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# Critical Investigation of Minimum Field Conductor for Overhead Transmission Lines

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**Abstract:** This paper explores the increase in power demand and the increased need for transmitting huge amount of power over a long distance. Large transmission line configurations with high voltage and current levels generates large value of electric and magnetic field stress, which affect the human being and the nearby objects located at ground surfaces. Apart from human effect, the electrostatic coupling and electromagnetic interference high voltage transmission lines have impact on plants and telecommunication equipments mainly operating in frequency range below UHF. The voltage level of high power transmission lines are 400KV, 230KV, 110KV, etc. This field can be minimized by re-designing the existing conductor by adding composite materials in it and comparison of EMF between existing and new conductors are being considered.

**Key words:** Epoxy · Nanomaterials · Dielectrics · Breakdown voltage · Resistivity. Liquid dielectrics · Tensile strength

## INTRODUCTION

This paper presents an effect of the electric component of an Electro Magnetic Field (EMF) of 50 Hz, originating from over ground 110 kV power line, on humans in its immediate vicinity. In this project, the electric field, which penetrates the human body, was calculated with the assistance of a human model, comprising of blocks, which symbolize different human structures or body fragments (brain, digestive organs, lungs, etc.).Based on their electromagnetic features (magnetic and electric permittivity, conductivity)the spreading of the electric field adjoining the human beings will be specified, as well as the values of the field, which penetrates humans etc. This field can be minimized by re-designing the existing conductor by adding nano particles by means of coating in it.In addition, comparison of EMF between existing and new conductors are analyzed [1]. A detailed reviewing on the consequence of thermal aging on insulation dielectric strength is studied. Aging of the insulating samples was conducted at three different times and temperatures. The study exhibited that dielectric strength might not be considered as a parameter to realize the thermal index [2]. The recommend of comprehensive theoretical preparation connecting geometrical parameters of the insulation and the maximum thermal voltage (MTV) is studied [3]. A relative life tests upon base and nanostructured epoxy resin models are performed. Specimens were subjected to ageing under surface discharge phenomena using CIGRE method II (standard electrode configuration). Extensive life of the nano composite materials are explained [4]. Cross-linking response under oxidant atmosphere is projected for illumination of electrical enhancements. Encouraging an improvement of the electrical and mechanical properties is sustained by FTIR chemical changes of PI during aging [5].

A comparison is made on the surface roughness produced by partial discharges and which is initiated by revelation to plasmas, between polyamide by and devoid of inorganic Nano fillers [6]. By examining the complex permittivity spectra, Nano filler stacking on the carrier transport and molecular motion in polyamide-6/mica Nano composites were conferred [7]. Polyester and polyesterimide mixtures for impregnation of electrical motors were improved by incorporating titanium dioxide, zinc oxide and fumed Nano silica [8]. The investigational outcomes on accelerated aging of enameled wires by means of Nano filler and without Nano filler in coating under partial discharge were presented [9].

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The evaluation of V-N characteristics and the time difference of lasting thickness of Nano composite enameled wires beneath repetitive surge-voltage application is presented [10].

The man aim is to reduce the electromagnetic field emission of conductors during conductions so as to minimize the harmful radiation emission of conductor and protect the humans, plants, animal from diseases caused by electromagnetic field. Here, work analysis starts with the choosing of overhead conductor with suitable condition for modifications. One of the overhead conductor chosen is ACSR (panther, kundha) 110kv line conductors. The reason for choosing this conductor is due to low cost, highly used, good conductivity, long life, etc. Modification of the conductor can be processed with nano coatings on the conductors. Thus the coating is done with different methods by using different materials.

**Review of Existing Methods:** Copper was the chief metal used to conduct electricity during the course of growth of the electrical industry in the early 1880's. Later, aluminum began to replace copperas the metal of choice for conductors. The first transmission line using aluminum conductor was constructed using a stranded (7-strand) aluminum cable and remained in daily operation for more than 50 years. Preliminary with these initial installations, the use of electrical conductors using aluminum has increased steadily. It ranks second to copper in volume conductivity and possesses a conductivity-to-weight ratio twice that of copper and its strength-to-weight ratio is 30% greater than copper, which paved wayfor a new aluminum-steel composite cable. This novel conductor collectively the lightweight and high current transporting capability of aluminum with the great strength of a galvanized steel core.

