



SATISHIELDING

**ELECTROMAGNETIC
SHIELDING
PRODUCTS**

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SATI SHIELDING

Sati Shielding S.r.l. was set up on 23 December 2015, thanks to the merger of different professional skills: marketing and organisational know-how of a historical company in the industrial electrical sector and technical and design know-how of a Team of Electrical Engineers of the Politecnico of Turin.

Sati Shielding S.r.l. is a new organisation specialising in solutions for: "Electromagnetic Shielding" and makes it possible to address issues connected to mitigating electromagnetic fields in all **stages**:

- Environmental impact assessment;
- Designing the shielding or mitigation system;
- Products and Solutions;
- Guide to Installation;
- Final testing and technical report.

The main objective of the new business - which will continue offering the existing services and products - will be to manage all market demands in Italy as well as abroad for mitigating electromagnetic fields.

The offer of **products, solutions** and **services** by Sati Shielding S.r.l. consists of:

- Range of WPL, WPM shielding plates;
- Range of standard shielding channel;
- Range of underground Shielding (buried channel and joint area);
- Ad hoc shielding solutions for transformation stations;
- Ad hoc shielding solutions for industrial machines;
- MAGIC® Software for environmental impact assessment;

The headquarters and administration offices is in Cascine Vica - Rivoli in the province of Turin. The internal organisation consists of: and engineering and design department, a sales department, marketing department, accounts department and test laboratory.

The Sati Shielding S.r.l. organisation also relies on a network of CEM consultants active on the whole Italian territory and a few Sales Agencies located in strategic points of our peninsula.

Sati Shielding S.r.l. is launched on the market with a product catalogue and website - www.satishielding.com - in English, French, German and Spanish.



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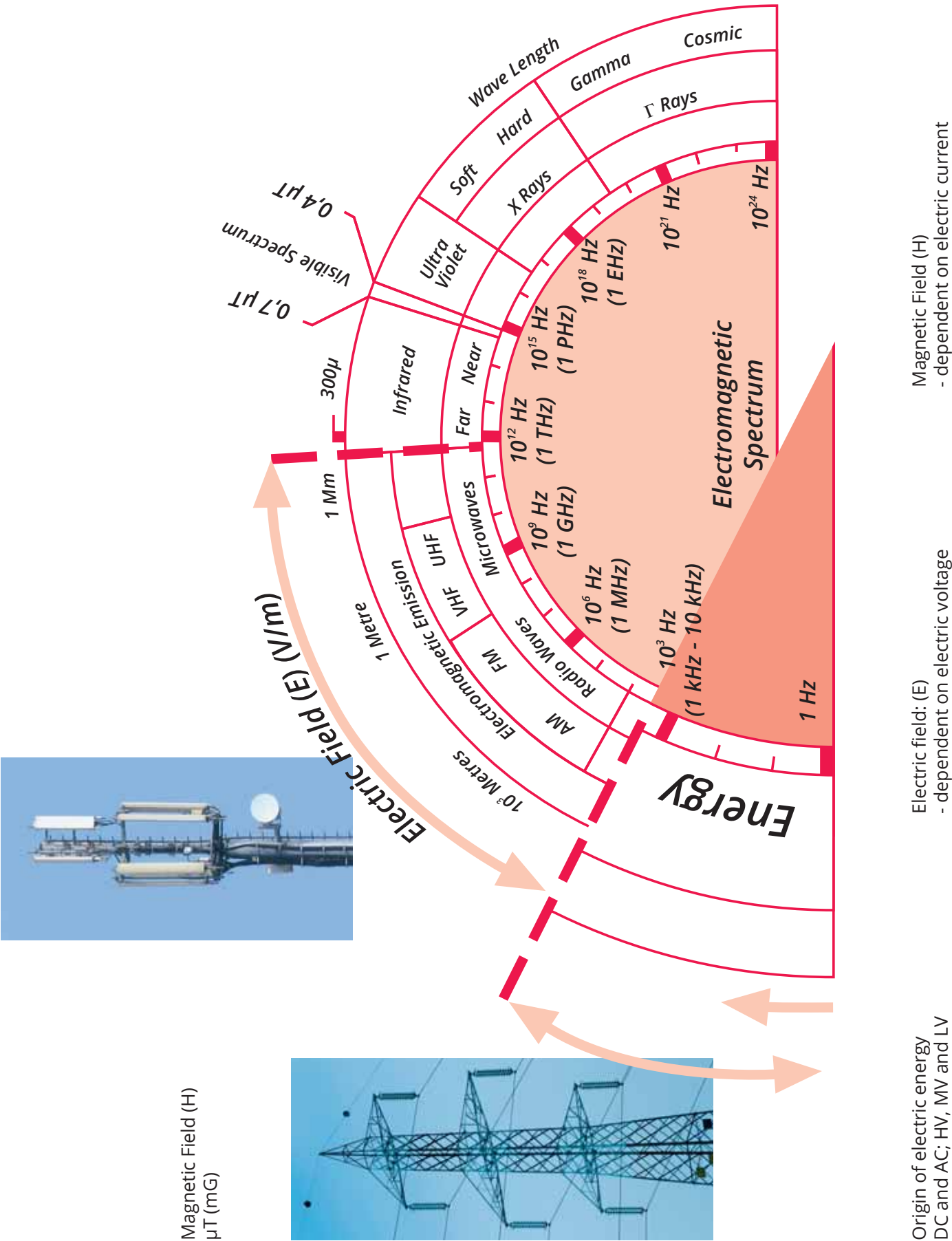
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Electromagnetic Spectrum



Introduction to Shielding

In all domestic and business environments there are electromagnetic fields which may occur naturally, as a consequence of light itself, or which may be artificially generated by the extensive presence of electrical plants and devices. In the twentieth century, environmental exposure to artificial electromagnetic fields has steadily increased as a result of a huge increase in energy demand, the continuing development of wireless technologies and because of changes in communication and work practices.

When people are exposed to electromagnetic fields their body absorbs energy. This causes an imbalance to the body's natural equilibrium and, while the scientific and medical community is still looking for conclusive evidence, it is important to protect people from the possible long-term effects of electromagnetic fields.

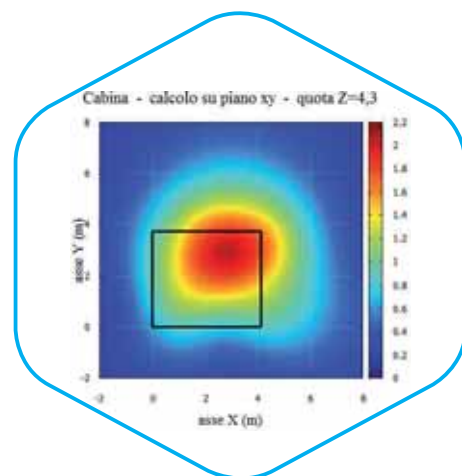
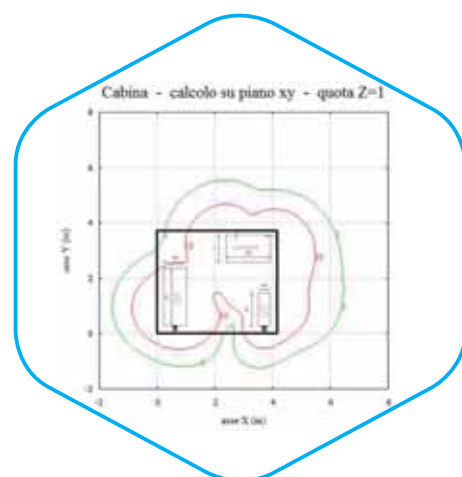
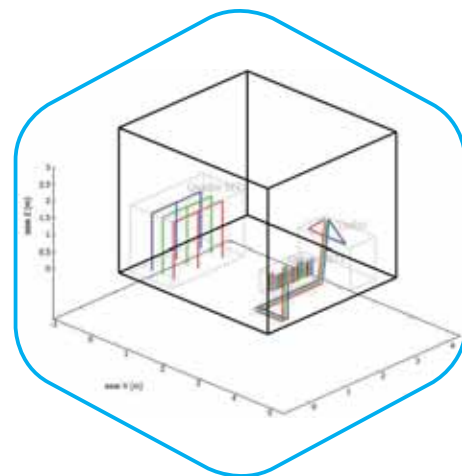
Interest in electromagnetic pollution has increased in recent years as a result of extensive research and studies. Standards and technical documents have been drafted and specific laws approved to protect the environments most at risk, such as the work place. It is important therefore that the risk to human health be evaluated and measures taken to limit electromagnetic exposure in order to guarantee health and safety at work.

As well as possible effects on human health, electromagnetic fields can create disturbance and cause interference with electronic equipment. European legislation has therefore set limits to guarantee the adequate and safe performance of instruments.

As a result, the use of appropriate screening systems is essential in all industrial processes that involve high current intensity or the use of intense electric or magnetic fields. This is to protect both workers and electric equipment near to the field sources.

SatiShielding offers a wide range of shielding solutions capable of mitigating magnetic fields at civilian and industrial frequency (up to kHz). All products are manufactured at the Latina (Italy) plant and come with a quality certificate issued by the Politecnico di Torino.

SatiShielding is also able to provide all the necessary technical support from the designing to the implementing of the most appropriate shielding solutions.



Example of "Environmental Impact Assessment" of a transformer substation MV / LV.

Effect of Electromagnetic Fields on People

Electric and magnetic fields that vary over time interact with the electrically charged particles which matter is made of. Of particular interest is the interaction with biological systems ranging from basic cellular structures to complex organisms such as plants and animals.

To properly quantify the energy absorbed by a material, especially by human tissue, dosimetric quantities are used. Dosimetry expresses the current and power density and the energy absorbed per unit area or volume as defined below:

- **Current density 'J':** is the current flowing through a cross section of a conductor such as the human body or a part of it. It is measured in terms of A/m^2 .
- **Density of power 'S':** is used for very high frequency types of current where depth of penetration is small. It is calculated as the radiant power perpendicular to a surface divided by the same surface area and is expressed in W/m^2 .
- **Specific energy absorption 'SA':** is defined as the energy absorbed per unit of mass of biological tissue and is expressed in Joule/kg.
- **Specific Absorption Rate of energy 'SAR':** This is the rate of absorption of energy per unit mass of body tissue averaged over the entire body or specific parts of it. It is used to assess and eventually limit excessive energy deposition in small parts of the body resulting from particular exposure conditions. Both SAR, averaged over the whole body, as well as local body part values are used. It is measured in W/kg .

The quantities mentioned above are used as references to measure the effects on the human body and to define exposure limits. These, however, cannot be measured directly on the individual exposed to assess the intensity of radiation. Instead, measurable physical quantities

such as magnetic field and induction are used. This limitation means that the quantities, which are obtained through mathematical models simulating the behaviour of the human body, are defined in terms of modules of magnetic flux density and magnetic field.

At low frequencies the tissue of the body are able to shield and so mitigate the electric field, by contrast, magnetic fields or magnetic induction are not shielded by the tissues and therefore does not attenuate its effect. Consequently, it is clear that at low frequencies the magnetic field is the main pollutant factor as far as affecting biological properties is concerned. The direct, short-term or acute effects due to electromagnetic fields are well represented by current density (A/m^2).

Current density J [mA/m^2]	Symptoms
$J > 1000$	Extrasystoles and fibrillation
$100 < J < 1000$	Tissues stimulation: possible risks
$10 < J < 100$	Possible symptoms on the nervous system
$1 < J < 10$	Minor effects

Effect of Electromagnetic Fields on People

Another type of impact on health which is the result of prolonged exposure (perhaps even years) to electromagnetic field levels even lower than those associated with the short-term effects, must be measured in the long-term. All that is known about the effects of electric and magnetic fields changing in time is in relation to the induction of fields and currents inside the exposed body.

Electric fields exert forces on any electrically charged particles, as for example ions in liquids. Accordingly, all particles covered by an electric field move to achieve an electrostatic balance, for which reason the field is null in the human body. In cases where the electric field is variable in time the electric charges, constantly trying to reach equilibrium, change their position according to the sign of the field, thus creating a fluctuating motion of charges on the surface (electric current induced by the electric field variable) which increases intensity with the increasing frequency with which the inducing field changes.

However, as far as a time-varying magnetic field is concerned, a different mechanism occurs as this generates an electric field in the surrounding space that changes over time. If the variable electric field is produced within the human body, it generates an electric current in accordance with Ohm's law: $J = \sigma E$.

While an electric field as a main source generates currents on the surface of the body, a magnetic field causes the movement of currents within the body thus affecting more delicate parts.

The electric field generated by a magnetic field has a variable spatial distribution that can be shown as lines of force which close in on themselves and link up with the lines of the magnetic field strength (see Figure 1).

The induction of electric fields and currents inside the human body causes two biological effects, both potential health issues. The first one relates to the electrical stimulation of muscles and nerves, while the second is the so called Joule thermal effect.

When the effects of these two phenomena occur immediately after exposure to the fields, one can speak of short-term effects. When they occur after a number of years after a prolonged exposure to lower field values we talk about long-term effects.

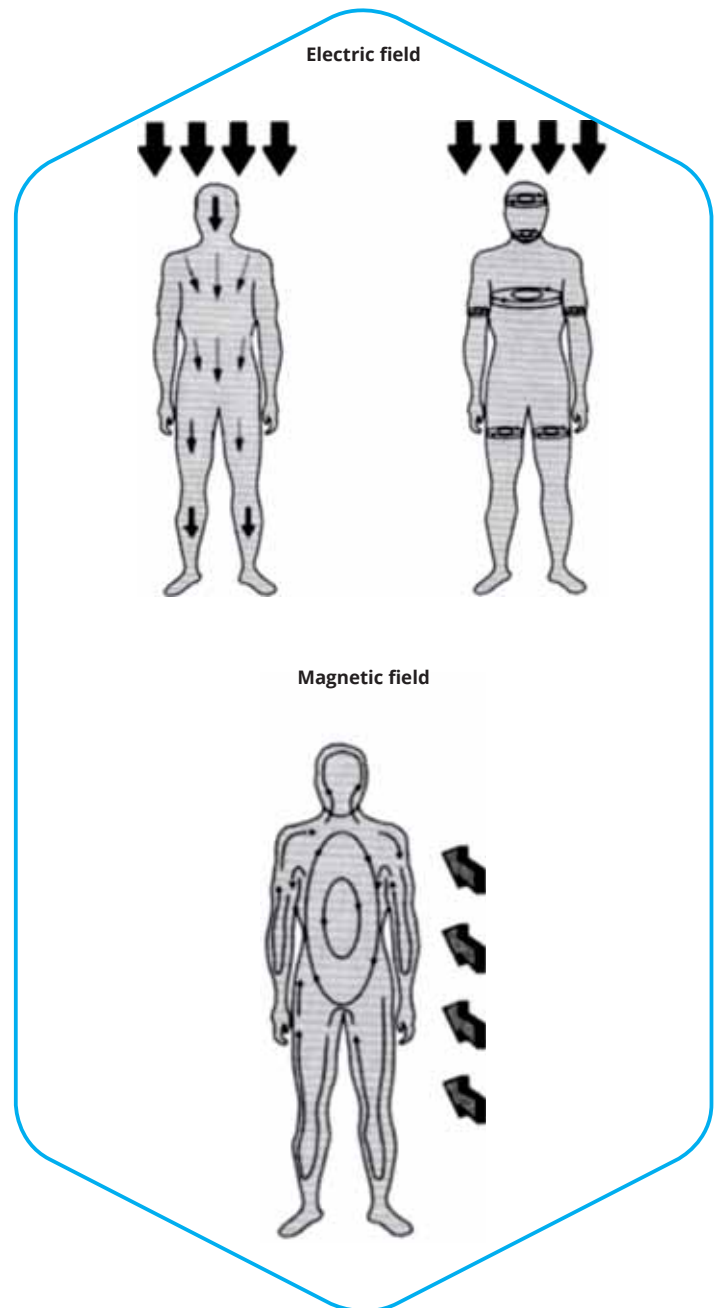


Fig. 1 - Induced currents in the body as a consequence of exposure to a (vertical) field E or a (vertical or horizontal field) H

Output of MV / LV Transformers

One of the main causes of magnetic field exposure in MV / LV electrical substations is represented by the output of the LV transformer.

As shown in Fig 2, the output is equivalent to the three sections of the conductor which are spaced out the same distance as the terminals of the transformer (D) on the transformer side. They are closer together (d) on the other side, where they form the bundle of cables directed toward the LV distribution substation. The height of the cables is a parameter that can vary depending on the installation mode. The distances on the different axis (with reference to Fig 2) when magnetic induction is equal to $3 \mu\text{T}$ (quality target) have been calculated on the basis of the nominal power and therefore on the basis of the secondary LV currents. The results are shown in Tables 1, 2 and 3 respectively for x, y and z.

It is clear from the tables that the output LV is a substantial pollutant component and that in the case of major power supplies the distances affected can be significantly more than 10 metres.

When substations are located in the vicinity of civilian, commercial or industrial settings where the quality target must be satisfied, it is necessary to implement shielding systems for almost all power supply levels.

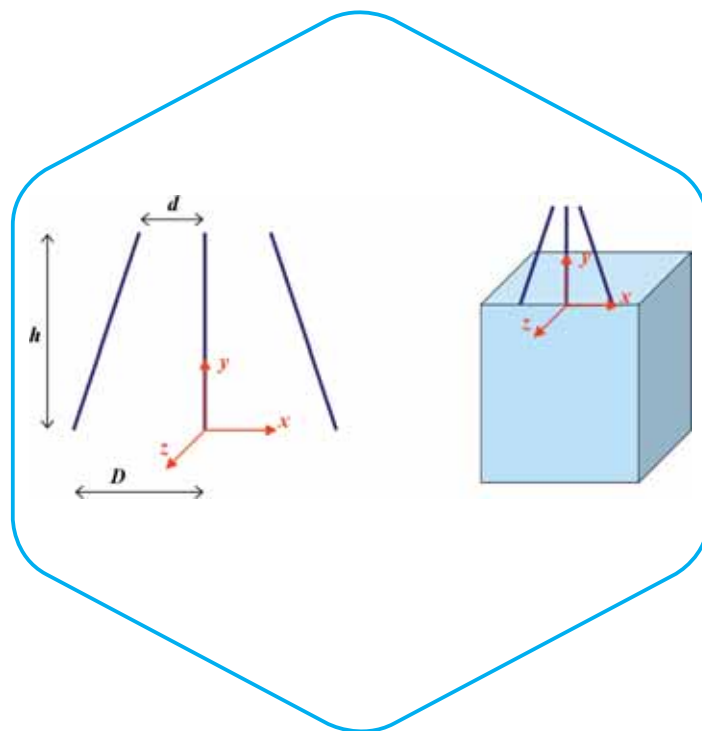


Fig. 2 - Graphic representation of a MV/LV transformer with the LV output pointing upwards.

Table 1. Distance from the centre of the system's coordinates along the X axis to obtain $3 \mu\text{T}$.

Rated power	Rated secondary power	h=0.5 (m)	h=0.6 (m)	h=0.7 (m)	h=0.8 (m)	h=0.9 (m)	h=1.0 (m)
250	361	2.47	2.69	2.90	3.09	3.26	3.43
315	455	2.77	3.03	3.25	3.47	3.68	3.86
400	577	3.13	3.41	3.68	3.92	4.14	4.36
500	722	3.49	3.81	4.11	4.38	4.64	4.88
630	909	3.91	4.28	4.61	4.92	5.22	5.49
800	1155	4.41	4.82	5.20	5.55	5.88	6.19
1000	1443	4.93	5.39	5.81	6.21	6.58	6.93
1250	1804	5.50	6.03	6.50	6.94	7.35	7.75
1600	2309	6.23	6.81	7.35	7.86	8.32	8.77
2000	2887	6.96	7.61	8.22	8.78	9.31	9.81
2500	3608	7.78	8.51	9.19	9.82	10.41	10.97

Output of MV / LV Transformers

Table 2. Distance from the centre of the system's coordinates along the Y axis to obtain 3 μ T.

Rated power	Rated secondary power	h=0.5 (m)	h=0.6 (m)	h=0.7 (m)	h=0.8 (m)	h=0.9 (m)	h=1.0 (m)
250	361	3.10	3.14	3.16	3.20	3.23	3.26
315	455	3.54	3.57	3.60	3.63	3.67	3.69
400	577	4.10	4.13	4.16	4.19	4.22	4.25
500	722	4.65	4.68	4.70	4.73	4.77	4.79
630	909	5.27	5.30	5.32	5.35	5.39	5.41
800	1155	6.05	6.08	6.11	6.14	6.16	6.20
1000	1443	6.87	6.90	6.93	6.96	6.99	7.02
1250	1804	7.86	7.88	7.90	7.94	7.96	7.99
1600	2309	9.05	9.07	9.09	9.12	9.14	9.18
2000	2887	10.37	10.39	10.42	10.45	10.47	10.50
2500	3608	11.94	11.96	11.98	12.01	12.04	12.07

Table 3. Distance from the centre of the system's coordinates along the Z axis to obtain 3 μ T.

Rated power	Rated secondary power	h=0.5 (m)	h=0.6 (m)	h=0.7 (m)	h=0.8 (m)	h=0.9 (m)	h=1.0 (m)
250	361	3.26	3.36	3.47	3.59	3.70	3.82
315	455	3.72	3.83	3.95	4.07	4.21	4.33
400	577	4.29	4.41	4.54	4.68	4.81	4.96
500	722	4.86	4.99	5.14	5.28	5.43	5.59
630	909	5.51	5.66	5.81	5.97	6.14	6.32
800	1155	6.32	6.48	6.65	6.82	7.01	7.20
1000	1443	7.18	7.34	7.52	7.71	7.92	8.13
1250	1804	8.17	8.35	8.54	8.75	8.96	9.19
1600	2309	9.39	9.59	9.80	10.02	10.26	10.50
2000	2887	10.74	10.94	11.17	11.40	11.65	11.92
2500	3608	12.33	12.53	12.76	13.02	13.28	13.56

Notes:

- (1) The D parameter is an average value which is not linked to any particular make of transformers.
- (2) The d parameter is calculated on the basis of the diameter of the output cables.

Distribution Lines and Shielding Cable Trays

Unipolar power cables are commonly used for high current distribution lines in industrial and civilian environments. A classic example is the power supply of air conditioning system engines where it is common to find more cables used in parallel, adding to thousands of amperes. The exposure level caused by induction is clearly to be kept within the quality target ($3\ \mu\text{T}$), but sometimes more stringent limits are required ($0.1\ \mu\text{T}$ near electronic microscopes for example).

