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COMPATIBILITY OF MANUFACTURING PROCESS FLUIDS WITH R-134a AND POLYOLESTER LUBRICANT

Final Report

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ABSTRACT

This report includes a broad list of processing fluids that are known to be used to manufacture air conditioning and refrigeration products. Sixty-four process fluids from this list were selected for compatibility studies with R-134a and ICI EMKARATE RL32H (32 ISO) polyolester lubricant. Solutions or suspensions of the process fluid residues in polyolester lubricant were heated for 14 days at 175°C (347°F) in evacuated sealed glass tubes containing only valve steel coupons. Miscibility tests were performed at 90 wt% R-134a, 10 wt% polyolester lubricant with process fluid residue contaminate and were scanned in 10°C (18°F) increments over a temperature range of ambient to -40°C (-40°F). Any sign of turbidity, haze formation or oil separation was considered the immiscibility point.

ACKNOWLEDGMENT

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SCOPE

Residues from process fluids used in the manufacturing process can contribute to the formation of contaminants that can react with polyolester (POE) lubricants or refrigerants to form acids and other unknown materials. Such contaminants may block capillary tubes, expansion valves, filters and desiccants while the acid formation may corrode metals. Objectives of this study were to compile a broad list of process fluids used by various air conditioning and refrigeration (AC&R) equipment manufacturers and conduct compatibility studies with R-134a and POE lubricant on selected process fluids.

BACKGROUND

The process fluids studied were provided by suppliers with little or no information regarding compatibility with HFCs or POEs. ICI EMKARATE RL32H POE contains no additives and was selected for this study as a representative lubricant. Information concerning specific structural properties of the POE remains with the manufacturer. The results of miscibility and solubility studies of the process fluids may have been affected by the POEs structural composition.

Many AC&R equipment manufacturers identified process fluids used in their manufacturing plants. The listed chemical compositions and formulas were taken from available material safety data sheets; however, the exact compositions and formulas remain unpublished. The available published compositions of the process fluids selected for testing are presented in the Appendix and are considered representative of process fluids currently used in the industry. The list of 64 process fluids selected for study is given in Table 1.

Table 1
Selected Processing Fluids for Compatibility Tests

(KEY)
B=Brazing Fluxes **C**=Coolant **S**=Sealant **R**=Rust Inhibitor/Preventative
I=Iron Phosphatizers **L**=Lubricant **D**=Detergent, Degreaser, Cleaner

PROCESS FLUID	COMPANY	TYPE
Handy Flux D	Lucas-Milhaupt	B
Stay Silv White Flux	Harris	B
Novamax No-Rez 65	Novamax	B
Solene 1000	Solene	C
Cimstar 3700T	Cincinnati Milacron	C
Safety Cool 800 / Syntilo 9954	Castrol Industrial	C
CT500	Chemtool	C
Cimstar 40 Pink	Cincinnati Milacron	C
Oakite Controlant 127 S	Oakite	C
Oakite Controlant 3000 ss	Oakite	C
Diversey Lubricoolant Tec	Diversey-Dubois	C
Brulin 1990 GD	Brulin	D
Castrol Kleen 3625	Castrol Industrial	D
Brulin 815 GD	Brulin	D
Brulin 815 QR	Brulin	D
Solvox Special 474	Solvox Mfg. Co.	D
D-Limonene	Florida Chemical Co.	D
Oakite Okemclean	Oakite	D
Oakite Inpro-clean 1300	Oakite	D
Oakite Rustripper	Oakite	D
Oakite LSD	Oakite	D
Oakite 77	Oakite	D
Parco 142	Parker-Amchem	D
Oakite 31	Oakite	D
Diversey Super Terj	Diversey-Dubois	D
Diversey ISW-29	Diversey-Dubois	D
Cryscoat 2147	Oakite	I
Cryscoat 1127	Oakite	I
Cryscoat Ultra Seal (rinse)	Oakite	I
Oakite Cryscoat 747	Oakite	I

Table 1 (continued)
Selected Processing Fluids for Compatibility Tests

(KEY)
B=Brazing Fluxes **C**=Coolant **S**=Sealant **R**=Rust Inhibitor/Preventative
I=Iron Phosphatizers **L**=Lubricant **D**=Detergent, Degreaser, Cleaner

