# Cigre- JWG B3.35: Substation Earthing System Design Optimisation through the application of Quantified Risk Analysis


**Ertuğrul PARTAL**

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**JWG B3.35, 8.Toplantısı**

**Sydney, Avustralya: 13-15 Eylül 2016**

**Toplantı İçeriği:**

Çalışma Grubunun bu toplantısı aynı tarihlerde gerçekleşen Down to Earth Conference(DTEC 2016) ile birlikte olması grup üyeleri için, Elektrik İletim ve Dağıtım şirketleri tarafından ileri yıllarda uygulanması muhtemel olan yeni Topraklama Tasarımı, Ölçüm ve Test metotları hakkında önemli bir bilgi depolaması olarak görmekteyim. Konferans esnasında, İletim Sistemi açısından bakıldığında aşağıdaki bazı konular dikkat çekicidir;

- **Earth Resistance Testing of Transmission Towers in service without disconnecting earth wires**
- **EPR hazard assessment for lines in densely populated areas**
- **Transmission Tower pipeline arcing**
- **The Development history of IEEE Std 80**
- **The Value of Performance & Condition Testing**
- **A review of risk assessment processes applied to transmission grounding systems**
- **Lightning Protection of substations using EMT modelling**

Ayrıca konferansta, Cigre-HQ **SC C4**'ün teknik sekreteri **Dr.Hideki Motoyama** '*EMT Analysis of grounding systems using numerical electromagnetic field computation methods*' hakkında bir sunum da yapmıştır.

WG B3.35 üyeleri daha sonra konferans çalışmalarından ayrılarak son grup çalışmasından bu yana hangi çalışmaların yapıldığına dair bilgi alışverişinde bulunulmuştur.

Grup daha sonra kendi arasında ikiye ayrılarak(Transmission & Distribution) daha önce belirlenen ve tek hat şemaları(SLD) üzerine çalışmalara devam edilmiştir.

Toplantının birinci gününde, çalışma grubu başkanı Dr.Bill Carman, **Cıgre-SESSION**'da toplanan **SC B3** üyelerine grup çalışmaları hakkında bilgi verildiğini ifade ederek, çalışmaların hangi aşamada olduğunu, teknik çalışmaların ve teknik dokümanın ne zaman tamamlanıp, ne zaman hazır olacağı hakkında kısa bir sunum yaptığını grup üyelerine bildirmiştir. Aktivite raporunu ekte(Ek-1) görebilirsiniz.

Aynı gün, yakın bir tarihte başlanacak olan '**TEİAŞ Topraklama Projesi**' hakkında çalışma grubu üyelerine sunum(Ek-Sunum) yapılmış olup, sunumum bir kopyası grup üyelerine sunulmuştur.

Toplantının ikinci gününde, Teknik Broşürün(TB) ilgili kısmına dâhil edilmesi planlanan, '***İletim Sisteminin yakınından geçecek olan metal borular üzerine sistemin normal işletilme ve sistemde oluşabilecek kısa devre esnasında meydana gelebilecek RESISTIVE, INDUCTIVE, CONDUCTIVE etkileşim***' hakkında hazırladığım doküman(Ek-2) grup üyeleri tarafından olumlu bir destek çalışması olarak kabul edilmiştir.

İletim sistemi üzerine verilen tek hat şemaları ve uygulanan kabulleri içeren doküman üzerinde çalışmalara devam edilmiş olup, gün boyunca her bir kabul ve sistem parametresi değişiklikleri için ayrı ayrı örnekleri tespit edilmiş olup, elde edilen analiz sonuçları üyeler tarafından gözden geçirilmiştir.

Toplantının üçüncü gününde Çalışma Grubu üyesi **Prof. Lother**, hazırladığı '**Procedure of Risk Analysis regarding Earthing**(Ek-3)' hakkında grup üyelerini bilgilendirdikten sonra bazı örnekler verilmiştir ve bu çalışma tam gün boyunca devam etmiştir.