Figure 3 shows the coloured map of the magnetic induction of a three-phase line with $400\ \text{mm}^2$ cables with an ampacity of 605 A.

It can be seen that in order to stay below $3\ \mu\text{T}$ the distance from the centre of the line is about 1.4 m. Table 4 shows the buffer zone values associated with the induction of $3\ \mu\text{T}$ for lines up to 2000 A consisting of single core cables in parallel.

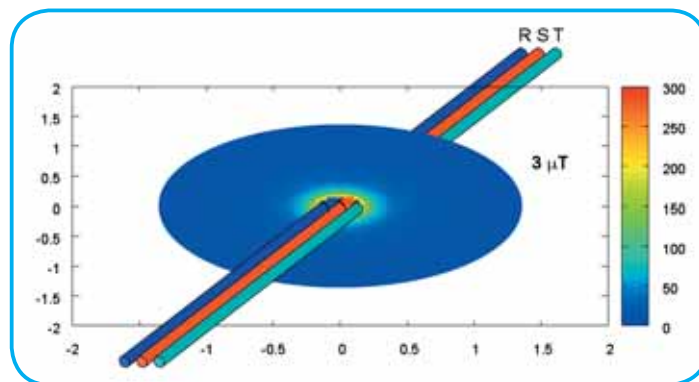


Fig. 3 - Coloured map of the magnetic induction of a three-phase line with $400\ \text{mm}^2$ cables with an ampacity of 605 A.

Table 4.

Thermal capacity of the line (A)	Nominal diameter of the conductors (mm^2)	Phase layout	Protection distance $3\ \mu\text{T}$ (m)
88	16	RST	0.24
117	25	RST	0.30
144	35	RST	0.37
175	50	RST	0.45
222	70	RST	0.55
269	95	RST	0.65
312	120	RST	0.74
355	150	RST	0.83
417	185	RST	0.95
490	240	RST	1.10
530	300	RST	1.21
605	400	RST	1.39
834	2x185	RRSSTT	1.90
980	2x240	RRSSTT	2.20
1251	3x185	RRRSSSTTT	2.85
1470	3x240	RRRSSSTTT	3.30
1668	4x185	RRRRSSSTTTT	3.80
1960	4x240	RRRRSSSTTTT	4.4

Distribution Lines and Shielding Cable Trays

Shielding Cable Trays have a high shielding performance with an average screen factor of approx 30. Figure 4 shows a coloured map of the magnetic induction of a three-phase line with 400 mm² cables with an ampacity of 605 A. The comparison with induction levels in the absence of shielding is obvious. The reduction in levels of induction involves a significant reduction in buffer zones. Table 5 shows the bands with respect to the different lines inserted into the shielding channel while Figure 4 shows the comparison between the buffer strips with and without channel shielding.

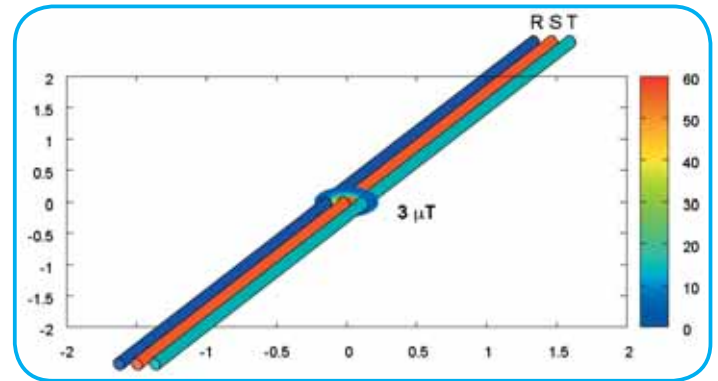


Fig. 4 - Coloured map of the magnetic induction of a three-phase line with 400 mm² cables, with an ampacity of 605 A, placed within a shielding channel.

Tabla 5.

Thermal capacity of the line (A)	Nominal diameter of the conductors (mm ²)	Phase layout	Protection distance 3 μT (m)
88	16	RST	-
117	25	RST	-
144	35	RST	-
175	50	RST	-
222	70	RST	-
269	95	RST	-
312	120	RST	-
355	150	RST	0.15
417	185	RST	0.17
490	240	RST	0.20
530	300	RST	0.21
605	400	RST	0.25
834	2x185	RRSSTT	0.35
980	2x240	RRSSTT	0.40
1251	3x185	RRRSSSTTT	0.52
1470	3x240	RRRSSSTTT	0.60
1668	4x185	RRRRSSSTTTT	0.69
1960	4x240	RRRRSSSTTTT	0.80

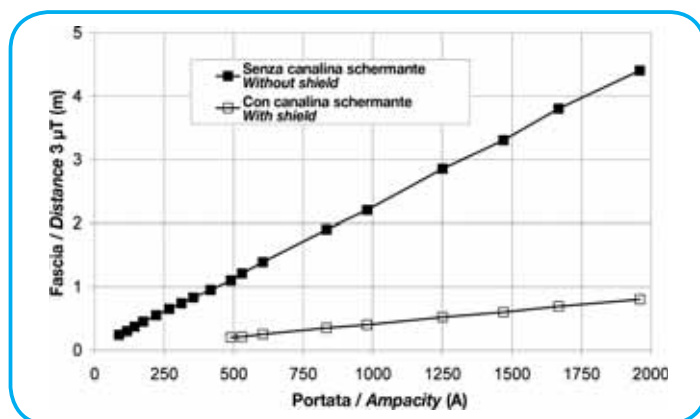


Fig. 4a - Comparison between the protection distance at 3 μT (m) with and without shielding channel.

Description of Shielding Materials

Mitigation of the magnetic flux density is achieved for both shielding plates and shielding Cable Trays by affixing magnetic shields made of two different materials:

- Material with high magnetic permeability.
- Material with high electrical conductivity.

The effect of incorporating both materials is clearly visible from simulations carried out using specific software that allows viewing the evolution of the field lines for the shielding materials when they are affected by a magnetic field generated by a coil. Figure 5 which also shows the progress of the field lines in the absence of a shielding system clearly demonstrates the effectiveness of the shielding materials:

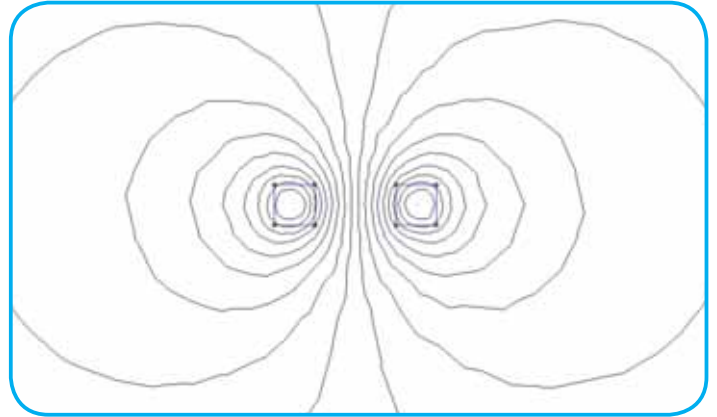


Fig. 5 - Magnetic field produced by a coil in the presence and the absence of shielding.

The layer of material with high magnetic permeability eliminates magnetic induction through absorption of the magnetic field. Its behaviour is similar to a shielding “umbrella” as protection from the intensity of the magnetic field can be very high close to the shield, but tends to decrease away from it.

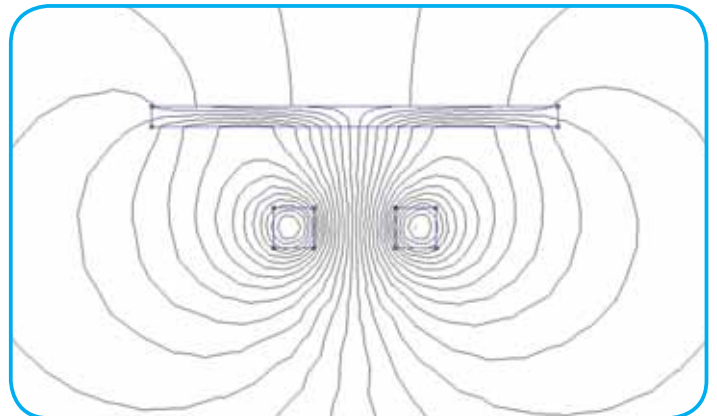


Fig. 6 - Magnetic field produced by a coil with ferromagnetic shielding.

The layer of material with high electrical conductivity in the presence of a variable magnetic field (induction field) becomes the site of current movement, which in turn generates a magnetic field of reaction (induced field). The combined effects of the fields, induction and induced, results in a reduction in the overall total magnetic field.

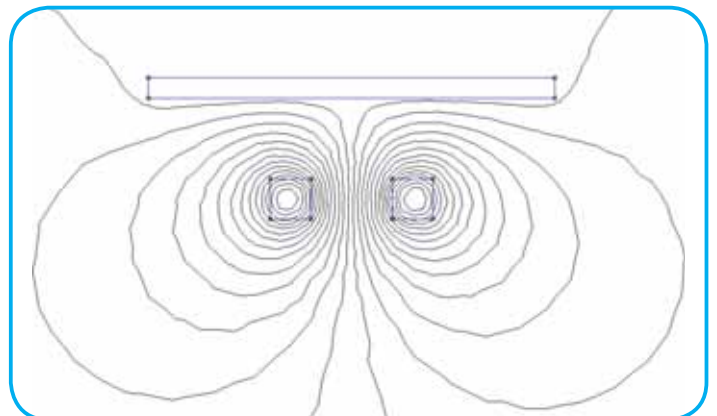


Fig. 7 - Magnetic field produced by a coil in with a conductive shield.

The combination of the two materials, magnetic and conductive, can produce good shielding capacities both close up, thanks mainly to the magnetic shield, and far away, thanks to the conductive shield.

Legislation, Regulations and Recommendations

Exposure of the general public

About protection from exposure to electromagnetic field in **Europe** and **outside Europe** the situation is not homogeneous. Regarding Europe, in 1999, the Council of the European Union published a recommendation (1999/519/EC, further called 'the Recommendation') on the limitation of exposure of the general public to EMF (0 hertz to 300 GHz). The Recommendation contains reference levels for the strength of EMF at the various frequencies.

The limits in both the Recommendation and the Directive are derived from the 1998 Guidelines for limiting exposure to time-varying EMF by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), as reported in Table 6.

ICNIRP has published new guidelines for EMF with frequencies between 1 Hz and 100 kHz in 2010, but these have not yet led to changes in EU legislation.

Because the Recommendation is not legally binding, EMF policy in member states can be divided into three different approaches.

In the first group of member states the Recommendation has been transposed in binding national legislation. This means that the basic restrictions and reference levels must be applied. Member states in this group are the **Czech Republic, Estonia, Greece, Hungary, Luxembourg, Portugal** and **Romania**.

Luxembourg also has a ministerial recommendation not to create any new living spaces in the immediate vicinity of overhead power lines (within 20 metres for 65 kV lines and 30 metres for 100 to 220 kV powerlines).

Finally, in **Germany** and **Slovakia** the reference levels in the Recommendation are applied without reference to basic restrictions.

In the second group of member states, the national limits based on the European Recommendation or ICNIRP are not binding, there are more lenient limits or there is no regulation. Member states in this group are **Austria, Cyprus, Denmark, Finland, Ireland, Latvia, Malta, Netherlands** and **United Kingdom**. In some of these countries, a precautionary policy has been advised, to which electricity companies and government can voluntarily conform (see below). **Spain** has no federal legislation for exposure of the general public to EMF of 50 Hz, but some regional governments prohibit construction of new power lines near homes, schools and public spaces.

In the third group of member states, there are stricter basic restrictions and/or reference levels based on the precautionary principle. A brief summary is therefore given per member state:

Belgium: The federal limit on electric field strength since 1987 equals the reference level in the Recommendation. In Flanders, a Decision on indoor environments is in force since 2004 which limits the magnetic flux density

in homes and buildings accessible to the public to 10 μ T.

Denmark: The Danish National Board of Health recommended in 1993 not to build new homes or children's institutions close to power lines or new power lines close to homes or children's institutions. The exact distance was left to pragmatic considerations. The Danish electricity sector and local government have agreed that measures at reasonable cost to reduce the magnetic field must be investigated if the average exposure per year is higher than 0.4 μ T. Like the National Board of Health advice, the agreement applies only to new developments.

Italy: The basic limits for magnetic flux density are identical with the reference levels in the Recommendation. An 'attention value' of 10 μ T applies to existing situations with exposure for more than 4 hours in homes, playgrounds and schools. A 'quality goal' of 3 μ T is applied to new construction of homes, playgrounds or schools near power lines, primary or secondary substations or vice versa.

Another important restriction to magnetic field at low frequency has been introduced in **France** since 2013. The "Ministère de l'Ecologie du Développement Durable et de l'Energie" has published indications regarding the maximum level of magnetic flux density in sensitive area as hospitals, maternity, nurseries, kindergartens, primary schools, etc..

Such value is 0.4 μ T as average value in 24 hours. In order to satisfy this limit a distance of compliance ("bordure de zone de prudence") associated to 1 μ T as to be guarantee for new plant installation as aerial and buried cable, substation, etc.

Netherlands: The Ministry of Infrastructure and the Environment has recommended that local authorities and grid companies avoid creating new situations with long-term stay of children in areas close to overhead high-voltage power lines with annually averaged magnetic flux density greater than 0.4 μ T. This advice was given because of epidemiological studies that found an association between residence near overhead power lines and childhood leukaemia.

Poland: A limit of 75 μ T for the magnetic field are applied to areas with homes, hospitals, schools and kindergartens.

Slovenia: A limit of 10 μ T is applied for new or modified sources near homes, schools, kindergartens, hospitals, sanatoria, playgrounds, parks, recreational areas, public buildings and buildings with a tourist destination.

Serbia: A limit of 40 μ T is applied for sources near homes, schools, kindergartens, hospitals, playgrounds, parks, recreational areas, public buildings etc.

Sweden: In conjunction with the Environmental code and legislation of 1998, guidance for policy makers has been published which explains how the precautionary principle is to be applied to electric and magnetic fields of 50 Hz. For existing situations, exposure to a magnetic flux density that differs strongly from natural background

Legislation, Regulations and Recommendations

(0.1 μT of the reference level in the Recommendation) must be reduced when possible at reasonable cost and with reasonable consequences. For new situations, an effort has to be made to reduce the exposure when designing and constructing sources.

Different approaches to limiting exposure to power frequency EMF also exist outside Europe.

In **Russia**, general rules for the protection are set in a 1999 framework law. The public exposure limit for the magnetic fields is 10 μT .

In **Switzerland**, an Ordinance on Non-ionising Radiation has been in force since 1999. Exposure limits identical to the reference levels in the European Recommendation apply to all areas accessible to the public. A stricter, precautionary limit on magnetic flux density of 1 μT is applied to new installations, unless the owner can prove that the phase order has been optimised and all technically possible and economically viable measures to reduce exposure have been taken. For existing installations, the phase order has to be optimised when the precautionary limit on magnetic flux density is exceeded.

In the **United States**, no federal legislation is in force. In some states (Colorado, Connecticut, Hawaii, Maryland, Ohio), variations on the 'prudent avoidance' principle have been adopted. This means that exposure of the public to EMF of 60 Hz must be limited at reasonable cost. In other states, fixed limits for the electric or magnetic field of power lines are set, varying from 20 μT to 240 μT (Florida, Minnesota, Montana, New Jersey, New York, Oregon).

International Standards

The protection of the population (which also includes workers not occupationally exposed) and occupationally exposed workers was the subject of guidelines by ICNIRP (International Commission on Non-Ionizing Radiation Protection). The levels established by said commission were included in the various European directives after 2004 (directive 2004/40/EC) up to the current directive of 2013 (2013/35/EU), which was transposed in Italy via Legislative Decree 159 dated 1 August 2016. This decree, which came into force from 02/09/2016 modified Title VIII part IV of Legislative Decree 81/08.

The tables below show the 2010 ICNIRP limits (those currently in force according to law 81: "Consolidated act regarding safety" limited to protection of professionally exposed workers).

Table 6. ICNIRP (2010) Reference levels for occupational exposure to timevarying electric and magnetic fields (unperturbed rms values).

Frequency range	E-field strength E (kV/m)	Magnetic field strength H (A/m)	Magnetic flux density B (T)
1 Hz - 8 Hz	20	$1.63 \times 10^5 / f^2$	$0.2 / f^2$
8 Hz - 25 Hz	20	$2 \times 10^4 / f$	$2.5 \times 10^{-2} / f$
25 Hz - 300 Hz	$5 \times 10^2 / f$	8×10^2	1×10^{-3}
300 Hz - 3 kHz	$5 \times 10^2 / f$	$2.4 \times 10^5 / f$	$0.3 / f$
3 kHz - 10 MHz	1.7×10^{-1}	80	1×10^{-4}

Note: f in Hz.

Table 7. ICNIRP (2010) Reference levels for general public exposure to timevarying electric and magnetic fields (unperturbed rms values).

Frequency range	E-field strength E (kV/m)	Magnetic field strength H (A/m)	Magnetic flux density B (T)
1 Hz - 8 Hz	5	$3.20 \times 10^4 / f^2$	$4 \times 10^{-2} / f^2$
8 Hz - 25 Hz	5	$4 \times 10^3 / f$	$5 \times 10^{-3} / f$
25 Hz - 50 Hz	5	1.6×10^2	2×10^{-4}
50 Hz - 400 Hz	$2.5 \times 10^2 / f$	1.6×10^2	2×10^{-4}
400 Hz - 3 kHz	$2.5 \times 10^2 / f$	$6.4 \times 10^4 / f$	$8 \times 10^{-2} / f$
3 kHz - 10 MHz	8.3×10^{-2}	21	2.7×10^{-5}

Note: f in Hz.

• Electronic equipment

Current regulation, in addition to establishing exposure limits for people, also sets out protection values for electronic equipment. **CEI EN 61000-4-8** requires that equipment not be exposed to fields with magnetic induction above **3,78 μT** .





Assessment and Designing

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Assessment of Environmental Impact of Magnetic Fields

Industrial frequency Electrical and Magnetic Fields

Sati Shielding S.r.l. performs assessments of electric and magnetic fields generated by electrical infrastructure (lines, substations, industrial electrical equipment), and also monitors the territory aimed at ascertaining compliance with the exposure limits and the attention thresholds. The assessment of electric and magnetic fields is very often mandated by law.

Sati Shielding S.r.l. uses two-dimensional and three-dimensional computational codes to perform electric and magnetic field assessments, and the relevant calculation of first and second approximation buffer zones for the fields generated by electrical infrastructure such as:

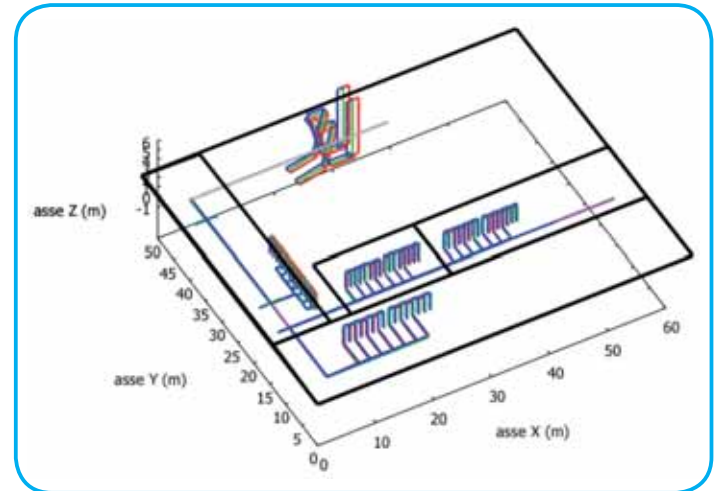
- power lines (overhead and cable);
- electrical substations (primary and secondary);
- electrical industrial equipment (welding machines, induction heating, etc.).

The assessment of electric and magnetic field levels produced by electrical infrastructure must be carried out and the field levels have to be compliant to the national laws.

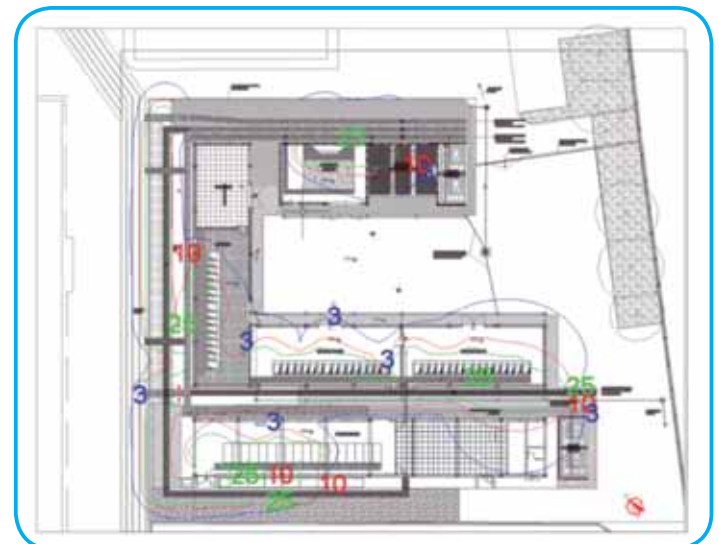
The complexity of the source under examination requires a more accurate assessment which mainly takes into account the three-dimensionality of the single sources and the effect produced by the combination of the same (superposition of effects).

Sati Shielding S.r.l. has therefore developed a three-dimensional software: MAGIC® which takes into account all these aspects and makes it possible to perform an environmental impact assessment that complies with the needs outlined above.

The cases of a primary and a secondary substation are set out below by way of example.

