gen. purpose • 4500™ – Fast cure • 4205™ – High temp. • 4307™ – Light cure	• 9423NA™ – Gen. purpose • 3984™ – Fast cure • 3985™ – High viscosity	• E-20NS™ – Gen. purpose • E-40FL™ – Flexible • E-20HP™ – High impact

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
gasketing applications



TYPICAL APPLICATIONS



OVERVIEW

Henkel has been replacing or augmenting cut gaskets for decades. Formed-in-place gaskets are the most commonly used “liquid gaskets”. They are dispensed on a flange as liquid. When the flange is mated to the second flange, the liquid hardens and bonds to both flanges forming a seal.

They offer the following benefits over cut gaskets, molded gaskets and o-rings:

- Easy to automate
- No misaligned gaskets
- One adhesive can seal many different flange configurations
- Lower inventory costs
- Lower labor costs
- Lower machining costs
- No gasket creep
- No gasket compression set

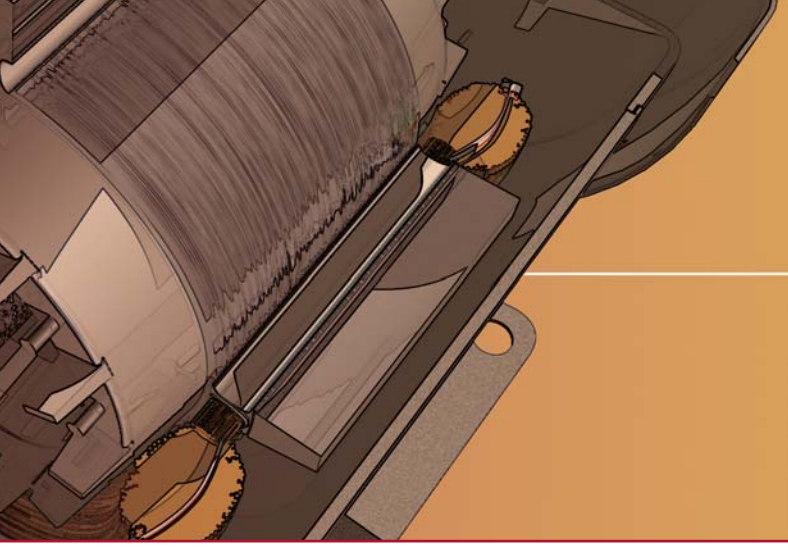
When it is necessary to service the gasketed assembly, cured-in-place gaskets can be used. They are robotically dispensed on a flange as a liquid and cured with light or heat. The cured gasket forms a compression gasket that is bonded to one flange. Cured-in-place gaskets share all the same benefits as formed-in-place gaskets with the exception that cured-in-place gaskets are susceptible to compression set.

ADHESIVE TYPE COMPARISON

Formed-in-place gaskets can be created with anaerobic or silicone adhesives and are well suited for manual, semi-automated and fully automated processes. Anaerobic gaskets are generally used on rigid metal flanges. Silicones are better suited for flexible joints with higher gaps.

When comparing the light cure and heat cure silicones for cured-in-place gaskets, the light cure silicones have the shortest cure time and the least work-in-process while the heat cure silicones offer higher adhesion, better thermal and chemical resistance, and lower volumetric cost.

Table 3 compares and contrasts the four most commonly used types of adhesives for gasketing.



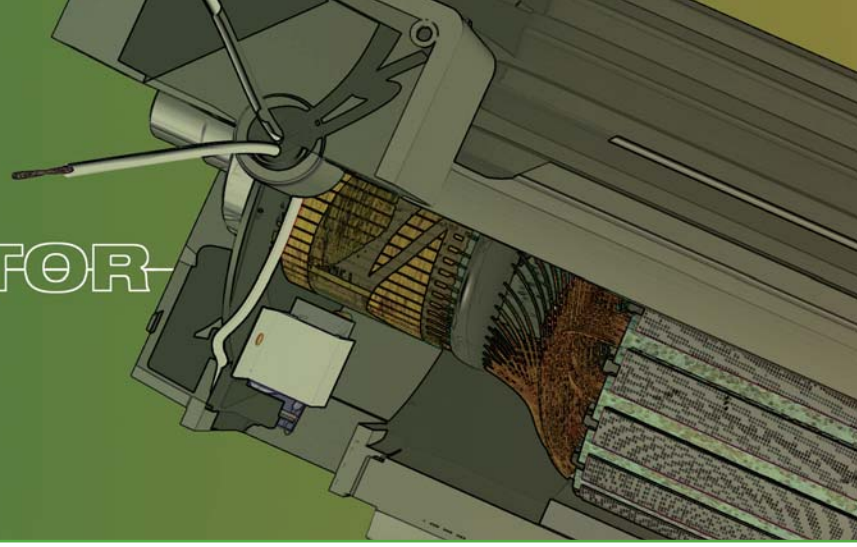
GASKETING

TABLE 3. COMPARISON OF ADHESIVE TYPES FOR GASKETING

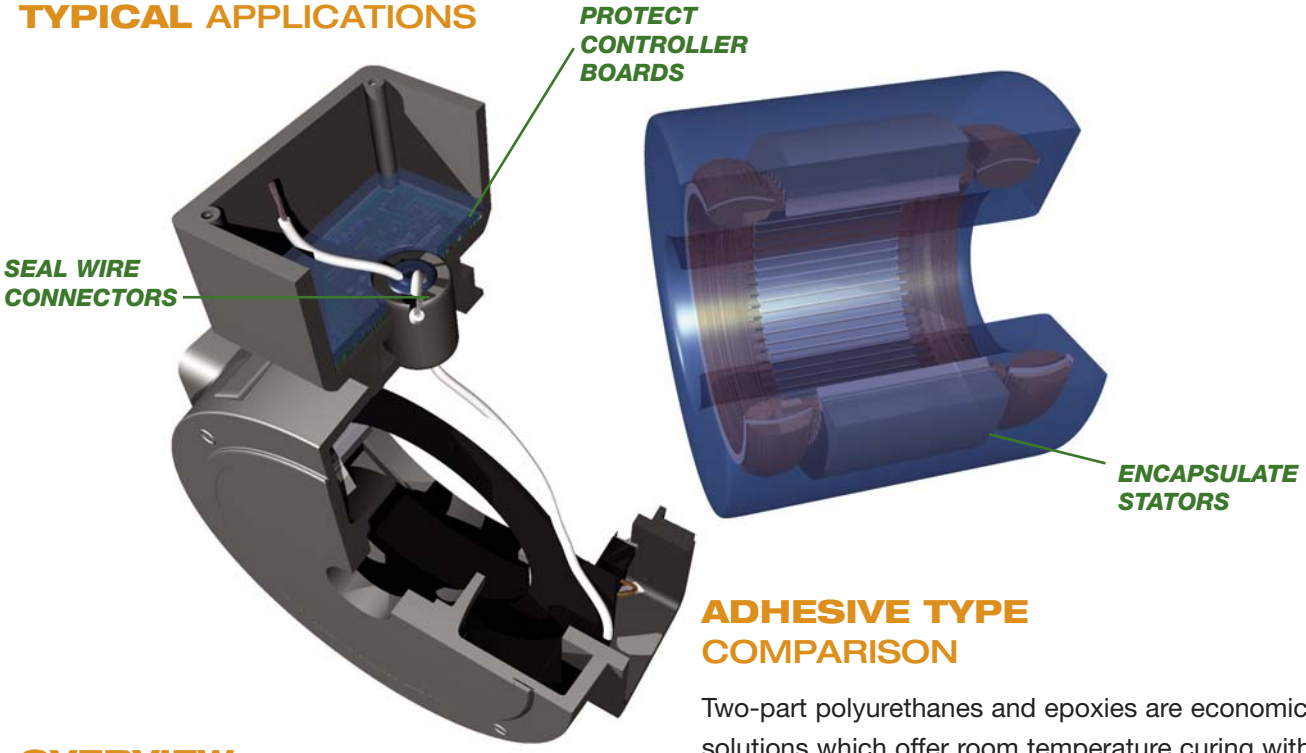
ATTRIBUTE		FORMED-IN-PLACE		CURED-IN-PLACE	
		ANAEROBIC	SILICONE, RTV	SILICONE, LIGHT CURE	SILICONE, HEAT CURE
OVERVIEW					
Key Benefits		• No compression set • Adds structural strength • High pressure seal	• No compression set • High joint movement • High gap fill • High temperature resistance	• Serviceable • Fastest cure time • Immediate properties • High gap fill	• Serviceable • Excellent temperature resistance • Excellent adhesion • High gap fill
Key Limitations		• Metal flanges only • Rigid flanges only	• Limited open time • Not for high pressure applications	• Must have dispensing and curing equipment • Not for high pressure applications	• Must have dispensing and curing equipment • Not for high pressure applications
PERFORMANCE					
Flange Type		Rigid	Rigid or Flexible	Rigid or Flexible	Rigid or Flexible
Suitable for Use With	Metals	Yes	Yes	Yes	Yes
	Plastics	No	Yes	Yes	Yes
Gap Fill	Ideal	0.001- 0.005"	0.004 - 0.006"	0.020 - 0.060"	0.020 - 0.060"
	Maximum	0.020"	0.25"	0.125"	0.125"
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 400°F	-65 to 350°F	-65 to 400°F
	Maximum	400°F	600°F	400°F	600°F
PROCESSING					
Cure Speed	Initial Cure	15 - 30 min	15 - 30 min	15 - 30 sec	15 - 30 min
	Full Cure	24 hours	24 hours - 7 days	24 hours - 7 days	15 - 30 min
Manual Dispensing		Yes	Yes	No	No
LOCTITE® BRAND PRODUCTS					
		• 518™ - Gen. purpose • 510™ – High temp. • 509™ – Flexible • 574™ – High gap	• 5910® – Gen. purpose • 5900® – Instant seal • 5699™ – High durometer • 5920™ – High temp.	• 5950™ – Gen. purpose • 5951™ – Fast cure / clear • 5960™ – Immediate assembly	• 5964™ – Gen. purpose • 5963™ – High durometer

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
potting applications



TYPICAL APPLICATIONS



OVERVIEW

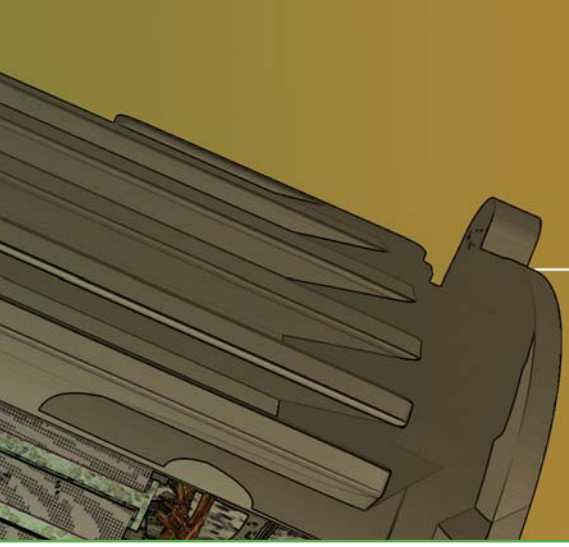
Potting is used to seal motors from solvent and moisture ingress and to protect critical components, such as controller boards, from mechanical damage and degradation caused by thermal cycling, vibration, and impact. To accomplish this, an enclosure is normally filled with adhesive completely encapsulating critical components and sealing the aperture. Potting is essential in explosion-proof motors and wash down motors.

ADHESIVE TYPE COMPARISON

Two-part polyurethanes and epoxies are economical solutions which offer room temperature curing with unlimited cure through depths. As a result, they are often used when potting large volumes. Epoxies generally offer better thermal and solvent resistance than urethanes, while urethanes are lower in cost and have higher flexibility. One-part heat-cure epoxies perform similarly to two-part epoxies but typically have better adhesion to plastics and are fully cured in an hour.

Light curing acrylics and light curing silicones are normally used for shallow potting applications. These chemistries offer much faster processing speeds, but at a higher volumetric cost.

Table 4 compares and contrasts the five most commonly used types of adhesives for potting applications.



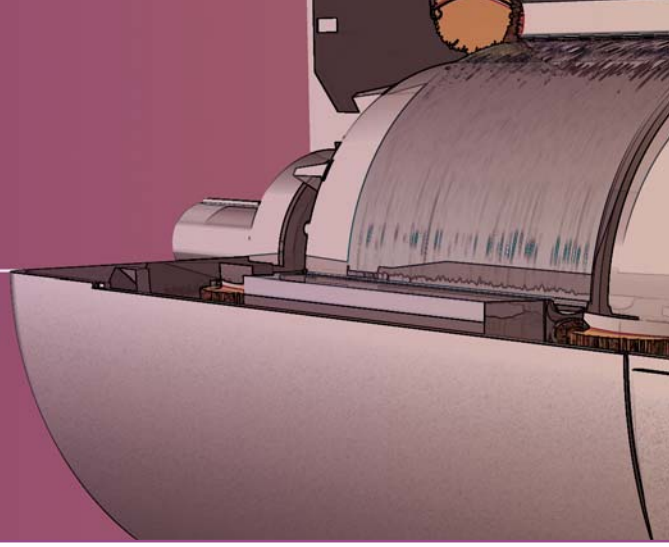
POTTING

TABLE 4. COMPARISON OF ADHESIVE TYPES FOR POTTING

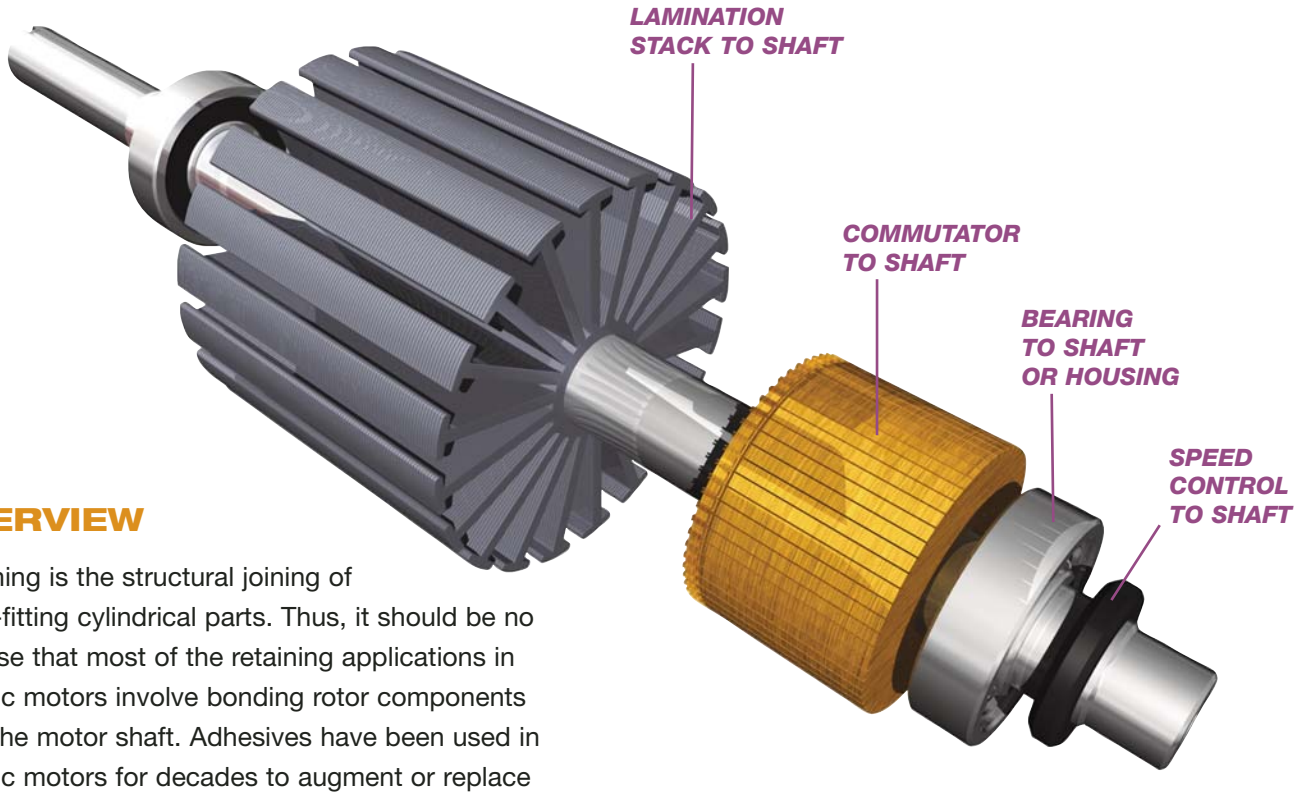
ATTRIBUTE		ACRYLIC, LIGHT CURE	EPOXY, ONE-PART HEAT CURE	EPOXY, TWO-PART	SILICONE, LIGHT CURE	URETHANE, TWO-PART
OVERVIEW						
Key Benefits		• Fast fixture speed • Fast full cure • Good adhesion	• High gap fill • Excellent temperature resistance • Fully cured in one hour	• High thermal resistance • High chemical resistance • Excellent adhesion • UL 1446 recognized	• Fast fixture speed • Flexible • Excellent chemical resistance to polar solvents • Good temperature resistance	• Low cost • Flexible • Excellent UV resistance
Key Limitations		• Light source required • Shadowed areas may not cure • Low gap fill	• Curing equipment required • Long cure times • Must allow parts to cool	• Must be mixed • Long cure time	• Light source required • Limited adhesion • May contaminate painting processes • Some formulations may cause corrosion	• Must be mixed • Long cure time • Moisture contamination during processing • Must handle isocyanates
PERFORMANCE						
Adhesive to Substrates	Metals	Good	Excellent	Excellent	Good	Good
	Plastics	Excellent	Good	Good	Fair	Very Good
	Paper	Excellent	Excellent	Excellent	Good	Good
Gap Fill	Ideal	0.020 - 0.125"	0.050 - 0.25"	0.050 - 0.25"	0.020 - 0.125"	0.050 - 0.25"
	Maximum	0.250"	>0.50"	>0.50"	0.250"	>0.50"
Tg		30 - 80°C	50 - 90°C	50 - 90°C	< -40°C	-10 - 50°C
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 300°F	-65 to 350°F	-65 to 250°F
	Maximum	350°F	400°F	400°F	400°F	300°F
PROCESSING						
Fixture Time	Average	30 sec	30 - 45 min	30 min	45 sec	30 min
	Fastest	5 - 10 sec	15 - 30 min	5 - 10 min	30 sec	5 - 10 min
Full Cure		30 sec	1 hour	24 hours	24 - 72 hours	24 hours
Equipment Required		Light Source	Cure Oven	Two-Part Dispense Equipment	Light Source	Two-Part Dispense Equipment
LOCTITE® BRAND PRODUCTS		• 3972™ – Gen. purpose • 3971™ – Low viscosity • 3944™ – High adh. to metals • 3926™ – High adh. to plastics	• 3981™ – Gen. purpose • 3982™ – Medium viscosity • 3985™ – High viscosity	• E-60NC™ – Gen. purpose • 3140™/3164™ – UL 1446 & UL 94HB • 3144™/3162™ – UL 94 V-0	• 5031™ – Gen. purpose • 5088™ – Non-corrosive	• 3173™/3183™ – Gen. purpose • 3173™/3182™ – Fast cure • 3173™/3184™ – UL 94 V-0

