product bulletin

EPIKOTE™ Resin 862/ EPIKURE™ Curing Agent W System

General description

The EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W system consists of a bisphenol-F epoxy resin and an aromatic amine for fabricating composite parts using resin transfer molding (RTM) or filament winding. EPIKURE Curing Agent W does not contain methylene dianiline (MDA). Low viscosity and very long working life at room temperature make this system versatile and easy to process. EPIKURE Curing Agent 537 may be utilized to decrease the gel time of the system with little or no effect on mechanical properties.

Advantages

- Low room temperature viscosity (about 2200 cP)
- Long working life (>20 hrs.)
- Low moisture absorption (2-2.5 wt%)
- Good epoxy performance characteristics
- Non-MDA aromatic amine
- High elongation

Applicable fabrication processes

- For advanced composite structures
- Resin transfer molding (RTM)
- Filament winding

Chemical description

- EPIKOTE Resin 862: Bisphenol-F (BPF) epoxy resin
- EPIKURE Curing Agent W: Non-MDA, aromatic amine curing agent
- EPIKURE Curing Agent 537: Substituted sulfur compound

RESOLUTION
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Typical Properties

EPIKOTE™ Resin 862

Epoxide equivalent weight (EEW)[1]	166-177
Viscosity @ 25 °C, (P)[2]	25-45
Color, Gardner[3]	2 max.
Weight per gallon, lb. at 20 °C (68 °F)	9.7-9.9
Flash point, Setaflash	>149 °C (300 °F)

EPIKURE™ Curing Agent W

Nitrogen Content, wt%[4]	15.7-15.9
Viscosity @ 25 °C, (cP)[2]	100-300
Color, Gardner[3]	7 max.
Amine hydrogen equivalent wt (AHEW)	43-46
Weight per gallon, lb. at 20 °C (68 °F)	8.4-8.6
Flash point, TCC	135 °C (275 °F)

EPIKURE 537 Curing Agent

Viscosity @ 25 °C, (P)[2]	6-70
Weight per gallon, lb. at 20 °C (68 °F)	10.7-10.9
Flash point, PMCC	>204 °C (400 °F)
Water content, wt%[5]	<2

MIXED SYSTEM

Mix ratio, parts by weight	100/26.4/0	100/26.4/1.0
Viscosity @ 25 °C, (P)[6]	21-23	21-23
Pot life @ 25 °C, hr[7]	21.5	7.9
Gel time @ 177 °C, min[8]	15	4.1

[1] Grams of resin containing one gram equivalent of epoxide. ASTM D-1652-97 (Perchloric Acid Method).
[2] ASTM-D 445-97 (Kinematic Viscosity, at 25°C, by Ubbelohde Viscometer).
[3] ASTM D 1544-80 (Gardner Color Scale).
[4] Amine nitrogen content determined by acid-base titration. ASTM D-2896-98 (Determination of Amine Nitrogen Content and Amine Number).
[5] ASTM E-203 (Karl Fisher method); at time of manufacture.
[6] Brookfield viscosity.
[7] Time to double initial room temperature viscosity (Brookfield Viscometer).
[8] Hot plate gel time.

Neat resin system properties — unaccelerated

The cured, unaccelerated, neat resin properties of the EPIKOTE Resin 862/EPIKURE Curing Agent W resin system as a function of cure time at 121 °C (250 °F) and 177 °C (350 °F) are provided in Table 1. The isothermal and dynamic viscosity curves of this system are shown in Figures 1 and 2.

Neat resin system properties — accelerated

The cured, accelerated, neat resin properties of the EPIKOTE Resin 862/EPIKURE Curing Agent W resin system as a function of cure time at 121 °C (250 °F) and 177 °C (350 °F) and accelerator concentration are provided in Tables 2 and 3. The isothermal and dynamic viscosity curves of this system at 1.0 phr (parts per hundred parts by weight of resin) of EPIKURE Curing Agent 537 are shown in Figures 3 and 4.

