ANGUS® CHEMICAL COMPANY

Key Performance Advantages

- Helps develop and maintain alkaline pH
- Improves corrosion inhibition
- Reduces cobalt leaching

Metalworking Fluids

AEPD™ 85

High Performance Amina Alcohol for Metalworking Fluids

Today's metalworking-fluid formulators require consistently high quality raw materials that are easy to handle and provide multifunctional benefits. AEPD™ 85 (2-amino-2-ethyl-1,3¬propanediol with 15% water) is a primary amino alcohol that has been used successfully in metalworking fluids for many years. AEPD 85 has intermediate base strength (pKa 8.8) and provides a good balance of pH development and reserve alkalinity properties. AEPD 85 is an excellent choice for replacement of diethanolamine because it has almost identical base strength (pKa).

AEPD 85 can offer the metalworking-fluid formulator and end-user the following key benefits:

- Efficient pH development
- Enhanced reserve alkalinity
- Improved ferrous corrosion protection
- Efficient neutralization of acidic components
- Enhanced performance of triazine biocides
- Reduced cobalt leaching
- Effective formaldehyde control
- Low foaming

For a more detailed discussion of other applications of AEPD and a summary of its toxicological properties, refer to ANGUS Technical Data Sheet No. 10.

Typical Properties

The following are typical properties of AEPD 85.
They are not to be considered product specifications.

Base strength of active material (pKa @ 25°C)	8.80
Molecular weight (of AEPD)	119.2
Specific gravity, 25/25°C	1.08
Weight per gallon, lb @ 25°C	9.03
Viscosity, cp Brookfield @: 25°C	650
Viscosity, cp Brookfield @: 10°C	2840
Freezing point, °C	<-24
Flash point (Pensky-Martens closed cup)	>200°F/93°C
pH of a 1% aqueous solution @25°C	10.3
Completely miscible in water	

Use in Metalworking Fluids

The effects of replacement of triethanolamine 85% (TEA-85) with AEPD 85 were studied using the two base formulations detailed below (Table 1). It is noted that TEA-85 contains 15% diethanolamine (DEA), and its use has declined in recent years due to regulatory pressures on DEA. TEA-99 is often used as a replacement for TEA-85, and the advantages of AEPD 85 over TEA-85 also apply to TEA-99.

Table 1

Soluble Oil Formula	
Ingredient	**Percent**
Naphthenic oil [A]	65.0
Petroleum sulfonate [B]	15.0
Sulfurized lard [C]	10.0
Alcohol ethoxylate [D]	1.0
Glycol ether [E]	1.0
Tall oil fatty acid [F]	3.0
Alkanolamine (See Table 2)	5.0
Synthetic Fluid Formula	
Ingredient	**Percent**
Boric acid ester [G]	20.0
Inversely soluble ester [H]	10.0
Alkanolamine (See Table 2)	5.0
Water (deionized)	65.0

Five individual metalworking-fluid concentrates were prepared, using each base-formulation, by varying the amine composition as described in Table 2.

Table 2

Alkanolamine Compositions		
Soluble/Synthetic Formula	**%AEPD 85**	**%TEA-85**
1	5.00	0.00
2	3.75	1.25
3	2.50	2.50
4	1.25	3.75
5	0.00	5.00

Key Benefits

pH Development and Reserve Alkalinity

Developing and maintaining an alkaline pH in a metalworking fluid is extremely important for maximum fluid performance. Low pH values can adversely affect fluid properties such as emulsion stability, and the ability to inhibit corrosion of freshly exposed metal surfaces. Also, microbial control agents are generally more effective when a moderately alkaline environment is maintained.

Figures 1-4 compare pH and reserve alkalinity with alkanolamine composition for the use-diluted soluble oil fluids (20:1 tap water) and synthetic fluids (10:1 tap water). Reserve alkalinity was measured by titrating a 50-gram sample of use-diluted fluid to pH 5.5, with 1N HCl. Both pH and reserve alkalinity increased as percent AEPD 85 was increased in the formula. Partial replacement of TEA-85 with as little as 1.25-2.50% AEPD 85 increased both pH and reserve alkalinity.