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
retaining applications



TYPICAL APPLICATIONS



OVERVIEW

Retaining is the structural joining of close-fitting cylindrical parts. Thus, it should be no surprise that most of the retaining applications in electric motors involve bonding rotor components onto the motor shaft. Adhesives have been used in electric motors for decades to augment or replace frictional methods, such as press and shrink fits, and mechanical methods, such as splines, keys, and locking pins.

The key benefits of adhesives over alternative methods are:

- Lower cost components
- Lower energy costs
- Easier to automate
- Eliminates wallowing and backlash of mechanical fits
- Eliminates run-out and warping of shaft
- Prevents fretting corrosion
- Prevents galvanic corrosion

ADHESIVE TYPE COMPARISON

Anaerobic adhesives are the dominant adhesive chemistry for metal-to-metal retaining applications. Anaerobics are single component, high strength, and cure rapidly at room temperature. When used with primers, they can achieve fixture times of less than 10 seconds.

When plastic components require retaining, cyanoacrylate adhesives are often used.

Table 5 compares and contrasts anaerobics and cyanoacrylates for retaining.

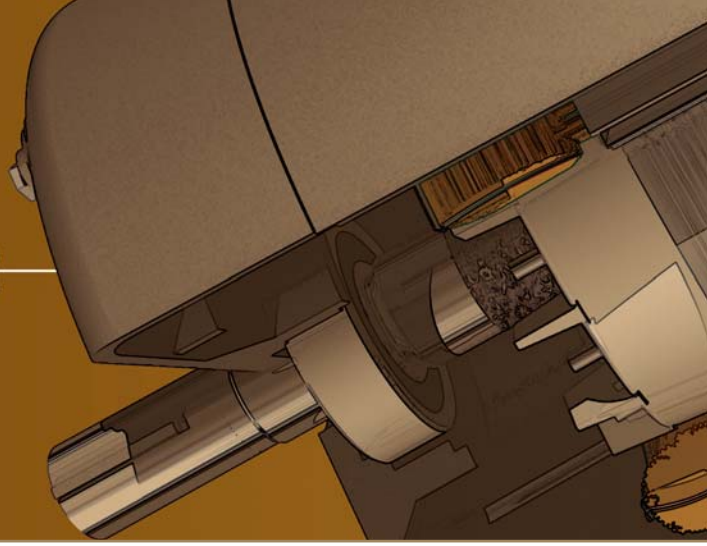
RETAINING

TABLE 5. COMPARISON OF ADHESIVE TYPES FOR RETAINING

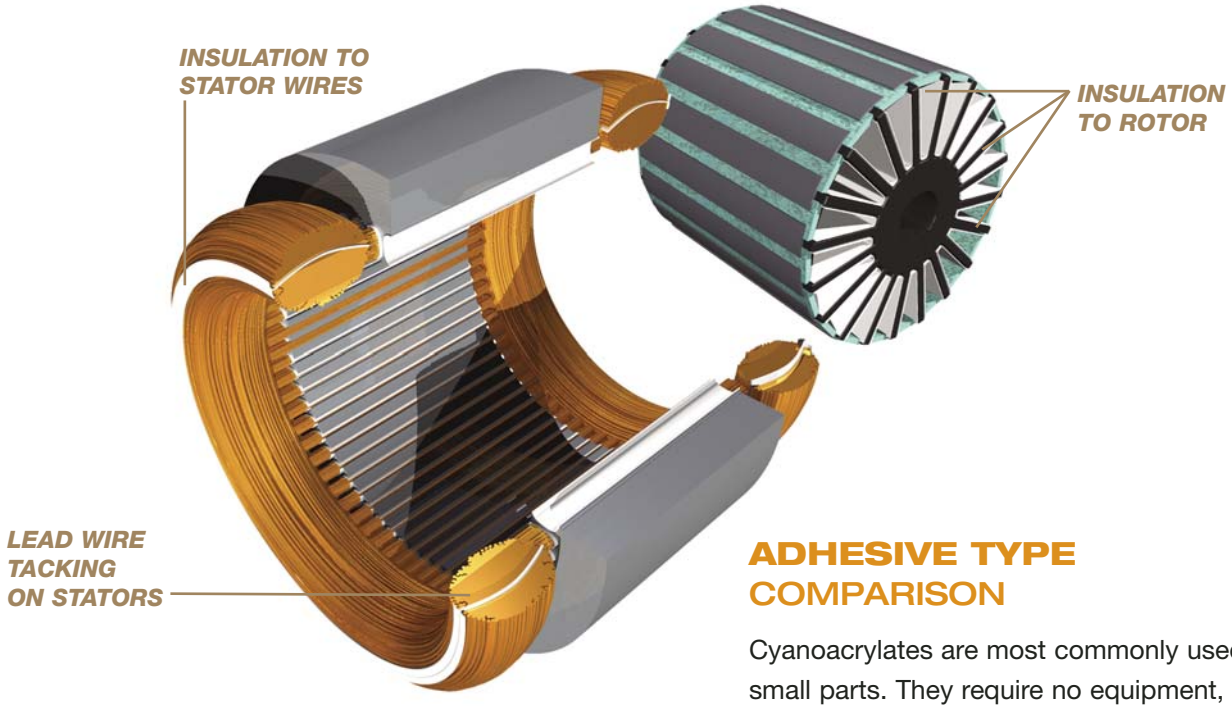
ATTRIBUTE		ANAEROBIC		CYANOACRYLATE
		LIQUID	SEMI-SOLID STICK	
OVERVIEW				
Key Benefits		• High strength • Excellent chemical resistance • High temperature resistance • Light cure available	• Semi-solid form • Will not drip or migrate • High strength • High thermal and chemical resistance	• Fast cure • High adhesion to plastics and elastomers • Light cure available • Compatible with plastics
Key Limitations		• Cannot be used with plastics • Cure speed highly dependent upon substrate • May require use of activator	• Cannot be used with plastics • Cure speed highly dependent upon substrate • May require use of activator	• Low temperature resistance • Susceptible to corrosion on metals • Cure speed sensitive to relative humidity
PERFORMANCE				
Shear Strength (steel)		3,000 - 4,000 psi	3,000 - 4,000 psi	2,500 - 4,000 psi
Suitable for Use With	Metals	Yes	Yes	Yes
	Plastics	No	No	Yes
Gap Fill	Ideal	0.001 - 0.003"	0.001 - 0.003"	0.001 - 0.003"
	Maximum	0.010"	0.005"	0.010"
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 180°F
	Maximum	400°F	400°F	250°F
PROCESSING				
Fixture Time	Average	5 - 10 min	30 min	20 - 30 sec
	Fastest	5 min - Unprimed <10 sec - Primed	30 min - Unprimed <1 min - Primed	5 - 10 sec
Full Cure		24 hours	24 hours	24 hours
LOCTITE® BRAND PRODUCTS		• 603™ – Gen. purpose • 648™ – Fast cure • 620™ – High temp. • 638™ – High strength • 290™ – Wicking grade • 661™ – Light cure	668™ – Gen. purpose	• 380™ – Gen. purpose • 4500™ – Fast cure • 4205™ – High temp. • 4307™ – Light cure

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
tacking applications



TYPICAL APPLICATIONS



OVERVIEW

Tacking applications are bonding applications where the adhesive is used to fixture the assembly very quickly. Adhesives are commonly used to tack lead wires, individual wires and insulation in electric motors. It is very common to tack lead wires and individual wires into position to reinforce them. Tacking is also used as a processing aid to ensure that the insulation on a motor or generator remains in the correct position until the entire assembly is unitized with varnish. This prevents electrical shorts caused by the insulation moving during subsequent operations such as mechanical shaping of the stator wires in large motors and generators.

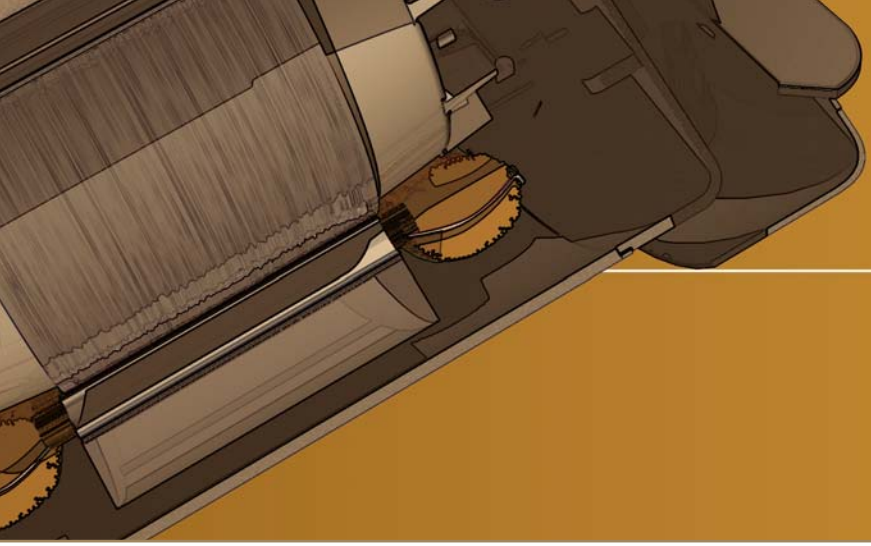
ADHESIVE TYPE COMPARISON

Cyanoacrylates are most commonly used to tack small parts. They require no equipment, cure rapidly at room temperature, achieve very high strengths to most substrates and any excess can be quickly cured with accelerator or light.

Hot melt adhesives are normally used on larger parts due to their low volumetric cost. They have fast cure speed, good adhesion to most substrates and can be sprayed from hand held applicators.

Light cure acrylic adhesives offer virtually unlimited positioning time with cure-on-command capability. If light can reach the joint, such as when wire tacking or through insulation paper, light cure is often the most user friendly process.

Table 6 compares and contrasts the three most commonly used types of adhesives for tacking applications.



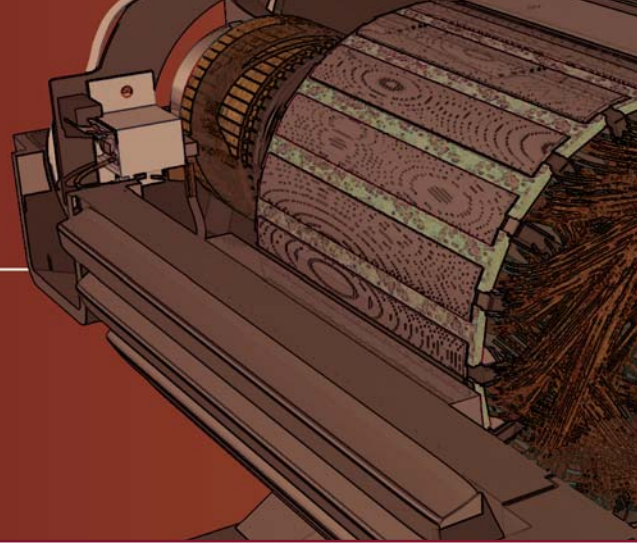
TACKING

TABLE 6. COMPARISON OF ADHESIVE TYPES FOR TACKING

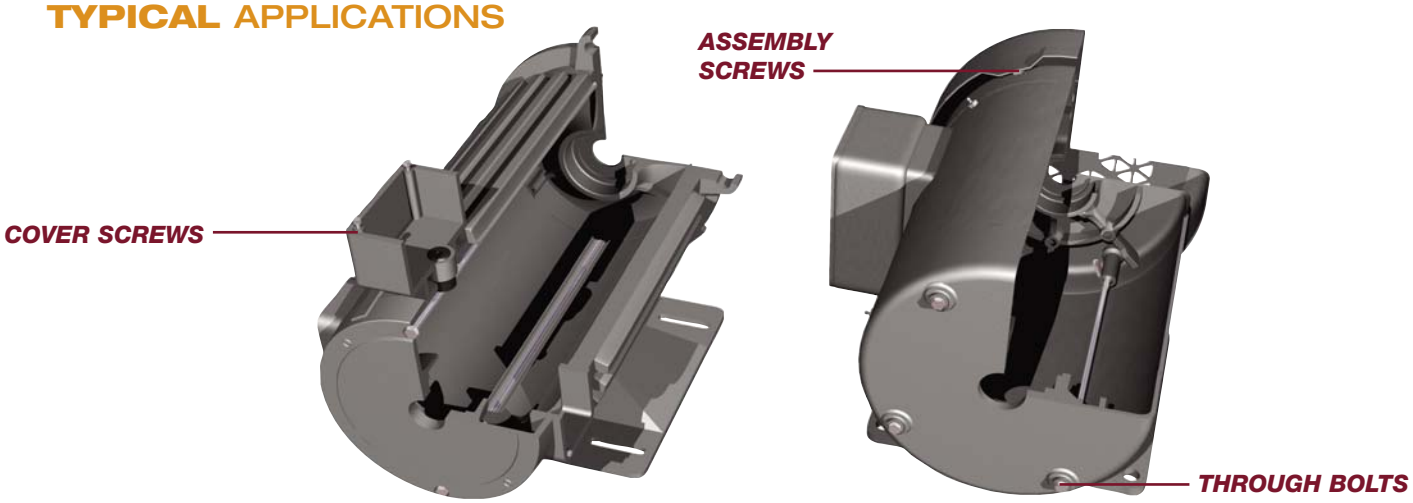
ATTRIBUTE		ACRYLIC, LIGHT CURE	CYANOACRYLATE	HOT MELT
OVERVIEW				
Key Benefits		• Fast fixture speed • Fast full cure • Good adhesion to metals, plastics and paper	• Fast fixture speed • High adhesion to most substrates • No equipment required • Light cure available	• Fast fixture speed • Low volumetric cost • Many types offer wide range of performance
Key Limitations		• Light source required	• Low gap fill • Low temperature resistance • Durability may be affected by substrate corrosion	• May have poor adhesion to metals • Dispensing equipment required • Hot dispense point can be a safety concern
PERFORMANCE				
Adhesive to Substrates	Metals	Good	Very Good	Good
	Plastics	Excellent	Excellent	Very Good
	Paper	Excellent	Excellent	Excellent
Gap Fill	Ideal	0.002 - 0.010"	0.001 - 0.003"	0.002 - 0.005"
	Maximum	0.25"	0.010"	0.25"
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 180°F	-65 to 250°F
	Maximum	350°F	250°F	330°F
PROCESSING				
Fixture Time	Average	30 sec	20 sec	30 sec
	Fastest	5 - 10 sec	5 - 10 sec	5 - 10 sec
Full Cure		30 sec	24 hours	<4 hours
Equipment Required		Light Source	No	Hot Melt Dispenser
LOCTITE® BRAND PRODUCTS				
		• 3972™ – Gen. purpose • 3971™ – Low viscosity • 3944™ – High adh. to metals • 3926™ – High adh. to plastics • 3526™ – Activator cure	• 380™ – Gen. purpose • 4500™ – Fast cure • 4205™ – High temp. • 4307™ – Light cure	• 7804FRM-HV™ – Gen. purpose • 3631™ – High adh. to metals • 0450™ – Long open time • 7901™ – High temp.