Table 1/ Properties of the EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W resin system (100/26.4) as a function of cure time

Cure schedule, hrs. at 350 °F	0.5	1.5	2.5
Density, g/cc	–	1.2003	–
Specific heat, cal/g °C or BTU/lb °F			
77 °F	–	–	0.31
140 °F	–	–	0.34
230 °F	–	–	0.39
Glass transition temperature			
°F, Rheometrics	266	302	322
°F, DSC	273	289	313
Fracture toughness, Kq			
Compact tension, psi-in 1/2	528	657	820
Flexure, RT/Dry			
Strength, ksi	No failure	12.5	18.6
Modulus, ksi	458	433	424
Elongation, %	No failure	7.9	8.3
Flexure, Hot/Wet			
Strength, ksi	8.1	9.4	8.9
Modulus, ksi	314	310	305
Elongation, %	4.6	5.5	6.4
Water absorption, wt%	2.2	2.1	2.1
Tensile, RT/Dry			
Strength, ksi	–	–	11.4
Modulus, ksi	–	–	394
Elongation, %	–	–	7.1
Dielectric properties			
Dielectric strength, V/mil 100 KHz	–	–	563
Dielectric constant	–	–	3.98
Dissipation	–	–	0.0293
Volume resistivity, ohm-cm	–	–	1.54E8
Cure schedule, hrs. at 250 °F	4	8	
Glass transition temperature			
°F, Rheometrics	235	273	
°F, DSC	–	–	
Fracture toughness, Kq			
Compact tension, psi-in 1/2	541	583	
Flexure, RT/Dry			
Strength, ksi	18.4	18.0	
Modulus, ksi	496	455	
Elongation, %	7.5	8.5	
Flexure, Hot/Wet			
Strength, ksi	9.5	9.0	
Modulus, ksi	300	295	
Elongation, %	6.6	6.2	
Water absorption, wt%	2.2	2.2	
Tensile, RT/Dry			
Strength, ksi	11.7	12.0	
Modulus, ksi	471	431	
Elongation, %	8.2	8.5	

Composite fabrication — resin transfer molding (RTM)

The low viscosity feature of the EPIKOTE Resin 862/EPIKURE Curing Agent W resin system permits low injection pressures, less fiber washout, high filler/fiber loading, and lower mold costs for RTM fabrication processes. An ambient temperature, one-pot, RTM process may be employed in which the mixed resin/curing agent increases from 2200 cP initially to 5000 cP after about 36 hours. Processing data for this system is provided in Table 4. Alternatively, a two-pot resin and curing agent system can be used in which either the resin or both pots may be heated, generally less then 60 °C (140 °F) unless otherwise required. A typical process includes injecting into a heated mold at 121 °C (250 °F). The system viscosity at this temperature is on the order of 10 cP. Following the resin injection, the system should be cured in the mold for between 0.5-1.5 hours at 177 °C (350 °F) followed by a 177 °C (350 °F) post-cure for another hour. Molding and postcure temperatures and times can be modified for optimum production. Isothermal viscosity traces (see Figure 1) can be used to select the process conditions based on fill viscosity and cure time criteria. EPIKURE Curing Agent 537 can be used to help modify the cure schedule according to processing (Figure 3) and property requirements. Air release agents, such as BYK® A-501* or equivalent, may be added if air entrainment problems are encountered. Carbon fiber reinforced composite test data are presented in Table 5.

Composite fabrication — filament winding

The low viscosity and long room temperature pot life of the EPIKOTE Resin 862/EPIKURE Curing Agent W resin system make it suitable for use in wet filament winding applications. The material may be used at room temperature or heated to reduce viscosity and facilitate fiber wetout. The initial mixed system viscosity of 2200 cP may be reduced to approximately 1000 cP by heating the system to about 40 °C (100 °F). The pot life at this temperature is in excess of 8 hours, sufficient for winding large or complex parts. EPIKOTE Resin 862/EPIKURE Curing Agent W is suitable for use with glass, carbon, and aramid reinforcements. If air entrainment during mixing or fiber impregnation proves to be a problem, air release agents, such as BYK™ A-501* or equivalent, may be added. Cure may be conducted through internal heat sources in the mandrel or externally with ovens or both. Additional resin/reinforcement compaction may be accomplished during cure using traditional vacuum and pressure techniques. Frequently, a staged cure is most desirable in order to minimize resin runout and void formation in the composite. If shrinkwrap, vacuum bagging, or other external containment is not utilized, it is recommended that the part be rotated during cure to ensure uniform resin distribution through the part. A suggested cure cycle would include 1 hour at 121 °C (250 °F) plus 2.5 hours at 177 °C (350 °F).

