

# EUROPEAN HEAT PUMP SUMMIT

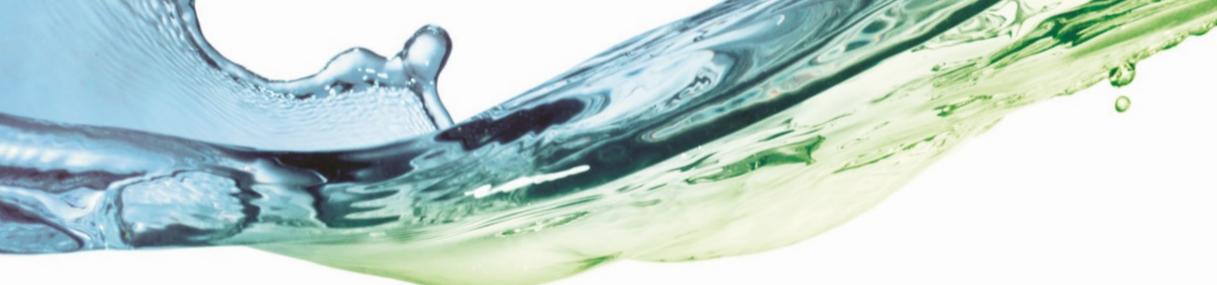
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SYMPOSIUM + EXPO  
NUREMBERG, 20–21.10.2015

Industrial | Commercial | Residential  
Heating & Cooling | Components & Equipment

[hp-summit.de](http://hp-summit.de)

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**Kilfrost**  
**GEO<sup>®</sup>**



## Setting The Standard For Heat Pump Thermal Fluids

**Dr Philip J Gray**

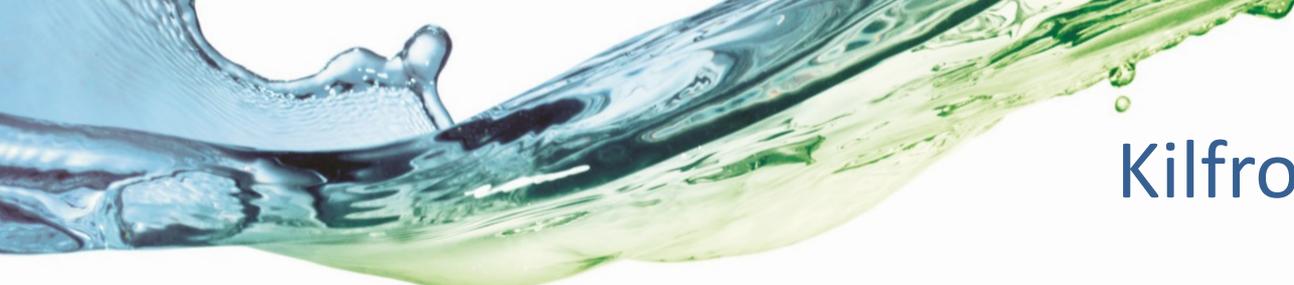


**Kilfrost**



- **Develops** and formulates a range of specialty chemical products
- **Supplies** Aerospace, HVAC, RAC & Renewable Energy Industries
  - **Invests** heavily in research and development
  - **Long pedigree** as pioneers setting industry stand





# Kilfrost Products & Services

Exporting  
Products & Solving  
Problems Across  
Europe



# Today's Agenda

## Setting the standard on thermal fluids for closed loop ground and water source heat pumps

1. What is a thermal fluid?
2. Importance of thermal fluids
3. Current practices and industry compromises
4. Industry requirements
5. New development: Kilfrost Geo



# What is a thermal fluid?

## Base Fluid

### Examples

Monoethylene Glycol (MEG)

Monopropylene Glycol (MPG)

Methanol & Ethanol

Glycerol



## Performance Additives

### Examples

Corrosion inhibitors

Preservatives/Biocide

pH Buffers

# Why consider the thermal fluid?



## Heat Transfer Efficiency

- Pressure Drops
- Heat Transfer Coefficients
- Pumping costs, piping diameters, COP



## System Protection

- System Efficiency
- System Reliability
- Industry Reputation



## Human & Environmental Impact

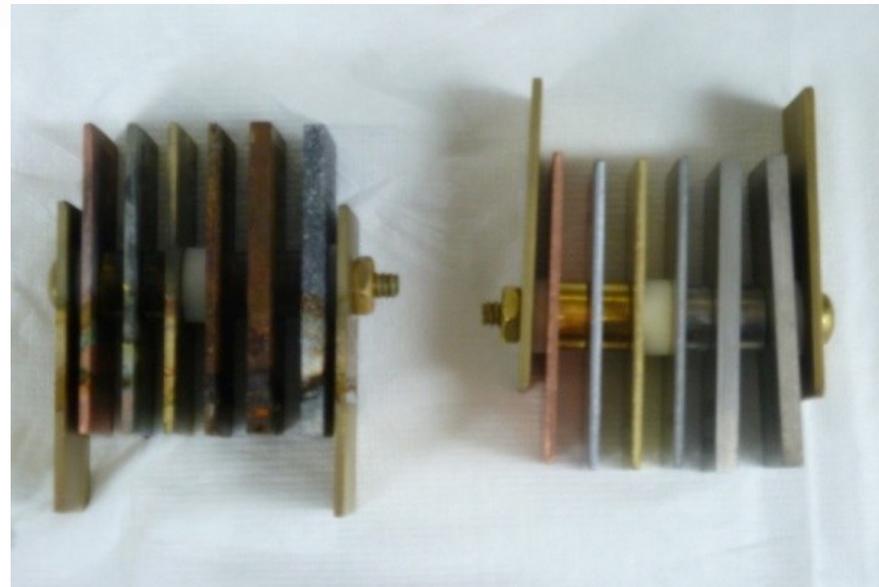
- Carbon footprint
- Safety
- Regulatory changes

# System Protection

**Thermal Fluid must provide corrosion, fouling and degradation protection**

## Impacts

- System efficiency
- Installation longevity
- Maintenance costs
- Industry reputation



**Different thermal fluids will offer different levels of protection**

# Heat Transfer Efficiency

Different fluid types have different thermo-physical properties

Thermo-Physical Property	Impact
Fluid Viscosity & Density	System Pressure Drops Hydraulic Efficiency
Specific Heat Capacity	Overall Heat Transfer Coefficients
Thermal Conductivity	