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
threadlocking applications



TYPICAL APPLICATIONS



OVERVIEW

Threadlockers prevent the loosening of threaded fasteners by completely filling the space between the threads, hardening to a strong polymer and bonding to both sides. Various viscosities and strengths are available to accommodate all fastener sizes. Threadlockers have a long history of improving the performance and reliability of threaded assemblies versus other frictional methods such as lock washers or stop nuts.

The key benefits threadlockers offer are:

- Lower cost
- More effective at preventing loosening
- Simple processing
- Controlled strengths
- Prevent corrosion

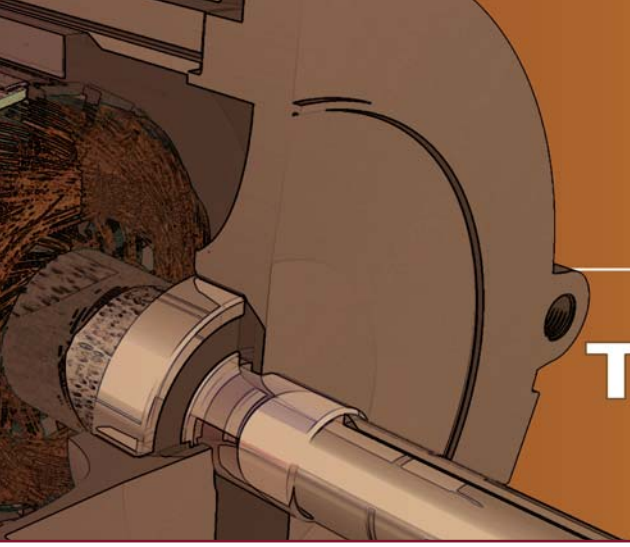
ADHESIVE TYPE COMPARISON

Liquid anaerobic threadlockers are the most widely used method to prevent vibrational loosening of metal fasteners. There is a large line of Loctite® brand threadlockers that offer a variety of viscosities, colors, strengths, and cure speeds.

Loctite® QuickStix™ are the most recent Henkel innovation. They offer the same performance as a liquid anaerobic threadlocker but in a semi-solid stick. The stick form allows the threadlocker to be applied to a nut or screw in any orientation without drips and it ensures that excess adhesive will not migrate into the motor bearings or moving parts that could cause reliability issues.

When threadlocking plastic fasteners or tamper proofing the heads of screws, cyanoacrylate liquids are normally used. They rapidly cure in plastic joints and will not stress crack most plastics.

Table 7 compares and contrasts the three most commonly used types of threadlocking adhesives.



THREADLOCKING

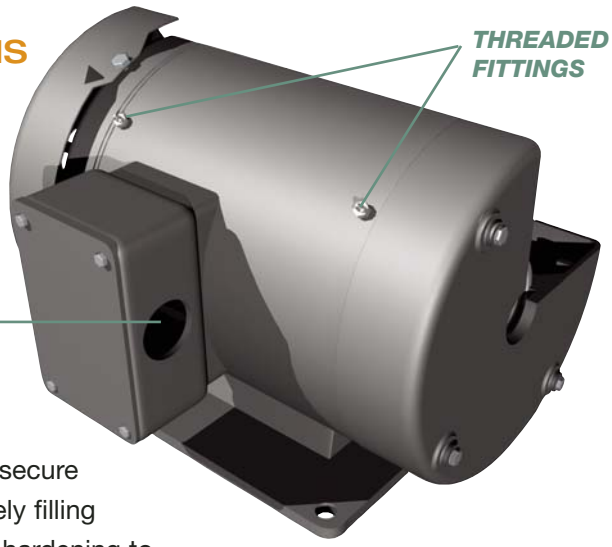
TABLE 7. COMPARISON OF ADHESIVE TYPES FOR THREADLOCKING

ATTRIBUTE		ANAEROBIC		CYANOACRYLATE
		LIQUID	SEMI-SOLID STICK	
OVERVIEW				
Key Benefits		• Controlled strengths • Variety of viscosities • Color coded by strength • High thermal and chemical resistance • Can post-apply wicking grade products • Wide variety of products available	• Semi-solid form will not drip or migrate • Controlled strengths • Color coded by strength • High thermal and chemical resistance	• Compatible with plastics • Fast cure
Key Limitations		• Not for use on plastics	• Not for use on plastics	• Low thermal and chemical resistance
PERFORMANCE				
Suitable For Use With	Metals	Yes	Yes	Yes
	Plastics	No	No	Yes
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 180°F
	Maximum	450°F	300°F	180°F
PROCESSING				
Cure Speed	Fixture	5 - 10 min	10 - 20 min	1 - 2 min
	Full Cure	24 hours	24 hours	24 hours
LOCTITE® BRAND PRODUCTS		• 243™ – Gen. purpose • 222™ – Low strength • 262™ – High strength • 290™ – Wicking grade • 2440™ – Fast cure • 272™ – High temp.	• 248™ – Gen. purpose • 268™ – High strength	• 425™ – Gen. purpose

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
thread sealing applications

TYPICAL APPLICATIONS



OVERVIEW

Anaerobic thread sealants seal and secure metal pipes and fittings by completely filling the space between the threads and hardening to prevent leakage. They have additives that facilitate assembly and maintain controlled strength to allow for easy removal with basic hand tools. The cured product has excellent temperature and chemical resistance that is compatible with many of the most severe operating environments.

Anaerobic thread sealants have been replacing alternatives such as PTFE tape, pipe dope and specialty fittings like dry seal fittings, flared fittings, compression fittings and confined o-rings for decades.

The advantages of anaerobic thread sealants over these methods are:

- Lower cost fittings
- Easy to automate
- No compression set
- No solvents
- Will not shred and contaminate systems
- Easy assembly
- Corrosion protection

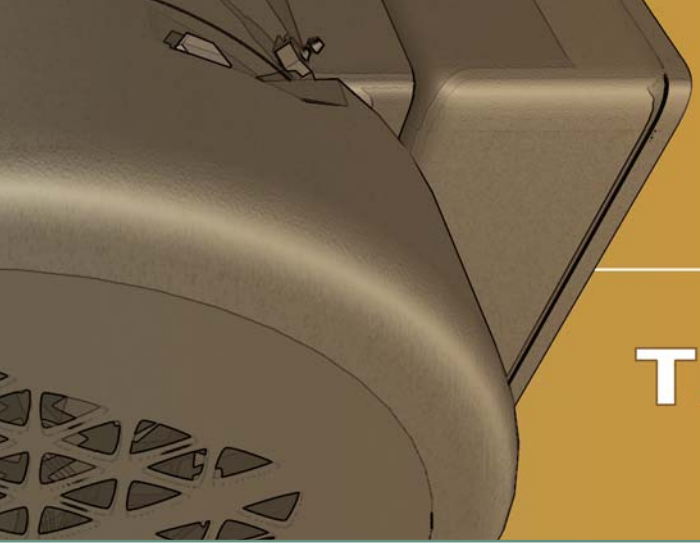
ADHESIVE TYPE COMPARISON

Anaerobic thread sealants are the most widely used liquid products for sealing pipe fittings. There is a large line of Loctite® brand thread sealants that offer a variety of viscosities, colors, strengths and cure speeds.

Loctite® QuickStix™ are the most recent Henkel innovation. They offer the same performance as a liquid anaerobic thread sealant but in a semi-solid stick. The stick form allows the thread sealant to be applied to a fitting in any orientation without drips and it ensures that excess adhesive will not migrate into the motor housing or moving parts that could cause reliability issues.

When thread sealing plastic fittings, use Loctite® No More Leaks™, a solvent-based product, or Loctite® 55™ Pipe Sealing Cord.

Table 8 compares and contrasts the three most commonly used types of thread sealants.



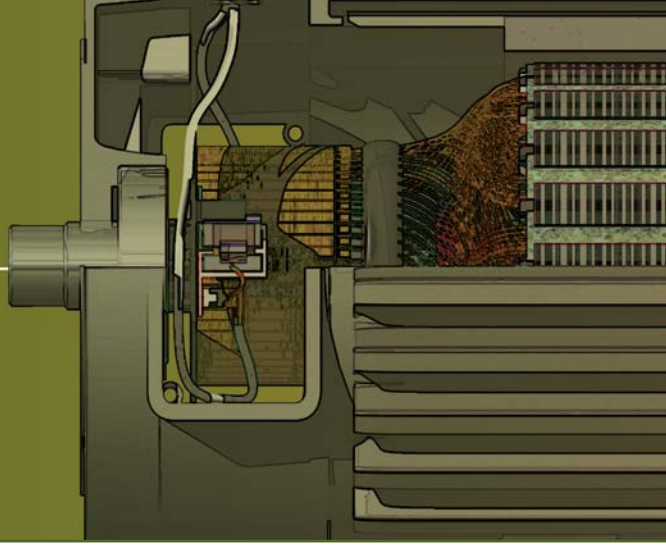
THREAD SEALING

TABLE 8. COMPARISON OF ADHESIVE TYPES FOR THREAD SEALING

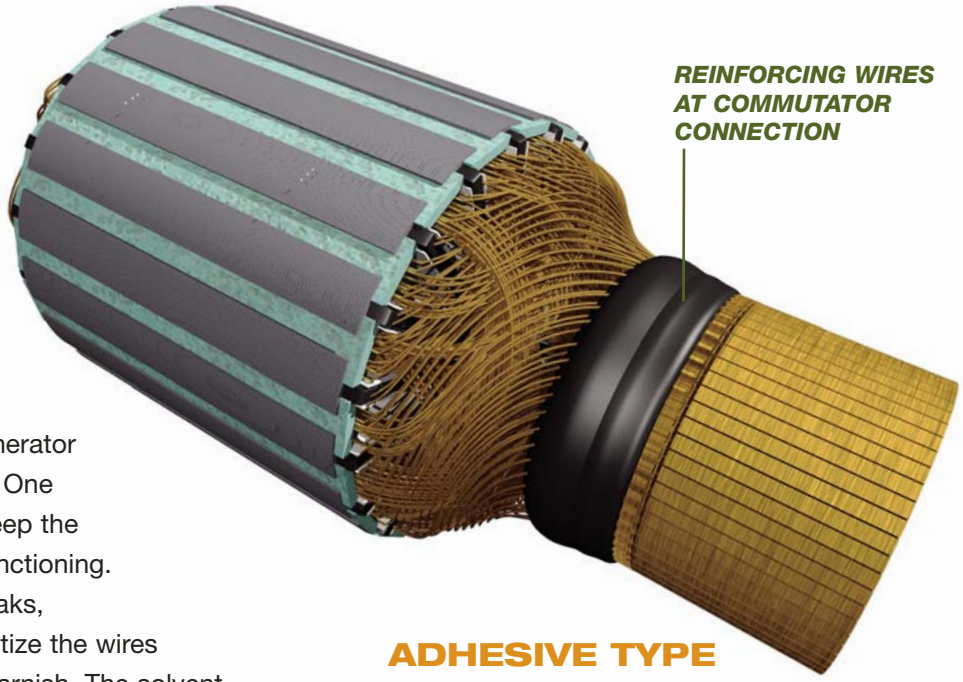
ATTRIBUTE		ANAEROBIC		NON-REACTIVE
		LIQUID	SEMI-SOLID STICK	
OVERVIEW				
Key Benefits		• Controlled strengths • Variety of viscosities • High thermal and chemical resistance • Wide variety of products available	• Semi-solid form will not drip or migrate • High thermal and chemical resistance	• Compatible with plastics
Key Limitations		• Not for use on plastics	• Not for use on plastics	• May contain solvents
PERFORMANCE				
Suitable for Use With	Metals	Yes	Yes	Yes
	Plastics	No	No	Yes
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 300°F
	Maximum	400°F	300°F	400°F
PROCESSING				
Seals Operating Pressure		4 hours	4 hours	Instant
LOCTITE® BRAND PRODUCTS				
		• 565™ – Gen. purpose • 545™ – Hydraulic/Pneumatic • 554™ – Refrigerant • 567™ – High temp. • 592™ – Slow cure	• 561™ – Gen. purpose	• 55™ – Sealing cord • No More Leaks™ – Solvent-based adhesive

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
wire reinforcement applications



TYPICAL APPLICATIONS



OVERVIEW

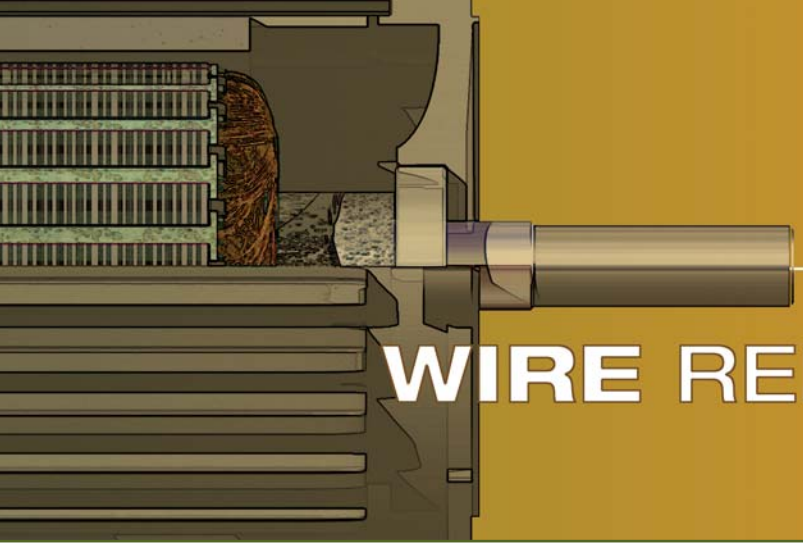
The wires in a motor or generator are critical to its operation. One broken or loose wire will keep the motor or generator from functioning. To protect against wire breaks, manufacturers normally unitize the wires in rotors and stators with varnish. The solvent-based varnishes that are used may be sufficient for many applications, but do not offer enough protection for all applications. For example, it is very common to reinforce the wires that connect to the commutator in DC motors when the motor will be in service in high impact or vibration service environments such as in power tools or in sink garbage disposals. In these applications, the thin coating of varnish on the wires that connect to the commutator do not offer sufficient reinforcement to prevent the flexing fatigue that can lead to failure. To reinforce these wires, a medium viscosity epoxy coating is applied that is thin enough to surround the wires, but thick enough to build up a rigid coating.

ADHESIVE TYPE COMPARISON

For high volume production, one-part heat cure epoxies are often the optimum method for reinforcing wires. They are easy to process, have excellent electrical properties, and can normally be dispensed and cured in the varnish trickle cure oven. Since the epoxy coating is being cured in the varnish cure oven, it does not add any work-in-process or time to manufacture to the process and the equipment and maintenance costs are very low.

Two-part epoxies are generally used in work cells where it is desired to dispense the adhesive manually and allow it to cure at room temperature.

Table 9 compares and contrasts the two most commonly used types of adhesives for wire reinforcement.



