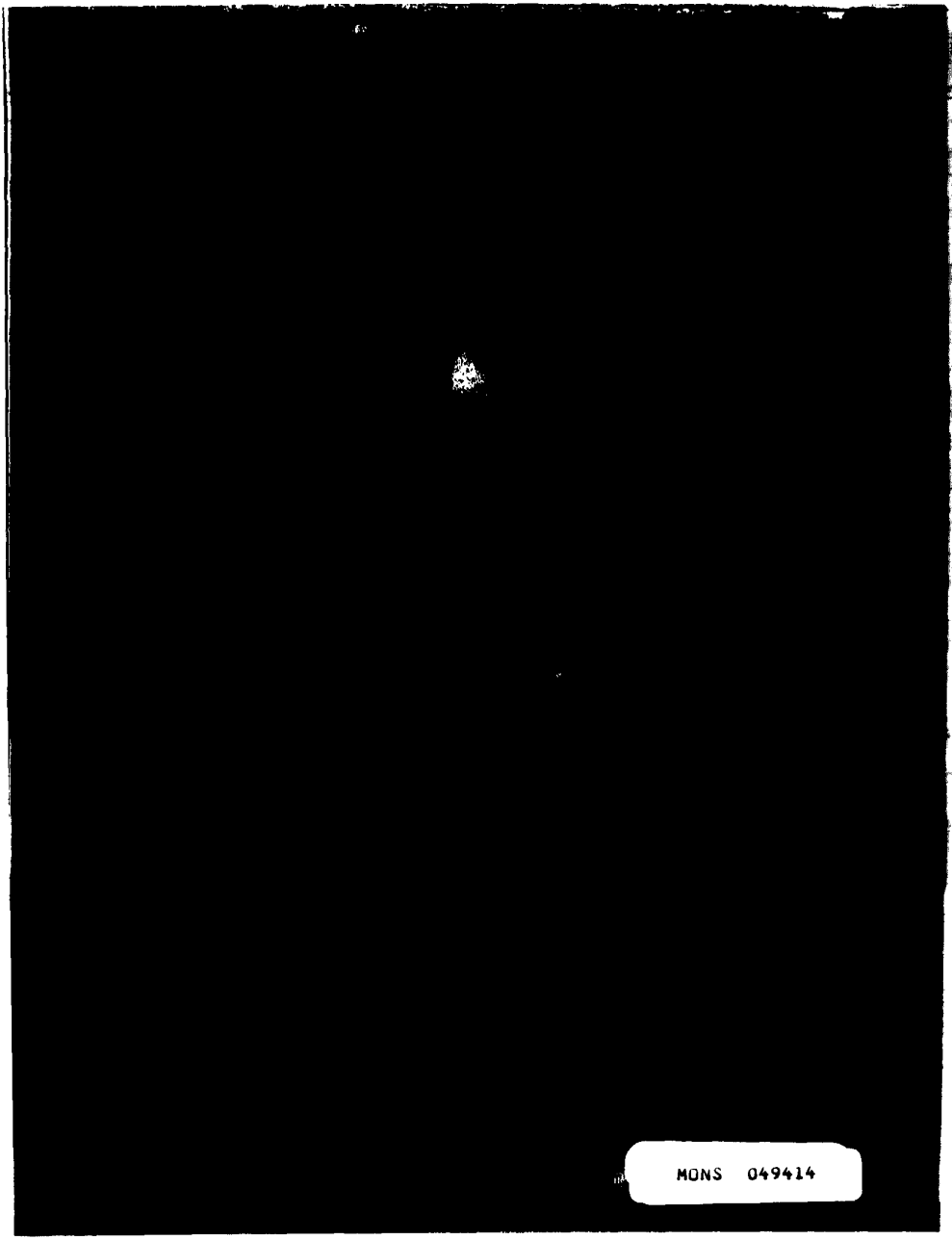


MONS 049413


MONS 049414

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This Copy For

APPROVAL OF SAFETY REVIEW COMMITTEE

Signed by H. E. Schulte
H. E. Schulte

Signed by P. K. Ward
P. K. Ward

J. C. Landwehr
J. C. Landwehr

MONSANTO COMPANY
ANNISTON PLANT

28 JUL 70

TENTATIVE AMENDMENT "C"

TO

AROCLOR BLENDS - STANDARD MANUFACTURING PROCESS

Dated August 1968

TITLE: PRODUCE VARIOUS BLENDS OF AROCLORS 1221, 5432, 5442 AND 5460.

OBJECTIVE: Make Aroclor blends to replace the plasticizer grade Liquid Aroclors which will be discontinued 31 Aug 70.

PRESENT PROCEDURE: These blends are not presently made.

PROPOSED AMENDMENT: These blends will be made in the 2000 gallon blend tank by adding the two ingredients in their approximate proportionate weights. Agitation, sample analysis, and further adjustments will be made to get the blend to meet the tentative specifications. The blended batch will then be drummed for storage and/or subsequent sales.

Initially the following blends are expected to be made:

Blend Name	Approximate Composition	Replaces
Aroclor 6090	90% 5460; 10% 1221	Aroclor 4465
Aroclor 6070	70% 5460; 30% 1221	Aroclor 1260
Aroclor 6062	62% 5460; 38% 1221	Aroclor 1254
Aroclor 6050	50% 5460; 50% 1221	Aroclor 1248
Aroclor 6040	40% 5460; 60% 1221	Aroclor 1242
Aroclor 4272	72% 5442; 28% 1221	Aroclor 1254
Aroclor 3270	70% 5442; 30% 5460	Aroclor 4465

Further blends may be required to meet marketing needs under this proposed amendment and will be done so as the need arises.

SOURCE OF DATA: 1. Letter J. W. Baker to J. T. Bell, 15 Jul 70

2. Letter W. S. Clark to A. W. M. Coaker, 10 Jul 70

SAFETY: This proposed amendment will not affect the safety of the Aroclor department.

QUALITY: The properties of the blends will be measured against the tentative specs issued 7/27/70.

EXTENT OF TRIAL: Six months will be needed to work out the proportions of the ingredients for each blend necessary to meet the desired sales specs. Research will be contacted for any changes necessary to produce a more marketable product.

Originated by: V. R. Haupt

:kd

MONS 049416

APPROVALS:

Department Supervisor: Orig. signed by G. W. Miller — 8/17/70
G. W. Miller — Date

Production Superintendent: Orig. signed by J. L. Corder — 8/31/70
J. L. Corder — Date

Plant Manager: Orig. signed by G. L. Jessee — 8/31/70
G. L. Jessee — Date

PR&D Group Leader: Orig. signed by J. L. Brown — 9/1/70
J. L. Brown — Date

Research Group Leader: Orig. signed by J. W. Baker — 9/10/70
~~J. W. Baker~~ — Date

Mgr. of Research & Dev.: Orig. signed by M. W. Farrar — 9/14/70
M. W. Farrar — Date

Manufacturing Manager: Orig. signed by J. E. Smith/J. R. Savage — 9/13/70
~~J. E. Smith~~ — Date

CONFIDENTIAL

MONSANTO COMPANY
ORGANIC CHEMICALS DIVISION
ANNISTON, ALABAMA

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

Department 826.47

Prepared by: M. J. Williams
Prod. Foreman

Reviewed by: R. A. Haydel
Prod. Supervisor

H. L. Williams
Prod. Superintendent

Issued: August 1968

COPY NO. 10

CONFIDENTIAL INFORMATION

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STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

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MONS 049420

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

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I. Process Control Procedures
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L. Time Cycles
M. Quality Considerations
N. Miscellaneous

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Plant Standards Dept. (Extras)

APPROVAL OF SAFETY REVIEW COMMITTEE

Signed by H. E. Schulte
H. E. Schulte

Signed by P. K. Ward
P. K. Ward

J. C. Landwehr
J. C. Landwehr

MONSANTO COMPANY
ANNISTON PLANT

28 JUL 70

TENTATIVE AMENDMENT "C"

TO

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Dated August 1968

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OBJECTIVE: Make Aroclor blends to replace the plasticizer grade Liquid Aroclors which will be discontinued 31 Aug 70.

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PROPOSED AMENDMENT: These blends will be made in the 2000 gallon blend tank by adding the two ingredients in their approximate proportionate weights. Agitation, sample analysis, and further adjustments will be made to get the blend to meet the tentative specifications. The blended batch will then be drummed for storage and/or subsequent sales.

Initially the following blends are expected to be made:

Blend Name	Approximate Composition	Replaces
Aroclor 6090	90% 5460; 10% 1221	Aroclor 4465
Aroclor 6070	70% 5460; 30% 1221	Aroclor 1260
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Aroclor 6050	50% 5460; 50% 1221	Aroclor 1248
Aroclor 6040	40% 5460; 60% 1221	Aroclor 1242
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Further blends may be required to meet marketing needs under this proposed amendment and will be done so as the need arises.

SOURCE OF DATA: 1. Letter J. W. Baker to J. T. Bell, 15 Jul 70

2. Letter W. S. Clark to A. W. M. Coaker, 10 Jul 70

SAFETY: This proposed amendment will not affect the safety of the Aroclor department.

QUALITY: The properties of the blends will be measured against the tentative specs issued 7/27/70.

EXTENT OF TRIAL: Six months will be needed to work out the proportions of the ingredients for each blend necessary to meet the desired sales specs. Research will be contacted for any changes necessary to produce a more marketable product.

Originated by: V. R. Haupt

:kd

APPROVALS:

Department Supervisor:	Orig. signed by G. W. Miller G. W. Miller	8/17/70 Date
Production Superintendent:	Orig. signed by J. L. Corder J. L. Corder	8/31/70 Date
Plant Manager:	Orig. signed by G. L. Jessee G. L. Jessee	8/31/70 Date
PR&D Group Leader:	Orig. signed by J. L. Brown J. L. Brown	9/1/70 Date
Research Group Leader:	Orig. signed by J. W. Baker J. W. Baker	9/10/70 Date
Mgr. of Research & Dev.:	Orig. signed by M. W. Farrar M. W. Farrar	9/14/70 Date
Manufacturing Manager:	Orig. signed by J. E. Smith/J. R. Savage J. E. Smith	9/13/70 Date

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R. A. Haydel
H. E. Schulte
Technical Services (3)
Plant Standards Department (Extras)

MONSANTO COMPANY
ANNISTON PLANT

March 17, 1970

TENTATIVE AMENDMENT "B"

TO

AROCLOR BLENDS - STANDARD MANUFACTURING PROCESS

Dated: August, 1968

TITLE: Produce Inerteen 54201-A9 by blending Aroclor 1242 and TCB in proportions such that final blend is approximately 65% 1242 and 35% TCB.

OBJECTIVE:

To produce new blend for sales.

PRESENT PROCEDURE:

Blend is not presently made. However, it will be similar to Inerteen 54201-A6 except that the components will be blended in different ratios.

PROPOSED PROCEDURE:

Aroclor 1242 and TCB will be blended in an agitated, aluminum tank to produce a blend which is approximately 65% Aroclor 1242 and 35% TCB. Actual ratios of the components will vary somewhat in individual blends depending on exact composition of the components. Upon producing each individual blend, control analyses will be run in the Lab to assure material meets specs before packaging for sales.

SOURCE OF DATA:

Lab made pilot blend of the A-9 and developed the tentative specs based on analyses of this pilot blend.

SAFETY: This process has no affect on the safety of the operations.

QUALITY: The quality of each batch produced will be lab monitored to insure shipment of in spec material.

R. A. Haydel
Department Supervisor

/md

APPROVALS:

Department Supervisor	R. A. Haydel	3-17-70 Date
Production Superintendent	H. L. Williams	3/17/70
Plant Manager	C. L. Jessee	3-17-70
Research Manager	Master copy signed W. R. Richard	3/27/70
Technical Prod. Manager	Master copy signed J. R. Savage	4/2/70

MONS 049426

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

AMENDING RECORD SHEET

Amendment No.	To: Std. Manufacturing Process	Title

MONS 049427

SYNOPSIS OF
PROCESS

MONS 049428

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

I. SYNOPSIS OF PROCESS

Production of Pyranols is a blending process. Distilled Aroclors, and other raw materials, are pumped to one of two Pyranol mix tanks. These raw materials may come from a filtrate tank, storage tank, tank car or drums. Each mix tank is equipped with an agitator for thorough mixing of material.

Quality of a Pyranol mix is analyzed by the laboratory and when in specification it is loaded into tank cars or drawn into suitable containers.

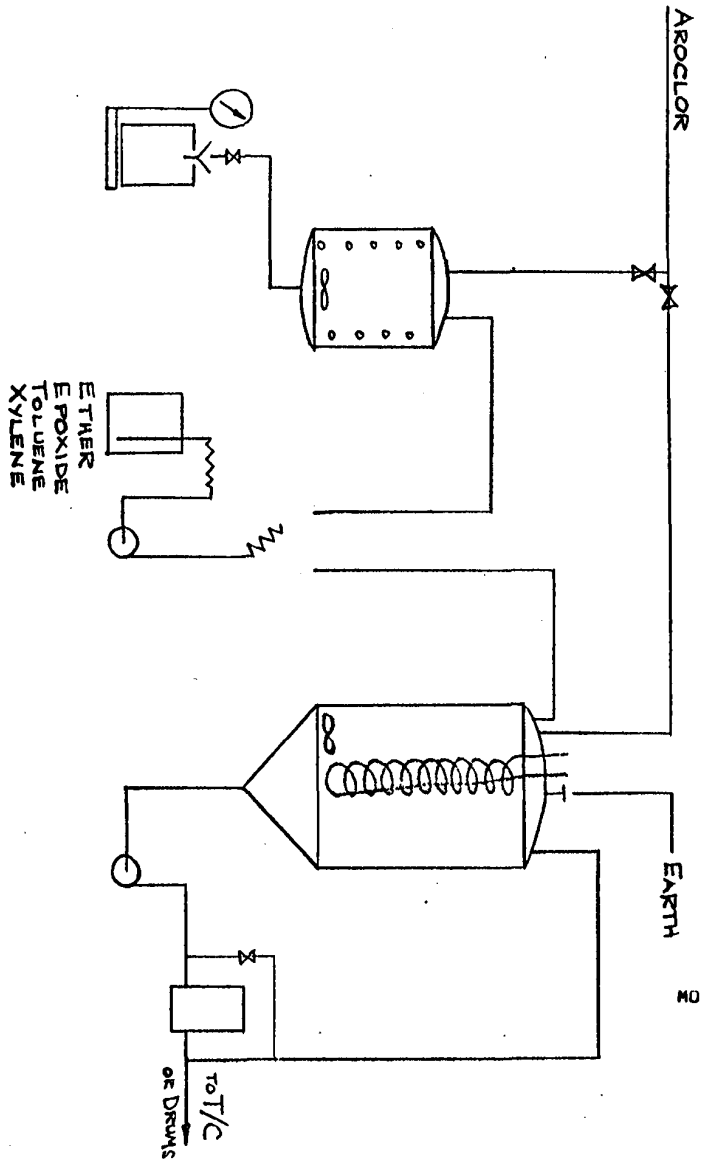
FLOW SHEET

MUNS 049430

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

II. FLOW SHEETS

BY VRH DATE 4/4/68 SUBJECT PYRANOL BLENDS FLOW SHEET SHEET NO ..... OF .....
CHKD. BY ..... DATE ..... JOB NO. .....



MONS 049432

PROCESS IN
DETAIL

MONS 049433

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

III. PROCESS IN DETAIL

A. Pyranol Mixes Produced

Most Pyranols are produced by the mixing of distilled Aroclor with various other raw materials. Some of the Pyranols are treated with attapulgus earth and filtered prior to loading for shipment. There are three Pyranol blends that are produced by the mixing of distilled Aroclors only.

The Pyranol area is actually a part of the Aroclor Department and all Pyranol mixes are made by the Aroclor operators.

The quality of each mix is analyzed by the laboratory and when approved it is loaded into tank cars or drawn out into drums.

See Table I for raw materials and quantity of each used in the production of each product or mix.

B. Mix Tank Area

There are two mix tanks used in the production of Pyranol mixes. One is a 12,000 gallon tank and the other is a 2,000 gallon tank. Each tank is equipped with an agitator to assure good mixing. Each tank is also equipped with a steam coil to provide desired temperature. Sales demand for some of the mixes does not warrant production of large batches which accounts for the second, or small mix tank. All mixes produced in the large tank are filtered through a Sparkler filter. Mixes produced in the small tank are not treated with attapulgus earth and are packaged in drums only and filtered through a diaper cloth sock on the end of the draw-out line.

TABLE

PRODUCT	ARO.% 1242	ARO. % 1248	ARO. % 1254	ARO. % 1260	ARO. % 1262	ARO.% 4465	% Toluene	% Xylene	% PPO	% TCB	% TTCB	% EARTH	% EP221
1254 - 10% Toluene			90.00				10.00						
1260 - 10% Toluene				90.00			10.00						
1262-10% Toluene					90.00		10.00						
1262-10% Xylene					90.00			10.00					
Pyranol A13B3B				45.00							55.00	0.03	0.125
Inerteen PPO				60.00					0.20	40.00		0.01	
Inerteen 54201-KA			70.00						0.20	30.00		0.03	
Inerteen 54201-CM	100.00								0.20			0.01	
Inerteen 54201-A-6	75.00									25.00		0.01	
Therminol FR-0	80.00										20.00		
Therminol FR-Lo Temp.	50.00										50.00		
Santicizer 794		50.00		50.00									
Aroclor Blend			85.00			15.00							
Aroclor Blend	28.00	72.00											

MONS 049435

COMMENTS ON
PROCESS

MONS 049436

IV. COMMENTS ON THE PROCESS

Do not allow temperature on mix tanks to exceed 120°C. TCB and TTCB will begin to vaporize above this temperature.

The large pyranol mix tank is calibrated in outage whereas other tanks are calibrated in innage.

All drums filled with pyranol mixes containing toluene are stenciled TOLUOL rather than toluene.

When a tank car is loaded from the large pyranol mix tank samples are taken from the car and analyzed for lot number. If the remaining material in the mix tank is drawn out in drums then samples must be taken from the drums and analyzed for another lot number.

The area where pyranol mixes are produced is considered a part of the Aroclor Department and these mixes are made by Aroclor operators.

Each car of TCB and TTCB must be analyzed and approved by the laboratory before being used, to prevent high chemical instability in the finished product.

Special precautions are necessary when making Inerteen 54201-KA:

1. TCB is earth treated to bring power factor below a value of ten.
2. TCB plus 1254 mix is earth treated until power factor is below a value of one.
3. Ether is added only after earth has been filtered out and filter cleaned.
4. Tank car is loaded only when power factor has a value of three max.
5. Most important, nitrogen is blown into mix tank through the bottom nozzle during the earth treatment to supplement the extremely poor agitation system presently employed.

MONS 049438

APPENDICES

MONS 049439

STANDARD MANUFACTURING PROCESS
FOR
AROCLOR BLENDS

APPENDIX A - EQUIPMENT LIST

Appendix A - Equipment List

Item	Equipment	Equip.No.	Description
205	South (large) Pyranol Mix Tank	22-0108	14'-0" I.D. x 10'-0" high. Dwg. D-6455 zinc-tin lined carbon steel.
206	North (small) Pyranol Mix Tank		6'-6" I.D. x 8'-2" jacketed 316 S.S. tank.
643	Pyranol Filter	15-0029	Model 18-S-23 horizontal plate type 304 S.S. w/scavenger plate feature on pipe legs. Purchased from Sparkler Mfg. Co.

Other equipment used in the production of Pyranol mixes is considered Aroclor equipment.

MONS 049441

J

MONS 049442

APPENDIX B - MATERIAL SPECIFICATIONS

I. Finished Goods

Material Code	Product
826.64	Aroclor 1254 - 10% Toluene
826.59	Aroclor 1260 - 10% Toluene
826.61	Aroclor 1262 - 10% Toluene
826.56	Aroclor 1262 - 10% Xylene
826.58	Pyranol A13B3B
826.49	Inerteen PPO
826.81	Inerteen 54201-KA
826.90	Inerteen 54201-CM
826.89	Inerteen 54201-A-6
826.12	Therminol FR-1
826.41	Therminol FR-2
826.13	Therminol FR-3
826.85	Therminol FR-0
826.88	Therminol FR-Lo Temp.
826.03	Therminol 66
826.78	Santicizer 794
826.79	Aroclor 1254 - 4465
826.87	Aroclor 1242 - 1248
	Inerteen 54201-A-9

APPENDIX B - MATERIAL SPECIFICATIONS

II. Raw Materials

Material Code	Product
826.12	Aroclor 1242
826.41	Aroclor 1248
826.13	Aroclor 1254
826.14	Aroclor 1260
826.15	Aroclor 1262
826.19	Aroclor 4465
58900	Toluene
64020	Xylene
36100	Phenyl Glycidyl Ether
60200	Trichlorobenzene
58500	Tri-Tetrachlorobenzene
19400	Attapulgus Earth
61325	EP-221

MONS 049444

K

MONS 049445

APPENDIX C - PHYSICAL CONSTANTS OF FINISHED GOODS, INTERMEDIATES, AND MAJOR RAW MATERIALS

MONS 049446

Copies for: H. L. Gray
V. R. Haupt
M. T. Williams
T. E. Lackey

Monsanto

FROM (NAME & LOCATION): St. Louis - General Offices

DATE: January 26, 1968

SUBJECT: Westinghouse
Inerteens

REFERENCE:

TO:

G. Axcell - Los Angeles
K. Buddy - KBUDD
L. M. Clark - Houston
R. Crabtree - Atlanta
B. Dolimount - Pittsburgh
A. Eckersley - Toronto
R. Ehrhardt - New York
L. Erman - Detroit
M. Fitzgerald - Everett
H. W. Hayden - HHAYD
J. Hendricks - Cleveland
C. Heybruch - Cincinnati
R. Mulholland - RMULH
V. Oliver - Pittsburgh
M. Penn - Chicago
F. Perkins - Minneapolis
J. Ritt - JRITT
W. Stewart - WSTEW
F. Stupfell - Seattle
J. Tannehill - Santa Clara
M. J. Tingle - Wilmington

cc:

P. G. Benignus
H. S. Bergen - HBERG
J. Bonavoglia - New York
R. Damiani - Chicago
H. Day - HDAY
D. E. Eriksen - Los Angeles
G. Fague - Detroit
G. R. Graham - New York
H. L. Gray - Anniston
D. A. Hall - Cleveland
R. C. Hamil - Atlanta
D. L. Hosmer - Chicago
W. G. Martin - New York
D. T. Mayer - WGK
R. C. Meyer - Cincinnati
G. Miller - Anniston
R. Kuster - WGK
T. Oneson - Montreal
D. R. Pogue - Los Angeles
J. Rains - WGK
H. Ray - WGK
D. Samford - DSAMF
M. T. White - MWHIT
H. Williams - Anniston
H. C. Carder - HCARD
W. B. Papageorge - Anniston

Westinghouse is now purchasing a number of our Aroclors and blends, all under the common name of Inerteen 54201. To differentiate between the various capacitor and transformer fluids, Westinghouse simply uses letters following the above number to signify the different types.

We are concerned that this common number showing on orders coming to us from Westinghouse may result in confusion and uncertainty as to which product is needed, and it might result in wrong product being shipped by mistake.

To assist in avoiding such possible errors, the following definitions of the various products may be helpful:

Westinghouse Name	Monsanto Name		Use
Inerteen 54201 CC	Inerteen PPO		
	Product Code:	1050-200-16-03/09	Transformers
	Composition:		
	Aroclor 1260	60%	
	TCB	40%	
	PPO	0.2%	

MONS 049447

IM 10 REV 11 65

Westinghouse Name	Monsanto Name	Use
Inerteen 54201KA	Inerteen 70-30 Transformer Product Code: 1050-210-16-03/09 Composition: Aroclor 1254 70% TCB 30% PPO 0.2%	Transformers
Inerteen 54201 CM	Inerteen 100-42 Transformer Product Code: 1050-215-16-03/09 Composition: Aroclor 1242 100% PPO 0.2%	Transformers
Inerteen 54201CF	Aroclor 1242 Product Code: 1040-240-16-09 Composition: Aroclor 1242 100%	Capacitors
Inerteen 54201A6	Inerteen 75-25 (Capacitor) Product Code: 1060-100-16-09 Composition: Aroclor 1242 75% TCB 25%	Capacitors

It is recommended that future orders to plants show both Westinghouse and Monsanto names for the individual products:

Monsanto	Westinghouse
Inerteen PPO	Inerteen 54201 CC
Inerteen 70-30 Transformer (1254-TCB)	Inerteen 54201 KA
Inerteen 100-42 Transformer (1242-PPO)	Inerteen 54201 CM
Aroclor 1242 (Capacitor)	Inerteen 54201 CF
Inerteen 75-25 (Capacitor) (1242-TCB)	Inerteen 54201 A6

C. M. WILLIAMS

/jm

Monsanto

FROM (NAME & LOCATION): St. Louis - General Offices

DATE: April 18, 1969

SUBJECT: THERMINOL 88

REFERENCE:

TO: Anniston
Harris Powell

cc: H. J. Day - HDAY
J. R. Fallon
D. E. Roush
D. Samford - DSAMF
S. Shaw
M. T. White - MWHIT
M. Williams - Anniston

Confirming our phone conversation, THERMINOL 88 is a new heat transfer media being offered; and you will be receiving orders for this product.

THERMINOL 88 is Santowax R; however, we must be extremely careful that all container markings and shipping papers on orders calling for THERMINOL 88 identify the product as THERMINOL 88 only. Any slip can jeopardize the special pricing for this product.

Product code - 7795-088-11-09 has been assigned to THERMINOL 88.

Marketing tentatively plans to offer this product in:

75 lb. net paper bags
225 lb. (51 gallon) lever-pak drums

which will conform with your Santowax packing.

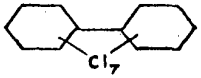
We appreciate your assistance in protecting the identity.

C. M. WILLIAMS

/jm

PHYSICAL CONSTANTS DATA

SUBSTANCE: AROCLOR 1262

STRUCTURAL FORMULA: 

COMPILED BY: A. M. Ellenburg

DATE: 7/3/57

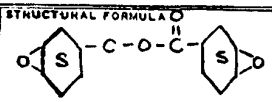
NAME		SOURCE & DATE
Formula	$C_{12}H_3Cl_7$	
Molecular Weight	395	
Appearance	Light yell. sticky Resin	Monsanto Bulletin OP-115
Boiling Point at 760 mm	390-425°C	" (1956)
Boiling Point at mm		
Boiling Point at mm		
Boiling Point at mm		
Crystallizing Point		
Melting Point		
Solution Point		
Specific Gravity @ 90/15.5°C	1.577-1.587	Specs. 4/11/55
Specific Gravity @ 25/25°C	1.646	MB OP-115
Pounds per Gal. @ 25 °C	13.72	"
Coefficient of Expension 25-65°C	0.00064 cc/cc/°C	"
Refractive Index @ 25°C n_D	1.648-1.650	"
Infra Red Spectrum *(Reference)*		
Ultra Violet Spectrum *(Reference)*		
Viscosity @ 210°F	86-100 SUS	Specs. 4/11/55
Viscosity @		
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in		
Flash Point °F *(Method)*	None	MB OP-115
Fire Point °C	None	"
Heat of Combustion		
Heat of Formation		
Thermal Stability (cal./kg/min.)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		
Pour Point	35-38°C	
Other Constants		
		MONS 049450
Toxicity *(Give Reference)*	Contact Med. Dept.	MB OP-115

NOTE: *These data should not be released outside of Monsanto Chemical Company. Use additional sheets if necessary.*

Jan 69

PHYSICAL CONSTANTS DATA

SUBSTANCE: UNOX EPOXIDE 221 (dicyclo diepoxy carboxylate)

STRUCTURAL FORMULA: 

COMPILED BY: VERHAUPT DATE: 4-5-68

NAME		SOURCE & DATE
Formula	$O(C_6H_8)CH_2OCO(C_6H_8)O$	REF 1
Molecular Weight	252.31	
Appearance		
Boiling Point at 760 mm	354°C	REF 1
Boiling Point at mm	<0.01 mm 20°C	
Boiling Point at mm		
Boiling Point at mm		
Crystallizing Point	-20°C	REF 1
Melting Point		
Solution Point		
Specific Gravity @ 20/20°C	1.1750	REF 1
Specific Gravity @		
Pounds per Gal. @ 20°C	9.76	REF 1
Coefficient of Expansion		
Refractive Index @ $n_D^{\ }$		
Infra Red Spectrum (Reference)		
Ultra Violet Spectrum (Reference)		
Viscosity @		
Viscosity @		
Surface Tension		
Solubility in Water @ 20°C	0.03 wt %	REF 1
Solubility in		
Solubility in WATER IN 221	2.8 wt %	REF 1
Flash Point °F (Method) CLEVE OPEN CUP	400°F	REF 1
Fire Point °C		
Heat of Combustion		
Heat of Formation		
Thermal Stability (cal./kg/min.)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		

Other Constants

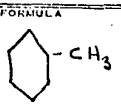
References:
1. 1967 ED - PHYS PROPS - UNION CARBIDE CHEMICALS

Toxicity (Give Reference)

MONS 049451

PHYSICAL CONSTANTS DATA

SUBSTANCE: TOLUENE (METHYL BENZENE)

STRUCTURAL FORMULA: 

COMPILED BY: VB/AVPT 4-6-68 DATE:

NAME		SOURCE & DATE
Formula	$(C_6H_5)CH_3$	REF 1
Molecular Weight	92.13	REF 1
Appearance	COL LQ	REF 1
Boiling Point at 760 mm	110.8 °C	REF 1
Boiling Point at 5.62 mm	5.4 °C	REF 1
Boiling Point at 40.00 mm	59.1 °C	REF 1
Boiling Point at 90.00 mm	404.6 °K	REF 1
Crystallizing Point		
Melting Point	−95 °C	REF 1
Solution Point		
Specific Gravity @ 20/4 °C	0.866	REF 1
Specific Gravity @		
Pounds per Gal. @		
Coefficient of Expansion		
Refractive Index @ n_D^{20}		
Infra Red Spectrum (Reference)		
Ultra Violet Spectrum (Reference)		
Viscosity @		
Viscosity @		
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in ALCOHOL, ETHER	MISCIBLE	REF 1
AUTOIGNITION PT	1026 °F	REF 1
EXPLOSIVE LIMITS % VOL	1.27 − 7.0	REF 1
Flash Point °F (Method) OPEN CUP	45 °F	REF 1
Fire Point °C		
Heat of Combustion		
Heat of Formation		
Thermal Stability (cal./kg/min.)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		
References: 1. LANGE'S HANDBOOK OF CHEMISTRY		
Other Constants		
Toxicity (Give Reference)		MONS 049452

PHYSICAL CONSTANTS DATA

SUBSTANCE: TRI-TETRA BLEND

STRUCTURAL FORMULA: Composition

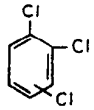
1, 2, 3, 4-Tetra	26-29%
1, 2, 4, 5-Tetra	0- 3%
Penta	0- 5.5%
Trichlorbenzene	Remainder

Syst. No. 466 [V 204

COMPILED BY: D. K. Lynch

DATE: 12/13/54

NAME		SOURCE & DATE
Formula	Mixture	Specification
Molecular Weight	---	
Appearance	W W Liquid	(GE material D5 B 69)
Boiling Point at 760 mm	210-270°C.	
Boiling Point at mm		
Boiling Point at mm		
Boiling Point at mm		
Crystallizing Point	-15°C. (Max.)	
Melting Point		
Solution Point	0°C	
Specific Gravity at 15.5/15.5°C.	1.510-1.520	
Specific Gravity at		
Pounds per Gal. at 15.5°C	12.6	
Coefficient of Expansion		
Refractive Index at 25°C. n D	1.5775-1.5790	
Infra Red Spectrum *(Reference)*		
Ultra Violet Spectrum *(Reference)*		
Viscosity at		
Viscosity at		
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in		
Flash Point °F *(Method)*		
Fire Point °C	None to B. P.	
Heat of Combustion		
Heat of Formation		
Thermal Stability (cal./kg/min.)		0
Mean Heat of Fusion		
Mean Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Association Constant		



TRICHLOROBENZENE, (Tech.) - DATA SHEET NO. 700-D

HOOKER SPECIFICATIONS

Description	Clear, almost colorless liquid
Freezing Point	10°C max
Distillation Range	5°C max, including 216°C
Specific Gravity, 15.5°C/15.5°C	1.460 to 1.475
Moisture Content	0.05% max

DESCRIPTION

Hooker Trichlorobenzene is a technical grade material being a mixture of 1, 2, 4 and 1, 2, 3-trichlorobenzenes. It is a clear, almost colorless mobile liquid having a characteristic chlorobenzene odor.

