

Comparison between two power-frequency electric-field dosimeters

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When a man enters a homogeneous electric field, the field around him is perturbed, and two identical electric-field dosimeters will get different readings of the field strength if they are positioned on different parts of the body. Therefore the measured values need to be adjusted to compensate for field perturbation enhancement, because exposure assessments should not be affected by the location of the instrumentation sensor. After the adjustments are made, results can be compared with measurements of the unperturbed field.

When a conducting object is placed in an electric field, currents are induced in the object. The sum of all currents flowing in different paths in the object could be measured as the current which is flowing to the ground, if the object is connected there. This current is called the short circuit current (1, 3).

When a normally built person stands erect under a transmission line, the induced circuit current is 14 μ A when the strength of the unperturbed electric field is 1 kV/m. The short circuit current is directly proportional to the electric field. The readings of the short circuit current could be said to give the total body exposure of the electric field.

Two individual dosimeters, BE-log and EFEM (2), have been compared in a field test, in which different work activities were carried out in a switchyard. The BE-log meter were also compared with the short circuit current.

Instruments and calibration

The BE-log meter measures 50-Hz electric and magnetic fields and stores samples of the field strength every 15 s for a maximum of 8.3 h. After a complete measurement the stored readings are transferred to a computer for further analysis.

The EFEM meter measures low-frequency electric fields. Every fourth second the average field strength during the past period determines which of seven field strength counters (bins) is to be incremented one step.

Both instruments are portable, the EFEM meter is preferably placed in a shirt pocket, but the larger BE-log meter is placed in a back pack on a harness. During the tests the EFEM meter was placed in a shirt or a chest pocket in overalls. In addition, a second EFEM

meter was positioned in a chest pocket of a quilted jacket or in the lanyard position outside the quilted jacket with the EFEM meter inside a thin plastic pouch, fastened with tape on the BE-log harness. The EFEM meters were positioned with the lid up, the sensor plate outwards, and no interfering objects close to the meter.

The BE-log meter has a separate electric-field antenna in the form of a conducting layer on top of a hard hat, which is connected to the electronics in the back pack.

The dosimeters were calibrated in the following way: The BE-log meter was checked from time to time against a dipole meter. The EFEM meters were checked flush-mounted in a parallel plate exposure device. When the subject wore two EFEM meters, the meters could also be checked against each other.

To compensate for reduced response from the lanyard EFEM meter (outside the quilted jacket), the readings were multiplied by 1.3, based on the result when the readings from two EFEM meters were compared when a subject stood facing a power line. The same correction was been applied to the EFEM meter positioned in the chest pocket of the quilted jacket.

Data treatment

The readings from the EFEM meters were presented in an exposure histogram showing the time spent in each of seven field-strength levels (bins). To make a direct comparison possible, the readings from the BE-log meters were sorted in accordance with the EFEM bin distribution scheme in order to simulate the EFEM time histogram output and to make a direct comparison possible. Furthermore, to avoid the complexity of comparing different histograms, a mean value was calculated for each histogram as the sum of bins for the "percentage of time spent in the bin" times the "mid-point of the bin."

A measure of how well readings of the field strength from the BE-log meter can predict short circuit currents in real work situations is the "field current" quotient. This is the relation between the readings of field strength from the BE-log meter in kilovolts per meter divided by short circuit currents/14, where the short circuit current is measured in microamperes. This quotient equals 1 when a man is standing erect under a transmission line. It has been calculated for all locations and all measured short circuit currents.

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Test sites

The test sites were chosen with the assumption that they would cause substantial exposure to electric fields. Earlier measurements with the instruments had shown lower values for the EFEM meters than for the BE-log meter, the result probably depending on shielding. The six sites were all situated in switchyards, and the activities performed during the measurements were walking around, overhaul on a circuit breaker, and simulated work in front of a switch cabinet. The used voltages were 70, 220, and 400 kV, and each measurement had a duration between 33 and 67 min.

During the activities the EFEM meter and the BE-log meter were used either on a worker performing as natural as possible or on an unskilled subject placed in different typical positions. At all the test sites the short circuit current was measured at randomly chosen time intervals.