Prosedür, TM topraklama sistem tasarımını yaparken **Olasılıklı** Risk Değerlendirmesini(**Probablistic Risk Assessment**) de hesaba katılmasını istemektedir ancak, mevcut durumda Olasılıklı Risk Değerlendirmesini Topraklama Tasarımlarına uygulayan çok az sayıda ülke bulunmaktadır ve iletim sistemi operatörleri topraklama tasarımlarında '**Deterministik**' metodu uygulamaktadırlar.

Toplantılar sonucu, oluşturulan taslak dokümanlar, yapılmış araştırmalar ve çalışmalar neticesinde son halini alacak kapsamlı Teknik Broşür CIGRE tarafından yayınlanacaktır.

**Toplantıya İlişkin Değerlendirme:**

Bu veya benzeri çalışma gruplarında yer almanın ve çalışmalar sonucu hazırlanan teknik raporların ilgili projelere uygulanmasının ve uluslararası standartların(özellikle Avrupa Normları-EN) takibinin hem Teşekkülümüz açısından ve hem de ülkemiz açısından öneme sahip olacağı düşünülmektedir.

**Bir sonraki Toplantı Tarihi ve Yeri:**

Toplantı # 9: Şubat,2017- Abu Dhabi
Toplantı # 10: Haziran,2017- Glasgow

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**Fotoğraflar:**

1. Condition &Performance Test Simulator


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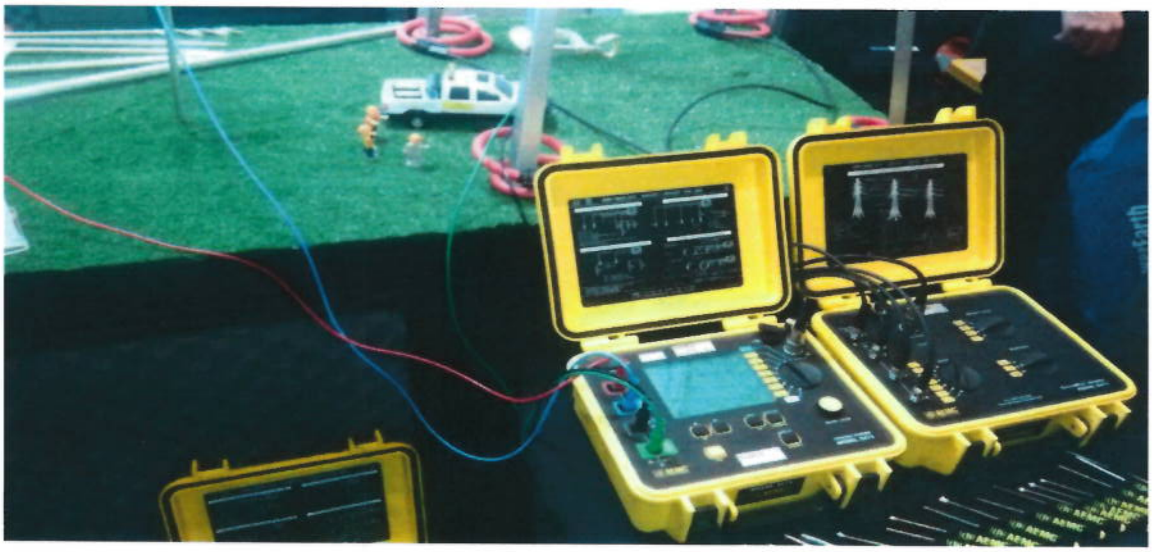
**2.** In service -Tower Ground Resistance Tester

