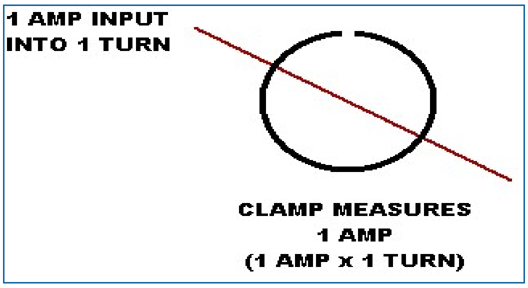
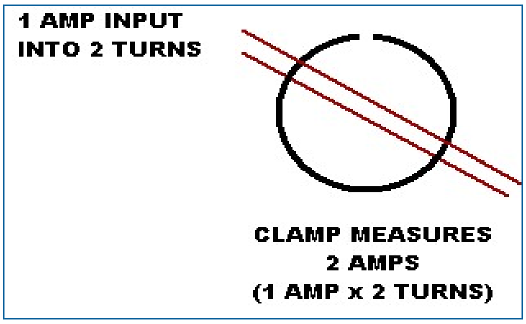
Understanding Errors When Calibrating Clamp Meters Using A Coil

When a current is passed through a wire, a magnetic field, which is proportional to the current, is created around the wire.

The wire itself does not affect the magnetic field produced; the dimensions, resistance and temperature do not affect the strength of the field. A clamp meter measures the magnetic field produced round a wire enclosed in its jaws, and displays the measured field as amps.

It can be easily seen that by passing 2 wires through the jaws, each carrying the same current will read twice that of 1 wire, as the magnetic fields add together. For example 50 Amps in one wire produces the same magnetic field as 1 Amp in 50 wires.





It is this principle, which enables a clamp meter to be calibrated at much higher currents than is directly available. By producing a coil with a known number of turns the input current is multiplies by the number of turns on the coil.

Accuracy Of A Coil

The only error in a coil is in the number of turns that pass through the 'centre section', e.g. the section of coil that gets enclosed by the jaws of the clamp meter. The number of turns of the coil must be a whole number, for example the wire must either pass through the centre section 49 or 50 times, it cannot be 49.2 turns.

The coil multiplies the current exactly by the number of times the wire passes through the centre section. The current multiplication works for any current, making the coil perfectly linear and is the same for AC or DC.

The Coils accuracy is unaffected by temperature, resistance, type of wire used, shape, the level of current, AC or DC. The accuracy of a coil does not drift or change with Time. The coil itself does not have any errors, and therefore no uncertainty. There is however an error when a clamp meter is calibrated using a coil.

The Contributions For Uncertainty For Clamp Coil Calibration

The uncertainties to be considered when a coil is used for calibrating a clamp meter are shown below.
Note that the coil itself is not in the list; it is the last item where the coils effect is introduced.

1. **Imported uncertainty for the current source.**
2. **Accuracy the current source.**
3. **Output variations due to the impedance of the current source.**
4. **Resolution of the clamp meter under test**
5. **Repeatability due to position centring of the clamp jaws within the coil**
6. **Uncertainties due to coil effect.**

The uncertainties when a coil is used for calibrating a clamp meter are caused by how a particular the clamp meter is influenced by the shape of the magnetic field particularly outside of its jaws. Although this should not affect the reading most clamp meters are imperfect, resulting in a difference in reading between a single conductor and a coil.

This error will depend on the design of both the coil and the clamp meter, and how well the jaws join etc. This error can only be evaluated experimentally. It is this error, which is sometimes referred to as the accuracy of the coil, often given by manufactures of the coil.

It is normal for an accreditation authority to require several measurements to be taken by the lab evaluating the differences found between measurements made on a single conductor and those obtained using the coil for several types of meter, including Hall effect and CT types. From this data it is possible to provide an uncertainty limit value, which can be used as a contribution covering different clamp types and models.

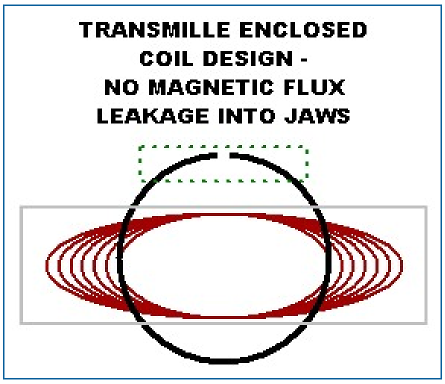
See Transmille web site for data evaluating several clamp meter models.

Coil Design

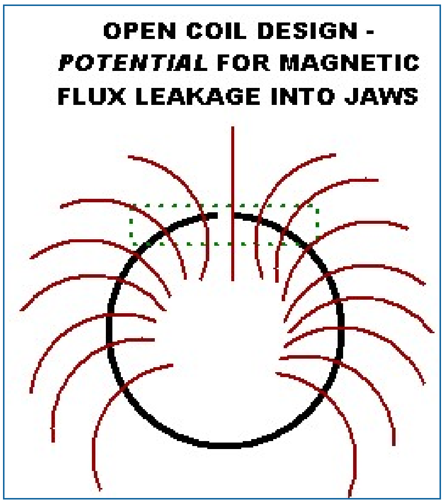
The difference between a single conductor and a coil when calibrating a clamp meter is the shape of the magnetic field produced by the coil. The current flowing back round the outer section of the coil produces a field in the opposing direction. Simply put this field can 'leak' through particular the join in the clamp meters arms. It is the presence of this opposing field, which is not present in single conductor, which causes reading errors. Different coil designs produce different field 'shapes' and this explains why different coil designs give slightly different performance, particularly when the clamp is moved within the coil.

Transmille after experimenting with several different designs including designs using magnetic shielding and wrap round windings has pioneered the design of the balanced coil which allows both arms of a clamp meter to be in the centre section field, while at the same time the arms of the clamp are providing screening the opposing field produced by the outside of the coil, with the jaws opening join being mainly out of the opposing field. This design that has been evaluated for many types of clamp meters, both new and old where the jaw opening join may be worn, seems to give the closet approach to simulating current measurement on a single conductor.

The Transmille coil: With this design the Jaw opening is outside of the main magnetic field, reducing errors from magnetic leakage through the opening.



Wrap Round Coil Design where jaw opening is inside the coils field gives potential for magnetic flux leakage increasing reading errors.



Certifying Coils

All that is required from the coil certificate is to verify the number of turns is correct. For open coils the turns can simple be counted, but for enclosed turns the simplest approach is to compare the coil with a known coil using a clamp meter.

As the coil does not age with time it does not require to be certified again, unless the number of turns has been physical altered by either mechanical damage, or overheating which has caused a shorted turn.
The uncertainty on the coil certificate only reflects the method used to verify the coil, and this should not be used as a contribution in calculations of uncertainty for clamp meter calibration.