Formula	$C_6H_3Cl_3$
Molecular Weight	181.5

TYPICAL PROPERTIES

Freezing Point	0°C to 5°C
Distillation Range	5°C between the limits 213° and 219°C
Decomposition Temperature	300 + °C
Color (APH)	20
Flash Point (Cleveland open cup)	240°F
Fire Point (Cleveland open cup)	None up to boiling point
Specific Gravity 15.5°C/15.5°C	1.466
Density Correction Factor per 1°C	.00124

MONS 049454

The information presented herein, while not guaranteed, is to the best of our knowledge true and accurate. No warranty or guarantee express or implied is made regarding the performance or stability of any product, since the manner of use and conditions of storage and handling are beyond our control. No suggestion for product use, nor anything contained herein, shall be construed as a recommendation for its use in infringement of any existing patent.

Refractive Index, n20/D	1.570
Pounds per Gallon at 15.5°C	12.2
Specific Heat at 25°C *	0.20
Latent Heat of Vaporization *	54 cal/gm (98 BTU/lb)
Boiling Temp at 50 lb gage	280°C
Surface Tension at 25°C	38.9 dynes/cm
Coefficient of Cubical Expansion at 30°C	.00086

Viscosity	Centistokes	Centipoises
at 100°F	1.100	1.579
at 210°F	0.549	0.746

Vapor Pressure (1) at 100°C 23 mm

Solubility at 25°C	gms/100 gms
Water in Trichlor	0.22
Trichlor in Water	0.0025
Acetone	Completely miscible
Benzol	" "
Butanol	" "
Carbon Tetrachloride	" "
Diethyl Ether	" "
Ethylene Dichloride	" "
Linseed Oil	" "
Methanol	" "
Petroleum Ether	" "
Solvesso No 2	" "

MONS 049455

* Literature data

USES

1. Insecticide: particularly effective as a soil poison in termite eradication.

2. Solvent: for fats, oils, waxes, resins and as a crystallization solvent.

3. Heat transfer medium; its physical properties indicate that it is particularly adaptable to condensing vapor systems for a range of from 210°C to about 300°C. It does not leak through ordinarily tight pipe joints. Tests indicate that at 200°C its corrosion of iron amounts to less than 0.125 mm/yr. It is also recommended as a dielectric fluid for transformers.

4. Chemical synthesis: used in manufacture of dye intermediates and other organic chemicals.

PRECAUTIONARY INFORMATION

The following precautions for handling trichlorobenzene are quoted from our package labels. This caution label has been prepared in accordance with a pattern established by the Manufacturing Chemists' Association.

"CAUTION! VAPOR HARMFUL.
Use with adequate ventilation.
Avoid prolonged breathing of vapor.
Avoid prolonged or repeated contact with skin."

MONS 049456

IN 619

PHYSICAL CONSTANTS DATA

SUBSTANCE	STRUCTURAL FORMULA
AROCLOR 1260 - 10% Toluol Mix	Mixture by Weight 90% - Aroclor 1260 10% - Toluol

COMPILED BY	DATE
A. [illegible] Ellenberg	7/3/57

NAME		SOURCE & DATE
Formula		
Molecular Weight		
Appearance	Syrupy liquid	Specs. 4/11/55
Boiling Point at 760 mm		
Boiling Point at [illegible] mm		
Boiling Point at [illegible] mm		
Boiling Point at [illegible] mm		
Crystallizing Point		
Melting Point		
Solution Point		
Specific Gravity @ 40/15.5°C	1.475-1.495	"
Specific Gravity @		
Pounds per Gal. @ 25 °C	12.5	"
Coefficient of Expansion		
Refractive Index @ n 5		
Infra Red Spectrum (Reference)		
Ultra Violet Spectrum (Reference)		
Viscosity @ 100°F	50.2 cs. (232 SUS)	WGK Lab 3/8/56
Viscosity @ 210°F	3.5 cs. (38 SUS)	"
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in		
Flash Point °F (Method) Mag open cup	105	WGK Lab 12/5/46
Fire Point °F " " "	110	"
Heat of Combustion		
Heat of Formation		
Internal Solubility (cal./cm/min.)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		
Other Constants		
Toxicity (Give Reference)		

MONS 049457

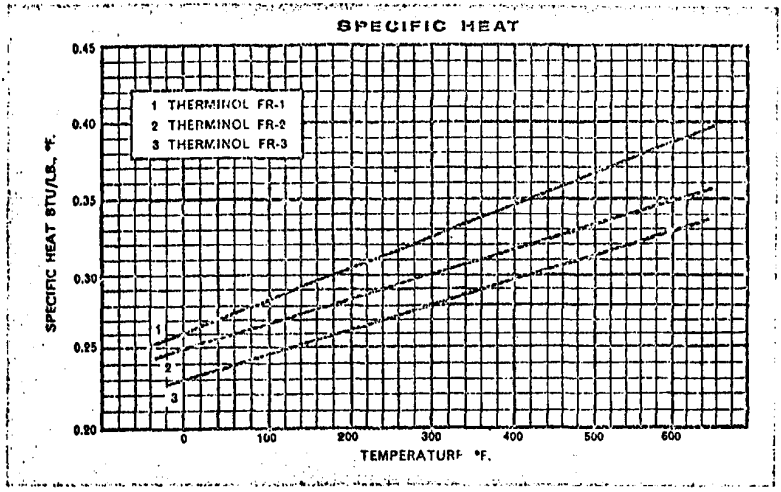
NOTE: These data should not be released outside of Monsanto Chemical Company. [illegible]

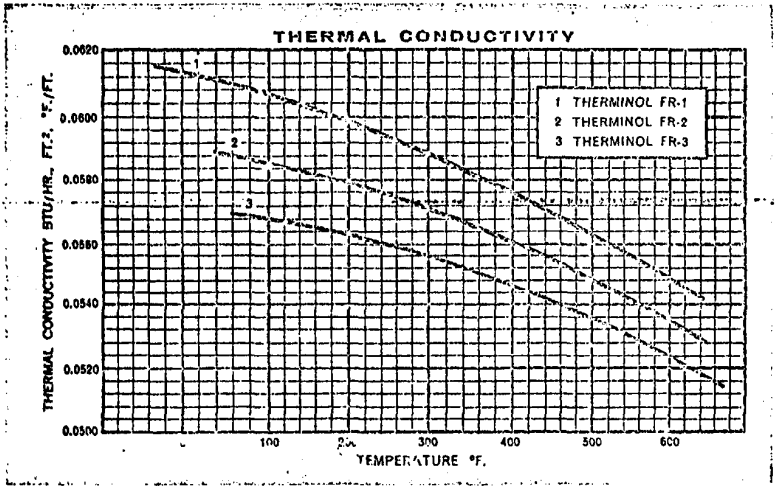
PHYSICAL CONSTANTS DATA

SUBSTANCE	STRUCTURAL FORMULA
ARCCLOR 1262 - 10% Toluol Mix	Mixture by Weight 90% - Arcclor 1262 10% - Toluol

COMPILED BY	DATE
A. M. Ellenberg	7/3/57

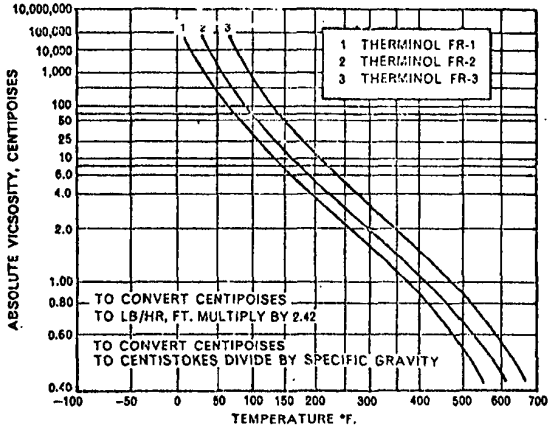
NAME		SOURCE & DATE
Formula		
Molecular Wt.		
Appearance	Syrupy Liquid	Specs 4/11/55
Boiling Point @ 760 mm		
Boiling Point @ mm		
Boiling Point @ mm		
Boiling Point @ mm		
Distillation Point		
Melting Point		
Solidus Point		
Specific Gravity @ 40/15.5°C	1.497-1.516	"
Specific Gravity @		
Pounds per Gal. @ 25 °C	12.7	"
Coefficient of Expansion		
Refractive Index @ n D		
Infra Red Spectrum (Reference)		
Ultra Violet Spectrum (Reference)		
Viscosity @ 100°F	103.3 cs. (477 SUS)	WGK Lab 3/8/56
Viscosity @ 210°F	4.5 cs. (41 SUS)	" "
Surface Tension		
Solubility in Water		
Solubility in		
Solubility in		
Pour Point	0°C	WGK Lab 12/5/48
Flash Point °F (Cleveland) Tag open cup	105	" "
Fire Point °F " " "	110	" "
Heat of Combustion		
Heat of Formation		
Thermal Stability (Explosive)		
Latent Heat of Fusion		
Latent Heat of Vap.		
Specific Heat		
Critical Temperature		
Critical Pressure		
Dissociation Constant		
Other Constants		


SPECIFIC HEAT
1 THERMINOL FR-1
2 THERMINOL FR-2
3 THERMINOL FR-3
SPECIFIC HEAT BTU/LB., °F.
0.45
0.40
0.35
0.30
0.25
0.20
0
100
200
300
400
500
600
TEMPERATURE °F.

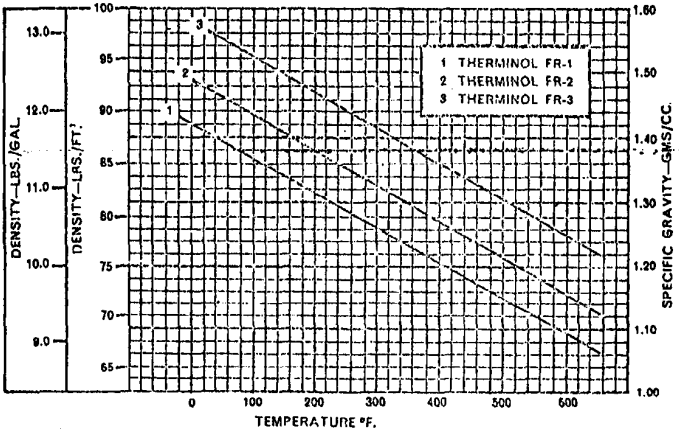

THERMAL CONDUCTIVITY
1 THERMINOL FR-1
2 THERMINOL FR-2
3 THERMINOL FR-3
THERMAL CONDUCTIVITY BTU/HR., FT.2, °F./FT.
0.0620
0.0600
0.0580
0.0560
0.0540
0.0520
0.0500
100
300
400
500
600
TEMPERATURE °F.

MONS 049459

VISCOSITY-TEMPERATURE CHART



DENSITY AND SPECIFIC GRAVITY



MONS 049460

PROPERTIES IMPORTANT TO HEAT TRANSFER DESIGN

THERMINOL FR-1

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.856	0.272	0.06098	11.633	745.36	
100	37.8	18.68	0.282	0.06060	11.458	86.144	
150	66	32.95	0.291	0.06021	11.216	15.972	
200	93	48.07	0.3047	0.05976	10.951	8.2431	
250	121	63.50	0.3151	0.05927	10.760	5.5270	
300	149	79.46	0.3255	0.05875	10.528	3.4158	
350	177	95.94	0.3359	0.05819	10.296	2.4753	10
400	204	112.96	0.3464	0.05760	10.055	1.8898	27
450	232	130.48	0.3568	0.05697	9.833	1.5028	65
500	260	148.52	0.3672	0.05630	9.601	1.2351	143
550	288	167.08	0.3776	0.05560	9.370	1.0426	291
600	316	186.16	0.3880	0.05487	9.138	0.90031	550
650	343	205.79	0.3985	0.05409	8.906	0.79126	18.8 psia
700	371	225.92	0.4089	0.05329	8.675	0.70731	31.9 psia

THERMINOL FR-2

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.59	0.257	0.05881	12.225	7090.6	
100	37.8	17.61	0.265	0.05852	12.000	151.01	
150	66	31.09	0.274	0.05801	11.750	27.83	
200	93	45.11	0.2840	0.05788	11.525	11.971	
250	121	59.43	0.2922	0.05748	11.293	6.949	
300	149	74.14	0.3003	0.05703	11.062	4.531	
350	177	89.26	0.3084	0.05655	10.830	3.201	6
400	204	104.81	0.3166	0.05603	10.598	2.399	15
450	232	120.74	0.3247	0.05548	10.367	1.881	37
500	260	137.08	0.3328	0.05488	10.135	1.529	84
550	288	153.85	0.3410	0.05424	9.903	1.2795	173
600	316	170.99	0.3491	0.05357	9.672	1.0971	340
650	343	188.58	0.3573	0.05286	9.440	0.9596	615
700	371	206.45	0.3654	0.05211	9.208	0.8535	20.3 psia

THERMINOL FR-3

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.28	0.239	0.05700	13.002	—	
100	37.8	18.37	0.245	0.05680	12.760	1628.6	
150	66	29.05	0.256	0.05634	12.634	101.64	
200	93	41.95	0.2689	0.05520	12.292	24.262	
250	121	55.36	0.2714	0.05598	12.061	12.091	
300	149	69.20	0.2799	0.05558	11.829	7.116	
350	177	83.46	0.2884	0.05513	11.597	4.669	3
400	204	98.15	0.2969	0.05466	11.366	3.306	9
450	232	113.26	0.3054	0.05415	11.134	2.476	24
500	260	128.77	0.3138	0.05360	10.902	1.937	55
550	288	144.73	0.3223	0.05302	10.671	1.5599	114
600	316	161.11	0.3308	0.05241	10.439	1.3095	223
650	343	177.92	0.3393	0.05176	10.207	1.1188	413
700	371	192.24	0.3478	0.05107	9.976	0.97531	735

MONS 049461

Introducing Therminol FR-O...

Newest member of the growing line of Monsanto heat transfer fluids. Therminol FR-O was formulated specifically to eliminate freeze-up during cold weather shut down for in-transit heating of sulfur, pitch, asphalt, naphthalene, bunker "C" fuel oil, and high melting resin materials. Therminol FR-O eliminates the need for high temperature reheating in order to pump out the material at its destination. Low temperature pumpability makes it ideally suited for space heating applications, outdoor plants in Northern climates, or in any application where good fluidity at low temperatures is a prerequisite.

Fire-Resistance...

Therminol FR-O permits installation of a non-pressurized system operating with a liquid that has no fire point, and will not support combustion ...so fire-resistant, Therminol fluids have achieved recognition by Underwriters' Laboratory, Factory Mutual, and Factory Insurance Association. Because of this extreme fire-resistance and its listing by insurance companies, important savings can be made in designing a process heating system around Therminol FR-O fluid.

Chemically Speaking...

Therminol FR-O fluid is a chlorinated biphenyl, manufactured under exacting process control to rigid specifications for long term thermal stability, specific heat, thermal conductivity, vapor pressure and viscosity. The liquid is an oily, clear, nearly colorless, fluid with a pour point of −15°F and a minimum pumpable temperature of −5°F.

Therminol FR-O fluid is recommended for use up to 500°F and will not show measurable change after years of exposure to such temperatures. The fluid is non-corrosive with all common metals used in heat transfer system designs.

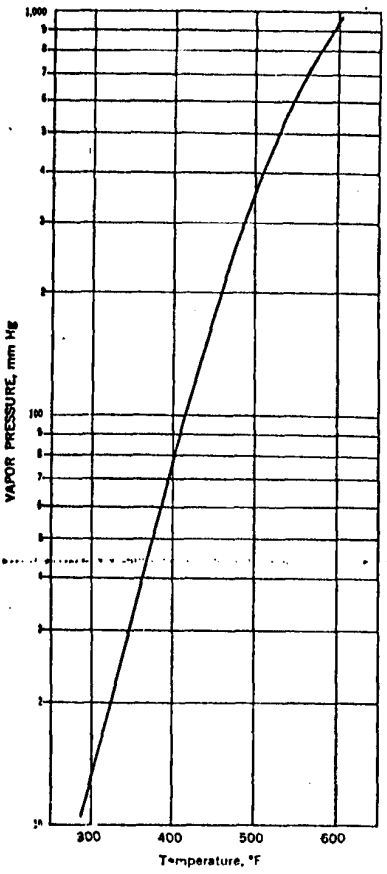
TYPICAL PROPERTIES OF THERMINOL FR-O

Property	Temperature, °F								
	−5	+10	40	100	200	300	400	600	600
Kinematic Viscosity, cs.	4545	1007	92.55	8.10	1.70[a]	0.95	—	—	—
Saybolt Viscosity, SSU	20850	4640	429	52.43	7.99[a]	4.54	—	—	—
Vapor Pressure, mm Hg	—	—	—	—	1.35	13.00	76.0	315	915
Specific Heat, BTU/lb.[b]	—	—	—	0.27	0.29	0.31	0.33	0.35	0.36
Thermal Conductivity, BTU/°F-Ft.-Hr.[b]	—	—	—	0.061	0.060	0.059	0.058	0.057	0.056
Density, g/cc.	—	1.45	1.43	1.40	1.34	1.28	1.23	1.17	1.11
Density, lbs./gal.	—	12.10	11.92	11.70	11 19	10.69	10.27	9.76	9.27

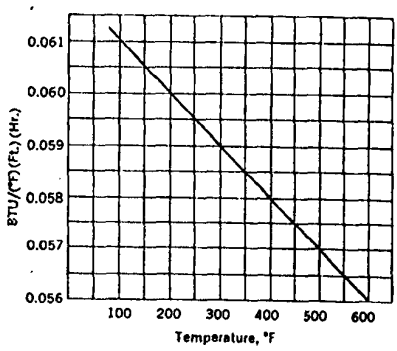
[a] Viscosity at 210°F
[b] Calculated values

MONS 049462

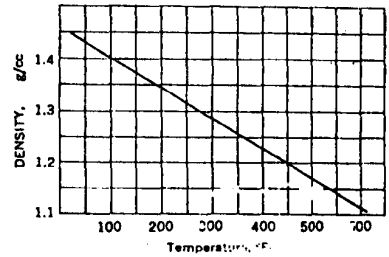
VAPOR PRESSURE



THERMAL CONDUCTIVITY (calculated)

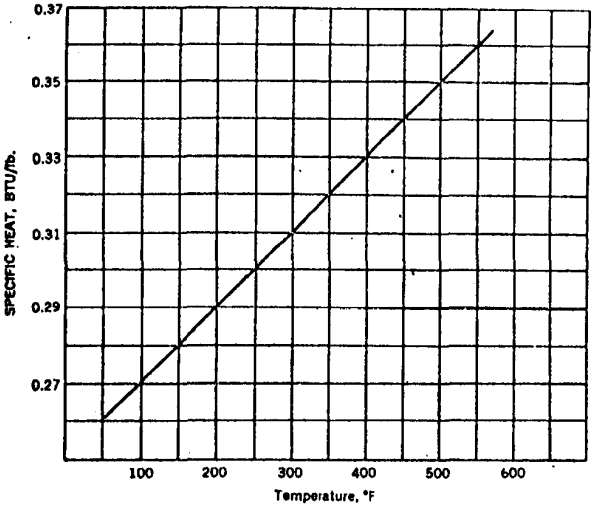


DENSITY

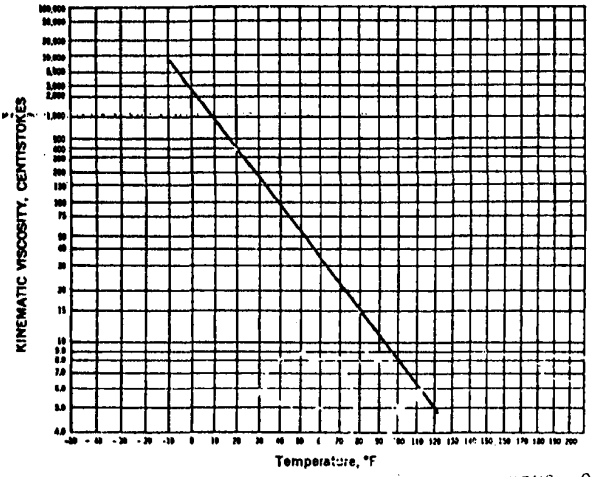


MONS 049463

SPECIFIC HEAT



KINEMATIC VISCOSITIES



MONS 049464

THERMINOL®
FR LO-TEMP
FIRE RESISTANT
HEAT TRANSFER
FLUID

... the fire-resistant, low-temperature liquid phase heat transfer fluid with very low temperature pumpability.

TECHNICAL BULLETIN (T-LT)

MONS 049465

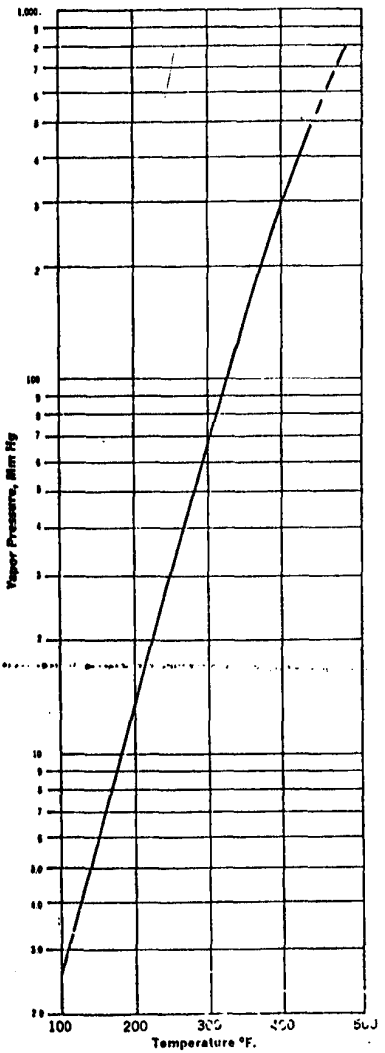
"Nothing contained herein is to be construed as a recommendation to use any product in conflict with any patent. MONSANTO MAKES NO WARRANTIES AS TO THE FITNESS OR MERCHANTABILITY OF ANY PRODUCTS REFERRED TO, no guarantee of satisfactory results from reliance upon contained in ... recommendations, and disclaims all liability for any resulting loss or damage."

Organic Division/800 N. Lindbergh Blvd./St. Louis, Missouri 63166

FUNCTIONAL FLUIDS

Monsanto

THERMINOL® FR Lo-Temp
Vapor Pressure



Introducing Therminol® FR Lo-Temp

Therminol FR Lo-Temp is our newest fire-resistant heat transfer fluid formulated specifically for practical pumpability at −40°F.

This low-temperature fluid permits installation of a non-pressurized system operating with a liquid which has no fire point and will not support combustion.

The recommended operating range of Therminol FR Lo-Temp is −40°F to 400°F. It will not show measurable change after years of exposure at such temperatures.

The fluid is a chemically inert, noncorrosive compound with a pour point of −60°F and a vapor pressure of only 800 mm of mercury at 400°F.

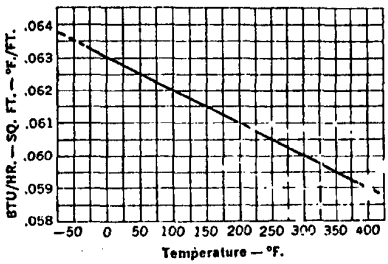
Listed as a fire resistant heat transfer media by Underwriters Laboratories, it can be installed for a wide range of uses in both space heating and cooling, gas processing and distribution, and industrial heating and cooling under conditions of low ambient temperatures.

TYPICAL PROPERTIES

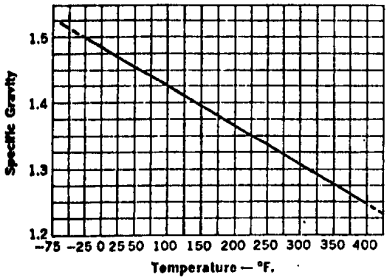
Composition	Chlorinated biphenyls and hydrocarbons
Appearance	Oily, clear, nearly colorless liquid
Pour Point	−60° F.
Flash Point	280° F.
Flame Point	None to boiling
Autoignition Temperature	Over 1100° F.
Boiling Range	432° F.—627° F.

THERMINOL® FR Lo-Temp
Thermal Conductivity

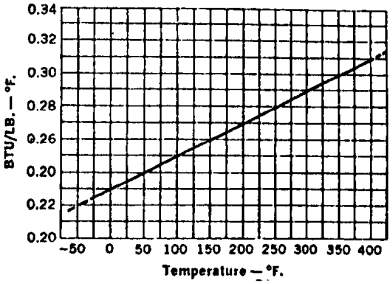
MONS 049466



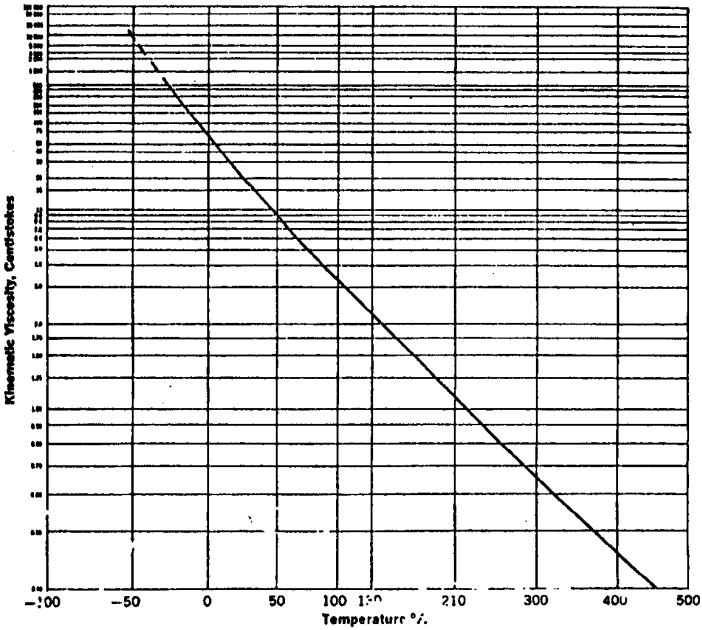
THERMINOL® FR Lo-Temp
Specific Gravity



THERMINOL® FR Lo-Temp
Specific Heat



THERMINOL® FR Lo-Temp
Viscosity



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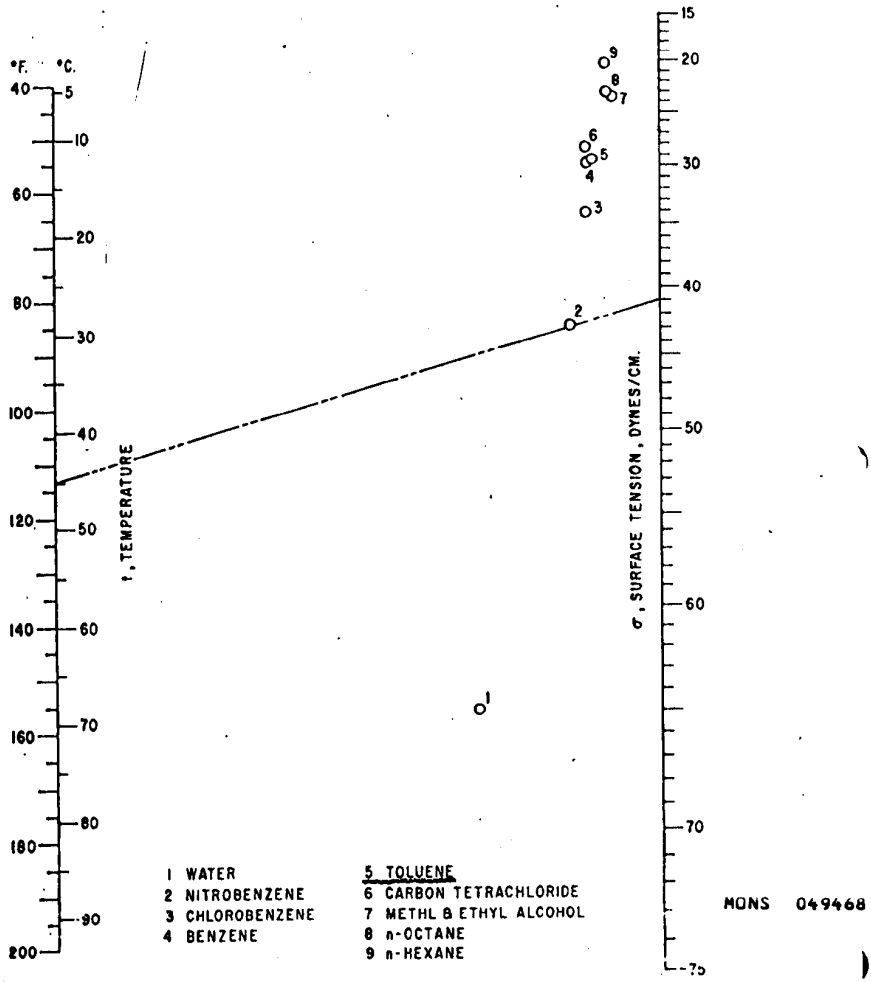
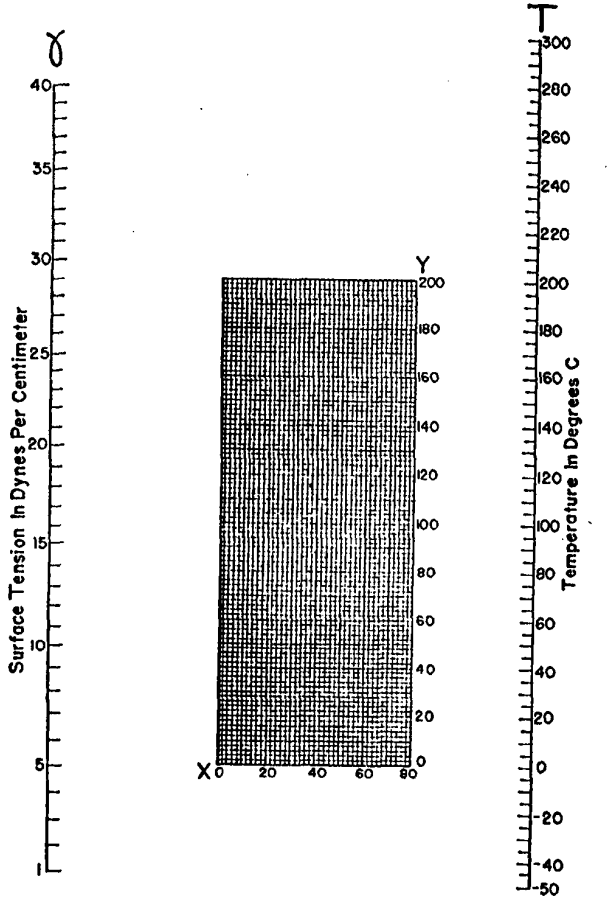


Figure 23.1. Surface tension of some common liquids. (Reproduced by permission *British Chemical Engineering*, Vol. 4, page 38, copyright 1958.)