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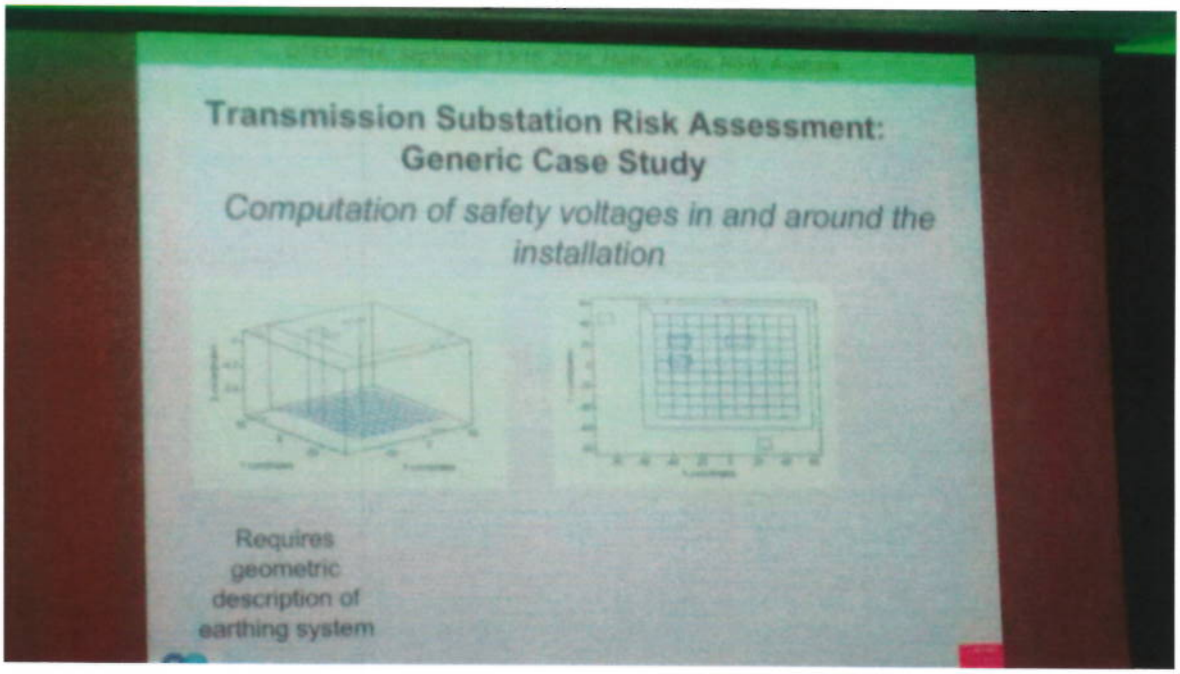
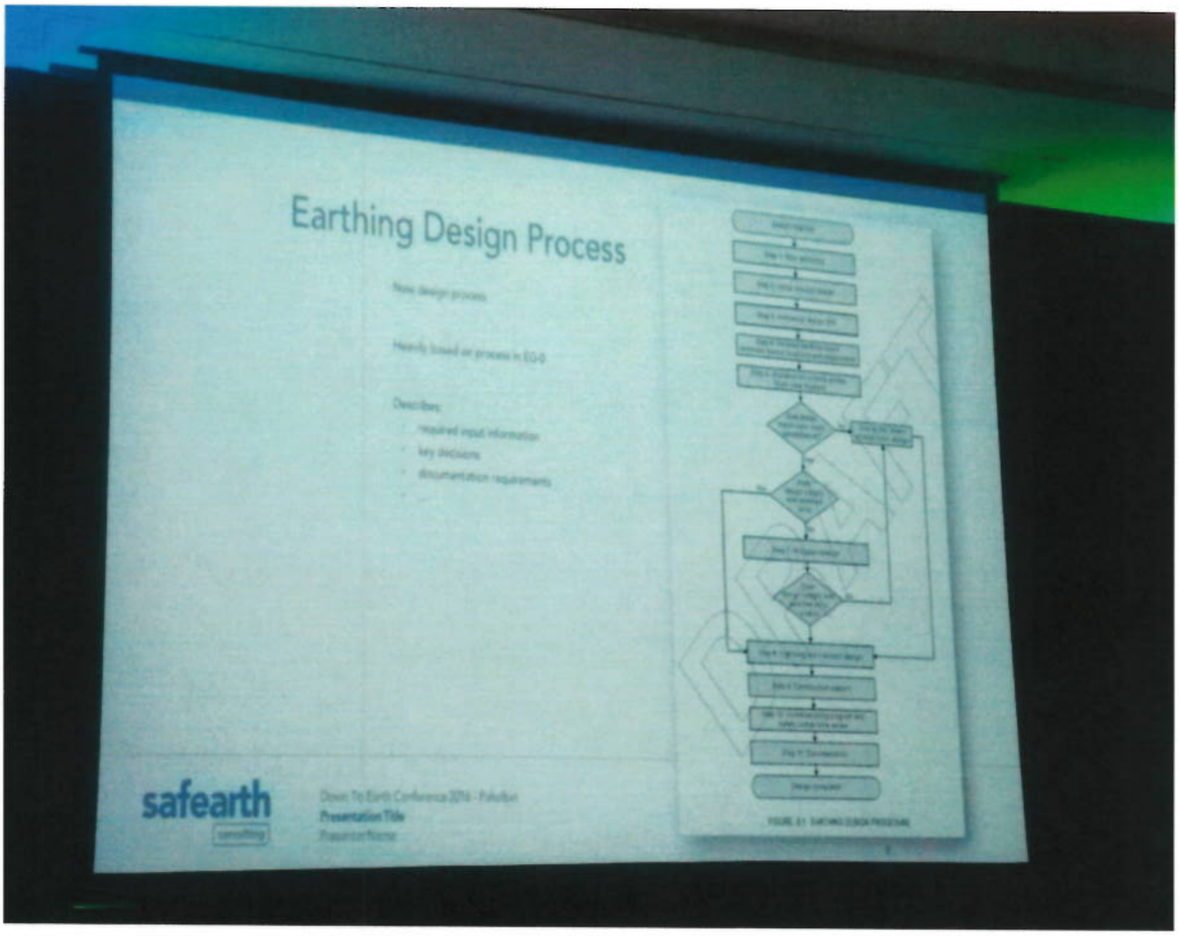
## 2. Some slides and notes from Conference

