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No. **CEI/1/2/2016**/447-489 Dated: 10.03.2016

Subject: Minute of Meeting of Chief Electrical Inspectors of all states held on 25.02.2016 at NRPC , Katwaria sarai, New Delhi.

A Meeting with State Chief Electrical Inspectorate on Amendment proposals of CEA (Measures relating to Safety and Electric Supply) Regulations, 2010 (as amended) held on 25.02.2016 at NRPC, Katwaria sarai, New Delhi. The Minutes of meeting is attached herewith.

(Goutam Roy) 10/3/16
Chief Engineer &
Chief Electrical Inspector to Govt. of India

Central Electricity Authority
Chief Electrical Inspectorate Division

Subject: **Minutes of Meeting with state Chief Electrical Inspectorate on Amendment proposals of CEA (Measures relating to Safety and Electric Supply) Regulations, 2010 (as amended).**

List of the participants is annexed.

2. A meeting with state Chief Electrical Inspectorate on Amendment proposals of Safety Regulations held on 25.02.2016 in the Conference Room, NRPC Building Katwaria Sarai, New Delhi. Shri Goutam Roy, Chief Engineer, CEI Division, CEA welcomed the Member (PS), CEA and other participants in the meeting. He thanked Member (PS) for his consent for holding and attending the meeting in spite of his hectic schedule. He highlighted the need for frequent interaction between Central and State Electrical Inspectorates. He stated that with the presence of engineers from government as well as private organizations looking after the electrical safety aspects, this meeting would provide excellent opportunity for interaction of the electrical safety experts of the country, over and above the regular agenda for discussion on the amendment proposed under the CEA regulation (Measures relating to Safety and Electric Supply) Regulations, 2010. He stated that the meeting would be in two sessions. The first session would be on the amendments on the issues proposed by CEA and Kolkata Metro. The second session would be on the issues highlighted by TPDDL and BSES. The second session would start with presentation from some reputed companies in the field of Aerial Bunched Cable (ABC)/covered conductors, natural/synthetic ester oil for transformer and dry type transformer. This would be followed by discussions on the agenda items pertaining to the presentation. He requested the participants and the presenters to be precise and focus on the subject of the agenda for discussion.

3. Member(PS) welcomed the participants to the meeting. He stated that power sector in the country has expanded many-fold in generation, transmission and distribution. The challenges in safe operation has equally increased, not only for electrical installations, but also towards ensuring the safety of lives. He emphasized on making the CEA regulation (Measures relating to Safety and Electric Supply) Regulations, 2010 more investor friendly and technologically updated without compromising on the operational safety and safety of human lives. He requested the participants to discuss the agenda on the amendment in the regulation with an open mind and reach to a solution which is for better technology and better work environment for the people associated with it. He wished for meaningful deliberations so that a quality of wisdom could be reached.

The regular agenda for discussion were taken up after brief introduction with the participants. The summery records for the discussion are as under:

Session I

i) In Session-I, the regulations amendment proposals of 2(fa), 5(2), 30(2), 30(3), 43(1), 43(3), 43(4), 63(4) were discussed.

Regulation 2(fa)

Existing Regulation: 2(fa) "**Charted** Electrical Safety Engineer" means a person as **notified** by the Appropriate Government as refered to in regulation 5A.

Proposed: 2(fa) "**Chartered** Electrical Safety Engineer" means a person as **authorised** by the Appropriate Government as refered to in regulation 5A.

Deliberations:

Director, Legal Division, CEA insisted that the word "notified" should be retained.

CEI, Gujarat expressed that notification procedure is very lengthy and cumbersome. So authorization word would be more appropriate.

CEI, Odisha expressed that they are not in favor of self-certification through Chartered Electrical Safety Engineer or Electrical safety officer because these are paid employees of owner, therefore can not go against owner in case of non complaince of any safety Regulations. Responsibility also cannot be fixed to those in case of any problem. If it is in the hands of the Government, public servants are responsible in this case. Action can be taken against them in the case of laxity.

CEI to GoI replied that the issue of appointment of safety engineers would be opted only for notified voltage and below. A Chartered Electrical Safety Engineer(CESE) could be appointed for this. For further clarification on the CESE, a committee has been constituted to finalize authorization procedure of CESE. The committee already had one meeting. The issue requires further deliberation. As soon as the recommendation of the committee on the basic guidelines for the CESE is obtained, the same would be discussed with the State Electrical Inspectorates. As such the issue of CESE need not be discussed in this meeting.

Director, EI Division, CEA said that this provision is already there in the regulations. we are rectifying only typographical error in the word 'Chartered' and replacing the word 'notified' by 'authorized' to make the definition in line with the regulation 5A.

The participants from the States were in general in agreement with the proposal.

<u>Regulation 5(2)</u>

Existing Regulation: 5(2) The Electrical Safety Officer shall be an Electrical Engineering degree holder with at least five years of experience in operation and maintenance of electrical installations.

Proposed: Diploma holders may be included

Deliberations:

CEI, Telangana expressed that inclusion of diploma holders in the said regulation is not acceptable. The qualifications and experience should be in line with the Electrical Inspector i.e. Degree Holder with 10 year experience. The experience in the field of Construction of Electrical installations shall also be included.

Director, EI Division CEA intimated that CEA has already proposed for reduction in experience of Electrical Inspector to 5 year.

CEI, Gujarat expressed that Diploma holders should not be allowed to be Electrical Safety Officer/CESE. Diploma holders with experience can be allowed up to a certain voltage level for self-certification, 05 year experience is not sufficient.

CEI, Delhi expressed that Diploma holder with 05 year experience can be allowed.

CEI, Haryana agrees with Delhi.

CEI, Chhattisgarh expressed that Degree holder with 05 year experience or diploma holder with 10 year experience can be allowed.

CEI, Tamilnadu expressed that 05 year of experience is not sufficient and it should be 10 years.

CEI, Andhra Pradesh said that we may not give safety responsibility to a person who do not have knowledge of Rules and Regulations.

CEI to GoI stated that since in many industries/organizations engineers with diploma holders are involved in O&M activities so it would not be fair if the Diploma holders engineers with longer experience are not considered for Electrical Safety Officer. As such the proposal of Chhatisgarh for degree holders with 05 year experience or diploma holders with 10 year experience in operation and maintenance of electrical installations is justified for Electrical Safety Officer. Further the proposal of Andhra Predesh regarding the need for knowledge in rules and Regulation also merits consideration.

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The participants from the States agreed with the proposal for degree holders with 05 year experience or diploma holders with 10 year experience in operation and maintenance of electrical installations along with knowledge in rules and Regulation for elecreical safety can be considered for Electrical Safety Officer.

Regulation 30(2) and 30(3)

Existing regulation: 30(2) The periodical inspection and testing of installation of voltage equal to or below the notified voltage belonging to the supplier or consumer shall be carried out by the supplier or owner or consumer and shall be self-certified.

Existing regulation: 30(3) The periodical inspection and testing of installations of voltage above the notified voltage belonging to the supplier or consumer shall be carried out by the Electrical Inspector:

Provided that the supplier or owner or consumer has the option to get his installation inspected and tested by the Electrical Inspector of the Appropriate Government:

Provided further that the every electrical installations of mines, oil fields and railways shall be periodically inspected and tested by the Electrical Inspector of the Appropriate Government.

Proposed: 30(2) The periodical inspection and testing of installation of voltage equal to or below the notified voltage belonging to the supplier or consumer shall be carried out by the supplier or owner or consumer and shall be self-certified.

Provided that the supplier or owner or consumer has the option to get his installation inspected and tested by the Electrical Inspector of the Appropriate Government.

Provided further that every electrical installation of mines, oil fields and railways shall be periodically inspected and tested by the Electrical Inspector of the Appropriate Government.

Proposed: 30(3) The periodical inspection and testing of installations of voltage above the notified voltage belonging to the supplier or consumer shall be carried out by the Electrical Inspector.

Deliberations: Director, CEI, CEA informed that this amendment is due to the two proviso, which were wrongly placed in regulation 30(3). As these proviso relates to the self-certification, these should be in regulation 30(2) instead of 30(3).

CEI, Karnataka suggested that the proviso regarding mines, oil fields and railways may be incoprorated in the principal Regulation 30(2) and the wording may be changed accordingly.

To this participants were of the view that as merging of this proviso with 30(2) is not going to change the spirit of the regulation, so there is no need to merge the proviso in 30(2) and rewording it and agreed with the proposal as put up under the agenda.

Existing regulation: 43(1) Every electrical installation of notified voltage and below shall be inspected, tested and shall be self-certified by the owner of the installation before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations and such owner shall submit the report of self-certification in the Form-I or Form-II or Form-III, as the case may be, of Schedule-IV to the Electrical Inspector.

Existing regulation: 43(3) Every electrical installation of voltage above the notified voltage and all the apparatus of the generating stations and above the capacity specified under regulation 32, shall be required to be inspected and tested by the Electrical Inspector before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations:

Provided that the owner or supplier or consumer has the option to get his installation inspected and tested by the Electrical Inspector of the Appropriate Government.

Existing regulation: 43(4) The Electrical Inspector may, on receipt of self-certification report referred to in sub-regulation (1), accept the report submitted by the supplier or owner and record variations as the circumstances of each case may require and may recommend that the defects may be rectified as recommended:

Provided further that every electrical installation covered under section 54 of the Act including every electrical installations of mines, oil fields and railways shall be inspected and tested by the Electrical Inspector of the Appropriate Government as specified in sub-regulation (3).

Proposed: 43(1) Every electrical installation of notified voltage and below shall be inspected, tested and shall be self-certified by the owner of the installation before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations and such owner shall submit the report of self-certification in the Form-I or Form-II or Form-III, as the case may be, of Schedule-IV to the Electrical Inspector.

Provided that the owner or supplier or consumer has the option to get his installation inspected and tested by the Electrical Inspector of the Appropriate Government.

Provided further that every electrical installation covered under section 54 b (i) of the Act including every electrical installations of mines, oil fields and railways shall be inspected and tested by the Electrical Inspector of the Appropriate Government as specified in sub-regulation (3).

Proposed: 43(3) Every electrical installation of voltage above the notified voltage and all the apparatus of the generating stations and above the capacity specified under regulation 32, shall be required to be inspected and tested by the Electrical Inspector before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations.

Proposed: 43(4) The Electrical Inspector may, on receipt of self-certification report referred to in sub-regulation (1), accept the report submitted by the supplier or owner and record variations as the circumstances of each case may require and may recommend that the defects may be rectified as recommended:

Deliberations: Director, CEI, CEA informed that this amendment is due to the two proviso, which were wrongly placed in regulation 43(3) and 43(4) respectively. As these proviso relates to the self-certification, these should be in regulation 43(1) instead of 43(3) and 43(4). This was agreed by the members. However, the amendment of replacing section 54 by section 54(b)(i) in second proviso was rejected by all the members stating that this change would be in contravention to the provision of the Act.

Dy. CEI, Delhi expressed that Form-I, Form-II may be deleted from Regulation 43(1) as these are applicable for below or equal to 650 V.

The participants from States agreed for the following amendments:

Regulation 43(1). Every electrical installation of notified voltage and below shall be inspected, tested and shall be self-certified by the owner of the installation before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations and such owner shall submit the report of self-certification in the **Form-III** of Schedule-IV to the Electrical Inspector.

Provided that the owner or supplier or consumer has the option to get his installation inspected and tested by the Electrical Inspector of the Appropriate Government.

Provided further that every electrical installation covered under section 54 of the Act including every electrical installations of mines, oil fields and railways shall be inspected and tested by the Electrical Inspector of the Appropriate Government as specified in sub-regulation (3).

43(3). Every electrical installation of voltage above the notified voltage and all the apparatus of the generating stations and above the capacity specified under regulation 32, shall be required to be inspected and tested by the Electrical Inspector before commencement of supply or recommencement after shutdown for six months and above for ensuring observance of safety measures specified under these regulations.

43(4). The Electrical Inspector may, on receipt of self-certification report referred to in sub-regulation (1), accept the report submitted by the supplier or owner and record variations as the circumstances of each case may require and may recommend that the defects may be rectified as recommended.

Regulation 63(4) (c)

Existing Regulation: 63(4)(c) supervision charges and charges incurred by the supplier or owner in complying with the provisions of section 67 of the Act, in respect of such alterations.

Proposed: 63(4)(c) supervision charges **to the extent of fifteen per cent of the wages mentioned in sub clause (b);** and charges incurred by the supplier or owner in complying with the provisions of section 67 of the Act, in respect of such alterations.

Deliberations:

Director, EI Division, CEA intimated that during the amendment of safety regulations some of the words are unintentionally omitted due to typographical error.

Representative of Kolkata Metro Rail Corporation Ltd expressed that the amendment is necessary and it should be done as soon as possible.

Director, Legal Division, CEA expressed that the Regulatory Commission may be consulted to determine the supervision charges.

Director, EI Division, CEA, emphasized that the proposed amendment would reset regulation 63(4)(c) in its original form as it was in the principal regulation 2010 and the typographical omission would be rectified. Also there is no necessity for introducing new phrase like in consultation with Regulatory Commission.

The participants from States were agreed for the proposal in the agenda.

Session II

1. Regulation- 61(3)

Existing Regulation: 61(3). The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than-

(i)	for lines of voltages exceeding 650 V upto and including 11,000 Volts	- 1.2 metres
(ii)	for lines of voltages exceeding 11,000 V and up to and including 33,000 V	- 2.0 metres
(iii)	for lines of voltages exceeding 33 kV	- 2.0 metres plus 0.3 metre for every additional 33kV or part thereof.

Proposed: 61 (3) The horizontal clearances between the nearest bare conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than 1.2 metres for lines of voltages exceeding 650 V upto and including 11,000 Volts. In case of insulated cable and Aerial Bunched Cable, the horizntal Clearence shall not be less than 0.1 meter.

Sr. VP Raychem RPG Pvt. Ltd. gave presentation on covered conductors. The details of the presentation is at **Annexure-I.**

Chief Engineer (DP&D) suggested that (1) IS for these type of conductor are not available so the manufacturers may approach BIS for preparation of IS and the effectiveness of insulation may be tested as per the Indian Standards. (2) As these type of conductors would require special type of fittings , the manufacturer may also approach for preparing IS for fittings also.

Representative of Raychem RPG Pvt. Ltd. stated that they are pursuing with BIS to notify the IS.

Head–Central Engg. Services BRPL gave presentation on High voltage ABC. The details of the presentation are at **Annexure II.** He stated that in the unauthorized colonies of Delhi & in JJ cluster many times it becomes difficult to take LV lines so the Delhi Discoms has to supply electricity by taking 11 KV ABC and stepped down at 220 V through pole mounted transformer and supply the same to the household through DB .

Deliberations:

CEI Maharashtra stated that reduction of the horizntal Clearence to 1.2 meter could pose a greater risk to the human life as the pole mounted transformer would be with in reach of the household. As with times the sleeves on the transformer and other insulation in the joints gets weared off posing a great denger to the near by house holds. As such this may not be allowed.

Most of the participants were also of the similar view as of CEI Maharashtra.

Director, Legal Division, CEA expressed that since laying of 11 KV distribution network in congested lanes in the city is a local problem. Regulation should not be amended to address local issues. In these type of cases, Appropriate Government may invoke the clause specified in regulation 116 and may allow deviations by order in writing, if need be. So there is no need for change in regulation for a specific case.

CEI, Gujarat agrees with the views of Director, Legal Division, CEA and suggested that in such cases where 11 KV line has to be laid in narrow lanes underground cables may be used.

SEI, Tamilnadu agreed with the proposal of Gujarat.

CEI Telangana & Maharastra agrees with the views of Director, Legal Division, CEA.

TPDDl as well as BRPL expressed that as per the mandate of Government of NCT of Delhi, the unauthorized colonies in Delhi, supply has to be extended. Since the lanes through which the cables are passing are narrow and they are facing difficulty in maintaining the horizontal clearance as per CEA regulation 61(3). Also stated that it is difficult to lay underground cables because of various other underground systems. He stated that LT cable is also dangerous in case of mishandling whereas no clearances required for LT cable in the said regulations.

Xen. Haryana suggested that LT cable may be used where the lanes are narrow.

Representative of BRPL stated that this result in more losses and the voltage would be difficult to maintain. Therefore, they requested to agree with the proposal of agenda.

Chief Engineer, DP&D Division, CEA stated that the issue is serious in nature as there is obligatory requirement on the part of Delhi DISCOMS to extend supply to these colonies so straight forward rejecting their proposals would not be fair and he requested the states to suggest remedy for the problem.

CEI CEA stated that considering the obligatory requirement of Delhi DISCOMS for extending power supply to all unauthorized colonies and problem faced by them for not obtaining the required approval from the appropriate government for charging the lines passing close to the buildings, there is need for giving a proper solution to the problem. He stated that the state may give a serious thought on this issue and **the proposal is flagged for discussion in the next meeting.** He stated that till such time a solution to this problem is found, DISCOMS may seek approval under regulation 116 (1) & (2) of the CEA (Measures relating to Safety and Electric Supply) Regulations, 2010.

Participants from the states agreed with CEI CEA.

2. Regulations 44(2)(vii) (e)

44(2)(vii)(e). Dry type of transformers only shall be used for installations inside the residential and commercial buildings;

Proposed: 44(2)(vii)(e). Dry type/ **K-class ester fluid filled** transformers only shall be used for installations inside the residential and commercial buildings;

Regulations 44(2)(ix)

44(2)(ix) he shall ensure that the transformers of 10 MVA and above rating or in case of oil filled transformers with oil capacity of more than 2000 liters are provided with firefighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system;

Proposed: 44(2)(ix). He shall ensure that the transformers of 10 MVA and above rating or in case of oil filled transformers with oil capacity of more than 2000 liters are provided with firefighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system **except in case of K-class ester filled transformers.**

Regulations 44(2)(xi)

i) 44(2)(xi) he shall ensure that oil filled transformers installed indoors in other than residential or commercial buildings are placed at the ground floor or not below the first basement;

Proposed:44(2)(xi). He shall ensure that oil filled transformers installed indoors in other than residential or commercial buildings are placed at the ground floor or not below the first basement **except in case of K-class ester filled transformers;**

M/S Cargil gave presentation on K-class fluid filled transformers. The details of the presentation is at **Annexure-III.**

M/S M&I gave presentation on K-class fluid filled transformers. The details of the presentation is at **Annexure-IV.**

M/S ABB gave presentation on dry type transformers. The details of the presentation is at **Annexure-V.**

Dupont gave presentation on dry type transformers. The details of the presentation is at **Annexure-VI.**

Deliberations:

Regulations 44(2)(vii) (e)

Representative of GETCO recommended use of ester oil filled transformer and requested CEA to amend regulations for use of K-class oil in place of dry type transformers.

CEI, Maharashtra expressed that there is a need for the study of the K-class fluid filled transformers. He stated that necessary recommendations on this will be provided later.

Haryana, Gujarat, Telengana (many other states) also agree with Maharashtra.

Chief Manager Tata power, Mumbai stated that the K-class fluid filled transformers are being used in their area and are working satisfactorily. They are compact, can be overloaded without any problem. They have also ordered for the 220kV power transformer with K-class oil.