Fig. 1: Overhead Conductors

ACSR, as this aluminum conductor, steel reinforced, cablegained rapid acceptance followed by a new all aluminum-magnesium-silicon alloycable. Recently, new alloys have been developed to provide thermal stability,increased conductivity, vibration resistance and other specific characteristics.

**Demerits of Existing Methods:**

- Maximum conductivity is only up to 63.3%
- Life of the conductor is nearly 20 years only.
- Implicated in behavioral changes, birth defects, memory loss and Alzheimer's disease.
- Disturbance in telecommunicationequipment's.
- Headaches, Fatigue, anxiety, insomnia, rashes, muscle pain.
- Risk of damaging DNA.
- Risk of Leukemia and Cancer.
- Risk of Neurodegenerative disease.
- Risk of Miscarriage.
- And also affect the birds,plant life, pipe line,Maintenance Worker and Vehicleparked near line.

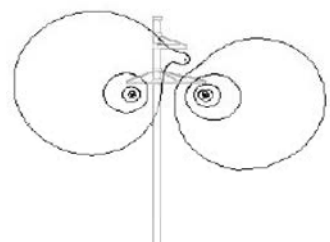

Fig. 2: Field around wires in poles


Fig. 3: Dangerous zone level

In the figure EMF around poles and dangerous zone level are mention. EMF affected around 10 feet from the pole.

**Proposed Methodology:** We propose here a novel system for designing the existing conductor by adding nano particle in it so as to increase the conductivity and to reduce the field emission around the conductor.

The added nano particles should increase the flow of current in conductor and to cool the conductors while conduction such that the heat emissions also get minimized.

By using this method, possible to achieve,

1. Reduce the electric and magnetic field around the conductor.
2. Increase the conductivity above 63%
3. Extensive lifetime of conductor.

Commonly three methods are available for coating on existing conductor with nano particles.

1. Single strand coating of conductor.
2. Layer by layer Strand coating conductor.
3. Outer surface coating of conductor.

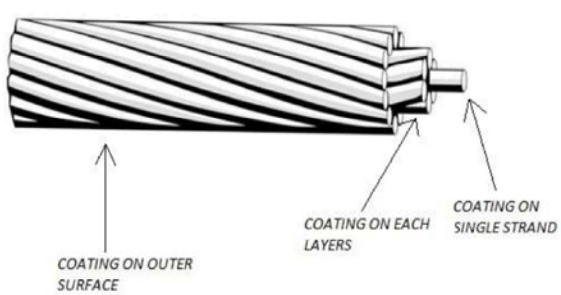


Fig. 4: Various coating techniques

**ACSR (Aluminum Conductor Steel Reinforced):** For analysis, ACSR is taken. ACSR is concentrically stranded conductor through one or more sheets of hard tense 1350-H19 aluminum wire on galvanized steel wire core. The core shall be stranded wire or single wire conditional to the size. For corrosion guard, steel wire core is presented in Class A, B, or Class C galvanization. Further corrosion shield is also available.The proportion of steel and aluminum in an ACSR conductor can be selected based on each application. ACSR conductors combine ruggedness of steel and good conductivity of aluminum with the great tensile strength and the light weight. In line design, this can deliver greater tensions, less sag and lengthier span lengths than obtainable with most other types of overhead conductors. The steel strands are added as mechanical reinforcements. The steel core wires are protected from corrosion by galvanizing. It commonly used in transmission, distribution circuits

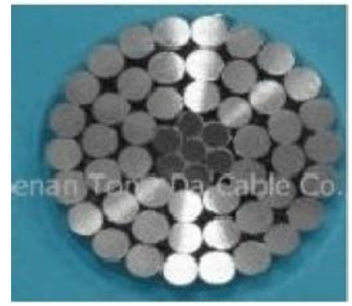

Fig. 5: Front view of ACSR conductor

Compact Aluminum Conductors, Steel Reinforced (ACSR) are used for overhead distribution and transmission lines. The first aluminum to be produced commercially in New Zealand was at the New Zealand Aluminium Smelters Ltd. plant at Tiwai Point, Southland, in April 1971.Aluminium are the root of many types of bare conductors for overhead lines and conductors for insulated cables. According to the final product, several levels of characteristics are proposed as:

1. Hard aluminium -Overhead line conductor
2. 3/4 hard aluminium - Underground cable conductor
3. Aluminium under other states - Other aluminium wire applications

**Manufacturing Process:** Aluminium take placeobviously as the mineral bauxite (primarily a mixture of $Fe_2O_3,Al_2O_3$. $3H_2O$ and $SiO_2$) and is refined in the following procedure.