PROCESS FLUID	COMPANY	TYPE
F4422 Oil	Schrader-Bellows	L
Honilo 480	Castrol Industrial	L
Master Draw 566	Etna Products	L
Master Draw 1969A1	Etna Products	L
HEG 18	Witco	L
Solene XE6512	Solene	L
Quaker Ferracote 5684	Quaker Chemical	L
Suniso 160	Witco	L
Oakite Formula 59	Oakite	L
Rex Draw 176	Benz Oil Co.	L
Suniso 3GS	Witco	L
Oak Oil 50-5	Oak International	L
Oak International 11-B	Oak International	L
Dri-Touch IRP1	Birchwood Casey	R
Rustilo DW 924	Castrol Industrial	R
Resco Ultra Koate XP	Research Metal Fluids	R
Resco Oxy Kleen 4926A	Research Metal Fluids	R
Resco Oxy Koate Syn	Research Metal Fluids	R
Almco 2420	Almco	R
Novamax R44	Novamax	R
Diversey E-314	Diversey-Dubois	R
Quaker Ferracote 368	Quaker Chemical	R
Protech 1300	Chemical Technologies	R
CT625	Chem Tool	R
Oakite Special Protective Oil	Oakite	R
Oakite Inpro-tect 600	Oakite	R
Inpro-tect 670	Oakite	R
Meca Lube	Puma Technologies	R
Met-Chem 211	Met-Chem	R
Diversey ICS-423	Diversey-Dubois	R
Oakite Renovator	Oakite	S
Loctite 640	Loctite	S
Loctite 515	Loctite	S
Loctite RC 1620	Loctite	S

EXPERIMENTAL METHODS

The process fluids were dehydrated in an open hood for 5 days. These materials were then further dehydrated at 45°C (113°F) in a circulating air bath oven for 3-8 days to constant weight. To make 0.1% by weight concentrations, the process fluid residues were weighed into test jars that contained 100 ml of POE. Many of the residues are not soluble in pure POE.

All process fluid residues were then heated with POE lubricant for 14 days at 175°C (347°F) in evacuated sealed glass tubes, similar to a method used by Tecumseh Products Co. The visual observations listed in Tables 2, 3, and 4 reporting POE color, composition and iron coupon color were done at room temperature while the tubes were sealed. Thermal stability parameters were controlled using a hot air oven that is equipped with an electronic temperature controller capable of ±1.0°C of the set point. After heating, the lubricant was evaluated for miscibility with R-134a, total acid number (TAN) and soluble iron.

Miscibility of dissolved process fluids in POE with R-134a was achieved by placing the POE samples from the reaction tubes under anhydrous conditions in a high speed centrifuge for 20 minutes to ensure that the POE did not have any suspended debris. Miscibility determinations were then performed on solutions of 90 wt% R-134a and 10 wt% of the POE removed from the evacuated sealed glass tubes. Miscibility measurements were made at 10°C (18°F) increments using methanol as the heat transfer medium in a refrigerated cryostat. Sealed tubes that exhibited any degree of haziness, cloudiness, turbidity, granular or crystal formation were reported at the temperature it first appeared. When turbidity was observed at 20°C (68°F), the reported temperature of immiscibility is indicated with a plus mark (+) if original turbidity remained when the temperature was decreased another 10°C (18°F) only.

The TAN value of a lubricant indicates the amount of free acids present. TAN is determined by titration of the lubricant acids with standardized potassium hydroxide (KOH) using a color indicator as an end-point to titration (ASTM method #D974-87). The resulting TAN tells the amount of milligrams of KOH necessary to neutralize the acids in 1 gram of the lubricant.

The iron content of the lubricants was quantitatively measured using an anion exchange column with high-pressure liquid chromatography (HPLC). The HPLC mobile phase contained 0.05% ethylene diamine tetra acetic acid (EDTA) which reacted instantaneously with iron (Fe) in the lubricant forming a Fe - EDTA complex. This complex is sensitive to ultraviolet detection and was detected as an HPLC peak at 254 nm wavelength. HPLC standards were prepared by dissolving known amounts of $FeCl_3$ in EMKARATE RL32H lubricant. A standard curve was prepared of lubricant iron concentration (ppm) versus HPLC peak heights. POE containing 0, 10, 20, 30, 40, 50

and 100 ppm iron was used to form the standard curve, which was then used to quantitatively measure the iron in lubricant samples. These samples were analyzed identically to those of the standards.

RESULTS

Hydrolytic Stability of EMKARATE RL32H

The POE used in this study (RL32H) was dried to less than 50 ppm water. The TAN value of pure unheated lubricant was determined to be 0.01. When heated in a sealed tube for 14 days at 175°C (347°F) containing only the valve steel coupon (100 ±0.5 cm^2), the POE had a TAN value of 0.04 and a soluble iron content of less than 5 ppm (by HPLC method). The TAN of RL32H and process fluid residue prior to heating was not determined.

Tests of Lubricants and Uncured Sealants at 0.5 wt% in EMKARATE RL32H (<50 ppm Water) for 14 days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

The process fluids described in this section are compounds that are soluble in POE (RL32H) as received from the manufacturer. Therefore, 0.5 wt% of the process chemical, dissolved in 100 ml of POE with less than 50 ppm water, was heated at 175°C (347°F) for 14 days in the presence of polished Sandvic Carbon Valve Steel in evacuated sealed glass tubes. The pressure in the sealed glass tubes was reduced to 30 millitorr before sealing. This pressure was achieved by gently heating the tubes and using light mechanical tapping to remove any dissolved gasses. After 14 days of heating, the sealed glass tubes were cooled, opened and the POE was tested for soluble iron and TAN. The miscibility point was then determined in a 10:90 lubricant:refrigerant mixture in glass sealed tubes. Table 2 reports the visual condition of the POE, soluble iron, TAN and the critical miscibility temperature of the mixture.