Director, DP&D Division, CEA stated that there is a oxidation problem in these type of oil, therefore, these need to be hermitically sealed and as such, there is a possibility of pressure build up problem inside the tank in case of fault.

Representatives of Cargil & M&I replied that transformers with K class oil are safe & used in many countries like Middle east, Japan, Europe and other counties like Brazil, Jordan where the climatic conditions are similar to India.

CEI to GoI suggested that the relevant data & regulations of these countries may be provided by the K-class fluid related manufacturers and they are agreed for the same.

CEI to GoI requested the states to study the matter in detail and regulation specific recommendations may be made to take a decision. **The issue is flagged for the next meeting.**

Regulations 44(2)(ix) & 44(2)(xi)

The participants from the states were of the views that since the proposal on Regulations 44(2)(vii) (e) has been deferred for the next meeting so decision on this proposal be deferred for the next meeting.

Regulations 44(2)(ix) – oil capacity

44(2)(ix) he shall ensure that the transformers of 10 MVA and above rating or in case of oil filled transformers with oil capacity of more than 2000 liters are provided with firefighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system;

Proposed: 44(2)(ix). He shall ensure that the transformers of 10 MVA and above rating are provided with fire fighting system as per IS - 3034: 1993 or with Nitrogen Injection Fire Protection system.

Deliberations:

Representative of GETCO requested that rating may be increased from 10 to 25 MVA considering the difficulties in providing the fire fighting system as per IS - 3034: 1993.

CEI to GoI stated that the present deliberation is limited for the proposal given in the agenda. The proposal for increasing it from 10 to 25 can be consider later.

The proposals for amendment as given in the agenda under 42(2)(ix) was agreed by the participants from states.

ADDITIONAL AGENDA

Electrocution of wild animals such as elephants in the forest areas of the country

CEI to GoI stated that it has been reported by the MoE&F that a large number of wild animals are being electrocuted accidently by coming in contact with the lines of voltage 33 KV and below passing through the forest area. The issue was deliberated with the MoE&F in detail wherein it was viewed that instead of overhead wires, ABC/covered conductors/underground cables should be taken through the forest corridors.

CEI, Karnataka stated that many Elephants have been electrocuted in their state. He suggested for the use of insulated cables instead of bare conductors.

CEI to GoI suggested that the height at the lowest sag point of the ABC/covered conductors may be more than elevated trunk height of the elephant i.e. over 6 metre so that elephant cannot damage these cable.

Participants from States agreed with the proposal.

Jurisdiction of the Central/State Electrical Inspectorate

Director, EI Division, CEA stated that as per the Rule 3: Applicability of rules, of "Qualifications, Powers and Functions of Chief Electrical Inspector and Electrical Inspectors Rules, 2006" notified by the Central Government on 17.08.2006, the electrical installation falling in the jurisdiction of the Central Government are as follows:

"(i) a generating company wholly or partly owned by the Central Government;
(ii) any inter-State generation, transmission, trading or supply of electricity and with respect to any mines, oil-fields, railways, national highways, airports, telegraphs, broadcasting stations and any works of defence, dockyard, nuclear power installations;
(iii) National Load Despatch Centre and Regional Load Despatch Centre; and
(iv) any works or electric installation belonging to the Central Government or under its control."

Sometimes, it is observed that electrical installations such as ISGS, SEZs etc. are being asked by the State Inspectorates for carrying out the inspection through the State Electrical Inspectorate. This is in contravention to the above Rule.

CEI, Karnataka expressed that the SEZs are developed with in the state and are developed using the state finances. Therefore they should be in state jurisdiction.

Director , EI Division, CEA replied that the SEZ comes under the control of Ministry of Commerce and the same was clarified by the Ministry of Power that they are in Central Government Jurisdiction. This has been intimated to Tamilnadu & Andhra Pradesh earlier in 2006 and 2011 when the issue came up. The copy of the MoP order is at **Annexure-VII.**

Submission of proposals/comments regarding amendments in CEA (Construction of plants, lines and substation) Regulations:

Chief Engineer (SE&TD), CEA has requested all participants in the meeting to furnish the comments on the CEA (Technical Standards for Construction of Electric Plants and Electric Lines) Regulations which deals inter-alia with all voltage level transformers. He asked participants fro States to comment or give their views that upto what voltage level (beyond 33 KV) we can go for K-class oil filled transformers for outdoor purposes so that their views/comments could be incorporated during revision of the CEA (Technical Standards for Construction of Electric Plants and Electric Lines) Regulations.

The meeting ended with vote of thanks to the Chair.

Annexure

List of Participants

Meeting of Chief Electrical Inspectors of all States to discuss CEA (Measures relating to Safety and Electric Supply) Amendment Regulations, 2015
Venue: Conference Room, NRPC, Katwaria Sarai, New Delhi
Date: 25/02/2016

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COVERED CONDUCTOR PRESENTATION TO CEA

PROBLEMS FACED BY UTILITIES

Right of Way (ROW) : Expensive, not available in Cities, constructions coming up under existing lines, clearances to adjacent buildings

No of Outages : Cost of unscheduled outages in transmission, reduced billings, no customer satisfaction

Safety : Electrocutions, Electric and Magnetic field effects on human beings

A SOLUTION !!!!

ACSR / AAAC conductor with longitudinal water blocking and triple extrusion

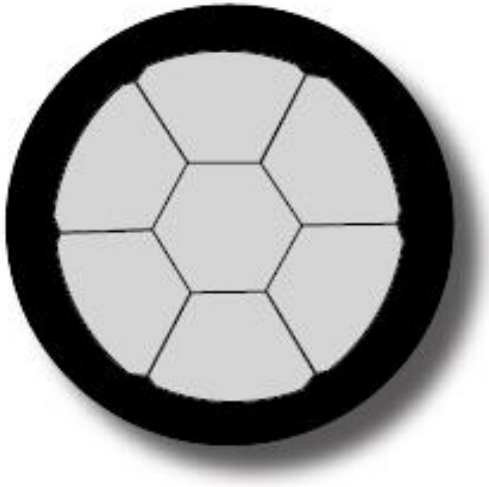
Longitudinal water blocking – No moisture entry

Semi conducting layer – Stress Equalisation on conductor surface

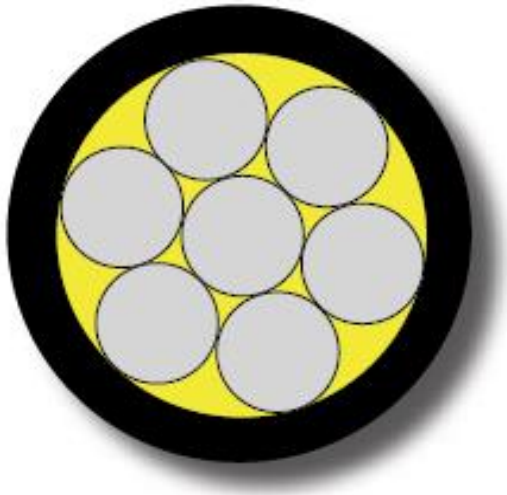
XLPE layer – Solid Insulation

Outer XLPE layer – With carbon black / Titanium oxide for Tracking & Erosion Resistance

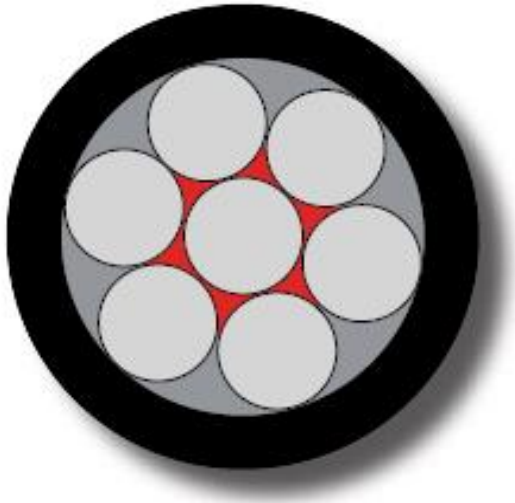
EVOLUTION



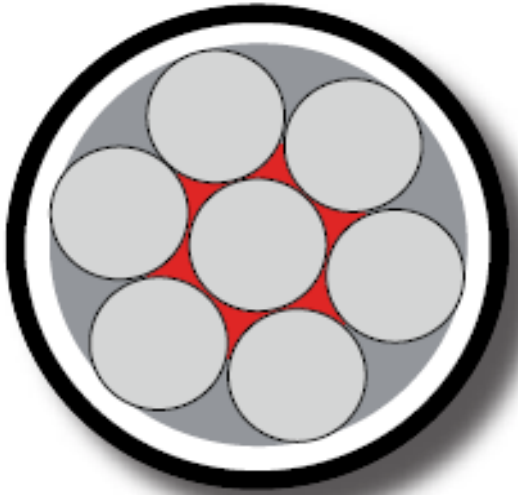
Compacted and sector shaped conductors
No water blocking
One layer of insulation



Round conductor non compacted,.
Water blocking by grease

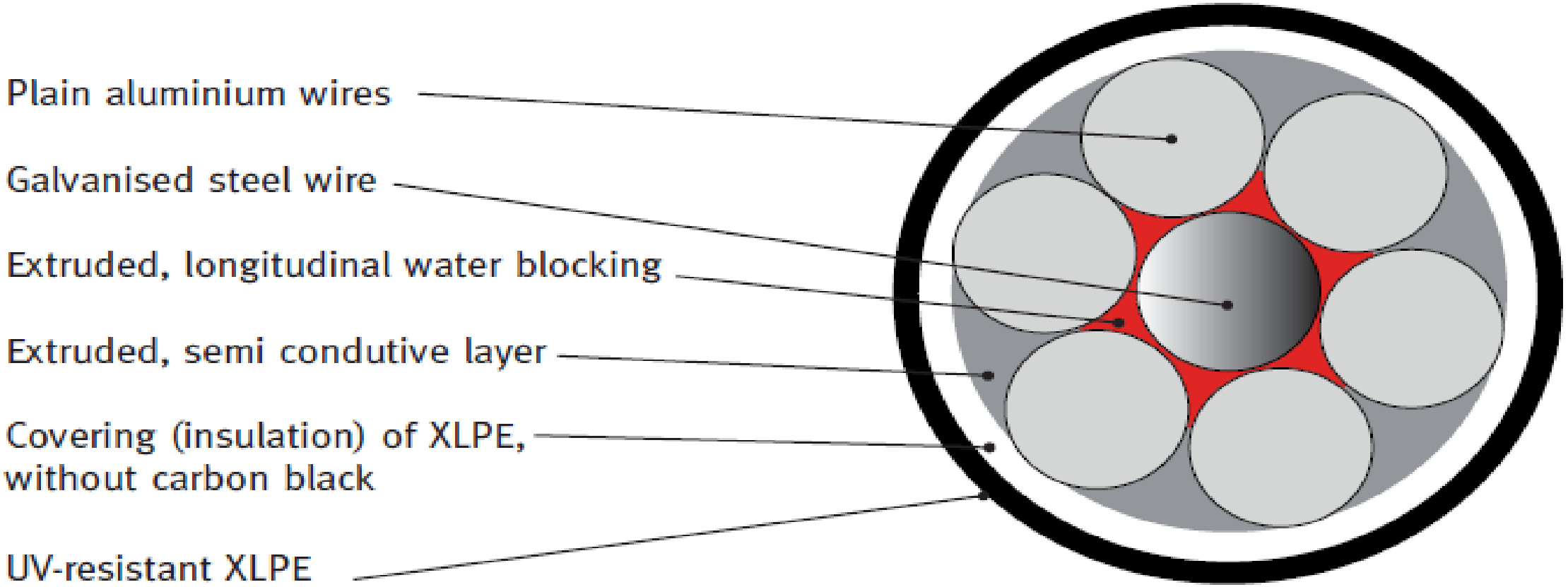


Round conductor.
Non compacted
Longitudinal water blocking, semi-conducting and one insulating layer



Round conductor, non-compacted, longitudinal water blocking, semi conducting layer, insulating layer and outer UV & Track resistant layer

Covered Conductor Construction



DIFFICULTIES OF UTILITIES WITH BARE CONDUCTORS

- Conductor clashing leading to outages
- Conductor slashing due to corrosion
- Outages due to temporary tree contact
- Corrosion at joints
- Right of Way (ROW)
- Electric and Magnetic Fields
- Safety
- Emergency Restoration System

Conductor clashing leading to outages

- **Test of simulated clashing of conductors .**
- Conductor attached together for approx. 80 min.
- Result
  - Voltage increased until 132 kV
  - Test interrupted after 80 min due to to high levels of ozon in the labratory
  - No visible damage on the conductor

The picture shows the conductor after 80 min test with132 kV voltage. No visible marks and no rise of temperature.

CONDUCTOR SLASHING DUE CORROSION

No corrosion of conductor

Aluminium conductor manufactured and immediately undergoes triple extrusion

No stripping of insulation. Conductor taken through suspension and tension clamp with insulation




Outages due to temporary tree contact

Corrosion at joints

Corrosion of bare conductors are due to formation of Aluminium Oxide at the joints and water entry in between conductor strands

Conductors and triple extrusion manufactured together. AlO_2

Conductor water blocked – No entry of moisture & consequent corrosion

Conductor runs through insulated from end to end,. No opening to air

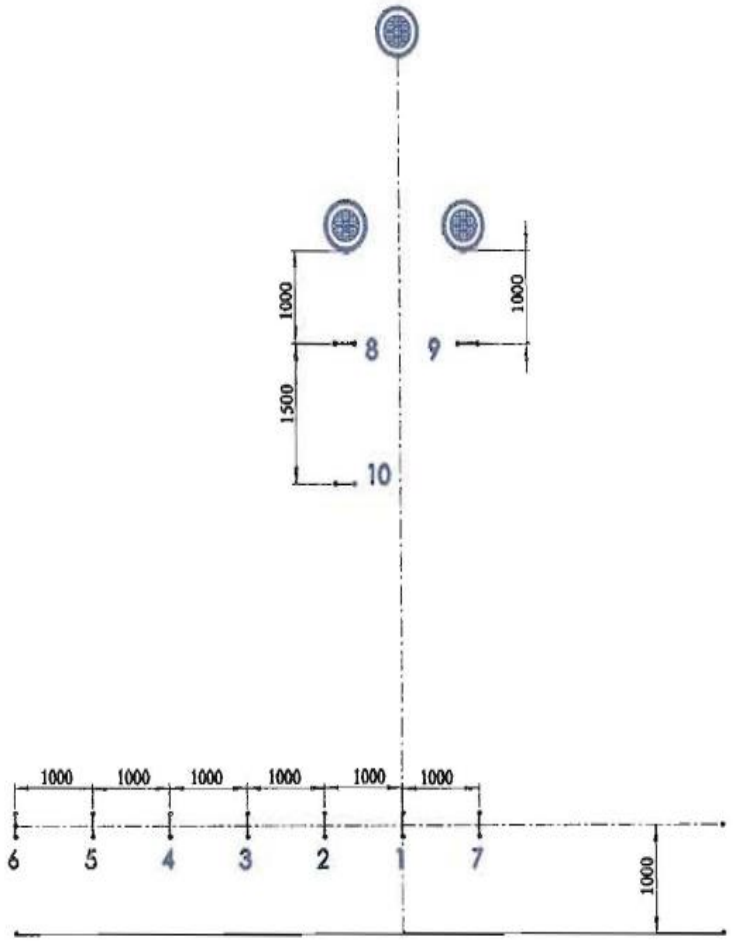
Tap offs taken through Insulation Piercing Connectors

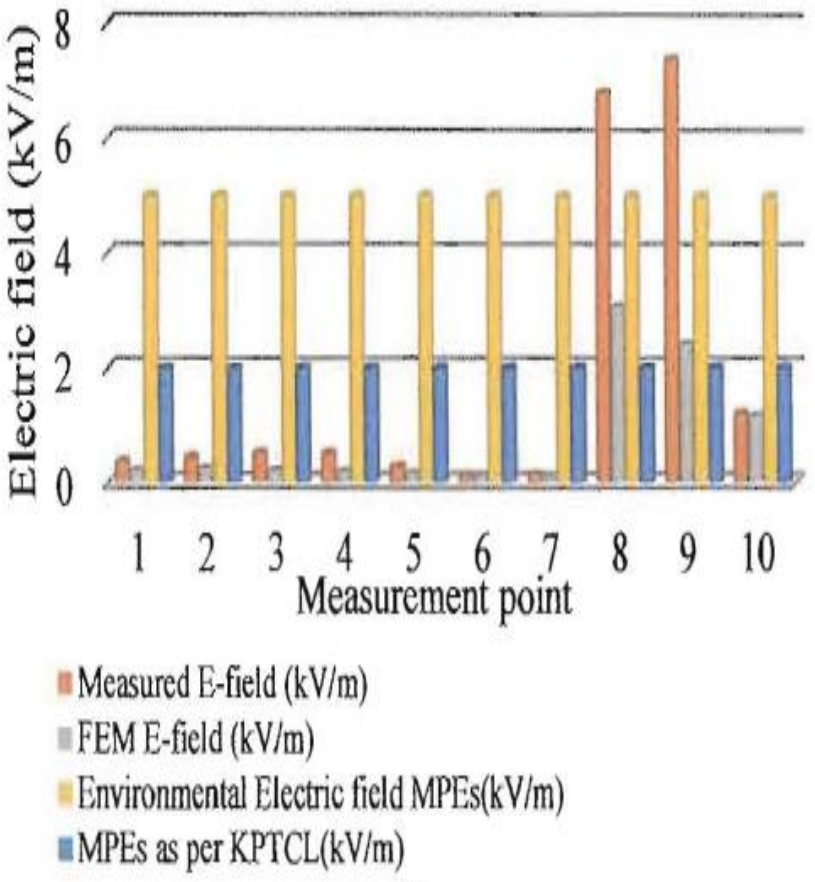
NARROW CORRIDOR / Right of Way (ROW)

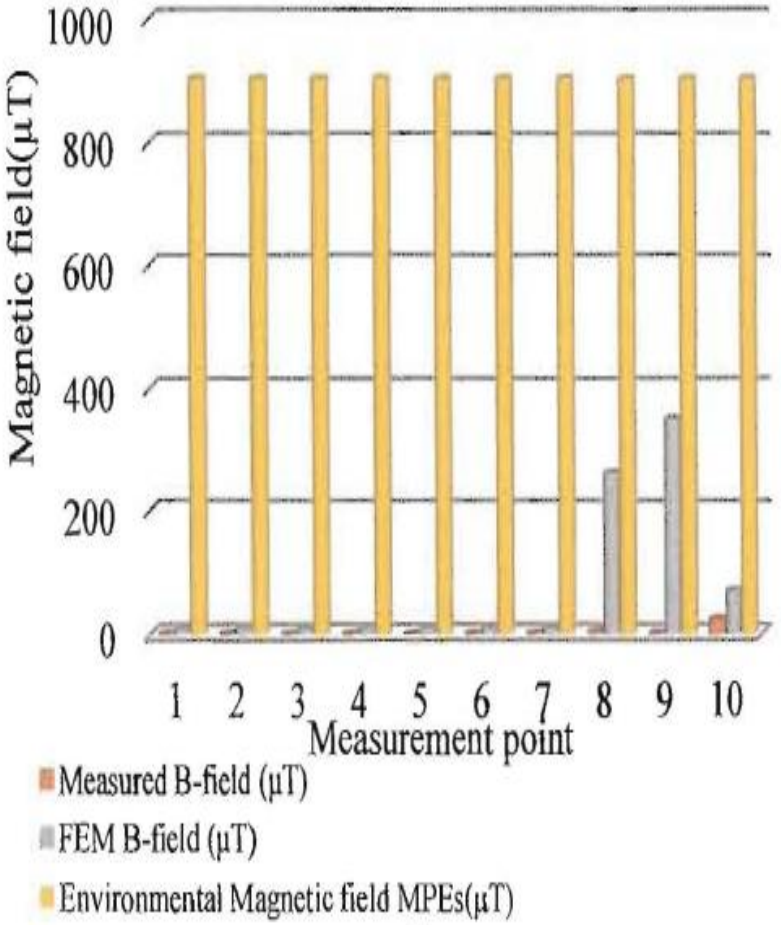
33kV Line 300mm phase to phase spacing

66kV Line with 750 mm phase to ground

MEASUREMENT OF ELECTRIC & MAGNETIC FIELDS FOR 66kV LINE







EXTRACT FROM ERDA REPORT - RESULT

II. LIMITS OF ELECTRIC AND MAGNETIC FIELD

According to IEEE C95.6-2002 Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz, the Maximum Permissible Exposures (MPEs) limits of electric and magnetic field to human exposure are 5000V/m and 0.904μT for general public at a frequency of 50Hz.