*A product of BYK Chemie.

Table 2/ **Properties of the EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W/EPIKURE™ Curing Agent Accelerator 537 resin system (100/26.4/0.5) as a function of cure time**

Cure schedule, hrs. at 350 °F	0.5	1.5	2.5
Density, g/cc	–	–	1.1947
Specific heat, cal/g °C or BTU/lb °F			
77 °F	–	–	0.32
140 °F	–	–	0.35
230 °F	–	–	0.40
Glass transition temperature			
°F, Rheometrics	266	284	302
°F, DSC	230	279	288
Fracture toughness, Kq			
Compact tension, psi-in 1/2	578	698	727
Flexure, RT/Dry			
Strength, ksi	17.1	17.2	17.5
Modulus, ksi	468	434	437
Elongation, %	9.9	8.6	8.5
Flexure, Hot/Wet			
Strength, ksi	4.6	7.6	5.4
Modulus, ksi	282	300	313
Elongation, %	6.9	6.9	6.8
Water absorption, wt%	2.5	2.1	2.1
Tensile, RT/Dry			
Strength, ksi	–	–	10.0
Modulus, ksi	–	–	408
Elongation, %	–	–	4.7
Dielectric properties			
Dielectric strength, V/mil 100 KHz	–	–	578
Dielectric constant	–	–	3.96
Dissipation	–	–	0.0303
Volume resistivity, ohm-cm	–	–	1.50E8
Cure schedule, hrs. at 250 °F	4	8	
Glass transition temperature			
°F, Rheometrics	253	273	
°F, DSC	–	–	
Fracture toughness, Kq			
Compact tension, psi-in 1/2	650	569	
Flexure, RT/Dry			
Strength, ksi	18.2	18.0	
Modulus, ksi	478	463	
Elongation, %	8.1	8.3	
Flexure, Hot/Wet			
Strength, ksi	9.0	8.9	
Modulus, ksi	292	288	
Elongation, %	5.1	5.2	
Water absorption, wt%	2.2	2.3	
Tensile, RT/Dry			
Strength, ksi	11.7	12.0	
Modulus, ksi	466	457	
Elongation, %	10.3	8.7	

Table 3/ **Properties of the EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W/EPIKURE™ Curing Agent Accelerator 537 resin system (100/26.4/1.0) as a function of cure time**

Cure schedule, hrs. at 350 °F	0.5	1.5	2.5
Density, g/cc	–	–	1.2010
Specific heat, cal/g °C or BTU/lb °F			
77 °F	–	–	0.30
140 °F	–	–	0.33
230 °F	–	–	0.41
Glass transition temperature			
°F, Rheometrics	248	302	302
°F, DSC	219	293	300
Fracture toughness, Kq			
Compact tension, psi-in 1/2	772	741	715
Flexure, RT/Dry			
Strength, ksi	20.0	18.1	18.9
Modulus, ksi	506	450	453
Elongation, %	7.8	6.7	8.4
Flexure, Hot/Wet			
Strength, ksi	9.3	8.6	9.1
Modulus, ksi	316	292	298
Elongation, %	4.9	5.5	5.2
Water absorption, wt%	2.3	2.1	2.0
Tensile, RT/Dry			
Strength, ksi	–	–	11.5
Modulus, ksi	–	–	401
Elongation, %	–	–	6.8
Dielectric properties			
Dielectric strength, V/mil 100 KHz	–	–	562
Dielectric constant	–	–	3.90
Dissipation	–	–	0.0289
Volume resistivity, ohm-cm	–	–	1.60E8
Cure schedule, hrs. at 250 °F	4	8	
Glass transition temperature			
°F, Rheometrics	235	291	
°F, DSC	–	–	
Fracture toughness, Kq			
Compact tension, psi-in 1/2	620	543	
Flexure, RT/Dry			
Strength, ksi	19.0	17.8	
Modulus, ksi	516	455	
Elongation, %	7.3	8.5	
Flexure, Hot/Wet			
Strength, ksi	9.2	8.7	
Modulus, ksi	295	283	
Elongation, %	5.2	6.2	
Water absorption, wt%	2.3	2.2	
Tensile, RT/Dry			
Strength, ksi	11.8	12.1	
Modulus, ksi	484	425	
Elongation, %	5.9	8.2	