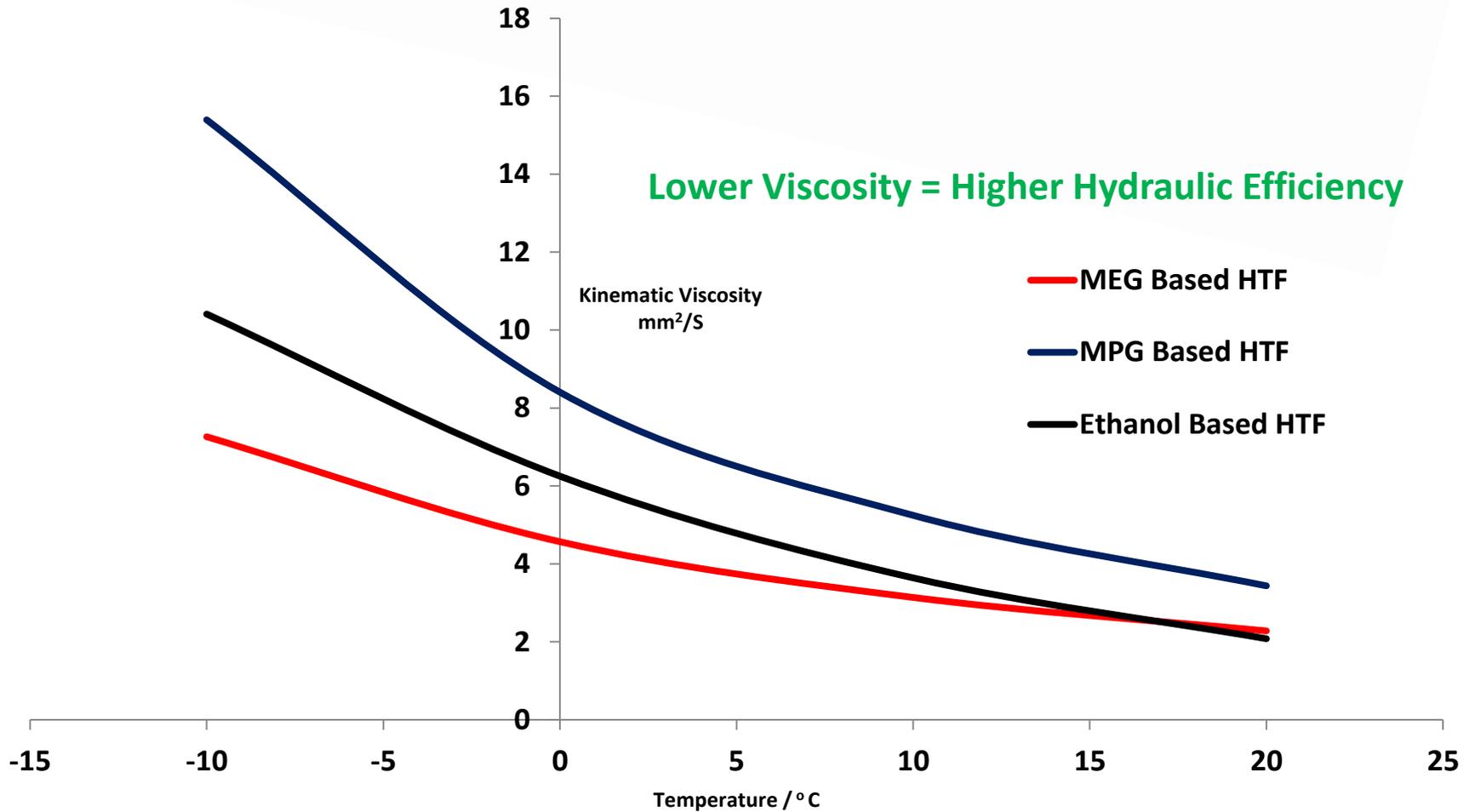
Low Viscosity Fluids



High Viscosity Fluids

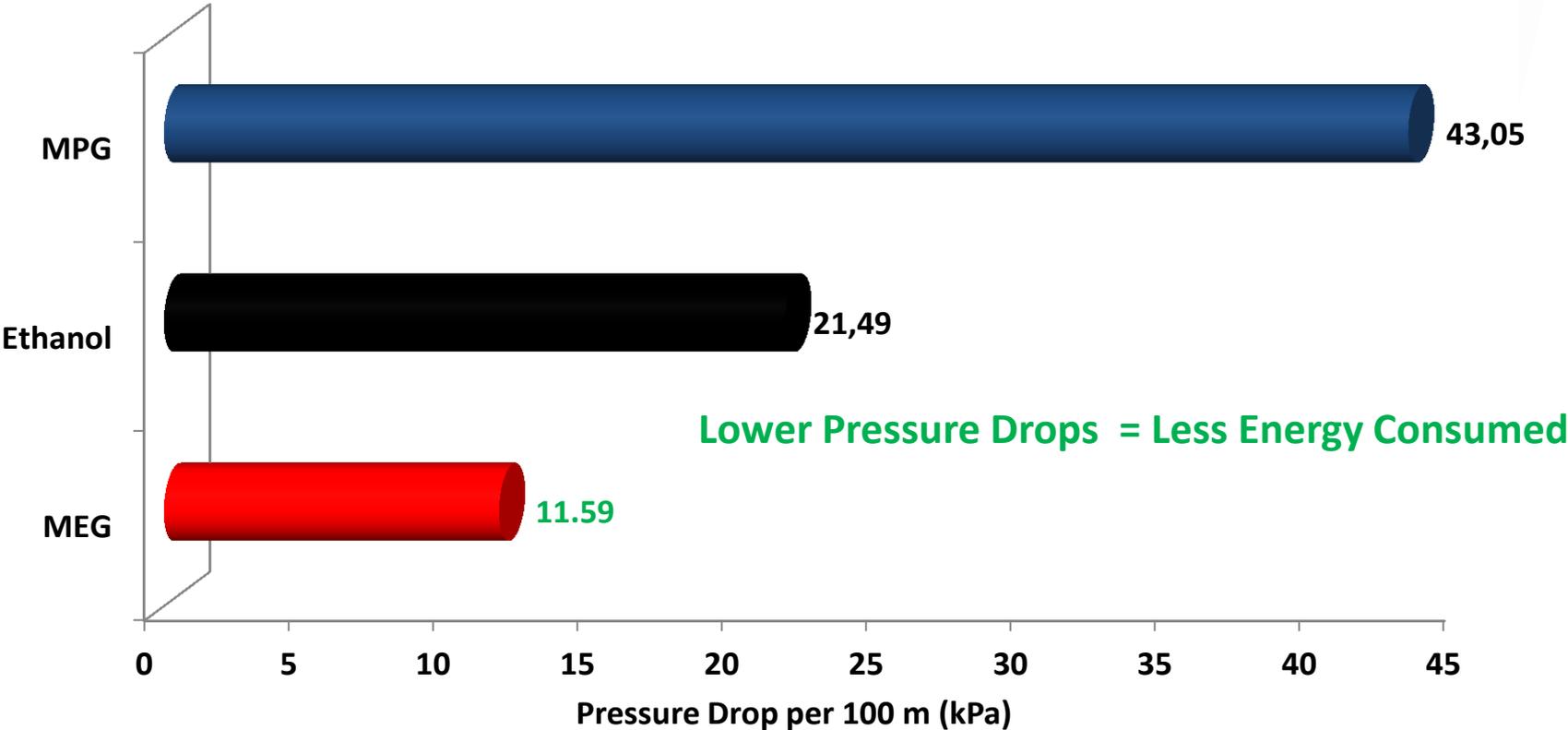
# Heat Transfer Efficiency

## Viscosity Comparison of Thermal Fluids (-15 ° C Freeze Protection)



# Heat Transfer Efficiency

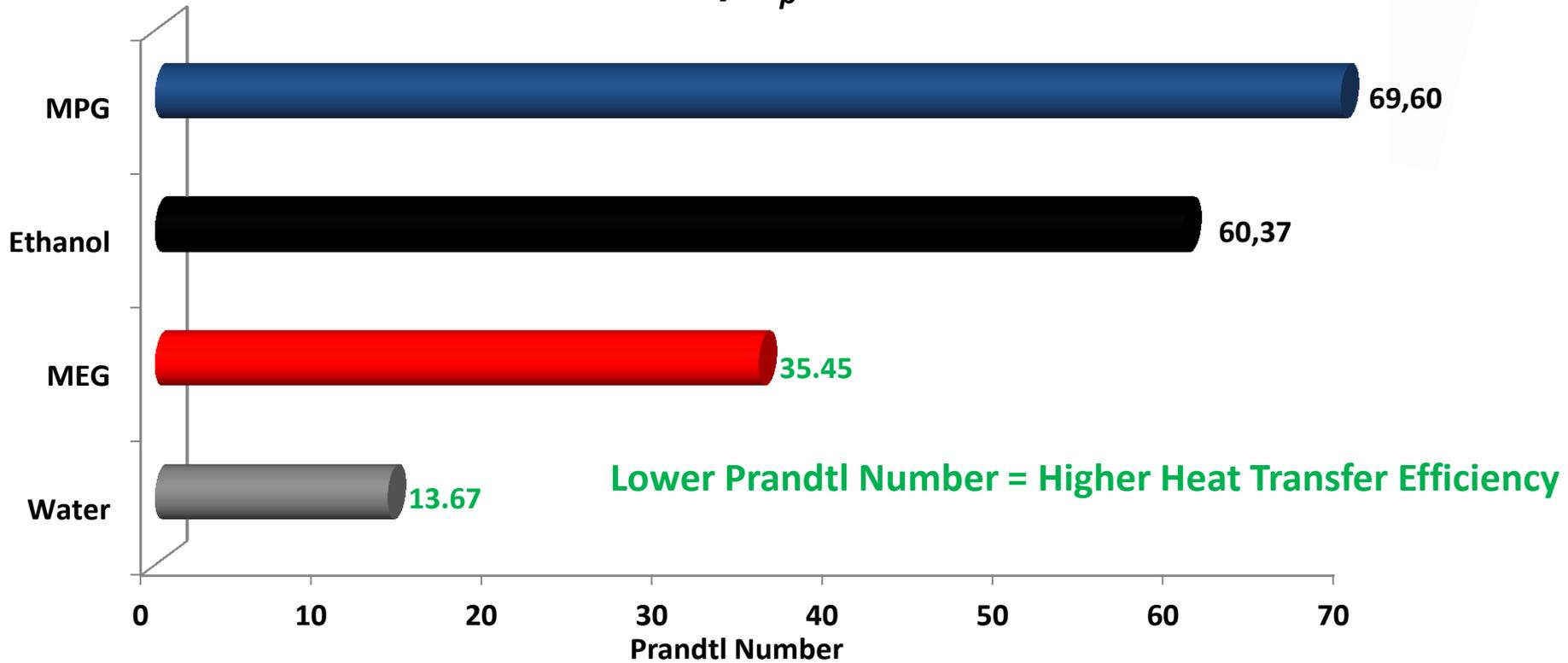
Pressure drop generated by fluids flowing through 32 mm diameter pipe (0 °C, Reynolds Number = 3000)



# Heat Transfer Efficiency

Prandtl Number Comparison (@ 0 ° C for -15 ° C Freeze Protection)

$$Pr = \mu c_p / k$$



# Human Health & Environmental Impact



## Wider Industry Implications

- Carbon footprint
- Installation safety
- Regulatory changes
- Industry reputation and growth

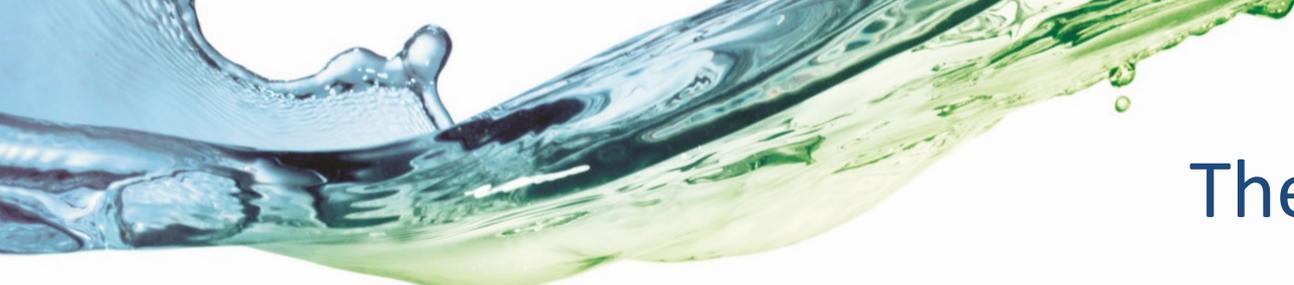
Base Fluid	Risks	Source	Efficiency
<b>MEG</b> 	High Mammalian Toxicity	100 % Crude Oil Derived	<b>Highest</b>  <b>Lowest</b>
<b>Ethanol</b> 	Highly Flammable  Volatile Organic	Variable	
<b>Glycerol</b>	Non-Hazardous	Sustainable Source	
<b>MPG</b>	Non-Hazardous	100 % Crude Oil Derived	



# The Compromise

Choosing efficiency over safety is commonplace