VI. CONCLUSION

From the study it is observed that the magnitude of electric and magnetic field obtained by both measurement and simulations for 66kV covered conductor are found within the specified limit of IEEE Standard [2]. From the analysis, it is found that the electric field around the covered conductor is nearly half when compared to bare conductor. The reduced electric field around the conductor reduces the effect of corona, which ultimately results in increased transmission efficiency. The estimated right of way width for the proposed 66kV pole configuration with covered conductor is found to be less with respect to bare conductor.

Right of Way (ROW)

6. RIGHT OF WAY FOR 66kV COVERED CONDUCTOR:

The Right-of-Way width of power lines can be assed directly by relating the maximum electric and magnetic field exposure levels through simulated values at various distances from the center conductor for the proposed pole configurations. It was stated in the standard that the maximum permissible level of electric and magnetic field for general public was 5 kV/m and 0.904 mT. The electric and magnetic field are found well within the expectable range at a distance of 1.85m from the center conductor. The variation of electric and magnetic field with respect to various distance from the center conductor is presented in Fig.3.

The estimated Right of Way for the proposed configuration was found to be 3.7m and is shown in Fig.4.

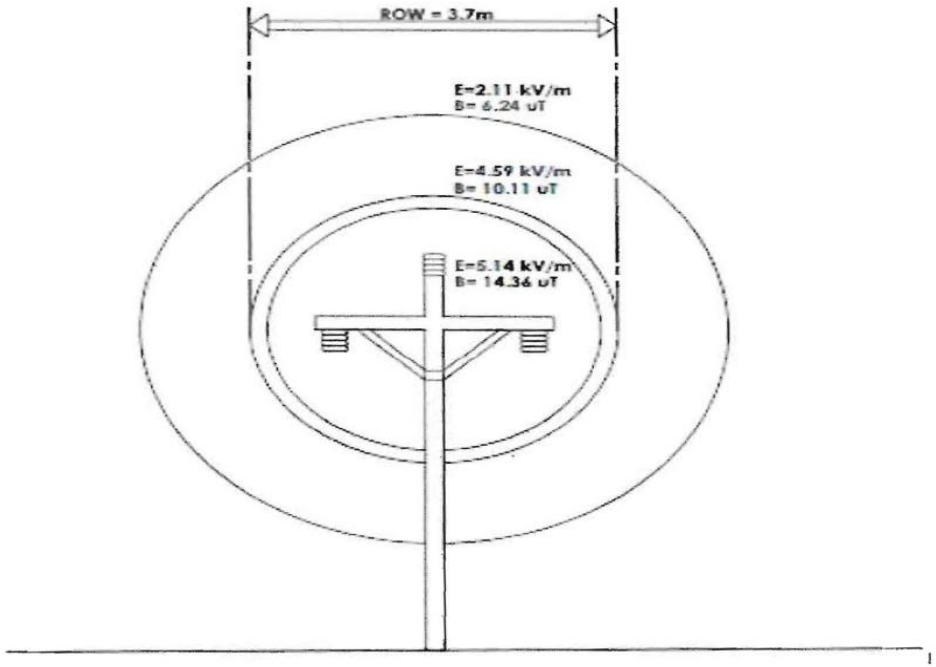


Fig.4 Estimated Right of Way

SAFETY to human life

Leakage Current on surface of the Covered Conductors:

11kV	:	0.122 milli Amps
33kV	:	0.591 milli amps
66kV	:	0.8 milli amps

Maximum permitted as per EN 50397 : 1 milli Amp (Max)

Maximum a human being can withstand without affecting heart : 10 milli amps

CONNECTIONS AND TAP OFFS

INSULATION PIERCING CONNECTORS

EMERGENCY RESTORATION SYSTEM - KPTCL

Existing 66kV Double Circuit line between Vidyaranyapura & Yelahanka to be converted to Double Circuit 220/66kV line without disturbing load

66kV System on 11 m spun poles with polymeric insulators & Covered Conductors type tested at CPRI and installed on foot path for 3kMs length.

Lattice towers in 3 kM length dismantled and 220/66 kV towers erected in its place, conductor strung and charged.

66kV system of Covered Conductors dismantled and shifted to next 3 kMs

Erection on Foot path and centre median of road with clear 8M clearance to ground. Full load of 25 MW given on Covered conductor.

COVERED CONDUCTOR WITH REDUCED ROW, DRASTICALLY REDUCED OUTAGES DUE TO CLASHING AND SLASHING AND PROVIDING IMPROVED SAFETY IS A DREAM OF THE UTILITY

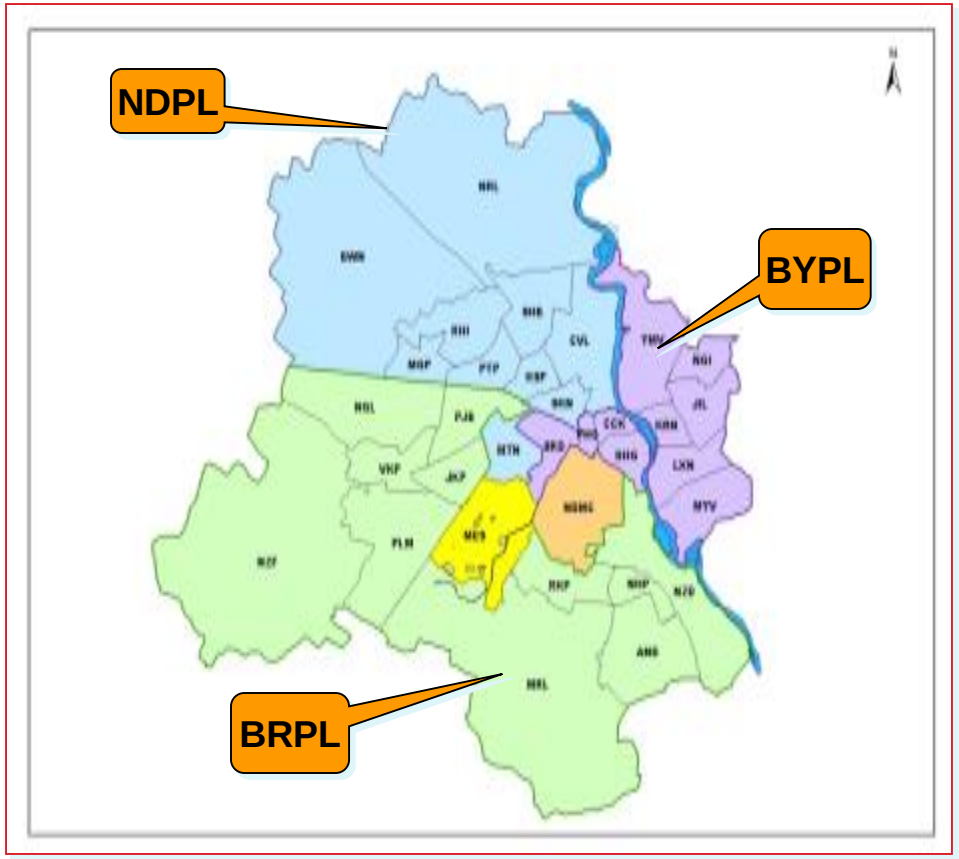
Annexure-III

HVAB cable Design and Safety Aspects

Presentation flow

- Discoms on Delhi Map
- Challenges for unauthorized/rural area
- Technology/Solution
- HVAB Cable
- HVAB cable adoption in Indian System
- Components of HVAB cable
- Significance of multiple sheaths
- Conclusion

DISCOMs on Delhi Map



REL acquired 51% stake in July'2002 in two out of three Discoms in Delhi

Delhi weightage is 1.2% of India in electricity consumption

BSES

Challenges for unauthorized/rural area

- Despite being national capital, Delhi is still having sizeable population living in rural / semi rural / unauthorized areas which we call Urbanized village
- Non-clarity of area development and load demand
- Non- availability of Space/ROW for installation/laying of Substations/Lines
- T&D loss increases due to long length of LT main and Service lines
- Direct Theft of power from LT network
- High level of expectations with respect to customer care and regulator
- Suitable technological solutions a must for such areas to curve the theft and to meet load growth.

BSES

Challenges for unauthorized/rural area

Dense populated area within periphery of approx 3.5 KMs

Exponential vertical growth

Non-availability of space and ROW for laying of lines and installation of substations

A major safety risk ,Difficult to maintain minimum vertical and horizontal clearances from O/H lines

Need suitable technology to satisfy the customers and taking care of safety

BSES

Technology/Solution

HVDS with 1-P/3-P HVAB cable
High Voltage Distribution System were used to electrify unauthorized/rural area. This system was used in high theft prone areas.

LVDS with HVAB cable
11kV overhead lines replaced with 3-phase HVAB cable and LT bare conductor lines with LT Aerial Bunch conductors

HVAB Cable

3-Phase HVAB cable
3 single core conductor with messenger Wire
3CX150+150 sqmm : Continuous current carrying capacity 290A in air at 40 deg C

1-phase HVAB cable
1 single core conductor with messenger Wire
1CX95+35 sq mm : Continuous current carrying capacity 245A in air at 40 deg C

BSES

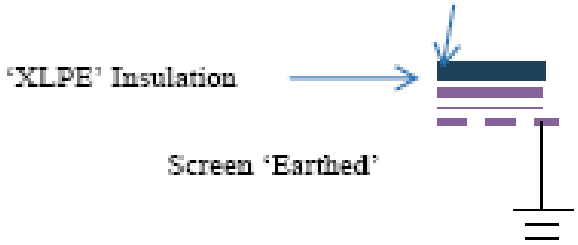
HVAB cable adoption in Indian System

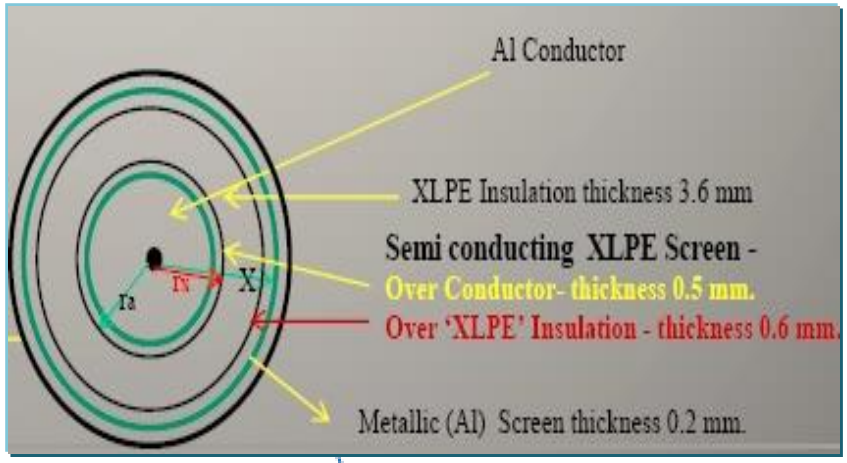
Issues related to use of HVAB cable

- REC framed technical specification 64, in year 1993 (only reference available in India)
- Phase-Phase and Phase-Earth clearance distance aspects of HVAB cable installation is not covered in regulation
- BIS is to be framed for reference
- No uniform and standard practice

Components of HVAB cable

SECTIONAL DIAGRAM





1. The AB Cable is a 'Capacitor' with two metal Electrodes (**Conductor** and **Metallic Screen**) separated by dielectric material(XLPE).
2. There is Voltage gradient from 'HV' to 'Earth'.
3. The Voltage gradient is required to be 'Uniformly' distributed to prevent 'stress' and insulation break-down.
4. The electro-static charge distribution on each of the surface/ layer is dependent on material property/quality.
5. The metallic screen 'Earthing' prevents the magnetic field/induction reaching external surface and conducting material.

Note: Diagram not to Scale

Components of HVAB cable

- Stranded Aluminium round Phase conductor - IS: 398
- Conductor screen of semiconducting compound (0.5 mm thick)
- Polyethylene (XLPE) Insulation - IS:7098 (Pt-II) (3.14 Min/3.6 Nom mm thickness)
- Insulation screen (0.6 mm thick)
- Conductors for insulated electric cables and flexible cords - IS:8130 and IS:398
- Copper tape (Min. 0.1 mm thick)
- Outer PVC sheath Type ST-7(1.4 Min/2.0 Nom mm thick)-IS: 5831
- Process for both conductor screen and insulation screen which is semi-conducting compound are extruded and are applied along with XLPE insulation in a single operation by ‘triple extrusion’ process. Method of curing is dry curing.

BSES

Components of HVAB cable

MESSENGER WIRE

- Messenger wire made of Aluminium alloy- IS: 398 (Part-IV)
- Messenger wire shall be of size 150 & 35 mm^2 aluminium alloy, generally conforming to IS: 398 (Part-IV)-1979.
- Comprising of 7 strands, suitably compacted, have smooth round surface to avoid damage to the outer insulating sheath of single-core ‘Phase cable’ twisted around the messenger.
- The messenger wire is ‘Earthed’ at multiple points during its normal service.

Components of HVAB cable

- There is risk to personal and apparatus (clamp/suspension hook) when messenger wire is not ‘Earthed’ properly or due to increased ‘Earth’ resistivity due to:

❖ Direct lightning stroke on Line

❖ Over Voltage in phase and resulting rise in Voltage/potential of messenger wire

❖ The messenger wire may break at weak ‘spot’ or dent, caused during installation mishandling

❖ Heating of termination/suspension hook due to induction, in case of selection of magnetic material

- Provide a return path for fault current to flow to ‘Earth’ and ‘Neutral’ in case of AB Cable insulation failure. Messenger wire is the second line of defense, in case of Cable failure and ‘flash over’

BSES

Significance of multiple sheaths

- First layer of semiconducting screen on outer surface of Conductor is semiconducting ‘XLPE’ compound of 0.5 mm thickness, gives smooth and uniform surface. This
  - ❖ Distribute the electric field uniformly around the conductor
  - ❖ Prevents the formation of ionized voids in the conductor.
  - ❖ Dampens impulse currents travelling over the conductor surface
- Extruded cross linked polyethylene (XLPE) of 3.6 mm thickness, forms the Primary Insulation of the overall A B Cable
- Again, 2nd layer of extruded semi-conducting compound of 0.6 mm thickness is a Voltage stress grader. This is
  - ❖ To reduce the surface voltage to zero
  - ❖ To confine the electric field within the insulation, eliminating tangential stresses

Significance of multiple sheaths

- Metallic screen of Aluminium or Copper tape or sheath limits the radial electrostatic field and shielding of the electromagnetic induction; this screen is to be compulsorily ‘Earthed'. The metallic Screen, while in service, generally fulfills the following electrical requirements:

- ❖ Conducting the earth fault current
- ❖ Returning the capacitive charging current
- ❖ Limit the radial electrostatic field
- ❖ Shielding of the electromagnetic field

BSES

Significance of multiple sheaths

- ‘Metallic’ screen, when not Earthed properly or loose connection

❖ Causes rise in Cable surface Voltage gradient and un-equal Voltage stress causing fault at the spot/failure of Cable

❖ During passage of through (external) fault current on the feeder, high magnetic field is produced around the Cable outer surface and lead to rise in potential of nearby metallic structures and increase the touch potential above safe limits.

