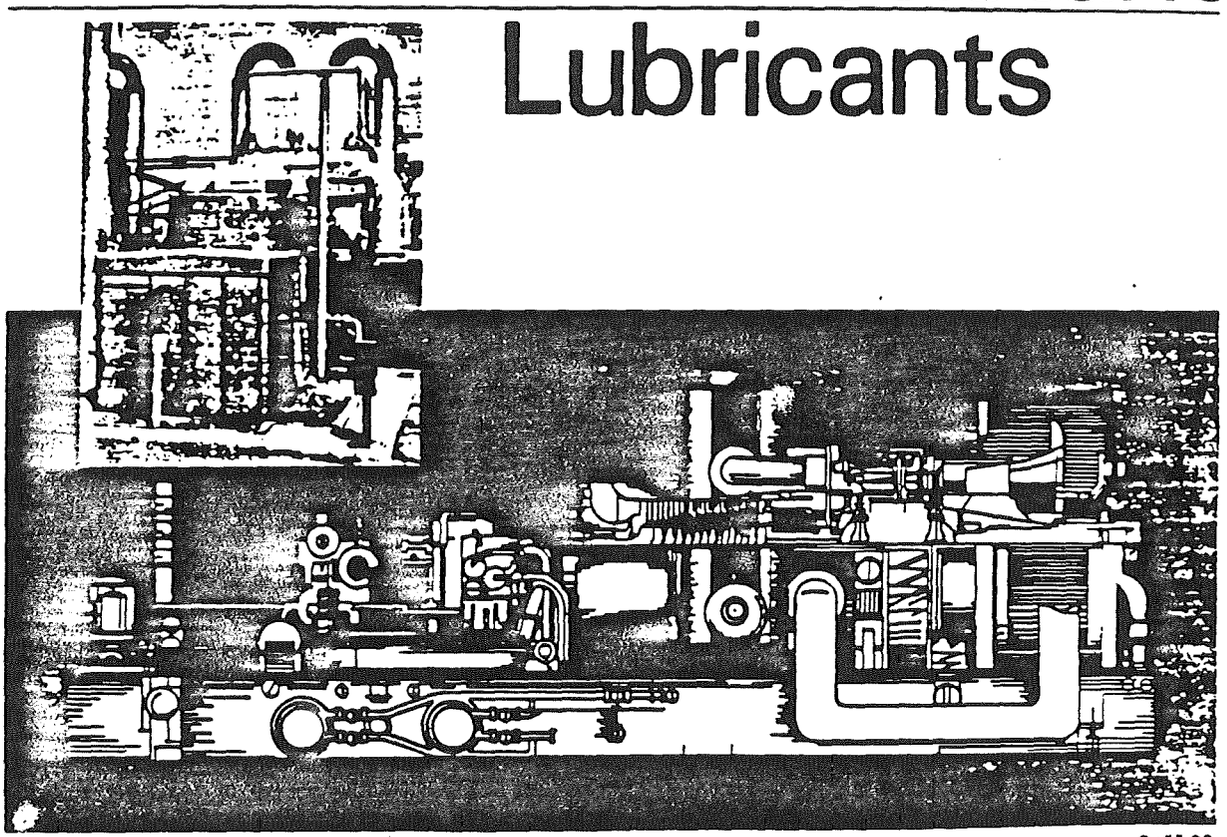
Facts About Fire-Resistant Lubricants



O/FF-23

TURBINOL

TURBINE LUBRICANT BY Monsanto

TEX 000330

TW1-0000304-000

PLAINTIFF'S EXHIBIT 6
1-9-92

HARTOLDMON0040802

Introduction

Monsanto's Turbinol® 153 is a fire resistant synthetic fluid specially designed for turbine systems. Turbinol 153 has years of safe, continuous operation as both the lubricant and control fluid in commercial pipe line gas turbines. The unique chemistry of Turbinol 153 offers excellent thermal-oxidative and hydrolytic stability.