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MEG and Ethanol Based Fluids widely used





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As the industry develops more installations will make use of these products



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**Risks are increasing with time**





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MEG and Ethanol Based Fluids widely used

As the industry develops more installations will make use of these products

**Risks are increasing with time**



**What will be the total volume of toxic and flammable fluids installed by 2050?**

# Is sacrificing efficiency the solution?

Less hazardous alternatives are being used



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Less hazardous alternatives are being used

These are less efficient



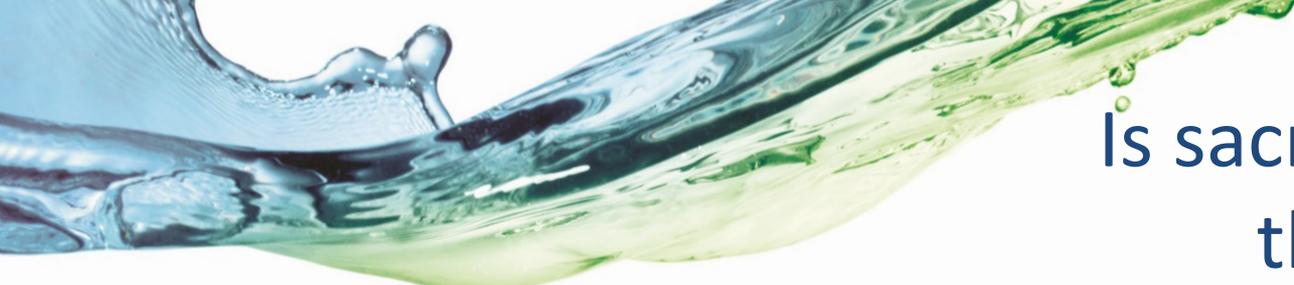
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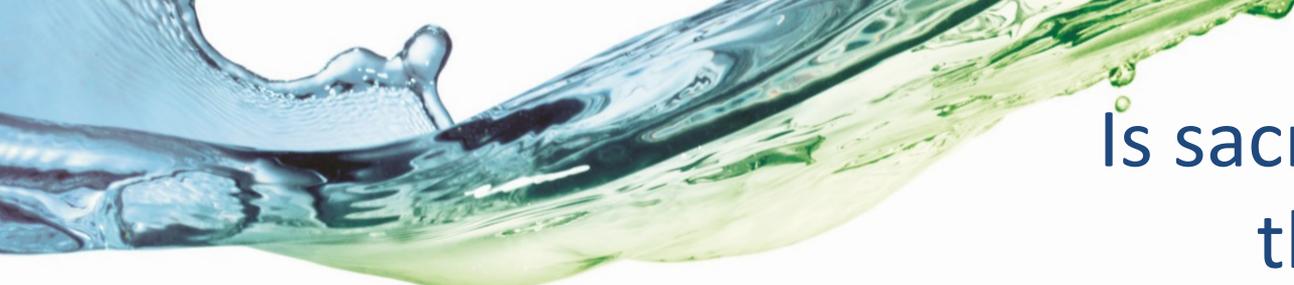
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The industry needs a non-hazardous **and** efficient alternative