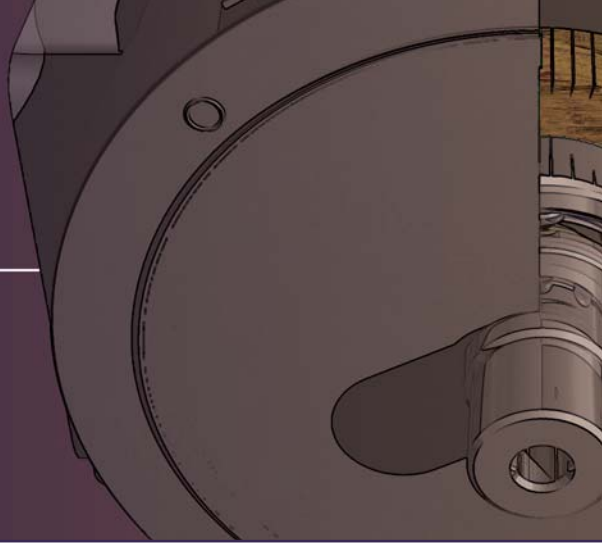
WIRE REINFORCEMENT

TABLE 9. COMPARISON OF ADHESIVE TYPES FOR WIRE REINFORCEMENT

ATTRIBUTE		EPOXY, ONE-PART HEAT CURE	EPOXY, TWO-PART
OVERVIEW			
Key Benefits		• Can cure adhesive in varnish cure oven • No mixing required	• Room temperature cure • Can accelerate cure with heat
Key Limitations		• Cool down time after cure	• Adhesive cures in mix tip • Adhesive waste due to pot life
PERFORMANCE			
Adhesive to Substrates	Metals	Excellent	Excellent
	Plastics	Good	Good
	Paper	Excellent	Excellent
Gap Fill	Ideal	0.050 - 0.100"	0.050 - 0.100"
	Maximum	>0.50"	>0.50"
Temp. Resistance	Typical Range	-65 to 350°F	-65 to 300°F
	Maximum	400°F	400°F
PROCESSING			
Fixture Time		30 - 60 min	20 - 30 min
Full Cure		1 hour	24 hours
LOCTITE® BRAND PRODUCTS			
		• 3985™ – Gen. purpose	• E-40FL™ – Gen. purpose • E-20HP™ – High impact

For additional information on the Loctite® products listed, please refer to the product selector in the back of this guide or visit www.loctite.com/datasheets.

ELECTRIC MOTOR
chemistries



OVERVIEW

For efficient selection of adhesives, a three step process is normally used.

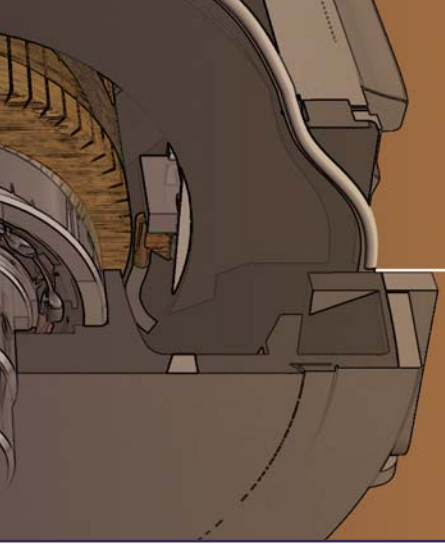
1. Select chemistries. The adhesive chemistries that are best suited for the application are selected.

2. Identify candidates. The best adhesive grades from each chemistry are identified for further consideration.

3. Validate performance. Prototypes are created to validate that the assembly process meets all requirements.

Tables 10 and 11 are designed to assist design, manufacturing and quality engineers in understanding where different adhesive chemistries are used on electric motors and generators and to simplify comparisons between the adhesive chemistries.

Table 10 describes the typical applications of adhesives and sealants as they relate to each component. The adhesive chemistries that are generally best suited for those applications are then listed.



CHEMISTRIES

TABLE 10: APPLICATIONS SUMMARY

MOTOR COMPONENT	APPLICATIONS	ADHESIVE TYPES								
		ACRYLIC, LIGHT CURE	ACRYLIC, TWO-STEP	ACRYLIC, TWO-PART	ANAEROBIC	CYANOACRYLATE	EPOXY	HOT MELT	POLYURETHANE	SILICONE
Bearings	Retaining to housings or shafts				●					
Bolts	Preventing loosening and corrosion				●					
Brackets	Bonding to stators or housings	●	●	●	●					
Brush holders	Bonding or reinforcing			●		●	●			
Commutators	Retaining to shafts		●		●					
Conduit boxes	Sealing joint with housing				●					●
End plates	Sealing joint with housing				●					●
Fans	Bonding to shafts or rotors		●	●		●	●			
Fittings	Sealing threaded fittings				●					
Gaskets	Replacing or augmenting gaskets				●					●
Gear boxes	Sealing covers, plugs and joint with housing				●					●
Insulation	Bonding to stators, rotors or wires	●				●	●	●		
Junction box	Sealing covers, plugs and joint with housing				●					●
Keys	Retaining in slots on shafts				●					
Laminates	Bonding and unitizing	●			●	●				
Lead wire	Bonding to stators or rotors	●				●	●			
Magnets	Bonding to rotors or housings		●	●		●	●			
Name plates	Bonding to housing			●		●	●			
Printed circuit board	Encapsulating or potting						●		●	●
Rotors	Retaining to shafts				●					
Screws	Preventing loosening and corrosion				●					
Speed control	Retaining to shafts				●					
Stators	Bonding to housings or mounting frames	●	●	●			●			
Wires	Reinforcing or insulating wires	●					●			
Connectors	Sealing, potting and reinforcing						●		●	●

ELECTRIC MOTOR chemistries

Table 11 is a summary that compares and contrasts the key attributes of the ten different adhesive chemistries typically used on motors and generators. For additional information on a particular chemistry, please see the detailed descriptions in the pages that follow.

TABLE 11. COMPARISON OF ALL ADHESIVE TYPES

ATTRIBUTE		ACRYLIC, LIGHT CURE	ACRYLIC, TWO-STEP	ACRYLIC, TWO-PART	ANAEROBIC	CYANOACRYLATE
OVERVIEW						
Key Benefits		• Fast fixture speed • Fast full cure • Good adhesion	• Fast fixture speed • No mixing • High impact strength • Light cure available	• High gap fill • Structural strengths • High impact strength • Able to cut through surface contaminants	• High strength • Excellent chemical resistance to polar solvents • Good temperature resistance	• Fast fixture speed • Excellent adhesion to plastics and elastomers • Light cure available
Key Limitations		• Light source required • Shadowed areas may not cure • Low gap fill	• Limited gap fill • Must control activator amount precisely • Activator may contain solvents	• Long cure time • Will cure in mix tip during idle times • May have strong odor • May have flammable vapors	• Cure speed dependent upon substrate • May require use of primer • Poor adhesion to and may stress crack plastics	• Low gap fill • Low temperature resistance • Durability may be affected by substrate corrosion
PERFORMANCE						
Adhesive to Substrates	Metals	Good	Excellent	Excellent	Excellent	Very Good
	Plastics	Excellent	Good	Very Good	Poor	Excellent
Gap Fill	Ideal	0.002 - 0.010"	0.002 - 0.004"	0.010" - 0.040"	0.001 - 0.005"	0.002 - 0.006"
	Maximum	0.250"	0.040"	>0.50"	0.020"	0.010"
Shear Strength		High	High	High	High	High
Peel Strength		Medium	Medium	High	Low	Low
Elongation/ Flexibility		Medium	Medium	High	Low	Low
Temp. Resistance	Typical Range	-65 to 300°F	-65 to 300°F	-65 to 300°F	-65 to 300°F	-65 to 180°F
	Maximum	350°F	400°F	350°F	400°F	250°F
PROCESSING						
# of Components		1	2	2	1	1
Fixture Time	Average	30 sec	1 - 2 min	15 - 30 min	30 - 60 min	30 sec
	Fastest	5 - 10 sec	15 - 30 sec	3 - 5 min	5 - 10 min	5 - 10 sec
Full Cure		30 sec	24 hours	24 hours	24 hours	24 hours
Light Cure Available		Yes	Yes	No	Yes	Yes
Equipment Required		Light Source	No	Two-Part Dispense Equipment	No	No

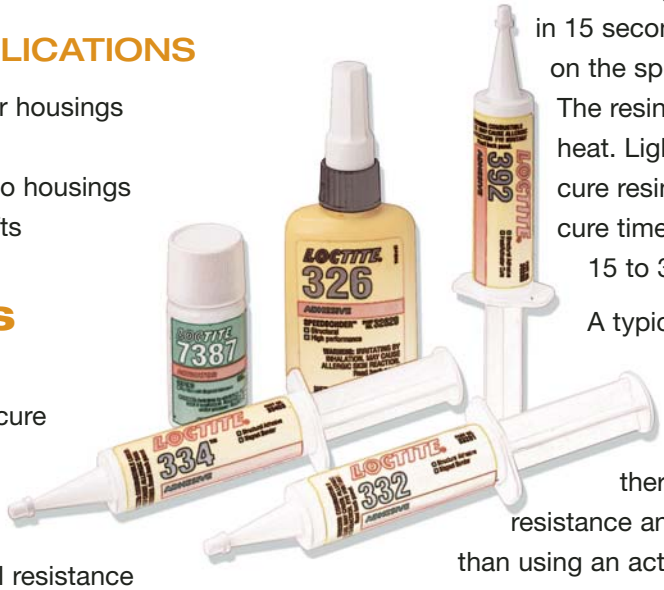
CHEMISTRIES

	EPOXY, ONE-PART HEAT CURE	EPOXY, TWO-PART	HOT MELT	SILICONES, RTV	URETHANES, TWO-PART
	• High gap fill • Excellent temperature resistance • Excellent chemical resistance • Fully cured in one hour	• Room temperature cure • High gap fill • Excellent temperature resistance • Wide variety of formulations	• Fast fixture speed • Low volumetric cost • Many types of hot melts offer a wide range of performance	• High thermal resistance • High flexibility • High gap fill • Excellent environmental resistance • Light cure available	• Low volumetric cost • High flexibility • Good UV resistance
	• Curing equipment required • Long cure times • Parts must withstand heat • Must allow parts to cool	• Long cure times • Adhesive cures in mix tip • Limited adhesion to plastics and elastomers • Equipment needed for bulk dispensing	• Dispensing equipment required • Hot dispense point • May have poor adhesion to metals • Durability may be affected by substrate corrosion	• Slow moisture cure • Low cohesive strength • Low chemical resistance • Cannot be painted	• Must be mixed • Long cure time • Sensitive to moisture during processing • Must handle isocyanates
	Excellent	Excellent	Good	Good	Good
	Good	Good	Very Good	Fair	Very Good
	0.004 - 0.006"	0.002 - 0.010"	0.002 - 0.005"	0.004 – 0.006"	0.004" – 0.006"
	>0.50"	>0.50"	0.25"	0.25"	>0.50"
	High	High	Low	Low	Medium
	Medium	Medium	Medium	Medium	Medium
	Low	Low	High	Very High	High
	-65 to 350°F	-65 to 300°F	-65 to 250°F	-65 to 400°F	-65 to 250°F
	400°F	400°F	330°F	600°F	300°F
	1	2	1	1	2
	30 - 45 min	30 min	30 sec	15 - 30 min	30 min
	15 - 30 min	3 - 5 min	5 - 10 sec	10 min	5 - 10 min
	1 hour	24 hours	<4 hours	24 hours - 7 days	24 hours
	No	Yes	No	Yes	No
	Heat Cure Oven	Two-Part Dispense Equipment	Hot Melt Dispenser	No	Two-Part Dispense Equipment

ACRYLICS, TWO-STEP

TYPICAL APPLICATIONS

- Magnets to rotors or housings
- Stators to housings
- Mounting brackets to housings
- Commutator to shafts



ADVANTAGES

- Fast fixture speed
- Room temperature cure
- No mixing required
- High peel and impact strength
- Good environmental resistance
- Bonds to lightly contaminated surfaces
- Cure can be accelerated with heat

DISADVANTAGES

- Limited cure through depth (0.040")
- Activator may contain solvents
- Activator requires controlled dispensing process
- Adhesive may have strong odor

GENERAL DESCRIPTION

Two-step acrylic adhesives consist of a resin and an activator. The resin component is a solvent-free, high viscosity liquid typically in the range of 10,000 to 100,000 cP. The activator is a low viscosity liquid catalyst typically in the range of 2 to 50 cP. The activator is available either as a solvent dispersion or pure (also called “solventless”).

When the resin and activator contact each other, the resin begins to cure very rapidly fixturing in 15 seconds to several minutes depending on the specific adhesive used and joint gap. The resin can also be cured with light or heat. Light curing can be used to fully cure resin that light can reach. While the cure time depends on many factors, 15 to 30 seconds is typical.

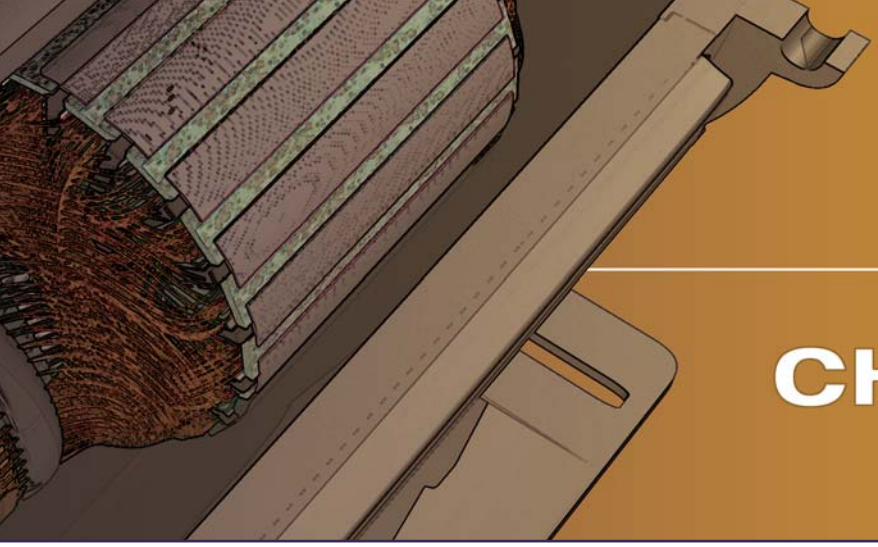
A typical heat cure cycle is 10 to 20 minutes at 300°F (149°C). Heat curing normally offers higher bond strengths, improved thermal resistance, better chemical resistance and achieves complete cure faster than using an activator. Heat cure is sometimes also used to eliminate any residual odor of the acrylic adhesive from the cured assembly and minimize outgassing.

PROCESS NOTES

Use the activator specified for the adhesive in the data sheet. All activators are not compatible with all adhesives.

Do not over apply. When using solventless activators, such as Loctite® 7380™, 7090™ or 7091™, do not over apply them. The target quantity is normally 4 to 8 mg/in^2. Solventless activators generally require automated dispensing via a rotospray or atomized spray valve.

Allow time for the carrier solvent to evaporate. If using a solvent-based activator, such as Loctite® 7387™ or 7075™, allow sufficient time for the carrier solvent to evaporate after applying the activator and before mating the two assemblies.



CHEMISTRIES

This is normally 30 to 60 seconds but can be longer based on the specific activator used.

Do not apply the activator and adhesive to the same part, unless they are to be assembled immediately after dispensing. The adhesive will start curing in as little as 5 to 15 seconds.

Do not apply the activator to porous surfaces such as a ferrite magnet. The porous surface may absorb the activator taking it away from the adhesive joint.

Be sure to assemble the parts before the activator open time expires. After that time, the adhesive may not cure properly. Activator open times range widely from an hour to 30 days so refer to the technical data sheet to determine the open time for the activator you are using.

Protect activators from air exposure. Depending upon their specific chemistry, some activators may oxidize readily upon exposure to air. Always close containers after use. Use a nitrogen blanket, if necessary, to minimize air contact.

ACRYLICS, TWO-PART

TYPICAL APPLICATIONS

- Magnet bonding
- Brackets to housings
- Support frame assembly
- Repairing broken cooling fins
- Bonding or reinforcing brush holders
- Fans to shafts or rotors
- Name plate assembly

ADVANTAGES

- High cure through depth
- Room temperature cure
- High peel and impact strength
- Good environmental resistance
- Bonds to moderately contaminated surfaces
- Cure can be accelerated with heat

DISADVANTAGES

- Slow fixture times (5 to 30 min)
- Waste associated with static mix process
- May have strong odor

GENERAL DESCRIPTION

Two-part acrylic adhesives consist of a resin and an activator both of which are normally high viscosity liquids typically in the range of 5,000 to 100,000 cP. While the activator is chemically similar to that of a two-step acrylic, it is delivered as a high viscosity liquid that is normally similar in viscosity to the resin. The two components are mixed just prior to dispensing at mix ratios ranging from 1:1 and 10:1 by volume. By mixing the activator and resin, two-part acrylics have much larger cure through depths than two-step acrylics that only have the activator applied to the surface.