**Step 1- Refinement of Raw Materials:** Bauxite is excavated at Weipa, in Queensland, then crumpled and wash away to removewater-soluble impurities. The outstanding material is dissolved in NaOH and heated. Where $Al_2O_3$ is selectively dissolved by the reaction

$$6NaOH + Al_2O_3+3H_2O \rightarrow 2Na_3Al\,(OH)_6$$

Certain crystalline forms of $SiO_2$ can also dissolve by the reaction

$$4NaOH +SiO_2 \rightarrow Na_4SiO_4 + 2H_2O$$

These two different species are solvable, but $Fe_2O_3$ is a basic oxide and therefore it is insoluble in this solution and shall be filtered out. Over while the $Na_3Al\,(OH)_6$ decays to $Al\,(OH)_3$ (an insoluble species), which is similarly filtered out.

$Na_3Al(OH)_6 + 2H_2O \rightarrow 3NaOH + Al(OH)_3.3H_2O$

This is then decayed by heating in a temperature beyond 1000°C to give alumina,

$Al_2O_3.2Al\ (OH)_3.3H2O \rightarrow Al_2O_3 + 9H_2O$

**Step 2 –Aluminareduction:** The resultant ($Al_2O_3$) alumina is dissolved in ($Na_3AlF_6$)molten cryolite,making an ionic and electrically conductive solution. This is decomposed by electrolysis, using a consumable carbon anode with two concurrent reactions proceeding rendering to the following equations:

$Al_2O_3 + 3C \rightarrow 2Al + 3CO$
$2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$

The aluminium manufacturedis subsequently alloyeddependent on the requiredproduct. Alloying reagents comprise Cu, Mg and Si and these are added in a metal treatment furnace for the reason that the importance of precise composition control in order toimpart the preferred properties.

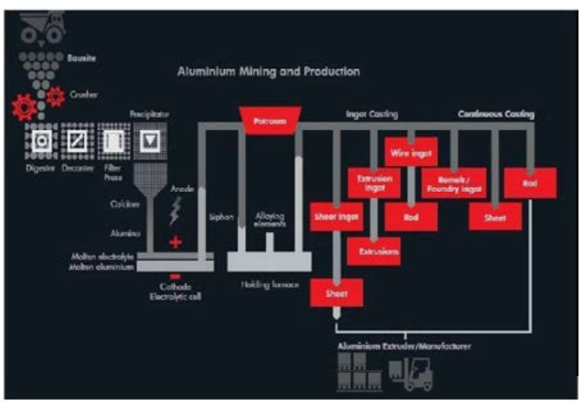


Fig. 6: Aluminum manufacturing process

**SIMULATION:** MAXWELL ANSOFT is used for simulation analysis and Simulation of changing the conducting material to any other conducting metals so that to absorb which metal emits higher electromagnetic field. For simulation 110 KV, 0.5 mm copper conductor and Distance between each phase conductor is 5mm.When changing the conducting material to EC grade aluminium (3 cm size) the field around the conductor, Distance between each phase conductor is 5cm and applied voltage is 110 KV can be analyzed as follow