The following abridged excerpts are from a paper titled, "Fire Resistant Lubricants In Gas Turbines," by Earl P. Farmer, Jr., of Texas Eastern Transmission Corporation. The paper was presented during the annual meeting of the American Society of Lubrication Engineers (ASLE), Power Generation Council Technical Session, in Chicago on May 4-7, 1970. It will appear as an article in Lubrication Engineer, the official ASLE magazine.

Hazards of Petroleum Lubricating Oils

The potential hazards inherent in using petroleum lubricating oils in high speed, high temperature gas turbine installations prompted Texas Eastern to investigate the applications of fire-resistant lubricants in our gas turbine installations. From our experiences, several potentially disastrous lube oil fires were prevented by alert operators who happened to be in the right place when turbine failures occurred. In another case, a turbine failure caused a lube oil fire, resulting in a complete station outage. A load compressor failure was responsible for another lube oil fire, which resulted in damages far more critical in the station operation than the compressor failure.

Still another hazard exists in the use of centrifugal pipe line compressors. These units require high-pressure seal oil systems with considerable external piping and controls. Even minor control and piping failures initiate emergency shut-down conditions, which, when using petroleum oil, necessitate the immediate shut-down of oil pumps to prevent feeding of possible fires. This means the high speed rotating elements must coast down with no lubrication, resulting in the strong possibility of wiped bearings. If the bearings are wiped badly, additional internal damage to the rotating elements and seals can result. Thus a minor failure can lead to a major station outage.

Advancing technology combined with rising operating costs led to the development and rapidly increasing use of automatic, remotely controlled, unmanned pipeline compressor stations. Obviously, this type of installation becomes most vulnerable to the potential hazards of lube oil fires. The obvious solution to these potential hazards is the use of fire-resistant lubricants.

Texas Eastern Tries Synthetics

In 1958, Texas Eastern pioneered the use of fire-resistant lubricants in large, industrial gas turbines when we installed four 13,400 HP @ 80°F. units with the phosphate ester based fluid as the only lubricant.

Today, we have twenty industrial type gas turbines in service using the fire resistant fluid in the oil systems. These twenty units, with a total of 323,800 HP, have operated in excess of 410,000 hours without any failures attributed to the fire resistant fluid.

Our operating experience over the past twelve years has proven the fire resistant fluid used in our gas turbines to be extremely stable, both thermally and oxidatively. None of the units using this lubricant have experienced an oil change because of excessive oxidation. Periodic tests have indicated little change in the neutralization number. A coupling guard leakage at one station provided a practical test of the oil's fire resistance by spraying oil against a 700 F exhaust housing with no fire resulting. Modifications and repairs by welding on oil piping within the oil tanks further demonstrated fire resistance.

Because of the added safety factor and the proven reliability and stability of the fire resistant fluid, it has become the standard lubricant in all our industrial type gas turbine installations placed in service since 1958.

TEX 000331

TW1-0000305-000

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Typical Properties of Turbinol

