# PRESENTATION of On the Hazardous Situations Due to the Presence of HV/MV Substations in Urban Areas

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# On the Hazardous Situations Due to the Presence of HV/MV Substations in Urban Areas

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# Definition of GGS

Equivalent earthing system created by the interconnection of local earthing systems that ensures, by the proximity of the earthing systems, that there are no dangerous touch voltages. Such systems permit the division of the earth fault current in a way that results in a reduction of the earth potential rise at the local earthing system. Such a system could be said to form a quasi-equipotential surface.

CENELEC DOCUMENT HD 637 S1

IEC STANDARD 61936-1

EN STANDARD 50522

## The METERGLOB Project

Funded by the Italian Minister for the Economic Development through the RSE Programme.

- Task: to carry out guidelines for the identification of GGSs. The guidelines must be defined on the basis of the definitions and methods present in the current international standards on grounding and safety and on the other results of the METERGLOB project.

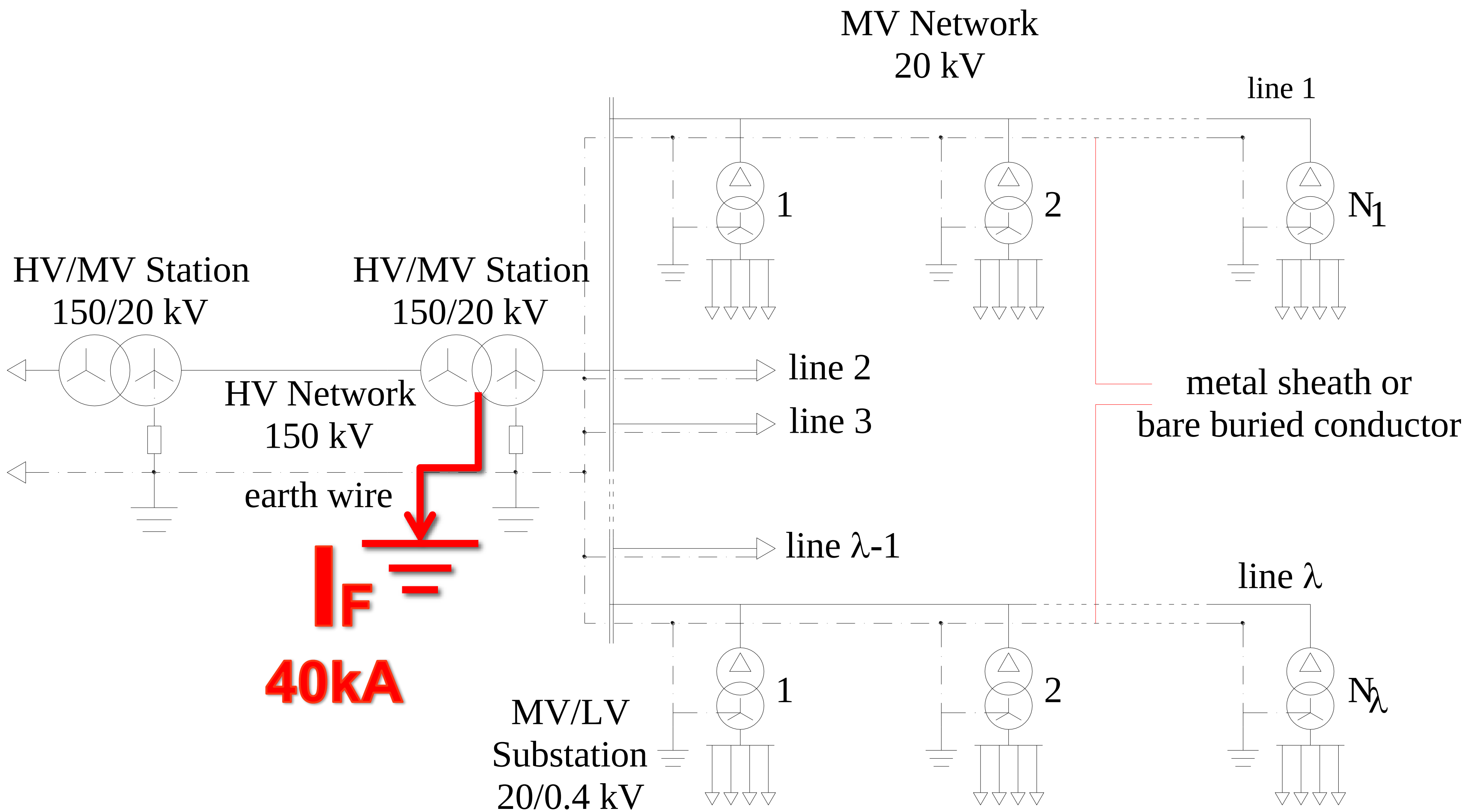
- This work study the impact of a 1LtG fault inside a HV/MV station on the ground electrodes of the MV/LV substations connected to the station.

# HV/MV station in urban centers

HV/MV stations are integrated in the urban context and, therefore, built very close to residential, commercial and tertiary buildings supplied by the LV utility grid.