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An alternative without  
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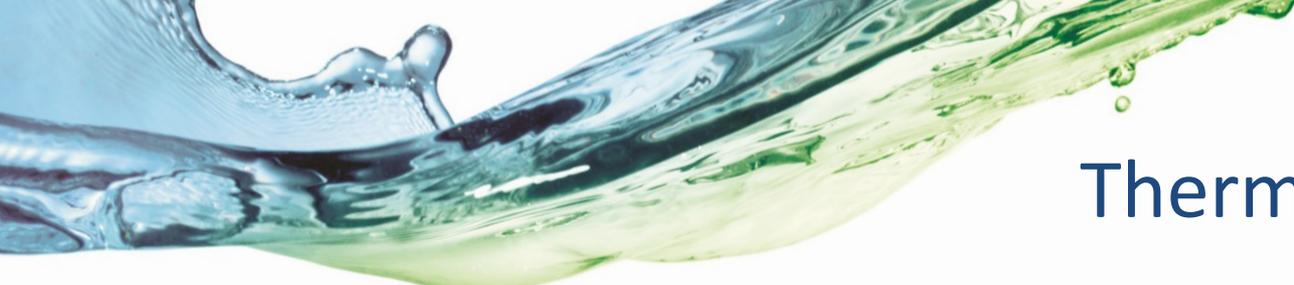
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**What will be the price for choosing safety over efficiency?**



# Thermal Fluid Standard

What does the **industry require** from a thermal fluid?

How can we promote **best practice**?



## The Thermal Fluid Wish List

1. **High Efficiency**
2. **Good Environmental Profile**
3. **Minimal Physical Hazards**
4. **Excellent System Protection**





Kilfrost Geo is an advanced heat transfer fluid engineered specifically for closed loop ground and water source heat pumps.

## How is it different?



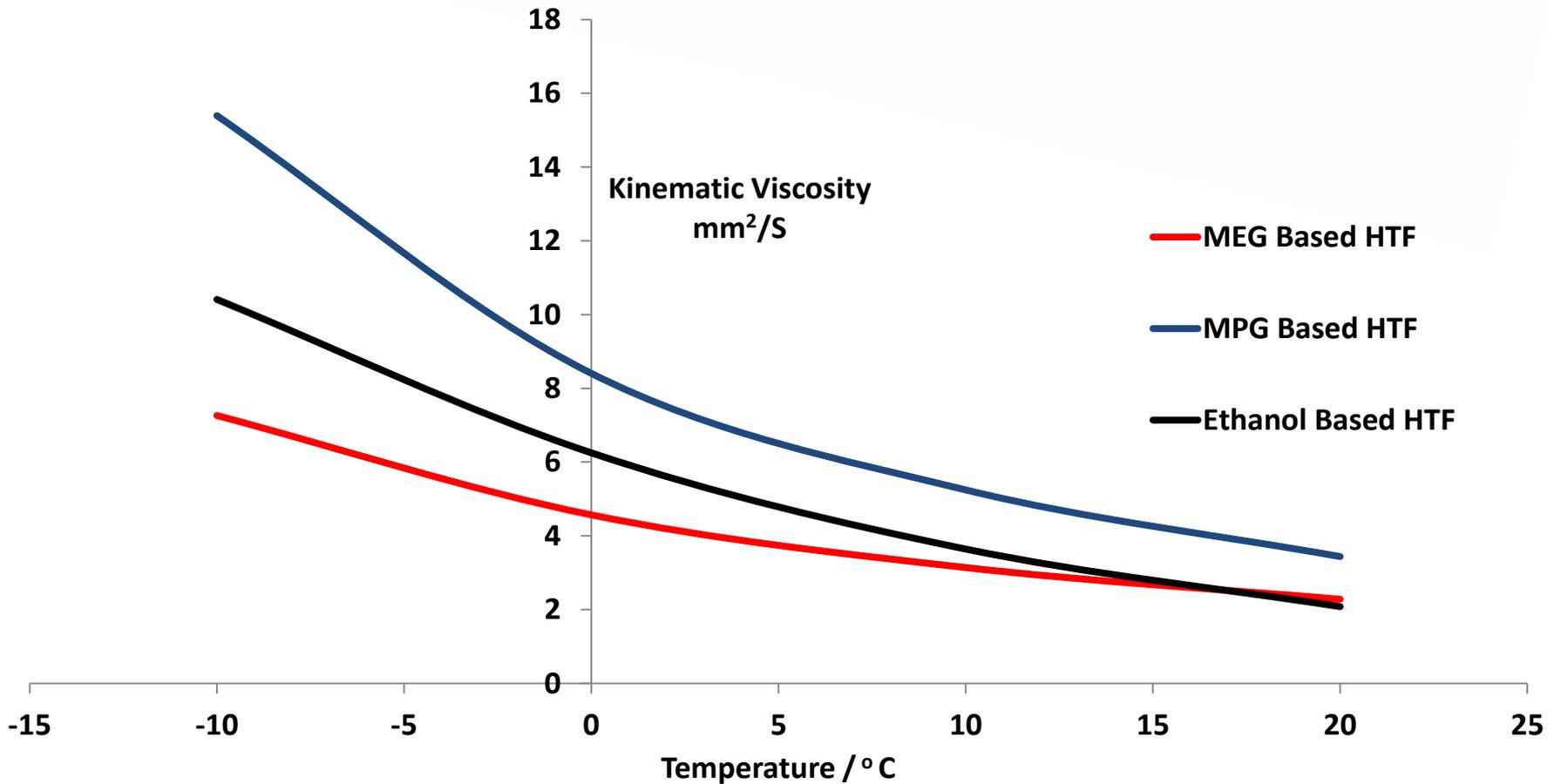
Kilfrost Geo has offers the following advantages over currently used technology;