Table 22.1

X AND Y VALUES FOR SURFACE TENSION NOMOGRAPH

Compound	X	Y
Acetal	19	88
Acetaldehyde	33	78
Acetaldoxime	33.5	127
Acetamide	17	102.5
Acetic acid	17.1	116.5
Acetic anhydride	26	130
Acetone	28	91
Acetonitrile	33.5	111
Acetophenone	18	163
Allyl alcohol	12	111.5
Anethole	13	148.1
Aniline	22.9	171.8
Anisole	24.4	138.9
Ammonia	56.2	63.5
Isoamyl acetate	10.4	103.1
Isoamyl alcohol	6	106.8
Benzene	30	110
Benzonitrile	19.5	159
Benzylamine	26	155
Bromobenzene	23.5	145.5
Isobutyl acetate	18	97.2
n-Butyl alcohol	9.6	107.5
Isobutyl alcohol	5	103
n-Butyric acid	14.5	115
Isobutyric acid	14.8	107.4
n-Butyronitrile	20.3	113
Carbon disulfide	35.8	117.2
Carbon tetrachloride	26	104.5
Chloral	30	113
Chlorine	45.5	60.2
Chlorobenzene	28.5	132.5
o-Chlorobromobenzene	14	162
Chloroform	32	101.3
o-Chlorotoluene	18.7	134
o-Cresol	20	161
m-Cresol	13	161.2
p-Cresol	11.6	160.6
Cyclohexane	42	86.7
Diethyl ketone	30	101
Diethyl oxalate	20.5	130.8
Diethyl sulfate	19.5	139.5
Diethyl aniline	17	149.6
Dimethyl sulfate	25.5	158
Dimethylamine	16	66
Ethyl aniline	20	149
Ethyl acetate	27.5	92.4
Ethyl acetoacetate	21	132
Ethyl alcohol	10	97
Ethyl benzoate	14.8	141
Ethyl bromide	31.6	80.2
Ethyl n-butyrate	17.5	102
Ethyl isobutyrate	20.9	93.7
Ethyl ether	37.5	64
Ethyl formate	30.5	88.8
Ethyl iodide	28	113.3
Ethyl mercaptan	35	81
Ethyl propionate	23.6	97
Ethylamine	11.2	83
Ethyl benzene	23	118
Ethylene chloride	33	180
Ethylene oxide	42	83
n-Hexane	22.7	78.9
Hydrogen cyanide	30.8	66
Isoxylene	17	119.8
Methyl acetate	36	90
Methyl alcohol	17	93
Methyl n-butyrate	24	88
Methyl isobutyrate	24	93.8
Methylene chloride	46.8	93.3
Methyl ether	44	37
Methyl ethyl ketone	23.6	97
Methyl formate	38.5	88
Methyl propionate	29	95
Methyl amine	43	88
Naphthalene	22.5	165
Nitroethane	26.4	128.1
Nitromethane	30	139
Nitrosyl chloride	38.5	93
Nitrous oxide	65.5	0.5
n-Octane	17.7	90
Oenaldehyde	22.3	103.8
Octanoic	20	124.2
Pentane	30	68
Phosphorus oxychloride	26	125.8
Piperidine	24.7	120
Propionic acid	17	112
Propionitrile	23	108.6
n-Propyl acetate	23	97
n-Propyl alcohol	8.9	103.2
n-Propyl formate	24	97
n-Propylamine	23.5	87.2
n-Propyl Toluene	12.6	121.5
Pyridine	24	138.2
Quinoline	18.5	187
Stilbene	28	161
Styrene	24	113
Triethylamine	20.1	79.8
Trimethylamine	31	41.6
Turpentine	9	121
Triphenyl methane	12.8	182.7
m-Xylene	20.5	118
p-Xylene	19	117



Values for X and Y, taken from Table 22.1, are used for any particular compound to give a point on the central grid. Using this point as a pivot for a straight line, the value of the surface tension may be read from the intersection of this line with the Y scale against the value of the temperature read from the intersection of this line with the T scale.

MONS 049469

Figure 22.1. Surface tension of liquids as a function of temperature. (Reproduced by permission, *Industrial & Engineering Chemistry*, Vol. 40, page 886, copyright 1948, The American Chemical Society.)

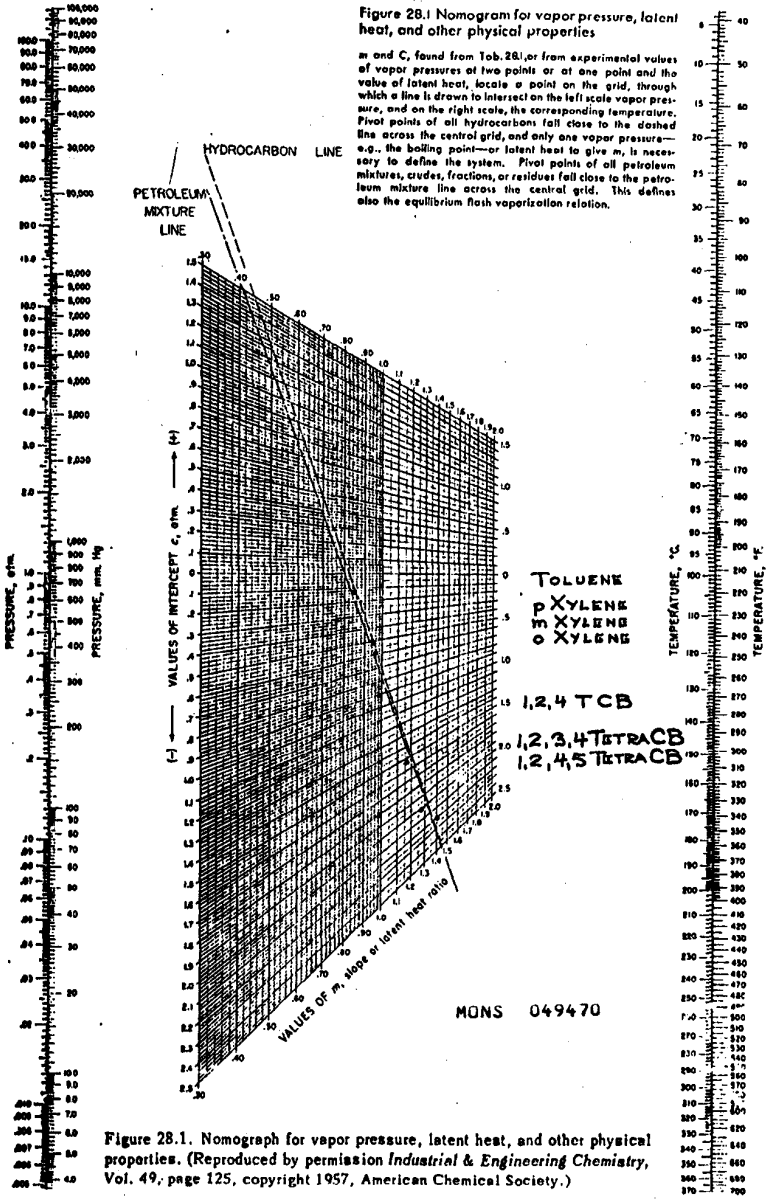
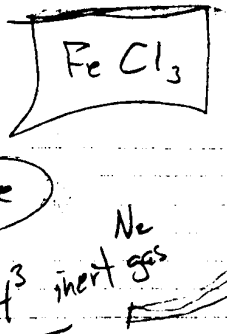


Figure 28.1 Nomogram for vapor pressure, latent heat, and other physical properties

m and *C*, found from Tab. 28.1, or from experimental values of vapor pressures at two points or at one point and the value of latent heat, locate a point on the grid, through which a line is drawn to intersect on the left scale vapor pressure, and on the right scale, the corresponding temperature. Pivot points of all hydrocarbons fall close to the dashed line across the central grid, and only one vapor pressure—e.g., the boiling point—or latent heat to give *m*, is necessary to define the system. Pivot points of all petroleum mixtures, crudes, fractions, or residues fall close to the petroleum mixture line across the central grid. This defines also the equilibrium flash vaporization relation.

Figure 28.1. Nomograph for vapor pressure, latent heat, and other physical properties. (Reproduced by permission *Industrial & Engineering Chemistry*, Vol. 49, page 125, copyright 1957, American Chemical Society.)



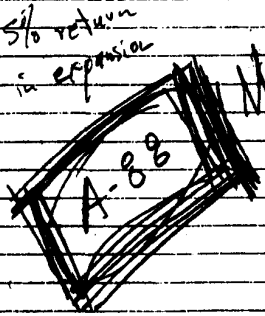
$FeCl_3$

Therminol from Don Roush
20 Jan 69 MH

purge

$\frac{0.4\ ft^3}{hr\ gal}$ inert gas Ne in surge tk

5% return in expansion



Monsanto

A-88

$\frac{0.5\ ft^3}{min}\ \frac{60\ m}{hr} = \frac{30\ ft^3}{hr}$

7.5 gal

$\frac{300}{0.4}$

MONS 049471

You can choose from seven Therminol® fluids with a combined operating range from -40°F. to more than 700°F. No pressurization needed!

Monsanto

All Therminol fluids work without pressure over the entire operating range. You save on construction, expensive monitoring and safety devices needed in high-pressure systems. With Therminol, you're assured of uniform, safe and economical flows to single or multi-users.

You can get two big jobs done at once by delivering high heat for processing or moderate heat for space heating lines.

Because these fluids are noncorrosive, nonvolatile, thermally stable and chemically inert, properly maintained equipment can operate for years with no make-up.

Therminol fire resistant (FR) fluids are the only heat transfer fluids listed by Underwriters' Laboratories and recognized by the FIA and FMA.

Call on our engineers for prompt, complete advice and technical service where you have a heat transfer problem. Circle the reader service card for more information. *Detach this chart and keep it for your permanent reference.*

(See our exhibit 4336 at the 31st Exposition of Chemical Industries, New York Coliseum, November 27-December 1.)

Fluid	Recommended Use Range (-0 100 200 300 400 500 600 700)	Pour Point	Vapor Pressure at Max. Recom. Temp.	Fire Resistance U.L. Listed
Therminol® FR Lo-Temp		-60°F	300 mm Hg	yes
Therminol FR-0		-15°F	315 mm Hg	yes
Therminol FR-1		2°F	550 mm Hg	yes
Therminol FR-2		19°F	340 mm Hg	yes
Therminol FR-3		50°F	225 mm Hg	yes
Therminol 66		-15° to -18°F	525 mm Hg	no—C.O.C. flash point 350°F
Therminol 77		45°F	168 mm Hg	no—C.O.C. flash point 460°F

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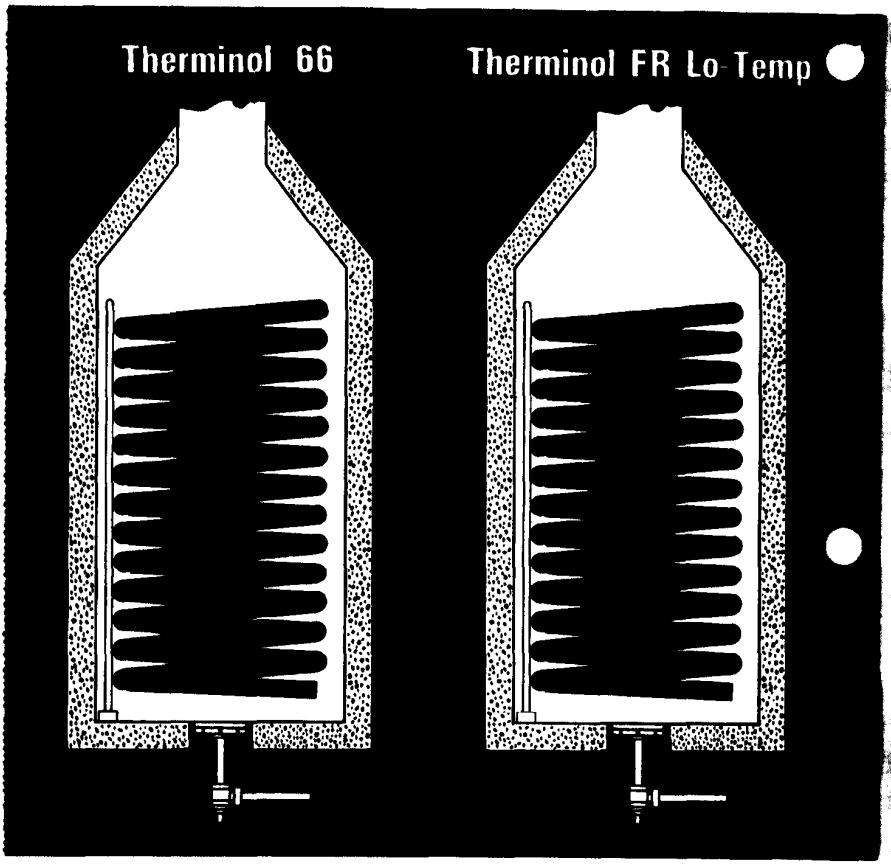
Introducing two new heat transfer fluids from Monsanto:



Now you get even greater high and low range capabilities!

Therminol FR Lo-Temp. Our newest fire resistant fluid. Gives you a low-cost, liquid phase indirect heat transfer system with extremely good low-temperature pumpability and sub-zero mobility to −40°F. Yet it can be operated up to 400°F, is ideal for space heating and cooling.

Therminol 66. Our most versatile and efficient fluid meets your needs for higher processing temperatures at low cost. Operating between 15°F and 650°F without pressure, its heat transfer properties are 10% better than other fluids in this range. Its −15°F to −18°F pour point permits start-up at fluid temperatures as low as 15°F.

For properties of all seven Therminol fluids, turn the page.

Monsanto

MONS 049473

THERMINOL®
FR LO-TEMP
FIRE RESISTANT
HEAT TRANSFER
FLUID

. . . the fire-resistant, low-temperature liquid phase heat transfer fluid with very low temperature pumpability.

TECHNICAL BULLETIN (T-LT)

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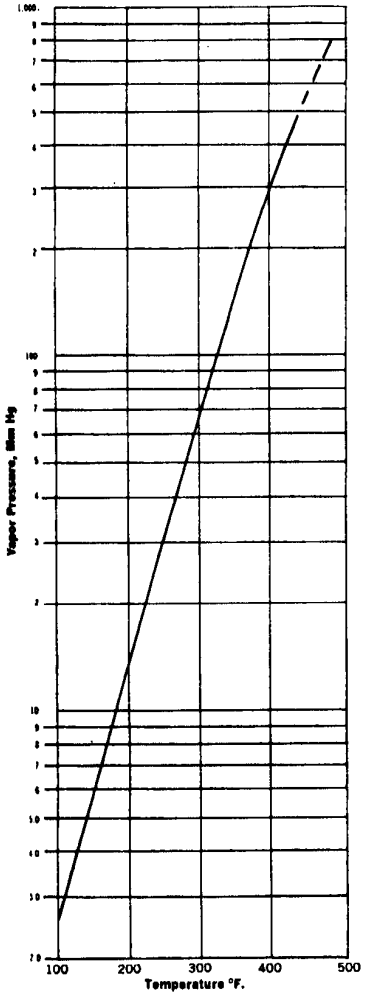
THERMINOL® FR Lo-Temp
Vapor Pressure



Introducing Therminol® FR Lo-Temp

Therminol FR Lo-Temp is our newest fire-resistant heat transfer fluid formulated specifically for practical pumpability at −40°F.

This low-temperature fluid permits installation of a non-pressurized system operating with a liquid which has no fire point and will not support combustion.

The recommended operating range of Therminol FR Lo-Temp is −40°F to 400°F. It will not show measurable change after years of exposure at such temperatures.

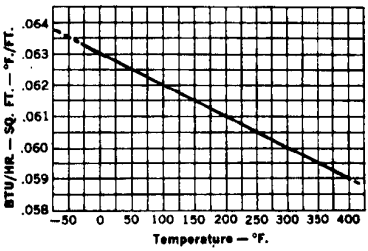
The fluid is a chemically inert, noncorrosive compound with a pour point of −60°F and a vapor pressure of only 300 mm of mercury at 400°F.

Listed as a fire resistant heat transfer media by Underwriters Laboratories, it can be installed for a wide range of uses in both space heating and cooling, gas processing and distribution, and industrial heating and cooling under conditions of low ambient temperatures.

TYPICAL PROPERTIES

Composition	Chlorinated biphenyls and hydrocarbons
Appearance	Oily, clear, nearly colorless liquid
Pour Point	−60° F.
Flash Point	280° F.
Flame Point	None to boiling
Autoignition Temperature	Over 1100° F.
Boiling Range	432° F. — 627° F.

THERMINOL® FR Lo-Temp
Thermal Conductivity



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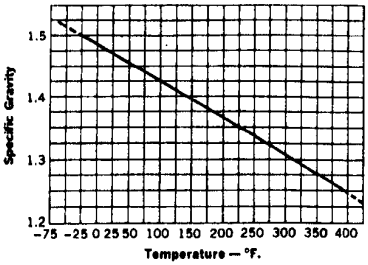
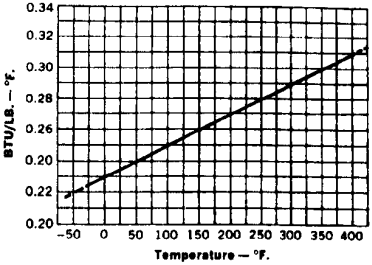
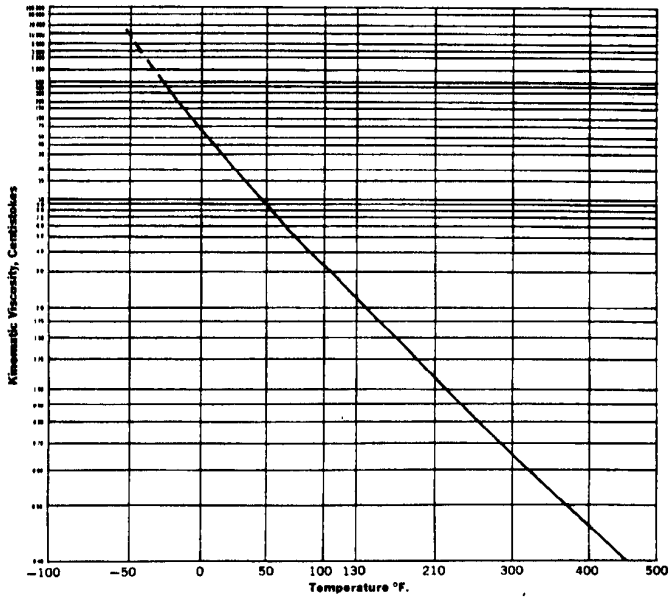
THERMINOL® FR Lo-Temp
Specific Gravity



THERMINOL® FR Lo-Temp
Specific Heat



THERMINOL® FR Lo-Temp
Viscosity



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MONS 049477

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THERMINOL® 77 HIGH-TEMPERATURE HEAT TRANSFER FLUID

TECHNICAL BULLETIN T-77

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N

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APPENDIX G - MATERIAL BALANCE

Standard and theoretical usages of raw materials for each Aroclor Blend is shown in Figure I.

FICURE NO. I

THEORY AND STANDARD USAGE FOR PYRANOLS
LBS. PER CWT OF BLEND

PRODUCT	THEORY	STANDARD
Aroclor 1254 - 10% Toluene		
Aroclor 1254	90.00	90.90
Toluene	10.00	10.10
Aroclor 1260 - 10% Toluene		
Aroclor 1260	90.00	90.90
Toluene	10.00	10.10
Aroclor 1262 - 10% Toluene		
Aroclor 1262	90.00	90.90
Toluene	10.00	10.10
Aroclor 1262 - 10% Xylene		
Aroclor 1262	90.00	90.90
Xylene	10.00	10.10
Pyranol A13B3B		
Aroclor 1260	45.00	45.45
Tri-Tetrachlorobenzene	55.00	56.12
Epoxide 221	--	0.13
Inerteen PPO		
Aroclor 1260	60.00	60.60
Trichlorobenzene	40.00	40.82
Glycidyl Phenyl Ether	--	0.22
Inerteen 54201-KA		
Aroclor 1254	70.00	70.71
Trichlorobenzene	30.00	30.61
Glycidyl Phenyl Ether	--	0.22

MONS 049579

FIGURE NO. I

PRODUCT	THEORY	STANDARD
Inerteen 54201-CM		
Aroclor 1242	100.00	100.10
Glycidyl Phenyl Ether	--	0.22
Inerteen 54201-A-6		
Aroclor 1242	75.00	75.75
Trichlorobenzene	25.00	25.25
Therminol FR-0		
Aroclor 1242	80.00	80.80
Tri-Tetrachlorobenzene	20.00	20.20
Therminol FR-Lo Temp		
Aroclor 1242	50.00	50.50
Tri-Tetrachlorobenzene	50.00	50.50
Santicizer 794		
Aroclor 1248	50.00	50.50
Aroclor 1260	50.00	50.50
Aroclor 1254-Aroclor 4465		
Aroclor 1254	85.00	85.50
Aroclor 4465	15.00	15.50
Aroclor 1242 - Aroclor 1248		
Aroclor 1242	28.00	28.28
Aroclor 1248	72.00	72.73
Aroclor 1260 - 5% Toluene		
Aroclor 1260	95.00	95.95
Toluene	5.00	5.05

MONS 049581

APPENDIX H - ATMOSPHERIC & STREAM DISCHARGE & WASTE DISPOSAL

The following is an estimate of the atmospheric and stream discharge from the Pyranol operations.

	Type	Amount
Toluene	Atmospheric	Negligible
Xylene	Atmospheric	Negligible
Trichlorobenzene	Atmospheric	Negligible
Tri-Tetrachlorobenzene	Atmospheric	Negligible

P

MONS 049583

APPENDIX I - PROCESS CONTROL PROCEDURES

Raw materials are analyzed by the laboratory before being used in a Pyranol mix.

Control samples are taken by the operator from the mix tank at various stages throughout the blending process. These samples are analyzed by the laboratory. The following control tests are performed by the laboratory.

Test	Anniston Analytical Method No.
Specific Gravity	14-49-54
Moisture	14-53-54
Refractive Index	14-34-54
Resistivity	14-35-57
Power Factor	--
Chlorides	014

A complete analysis is run by the laboratory on all final lot samples.

All Aroclor 1242 used in the I-54201-CM blend is analyzed for TCC, HST, and Monsanto Stability to assure top quality 1242 in the blend.

Q

MONS 049585

APPENDIX J - SAFETY & TOXICITY DATA AND ACCIDENT REPORTS

Safety of operations in the Aroclor Plant depends on the individual operator. Materials being handled and operations must be observed closely to guard against the following:

	Cause and Action to Prevent
1. Chlorine Gas	Chlorine gas is a very toxic corrosive gas. Leaks or high pressure can occur to liberate it.

Action to Prevent:

a. Report chlorine gas exposure immediately for treatment with Antidote. Milk may be used in mild cases to relieve throat irritation. Oxygen from the resuscitator in the Dispensary is available.

b. Keep gas mask in good condition. Keep a good canister in the mask. Use these type masks only in chlorine concentrations to 2-3% chlorine in air.

c. Use a Scott Air Pak in concentrations of chlorine gas above 3% in air. Three units are available in the Aroclor-Biphenyl Department.

d. If caught in chlorine gas without a mask, hold your breath and go cross wind until you are out of range of the gas. Place a handkerchief over your nose in small quantities of chlorine.

e. Report all chlorine leaks for repair immediately. Make temporary repairs with tape if possible.

f. In case of a major chlorine leak, the source of chlorine gas must be stopped.

Notify the chlorine plant immeidately if the pressure on the chlorine manifold exceeds 30 psig. Cut off liquid chlorine from the car.

Cause and Action to Prevent

2. Thermal Burns

Contact with hot uninsulated product lines at the chlorinators and still areas.

Contact with uninsulated steam lines and open steam.

Contact with hot Aroclors from broken lines or leaks.

Contact with open flames at stills or from heating lines in the department.

Action to Prevent:

a. Know that contact with equipment and product will cause a thermal burn due to the high temperatures. Make changes in operations with this hazard in mind.

b. Know the first aid treatment for burns. Cold Water Treatment (See Appendix A - Emergency Section of Operating Instructions.

c. Wear gloves and long sleeve shirt with the sleeves rolled down when operating. Gloves and clothing can make the difference between first and second degree burns.

d. Report uninsulated lines for repair of insulation.

e. Use only steam lines with hose and hose clamps in good condition.

f. The following operations are hazardous and should be done with care:

   (1) Catching samples at the Aroclor chlorinator circulating lines.

   (2) Sampling the Solid Aroclor still receiver.

   (3) Drawing bottoms on the Aroclor stills.

Cause and Action to Prevent

3. Explosion

An explosion could occur in the chlorinators by slugging liquid chlorine to the distributor. Slugs of liquid chlorine could react fast enough to cause excessive pressure in the vessel. A rupture of the chlorinator could occur.

Action to Prevent:

a. Observe operation of the chlorine vaporizer and do not let liquid chlorine get into the rotameters. Pipe lines will be frosted.

b. In case chlorine feed lines are frosted, close liquid chlorine feed valve to the vaporizer. Check steam addition to the vaporizer. Do not start up until source of trouble has been located.

c. Do not close valve in water discharge line from the chlorinator coil.

d. Observe temperature of the chlorinator periodically and be sure it is not too hot (180°C. maximum).

4. Falls

Slipping on cement floors, stairs, Aroclor on floor, ice conditions; tripping over objects (hose, pipe, valve handles, etc.); or losing footing on ladders, etc., can cause falls.

Action to Prevent:

a. The majority of minor, serious, and near-miss injuries in the Aroclor Dept. are the result of falls. Prevention is always within the ability of the operator by use of expert operating practices.

b. The following items should be done:

(1) Return hose to rack after using.

(2) Keep operating areas clean of all foreign objects.

(3) Return ladders to racks when not in use.

(4) Keep gloves on and hands out of pockets, especially going up and down stairs.

Cause and Action to Prevent

4. Falls (Contd.)

(5) Place guards around any area that presents a hazard that should be guarded.

c. Poor lighting due to burned out bulbs should be corrected at once. Poor lighting due to inadequate facilities should be reported.

d. Spills must be cleaned up immediately following their occurrence. Report any spill that cannot be cleaned up within the shift to the Chief Operator. Spills are to be reported in the log book.

5. Fires

Fires can occur by:

Biphenyl, Santowax R, or Santowax C ignition.

Chlorine problems in the vaporizer allowing reaction with steam to release hydrogen.

Furnace burner backfire.

Wood, rags, or paper on hot lines.

Sparks from welding apparatus of open flames.

Action to Prevent:

a. Area must be clear of trash or flammable materials. Use trash skips and cans.

b. Smoke only in areas so designated.

c. Use spark producing equipment only with a fire permit and proper inspection.

d. Use care in lighting gas torch or the still furnaces.

Cause and Action to Prevent

5. Fires (Contd.)

e. Fire fighting equipment includes:

(1) Two wheeled dry powder units.

(2) Hose house with 200 ft. of hose.

(3) Two dry powder hand extinguishers, One CO_2 hand extinguisher.

(4) Two 3/4" water hoses.

(5) Hose connection north of Santowax.

(6) Scott Air Paks.

(7) Fire truck in fire house.

f. Observe visitors in the plant and be sure they observe safety rules.

6. The following is a list of chemicals handled in the Aroclor Plant operations and the precautions to be taken during their handling:

a. Chlorine Gas - This is a corrosive gas which is toxic. Leaks or back pressure can occur and liberate chlorine gas in the area. Operators should have their cartridge type respirators handy at all times while in the area.

If you are caught without a gas mask, and large amount of chlorine gas is liberated, hold your breath and go cross wind until you are out of range of the gas. Once out of the area, obtain an emergency gas mask and return to the area and correct the trouble.

A victim of chlorine gas fumes must be removed as quickly as possible from the gaseous area. Place patient on his back with head and back elevated. Milk may be used in mild cases as a relief from throat irritation. If the patient has stopped breathing, start artificial respiration immediately.

b. Biphenyl - Biphenyl is a flammable material which will burn. Burning should not be done in the presence of Biphenyl or Biphenyl vapors. The melting point is 68.7°C., and the auto ignition temperature is 258°C. Inhalation of Biphenyl fumes is not recommended, since it can cause a drugged effect on the person.

c. Santowax R - Santowax R is a flammable material which will burn. It is relatively non-toxic to human beings. However, the vapors of Santowax R are irritating to the mucous membranes and bronichial tract. Prolonged breathing of the vapors should be avoided. The melting point is 140°C.

d. Santowax C - Same as Santowax R, since it is the crude material prior to distillation.

e. Ferric Chloride- Ferric Chloride is a black-brown solid. It causes only slightly irritating effects on the skin or mucous membranes. When heated it will decompose and release toxic fumes of Chlorine. It will react with water to produce toxic and corrosive HCl fumes.

f. Attapulgus Earth - This material is a dried earth. No danger in handling. Wash off with water to clean.

g. Hydrated Lime - No particular hazard in handling this material. The dust is irritating to the eyes and skin, and should be washed off with water.

h. Crude Aroclors - Crude Aroclors are hot, since all are handled in steam traced or jacketed lines. They can easily cause thermal burns in contact with the skin. Prior to air blowing, the material has HCl fumes entrained in it which are irritating to the skin or mucous membranes.

i. Hydrogen Chlorine Gas - This is a corrosive gas which is toxic. It is irritating to the mucous membranes, to the eyes, and to the respiratory tract. It will react with water to form Hydrochloric Acid.

j. Still Bottoms - or Residue Fumes from still bottoms are toxic. They are extremely irritating to the mucous membranes, to the eyes, and respiratory tract.

R

MONS 049592

APPENDIX K - BACKGROUND INFORMATION

History of Pyranols (Inerteens) in Monsanto

Registered trademarks for some commercial brands of chlorinated biphenyls in the United States are the following: Aroclor (Monsanto Company), Chlorextol (Allis-Chalmers Manufacturing Co.), Dykanol (Cornell-Dubilier Division, Federal Pacific Electric Co.), Inerteen (Westinghouse Electric Corporation), Noflamol (Wagner Electric Corporation), Pyranol (General Electric Company), and Therminol (Monsanto Company). Some other registered trademarks or trade names for commercial chlorinated biphenyls found throughout the world are the following: Clophen (I. G. Farbenindustrie A.G., Germany), Fenclor (Caffaro, Italy), Kannechlor (Kanegafuchi Chemical Co., Japan), Pyralene (Prodelec, France), and Sovol (Russia).

Aroclor used either alone or in blends with other materials such as trichlorobenzene, meet the need for a fire-resistant dielectric fluid with a high resistivity, a high dielectric strength, a relatively high dielectric constant, and a very low power factor. By replacing hydrocarbon oil with chlorinated biphenyls or mixtures of chlorinated biphenyls with trichlorobenzene, it has been possible to redesign equipment with a great reduction in size for the same capacity and voltage. At the same time, the fire hazards have been eliminated.

The first production of Pyranol by Monsanto was in 1936 when Pyranol 1488 was made for General Electric Co. These blends have grown through the years until there are now (1968) five Pyranol-Inerteen blends made at the Anniston Plant. Table I shows the approximate date when each blend was first made at the Anniston Plant.

History of Therminols in Monsanto

Aroclor 1248 has been used as a heat transfer medium since 1941 and in 1963 the name Therminol FR was assigned to Aroclors used as heat transfer mediums. There are now, in 1968, seven types of Therminol made. Six are made in the Anniston Plant. The seventh (Therminol 77) is made at the J. F. Queeny plant. The various types are as follows:

Therminol FR-1	is Aroclor 1242
Therminol FR-2	is Aroclor 1248
Therminol FR-3	is Aroclor 1254
Therminol FR-0	is an Aroclor blend
Therminol FR-Lo Temp	is an Aroclor blend
Therminol 66	is HB-40
Therminol 77	is an Aroclor blend

Table I shows the approximate date when each blend was first made at the Anniston Plant.

