FeeFo
Electro Products Pvt Ltd

"FAIL-PROOF" TRANSFORMER

multi-benefits over regular transformers

FP Series - Transformers

Compact, High Efficient, Longer Service Life, Lower Costing - in this "Fail-Proof" Category

machine shop floor

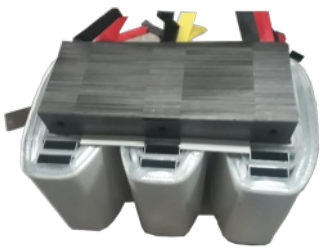
healthcare

IT Equipments

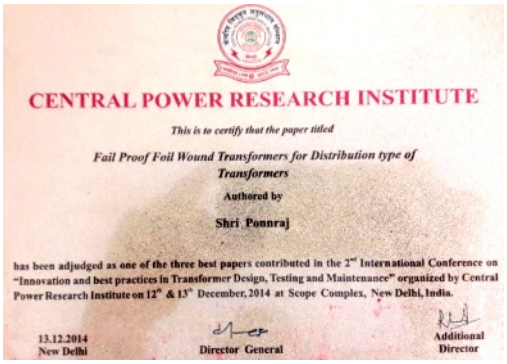
ships & defence systems

- *AIR-Cooled - upto 600 KVA*
- *OIL-Cooled - upto 2,500 KVA*

- *Isolation Transformer*
- *Ultra Isolation Transformer*
- *Auto Transformer*
- *K-Rated Transformer*
- *LT / HT Transformer*
- *Fire-Rated Transformer*



"FAIL-PROOF" - How ?



CENTRAL POWER RESEARCH INSTITUTE

This is to certify that the paper titled

Fail Proof Foil Wound Transformers for Distribution type of Transformers

Authored by

Shri Ponnraj

has been adjudged as one of the three best papers contributed in the 2nd International Conference on "Innovation and best practices in Transformer Design, Testing and Maintenance" organized by Central Power Research Institute on 12th & 13th December, 2014 at Scope Complex, New Delhi, India.

13.12.2014
New Delhi

Director General

Additional Director

Our emphasis on all the basics *:*

- *design to take care of points of conflict*
- *right materials and in right format*
- *optimised production*
- *to make it - FIRE RATED - in next design*

making the end product to function at its optimum, for years together, for longer years

Design *parameters emphasis on :*

- *optimum heat - conduction & radiation*
- *fit to perform in - dry / high humidity / oil rich (CNC shops) etc*
- *prevent air-gaps & hot-spots*
- *space saving*
- *more economical*
- *higher capacity even for Air-Cooled (upto 600 KVA)*

and others - based on site / special needs

Material *- Right one & in Optimum Format :*

- *optimum & economically viable*
- *Form conducive for faster heat radiation outside*
- *Format preventing Heat Stack up & Scaling up*
- *Not-getting deformed due to soaking of oil*
- *in future design - for epoxy coating - FIRE-RATED*

Optimised Production emphasis on *:*

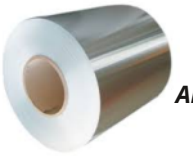
- *materials from Original Mfrs - high quality*
- *correct Size & Guage*
- *built-in Heat Sink - for faster & higher cooling*
- *CNC machinery Winding - faster & homogenous*
- *skilled Production Personnel*
- *Quality Assurance Testing in every stage*

Fire-Rated Transformer - next model *:*

- *Dry Type Transformer - LT & HT*
- *new Epoxy Coating - No Insulation Paper*
- *can withstand 400 Deg C & above*
- *no Oil costing*
- *longer Service Life - 40 years & above*

Format - Wire Vs. Foil

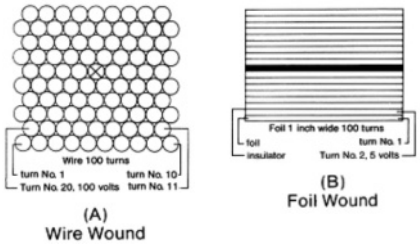
Aluminium Wire with enamel coating



Aluminium Foil

1. Space

The most efficient use of winding space is to layer wrap using magnet wire as shown in Figures, for Wire-Wound & Foil-Wound, seperately.

