CONTACT

No. 17 MEASUREMENT • NEWS 2002

Temperature Measurement & Control

Protective sheaths for pyrometer assemblies

Power Measurement & Control Division

Concentrate your energies!

Test & Measurement Division

Three phase quality analyser

CHAUVIN ARNOUX

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Cover photo:
Pyrometer assemblies for high temperatures

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To receive sales literature, fill out the Reader Service form between pages 12 and 13.

EDITORIAL

Innovating to serve you better

In this issue of your magazine, you will find numerous products and services that have become available to you over the last few months. For the Test & Measurement division: three phase electrical network quality analyzer, VAT tester, hand-held multimeter clamps, several megohmmeters, cable tester for LANs and LAN tester. For the Power Measurement & Control division: current transformers, power monitors, new energy meters and a pulse receiver. For the Temperature Measurement & Control division: new temperature measurement applications and as many corresponding sensors and associated regulation equipment. Finally, as regards Service, new metrology approvals complete our product offer.

As each year, we are making considerable efforts to provide you with new tools that are totally tailored to your needs, taking your many remarks into consideration. Our organization, with its different divisions, enables us to concentrate and enrich specific skills and technical knowledge, in terms of marketing and research and development, for each profession.

In this way, whether they concern electrical safety, user software, ergonomics and the man-machine infrastructure, cost or long-term quality, the demands of each trade are better understood and passed on directly by specialists in the development of new products.

Specialized and dedicated sales teams, in France and for export, are also available to help you. In each of our divisions, specialized representatives can answer your questions and help you choose equipment that best fulfils your specifications.

There are five divisions at your service: Test & Measurement, Power Measurement & Control, Temperature Measurement & Control, Service, and Industry.

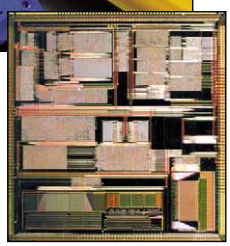
Do not hesitate to give us a call. We are here to serve you, as we have been for almost 110 years, trade by trade.

Axel Arnoux
Vice-president
Groupe Chauvin Arnoux

Designing and Manufacturing

The Chauvin Arnoux Group is organized into five divisions: Test & Measurement, Power Measurement & Control, Temperature Measurement & Control, Service, and Industry.

Some parts manufactured in the factory in Vire



For improved metrological performance with compact size at optimized cost, Chauvin Arnoux integrates ASIC components into its products.

To better meet professional requirements, the product divisions each have their own means for research and development, marketing and sales and are assisted by the group industry division for manufacturing.

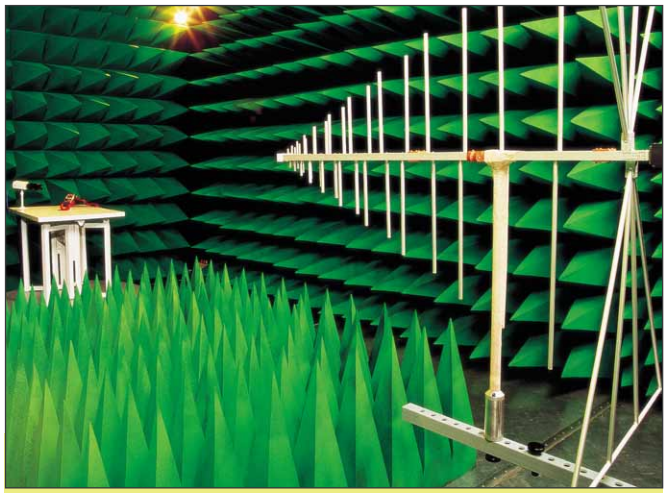
Stringent design

When it comes to developing new products, considerable efforts have been deployed to enable the divisions to keep up with the very best and offer many innovations each year. Compliance with standards, metrological rigor, ergonomics, technological and marketing watch are key words for our experts in each division. The demands applied in terms of developments are a measure of the quality of the products, designed to last and safe to use.

Built-in manufacturing

Our products are designed in our laboratories in France, Austria or the USA and then manufactured in our Industry division's factories. Mechanical parts, in plastic or metal, are manufactured in Vire and printed circuits, in Villedieu. Product assembly and testing are then carried out in factories in Europe and the USA.

Confirmed quality, Chauvin Arnoux is ISO 9001 certified by TÜV CERT.



EMC laboratory in Pont-L'Evêque for electromagnetic compatibility testing on the group's products.

An assembly shop in Normandy.

Printed circuit manufacturing in Villedieu (Manche).

Precision mechanics in Vire (Calvados).