History of other Aroclor Blends

Various blends are made for specific customer needs other than electrical and heat transfer mediums. The toluene blends were started ten years ago. FMC requires the 1242-1248 blends with viscosity being the critical property. Table I shows the approximate date when each blends was first made at the Anniston plant.

TABLE I

AROCLOR BLEND STARTING DATES

	BLEND NAME	PRODUCTION STARTED	REMARKS
1.	Pyranol 1467	1957	Changed scavenger to GPE from Tin Tetraphenyl and called Inerteen PPO
2.	Pyranol 1470	1957	Changed scavenger to EP 221 from Tin Tetraphenyl and called Pyranol A13B3B
3.	Pyranol 1481	1957	No longer made at Anniston
4.	Pyranol 1488	1957	No longer made at Anniston
5.	Aroclor 1254 - 10% Secondary Butyl Acetate	1957	No longer made
6.	Aroclor 1254 - 10% Toluene	1958	--
7.	Aroclor 1260 10% Toluene	1958	--
8.	Aroclor 1262 10% Toluene	1958	--
9.	Aroclor 1262 10% Xylene	1958	--
10.	Inerteen PPO	July 1958	--
11.	Pyranol A13B3B	Jan. 1963	--
12.	1254-4465 Blend	Mar. 1965	--
13.	Inerteen 54201-KA	Aug. 1965	--
14.	Therminol FR-0	Mar. 1966	--
15.	Therminol FR-Lo Temp	Feb. 1967	--
16.	Inerteen 54201-A-6	Jan. 1968	--
17.	Inerteen 54201-CM	Jan. 1968	--

TABLE II

TENTATIVE PROCESSES

1. Therminol FR-Lo Temp

   Research Report P-1441 by C. P. Duncker, dated 13 Feb. '67.

2. Inerteen 54201-KA

   Research Report P-1342 by J. D. Sullivan, dated 11 Nov. '64.

3. Inerteen 54201-A6

   First made in Anniston as lab batch
   (55 gal. drum) 21 Nov. '67 .
   Plant batch made after letter from P. G. Benignus to H. C. Carder
   anticipating first order.
   There is no know Tentative Process for this product.

4. Inerteen 54201-CM

   There is no known Tentative Process for this product.
   Plant batch made after phone call from P. G. Benignus to
   H. L. Williams and resultant sales order from Westinghouse.

5. There are no known Tentative Process descriptions for the remaining Aroclor Blends.

S

MONS 049597

APPENDIX L - TIME CYCLES

A batch process is used for the production of all Pyranols.

See Table II for time cycles and batch weights of various Pyranol mixes. These are normal size batches, however, a batch size might be increased or decreased depending on need for the material.

There are no bottlenecks in the production of Pyranols at the present time. The time required to load a car, approximately six hours, might become a bottleneck if demand for these products should increase.

TABLE II

PRODUCT	APPROXIMATE POUNDS PER BATCH	APPROXIMATE TIME REQUIRED TO PRODUCE & PACKAGE A BATCH
1254 - 10% Toluene	20,000 Pounds	24 Hours
1260 - 10% Toluene	20,000 "	24 Hours
1262 - 10% Toluene	20,000 "	24 Hours
1262 - 10% Xylene	20,000 "	24 Hours
A13B3B	100,000 "	24 Hours
Inerteen PPO	100,000 "	24 Hours
Inerteen 54201-KA	100,000 "	48 Hours
Therminol FR-0	20,000 "	24 Hours
Santicizer 794	20,000 "	24 Hours
Aroclor Blend	20,000 "	24 Hours

T

MONS 049600

APPENDIX M - QUALITY CONSIDERATIONS

Pyranols and Inerteens are used as capaciter and transformer fluids by the electrical industry. The Aroclors used must meet rigid electrical grade specs. The Hooker supplied trichlorobenzenes (TCB) and Tri-tetrachlorobenzenes (TTCB) are analyzed before use. Power factor is measured to determine the need for earth treatment before use in a blend. As the batch is being made samples are analyzed for the electrical properties as well as the physical properties to determine the necessity of further earth treatment.

The other blends are analyzed for physical properties only although all Aroclor 1242, 1254, and 1260 used meet the electrical specs.

U

MONS 049602

APPENDIX N - MISCELLANEOUS

Specialized Equipment

Iron rust has a deleterious effect on the electrical properties of Pyranols. Every effort is made to prevent rust from coming in contact with the product. The Pyranol mix tank and tank cars are zinc-tin lined to prevent rust. Galvanized, aluminum lines and stainless steel pumps and valves are used.

MONS 049604

Therminol 77 is a *liquid-phase* heat transfer fluid particularly suitable for continuous use for temperatures up to 700°F. It has been used for several years in commercial scale and pilot plant systems in a diversity of applications; e.g., paint and resin manufacture, high-temperature plastic extrusion, lamination of plastics, chemical processing, laboratory baths, and thermostatic devices.

Unlike Monsanto's Therminol FR line of fire-resistant heat transfer fluids (chlorinated hydrocarbons), Therminol 77 does not contain halogen and is not fire resistant. The recommended design considerations described in the Therminol FR Engineering Manual, such as flow rate, ΔT, heat-flux density, etc., are also applicable to Therminol 77.

Although Therminol 77 does thermally degrade at temperatures above 700°F, it has been used in commercial heat transfer systems up to its atmospheric boiling point of 830°F. Degradation rate is very low at 700°F and increases progressively at increasing temperatures. Therminol 77 degradation products are predominantly polymers which are completely soluble in the bulk fluid and, therefore, do not form insulating deposits in the system. Degraded fluid is, however, more viscous than fresh fluid but can be reclaimed economically to essentially new-fluid condition.

MONS 049479

THERMINOL® 77 FLUID PROPERTIES

Temp °F	Vapor Pressure (mm Hg)	Viscosity (cs)	Viscosity (Lbs Ft-Hr)	Density (GMS cc)	Density (Lbs Gal)
100	—	181	505	1.152	9.60
210	—	7.78	20.8	1.106	9.26
300	0.27	2.65	—	1.070	8.94
400	1.03	1.50	3.74	1.029	8.58
500	9.2	0.96	2.28	0.981	8.16
600	44	0.66	1.49	0.931	7.76
700	168	0.46*	0.99	0.885	7.38
800	530	—	—	—	—

*Extrapolation

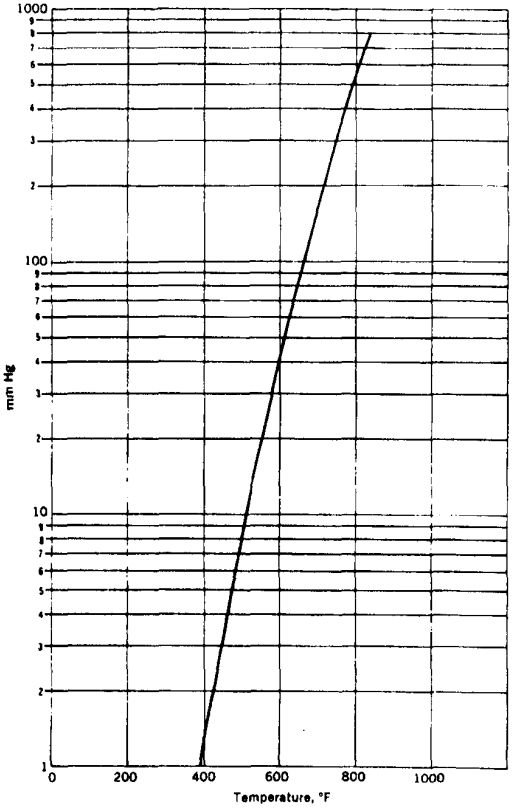
THERMAL CONDUCTIVITY

Temp °F	Specific Heat (BTU Lb)	(Cal cm, °C, sec)	(BTU °F, Ft-Hr)	Thermal Expansion, (cc °F)
100	0.350	32.25×10^{-4}	0.0781	0.00034
200	0.375	31.40×10^{-4}	0.0760	—
300	0.420	30.50×10^{-4}	0.0739	0.00037
400	0.455	29.65×10^{-4}	0.0719	—
500	0.495	28.80×10^{-4}	0.0698	0.00049
600	0.530	—	—	—
700	0.565	—	—	0.00062
800	0.600	—	—	—
Pour Point		+45°F	Fire Point	540°F
Flash Point		460°F	A. I. T.	1115°F
			Thermal Decomposition**	800°F

**Thermal decomposition was determined by the isoteniscope method as described in the "Journal of Chemical and Engineering Data," January 1961, Vol. 6, No. 1. It is defined as the temperature at which $dp/dt = 0.014$ mm Hg per second, or 500 mm Hg per 10 hours.

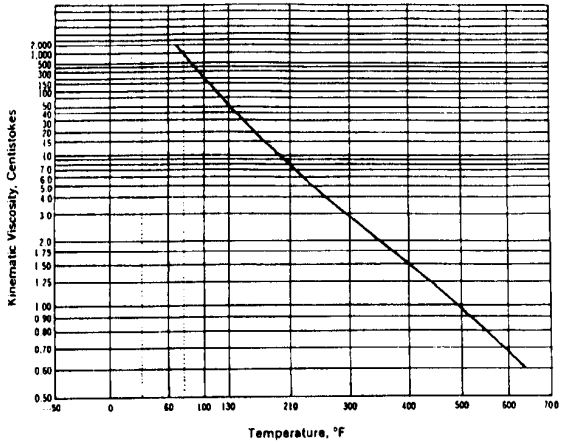
MONS 049480

VAPOR PRESSURE

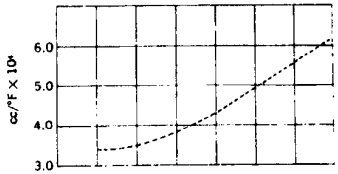


MONS 049481

KINEMATIC VISCOSITIES



COEFFICIENT OF THERMAL EXPANSION



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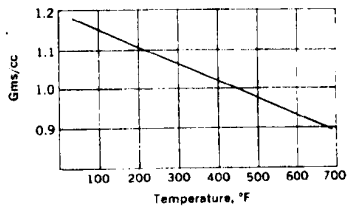
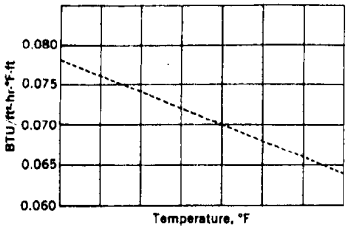
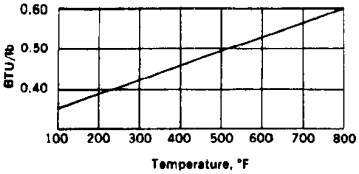


MONS 049482

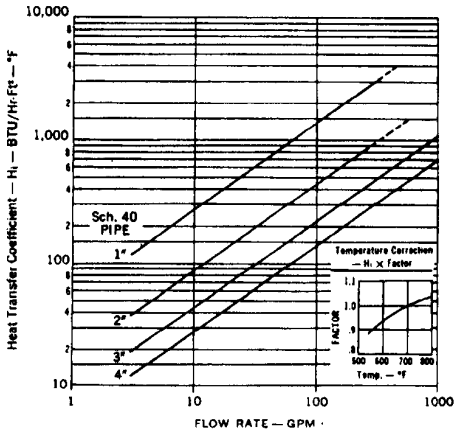
THERMAL CONDUCTIVITY



SPECIFIC HEAT



Inside Film Heat Transfer Coefficient versus Flow Rate at 700°F

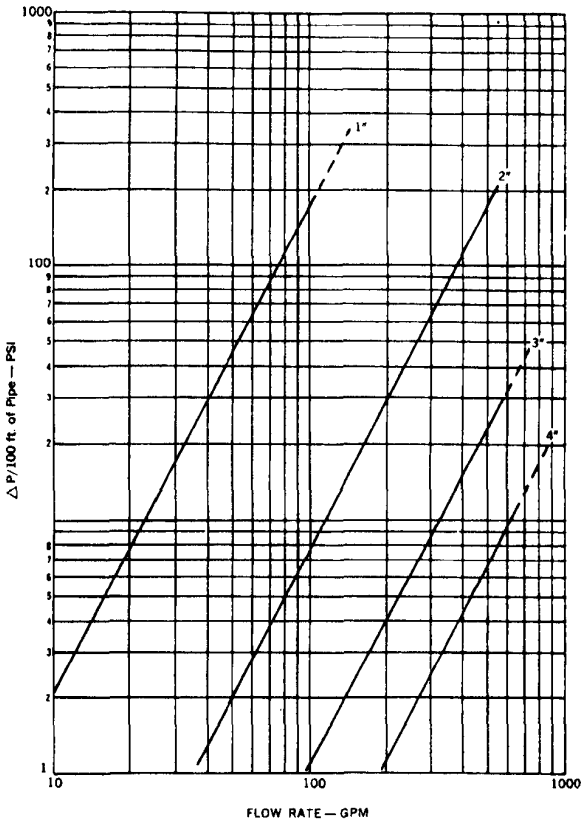


MONS 049483

Pressure Drop Per 100 Ft. of Pipe

versus

Flow Rate at 700°F



MONS 049484

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MONS 049485

2-2475 0767-B LITHO IN U.S.A.

TECHNICAL BULLETIN FR-O (T)

THERMINOL®
FR-O
FIRE-RESISTANT
HEAT TRANSFER
FLUID

Therminol FR-O liquid phase heat transfer fluid with low temperature pumpability.

Nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or its use. The information contained herein is, to our best knowledge, accurate; but all recommendations or suggestions are made without guarantee, since the conditions of use are beyond our control. Monsanto disclaims any liability for loss or damage incurred in connection with the use of the above.

Organic Division / 800 N. Lindbergh Blvd. / St. Louis, Missouri 63166

FUNCTIONAL FLUIDS Monsanto

MONS 049486

Introducing Therminol FR-O...

Newest member of the growing line of Monsanto heat transfer fluids. Therminol FR-O was formulated specifically to eliminate freeze-up during cold weather shut down for in-transit heating of sulfur, pitch, asphalt, naphthalene, bunker "C" fuel oil, and high melting resin materials. Therminol FR-O eliminates the need for high temperature reheating in order to pump out the material at its destination. Low temperature pumpability makes it ideally suited for space heating applications, outdoor plants in Northern climates, or in any application where cold [illegible] peratures is a prerequisite.

Fire-Resistance...

Therminol FR-O permits installation of a non-pressurized system operating with a liquid that has no fire point, and will not support combustion ... so fire-resistant, Therminol fluids have achieved recognition by Underwriters' Laboratory, Factory Mutual, and Factory Insurance Association. Because of this extreme fire-resistance and its listing by insurance companies, important savings can be made in designing a process heating system around Therminol FR-O fluid.

Chemically Speaking...

Therminol FR-O fluid is a chlorinated biphenyl, manufactured under exacting process control to rigid specifications for long term thermal stability, [illegible] thermal conductivity, [illegible] and viscosity. The liquid is an oily, clear, nearly [illegible] at temperature of [illegible].

Therminol FR-O fluid is recommended for use up to 500°F and will not show measurable change after years of exposure to such temperatures. The fluid is non-corrosive with all common metals used in heat transfer system designs.

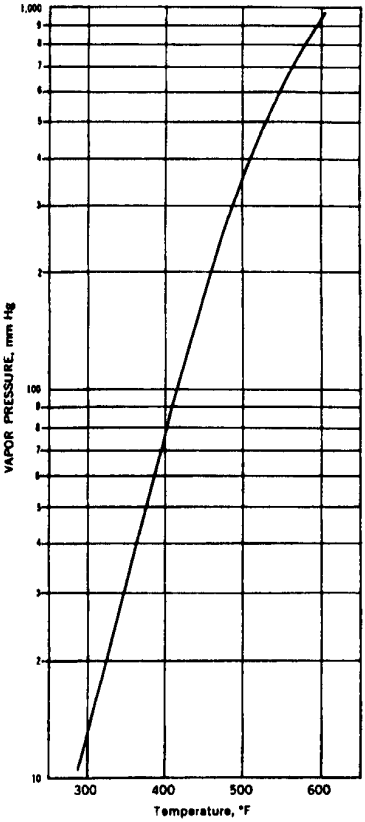
TYPICAL PROPERTIES OF THERMINOL FR-O

	Temperature, °F								
Property	−5	+10	40	100	200	300	400	500	600
Kinematic Viscosity, cs.	4545	1007	92.55	8.10	1.70[a]	0.95	—	—	—
Saybolt Viscosity, SSU	20850	4640	429	52.43	7.99[a]	4.54	—	—	—
Vapor Pressure, mm Hg	—	—	—	—	1.35	13.00	76.0	315	915
Specific Heat, BTU/lb.[b]	—	—	—	0.27	0.29	0.31	0.33	0.35	0.36
Thermal Conductivity, BTU/°F-Ft.-Hr.[b]	—	—	—	0.061	0.060	0.059	0.058	0.057	0.056
Density, g/cc	—	1.45	1.43	1.40	1.34	1.28	1.23	1.17	1.11
Density, lbs./gal.	—	12.10	11.92	11.70	11.19	10.69	10.27	9.76	9.27

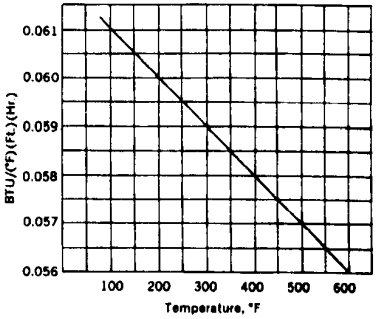
[a] Viscosity at 210°F
[b] Calculated values

MONS 049487

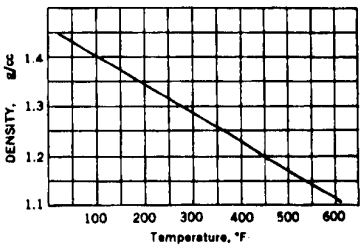
VAPOR PRESSURE



THERMAL CONDUCTIVITY (calculated)

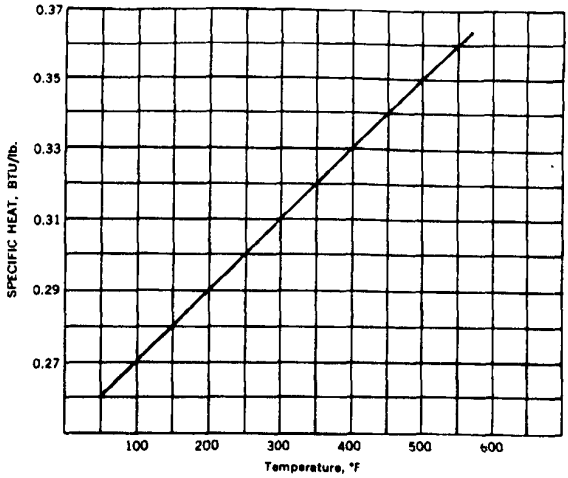


DENSITY

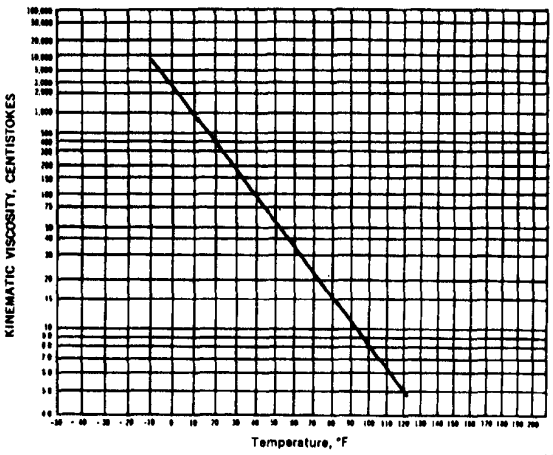


MONS 049488

SPECIFIC HEAT



KINEMATIC VISCOSITIES



MONS 049489

2-2169-0586-6 LITHO IN U. S. A.

THERMINOL® 66 HEAT TRANSFER FLUID

...for use in liquid phase between 0-650°F without system pressurization

TECHNICAL BULLETIN (T-66)

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FUNCTIONAL FLUIDS Monsanto

MONS 049490

Introducing Therminol® 66

Therminol® 66 is a heat transfer fluid for use in liquid phase between 0-650°F without system pressurization. The low pour point of this product permits start up at fluid temperatures as low as 0°F.

To minimize fluid oxidation, systems with Therminol 66 should be blanketed with an inert atmosphere. A system relief valve should also be provided. Therminol 66 is ideally suited to replace organic fluids that have lower boiling points and must operate under system pressure at 650°F.

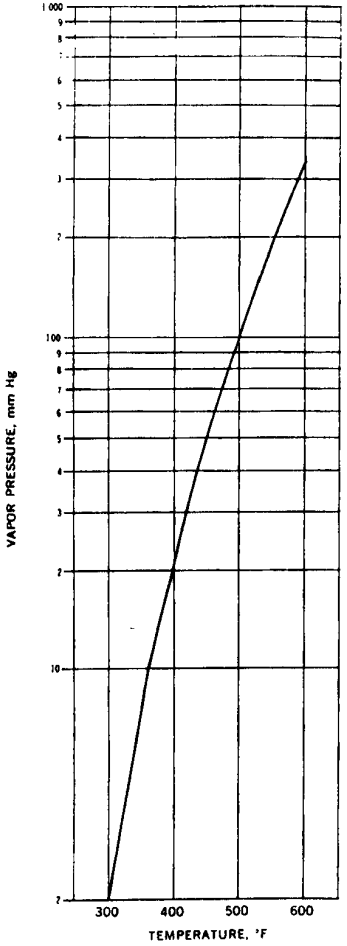
Therminol 66 can support combustion and should not be confused with Monsanto's Therminol FR fire-resistant fluids.

TYPICAL PROPERTIES OF THERMINOL® 66

Composition	Modified terphenyls
Appearance	Oily liquid
Color	Practically colorless
Odor	Faint, characteristic
Pour Point	−26° — −28°C. −15° — −18°F.
Flash Point	168° — 180°C. 334° — 356°F.
Flame Point	190° — 202°C. 374° — 392°F.
Autoignition Temp.	364°C. 705°F.
Coefficient of Expansion	0.000741 cc. cc. °C.
Boiling Range	340° — 396°C 644° — 745°F

MONS 049491

VAPOR PRESSURE



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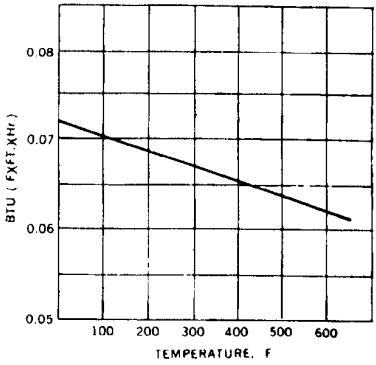

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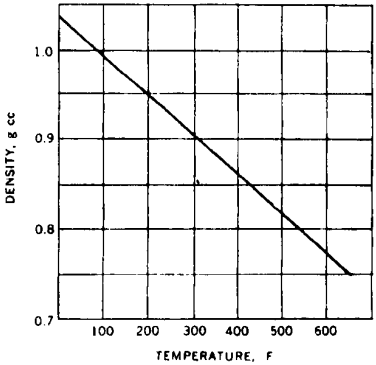

MONS 049492

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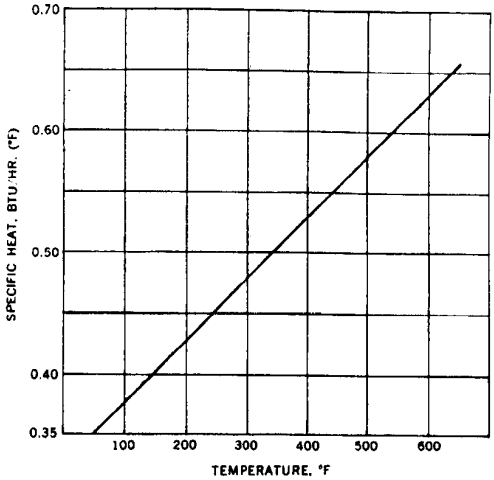

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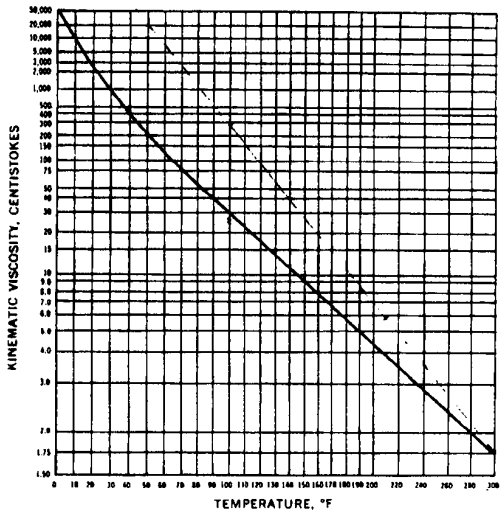

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September 5, 1961

REPORT

on

HEAT TRANSFER FLUIDS

Monsanto Chemical Co.
St. Louis, Missouri

D E S C R I P T I O N

PRODUCT COVERED:

Heat transfer fluids, "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3."

GENERAL CHARACTER AND USE:

These products are mixtures of liquid chlorinated aromatic hydrocarbons in different proportions intended for use as heat transfer mediums in systems operating at atmospheric pressure.

MARKING:

Listee's name and trade name.

G E N E R A L

The products covered by this Report are mixtures of liquid chlorinated aromatic hydrocarbons in different proportions intended for use as liquid phase heat transfer mediums in systems operating at atmospheric pressure. Products of similar formulation have been previously investigated and listed by the Laboratories for use as dielectric and cooling mediums in electrical apparatus.

The object of this investigation was to determine the fire and explosion hazards of the products.

In planning the investigation, consideration was given to the general nature of the products, their fire and toxicity hazards, corrosive action, stability, and practicability. The method of investigation of each of these features is given below.

Information as to the general nature of the products was obtained from identification tests.

In the study of the fire and toxicity hazards, the products were investigated as to flammability, explosiveness of the vapors when mixed with air, ignition temperature, behavior in the presence of hot metals, and decomposition temperature. The products of decomposition were investigated in respect to flammability and explosibility. Consideration was also given to the toxicity of the gases produced on contact of the products with hot metal surfaces and electric arcs. The tests included flash point tests, fire point tests, ignition temperature tests, tests for explosiveness of vapors in air, explosive range tests, test of behavior in the presence of hot metals, decomposition temperature tests, and analytical tests of decomposition products.

Corrosion tests of the products on some common metals were conducted.

Information bearing on the stability of the products was obtained from decomposition temperature tests, corrosion tests, spontaneous heating tests, and consideration of the chemical properties of the products.

The practicability of the products was considered from the standpoint of their general nature and available data.

TEST RECORD NO. 1

SAMPLES:

Samples representative of the products "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3" were used in the tests.

IDENTIFICATION TESTS:

METHOD

Specific Gravity - The specific gravity of each product was determined by means of a pycnometer.

Tests for Chlorine - A few drops of each product, together with a small piece of metallic sodium, were heated in a test tube over a Bunsen burner. After the reaction was completed, the test tube was broken in water, the resulting solution filtered, and nitric acid and silver nitrate solution were added. The formation of a white precipitate of silver chloride indicates the presence of chemically combined chlorine in the product.

Distillation Test - A 100 g sample of each product was distilled, using the Method (D20-30) of the American Society for Testing Materials.

RESULTS

The results of the identification tests are recorded in Table I.

Table I

Results of Identification Tests

	"Thermofluid FR1"	"Thermofluid FR2"	"Thermofluid FR3"
Specific gravity at 15.6 C (60 F) / 15.6 C (60 F)	1.384	1.456	1.548
Chlorine	Present	Present	Present
Distillation test:			
Initial boiling point	312 C (594 F)	330 C (626 F)	352 C (666 F)
Per cent, by weight, distilled at indicated temperatures	88.7 per cent below 335 C (635 F). 10.2 per cent at 355 C (635 F) 358 C (676 F).	60.5 per cent below 340 C (644 F). 27.5 per cent at 340 C (644 F) to 350 C (662 F). 9.5 per cent at 350 C (662 F) to 379 C (635 F).	72.1 per cent at 270 C (518 F) to 366 C (690 F). 24.0 per cent above 366 C (690 F).
End point	358 C (676 F)	379 C (714 F)	374 C (706 F)
Residue, per cent by weight	0.8	1.3	3.5
Distillation loss, per cent by weight	0.3	1.2	0.4

FLASH POINT TESTS:

METHOD

The flash point of each product was determined with the Pensky-Martens closed tester, using the Method (D93-46) of the American Society for Testing Materials.

RESULTS

The results of the flash point tests were as follows:

Product	Flash Point (1)
"Thermofluid FR1"	176.7 C (350 F)
"Thermofluid FR2"	196.1 C (385 F)
"Thermofluid FR3"	232.2 C (450 F)

FIRE POINT TESTS:

METHOD

The fire point tests were made with the Cleveland open cup tester, using the Method (D92-46) of the American Society for Testing Materials.

RESULTS

The products "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3" gave negative results in the fire point tests.(2) Intermittent flashes were obtained, but the products did not continue to burn. The samples were heated to the boiling point, and the test then discontinued.

(1) The flash point alone is not necessarily a true measure of the fire hazard of a liquid. In this connection, see note (2).

(2) In view of the negative results obtained in the fire point tests, it is clear that the flash point tests cannot be depended upon to give a true measure of the fire hazard of these products. It was therefore necessary to conduct tests for explosiveness of vapors in air.

MONS 049499

IGNITION TEMPERATURE TESTS:

METHOD

The apparatus consisted essentially of a combustion chamber surrounded by a molten solder bath, which was heated at a constant temperature during the test. The temperature of the solder bath was measured by means of a calibrated thermocouple provided with a quartz tube to protect the hot junction.

The combustion chamber consisted of a quartz flask of conical form with flat bottom, 11.4 cm in height, 6.0 cm in diameter at bottom, and 2.8 cm in diameter at top. It was of about 160 ml capacity (rated capacity 125 ml) having a ratio of surface area to volume of about 1:1.

Measured test samples of the products in the liquid phase were introduced into the heated combustion chamber by means of a micropipette. Different amounts of the product were admitted to the chamber in successive tests at progressively lower temperatures in order to determine the minimum temperature at which the vapor, in any proportion with air, will ignite without application of a flame. The residual vapors or gases in the combustion chamber were displaced by a stream of air in the interval between tests.

RESULTS

The results of the ignition temperature tests were as follows:

Product	Ignition Temperature (3)
"Thermofluid FR1"	652 C (1206 F)
"Thermofluid FR2"	672 C (1243 F)
"Thermofluid FR3"	571 C (1060 F)

(See note (3) on following page.)

(3) The main value of the ignition temperature test is to determine the minimum temperature required to produce ignition under the most favorable conditions in the absence of a flame or spark, including ratio of vapor to air and ratio of heated surface to volume of vapor-air mixture. Under less favorable conditions, as when the liquid is applied to a hot place, a higher temperature for ignition is required. A limitation of the ignition test in a small vessel is that it does not show whether flame propagation for any material distance will occur. After determining the ignition temperature, therefore, it is necessary to obtain additional data having a bearing on flame propagation. These data are given by tests for explosiveness of vapors in air.

TESTS FOR EXPLOSIVENESS OF VAPORS IN AIR:

METHOD

The apparatus consisted of a horizontal cylindrical steel vessel, 6 in. in diameter (internal) and 26 in. long. It was provided with a small mica window and an outlet to the atmosphere, this outlet being normally closed by a loosely fitted asbestos plug. Openings were provided halfway between the ends of the vessel to admit electrode terminals connected to an induction coil. The electrode terminals were centrally located in the vessel, and were spaced to give a spark gap of 1/4 in.

The vessel was heated externally by gas burners. An iron constantan thermocouple connected to a potentiometer was used for rough measurements of the temperature of the vapor inside of the vessel.