- Outer ‘PVC’ ST7 sheath of light grey colour of 2.0 mm Nom thickness is to protect ‘XLPE’ insulation from direct solar rays and act as outer guard

BSES

Conclusion

- With use of standard HV-AB cable and installation, electrical clearance of HV AB Cable line and nearby structure, under normal operation, can be negligible with spatial separation provided to protect the Cable insulation damage due to mechanical damage

- Phase to phase and phase to earth clearance distance aspects of HVAB cable installation has not addressed in the regulation

- BIS is to be framed for reference and validation during factory testing users

- **Technical standard is required for adaptation of uniform design and safe installation practices by all states DISCOMs/Utilities**

BSES

Thank You

www.bsesdelhi.com

Annexure-III

Amendment Recommendation to CEA Regulation

(Chapter 6 sub clause 44)

25-02-2016

Agenda

- **Cargill Introduction**
- **Fire Safety & Reference Standards for transformers**
- **Proven Experience – Including tropical climates**
- **Local Experience & Acceptance**
- **Long Term Supply Reliability – Make in India**
- **Practical Aspects**

Cargill Inc – 150 Years of helping the world *thrive*

USD 120 billion
enterprise

With more than
155,000
employees

across nearly
70
businesses

located in
67
countries

our purpose is singular:

to be the global leader in nourishing people

Cargill

Cargill in India

New investments:

- Wet corn milling plant and bulk storage in Davangere, Karnataka
- Animal Feed Mill in Bathinda, Punjab

A snapshot

- Rs. 7, 130 Cr. ($1.12 bn) company
- Over 2300 people across 100+ locations
- Originate upto 2.5 million MT of grains & oilseeds per annum at 240 storage locations
- 3 production sites + 1 Food Application Centre
- Industrial Specialties Business in Electrical, Paints, PU, Construction, Lubricants and related industries

LEONARDO® Olive Oil

NatureFresh® ACTI-LITE

Enriched with Soyabean Oil
Sunflower® Brand Vanaspati

gemini™ REFINED COOKING OIL

SWEEKAR® REFINED SUNFLOWER OIL
Kum sokha jaanewala tel

RATH® VANASPATI
Cargill

FR3™

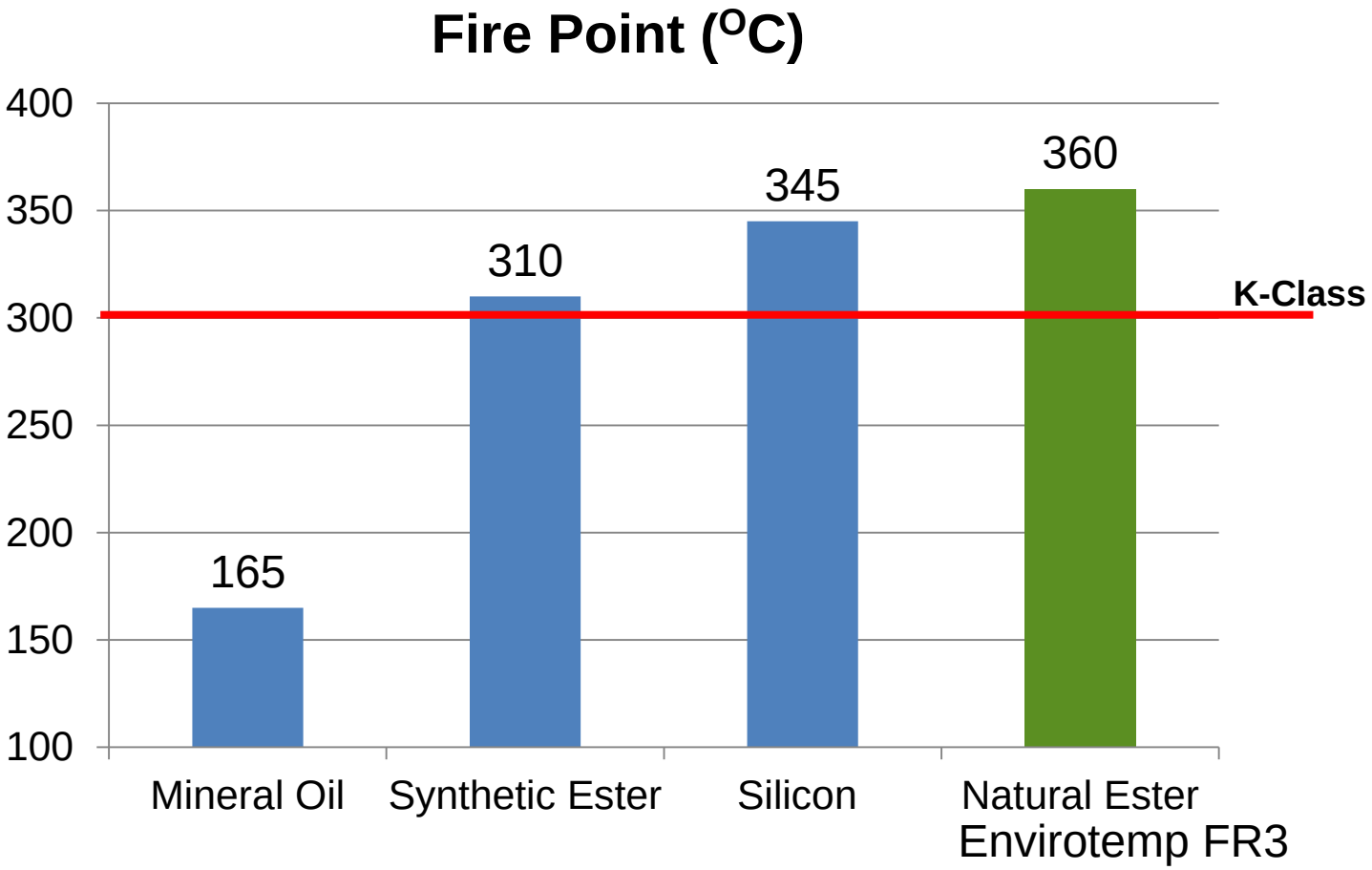
ENVIROTEMP™ NATURAL ESTER FLUID

Cargill

Fire Point is the single most important factor determining Fire Safety

Fire Safety – Fire Point

K – Class fire resistant fluid must have Fire Point >300 °C



Reference Standards

IS 2026 – PART 2; 2010

a) **First Letter** — Internal cooling medium in contact with the windings:

1) O : mineral oil or synthetic insulating liquid with fire point 'Cleveland open-cup' test method {*see* IS 1448 [P : 69]};

2) K : insulating liquid with fire point 'Cleveland open-cup' test method {*see* IS 1448 [P : 69]}; and

3) L : insulating liquid with no measurable fire point.

IEC 60076-2; 2011

First Letter : Internal cooling medium in contact with the windings

O	mineral oil or synthetic insulating liquid with fire point ≤300°C
K	insulating liquid with fire point > 300°C
L	insulating liquid with no measurable fire point

FM Global Requirements

FM GLOBAL 6933 – APPROVAL STANDARD FOR LESS FLAMMABLE TRANSFORMER FLUIDS

II REQUIREMENTS

Three basic requirements are necessary to qualify for FM Approval.

2.1 The fluid shall have a fire point of at least 572°F (300°C).

2.2 The following fluid specifications, under the control of the fluid manufacturer's surveillance program, shall be determined:

(1) Dielectric breakdown voltage;
(2) Neutralization number;
(3) Color;
(4) Water content; and
(5) Viscosity.

2.3 The fluid shall have convective and radiative heat release rates, expressed in Btu/ft^2-min (kW/m^2), which find practical applications through the use of FM Global Property Loss Prevention Data Sheet 5-4S/14-8S.

Tests with K-Class fluids for Fire safety

1 – Fire Safety
How to evaluate?

- Flammability Tests - FM Global (Factory Mutual)
- Target
  - Determine if the ignition of internal arcs in transformers with fire resistant fluids results in fires.

- Summary
  - A low energy failure heats up the transformer insulating liquid.
  - The failure results in a rupture of the pressure relief valve, releasing oil to the ambient.
  - The fluid deposits around the transformer on the floor.
  - The arc is kept and causes a high energy fault and, probably, an explosion breaking the tank, resulting in the discharge of the hot fluid on the floor.

Internal fault - MO Trfr

- **Oil Temperature**
  - Tank 128°C
  - Channel 133°C
- **Arc duration 7.77s**
- **Overpressure open the rupture disc**
- **Spray of hot oil and fire over the oil in the channel**

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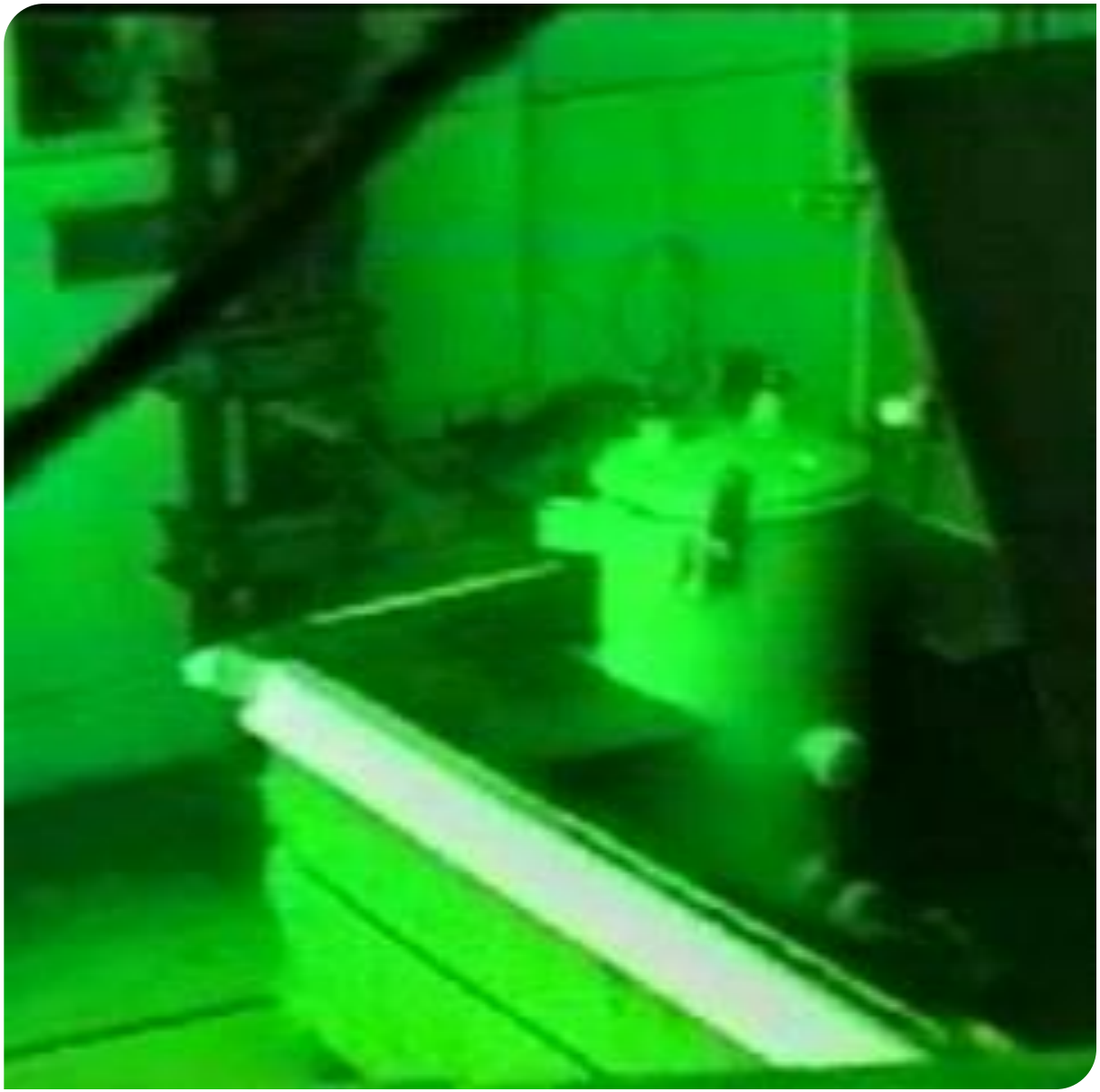

Internal fault - K-class fluid Trfr

- **Oil Temperature**
  - Tank 140°C
  - Channel 133°C
- **Arc duration 7.56s**
- **Disc Open**
- **No Ignition**
- **Losses limited to the failed equipment**

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Internal fault + Fire source - K-class fluid Trfr

- **Oil Temperature**
  - Tank 133 ~188°C
  - Channel 135°C
- **Arc duration 10s**
- **Disc open, ignition of the gases at the external ignition source.**
- **External flame extinguished after 3.5s**

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How to evaluate “Fire Safety”? Flammability Tests Conclusions

- The internal arc in a mineral oil insulated transformer can cause a fire (even without external ignition source).
- The internal arc in a transformer insulated with fire resistant fluid has no ignition.
- Discharged gases from the transformer with fire resistant fluids, in spray form, can burn if there is an external ignition source (but no liquid fire).
- Since the quantity of energy from the initial fire is not enough to keep the fluid temperature, the fire is self extinguished.

How to evaluate “Fire Safety”?
Flammability Test – Open Tank (FM Global 2002)

- Target
  - Determine the possibility of reducing the distances and containment from standard FM, **without any additional protection or fire extinguishing system**.

- Summary
  - External and internal failures of high energy and / or induced currents from the system that can heat up metal pieces to red.

- Procedure
  - Insert quickly a metal piece heated to red (750°C) in a tank with fluid heated at 130°C. Measure the temperatures and verify the occurrence of fire.

External fault - MO Sump

- Metal piece heated to red (750°C)
- Fluid tank heated at 130°C
- Insert the metal quickly
- Fire ignited by the energy of the plate in contact with the fluid

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External fault - FR3 Sump

- Metal piece heated to red (750°C)
- Fluid tank heated at 130°C
- Insert the metal quickly
- No fire ignition
- No need to drain or chill the fluid if in a sump

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External fault - FR3 + 4.5%MO Sump

- Metal piece heated to red (750°C)
- Fluid tank heated at 130°C
- Insert the metal quickly
- No fire ignition
- No need to drain or chill the fluid if in a sump

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Acceptance of K-class fluid filled Transformers - Indoor

Cargill

IEC 61936-1

Table 4 – Minimum requirements for the installation of indoor transformers

Transformer type	Class	Safeguards
Oil insulated transformers (O)	Liquid volume	
	≤ 1 000 l	EI 60 respectively REI 60
	> 1 000 l	EI 90 respectively REI 90 **or** EI 60 respectively REI 60 and automatic sprinkler protection
Less flammable liquid insulated transformers (K)	Nominal power/max. voltage	
Without enhanced protection	(no restriction)	EI 60 respectively REI 60 **or** automatic sprinkler protection
With enhanced protection	≤ 10 MVA and U_m ≤ 38 kV	EI 60 respectively REI 60 **or** separation distances 1,5 m horizontally and 3,0 m vertically
Dry-type transformer (A)	Fire behaviour class	
	F0	EI 60 respectively REI 60 **or** separation distances 0,9 m horizontally and 1,5 m vertically
	F1	Non combustible walls

NOTE 1 REI represents the bearing system (wall) whereas EI represents the non-load bearing system (wall) where R is the load bearing capacity, E is the fire integrity, I is the thermal insulation and 60/90 refers to time in minutes.

NOTE 2 Enhanced protection means

– tank rupture strength,

– tank pressure relief,

– low-current fault protection,

– high-current fault protection.

For an example of enhanced protection, see Factory Mutual Global standard 3990 [33], or equivalent.

NOTE 3 Sufficient space should be allowed for periodic cleaning of resin-encapsulated transformer windings, in order to prevent possible electrical faults and fire hazard caused by deposited atmospheric pollution.

FM Global – Property Loss Prevention Data Sheet 5-4

Table 4. Recommended Construction for Transformer Buildings and Rooms

Transformer Type	*Fluid Type*	*Fluid Volume in Largest Transformer*	*Room or Building Fire Rating*	*Fire Protection for Transformer Liquids*
Dry or gas insulated[a]	Not applicable		Noncombustible	None[b]
FM Approved or equivalent[c]	FM Approved liquids	Any[d]	Noncombustible	None[b]
Non-Approved Transformer	FM Approved liquids	Any[d]	One-hour fire-rated	None[b]
			Noncombustible	Per Section 2.2.3[e]
	Non- Approved liquids	Less than 100 gal (380 L)[d]	One-hour fire-rated	None[b]
		More than 100 gal (380 L)[d]	Three-hour fire-rated with subdivisions if multiple transformers[f]	None[b]
			Three-hour fire-rated with multiple transformers and no subdivision	Per Section 2.2.3[e]
			One-hour fire-rated with single transformer	

[a] With no oil-filled bushings, oil-filled tap changers or other oil-filled accessories that could increase the fire hazard.
[b] See also Section 2.2.3.4 for protection of combustibles other than transformer liquids.
[c] Section 3.3 describes FM Approved and equivalent transformers.
[d] Provide liquid spill containment in accordance with Section 2.2.1.5
[e] Automatic sprinklers, foam-water sprinklers or water mist. Also provide emergency drainage for sprinkler discharge per Section 2.2.1.6
[f] Subdivide room or building with three-hour fire-rated construction for each transformer if multiple transformers are present.

US Fire Code

The US NEC (NFPA 70) allows for indoor installations of less flammable liquid filled transformers w/o fire suppression systems. Download a copy at www.NFPA.org

Brazil,

- Brazil: São Paulo revised fire code IT-37according to Brazilian Standard ABNT NBR 13231. Code gives acceptance of K-class fluid filled transformers for indoor applications with removal of fire walls/barriers for power transformers.

Installed in Basement

50MVA
132/11kV

- EnergyAustralia's Sydney CBD City South Substation
- Since 2008
- Wilson, Australia
- Filled with Cargill Envirotemp™ FR3™

Cargill®

Indoor Transformer Installation

Specifically designed and approved for all indoor or roof-mounted applications placing the transformer near the load, Envirotran™ transformers are suitable in all commercial and industrial environments.

Product Scope:

- Unit substation transformers thru 10 mVA
- Close-coupled or stand-alone
- Primary Voltages: 5 kV through 35 kV, 200 kV BIL
- Secondary Voltages: 120 V through 15 kV, 95 kV BIL
- Classified by UL® and Approved by FM®
- 15% or 25% fan cooling
- 65 °C or 55/65 °C temperature rise

Standard Features:

- Envirotemp™ FR3™ Fluid—the highest firepoint of any fluid in the industry
- Enhanced transformer insulation life
- Meets all NEC safety requirements of Section 450-23 for indoor transformer applications
- EPA/ETV tested and approved

Extract from Cooper Power Catalog - Indoor Powercenter™ Transformer

Indoor Transformer Installation

Envirotran™
The Indoor-Powercenter Transformer

Use anywhere dry-type transformers have been specified.

Applications

- Schools and Universities
- Steel Producers
- Hospitals
- Insurance Companies
- Religious Institutions
- Automotive Industry
- Theme Parks
- Commercial/Institutional
- Industrial Manufacturing
- Petro/Chemical Industry
- Power Generation
- Pulp & Paper Industry
- Office Buildings
- Food & Drug Industry

Optional Features:

- Deadfront termination: radial, or loop configurations
- Containment pan
- K-factor rated
- NEMA TP-1 energy efficiency
- Vacuum fault interrupter (VFI) integral to the transformer tank
- 33% fan cooling rating

For more information on Envirotran Indoor-Powercenter transformers, see catalog 210-15, Bulletin B100-98077, or contact your Cooper Power Systems sales representative or a product engineer.

Make the Indoor-Powercenter Work for You

- No Fire-Rated Electrical Vaults Required
- No Sprinkers or Deluge Systems Required
- Containment Pans Available
- Less Clearance Distances Required
- Lower Insurance Rates

Extract from Cooper Power Catalog - Indoor Powercenter™ Transformer

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Benefits of K-class fluids in Transformers - Outdoors

Cargill

IEC 61936

Fluid	Fluid Volume (liters)	Minimal separation distances		
		From equipment to edification X1		Between equip X2
		Fire resistant for 2h	Non combustible	
Mineral Oil	< 1,900	1.5 m	4.6 m	1.5 m
	≥ 1,900 ≤ 19,000	4.6 m	7.6 m	7.6 m
	> 19,000	7.6 m	15.2 m	15.2 m
K-Class Less Flammable Fluid	≤ 38,000	**1.5 m**		**1.5 m**
	> 38,000	**4.6 m**		**7.6 m**

FM Global – Property Loss Prevention Data Sheet 5-4

Fluid	Fluid Volume (liters)	Minimal separation distances outdoor		
		From equipment to building		Between equipment
		Fire resistant for 2h	Non combustible	
Mineral Oil	< 1,900	1.5 m	4.6 m	1.5 m
	≥ 1,900 ≤ 19,000	4.6 m	7.6 m	7.6 m
	> 19,000	7.6 m	15.2 m	15.2 m
K-Class Less Flammable Fluid (FM Approved)	≤ 38,000	**1.5 m**		**1.5 m**
	> 38,000	**4.6 m**		**7.6 m**

Cargill

USBR – FIST 3-32

Table 2a. Separation Distances between Outdoor Liquid Insulated Transformers and Bushings

Liquid	Approved Transformer or Equivalent	Liquid Volume (gallons)	Horizontal Distance (feet)			Vertical Distance (feet)
			2-hour Fire Resistant Construction	Non-combustible Construction	Combustible Construction	
Less Flammable (approved fluid)	Yes	N/A	3			5
	No	≤ 10,000	5		25	25
		> 10,000	15		50	50
Mineral Oil or Unapproved Fluid	N/A	< 500	5	15	25	25
		500-5,000	15	25	50	50
		> 5,000	25	50	100	100

Table 2b. Outdoor Fluid Insulated Transformers Equipment Separation Distances

Liquid	Approved Transformer or Equivalent	Fluid Volume (gallons)	Distance (feet)
Less Flammable (approved fluid)	Yes	N/A	3
	No	≤ 10,000	5
		> 10,000	25
Mineral Oil or Unapproved Fluid	N/A	< 500	5
		500-5,000	25
		> 5,000	50

USBR – FIST 3-32

Factory Mutual's endorsement of these distances used in conjunction with approved less-flammable fluids such as ester-based insulating fluids, is strong assurance that such fluids can be used safely in Reclamation transformers without fire suppression and/or barrier walls, in most cases.

