

# Natural Ester Transformer Fluid Overview

**Cargill India Pvt Ltd**  
**Naveen Jain**

# Global producer of natural and synthetic ester transformer fluids



**enviro****temp**<sup>™</sup>  
ester dielectric fluids

  
**FR3**<sup>™</sup>  
ENVIROTEMP<sup>™</sup> NATURAL ESTER FLUID

  
**200**<sup>™</sup>  
ENVIROTEMP<sup>™</sup> SYNTHETIC ESTER FLUID

# Examples of how utilities worldwide are using FR3 fluid to achieve results



## 2011 Lifecycle analysis study for distribution transformers

### Highlights of analysis

- A life extension of only 2 years yields a positive net present value of \$19.2M net benefit over 20 years
- 17% per year reduction in number of transformers replaced
- Increased load capability
- Superior fire safety
- Environmentally preferable
- Enables smaller, lighter designs (75-85°C)
- OEM: Eaton-Cooper Power Systems



## 12 years in operation: FR3 fluid-filled transformer in excellent condition

- CPFL replaced a 112.5 kVA MO transformer with a 45 kVA FR3 fluid-filled transformer
- After 12 years in operation,
  - Transformer worked with 273% overload peaks
  - DP of paper averaged 915
  - No sludge, degradation
- OEM: Itaipu Transformadores



# Examples of how utilities worldwide are using FR3 fluid to achieve results

## TRANSNET BW

### First 420kV transformer filled with natural ester – FR3 fluid

- First in this high voltage category to be filled with a renewable, vegetable-oil-based, natural ester fluid
- Power rating of 300 MVA with an overload condition of up to 400 MVA
- OEM: Siemens



**TATA POWER**  
Lighting up Lives!

### New 20MVA design with FR3 fluid meets key needs:

- 25% capacity increase in space constrained area
  - 20/28MVA with traditional temperature rise; 25/30MVA utilizing FR3 fluid thermal capabilities (per IEC 60076-14), fits within available space
  - Capacity percentage increase based on KNAN
- Increased fire and environmental safety in densely populated area
- Multiple economic benefits
  - Total ownership cost is similar to functionally equivalent (25 MVA) mineral oil transformer
  - Slower aging/extended life and higher reliability of assets by extending insulation life
  - Incorporated ester-filled on-load tap changer by Easun-MR
  - Lower land costs due to smaller footprint
  - Elimination of firewalls/suppression systems (pending approval)
- OEM: Schneider Electric



# Examples of how commercial and industrial customers use FR3 fluid



## US Kennedy Space Center chooses FR3 fluid to improve environmental profile

- FR3 fluid part of US Bio Preferred Program
- Government agency's strategic priority to increase purchase of biobased products
- 81 FR3 fluid-filled distribution transformers



## Petrobras refinery chooses FR3 fluid for improved fire safety

- Petrobras Northeast Refinery Project "Abreu e Lima"
- 14 Transformers using Envirotemp FR3
  - 75/100MVA – 242/72.5 KV  
2 transformers
  - 70MVA – 72.5/15/15 KV  
4 transformers
  - 45/60MVA – 72.5/15KV  
8 transformers



# FR3 fluid designed to deliver:

1. Cost efficiencies, optimized transformer performance, grid reliability
  - Extend insulation system life
  - Increase loadability