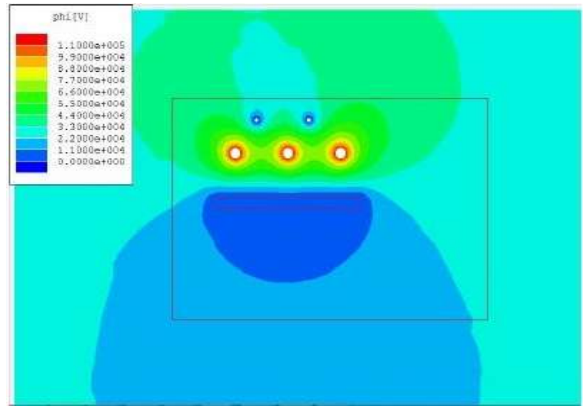

Fig. 7: Field around the conductor when choosing copper as conducting material

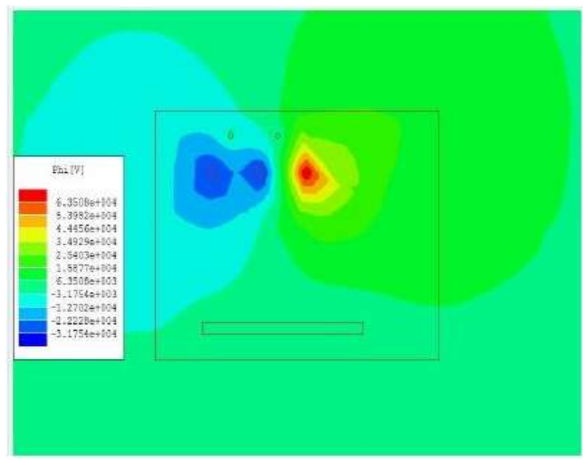

Fig. 8: Field around the conductor when choosing ECgrade aluminium as conducting material

**Review of Nano Particles:** Nanotechnology is a rapidly growing area of importance and interest, incorporating a wide range of research fields. It deals with materials or structures in nanometer scale, typically ranging from sub nanometers to several hundred nanometers. One nanometer is 10-3 micrometer or 10-9 meter. It deals with single nano-objects, materials and devices based on them and with processes that take place in the nanometer range. Nanomaterial's are those materials whose key physical are characteristics are dictated by the nano objects they contain. Nanomaterial's classified into compact materials and nano dispersions. The first type includes nanostructured materials (Moriarty2001), i.e., materials isotropic in the macroscopic composition and consisting of contacting nanometer-sized units as repeating structural elements (Gusevand Rampel 2004). The particles with small size in the range from a few to several tens of nano meters are called quasi zero-dimensional mesoscopic systems, quantum dots, quantized or Q-particles, etc.,(Khairutdinov et al1996). The reason that nano scale materials and structures are so interesting is that size constraints often produce qualitatively new behavior.

For analysis, three types of nano particles are used.

1. Copper nanoparticle
2. White emulsion
3. Epoxy resin

**Copper Nanoparticle:** Nanomaterials are being smeared in more and more ground sinside engineering and technology. One of the crucial benefits of nanomaterials is that their properties differ from bulk material of the similar configuration. The properties of nano particles, for example, can be simply changed by changing their shape, size and chemical environment. Copper is a Period 4, Block Delement. It is a ductile metal with electrical conductivity and high thermal property. The morphology of copper nano particles is round and they look like as a black to brown powder. Copper is initiated to be too soft for certain applications and hereafter it is often pooled with other metals to form various alloys for a sample brass, which is a copper-zinc alloy. Highly combustible solids are copper nano particles therefore; it must be deposited away from sources of ignition. They are similarly known to be very toxic to aquatic life.

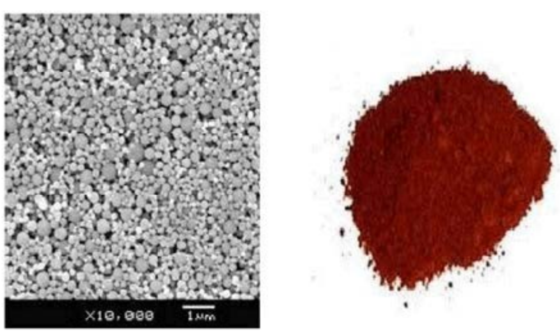

Fig. 9: Copper nanoparticle

Applications of copper nanoparticles are,

1. Acts as anti-fungal agent when added to plastics, coatings and textiles and as an anti-biotic and anti-microbial agent.
2. Copper diet complements with efficient delivery features.
3. High strength metals and alloys
4. EMI shielding
5. Heat sinks and highly thermal conductive materials
6. Effectual catalyst for chemical reactions and for the creation of methanol and glycol
7. As sintering essences and capacitor ingredients
8. Conductive inks and pastes comprising Cu nano particles can be used as a ancillary for very classy noble metals used in displays, transmissive conductive thin film and printed electronics applications.
9. Superficial conductive coating processing of metal and non-ferrous metal.

**White Emulsion:** Emulsion is any liquid, liquefiable, or mastic configuration that, after application to a substrate in a thin layer, alters to a solid film. It is most usually used to guard, color, or offer texture to objects. Paint can be prepared or acquired in many colors and in many diverse types, such as watercolor, artificial, etc. Paint is naturally stored, sold and applied as a liquid, but dries into a solid.