In the event of 1LtE fault occurring on the HV side inside a station, high voltages can be transferred to the closest buildings, creating dangerous situations for persons or damage to equipment insulation.

# 1LtG fault inside the HV/MV station



## Aim of the paper

Analysis of the factors influencing the transfer of the hazard from the station towards neighboring installations, when a 1LtE fault occurs within a HV/MV station.

Definition of an operative protocol for assessing the risk and some measures to be applied for reducing the hazard due to the fault.

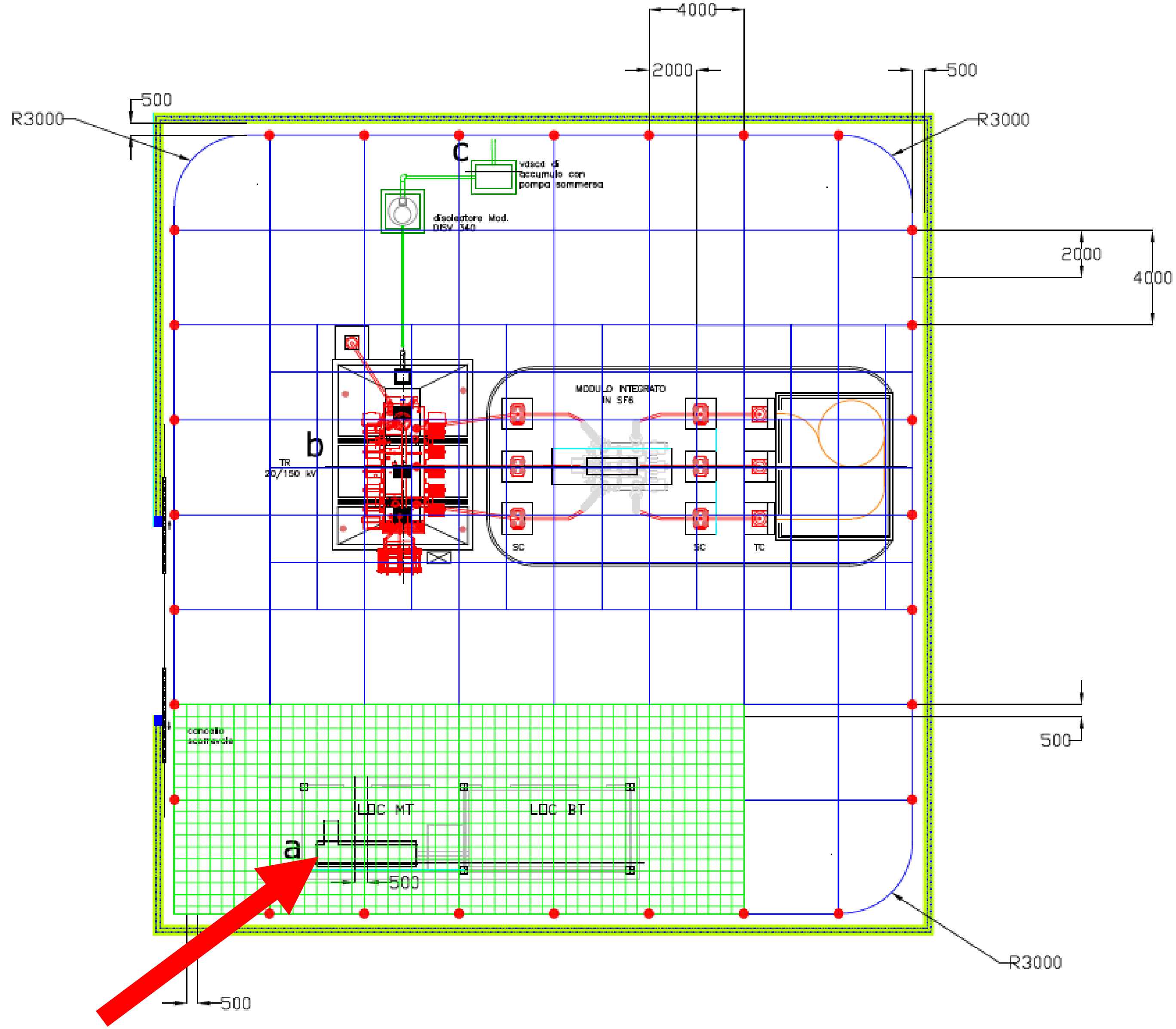
The novelty of the paper is in merging both IEEE and IEC/EN main recommendations in order to propose an unique and practical guide for protecting against the risks due to the proximity of HV/MV substations to LV installations.

# Elements to be taken into consideration

- Metal shields of the cables of the MV lines supplied by the station
- Accessible metal fences
- Metal pipelines connecting the earthing system of the faulted substation to the earth electrodes of the surrounding buildings
- metal railways outgoing from the station
- LV network neutral point connected to the same earthing system of the faulted station.