Samples of the liquid products, ranging in volume from 20 to 80 ml, were introduced into the vessel which had previously been heated to a predetermined temperature. Sparks were passed between the electrode terminals at intervals of 1/2 min, and observations made as to whether ignition of the test mixture and flame propagation occurred.

Residual gases and vapors were displaced from the cylinder by a stream of air in the interval between tests.

RESULTS

"Thermofluid FR1" - No propagation of flame occurred in mixtures of the vapors of the product with air at temperatures up to 141 C (286 F). Flame propagation with weak pressure effects (sufficient to push asbestos plug from the outlet of cylinder) occurred at 144 C (291 F). Moderate pressure effects (asbestos plug thrown about 3 or 4 ft horizontally from outlet of cylinder) were obtained at temperatures somewhat above 144 C (291 F).

"Thermofluid FR2" - No propagation of flame occurred in mixtures of the vapors of the product with air at temperatures up to 148 C (298 F). Flame propagation with weak pressure effects (sufficient to push asbestos plug from the outlet of cylinder) occurred at 150 C (302 F). Moderate pressure effects (asbestos plug thrown about 3 or 4 ft horizontally from outlet of cylinder) were obtained at temperatures somewhat above 150 C (302 F).

"Thermofluid FR3" - No propagation of flame occurred in mixtures of the vapors of the product with air at temperatures up to 204 C (399 F). Flame propagation with weak pressure effects (sufficient to push asbestos plug from the outlet of cylinder) occurred at 208 C (406 F). Moderate pressure effects (asbestos plug thrown about 3 or 4 ft horizontally from outlet of cylinder) were obtained at temperatures somewhat above 208 C (406 F).

EXPLOSIVE RANGE TESTS:

METHOD

The apparatus consisted essentially of an explosion chamber of glass equipped with a spark gap and a stirrer. The chamber was cylindrical with the lower end hemispherical. It was approximately 3 in. in diameter, 8 in. in height, and had a net volume of 52.6 cu in. (863 cc). The chamber was provided with a glass lid supporting the stirrer and the leads to the spark gap near the bottom of the chamber. An opening in the lid was provided for introduction of the sample. The glass chamber was immersed in a molten solder bath to a depth of 6 in.

In conducting tests, the solder bath was maintained at a constant temperature of 400 C (752 F), a measured quantity of the liquid product to be tested was placed in the chamber, and the contents of the chamber stirred to produce a uniform vapor-air mixture. The electrical discharge from an induction coil was then passed at the spark gap while observations were made for flame travel (upward propagation) and pressure effects. Following each test the residual gases and vapors were displaced from the chamber by a slow stream of air in preparation for the next test.

RESULTS

The results of the explosive range tests of "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3" in air at 400 C (752 F) are shown in Table II.

Table II

Results Of Explosive Range Tests

Product	Lower Limit			Upper Limit		
	Volume Of Liquid Used In Test, Ml	Lb Vaporized Liquid Per 1000 Cu Ft Of Air (Calculated)	Per Cent Vapor By Volume In Mixture With Air (Calculated)	Volume Of Liquid Used In Test, Ml	Lb Vaporized Liquid Per 1000 Cu Ft Of Air (Calculated)	Per Cent Vapor By Volume In Mixture With Air (Calculated)
"Thermofluid FR1"	0.038	3.9	1.3	0.110	11.4	3.9
"Thermofluid FR2"	0.033	3.5	1.1	0.119	13.0	3.9
"Thermofluid FR3"	0.038	3.7	1.0	0.100	9.7	2.7

Weak pressure effects were obtained in these tests as would be expected for mixtures near the limits of flammability.

MDNS 049504

TESTS OF BEHAVIOR IN THE PRESENCE OF HOT METALS:

METHOD

The apparatus consisted essentially of a horizontal steel plate, 10 in. square and 1/4 in. in thickness, heated by gas burners underneath. Flames and hot gases from these burners were deflected from the upper surface of the steel plate by a thin sheet of steel extending 10 in. horizontally beyond the edges of the plate. This deflector was bolted to the edges of the plate, asbestos gaskets being provided at the joints. A calibrated chromel-alumel thermocouple (No. 14 Awg), connected with an indicating potentiometer, was used to measure the temperature of the plate, the hot junction of the thermocouple being brazed to the center of the upper surface of the plate. Check measurements of the temperature of the plate were also made using an optical pyrometer of the disappearing filament type.

In conducting tests, measured samples (up to 10 ml) of the product "Thermofluid FR3" were dropped onto the center of the upper surface of the heated plate. A slow stream of air was applied to the evaporating sample in some of the tests. The minimum ignition temperature was determined by successive trials, during which the steel plate was maintained at progressively lower temperatures.

RESULTS

The product "Thermofluid FR3" when applied to the steel plate heated at 754 C (1390 F), or higher, ignited. The combustion was very weak and did not show any tendency to propagate beyond the vicinity of the heated surface. It will be noted that there was no confinement of the vapors in these tests with the heated steel plate.

DECOMPOSITION TEMPERATURE TESTS:

METHOD

The apparatus previously described in connection with ignition temperature tests was used in these tests. The vapors evolved on introducing samples of the products into the heated chamber were tested with moist blue litmus paper, a change in the color of the paper from blue to red indicating decomposition of the product. The minimum temperature at which litmus paper showed an appreciable change in color within a short time (3 min) was considered to be the decomposition temperature.

RESULTS

The results of the decomposition temperature tests are recorded below:

Product	Decomposition Temperature
"Thermofluid FR1"	309 C (588 F)
"Thermofluid FR2"	305 C (581 F)
"Thermofluid FR3"	300 C (572 F)

ANALYTICAL TESTS OF DECOMPOSITION PRODUCTS:

METHOD

Hot Iron Surfaces - The cylindrical vessel previously described under tests for explosiveness of vapor in air was also used for exposing vapor-air mixture to hot iron surfaces. Connections for withdrawing samples of the decomposition products for analysis were inserted in the outlet pipe. The cylinder was externally heated to a temperature of 600 C (1112 F) by gas burners.

The heat transfer fluids, in the liquid phase, were introduced into the heated cylinder at a uniform rate. Samples of the decomposition products were withdrawn from the outlet pipe and hydrochloric acid, free chlorine, phosgene, carbon dioxide, oxygen, carbon monoxide, gases absorbed by fuming sulphuric acid or bromine, methane and other paraffin hydrocarbon gases, and in some cases hydrogen, were determined using the following methods.

Hydrochloric acid was determined by absorption in water and subsequent titration with standard alkali solution. Samples were collected in evacuated glass sampling tubes, or a measured sample was drawn by means of a calibrated aspirator bottle through an absorption train consisting of three spiral form bubbling towers. Free chlorine interferes with the determination and is removed by mercury in contact with the absorbing water.

Tests for free chlorine were made by liberation of iodine from aqueous potassium iodide solution and subsequent titration with sodium thiosulphate solution, using starch solution as an indicator. A measured sample was drawn by a calibrated aspirator bottle through an absorption train consisting of two spiral form bubbling towers containing potassium iodide solution.

Phosgene was determined by absorption in aqueous aniline solution. Phosgene reacts quantitatively with aniline to form diphenylurea, one molecule of phosgene being equivalent to one molecule of diphenylurea. A measured sample was drawn through a train of three bubbling towers containing freshly prepared aqueous aniline solution saturated with diphenylurea. Free chlorine interferes with the determination and was removed by granulated antimony contained in a tube through which the sample passed before entering the bubbling towers. The precipitate of diphenylurea was separated from the aniline solution by filtration, washed with cold water, dissolved in ethyl alcohol, recrystallized, dried, and weighed.

Carbon dioxide, oxygen, gases absorbed by bromine or fuming sulphuric acid, and methane and other paraffin hydrocarbon gases, were determined using either the Morehead form of gas analysis apparatus or an Orsat form of gas analysis apparatus of the precision type. In some tests, hydrogen was also determined, using the Orsat apparatus. Samples of the decomposition products for these determinations were collected in evacuated glass sampling tubes. The samples were treated with silver nitrate solution to remove hydrochloric acid, before proceeding with the gas analyses.

Electric Arcs - These tests were conducted with the product "Thermofluid FR3."

The apparatus consisted of a cylindrical steel vessel 10 in. in diameter (internal) and 18 in. in height. It was provided with a small mica window and an outlet to the atmosphere. Openings were provided in the vessel to admit two electrode holders, one holder being fixed and the other movable. The electrodes were copper rods 1/2 in. in diameter, their arcing terminals being horizontal. A connection for withdrawing samples of decomposition products for analyses was inserted in the wall of the vessel, above liquid level. A small cylindrical settling chamber for the removal of solid products of decomposition was attached to the sampling connection.

The electrodes were connected to a 230 v, d-c test circuit, the current being controlled by resistors. An ammeter was connected in the circuit, and a voltmeter was connected across the electrode terminals.

A sample of the product, about 15 lb, was placed in the vessel, the arcing terminals of the electrodes being partially immersed in the sample. The arcing terminals were located on the axis of the cylinder, 3-1/2 in. above the bottom. A continuous arc (170 amp) was maintained between the electrodes until destruction of the arcing terminals (5 min).

Samples of the decomposition products were withdrawn continuously from the test vessel while the arc was in operation, and tested for phosgene and chlorine, using the methods previously described. Samples of the decomposition products were also collected in evacuated glass sampling tubes at the conclusion of the test, and the chief constituents determined, using the following methods.

Hydrochloric acid was determined by absorption in water and subsequent titration with standard alkali solution. Carbon dioxide, carbon monoxide, oxygen, gases absorbed by bromine, and paraffin hydrocarbon gases were determined using the Morehead apparatus. The samples were treated to remove hydrochloric acid before conducting the gas analyses.

Tests were also conducted with the arcing terminals of the electrodes immersed 2-3/4 in. below the level of the sample in the vessel. A 21 lb sample of the product was used in these tests. The arcing terminals were located on the axis of the cylinder, 2 in. from the bottom. A continuous arc (125 to 190 amp) was maintained between the electrodes until destruction of the arcing terminals. Samples of the decomposition products were withdrawn at intervals during the tests (see Table V), and the chief constituents determined using the methods previously described.

RESULTS

Hot Iron Surfaces - The results of analytical tests of the decomposition products of the heat transfer fluids "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3" in the presence of hot iron surfaces are shown in Table III.

Electric Arcs - The results of analytical tests of the decomposition products of the heat transfer fluid "Thermofluid FR3" in the presence of an electric arc between terminals partially immersed in the fluid are shown in Table IV.

The results of analytical tests of the decomposition products of the heat transfer fluid "Thermofluid FR3" in the presence of an electric arc between terminals totally immersed in the fluid are shown in Table V.

Table III

Results Of Analytical Tests Of Decomposition Products In Presence Of Hot Iron Surfaces

Concentration, Per Cent By Volume (1)	"Thermofluid FR1" 5 Min (2)	"Thermofluid FR1" 13 Min	"Thermofluid FR2" 5 Min	"Thermofluid FR2" 13 Min	"Thermofluid FR3" 5 Min	"Thermofluid FR3" 13 Min
Carbon dioxide (CO_2)	20.8	24.1	16.9	10.5	27.6	20.2
Carbon monoxide (CO)	8.7	11.8	12.2	13.0	13.2	8.0
Oxygen (O_2)	6.2	0.6	2.7	4.4	1.0	1.0
Gases absorbed by fuming sulphuric acid or bromine	0.5	0.7	0.5	0.4	0.0	0.0
Paraffin hydrocarbon gases calculated as methane	2.5	1.6	1.4	1.4	0.0	0.0
Hydrogen (H_2)	0.8	3.8	0.7	3.5	-	-
					5 to 13 Min	
Hydrochloric acid (HC_1)	25.3	34.8	22.3	44.8	11.2	
	5 to 13 Min		5 to 13 Min			
Chlorine (Cl_2)	0.000		0.000		0.000	
Phosgene ($COCl_2$)	0.000		0.000		0.000	

(1) In addition to the volatile decomposition products some finely divided carbon was formed.
(2) Time of sampling, after start of test.

MONS 049510

Results Of Analytical Tests Of Decomposition Products In Presence Of Electric Arcs Between Terminals Partially Immersed In Heat Transfer Fluid

Concentration, Per Cent By Volume (1)	"Thermofluid FR3" 5 Min (2)
Carbon dioxide (CO_2)	1.3
Carbon monoxide (CO)	7.7
Oxygen (O_2)	7.7
Gases absorbed by bromine	0.0
Paraffin hydrocarbon gases calculated as methane	0.0
Hydrochloric acid (HCl)	26.7
	Start Of Test To 5 Min
Chlorine (Cl_2)	0.000
Phosgene ($COCl_2$)	0.000

(1) In addition to the volatile decomposition products a large amount of finely divided carbon was formed.

(2) Time of sampling, after start of test.

Table V

Results Of Analytical Tests Of Decomposition Products In Presence Of Electric Arcs Between Terminals Totally Immersed In Heat Transfer Fluid

Concentration, Per Cent By Volume (1)	"Thermofluid FR3" 2-1/2 Min (2)	5 Min	5-1/2 Min
Carbon dioxide (CO_2)	0.0	0.0	0.0
Carbon monoxide (CO)	0.8	0.5	0.4
Oxygen (O_2)	12.4	7.4	5.7
Gases absorbed by bromine	0.0	0.0	0.0
Paraffin hydrocarbon gases calculated as methane	0.0	0.0	0.0
Hydrochloric acid (HC_1)	36.5	62.0	69.2

	Start Of Test To 5-1/2 Min
Chlorine (Cl_2)	0.000
Phosgene ($COCl_2$)	Less than 0.000

(1) In addition to the volatile decomposition products a large amount of finely divided carbon was formed.

(2) Time of sampling, after start of test.

SPONTANEOUS HEATING TESTS:

METHOD

The apparatus used for the spontaneous heating tests consisted essentially of a vertical, cylindrical test chamber, 7 in. in height and 4 in. in diameter, surrounded at the side and bottom by a water bath heated by an electric hot plate. The test chamber was provided with a cover having two air vent tubes and an opening for introduction of a thermocouple or a maximum registering thermometer. The sample was contained within the test chamber by a cylinder of wire gauze, 6 in. in height and 1-1/2 in. in diameter. This cylinder was condentric with the axis of the test chamber, there being an annular space through air of 1-1/4 in. between the cylinder and the wall of the chamber.

In conducting the tests, 14 g of the product were evenly distributed over 7 g of cotton fiber (commercial absorbent cotton) and placed in the containing cylinder within the test chamber. A maximum registering thermometer was inserted in the cotton bearing the test sample so as to measure the temperature at the approximate center of the mass. The cover was then placed on the test chamber and the water bath surrounding the chamber maintained at boiling for a period of 24 hr. A rise in the temperature of the sample above the temperature of the ambient water bath under the conditions of the test is an indication of spontaneous heating of the material.

RESULTS

The products "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3" showed no indications of spontaneous heating.

CORROSION TESTS:

METHOD

The metals used in the corrosion tests were copper, yellow brass, iron, tin-lead solder, copper and lead-tin solder, and copper and iron coupled. Test specimens, 3/4 in. wide and 6 in. long, were cut from sheets of the metals. The specimens were buffed, measured, cleansed with soap and water, washed with ethyl alcohol and ethyl ether, dried, and weighed.

Each metal specimen was immersed separately for half its length in a sample of the product contained in a glass tube provided with a cork stopper. The tubes and contents were maintained at a temperature of 90 C (194 F) in a thermostatically controlled electrically heated oven.

The metal specimens were examined visually at weekly intervals during the test for evidences of corrosion. At the conclusion of the test, the metal specimens were cleansed, dried, again weighed, and the change in weight per square centimeter of surface area calculated.

RESULTS

When heated in glass tubes containing the product "Thermofluid FR2" at 90 C (194 F) for 1465 hr, the specimens of metals showed little visible evidence of corrosion, except for a slight discoloration of the surfaces above the liquid. The change in weight of the specimens was very small (less than 1.0 mg/sq cm).

When heated in glass tubes containing the product "Thermofluid FR3" at 90 C (194 F) for 1680 hr, specimens of copper, yellow brass, copper and tin-lead solder, and copper coupled with iron showed no visible evidence of corrosion, except for a slight discoloration on the surfaces above the liquid. Specimens of iron, iron coupled with copper, and tin-lead solder showed no change in appearance. The change in weight of the specimens was very small (less than 1.0 mg/sq cm).

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C O N C L U S I O N S

GENERAL NATURE:

These products are essentially mixtures of aromatic hydrocarbons, the nature of which is considered a trade secret and is on file at Underwriters' Laboratories, Inc.

The results of identification tests indicate the products to be of the compositions stated by the manufacturer.

FIRE AND TOXICITY HAZARDS:

These products are nonflammable at ordinary temperatures. They are capable of forming moderately combustible and explosive mixtures with air under laboratory test conditions at higher temperatures, beginning at a temperature level of 144 C (291 F) in the case of "Thermofluid FR1," 150 C (302 F) in the case of "Thermofluid FR2," and 208 C (406 F) in the case of "Thermofluid FR3" but under practical conditions formation of combustible or explosive mixtures is regarded as extremely unlikely. The fire hazard is very small.

With respect to fire hazards, the products are classed 2 to 3 in accordance with Underwriters' Laboratories, Inc.'s Standard for the Classification of Liquids in which:

Ether rates	100
Gasoline rates	90-100
Alcohol (ethyl) rates	60-70
Kerosene (100 F flash closed cup) rates	30-40
Paraffin oil rates	10-20

It will be noted that the flash points of these products are comparatively high, and that a so-called "fire point" was not obtained. Although intermittent flashes occurred in the fire point tests in the open cup, the products did not continue to burn. The flash point and the so-called "fire point" tests, particularly the latter, in the case of chlorinated aromatic hydrocarbons, are of limited value as a measure of fire hazard, but are useful for the purposes of identification. The practical significance of the above tests in the case of these products is that their fire hazard is of a low order.

As shown by the results of tests for explosiveness of vapors in air, vapors of "Thermofluid FR1" failed to ignite or explode in tests at initial temperatures of 141 C (286 F), but propagated flame with weak pressure effects in tests at 144 C (291 F). Vapors of "Thermofluid FR2" failed to ignite or explode in tests at initial temperature of 148 C (298 F), but propagated flame with weak pressure effects in tests at 150 C (302 F). Vapors of "Thermofluid FR3" failed to ignite or explode in tests at initial temperature of 204 C (399 F), but propagated flame with weak pressure effects in tests at 208 C (406 F). Moderate pressure effects were obtained in tests with mixtures at somewhat higher initial temperatures. At a temperature of 400 C (752 F), the lower and upper limits of flammability (upward propagation) of the vapors of the products were found to be as follows:

	Per Cent Vapor Of Product, By Volume, In Mixture With Air		
Product	Lower Flammable Limit	Upper Flammable Limit	Flammable Range
"Thermofluid FR1"	1.3	3.9	2.6
"Thermofluid FR2"	1.1	3.9	2.8
"Thermofluid FR3"	1.0	2.7	1.7

It will be noted that these are relatively narrow flammable ranges.

The minimum ignition temperatures of the products under laboratory conditions were found to be 652 C (1206 F), 672 C (1243 F), and 571 C (1060 F) for "Thermofluid FR1," "Thermofluid FR2," and "Thermofluid FR3," respectively, as recorded in the results of ignition temperature tests.

The product "Thermofluid FR3" when applied to a hot iron surface did not ignite at plate temperatures below 754 C (1390 F). At higher temperatures the combustion was very weak and did not propagate beyond the vicinity of the heated iron surface.

The gases produced by burning, or decomposition of the products by heat, are nonflammable or nonexplosive, as evolved or mixed with air. The gases formed by burning or thermal decomposition were similar, whether formed by hot surfaces or electric arcs.

The gases or fumes produced by decomposition of the products include hydrochloric acid, carbon monoxide and in some cases trace amounts of phosgene. This will ordinarily constitute a toxic hazard only where the conditions are such as to cause confinement of the fumes, as in a closed room in which combustion or decomposition of the products is maintained by fire, highly heated surfaces, or electric arcs.

The exceedingly unpleasant and irritating fumes from the decomposition of these products, even in concentrations of a very low order, act not only to give warning of their presence but to prevent dangerous exposure of persons. While carbon monoxide is odorless and toxic, its formation from these products is always accompanied by the simultaneous formation of hydrochloric acid gas, which gives adequate warning of its presence as brought out above.

It will be noted that combustion and decomposition of the products were maintained by heated surfaces (600 C, 1112 F) or by an electric arc in carrying out the analytical tests of the decomposition products. As shown by the results of the decomposition temperature tests, the products were not appreciably decomposed at temperature below 300 C (572 F).

CORROSIVE ACTION:

No corrosion occurred in the tests conducted with representative metals and alloys in the presence of the products, as recorded under corrosion tests.

It will be noted from the results of analytical tests of decomposition of products that appreciable amounts of hydrochloric acid, a corrosive agent, are formed on combustion or decomposition of the products in the presence of hot metal surfaces or electric arcs.

STABILITY:

The products are reasonably stable, and in use are unlikely to undergo decomposition resulting in an increase in fire hazard.

In the decomposition temperature tests the products did not undergo appreciable decomposition at temperatures below 300 C (572 F). Considerations of the chemical composition and properties of the products also indicate that they are reasonably stable.

In the spontaneous heating tests, the products showed no tendency to heat or ignite spontaneously under test conditions designed to start and accelerate the process.

PRACTICABILITY:

It is considered practicable to use these products as heat transfer fluids in systems operating at atmospheric pressure.

The products are not intended to replace other heat transfer fluids unless the equipment is designed for such heat transfer fluids or these products. Due to the fact that some gasket, seal, packing, and hose materials may not be suitable for use with these products, the equipment manufacturer should be contacted with respect to his recommendations in connection with the replacement of such materials.

CONFORMITY:

These products have been classified as to their fire hazard in accordance with the Laboratories' Standard of Classification.

FOLLOW-UP PROGRAM:

These heat transfer fluids will be placed under the Reexamination Service of Underwriters' Laboratories, Inc.

RECOMMENDATION

TO THE FIRE COUNCIL OF UNDERWRITERS' LABORATORIES, INC.

We recommend promulgation of the following notice to subscribers and the action indicated thereby.

Guide No. 540 I.8. September 5, 1961 MH7640.
Heat Transfer Fluids.

Monsanto Chemical Co., St. Louis 66, Mo.

"Thermofluid FR1," "Thermofluid FR2," "Thermofluid FR3." Mixtures of chlorinated aromatic hydrocarbon liquids intended for use as heat transfer fluids in systems operating at atmospheric pressure.

The fire hazard of these products is small, being considerably less than that of paraffin oil.

Upon heating the liquid to temperatures of the order of 144 C (291 F) in the case of "Thermofluid FR1," 150 C (302 F) in the case of "Thermofluid FR2," and 208 C (405 F) in the case of "Thermofluid FR3," it may burn weakly upon ignition. Form moderately combustible and explosive mixtures with air at somewhat higher temperatures. Ignition temperature 652 C (1206 F) for "Thermofluid FR1," 672 C (1243 F) for "Thermofluid FR2," and 571C (1060 F) for "Thermofluid FR3." Not subject to spontaneous heating.

Classed 2 to 3 in respect to fire hazard.

---

800 N. Lindbergh Blvd.

Reexamination Service - See General Information Card of above guide number.

MONS 049519

Report by:

R. E. DUFOUR
Senior Assoc. Managing Engr.
Chemical Department

REVIEWED BY AND SUBMITTED:

E. N. DAVIS
Managing Engineer
Chemical Department

The foregoing Recommendation has been accepted NOV 9 1961

UNDERWRITERS' LABORATORIES, INC.

(SIGNED) W. S. AUSTIN

Vice President and Secretary

RED:DCG

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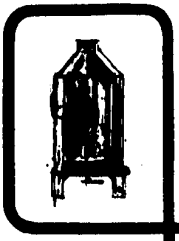
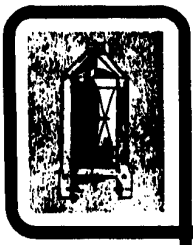
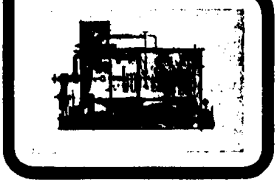
Monsanto









therminol FR

FLUID HEAT SYSTEMS

ENGINEERING HEAT TRANSFER DATA

A Design Guide For
Engineering Low-Cost, Low-Pressure
FIRE-RESISTANT HEAT TRANSFER SYSTEMS

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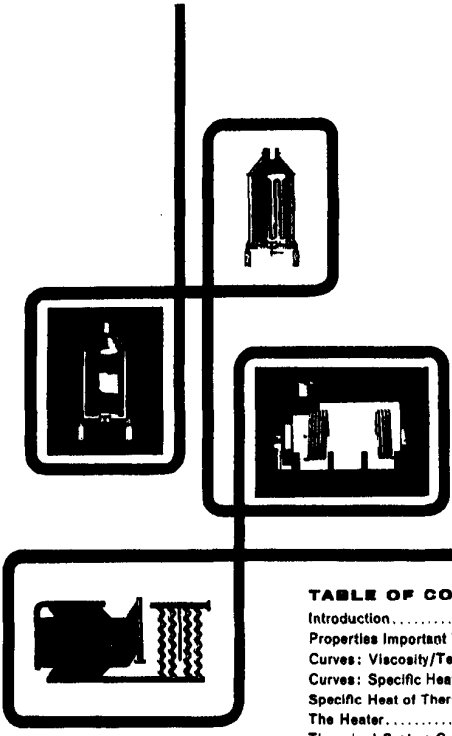

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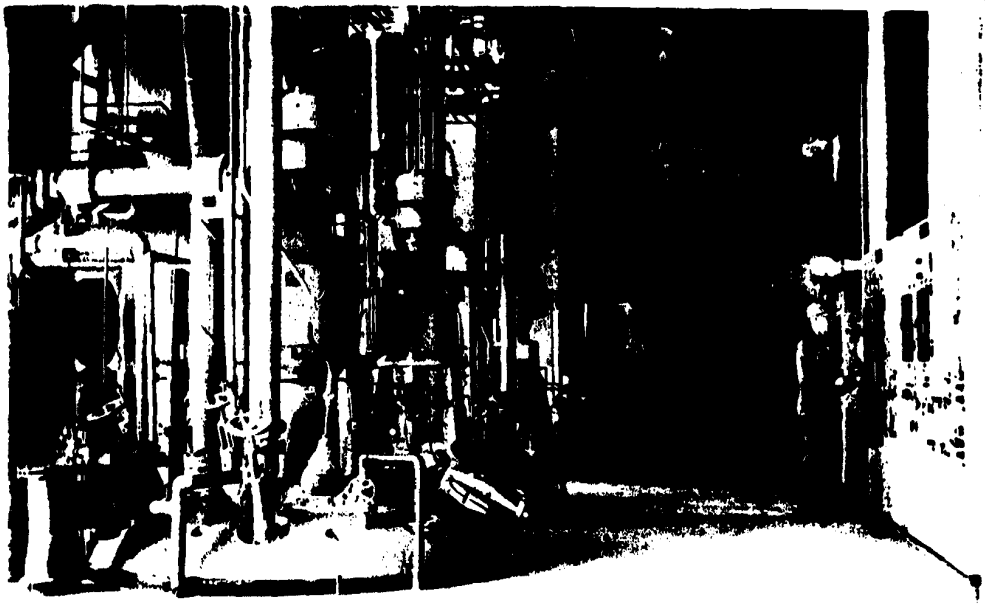

therminol FR FLUID HEAT SYSTEMS...

Delivering High-Temperature Process Heat as a Liquid

As recently as 1941, process engineers were limited to two methods of delivering process heat: DIRECT FIRING or PRESSURIZED VAPOR. Each method had definite drawbacks. Direct firing was often unsatisfactory because the heating was uneven, the temperatures difficult to control, and the processing of combustible materials extremely hazardous. Pressured-vapor, such as steam, required costly, high pressure piping, valves, and processing equipment—plus constant chemical "conditioning" of boiler water. Heat energy and temperature loss were common with pressured-vapor systems because of "blowdowns," condensation, and the inevitable pressure loss with long runs of piping.

Today, non-pressurized, high-temperature, fire-resistant heat transfer systems based on Monsanto's THERMINOL FR Heat Transfer liquids overcome practically all the deficiencies and drawbacks of direct firing and pressurized-vapor heating. THERMINOL FR—a series of high-boiling, heat-stable organic liquids, delivers processing heat to single or multi-users as a *liquid* without pressurizing. THERMINOL fluids are safe and fire resistant. Heating is uniform; and temperature control is accurate within a range of plus-or-minus 2°F.

Heat transfer systems now in use for several years have proved THERMINOL fluid heat successful in a wide variety of process heating operations . . . from food cooking to chemical processing, from distillations to drying ovens and in petroleum refining.

Design engineers and manufacturers have developed a variety of THERMINOL FR Fluid Systems ranging from small electrically heated units to giant gas or oil fired units—all capable of delivering heat AS A LIQUID.

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This manual explains and illustrates the fundamentals of THERMINOL fluid heat transfer systems design. It lists materials of construction and components for use with THERMINOL, and explains how each is "designed in" to make the most efficient system for safe, economical and reliable operation. It shows how these systems can be adapted to a wide variety of heating and cooling processes. This engineering heat transfer data has been compiled to aid the Process Engineer in designing a safe, minimum maintenance system for delivering heat to the points of use in practically any commercial or industrial process.



therminol FR HEAT TRANSFER LIQUIDS...

Monsanto THERMINOL FR heat transfer liquids are chlorinated biphenyls, manufactured under exacting process control to produce fluids consistent in all properties important to heat transfer. THERMINOL FR products are unique in that they are actually produced to rigid specifications for thermal stability, specific heat, thermal conductivity, vapor pressure, and viscosity.

