



**NYCO**  
INDUSTRY & AUTOMOTIVE



# HIGH PERFORMANCE INSULATING FLUIDS

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# I - NYCO

## 1.1 COMPANY PROFILE

For over 50 years, Nyco has focused its research and development on synthetic esters for use in the industrial, automotive, aviation and military sectors.

### NYCO, SINCE ITS CREATION

Created in 1929, the company first specialized in derivative products for pharmaceutical industry and PVC stabilizers.

In 1957, Nyco took an interest in ester-based lubricant market for aviation industry and received its first certification from French Ministry of Defense for aviation turbine oil. Nyco then extended its range of lubricants to meet British, American and Russian specifications.

Nowadays, Nyco is one of the leader in aviation lubricant industry and the only european manufacturer.



Nyco has a business unit organization, dedicated to specific markets : on one hand lubricants for Civil Aviation and Defence where Nyco brands are promoted worldwide for these two business units, and on the other hand Products for Automotive and Industrial applications, where Nyco proposes basestocks and speciality lubricants (food grade, eco-label, very high technology products). Insulating fluids are part of this third business unit, Nycodiel is the brand name of finished product being sold directly to the user.

Through continuous investment in research and in people, Nyco took benefit from its aviation expertise to focus also on industrial and automotive markets and accomplished the followings:

- ▶ 1972: development of neopolyol-based synthetic esters for four-stroke engines and industry
- ▶ 1980: formulation and sale of synthetic ester-based two-stroke oil
- ▶ 1987: development of lubricants for refrigeration compressors
- ▶ 1990: development, production and sale of biodegradable hydraulic fluids
- ▶ 1995: development, production of biodegradable synthetic dielectric fluids
- ▶ 2008: development, production, sale and use in its own formulas of additives pushing up thermal oxidation limits (Patent application in High Temperature Chain Oils and Aviation Turbine Oil).
- ▶ 2008: Nycolube 210, 2-stroke oil for outboard engine is European Ecolabel certified
- ▶ 2009: development, production and sale of HX1 Incidental Food Contact components, and H1 Incidental Food Contact lubricant (chain oil).



## NYCO, MANPOWER & ASSETS

Thanks to its teams of researchers, engineers and technicians, Nyco is able to provide a complete and optimal service that extends from development of appropriate ester to final use of formulated product by customers.

Using specialized and specific equipment, Nyco applies its know-how to designing, development, production and inspection of its customer solutions. These are promoted through a network of subsidiaries, selected distributors and agents in over 90 countries across the world.

Nyco is the only company able to provide tailor-made solutions to even the most complex needs in the formulation of high performance synthetic esters while also guaranteeing qualitative monitoring of its products and providing customers with high performance technical support.

Aim of Nyco is to support its partners in developing their industrial strategies by proposing ester solutions and formulated lubricants fully adapted to their requirements and specified performance levels.

## 1.2 KNOW-HOW

Nyco develops for Industrial and Automotive applications :

- ▶ Synthetic ester dielectric fluids
- ▶ High performance lubricants (oils and greases)
- ▶ Biodegradable and non eco-toxic lubricants

Since its creation, Nyco has always entirely controlled quality, from raw materials selection to the finished products. It constantly endeavors to improve its synthesis processes to adapt to specific demands of each application.

## 1.3 RESSOURCES & EXPERTISE

The Research and Development department is central to Nyco's activities and allows the group to propose innovative, high performance lubricants and esters. Therefore, 10% of Nyco's manpower is dedicated to R&D.

Nyco has specialized in the production of very high performance synthetic fluids able to perform in extreme operational conditions where other oil base lubricants don't.

Nyco has created a complete range of biodegradable and non eco-toxic synthetic esters for dielectric fluids, automotive applications (oils for land or marine two-stroke engines, oils for petrol or diesel four-stroke engines, transmission fluids, ground gas turbine oil) and industrial applications (hydraulic oils, gear oils, air compressor oils, chain oils, high performance greases).

Nyco has also developed synthetic esters - used as plasticizers - for the polymer industry.

These esters meet our customers market requirements : thermal stability, low volatility, polarity, lubricity, biodegradability, non-toxicity and eco-compatibility.

Flexibility of ester chemistry, associated with Nyco's laboratory and industrial facilities, make possible the design of the most suitable ester for each requirement.

The company is quality focused, ISO 9001-2008 and 14001-2010 certified.