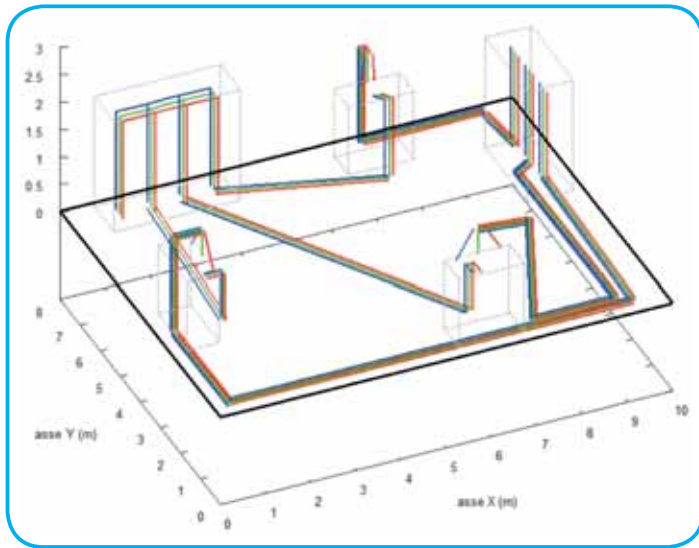


Primary substation model.

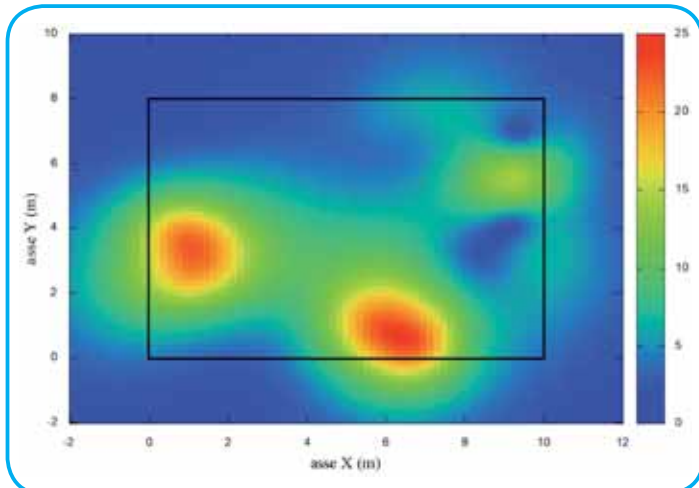


Induction levels associated to the primary substation.

Assessment of Environmental Impact of Magnetic Fields



Secondary substation model



Induction levels associated to the secondary substation.

Monitoring and Environmental Impact Assessment of radio-electrical systems

The activity of Sati Shielding S.r.l. in this sphere consists in territorial monitoring aimed at ascertaining compliance with exposure limits and attention thresholds for the prevention of short-term effects and possible long-term effects in the population due to exposure to the electromagnetic fields generated by fixed sources with frequency between 100 kHz and 300 GHz.

The type of checks to be implemented consists in broadband field measurements (as set out by IEC Standard 211-7) aimed at identifying critical points in an area where are installations or possible receptors.

Operative Stages

- Survey of radio-electric sources.
- Assessment of the collected information and definition of measuring points.
- Broadband electric field measurements (IEC 211-7).
- Entering the measurement data on geo-referenced maps.
- Assessment of compliance with the limits of the Regional and National laws.
- Possible additional assessment of electric fields levels in the case of Radio Base Stations (IEC 211-10/2002 "Guide to setting up a Radio Base Station to comply with the limits of exposure to high frequency electromagnetic fields").

Designing the Shielding System

Sati Shielding S.r.l. boasts an extensive, ten-year experience and thorough knowledge of the sector, and is able to supply standard as well as innovative solutions to suit the customer's special requirements.

Sati Shielding S.r.l. is able to deal with large and small customers, and is able to manage small and large electrical infrastructures (from small LV systems, cable lines, small devices, to the extensive overhead and cable HV lines).

At the end of the environmental impact stage or after a measurement survey, in the event of finding the legal limits or limits set by suitable specifications defined by the customer have been exceeded, it is possible to design mitigation solutions that reduce magnetic induction levels.

Through its Engineering department, Sati Shielding is able to design passive, active or miscellaneous mitigation systems for human protection or to assure immunity of electronic devices and systems.

The design and construction of a shielding system is similar to "tailoring" and in order to meet certain magnetic fields reduction objectives it requires the shape, dimensions and thicknesses of the shielding solutions to be chosen so as to optimise the amount of material according to the area to be shielded and according to the sources (e.g. position and power of the various components).

A shielding design and construction project is provided by way of example, which shows how design is able to accurately foresee the reduction of magnetic induction levels when the mitigation system is installed.

Fig. 8 shows the case of shielding a building located underneath a HV overhead power line. The shielding (Fig. 9) features openings at the windows, assessed in the design stage. Fig. 9 shows the designed shielding model indicating the floor where magnetic induction is assessed (it must be lower than 3 μT).

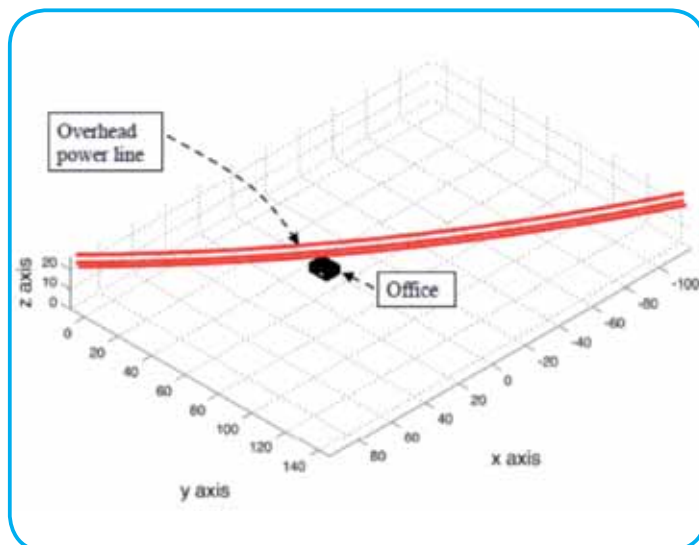


Fig. 8 - Premises located underneath an overhead HV line.

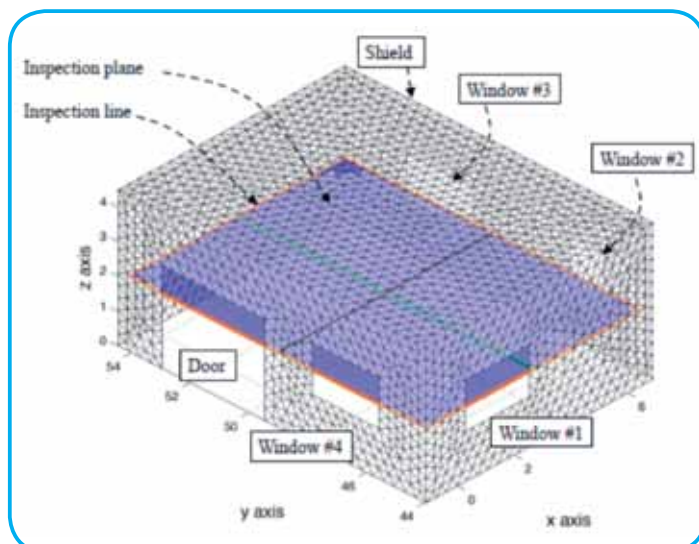


Fig. 9 - Geometric model of the shielding

Designing the Shielding System

Fig. 10 shows the colour map of magnetic induction before and after the implementation of the shield, which evidences the reduction effect introduced by the same.

Fig. 11 shows the shielding system during its installation while Fig. 12 shows the magnetic induction levels measured after the mitigation operation; these levels show optimal consistency with the design specifications (Fig. 10).

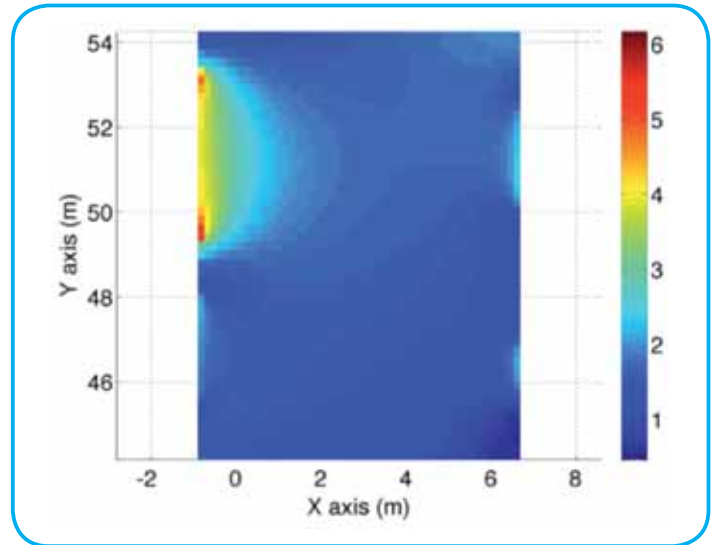
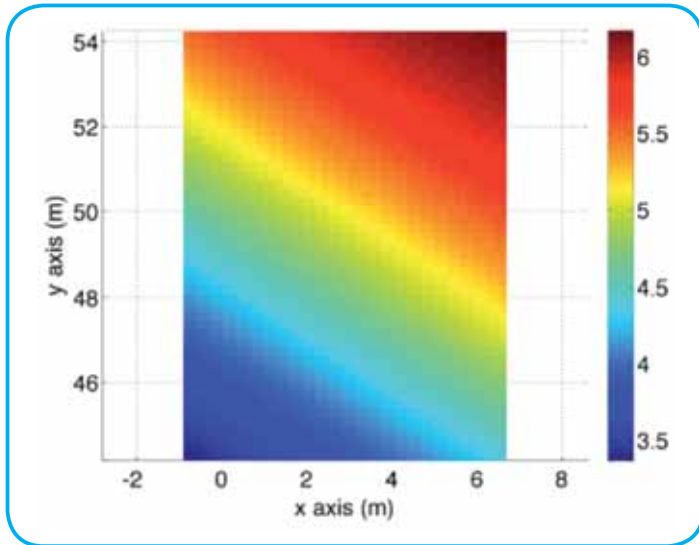


Fig. 10 - Colour map of magnetic induction without and with shielding



Fig. 11 - Installation of the shielding

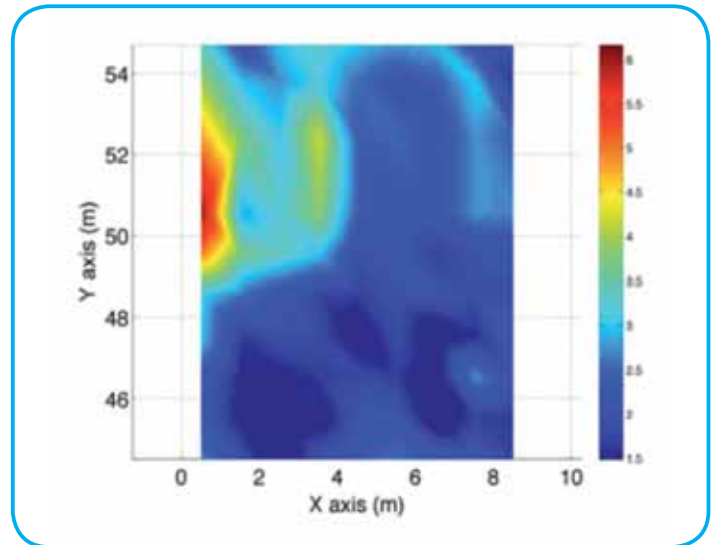


Fig. 12 - Colour map of magnetic induction measured with shielding





Products and Solutions

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Shielding Products

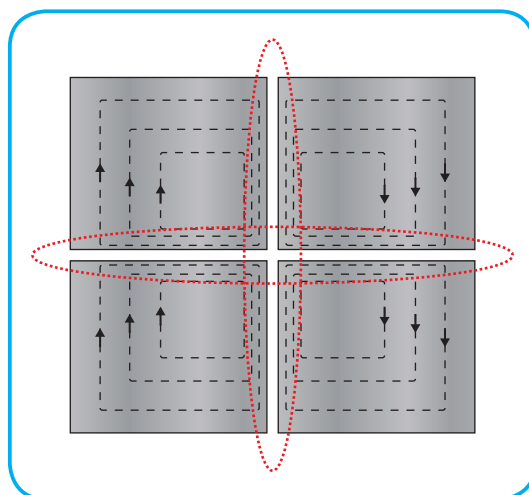
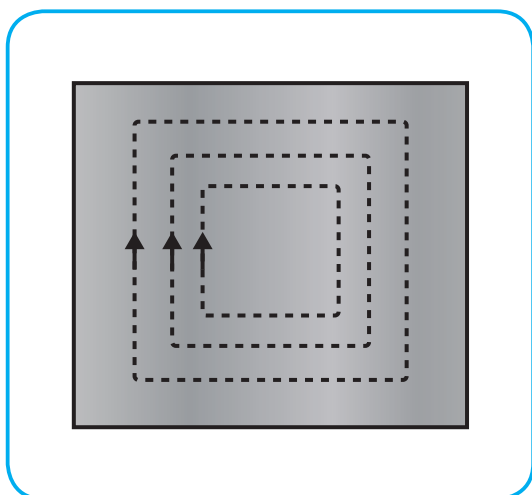
Introduction to the Product

The shielding plates offered by Sati Shielding S.r.l. are multi-layer type consisting of conductive and ferromagnetic material. The different behaviour of the two materials results in a product with optimal shielding efficiency close to the source and maintains a good shielding factor even when moving away from it.

The orientation of the shielding plates compared to the "field source Magnetic", is crucial for mitigation. From Theoretical analysis also supported by experimental testing it is suggested that the placing of the plates with the ferromagnetic part facing towards the source ensures a better shielding efficiency only if that is at few centimeters from the shield and in the case in which is carried a complete shielding of the room where the sources are. Therefore we recommend this type of installation only in the case where the "Victim" is very close (few cm) to the shield.

In all other cases the best performances are obtained with the shielding material with high conductivity facing the "source" and the ferromagnetic to the "victim". This is related to two factors which may be summarized as follows:

- 1) The conductive material operates on the principle of creating a magnetic field which is opposed to the source field, through the currents induced in the same. And therefore it is appropriated that the conductive material refer to the higher source field. If we orient the plate with the side of the ferromagnetic material to the source, this reduces the operating effect of the conductive material.
- 2) The efficiency of a screen is linked to the magnetic and electric continuity of the shielding plates. Failure to link of the plates with on the conductivity face, greatly reduces the overall shielding features, because the induced currents that create the reverse field can only circulating in the single plate and can't move between a plate and the others. It is therefore essential an electrical connection between the plates, using profile or welding.



Shielding Products

The negative effects due to conductive and ferromagnetic discontinuity can be in the practice emphasised by inevitable installation tolerances that can generate significant gaps (several millimetres) between the plates on large surfaces. These gaps generate an increase in the effects on the conductive and ferromagnetic shields and make welding operations between the conductive parts even more complex.

Wanting to maintain the advantages inherent in the concept of the modular plate, Sati Shielding has developed a new patent-protected product (no. 102016000073893), which improves the problems mentioned with regard to the conductive and ferromagnetic parts.

The flat plate is usually square-shaped with one part of the sides flat and the other moulded to form a wing. The wings of a plate will overlap with the flat parts of the adjoining wings. Installation of the different plates is as shown in Fig. 13.

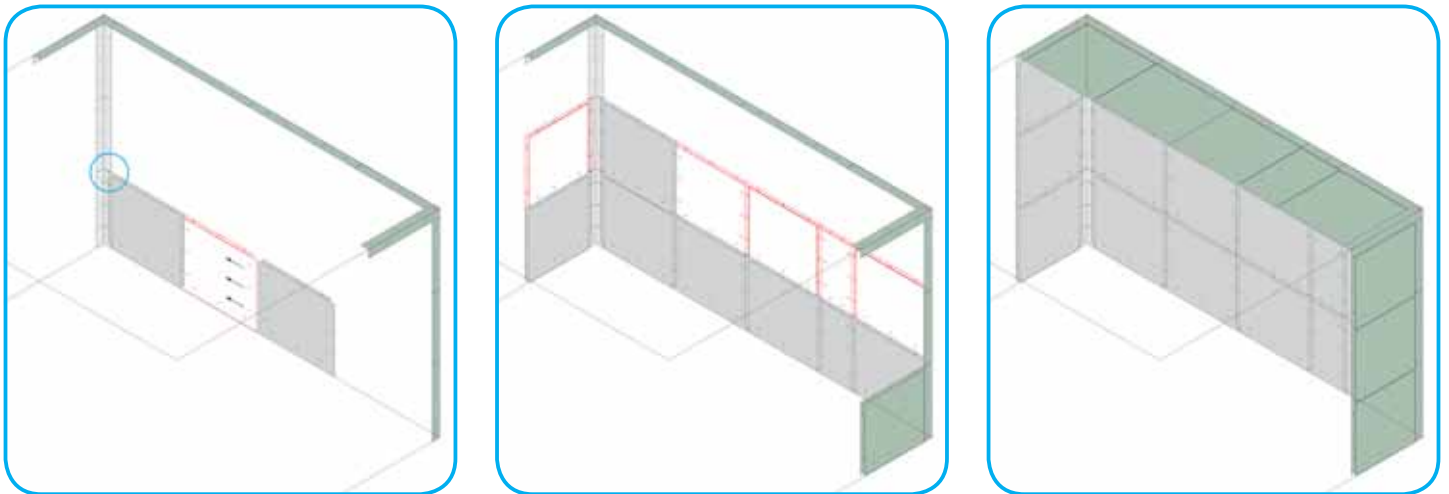


Fig. 13. Example of installation

The detail of the wing inserted in the new plate by Sati Shielding is shown in Fig. 14.

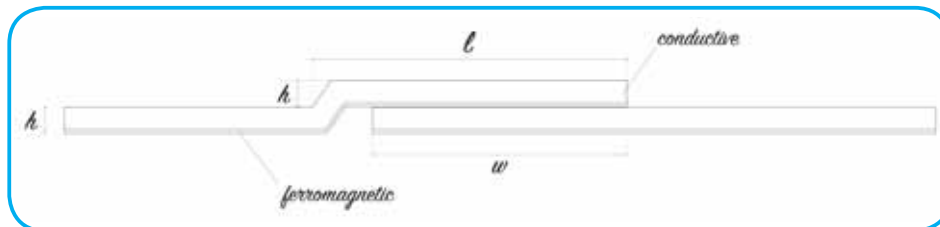


Fig. 14. Detail of the wing element

The proposed solution enables the following advantages:

- Reduction in magnetic coupling reluctance between the plates. Consider having a mixed system of conductive and ferromagnetic plates. In the area where the lower and upper plates overlap, the magnetic field passes from one ferromagnetic plate to another through the thickness limited to the conductive layer (Fig. 15).

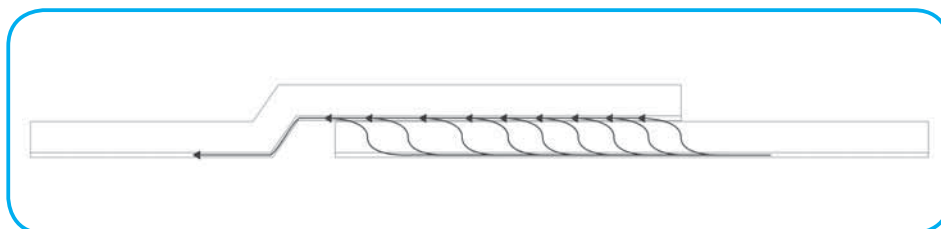


Fig. 15. Detail of the wing element

Shielding Products

- b) Compensation of edge effect on magnetic fields due to induced currents in the edges of the plates. As shown in Fig. 16, the induced currents in the two plates have opposite direction and therefore generate local magnetic fields that mutually compensate each other. This compensation is an advantage regarding the effects to the edges, even without welding.

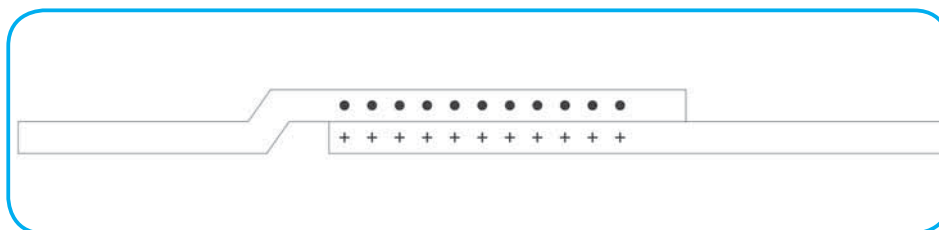


Fig. 16. Compensation of the currents in the overlapping area of the plates

- c) By welding the conductive plates the induced current are not confined in each single plates and this correspond to an increase in the performance of the shielding system. In fact, welding restores electrical continuity between the plates, thus enabling the induced current to circulate freely. Welding carried out between the edge of the upper plate and the flat part of the lower plate (Fig. 17) is facilitated by the natural recovery of mechanical tolerances in connection with overlapping between the plates. This facilitates the installation phase of the plates and enables increased margins on mechanical tolerances.

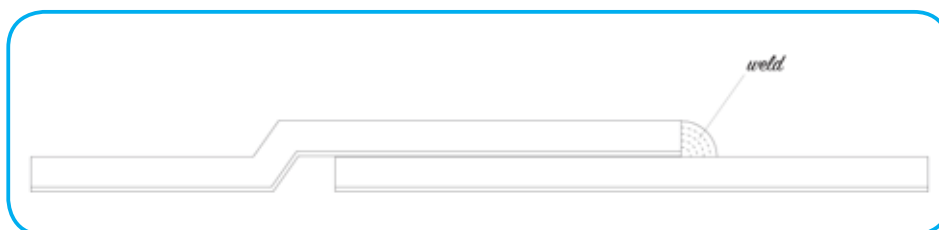


Fig. 17. Positioning of the weld between the conductive parts

- d) Lastly, overlapping between the plates facilitates installation of the plates on the ceiling. By fixing the first upper plate on the ceiling, the next one, which will be a lower type, can use the wing of the upper one as a support base. The proposed solution can be used on plates made from different compositions of ferromagnetic and conductive plates, and therefore on the entire range offered by Sati Shielding.

Shielding Products

WPL Low Thickness plate - 2.7 mm

The overall thickness of the plate is equal to 2.7 mm, with layers having the following features:

- 1st layer: high-permeability magnetic material composed of two overlaid plates each 0.35 mm thick.
- 2nd layer: material with high electrical conductivity 2 mm thick.

The shielding factor is shown in Fig. 18.