There are three THERMINOL FR products, with a range of low temperature fluidity and boiling points that allows the user to select the best balance of fluid properties for a *specific* use:

THERMINOL FR 1

with lowest temperature fluidity — excellent for processes requiring both heating and cooling

THERMINOL FR 2

with optimum balance of properties for use in most common industrial heating applications

THERMINOL FR 3

with highest boiling point for special processing equipment applications

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PROPERTIES IMPORTANT TO HEAT TRANSFER DESIGN

THERMINOL FR-1

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.856	0.272	0.06096	11.683	745.36	
100	37.8	18.56	0.282	0.06060	11.458	56.144	
150	66	32.95	0.291	0.06021	11.216	15.972	
200	93	48.07	0.3047	0.05976	10.991	6.2431	
250	121	63.50	0.3151	0.05927	10.760	5.5270	
300	149	79.46	0.3253	0.05876	10.528	3.4156	
350	177	95.94	0.3359	0.05819	10.296	2.4753	10
400	204	112.96	0.3464	0.05760	10.066	1.8906	27
450	232	130.48	0.3568	0.05697	9.833	1.5026	65
500	260	148.52	0.3672	0.05630	9.601	1.2351	143
550	288	167.08	0.3776	0.05560	9.370	1.0428	291
600	316	186.16	0.3880	0.05487	9.138	0.90031	550
650	343	205.79	0.3985	0.05409	8.906	0.79186	18.8 psia
700	371	225.92	0.4089	0.05329	8.675	0.70731	31.9 psia

THERMINOL FR-2

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.56	0.257	0.05881	12.225	7090.8	
100	37.8	17.61	0.265	0.05852	12.000	181.01	
150	66	31.09	0.274	0.05801	11.790	27.83	
200	93	45.11	0.2840	0.05788	11.825	11.871	
250	121	59.48	0.2922	0.05748	11.293	6.949	
300	149	74.14	0.3008	0.05703	11.082	4.531	
350	177	89.26	0.3084	0.05655	10.839	3.201	6
400	204	104.81	0.3166	0.05603	10.595	2.369	18
450	232	120.74	0.3247	0.05548	10.367	1.881	37
500	260	137.08	0.3328	0.05488	10.135	1.529	84
550	288	153.85	0.3410	0.05424	9.902	1.2796	173
600	316	170.99	0.3491	0.05357	9.672	1.0871	340
650	343	188.58	0.3573	0.05286	9.440	0.9506	615
700	371	206.46	0.3654	0.05211	9.208	0.8585	29.8 psia

THERMINOL FR-3

Temperature °F.	Temperature °C.	Enthalpy BTU/Lb.	Specific Heat BTU/Lb.—°F.	Thermal Conduct. BTU/Ft², Hr., °F./Ft.	Density Lb./Gal.	Viscosity Lb./Hr.—Ft.	Vapor Pres. mm. Hg. Absolute
50	10.0	4.26	0.239	0.05700	13.002	———	
100	37.8	16.57	0.245	0.05680	12.760	1626.6	
150	66	29.06	0.256	0.05634	12.534	101.64	
200	93	41.95	0.2629	0.05620	12.292	24.262	
250	121	55.36	0.2714	0.05598	12.061	12.091	
300	149	69.20	0.2799	0.05558	11.829	7.116	
350	177	83.46	0.2884	0.05513	11.597	4.669	3
400	204	98.15	0.2969	0.05466	11.366	3.306	9
450	232	113.26	0.3054	0.05415	11.134	2.476	24
500	260	128.77	0.3138	0.05360	10.902	1.937	55
550	288	144.73	0.3223	0.05302	10.671	1.5699	114
600	316	161.11	0.3308	0.05241	10.439	1.3095	223
650	343	177.92	0.3393	0.05176	10.207	1.1188	413
700	371	192.84	0.3478	0.05107	9.976	0.97581	735

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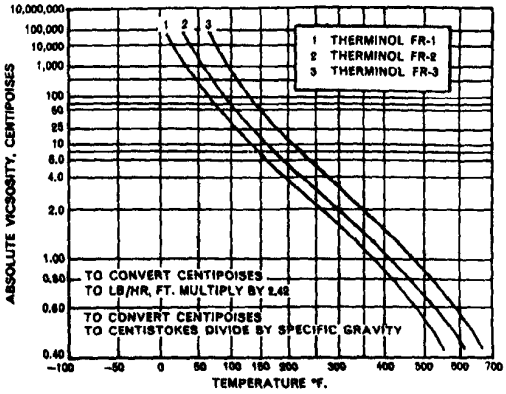
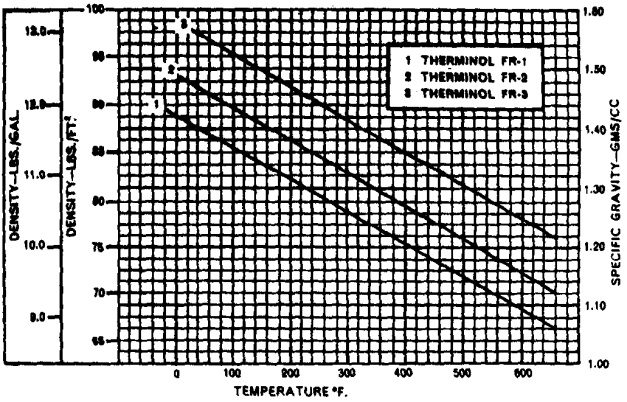
VISCOSITY-TEMPERATURE CHART



DENSITY AND SPECIFIC GRAVITY



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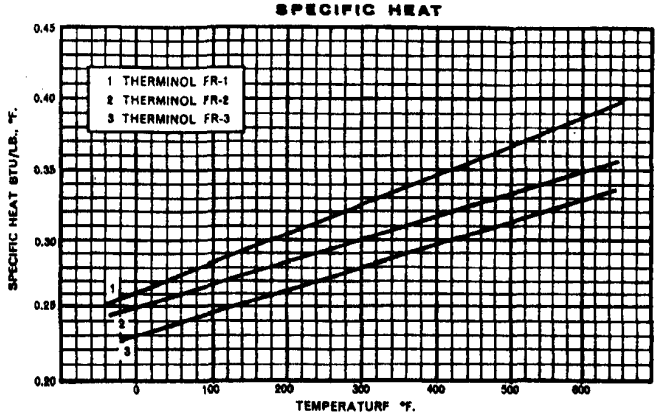
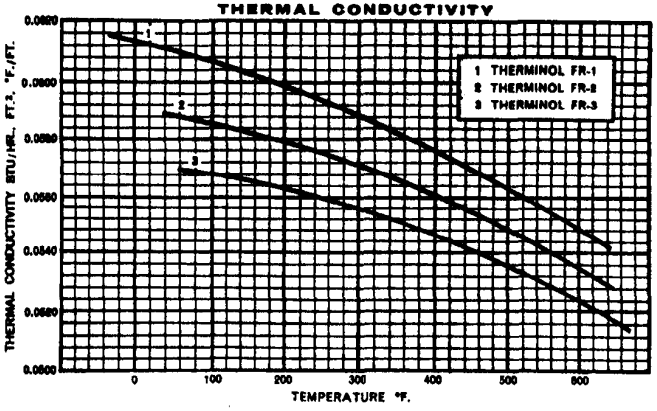

SPECIFIC HEAT
1 THERMINOL FR-1
2 THERMINOL FR-2
3 THERMINOL FR-3
SPECIFIC HEAT BTU/LB., °F.
0.45
0.40
0.35
0.30
0.25
0.20
0
100
200
300
400
500
600
TEMPERATURF °F.


THERMAL CONDUCTIVITY
1 THERMINOL FR-1
2 THERMINOL FR-2
3 THERMINOL FR-3
THERMAL CONDUCTIVITY BTU/HR., FT.2, °F./FT.
0.0820
0.0800
0.0780
0.0760
0.0740
0.0720
0.0700
0
100
200
300
400
500
600
TEMPERATURE °F.

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SPECIFIC HEAT OF therminol FR

Its Relationship to Density

Specific heat—the quantity of heat required to raise the temperature of a material one degree, compared to the heat required to raise a like mass of water one degree—compares the material with water, pound for pound.

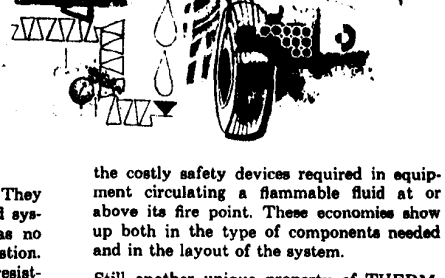
When comparing specific heat values of THERMINOL FR liquids with corresponding values of other heat transfer fluids, it is important to note that the *density* of THERMINOL is much higher than the density of other fluids commonly used in heat transfer. In consequence, the heat capacity of THERMINOL fluids is greater than immediately apparent from the specific heat values.

In transferring heat, a *volume* of fluid is circulated to give up or absorb heat and the heat capacity of that *volume* of fluid is the factor that determines the heat transfer capacity of the system.

When a comparison is made on a volume basis (as illustrated below), THERMINOL liquids are comparable to other organic liquids and superior to some:

SPECIFIC HEATS OF VARIOUS FLUIDS at ROOM TEMPERATURE

	Pounds/ Gal.	Specific Heat (BTU/lb./ °F.)	Heat Capacity (BTU/gal./ °F.)
THERMINOL FR 2	12.03	0.276	3.32
Organic Fluid "A"	8.82	0.378	3.33
Petroleum Oil	7.9	0.378	2.98



THE FLUIDS

THERMINOL FR liquids are unique. They permit installation of a non-pressurized system operating with a liquid which has no fire point, and will not support combustion. THERMINOL FR liquids are so fire-resistant they have been *listed with Underwriters' Laboratories!*

Because of this extreme fire resistance and its recognition by insurance companies, important savings can be made in designing a process heating system around THERMINOL FR fluids. The savings include not only the lower capital cost of non-pressurized equipment, its simplified installation and lower maintenance; but also elimination of some of the costly safety devices required in equipment circulating a flammable fluid at or above its fire point. These economies show up both in the type of components needed and in the layout of the system.

Still another unique property of THERMINOL fluids is their unusual chemical inertness. They are among the most oxidation-resistant compounds known. This inertness prevents the formation of oxidation sludges if the hot fluid comes in contact with air. This extends the useful service life of the heat transfer fluid; occasionally allows economies in design. However, THERMINOL FR fluids are not intended for use in open vessels but in properly vented, closed systems.

MONS 049528

Chemically, THERMINOL FR fluids are resistant to strong acids, mild alkalies, and dilute solutions of strong alkalies.

THERMAL STABILITY

THERMINOL FR fluids are thermally stable. They are manufactured to meet strict thermal stability specifications. Each production run is tested in Monsanto's laboratories with special equipment developed by Monsanto to assure that these fluids meet the high standards of thermal stability. Any material which does not meet these standards is rejected.

It is characteristic of almost all organic materials to undergo chemical change when exposed to high temperatures for long periods of time. The *type* of chemical change depends upon the molecular structure of the fluid; the *degree* of change depends on the temperature, and the length of time of exposure.

THERMINOL FR fluids resist chemical change up to temperatures of 600°F. and show no measurable change after years of exposure to such temperatures. Exposure to temperatures above 600°F.—even localized overheating will only cause some formation of "high boilers": molecules of THERMINOL FR will join together to form larger molecules quite similar to the original material, but higher in viscosity and in boiling point. These high boilers are soluble in the fluid up to reasonable concentrations; so overheating only increases the fluids' room temperature viscosity slightly. When a concentration of approximately 5-10 percent "high boilers" has been formed, however, the viscosity begins to rise quite sharply.

With this change, small but measurable amounts of dry hydrogen chloride gas are evolved. This should be removed from the system by appropriate venting. When THERMINOL FR fluids operate at high bulk temperatures, or, where some local overheating may occur, the system should be designed to prevent moisture from condensing in the vapor spaces where this hydrogen chloride gas is being vented.

When the hydrogen chloride is dry, it has little or no effect on metals in the system. However, if the hydrogen chloride dissolves in moisture, an acid corrosive to certain metals is formed. A properly designed heater and distribution system operated at or below 600°F., will allow use of the same fluid for many years.

While THERMINOL FR fluids normally are operated to a maximum temperature of 600°F. —systems specially designed for operation at higher temperatures have proved successful. At higher temperatures—"high boiler" formation with attendant viscosity increase is, of course, accelerated and a shorter service life must be expected. However, side stream distillation can be employed to constantly remove higher boiling materials while the system is in operation. Periodic make-up is added to replace the quantity of the high boiler material removed.

An alternate procedure for higher temperature operation, which is sometimes more suitable for smaller installations, is periodic replacement of the THERMINOL charge, reclaiming the used fluid by straight takeover distillation. (Monsanto should be contacted for details regarding this procedure.) On systems containing only 50-100 gallons of THERMINOL, it is usually most economical to periodically discard the entire charge and replace it with new fluid.

THERMINOL SYSTEM DESIGN

When designing a THERMINOL FR system it is important to remember this fact: THE FLUID CAN BE NO BETTER THAN THE SYSTEM! THERMINOL FR liquids are ideally suited for high temperature precision heating and temperature control applications, but only if the heater and distribution *system* are properly designed, constructed and operated. While there is nothing profoundly different or complicated about a THERMINOL system, certain design parameters must be rigidly observed if the system is to operate trouble-free, efficiently, and with realization of the full benefits of heat delivered by a liquid.

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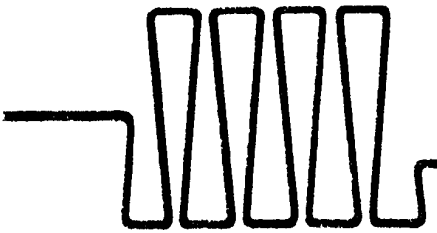


THE HEATER

The heater is the most critical component in a THERMINOL system. Accordingly, the heater should be selected with great care!

Two basic heater designs for THERMINOL fluids are available: the liquid tube and fire tube types. In liquid tube heaters, the THERMINOL is pumped through the tubes at a definite flow rate as it is heated; in fire tube types, THERMINOL flows through the "shell" of the heater surrounding the fire tubes.

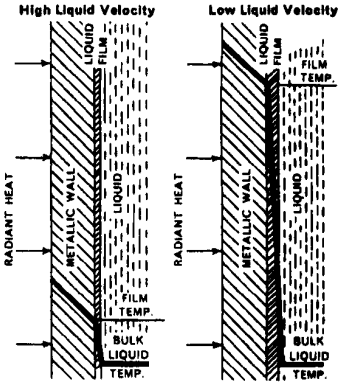
When operating temperatures of 500°F. (or higher) are required, a liquid tube type heater is to be preferred . . . *unless* a specific design is devised to force a steady flow over the heat donor surfaces.

Since THERMINOL fluids transfer heat in liquid form, they do not form vapor to accelerate convection circulation. To avoid hot spots in a THERMINOL heater, the fluid should be pumped over the heating surfaces so that no area of stagnant fluid occurs.

Fluid velocities over the heat donor surfaces should be relatively high; generally 4 to 10 feet per second. This helps avoid both excessive fluid film temperatures and also reduces the quantity of fluid in the high temperature film that is in direct contact with the heat donor surface.

The illustration shows the effect of fluid velocity on film temperature and indicates the importance of this design requirement.

EFFECT OF LIQUID VELOCITY ON FILM TEMPERATURE DURING HEATING



Importance of Fluid Velocity and Film Temperature through Heater

A bulk fluid temperature of 600°F. and a *maximum* film temperature of 640°F. assures long service life of THERMINOL FR fluids. Note the significance of "*maximum*" film temperature: heating is not uniform in fired

MONS 049530

heaters, and *maximum conditions*—not average—must be used to determine the recommended 640°F. ceiling.

Example:

The film coefficient for THERMINOL in a given heater is 250 BTU/hr. sq. ft., °F., and the fluid temperature is 570°F.

The average radiant absorption rate is 9,000 BTU/sq. ft., hr. The maximum radiant absorption rate is 17,000 BTU/sq. ft., hr.

The average film temperature is then

$$570° + \frac{9{,}000}{250} = 606°F.,$$

but the maxmium film temperature is

$$570° + \frac{17{,}000}{250} = 638°F.$$

Past experience shows that when purchasing a heater, the buyer should insist that design and capacity provide optimum film temperature for the fluid.

The method of Lobo and Evans[1] is useful in calculating film temperatures in radiant heaters.

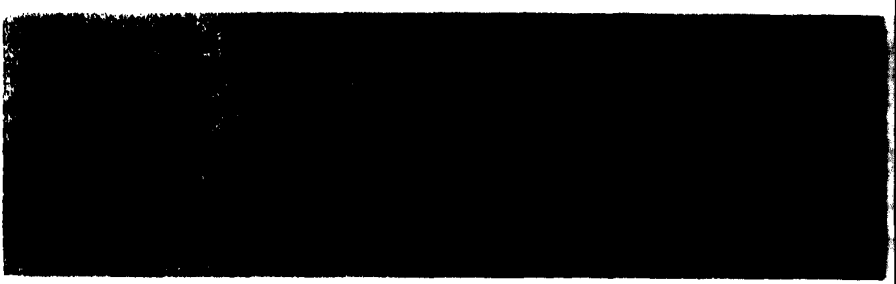
When electric heaters are used—heat flux is more even. However, it is important to remember that *all* of the heat from the electric element passes into the fluid. The watt-density on the surface of the heater tube and the fluid velocity past the tube should be in proper balance to avoid excessive THERMINOL film temperatures. Watt-densities in the range of 8 to 10 watts per square inch with a minimum velocity of 4 feet per second are suggested. However, watt-densities in the 18 to 22 watt per square inch range have proved satisfactory in properly designed installations.

Heaters for THERMINOL should meet local code requirements. However, the fire resistance of THERMINOL FR fluids will often permit important economies in the design and placement of fired heater equipment. With gas-fired heaters, the THERMINOL unit need not be placed outside of the building or isolated in a fireproof structure unless the use process requires such precaution. Steam or inert gas smothering devices can generally be eliminated and a vapor tight firebox to retain smothering gases is not necessary.

The fuel for THERMINOL heaters is purely optional. Gas- or oil-fired heaters, and electric resistance heating are all used with success. Coal-fired heaters are generally not recommended because of their slow response to change of load at the heat source.

The over-all thermal efficiency of a fired heater will generally be comparable to steam boilers of similar size. Efficiencies of 75 to 80 percent can be expected when convection sections are added. Efficiencies of 60 to 70 percent are achieved with only a radiant section.

[1] Lobo, W. E., and J. E. Evans, Trans. AIChE, 35, 743 (1939)



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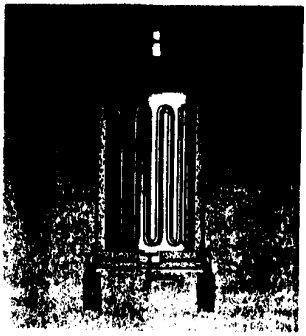
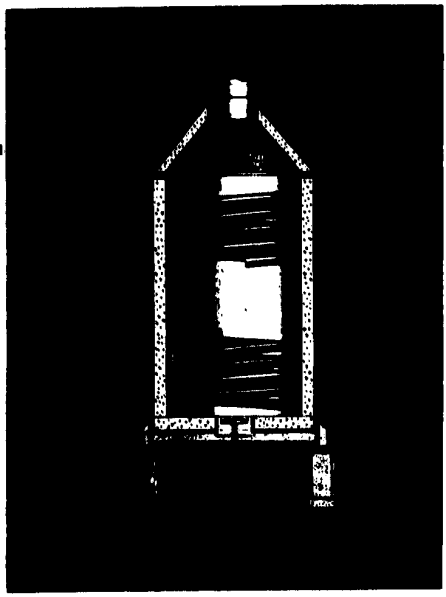


THE HEATERS



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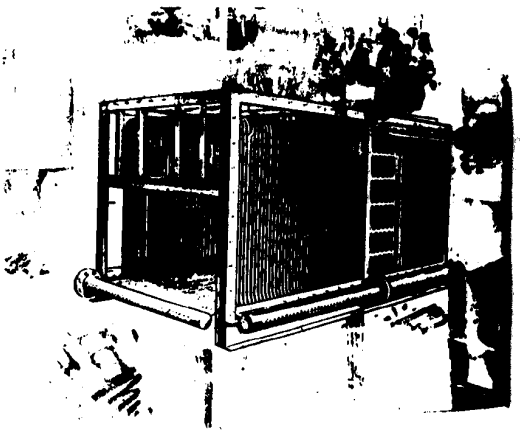



PUMPS FOR THE therminol FLUID HEAT SYSTEM...

In selecting pumps for a THERMINOL system, it is important that the pump capacity and pressure head be sufficient to circulate the fluid at the rate demanded by the particular installation. For large flow rates, the fluid circulating pump should generally be the centrifugal type and any one of a number of brands of standard high temperature centrifugal pumps designed for hot liquid service is suitable. Dean Brothers, Worthington, Ingersoll-Rand and Chempump for example, are all used satisfactorily. For most THERMINOL systems, cast steel pumps are best. Pump manufacturers usually specify that above 450°F. fluid temperatures, a water jacketed, deep stuffing box or mechanical seal and water-cooled bearings be used. Mechanical seals are used widely today.

It is suggested that with a stuffing box, eight rings of packing be provided. Durametallic No. D-110, Garlock No. 736 and equivalent packings are satisfactory for the pump, and an open, non-overloading impeller is desirable to handle the cool, relatively viscous liquid at start up.

When a new system is first put into operation, a slight leakage may be noticed at the pump packing. It is not advisable to tighten the pump gland, however, until the system has heated up close to the temperature of operation.

Canned pumps such as Chempump Series T require no seal and have proved very serviceable in THERMINOL systems. Small gear pumps are also used successfully in THERMINOL FR service because the fluids have good high temperature lubricating properties. However, gear pumps characteristically decrease in pumping capacity after extended use. When gear pumps are used, care should be taken in selecting the capacity so there is a margin that will assure adequate flow through the heater. Regardless of the type of pump selected, the flow rate should be checked regularly against its performance when new.

To avoid shaft trouble and leakage at the seals, it is important to provide adequate expansion joints and to support the piping in a way that avoids stresses on the body of the pump. Direct-connection pumps driven by 1,750 rpm. motors are most commonly used. Each pump should be fitted with a control to switch off the burner in case of pump failure.

If expansion loops are used in the pump suction piping, they should be horizontal or vertically downward. They should not be vertically upward, for in such a position they form a trap which can collect air and noncondensibles, and seriously hamper the pump's performance.

PIPING...

The most important factors in the piping layout for a THERMINOL FR system are: (A) Proper sizing for the required flow rate and (B) minimizing pressure drop. Because the system will undergo temperature changes,

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adequate expansion joints and loops to relieve expansion and contraction stress are essential.

Generally, Schedule 40 seamless steel pipe is used with THERMINOL FR systems. It is characteristic of most organic fluids (including THERMINOL) to have a tendency to leak through joints and fittings at high temperatures unless these fittings are very tight. Therefore, flanged joints should be used sparingly to minimize potential leak points.

Threaded connections are used with THERMINOL FR up to a one-inch maximum size. Care is required in cutting the threads to assure a proper fit; a clean, new die is recommended. Careful attention to threading procedure should provide a good threaded connection. It is not wise to rely upon the use of pipe dope to eliminate leakage. However, pipe dope should be used. Q-seal (Quigley Company, Inc.); Plastiseal (Johns Manville); and Crane's No. 425 are all used successfully in THERMINOL FR systems.

In larger size pipes, welded connections should be used wherever practical. Careful layout and use of curved sections of pipe can minimize the welded or flanged connections required. When a flanged connection is made, 150 pound raised face flanges are recommended. The flange should be back-welded to the pipe and proper gasketing used. Spiral wound (Spiratalic or Flexitallic) asbestos and stainless steel gaskets are good. Small lip spiral wound gaskets are preferred over the wide lip type, because they allow better compression with the 150 pound flange. Garlock short fiber, pre-cut and cured asbestos gaskets have also proved satisfactory.

It is recommended that high temperature bolts, such as Crane Triplex steel bolts, which do not stretch, be used.

All high points in the piping system should be provided with vent valve connections.

VALVES...

One hundred and fifty pound cast steel valves with deep stuffing boxes are satisfactory for THERMINOL systems. Cast steel ball valves designed for high temperature (such as offered by Hills McCanna have also proved very effective, particularly where quick open-and-close action is desired.

ROTARY JOINTS...

It is wise to take particular care in the installation and maintenance of rotary joints in order to assure long service life and minimum leakage. Install such joints with proper flexible connections to assure alignment at all times. Rotary joints should not be operated in a new system until the system has been thoroughly cleaned of abrasive particles which could score the sealing faces and cause leakage. Rotary joints such as those manufactured by the Johnson Corp. and Perfecting Service Co. are satisfactory with THERMINOL FR.

THE EXPANSION TANK...

Proper design of the expansion tank for the THERMINOL system is quite simple, but is also very important to proper system operation.

Characteristic of most organic liquids, THERMINOL expands in volume about 4 percent for every 100°F. temperature rise. In heating THERMINOL from room temperature (70°F). to 600°F., the fluid in the system expands about 20 percent. Therefore, the expansion tank should be large enough to accommodate about 20 percent of the total volume of the entire system, including the fluid content of the heater, piping and all heat users. The tank should be sized so it is about one quarter full when the system is cooled to 70°F. and three quarters full when the system is at a maximum operating temperature. The expansion tank should be fitted with a sight glass at the "full" range and with a float operated, low-level switch to shut off the burner in case of accidental fluid loss in the system.

Place the expansion tank in the circuit on the pump's suction side—above the highest point in the system.

The expansion tank also serves as the major venting point of most THERMINOL sys-

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tems. The temperature of the fluid in the expansion tank is much lower than the bulk fluid temperature in the system. Connect the expansion tank to the system with a small diameter line to avoid thermal recirculation. However, make this line large enough to readily pass the flow caused by expansion and contraction in the system and to permit recirculation of fluid for moisture removal as explained below.

Because THERMINOL FR fluids are fire resistant, the vent need not be isolated from potential sources of ignition. However, the vent should be out of doors, particularly away from working areas, to eliminate prolonged or repeated contact with the vapors.

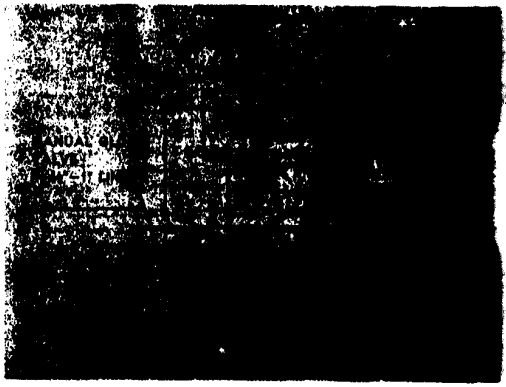
Care should be taken to prevent the entry of atmospheric moisture into the system as the expansion tank 'breaths' air. The vent can be equipped with an air dryer, such as a calcium chloride pot or other desiccant.

An alternate procedure would be to blanket the expansion tank with nitrogen. However, if this is done, the THERMINOL system should be *dried thoroughly* before the system is sealed with nitrogen.

In systems using THERMINOL above 600°F. (or in systems where accidental high film temperatures may occur in the heater) some provision must be made for venting any hydrogen chloride gas formed in the system and to assure that the system remains dry. Gas or water vapor will not escape readily through the "cold seal" connecting the expansion tank to the THERMINOL system. It is advisable to provide a pipe to feed a small side stream of hot THERMINOL through the expansion tank as illustrated at right to allow hydrogen chloride and water vapor to flash from the fluid. A small stream of hot THERMINOL from near the pump discharge should be piped directly into the vented expansion tank, so it enters the tank above the highest liquid level. A globe valve should be installed in the line to permit throttling the flow to the desired rate.

Experience shows this simple procedure to be extremely effective and completely satisfactory for removing hydrogen chloride and moisture from the THERMINOL system. Analysis of samples drawn from systems operating with such a device show that the THERMINOL fluid maintains minimum acidity and holds moisture at the low levels equivalent to newly manufactured fluid, even after prolonged periods of operation.

Provision should be made to prevent moisture from condensing in the vapor space above the liquid level in the expansion tank and in the vent. It is advisable to trace and insulate the expansion tank and the vent so that any moisture accidentally entering the system will remain as a vapor and will not condense. This will prevent corrosion of steel and eliminate the need for higher cost alloys. The use of non-metallic vent pipe is also recommended. Polyester piping (available from Fibercast), resin lined steel piping or other non-metallics resistant to THERMINOL vapors and to hydrogen chloride are commercially available and have been used with great success.



NOTES...
The expansion tank and vent should be traced and insulated. If steam is not available at the site, hot THERMINOL fluid can be passed through steel tracing tube.

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TESTING FOR LEAKAGE...

When a new system has been installed, it is important to test for leaks. Probably the most widely used technique is to check for leaks with ammonia gas. In this method, the system must be relatively dry and sealed. All vent valves should be closed and a temporary pipe cap or slip blank installed at the expansion tank vent and at other points where there is no valve.

Ammonia gas is fed into the sealed system followed by air under pressures up to ten pounds per square inch. Any leakage areas can be readily detected by the escape of ammonia. Tiny amounts of ammonia vapors can be made visible as white smoke by directing a small stream of hydrogen chloride gas over each joint or fitting, and around each welded connection. Any leakage points can be marked, tightened, and then the system purged free of ammonia with plenty of air.

A satisfactory alternate procedure is Halogen Testing: in this procedure, introduce one pound of Freon F-12 or Freon F-22 for each fifty cubic feet of volume of the system. Carefully introduce air not exceeding 10 psig of pressure. At this air pressure, the concentration of Freon will be sufficient to give a sensitive test.

Attach a halide torch to an acetylene tank and light it. Using the ¼ inch flame as a probe, explore for leaks by passing the end of the flame along seams and joints. If a leak is present, the escaping Freon will be drawn into the acetylene flame turning it green. A large leak will produce a violet color.

Leak testing with water is not recommended. Though effective, it creates a problem of introducing a large amount of water into the THERMINOL system which will be hard to remove.

CLEANING THE SYSTEM...

After testing for leaks and making any required adjustments, the system must be thoroughly cleaned.

A new system will contain dirt, weld and mill scale and other foreign particles. Unless removed, these particles will be carried in suspension by the circulating THERMINOL. They may "lodge" in valves, controls, mechancial seals, rotary joints and other mechanical equipment, causing faulty operation or component failure.

When purchasing the heating equipment, the supplier should be requested to clean the equipment as thoroughly as possible using brushes, wiping rags and suitable solvents, such as tri- or perchlorethylene.

When completed, fill the system with the operating charge of THERMINOL. Bring the system up slowly to approximately 200°F. At this temperature, the viscosity of THERMINOL will be very low. The turbulence from this low viscosity, plus the excellent solvent action of THERMINOL fluid, will further clean the system. Circulate the warm THERMINOL through the system *without operating rotary joints* (if they are installed in the system).

FILTERING...

Install a strainer, made of ordinary fine mesh screen backed up with ¼" screen, in the pump suction of the new system. As foreign material collects, this screen should be periodically removed and cleaned. When, after several days during which the strainer collects no material, remove it permanently from the line. The system should be heated and cooled for a minimum of two cycles with the suction screen in place, since the resultant expansion and contraction will loosen mill

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scale. The screen may be placed in the main stream line, gasketed between two flanges.

It is advisable, when operating where solids and contaminants might enter the system, to permanently install a high temperature filter on a by-pass line that can be isolated with valves for periodic cleaning.

CONTROLS...

Controls for heating systems using THERMINOL should be installed both on the heater itself and on the heat-using units. A wide variety of thermal-operating controls are available, and any reliable standard equipment is satisfactory.

Install heater controls to regulate the firing mechanism in direct proportion to the required output. These controls should increase or decrease the heat in-put to maintain the THERMINOL at the operating temperature required by the heat-demand of the user. Small units may be operated satisfactorily by relatively simple "on-off" or "high-low" controllers; larger units will operate more uniformly if equipped with modulating temperature controls.

Install *user* controls to regulate the flow of the heat transfer fluid in proportion to the heat-consumption of the heat-using equipment. In a multiple-user system, separate controls should be installed on each consuming unit, to assure the proper heat-delivery.

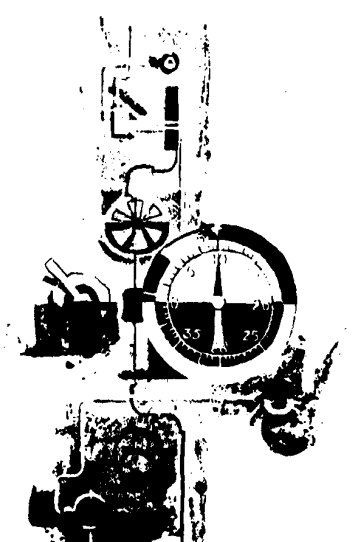
Safety Controls. In addition to activating controls, the heater must also be fitted with the proper safety controls to meet the local code requirements. Safety controls should include:

a. **High temperature cutoff at the heater outlet** . . . to shut off the burner in the event of an excessive temperature rise.

b. **High tube wall temperature cutoff.** A thermocouple sensing element should be installed in contact with the radiant heated surface at the highest temperature point in the heater and protected as much as possible from direct or reflected radiation. Such a controller is usually of the on-off type with the switch wired into the flame safety circuit so that the burner is shut down when the switch opens. Aside from protecting the tube bundle, this safety control protects the THERMINOL fluid from overheating.

c. **Low flow cutoff.** This control will shut down the burner should flow rate drop below design rates, or if a loss of flow occurs due to pump mal-function or failure.

Equip burners with regular automatic ignition controls and flame failure controls. In wide range firing operations, an over-fire draft control will increase the economy of the operation. Electric power failure and instrument air failure safety controls are also desirable. In general, the practice of "fail-safe" instrumentation and control is essential: use good quality indicating and recording gauges, with scales calibrated for the particular limits of operation for best reading accuracy.