Results

The results of the measurements with the two instruments are presented in figure 1. The results of the EFEM meters were divided by the results of the BE-log meter for each measurement (location). This ratio

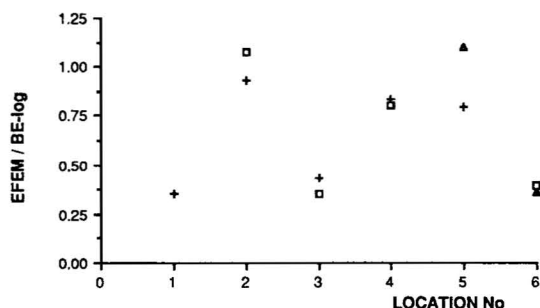


Figure 1. Quotients of "calculated time-weighted average exposure" between two electric-field dosimeters, EFEM and BE-log, at six locations. (+ = EFEM meter in shirt pocket / BE-log meter, o = EFEM meter in lanyard position (multiplied by 1.3) / BE-log meter, Δ = EFEM meter in chest pocket in quilted jacket (multiplied by 1.3) / BE-log meter)

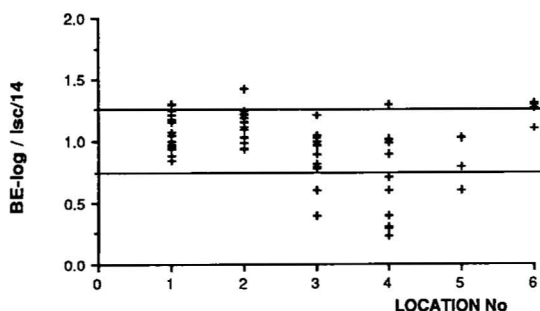


Figure 2. Quotient of samples taken from discrete points between the electric-field strength measured with the BE-log meter and the short circuit current (Isc) which flows to the ground when a person is connected there.

describes the difference between the EFEM meters and BE-log meter. Since two EFEM meters were used, there should be two values for each location. However, since one of the EFEM meters had, for an unknown reason, an overflow for location number 1, there is only one result for that location.

In figure 2 the results are presented as quotients between readings from the BE-log meter and readings of the short circuit current. This quotient determines the relationship between the quantities. It varies between 0.25 and 1.4.

Discussion

The results in figure 1 should ideally have a quotient of 1, ie, if the two instrument types give the same dose, but the quotient varies between 0.35 and 1.1. The differences between the results from the same type of instrument (EFEM meter) in different positions were small, except for location 5. For location 5 the schematic-applied correction for the EFEM meter, worn in the chest pocket of the quilted jacket, probably did not fit very well.

The scattered results could have been caused by shielding of the EFEM meter. The average dose measured with the BE-log meter was 2.3 kV/m for locations 1, 3, and 6 and 4.4 kV/m for location 2. For locations 4 and 5 the field strength was 0.36 and 1.1 kV/m, respectively.

The comparison between the two types of meters could be summarized in different ways. The average of the quotients in figure 1 (for the EFEM meter in the shirt pocket) has been calculated. This average is around 0.6, which can be used as an approximation of the relation between measurement results from the two instrument types.

The quotient in figure 2 should equal 1.0 when a normally built person stands erect under a transmission line. Most of the results can be found in the range between +25 % and -25 % of this value. Most of the results below 0.75 could be traced to work being done in a skylift at approximately the same height as the power line. This finding could mean that the field was horizontal instead of vertical, a phenomenon which would influence the BE-log meter, which was calibrated for vertical fields. The correlation coefficient between the results from the BE-log meter and the measured short circuit current for all points is 0.98. Therefore, in general, the correlation between the readings from the meter and the short circuit current was good.

Summary

Two instruments, an EFEM meter and a BE-log meter, have been tested on people working in switchyards for voltages between 70 kV and 400 kV. The results from the BE-log meter correlate well with the short circuit

currents through people connected to the ground. The EFEM meter showed lower measured doses than the BE-log meter, and the relation between the two instruments was around 0.6.

References

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