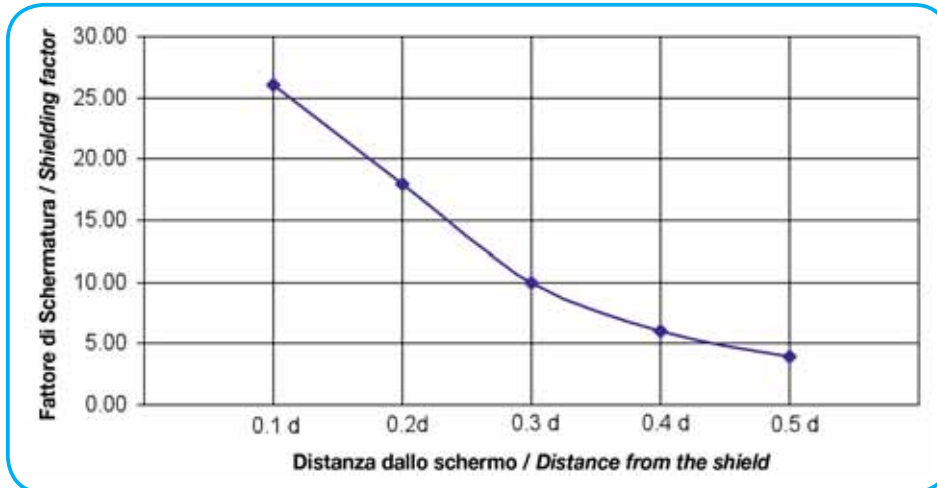


Fig. 18a - Shielding factor for plates type LT with high permeability material facing the source.

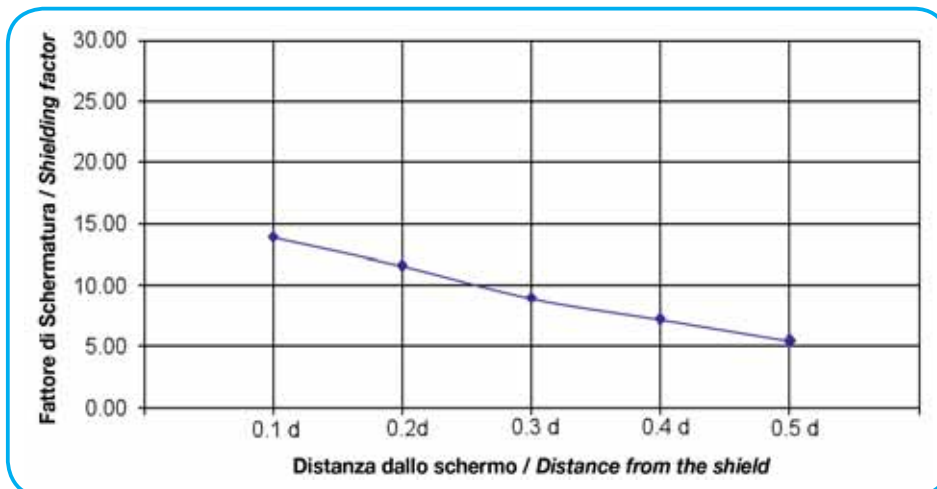
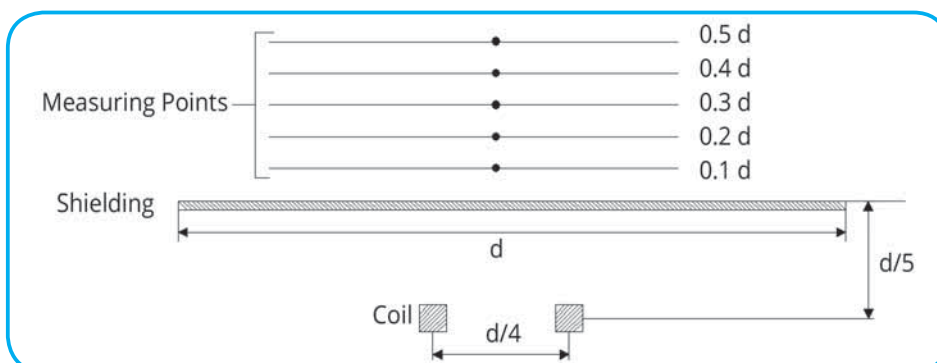


Fig. 18b - Shielding factor for plates type LT with high conductivity material facing the source.



Shielding Products

WPM Medium Thickness plate - 4.7 mm

The overall thickness of the plate is 4.7 mm, with layers having the following features:

- 1st layer: high-permeability magnetic material composed of two overlaid plates each 0.35 mm thick.
- 2nd layer: material with high electrical conductivity 4 mm thick.

The MT series has improved conductive shielding factors and is capable of maintaining high levels of protection at a distance from the shield.

The shielding factor is shown in Fig. 19.

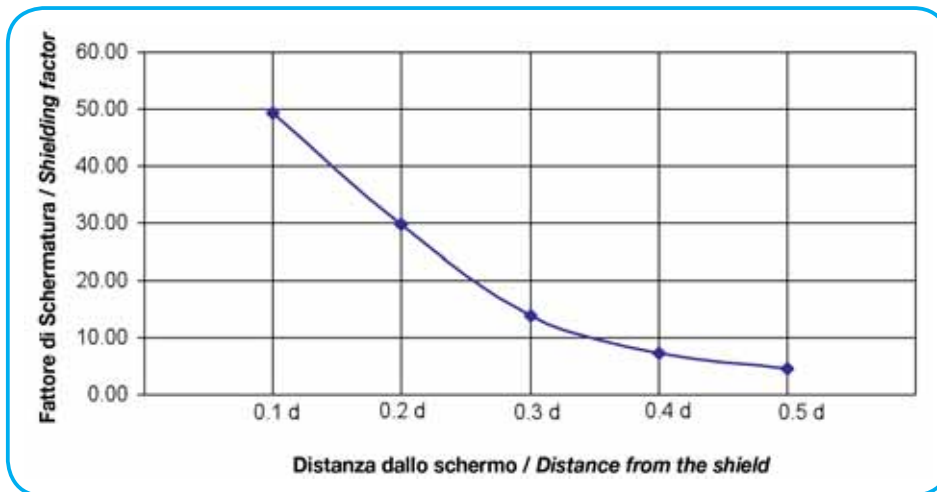


Fig. 19a - Shielding factor for plates type MT with high permeability material facing the source.

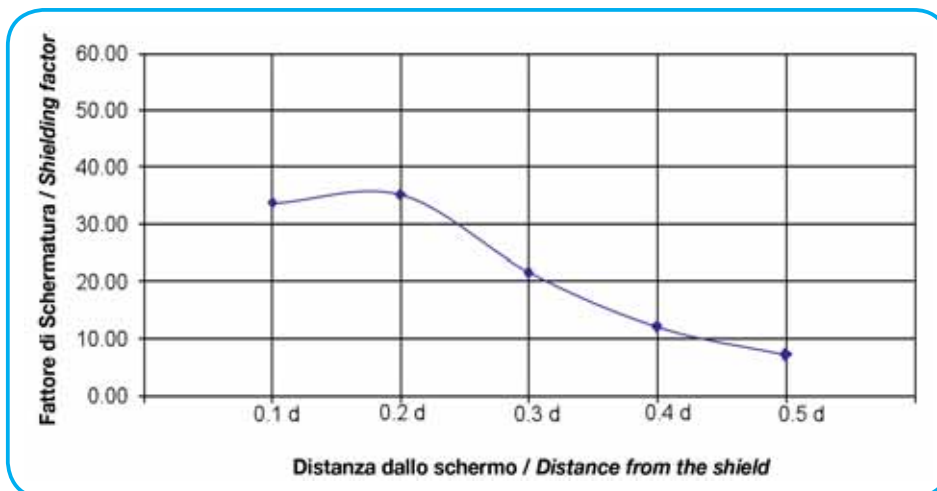
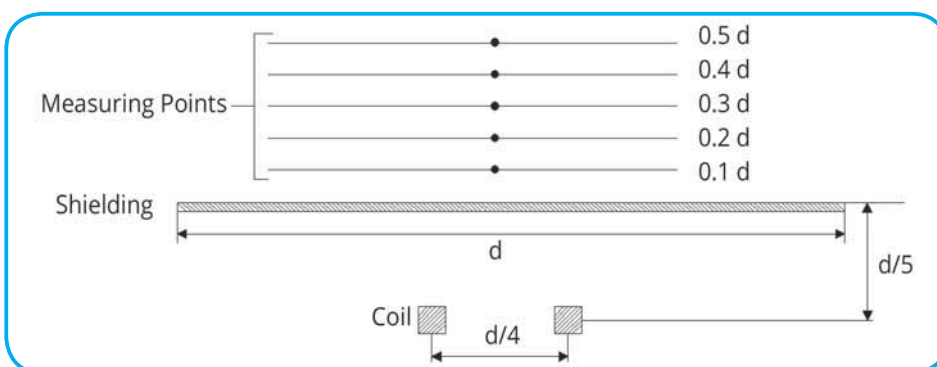


Fig. 19b - Shielding factor for plates type MT with high conductivity material facing the source.



WPL Shielding Products

Low thickness plate 2.7 mm (WPL Low Thickness)

Plate



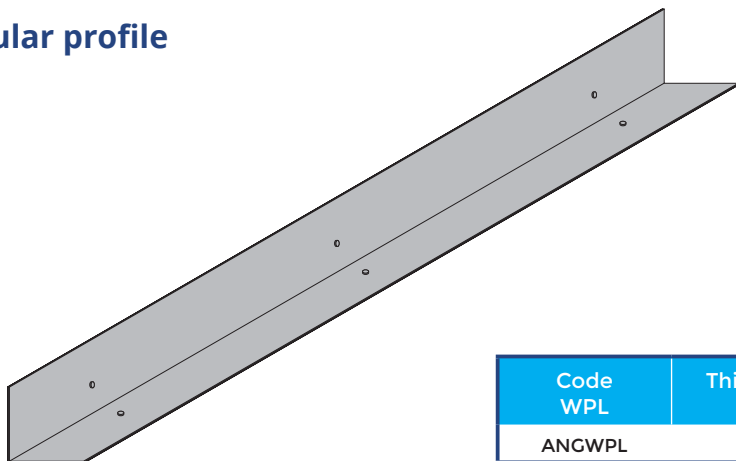
Standard 3 wings

Code WPL	Thickness mm	Dimensions m ²	kg./m ² .
WPL0103	2,7	1,00	10,895
WPL2103	2,7	2,00	21,790
WPL0102	2,7	0,50	5,448
WPL0101	2,7	0,25	2,724

Standard 1 wing

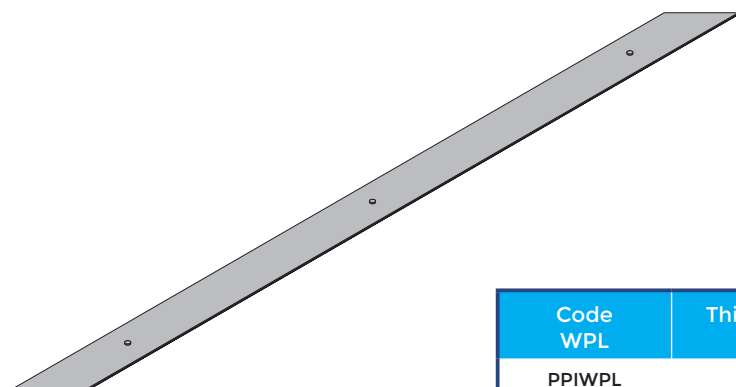
Code WPL	Thickness mm	Dimensions m ²	kg./m ² .
WPL1103	2,7	1,00	10,895
WPL21103	2,7	2,00	21,790
WPL1102	2,7	0,50	5,448
WPL1101	2,7	0,25	2,724

Angular profile



Code WPL	Thickness mm	Length mm	Dimensions mm	kg./Pz.
ANGWPL	2,7	1000	Max. 125 + 125	Max. 2,724

Flat profile



Code WPL	Thickness mm	Length mm	Dimensions mm	kg./Pz.
PPIWPL	2,7	1000	Max. 125	Max. 1,362

WPM Shielding Products

Medium thickness plate 4.7mm (WPM Medium Thickness)

Piastra



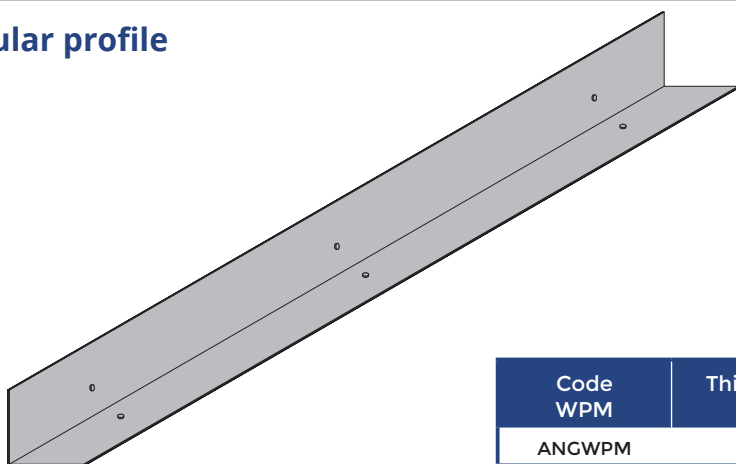
Standard 3 wings

Code WPM	Thickness mm	Dimensions m ²	kg./m ² .
WPM0203	4,7	1,00	16,295
WPM2203	4,7	2,00	32,590
WPM0202	4,7	0,50	8,148
WPM0201	4,7	0,25	4,074

Standard 1 wing

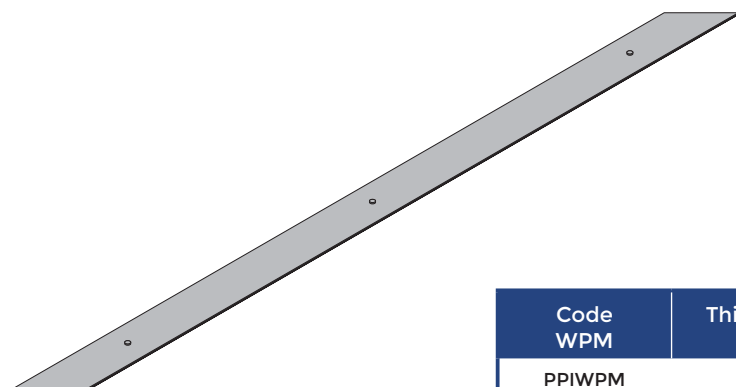
Code WPM	Thickness mm	Dimensions mm	kg./m ² .
WPM1203	4,7	1,00	16,295
WPM21203	4,7	2,00	32,590
WPM1202	4,7	0,50	8,148
WPM1201	4,7	0,25	4,074

Angular profile



Code WPM	Thickness mm	Length mm	Dimensions mm	kg./Pz.
ANGWPM	4,7	1000	Max. 125 + 125	Max. 4,074

Flat profile



Code WPM	Thickness mm	Length mm	Dimensions mm	kg./Pz.
PPIWPM	4,7	1000	Max. 125	Max. 2,037

Shielding Products

Low thickness plate 2.7 mm (LT Low Thickness)



Standard

Code LT	Thickness mm	Dimensions mm	kg./Pcs.
PLT0101	2,7	500 x 500	2,724
PLT0102	2,7	500 x 1000	5,448
PLT0103	2,7	1000 x 1000	10,895

Special Design plates

Code LT	Thickness mm	Dimensions mm	kg./Pcs.
PLT0111	2,7	500 x 500	2,724
PLT0112	2,7	500 x 1000	5,448
PLT0113	2,7	1000 x 1000	10,895

Medium thickness plate 4.7mm (MT Medium Thickness)



Standard

Code MT	Thickness mm	Dimensions mm	kg./Pcs.
PMT0201	4,7	500 x 500	4,074
PMT0202	4,7	500 x 1000	8,148
PMT0203	4,7	1000 x 1000	16,295

Special Design plates

Code MT	Thickness mm	Dimensions mm	kg./Pcs.
PMT0211	4,7	500 x 500	4,074
PMT0212	4,7	500 x 1000	8,148
PMT0213	4,7	1000 x 1000	16,295

High thickness plate 6.4 mm (HT High Thickness)



Standard

Code HT	Thickness mm	Dimensions mm	kg./Pcs.
PHT0301	6,4	500 x 500	6,123
PHT0302	6,4	500 x 1000	12,246
PHT0303	6,4	1000 x 1000	24,490

Special Design plates

Code HT	Thickness mm	Dimensions mm	kg./Pcs.
PHT0311	6,4	500 x 500	6,123
PHT0312	6,4	500 x 1000	12,246
PHT0313	6,4	1000 x 1000	24,490

Shielding for Energy Distribution Substations with Buffer Zone 0: FRzero Substation

The mitigation solution called "Zero buffer zone substation" has the objective of eliminating the buffer zone of a MV/LV energy distribution substation which is normally equal to approximately 2-2.5 metres from the perimeter of the substation itself.

Elimination of the buffer zone, as set forth in the regulation, is ascertained by using software that is experimentally validated and verified in compliance with standard IEC EN 62110:2012-11 at 20 cm from the substation walls.

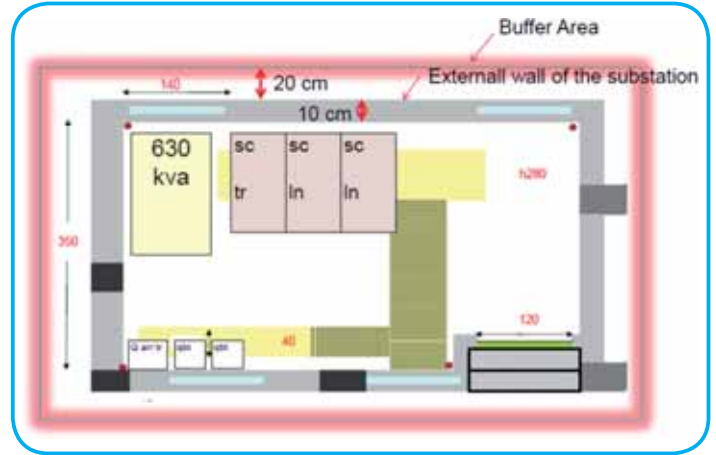


Fig. 16 - Secondary transformer substation

Based on the configuration of the MV/LV transformer substation usually comprised of a MV panel, a MV/LV transformer generally in oil bath and a LV panel, the calculation model is created using MAGIC software, which is used to take into consideration the major sources of magnetic emissions:

- MV panel;
- MV/LV transformer;
- connection wires between MV/LV transformer and LV switching panel;
- connection wires between MV panel and the MV transformer terminals
- LV switch panel.

The study is conducted by verifying the magnetic induction values generated by the substation in its surrounding area on different x-y planes parallel to the treadable surface of the substation and placed at various z distances from it.

A shield that guarantees observance of the quality limit (3 μ T) at the nominal current is designed for each emission source.

The shielding elements that, as a whole, provide the magnetic induction mitigation action, are built by coupling highly conductive and high magnetic permeability materials, and refer to all aforementioned sources.

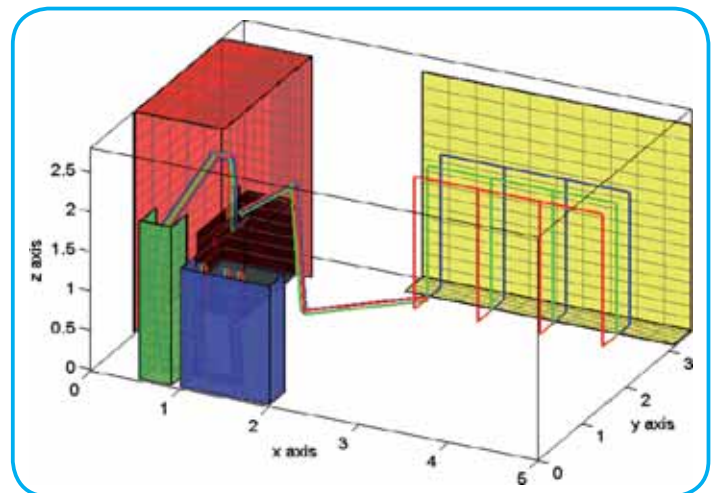


Fig. 17 - Shielding element design and simulation

Shielding for Energy Distribution Substations with Buffer Zone 0: FRzero Substation

The substation is built by installing the equipment and shields in accordance with the project and the provided instructions.



Fig. 18 - Shielding element installation

The demonstration of the performance of this shielding solution was verified through a campaign of magnetic induction measurements along the outer perimeter of the substation every 0.50 m and at a distance of 0.20m from it. Measurements were taken at each point, at three different heights from the substation's treadable surface (0.5; 1; 1.5 m). Lastly, the average of the measurements taken at the three different heights was calculated for each measuring point.

This activity confirms the elimination of the buffer zone of the secondary substation and represents the final testing of the installed mitigation system.

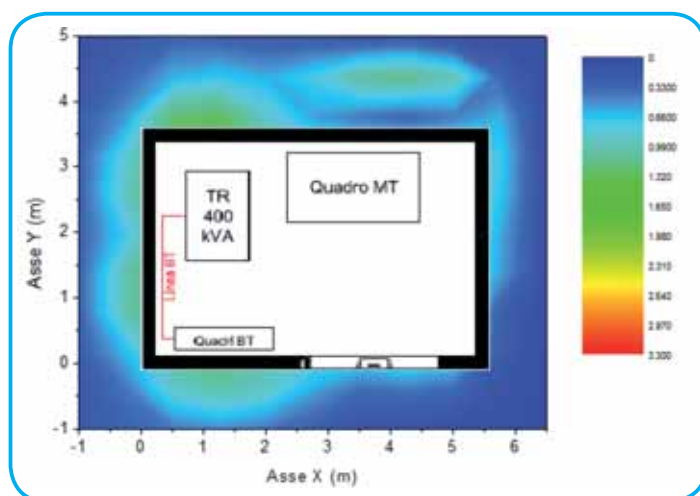


Fig. 19 - Values measured during final testing of the shielding system

Following the proposed mitigation activity, it is possible to affirm that the substation has a buffer zone of 0 (zero) metres from all of its walls.

There are two types of shielding that can be adopted for 400 and 630 kVA substations.

Transformer substation	Code
400 kVA	FRZ0400
630 kVA	FRZ0630

Free-standing Shielding Structure

Dry transformer shielding is often challenging due to the intense magnetic fields that they produce. It is necessary to have a shielding system that features a high shielding factor which can only be achieved through the combined use of materials with magnetic and conductive behaviour. Based on the standard product, Sati Shielding developed an innovative localised transformer shield comprised of a free-standing wall to be installed near the transformer.