IEC – 60695-1-40; 2013

a) whether the insulating liquid can be heated to its fire point under equipment overload conditions. This could result in fire initiation if exposed to an external source of ignition;

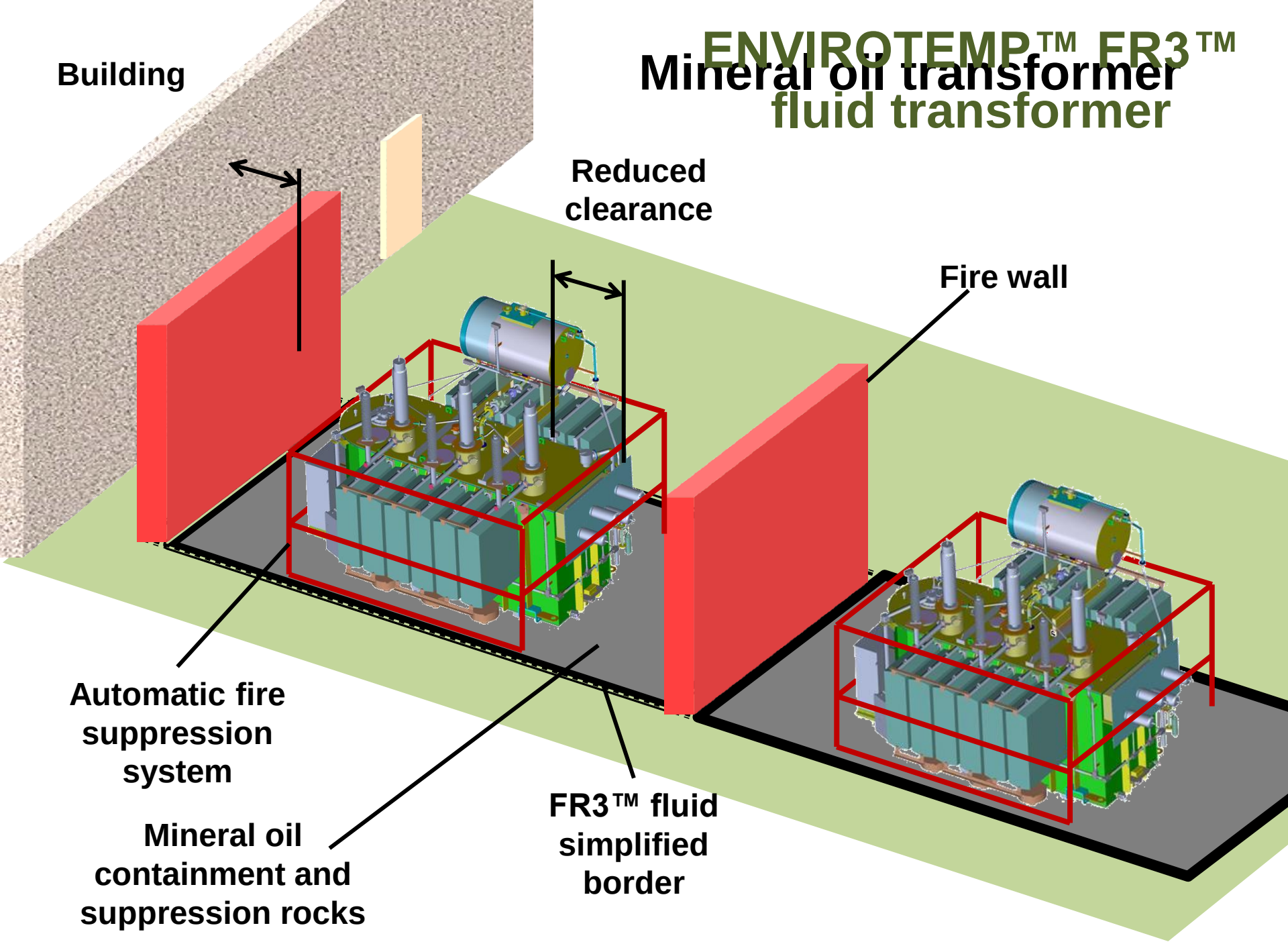
b) whether fire can be initiated by an uncontrolled high-energy internal arc.

Either of these situations may create internal pressure sufficient to rupture the insulating liquid container in the electrotechnical equipment. The liquid is then ejected, normally as a spray, which may be ignited. The spray burns intensely for a short period but then forms a pool, which may or may not be burning at the base of the electrotechnical equipment. Experience with Class O1 insulating liquids has shown that burning of a resultant pool fire causes most damage but no pool fires have been reported for Class K liquids.

Brazil, China,

- Brazil: São Paulo revised fire code IT-37according to Brazilian Standard ABNT NBR 13231. Code concludes with removal of fire walls/barriers for power transformers.

- China: Tianjin Fire Research Institute certificate to achieve fire code change


Building
ENVIROTEMP™ FR3™
Mineral oil transformer
fluid transformer
Reduced
clearance
Fire wall
Automatic fire
suppression
system
Mineral oil
containment and
suppression rocks
FR3™ fluid
simplified
border

Global References & Installations

Cargill

Outdoor Installation – NASA
Close to building

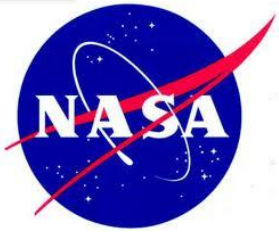
Customers & OEMs

Customers

OEMs

Global








Indian
















Cargill

FR3™

ENVIROTEMP™ NATURAL ESTER FLUID

Cargill

Long Term Supply Reliability

Envirotemp FR3 Plant in Pune

- State of the art facility
- Meets all international quality standards
- Supports “Make in India”

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Journey Begins ...

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Annexure-IV

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K-Class Fluids as a Viable Cost effective Alternative to Cast Resin

APIEZON METROSIL MIDEL WOLFMET

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What is a K Class Fluid?

- Fluids are fire resistant dielectrics with a fire point > 300'C
- Several choices of K Class fluids and manufacturers
- Examples include
  - Natural Esters
  - Silicone fluid
  - Synthetic Ester (Midel 7131)
- Originally introduced as an alternative to PCBs
- K Class fluids have been used successfully for many years in densely populated & fire sensitive locations

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Relevant Fluid Standards

- IS 16081 equivalent to IEC 61099
  - Specifications for Unused Synthetic Organic Esters for Electrical Purposes
- IS 16099 equivalent to IEC 61203
  - Synthetic Organic Esters for Electrical Purposes - Guide for Maintenance of Transformer Esters in Equipment
- IS 13503 Equivalent to IEC 61039
  - Classification of Insulating Liquids

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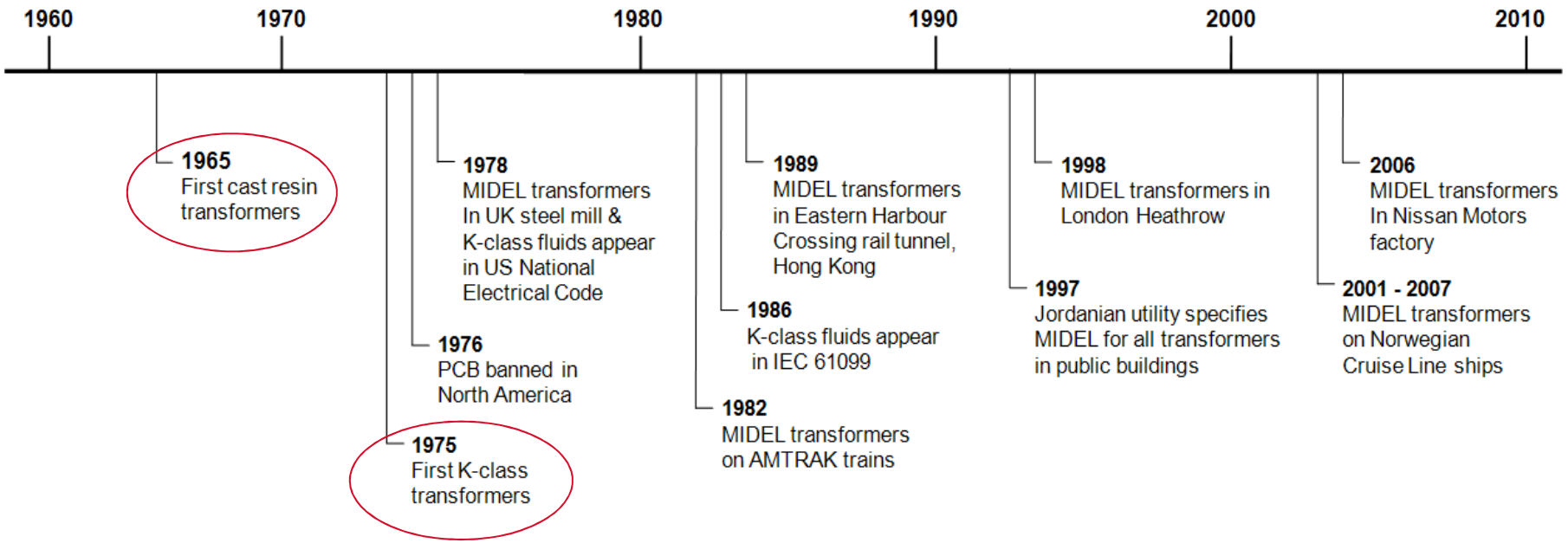
The Development of PCB Alternatives

Replacement technologies in fire safe transformer materials



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K-class Fluid Filled Transformers

- Indoor Installations
  - Hospitals – Guys London
  - Airports – BAA Heathrow
  - Public Buildings – Scottish Power, Albert Hall
  - Data centres – Critical for equipment protection
  - Factories – FM Global recommend retrofill of mineral oil with K-class

Heathrow

Royal Albert Hall

East Midland Hospital

London STOCK EXCHANGE

SCOTTISHPOWER

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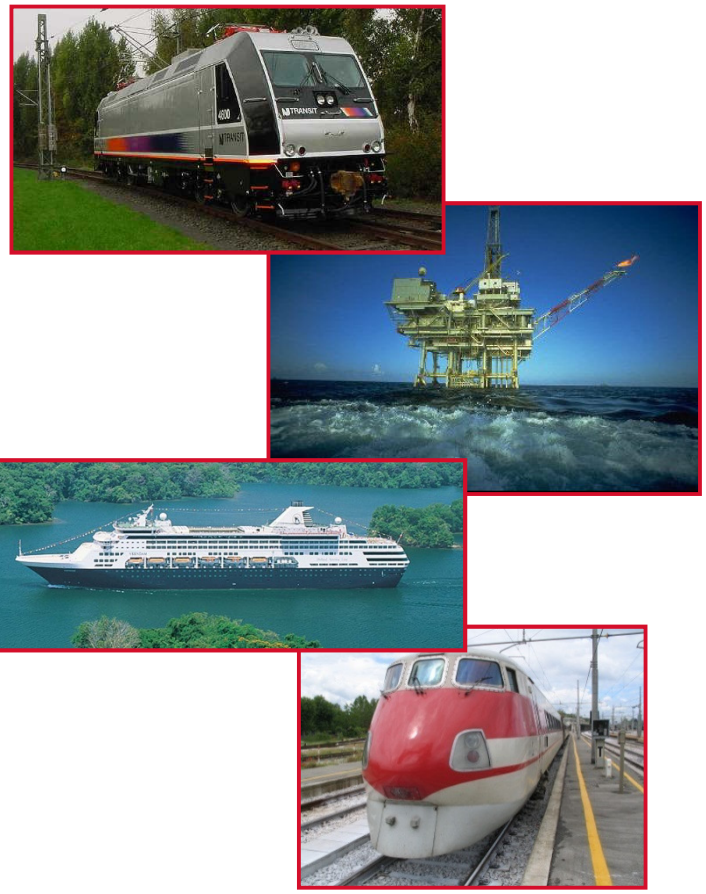
K-class Fluid Filled Transformers

- Locations with high fire risk
  - Underground – Vattenfall 238kV, LU, Hong Kong, RATP
  - Offshore oil and gas installations – Oil rigs, FPSO vessels
  - Cruise ships – Queen Mary II, Holland America Line
  - Onboard rolling stock – Amtrak 1980's, Passenger trains
  - Wind turbines – CG Power SLIM transformer



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Power References

Transformer manufacturer = Ganz Ungarn

- End user = Vattenfall, Sweden
- Location = Umlusen, Sweden
- Details of Transformer = **11/151kV step up & 110MVA**

Transformer manufacturer = Siemens Austria

- End user = Vattenfall, Sweden
- Location = Stalon, Sweden
- Details of Transformer = **238kV / 135MVA**

Transformer manufacturer = Siemens Austria

- End user = Vattenfall, Sweden
- Location = Hydro power plant, Sweden
- Details of Transformers = **235kV / 100MVA**

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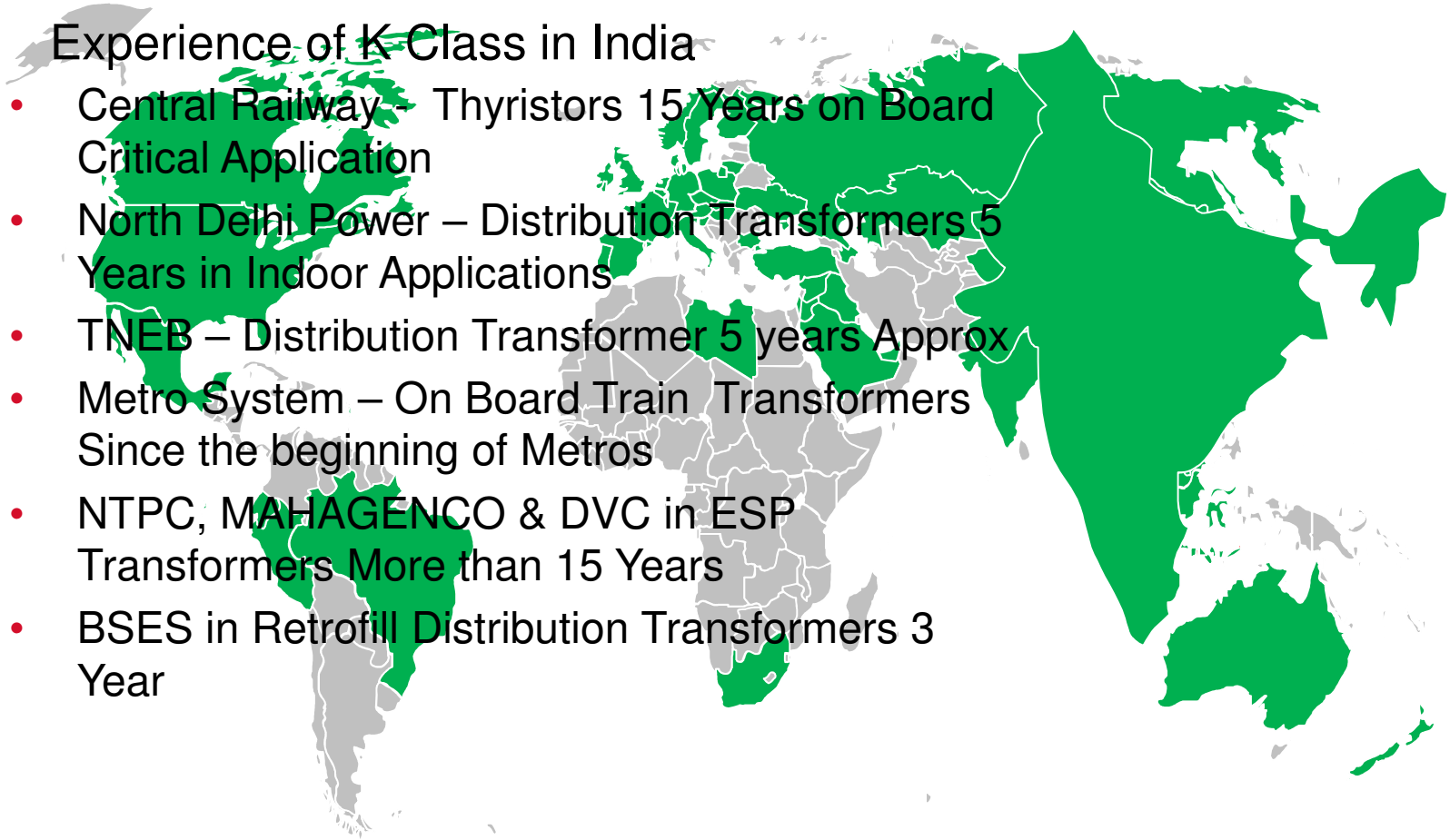
Worldwide Experience with K-Class Fluid

- Experience of K-Class in India
  - Central Railway – Thyristors 15 Years on Board Critical Application
  - North Delhi Power – Distribution Transformers 5 Years in Indoor Applications
  - TNEB – Distribution Transformer 5 years Approx
  - Metro System – On Board Train Transformers Since the beginning of Metros
  - NTPC, MAHAGENCO & DVC in ESP Transformers More than 15 Years
  - BSES in Retrofill Distribution Transformers 3 Year



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Global Regulations for K-Class Fluids

- IEC 61936
  - Significantly reduced clearance for K-class fluid
  - Lower fire protection requirements for indoor installations
- FM Global®
  - Worldwide insurance company
  - Significantly reduced clearances, allows grouped containment
- NFPA 70 (National Electrical Code)
  - American standard
  - No need for transformer vault for indoor installations <38kV
- CEN/TS 45545
  - Fire protection standard - only use K-class fluid on rolling stock

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US National Electrical Code - 1978

Type	Rating	Indoor	Outdoor
K-class	< 35kV	Catch Basin Required	No Requirements
	> 35kV	Vault Required	No Requirements
Cast Resin	< 112.5KVA, < 600V	12” clearance or fire barrier	Weatherproof Enclosure Required
	> 112.5KVA, < 35kV	Fire-resistant transformer room	Weatherproof Enclosure Required
	> 35kV	Vault Required	Weatherproof Enclosure Required

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Approved in Potentially Explosive environments/ Nuclear Power Plant Sites

- MIDEL 7131 Binder Data Sheets\Test report\BASEEFA Rating.pdf
- personal\NPCIL Mumbai\NIFSCC.pdf

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Comparison K Fluid Filled and Cast Resin

	K Fluid Filled	Cast Resin
Fire Behaviour	Good	Good
Initial Cost	Medium	High
No Load Losses	Medium	High
Load Losses	Medium	Medium
Periodic Cleaning	Not Required	Required
Overload Resistance	Good	Poor
Diagnostics	Temperature, DGA	Temperature, PD
Repairability	Good	Poor
Noise Level	Low	Medium

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History of use in Public Spaces

- Four decades of use of synthetic ester
- 1970s
  - The Royal Mint, South Wales
  - Rolling Steel Mill, UK
- 1980s
  - Offshore Oil Platform, North Sea
  - Hotel Complex, Hong Kong
- 1990s
  - Schönhauser Arcaden Shopping Complex, Berlin, Germany
  - London Underground Victoria Line, UK
- 2000s
  - Olympic Stadium, London
  - Gold Souk Sharjar, UAE

London Underground

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History of use in Public Spaces in India

- CENTRAL Railways More Than 15 Years
- NDPL (Now Tata Power Delhi) 5 Years
- BRPL almost 3 Years
- TNEB 5 Years Approx.