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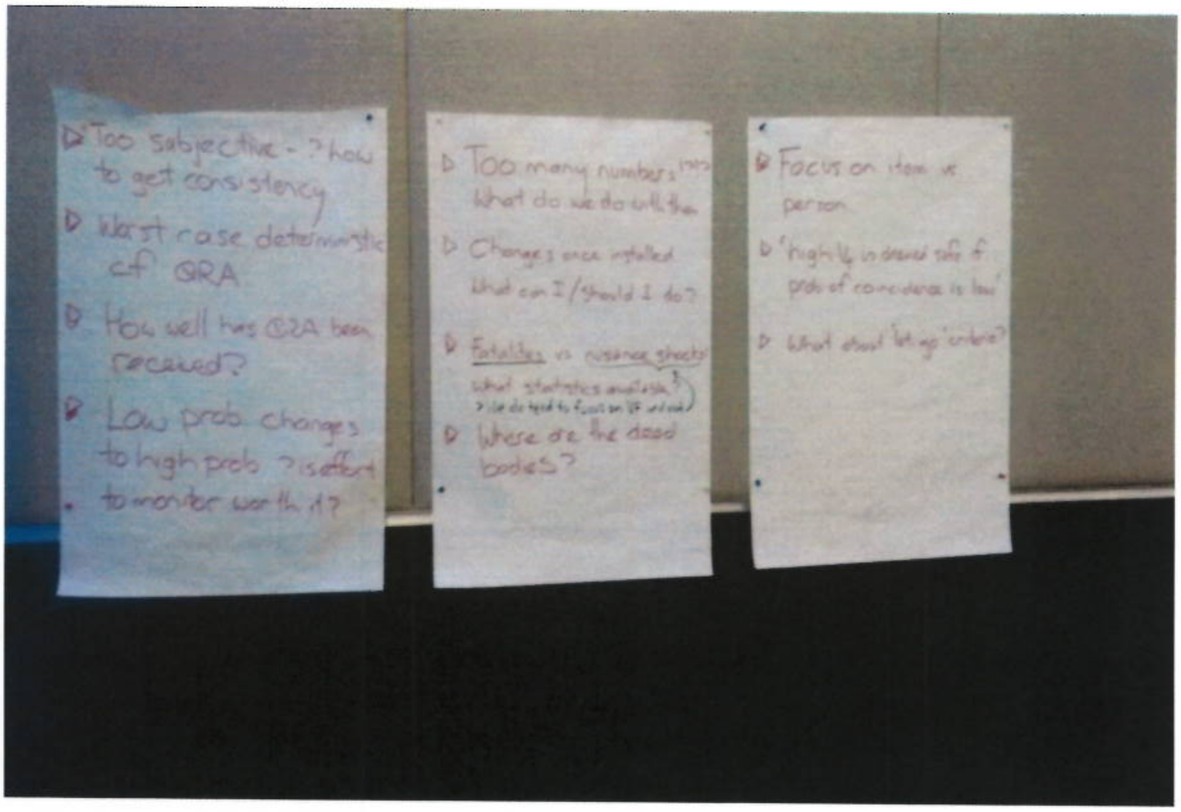