Description of the shielding materials and their shielding efficiency:

The magnetic induction mitigation system is achieved by installing magnetic shielding obtained by coupling two different materials:

- Material with high electric conductivity
- Material with high magnetic permeability

In the presence of a variable magnetic field (inducer field) the layer of material with high electrical conductivity becomes a place of circulation currents, which in turn generate a reaction magnetic field (induced field). The combined effect of the fields, induced and inducer, translates into an overall reduction of the total magnetic field.

The layer of material with high magnetic permeability reduces magnetic induction by absorbing the existing magnetic field. Its shielding behaviour, similar to an "umbrella" of protection against the magnetic field can be very intense next to the shield, but tends to decrease the further the distance from the shield.

The combination of the two materials, ferromagnetic and conductive, create a shield with excellent shielding capacities, both next to the shield, mainly thanks to the ferromagnetic shield, as well as far away from the shield, thanks to the conductive shield.

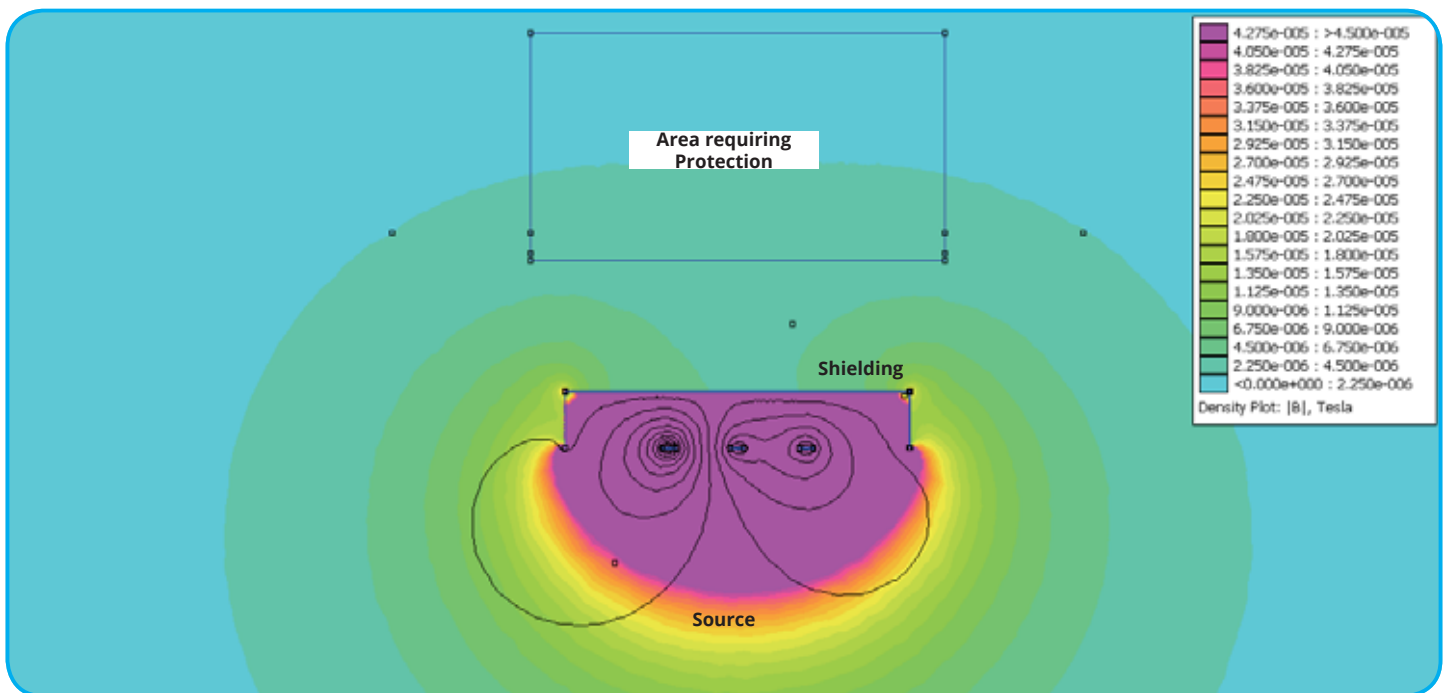


Fig. 20 - The shielding effect with display of the levels of magnetic induction in the area requiring protection

Free-standing Shielding Structure

The shielding specifications are defined through the shielding factor measurement (SF: Shielding Factor) carried out at the Sati Shielding S.r.l. research and development laboratory in via Ferrero 10, Rivoli Cascone Vica (TO).

The tests were performed by measuring the magnetic induction values emitted by a resin transformer with a nominal power of 630 kVA before and after field mitigation activity.

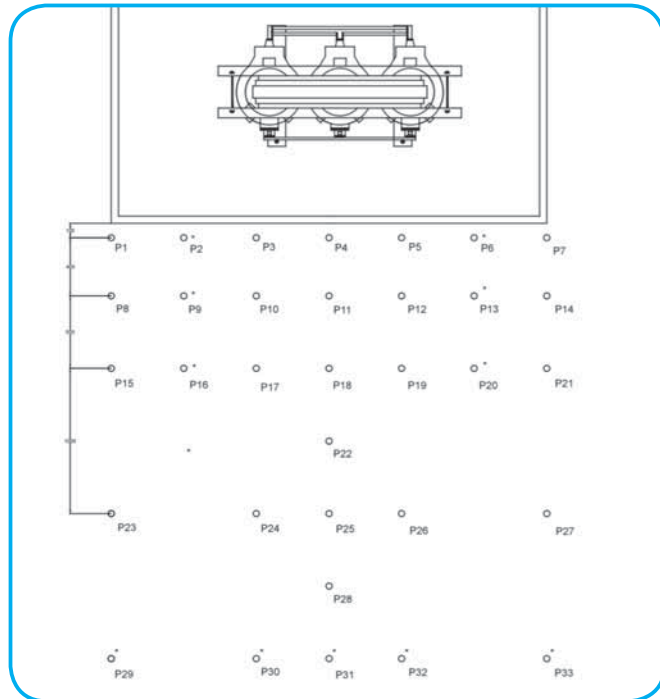


Fig. 21 - Test layout to determine the shielding factor

The configuration of the tests and the obtained results are provided here:

Shield dimensions were adapted to the size and therefore the dimensions of the installed transformer.

The dimensions of the wall that the experimental tests refer to are provided by way of example.

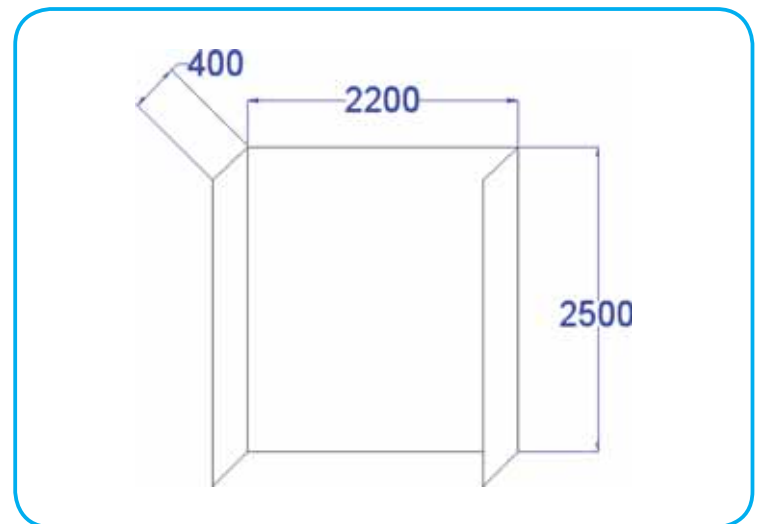


Fig. 22 - Shielding solution dimensions

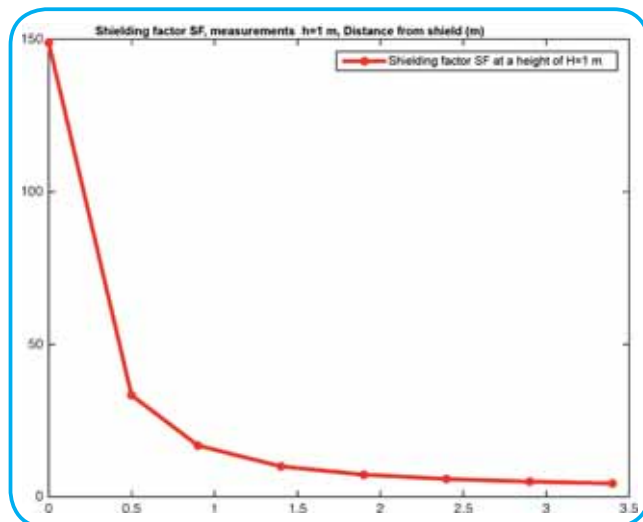


Fig. 23 - Shielding factor trend based on the distance from the shield at a height of 1 m from the ground.

The shielding factor suggested below is calculated as a ratio between the magnetic induction modules in the pre and post shielding situation, based on the distance from the shield.

It represents a simple and immediate indication of how many times it is possible to reduce the magnetic induction value by applying the shielding solution.

Dimensions (mm) B x H x P	Code	kg./Pcs.
2200 x 2500 x 400	SPU0102	94,50
	SPU0104	143,10
	SPU0106	191,70

Shielding Cable Trays and Covers

Shielding Cable Trays.

Shielding Cable Trays are capable of ensuring a magnetic field mitigation factor of 25. The layout is shown in Fig 24. It is possible to choose different sizes of shielding channel all having the same shielding factor running through the entire length of the channel.

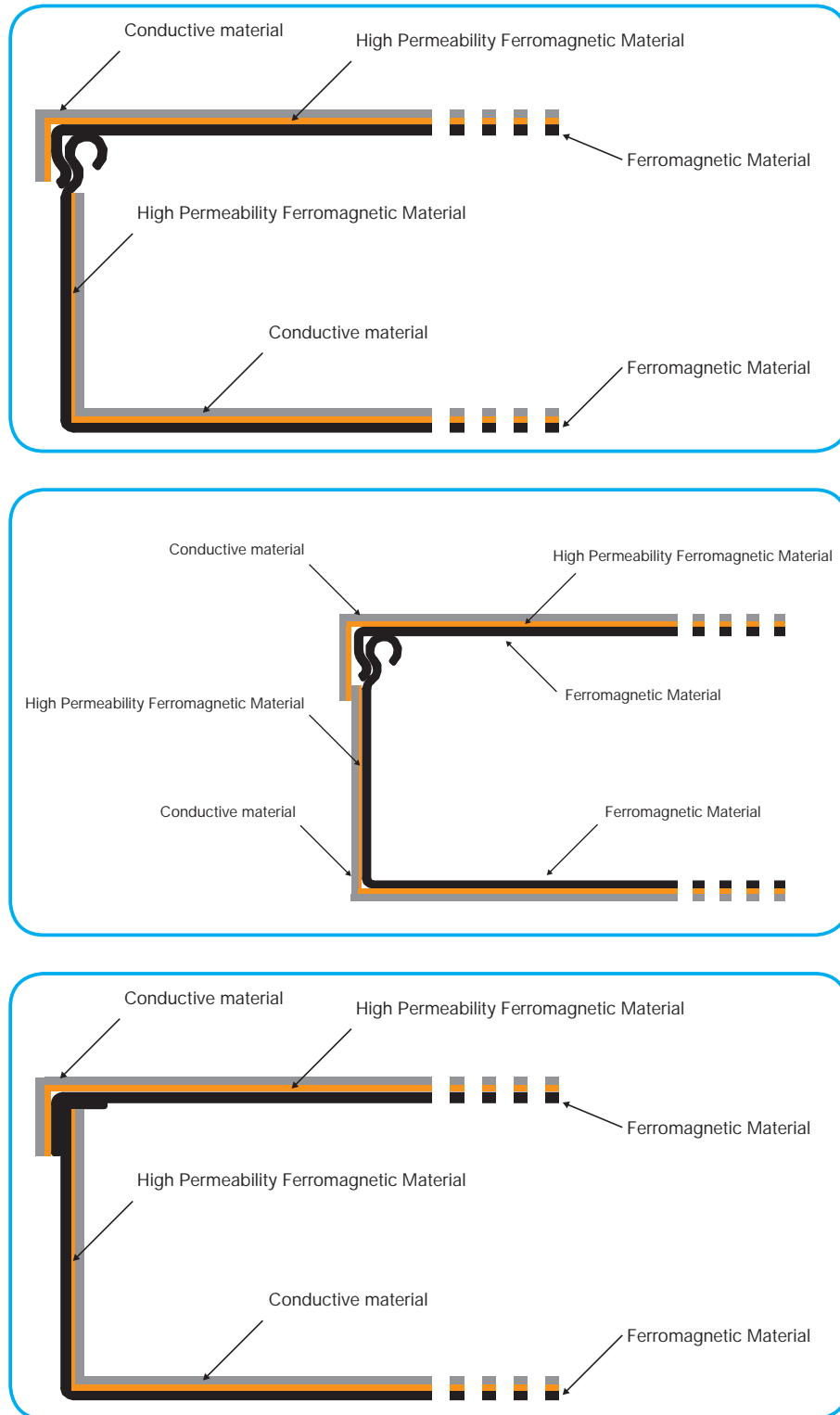
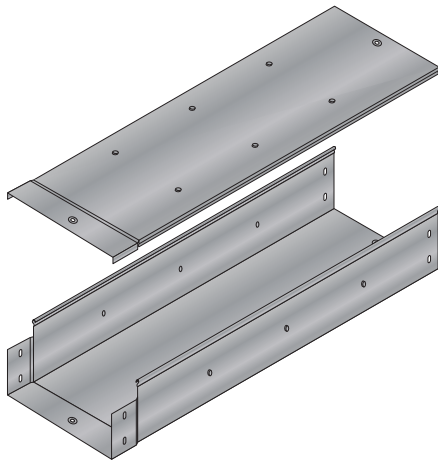


Fig. 24 - Layout Shielding Cable Trays.

Shielding Cable Trays and Covers

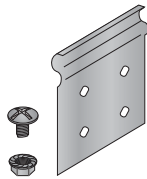
Channel complete with snap fitting cover.



Lenght L	Height H	Base B	Code	kg./m.
3000	80	200	SCT0733	7,271
	100	100	SCT0717	5,397
		200	SCT0719	8,432
		300	SCT0720	11,893
		400	SCT0721	15,142
		500	SCT0722	17,996

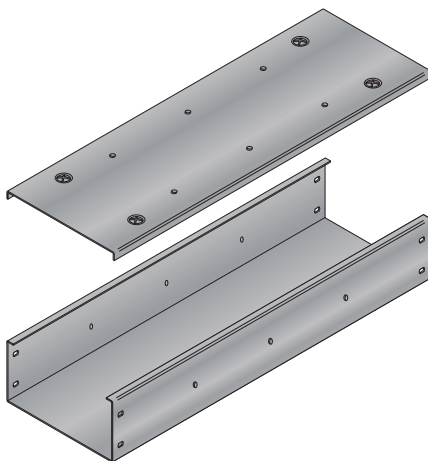
Linear coupling.

Complete with nuts and bolts M 6 x 10 mm.



Height H	Code	kg./Pcs.
100	SCT0800	0,047

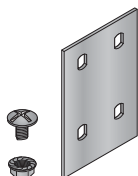
Channel complete with lid with hooks.



Lenght L	Height H	Base B	Code	kg./m.
2000	100	100	SCT0741	9,887
		200	SCT0743	14,382
		300	SCT0744	18,877
		400	SCT0745	23,372
		500	SCT0746	27,866

Linear coupling.

Complete with nuts and bolts M 6 x 10 mm.

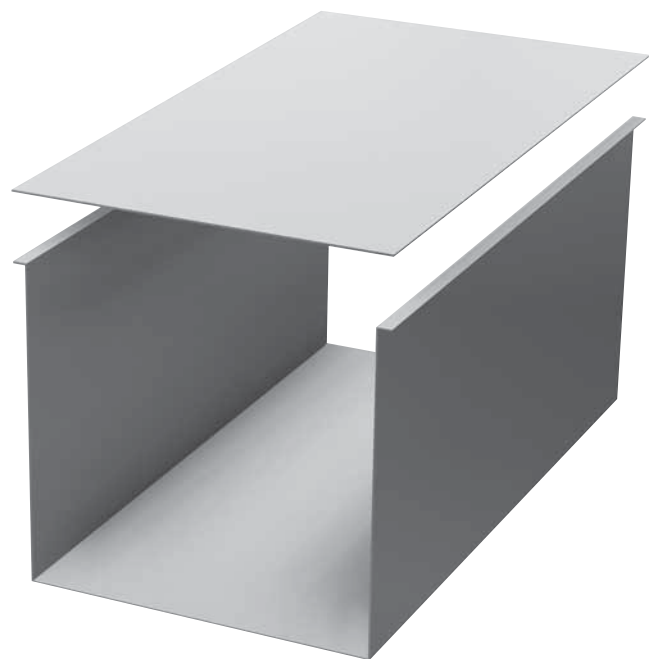


Height H	Code	kg./Pcs.
100	SCT0851	0,090

Shielding Underground Lines

The shielding ducts suitable for outdoor installations are designed according to the size required. The choice of the materials of the duct, the type of processing and the dimensions depend on the conditions of installation and on the shielding factor request for the mitigation. The Ducts are available with shielding configurations characterized by different shielding factors between 8 and 30 times, In addition there are different ducts, suitable for outdoor or underground installation.

Channel complete with lid and locking clip



Lenght L	Height H	Base B	Code	kg./m.
3000	500	510	On Request	48,000



Shielding Underground Lines

Sati Shielding S.r.l. has patented a shielding technique based on the principle of deleting sources. This method is similar to the passive loop technique but features significantly higher performance and lower costs.

The Sati Shielding S.r.l. system falls within the passive shield group. These systems are so called because they take the energy to operate directly from the source that generates the field to be mitigated.

The innovation of the Sati Shielding S.r.l. system consists in the high coupling between source and shield which is obtained by using an appropriately sized magnetic core.

The high magnetic coupling results in higher performance than traditional systems. Furthermore, the appropriate sizing fully exploits the materials used, significantly reducing costs compared to conventional solutions.

The system offered consists of relatively simple components made of common electrical material that requires, however, accurate electrical and magnetic sizing. The shielding system offered is suitable to be classified in a series of standard components that may make up a product catalogue.

In a variety of applications, the most important of which is underground cables, the solution put forth has higher performance than competing ones and features a significantly lower cost.

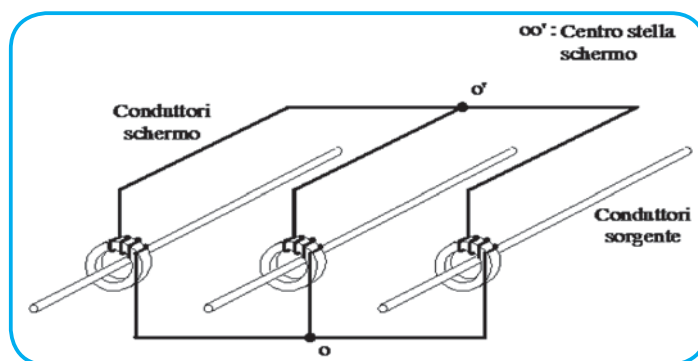
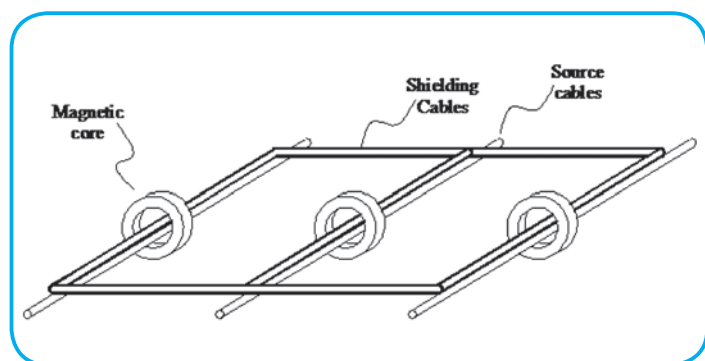
The Sati Shielding S.r.l. system has been patented under the name of: "High magnetic coupling meshed and conductive shielding system"..

Technology

Sati Shielding S.r.l. develops, designs and markets solutions for shielding the magnetic fields produced by underground cable power lines, transformation stations and electrical equipment.

Sati Shielding S.r.l. has patented a shielding technique based on the principle of deleting sources. This method is similar to the passive loop technique - already implemented in cable power lines - but features significantly higher performance at lower costs.

The improvement is achieved by coupling the sources to the passive loops through appropriately sized magnetic cores. The shielding technique we offer features a number of variants according to the various applications.



Shielding Underground Lines

Cable lines

Shielding of cable power lines is important to meet the magnetic field levels introduced by the relative national laws framework related to the population protection from the long or short-term effects produced by magnetic fields.

In installations of high-voltage power lines the so-called Joint Bay are inevitable: areas of the line in which there are connections (joints) between the various sections. The presence of joints involves a higher distance of the line conductors which results in exceeding the levels of admissible magnetic field.

There is therefore the possibility to shield said section of the line and Sati Shielding S.r.l. has designed ad hoc shielding for this application.

Compared to other existing solutions applied to this case, the Sati Shielding S.r.l. system reduces material use by a factor of 2-3, reduced installation time by a factor of 3-4 and increases performance i.e. shielding coefficient by a factor of 5-10.



Description	Code
Joint Bay < 1200A < 15MT	On Request

Software MAGIC®

MAGIC® – *Magnetic Induction Calculation* is a software for calculating the magnetic fields generated by electrical type sources such as transformers, power line systems, MV/LV substations, joint holes, busbars, electrical systems.

MAGIC® is a tool for **environmental impact analysis** of magnetic fields and to establish the **buffer zones for MV/LV power lines and substations**.

The software is aimed at design offices, engineering firms and professionals who perform environmental impact assessments. It is simple and user-friendly, and the inputs required for the assessment of a case study can be easily obtained from the floor plans and design data.

MAGIC® makes it possible to analyse:

- **Single sources** (power lines, cables, multi-conductor systems, transformers) by two-dimensional and three-dimensional configurations by integrating the Biot-Savar law.
- **Complex systems**, such as MV/LV electrical substations, taking into account the three-dimensionality of the sources, their actual position and the superposition of effects of the various substation components. Special attention has been paid to the modelling of components such as power transformers present in transformation stations.