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Ignition Behaviour and Fire Testing

K class Fluids and Cast Resin Transformers

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Ignition Behaviour of Dielectric Materials

- Comparison of Epoxy cast resin with K-class fluid
- Two separate studies using similar methods
- Application of an oxy-acetylene torch directly to the dielectric material
- **Cast Resin**
- Oxyacetylene flame applied to the resin for 30 seconds
- The time from removing the fire source until the flames extinguish was measured
- **MIDEL 7131 synthetic ester (class K3)**
- Oxyacetylene flame applied to the surface of the liquid for 70 minutes to assess ignition resistance

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Cast Resin Test Results

Torch Applied	Time to Flame Extinction
30s	12.4s
30s	22.0s

- Cast resin material ignited when the oxyacetylene torch was applied
- Cast resin material continued to burn after the torch was removed
- Time of burning is short, so the material is still considered self extinguishing

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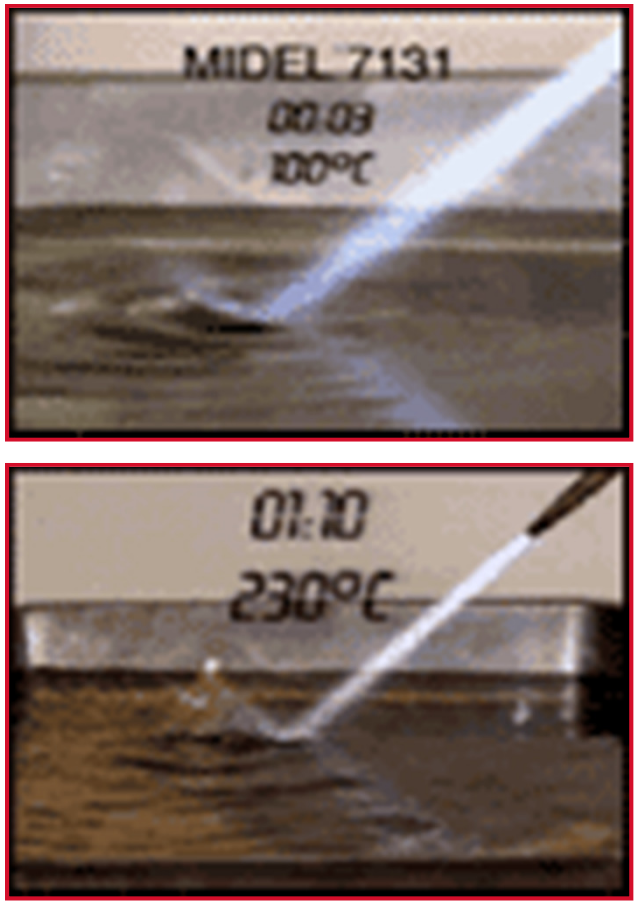
K-class Fluid Results

- Fluid did not ignite after 70 minutes of continuous flame contact
- No smoke or fumes from the fluid
- K-class fluid dielectric is far more resistant to ignition than cast resin dielectric when exposed to a flame
- Even if the fluid exits the tank it is very unlikely to ignite



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Dry Type Transformer Standard

- Under IEC 60076-11 there are specific tests for fire behaviour
- Fire behaviour class F0
  - No special requirements with regards to fire behaviour
- Fire behaviour class F1
  - Must pass test as set out in the standard
  - Low levels of smoke production
  - Low levels of toxicity
  - Self extinguishing

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Fire Behaviour Test

Siemens Geafol - F1 Dry Type Transformer

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Fire Behaviour Test for IEC 60076-11

- A cast resin transformer would be expected to produce smoke in this test
- To pass the F1 standard the transformer must produce smoke at low levels
- Light transmission must be at least 20% of maximum during the 20th to 60th minute of the test
- A cast coil is shown after the test

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Siemens Geafol Transfomers

- Siemens produce a very fire safe cast resin transformer
- Insulation is 1/3 Epoxy to 2/3 Quartz for enhanced fire safety
- This transformer passed the IEC 60076-11 test for F1 rating
- Combustible material makes up <5% of weight
  - For 11kV, 630kVA low noise unit this is 100kg of combustible material
- If subjected to an external fire of sufficient intensity this combustible material will burn and produce smoke

"Any dielectric may actually 'burn'; you only need to subject it to sufficiently high a temperature." *G Le Roy F Sandoz, Electricite de France-GIMELEC*

Siemens Geafol Fire Test

- Propane flame directed onto the base of a cast coil transformer
- Duration of flame was around 32 minutes constant
- Energy input to the fire of 111MJ

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Test Photos

- Effect of Propane flame held constant over time

After 8 minutes

After 20 minutes

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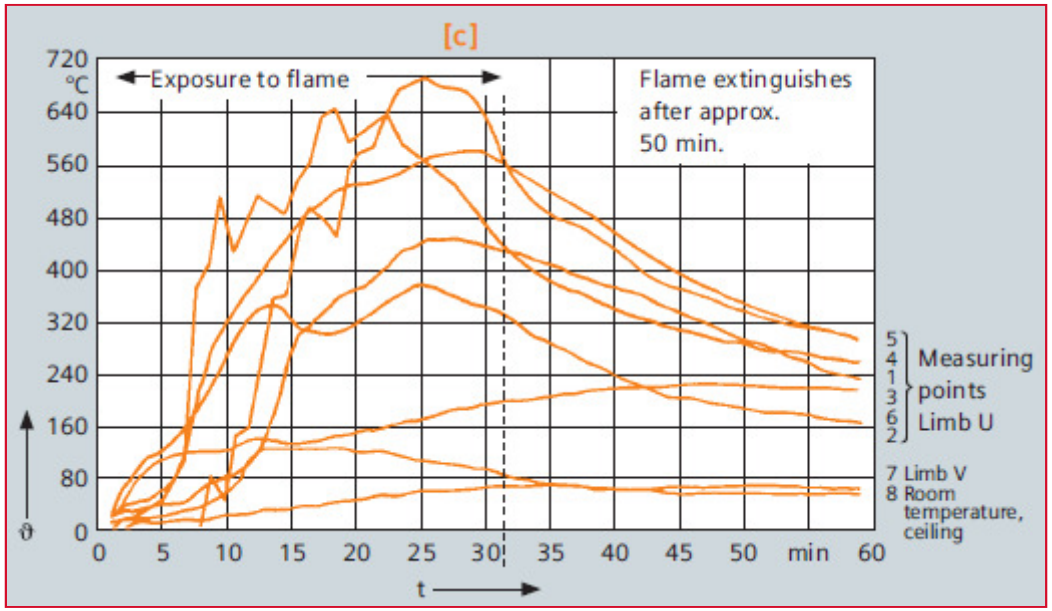
Siemens Fire Test Data



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Condition of Transformer After Test

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Conclusion from Siemens Test

- The cast resin transformer is relatively fire safe as it self extinguishes
- It does produce smoke when exposed to a flame
- It will continue to burn after the flame is removed
  - In this test the transformer burned for around 20 minutes with no external flame

- *Reference - Siemens Geafol Brochure*

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What About a K-Class Fluid Transformer?

- In theory if exposed to the same conditions
  - 111MJ of heat energy directed at one point on the tank
  - 630kVA transformer filled with 365kg of Midel ester fluid

- What would be the maximum fluid temperature rise assuming no loss of heat to convection
  - Midel has a Specific Heat of 1994J/kg.K at 60° C operating temperature
  - Temperature rise would be 153° C, reaching 213° C
  - Fluid is still a long way below the fire point of 312° C

- There would be no ignition of the insulation and hence no smoke

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Real Test of Midel Filled Transformer

- Allianz tested a 630kVA Midel filled transformer with 365kg of fluid
- Wood fire burned for over one hour, inputting far more than 111MJ of energy
- Maximum fluid temperature reached was 204° C
- Transformer electrically working after test

- In real situation heat is lost to convection, so fluid does not heat as quickly when exposed to fire as theory suggests

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Comparison Fire Test

CG Power (Pauwels) 2004

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Test Parameters

- Direct comparison between F1 Cast Resin and K-class filled
- Rating 1MVA
- Based on standard test parameters from Cenelec HD464
- Similar requirements to IEC 60076-11 F1 class
  - Alcohol fuelled fire and radiant panels at 750° C for 20 minutes
  - Radiant panels at 750° C only for further 20 minutes

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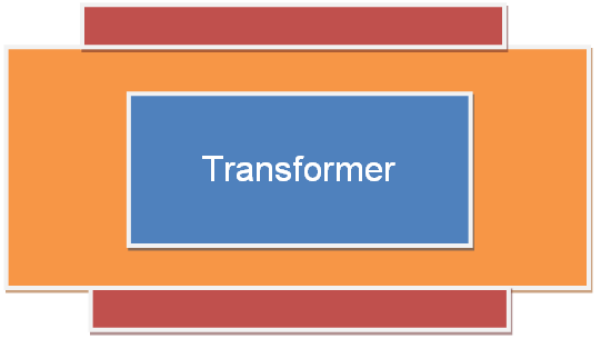
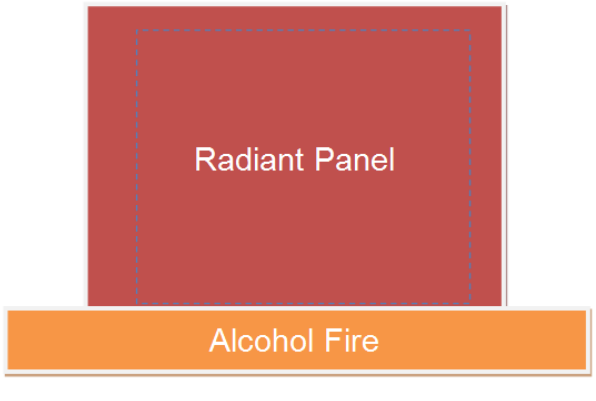
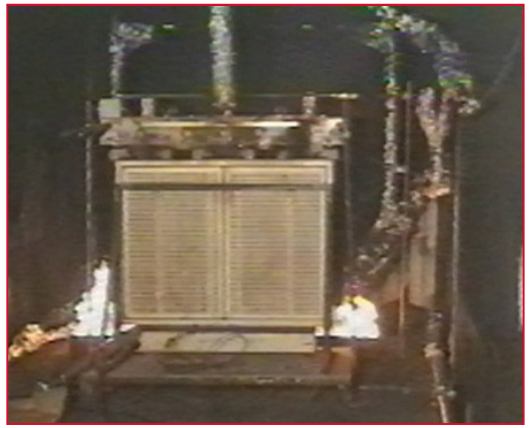
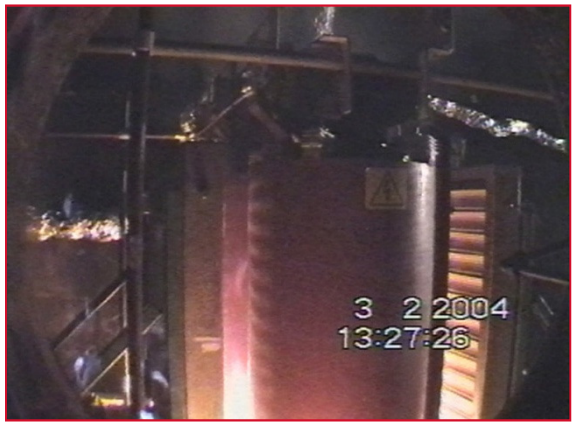
Test Set Up









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Cast Resin Behaviour

- 4 minutes – ignition and smoke production
- 8 minutes – central winding temperature 800+° C
- 14 minutes – cast resin on fire, smoke density increasing
- 23 minutes – radiant panels only, cast resin still burning
- 40 minutes – no external heat source, resin continues to burn
- 53 minutes – resin still burning

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Cast Resin Video

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K-class Fluid Filled Behaviour

- 5 minutes – flames from alcohol fire engulf tank
- 14 minutes – alcohol fire continues to burn
- 23 minutes – alcohol fire dies away
- ***The transformer did not burn or contribute to the fire***
- Maximum external temperature 600° C
- Maximum internal temperature 260° C
- Sealed transformer tank represents worst case, due to potential for pressure build up
- Breathing tank would be expected to behave in a similar way

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K-class ‘Slim’ Style Transformer Video

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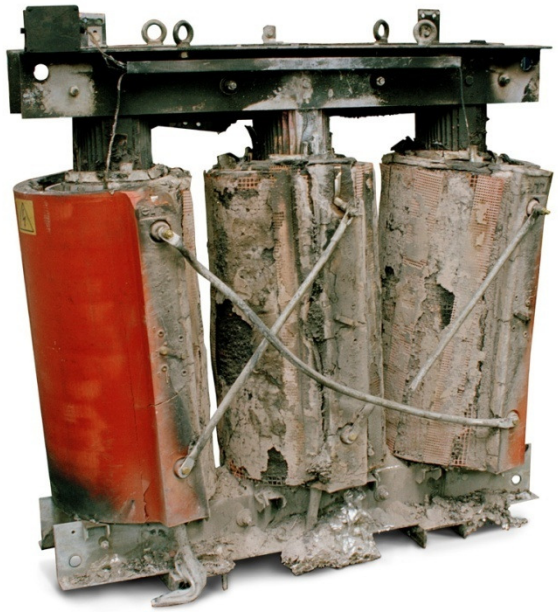
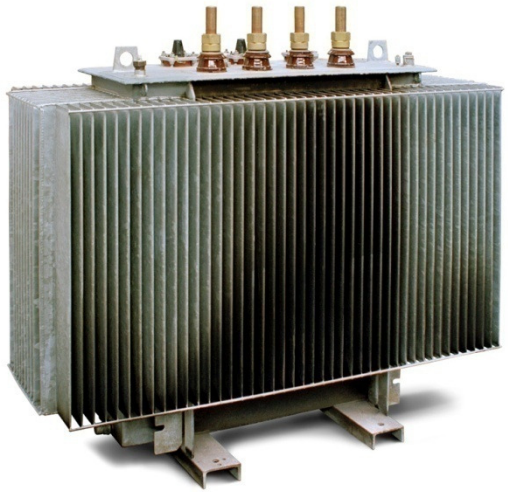
Transformers After Test





APIEZON METROSIL MIDEL WOLFMET

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Conclusions

- Cast resin transformer burned in test and continued to burn after external heat sources were removed
- K-class fluid filled transformer did not burn or contribute to the fire
- K-class fluid filled transformer has excellent resistance to fire
- Smoke production in this case is higher for cast resin since the fluid filled transformer did not burn

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Conclusion

- Cast resin transformers offer a fire safe solution, which is unlikely to spread fire to other areas
- K-class fluid filled transformers also similarly offer a fire safe solution, which is unlikely to spread fire to other areas
- Cast resin transformers will produce smoke if exposed to fire
- K Class fluids are less likely to produce smoke, as they are harder to burn
- Cast resin transformers have been the source of fires
- There are no reported K Class transformer fires in > 30 years of use

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Other Reasons to Choose K Class Fluid

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Maintenance

- Dry type transformers, including cast resin are less suitable for dirty, dusty environments
- Regular cleaning is required
- Cleaning is necessary to prevent the build up of flammable materials and maintain adequate cooling
- Deposits can lead to PD and eventually increased fire risk
- Fluid filled transformers do not require regular cleaning as there are no exposed coils
- In case of major fault fluid filled transformer coils can be repaired
- Cast resin coils cannot be repaired and must be replaced

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Efficiency

- Fluid filled transformers are typically more efficient than dry type transformers
- No load losses are higher, increases running costs, especially in low load periods
- Forced cooling rating of dry type units may be higher than liquid filled, but has knock on effect for efficiency
- When running in forced air cooling mode dry type transformers have much higher losses
  - For transformers operating at 133% of self cooled rating losses will be nearly 1.8 times higher than self cooled losses

M&I MATERIALS

Longer Operating Life

- Mineral oil filled transformers are well established technology with a long operating life
- K-class synthetic esters are very robust and likely to give longer service life
- Cast resin lifetime is unknown and in the past reliability has been called into question

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Ease of Recycling

- Fluid filled transformers can be recycled
- It is possible to recycle cast resin transformers, but the costs are higher due to the need to separate the resin from the conductors
- This adds to overall lifetime cost of cast resin transformers
- Increase environmental impact as a greater proportion of the material must go to landfill with cast resin

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Other Considerations

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Installation of Cast Resin Transformer

- Cast resin will run hotter than fluid filled unit
  - Standard temperature rise at full load is higher for cast resin, compared to fluid filled, 80˚C vs. 65˚C
  - Requires extra cooling of ambient air
- Cast resin cannot use remote coolers
  - Any cooling equipment must be mounted on the transformer enclosure to cool the incoming air
  - Fluid filled transformers allow the option to have remote coolers and pump the fluid around the system
- Cast resin coils are exposed
  - Requires an enclosure in many installations which makes it prohibitive to be used indoors mostly
  - Must be protected from harsh environments

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Noise Level

- According to **Patrick K Dooley***, cast resin transformers typically have a higher noise level than fluid filled
  - Cast resin 1 – 1.5MVA 65dB
  - Fluid filled 1 – 1.5MVA 59dB

- How is this perceived?
  - Twice the loudness feeling is obtained by an increase of the (loudness) level of about 10 dB
  - *Reference - Sengpielaudio.com*

- Given above noise levels cast resin transformer would sound around 1.5 times louder than fluid filled

- May be relevant in noise critical locations

- ** IEEE – A comparison of Liquid Filled and Dry Type Transformers for Industrial Applications*

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Purchase Cost Comparison

- Comparison between cast resin dry type transformer and K-class fluid filled transformer
- 11kV distribution class transformers
- Based on data received from BRPL and Reliance Power

Type of Transformer	630kVA	990kVA	20 MVA
Dry Type	INR 11.0 Lacs	INR 15.0 Lacs	INR 4.5 Cr
MIDEL 7131 Fluid Filled	INR 9.2 Lacs	INR 10.5 Lacs	INR 1.95 Cr

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Losses and Lifetime Cost

- No load losses typically higher for dry type transformers
- Adds to lifetime cost of transformer
- Especially critical in low load conditions
- Capitalisation cost, based on factory transformer, 25 year lifetime
  - Cost of NLL = INR 3.18 Lacs per kW, cost of LL = INR 0.66 Lacs per kW

	Dry Type 1MVA	**Fluid Filled 1MVA**
Total Cap. Cost due to NLL and LL	INR 17.5 Lacs	INR 14.3 Lacs

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User Experience

- Oil filled transformers in use for 100+ years
  - Users have experience of operation and maintenance
  - K-class fluid filled transformers have the same operating parameters
  - Maintenance requirements lower for K class fluid filled synthetic esters transformer (Ref IEC 61203)
  - Long term behaviour better understood

- Cast Resin Newer Technology
  - Users have less experience with the technology
  - Operation in dusty environments requires regular maintenance
  - Fire safety will depend on correct maintenance (see IEC 61936)

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Maintenance of Transformers

- Cast resin requires periodic cleaning in dusty environments
  - HV coils create static field, which attracts dust
  - Risk of surface flashover due to dust and dirt build up
  - Impact on fire safety if not regularly cleaned
  - Must shutdown to perform maintenance
  - Alternatively enclosure with filters and fans required, also needs maintenance (Very Necessary in High Ambient Temperature Environments)

- Fluid filled transformer does not require cleaning
  - Tank acts as enclosure
  - Not affected by dusty and dirty environments
  - Fluid maintenance is reduced for K class fluids

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Repair of Failed Transformers

- In the case of failure coils may need to be repaired
- K-class fluid filled can be repaired in same way as oil filled
  - Need to drain fluid to access windings
  - Existing repair infrastructure can be used
- Cast coils cannot be repaired, whole coil must be replaced
  - Whole coil can be removed relatively easily
  - May not be practical in-situ depending on location
  - Repair likely to be more expensive than fluid filled and has to be carried out by OEM.

