Department of Energy & Climate Change

# Power Lines: Control of Microshocks and other indirect effects of public exposure to electric fields

## A voluntary Code of Practice

July 2013

## About this voluntary Code of Practice

The companion Code of Practice[1] "Power Lines: Demonstrating compliance with EMF public exposure guidelines" issued in March 2012, specified how compliance with guidelines for exposure of the public to electric and magnetic fields (EMFs) in the UK would be assessed. The quantitative limits in those guidelines concern direct effects of the fields, i.e., the induction of currents and fields within the body. The guidelines also cover indirect effects that occur as a result of charges induced on conducting objects in electric fields.

This voluntary Code of Practice relates to situations where it is necessary to apply the public exposure guidelines to these indirect effects.

Current Government policy[2],[3] is that exposures to power-line EMFs should comply with the 1998 International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines[4] in the terms of the 1999 EU Recommendation[5], and this Code of Practice reflects that policy. As and when either ICNIRP issue new Guidelines (as they did in 2010) or the EU revise their Recommendation, it will be for Government to consider those changes and to decide whether to adopt them or not. If Government policy changes, this Code of Practice and its companion Codes will also be amended accordingly.

This Code of Practice has been agreed by the Department of Energy and Climate Change, the Department of Health, the Energy Networks Association, the Welsh Government, the Scottish Government, and the Northern Ireland Executive. It sets out what is regarded as compliance with those aspects of the EMF exposure guidelines that relate to indirect effects as far as the electricity system is concerned.

There are further Government policies relating to EMFs from overhead power lines, specifically that as a precautionary measure they should, where reasonable, have optimum phasing. That is the subject of a companion Code of Practice "Optimum phasing of high voltage double-circuit power lines"[6].

This Code of Practice applies in England, Wales, Scotland, and Northern Ireland.

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[1] Power Lines: Demonstrating compliance with EMF public exposure guidelines: A voluntary Code of Practice. Reissued March 2012.
2 Letter with ten-point annex from Parliamentary Under Secretary of State for Public Health to the Chairman of the National Radiological Protection Board, 22 July 2004
3 "Government response to the Stakeholder Advisory Group on extremely low frequency electric and magnetic fields (ELF EMFs) (SAGE) recommendations.", Written Ministerial Statement 16 October 2009
4 ICNIRP (1998). Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Phys, 74(4), 494-522.
5 COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC)
[6] Optimal Phasing of high voltage double-circuit Power Lines: A voluntary Code of Practice. Reissued March 2012.

## What are the electricity industry and Government agreeing?

*The Electricity Industry*[7] agrees that whenever new power lines are being designed and constructed, or whenever issues of the safety or acceptability of indirect effects arise in the context of existing power lines, it will follow the provisions of this Code of Practice. *Government* agrees that compliance with the provisions of this Code of Practice will be regarded as sufficient to demonstrate compliance with the exposure guidelines in as far as they relate to indirect effects, and hence with Government policy.

## Indirect Effects

Indirect effects occur when an electric field induces charges on the surface of a conducting object. Those charges can then either interact with the electric field (e.g. when charges induced on human hairs have a force exerted on them by the field, which causes the hair to vibrate), or the charges can be transferred to another object. When that transfer of charges takes place between a person and another object in the form of a small spark across the gap between the two objects, it is known as a microshock. Once the two objects are touching, the continuous transfer of charge is known as the contact current.

Direct effects are protected against by quantitative exposure limits known as basic restrictions. However there are no equivalent limits to protect against indirect effects such as microshocks. The Code of Practice "Power Lines: Demonstrating compliance with EMF public exposure guidelines: A voluntary Code of Practice" states:

> "For indirect effects, while the Guidelines give a cautionary reference level of 5 kV $m^{-1}$ for the general public as a trigger to fuller assessment of compliance with the exposure guidelines, using that as a limit is not the most appropriate way of dealing with indirect effects. Rather, there is a suite of measures that may be called upon in particular situations, including provision of information, earthing, and screening, alongside limiting the field which should be used to reduce the risk to the public of indirect effects. In some situations, there may be no reasonable way of eliminating indirect effects, for instance where erecting screening would obstruct the intended use of the land."

This Code of Practice provides the necessary detail to apply this principle.