Table 2

Tests of Lubricants and Uncured Sealants at 0.5 wt% in Polyolester Lubricant Emkarate RL32H (<50 ppm Water) for 14 days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

	Observations After Reaction						
Process Fluid	**Oil Composition**	**Oil Color**	**Iron Color**	**Total Acid Number (mg KOH / g sample)**	**Soluble Iron (ppm)***	**Temperature of Immiscibility** (90:10 134a:oil)**	**Description of Immiscibility at 20°C (68°F)**
F4422 Oil	Clear	Clear	Silver	.08	< 5	0°C (32°F)	Turbidity
Honilo480	Clear	Yellow	Brown	.23	15.4	10°C (50°F)	Turbidity
Quaker Ferracote 368	Clear	Yellow	Tan	.12	13.5	M	
Etna 566	Clear	Light Yellow	Silver	.08	< 5	20°C + (68°F)	Milky haze
Master Draw 176	Clear	Light Yellow	Silver	.11	10.3	-20°C (-4°F)	Turbidity
Witco HEG 18	Turbid (insoluble)	Light Yellow	Tan	.39	< 5	M	
Quaker Ferracote 5684	Clear	Yellow	Silver	.20	15.7	20°C + (68°F)	Milky haze
Witco Suniso 160	Clear	Light Yellow	Tan	.04	12.8	0°C (32°F)	Turbidity
Oakite Formula 59	Clear	Light Yellow	Tan	.15	12.2	20°C + (68°F)	Milky haze/Milky and Dark Brown ppt
Rex Draw 176	Turbid (insoluble)	Brown	Black	1.1	21.3	20°C + (68°F)	Brown ppt
Meca Lube	Clear	Clear	Silver	.13	10.5	20°C + (68°F)	Milky ppt
Loctite 640	Turbid (insoluble)	Light Yellow	Gray	.10	10	10°C (50°F)	Turbidity
Loctite 515	Turbid (insoluble)	Light Yellow	Silver	.07	< 5	0°C (32°F)	Turbidity
Suniso 3GS Oil	Clear	Light Yellow	Silver	.12	14	M	
Loctite RC 1620	Turbid (insoluble)	Clear	Silver	.05	< 5	20°C + (68°F)	Tan ppt
OakOil 50-5	Clear	Clear	Gray	.12	< 5	M	
Oak International 11-B	Clear	Light Yellow	Silver	.11	10.7	-10°C (14°F)	Turbidity

***High soluble iron may indicate oil decomposition and may be reason for incompatibility**

****M = Miscible**

Tests of Dried Process Fluid Residues Classified as Coolants, Rust Inhibitors, Detergents, Degreasers, Cleaners and Cured Sealants at 0.1wt% in EMKARATE RL32H (<50 ppm Water) for 14 Days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

In this section, 100 mg of anhydrous process fluid residues or 100 mg of cured sealant produced in actual threaded assemblies, was added to 100 ml of EMKARATE RL32H with less than 50 ppm water and ultrasonically mixed (Branson Sonifier 250) at a constant duty cycle for 2 minutes to fully disperse the insoluble mixture at room temperature. This mixture was heated at 175°C (347°F) for 14 days in evacuated sealed glass tubes containing only polished Sandvic Carbon Valve Steel coupons (100 ±0.5 cm^2). Pressures in the evacuated sealed glass tubes were reduced to 30 millitorr before sealing by gently heating and using light mechanical tapping to remove any dissolved gasses. After 14 days of heating, the glass tubes were cooled, opened and the POE tested for soluble iron and TAN. The miscibility point was determined in a 10:90 lubricant:refrigerant mixture in glass sealed tubes. Table 3 reports the visual condition of the POE, soluble iron, TAN and the critical miscibility temperature of the mixture.

Tests of Residues Derived from Brazing Fluxes and Iron Phosphated Surfaces in EMKARATE RL32H (<50 ppm Water) for 14 days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

In this section, actual brazed parts consisted of 1010 steel sheet (100 ±0.5 cm^2), 1.5 cm diameter copper wire brazed with 45% silver solder and the test flux. The three individual metal parts were individually weighed. The weight of remaining flux residue on the part was determined to be 100 mg.