Three Phase Quality Analyzer: check the quality of an electrical network quickly and properly

Some days everything goes as planned. However, other days, one failure is followed by another and never comes from the same place or source on the network. It is impossible to get the big picture! In this case, you need Qualistar to check the quality of your network to standard EN 50-160 and detect any polluting equipment!

Random failures, weird operation, inadvertent stoppage, there's no doubt: you need a power analyzer. **C.A 8332** and **C.A 8334** Qualistar devices are designed specially for those who need to check the quality of their network rapidly and obtain a definite result.
First, immediately knowing how the instrument works is essential. This is why the large bright color LCD screen displays the keyboard pictograms with a particularly well-structured display mode. The keyboard is split into immediately identifiable zones (direct functions, pop-up menus, cursors).

Three separate operations for six display modes

The first operation concerns phenomenon **Observation**. It is based essentially on graphic representations of the general waveform (mode), for current and voltage. A glance at the phase diagram (or Fresnel diagram) suffices to check amplitude, phase shift and the wiring of current sensors.

At this stage, the user can already highlight the presence of problems and, if the need arises, can take analysis further by moving on to the next stage, **Diagnosis**.

There are two modes available for diagnosis: the harmonic mode for quantifying and qualifying the influence of harmonics on the voltage standard across the terminals of each piece of equipment, on heating of the neutral, or on rotating machinery; and the power/energy **W** mode, which clearly indicates the various power and energy levels (active, reactive and apparent), but also gives the power factor value PF, DPF, tangent, information for determining whether there are any power losses and if it is necessary to install compensation capacitors, consider a load-shedding system, etc. At this stage, we are already thinking in terms of solutions.

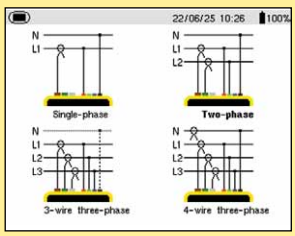
Then, the user can move on to the **Monitoring** stage to check the quality of the network over a period of time he himself defines. Here again, there are three different modes: recording during which parameters are saved; the alarm mode which, with thresholds determined at the time of configuration, makes it possible to edit any overruns occurring during the measurement-taking phase, and finally the transient mode (**C.A 8334** model) displaying and recording on three phases, any fast current and voltage phenomena liable to disturb equipment operation.

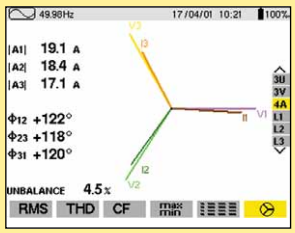
The "Screen shot" or the immortalized screen!

On site, conditions are not always the very best for reflecting about, interpreting or analyzing the results of a measurement run. It may simply be necessary to have need of information to illustrate a report or back up expertise. The Screen Shot is a particularly useful application. Simply pressing the key will immortalize your screen! Later, it will be easy to identify it by its date, time and type, and call it up to print it or simply display it again.

In the same way, the software combined with the Qualistar devices offers full possibilities of displaying and processing data acquired on site. Its multi-windows and multi-language operation presents data in the form of graphics, bar charts or allows its transfer toward office automation tools such as a spreadsheet.

The Qualistar divisions offer many other useful features. For instance, easy-to-use configuration, on-line help, internal rechargeable battery or the possibility of direct printout on a printer.
All of these are a way of gaining time so as to concentrate more closely on performing measurements. So, for random failures, weird operation or inadvertent stoppages, check your network!





The Qualistar giant color screen displays clear and detailed results of the various possible modes. Each feature can be identified immediately on the display and keyboard for easy test processing operations.

Reader Service No. 1

F01, F03, F05, F07: Multipurpose RMS Multimeter Clamps

Chauvin Arnoux has just released a new range of multimeter clamps. They are characterized by a handy size and their exceptional ergonomic design. Completely automatic and RMS, the F01, F03, F05 and F07 offer extraordinary measurement capabilities, making them ideal for electricians.

A host of features accessed with just one hand

Numerous measurements are available on their large 4,000-count liquid crystal display, depending on the model:

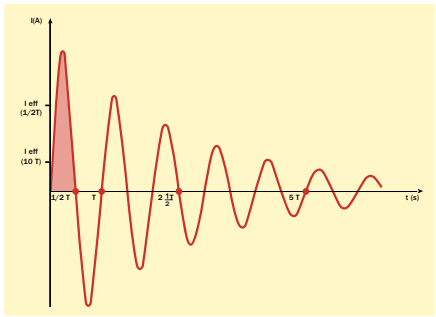
- DC and AC voltages up to 600 V/900 V peak,
- AC and DC current up to 400 A/600 A peak,
- Temperatures from - 50 to + 1000°C,
- Resistances up to 40 kΩ,
- Continuity audible test (with buzzer) and semiconductor test (diodes).

