Natural Ester Transformer Fluid Overview

Cargill India Pvt Ltd
Naveen Jain
Global producer of natural and synthetic ester transformer fluids
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

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

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 Envirotect 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

2. Increased fire safety

3. Improved environmental footprint with best-in-class environmental properties
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
- Envirotex™ 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
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
FR3™ 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

* 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)
FR3™ fluid is in over 1 million power and distribution transformers world-wide. But who’s counting?
Customers & OEMs

Global

Indian

- Apple
- CPFL Energia
- NASA
- AOL
- DuPont
- Facebook
- SMUD
- Goodyear
- TATA Power
- CESC Limited
- Torrent Power
- BSES

OEMs

- Alstom
- ABB
- Siemens
- Schneider Electric
- SPX
- ESSNER
- Voltamp
- CR

Smart solutions. Strong relationships.
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
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

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**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
Envirottemp FR3 Plant in Pune

- State of the art facility
- Meets all international quality standards
- Supports “Make in India”
- 4th plant of FR3 plant globally
Cargill at a glance

With 150,000 employees

Located in 70 countries

Speaking 65+ languages

And 151 years of experience

Cargill FR3™ fluid overview