- 1. Higher Efficiency**
- 2. Superior Environmental Profile**
- 3. Lower Risk**

Kilfrost Geo is a heat transfer fluid that removes the need for compromise

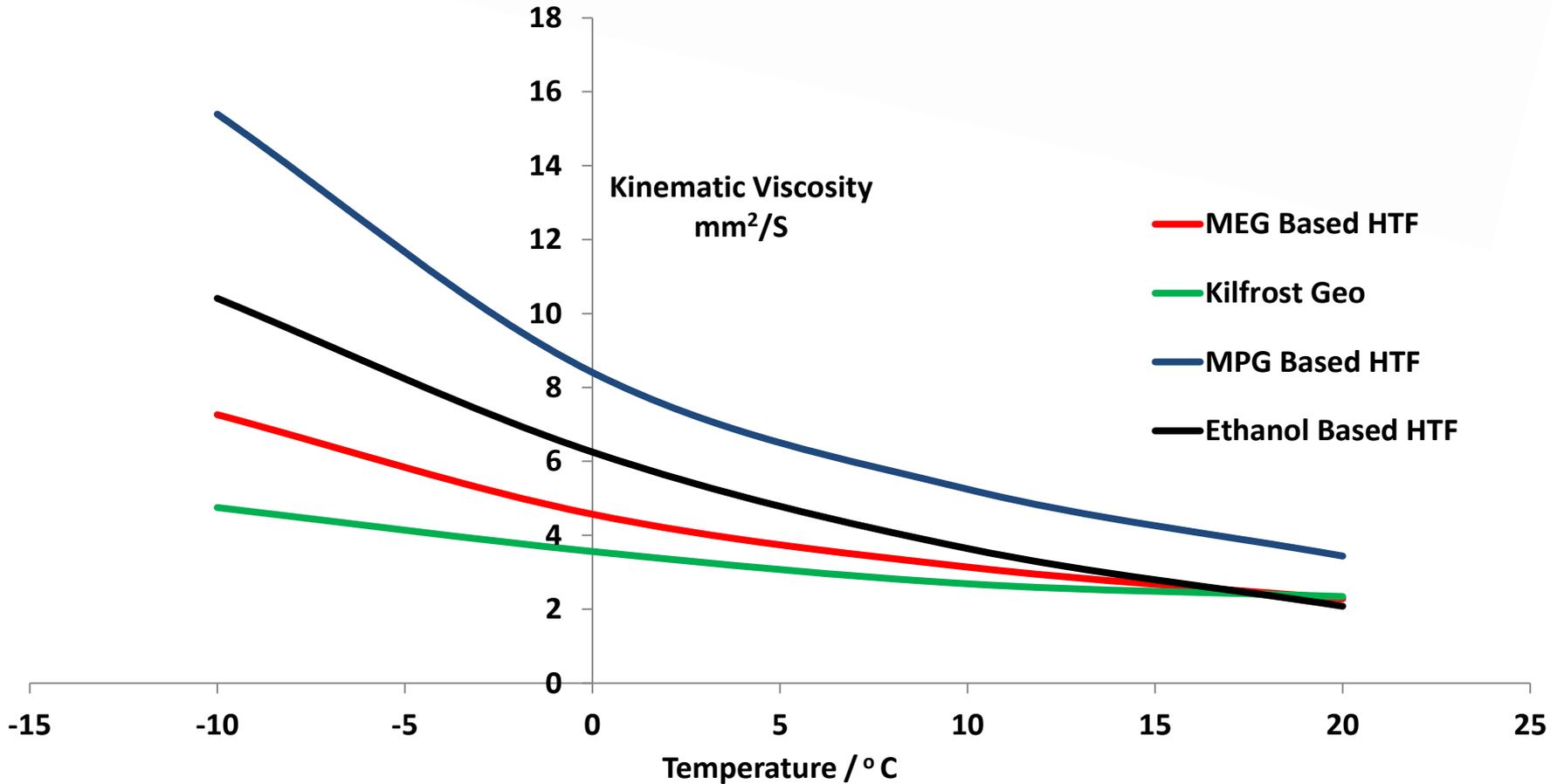
# Heat Transfer Efficiency

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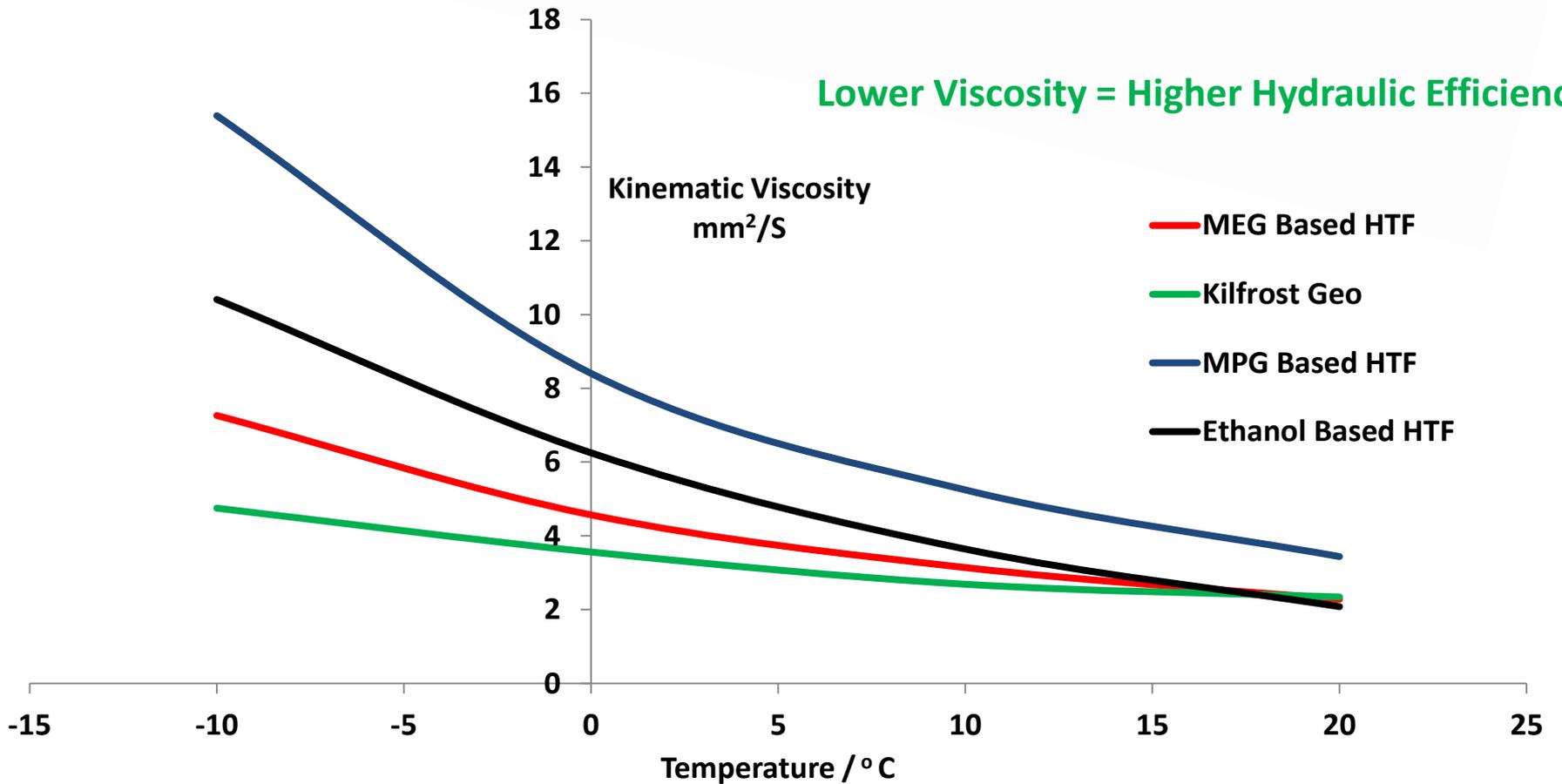
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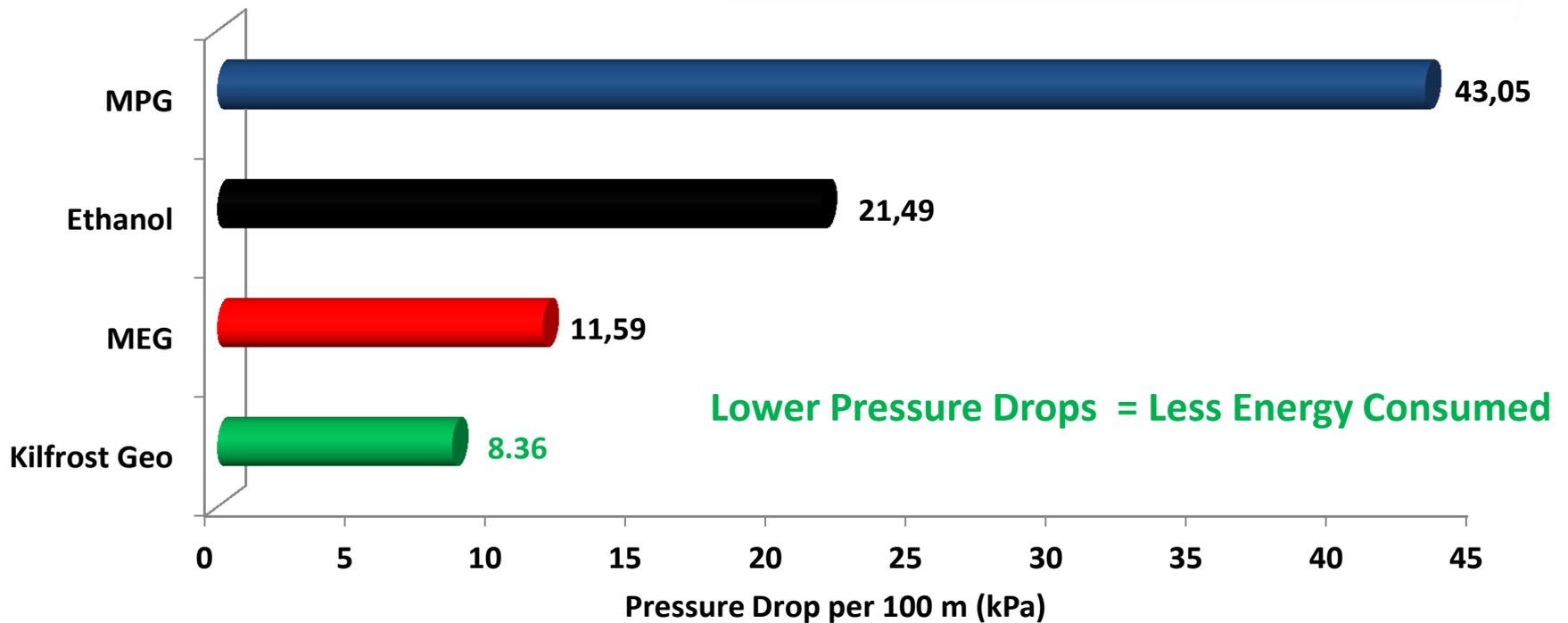