PHYSICAL PROPERTIES

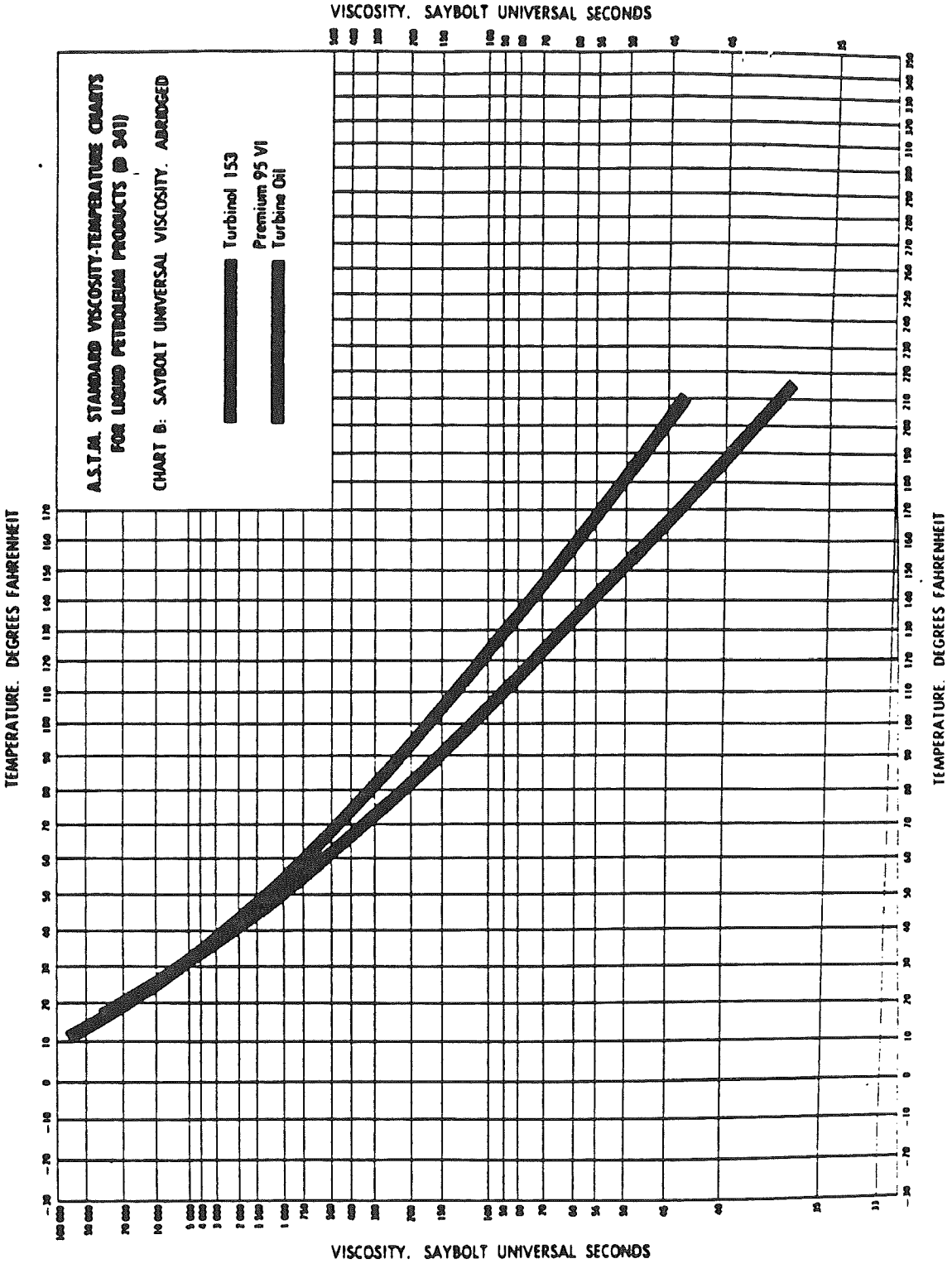
Appearance		Clear, amber colored oily liquid
Specific Gravity, variation with temperature:	40°F./60°F.	1.356
	100°F./60°F.	1.325
	200°F./60°F.	1.273
Neutralization Number (Acidity) (Mg KOH/gm)		0.02-0.1
Moisture (Max.)		0.15%
Viscosity Saybolts (SSU) Measured: @	40°F.	2160
	100°F.	108
	210°F.	37.1
Absolute-centipoise: @	40°F.	469
	100°F.	29.7
	210°F.	4.1
Pour Point		0°F.
Vapor Pressure (mm Hg @ 200°F.)		0.025
Boiling Point		625°F.
Secant Bulk Modulus (psi) @ 100°F.		412,000
Coefficient of Thermal Expansion cc/cc/°F.		0.00037
Solubility In Water		Negligible

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TEX 000333

LUBRICATION PROPERTIES

	Turbinol 153	Typical Premium R&O Turbine Oil
Four-Ball Wear Test (mm scar diameter) 620 rpm, 167 F., 1 hr.		
Steel/steel 10 kg	0.23	—
40 kg	0.53	0.6 to 1.0
Steel/bronze 10 kg	0.92	2.0 to 3.0
Timken Test Passing Load, lbs.	40	15
Falex Load Jaw Load, lbs.	4050	880
Torque, lb. inches	60	27