Extending well beyond these capabilities, each clamp offers individual performance making it a tool specifically designed for each user:

- **The "temperature clamp" F03** indicates (like F07) internal and external temperatures up to 1000°C,
- **The "motor clamp" F05** indicates **power**, power factor, frequency and **phase rotation**,
- **F07** benefits from the **TRMS AC + DC** technology. It also includes the adapter feature, capable of converting it in a jiffy to a tachometer, light meter, RH-meter, etc.

There are many more advantages to the range: on F05 and F07, in addition to frequency measurement, the inrush current function will analyze the current demands on motor starting. To guarantee faultless quality, current and voltage measurement is given in true RMS value (RMS) - (TRMS for F07) whatever the current, deform or sinusoidal reading.

This means that the clamps can measure any type of current, even for applications suffering from the greatest signal perturbation, like computer power supplies, fluorescent tubes, etc.



The F05 and F07 clamp inrush current function gives an automatic display of the RMS values of a sinusoidal signal calculated on $\frac{1}{2}$, 1, 2 $\frac{1}{2}$, 5 and 10 signal periods.

User ease and simplicity

More than simple measuring apparatus, the four multimeter clamps offer a host of additional functions depending on the models:

- Open "Hold" display memory for all the functions,
- Automatic AC/DC and range selection,
- Diode test,
- Backlighting,
- Minimum, maximum and peak values,
- The selectable V-Live function (buzzer warning of voltage > 45 V peak, considered to be hazardous),
- Selectable automatic shut-off,
- Life and over-range indicators,
- Date of last calibration.

Maximum safety

Naturally, these new clamps are specially designed for the industrial environment and offer all the safety characteristics of their "big sister" versions (grip guard, anti-pinching protection of the aperture, accidental overvoltage protection) and conform to the recent demanding international safety standards **EN 61010-1 / EN 61010-2-032 - 600 V Cat. III pol. 2**

Reader Service No. 2

Why use an RMS multimeter clamp?

	U_{AVG} Multimeter$_R$ x 1,1	RMS Multimeter (AC)	RMS Multimeter (AC+DC)*
Sinusoidal signals with DC component	Accurate	Accurate	Accurate
Distorted AC signals without DC component	Error by default capable of reaching 30 to 50%	Accurate	Accurate
Distorted AC signals with DC component	Error by default capable of reaching 30 to 50%	Error by default (depending on UDC value)	Accurate

* For an RMS multimeter (AC + DC), we also refer to TRMS (True RMS).

Complete certification of LANs in just a few steps

After installation, any copper or optical (computer or telephone) local area network must be certified to highly specific procedures. The new CERTILAN C.A 7040 network analyzer measures the performance of your LAN to ensure its conformity with current and future international standards. It is light and handy, immediately adopted for extremely complete and reliable certification jobs.

Often referred to as the LAN Tester, the network analyzer has to offer high technical performance and considerable self-sufficiency in the field. CERTILAN **C.A 7040** stands out at every step of analysis through its ergonomics and analysis capability. Comprising two modules - a measurer and a responder - fitted in storage case with a set of essential accessories for network connections, CERTILAN with a frequency measurement range of up to 300 MHz, indicates accurately the state of LAN network conformity, tested according to international certification standards TIA/EIA 568 through to category 6, ISO 11801 and EN 50173 to class E for copper networks.

Simplified parameters

The tests are particularly simple, performed by connecting the MEASURER: it measures in two different user modes - automatic or manual - for a test run adapted to installer needs. The RESPONDER, connected to the other end of the link, handles all the loops needed by measurement. Tests are run quickly and correspond to the specific properties of multi-pair or coaxial transmission lines used in computer transmission networks: Next (Near-end crosstalk), Elfext (Far-end crosstalk), attenuation, ACR, Return loss (matching), Skew (propagation time difference), line length, loop resistance, mapping (cabling) and fault location up to 30 m distance. The apparatus checks continuity and measures optical fibre attenuation in mono-mode and multi-mode. Finally, it detects automatically the unwanted voltages on the line that would interfere with measurements.