To maintain the ratio of the resin and activator, equipment is required. For small to moderate volume applications, the adhesive is packaged in a dual cartridge that sets the ratio. For high volume applications, meter mix dispense equipment is used.

Acrylics, Two-Part continued.

The resin and activator are mixed by passing them through a static mix tip which allows the material to be dispensed as a homogenous one-part material. Since the mixed adhesive is curing in the mix tip, there will be trade-off between the open time and the fixture time. Faster curing products will require that mix tips be changed after shorter idle times.

PROCESS NOTES

Properly prime the mix tip by dispensing a small amount before attaching the mix tip (also called "bumping") then dispense several grams after attaching the tip to prime the mix tip before creating production parts.

Audit to ensure proper mixing. Many two-part acrylics are color coded to allow for visual inspection of the mixing. For example, a blue resin and yellow activator would result in a green product. There should not be visual pockets of unmixed (i.e. yellow or blue) product.

Use equipment designed for two-part acrylics. Two-part acrylics are very reactive systems that may cure when contacting active metals such as steel, copper, or brass. When dispensing from a meter mix dispense system, two-part acrylics must be dispensed from inactive systems such as stainless steel. Care should be taken not to replace fittings during maintenance with active metals.

Evaluate peak exotherm for large volume applications. Two-part acrylics cure very rapidly via an exothermic reaction that releases heat. When curing large volumes, the heat can be sufficient to warp plastic parts or degrade the adhesive.

ANAEROBICS

TYPICAL APPLICATIONS

Gasketing
- Gear box covers
- End plates

Retaining
- Bearings to shafts or housings
- Rotors to shafts
- Speed controls to shafts
- Commutators to shafts
- Keys in slots
- Unitizing lamination stacks

Threadlocking
- Through bolts
- Assembly screws

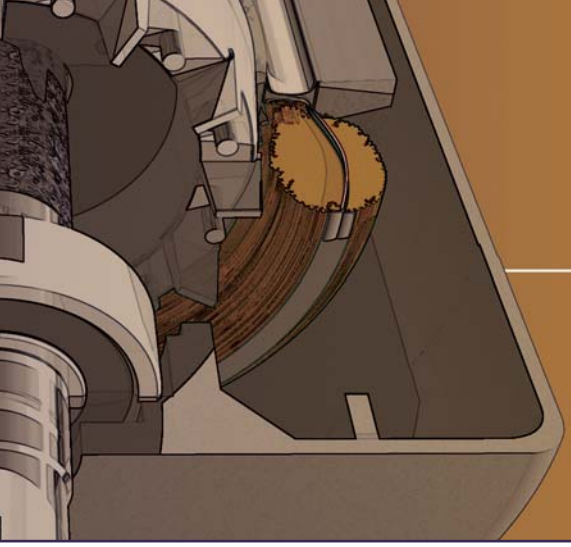
Thread Sealing
- Grease fittings
- Plugs for junction boxes

ADVANTAGES

- One-part, solvent-free
- Room temperature cure
- Controlled strengths
- Superior chemical and thermal resistance
- Long shelf life / room temperature storage

DISADVANTAGES

- Limited cure through depth (0.020")
- Low peel / impact strength
- Generally not compatible with plastics



CHEMISTRIES

GENERAL DESCRIPTION

Anaerobics are one-part, solvent-free liquids that typically range in viscosity from 10 cP to thixotropic pastes. Anaerobics cure in the absence of air and the presence of metal. A typical fixture time on steel generally ranges from 5 minutes to 1 hour. Using a primer or heating the assembly can accelerate the cure speed. When using a primer, such as Loctite® 7090™, 7649™ or 7471™, fixture times can be less than 10 seconds.

The presence of metal acts as a catalyst to initiate the polymeric reaction. The more “active” the metal, the faster the adhesive will cure. Active metals are metals that rust or oxidize easily such as steel, aluminum, brass, and copper. Inactive metals are those that do not easily rust including stainless steel, zinc dichromate, or nickel. Since anaerobics do not cure unless confined between two metal surfaces, excess adhesive outside the joint will not cure and can be easily wiped off.

Anaerobics are generally not compatible with plastics or elastomers. The absence of metal prevents them from curing and uncured anaerobic can stress crack some plastics. Anaerobics have been successfully used to join an active metal to a plastic that is not prone to stress cracking, such as when a nylon bearing is retained onto a steel shaft.

While all anaerobics cure similarly, their viscosity, bond strength and cured properties vary widely depending on their intended use:

Retaining compounds are the strongest and are intended for bonding close-fitting cylindrical metal assemblies. Generally, they are the fastest curing anaerobic formulations.

Threadlockers have strengths that vary widely to make them suitable for a wide range of threaded fastener sizes.

Thread sealants are designed to create a chemically resistant seal on threaded fittings and also to maintain low strength to facilitate maintenance.

Gasketing materials are thixotropic gels designed to replace or augment gaskets for sealing flanges.

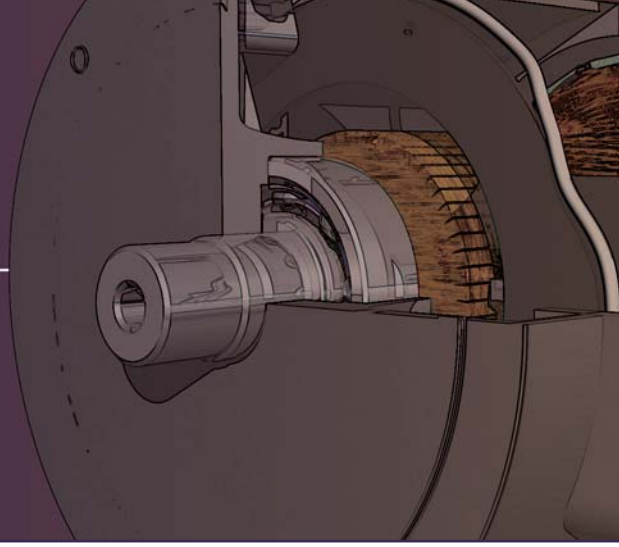
PROCESS NOTES

Surface cleanliness is important. The surface should be free of oil, grease, dust and other contaminants to ensure optimum, consistent performance.

Primers can be used to accelerate the cure, especially when assembling inactive metals. When using a primer, such as Loctite® 7090™, 7649™ or 7471™, fixture times can be less than 10 seconds.

Evaluate rust preventatives for compatibility. Some rust preventatives contain nitrites that will slow or stop the cure of anaerobic adhesives.

Use equipment designed for anaerobics. Due to their sensitivity to metals, equipment must be carefully designed to ensure compatibility. Care should be taken when replacing fittings during maintenance.



CYANOACRYLATES

TYPICAL APPLICATIONS

- Insulation to stators, rotors, and wires
- Magnets to plastic rotors
- Tacking lead wires
- Bonding brush holders

ADVANTAGES

- One-part, solvent-free
- Rapid room temperature cure
- Excellent adhesion to most substrates
- Wide range of viscosities available
- Primers available for polyolefins and difficult-to-bond plastics
- Light cure versions available

DISADVANTAGES

- Poor peel strength
- Limited gap cure
- Poor durability on glass
- Poor solvent resistance
- Low temperature resistance
- Bonds skin rapidly
- May stress crack some plastics

GENERAL DESCRIPTION

Cyanoacrylates are one-part, room-temperature-curing adhesives that are available in viscosities ranging from water-thin liquids to thixotropic gels. When pressed into a thin film between two surfaces, the moisture present on the bonding surfaces causes the cyanoacrylate to cure rapidly to form rigid thermoplastics with excellent adhesion to most substrates. Typical fixture times are 5 to 30 seconds.

In addition to standard cyanoacrylates, there are many specialty formulations with enhanced performance properties:

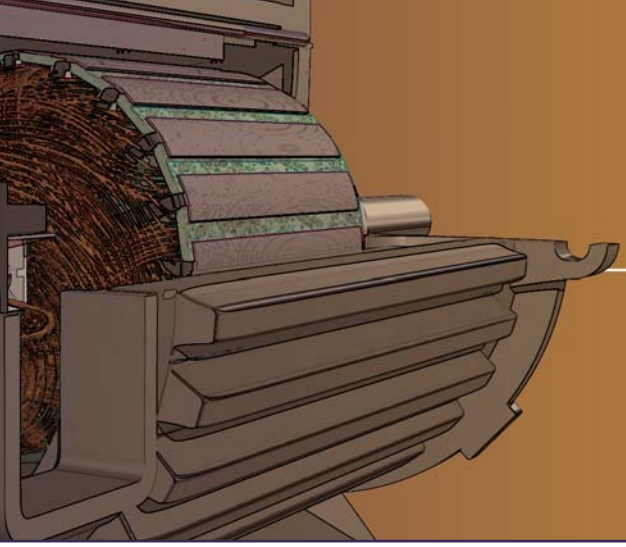
Rubber toughened grades offer high peel strength and impact resistance.

Thermally resistant cyanoacrylates are available which offer excellent bond strength retention after exposure to temperatures as high as 250°F for thousands of hours.

Surface insensitive cyanoacrylates offer rapid fixture times and cure speeds on acidic surfaces, such as wood or dichromated metals, which could slow the cure of a standard cyanoacrylate.

Low odor/low bloom grades minimize the potential for a white haze to occur around the bond line.

Light curing cyanoacrylates utilize proprietary photoinitiators to cure cyanoacrylates in seconds when exposed to light of the appropriate wavelength.



CHEMISTRIES

Accelerators, such as Loctite® 712™, 7109™, 7113™, 7452™ and 7453™, can be used to speed the cure of cyanoacrylate adhesives and are primarily used to reduce fixture times and to cure excess adhesive.

Primers, such as Loctite® 770™ and 793™, dramatically increase the strength achieved on difficult-to-bond plastics such as polypropylene, polyethylene and Delrin (Acetal).

PROCESS NOTES

A controlled environment is necessary for consistent fixture times. Temperature and, more importantly, relative humidity have a significant effect on cure speed. The optimum relative humidity is 40 to 60%. Hot and moist environments will accelerate the cure speed, while cold and dry environments will slow the cure speed.

Proper storage is critical. Cyanoacrylates should be stored refrigerated. If cyanoacrylates are exposed to high temperature during storage, their viscosity will rise and their cure speed will slow. Once a bottle is opened, it must not be returned to refrigerated storage.

Use equipment designed for cyanoacrylates. Because cyanoacrylates are so reactive, only equipment that has been tested for compatibility, such as the Loctite® 98013 Dispense Valve, should be used.

Ensure that dry air is used for reservoirs. When dispensing cyanoacrylates from pressure reservoirs, dryers should be used to remove moisture from the supply air, otherwise, the moisture could cause the cyanoacrylate to cure.

EPOXIES

TYPICAL APPLICATIONS

- Magnet bonding
- Reinforcing wires
- Potting wire connectors
- Tacking lead wires
- Bonding or reinforcing brush holders
- Bonding fans to shafts or rotors
- Potting printed circuit boards
- Bonding stators to housings or frames

ADVANTAGES

- Wide variety of formulations available
- High adhesion to many substrates
- Good toughness
- Cure can be accelerated with heat
- Excellent depth of cure
- Superior environmental resistance

DISADVANTAGES

- Two-part systems require mixing
- One-part systems require heat cure
- Long cure and fixture times

Epoxies continued.

GENERAL DESCRIPTION

Epoxy adhesives are supplied as one and two-part systems with viscosities that range from a few thousand centipoise to thixotropic pastes. Upon cure epoxies typically form tough, rigid, thermoset polymers with high adhesion to a wide variety of substrates and superior environmental resistance. A major advantage of epoxies is there are a wide variety of commercially available resins, hardeners and fillers that allow the performance characteristics of epoxies to be tailored to the needs of almost any application.

When using a one-part, heat cure system, the resin and a latent hardener are supplied already mixed and typically need to be stored refrigerated or frozen. By heating the system, the latent hardener is activated causing cure to initiate. The epoxy will normally start to cure rapidly at temperatures of 100 to 125°C (212 to 257°F) and cure times of 30 to 60 minutes are typical. Heat curing also generally improves bond strengths, thermal resistance, and chemical resistance.

When using a two-part system, the resin and hardener are packaged separately and are mixed just prior to use. This allows more active hardeners to be used so that the two-part epoxies will rapidly cure at ambient conditions.

Two-part system are normally mixed by passing them through a static mix tip. This allows the two-part material to be dispensed as a single homogenous liquid when it exits the mix tip.

Since the mixed adhesive is curing in the mix tip, the adhesive's viscosity and performance changes during idle times and the mix tip must be changed after the idle time exceeds the adhesive's open time. This creates a trade-off between fixture time and open time. Faster curing products will require that mix tips be changed after shorter idle times.

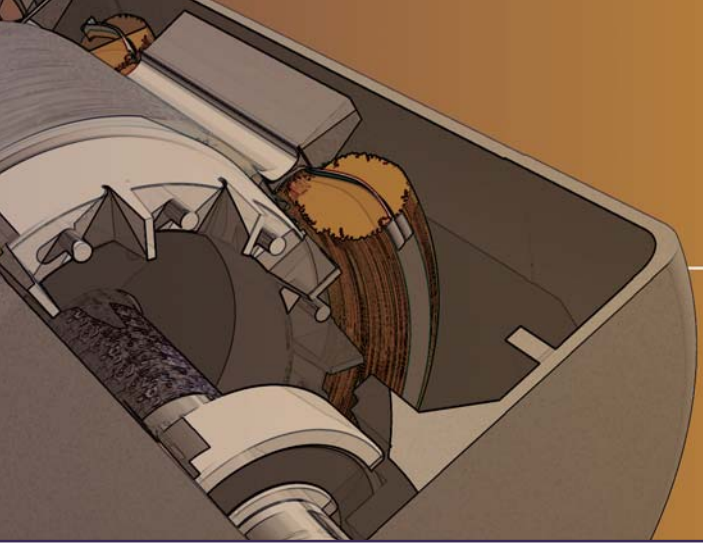
To maintain the ratio of the resin and hardener, equipment is required. For small to moderate volume applications, the adhesive is normally packaged in a dual cartridge that sets the ratio. For high volume applications, meter mix dispense equipment is recommended.

PROCESS NOTES

Properly prime the mix tip by dispensing a small amount before attaching the mix tip (also called "bumping") then dispense several grams after attaching the tip to prime the mix tip before creating production parts.

Significant exotherms can occur for large volume applications. The curing reaction of the epoxy can release a great deal of heat (exotherm) and can result in a significant temperature rise in the adhesive.

Ensure that meter mix systems are on-ratio and air free. To maintain consistent performance when using a meter mix dispense system, it is critical that the equipment is at the required mix ratio. This should be audited periodically with quality control tests. Air in the equipment is a frequent cause of the equipment becoming off ratio. Care should be taken not to introduce air in the equipment when changing packages.



CHEMISTRIES

Induction curing typically offers the fastest heat cures. Induction heats ferrous components much faster than convection or infrared ovens.