**Epoxy Resin:** Epoxy resin is a chemical that is part of an epoxy resin system. Epoxy resinsystems are used widely in industry because of their chemical resistance, strong adhesive properties and toughness. Common two-part epoxy resin systems contain catalysts/curing agents, epoxy resin and diluents and/or other additives. Any of these chemicals on their possess may cause irritation and/or allergic contact reactions. Curedepoxy resin (the entirely toughened mixture of the epoxy resin system chemicals) must be non-sensitizing andnon-irritating [11].

Uses are,

1. Surface coatings
2. Paint for ships and other marine uses.
3. Primers for cars, Steel pipes.
4. Electrical insulation materials
5. Enclosing transformers, condensers, capacitors and other electrical components.
6. Adhesives and glues
7. Extensively used through many industries for its strong bonding characteristics, e.g. flooring, aircraft, concrete bonding, bridge and road surfacing, automobile producers.
8. Home DIY, hobbyist, artist, sculptors all find many uses for epoxy glues
9. Used in certain dental bonding agents

10. PVC manufacturing - Some vinyl, plastic and PVC products comprise epoxy resins, e.g. vinyl gloves, eyeglass frames, plastic necklaces, handbags.

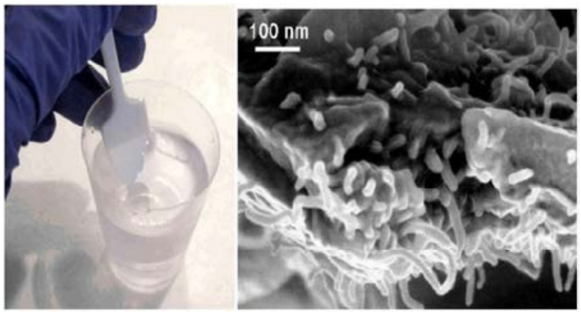


Fig. 10: Epoxy resin

**Experimental Analysis:** This chapter deals with various coating process, testing of conductor and theresult of nanomaterials based coating on the conductor. Field-testing sequences andprocedures are defined by various international standards. Test methods includeIEC, ASTM, IS, BS and other recognized conductor field testing procedures.

Various coating process we done on the conductor are as follow:

1. White emulsion with copper nanoparticles coating
2. Epoxy resin mixed with copper nanoparticles coating

**Coating Process:** The coating to the conductor outer surface can be done with spray coating and dip coating machines. Before the coating some of the following steps are performed them are:

1. The material to be used is taken in beaker of 250ml,
2. The nano particle of copper is added to the materials in small amount of 2.5grams.
3. The mixing of these two materials can be done with the magnetic stirrer
4. In magnetic stirrer the mixer is taken for 3 hour with 20minutes on the stirrer and 15minutes gap. This process is repeated until it gets completely mixed.
5. After the complete stir process the nano material is taken in spray gun for spray coating and in dip chamber for dip coating.

A magnetic stirrer is useful for liquefying solids in liquids. As there are numerous dissimilar appearances, all of them will at least have a base with a speed-controlled spinning magnet interior and an exterior stirring bar. The stirring bar is placed into a container or beaker by kindly sliding it beside the wall of the container. Stirrers are used to stir solutions or pastes: to obtain a homogeneous mixture or to increase the reaction rate.


Fig. 11: Magnetic stirrer

**Spray Process:** Spray coating is done with the help of spray gun and compressor. The material is taken in small amount and spraying process can be easily done on the surface of the conductor. This method of thermal spraying involves the projection of small molten or softened particles onto a prepared surface where they adhere and form a continuous coating. To create the molten particles, a heat source, a spray material and anatomization/ projection method is required.