Iron phosphatizers were used to produce an iron phosphate coating on 1010 sheet steel (100 ±0.5 cm^2) that had a total coating weight equal to 100 mg. Both types of treated metal parts were heated with POE and then analyzed. Pressures in the sealed glass tubes were reduced to 30 millitorr before sealing by gently heating and using light mechanical tapping to remove any dissolved gasses. After 14 days of heating at 175°C (347°F), the glass tubes were cooled, opened and the POE tested for soluble iron and TAN. The miscibility point was determined in a 10:90 lubricant:refrigerant mixture in glass sealed tubes. Table 4 reports the visual condition of the POE, soluble iron, TAN and the critical miscibility temperature of the mixture.

Table 3

Reaction of Dried Process Fluid Residues Classified as Coolants, Rust Inhibitors, Detergents, Degreasers, Cleaners and Cured Sealants at 0.1 wt% in Polyolester Lubricant Emkarate RL32H (<50 ppm Water) for 14 days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

	Observations After Reaction						
Process Fluid	**Oil Composition**	**Oil Color**	**Iron Color**	**Total Acid Number (mg KOH / g sample)**	**Soluble Iron (ppm)***	**Temperature of Immiscibility** (90:10 134a:oil)**	**Description of Immiscibility at 20°C (68°F)**
Brulin 1990GD	Clear	Light Yellow	Silver	.14	< 5	10°C (50°F)	Turbidity
Castrol Kleen 3625	Turbid (insoluble)	Tan	Black	.60	45.4	20°C + (68°F)	Milky ppt
Brulin 815GD	Turbid (insoluble)	Yellow	Tan	.20	13	20°C + (68°F)	Milky ppt
Brulin 815QR	Clear	Yellow	Silver	.12	13	M	
Dri-Touch IRP1	Clear	Yellow	Tan	.17	12	20°C + (68°F)	Milky ppt
Rustila DW 924	Clear	Clear	Silver	.09	12	20°C + (68°F)	Milky haze
Resco Ultra Koate XP	Clear	Yellow	Tan	.20	13	20°C + (68°F)	Tan ppt
Resco Oxy Kleen 4926A	Clear	Light Yellow	Silver	.23	10.4	M	
Solvox Special 474	Clear (insoluble)	Light Yellow	Brown	.19	15	20°C + (68°F)	Tan ppt
Solene 1000	Clear (insoluble)	Clear	Silver	.16	< 5	M	
Solene XE6512	Clear	Clear	Silver	.02	< 5	M	
Resco Oxy Koate Syn	Clear	Light Yellow	Gray	.23	15.7	M	
Almco 2420	Turbid (brown insoluble)	Yellow	Brown	.25	14.6	0°C (32°F)	Turbidity
Novamax R44	Clear	Light Yellow	Silver	.12	< 5	M	
Cimstar 3700T	Turbid (insoluble)	Yellow	Tan	.20	10.2	10°C (50°F)	Turbidity
Diversey E-314	Clear	Yellow	Tan	.15	11.5	M	
D-Limonene	Clear	Brown	Brown	.20	17	M	
Safety Cool 800	Clear (insoluble)	Light Yellow	Gray	.12	< 5	-10°C (14°F)	Turbidity
Novamax Protech 1300	Clear	Light Yellow	Gray	.12	12.5	-10°C (14°F)	Turbidity
Chemtool CT500	Turbid (insoluble)	Light Yellow	Tan	.26	29	20°C + (68°F)	Brown ppt

***High soluble iron may indicate oil decomposition and may be reason for incompatibility**

****M = Miscible**

Table 3 (continued)