STABILITY AND CORROSION PROPERTIES

	Turbinol 153	Typical Premium R&O Turbine Oil
ASTM Rust Test D-665 140°F. Distilled Water	Pass	Pass
ASTM Emulsion Test D-1401 ml Emulsion after 30 minutes	0	0
ASTM Foam Test D-892		
Sequence 1	Pass	Pass
Sequence 2	Pass	Pass
Sequence 3	Pass	Pass
ASTM Turbine Oil Stability Test D-943 (Modified*) Hrs. to reach 2.0 mg KOH/g	>2000	2000
Hydrolytic Stability Test (MILH 19457—Beverage Bottle Test) 200°F. water, 48 hrs., Cu strip	Pass	Pass
Oxidation/Corrosion Test 168 hrs., 250°F., air		
Metal Attack, mg/cm²		
Al	−0.01	0.0
Mg	−0.01	0.0
Cu	−0.04	0.0
Fe	0.0	0.0
Cd	−0.01	0.0
Viscosity		
% Change, 100°F.	+8.5	+1.7
% Change, 210°F.	+0.6	+1.1
Acidity, TAN Change	+0.02	+0.41

*Because of the higher specific gravity of Turbinol, water used in the test would not settle to the bottom of the test cylinder. Hence, oxygen stream was saturated with water before being bubbled through the test fluid.

FIRE RESISTANCE PROPERTIES

High-Pressure Spray Test (AMS 3150-C and Federal Test Method Std. 791)	Localized flashing in contact with flame but self-extinguishing.
Low Pressure Spray Test	Slight increase in flame intensity.
Hot Manifold Test (Federal Test Method Std. 791)	
1300°F. Tube	Intermittent flashing on tube. Does not propogate flame to pan below.
950°F. Tube	Does not flash.
Molten Metal Ignition (Aluminum alloy @ 1200°F.)	Does not ignite spontaneously. Flashes intermittently with ignition source, but self-extinguishes.

ALCOR DEPOSITION TEST

48 hours, 250°F. fluid, 1000 ml/min. air flow @ 400°-475°F. tube temperature.

	Turbinol 153	Petroleum Oil
Total Deposit Rating	10.5	10.5
Filter, mg.	10	13
Acidity, TAN Change	+ 0.03	+ 0.02

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Seals and Packings Information

Materials compatible with Turbinol are necessary for dynamic or moving seals. For static seals they are preferred, but not essential. The following table indicates materials recommended. Packing materials such as impregnated asbestors are usually satisfactory with Turbinol. Consult your Monsanto fluid specialist for specific recommendations.

This list of component manufacturers is a guide to obtaining seals compatible with Turbinol. Please contact your equipment manufacturer or seal supplier for their most current recommendations.

Acushnet Process Company
776 Belleville Avenue
New Bedford, Massachusetts 02745

Anchor Packing Company
401 North Broad Street
Philadelphia, Pennsylvania 19108

Bearings, Inc.
3634 Euclid Avenue
Cleveland, Ohio 44115

A. W. Chesterton Company
Everett
Massachusetts 02149

Chicago Rawhide Manufacturing Company
1311 Elston Avenue
Chicago, Illinois 60622

C. E. Conover & Company, Inc.
333 Passaic Avenue
Fairfield, New Jersey 07006

Crane Packing Company
6400 Dakton Street
Morton Grove, Illinois 60053

Garlock Packing Company
Palmyra
New York 14522

Goshen Rubber Company, Inc.
P. O. Box 416
Goshen, Indiana 46526

Greene, Tweed & Company
North Wales
Pennsylvania 19454

Hercules Packing Corporation
11061 Walden Road
Alden, New York 14004

International Packing Corporation
Bristol
New Hampshire 03104

Johns-Manville
22 East 40th Street
New York, New York 10016

C. W Marsh Company
36 Hudson Street
Muskegon, Michigan 49441

Minnesota Rubber Company
3630 Wooddale Avenue
Minneapolis, Minnesota 55416

Parker Seal Company
10567 Jefferson Boulevard
Culver City, California 90230

Plastic & Rubber Engineering, Inc.
756 East Florence Avenue
Los Angeles, California 90001