HOT MELTS

TYPICAL APPLICATIONS

- Tacking insulation to stators, rotors, or wires

ADVANTAGES

- One-part, solvent-free
- Fast fixturing
- High adhesion to plastics
- Wide variety of formulations available
- Low volumetric cost

DISADVANTAGES

- Hot dispense point
- Poor adhesion on metals
- Cools quickly
- Equipment is required
- Thermoplastic parts may deform
- Charring in reservoir
- Moisture sensitivity

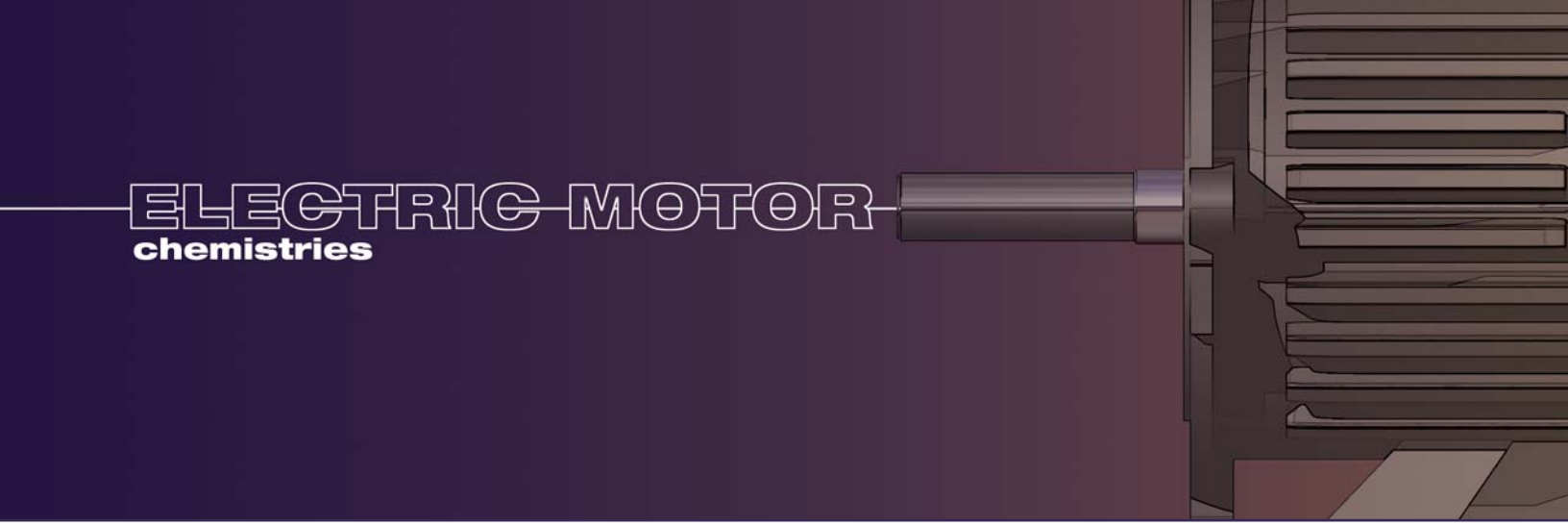
The performance of the hot melt varies widely based on their chemistry:

Ethylene vinyl acetate (EVA) hot melts are the "original" hot melt. They have good adhesion to many substrates, the lowest cost and a wide range of open times, but typically have the poorest temperature resistance.

Polyamide hot melts are a higher cost, higher performing adhesive with excellent high temperature resistance (up to 300°F). Specialty formulations are available that carry a UL-94 V-0 flammability rating.

Polyolefin hot melts are specially formulated for adhesion to polyolefins such as polypropylene and polyethylene plastics. Compared to other chemistries, they have longer open times and they have excellent resistance against polar solvents.

Reactive polyurethanes (PUR) are supplied as an urethane prepolymer, behaving much like a standard hot melt until it cools. Once the PUR cools, it reacts with moisture over time (a few days) to crosslink into a tough thermoset polyurethane. They offer lower dispense temperatures, higher adhesion to metals and improved thermal resistance.



Hot Melts continued.

PROCESS NOTES

Operators should wear protective gloves to avoid burns. Cotton gloves are recommended.

Dispense equipment is required to heat the hot melt. Sticks are used in hand held applicators for low to medium volume applications and pellets are loaded into large tanks for bulk hot melt dispensers.

When bonding metals, match the open time of the hot melt to increase the strength of the adhesive. Hot melt adhesives cool very rapidly on metals due to their high heat capacity. If this results in low strengths, the strength can be increased by using a longer open time hot melt, the metal can be heated before or after assembly, or reactive polyurethane hot melts, which inherently have excellent adhesion on metals, can be used.

Polyamides and PURs must be handled carefully. Polyamides absorb water rapidly if not stored properly. This is generally not a problem for bulk dispensers that heat the product well above the boiling point of water in the tank, but it can cause bubbles when dispensing sticks. Sticks should be stored in their original packages and packages should be sealed during storage. PUR hot melts cure when exposed to ambient humidity, so dispense tips must be protected from air during idle times.

Tanks must be maintained for bulk dispensers. All hot melts will char over time in the melt tank of bulk dispensers, so the tanks should be maintained periodically. To minimize charring, one can put a nitrogen blanket over the tank, program the tank to cool down for long idle time, or dispense at lower temperatures.

LIGHT CURE

TYPICAL APPLICATIONS

- Stators to housings
- Tacking lead wires
- Insulation to rotors, stators or wires
- Wire reinforcement
- Bonding or unitizing laminates

ADVANTAGES

- One-part, solvent-free
- Fast cure time (seconds)
- High cure through depths (>0.5")
- Wide range of viscosities available
- Wide range of physical properties

DISADVANTAGES

- Light must be able to reach the joint line
- Oxygen can inhibit cure at the surface
- Equipment expense for light source
- If a high intensity light source is used, ozone must be vented

CHEMISTRIES

GENERAL DESCRIPTION

Light cure adhesives “cure on demand” eliminating the normal trade-off between open time and cure speed. At ambient conditions, all but the fastest light curing adhesives remain unaffected by ambient light for hours allowing for almost infinite part adjustment time. Upon exposure to light of the proper intensity and spectral output, the photoinitiator in the adhesive initiates cure rapidly yielding a cured polymer. While cure times depend on many factors, 10 to 30 second exposure times to achieve full cure are typical and cure depths in excess of 0.5" (13 mm) are possible. Light curing adhesives are available with physical properties ranging from soft, flexible elastomers to very rigid glass-like materials.

While light cure acrylic adhesives are the most well known and commonly used type of light curing adhesive, the four other chemistries that can be cured with light are anaerobics, cyanoacrylates, epoxies and silicones. Significant development has occurred on these light curing adhesives in the last five years and they may offer improved performance when compared to light cure acrylics in many motor applications as shown below.

CHEMISTRY	TYPICAL USE
Acrylics	• General purpose
Anaerobics	• Curing exposed adhesive when retaining cylindrical metal assemblies
Cyanoacrylate	• Adhesion to plastics • Cyanoacrylate shadow cure
Epoxy	• Temperature resistance • Chemical resistance • Two-part for deep potting
Silicone	• Highest temperature resistance • Flexibility

PROCESS NOTES

Audit the light source using a radiometer. To ensure consistent curing, a radiometer should be regularly used to audit the output of the light source.

Use opaque (black) feed lines. Prolonged exposure to ambient light can thicken or cure the faster curing light cure adhesives.

POLYURETHANES

TYPICAL APPLICATIONS

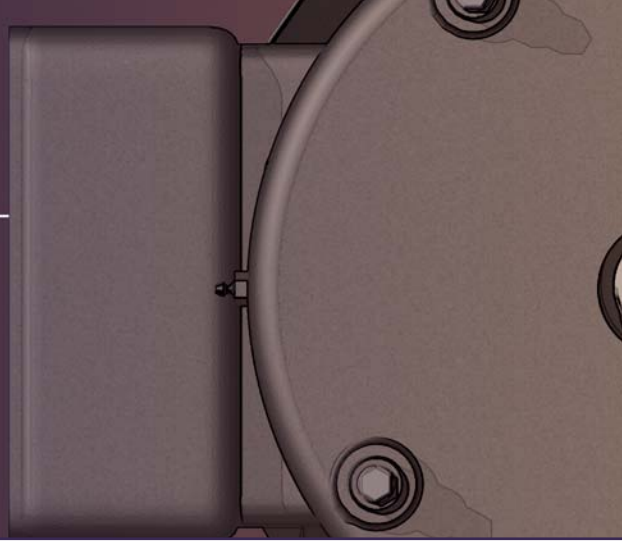
- Potting wire connectors
- Potting printed circuit boards

ADVANTAGES

- Extremely tough
- Good resistance to solvents
- High cohesive strength
- Good impact resistance
- Good abrasion resistance

DISADVANTAGES

- Mixing required for two-part polyurethanes
- Limited depth of cure for one-part polyurethanes
- Primer may be needed for adhesion to some substrates
- Limited high temperature use



Polyurethanes continued.

GENERAL DESCRIPTION

Polyurethane adhesives are supplied as one and two-part systems which range in viscosity from self-leveling liquids to non-slumping pastes. They cure to form thermoset polymers with good solvent and chemical resistance. They are extremely versatile and can range in cured form from extremely soft elastomers to rigid, extremely hard plastics.

Polyurethanes offer a good blend of cohesive strength and flexibility that makes them very tough, durable adhesives. They bond well to most unconditioned substrates, but may require the use of solvent-based primers to achieve high bond strengths. They offer good toughness at low temperatures, but typically degrade in strength after long-term exposure over 302°F (150°C).

Since the cure of one-part, moisture-curing polyurethanes is dependent on moisture diffusing through the polymer, the maximum depth of cure that can be achieved in a reasonable time is limited at approximately 0.375" (9.5 mm). Two-part systems, on the other hand, offer unlimited depth of cure.

Two-part system are normally mixed by passing them through a static mix tip. This allows the two-part material to be dispensed as a single homogenous liquid when it exits the mix tip. Since the mixed adhesive is curing in the mix tip, the adhesive's viscosity and performance changes during idle times and the mix tip must be changed after the idle time exceeds the adhesive's open time. This creates a trade-off between fixture time and open time. Faster curing products will require that mix tips be changed after shorter idle times.

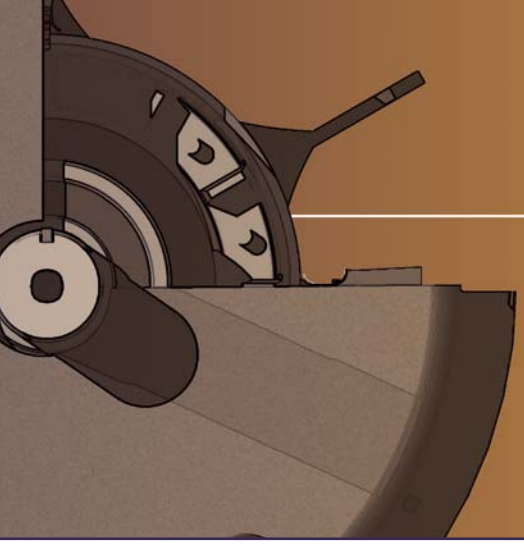
To maintain the ratio of the resin and hardener, equipment is required. For small to moderate volume applications, the adhesive is packaged in a dual cartridge that sets the ratio. For high volume applications, meter mix dispense equipment is used.

PROCESS NOTES

Properly prime the mix tip by dispensing a small amount before attaching the mix tip (also called "bumping") then dispensing several grams after attaching the tip to prime the mix tip before creating production parts.

Audit to ensure proper mixing. When setting up a new process, the mix tip should be evaluated in application representative conditions including planned downtimes to ensure proper mixing.

Significant exotherms can occur for large volume applications. The curing reaction of the polyurethanes can release a great deal of heat (exotherm) and can result in a significant temperature rise in the adhesive.



CHEMISTRIES

Protect the adhesive from moisture.
Polyurethanes will absorb moisture from the ambient atmosphere which may cause premature gelling or bubbling of the adhesive. As a result, bulk systems must be designed with dryers to prevent this.

Use proper personal protection equipment.
Some polyurethanes contain isocyanates which are strong sensitizers.

SILICONES

TYPICAL APPLICATIONS

- Potting printed circuit boards
- Potting / sealing wire connectors
- Sealing end plates
- Sealing gear boxes

ADVANTAGES

- One-part, solvent-free
- Room temperature cure
- Excellent adhesion to many substrates
- Extremely flexible
- Superior thermal resistance
- Light curing formulations available

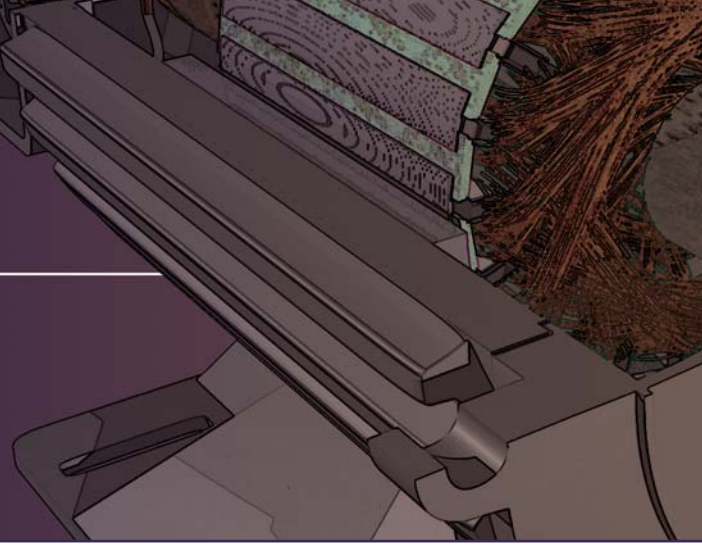
DISADVANTAGES

- Poor cohesive strength
- Moisture cure systems have limited depth of cure
- May be swelled by non-polar solvents

GENERAL DESCRIPTION

Silicone adhesives are typically supplied as one-part systems that range in viscosity from self-leveling liquids to non-slumping pastes. They cure to soft thermoset elastomers with excellent property retention over a wide temperature range. Silicones have good adhesion to many substrates, but are limited in their utility as structural adhesives by their low cohesive strength. Silicone adhesives are typically cured via reaction with ambient humidity, although formulations are also available which can be cured by heat, mixing of two components, or exposure to light.

Since the cure of moisture-curing silicones is dependent on moisture diffusing through the silicone matrix, the cure rate is strongly affected by the ambient relative humidity and the maximum depth of cure is limited to 0.375 to 0.500". At 50% relative humidity, moisture cure silicones will generally cure to a tack-free surface in 5 to 60 minutes. Complete cure through thick sections of silicone can take up



Silicones continued.

to 72 hours. It should be noted that adhesive strength may continue to develop for 1 to 2 weeks after the silicone has been applied. This occurs because the reaction between the reactive groups on the silicone polymer and the reactive groups on the substrate surface is slower than the crosslinking reaction of the silicone groups with themselves.

Moisture curing silicones are categorized by the by-product they give off as they react with water:

Acetoxy silicones are general-purpose silicones. Their largest limitation is the potential for the by-product, acetic acid, to promote corrosion.

Alkoxy silicones have alcohol by-products so they are non-corrosive. This makes them well suited for electronic and medical applications where acetic acid could be a problem. They have lower adhesion and take longer to cure than acetoxy silicones.

Oxime silicones are non-corrosive, fast curing, and have excellent adhesion. There are also grades available with improved chemical resistance.

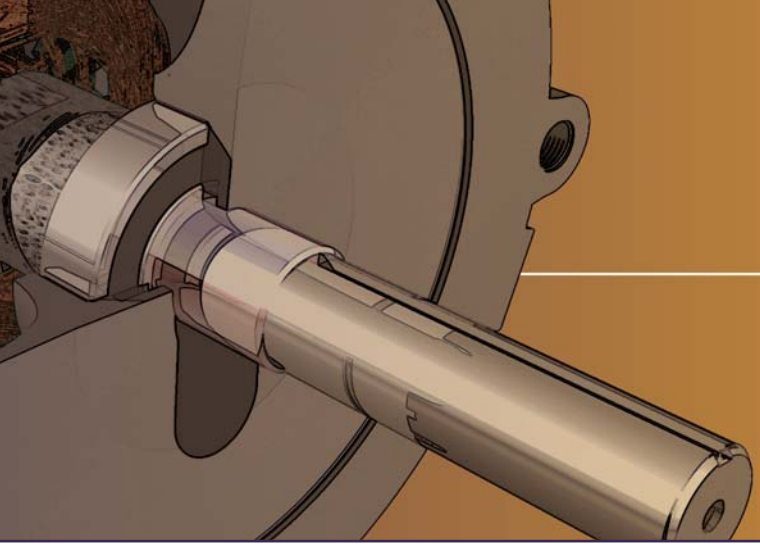
Light curing silicones in general, also have a secondary moisture cure mechanism to ensure that any silicone that is not irradiated with ultraviolet light will still cure. Upon exposure to ultraviolet light of the proper wavelength and intensity, they will form a tack-free surface and cure to a polymer with up to 80% of its ultimate physical strength in less than a minute. Initial adhesion can be good, but because ultimate bond strength is dependent on the moisture cure mechanism of the silicone, full bond strength can take up to a week to develop. Silicones with a secondary acetoxy cure show good bond strength while those with a secondary alkoxy cure will show lower bond strength.