**5-8X**  
**LONGER**  
cellulose insulation life  
THAN MINERAL OIL

up to  
**20%**  
MORE LOAD  
CAPABILITY

2. Increased fire safety

**ZERO**   
TRANSFORMER FIRES  
IMPROVED FIRE SAFETY

3. Improved environmental footprint with best-in-class environmental properties

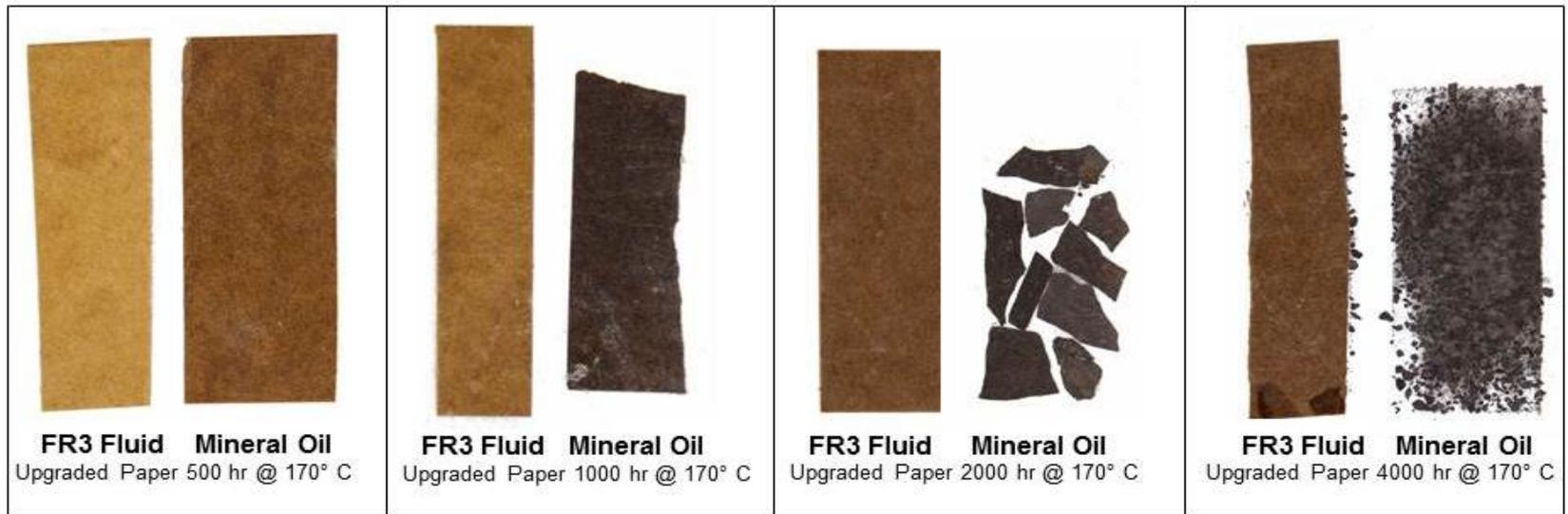
## HIGHEST BIODEGRADATION RATE



# FR3 fluid extends insulation life 5-8 times longer than mineral oil

PROTECTING LIFE OF INSULATION PAPER IS THE NUMBER ONE FACTOR THAT DETERMINES ASSET LIFE

FR3™ natural ester fluid vs. Mineral oil  
Sealed Tube Test – ML 152-2000

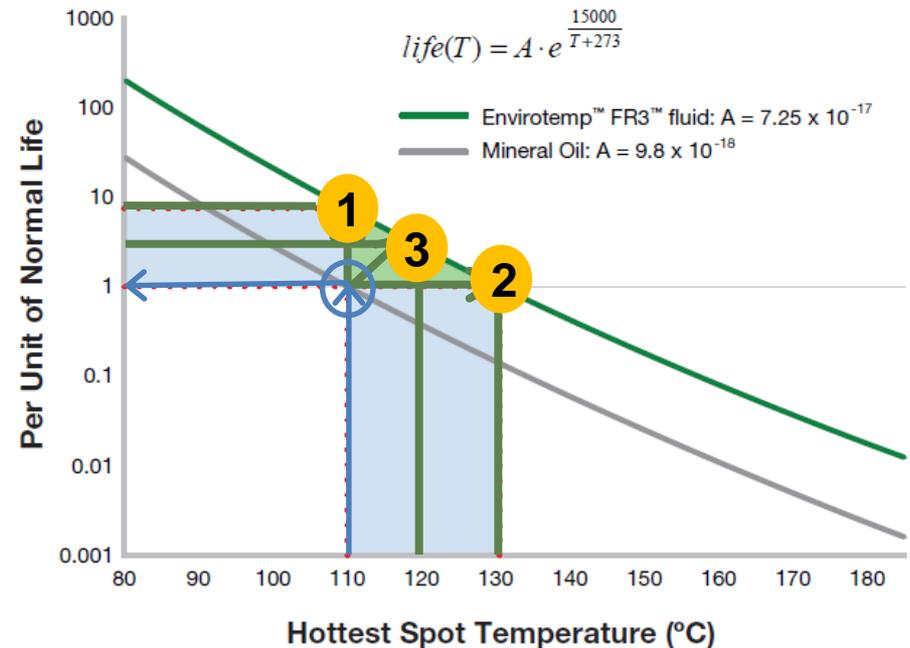


# Use high temperature capability to increase load capacity extend asset life or both

## High temperature insulation system standard

(IEEE C57.154 or IEC 60076-14)

- Current TUK standard 110°C hot spot with 75 AWR (IEC) or 65 AWR (IEEE) limits transformer capability
- Current Kraft 95°C hot spot with 65 AWR (IEC) or 55 AWR (IEEE) limits transformer capability
- Envirotemp™ FR3™ fluid-based insulation systems can be run 20°C warmer without degrading life
- Design new transformers smaller with same or more load capacity
- Existing transformers can be upgraded to potentially provide additional load capacity