# Meshed grounding grid

**Ground electrodes with meshes having different sizes depending on the voltage level**

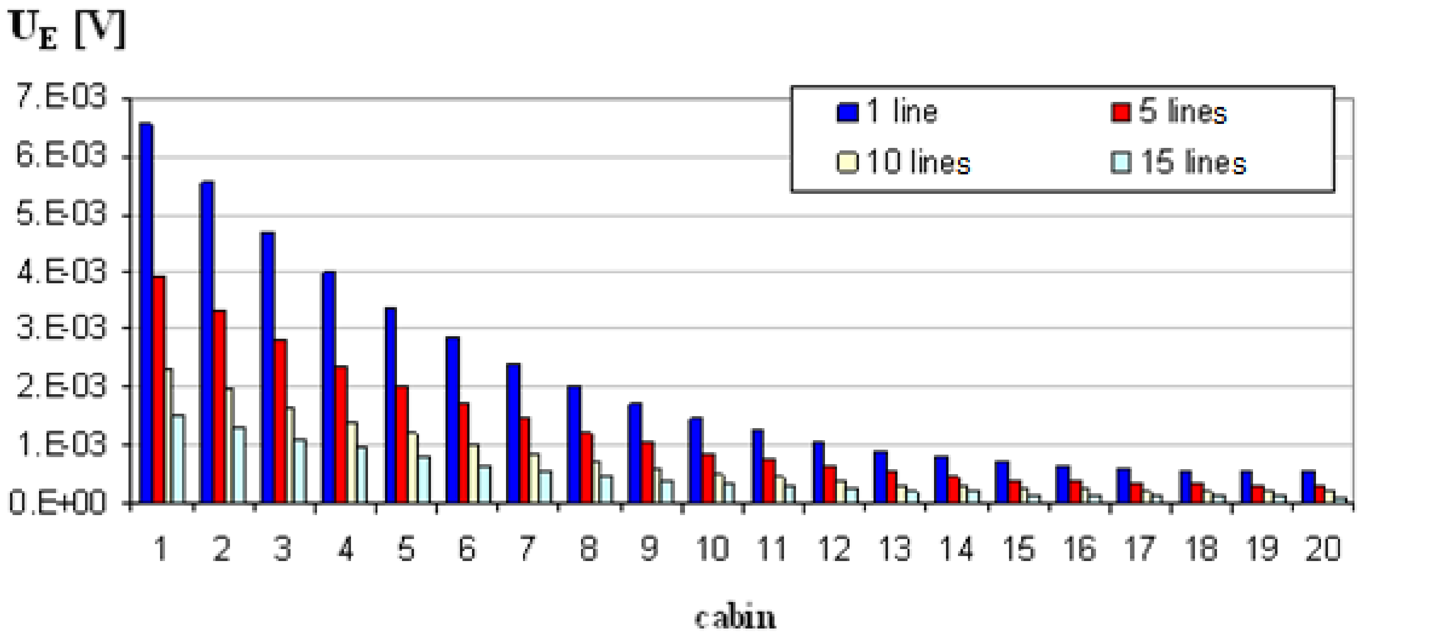


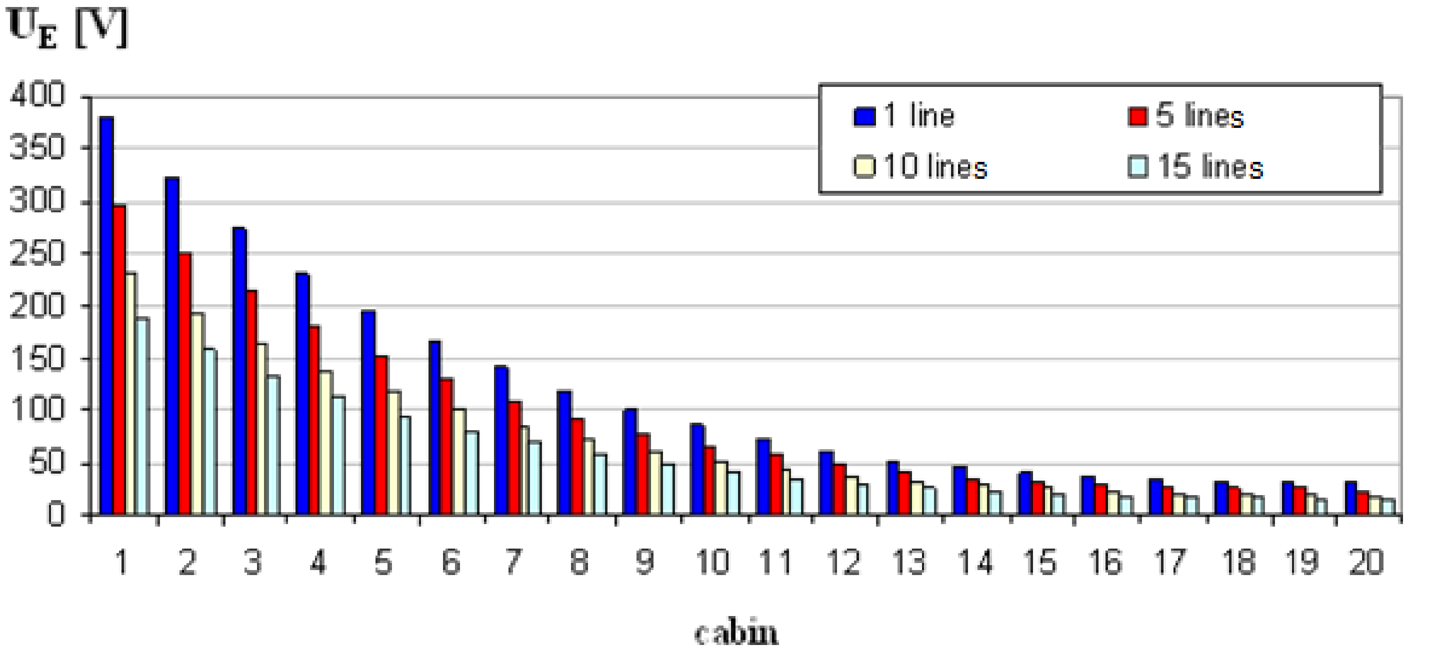

**Buildings with MV and LV installations**

## Cable's metal shields

The 1LtG fault inside the station can be as dangerous as or more dangerous than the 1LtG fault inside a cabin.

The factors influencing the GPR distributions are various.