	Observations After Reaction						
Process Fluid	**Oil Composition**	**Oil Color**	**Iron Color**	**Total Acid Number (mg KOH / g sample)**	**Soluble Iron (ppm)***	**Temperature of Immiscibility** (90:10 134a:oil)**	**Description of Immiscibility at 20°C**
Cimstar 40 Pink	Turbid (insoluble)	Yellow	Brown	.35	30	10°C (50°F)	Turbidity
Chemtool CT625	Clear	Light Yellow	Brown	.20	20.7	-10°C (14°F)	Turbidity
Oakite Okemclean	Turbid (insoluble)	Yellow	Tan	.43	32.8	20°C + (68°F)	Milky Brown ppt
Oakite Special Protective Oil	Clear	Light Yellow	Tan	.32	17.3	20°C + (68°F)	Milky haze
Oakite Contolant 127S	Clear	Light Yellow	Silver	.19	< 5	20°C + (68°F)	Dark Brown ppt
Oakite Inproclean 1300	Clear (insoluble)	Clear	Silver	.04	< 5	-10°C (14°F)	Turbidity
Oakite Rustripper	Turbid (insoluble)	Yellow	Brown	.40	45.3	20°C + (68°F)	Milky haze/ Milky Brown ppt
Oakite Inprotect 600	Clear (insoluble)	Light Yellow	Tan	.17	< 5	20°C + (68°F)	Dark Brown ppt
Oakite LSD	Turbid (insoluble)	Yellow	Brown	.45	46.4	20°C + (68°F)	Milky Tan ppt
Oakite Inprotect 670	Clear (insoluble)	Yellow	Brown	.38	< 5	M	
Oakite 77	Clear (insoluble)	Light Yellow	Tan	.24	< 5	M	
Oakite Renovator	Clear (insoluble)	Clear	Silver	.30	< 5	M	
Parco 142 Cleaner	Clear	Light Yellow	Silver	.03	< 5	M	
Oakite 31	Clear (insoluble)	Light Yellow	Gray	1.3	10.5	20°C + (68°F)	Tan ppt
Oakite Contolant 3000 ss	Clear	Yellow	Gray		25.4	20°C + (68°F)	Dark Brown ppt
Met-Chem 211	Clear	Yellow	Tan	.12	11	M	
Diversey Lubricoolant Tec	Turbid (insoluble)	Tan	Brown	.36	21.8	20°C + (68°F)	Dark Brown ppt
Diversey Super Terj	Turbid (insoluble)	Tan	Brown	.28	23.3	20°C + (68°F)	Tan ppt
Diversey ICS - 423	Clear	Light Yellow	Tan	.16	10.8	20°C + (68°F)	Milky ppt
Diversey ISW - 29	Turbid (insoluble)	Yellow	Brown	.44	43.6	20°C + (68°F)	Milky Tan ppt
Loctite RC 1620	Turbid (insoluble)	Clear	Silver	.06	10.3	20°C + (68°F)	Tan ppt
Oakite Renovator	Clear (insoluble)	Clear	Silver	.16	< 5	20°C + (68°F)	Milky Gray ppt
Loctite 640	Turbid (insoluble)	Light Yellow	Gray	.07	16	20°C + (68°F)	Gray ppt
Loctite 515	Turbid (insoluble)	Yellow	Tan	.26	15.5	20°C + (68°F)	Milky Tan ppt

***High soluble iron may indicate oil decomposition and may be reason for incompatibility**

****M = Miscible**

Table 4

Reaction of Residues Derived from Brazing Fluxes and Iron Phosphatized Surfaces in Polyolester Lubricant Emkarate RL32H (<50 ppm Water) for 14 days at 175°C (347°F) Containing Only Valve Steel Coupons Sealed in Glass Tubes under a Vacuum

	Observations After Reaction						
Process Fluid	**Oil Composition**	**Oil Color**	**Iron Color**	**Total Acid Number (mg KOH / g sample)**	**Soluble Iron (ppm)***	**Temperature of Immiscibility** (90:10 134a:oil)**	**Description of Immiscibility at 20°C (68°F)**
Handy Flux D	Turbid (brown)	Brown	Black	2.1	52.3	20°C + (68°F)	Milky haze/Tan ppt
Stay Silv White Flux	Clear	Clear	Black	.81	14.5	20°C + (68°F)	Tan ppt
Novamax No-Rez 65	**Could Not Be Used In This Study**						
Oakite Cryscoat 2147	Clear	Clear	Black	.32	< 5	M	
Cryscoat 1127	Clear	Clear	Tan	.28	< 5	M	
Cryscoat Ultra Seal (rinse)	Clear	Clear	Silver	.15	< 5	M	
Oakite Cryscoat 747	Clear	Clear	Black	.18	< 5	M	

***High soluble iron may indicate oil decomposition and may be reason for incompatibility**

****M = Miscible**

COMPLIANCE WITH AGREEMENT

Imagination Resources, Inc. is in compliance with the contract agreement.

PRINCIPAL INVESTIGATOR EFFORT

The principle investigators and support personnel have devoted more than 2940 hours toward the completion of this contract. Additional activities include reporting early refrigerant miscibility information to the Technical Oversight Group and the continuous establishment of experimental methodologies.

REFERENCES

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Private communication with Keshav Sanvordenker regarding Tecumseh Products Company Research Lab Test Method *"Sealed Tube Test on Water Based Process Fluids"* **8/9/95**

APPENDIX A
List of Process Fluids Identified by AC&R Equipment Manufacturers

Table A.1
Brazing Fluxes

Product	Manufacturer	Published Composition	Working Concentration
No Rez 65	Novamax	Water, >60% Hydrobromic acid, <25% Glycol ether, >5% Amino alcohol, >5% Ethylene diamine, <5%	flux:water 1:1 to 1:3 v/v
Stay Silv Black	J. W. Harris	Boric acid, 30-50% Potassium bifluoride, 25-40% Water, 15-20% Potassium tetraborate, undisclosed amount Potassium pentaborate, undisclosed amount	use as packaged; may be thinned with water
Stay Silv White	J. W. Harris	Boric acid, 30-50% Potassium bifluoride, 25-40% Water, 15-20% Potassium tetraborate, undisclosed amount Potassium pentaborate, undisclosed amount	use as packaged; may be thinned with water
Mocolok 100	Soluay	Potassium Tetra Aluminate (KAlF4), undisclosed amount	use as packaged
DAG - 137	Acheson Colloids	Graphite (?%) Colloid, undisclosed amount	use as packaged
Flux 604 PD	Superior	Potassium bifluoride 30-35% Potassium pentaborate 30 - 30%	as packaged; may be thinned with water
Flux DB	Lucas-Milhaupt, Inc.	Potassium; salt of Boron and Fluoride Potassium Boron Oxide	use as packaged
Handy Flux D	Lucas-Milhaupt, Inc.	Potassium bifluoride, 30-35% Potassium pentaborate 30 - 30%	as packaged; may be thinned with water
Handy Flux D-2	Lucas-Milhaupt, Inc.	Potassium bifluoride, 30-35% Potassium pentaborate 30 - 30%	as packaged; may be thinned with water