Figure 1
pH, Soluble Oil Fluid
20:1 Tap Water

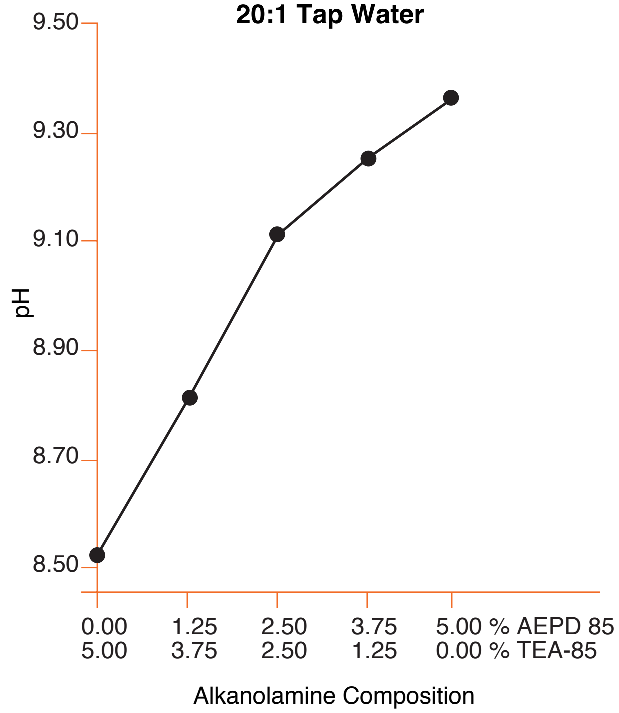


Figure 2
pH, Synthetic Fluid
10:1 Tap Water

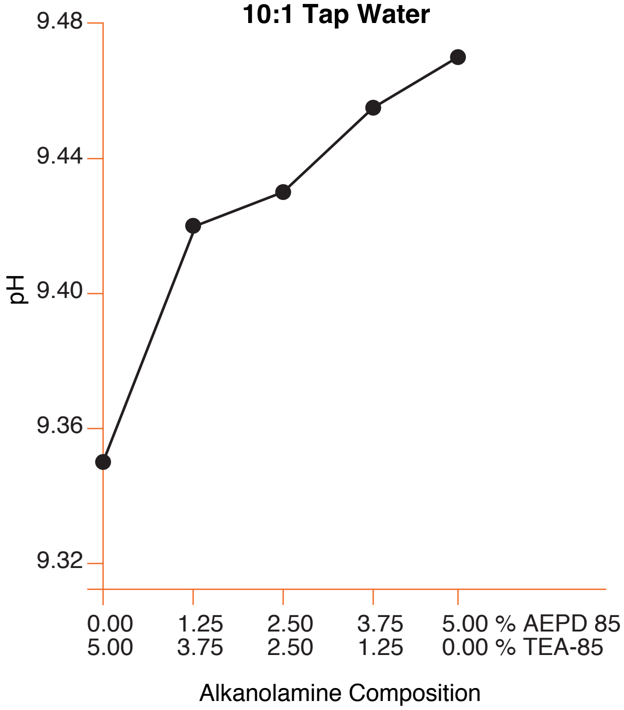


Figure 4
Reserve Alkalinity Synthetic Fluid
10:1 Tap Water

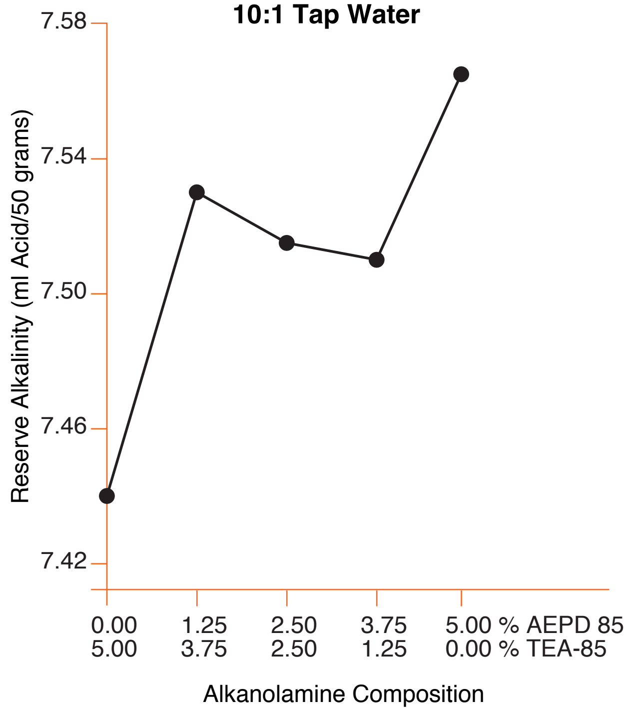
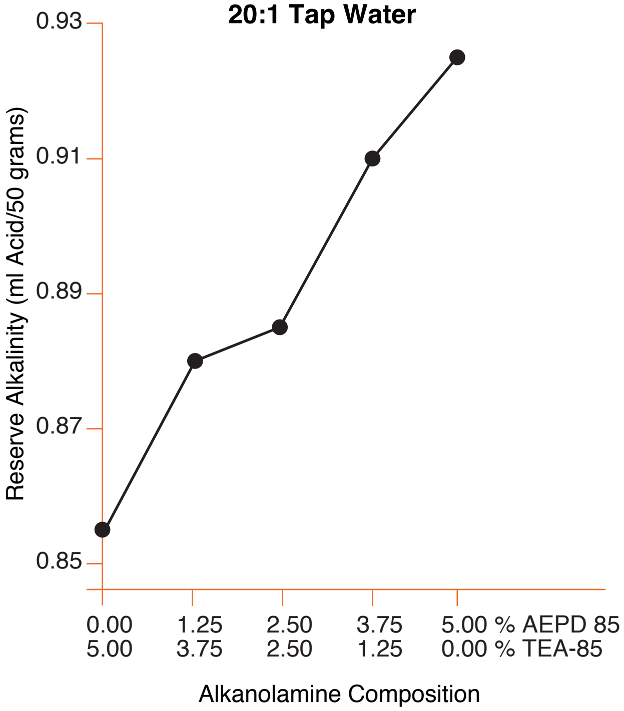


Figure 3
Reserve Alkalinity Soluble Oil Fluid
20:1 Tap Water



Corrosion Control

Another important function of a metalworking fluid is to inhibit corrosion on freshly-formed metal surfaces. The type of alkanolamine selected will affect alkalinity development and may affect the corrosion-inhibiting properties of the fluid.

A common industry test for evaluating corrosion-inhibiting properties of metalworking fluids is the cast-iron chip test (ASTM D4627). Cast-iron chips are placed on a filter paper in a petri dish and the dish is then filled with test fluid. The dish is covered and allowed to stand for 24 hours. After this time, the fluid is drained and the filter paper examined for corrosion stains. The degree of staining correlates with corrosion, and little or no staining is preferred.

Results for the soluble oil and synthetic fluids are presented in Figures 5 and 6. Each fluid was tested at dilutions of 1.0% and 1.5% in deionized water. Partial or total replacement of TEA-85 with AEPD 85 resulted in fewer stains and therefore better corrosion control.