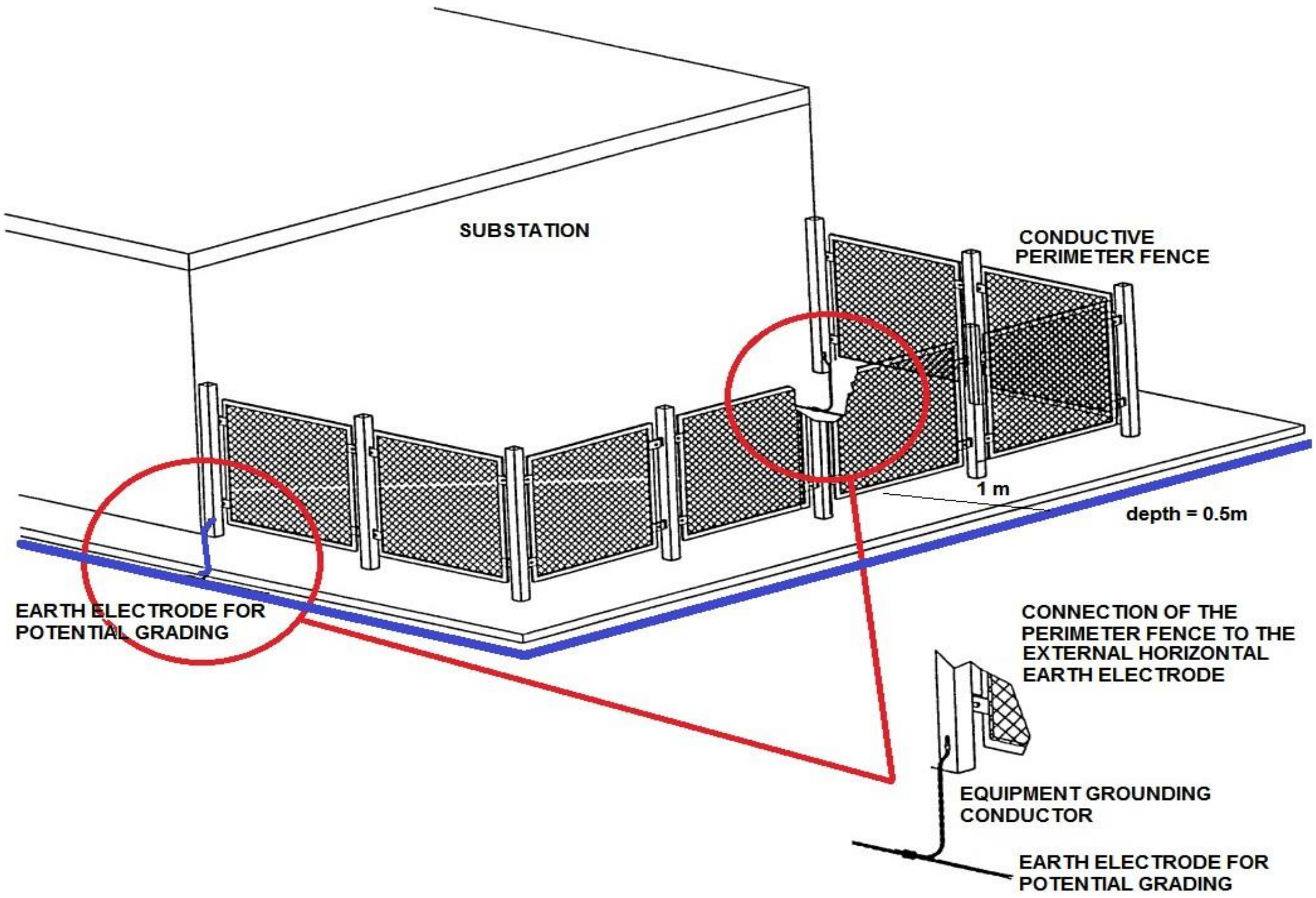


# Accessible metal fences

**IEEE Standard 80/2013**
**NEC**
**IEC 61936-1**

Metal fences' earthing can be accomplished in two different ways: electrically connecting the fence to the substation earthing grid (in this case the metal fence can be inside or outside the grid area), using a separated earthing systems (in this case the metal fence MUST be outside the grid area).