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Overload Resistance

- Ability to withstand overload based on efficiency of cooling
- Fluid filled cooling is more efficient and allows higher short term overload without failure of insulation

- IEC 60076-7: Loading guide for oil immersed power transformers
  - Section 7.1 Current and temperature limitations
  - Normal and cyclic loading current limit 1.5 times
  - Long term emergency loading current limit 1.8 times
  - Short term emergency loading current limit 2.0 times

- IEC 60076-12: Loading guide for dry type power transformers
  - Section 6.1 Current and temperature limitations
  - Current limit 1.5 times to avoid mechanical damage to windings
- Current limits apply irrespective of temperature limits

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Diagnostics

- Fluid filled have the possibility for fluid sample
  - Fluid sample can be taken online
  - DGA, BDV, Moisture Etc
  - Fluid condition indicates transformer condition
  - Monitor temperature

- Cast resin
  - Monitor temperature (With RTD's that leads to higher maintenance)
  - Use PD detectors (susceptible to background noise)

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Conclusions

- K-class fluid has 30+ year history of use in indoor and high risk locations around the world
- Allowing the option of K-class fluid filled transformers indoors **as well as** dry type brings the following benefits
  - Fire safety is equivalent between the technologies
  - Allowing K-class fluid filled widens the tendering scope
  - Allows utilities to choose the best solution for each case
  - Using fluid filled reduces capital and running costs
  - Where existing or new buildings cannot fit cast resin, K class fluids give an alternative which is superior in fire safety
  - Capital Costs reduced and therefore may be a less burden on the consumer thereby a Service to the Society

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Thank-you for listening

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APIEZON METROSIL MIDEL WOLFMET

25th February 2016, Puneet Arora – Head, Marketing & Sales, Dry Transformers

Duration: 15 mins

Essentials for Indoor Transformer installations

ABB India Limited, Savli, Vadodara

Indoor installation options
Content agenda

1. Introduction
2. Less-flammable insulating liquid requirements as per NEC
   A. NEC Section 450.23 requirements
   B. Underwriters Laboratories classification requirements
   C. FM Global requirements
3. Dry Transformers
   A. Check Multiple benefits
   B. Value proposition
   C. Low maintenance technology
4. Dry Transformer Vs. Ester Oil Transformers
5. High level summary

Distribution transformers from ABB







- ABB is globally the leading transformer manufacturer in both Power and Distribution area
- ABB is committed to develop all its products to meet the ever more demanding environmental and higher efficiency requirements
- ABB offers a complete portfolio of distribution transformers fitting any customer need, specification requirement and demand
  - Liquid filled distribution transformers – Ester Oil
  - Dry transformers

In this presentation we focus on
Indoor installation Distribution Transformers

Indoor installation options as per NEC
Less-flammable Liquid-insulated Transformers

Transformer rated ≤ 35 kV, installed in a non-combustible building with no combustible materials stored in area.

NEC Options

- Indoor installations using less-flammable liquid-insulated transformers must comply with NEC Section 450.23,
- Both liquid confinement, and either of the following listing requirements:

  A. Underwriters Laboratories

  B. FM Global;

or

- Both liquid confinement and auto-extinguishment;

or

- Vault per NEC 450, Part III

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Less-flammable Liquid-insulated Transformers NEC Section 450.23 requires:

- Liquid confinement area. Liquid confinement may include:
  - Containment pan
  - Curbing
  - Room containment (e.g. door sill) **AND**
- The transformer be filled with a listed less-flammable insulating liquid with a minimum 300 °C fire point **AND**
- The installation complies with all restrictions provided for in the listing of the liquid

If the installation cannot meet the liquid listing requirements

- Provided with an automatic fire extinguishing system and a liquid containment area **OR**
- Installed in a vault complying with NEC 450 Part III, Transformer Vaults

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Less-flammable Liquid-insulated Transformers Option A: UL Classification requires

- Tanks capable of withstanding 12 psig without rupture
- Pressure relief devices with minimum pressure relief capacity per the UL Classification Marking
- Transformer primaries be protected with overcurrent protection options per the UL Classification Marking
  - Option I, allows internal expulsion fuses only if in series with current limiting fuses
  - Option II allows stand-alone expulsion fuses, but they must be located outside the transformer tank.

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Less-flammable Liquid-insulated Transformers FM Global requirements:

- Minimum 3 ft. clear from building walls, and
- Liquid containment provisions, and
- Room fire resistance rating based on fluid and transformer type, and
- Room ventilation, if necessary, to prevent non-thermal damage, and
- Smoke detection with alarm in the electrical room

Less-flammable liquid-filled transformers must comply with one of the following:

- Be FM Approved or equivalent, or
- Be located in a room with a one hour fire resistance rating, or
- Have automatic sprinklers above the transformer and 20 ft. beyond with a discharge density of 0.20 gpm/sq. ft.

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Less-flammable Liquid-insulated Transformers FM Global requirements:

FM Approved Transformer:

- Equipped with specific design and protection features to be FM Approved or equivalent
- Key characteristics of this protection system are fire properties of the liquid, the ability to mechanically withstand pressure generated by a low level electrical fault and the ability of electrical protection to clear a fault before tank rupture.

According to FM Global Standard 3990, the key protection features are as listed below. Refer to the FM standard for complete requirements:

- Tank rupture strength shall be a minimum of 15 psig for rectangular and 20 psig for cylindrical tanks. Tanks to withstand a pressure of 7 psig without permanent distortion, AND
- Pressure relief device to vent internal over-pressures. The device must be capable of venting a minimum specified flow rate, based on the kVA
- Proper pressure venting coordinated with proper tank pressure withstand rating has proven highly effective in preventing tank rupture from overpressure due to internal fault currents below the trip rating of primary circuit current limiting fuses, AND
- The unit is filled with an FM Global Less-Flammable fluid* to reduce the probability of ignition of the liquid
- Less-Flammable fluids, also known as high fire point or fire resistant liquids, are dielectric coolants that have a minimum fire point of 300 °, AND

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Less-flammable Liquid-insulated Transformers FM Global requirements:

- Over-current protection which limits the let-through current (I2t) to a specified maximum value.
- Current-limiting fusing and its functional equivalents are designed to interrupt a high current internal fault before the tank withstand pressure level is reached. If protection is designed to vent gas during operation, such as with expulsion fuses, this protection shall be located outside the transformer tank. Exception: Envirotemp FR3 fluid-immersed expulsion fusing (e.g. bay-o-net) may be mounted in the transformer tank if in series and properly coordinated with current limiting fusing, AND
- The transformer shall have an additional nameplate with the FM Global mark with the following data: tank pressure rating, fuse part number, pressure relief device part number, and requirements particular to the type of installation.

Excerpts: 2008 Code Options for the Installation of Listed Less-Flammable Liquid-Filled Transformers

Dry-type transformers
Check the multiple benefits

Safety for people and property:

- No fire hazard
- Non flammable and self extinguishing
- No special safety features required

Ecological and environmental safe:

- Environmentally conscience manufacturing (process and materials)
- Able to be installed closer to the point of consumption, reducing load cable losses
- No risk for leakage of insulation fluids, no ground or water contamination

Maintenance free

Reliability and quality:

- 40 years' experience
- Several hundred thousand references
- Long transformer life
- Optimized design
- Specialized factories
- Well suited to damp or polluted areas
- High short-circuit current strength
- High capacity to support overloads
- High performance in case of seismic events
- Withstands the most severe rolling and vibrating conditions
- Virtually maintenance free

Easy and fast installation

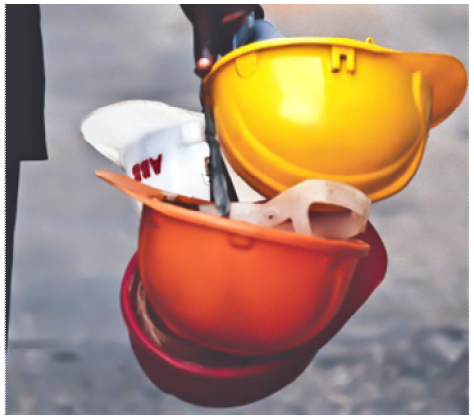
- Less civil work needed

Assurance of dry-type transformers
Value proposition

Non-Flammable	**Environmentally Safe**	**No Containment Needed**
Best lead times: Product & Drawings	**High Reliability**	**Lower Insurance Premiums**
Ease of Installation	**Extreme Environments**	**Minimal Maintenance**

Vacuum cast coil
Low-maintenance technology

- Vacuum cast-coils are hermetically sealed with smooth surfaces that resist dirt accumulation – less frequent and easier cleaning
- Added dry-type benefits:
  - No possibility for leaks
  - No annual testing required
  - No gaskets to replace


Transformer technology comparison
Easter Vs Cast Resin

Technology		Susceptibility of VCB Transients	Size / Footprint (SQ-FT)	Weight (lbs.)	Efficiency (ex: 2000 kVA)	Maintenance	Pros	Cons
	**FR3 Filled**	Medium	54	18500	High 99.46%	Monitor oil level, temperature (monthly)	Higher fire / flash point than oil	Increased size and weight
						Check connections (annual)	Environmentally friendly	Will burn at higher fire point
						Oil sampling (annual)	Greater tolerance to moisture	No spill cleanup benefit over oil
						Monitor vacuum pressure gauge (monthly)	Good dielectric properties	
	**Cast**	Medium	59	15100	High 99.36%	Check connections (annual)	Non-flammable	Air is a poor thermal conductor
							No fluid leaks	Lower thermal capability
							Hermetically sealed windings	
							Environmentally friendly	

[1] Cost of containment pan is included in the first cost for purposes of this comparison since it is being included in the transformer BOM.

Transformer technology comparison
Ester Vs Cast Resin

Technology		Susceptibility of VCB Transients	First Cost	Supplementary first-cost item	Supplementary Installation Costs	ANNUAL Maintenance cost	Safety risk	Total Ownership Cost
	FR3 Filled	Medium	$1.20	Containment[1]	$3,000.00	$4,600	$1,969	High
				Fire suppression	$2,500.00			- Containment Systems
								- Fire suppression
	Cast	Medium	$1.32	Footprint impact vs oil	$0.00	Negligible	N/A	Low
								- No containment
								- No fire supression

[1] Cost of containment pan is included in the first cost for purposes of this comparison since it is being included in the transformer BOM.

Indoor installation options
High level summary

- Dry Transformers don't need maintenance, containment tank, special civil works etc.
- In USA or Europe it's much more tricky to install oil transformers than for a dry
- In all developed and industrialized countries: North America, Europe, Middle East, Asia Pacific (Japan, Korea, China, Australia, Singapore, etc) Dry transformers are the most used solution for indoor installations in buildings, airports etc...
- The other regions are following the trend and installing mainly Dry transformers on indoor solution (Egypt, Saudi Arabia, Brazil, South Africa, Indonesia...). The more the countries develop their economy the more are exclusively going toward a Dry transformer solution for buildings, airports, shopping malls, hospitals...
- Less-flammable liquid transformer is rarely used for indoor installations and in the few cases where that is used the regulation are quite strict and requires a number of civil works, plus maintenance to use that
- Incase of any internal arc faults, extremely hot oil (360^{o} C) is expelled out – Shall be dangerous for people around
- Incase of replacement of Mineral Oil Transformers with Less-flammable Liquid insulated transformers, it is difficult to maintain room fire resistance rating
- Appropriate only for Sealed or Positive Pressure Dry Nitrogen Equipped Tanks

Something to consider…
Thank you for your attention!!

Power and productivity
for a better world™

DuPont Technical Presentation

Open Ventilated Dry Transformers

The miracles of science™

Agenda

1. About DuPont

2. Nomex® engineered Open Ventilated Dry Type transformers

3. Comparison of OVDT & CRT transformers

About DuPont

Vision

To be the world's most dynamic science company, creating sustainable solutions essential to a better, safer, healthier life for people everywhere.

DuPont's 13 Businesses

- Pioneer Hi-Bred
- Crop Protection
- Nutrition & Health

- Protection Technologies
- Building Innovations
- Sustainable Solutions

- Electronics & Communications

- Performance Polymers
- Packaging & Industrial Polymers

- Titanium Technologies
- Chemical & Fluoroproducts

- Applied BioSciences

- Performance Coatings

DuPont Protection Technologies


Energy


Medical


Government


Worker Protection


Automotive


Performance Materials

Nomex® Paper

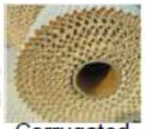
Fabricated Parts & Specialised Forms


Pressboard


Crepe Paper


Fabricated Parts


Cooling Dust Sticks


Corrugated Paper


Coated Paper


Wrapped Conductor

Main Applications

- AC/DC Motors
- Gas Filled Transformers
- Generators
- Liquid Immersed Transformers
- Open Ventilated Dry Transformers
- Reactors
- Resin Cast Transformers

End Users

- Industrial
- Traction
- Automotive
- Aircraft
- Hermetic

Nomex®
brand fiber

Kevlar®
brand fiber

Tyvek®
protective materials

Tychem®
protective garments

Sontara®
spunlaced products

Why are we here today?

To address the Major concerns in Power Distribution

Major Concerns in Power Distribution

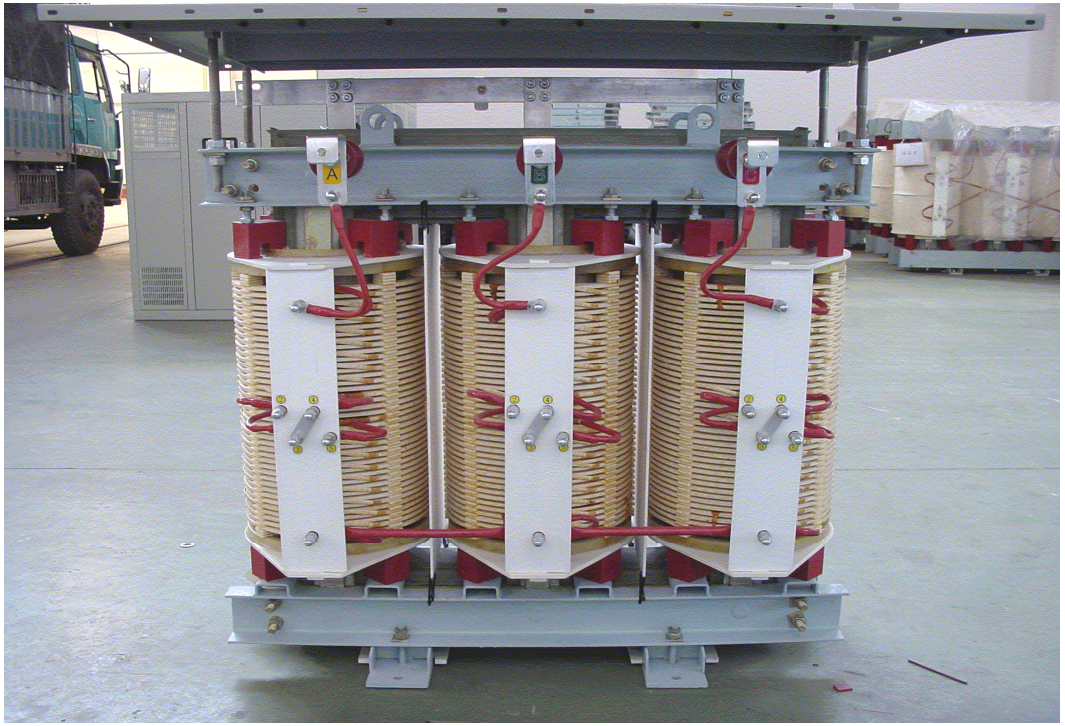
- **Safety of the equipment against fire**

- **Maintenance**

- **Reliability of the electrical equipment**

Nomex® based technologies can help you overcome these challenges

Nomex® Engineered Open Ventilated Dry type transformers



Open Ventilated Dry Type Transformers

Why Dry Type Transformers In the Process Industry?

✓ Safety

No flammable liquids, hence less risk of fire

✓ Less Maintenance

No issues of oil leakages. Dry type require very less maintenance as compared to oil filled ones

✓ Can be placed near to the load

Higher cost of low voltage bus and cables can be reduced, if high voltage lines can be brought close to load. This is possible if the transformer is lesser degree of fire risks

✓ Overload capabilities (for OVDT)

In Liquid filled the heat transfer is a 2 stage process – from conductors to oil and from oil to environment. In case of OVDT, the heat is directly transferred to air. Hence it can withstand brief higher overloads

✓ Aesthetics

As there is no radiator tanks in Dry Type, its easier to terminate bus work in any desired location, making switchgear coordination simple as well as aesthetically pleasing. Often disconnecting chambers are required for liquid filled, which add up costs. For Dry Type there are no issues of safety/ aesthetics compromise due to oil leakages

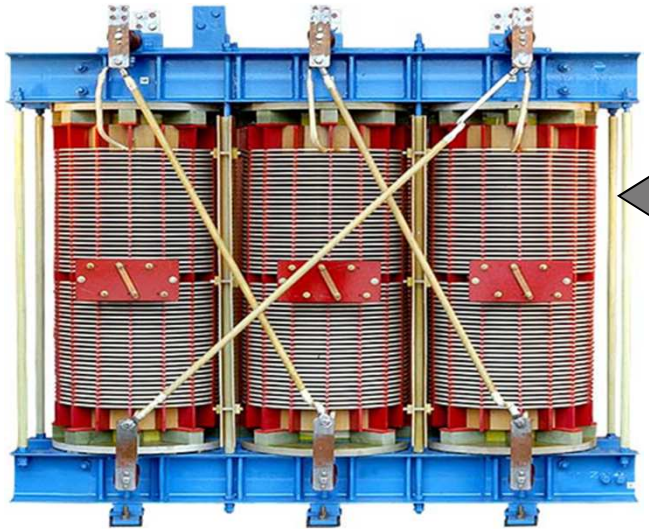
✓ Compact – Space utilization

Even though core and coils of Dry Type are of larger size of corresponding oil filled unit, but as dry type do not require cooling radiators, the over all size is reduced

DUPONT

What do we have to offer ?