ABB Traction transformer

# II - NYCODIEL FLUIDS

## 2.1 INSULATING FLUIDS

### Dielectric fluids – actuality and trends

Nowadays, the general trend is to move to safe and ecological products and the electrical industry is more and more involved as well. Traditional dielectric fluids have some limitations against these requirements, and do not fulfill all required criteria. Vegetable oils are biodegradable but have some limitations at low and high temperatures. Mineral oils have poor fire point and are not biodegradable. Silicone oils have good high temperature properties but are not biodegradable either. Synthetic esters are able to combine eco-compatibility, high temperature properties and excellent thermal stability, and have very good low temperature behavior too. Synthetic Ester technology is attractive and opens the way for new developments, new applications and new equipment designs.

### ENVIRONMENTAL ISSUES

PCBs have revealed dielectric fluids pollution issues. The full scale of the problem is not known, but pollution is a real problem, most dielectric fluids are currently not biodegradable and harmful to soil or water.

Vegetable oils or synthetic esters are two more ecological alternatives. These products are biodegradable. Other advantages include low flammability and they can be used for safety applications instead of silicone oils.

## SYNTHETIC ESTERS : NYCODIEL FLUIDS AND OTHER TECHNOLOGIES

Mineral Oils have been used as dielectric fluid in generations of transformers. For several decades, silicone were the fluid of choice as “less-flammable” dielectric fluid. Vegetable oils are proposed as environmentally friendly products. But, as an overall outperformer to all these technologies, synthetic esters combine all required characteristics in one solution.

Hereunder, the requisite standards for insulating fluids are listed in the table.

### Dielectric fluids standards

Product	Naphthenic Oils	Silicone Oils	Vegetable Oils	Synthetic Esters
Europe	IEC 60296	IEC 60836	--	IEC 61099
USA	ASTM D 3487	ASTM D 4652	ASTM D 6871	--

## 2.2 NYCODIEL 1244 & 1255

Nycodiel 1255 and Nycodiel 1244 are synthetic ester based dielectric fluids. They have high safety characteristics (K3 according to IEC 61100), high resistance to oxidation, large operating temperature range, and are biodegradable.

IEC 61099 standard is meant specifically for synthetic esters with a certain molecular design, based on a polyol (polyhydric alcohol) and a mixture of monocarboxylic acids . Synthetic esters for use as dielectric fluid must match these specifications. Both Nycodiel 1244 and 1255 are perfectly compliant.





## Nycodiel fluids – IEC 61099

Characteristic	Unit	Typical Values		IEC 61099 Limits	Method
		Nycodiel 1244	Nycodiel 1255		
Color		80	20	Max 200 Hazen	ISO 2211
Appearance		Limpid	Limpid	Clear	Visual
Density at 20°C	kg/m <sup>3</sup>	0.98	0.97	Max 1	ISO 3675 or 12185
Viscosity at 40°C	mm <sup>2</sup> /s	21.4	26.4	Max 35	ISO 3104
Viscosity at -20°C	mm <sup>2</sup> /s	645	1250	Max 3000	ISO 3104
Flash Point COC	°C	275	265	Min 250	ISO 2719
Fire Point COC	°C	304	315	Min 300	ISO 2592
Pour Point	°C	-45	-54	Max -45	ISO 3016
Water content	mg/kg	50	40	Max 200	IEC 60814
Acid Number	mgKOH/g	0.02	0.02	Max 0.03	IEC 62021 -1 or -2
Acid Number 164h	mgKOH/g	0.08	0.19	Max 0.3	IEC 61125 Method C
Deposit 164h	% in mass	0.007	0.008	Max 0.01	IEC 61125 Method C
Breakdown Voltage	kV	>60	>60	Min 45	IEC 60156
Dielectric Dissipation Factor at 90°C	tan δ	0.02	0.02	Max 0.03	IEC 60247 or 61620
Resistivity	GΩxm	7.5	10	Min 2	IEC 60247

NYCODIEL 1255 has high flash point and very low pour point.

NYCODIEL 1244 is less viscous to provide better cooling while keeping high fire resistance properties.

## 2.3.1 FIRE SAFETY

Nycodiel fluids have higher flash point and fire point than IEC 61099 standard.