Figure 5
Herbert Rust Test
Soluble Oil Fluid

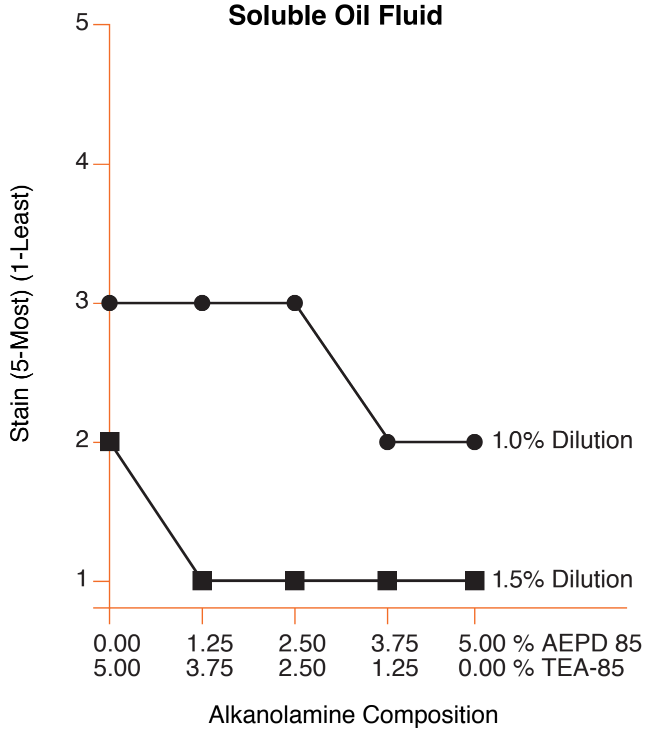
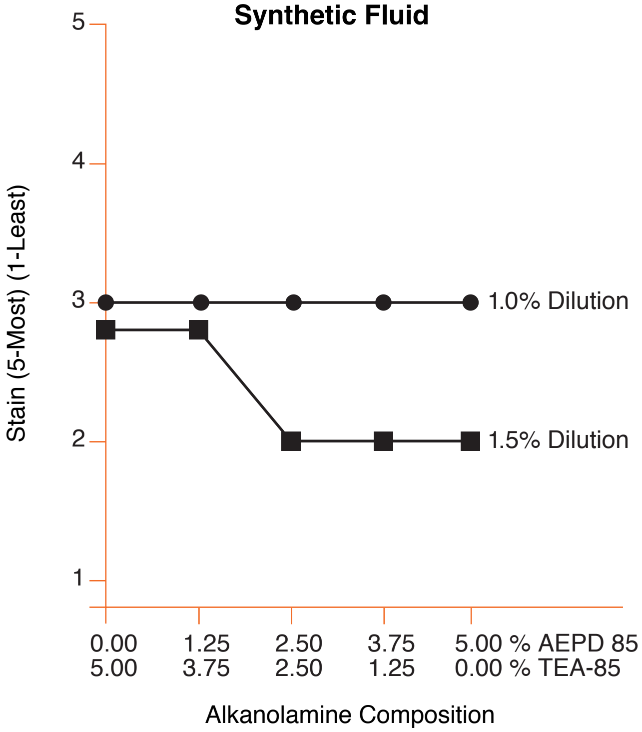


Figure 6
Herbert Rust Test
Synthetic Fluid

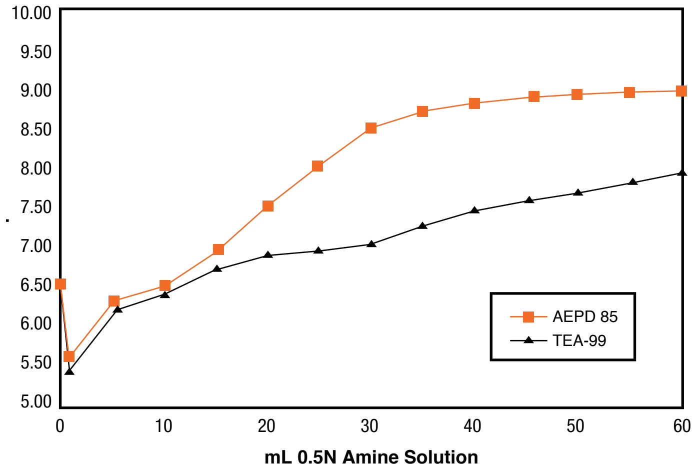


Efficient Neutralization of Acidic Components

Many metalworking fluid ingredients must be neutralized to make them water soluble and to perform properly. Examples include phosphate esters, mono- and dicarboxylic acids, fatty acids, and boric acid. The main requirements of a good neutralizer are efficiency and proper performance of the neutralized ingredient. Efficiency is related to the base strength and equivalent weight of the neutralizer, while performance depends upon the types of neutralizers and acidic materials that are used.

The neutralization efficiencies of AEPD 85 and TEA-99 are compared in Figure 7. A 0.1N solution of oleic acid in propylene glycol was titrated with 0.5N solutions of each amine. Clearly, AEPD 85 is a much more efficient neutralizer than TEA-99. Since significantly less amine is required, cost savings may result with use of AEPD 85.