Plastic & Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles, California 90047

Precision Rubber Products Corporation
Hartmann Drive
Lebanon, Tennessee 37087

Raybestos-Manhattan, Inc.
Packing Division
Passaic, New Jersey 07055

Reliable Rubber Products
Eddyington
Pennsylvania 19020

Rockwell Mechanical Packing Company, Inc.
1634 Long Beach Avenue
Los Angeles, California 90021

W. S. Shamban Company
11617 West Jefferson Boulevard
Culver City, California 90230

Vellumoid Company
Rockdale Street and Beaman Avenue
Worchester, Massachusetts 01606

The James Walker Packing Company, Inc.
P. O. Box 75
Chicago Heights, Illinois 60411

Filters and Hoses

FILTERS Most standard oil filters are satisfactory. You can use active earth or clay types. Filter manufacturers include:

Briggs Filtration Division
Bowser Corporation
Cookeville, Tennessee 38501

Capital Engineering Company
5839 Ashland Avenue
Chicago, Illinois 60610

Commercial Filters Corporation
(Honan-Crane)
Lebanon, Indiana 46052

Cuno Engineering Corporation
Sub. of American Mechine & Foundry
4627 S. Vine Street
Meriden, Connecticut 06450

Dollinger Corporation
20 Centre Park
Rochester, New York 14608

Fulflo Specialties Company, Inc.
410 Fancy Avenue
Blanchester, Ohio 45107

Hilliard Corporation
98 W. Fourth Street
Elmira, New York 14903

Marvel Engineering Company
7227 North Hamlin Avenue
Chicago, Illinois 60645

Pall Corporation
32 Sea Cliff Avenue
Glen Cove, L. I., New York 11542

Purolator Products
1000 New Brunswick Avenue
Rahway, New Jersey 07065

Rosaen Filter Corporation
1776 E. Nine Mile Road
Hazel Park, Michigan 48030

Schroeder Bros. Carporation
101 Nichol Avenue
McKees Rocks, Pennsylvania 15136

Serfilco Division
Service Filtration Corporation
7408 North Milwaukee
Niles, Illinois 60048

HOSES Butyl, nylon, Viton or Teflon are preferred when new hoses are installed. Suppliers include:

Anchor Coupling Company
3600 N. Fourth Street
Libertyville, Illinois 60048

Eastman Mfg. Company
(See Imperial-Eastman Carp.)
Department T. R.
6300 West Howard Street
Chicago, Illinois 60648

Electric Hose & Rubber Co.
1201 Duro Street
Wilmington, Delaware 19899

Gates Rubber Company
999 South Broadway
Denver, Colorado 80217

Imperial Eastman Corp.
6300 W. Howard Street
Chicago, Illinois 60648

Lewis Products
Hohenwald, Tennessee 38462

Samuel Moore Co.
Mantua, Ohio 44255

Resistoflex Corp.
Roseland New Jersey 07068

Stratoflex, Inc.
222 Roberts Cutoff Rd.
Fort Worth, Texas 76114

Weatherhead Corp.
302 E. 131st Street
Cleveland, Ohio 44108

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Other Components

SWIVEL COUPLINGS

Systems for Turbinol fluids often contain swivel couplings. Some suppliers are:-

Chiksan Division
FMC Corporation
332 N. Brea Boulevard
Brea, California 92621

PIPE JOINT SEALERS

. . . can be bought from:

American Sealants Company
(See Loctite Corporation)
115 N. Mountain Road
Hartford, Connecticut 06111

Crane Packing Company
6410 Oakton Street
Morton Grove, Illinois 60053

Dow Corning Corporation
Midland, Michigan 48640

Friesland Plastics Company
Friesland, Wisconsin 53935

General Electric Company
Insulating Materials Department
1 Campbell Road
Schenectady, New York 12306

Permatex Company
Department T. R.
Flagler Court Building
West Palm Beach, Florida 33401