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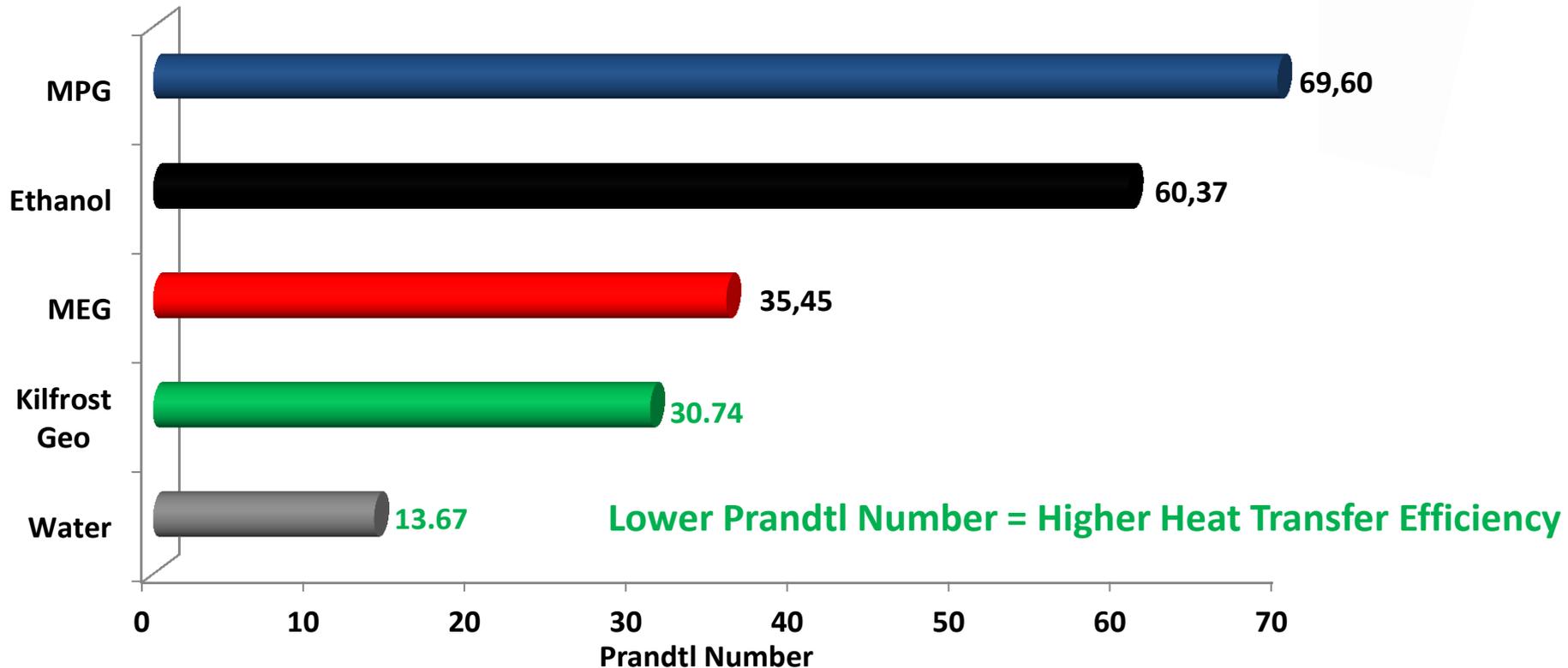
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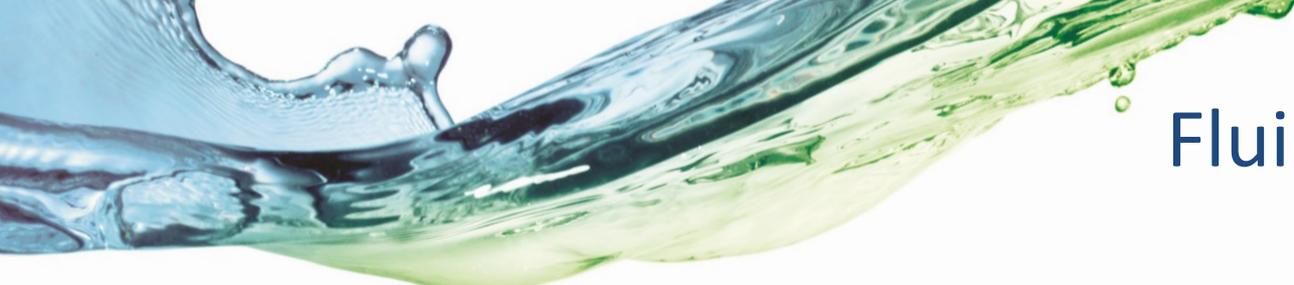
Pressure drop generated by fluids flowing through 32 mm diameter pipe (0 ° C, Reynolds Number=3000)



# Heat Transfer Efficiency

Prandtl Number Comparison (@ 0 ° C for -15 ° C Freeze Protection)