Furthermore, tests have been run to emphasize how safe Nycodiel fluids can be according to IEC 61100 standard. It classifies product fire risks based on fire point and heat of combustion. Fire point is representative of ease of inflammation of a liquid, but the risk of fire depends also on the heat release, which can be represented by heat of combustion. There are three product classes based on fire point and three classes for heat of combustion; the combination of both parameters states the final classification.

Fire Safety Comparison of Dielectric Fluids

Characteristic	Unit	Typical Values		Vegetable Oil	Mineral Oil	Silicone Oil	Method
		Nycodiel 1244	Nycodiel 1255				
Flash Point PM	°C	255	265	305	150	285	ISO 2719
Fire Point COC	°C	304	312	360	172	360	ISO 2592
Auto Ignition Temperature	°C	435	436	440	~300	440	ASTM D2155
Heat of Combustion	MJ/kg	30,6	31.8	~ 40	~ 46	28 - 32	ASTM D240
IEC 61100 Classification	--	K3	K3	K2	O1	K3	

Only two product categories meet K3 classification of IEC 61100 standard: synthetic esters, and silicone oils. Vegetable oils have a high fire point but have higher heat of combustion.

## 2.3.2 ENVIRONMENT

This particular topic answers a growing concern of electrical industry, sustainability and eco-friendly behavior.

No European Ecolabel for dielectric fluids has been implemented yet. But existing lubricant criteria can shed light on the eco-compatibility of dielectric fluids.

Since 2005 the European Commission has implemented a unified regulation for environmentally friendly lubricants (2005/360/CE of 25<sup>th</sup> April 2005). This Ecolabel defines targets for :

- ▶ Biodegradability
- ▶ Water hazard
- ▶ Renewable raw materials content
- ▶ Toxicity of components
- ▶ Hazard to health
- ▶ No risk phrase on material safety data sheet

Properties of different dielectric fluid technologies have been evaluated against European Ecolabel and UBA (1) criteria. UBA, Umwelt Bundes Amt, (federal environment agency of Germany) defined standards and behavior of products in water. NWG classification, Nicht Wasser Gefährdende, defines substances not hazardous in water.

### Comparison of different types of Dielectric Fluids against European Ecolabel

Characteristic	Unit	Synthetic Ester		Vegetable Oil	Mineral Oil	Silicone Oil	Ecolabel Limit (1)
		Nycodiel 1244	Nycodiel 1255				
Biodegradability OECD 301B	%	84	72	>80	<30	0-5	>60
Aquatic Toxicity:							
- Fish OECD 203	mg/l	>1000	>1000	>1000	>100	(2)	>100
- Daphnia OECD 202	mg/l	>1000	>1000	>1000	>1000		>100
- Algae OECD 201	mg/l	>1000	>1000	>1000	>1000		>100
Renewable Carbon Content (calculation)	%	79	61	100	0	0	>50
UBA Ranking	-	NWG	NWG	NWG	WGK 1	WGK 1	-
Ecolabel Potentiality	-	Yes	Yes	Yes	No	No	-

(1) Requirements for hydraulic fluids.

(2) Is not considered harmful to aquatic organisms.

NWG = not hazardous in water.

WGK 1 = slightly hazardous in water.

Among all dielectric fluids, only synthetic esters and vegetable oils have a low impact on the environment. They show a very low aquatic toxicity, a high level of renewable carbon content and a very good ultimate biodegradability. Having this in mind, using Nycodiel fluids guarantees a responsible approach, at any place where nature has to be protected.

## 2.3.3 THERMO-OXIDATION STABILITY





The dedicated test to measure thermo-oxidation resistance is IEC 61125 Method C.

To better underline the differences between each dielectric fluid technology, the test duration was extended from 164 h to 500 h and even to 800 h. Test at 500h is a recommendation of IEC 61099 but not mandatory. Test at 800h is not required nor recommended, it has been performed to show how the different technologies resist longer stress.

IEC 61125 Test Conditions:

- ▶ Temperature: 120°C
- ▶ Air flow: 0.15 l/h
- ▶ Metal: Cu
- ▶ Oil quantity: 25 g

### IEC 61125 Test Results

Characteristic	Duration Hours	Synthetic Ester		Vegetable Oil	Mineral Oil	Silicone Oil
		Nycodiel 1244	Nycodiel 1255			
Acid Number mgKOH/g	0	0.02	0.02	0.07	0.03	0.01
	164	0.08	0.09	2.84	0.40	0.01
	500	0.14	0.20	ND	1.1	0.01
	800	0.23	0.23	ND	1.29	0.01
Deposit	164	0.005	0.005	0.5	0.10	0.01
	500	0.005	0.005	ND	0.14	0.01
	800	0.005	0.003	ND	0.17	0.02
Appearance After 800 hrs				N/A; product become solid between 164 h and 500 h.		