High temperature curve based on Thermally Upgraded Kraft (TUK) paper



Same power + Smaller transformer • Increase load capacity • Extend asset life • Improve fire safety

# Our fire prevention strategy works like this:

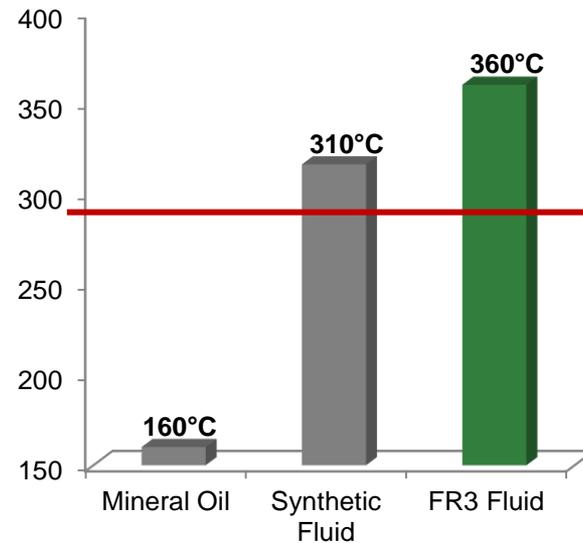
## Step 1: Zero fires.

# Fire point is most critical factor for transformer fire safety

- FR3 fluid fire point = 360°C
- Zero fire history in FR3 fluid filled transformers
- K-Class fluid: UL Classified and FM Approved
- For power transformers,
  - Eliminate deluge systems and fire walls
  - Reduce building clearances
  - Retrofill to meet fire codes versus replacing/moving unit



Dielectric fluid fire point comparison





Same power + Smaller transformer • Increase load capacity • Extend asset life • Improve fire safety

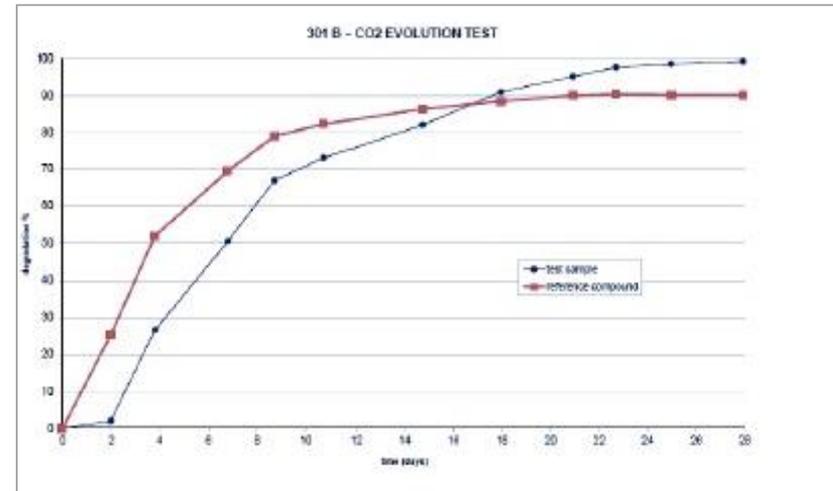
**FR3<sup>™</sup> fluid is designed with  
best-in class  
environmental properties.**

**Actually, all its properties are  
designed to be best-in class.**

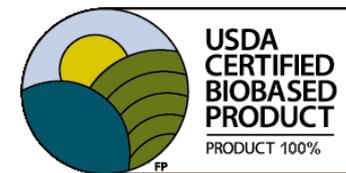
# Natural ester fluid is a better choice for the communities you serve



- Made from a renewable resource
  - >98% vegetable oil
  - Carbon neutral\*
  - Contains no petroleum, halogens, silicones or sulfurs
- Non-toxic, non-hazardous in water and soil
  - OECD oral and aquatic toxicity test
- Biodegrades in less than 28 days
  - Readily biodegradable according to OECD 301 B and the Environmental Protection Agency (EPA) OPPTS 835.3110 and 835.3100
    - Ultimately biodegradable (over 99%)
- Recyclable