Table 4/ Processing data for the EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W resin system (26.4 phr) as a function of EPIKURE™ Curing Agent Accelerator 537 level

EPIKURE™ Curing Agent Accelerator 537 level, phr	0.0	0.5	1.0
Pot life, hrs. at 77 °F	21.5	8.5	7.9
Gel time, min.			
250 °F	94.6	45.4	30.5
300 °F	30.3	14.7	12.0
350 °F	15.0	7.4	4.1

Table 5/ Mechanical properties for the EPIKOTE® Resin 862/EPIKURE® Curing Agent W resin system (26.4 phr) fabricated using resin transfer molding (RTM) with unidirectional and 8 harness satin woven graphite fabrics

	Undirectional	**8HS**
0° Tensile, RT/Dry		
Strength, ksi	314	–
Modulus, msi	18.4	–
Elongation, %	–	–
0° Compressive, RT/Dry		
Strength, ksi	210	–
Modulus, msi	18.7	–
Elongation, %	1.3	–
0° Compressive, Hot/Dry		
Strength, ksi	168	–
Elongation, %	1.0	–
0° Compressive, RT/Wet		
Strength, ksi	212	–
Elongation, %	2.0	–
0° Flexure, RT/Dry		
Strength, ksi	–	122
Modulus, msi	–	10.0
Elongation, %	–	1.5
0° Short beam shear strength, ksi	–	8.2

Tensile test method	ASTM D-3039
Compressive test method	Modified ASTM D-695
Flexure test method	ASTM D-790
Short beam shear	
Strength test method	ASTM D-2344
RT/Dry	Tested at ambient temperature/humidity (75 °F/50% R.H.)
RT/Wet	Conditioned for 2 weeks in 200 °F (93 °C) water. Tested at ambient temperature/humidity (75 °F/50% R.H.)
Hot/Dry	Tested at 200 °F (93 °C). No water conditioning.
8HS	8 Harness satin woven fabric with 3K Celion G30-500 fibers.
Uni	Undirectional woven fabric with 3K Toray T400 fibers with fiberglass cross fibers.

Figure 1/ **Isothermal viscosity sweeps for EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W using a Rheometrics Parallel Plate Viscometer**

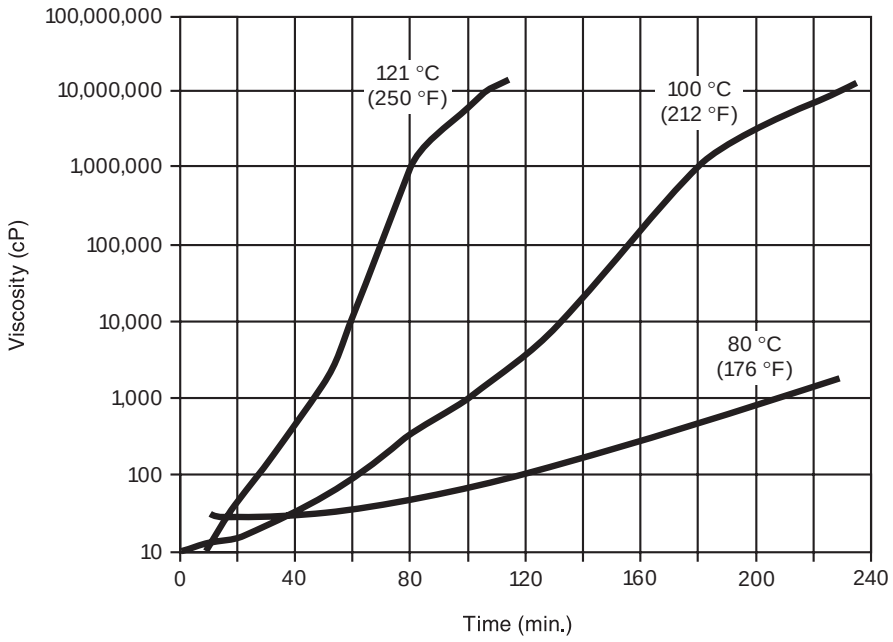


Figure 2/ **Viscosity cure sweep for EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W at 5 °C/min. using a Rheometrics Parallel Plate Viscometer**