- ▶ Synthetic esters and silicone oils show exceptional resistance to thermo-oxidation. Both products are able to run at high temperatures for long periods without degradation.
- ▶ Vegetable oils are unable to comply with the IEC 61125 standard.

Thermo-oxidation Properties :

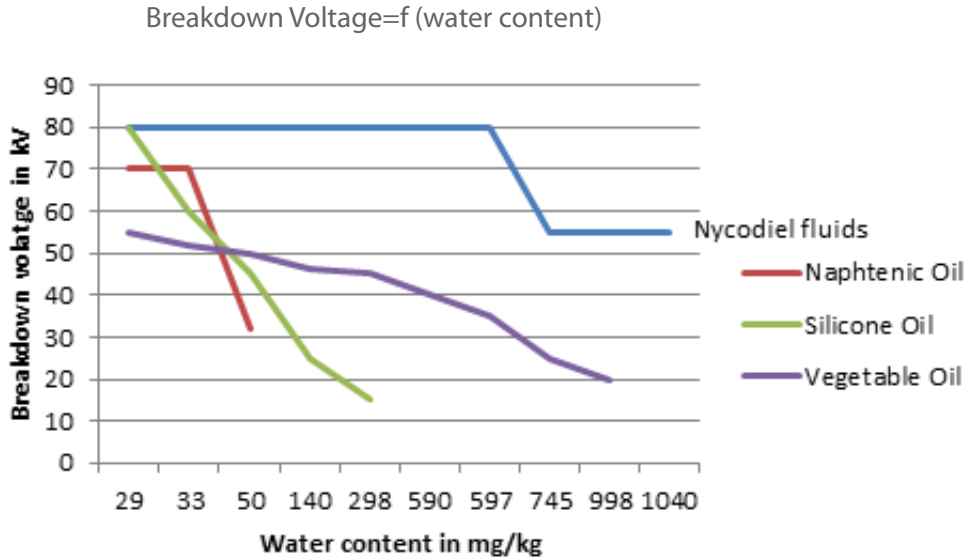
Nycodiel fluids and silicone oils exhibited very good resistance to oxidation and corrosion in harsh conditions. They resisted high temperatures and showed long in-service lives. Mineral oils performed well at medium temperatures. Vegetable oils have a poor thermal stability due to their chemical structure; the presence of unsaturated fats (double bonds) weakens the structures of the molecules.

Synthetic esters are the best performing products under extreme high temperature conditions compared to other technologies tested.

## 2.3.4 WATER INFLUENCE

Due to their structures, synthetic esters and vegetable oils absorb water. Once absorbed, water is not free but “inactive”. Functionally, water links to ester molecules by Hydrogen bonds and Van der Waals links. Synthetic esters and vegetable oils can absorb a high level of water without loss of dielectric breakdown voltage.

### Voltage Breakdown & Water Content



As mentioned, vegetable oil and synthetic esters have water absorption capacity without loss of dielectric breakdown voltage. This ability allows them to dry insulating paper. This property is of great advantage in case of retrofilling as dehydrating insulating paper will expand transformer lifetime without power loss.

## 2.3.5 RETROFILLING - FLUID MAINTENANCE

Thanks to ester technology, retrofilling is a possible solution to expand transformer lifetime. Due to its ability to entrap water, it will even dehydrate the insulating paper. An important characteristic is that Nycodiel fluids are fully compatible with mineral oils and vegetable oils. To guarantee fire resistance properties remain after refilling, (class K3 of IEC 61100 standards, fire point above 300°C) it is recommended to measure fire point if mineral oil content is more than 1%.

Note that Nycodiel fluids are not compatible with silicone oils.

Regarding service survey-fluid maintenance, IEC 61203 is the dedicated standard to be used to monitor the in-service fluid.

Service survey is carried out like conventional dielectric fluids:

- ▶ Water content
- ▶ Acidity
- ▶ Fire point
- ▶ Dielectric breakdown voltage
- ▶ Dielectric dissipation factor

Other analyses like viscosity, density, dissolved gas content, should be made to evaluate main characteristics of the product.