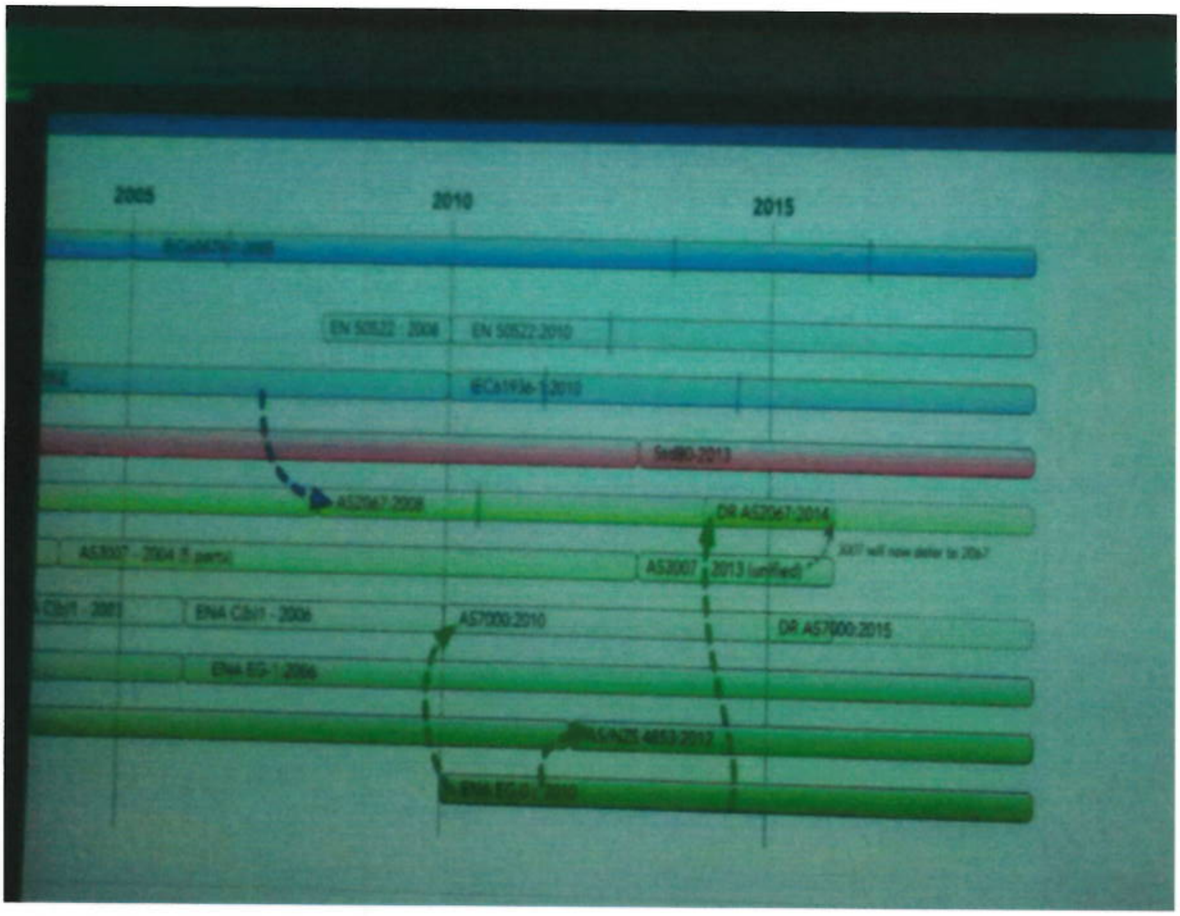


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**Convenors Annual Activity Report – Study Committee B3**

| **Working Group or Task Force:** | | **Reporting Date:** |
|---|---|---|
| Number: **B3.35** | Title: **Substation earthing system design optimisation through the application of quantified risk analysis** | **11-08-'16** |