**Dip Coating Process:** Dip coating is a perfect technique to make thin layers from chemical solutions subsequently it is a low-cost and waste-free procedure that is easy to scale up and deals a noble governing on thickness. On behalf of such reasons, it is fetching more and more popular not only in research and development laboratories, but also in industrial manufacture, as testified by the accumulative amount of annual publications (9, 180 and 480 articles in 1990,2000 and 2010, correspondingly). Despite that, the full potential of dip-coating has not yet been fully discovered and exploited. This paper highlights the recent developments made by tuning the processing settings beyond conventional ranges to prepare more and more composite and controlled nano structured layers. Particularly, how one can take benefit of an precise tuning of the withdrawal speed and of the atmosphere to control the nano structuration devising from evaporation-induced- self-assembly (EISA), organized with the final thickness after a few nm up to 1 ìm from the similar initial solution. A new scheme of deposition, relating capillary induced convective coating that is highly appropriate for the deposition. It will be demonstrated that dip coating is also a compatible method to impregnate porosity, to create nanocomposites [12]. The present confab is illustrated with schemes of interests in domains such as energies, optics, Nano electronics, Nano fluidics, etc.

Fig. 12: Spray process on conductor with white emulsion

Fig. 13: Dip coating machine

Fig. 14: Dip coating with epoxy resin

**Test Results**

**Result 1:** It is a testing of an existing conductor (ACSR –panther 110kv conductor) with 1.5 meter, 3mm diameter.The result are given in table 1

**Result 2:** It is a testing of an existing conductor (ACSR –panther 110kv conductor with copper nano mixed with epoxy resin) with 1.5 meter, 3.002mm diameter.The result are given in table 2

**Result 3:** It is a testing of an existing conductor (ACSR –panther 110kv conductor with copper nano mixed with white emulsion) 1.5 meter, 3.002mm diameter.The results are given in table 3 and comparison results in table 4. The field test result shows that the field around the conductors can be minimized by redesigning the existing conductors with insulating materials in it outer surface. As a result, the epoxy resin with nano particle copper provides good result on conductivity and less field around the conductor.

## CONCLUSION AND FUTURE WORK

We have introduced a novel system for designing minimum field conductor for overhead transmission lines. Our proposed techniques in reducing the field of the conductor show result of field reduction up to 33% of overall emission of field in existing conductor. After the redesigning of the conductor the electromagnetic field emission is minimized and further upgrades and accuracy in result will be obtained in future.

Choosing different material, which exhibits high melting point, can be used withhigh conductivity nano particles with less cost and in efficient manner.

Table 1: Test result of existing conductor

| Apply voltage (KV) | Field at surface (V/M) | Field at 16 cm (V/M) | Field at 26 cm (V/M) | Field at 36cm (V/M) |
|---|---|---|---|---|
| 1.0045 | 1249 | 469 | 324 | 238 |
| 2.220 | 1454 | 489 | 334 | 239 |
| 3.370 | 1693 | 642 | 496 | 350 |
| 4.2613 | 1915 | 750 | 582 | 372 |

Table 2: Test result of coated conductor with epoxy resin

| Apply voltage (KV) | Field at surface (V/M) | Field at 16 cm (V/M) | Field at 26 cm (V/M) | Field at 36cm (V/M) |
|---|---|---|---|---|
| 1.0045 | 1188 | 428 | 316 | 216 |
| 2.220 | 1157 | 472 | 314 | 219 |
| 3.370 | 1447 | 615 | 450 | 300 |
| 4.2613 | 1414 | 646 | 515 | 341 |

Table 3: Test result of coated conductor with emulsion

| Apply voltage (KV) | Field at surface (V/M) | Field at 16 cm (V/M) | Field at 26 cm (V/M) | Field at 36cm(V/M) |
|---|---|---|---|---|
| 1.0045 | 1200 | 430 | 321 | 217 |
| 2.220 | 1247 | 461 | 328 | 230 |
| 3.370 | 1574 | 468 | 419 | 300 |

Table 4: Comparison result

| Applied voltage | Field (V/M) | Existing conductor | Coated conductor with white emulsion + copper nanoparticle | Coated conductor with epoxy resin + Copper nanoparticle |
|---|---|---|---|---|
| 1.0 KV | Field at surface | 1279 | 1200 | 1188 |
| 4.2 KV | | 1915 | 1574 | 1414 |
| 1.0 KV | Field at 16 cm | 469 | 430 | 428 |
| 4.2 KV | | 750 | 468 | 646 |
| 1.0 KV | Field at 26 cm | 324 | 321 | 316 |
| 4.2 KV | | 582 | 419 | 515 |
| 1.0 KV | Field at 36 cm | 238 | 217 | 216 |
| 4.2 KV | | 372 | 300 | 341 |

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