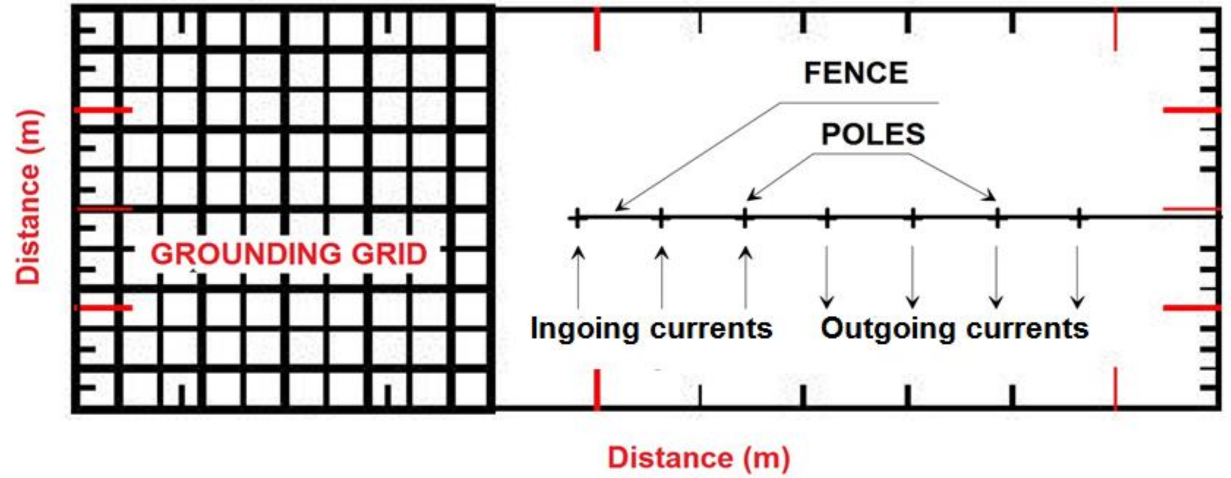

<u>Recognized specified measure M2.2 IEC Standard 61936-1:</u> supplementary horizontal earth electrode connected to the fence at about 1 m from the fence and at a maximum depth of 0.5 m

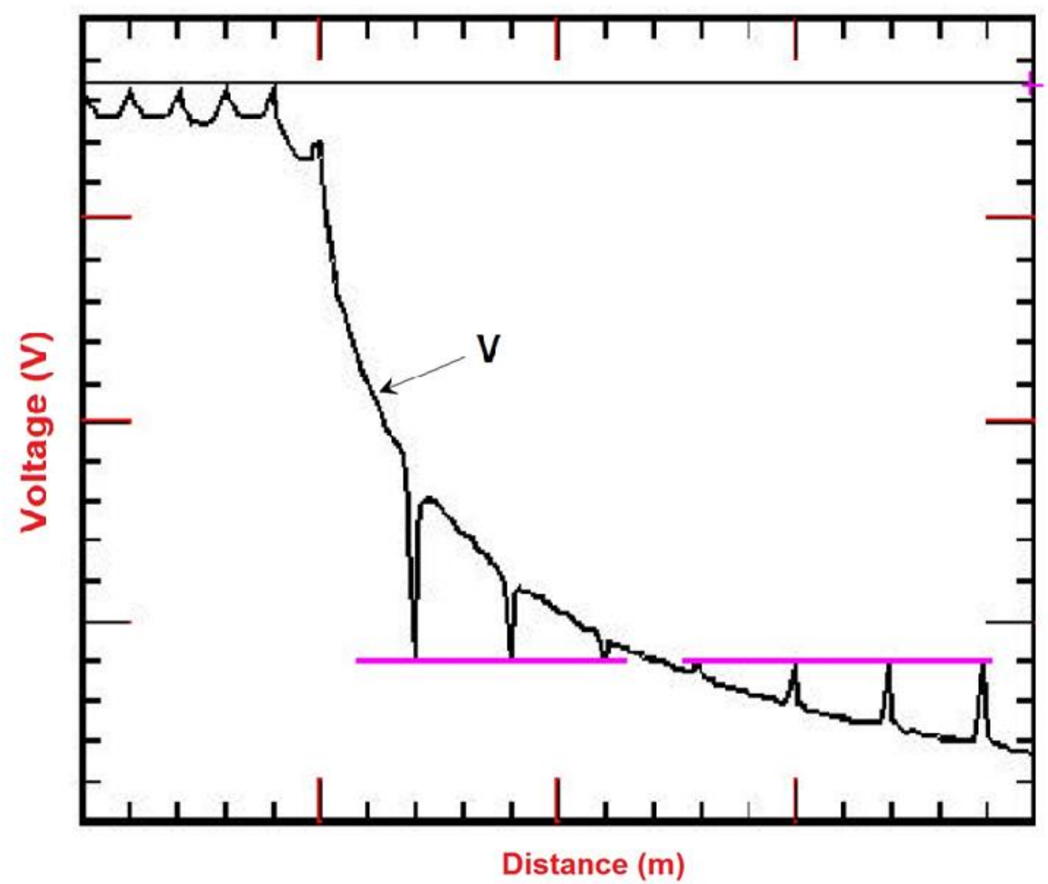
## Accessible metal fences

Metal fences not following the normal equipotential lines on the earth surface resulting from a fault in the HV/MV station.