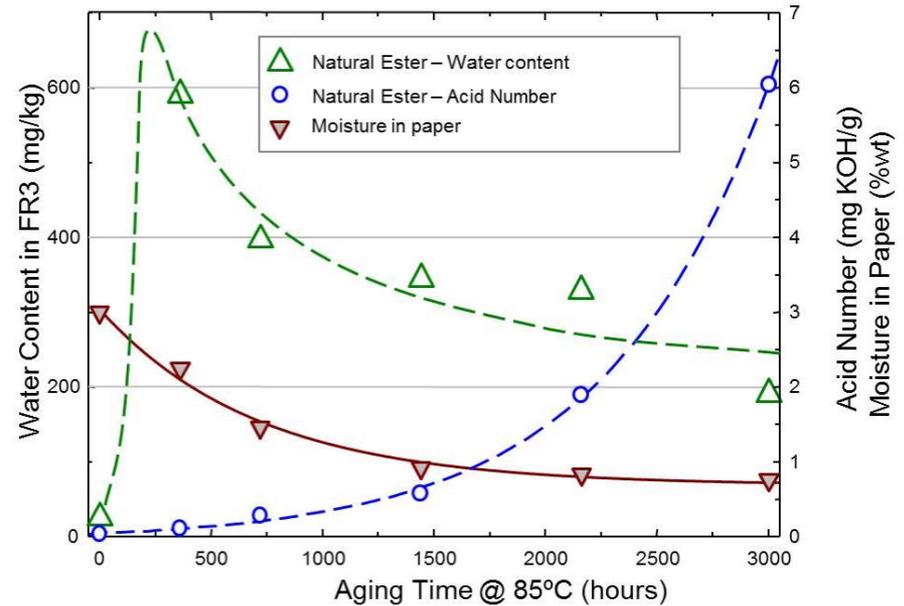
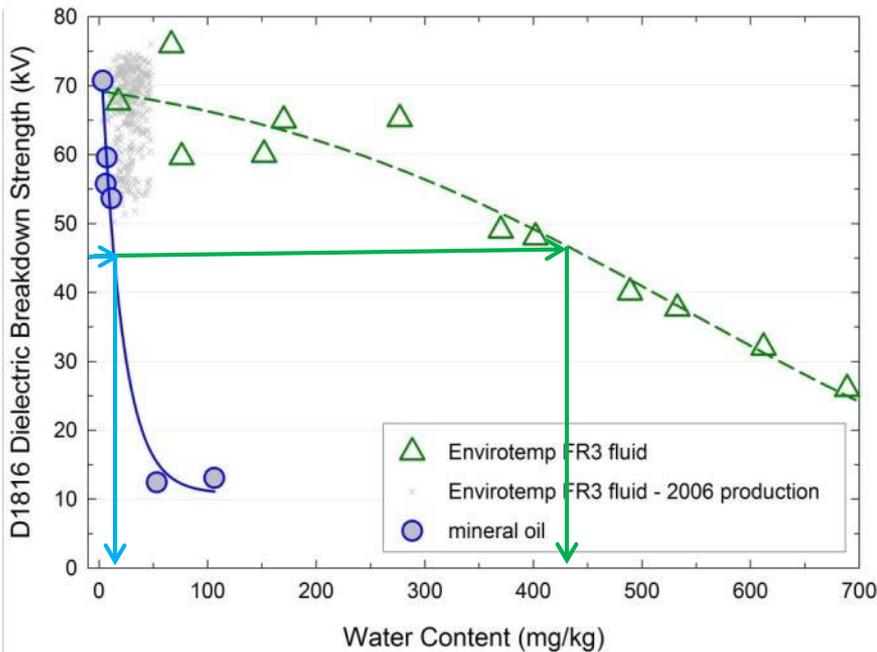
SEA Marconi Technologies, March 15, 2017 using the OECD 301 B Ready Biodegradability CO<sub>2</sub> Evolution Method as modified for oily substances according to the American Society for Testing and Materials (ASTM D5864.05, Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or their Components).



\* According to BEES 4.0 lifecycle analysis

$$BDV = f(\% \text{ moist})$$

FR3 keeps proper breakdown voltage for water content up to 430ppm (>45kV)



## FR3 Hydrolysis

Water extracted from paper is consumed by the chemical reaction with the fluid, resulting in continuous paper and fluid drying (long term)



Same power + Smaller transformer • Increase load capacity • Extend asset life • Improve fire safety