PROCESS NOTES

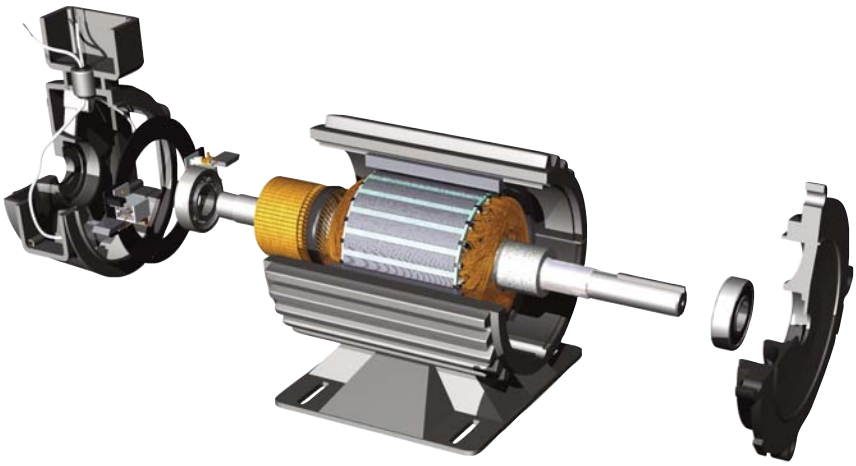
A controlled environment is necessary for consistent fixture times. Temperature and, more importantly, relative humidity have a significant effect on cure speed. The optimum relative humidity is 40 to 60%. Hot and moist environments will accelerate the cure speed, while cold and dry environments will prolong cure.

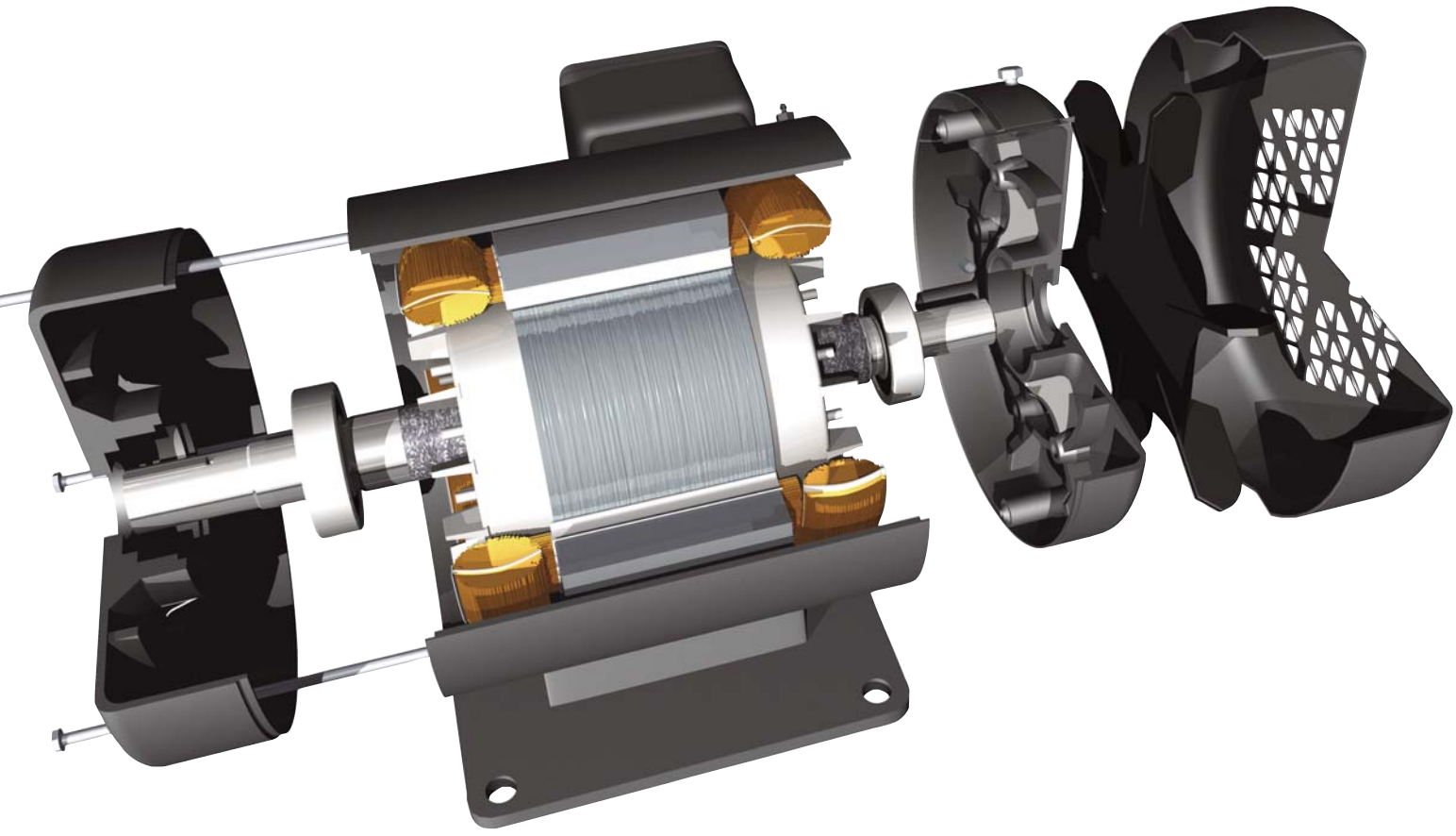
Use equipment designed for silicones. Because silicones moisture cure, the system must be design to prevent moisture for penetrating the system. To that end, dryers should be used to remove moisture from supply air that could cause the silicone to cure.

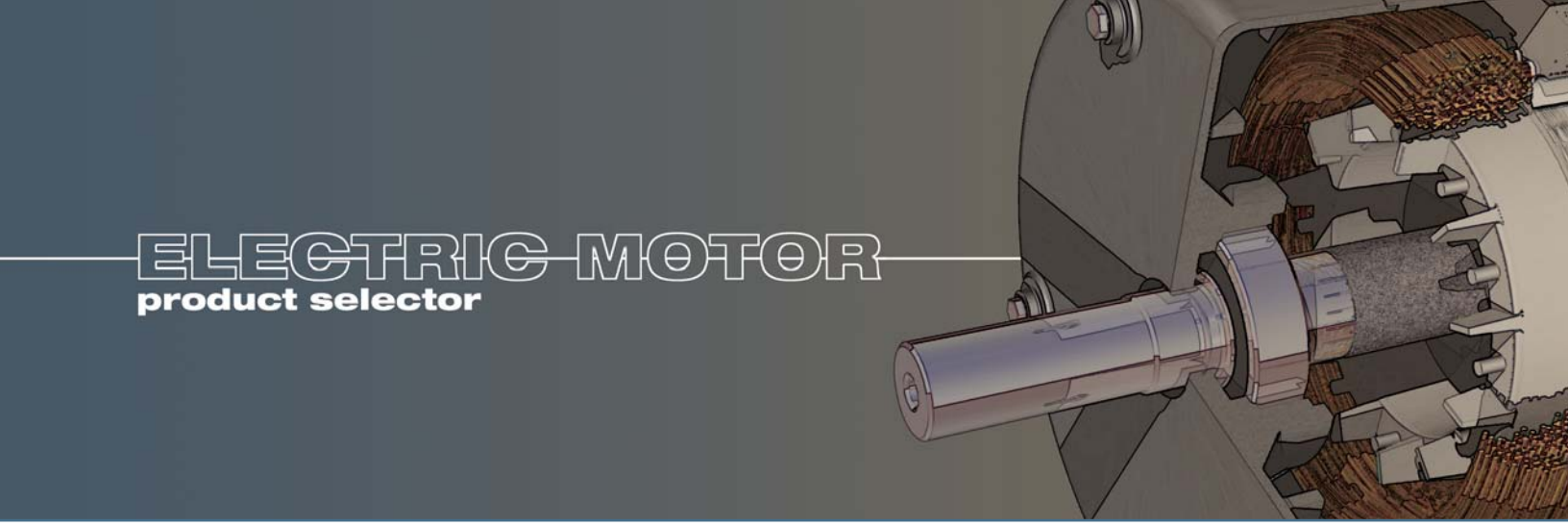
May not be compatible with painting operations. Silicones contain volatiles that may cause “fish eyes” in nearby painting operations.



CHEMISTRIES



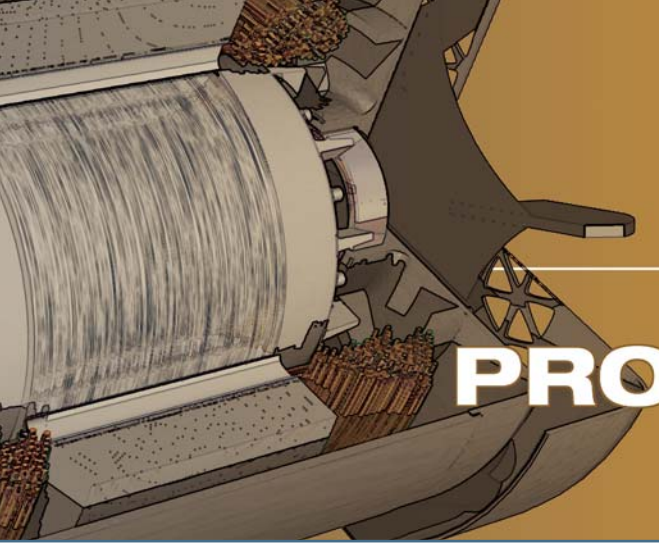




ELECTRIC MOTOR
product selector

APPLICATION	CHEMISTRY	TYPICAL USE	PRODUCT NUMBER	# OF COMP.	CURE METHOD	COLOR	VISCOSITY, cP
BONDING AND TACKING	ACRYLICS	General purpose	392™	2	Activator	Amber	60,000
		Fast cure	326™ Speedbonder™	2	Activator	Amber	18,000
		High temp. & impact	334™	2	Activator	Pale yellow	80,000
		Severe environment	332™	2	Activator	Pale yellow	100,000
		Light cure	3920™	2	Activator	Amber	45,000
		General purpose	H3300™ Speedbonder™	2	Two-Part (1:1)	Light yellow	120,000
		Metal bonding	H4500™ Speedbonder™	2	Two-Part (10:1)	Light yellow	55,000
		High impact	H8000™ Speedbonder™	2	Two-Part (10:1)	Green	150,000
		Severe environment	H8600™ Speedbonder™	2	Two-Part (2:1)	Blue	90,000
	EPOXIES	General purpose	9432NA™ Hysol®	1	Heat	Grey	225,000
		Fast cure	3984™ Hysol®	1	Heat	Light grey	25,500
		High viscosity	3985™ Hysol®	1	Heat	Black	47,500
		General purpose	E-20NS™ Hysol®	2	Two-Part (2:1)	Light tan	50,000
		Flexible	E-40FL™ Hysol®	2	Two-Part (1:1)	Grey	70,000
		High impact	E-20HP™ Hysol®	2	Two-Part (2:1)	Off white	45,000
	CYANOACRYLATES	General purpose	380™ Black Max®	1	Humidity	Black	200
		Fast cure	4500™ Prism®	1	Humidity	Clear	Gel
		High temperature	4205™ Prism®	1	Humidity	Clear	Gel
		Light cure	4307™ Flashcure®	1	Light / Humidity	Light green	900
	HOT MELTS	General purpose	7804-FRM-HV™ Hysol®	1	Cooling	Off white	6,000
		High adhesion to metals	3631™ Hysol®	1	Cooling / Humidity	Off white	12,000
		Long open time	0450™ Hysol®	1	Cooling	Natural	4,500
		High temperature	7901™ Hysol®	1	Cooling	Amber	750
	LIGHT CURE	General purpose	3972™	1	Light	Transparent	4,500
		Low viscosity	3971™	1	Light	Transparent	300
		High adhesion to metals	3943™	1	Light	Transparent	6,000
		High adhesion to plastics	3926™	1	Light	Transparent	4,500
		Activator shadow cure	3526™	1	Light / Activator	Transparent	17,500
GASKETING	ANAEROBICS	General purpose	518™ Gasket Eliminator®	1	Anaerobic	Red	800,000
		High temperature	510™ Gasket Eliminator®	1	Anaerobic	Red	188,000
		Flexible	509™ Gasket Eliminator®	1	Anaerobic	Blue	65,000
		High gap fill	574™	1	Anaerobic	Orange	30,000
	SILICONES	General purpose	5910®	1	Humidity	Black	600 g/min[6]
		Instant seal	5900®	1	Humidity	Black	35 g/min[6]
		High durometer	5699™	1	Humidity	Grey	250 g/min[6]
		High temperature	5920™	1	Humidity	Copper	>300 g/min[6]
		General purpose	5950™ Fastgasket®	1	Light / Humidity	Black	350 g/min[6]
		Fast cure / clear	5951™ Fastgasket®	1	Light / Humidity	Clear	350 g/min[6]
		Immediate assembly	5960™ Fastgasket®	1	Light	Clear	350 g/min[6]
		General purpose	5964™ Procure®	1	Heat	Brown	120 g/min[6]
		High durometer	5963™ Procure®	1	Heat	Grey	250 g/min[6]
POTTING	POLYURETHANES	General Purpose	3173™ / 3183™ Hysol®	2	Two-Part (1:3)	Black	450
		Fast cure	3173™ / 3182™ Hysol®	2	Two-Part (1:5.2)	Black	5,500
		UL 94 V-0	3173™ / 3184™ Hysol®	2	Two-Part (1:4.8)	Opaque White	2,250
	EPOXIES	General purpose	E-60NC™ Hysol®	2	Two-Part (1:1)	Black	10,000
		UL1446 & UL 94 HB	3140™ / 3164™ Hysol®	2	Two-Part (2:1)	Black	1,500
		UL 94 V-0	3144™ / 3162™ Hysol®	2	Two-Part (4.5:1)	Black	4,000
		General purpose	3981™ Hysol®	1	Heat	Transparent Yellow	5,300
		Medium viscosity	3982™ Hysol®	1	Heat	Off White	8,000
		High viscosity	3984™ Hysol®	1	Heat	Off White	25,500
	SILICONES	General purpose	5031™ Nuva-Sil®	1	Light / Humidity	Translucent	5,500
		Non-corrosive	5088™ Nuva-Sil®	1	Light / Humidity	Light Yellow	60,000

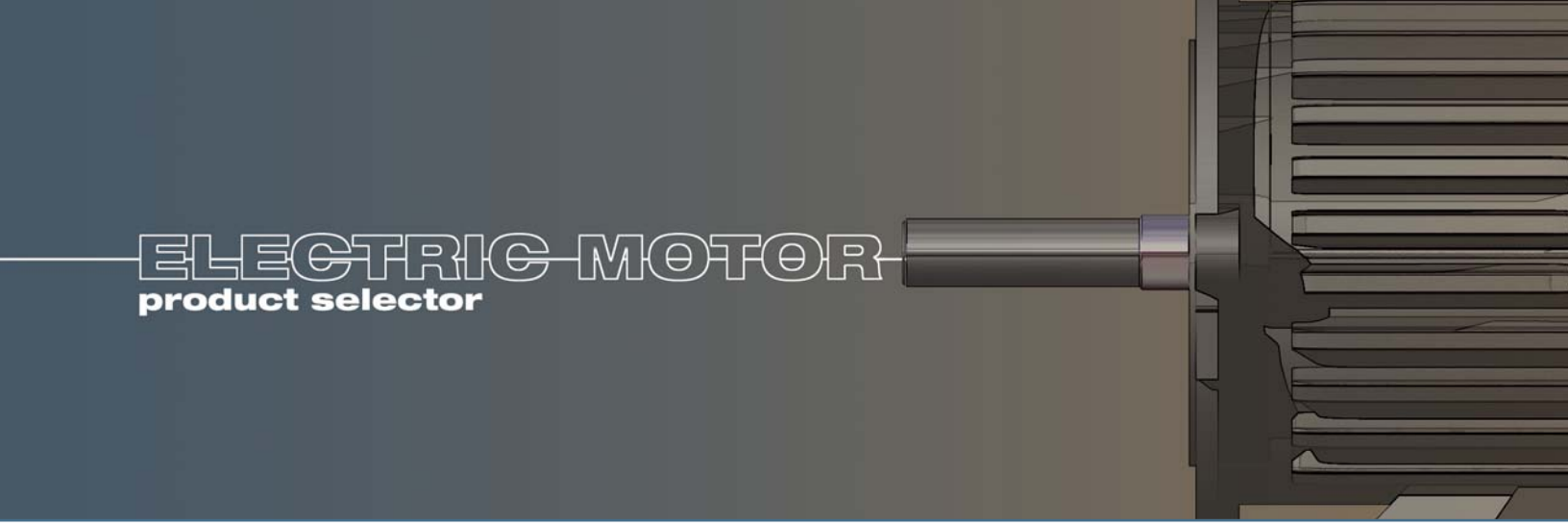
Legend:
1 *- Heat cure,* ***2*** *- Work Life,* ***3*** *- Open time,* ***4*** *- Time to light cure,* ***5*** *- Skin over time,* ***6*** *- Extrusion rate*