Table A.2
Cleaners, Degreasers, and Detergents

Product	Manufacturer	Published Composition	Working Concentration
Careclean MP	Dubois	company declined to participate	
Cerfakleen 5380	E.F. Houghton	proprietary; alkaline	2-3% v/v with water
Cerfakleen 5382	E.F. Houghton	proprietary; alkali salts and surfactants	2% v/v with water
Cerfakleen 5384	E. F. Houghton	proprietary, alkali salts and surfactants	1-3% v/v with water
Cerfakleen 5391	E.F. Houghton	proprietary	2-4% v/v with water
Citrus Cleaner (aerosol)	3M	d-limonene, 70-80% propane (propellant), 10-20% proprietary surfactants; 7-13%	as packaged
Dustrypp	Dubois	company declined to participate	
FAC 106	Dubois	company declined to participate	
Liftaway	Dubois	company declined to participate	
Oakite LSD	Oakite	sodium hydroxide, 10-20%, sodium xylenesulfonate,<5% sodium silicate, <5% nonylphenoxy polyethoxy ethanol, 5% undisclosed nonhazardous ingredients	
Brulin 815 GD	Brulin Corporation	proprietary; includes detergents, alkaline builders, and inhibitors	1:10-1:20 (v/v) product:water depending on use
Brulin 1990 GD	Brulin Corporation	proprietary; includes detergents, phosphates, silicates, and inhibitor	1:20 (v/v) product:water
Brulin 63-G	Brulin Corporation	proprietary; includes detergents, phosphates, silicates, and inhibitor	1:20 (v/v) product:water

Table A.2
Cleaners, Degreasers, and Detergents (continued)

Product	Manufacturer	Published Composition	Working Concentration
Brulin 224	Brulin Corporation	proprietary: includes water, alkaline builders, and surfactants	1:64-1:128 (v/v) product:water depending on use
Brulin 815 QR (degreaser)	Brulin Corporation	proprietary; includes detergents, phosphates, silicates, and amines	1:10-1:20 (v/v) product:water for most uses
Oakite 77 (degreaser)	Oakite	sodium hydroxide, 40-50% sodium dodecylbenzene sulfonate, <10% sodium metasilicate, <10% sodium carbonate, <10% dipentene, <5% undisclosed nonhazardous ingredients	unknown
Gillite 0650	Man-Gill Chemical	none	unknown
Dubois 422	Dubois	company declined to participate	
Parco 142	Parker/Amchem	proprietary; includes surfactants	5-10% w/w with other cleaners
Parco 328	Parker/Amchem	proprietary; include potassium hydroxide (10-30%).	1.5 - 4% v/v with water
Simple Green	Sunshine Makers	proprietary, includes nonionic surfactants	depends on use; 1:10 (v/v) product:water for most industrial applications
D-Limonene	Florida Chemical Co.		
Okemclean	Oakite		
Inproclean 1300	Oakite		
Rustripper	Oakite		
Castrol Kleen 3625	Castrol Industrial		
Solvox Special #474 - R - I Hard Surface	Solvox Manufacturing Co.	alcohols, ethoxylated or propoxylated; sodium metasilicate; 2 - butoxyethanol; sodium nitrite	unknown

Table A.3
Coolants

Product	Manufacturer	Published Composition	Working Concentration
Chemtool 415	Chemtool	synthetic fluid	not given
Chemtool 500	Chemtool	synthetic fluid	not given
Chemtool 643	Chemtool	synthetic fluid	not given
Cimstar 3700T	Cincinnati Milacron	proprietary; alkaline	1:20 (v/v) product:water
Cimstar 40	Cincinnati Milacron	proprietary with mineral oil, semi-synthetic	1:20 (v/v) product:water
Cimtech 3900	Cincinnati Milacron	proprietary; alkaline	1:20 (v/v) product: water
Tech Cool	Chemical Technologies, Inc.	proprietary	1:10-1:40 (v/v) product:water, depending on use
Solene 1000	Solene Industrial Lubricants	alkanolamine proprietary additives	1:9 to 1:30 dilution with water
Solene 4000	Solene Industrial Lubricants	alkanolamine proprietary additives	1:9 to 1:30 dilution with water
Controlant 127S	Oakite		
Safety Cool 800	Castrol Industrial Central, Inc.	petroleum oil sodium tetraborate	(?%)