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OPERATION AND MAINTENANCE OF THE THERMINOL SYSTEM...

The following recommendations are intended only as guides. These suggestions are supplemental to the equipment manufacturer's recommendations as they relate to the particular heater or the user equipment in the installation. The following comments on start-up, shut-down, power failure precautions, and periodic fluid check-ups apply generally to all sizes and types of equipment.

NEW SYSTEM START-UP...

For a new installation, or an existing system that has been drained and is idle:

1. **Check the safety and control devices.** Check the safety and control devices for proper installation, proper range settings for the operation, and actual operation (by manually activating the instrument).

   For protection of the over-all system and for predictable long fluid life, it is vital that all instruments and controls perform properly.

2. **Check for leaks (see section on leak testing, page 14.)**

3. **Pull Vacuum on System.**

   a. The vacuum should be pulled from a point of high elevation in the system; usually at a point just below the expansion tank. Prior to drawing a vacuum, *close* all valves to the expansion tank; close all valves and vent connections to the atmosphere; close all valves to non-pressure equipment in the system (such vessels may collapse under vacuum) and *open* all valves in the interconnecting piping of the system.

   b. Turn on vacuum equipment and evacuate the entire system (including the "users") to 26-27 inches of mercury vacuum (if possible), or until the absolute pressure of the system has reached the limit of the available vacuum equipment.

   c. Shut off vacuum equipment.

4. **Charge the System with THERMINOL.**

   a. Fill the expansion tank with THERMINOL, and introduce the fluid slowly into the system through the expansion tank valve until the tank is almost empty. Close the valve and again fill the tank. Open the valve allowing the fluid to enter the system and repeat until it no longer flows by gravity.

   b. Open all valves then start the main circulating pump in accordance with the manufacturer's recommendations. Observe the liquid level in the expansion tank repeating "a" above until the system has been filled. The thermal expansion of THERMINOL must be allowed for in determining the cold charge level. (A 20% expansion can be expected when heated to 600°F.—as a guide, the expansion tank should be 70-75% full at the hot operating condition.)

   c. Circulate the THERMINOL fluid through the system for about 3 to 4 hours to eliminate air pockets and to assure complete fill of the system.

BEFORE FIRING HEATER, BE SURE THAT THERMINOL IS CIRCULATING FREELY.

5. **Fire Heater.**

   a. On new installation start-up, or after prolonged shut-down, bring the system up to temperature slowly—about 100°F. per hour. This will prevent thermal shock to heater tubes, tube/header joints, refractory materials, etc., and allow operators to check the functioning of instruments and controls and become familiar with the equipment's operation. The slow heat-up will also allow any moisture trapped in the system to escape as a vapor.

   b. Bring system to operating temperature and put "users" on the line.

DAILY START-UP . . . when equipment has been shut down overnight or for weekends, follow this procedure:

1. Start the circulating pump and check the expansion tank level to see that the

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THERMINOL is at the proper cold-start level (¼-full).

2. Start burner at the "low" flame setting and continue full circulation until the THERMINOL bulk temperature reaches 180°F.
3. Turn heater up to full heat.

SHUT-DOWN . . . should be performed as follows to avoid overheating:

1. Shut off burner completely with circulating pump still operating. Continue to run the pump at full capacity for at least 30 minutes to dissipate residual heat in the combustion chamber of the burner.
2. Shut off circulating pump after ½ hour, and switch off all heater electrical controls.

COLD WEATHER PRECAUTIONS . . .

When the THERMINOL system is exposed to low ambient temperatures, it is often most practical to leave the system "idling." Turn the burner to "low" position, and allow the fluid to circulate continuously at about 200°F. The unit will then be "at ready" for immediate high-temperature operation, and the viscosity of the fluid will remain low and workable.

IN CASE OF POWER FAILURE . . .

The burner circuit should be shut down by the heater controls. When the power comes on, run the circulating pump for a few moments to eliminate any vapor pockets that might have been formed by the fluid remaining static in the hot combustion chamber. If there is no knocking in the piping system, full-fire may be resumed immediately if the fluid temperature is above 180°F.

PERIODIC CHECK-UPS . . .

The regular maintenance inspection schedule should include the manufacturer's recommendations, as well as inspection of the THERMINOL. Following is a listing of inspection check-points:

1. Lubrication of moving parts.
2. Operating fidelity and accuracy of readings of safety controls and temperature limit controls.
3. Inspection of heater tubes, burner, refractory linings.
4. Periodic inspection of heater surfaces.
5. Inspection of water cooling at the circulating pump.
6. Repacking of stuffing boxes (according to manufacturer's specifications).
7. Semi-annual or annual sampling and analysis of THERMINOL.

Under normal operating conditions, it should not be necessary to check on the condition of the fluid more than once or twice annually. The analysis for fluid condition is a simple test of fluid viscosity. The exact viscosity limits will be affected by the specific mode of operation and can vary somewhat from system to system. Monsanto should be contacted to determine specific values for the intended operation. Most users do their own testing; some have the viscosity determination made by an outside laboratory. A simple test kit for in-plant testing of THERMINOL is available at a low cost.

Customers can have their fluid tested by Monsanto free of charge. For sampling container and application data form, write to:

MONSANTO COMPANY
FUNCTIONAL FLUIDS MARKETING
ORGANIC CHEMICALS DIVISION
ST. LOUIS, MISSOURI 63166

Analysis results will be returned to the customer with complete recommendations for improving or continuing the performance of THERMINOL heat transfer liquid.

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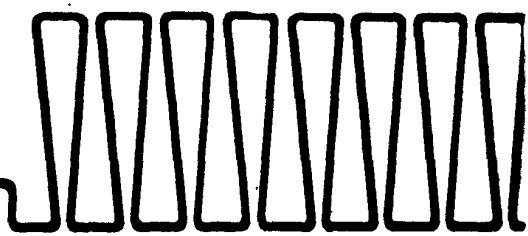

TYPICAL therminol® FR SYSTEMS

THE HEATING PLANT

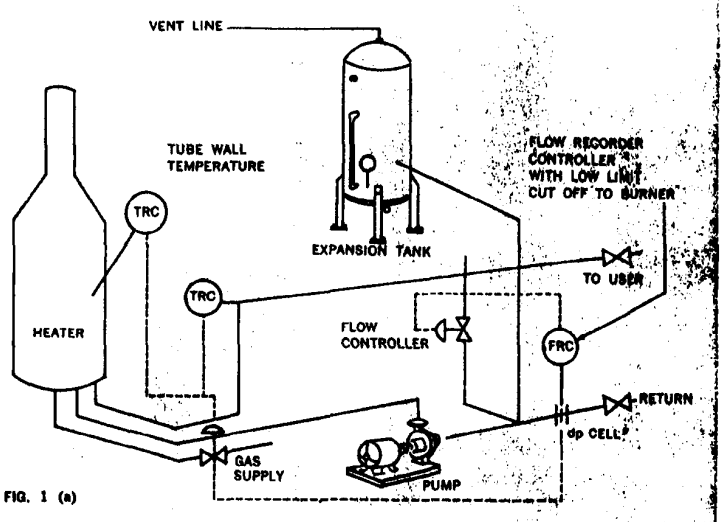

FIG. 1 (a)

Figure 1 above illustrates a typical basic heating "plant" for a THERMINOL FR system. Note the use of instruments to control THERMINOL temperature leaving the heater and by-pass flow control to assure adequate flow through the heater regardless of "user" demands.

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HEATING A SINGLE USER:

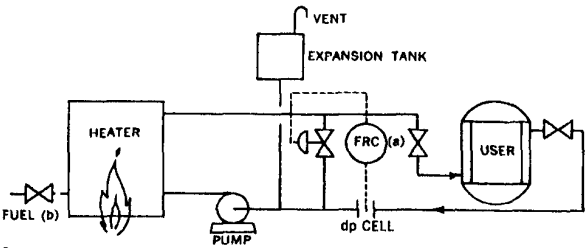

FIG. 2 FRC=FLOW RECORDER CONTROLLER WITH LOW LIMIT CUTOFF TO BURNER

Note that the user temperature can be controlled by either (a) rate of flow of THERMINOL to the user, or (b) temperature of THERMINOL, varied by fuel input to the heater.

HEATING MULTIPLE USERS:

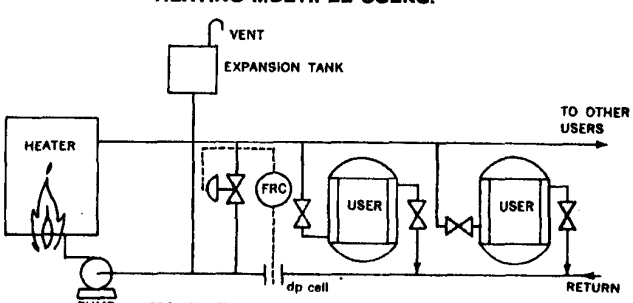

FIG. 3 FRC=FLOW RECORDER CONTROLLER WITH LOW LIMIT CUTOFF TO BURNER

Note that each user can be controlled at a different temperature by control of the flow of THERMINOL and therefore the rate of flow of heat offered.

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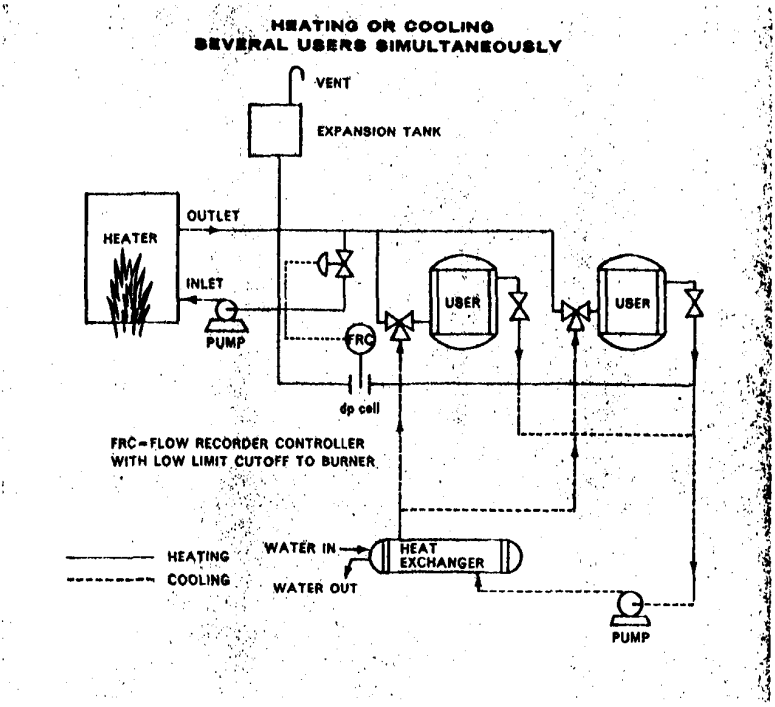
HEATING OR COOLING
SEVERAL USERS SIMULTANEOUSLY
VENT
EXPANSION TANK
HEATER
OUTLET
INLET
PUMP
FRC
dp cell
USER
USER
FRC=FLOW RECORDER CONTROLLER
WITH LOW LIMIT CUTOFF TO BURNER
HEATING
COOLING
WATER IN
WATER OUT
HEAT
EXCHANGER
PUMP

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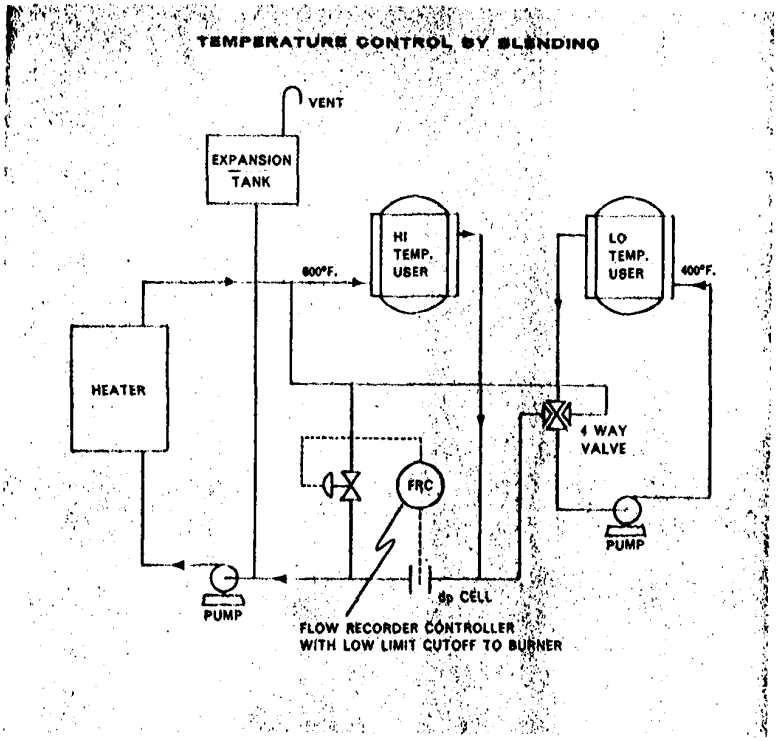
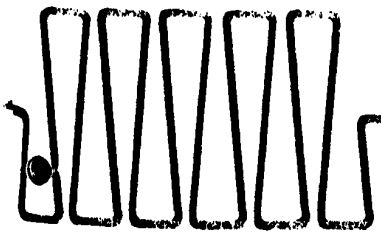


Single heater system provides varying THERMINOL temperatures to users ... finds application for processing heat-sensitive materials.



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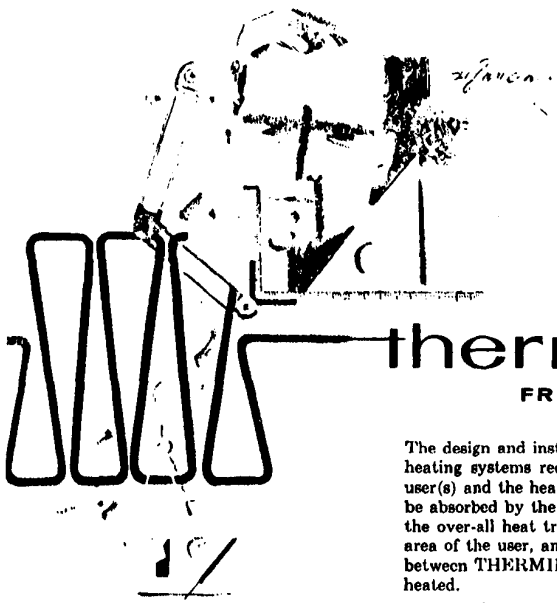

therminol.

FR ENGINEERING DATA

The design and installation of THERMINOL indirect heating systems requires a heat balance between the user(s) and the heater. The amount of heat which will be absorbed by the user in a given time depends upon the over-all heat transfer coefficient, the heat transfer area of the user, and the mean temperature difference between THERMINOL and the process or area being heated.

In processing most organic chemicals, oils, food cooking — the rate of heat transfer is usually dictated by the process and not by the heating medium. However, in designing a system– it is important to know the heat transfer coefficient of THERMINOL. This is affected by a number of variables, probably the most important of which is flow rate.

The following curves provide engineering data on THERMINOL heat transfer coefficients as a function of flow rate . . . and pressure drop as a function of flow rate . . . in various common sizes of pipes and tubes.

NOTE: The following charts depicting heat transfer coefficients and pressure drops for various sizes of pipes and tubes are available in full page reproduction for greater accuracy in interpretation. Write to:

Monsanto Company
Organic Chemicals Div.
800 N. Lindbergh Blvd.
St. Louis, Mo. 63166

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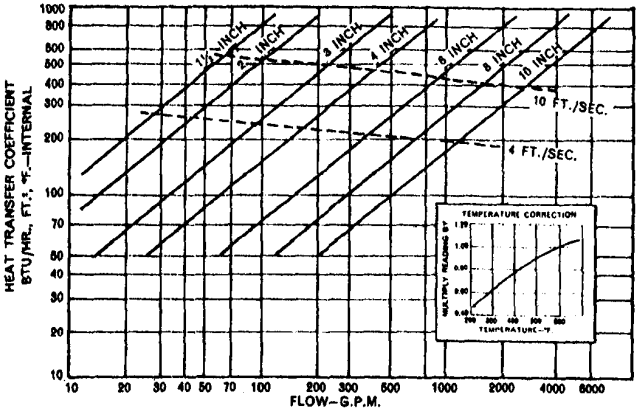
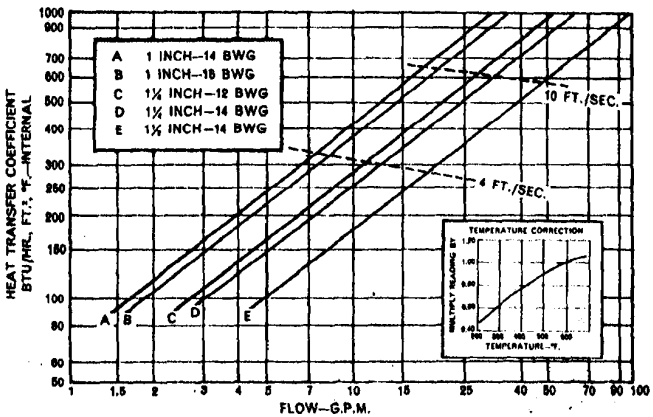
THERMINOL FR-1

HEAT TRANSFER COEFFICIENTS INSIDE SCHEDULE 40 PIPE



HEAT TRANSFER COEFFICIENTS INSIDE TUBES



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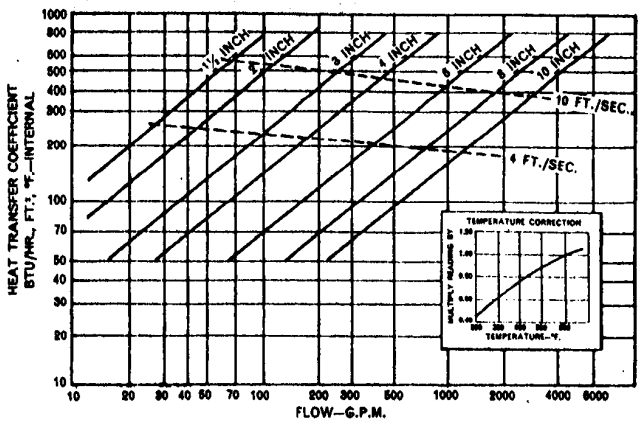
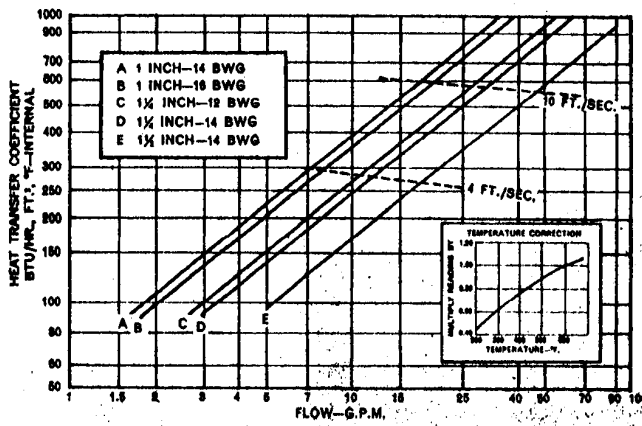
THERMINOL FR-2

HEAT TRANSFER COEFFICIENTS INSIDE SCHEDULE 40 PIPE



HEAT TRANSFER COEFFICIENTS INSIDE TUBES



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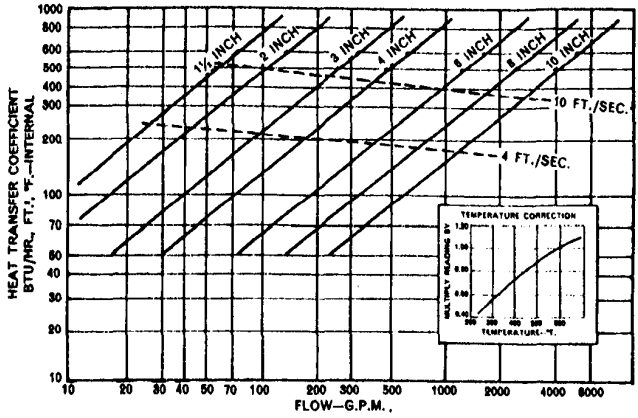
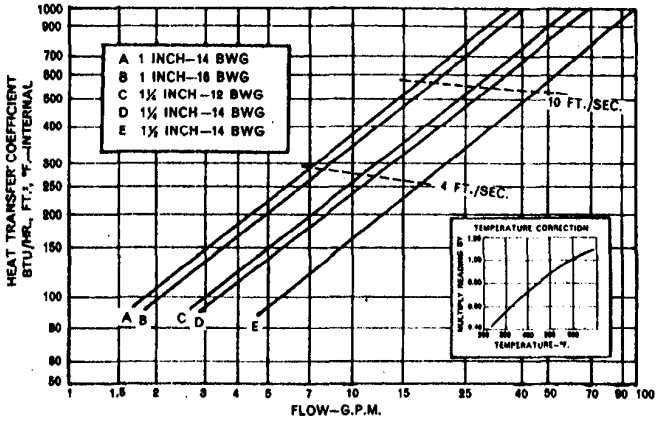
THERMINOL FR-3

HEAT TRANSFER COEFFICIENTS INSIDE SCHEDULE 40 PIPE



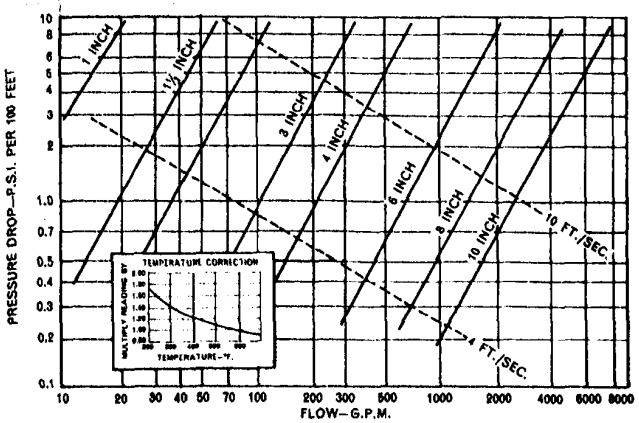
HEAT TRANSFER COEFFICIENTS INSIDE TUBES



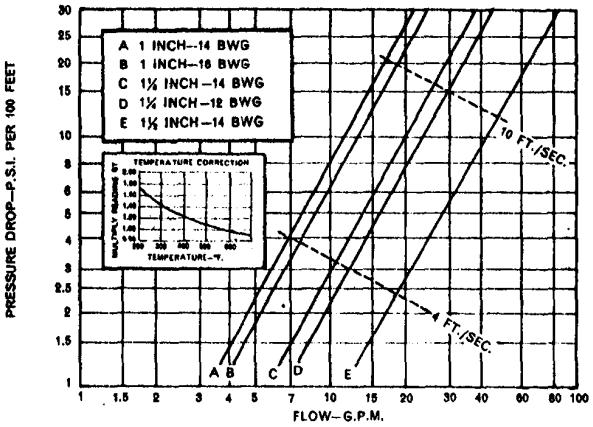
MONS 049547

THERMINOL FR-1

PRESSURE DROP IN SCHEDULE 40 PIPE



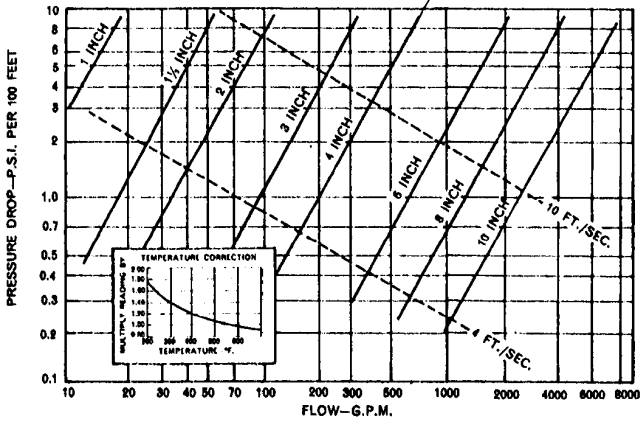
PRESSURE DROP IN TUBES



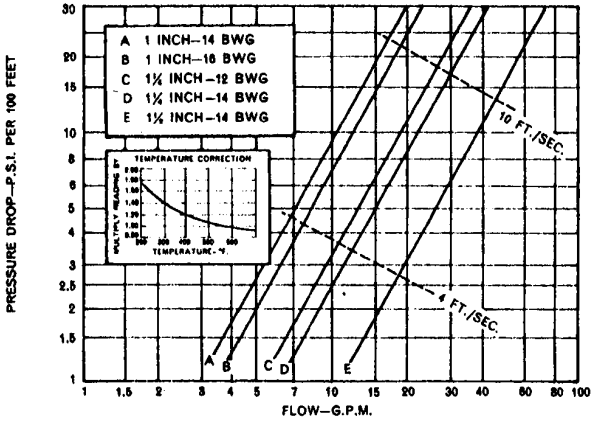
MONS 049548

THERMINOL FR-2

PRESSURE DROP IN SCHEDULE 40 PIPE



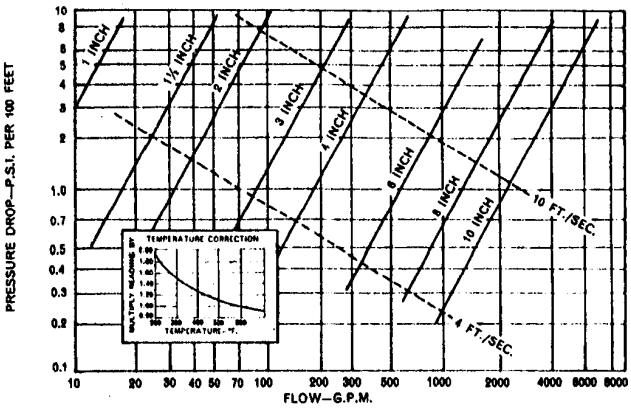
PRESSURE DROP IN TUBES



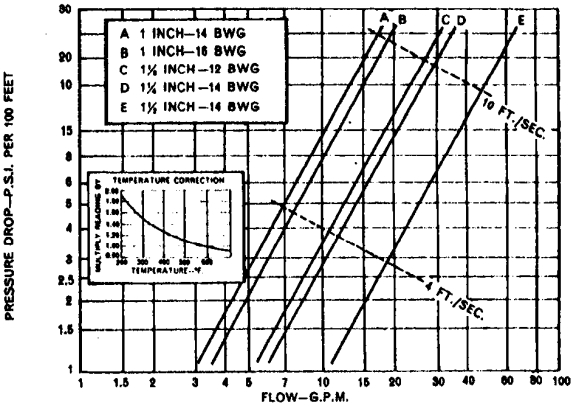
MONS 049549

THERMINOL FR-3

PRESSURE DROP IN SCHEDULE 40 PIPE

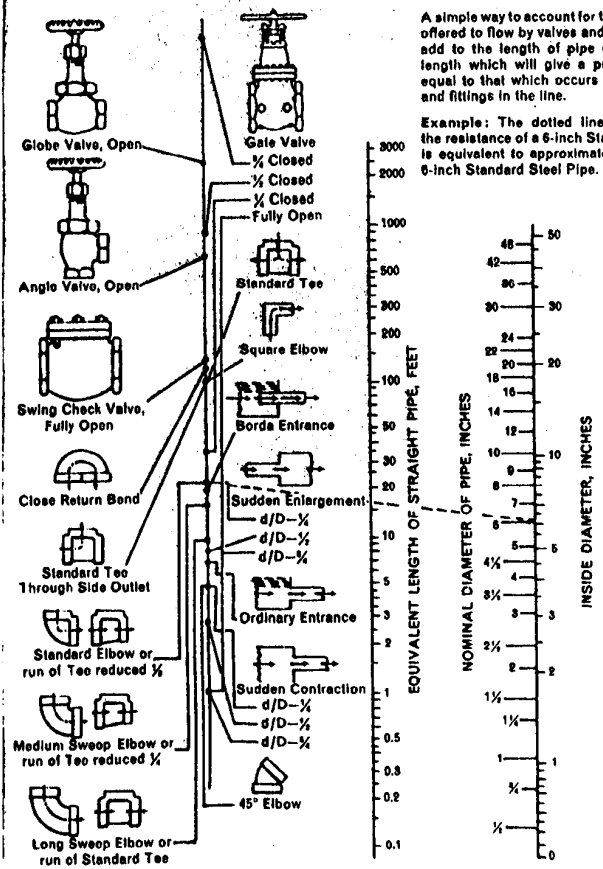


PRESSURE DROP IN TUBES



MONS 049550

RESISTANCE OF VALVES AND FITTINGS TO FLOW OF FLUIDS



A simple way to account for the resistance offered to flow by valves and fittings is to add to the length of pipe in the line a length which will give a pressure drop equal to that which occurs in the valves and fittings in the line.

Example: The dotted line shows that the resistance of a 6-inch Standard Elbow is equivalent to approximately 16 feet of 6-inch Standard Steel Pipe.

MONS 049551

PRESSURE DROP AND HEAT TRANSFER RATE FOR HEAT EXCHANGERS

Part I

PROCEDURE TO OBTAIN PRESSURE DROP SHELL SIDE OF TUBULAR EXCHANGERS WITH THERMINOL FR-2

1. Enter Chart No. 1 with GPM @ average flowing temperature--read average shell side velocity.
2. Multiply average shell side velocity with baffle correction (Bc--Chart No. 3) to obtain corrected velocity.
3. Enter Chart No. 3 with corrected velocity--read uncorrected pressure drop.
4. Correct pressure drop--3 above--for temperature, tube diameter and tube length.

Example:

THERMINOL FR-2	400°F.	400 GPM
20" Shell	¾" Tubes on 15/16"	
Baffles	12" Pitch	
Tubes	16' Long	

1. **Chart No. 1**
   400 GPM--20" shell--2.7 ft/sec. average velocity.
2. **Chart No. 3**
   12" Baffle Pitch--0.6 correction
   2.7 ft/sec. x 0.6 = 1.62 ft/sec. corrected velocity
3. 1.62 ft/sec. in 20" Shell = 4.1 PSI uncorrected pressure drop.
4. Correct for temperature, tube size and length.
   Pressure Drop = 4.1 x 1.2 x 1.0 x 1.33 = 6.54 Ans.

Part II

PROCEDURE TO OBTAIN HEAT TRANSFER RATE SHELL SIDE OF TUBULAR EXCHANGERS WITH THERMINOL FR-2

1. Enter Chart No. 1 with GPM at average flowing temperature--read average shell side velocity.
2. Multiply average shell side velocity with baffle correction (Bc1, Chart No. 2) to obtain corrected velocity.
3. Enter Chart No. 2 with corrected velocity--read uncorrected h.
4. Correct h--(3 above)--for temperature and tube diameter.

Example:

THERMINOL FR-2	300°	350 GPM
20" Shell	1" on 1¼"	
Baffles	10" Pitch	

1. **Chart No. 1**
   350 GPM--20" Shell = 2.35 ft/sec. average velocity.
2. **Chart No. 2**
   10" Baffle Pitch--0.875 correction
   2.35 ft./sec. x 0.875 = 2.06 ft./sec. corrected velocity
3. 2.06 ft./sec. Chart No. 2 = 225 uncorrected h.
4. Correct h for temperature and tube diameter.
   225 x 0.61 x 0.88 = 121 Ans.

Part III

NOTES:

a. Tubes to be on triangular pitch ⅝" on ¹³⁄₁₆"; ¾" on ¹⁵⁄₁₆"; 1" on 1¼".

b. All baffles cut 1 row of tubes past horizontal centerline.

c. Charts have base condition--¾" on ¹⁵⁄₁₆"; Baffles at 6" pitch. THERMINOL FR-2 at 550°F.