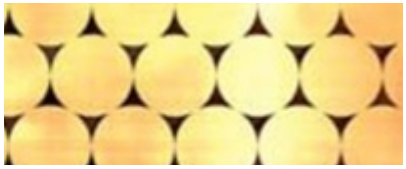


- *Depending upon the size of the wire used, a percentage of the winding area which cannot be used for the conductors.*
- *This lost area is the space between the wires and the insulation with which each wire is coated.*
- *As the voltage stress of the winding is increased, then using inter-layer insulation creating more lost space*

- *do not have gap between windings & insulation*
- *Every winding will have foil - edge to edge, a single form and have insulation which is also a single form (edge to edge)*
- *There is no lost winding space - meaning the transformer will be compact than the wire wound*
- *more over it will have no Air-Gap, and meaning it will have NO HOT-SPOT, making it "FAIL-PROOF".*

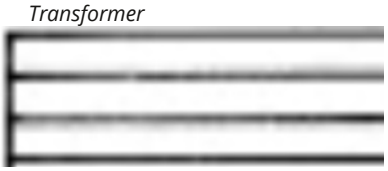
2. Hot-Spot Problem - due to air-gap

- *Hot-spot occurs when, heat builds up very high in some areas of the winding, which disrupts the enamel coating on the wires, and also the insulation sheet.*
- *This affects the Transformer, because of chance of short-circuit, resulting in complete disruption.*
- *When there is air-gap, due to humidity formation, water molecules forms and this expands due to increase in heat developed by the wire, and does not get radiated due to insulation paper.*
- *This air / water molecules expand and creates insulation problem, and sometimes ruptures it. Due to rupture of Insulation paper & also due to rupture in the enamel coating of the wire, short circuit happens.*



- *By Design, there is every chance of Air-Gap formation happens, due to space in between the circular wires, and insulation paper.*
- *There is always a gap / space - (1) between consecutive wire (2) between wire & insulation paper*
- *This is avoided, only if VACUUM IMPREGNATION happens, which sucks all the air from the vacant space between wires, and between wire & insulation*
- *Then varnish will be used to fill the air gap, and also to cover the entire coil, preventing the air-gap formation in the transformer coil, later*
- *Varnish is an inflammable material, and also, if water / humidity is present, then varnish gets diluted, and it becomes weak, in the later days*
- *So, Air-Gap happens, and resulting in Hot-Spot, and resulting in sudden failure of Costly Transformer.*
- *This can be avoided, if it is oil-cooled. But, the cost of Oil-Cooled Transformer for lower capacities like < 40 KVA, compared to Air-*

- *By Design itself, THERE IS NO AIR-GAP*
- *There is no space between two foils - so no formation of air-gap*
- *And, there is no space between foiil & Insulation material - so here too no air-gap*
- *There is no chance of failure due to air-gap / hot-spot in Foil Wound Transformer*



3. Enamel coating - rupture Problem

- *Generally all winding cables / wires, both Aluminium & Copper, is coated with enamel, to avoid, short-circuit hazards.*
- *When cable / wires are bent continuously, elongation (weaking of enamel) happens in the outer surface, and shrinkage (or rupture) happens in the inner side of the bend.*
- *Both is problem for a transformer longevity. In the long run, due to continuous excess heat, the enamel rupture happens, and short circuit happens.*
- *So, Transformer fails.*
- *This is always possible, when installing cheaper products*

- *By default - when the wires are bent 90 deg,*
- *the upper portion of the bend - enamel coating elongates and generally weakens since the coating is expaned for more than 30 % more after formation at the factory.*
- *the bottom portion of the bend - enamel coating is shrunk - looses shape, and chance of rupturing.*
- *This is generally avoided - by giving a tilt - instead of sharp bend in the bobbin - on which the coil is wound*
- *still instead of 90 deg - at least 45 deg BEND HAPPENS, so still the problem happens.*
- *So short-circuit problem can be expected at a later stage, any time, resulting in complete failure of Transformer*
- *Sometimes - if the wire is bigger / thicker, they use circuilar / cylindrical winding, which is costlier, and not everyone does it, mainly due to double the cost of core, to be stacked in a cyclindrical manner.*

- *There is no enamel coating on the foil - by default.*
- *Also nothing happens to the foil even if bent more than 90 deg too*
- *So THERE IS NO CHANCE OF RUPTURE*
- *So, by Design itself - no chance of failure due to short circuit.*