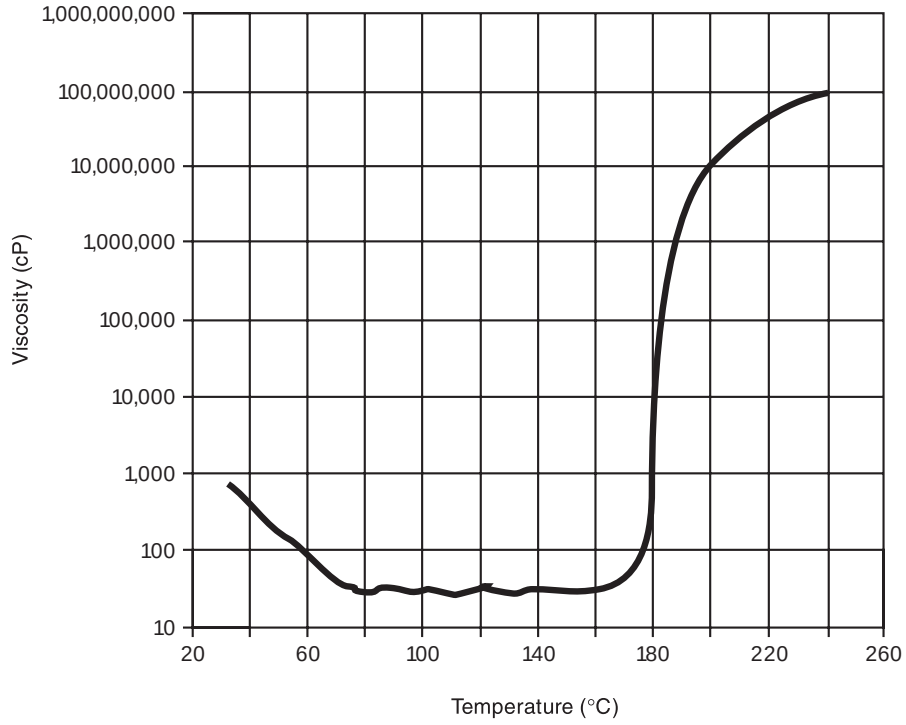


Figure 3/ **Isothermal viscosity sweeps for EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W/EPIKURE™ Curing Agent Accelerator 537 using a Rheometrics Parallel Plate Viscometer**