Irregular voltage distribution, presenting rapid variations and high probability of dangerous touch voltages at fence poles .

Use of insolating joints in the fence.

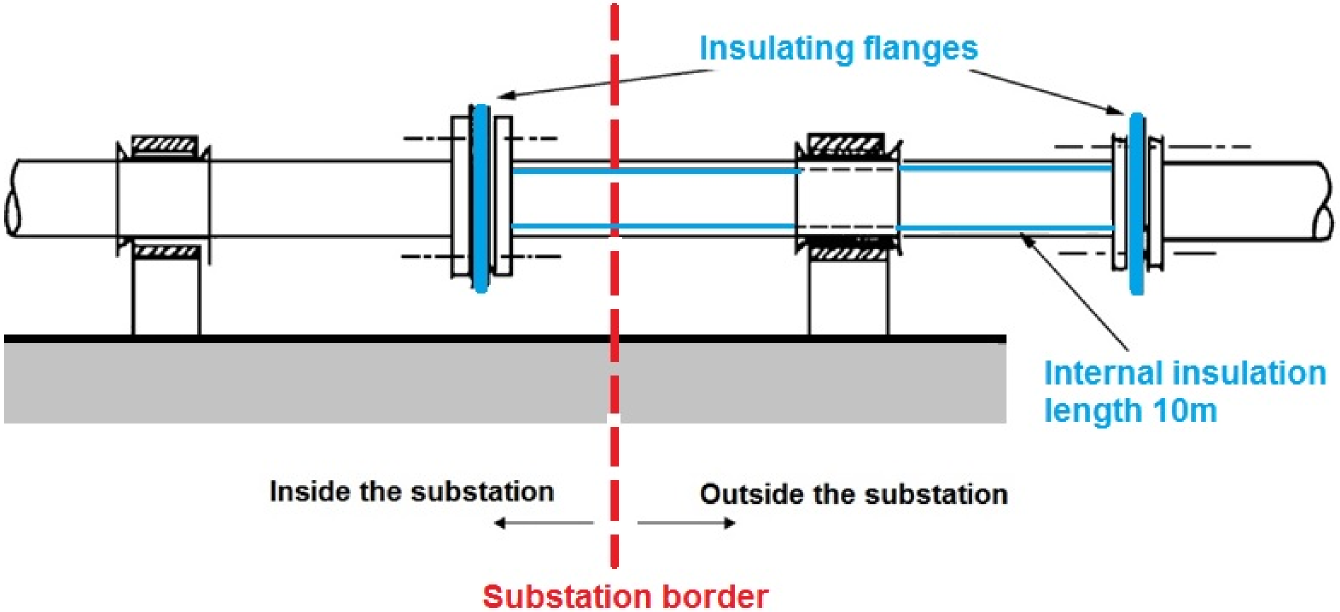


## Metal pipelines

Can be safely connected to the metal parts of LV supplied building only if the HV/MV station’s grounding system is intrinsically safe.

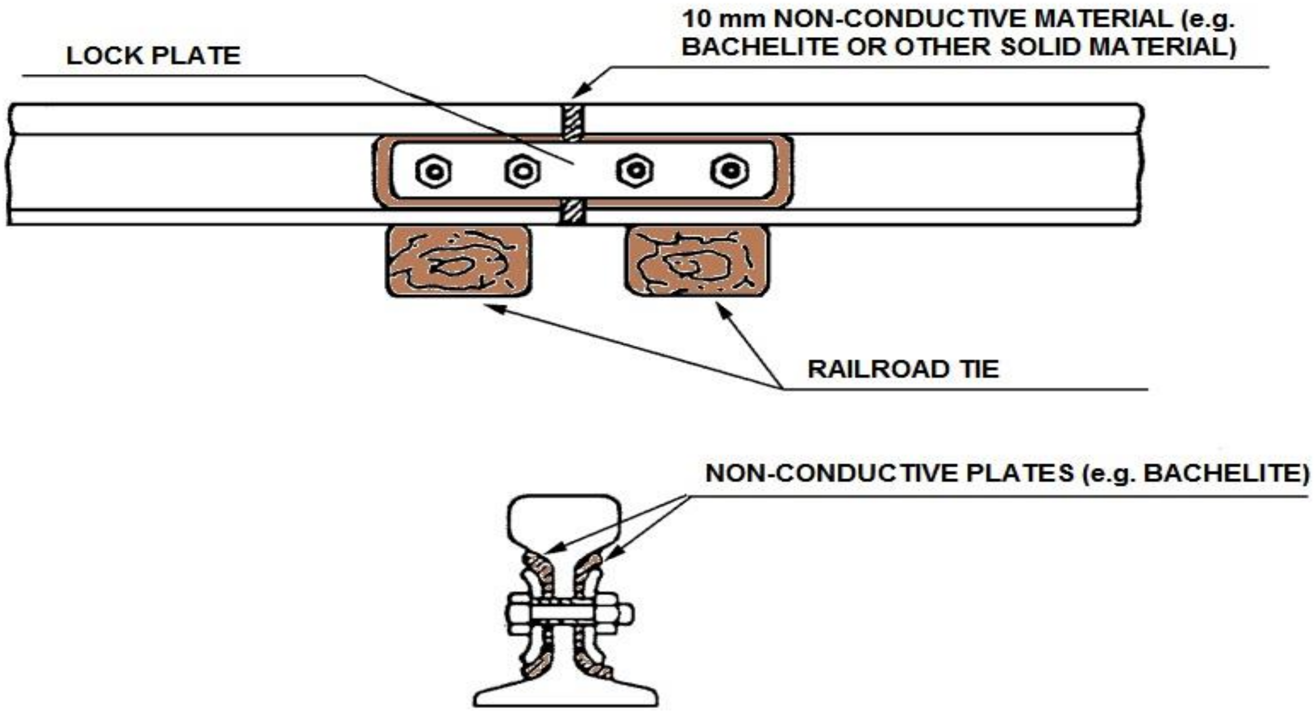
Otherwise, insulating flanges, internal insulation or span of not conductive pipes must be used for avoiding the transfer of dangerous voltages.