Figure 7
Neutralization Efficiency with Oleic Acid*

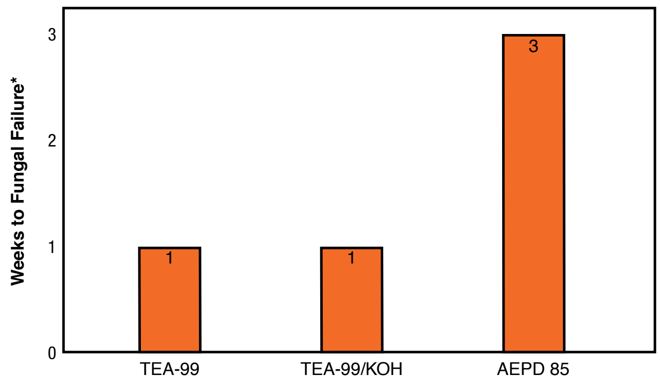


Enhanced Performance of Triazine Biocides

Triazine biocide [hexahydro-1,3,5-tris(2-hydroxyethyl)-striazine] is an effective antibacterial agent in metalworking fluids, but does not normally control fungal growth except at very high use levels. AEPD 85 can be used with triazine biocide to improve its fungal efficacy. The level of AEPD 85 required to achieve this benefit will vary with the formulation. A good starting point is to add triazine and AEPD 85 to the fluid concentrate at levels which provide 1000 ppm triazine and 2000 ppm AEPD 85 at the expected use dilution. An example of this benefit is shown in Figure 8 for the synthetic fluid formulations in Table 3. The fluid with the triazine/AEPD 85 system resisted fungal growth for three weeks, while those containing triazine and TEA-99 or TEA/KOH failed at one week.

AEPD 85 may therefore prolong the life of coolants preserved with triazine, which could result in reduced operating costs.

Figure 8
Triazine/AEPD 85 Antifungal Benefits



*Failure is 1000 CFU/mL

Figure 9
Cobalt Leaching Study

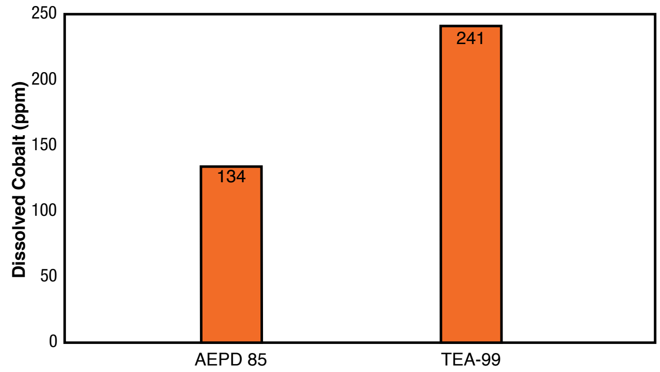


Table 3
Synthetic Fluid Formulations
(Triazine/AEPD 85 Antifungal Study)

Ingredients, wt %			
	TEA-99/	**TEA-99 KOH**	**AEPD 85**
Deionized Water	73	71	79
Amine Carboxylate [I]	5	5	5
Inversely SolubleEster [H]	10	10	10
Amino Alcohol	10	10	4
KOH (45%)	-	2	-
Triazine [J]	2	2	2
	100	100	100
pH @ 20:1 Dilution	8.8	9.6	9.1

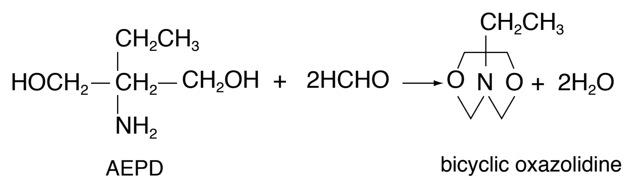
Colbalt Leaching

Leaching of cobalt from tungsten carbide during production and use of carbide tools can result in dermatitis problems for workers handling the fluids, as well as fluid waste-disposal problems. The cobalt leaching properties of AEPD 85 and TEA-99 were compared by exposing tungsten carbide swarf to one percent solutions of these amines. The pHs of the amine solutions were adjusted to 9.0 with acetic acid. The amine solutions were mixed vigorously with carbide swarf for five days. The swarf was removed by filtration (0.2 µm teflon filters) and the filtrates tested for dissolved cobalt by atomic absorption. Test results are shown in Figure 9. AEPD 85 leached only half as much cobalt as an equal weight of TEA-99. Also, since less AEPD 85 is normally required in fluids than TEA-99, the potential advantage of AEPD 85 may be even greater than that shown in Figure 9.