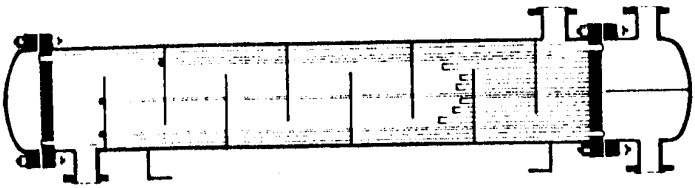
Data on shell side pressure drop and coefficients Courtesy of Struthers Wells Corporation.

MONS 049552

UNIT SELECTION CHART

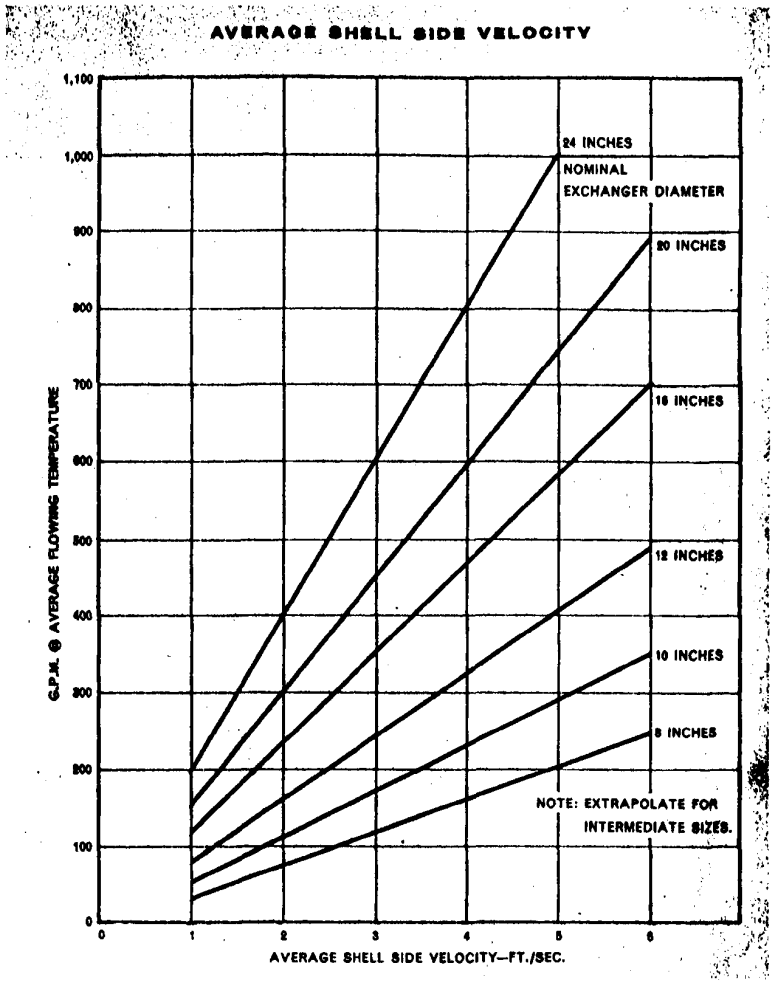
ARRANGEMENT

Nom. Shell Diameter Inches	Tube Length Feet	¾" O.D. on No. of Tubes	15/16" Trl. Surface Sq. Ft.	¾" O.D. on No. of Tubes	15/16" Trl. Surface Sq. Ft.	1" O.D. on No. of Tubes	1¼" Trl. Surface Sq. Ft.
6	4	36	24	28	20	14	15
6	8	36	48	28	40	14	30
8	8	68	89	48	75	26	55
10	8	114	150	82	129	48	101
10	12	114	224	82	193	48	151
12	12	164	322	120	283	66	208
14	12	210	412	152	358	82	258
16	12	286	562	208	490	110	345
18	12	348	684	252	593	138	434
20	12	432	850	314	740	174	546
20	16	432	1132	314	985	174	730
24	16	652	1710	474	1485	268	1122



MONS 049553

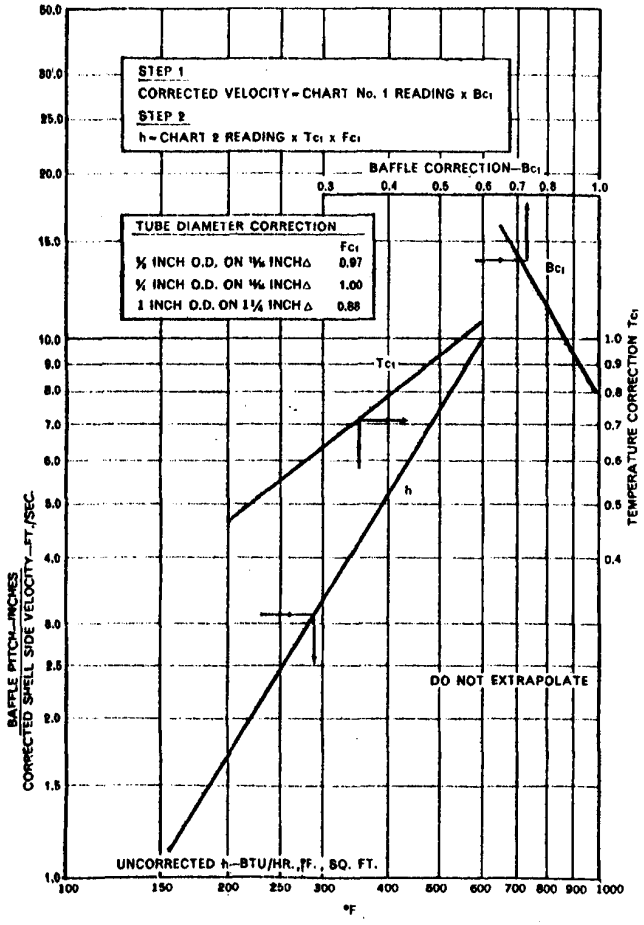
CHART No. 1



MONS 049554

CHART No. 2

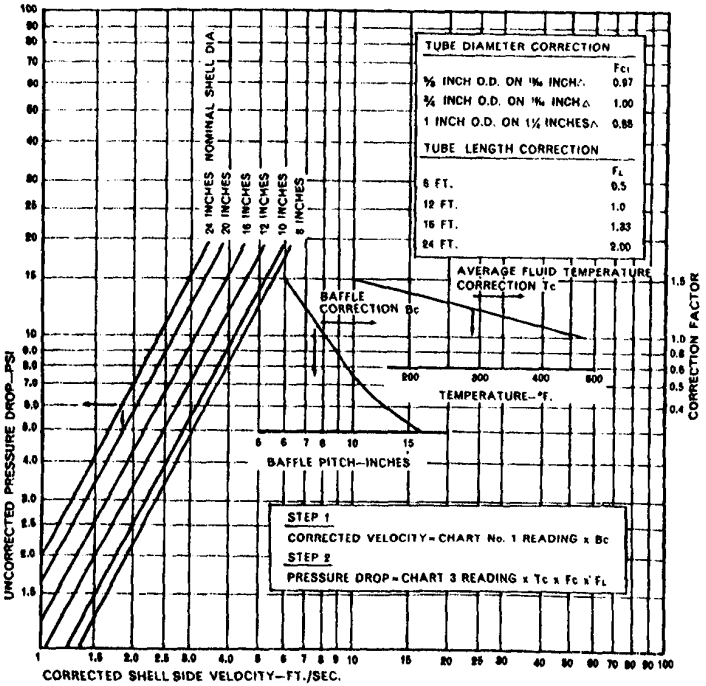
HEAT TRANSFER SHELL SIDE



MONS 049555

CHART No. 3

PRESSURE DROP SHELL SIDE



MONS 049556

VISCOSITY CONVERSION CHART

(Converting Kinematic and Saybolt Viscosity to Absolute Viscosity)

MONS 049557

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
ATMOSPHERES	14.70	lb./sq. in.
ATMOSPHERES	2116.8	lb./sq. ft.
ATMOSPHERES	760	mm. Hg.
ATMOSPHERES	29.92	in. Hg.
ATMOSPHERES	33.90	ft. of water
ATMOSPHERES	1.033×10^{4}	kg./sq. meter
British thermal units	778.2	ft. lb.
British thermal units	107.6	kg.-meters
British thermal units	1055	joules
British thermal units	0.2520	kg.-cal.
British thermal units	3.930×10^{-4}	hp. hr.
British thermal units	2.930×10^{-4}	kw. hr.
British thermal units	0.5556	P.C.U.*
Btu/cu. ft.	8.90	kg.-cal./cu. meter
Btu/hr.	3.927×10^{-4}	hp.
Btu/hr. sq. ft.	2.712	kg.-cal./hr. sq. meter
Btu/(hr. sq. ft. ° F.)	4.882	kg.-cal./(hr. sq. meter ° C.)
Btu/(hr. sq. ft. ° F.)	1.0	P.C.U.*/(hr. sq. ft. ° C.)
Btu/(hr. sq. ft. ° F.)	1.356×10^{-4}	gram-cal./sec. cm.^{2} ° C.
Btu/(hr. sq. ft. ° F.)	5.68×10^{-4}	watts/cm.^{2} ° C.
Btu/(hr. sq. ft. ° F.)	2.035×10^{-3}	watts/sq. in. ° F.
(Btu/hr. sq. ft.)/(° F./in.)	12.4	(kg.-cal./hr. sq. meter)/(° C./cm.)
(Btu/hr. sq. ft.)/(° F./in.)	3.445×10^{-4}	(gram-cal./sec. cm.^{2})/(° C./cm.)
(Btu/hr. sq. ft.)/(° F./ft.)	4.13×10^{-3}	(gram-cal./sec. cm.^{2})/(° C./cm.)
(Btu/hr. sq. ft.)/(° F./ft.)	0.0173	(watts/cm.^{2})/(° C./cm.)
(Btu/hr. sq. ft.)/(° F./ft.)	14.88	(gram-cal./hr. cm.^{2})/(° C./cm.)
Btu/min.	12.97	ft. lb./sec.
Btu/min.	0.02358	hp.
Btu/min.	0.01758	kw.
Btu/lb.	0.556	gram-cal./gram
Btu/lb. mol.	0.556	gram-cal./gram mol.
Btu/lb. ° F.	1.0	gram-cal./gram ° C.

*Pound-Centigrade Unit

MONS 049558

MULTIPLY	BY	TO OBTAIN
Btu/sec.	778.2	ft. lb./sec.
Btu/sec.	1.4147	hp.
Btu/sec.	1.0549	kw.
Btu/sec.	107.6	kg.-meter/sec.
Btu/sq. ft.	0.2712	gram-cal./cm.^{2}
Btu/sq. ft.	2.712	kg.-cal./sq. meter
CALORIES	See gram-cal.	
CENTIMETERS	0.3937	in.
CENTIMETERS	0.0328	ft.
cm. Hg.	0.01316	atm.
cm. Hg.	0.1934	lb./sq. in.
cm. Hg.	27.85	lb./sq. ft.
cm. Hg.	136.0	kg./sq. meter
cm. Hg.	5.353	in. of water
cm. Hg.	0.4461	ft. of water
cm./° C.	0.2187	in./° F.
cm./sec.	1.969	ft./min.
cm./sec.	0.03281	ft./sec.
cm./sec.	0.036	km. /hr.
cm./sec.	0.60	meters/min.
cm./sec.	0.02237	mph
CENTIPOISES	0.01	poises
CENTIPOISES	2.42	lb./ft. hr.
CENTIPOISES	6.72×10^{-4}	lb./ft. sec.
CENTIPOISES	3.60	kg./meter hr.
cubic centimeters	0.06102	cu. in.
cubic centimeters	3.531×10^{-5}	cu. ft.
cubic centimeters	2.642×10^{-4}	gal.
cm.^{3}/sec.	2.119×10^{-3}	cu. ft./min.
cm.^{3}/sec.	0.0864	cu. meter/day
cm.^{3}/sec.	0.01585	gal./min.
cm.^{3}/sec.	3.6	liter/hr.
cm.^{3}/gram	0.01602	cu. ft./lb.
cm.^{3}/gram mol.	0.01602	cu. ft./lb. mol.
CUBIC FEET	0.02832	cu. meters
CUBIC FEET	7.481	gal.

MONS 049559

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
CUBIC FEET	28.32	liters
CUBIC FEET	62.43	lb. of water
cu. ft. gas (60° F. at 1 atm)	2.636×10^{-5}	lb. mol.
cu. ft./lb.	62.43	$cm.^3$/gram
cu. ft./min.	472.0	$cm.^3$/sec.
cu. ft./min.	0.1247	gal./sec.
cu. ft./sec.	448.8	gal./min.
cu. ft./sec. sq. ft.	0.0305	liters/sec. $cm.^2$
CUBIC INCHES	16.39	$cm.^3$
CUBIC INCHES	5.787×10^{-4}	cu. ft.
CUBIC INCHES	0.01639	liters
CUBIC INCHES	4.329×10^{-3}	gal.
CUBIC METERS	35.31	cu. ft.
CUBIC METERS	264.2	gal.
cu. meters/day	11.57	$cm.^3$/sec.
degrees/sec.	2.778×10^{-3}	rev./sec.
degrees/sec.	0.1667	rpm
ERGS	1.0×10^{-7}	joules
FEET	30.48	cm.
FEET	0.3048	meters
ft. of water	0.0295	atm.
ft. of water	2.242	cm. Hg.
ft. of water	0.8826	in. Hg.
ft. of water	304.8	kg./sq. meter
ft. of water	62.43	lb./sq. ft.
ft. of water	0.4335	lb./sq. in.
ft./min.	0.508	cm./sec.
ft./min.	0.01667	ft./sec.
ft./min.	0.01829	km./hr.
ft./min.	0.01136	mph
ft./sec.	1.097	km./hr.
ft./sec.	18.29	meters/min.
ft./sec.	0.6818	mph
FOOT POUNDS	1.285×10^{-3}	Btu
FOOT POUNDS	3.239×10^{-4}	kg.-cal.
FOOT POUNDS	3.766×10^{-7}	kw. hr.
FOOT POUNDS	5.05×10^{-7}	hp. hr.

*Pound-Centigrade Unit

MONS 049560

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
ft. lb./min.	3.03×10^{-5}	hp.
ft. lb./min.	2.26×10^{-5}	kw.
ft. lb./sec.	0.0771	Btu/min.
ft. lb./sec.	1.818×10^{-3}	hp.
ft. lb./sec.	0.01943	kg.-cal./min.
ft. lb./sec.	1.356×10^{-3}	kw.
GALLONS (imperial)	1.201	gal. (U.S.)
gal. (U.S.)	231	cu. in.
gal. (U.S.)	0.1337	cu. ft.
gal. (U.S.)	3785	$cm.^3$
gal. (U.S.)	3.785	liters
gal./hr.	3.71×10^{-5}	cu. ft./sec.
gal./min.	2.228×10^{-3}	cu. ft./sec.
gal./min.	0.227	cu. meters/hr.
gal./min.	0.06309	liters/sec.
gal./min. of water	500.8	lb./hr. of water
GRAMS	980.7	dynes
GRAMS	2.205×10^{-3}	lb.
gram mole gas	2.24×10^{4}	$cm.^3$ gas (0° C. and 760 mm.)
gram-cal.	3.968×10^{-3}	Btu
gram-cal./gram	1.8	Btu/lb.
gram-cal./gram mol.	1.8	Btu/lb. mol.
gram-cal./gram ° C.	1.0	Btu/lb. ° F.
gram-cal./$cm.^2$	3.687	Btu/sq. ft.
(gram-cal./$cm.^2$)/cm.	1.452	(Btu/sq. ft.)/in.
gram-cal./(sec. $cm.^2$ ° C.)	7.373×10^{3}	Btu/(hr. sq. ft. ° F.)
(gram-cal./sec. $cm.^2$)/(° C./cm.)	2.903×10^{3}	(Btu/hr. sq. ft.)/(° F./in.)
gram-cm.	9.294×10^{-8}	Btu
gram-cm.	980.6	ergs
gram-cm.	7.233×10^{-5}	ft. lb.
gram-cm.	2.342×10^{-8}	kg.-cal.
grams/cm.	5.60×10^{-3}	lb./in.
grams/$cm.^3$	1.0	specific gravity at 4° C.
grams/$cm.^3$	62.43	lb./cu. ft.
grams/$cm.^2$	0.07355	cm. Hg.
grams/$cm.^2$	10	kg./sq. meter
grams/$cm.^2$	0.394	in. of water
grams/$cm.^2$	0.03281	ft. of water

MONS 049561

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
grams/cm.^{2}	9.678×10^{-4}	atm.
grams/cm.^{2}	0.01422	lb./sq. in.
grams/cm.^{2}	2.048	lb./sq. ft.
HORSEPOWER	42.41	Btu/min.
HORSEPOWER	3.3×10^4	ft. lb./min.
HORSEPOWER	550	ft. lb./sec.
HORSEPOWER	10.7	kg.-cal./min.
HORSEPOWER	0.7457	kw.
hp. (boiler)	3.3479×10^4	Btu/hr.
hp. (boiler)	9.804	kw.
hp. hr.	2.545×10^3	Btu
hp. hr.	1.98×10^6	ft. lb.
hp. hr.	2.684×10^6	joules
hp. hr.	641.2	kg.-cal.
hp. hr.	2.737×10^5	kg.-meters
hp. hr.	0.7457	kw. hr.
hp. hr.	1.414×10^3	P.C.U.*
INCHES	2.54	cm.
in. Hg.	0.03342	atm.
in. Hg.	1.133	ft. of water
in. Hg.	0.4912	lb./sq. in.
in. Hg.	70.73	lb./sq. ft.
in. Hg.	345.3	kg./sq. meter
in. of water	2.458×10^{-3}	atm.
in. of water	0.07355	in. Hg.
in. of water	0.1869	cm. Hg.
in. of water	25.40	kg./sq. meter
in. of water	0.03613	lb./sq. in.
in. of water	5.202	lb./sq. ft.
in./° F.	4.572	cm./° C.
KILOGRAMS	9.807×10^5	dynes
KILOGRAMS	70.93	poundals
KILOGRAMS	2.205	lb.
KILOGRAMS	1.102×10^{-3}	tons (short)
kg.-meters	9.302×10^{-3}	Btu
kg.-meters	7.233	ft. lb.
kg.-meters	2.344×10^{-3}	kg.-cal.
kg.-meters	2.724×10^{-6}	kw. hr.

*Pound-Centigrade Unit

MONS 049562

MULTIPLY	BY	TO OBTAIN
kg.-meters	5.165×10^{-3}	P.C.U.*
kg./cu. meter	1.0×10^{-3}	gram/cm.^{3}
kg./cu. meter	0.06243	lb./cu. ft.
kg./meter	0.6720	lb./ft.
kg./sq. meter	9.678×10^{-5}	atm.
kg./sq. meter	7.355×10^{-2}	cm. Hg.
kg./sq. meter	3.281×10^{-3}	ft. of water
kg./sq. meter	2.896×10^{-3}	In. Hg.
kg./sq. meter	0.2048	lb./sq. ft.
kg./sq. meter	1.422×10^{-3}	lb./sq. in.
KILOMETERS	3.281×10^{3}	ft.
KILOMETERS	0.6214	mi.
km./hr.	27.78	cm./sec.
km./hr.	54.68	ft./min.
km./hr.	0.9113	ft./sec.
km./hr.	16.67	meters/min.
KILOWATTS	56.92	Btu/min.
KILOWATTS	4.425×10^{4}	ft. lb./min.
KILOWATTS	737.6	ft. lb./sec.
KILOWATTS	1.341	hp.
KILOWATTS	14.34	kg.-cal./min.
KILOWATTS	1×10^{3}	watts
kw. hr.	3.413×10^{3}	Btu
kw. hr.	2.655×10^{6}	ft. lb.
kw. hr.	1.341	hp. hr.
kw. hr.	3.6×10^{6}	joules
kw. hr.	860.5	kg.-cal.
kw. hr.	1.895×10^{3}	P.C.U.*
LITERS	1×10^{3}	cm.^{3}
LITERS	0.0353	cu. ft.
LITERS	61.02	cu. in.
LITERS	0.2642	gal. (U.S.)
LITERS	1.057	qt. (liq.)
liters/gram mol.	16.02	cu. ft./lb. mol.
liters/hr.	0.2778	cm.^{3}/sec.
liters/kg.	0.01602	cu. ft./lb.
liters/min.	6.0×10^{4}	cm.^{3}/hr.
liters/min.	5.885×10^{-4}	cu. ft/sec.

*Pound-Centigrade Unit

MONS 049563

ENGINEERING CONVERSION FACTORS

MULTIPLY	BY	TO OBTAIN
liters/min.	15.851	gal./hr.
liters/min.	4.403×10^{-3}	gal./sec.
liters/sec. $cm.^2$	32.8	cu. ft./sec. sq. ft.
METERS	3.281	ft.
METERS	39.37	In.
meters/° C.	1.824	ft./° F.
meters/min.	1.667	cm./sec.
meters/min.	0.05468	ft./sec.
meters/min.	0.06	km./hr.
meters/min.	0.03728	mph
meters/sec.	196.8	ft./min.
meters/sec.	3.6	km./hr.
meters/sec.	2.237	mph
OUNCES	28.35	grams
OUNCES	0.0625	lb.
OUNCES (fluid)	1.805	cu. in.
OUNCES (fluid)	0.02957	liters
oz./sq. in.	1.732	in. of water
POISES	1	gram/cm. sec.
POUNDS	4.448×10^5	dynes
POUNDS	453.6	grams
POUNDS	32.17	poundals
lb. mols gas	379.4	cu. ft. gas (60° F. at 1 atm.)
lb. of water	0.01602	cu. ft.
lb. of water	0.1198	gal.
lb. of water/hr.	2.669×10^{-4}	cu. ft./min.
lb. of water/hr.	1.997×10^{-3}	gal./min.
lb./cu. ft.	0.01602	grams/$cm.^3$
lb./cu. ft.	16.02	kg./cu. meter
lb./cu. In.	27.68	grams/$cm.^3$
lb./ft.	1.488	kg./meter
lb./ft. hr.	4.13×10^{-3}	grams/cm. sec.
lb./ft. hr.	0.413	centipoises
lb./gal.	0.1198	grams/$cm.^3$
lb./In.	178.6	grams/cm.
lb./sq. ft.	0.01602	ft. of water
lb./sq. ft.	4.882	kg./sq. meter

MONS 049564

MULTIPLY	BY	TO OBTAIN
lb./sq. ft.	6.944×10^{-3}	lb./sq. in.
lb./sq. in.	0.06804	atm.
lb./sq. in.	2.307	ft. of water
lb./sq. in.	2.036	in. Hg.
lb./sq. in.	51.7	mm. Hg.
lb./sq. in.	703.1	kg./sq. meter
lb./sq. in.	144	lb./sq. ft.
REFRIGERATION—STD. TON	200	Btu/min.
SQUARE CENTIMETERS	1.076×10^{-3}	sq. ft.
SQUARE CENTIMETERS	0.1550	sq. in.
SQUARE FEET	929	sq. cm.
SQUARE FEET	144	sq. in.
SQUARE FEET	0.0929	sq. meters
SQUARE INCHES	6.452	$cm.^2$
SQUARE INCHES	6.944×10^{-3}	sq. ft.
SQUARE INCHES	6.452×10^{-4}	sq. meters
SQUARE KILOMETERS	1.076×10^{7}	sq. ft.
SQUARE KILOMETERS	0.3861	sq. mi.
SQUARE METERS	10.76	sq. ft.
temperature ° C. 273	1.0	abs. temp. ° K.
temperature ° C. 17.8	1.8	temp. ° F.
temperature ° F. 460	1.0	abs. temp. ° R.
temperature ° F. −32	0.5555	temp. ° C.
TONS (long)	1.016×10^{3}	kg.
TONS (long)	2.24×10^{3}	lb.
tons (metric)	1×10^{3}	kg.
tons (metric)	2.205×10^{3}	lb.
tons (short)	907.2	kg.
tons (short)	2×10^{3}	lb.
tons (short)/sq. ft.	9.765×10^{2}	kg./sq. meter
tons (short)/sq. ft.	13.89	lb./sq. in.
tons (short)/sq. in.	1.406×10^{6}	kg./sq. meter
tons (short)/sq. in.	2×10^{3}	lb./sq. in.
tons of refrigeration	See refrigeration	
WATTS	0.05692	Btu/min.
WATTS	1×10^{7}	ergs/sec.
WATTS	44.26	ft. lb./min.

MONS 049565

MULTIPLY	BY	TO OBTAIN
WATTS	0.7376	ft. lb./sec.
WATTS	1.341×10^{-3}	hp.
WATTS	0.01434	kg.-cal./min.
WATTS	1.0×10^{-3}	kw.
WATT HOURS	3.413	Btu
WATT HOURS	2.655×10^{3}	ft. lb.
WATT HOURS	1.341×10^{-3}	hp. hr.
WATT HOURS	0.8605	kg.-cal.
WATT HOURS	367.1	kg.-meter
WEEK	168	hr.
WEEK	1.008×10^{4}	min.
WEEK	6.048×10^{5}	sec.
YEARS (common)	8.76×10^{3}	hr.

STEEL PIPE DIMENSIONS—CAPACITIES AND WEIGHTS*

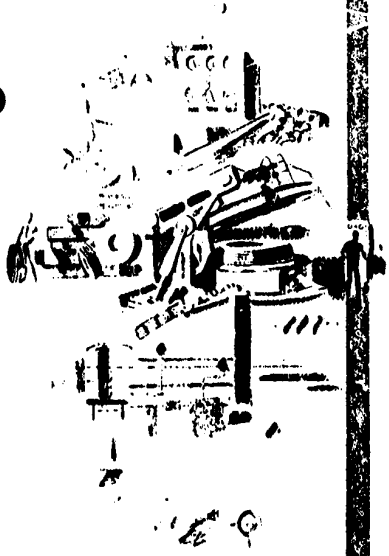
Nominal pipe size, in.	Outside diam., in.	Schedule No.	Wall thickness, in.	Inside diam., in.	Cross-sectional area metal, sq. in.	Inside sectional area, sq. ft.	Circumference, ft., or surface sq. ft. per ft., of length		Capacity at 1 ft. per sec. velocity		Weight of pipe per ft. lb.
							Outside	Inside	U. S. gal. per min.	Lb. per hr. water	
⅛	0.540	40	.088	.364	.125	.00072	.141	.0954	.323	161.5	.43
¼	0.675	40	.091	.493	.167	.00133	.177	.1293	.596	298.0	.57
⅜	0.840	40	.109	.622	.250	.00211	.220	.1630	.945	472.5	.85
½	1.060	40	.113	.824	.333	.00371	.275	.2158	1.665	832.5	1.13
1	1.315	40	.133	1.049	.494	.00600	.344	.2745	2.690	1,345.0	1.68
1¼	1.860	40	.140	1.380	.669	.01040	.435	.362	4.57	2,285.0	2.28
1½	1.990	40	.145	1.610	.799	.01414	.498	.422	6.34	3,170.0	2.72
2	2.375	40	.154	2.067	1.075	.02330	.622	.542	10.45	5,225.0	3.66
2½	2.875	40	.203	2.469	1.704	.03322	.753	.647	14.92	7,460.0	5.80
3	3.500	40	.216	3.068	2.228	.05130	.917	.804	23.00	11,500.0	7.58
3½	4.000	40	.226	3.548	2.680	.06870	1.047	.930	30.90	15,400.0	9.11
4	4.500	40	.237	4.026	3.173	.08840	1.178	1.055	39.6	19,800.0	10.8
5	5.563	40	.258	5.047	4.304	.1390	1.456	1.322	62.3	31,150.0	14.7
6	6.625	40	.280	6.065	5.584	.2006	1.734	1.590	90.0	45,000.0	19.0
8	8.625	40	.322	7.981	8.396	.3474	2.258	2.090	155.7	77,850.0	28.6
10	10.75	40	.365	10.020	11.90	.5475	2.814	2.620	246.0	123,000.0	40.5
12	12.75	40	.406	11.938	15.77	.7773	3.338	3.13	349.0	174,500.0	53.6

*Based on A. S. A. Standards B36.10.

MONS 049566

TYPICAL APPLICATIONS FOR therminol LIQUID HEATING SYSTEMS...

Indirect liquid heating with THERMINOL FR systems is recommended wherever low-pressure, high-temperature processing – requiring safe, uniform delivery of heat – is needed. Here are a few typical applications.



CHEMICAL PROCESSING

. . . especially where flammable materials are handled.

VARNISHES AND RESINS PROCESSING

. . . where a single "circuit" with multiple users and varying temperatures is desirable.

PLASTICS AND RUBBER MOLDING

. . . where uniform heating, rapid temperature flux, and pin-point control is essential.

BITUMINOUS MATERIALS HEATING

. . . for maximum safety where explosive gases and volatile fumes occur.

FOOD PROCESSING

. . . for controlled, quality "cooking" of potato chips, pre-cooked soups, other foodstuffs.

MATERIALS CONVERSION

. . . to heat corrugating rolls, crimping presses, calenders.

METALS TREATING OVENS

. . . for heat-treating metals such as titanium and vanadium; for "seasoning" weldments, castings and forgings.

MALT COOKING AND LIQUID DISTILLATION

. . . for efficient indirect heating of distillation equipment.

MONS 049567

Therminol FR

SAFETY OF HANDLING

On the basis of animal toxicity studies, THERMINOL FR may be considered only slightly toxic from the standpoint of accidental massive skin exposure or accidental ingestion. Similarly, single exposures to high concentrations of vapors (when heated sufficiently to volatilize) or high concentrations of decomposition products (if the fluid is accidentally discharged into the fire chamber) are not serious hazards because the irritating character of such concentrations preclude voluntary exposure.

Repeated or prolonged skin exposure should be avoided since THERMINOL FR acts as a solvent for fats and oils of the skin. Removal of these natural, protective barriers can lead to drying and chapping such as occurs with exposures to paint thinners. More important, THERMINOL FR may be absorbed if it is allowed to remain on the unbroken skin. For these reasons, we recommend that the skin be washed with soap and water if there is contact. A skin burn resulting from accidental contact with hot fluid should be treated in the normal manner for any thermal burn due to hot oils.

Because of its low vapor pressure, there is no significant vapor inhalation hazard when THERMINOL FR is at room temperature. For example, there is no vapor exposure problem while transferring the fluid from its shipping container to the heat transfer system. On the other hand, the vapors emitted by THERMINOL FR heated to elevated temperatures are injurious on prolonged exposure. It is indicated that the "threshold limit value" or atmospheric vapor concentration which cannot be safely exceeded (on a daily basis) is 0.5—1.0 milligrams of THERMINOL FR vapor per cubic meter of air in the workroom. In heat transfer installations, the fluid must be used in a closed system free from leaks with the expansion tank vented to the outdoors. Accordingly, there should be little or no opportunity for workers to come in contact with vapors.

MONS 049568



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MONS 049571

APPENDIX D - UTILITIES

The following is a list of utilities supplied to the Pyranol mix area.

Steam

Steam is supplied to the department through a 6" main at 120 psig. Standard practice on steam is 25 lbs/cwt.

Recovered Water

Water is not used in this department.

Electricity

Electrical power is supplied at 440 volts for power and 110 volts for lighting. Standard practice is 500 KWH/cwt.

M

MONS 049573

APPENDIX E - PERSONNEL

Production of Pyranol mixes is a part time operation. When these mixes are produced they do not require constand attention of an operator.

All Pyranol mixes are produced by Aroclor department operators.

Mc

MONS 049575

APPENDIX F - PACKAGING AND SHIPPING

Pyranols are packaged in 55 gallon steel drums, 33 gallon galvanized drums and five gallon steel cans. These containers are transferred to warehouse for storage until time of shipment.

Some Pyranols are loaded into tank cars for shipment.

All tank cars are entered, cleaned and inspected prior to loading.