W. S. Shamban & Company
11617 W. Jefferson Boulevard
Culver City, California 90230

Shell Chemical Company
110 W. 51st Street
New York, New York 10019

ACCUMULATORS

. . . some systems for Turbinol contain an accumulator which uses a bladder to separate the fluid from air or nitrogen pressure. For these, a rubber compatible with the fluid is necessary. Suppliers include:

Greer Hydraulics, Inc.
5930 W. Jefferson Boulevard
Los Angeles, California 90016

PAINTS

. . . resistant to Turbinol are supplied by:

Amercoat Corporation
Department T
Brea, California 92621

Andrew Brown Paint Company
5413 S. District Boulevard
Los Angeles, California 90022

Carboline Company
32-R Hanley Industrial Court
St. Louis, Missouri 63130

Carrol Products
148 Marine Street
Farmingdale, New York 11735

Finch Paint & Chemical Company
Torrence, California 90507

W. P. Fuller & Company
1645 W. Valencia Drive
Fullerton, California 92633

The Glidden Company
900 Union Commerce Building
Cleveland, Ohio 44114

Interchemical Corporation
Finishes Division
1255-T Broad Street
Clifton, New Jersey 07011

Lowe Brothers Company
Third & Madison Streets
Dayton, Ohio 45426

Magna Coatings & Chemical Corporation
1785 N. Eastern Avenue
Los Angeles, California 90032

Nycote Laboratories
15002 Delano Street
Van Nuys, California 91401

Pittsburgh Plate Glass Company
One Gateway Center
Pittsburgh, Pennsylvania 15222

Rinshed-Mason Company
5935 Milford
Detroit, Michigan 48210

Royalty Paint & Varnish Company
Pasadena, California 91101

Saran Protective Coatings Company
2415 Burdette at Reed
Ferndale, Michigan 48220

Sherwin-Williams Company
101 Prospect Avenue, N. W.
Cleveland, Ohio 44115

Titanine, Inc.
Seagrave Corporation
Elmwood & Morris Avenues
Union, New Jersey 07087

U. S. Paint, Lacquer & Chemical Company
2101 Singleton
St. Louis Missouri 63103

SOLUBILITY WITH OTHER FLUIDS

Other Phosphate Ester and Phosphate Ester-Base	Soluble in all proportions
Petroleum Oils	Soluble in all proportions, but petroleum oil can reduce the fluid's fire resistance.

HEAT TRANSFER PROPERTIES

Specific Heat BTU/lb/°F	
60°F.	0.297
100°F.	0.304
150°F.	0.318
200°F.	0.327
Thermal Conductivity BTU/°F./ft/hr	
60°F.	0.061
100°F.	0.061
150°F.	0.060
200°F.	0.060

ELECTRICAL PROPERTIES

Dielectric Constant @ 25°C.	
@ 60 cycles/sec.	6.52
@ 1000 cycles/sec.	5.94
Power Factor @ 25°C., %	
@ 60 cycles/sec.	52.00
@ 1000 cycles/sec.	3.45
Specific Resistivity (ohm-cm)	
@ 25°C.	1.7×10^{10}
@ 100°C.	2.0×10^{9}

TEX CCC336

HARTOLDMON0040808

DISTRICT SALES OFFICES ALL DIVISIONS

AKRON, OHIO 44313
260 Springside Drive
Montrose Development Park
Tel. (216) 666-4111

ATLANTA, GEORGIA 30326
Lenox Towers East
3400 Peachtree Rd. N. E. — Suite 1711
Tel. (404) 577-2260

BOSTON, MASSACHUSETTS 02149
Everett Station
Tel. (617) 387-5010

CHICAGO, ILLINOIS
3158 Des Plaines Ave.
Des Plaines, Illinois 60018
Tel. (312) 296-6688

CINCINNATI, OHIO 45206
1501 Madison Road
Tel. (513) 751-6707

DETROIT, MICHIGAN 48235
500 Northland Towers East
Tel. (313) 357-0910

HONOLULU, HAWAII 96812
205 Pacific International Bldg.
677 Ala Moana Blvd., P. O. Box 3824
Tel. (808) 531-2744