# Metal railways

Use of insulating joints or intermediate insulating material between the tracks inside and outside the station's perimeter.

Use of non conductive span for passing the station's perimeter.




**Connected to the HV/MV station earthhing system**

# Stress voltages

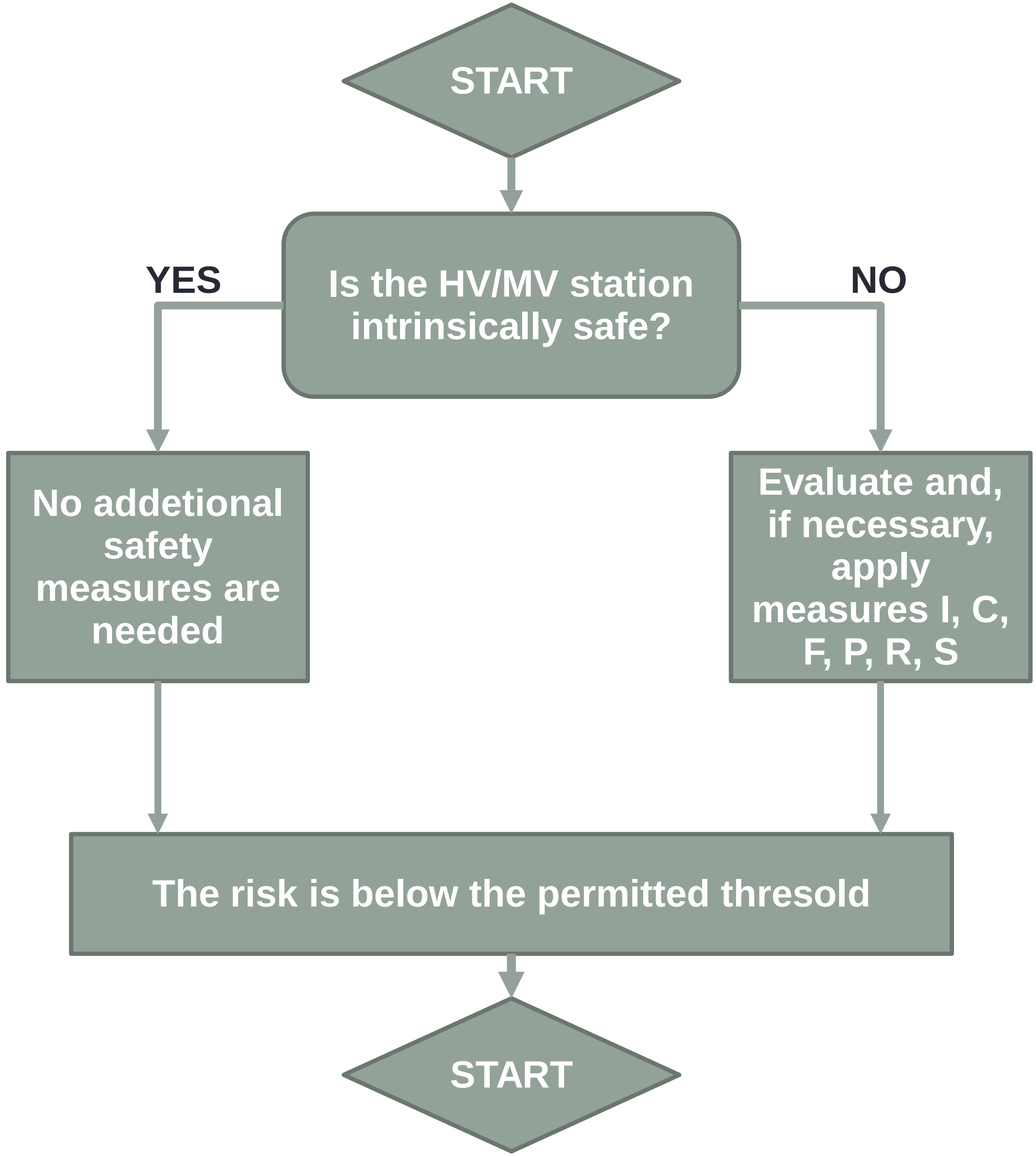
<table>
<tr><th colspan="4">Limits for the GPR for the protection against electric schock</th></tr>
<tr><th rowspan="2">Ground connection of the LV system</th><th rowspan="2">Neutral grounding</th><th colspan="2">Requirements</th></tr>
<tr><th>LV system inside the area delimited by the ground electrode of the substation</th><th>LV system outside the area delimited by the ground electrode of the substation</th></tr>
<tr><td>TT</td><td>-</td><td colspan="2">$U_E \leq 2 \cdot U_{Tp}$<br>(or $U_E \leq 4 \cdot U_{Tp}$)*</td></tr>
<tr><td rowspan="2">TN</td><td>Single grounding of PEN through the ground electrode of the</td><td rowspan="2">$U_E \leq U_{Tp}$</td><td>$U_E \leq U_{Tp}$</td></tr>
<tr><td>Multiple grounding of PEN</td><td>$U_E \leq F \cdot U_{Tp}$<br>$2 \leq F \leq 5$</td></tr>
<tr><td colspan="4">* when specified measures M are taken</td></tr>
</table>