PRODUCT SELECTOR

	FIXTURE TIME	CURE THROUGH DEPTH, INCHES	TEMP. RANGE, °F	PACKAGE SIZE - PART NUMBER		
	60 sec	0.025"	-65 to 300	50 ml tube - 39250	300 ml cart.- 39275	Liter - 39280
	30 sec	0.020"	-65 to 225	50 ml bottle - 32629	Liter - 32685	
	90 sec	0.020"	-65 to 300	25 ml syr. - 33403	300 ml cart.- 33470	
	3 min	0.020"	-65 to 400	25 ml syr. - 33201	300 ml cart.- 33275	Liter - 33290
	60 sec	0.020"	-65 to 300	Liter - 17822		
	6-12 min	0.375"	-65 to 300	50 ml dual cart. - 83020	400 ml dual cart. - 83019	Adhesive - 40 lb pail - 83024* Activator - 40 lb pail - 83022*
	15-20 min	0.50"	-65 to 300	490 ml cart. - 83041		
	15-20 min	0.50"	-65 to 300	490 ml cart. - 36160	Adhesive - 35 lb pail - 35939 Activator - 45 lb pail - 35940	
	55 min	>0.50"	-65 to 400	400 ml dual cart. - 38762	Adhesive - 40 lb pail - 38760 Activator - 40 lb pail - 38761	
	60 min at 250°F[1] / 30 min at 300°F[1]	>0.50"	-65 to 400	2 lb can - 83217	55 lb pail - 83216	
	25 min at 212°F[1] / 17 min at 300°F[1]	>0.50"	-65 to 300	30 ml syr. - 36768	Liter - 37299*	
	45 min at 250°F[1] / 30 min at 300°F[1]	>0.50"	-65 to 400	Liter - 40870	5 gal pail - 34731	
	20 min[2]	>0.50"	-65 to 400	50 ml dual cart. - 29334	200 ml dual cart. - 29335	400 ml dual cart. - 29336
	40 min[2]	>0.50"	-65 to 400	50 ml dual cart. - 29304	200 ml dual cart. - 29305	400 ml dual cart. - 29306
	20 min[2]	>0.50"	-65 to 400	50 ml dual cart. - 29314	200 ml dual cart. - 29315	400 ml dual cart. - 29316
	90 sec	0.006"	-65 to 225	1 oz bottle - 38050	1 lb bottle - 38061	
	5 sec	0.010"	-65 to 180	20 g tube - 35534	200 g tube - 35813	300 g cart.- 35814
	30 sec	0.010"	-65 to 250	20 g tube - 28028	200 g tube - 28029	300 g cart. - 28030
	20 sec	>0.25"	-65 to 180	1 oz bottle - 37441	1 lb bottle - 37443	
	35 sec[3]	0.25"	-65 to 225	30 lb Superstick™ - 83384	25 lb Polyshot™ - 83387	40 lb pellets - 83382
	60 sec[3]	0.25"	-65 to 250	300 ml cart.- 31291	5 gal pail - 31279	
	5-8 min[3]	0.25"	-65 to 156	12 oz Polyshot™ - 83353	35 lb Polyshot™ - 83354	
	35 sec[3]	0.25"	-65 to 300	5 lb pellets - 83341	25 lb Polyshot™ - 83344	40 lb pellets - 83342
	<30 sec[4]	>0.50"	-65 to 300	25 ml syr. - 36294	Liter - 36295	
	<30 sec[4]	>0.50"	-65 to 300	25 ml syr. - 36792	Liter - 36805	
	<30 sec[4]	>0.50"	-65 to 300	25 ml syr. - 36480	Liter - 36478	
	<30 sec[4]	>0.50"	-65 to 300	25 ml syr. - 36492	Liter - 36493	
	<30 sec[4]	>0.50"	-65 to 300	25 ml syr. - 30756	Liter - 30764	
	Unprimed - 4 hrs / Primed - 30 min	Unprimed - 0.010" / Primed - 0.050"	-65 to 300	6 ml tube - 51817	50 ml bottle - 51831	300 ml cart.- 51845
	Unprimed - 4 hrs / Primed - 30 min	Unprimed - 0.010" / Primed - 0.020"	-65 to 400	50 ml bottle - 51031	250 ml bottle - 51041	300 ml cart.- 51074
	Unprimed - 6 hrs / Primed - 1 hr	Unprimed - 0.010" / Primed - 0.020"	-65 to 300	300 ml cart. - 21525	850 ml cart. - 50965	
	Unprimed - 1 hrs / Primed - 15 min	Unprimed - 0.010" / Primed - 0.020"	-65 to 300	50 ml bottle - 24018	250 ml bottle - 26338	
	20 min[5]	0.25"	-65 to 500	300 ml cart. - 21746	50 lb pail - 21747	550 lb drum - 21748
	20 min[5]	0.25"	-65 to 500	300 ml cart. - 20166	50 lb pail - 20167	550 lb drum - 20168
	30 min[5]	0.25"	-65 to 625	300 ml cart. - 18581	50 lb pail - 18582	550 lb drum - 18583
	60 min[5]	0.25"	-65 to 700	70 ml tube - 30542	300 ml cart.- 82046	40 lb pail - 21472
	<30 sec[4]	0.25"	-65 to 350	300 ml cart. - 29287	40 lb pail - 18495	
	<30 sec[4]	0.25"	-65 to 350	40 lb pail - 18198		
	<30 sec[4]	0.25"	-65 to 350	300 ml cart. - 31132	40 lb pail - 24707	
	10 min at 300°F[1]	>0.50"	-65 to 400	300 ml cart. - 34348	50 lb pail - 34347	
	10 min at 300°F[1]	>0.50"	-65 to 400	50 lb pail - 34337		
	20-40 min[2]	>0.50"	-65 to 300	3173 - 1 qt can - 39984	3173 - 1 gal can - 39985 3183 - 1 gal can - 39998	3173 - 5 gal pail - 39986 3183 - 5 gal pail - 39999
	<7 min[2]	>0.50"	-65 to 300	3173 - 1 qt can - 39984	3173 - 1 gal can - 39985 3182 - 1 gal can - 39995	3172 - 5 gal pail - 39986 3182 - 5 gal pail - 39996
	45 min[2]	>0.50"	-65 to 300	3173 - 1 qt can - 39984	3173 - 1 gal can - 39985 3184 - 1 gal can - 39398	3173 - 5 gal pail - 39986 3183 - 5 gal pail - 39397
	60 min[2]	>0.50"	-65 to 300	50 ml dual cart. - 29324	200 ml dual cart. - 29325	400 ml dual cart. - 29326
	10-15 min[2]	>0.50"	-65 to 300	3140 - 1 gal can - 39944 3164 - 1 gal can - 39969	3140 - 5 gal pail - 39945 3164 - 5 gal pail - 39970	
	15-20 min[2]	>0.50"	-65 to 300	3162 - 1 qt can - 39960	3144 - 1 gal can - 39953 3162 - 1 gal can - 39961	3144 - 5 gal pail - 39954 3162 - 5 gal pail - 39962
	35 min at 212°F[1] / 16 min at 300°F[1]	>0.50"	-65 to 300	30 ml syr. - 36766	Liter - 37297	
	25 min at 212°F[1] / 17 min at 300°F[1]	>0.50"	-65 to 300	30 ml syr. - 36767	Liter - 37298	
	25 min at 212°F[1] / 17 min at 300°F[1]	>0.50"	-65 to 300	30 ml syr. - 36768	Liter - 37299*	
	<30 sec[4]	>0.50"	-65 to 350	300 ml cart. - 40086	40 lb pail - 40087	
	<30 sec[4]	0.25"	-65 to 350	300 ml cart. - 17614	40 lb pail - 17382	

✱ - *Made to order*



ELECTRIC MOTOR
product selector

-APPLICATION	CHEMISTRY	TYPICAL USE	PRODUCT NUMBER	# OF COMP.	CURE METHOD	COLOR	VISCOSITY, cP
RETAINING	ANAEROBICS	General purpose	603™	1	Anaerobic	Green	125
		Fast cure	648™	1	Anaerobic	Green	500
		High temperature	620™	1	Anaerobic	Green	8,500
		High strength	638™	1	Anaerobic	Green	2,500
		Light cure excess	661™	1	Light / Anaerobic	Amber	500
		Wicking grade	290™	1	Anaerobic	Green	12
		Semi-solid stick	QuickStix™ 668™	1	Anaerobic	Green	Semi-Solid
	CYANOACRYLATES	General purpose	380™ Black Max®	1	Humidity	Black	200
		Fast cure	4500™ Prism®	1	Humidity	Clear	Gel
		High temperature	4205™ Prism®	1	Humidity	Clear	Gel
		Light cure	4307™ Flashcure®	1	Light / Humidity	Light green	900
THREADLOCKING	ANAEROBICS	General purpose	243™	1	Anaerobic	Blue	2,250
		Low strength	222™	1	Anaerobic	Purple	1,200
		High strength	262™	1	Anaerobic	Red	1,800
		High temperature	272™	1	Anaerobic	Red	9,500
		Wicking grade	290™	1	Anaerobic	Green	12
		Fast cure	2440™	1	Anaerobic	Blue	1,800
		Semi-solid stick	QuickStix™ 248™	1	Anaerobic	Blue	Semi-solid
		Semi-solid stick	QuickStix™ 268™	1	Anaerobic	Red	Semi-solid
	CYANOACRYLATES	For plastics	425™ Assure™	1	Cyanoacrylate	Blue	80
THREAD SEALING	ANAEROBICS	General purpose	565™ PST®	1	Anaerobic	White	300,000
		Hydraulic / Pneumatic	545™	1	Anaerobic	Purple	14,000
		Refrigerant	554™	1	Anaerobic	Red	2,500
		High temperature	567™	1	Anaerobic	White	540,000
		Slow cure	592™ PST®	1	Anaerobic	White	250,000
		Semi-solid stick	QuickStix™ 561™ PST®	1	Anaerobic	White	Semi-solid
	NON-REACTIVE	String for plastics	55™	1	Sealing cord	White	N/A
		Liquid for plastics	No More Leaks™	1	Solvent-based	White	40,000
WIRE REINFORCEMENT	EPOXIES	General purpose	3985™ Hysol®	1	Heat	Black	47,500
		General purpose	E-40FL™ Hysol®	2	Two-Part (1:1)	Grey	70,000
		Non-sag	E-20NS™ Hysol®	2	Two-Part (2:1)	Light tan	50,000
		High impact	E-20HP™ Hysol®	2	Two-Part (2:1)	Off white	45,000

Legend:
1 *- Heat cure,* ***2*** *- Work Life,* ***3*** *- Open time,* ***4*** *- Time to light cure,* ***5*** *- Skin over time,* ***6*** *- Extrusion rate*

PRODUCT SELECTOR

	FIXTURE TIME	CURE THROUGH DEPTH, INCHES	TEMP. RANGE, °F	PACKAGE SIZE - PART NUMBER		
	Unprimed - 10 min / Primed - <1 min	0.005"	-65 to 300	10 ml bottle - 21440	50 ml bottle - 21441	250 ml bottle - 21442
	Unprimed - 5 min / Primed - <1 min	0.006"	-65 to 350	10 ml bottle - 21443	50 ml bottle - 21444	250 ml bottle - 21445
	Unprimed - 30 min / Primed - <1 min	0.015"	-65 to 450	10 ml bottle - 62015	50 ml bottle - 62040	250 ml bottle - 62070
	Unprimed - 5 min / Primed - <1 min	0.015"	-65 to 300	10 ml bottle - 21447	50 ml bottle - 21448	250 ml bottle - 21449
	<30 sec[4]	0.006"	-65 to 350	250 ml bottle - 66141		
	30 min	0.006"	-65 to 300	10 ml bottle - 29021	50 ml bottle - 29031	250 ml bottle - 29041
	90 sec	0.005"	-65 to 400	9 g stick - 39147	19 g stick - 39148	38 g stick - 39149
	90 sec	0.006"	-65 to 225	1 oz bottle - 38050	1 lb bottle - 38061	
	5 sec	0.010"	-65 to 180	20 g tube - 35534	200 g tube - 35813	300 g cart.- 35814
	30 sec	0.010"	-65 to 250	20 g tube - 28028	200 g tube - 28029	300 g cart. - 28030
	20 sec	>0.25"	-65 to 180	1 oz bottle - 37441	1 lb bottle - 37443	
	5 min	N/A	-65 to 300	10 ml bottle - 24077	50 ml bottle - 24078	250 ml bottle - 24079
	10 min	N/A	-65 to 300	10 ml bottle - 21463	50 ml bottle - 21464	
	5 min	N/A	-65 to 300	10 ml bottle - 26221	50 ml bottle - 26231	250 ml bottle - 26241
	30 min	N/A	-65 to 450	50 ml bottle - 27240	250 ml bottle - 27270	Liter - 27285
	6 min	N/A	-65 to 300	10 ml bottle - 29021	50 ml bottle - 29031	250 ml bottle - 29041
	3 min	N/A	-65 to 300	10 ml bottle - 33946	50 ml bottle - 33947	250 ml bottle - 33948
	10 min	N/A	-65 to 300	9 g stick - 37684	19 g stick - 37087	
	20 min	N/A	-65 to 300	9 g stick - 37685	19 g stick - 37686	
	1.5 hour	N/A	-65 to 180	20 g bottle - 42540	1 lb bottle - 42561	
	1 hour	N/A	-65 to 300	50 ml tube - 56531	250 ml bottle - 56541	Liter - 56543
	4 hours	N/A	-65 to 300	10 ml bottle - 32429	50 ml bottle - 54531	250 ml bottle - 54541
	4 hours	N/A	-65 to 300	10 ml bottle - 25882	250 ml bottle - 55441	
	4 hours	N/A	-65 to 400	50 ml tube - 56747	250 ml bottle - 56765	Liter - 56790
	4 hours	N/A	-65 to 450	50 ml tube - 59231	250 ml bottle - 59241	Liter - 59243
	4 hours	N/A	-65 to 300	19 g stick - 37127		
	Instant	N/A	-65 to 300	1968 in - 39036	5700 in - 35082	
	Instant	N/A	-65 to 400	2 oz tube - 80725	7 oz. tube - 80724	1 pint brush can - 80726
	45 min at 250°F[1] / 30 min at 300°F[1]	>0.50"	-65 to 400	Liter - 40870	5 gal pail - 34731	
	40 min[2]	>0.50"	-65 to 400	50 ml dual cart. - 29304	200 ml dual cart. - 29305	400 ml dual cart. - 29306
	20 min[2]	>0.50"	-65 to 400	50 ml dual cart - 29334	200 ml dual cart. - 29335	400 ml dual cart. - 29336
	20 min[2]	>0.50"	-65 to 400	50 ml dual cart - 29314	200 ml dual cart. - 29315	400 ml dual cart. - 29316

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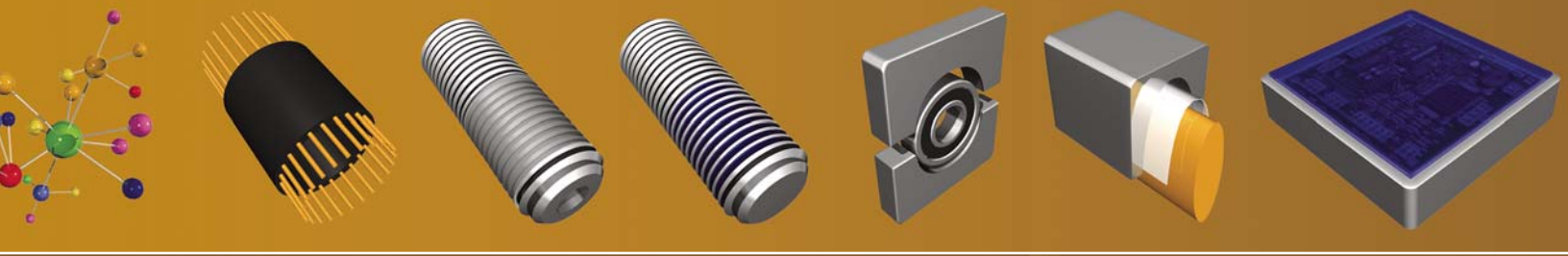

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