### Service survey IEC 61203

Characteristics	unit	Method	Limit
Appearance	-	visual	clear
Water content	mg/kg	IEC 60814	max. 400
Acid number	mgKOH/g	IEC 61099	max. 2.0
Fire point	°C	ISO 2592	min. 300
Dielectric breakdown voltage	kV	IEC 60156	min. 30
Dielectric dissipation factor ambient temperature	-	IEC 60247	max. 0.01
Resistivity at ambient temperature	GΩ.m	IEC 60247	min. 6



CG Bio-SLIM® transformer

## 2.3.6 APPLICATION

Nycodiel synthetic esters technology meeting IEC 61099 standard are the best compromise to match high temperature applications, safety and eco compatibility performances.

### Summary of main characteristics of Dielectric Fluids

Characteristic	Synthetic Esters	Vegetable Oils	Mineral Oils	Silicone Oils
Eco Compatibility	Yes	Yes	No	No
Security	Yes	Yes	No	Yes
Low Temperature Ability	Yes	No	Yes	Yes
High Temperature Resistance	Yes	No	Yes/No	Yes
Water Influence	No	No	Yes	Yes

### Applications and Market:

More and more, synthetic esters are chosen for new applications in Europe, where overall consumption is increasing at high rate, especially in traction and wind turbine sectors. Most of OEMs for traction transformers and many of end users moved to synthetic esters, such as SNCF (French railways) and SBB (Swiss railways).

### Synthetic Ester Applications & Market

Current Main Applications	Criteria	Synthetic esters instead of
Transformers for Traction	Heat, Safety, Low Temperature, Ecology	Silicone Oils
Transformers for Wind Turbines	Compact Transformers, Heat, Safety, Ecology	Silicone Oils and Mineral Oils
Indoor Distribution Transformers	Safety, Ecology	Silicone Oils and Mineral Oils
Marine	Safety, Ecology	Silicone Oils
Power Transformers	Heat, Safety, Ecology	Mineral Oils
Immersed Tap Changer	Heat, Safety, Ecology	Silicone Oils and Mineral Oils

# III - NEW SOLUTION :

## NYCODIEL 1233

Nycodiel fluids, as synthetic esters, comply with IEC 61099 standard. With Nyco expertise in developing ester molecules, further applications can be considered. Ester technology can offer better performances on specific topics, like very low temperature behavior of the fluid for instance. Higher thermal stability can be another example, allowing the fluid to resist to more severe stress from the transformer.

TO REACH SUCH CHALLENGING OBJECTIVES, HERE IS A SHORT INTRODUCTION TO ESTERS CHEMISTRY.

There are lots of ester types and many ways to design them. Different ester families like monoesters (MOE), diesters (DIE), polyol esters (PE) can be used. Monoesters come from reaction of mono-acid(s) with mono-alcohol(s). Diesters come from reaction of mono-alcohol(s) with di-acid. Polyol esters come from reaction of poly-alcohol with monoacid(s). Origins of the two main raw materials used to manufacture synthetic esters are petrochemical and vegetable.





## Main Characteristics of Synthetic Esters

Characteristic	Monoesters	Diesters	Polyol Esters
Viscosity	Very Low to Low	Low to Medium	Low to High
Pour Point	Very low -50°C to < -80°C	Very low -50°C to < -70°C	Low -40°C to < -60°C
Fire Point	Low to Medium	Medium	Medium to High
Dielectric Properties	Good	Good	Good
Thermo-oxidation Stability	Good	Good	Very Good
Biodegradability	Good	Medium to Good	Low to Good
Renewable Carbon Content	0 to 100	0 to 100	0 to 100
Aquatic Toxicity	Good	Good	Good

Due to wide differences in raw materials, synthetic esters offer numerous possible molecular structures. New esters can be developed to meet various specific demands, by assembling the parts (alcohols and acids) of the molecule as a construction game. This assembling is not done randomly, there are too many possibilities. R&D expertise coming from long experience shortens dramatically the way to the solution.

### NYCODIEL 1233 – AN ANSWER FOR NEW APPLICATION FIELDS – VERY COLD ENVIRONMENT

Low viscosity dielectric fluids can be developed to have better cooling properties, with higher thermo-oxidation resistance and higher fire point than mineral oils for instance. These properties can be useful for smaller transformers requiring improved cooling because of higher in-service temperatures. Consequently oil usage can be decreased, as well as transformer weight and volume.