**Convener:** Bill Carman
**Secretary:** Stephen Palmer

## 1 Membership

| | | |
|---|---|---|
| Number of members: 24 | Full: 17 | Corresponding: 7 |
| Retiring members: | 0 | |
| New members: | 2 | |
| Comments to membership: | Some corresponding members only taking an observation role. Have prompted several regarding appointing an alternative active member with little success. | |

## 2 Meetings

| | | |
|---|---|---|
| Meetings since last SC B3 meeting: | Date: 25-26/02/16 | Place: Lisbon Portugal |
| | Date: | Place: |
| | Date: | Place: |
| | Date: | Place: |
| Next meeting(s): | Date: 29-30 Aug 2016 | Place: Brno |
| | Date: Feb 2017 | Place: Abu Dhabi |

## 3 Activity since last SC B3 Meeting

**Highlights:**

The need to demonstrate due diligence in the management of inadvertent shock risk during earthfault conditions, through the explicit use of quantified risk analysis, has been incorprated in a number of national standards. In particular the UK has added an addendum to the transmssion earthing standard and Australia is gradually incorporating the requirement in all HV standards. The latest Australia equivalent edition to the HV assset standard IEC61936 gives case studies covering a wide range of systems, including:

- Residential distribution – includes commercial sites (eg shopping centres), and aquatic centres (eg public pools)
- Light industrial – sawmill, batching plant, abattoir
- Large interconnected systems – power stations, heavy industrial, wind turbines
- Mining – surface plant operations, underground coal, underground metals, open cut Road tunnels - construction and operation.

A number of other countries are reviewing their earthing design standards and considering the implication and use of quantified risk analysis.

**Progress of work:**

The two case study working groups covering a 400/110kV transmission system and a typical distribution system spent most of the meeting time working through analysis approaches and data. Each team is working to use sufficient cases to clearly show:

- The characteristics of the parameters we are investigating
- How the various risk analysis approaches may be used.
- How significant are the changes in the resultant risk associated with variations in that parameter for a range of human exposure scenarios.
- How work processes may be constructed to enable designers to appropriately incorporate that factor or parameter in their design standards.

**Documents to be discussed during the SC B3 meeting:**

None

## 4 Proposed new work (specified in Terms of Reference distributed before the SC-meeting)

N/A

## 5 Future program

Two meetings are planned for 2017, one in February in Abu Dabhi and another tentatively targetted for Ausgust to correspnd with the Cired meeting in Glasgow. The group is considering the development of a tutorial to be firstly delivered at the Glasgow meeting.

## 6 Miscellaneous (e.g. encountered difficulties, needed support from the Study Committee)

N/A

## 7 Reports proposed for publication

| Title | Stage of preparation 1) | Type of publication 2) | Planned publication date |
|---|---|---|---|
| | | Click here + select | |
| | | Click here + select | |
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| | | Click here + select | |

1) Number of draft; already discussed by WG/SC ?

2) Click on field and select option. All reports shall be published in Electra, either as a summary or complete (max. 6 pages)

**Additional information on proposals for publication:**

The group is aiming to publish a brochure in the second half of 2017.

# Electrical interference from overhead power lines to metal pipelines:

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## Background

The proximity of overhead power lines, underground cables or traction lines to adjacent structures that have metallic parts such as communication cables, fences, surface or underground pipelines can produce harmful voltages in these structures. Focus is on the voltages produced in metal pipelines by overhead power lines. Metal pipelines are usually formed of steel tubes that are welded together and used for the transportation of various substances such as crude oil,natural gases, water, liquefied petroleum gases and sewage. The length of pipelines may range from several kilometres to hundreds or even thousands of kilometres.

Most pipelines are usually buried at low depth although some may be installed above ground. Since the soil is electrolytic, ac corrosion of buried pipelines may occur when ac current is exchanged between the pipe and the earth. Therefore, buried pipelines have a few millimetre thick coating that insulates the metal from the surrounding earth and provides the primary protection against corrosion. New coatings include polyethylene and epoxy but for old pipelines, bitumen and glass cloth were used. Cathodic protection systems provide additional protection against ac corrosion. The technique consists of applying a lowdc voltage along the pipe that negatively polarizes the metal with respect to earth thereby helping to minimise electrochemical corrosion of the metal by the soil. The risk of ac corrosion of pipelines begins at a much lower ac pipeline voltage than that which endangers safety.