Formaldehyde Control

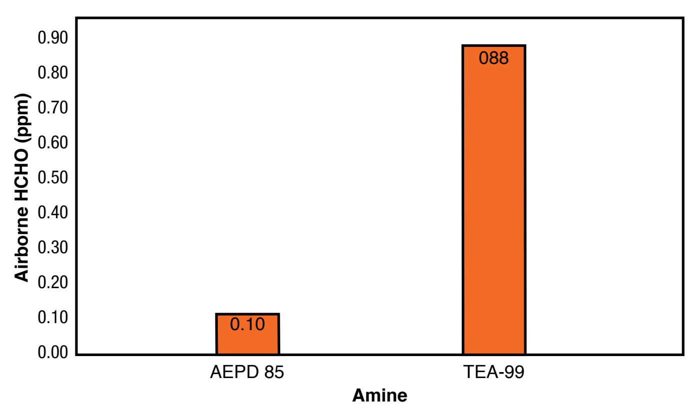
Formaldehyde (HCHO) release from metalworking fluids can occur in systems containing triazine biocide. AEPD 85 reacts readily with HCHO at room temperature and efficiently reduces airborne HCHO above these fluids. AEPD 85 can scavenge two moles HCHO per mole amine and is the product of choice for controlling HCHO release. The reaction scheme is shown in Figure 10.

Figure 10
Formaldehyde Scavenging Mechanisms



Laboratory measurements of airborne HCHO levels above a typical synthetic fluid dilution containing 1000 ppm triazine are shown in Figure 11. With 1000 ppm triazine and 5000 ppm TEA-99, the airborne HCHO level was 0.9 ppm. Replacement of TEA-99 with 1000 ppm AEPD 85 reduced the HCHO level to 0.1 ppm. The level of AEPD 85 required for effective HCHO control will depend upon the formulation type and pH.

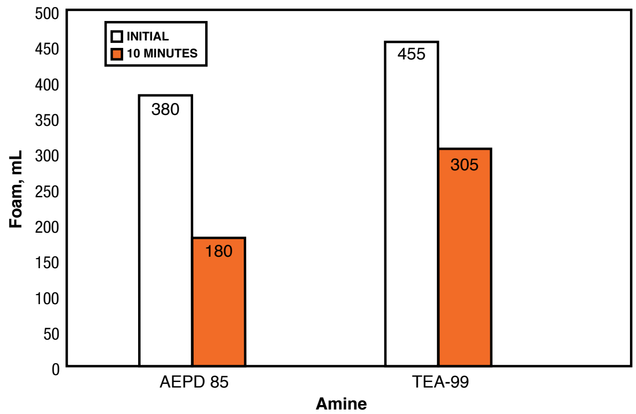
Figure 11
Formaldeyde Scavenging Results
Synthetic Dilutions



Low Foaming

Foam generation is undesirable because it can result in loss of cooling and lubrication, and cause unsightly maintenance problems. The addition of defoamers can often result in concentrate stability problems and poor adhesion of coatings to finished parts. Several types of fluid components such as fatty-acid soaps and amides can contribute to foaming. Studies have shown that the amine portion of fatty-acid soaps can significantly affect foaming potential. For example, the TEA-85 soap of tall oil fatty acid generates significantly more foam in soluble oils than does the AEPD 85 soap. Foaming results using a Waring blender test are shown in Figure 12. The fluid with AEPD 85 generated less foam and a less stable foam than did the TEA-85 fluid.

Figure 12
Foaming Results
Waring Blender Test on Soluble Oil Fluid*



*mL Foam on 300 mL of Emulsion

Supplier Key

[A] 100 Pale Oil, Lyondell Petroleum
[B] Actrabase PS 470, Actrachem
[C] Base 14-L, Keil Chemical
[D] Neodol 25-3, Shell Chemical
[E] Butyl Cellosolve, Union Carbide
[F] Acintol FA 3, Arizona Chemical
[G] Synkad 204, Keil Chemical
[H] Inversol 170, Keil Chemical
[I] Aqualox 232, Alox Corporation
[J] BIOBAN® GK, Dow Chemical Company

Product Stewardship

ANGUS encourages its customers to review their applications of ANGUS products from the standpoint of human health and environmental quality. To help ensure that ANGUS products are not used in ways for which they are not intended, ANGUS personnel will assist customers in dealing with environmental and product safety considerations. For assistance, product Safety Data Sheets, or other information, please contact your ANGUS representative at the numbers provided in this document. When considering the use of any ANGUS product in a particular application, review the latest Safety Data Sheet to ensure that the intended use is within the scope of approved uses and can be accomplished safely. Before handling any of the products, obtain available product safety information including the Safety Data Sheet(s) and take the necessary steps to ensure safety of use.

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