4. Thermal Conduction & Radiation

- *The Wider the metal surface, better heat radiation, resulting in most efficient operation.*
- *If the rising heat is blocked / contained in each layer (due to Insulation Paper) wrap, then the Heat gets Blocked, resulting in reliability issues, and lower service life*

- *the wire has a very less surface area (cross section wise) - so very less heat can be radiated outside, so heat is getting blocked continuously*
- *the length of the wire is longer, still the entire section is covered by insulation paper, the heat does not get radiated outside*
- *due to both the above, the heat build up is continuous and steadily increase*
- *the heat in the inner layer is 30 to 40 deg higher than at the top layer*
- *and the primary since inside the secondary (99 % of the time) - it is more hotter*
- *to avoid heat build-up, Wire-Wound simply inform the customer that above 100 KVA recommend Oil-Cooled*
- *Oil-Cooled is more costlier CAPEX, and more costlier for maintenance, and hazardous too*

- *foil has more & more surface area, and has 10 or more times radiates heat*
- *and the continuous surface area - both sides - transports heat from the inner layer to outer layer - faster & continuously*
- *the heat radiation from inner to outer layer - is not stopped by lamination*
- *generally the difference in temperature between the inner & outer layer is around 8 to 10 deg C*
- *longer life, and higher efficiency*
- *can even have Air-Cooled upto 600 Deg C (have already delivered some)*

5. In built Heat Sink

- *Heat Sink is prevalent in almost all the machinery where continuous heat build up is there - as a design*
- *helps in stopping Heat Avalanche problems*
- *helps in longer service life*

- *not possible to have a heat sink inbuilt in the winding itself*
- *it will disturb the voltage parameters*
- *Wire-Wound is always prone to heat build up problems*
- *only better design & good materials - mitigates & control this heat buildup safely*

- *fvery easy to have it without any design changes*
- *before the actual Zero voltage tapping - can have 1 or 2 winding*
- *after the actual end voltage tapping - can have 1 or 2 additional foil winding*
- *both will act as a heat sink - to provide additional heat radiation*
- *no big additional costing involved*
- *ensures higher efficiency, longer service life*

6. Harmonics related Heating - K Rating

- *Harmonics creates heat build up in all material which has thicker guage*
- *Current will be passing more on the surface than at the centre*
- *destroys enamel & insulation material*
- *needs additional winding & higher insulation - to make it K-Rated*
- *increased CAPEX, and increased Floor Space*

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Insulation - Paper Vs. Polyester Film

Paper Based - ex Nomax

Polyester Film - ex Garware

1. Insulation

- *the 2nd most important material in transformer*
- *to seperate voltage range*
- *used in between every 2 layers of winding*
- *both in primary & secondary*
- *used in both air & oil cooled*

- *traditionally the most used in transformers*
- *mostly paper based - A,B, F & H class etc*
- *used in both air & oil cooled*

- *Polyester based Insulation material is used in Foil Wound Transformers*
- *by nature it is water resistent & oil / cutting oil (CNC shop) resistent*
- *has a wide range of grades to suit all Classes A to H, and newer C & R type too*

2. Insulation Material

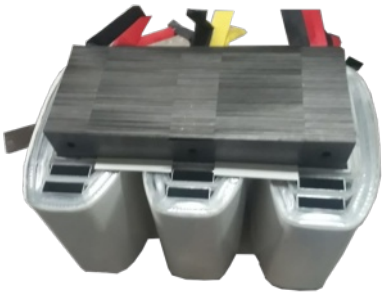
- *If Insulation material blocks the heat being radiated from layer to layer*
- *creating heat build up in the inner layers*
- *unless good material used - creates heat related problems*
- *damaged insulation creating sudden short-circuit*

- *traps heat & soaks oil (in oil cooled types)*
- *if wire is wounded tighly on layers - the insulation paper gets damaged*
- *resulting in insulation failure - short circuits happen*
- *due to this creation of air-gap is always a possibility*
- *this is prevented by painting with varnis - which also creates heat trapping*
- *also if exposed to humidity & oil (in CNC shops) reacts & weakens the varnish coating*
- *also varnish coating is fire-hazardous*