Low temperature conditions are of concern too, according to limits imposed by traditional dielectric fluids performances. Key again is the behavior of the fluid under severe conditions, low viscosity being crucial without any compromise on the other main requested characteristics for dielectric fluids, like safety and electrical properties not forgetting biodegradability. Nycodiel 1233 has been developed to match these requirements, based on synthetic ester technology.

## Properties of Nycodiel 1233 compared to traditional dielectric fluids

Characteristic	Unit	Nycodiel 1233 (typical values)	Synthetic Ester IEC 61099	Vegetable Oil	Silicone Oil	Mineral Oil	Method
Density at 20°C	g/ml	0.95	0.98	0.92	0.96	0.88	ISO 12185
Thermal Expansion Factor	°C-1	0.0007	0.0007	0.0007	0.0009	0.0007	
Kinematic Viscosity at 100°C	mm²/s	3.8	4.6	8.3	15	2.6	ISO 3104
Kinematic Viscosity at 40°C	mm²/s	16.1	22	35	40	10	ISO 3104
Kinematic Viscosity at 20°C	mm²/s	400	650	2600 instability	200	270	ISO 3104
Kinematic Viscosity at 50°C	mm²/s	11450	frozen	frozen	ND	ND	ISO 3104
Pour Point	°C	<-66	-45	- 33	-70	-45	ISO 3016
Acid Number	mg KOH/g	0.02	0.02	0.08	< 0.01	< 0.03	ISO 6618
Dielectric Dissipation Factor at 90°C	-	0.01	0.02	0.12	<0.001	<0.002	IEC 60247
Breakdown Voltage	kV	70	>60	50	50	30 to >70	IEC 60156
Fire Point	°C	284	304	360	360	172	ISO 2592
Flash Point (PM)	°C	241	255	305	285	150	ISO 2719
Flash Point (COC)	°C	248	262	335	328	166	ISO 2592
Heat of combustion	MJ/kg	32	30.6	~ 40	32	~ 46	ASTM D240
Oxidation 164 h							
Acid Number	mg KOH/g	0.09	0.08	2.84	0.01	1.44	IEC 61125 Method C
Deposit	%	0.004	0.007	0.5	0.01	0.08	
Oxidation 800 h							
Acid Number	mg KOH/g	0.23	0.23	--	0.01	1.29	IEC 61125 Method C
Deposit	%	0.005	0.005	--	0.002	0.17	
Biodegradability	%	80	84	>80	< 5	< 20	OECD 301B
Aquatic Toxicity							
- Algae	mg/l	>1000	>1000	>1000	(1)	>1000	OECD 201
- Daphnia	mg/l	>1000	>1000	>1000		>1000	OECD 202
- Fish	mg/l	>1000	>1000	>1000		>100	OECD 203
Renewable Raw Material Content	%	79	61	100	0	0	Calculation

- ▶ Nycodiel 1233 is very stable at low temperatures.
- ▶ Nycodiel 1233 has good ecological properties, high biodegradability and high content of renewable carbon content.
- ▶ Nycodiel 1233 fire point is above 280°C and heat of combustion is equal to IEC 61099 standard for synthetic esters.
- ▶ Nycodiel 1233 shows a very good thermal stability, equal to synthetic esters meeting IEC 61099 standard.
- ▶ Nycodiel 1233 dielectric properties meet IEC 61099 standard.

Nycodiel 1233 is proposed to answer very low temperature applications: traction transformers in extreme conditions, wind turbines in extreme conditions, distribution (on roofs, inland, anywhere where there can be very cold areas) and power transformers in extreme conditions. Nycodiel 1233 offers new perspectives for future developments, not only based on the existing standards but opening doors to new solutions.

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## NYCODIEL FLUIDS

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Main properties of synthetic esters are:

- ▶ Safe
- ▶ Good dielectric behavior
- ▶ Good environmental behavior
- ▶ Highly thermal resistant
- ▶ Water compatible, to mitigate adverse effects of moisture and humidity

Nycodiel fluids include all these properties, with enhanced performances regarding specific characteristics. Nycodiel fluids offer now a new solution for very low temperature applications, Nycodiel 1233. This is one of the next generation products that Nyco developed with and for dielectric fluids users, allowing the choice of a dedicated product.

Synthetic esters have the flexibility of design and the technical potential to respond to many special technical demands. Nyco's expertise in that field can help to support your challenges.

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