Regarding particular sources MAGIC® makes it possible to analyse:

- **MV/LV substations up to 6 transformers**, tracing buffer zones for the aims of environmental impact assessment, optimising the arrangement of components in the design stage to reduce the generated **magnetic field to the minimum**, assessing the need for magnetic field mitigation operations for existing or designed substations, with no need for measurements.
- Magnetic field generated by **cable lines**, or cable line systems (underground, in runways, ducts, conduits etc.), finding cable configuration that assures reducing the generated magnetic field to the minimum, generating graphics outputs that may be directly used in environmental impact assessments.
- Magnetic field generated by **overhead line** systems in arbitrary configuration (in power lines with crossed, side by side, close-up spans etc.).

To address these needs Sati Shielding S.r.l., thanks to the experience acquired in many real applications, has developed the MAGIC® software.

Main features of the MAGIC® software

- Simple user interface for rapidly displaying magnetic induction levels.
- Calculation on points and graphical display on lines and surfaces.
- Analyses two-dimensional and three-dimensional structures.
- Analyses notable system engineering configurations: distribution, transport lines, electrical substations etc.
- Parametric models
- Widely tested by experts in the field.
- Implementation of accurate models with special reference to power transformers.
- Utmost compliance with the sector's regulations and standards.
- Possibility to implement any three-dimensional source through an open environment.

The Sati Shielding S.r.l. team does not merely wish to sell a software but seeks to establish a network of specialists that may meet and discuss the issues associated with the environmental impact assessment of magnetic fields. **MAGIC®** will be periodically updated by entering new sources, also taking into account its users' feedbacks.

Software MAGIC®

What is it for?

The MAGIC® software allows the user to make by themselves the assessment of magnetic fields generated by system sources (power lines, MV/LV substations, industrial electrical systems, High and Medium Voltage overhead lines, joint holes etc.), in a simple and efficient manner, with no need for specific skills in electromagnetic fields regulations, with no need to use consultants.

Risk assessment (European Directive 2013/35/UE) for the exposure to magnetic fields in the workplace

European Directive 2013/35/UE obliges companies to carry out the assessment of the risk due to exposure to magnetic fields. The assessment of magnetic fields may be carried out with measurements or via calculation algorithms. The MAGIC® Software allows the personnel of the company's internal engineering department to perform the assessment of the magnetic fields generated by its electrical devices and systems by themselves, with no need for measurements, and in compliance with the regulations.

Assessment of field levels in civil environments

The MAGIC® Software makes it possible to assess the magnetic induction generated in civil environments by power lines, MV/LV transformation stations, overhead lines, plant engineering configurations.

Examples of analyses that may be carried out with the MAGIC® software:

- Analysis of the exposure to magnetic fields generated by underground power lines.
- Analysis of the exposure to magnetic fields generated by overhead lines (High Voltage pylons).
- Analysis of the exposure to magnetic fields generated by industrial electrical installations.
- Analysis of the exposure to magnetic fields generated by MV/LV substations.

Streamlining of electrical substations and installations with the aim of reducing emitted magnetic fields

In the design stage of an electrical installation or MV/LV substation, it is possible to make use of cost free measures for reducing magnetic fields (e.g.: transposing the phases of power lines, transposing the phases on two transformers side by side, etc.) and assessing the emitted magnetic fields, in order to achieve a configuration that often results in magnetic induction levels below law limits at no costs.

Who is it for?

Engineering Firms and Design Firms

The MAGIC® software makes it possible, for example, to assess in the design stage the levels of magnetic field that the power line, electrical substation or electrical installation will produce. It is for instance possible, in the design stage of the substation or installation, to assess various cable arrangements (RSTRST, RSTTSR, RRSSTT, etc.), or paths of power lines and ducts, in order to achieve a solution to even avoid having to use further magnetic field mitigation measures, thus leading to significant economic benefits.

Bodies that perform environmental impact assessments

The calculation algorithms used by the MAGIC® software comply with the law provisions in force on magnetic field assessment and therefore produce valid results for the aims of assessment of the exposure limits for the population and the risk assessment in the workplace, in all cases where the magnetic field source is a low frequency electrical system (transformation substations, power lines, transformers, HV and MV overhead lines, joint holes etc.).

Engineering departments of private companies or public bodies

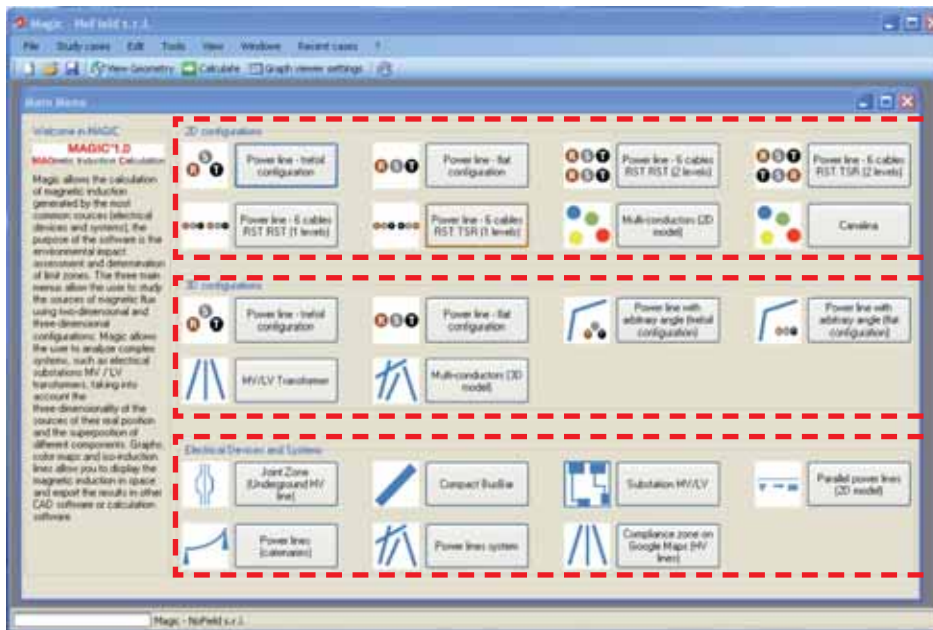
The use of the MAGIC® software does not require specific skills in electromagnetic fields. In this way an engineering department may perform independently magnetic field assessments, in a simple and cost-effective manner, without using consultants and measurements carried out by external personnel. In this way the engineering department may perform the assessment of the risks due to exposure to low frequency magnetic fields.

The engineering department may also independently assess whether a magnetic field source requires mitigation measures or not (e.g.: MV/LV substation next to offices, power line next to work areas etc.) The software is supplied with user guides and tutorials that provide the user with all the information required to start using the software.

Software MAGIC®

Analysis of electrical installations

There are examples of common electrical installations that are often found in practical applications where it is required the superposition of the effects. In MAGIC® there is a section dedicated to these situations that can be updated with new or customized types of sources. In particular MAGIC® provides three types of sources: the Joint Bay of HV cable, MV/LV substations and overhead HV power lines.



**2D
Configurations**

**3D
Configurations**

**Systems
Configurations**

Components

Cast resin transformers, differently from the oil transformers, are not enclosed in a metallic cage that provides a shielding effect. The integral model of the cast resin transformer implemented in MAGIC® makes possible the evaluation of the stray field.

The model has two degrees of accuracy that influence the computational time. They are identified in the software by the name "simplified model" and "rigorous model".

When the stray field is computed at one meter from the transformer the two models are equivalent, while when points are very close to the transformer it is recommended to use the "rigorous model".

MAGIC® is the only commercial software that currently implements the model of the stray fields of transformers. Depending on the power of the transformers, the software defines the main geometric parameters that allow the operator to calculate the magnetic field without knowing more data besides the rated output power of the transformer.

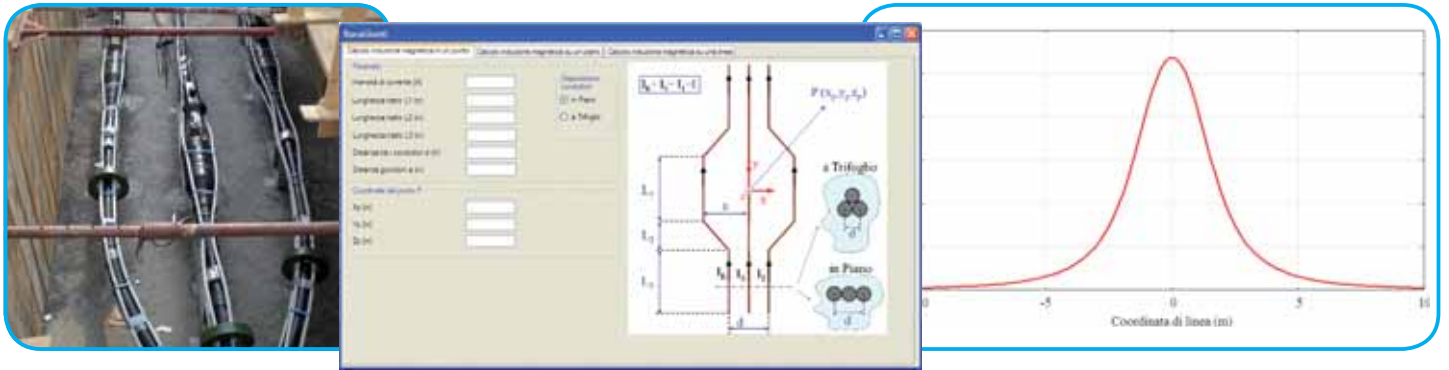


Software MAGIC®

HV lines: Joint Bay

In a joint bay of a HV power lines there are three conductors which are far one from each other even up to one meter. This distance creates an increment of the magnetic flux density that, at rated current, may also exceed $100 \mu\text{T}$. Due to this reason the joint bay can be critical and requires magnetic field assessment and further mitigation. The limit of $100 \mu\text{T}$ is associated with short-term effects and, therefore, must be satisfied at any time, even in places where there may be a short permanence by the general public (ICNIRP requirements).

MAGIC® allows the magnetic study of joint bays using a 3D parametric model. The user does not need to build the system geometry but only set the values of the design parameters.

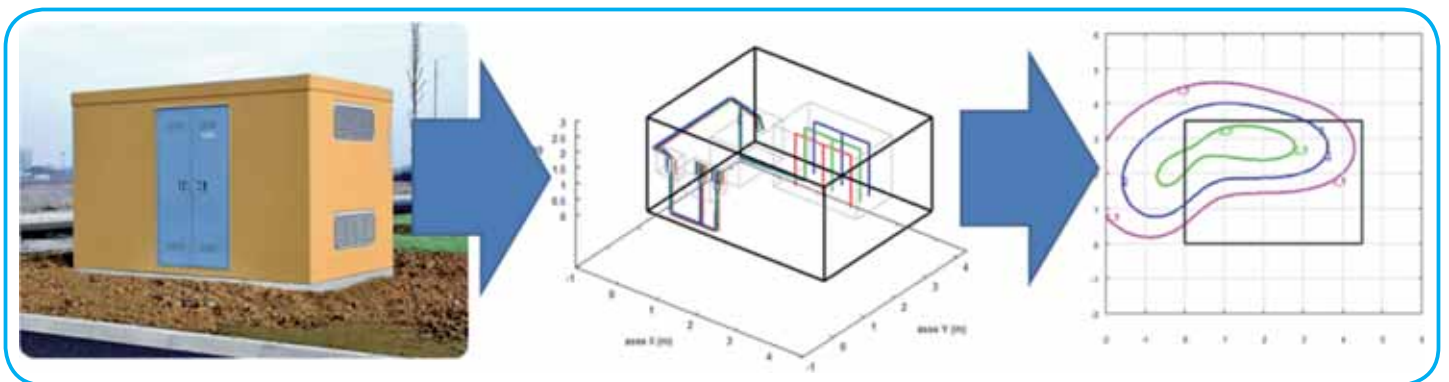


Electrical substations

Many times it was highlighted the need to be able to calculate the magnetic impact of MV/LV electrical substations. The Italian regulatory framework requires to achieve the quality objective ($3 \mu\text{T}$), but there are countries like Switzerland where the limits are stricter ($1 \mu\text{T}$). It is estimated that about 1% of the substations, mainly in civil environment, needs a mitigation action to bring the levels of the magnetic field to the required levels. Since the substations in Europe are estimated to be several millions, one can understand the extent of the issue. The main components of a substation that causes different magnetic impacts on the environment are: MV and LV connections, MV and the LV switchgears and MV/LV transformers.

MAGIC® allows the analysis of substations including up to 6 power transformers, where it is possible to consider the various aspects of design and installation:

- selection between cast resin transformer or oil transformer where the stray field of the transformer is taken into account with a proper model.
- Power lines: MV and LV connections.
- MV panels with in and out cells.
- BT switchgears for the out power delivery.

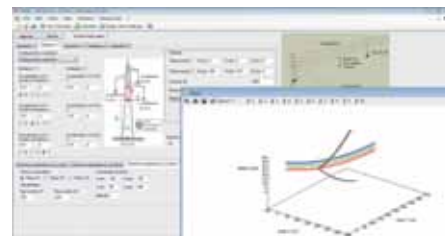


Software MAGIC®

Overhead power lines

MAGIC® calculates the magnetic field generated by overhead power lines HV, MV or LV. There are no limitations to the geometry of the sources, to the number of power lines, to the arrangement of the conductors.

MAGIC® can build a complete 3D model of the sources and can calculate the magnetic field on any 3D inspection plane. The output can be exported as image or in a vectorial format.



MAGIC software is distributed in 3 different modes:

- 30-day licence (trial, or one-off magnetic field assessment).
- 1-year licence.
- Unlimited licence.

Magic® software will be delivered on a USB key that is used for installation and authentication. It can be installed on different terminals, however, use is limited to one PC only where the USB key is connected to authenticate access.

Upon expiry of the validity period of the licence, the software stops working and a new licence must be purchased. The user is entitled to receive updates free of charge, which include new features, case studies etc.

The Magic® licence includes the user manual and calculation's authentication document. Also included with the software is free user assistance or basic training provided at our offices or via Skype.

30-day licence.

This licence makes it possible to install the software on one's PC and use it for 30 days. For example, use enables you to study certain cases without making any significant investments.

If upon expiry of the 30-day period the user decides to purchase a 1-year licence or an unlimited licence, the cost incurred for purchasing the 30-day licence shall be deducted from the new licence fee. This advantage is only valid if the purchase is done within 7 days from expiry of the 30-day licence.

Licence expiring in 1 year.

The software is supplied with a 1-year licence.

If within 2 months from the date of purchase, the user decides to convert the licence to unlimited use, the cost previously incurred shall be deducted from the cost of the new licence.

Unlimited use licence.

This licence allows the user to have a copy of the MAGIC® software with unlimited expiry.

Code	Duration of the Licence Contract of use
MAG0101	30 day
MAG0001	1 year
MAG0201	Unlimited





Installation

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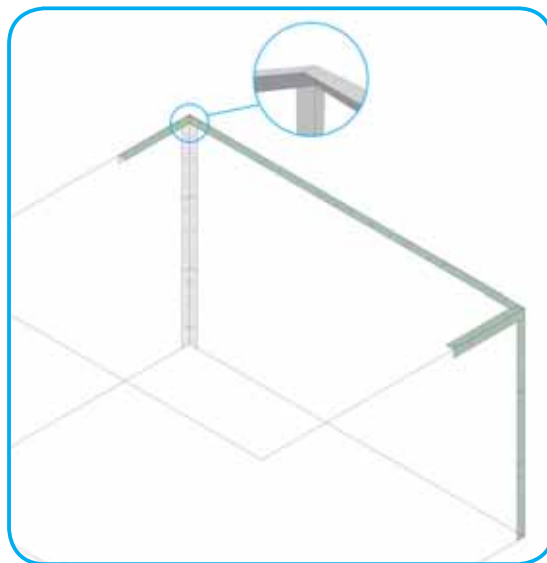
Installation Guide for Flat Plates

Step 1: corner installation.

Note: to install all elements of the shielding system, suitable fastening devices must be selected according to the type of existing structure. There are dowels available for different construction types on the market (solid or perforated brick, solid or perforated cement, drywall etc.)

The profiles and plates must be perforated prior to fixing with a Ø 7 mm iron carbon bit, or suitable for the dowel you will be using. If envisaged, the upper corner profiles must be installed in the first phase (wall/ceiling), followed by the vertical ones on the walls. The corner profiles placed horizontally must be cut by approximately 45° in the corner joints (see figure to the side), adapting the length of the central profile. It is recommended to use four dowels per side for a corner profile length of 1000mm.

Note: before installing the shielded plates, it is recommended to measure the actual dimensions of the wall/soffit from various points. If corners are present, measurements must be taken after installing them. The measurements obtained must be compared with those shown in the attached layout. This enables you to highlight any construction differences and enable you to change and adapt the dimensions of the plates (see STEP 3) according to the actual measurements of the structure.



Step 2: installation the first plate.

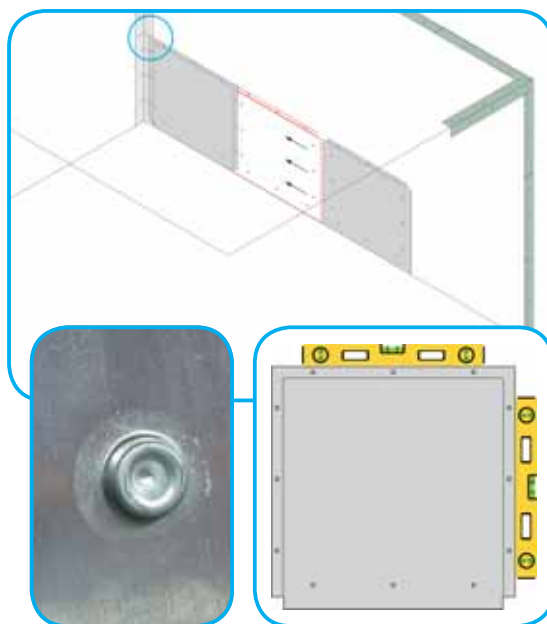
Note: to start installation, refer to the attached layout. All adjoining plates to the walls or corner profiles, if applicable, must have wings on three sides (except in exceptional cases specified in the layout).

The attached installation layout shows the shielded plate that must be initially installed on the wall, with spatial indication of the direction.

The shielded plates must be positioned in such a way that the high electrical conductivity part (the thickest part with the protruding embossment, see photo) is facing the magnetic field sources.

The first perforated shielding plate that must be installed must have wings on three sides, must overlap the corner profile, if applicable, by approximately 50mm, until reaching the end or aligned with the wall.

Horizontal and vertical alignment must be checked before final securing with dowels, without tightening them too much in order to enable installation of the subsequent side and upper plates.

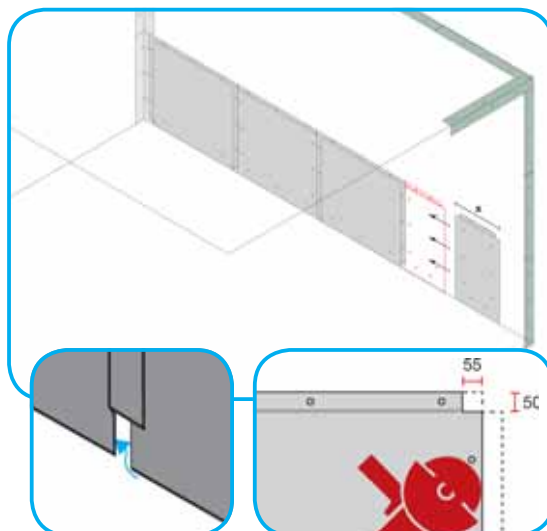


Step 3: plate installation.

In installation sequence, the second plate that must be used has only one wing on the upper side, and before being secured to the wall must slide, by a depth of approximately 50mm until the end, under the wing of the previously secured plate.

Install the plates one after the other, being careful to alternate the version with one wing with those having three wings.

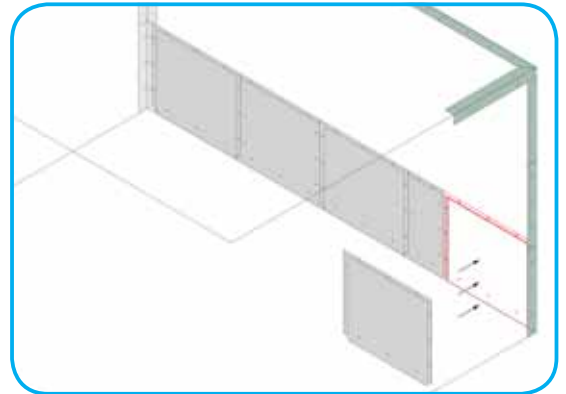
Note: flat plates that only have one upper wing enable you to recover any construction irregularities of the structure and can be cut on three sides according to requirements. If the sides are cut, you must make up for the difference on the upper wing, bringing it back to its original dimensions (50x55mm, see photo). This must be carried out before securing the last plate having three wings, which, by overlapping, will cover any cutting imperfections.



Installation Guide for Flat Plates

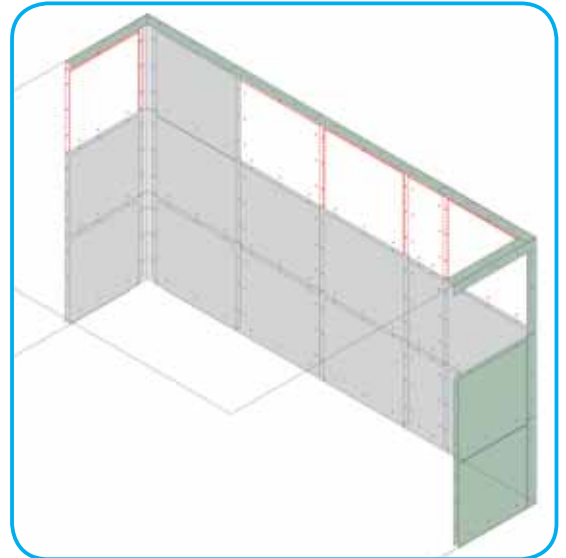
Step 4: plate installation.

Completion of the first row of plates is completed by using a plate having three wings, which will overlap the previous plate and corner profile, if applicable, or reach the end of the opposite wall.



Step 5: plate installation.