Table A.4
Iron Phosphatizers

Product	Manufacturer	Published Composition	Working Concentration
IPI 25	Dubois	company declined to participate	
IS 1	McGean-Rohco	detergent, accelerator, phosphoric acid	0.5 - 2% v/v with water, depending on use
Cryscoat 747	Oakite	phosphates, activator agents, surfactants, and fluorides	3-5% v/v with water
Cryscoat 2147	Oakite		
Cryscoat 1127	Oakite		
Cryscoat Ultra Seal	Oakite		

Table A.5
Lubricants

Product	Manufacturer	Published Composition	Working Concentration
Oakite SPO2 (assembly)	Oakite		
Suniso 3GS	Witco	refined mineral oil	insoluble in water
Suniso 4GS (assembly)	Witco	refined mineral oil	insoluble in water
Oakite 59 (ball expanding)	Oakite		
Oak 50-5 (drawing)	Oak International		
Quaker Ferrocote 5684 (drawing)	Quaker		
Oak 14B-1 (drawing)	Oak International		HFC-compatible (miscible)
Oak 14B-2 (expansion)	Oak International		HFC-compatible (miscible)
Oak 60-1 (forming)	Oak International		not in contact with internals
Oak Oil HC (forming)	Oak International		not in contact with internal
Tower A-1830 (forming)	Tower Chemical		
Honilo 480 (honing)	Castrol		
Care Tech (honing)	Castrol		
F4422 Oil (honing)	Schrader Bellows	severely refined heavy paraffinic petroleum oil (90-100 %)	as packaged
Maaco HEG-18 (honing)	Witco		
Oak Oil 11C (tube bending)	Oak International		not compatible with HFCs?
Master Draw 1969-A-1 (tube fitting)	Etna Products	synthetic wetting agents, fats, and emulsifiers; water soluble	~ 10% v/v with water, depending on use
Baker and Grubbins D1337 (tube fitting)			

Table A.5
Lubricants (continued)

Product	Manufacturer	Published Composition	Working Concentration
XE - 6368	Solene	90-92% alphatic petroleum distillates	use as packaged
XE - 6512	Solene	polyalkaleneglycol + additives	use as packaged
XE - 6338 Drawing Lube Cutting Lube	Solene	petroleum based with chlorinated paraffin	use as packaged
Rex Draw 176	Benz Oil, Inc.	mineral oil, 40% chlorinated paraffin, 40% proprietary emulsifier, 3% Ba & Na sulfonate, 10%	
Safety Kleen 140	Safety Kleen Corporation	petroleum naphtha, 100%	
Lab Oil #720	Heatbath Corporation	sorbitan monooleate, 2.4% naphthenic oil, 64.9% tetraethylene glycol, 2.4% polyglycol 400, 1.5% tripropylene glycol, 1.0% Alox 575, 27.8%	
Piedmont 562 Drawing & Extruding	Piedmont Chemical Co.	distillates (petroleum) hydro-treated, heavy naphthenic, >5% solvent refined paraffinic distillates, >5% sulfonic acid, petroleum, calcium salts, overbased (calcium sulfonate) >5%	
Draw Clean V	Oakite	aliphatic solvent 100%	
ZEROL 150	Shrieve Chemical Products Co.	alkylbenzene	
Oakite Formula #59	Oakite	paraffinic base stock, 2% ZDTP, pour point +10°F	
Etna 566	Etna Products		
Suniso 160	Witco	paraffinic base stock, 2% ZDTP, pour point +10°F	
CutMax-570		paraffinic base stock, 2% ZDTP, pour point +10°F	

Table A.6
Rust Inhibitors

Product	Manufacturer	Published Composition	Working Concentration
Resco 27-ABE-4	Research Metal Fluids	amine carboxylate salts	
Maaco 1961	Witco	none	
Maaco 102LK-6	Witco	none	
Rustarest 1073	Man-Gill Chemical	non-hazardous material	dilute with water
Novamax R44	Pillsbury Chemical & Oil	alkanolamine borates ethanolamine, 3-6%	
Rustproof 4200 Alkaline Corrosion Inhibitor	Ardrox	monoethanolamine, 15%	dilute with water
Protech 1300	Chemical Technologies, Inc.	petroleum naphtha and non-hazardous additives	
Gilcote 4127	Man-Gill Chemical	Borax (10 mole) dodecanoic acid sodium nitrite	dilute with water
Meca Lube	Puma Chemical Inc. Co.	ethyleneglycol monobutyl ether, <58% aliphatic hydrocarbon solvent, <2.0% mineral oil, >40%	use as packaged
Tectyl 900	Ashland Chemical, Inc.	barium petroleum sulfonate neutral, 1-5% lubricating oil base, 55-70% petroleum hydrocarbon, 10-25%	use as packaged
Eaken A/R - 10	R. W. Eaken Inc.	aliphatic hydrocarbon proprietary additive	
Resco Oxykoate Syn	Research Metal Fluids		
Resco Ultra Koate XP	Research Metal Fluids		
W&B Rust Inhibitor 3340	White & Babley of Michigan, Inc.	triethanolamine water boric acid caprylic acid oxygenated hydrocarbon partially neutralized with triethanolamine fatty amide concentrate	