## The focus of this Code of Practice

Surface charge effects (e.g. vibrating of hairs) are, in practice, adequately protected against by the limits on electric fields covered by the preceding Code of Practice[1]. Contact currents are protected against by specific reference levels in the guidelines. Therefore this Code of Practice is concerned with microshocks.

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[7] This Code of Practice is agreed between Government and the Energy Networks Association (ENA). Formally, therefore, it binds only the member companies of ENA. However, Government and ENA hope that all network operators will follow these provisions.

Microshocks are, in practice, generally an issue only with overhead power lines of voltages of 275 kV and 400 kV. Therefore, although the provisions of this Code of Practice apply to power lines of all voltages, it is of relevance principally to companies with transmission assets comprising overhead lines at these voltages.

## Relevant characteristics of microshocks

The electric field produced by high-voltage overhead power lines induces charges on the surfaces of any objects that are exposed to it, or, expressing the same physical concept in a different way, any object that is not grounded acquires an electric potential (a voltage) from the field. When two conducting objects that are at different potentials touch, the potentials equalise by means of a transfer of charge from one to the other.

As the two objects get closer, the difference in potential between them is applied across a smaller and smaller gap. When the gap becomes small enough, and if the potential difference is large enough, the potentials equalise across the gap by means of a small spark. When one of the two objects is a person touching a conducting object, that small spark is concentrated on one very small area of the skin, typically a few tenths of a millimetre across. The total energy in the spark is very low, but because it is so concentrated and localised, it is experienced at that point of the skin as a small shock. The sensation can range from a small tingle through to pain.

Microshocks are not known to have long-term health effects or cause any discernable skin damage, except in rare circumstances where continuous repeated shocks are experienced at the same place on the skin. Normally, any sensation is confined to the momentary spark discharge as contact is made or broken. The electric fields produced by power lines are, however, alternating fields, with a frequency of 50 Hz. This means that if the gap between a person and an object is being closed only relatively slowly, it is possible for several spark discharges to be experienced, on each successive peak of the electric field. If the field is large enough, it is also possible to have more than one discharge on the same half-cycle of the field, when the first discharge duly removes the potential difference between the objects, but the potential is then able to increase again as the field rises. The microshocks will cease as soon as the gap is closed by contact with the object. The only way for them to be a continuous phenomenon is if the gap is preserved at exactly the necessary width, which is extremely unlikely in practice.

The sensation of a microshock is similar to that caused by the static discharges commonly experienced in dry atmospheric conditions after frictional contact with a nylon carpet or car seat. Scientific investigations have shown that the voltages and charges are comparable for the two phenomena, and therefore any effects on the body can be presumed to be similar.

The size of a microshock depends on the size of the electric field, as it is this that determines the extent of charging of the objects concerned. It also depends on the sizes of the objects concerned, how well grounded or insulated they are, meteorological conditions, and the sensitivity of the skin (which varies over the body as well as from person to person).

Microshocks can occur whenever a person and a conducting object almost touch under a power line and are not (by virtue of being connected to each other or both being connected to earth) at the same potential. The conducting object can be anything, and either the person or

the object can be at a floating potential. In practice, experience has identified several common scenarios:

- person touches ungrounded motor vehicle
- person touches ungrounded fence
- ungrounded person touches grass with bare feet or legs
- person touches small objects (e.g. gardening utensils, washing and washing line), either or both ungrounded
- person touches metal parts of umbrella
- person touches golf clubs or golf umbrella
- person riding bicycle
- person riding, leading, or touching horse or other animal
- person touches another person

As well as the actual physical sensation of the microshock, microshocks could in some circumstances give rise to further effects, either if the microshock causes a person to startle with dangerous consequences, or if repeated microshocks cause aversive responses to the situation that produces them.

## Possible methods of controlling microshocks

Microshocks depend on the sizes of the objects concerned as well as the size of the field, so there is no threshold for electric field for preventing microshocks. However, in many circumstances the risk of perceiving a microshock and its severity diminish significantly as the field is reduced below 5 kV $m^{-1}$, the reference level in the ICNIRP guidelines.