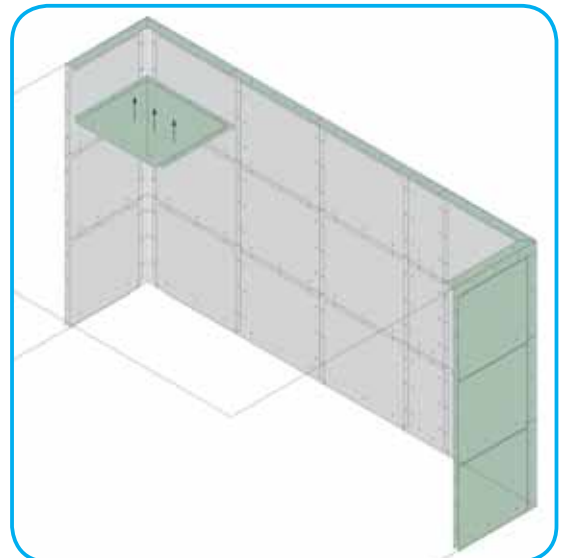
Proceed with installing the plates in the same way described above. If there are any side annexes, use the same operating procedure (STEP 2).



Step 6: Ceiling plate installation.

After installing the shielding system on the wall, if provided in the layout, start securing the first plate on the ceiling, which must have wings on three sides.

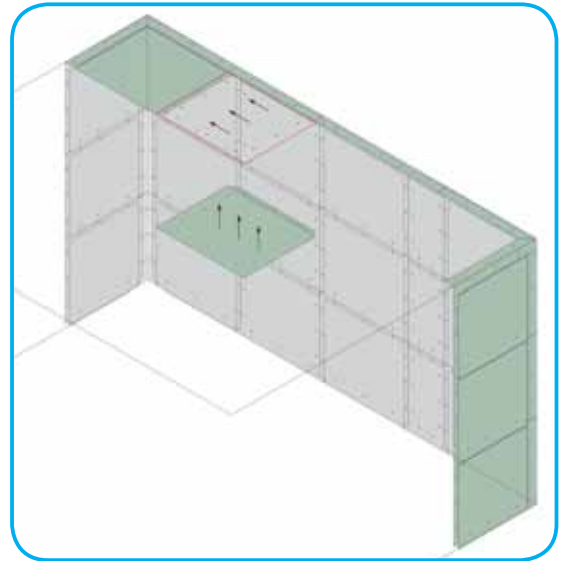
Also in this case, the plate must overlap the corner profile of the one previously installed.



Installation Guide for Flat Plates

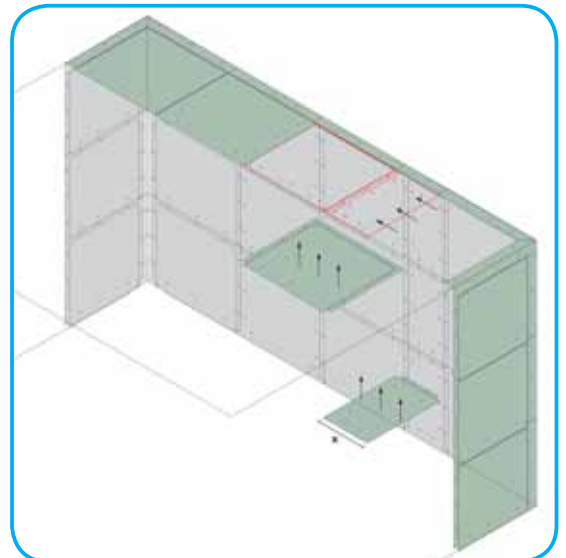
Step 7: Ceiling plate installation.

The second plate that must be used has only one wing on the upper side, and before being secured to the ceiling must slide under the wing of the previously secured plate, by a depth of approximately 50mm and overlapping the wing on the corner profile.



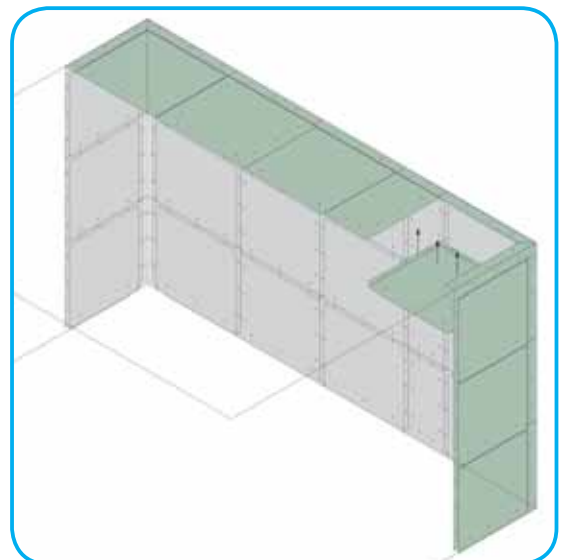
Step 8: ceiling plate installation.

Install the plates one after the other, being careful to alternate the version with one wing with those having three wings.



Step 9: ceiling plate installation.

Proceed with installing the plates, being careful to recover any construction differences of the ceiling, if necessary changing the plate with one wing (**see Note STEP 3**).



Step 10: ceiling plate installation.

Completion of the first row of plates is completed by using a plate having three wings, which will overlap the previous plate and corner profile, if applicable, or reach the end of the corresponding slab of the opposite wall.

Installation Guide for Flat Plates

Step 11: Ceiling plate installation.

After installing all shielding system plates, proceed with tightening the fastening system and, if requested, weld the conductive part, at section intervals of 100mm starting from the intersection of the plates and proceeding throughout the entire perimeter (see drawing). The same method must also be used on the corner profiles and flat profiles, if applicable

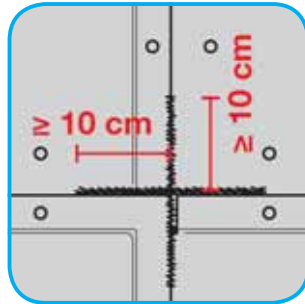
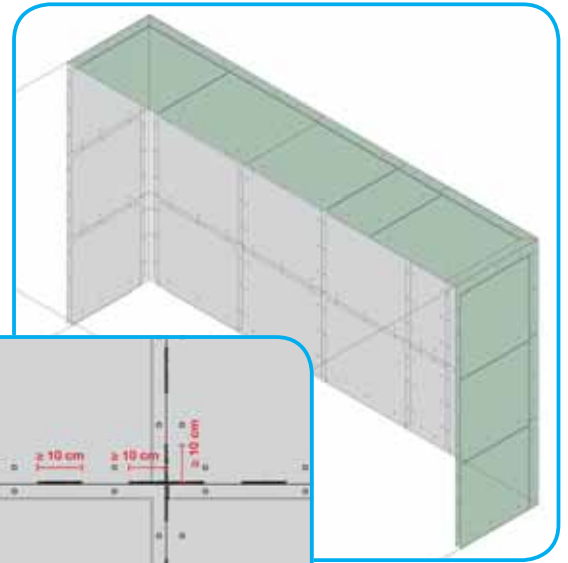


Fig. 30 - Intersection welding between the plates



Fig. 31 - Welding completion



Step 12: final securing of plates.

Earthing the system completes the installation operation of the shielding system.

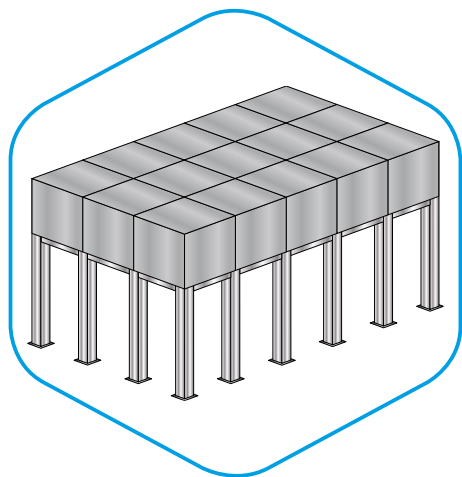
As there is electrical continuity between the plates, it will suffice to connect the shielding system to an equipotential node of the electrical system, in a point, using a 25 mm² copper wire with relative terminal.



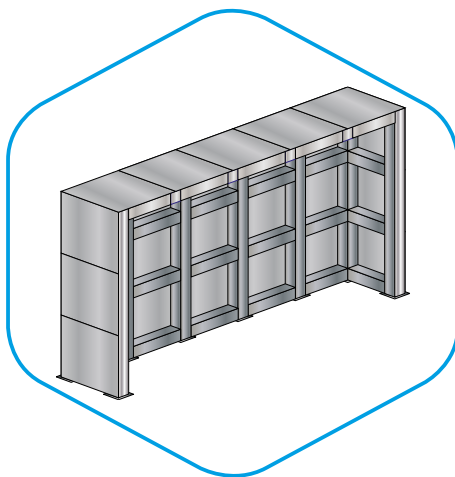
Structural Design of Shielding Plates

It is not always possible to position the shielding plates directly on the wall or ceiling. For this reason Sati Shielding works with specialised companies which are able to provide and assemble metal structures on which to mount the plates.

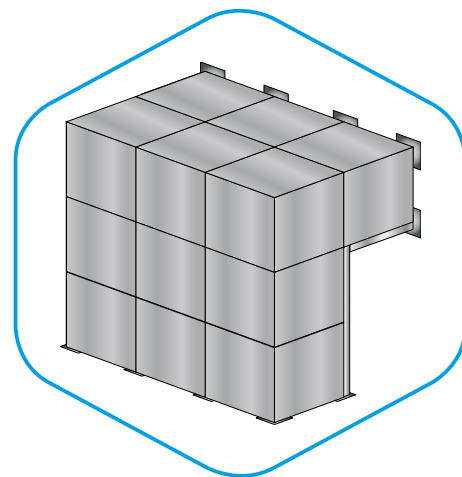
This solution has made it possible, for example, to screen a distribution transformer located in a museum where the positioning of the shields directly on the wall or ceiling was not an option given the architectural value and the type of wall construction.



Example of self-supporting ceiling structure designed for the reduction of the magnetic field produced by MV / LV transformers positioned above the ceiling.



Example of a self-supporting wall structure designed for the reduction of the magnetic field produced by an electric distribution substation positioned on the adjacent wall.

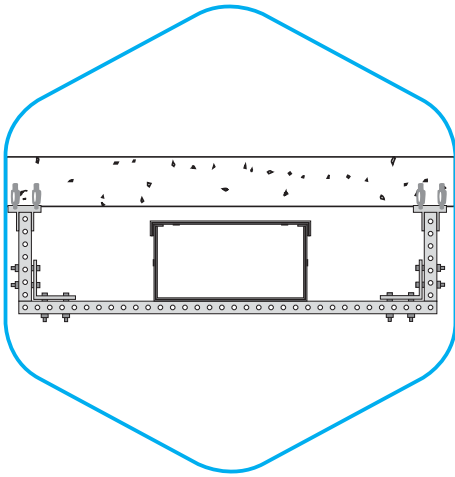
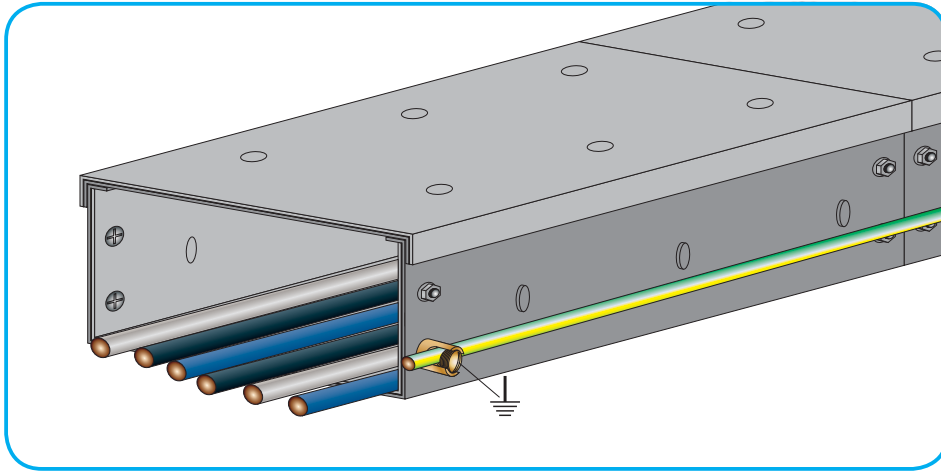


Example of a self-supporting wall/ceiling structure designed for the reduction of the magnetic field produced by an electric distribution substation positioned on the adjacent wall/ceiling.

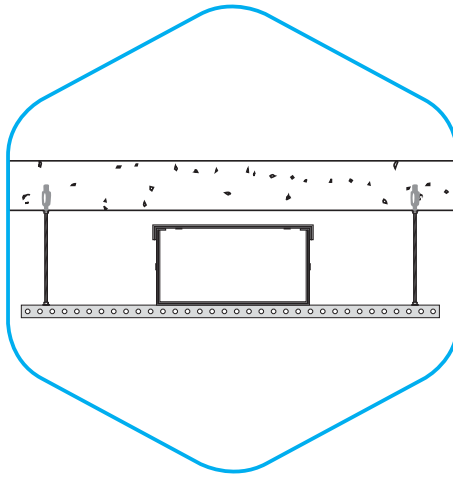


Guide for the Installation of Shielding Cable Trays

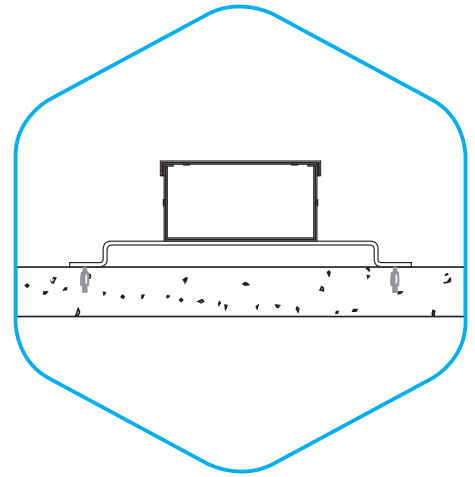
Connect the cable channel with a 25 mm² copper conductor to the earth.



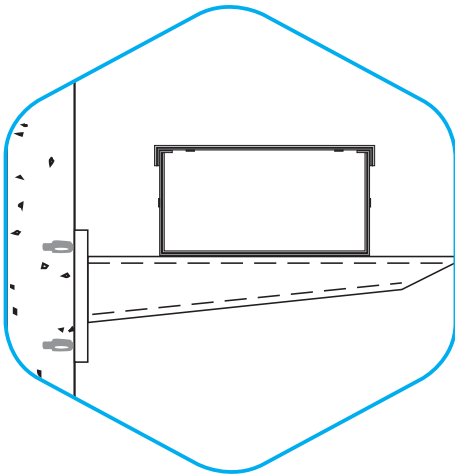
Example of suspension supports attached to concrete ceiling.



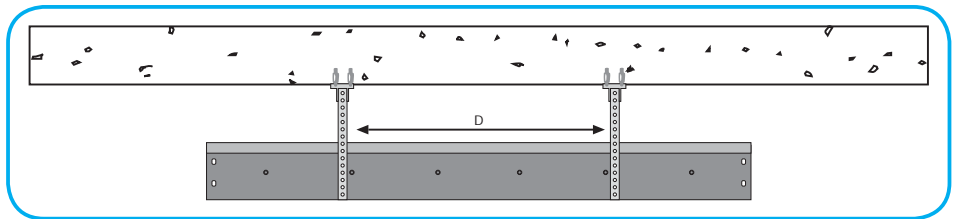
Example of suspension supports with threaded rod profiles.



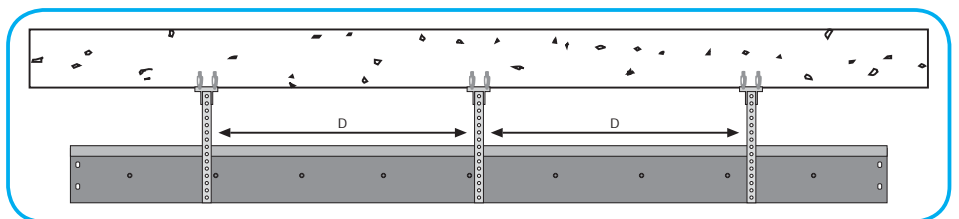
Example of floor installation.



Example of wall installation.



The distance between supports should be $D = 1$ m.
Example of mounting with 2000 mm channel.

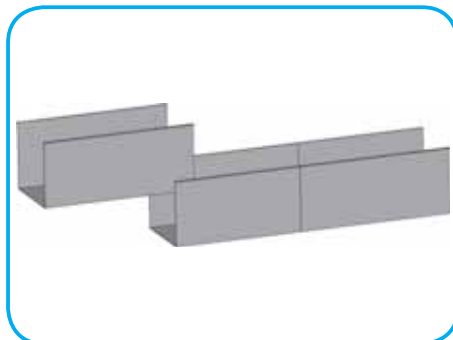
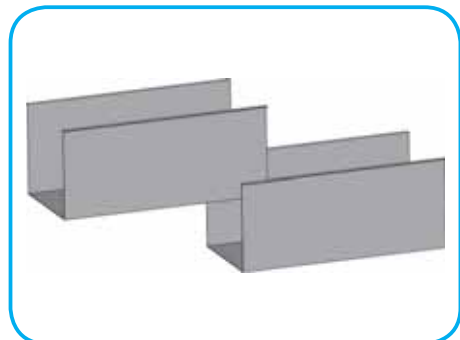


Example of mounting with 3000 mm channel.

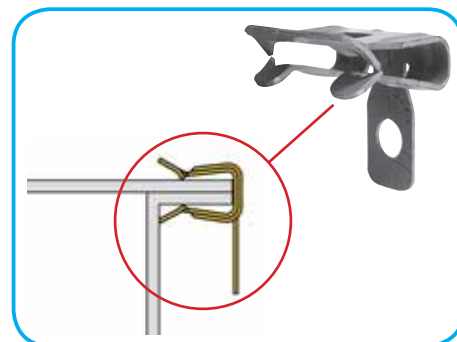
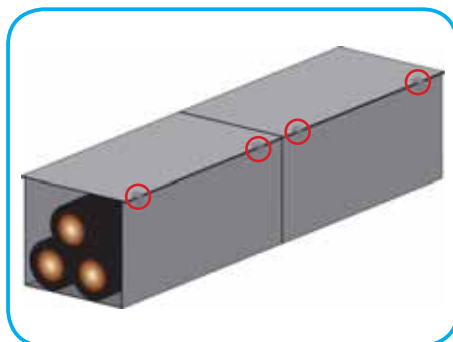
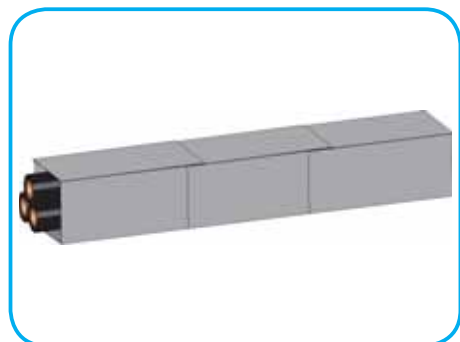
Guide for the Installation of Shielding Cable Trays for Underground Lines

The Cable Trays Shielding underground shall be installed with an overlap of approximately 200 mm, to ensure the electrical continuity.

In the next step, they will place the cables in the training specified in the project (in Clover or Flanked).



Installed the cables of energy, in the last stage we will be installed the covers, always with the overlap of approximately 200 mm and subsequently coupled with the underlying channel by means of metal hooks spring, at a distance of about 300 mm.



Installation of Shielding Joint Area

The magnetic cores (also called toroids) must be inserted before making the joints. The toroid position along the cable section of the joint hole is irrelevant.

After making the joints, the toroids can no longer be extracted and the shielding cables are installed. In general four shielding cables are positioned for every source cable. The length of the shielding cables must be equal to the joint hole. The shielding cables must be positioned symmetrically, the minor, unavoidable asymmetries due to installation do not affect shielding efficiency at all.



Toroids on the three phases.



Start of the shielding cable positioning stage.



Shielding cables near the HV cable joint.



Shielding cables installed on all HV cables.

Positioning of the shielding cables is secured by plastic covered metal straps to withstand corrosion.



Flexible headers.

The shielding cables must be connected at the ends of the joint hole with headers (also called star points). These components must have sufficient flexibility to connect all shielding cables to them in a simple manner.

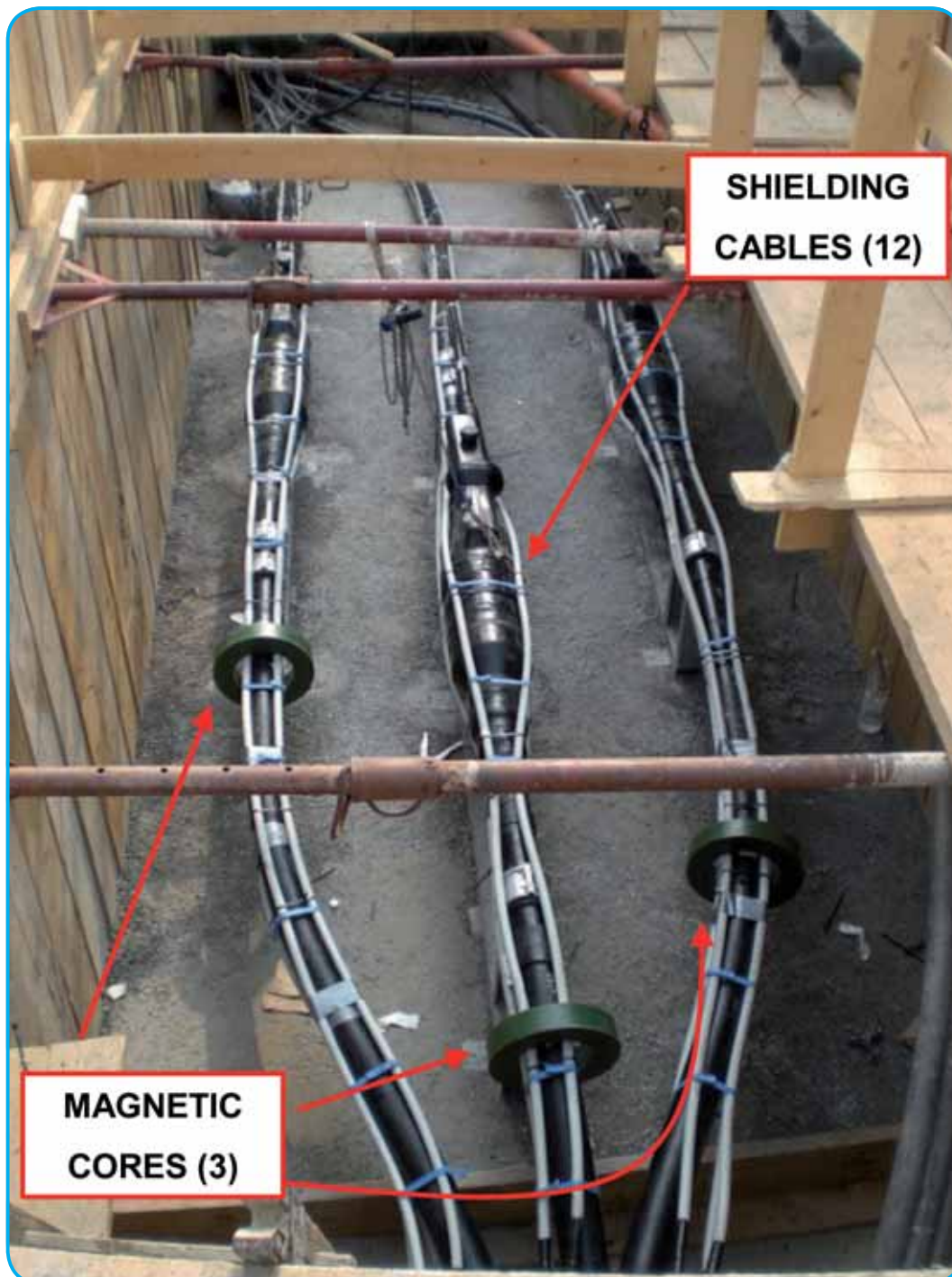


Fixing the heat-shrink sheath between cable and header.