Self-contained memory

Thanks to the extraordinary memory capacity of the MEASURER which stores the results, up to 1,700 complete tests can be filed away. What is more, this number of certification results is unchanged in category 6! It is even possible to save curves. Offering outstanding ergonomics with navigation and selection keys, CERTILAN also offers users different languages for their menus (French, English, German, Italian or Spanish).
The graphic liquid crystal screen is backlit to guarantee optimum legibility. The intercom function which is built into each module allows technicians to communicate from both sides of the network while taking remote measurements.

Transfer and printing in a jiffy

Test efficiency is complemented by the quality of the issued certification reports. CERTILAN comes with its certification software on the PC: CERTISOFT, a way of importing results of tests stored by the meter in a few simple clicks. There are two operating modes: “certification” or “graphic”, subsequently proposed for processing the results in the Windows™ environment, depending on the desired mode.

Reader Service No. 3

Wiring checks as simple as that

A pioneer within Chauvin Arnoux’s LAN and telecommunications testing range, the C.A 7010 cable tester is stunning in its simplicity, ease in handling, and price. It takes just a few seconds to check the conformity of multipair or coaxial cables.

The tester consists of two modules, the tester itself and a receiver. This equipment will **locally** test any cable before installation by looping it back directly to the tester. The use of the **remote** receiver mode also allows remote testing of cables already installed in baseboards or wiring cabinets.

In a jiffy, the tester will verify any continuity fault affecting Ethernet networks (10BaseT, Ethernet 10 Base2, RJ45/RJ11, 258A, TIA-568/A568B) or Token Ring by detecting cutoffs, short-circuits, cross-wiring and by earth testing.
Several additional features have been added to the basic functions to improve user capability. Above all, the user can choose to run the test in two different **modes**:

- **automatic**, pressing the Test key will immediately trigger a scan, LED by LED, along each of the rows corresponding respectively to the transmitted signal and the received signal;
- in **manual mode**, the same operation takes place at the rate set by the user, generating a wire-by-wire test.

The detection of any break is reported by a **buzzer**, in which case the test is stopped and can then be resumed using another key.
Before or after cable installation, the **C.A 7010** simply ensures cabling conformity at the lowest cost.

Reader Service No. 4

NEW PRODUCT

Test your surge arresters and insulation resistors in telecom installations

Specially designed for the telecommunications market, MX 604 is a lightning arrester (or para-overvoltage) tester, also capable of testing insulation resistance.

Lightning arrester tests

A lightning (or para-overvoltage) arrester is a device providing protection against perturbations of atmospheric origin.

The role:

To limit transient overvoltages from networks to an acceptable level for the electrical equipment of an installation. So as not to endanger electrical equipment, it is necessary to check that these arresters work to prevent lightning-induced overvoltages. To avoid problems with difficult test conditions, **MX 604** has been given an ergonomic capacity making it an easy task to quickly test para-voltage arresters, whether dismounted on in situ.

Two possible methods

- Tests on removed lightning arresters:
  A lighting arrester support module is connected to the head of the unit. The user simply inserts the lightning arrester to be checked (260 V or 420 V lightning arrester) in the appropriate housing, depending on its shape and presses the test button on the support module. The deviation of the pointer on the **MX 604** dial indicates the imposed voltage limit value set by the lightning arrester.

- In-situ lightning arrester tests:
  A support clamp that can be adapted to a remote control probe is a way of testing lightning arresters in place, without disassembly, by pressing a test button on the probe.

Application example: telecom installations

MX 604 is designed for testing lightning arresters and insulation during malfunction checks on operational telecom lines. Its functions have been designed in close collaboration with France Telecom.

On telecom lines, lightning arresters are generally at the telephone exchange, in the distribution frame, but may also be located at the distribution sub-frames.

The test procedure consists in applying a 0 to 600 V DC voltage gradient and checking that the lightning arrester limits the voltage in its specified range.

What result is needed to ensure that overvoltage limitation characteristics are not drifting?

Whether using the disassembled lightning arrester test module or the clamp for testing in situ, the value given on the dial shall be included between:

- ***220 and 430 V for 260 V lightning arresters***
- ***330 and 650 V for 420 V lightning arresters***

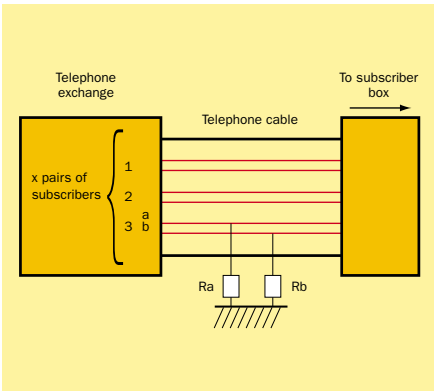
Insulation tests

When it is not equipped with the lightning arrester support clamp, the remote control probe can be used for testing insulation resistors. On a logarithm scale, the results of the measurement can be read directly without changing calibres.