Generally, the ac voltage between the pipeline and a reference electrode above the pipeline should be less than 10V if earth resistivity is greater than 25 metres but should not exceed 4V if earth resistivity is less than or equal to 25 metres.

Metal pipelines are conductors that are generally insulated from earth. In proximity to overhead power lines, pipelines may be exposed to electrical interference for part of their length and this causes voltages to appear on the pipeline. Many countries specify maximum permissible touch voltages to protect pipelineworkers. Under permanent or steady state conditions, maximum permissible touch voltages tend to range from 15 to 65V. Under short duration fault conditions, the range is generally from 300 to 1500V depending on short-circuit fault clearance times. In some countries, the limits are reduced if the public has access to the pipelines.

There are three types of electrical interference from power lines to pipelines. These are **electrostatic** or **capacitive**, **electromagnetic** or **inductive**, and **resistive** or **conductive couplings.**

## 1. Electrostatic or capacitive coupling from power lines to pipelines

Buried pipelines in proximity to overhead lines are not exposed to capacitive coupling from the power line because the earth acts as an electrostatic shield. Only pipelines installed above earth are subject to capacitive coupling from the conductors of overhead lines. Where the pipeline runs physically in parallel with the conductors of the power line, the parallel exposure of the pipeline and power line is termed a parallelism.

The coupling occurs under both normal and faulted power system conditions.The coupling causes voltages to appear on the insulated pipeline metal with respect to earth or currents to circulate in an earthed pipeline through the earthing connection.

In general, voltage problems caused by capacitive coupling can be easily solved by earthing the pipeline. The pipeline voltages for a given pipeline exposure with the power line can be calculated using matrix analysis techniques.The self and mutual potential coefficients of the power line conductors to be obtained from well known Carlson Equations which can also be used to calculate the mutual potential coefficients between the pipeline and the power line's conductors where these form a parallelism.

## 2. Electromagnetic or inductive coupling from power lines to pipelines

Since the earth does not act as an electromagnetic shield, both above ground and buried pipelines in proximity to overhead lines are exposed to inductive coupling from the power line. The coupling exists under both normal steady state and faulted power system conditions and induces longitudinal voltages or electromotive forces (EMFs) on the pipeline. These EMFs produce voltage stresses on the pipeline and can also cause currents to circulate in the pipeline. These voltages (to earth) can reach several tens of volts under steady state conditions and a few kilovolts under fault conditions. The latter can damage the pipeline's insulation coating and cathodic protection systems. The longitudinal induced EMF depends on the distance between the power line and pipeline and the length of parallelism. The inductive zone of influence of a power line increases with the earth's resistivity($\rho e$) and is generally taken as $y$=sqrt(200$\rho e$) where $y$ is in metres.

## 3. Resistive or conductive coupling from power systems to pipelines

It is a well known fact that earth return currents due to short-circuit earth faults in substations and on overhead line towers cause a rise of earth potential with respect to remote earth over a given area. If a buried pipeline is located in the zone of influence, i.e. earth potential rise, irrespective of whether the pipeline is parallel to the power line or not, the coating insulation will be exposed to a voltage stress since the pipeline's metal remains at virtually earth potential. If this voltage stress is greater than the dielectric strength of the insulation coating, it may puncture the coating and damage cathodic protection systems.

If the pipeline passesthrough the earth electrode systems of substations or overhead power line towers, the voltage stress may be so high that it may puncture the coating. The intense leakage current may damage the pipeline's metal. If the pipeline is earthed and connected to the earth electrode of a substation or tower, the rise of earth potential of the substation or tower will be transferred to the pipeline and may endanger safety.

*Reference:* *Cigre* ***TB 95-1995****(GUIDE ON THE INFLUENCE OF HIGH VOLTAGE AC POWER SYSTEMS ON METALLIC PIPELINES)*