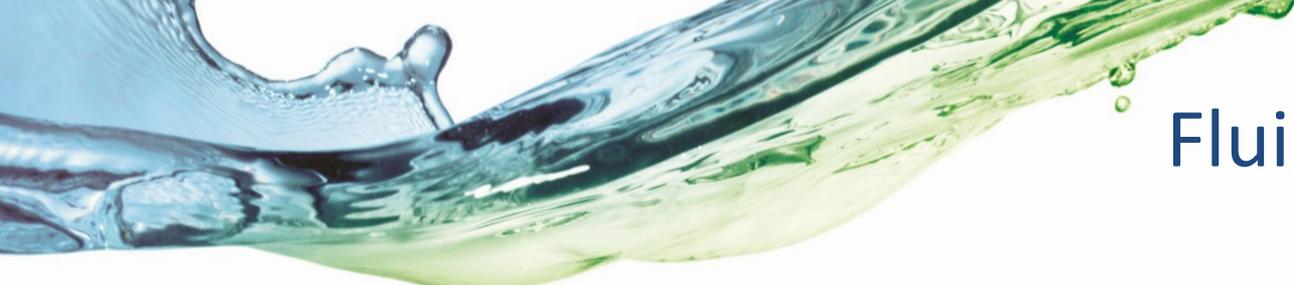


# Fluid Comparison



System Parameters	
Heat Pump Heating Power	12 kW
Heat Pump Cooling Power for 0/35	9.16 kW
Ground Heat Factor	35 W/m
Vertical Collector FF20 HDPE 100 RC	3 x 90 m
Delta T (Supply/Return)	3 K
Supply/Return Pipes HDPE	40 x 2,4
Main Supply/Return Pipes HDPE	50 x 3,0

- Thermal fluid performance modelled in a vertical closed loop ground source heat pump
- MPG & MEG based fluids compared with Kilfrost Geo
- **Details of the comparison available at [www.kilfrost.com](http://www.kilfrost.com)**

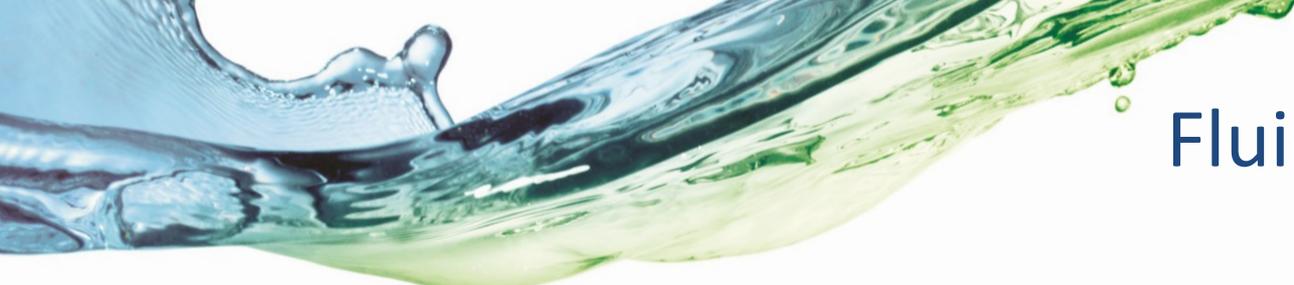


# Fluid Comparison

## Kilfrost Geo vs MPG Based Products

MPG Based	
Flow Rate	2.87 m <sup>3</sup> /h
Pipe Diameter	50 mm
Reynolds Number	2873.83
Heat Transfer Coefficient	333.3 W/m <sup>2</sup> K
Pressure Drop	14.07 kPa

Kilfrost Geo	
Flow Rate	2.71 m <sup>3</sup> /h
Pipe Diameter	50 mm
Reynolds Number	6111.63
Heat Transfer Coefficient	351.7 W/m <sup>2</sup> K
Pressure Drop	11.20 kPa

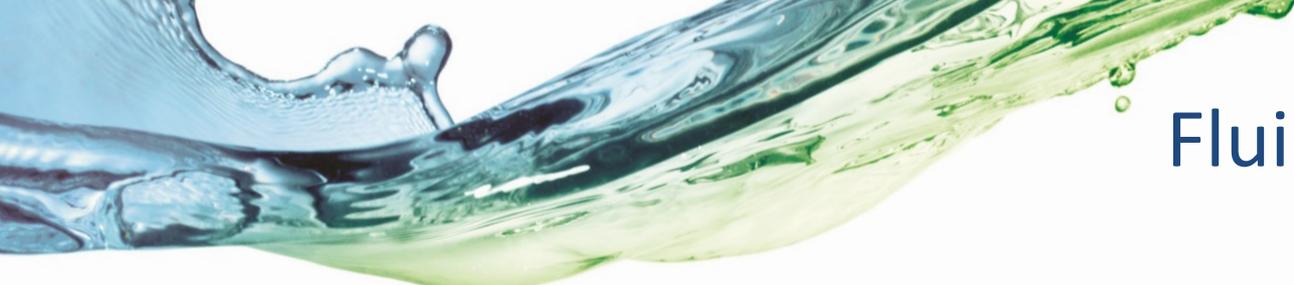


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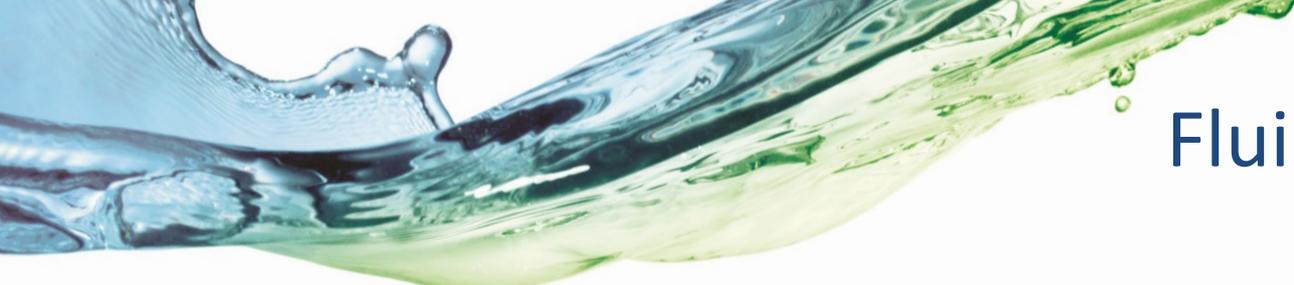


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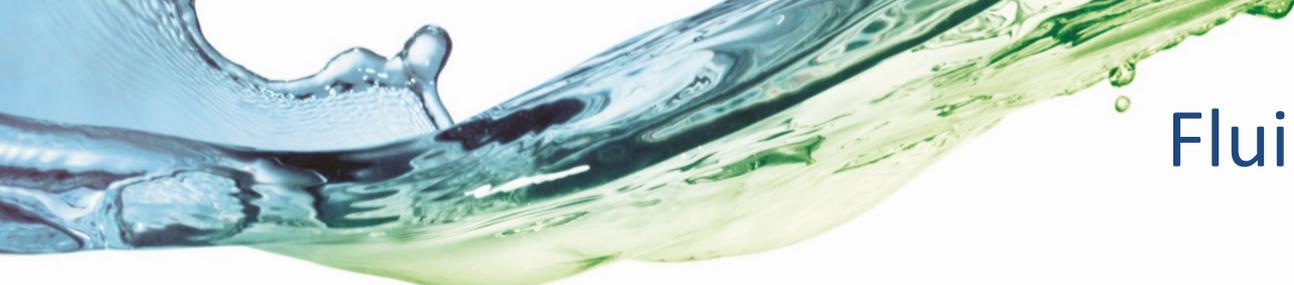