HOUSTON, TEXAS 77027
1301 Post Oak Tower
5051 Westheimer Road
Tel. (713) 621-9550

LOS ANGELES, CALIFORNIA 90022
6570 E. Flotilla St.
Tel. (213) 723-2492

NEW ENGLAND AREA
Hydrocarbons & Polymers Div.
730 Worcester St., Indian Orchard, Mass. 01051
Tel. (413) 788-6911
Plastic Products & Resins Div.
P. O. Box 2130, Springfield, Mass. 01101
Tel. (413) 788-6911

NEW YORK, NEW YORK 10017
277 Park Avenue
Tel. (212) 922-4111

ST. LOUIS, MISSOURI 63166
800 N. Lindbergh Blvd.
Tel. (314) 694-1000

SAN FRANCISCO BAY AREA
2710 Lafayette, Santa Clara, Calif. 95052
Tel. (408) 243-0414

SEATTLE, WASHINGTON 98121
2112 Third Avenue
Tel. (206) 622-4203

WILMINGTON, DELAWARE 19803
2005 Concord Pike, Fairfax
Tel. (302) 658-6631

Additional District Offices are maintained by:

Agricultural Division

ALLENTOWN, PENNSYLVANIA 18104
Park Professional Building
2200 Hamilton Street
Tel. (215) 437-8471

DECATUR, ILLINOIS 62523
207 Decatur Professional Building
363 South Main Street
Tel. (217) 423-6031

DES MOINES, IOWA 50318
312 Merle Hay Tower
Tel. (515) 276-8503

FREMONT, NEBRASKA 68025
150 South Main Street
Tel. (402) 727-1230

INDIANAPOLIS, INDIANA 46208
Suite 218, 4000 Meadows Drive Building
Tel. (317) 547-9148

KANSAS CITY, MISSOURI 64133
761 Blue Ridge Tower
4240 Blue Ridge Boulevard
Tel. (816) 353-8060

LULING, LOUISIANA 70070
P. O. Box 174
Tel. (504) 764-8263

MANKATO, MINNESOTA 56001
111 Madison East
Tel. (507) 387-3409

MEMPHIS, TENNESSEE 38104
303 Union Plaza Building
1838 Union Avenue
Tel. (901) 276-7811

MUSCATINE, IOWA 52761
P. O. Box 473
Tel. (319) 263-1331

Hydrocarbons & Polymers Division-Lisa Bill

EL DORADO, ARKANSAS 71730
Lion Oil Building
Tel. (501) 863-3111

JACKSON, MISSISSIPPI 39209
P. O. Box 10837, Westland Station
Tel. (601) 352-3648

N. LITTLE ROCK, ARKANSAS 72119
418 West 8th Street, P. O. Box 5821
Tel. (501) 376-2437

MEMPHIS, TENNESSEE 38113
1023 Riverside Drive, P. O. Box 13248
Tel. (901) 948-4481

Organic Division *(Rubber Instruments)*

AKRON, OHIO 44311
820 Brown Street, P. O. Box 2307
Tel. (216) 434-1982

Plastic Products & Resins Division

EUGENE, OREGON 97401
P. O. Box 1819
855 Seneca Road
Tel. (503) 342-7201

KENILWORTH, NEW JERSEY 07033
North Seventh St. & Monroe Ave.
Tel. (201) 276-2900

Textiles Division

ATLANTA, GEORGIA 30303
Atlanta Merchandise Mart
240 Peachtree St. N. W.
Tel. (404) 577-2260

CHARLOTTE, NORTH CAROLINA 28218
6230 Fairview Road, Suite 400
Tel. (704) 364-0116

GREENVILLE, SOUTH CAROLINA 29606
McAlister Plaza
P. O. Box 5664, Station B
Tel. (803) 239-8171

NEW YORK, NEW YORK 10001
350 Fifth Ave.
Tel. (212) 868-0100

Monsanto

TEX C0C337

Monsanto Company / Functional Fluids / 800 North Lindbergh Blvd. / St. Louis, Missouri 63166

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