**FR3™ fluid is in over 1 million  
power and distribution  
transformers world-wide.  
But who's counting?**

# Customers & OEMs

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## Global



## Indian



# Customers – Torrent Power



**10 + 18 Nos 20MVA 33/11kV Power Transformers**

**15+ DTs Retrofills – more retrofills planned**

# Customers – GETCO



**2 Nos 16MVA 66/11kV in-service**

**10 Nos 20MVA 66/11kV – in manufacturing**

**115 Nos 20&15MVA 66/11kV Transformers**

# Customers – Tata Power



**2 Nos 25MVA 33/11kV in-service**

**4 Nos 20MVA 33/11kV – in manufacturing**

**40+ DTs retrofills – in-service**

# FR3 fluid References - India

Largest ester filled  
transformer with  
Cargill's FR3 fluid

75MVA, 145kV  
T&R India  
Export to Colombia



## Getco

16MVA 66/11kV  
Transformer  
Commissioned in  
Sept'15

## Tata Power

25MVA 33/11kV  
Schneider India  
Commissioned in June'15

# Current List of Standards

	<u>Natural Esters</u>	<u>Mineral Oil</u>
New Oil	ASTM D6871 IEC 62770 IS 16659	ASTM D3487 IEC 60296 IS 335
Use and Maintenance	IEEE C57.147	IEEE C57.106 IEC 60422
Transformers	IEEE C57.12.00 IEC 60076 series IEEE C57.154 IEC 60076-14	IEEE C57.12.00 IEC 60076 series IEEE C57.154 IEC 60076-14
Loading Guide	(use MO std)	IEC 60076-7
Dissolved Gases	IEEE C57.155	IEEE C57.104 IEC 60599

## Fire

- FM Global Property Loss Prevention Data Sheets, 5-4 Transformers
- IEC 61936-1 Power installations exceeding 1 kV a.c. – Part 1: Common rules

# Long Term Supply Reliability

## Envirotemp FR3 Plant in Pune

- State of the art facility
- Meets all international quality standards
- Supports “Make in India”
- 4<sup>th</sup> plant of FR3 plant globally



# Cargill at a glance

With  
**150,000**  
employees



Speaking

**65+**

languages



Located in

**70**

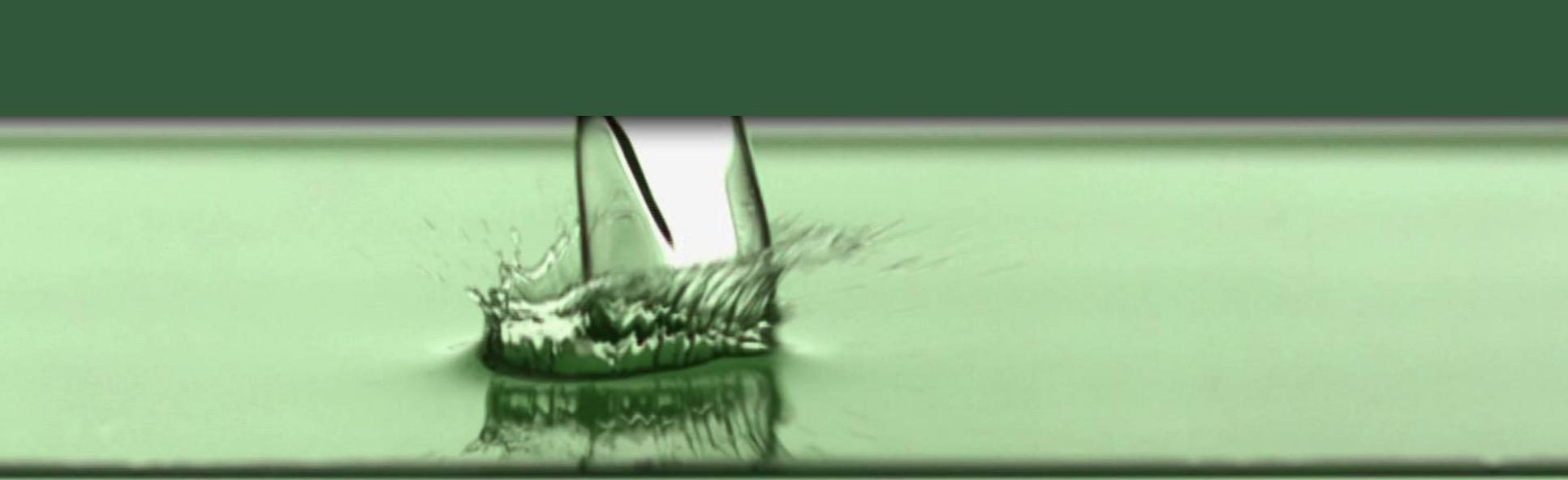
countries



And

**151**

years of experience



Email:

Phone:

[envirottempfluids.com](http://envirottempfluids.com)