Microshocks can be controlled by:

- **Reducing the electric field at its source**. Reducing the field from a power line almost always means in practice raising the height of the line so as to increase the ground clearance. For existing lines, this is extremely complicated and expensive. For new power lines, the cost is lower, but there is still a significant impact in terms of increased visual impact. Re-routing or undergrounding of a line is also an option for reducing the field but again this is complicated and expensive for existing lines.
- **Reducing the electric field by screening**. Screening by extra conductors hung from the existing pylons is rarely possible because of the limited clearances. Freestanding structures (either artificial structures, or trees or vegetation) for screening electric fields, however, are often bulky and extensive, visually intrusive, may interfere with land use, and have their own safety, maintenance and ownership issues.
- **Replacing a conducting object with an insulating one**. This may be possible but is subject to maintaining necessary functionality and not compromising the earthing necessary for safety.
- **Earthing**. This is effective at eliminating microshocks but not always possible. It is often easy for fixed items (e.g. fences) but harder for mobile objects (e.g. people, animals and vehicles).
- **Restricting access to land**. This may be an option but will often have practical difficulties.
- **Protective equipment or clothing**. Suitable insulating footwear or gloves can reduce microshocks in some circumstances.

- **Provision of information**. Some microshocks can be avoided if the person knows, for example, what order to perform certain operations in, or to make firm contact rather than brushing contact. Even where provision of information does not alter the physical circumstances of a microshock, it can still often reduce the extent of concern about a microshock by removing the element of the unknown.

## Requirements for controlling microshocks

This Code of Practice recognises that there is no reasonable way to avoid microshocks in all circumstances, even in circumstances when they are at a frequency and severity that is clearly undesirable, and therefore that not all situations producing microshocks are expected to be remedied.

This Code of Practice also recognises that control of microshocks is not based on a simple quantitative limit. Rather, there is a suite of measures that may be called upon in particular situations.

The simpler measures, such as avoiding creating new situations particularly prone to microshocks, provision of information, and earthing, where any of these are applicable, are to be preferred and adopted first. More intrusive and expensive options, such as screening, are to be adopted only where justified by circumstances. It is less likely that specific circumstances exist that would justify particularly extreme measures, such as raising clearances or re-routing of existing lines.

Specifically:

- Electricity companies will, where reasonably practicable, avoid designing new power lines that would create fields of 5 $kVm^{-1}$ or greater in homes, other land in residential use, their curtilage, and schools[8]
    - Note that existing good line-routing practice will normally achieve this anyway by routing lines away from existing homes and schools. If a new line over a home, its curtilage, or a school is unavoidable, a field below 5 kV $m^{-1}$ can be achieved by designing the line with an appropriate clearance. In the converse situation of new homes close to existing power lines, electricity companies will encourage sensitive design that avoids such situations, but no restrictions or controls are created by this Code of Practice.

- Electricity companies will continue to make information available to the public about microshocks. They will seek appropriate ways to communicate to specific communities affected (e.g. cyclists and horse-riders)
- When an electricity company becomes aware that a particular situation is giving rise to microshocks in a persistent and annoying manner:

[8] The definition of the land affected is the same as that given in full in "Power Lines: Demonstrating compliance with EMF public exposure guidelines: A voluntary Code of Practice. Reissued March 2012"

- The company will offer focussed advice and information specific to the situation;
- Where earthing is an easy solution, this is encouraged, and will be explained to the landowner or occupier by the electricity company. The allocation of the cost of any earthing installed is a matter between the electricity company and the landowner depending on existing contractual arrangements;
- Where microshocks occur in someone's garden, or in other circumstances where one individual could be exposed to multiple shocks over a prolonged period, every reasonable effort will be made by the electricity company to develop solutions by earthing, by changing a conducting object to an insulating one, by use of appropriate clothing, or by screening structures or trees and vegetation, with the allocation of the cost being a matter between the electricity company and the landowner or occupier (but note that, to be effective at resolving someone's complaints, screening may have to be so extensive as to be impracticable); and
- Where a site-specific risk analysis indicates a significant risk of injury (assessed using normal health and safety practice) from startle reactions to a microshock, mitigation measures, potentially including screening structures, will be developed by the electricity company, and, to the extent that it lies within the company's control, deployed, if this can be done without becoming unreasonable.

- There is no requirement that clearances of existing overhead lines, or of new overhead lines except where they unavoidably pass over homes, other dwelling places, their curtilage, and schools, should be increased because of microshock issues, though this could be done voluntarily by electricity companies.
- No individual assessments of the risks of microshocks, even quite rudimentary assessments, shall be required for every single span, either of existing lines or for proposed new line.

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