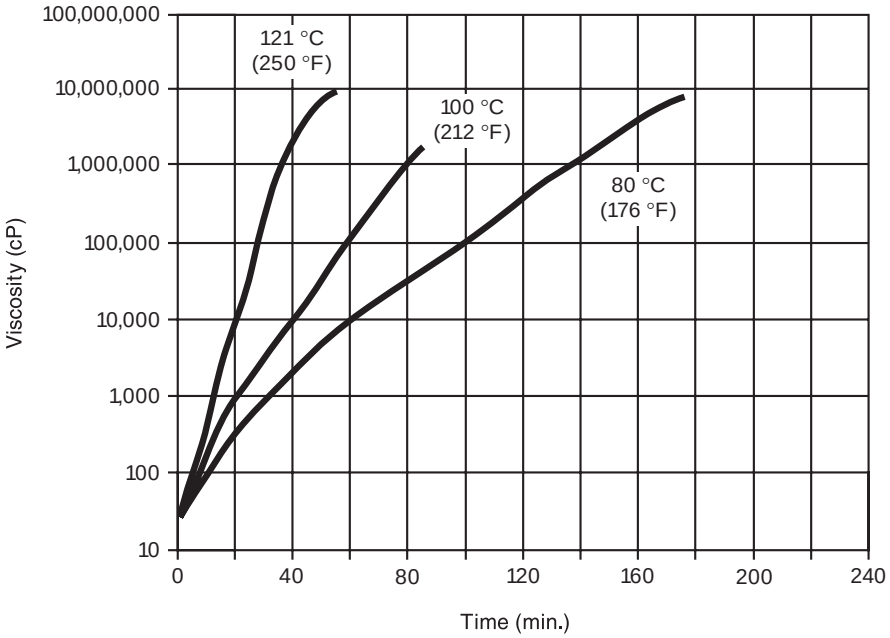
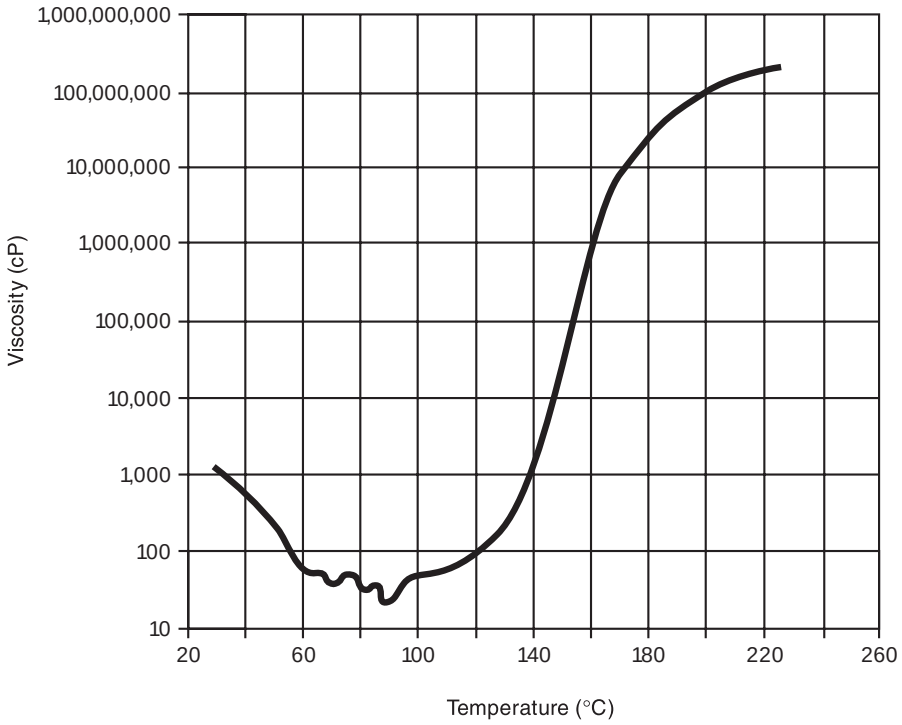


Figure 4/ **Isothermal viscosity sweeps for EPIKOTE™ Resin 862/EPIKURE™ Curing Agent W/EPIKURE™ Curing Agent Accelerator 537 at 5 °C/min. using a Rheometrics Parallel Plate Viscometer**



Packaging, storage and shipping

EPIKOTE Resin 862 is supplied in 55-gallon, DOT 17E, lined steel drums and in bulk and is classified as non-hazardous by DOT regulations (Code of Fed. Reg. Title 49). With time under certain storage conditions, EPIKOTE Resin 862 may develop crystals. Recommendations regarding storage conditions and reconstitution procedures may be obtained by contacting Resolution Performance Products' technical support phone line at 1-800-TEC-EPON (1-800-832-3766).

EPIKURE Curing Agent W is supplied in 5-gallon and 55-gallon drum quantities and is classified as non-hazardous by DOT regulations (Code of Fed. Reg. Title 49). Although stable at room temperature in an unopened container, this material will become darker in color with exposure to the atmosphere. If you have any questions regarding this behavior, contact Resolution Performance Products' technical support phone line at 1-800-TEC-EPON (1-800-832-3766).

EPIKURE Curing Agent 537 is supplied in 1-quart, 1-gallon, 5-gallon and 55-gallon drum quantities and is classified as a corrosive liquid by DOT regulations (Code of Fed. Reg. Title 49). Although stable at room temperature in an unopened container, this material will absorb moisture from the atmosphere resulting in reduced activity. A dry, nitrogen blanket is highly recommended to maintain activity. If you have any questions regarding this behavior, contact Resolution Performance Products' technical support phone line at 1-800-TEC-EPON (1-800-832-3766).

Resolution Performance Products

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For product prices, availability, or order placement, call our toll-free customer service number at:

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For sales in North and South America outside the United States, call:

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