Table A.6
Rust Inhibitors (continued)

Product	Manufacturer	Published Composition	Working Concentration
Rustproof Oil 00564	Texaco, Inc.	petroleum oil, 35-50% additive package containing barium, sulfur 1-5% additive package containing phosphorous, <1%	
Inhibitor W	Madison Chemical Co., Inc.	sodium nitrite, <60%	dilute in water
Rust Prevent 100	Dubois Chemicals, Inc.	non-hazardous	water reducible
Rust-Ban 343	Exxon Company, USA	distillate petroleum, <90% proprietary additives, <10%	use as packaged
Rust Vito 4214	E.F. Houghton & Co.	stoddard solvent, >60% mineral oil, 1-10%	unknown
Dri-Touch IRP1	Birchwood Casey	mineral spirits, >84% heavy petroleum oxygenates, barium neutralized ,12% propylene glycol monomethyl ether, <4%	unknown
Met-Chem 211	Met-Chem, Inc.	mixture of triethanolamine (85%) plus Aqualox 232 of amine salts of organic acids	dilute in water
Anti-Rust Oil #2-V	Amoco Oil Co.	stoddard solvent solvent refined paraffinic petroleum oil	use as packaged
Ferrocote 368	Quaker Chemical Corporation	diethylene glycol monobutyl ether, 1-5% barium sop of oxygenated hydrocarbon, 5-10%	unknown
Dubois 200 NT	Dubois Chemicals, Inc.	none given	unknown

Table A.7
Rust Preventatives

Product	Manufacturer	Published Composition	Working Concentration
Almco 2420	Almco	proprietary; mildly alkaline	0.5 - 2% v/v with water
Almco H10	Almco	proprietary	not stated
Rustilo 924	Castrol		
Rustilo DWX 30	Castrol		
Chemtool 625 ND	Chemtool	proprietary: "synthetic metalworking fluid"	not stated
Chemtool 1256	Chemtool	proprietary: "synthetic metalworking fluid"	not stated
Inpro-tect 600	Oakite	amines, phosphates, surfactants	3-7% v/v with water
Inpro-tect 670	Oakite	amines, phosphates, surfactants	3-7% v/v with water
Prevox 501	Parker	proprietary	3-10% v/v with water for spray, 5-20% for dip
Diversey E-314 Emulsion Cleaner/ RP	Diversey Corp.	unknown, but contains hydrocarbon mixture	dilute in water
ICS-423	Diversey Corp.		
Rust Preventative #308	Mullen Circle Brand, Inc.	mineral spirits, <1% glycol ether, >1%	

Table A.8
Sealants and Other Compounds

Product	Manufacturer	Published Composition	Working Concentration
Roto-Brite(R) L-543 Burnishing Compound	Roto-Finish	proprietary	1:12
Loctite 640 Sealant	Loctite	polyurethane methyl acrylate resin, 55-60% polyglycol dimethyl acrylate, 25-30%	use as packaged
Loctite 515 Gasket Eliminator Sealant	Loctite	polyurethane methyl acrylate resin, 70-75% polyglycol dimethyl acrylate, 25-30%	use as packaged
Renovator Deoxidizer	Oakite	phosphates, surfectants, fluorides, sequestrants	
Oakite 80 Biocide	Oakite	hexahydro-1,3,5-tris (2-hydroxyethyl)-s-triazine, 78.5% proprietary ingredients, 21.5%	
Loctite RC 620 Retaining Compound	Loctite	aromatic dimethacrylate ester, 75-80% maleimide resin, 10-15% cumene hydroperoxide 1-3 hydroxyalkyl methacrylate 1-3 methyl alcohol 1-3 silica, amorphous treated 1-3 1-acetyl-2-phenylhydrazine 0.1-1 N,N-dialkyltoluidines 0.1-1 maleic Acid 0.1-1 saccharin 0.1-1	use as packaged
Loctite Liter Retaining Compound 620	Loctite	aromatic dimethacrylate ester, 75-80% maleimide resin, 10-15% cumene hydroperoxide 1-3 methyl alcohol 1-3 silica, amorphous treated 1-3 1-acetyl-2-phenylhydrazine 0.1-1 N,N-dialkyltoluidines 0.1-1 maleic acid 0.1-1 saccharin 0.1-1	use as packaged