- *does not get damaged even wound tightly, as the winding does not have any edges*
- *does not create air-gap and so prevents hot-spot*
- *does not need varnish coating*
- *so heat is continuously radiated outside, preventing heat building in the winding*
- *longer server life*

3. Air - Cooled Models

- *in Air-Cooled models - due to heat related winding elongation & contraction - the insulation paper gets brittle over a period of time*
- *creates space in between layers - creating air gap & hot spot*
- *shortened service life*



4. Oil-Cooled Model

- *problem is in oil cooled - due to prolonged immersion in oil, over years it becomes soft and damged due to constant elongation & contraction of windings due to heat buildup while in operation*
- *when the design is not good & sub standard materials used - it gets damaged faster*
- *so the transformer service life is shortened*

With more than 2 decades experience of the Team, FeeFo Brings new innovations to the prevailing electro-mechanical products, with new advantages :

- ***No-Failure CNC Winding***
- ***More Compact (in size)***
- ***More Heat Resistant***
- ***More Efficient***
- ***Lower Capital Cost***
- ***Lower Maintenance Cost***

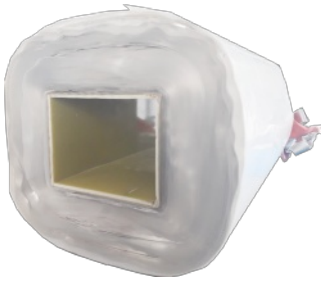
and with a slew of new products featuring all the above.

We use (patent pending) technologies to offer 'VALUE FOR MONEY' products & services.

FeeFO's Team had been involved in 1,000's of installations across India, and abroad. Was supplying many of the products to OEM & Dealers in their earlier venture - before consolidation.

Some of the Key Customers are :

- GE Prolec
- Leitner Shriram
- Regen Powertech
- Consul Consolidated Pvt Ltd
- Delta Power & Electronics
- Eaton Power & Quality
- Emerson Network Power Ltd
- Bharti Airtel Ltd
- Tata Solar
- CPRI
- Kalpakkam Atomic Power



Parameter	Isolation Transformer	Ultra Isolation Transformer	K-Rated Transformer
Air Cooled	**1 to 500 KVA**	**1 to 500 KVA**	**1 to 500 KVA**
Oil Cooled	**5 to 2,000 KVA**	**5 to 2,000 KVA**	**5 to 2,000 KVA**
Type of Rating	**K1**	**K1**	**K4, K7, K10, K13 & K20**
Neutral Capacity	Single	Single	Double
Duty Cycle	Continuous		
Type	**1:1 / Step UP / Step Down / Single Phase**		
Winding Type	Delta / Star (others against order)		
Material	Aluminium Wire / Copper Wire / Aluminium Foil		
Output Regulation	2 ~ 4 % (0.8 ~ 1 PF)		
Operating Freq	50 Hz ± 3 Hz		
Operating PF	0.75 lagging to leading 0.75		
Dielectric Strength	**5 KV, 50 Hz for 1 minute**, ***compared to others (2.5 KV) – DOUBLE THE STRENGTH***		
Coupling Capacitance	0.1 Pico Farad	0.001 Pica Farads	0.1 Pico Farad
Galvanic Insulation	> 500 M Ω	> 1,000 M Ω	> 500 M Ω
Noise Attenuation	100 DB upto 10 kHz	120 dB upto 10 kHz 70 dB for 10 ~ 50 kHz 50 dB for 50 kHz to 1 MHz	100 DB upto 10 kHz
Inter-Winding Shielding	Not needed	At Primary & Secondary	Not Needed
Line Leakage Current	< 20 Micro Ω	< 20 Micro Ω	< 20 Micro Ω
Class of Insulation	**Std Class F, Optional** H / C / others		
Efficiency	> 97.5 %		
Indications	LED, LCD Optional. WiFi Optional		
Optional	MCCB, SPD, Spike & RFI Filter, Auto / Manual Soft-Start, Auto / Manual Bypass		
IP Standards	Std IP20, others against orders		
Construction	Rugged, with Castor Wheels		
Operating Temperature	0 to 45° C		
Standards Compliance	IS-2026, IS-11171		
Colour	Std – Orange with Beige, others against request		

FeeFo
Electro Products Pvt Ltd

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