ReliatraN™



DuPont™ Technology

Certified Manufacturers

Kotsons

GE Prolec

Sudhir Intra Vidyut Ltd

ReliatraN™ Manufacturing Process

Insulation

✓ ReliatraN™ transformers are Class H Transformers, with Nomex® (class 220 Deg C) on the windings and between the layers

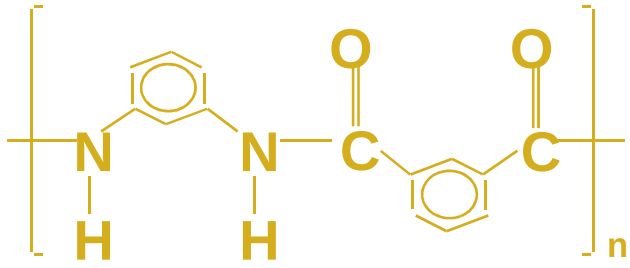
✓ Highest quality higher temp. material are used like silicon coated Fiber Glass, glass fiber dog bones etc.

✓All materials either exceed or meet UL, IEC, IS standards for Dry Type Transformers

Nomex®

Nomex® aramid has been used as the primary insulating material for electrical equipment applications since the 1960's.

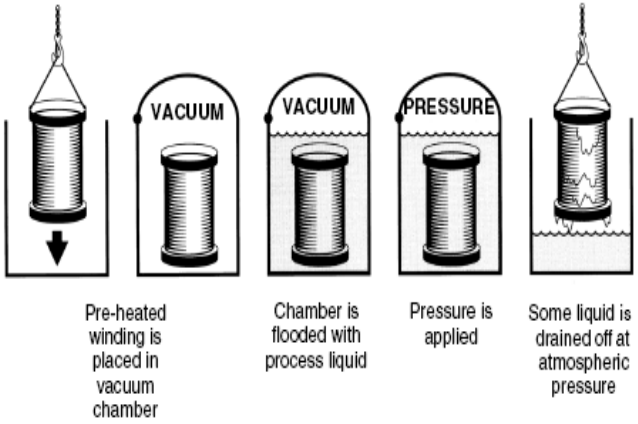
- ✓ Certified **Long Term** Stability up to **220℃**
- ✓ **Short term** exposures up to 350℃ is possible
- ✓ Will not Melt, Flow, or Support Combustion below **250℃**
- ✓ Contains **no toxic or corrosive off-gases**
- ✓ **Low Dielectric Constant** enables better distribution of stresses
- ✓ **Low Dissipation factor** reduces potential of dielectric losses
- ✓ **High Resistivity** even up to 250℃ makes it an superior insulator

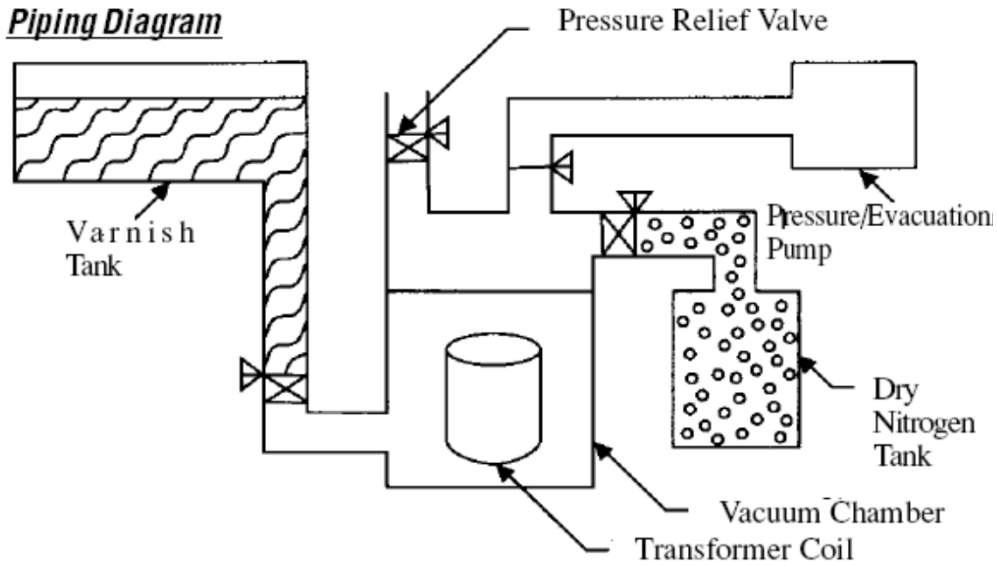


ReliatraN™ Manufacturing Process

Vacuum Pressure Impregnation (VPI) Process

ReliatraN™ transformers are designed to maintain the integrity of the dielectric properties of the insulation materials over a long period of time. This is obtained by a VPI process.





Vacuum Pressure Impregnation Technology (VPI) provides reliable operation in hostile environments, such as dust, moisture, dirt, chemicals and other contaminants and pollutants.

The VPI process fully penetrates and seals the coils into a high strength composite structure for complete protection

Coils sealed with VPI Technology vs. molded construction provides maximum flexibility in design to allow conformance to the most critical needs of the user for the widest range of applications

Addressing Reliability

Thermal Ratings

What are the different of thermal ratings on the transformers ?

The thermal classification of transformers represent the highest temperature the electrical winding can accept while operating at the highest load condition (Hot Spot) and should have insulating materials which at least match this rating

Highest Temperature = Average Winding Rise (K) + Max. Ambient +Hot Spot Allowance

What does it mean in INDIA?

This means the insulation system must be rated to match the hottest temperature of the winding, not just the average winding temperature (IEC 60726)

Temp. Class	Avg. Winding Temp. Rise	Maximum Ambient	Hot Spot Allowance	Hottest Temp.
Class B	70	50	10	130
Class F	90	50	15	155
Class H	115	50	15	180
Class R	140	50	30	220

Addressing Reliability

Life Expectancy

IEEE
Std C57.96-1999

IEEE GUIDE FOR

1.3 Transformer life expectancy

Recommendations in this guide are based on life expectancy of transformer insulation as affected by operating temperature and time.

Transformer life expectancy at various operating temperatures is not accurately known, but the information given regarding loss of life of insulation is considered to be conservative, and the best that can be produced from present knowledge of the subject. (The effects of temperature on insulation life are being investigated continuously, and new findings may affect future revisions of the guide. The word *conservative* is used in the sense that the expected loss of insulation life for recommended load will not be greater than the amount stated.)

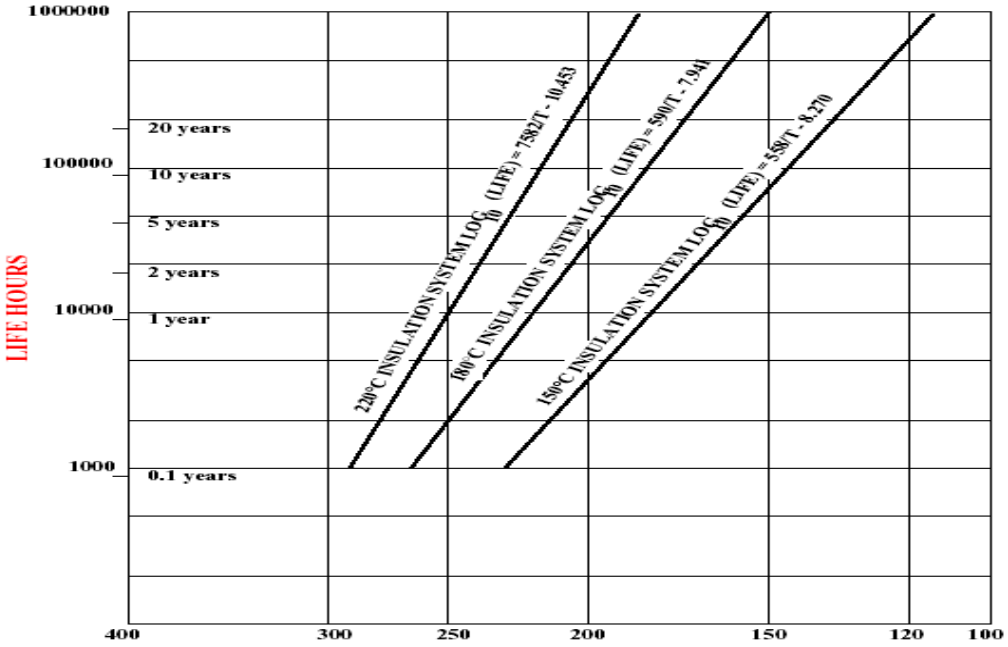


Figure 1—Life expectancy curve—base 10

Note: In general, life span of transformers in most of standards (ANSI/IEEE, IEC, UL) depends on insulation around conductors. So, we use data of insulation materials to predict life span of dry type transformers based on ANSI/IEEE C57.96

If we calculate life expectancy of class H VDT with Equation (1)

Log life (t) = (B10/T) + A10

Where

T = 170 + 273 = 443 K

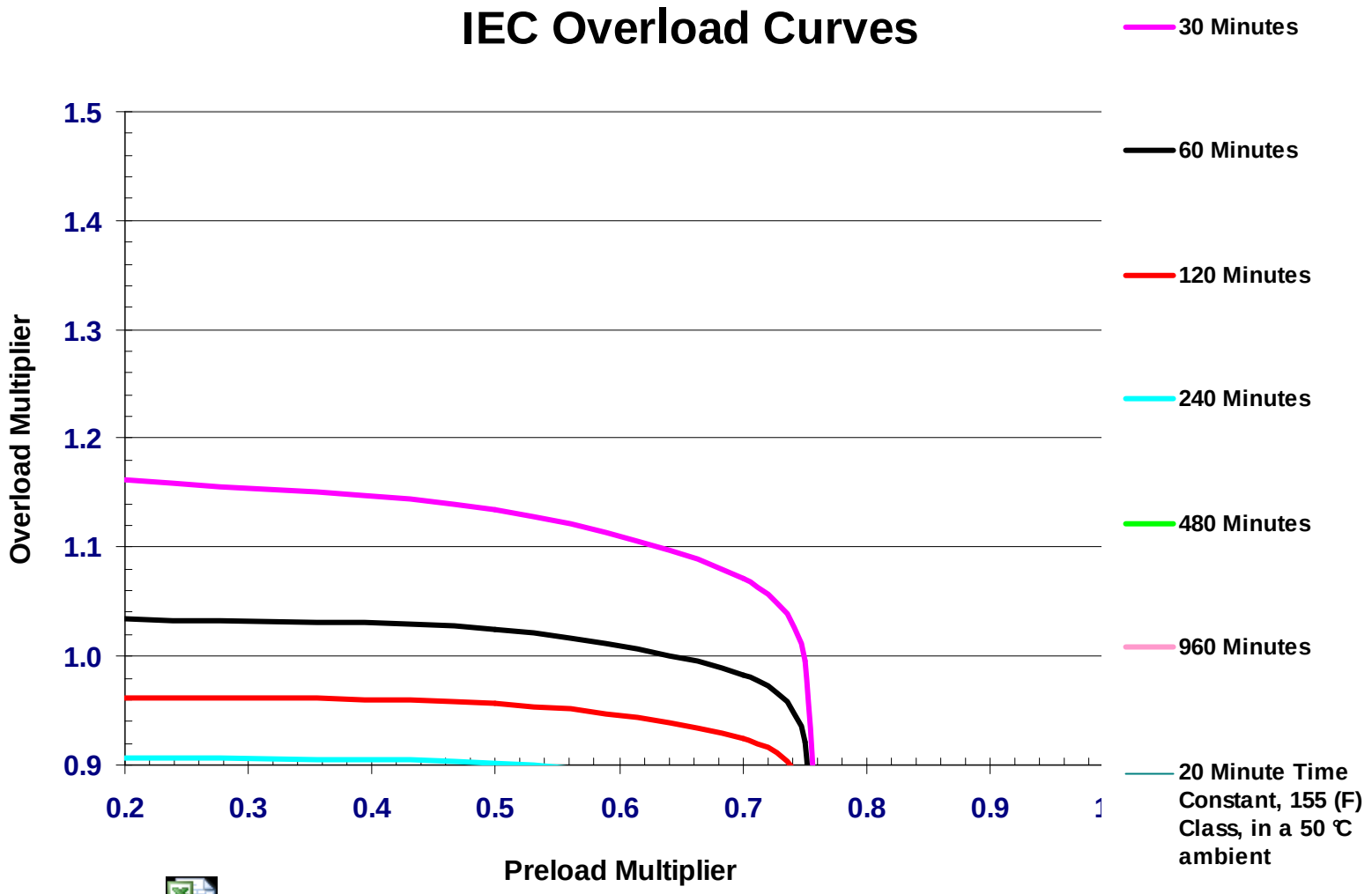
Then , log life (t) = (7582/443) - 10.453

= 6.662

So, t = 4,591,980 hrs = 524 years

This is a case of 115C winding rise with 220 insulation system

Loading Guide



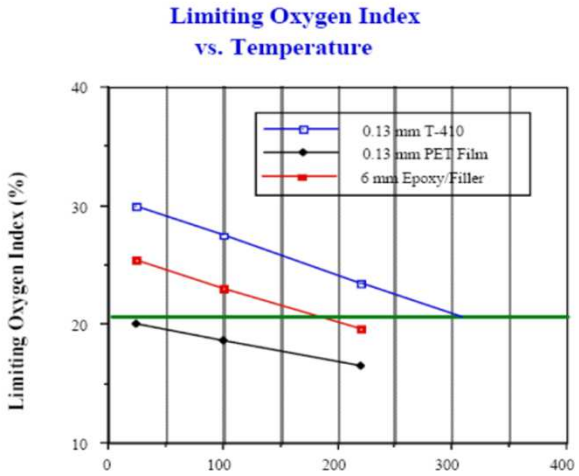
Microsoft Excel Worksheet

Partial Discharge

• The Partial Discharge in a transformer is the corona discharge which happens on the conductors/active part

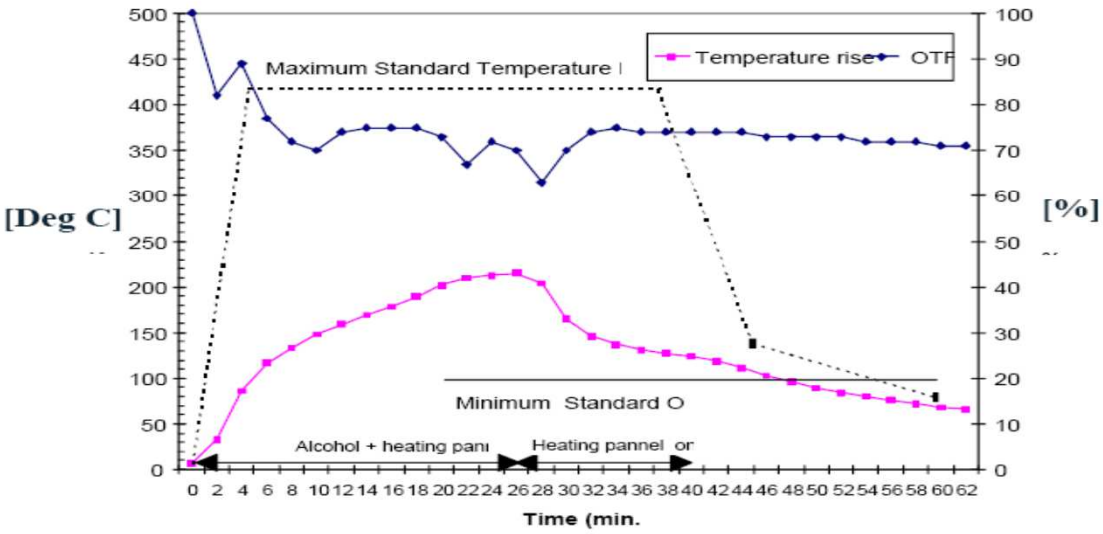
• The Industry norms are now moving towards having less than 10 Pc for dry type transformers

Addressing Fire Safety



Fire Behavior Test

Fire Test Behavior According to IEC60076-11
Temperature Rise and Optical Transmission Factor [OTF]



Effect of Humidity and Water

1. ReliatraN™ Ventilated Dry Type Transformers (VDT) are well protected from invasion of water

2. Nomex® insulation is fully coated with varnishes for usage at 180℃ and higher with VI or VPI Coils are fully sealed from the environment

3. Nomex® is not adversely effected by water, even if it does become exposed to 95% RH
   - Retains 80% of dielectric strength
   - Retains low dielectric constant and dissipation factor
   - Retains superior volume resistivity

4. The US Navy specifies VDT transformers insulated with Nomex®

Status of windings of OVDT transformers after 72 hours in water (Worked perfectly fine just after drying)

ReliatraN™ Testing and Standards Conformation

Underwriter's Laboratories (UL) qualifies dry transformers under UL 1561 and UL 1562. These are based on IEEE C57 and establish Insulation Thermal Index under C57.12.56

CENELEC HD-464 used for certification of dry type transformer climate, environmental & fire performance; Thermal Index of insulation systems will be established under TC-98

The specification is near identical to IEC60726 but includes three main criteria to enhance the safety of the equipment in operation:
(i) Environmental (pollution level)
(ii) Climactic (Severe temperature exposure)
(iii) Flammability (smoke, gas toxicity, after burn)

IEEE Standard C57.12.56 & C57.12.60

Model Coils or Full Size Coils are aged at high temperatures for accelerated aging by ovens or by resistance heating (3 or 4 temperatures)

After each aging cycle, coils are tested:
Thermal shock to - 30 C for 2 hours
Humidification at 95% RH for 48 hours

Electrical Testing

Impulse dielectric test at 75% of rated BIL
Applied or induced voltage at 100% of rated tension
Continuous, repeated aging cycles until failure - Plot arrhenius curve of temp. vs. time of failure to determine the thermal index of insulation system.Based on this test, VDT units are rated for outdoor use

Comparison of OVDT with CRT

Parameters	OVDT	Cast Resin
Maintenance Free	Yes	Yes
Short Circuit Strength	Yes	Yes
Outdoor Application	Yes	Yes
Insulation Temp. Class	220^{o} C (Class C)	155^{o} C (Class F)
Max Temp. rise (^{o} C)	140	90
Partial Discharge	No mandatory test as it is free of partial discharge	Mandatory test as there is a possibility of partial discharge
Overload capability	20%	0%
Reparability	Easy	Impossible
Smoke & toxic gases	Reduced smoke. No toxic gases	More smoke. Toxic gases emitted
Quality dependency on mfr process	Simple process. Less sensitive to human & equipment errors	Complicated. Highly sensitive to human & equipment errors
Cracking of coils	Not possible	High possibility during handling & operation
End of life recovery/disposal	All copper recovered	Copper Impossible to recover. Coils have to be buried

Transformers – Buying Smart. Having the right Specs!

1. Indoor Application – Always use a dry type transformer, and that too preferably OVDT because of its inherent Fire retarding nature

2. High dependence on Transformers – OVDT far outscores all other technologies in terms of reliability

3. Environmental Friendly – OVDT is the most environmentally friendly transformer technology

Thank You!