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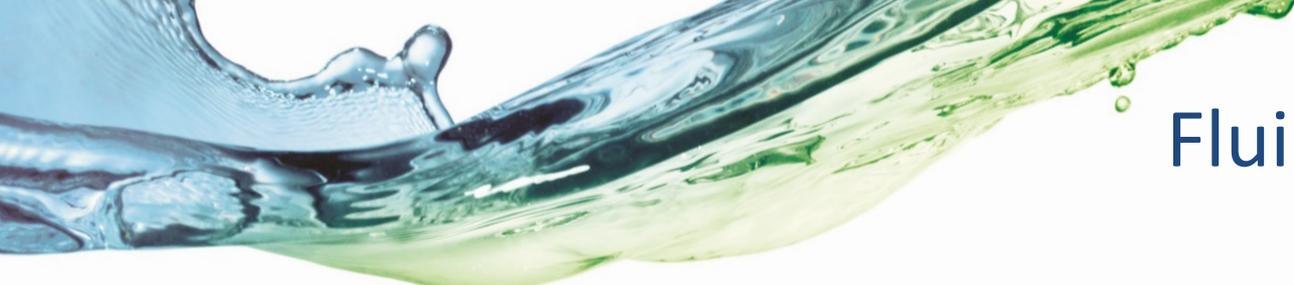


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# Human & Environmental Impact

	MEG Based	Ethanol Based	MPG Based	Kilfrost Geo
<b>Classification (CLP regulation 1272/2008)</b>				
<b>Toxicity Notes</b>				
<b>Chemical Oxygen Demand (COD)</b>				



# Human & Environmental Impact

	MEG Based	Ethanol Based	MPG Based	Kilfrost Geo
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	MEG Based	Ethanol Based	MPG Based	Kilfrost Geo
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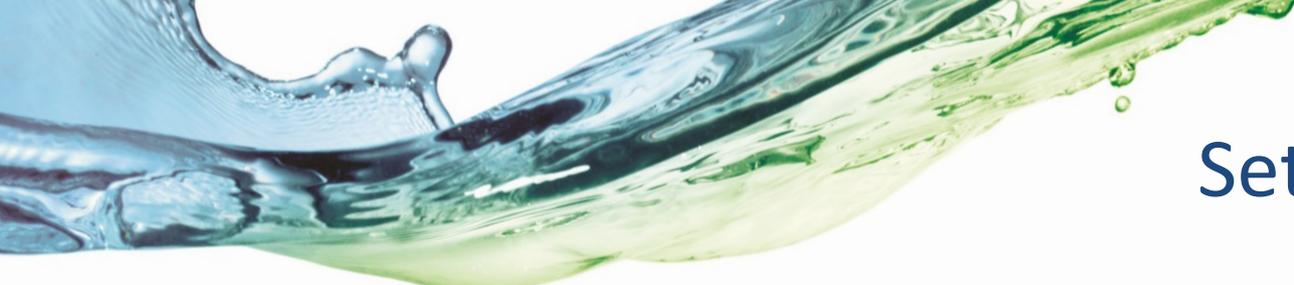
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# Setting the Standard

*A thermal fluid is more than a system antifreeze.  
The industry requires products formulated  
specifically for the job in hand and standards that  
raise awareness.*



## Key areas to be covered by a thermal fluid standard

**Fluid Efficiency**

Increase performance and save money

**System Protection**

Ensure reliability and confidence

**Fluid Human & Environmental Risks**

Protect the wider environment



# Kilfrost GEO®

- Designed for its intended application
- Proves that safety and efficiency are not mutually exclusive
- Removes the need for any compromise





**Thanks for your attention**

For more information please visit [www.kilfrost.com](http://www.kilfrost.com)

<http://www.kilfrost.com/speciality-fluids/heating/kilfrost-geo>

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NÜRNBERG / MESSE

# Thermal Fluid Efficiency



Heat Pump System Parameters		Units
Heat pump heating power	12	kW
Heat pump cooling power for 0/35	9.16	kW
delta T (supply/return)	3	K
Ground heat factor	35	W/m
vertical collector FF240 HDPE100 RC	3 x 90m	
Supply/return pipes	HDPE 40x2,4	
Main supply/return pipes (2x50m)	HDPE 50x3,0	

MPG Based	Value	Unit
Cooling Capacity	9.1600	kW
Delta T	3	°C
Specific Heat	3.670	kJ/kgK
Density	1.0590	g/cm <sup>3</sup>
Dynamic Viscosity	0.00973	Pa.S
Kinematic Viscosity	9.1879131	mm <sup>2</sup> /s
Thermal Conductivity	0.443	W/mK
Flow Rate	2.8282	m <sup>3</sup> /h
Pipe Diameter	50	mm
Wall Thickness	3	mm
Pipe Capacity	1.521	dm <sup>3</sup>
Fluid Speed	0.517	m/s
Reynolds Number	2474.30	

Kilfroast Geo	Value	Unit
Cooling Capacity	9.1600	kW
Delta T	3	°C
Specific Heat	3.801	kJ/kgK
Density	1.1228	g/cm <sup>3</sup>
Dynamic Viscosity	0.00400	Pa.S
Kinematic Viscosity	3.5651051	mm <sup>2</sup> /s
Thermal Conductivity	0.495	W/mK
Flow Rate	2.5756	m <sup>3</sup> /h
Pipe Diameter	50	mm
Wall Thickness	3	mm
Pipe Capacity	1.521	dm <sup>3</sup>
Fluid Speed	0.471	m/s
Reynolds Number	5807.10	

Output	Value	Unit
Heat transfer coefficient for main supply/return pipes [W/(m2K)]	<b>333.323776</b>	W/(m2K)
pressure drops for main supply/return pipes	<b>14.41</b>	kPa

Output	Value	Unit
Heat transfer coefficient for main supply/return pipes [W/(m2K)]	<b>358.954474</b>	W/(m2K)
pressure drops for main supply/return pipes	<b>10.24</b>	kPa

# Thermal Fluid Efficiency



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vertical collector FF240 HDPE100 RC	3 x 90m	
Supply/return pipes	HDPE 40x2,4	
Main supply/return pipes (2x50m)	HDPE 50x3,0	

MEG Based	Value	Unit
Cooling Capacity	9.1600	kW
Delta T	3	stC
Specific Heat	3.742	kJ/kgK
Density	1.0490	g/cm <sup>3</sup>
Dynamic Viscosity	0.00456	Paxs
Kinematic Viscosity	4.3469971	m <sup>2</sup> /sx10 <sup>-6</sup>
Thermal Conductivity	0.476	W/mK
Flow Rate	2.8003	m <sup>3</sup> /h
Pipe Diameter	50	mm
Wall Thickness	3	mm
Pipe Capacity	1.521	dm <sup>3</sup>
Fluid Speed	0.512	m/s
Reynolds Number	5178.01	

Output	Value	Unit
Heat transfer coefficient for main supply/return pipes [W/(m <sup>2</sup> K)]	<b>349.6980802</b>	W/(m <sup>2</sup> K)
pressure drops for main supply/return pipes	<b>11.63558</b>	kPa

Kilfrost Geo	Value	Unit
Cooling Capacity	9.1600	kW
Delta T	3	° C
Specific Heat	3.801	kJ/kgK
Density	1.1228	g/cm <sup>3</sup>
Dynamic Viscosity	0.00400	Pa.S
Kinematic Viscosity	3.5651051	mm <sup>2</sup> /s
Thermal Conductivity	0.495	W/mK
Flow Rate	2.5756	m <sup>3</sup> /h
Pipe Diameter	50	mm
Wall Thickness	3	mm
Pipe Capacity	1.521	dm <sup>3</sup>
Fluid Speed	0.471	m/s
Reynolds Number	5807.10	

Output	Value	Unit
Heat transfer coefficient for main supply/return pipes [W/(m <sup>2</sup> K)]	<b>358.954474</b>	W/(m <sup>2</sup> K)
pressure drops for main supply/return pipes	<b>10.24</b>	kPa