<table>
<tr><th colspan="3">Minimum Requirements for Interconnection of LV and MV Grounding Systems Based on GPR Limits for Stress Voltage According to EN Standard 50522.</th></tr>
<tr><th rowspan="2">Type of LV system</th><th colspan="2">Stress Voltage</th></tr>
<tr><th>Fault duration<br>$t_F \leq 5$ s</th><th>Fault duration<br>$t_F > 5$ s</th></tr>
<tr><td>TT, TN and IT</td><td>$U_E \leq 1200\ V$</td><td>$U_E \leq 250\ V$</td></tr>
</table>

# Checklist for Risk assessment

| | |
|---|---|
| I.1 | The earthing system of the station is intrinsically safe and is able to contain the EPR within the value of 50V. |
| C.1 | Disconnection of the metal shields of the MV cables from the earthing system of the HV/MV station. The connection point must be made not accessible to the workers inside the station. |
| C.2 | Connection of all the metal shields of all the MV lines outgoing the station. The connection point must be made not accessible to the workers inside the station. |
| F.1 | Use of non conductive fences. |
| F.2 | Use of non-conductive outer walls. |
| F.3 | No earthed metal parts accessible from outside the HV/MV station. |
| F.4 | Earthing of the metal fence by the station earthing system or by a separated earthing system if the fence is outside the station's earth electrode area. |
| F.5 | In case of conductive perimeter fences, potential grading by installing a horizontal earth electrode connected to the earthing grid at a distance of 1 m outside the fences and buried at a depth not over 0.5 m. |
| F.6 | Installation of insulating joints in the metal fences. |
| F.7 | Use of high resistivity material for covering the soil outside the station |
| P.1 | Use of insulating flanges on metal pipes outgoing the station. |
| P.2 | Use of insulating pipes inside the station. |
| R.1 | Remove unused track sections. |
| R.2 | Installation of insulating joints between tracks. |
| R.3 | Substitution of a metal track section with an insulating one. |
| S.1 | If the maximum earth potential rise in the HV/MV station is over 1200 V, disconnect the neutral point of the MV/LV transformers from the earth electrode of the station. |

# Risk assessment procedure



## Application example

HV/MV station with:

- 5 MV ARG7H1RX cable lines outgoing from the station;
- perimeter reinforced concrete walls on 3 sides and a metal fence on one side;
- earthing grid of the station within the boundaries of the station;
- no railways ingoing in the station;
- one metal pipe from the local aqueduct entering the station boundaries.

## Application example

| | |
|---|---|
| **C.1** | Disconnection of the metal shields of the MV cables from the earthing system of the HV/MV station. The connection point must be made not accessible to the workers inside the station. |
| **C.2** | Connection of all the metal shields of all the MV lines outgoing the station. The connection point must be made not accessible to the workers inside the station. |
| **F.5** | In case of conductive perimeter fences, potential grading by installing a horizontal earth electrode connected to the earthing grid at a distance of 1 m outside the fences and buried at a depth not over 0.5 m. |
| **F.6** | Installation of insulating joints in the metal fences. |
| **F.7** | Use of high resistivity material for covering the soil outside the station |
| **P.2** | Use of insulating pipes inside the station. |
| **S.1** | If the maximum earth potential rise in the HV/MV station is over 1200 V, disconnect the neutral point of the MV/LV transformers from the earth electrode of the station. |

# Conclusion

- The paper has presented a comprehensive risk analysis of the hazard due to to a 1ltE fault inside a HV/MV station located in an urban area. The main international standards have been examined in order to define a complete procedure for assessing the risk for the LV installations due to the fault.

- Six categories of technical measures for reducing the risk have been defined together with a checklist for risk assessment. This set of measures includes part of the recognized specified measures M defined by IEC 61936-1.

- Finally, an application example of the risk assessment methodology has been presented.

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