The headers are also suitably insulated to withstand corrosion. Likewise, the connecting point between cable and header is protected by a heat-shrink sheath.

Installation of Shielding Joint Area

At the end of installation of the headers shielding is completed and appears as a strong and secure "armour" that assures reduction of magnetic fields like no other shielding is able to offer.



Step-by-step guide to using the MAGIC® software

Example of use.

MAGIC® is aimed at plant engineering applications, analysing configurations such as MV/LV substations, power lines, joint holes, etc. and is simple and user-friendly.

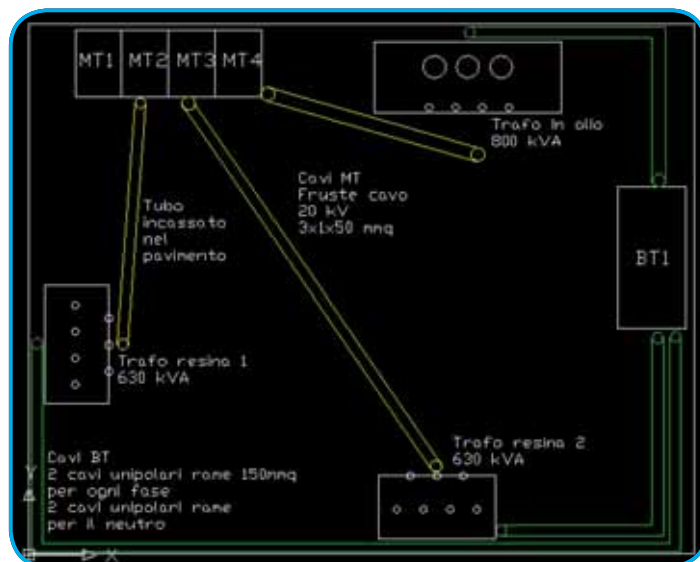
Let us look step-by-step at the **environmental impact analysis of the magnetic field generated by an MV/LV substation.**

Step 1: substation floor plan.

We start from the floor plan of the substation we intend to analyse.

The substation we are going to analyse is shown sideways, and consists of:

- 1 MV switchboard.
- 2 resin transformers.
- 1 oil transformer.
- 1 LV main switchboard.



Step 2: Choice of the case study.

When launching the software, it is possible to choose the case to be analysed from the Main Menu.

Let us choose the **SUBSTATION** case.



Step 3: devices in the substation.

Now choose the devices the substation consists of. In our case:

- 1 MV switchboard.
- 3 transformers
- 1 LV switchboard.
- 3 MV lines.
- 3 LV lines.

A sheet to be filled in will be displayed for every device entered

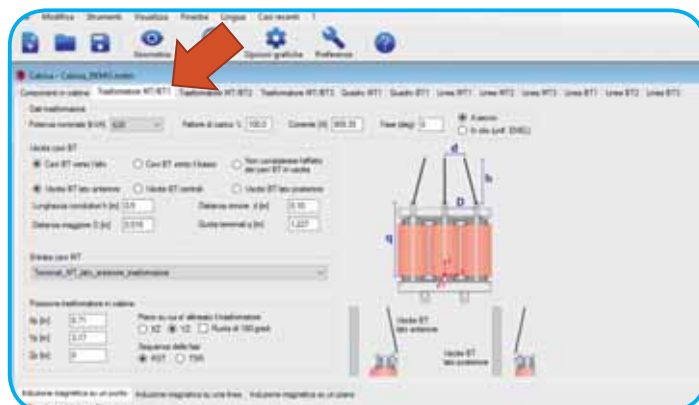


Step-by-step guide to using the MAGIC® software

Step 4: description of the transformers.

For each of the transformers it is required to specify:

- Rated power.
- Current (or load factor).
- Type of transformer (in resin/in oil).
- Description of the LV cable outputs, specifying the geometric parameters shown in the picture.
- Description of MV inputs.
- Position of transformer in the substation.



Step 5: description of MV board.

The following must be specified for the MV board:

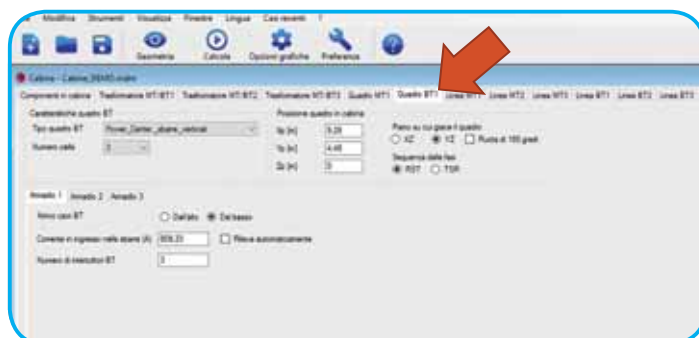
- Number of cells.
- Type of cells (line end, switch, transformer start etc.).
- Board position in the substation (X,Y coordinates with respect to the reference indicated in the initial floor plan).



Step 6: description of LV board.

The following must be specified for the LV board:

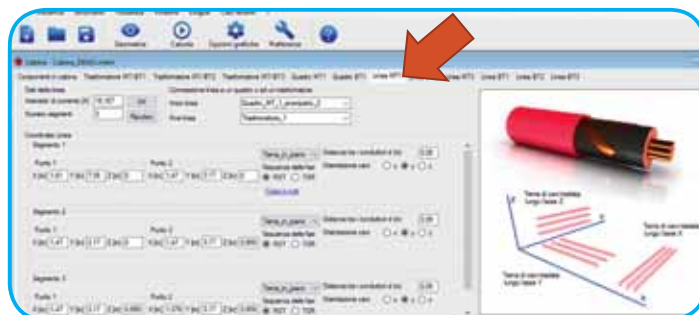
- Number of cabinets the PowerCenter consists of.
- Cables running downwards/upwards.
- Board position in the substation (X,Y coordinates with respect to the reference indicated in the initial floor plan).



Step 7: description of MV and LV lines.

The following must be specified for every MV line:

- Number of straight segments.
- Line start and line end (e.g.: from "QMT cell2" to "Transf1", in this case the current will be imported by the transformer, and the initial and final line coordinates from the relevant devices).
- Coordinates of the initial and final points of each segment.
- Configuration of triads of cables (e.g. trefoil, flat, double triad etc.).



Step-by-step guide to using the MAGIC® software

Step 8: substation perimeter.

To define the substation perimeter:

- Choose "Display Options" from the tool bar, then "Add poly-lines", and the "Add".
- Choose the number of substation vertices (e.g.: rectangular floor plan -> 4 vertices) and define the coordinates.
- Choose OK.

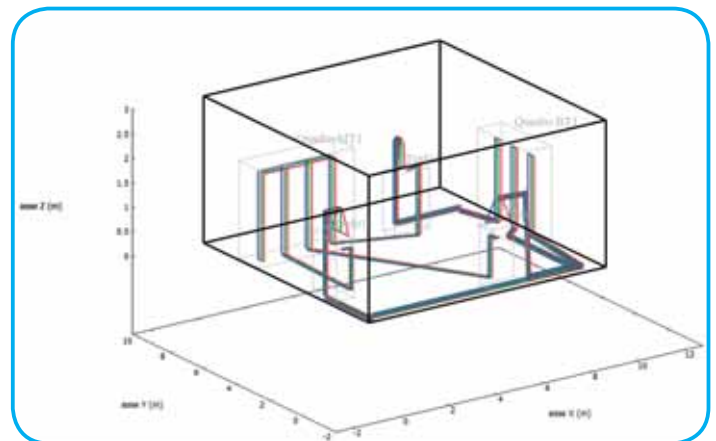


Step 9: 3D representation.

After completing all tabs, choose "Geometry" from the Tool Bar

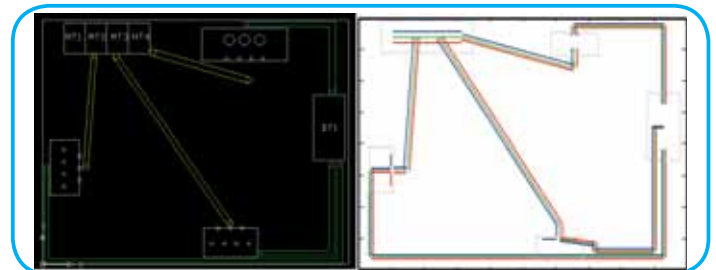
A window opens up showing the 3D substation model.

If the data have not been entered correctly, an error message is displayed.



Step 10: comparison with the floor plan.

At this stage it is good practice to compare the original floor plan with the generated 3D model, in order to find and correct any errors. The desired data may therefore be corrected, and the 3D model be generated again by selecting "Geometry" again.

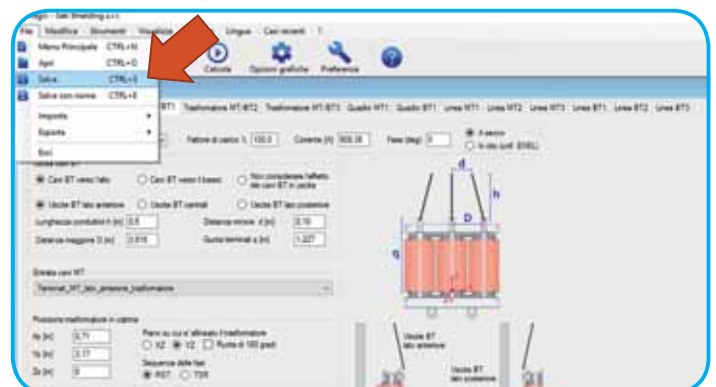


Step 11: Saving in a file.

Once the model has been corrected and checked, it should be saved in an MDM file.

Select "Save" from the "File" menu.

In this way it is then possible to open the saved form at a later time by selecting "File" "Open".

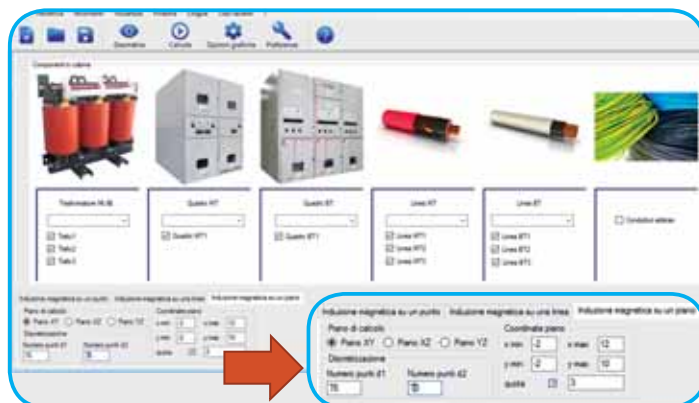


Step-by-step guide to using the MAGIC® software

Step 12: Selecting the calculation plane.

Calculation may now start. You need to select a calculation plane: if for instance you wish to assess magnetic induction on the floor of the room above the substation, you will select e.g.:

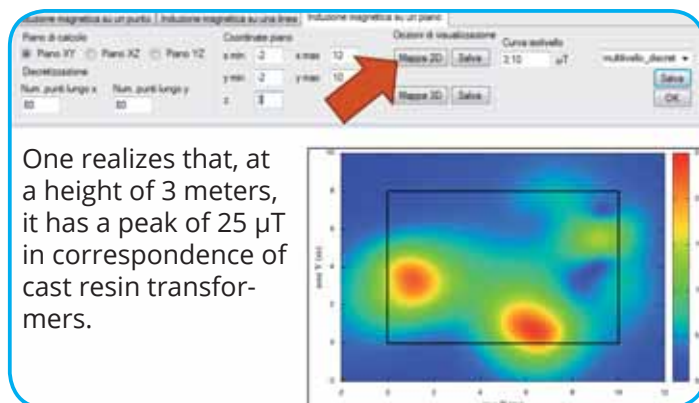
- Plane XY.
- Dimension: 3 metres.
- Margins: x: -2; 12 metres y: -2; 10 metres.
- Discretisation: 70 points.



Step 13: Displaying results.

Choose "Calculate" from the tool bar to start calculation. After a few seconds, the results are ready and a menu is displayed to select how to view them.

For example, it is possible to select a "2D map".



Step 14: Distance of compliance for environmental impact assessments.

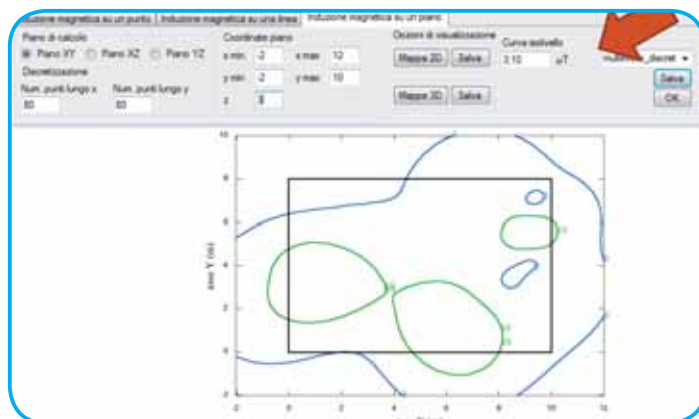
It is also possible to trace level curves choosing the desired values in μT (e.g.: 3 μT and 10 μT)

It is for instance possible to choose the limit set by law and immediately obtain the representation of the first approximation distance to be reported on the environmental impact assessment.

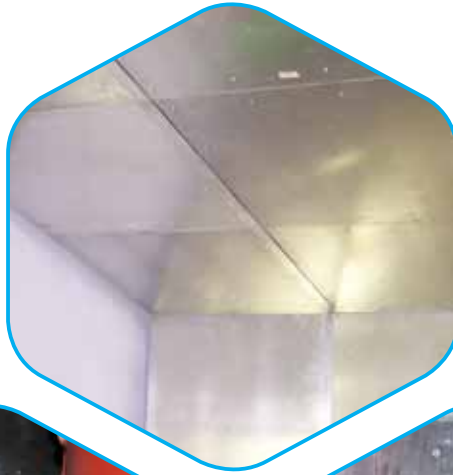
The user may then save the graphic result in a file by selecting "Save" in the "Level curve" section.

At this stage the file may be processed and imported in AutoCAD to be overlaid on the original floor plan, in order to obtain a result of this kind.

The blue line represents the buffer zone for the 3 μT limit.



Installation Examples





Final Testing and Technical Report

At the end of constructing a shielding system, Sati Shielding S.r.l. is able to perform final testing of the same by direct measurement of the magnetic induction in the areas that have been protected. The source may be artificial, such as a winding powered by a set current, but in order to carry out actual testing one should refer to the actual source as the spatial distribution of the magnetic field may be very different. In case of installation of shielding for new installations it is therefore required to wait for the source to be installed and commissioned.

The measurements shall be made in compliance with IEC standards 106-27, EN 62110 that entail, in case of fields considered as non uniform, the level of the magnetic field in the point of interest to be measured at three heights: 0.5 m, 1.0 m and 1.5 m from the ground or from the floor level of the building.

Furthermore, the regulations call for the measurement to be conducted at a horizontal distance of 0.2 m from the surface, edge or wall near the power equipment or in a building.

Sati Shielding S.r.l. only uses certified instrumentation for testing with calibration effected every two years. Sati Shielding S.r.l. is able to carry out thorough testing with portable instrumentation (PMM8053 with EHP50C and EP330 probe) and monitoring over time with a self-powered fixed station with datalogging function (AMB-8057).



Fig. 17 - Measurement Kit consisting of palm PMM8053 and sensors EHP50C, for measuring up to 100 kHz, and EP330 for frequencies up to 3 GHz.



Fig. 18 - Sensor for continuous measurement of the electric and magnetic field.

At the end of the testing stage a technical report is prepared showing the comparison between the magnetic induction figures detected without and with the mitigation system.



Certifications

66

Certification



SATI SHIELDING SRL

Head Office and Operative Site:
Via Carlo Ferrero, 10 Frazione Cascine Vica – 10098 RIVOLI (TO) - ITALY

*Bureau Veritas Italia spa certify that the Management System of the
above organisation has been audited and found to be in accordance
with the requirements of the management system standards detailed below*

Standard

ISO 9001:2015

Scope of certification

Design and production management of mitigation solutions and
systems, for electromagnetic fields (shielding systems).

EA Sector(s): **29, 34**

Certification cycle start date: **28 April 2016**

Subject to the continued satisfactory operation of the organization's
Management System, this certificate expires on: **27 April 2019**

Original certification date: **28 April 2016**

Certificate No. **IT267470** Version. **N. 1** Revision date: **28 April 2016**



ANDREA FILIPPI - Local Technical Manager

Certification body address:
Bureau Veritas Italia spa, Via Miramare, 15, 20126 Milan, Italy

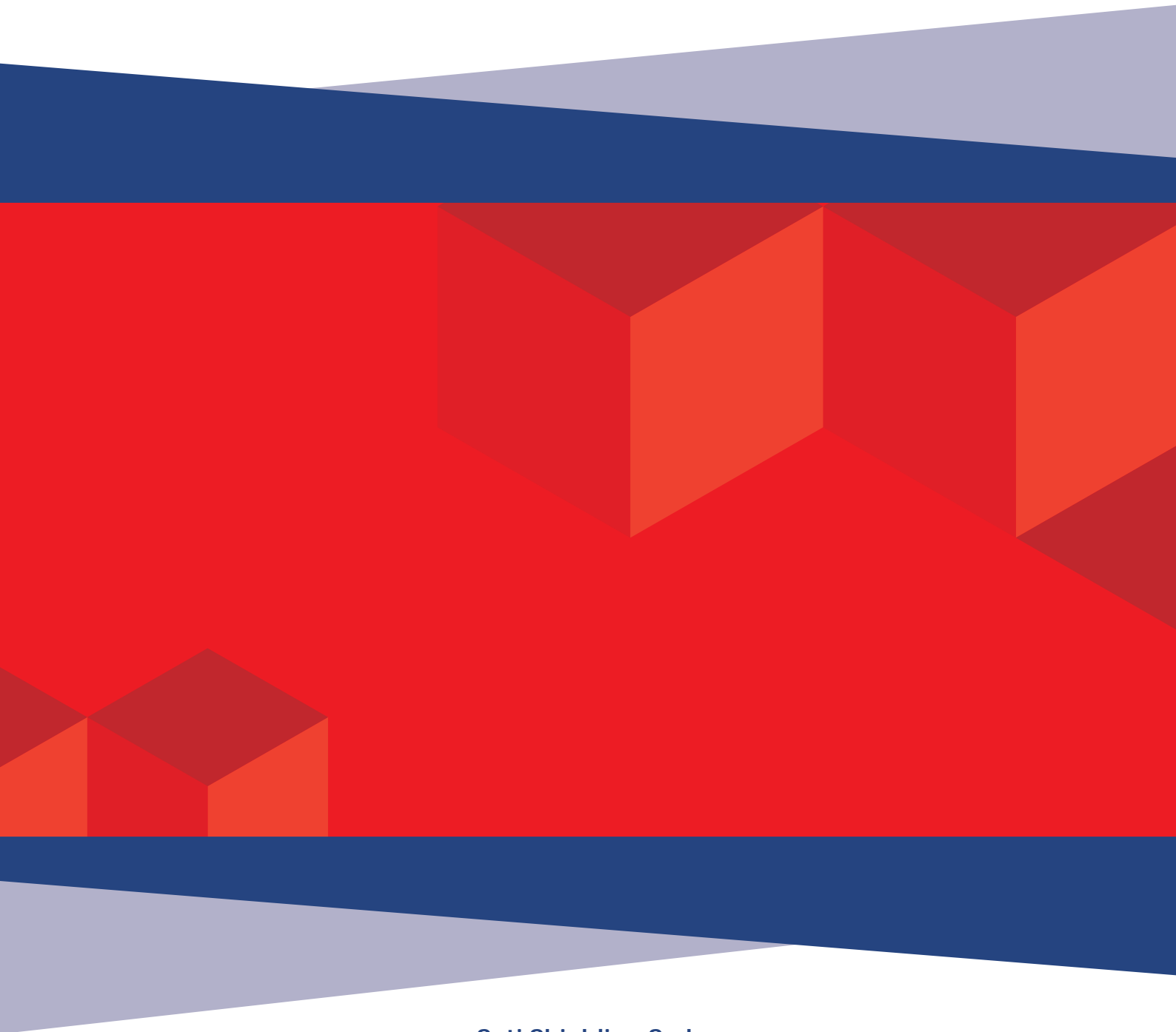


Further clarifications regarding the scope of this certificate and the applicability
of the management system requirements may be obtained by consulting the organization.
To check this certificate validity please refer to the website www.bureauveritas.it



SGS N° 009A	PKS N° 026C
SGA N° 009D	SGE N° 009H
PHD N° 009B	ENAS N° 004P
SCR N° 008P	GILO N° 009D
FSMS N° 003I	DSP N° 005E

Members degli Accordi di Mutual Recognition EA e JAF
Signatory of EA and JAF Mutual Recognition Agreements



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