For better safety and precision in measurement, a voltage presence indicator light warns the user if the installation is still live. This situation is counter to the requirements of the insulation test.

An application example:

Insulation between a telephone pair and a screen connected to earth.



Check there are no AC or DC voltages between a pair and earth.

Measure the insulation between each conductor and earth (Ra then Rb) at 50 V on cables in operation:

Ra = Rb (+/- 20%) and R > 50 MΩ to 100 MΩ

MX 604:
A few characteristics

Test functions	Characteristic
Lightning arrester test	
Test voltage	Gradient 0...600 VDC
Class	2.5
Short-circuit current	<400 µA
Insulation test	
Test voltage	50 V, 100 V and 500 VDC
Measurement range	100 kΩ...20 MΩ, 200 MΩ and 2000 MΩ
Class	10
Battery test	
	> 200 mA

IEC 1010-1 Cat. III conformity for 300 V

- A casing adapted to use in the field: anti-shock, elastomer and resistant to the harshest environments.
- Direct analogue and clear reading without changing calibres in all functions:
  - *insulation reading scale*
  - *lightning arrester limit voltage reading scale.*
- An AC voltage presence LED to check de-energizing before insulation tests.
- A function rotary selector (6 functions):
  - *"lightning arrester test" position*
  - *"battery test" position*
  - *3 "insulation test" positions: 50 V, 100 V and 500 V.*
- Supplied complete, **MX 604** is delivered ready to use.

The equipment and its accessories (lightning arrester support, remote control probe, test probes) are delivered in their own case.

Reader Service No. 5

Earth measurement

The extraordinary explosion in the use of electricity in everyday life, private and professional, and the extraordinary development of the distribution networks that followed meant rewriting the professional practice rules for installation construction.
Standard NF C 15-100 stipulates the general installation conditions to be fulfilled to ensure the safety of people, pets or farm animals, and the protection of property from danger and damage that could be caused by the use of electrical installations.

However, there is no guarantee that the safety measures implemented will be efficient unless regular tests confirm their performance figures.

Risks due to a lack of protection of electrical installations can represent:
- *a real danger to human life,*
- *the imperiling of electrical installations and property.*

For the user, anybody coming into contact with electric voltage, depending on the power involved, will suffer more or less serious effects, sometimes fatal. The results of studies by a working group consisting of doctors and experts in safety have determined a permanent contact voltage accepted as not being dangerous to individuals: 50 V AC for dry rooms, 25 V AC for wet rooms and 12 V AC for immersed rooms.

Connecting an earth electrode

Why have an earth electrode?

The legislation, with a concern for safety, has made an earth electrode installation mandatory. It avoids dangerous increases in earth potential and the accidental energizing of metal or conducting earths that an individual may touch. When an abnormal (or fault) voltage is generated, the outflow of the associated "fault current" through the earth connection will trip protection devices if necessary.
Therefore, an earth connection must always be associated with a cutoff or will be otherwise of little interest.

Which earth resistance value needs to be established?

In an installation built to standards, to guarantee individual safety, protection devices must trip as soon as "error voltage" circulating through the installation exceeds the limit voltage accepted by the human body.
To minimize risks, we will consider: **U limit = 25 V AC**

In addition, in general in domestic installations, a differential cutoff device (VCD) associated with the earth connection, will accept a current increases of 500 mA.
Through Ohm's Law, **U = RI**
We obtain: **R = 25 V / 0.5 A = 50 Ω**

To guarantee the safety of people and property, the earth electrode resistance must be less than 50 Ω: R earth < 50 Ω

Setting up of an earth connection

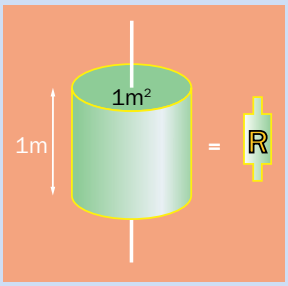
A good earth connection (i.e. with resistance < 50 Ω) depends on three essential elements:
- *the nature of the earth connection,*
- *the nature and resistivity of the soil,*
- *the earth conductor.*

Nature of earth connections

In conformity with standard NF C 15-100, earth connections can be any one of the following types:
- *vertical metal rods or tubes*
- *horizontally laid buried cables or tapes*
- *metal plates*
- *metal belts running at the bottom of ditches*
- *reinforcement metal in concrete embedded in the earth*
- *metal water distribution pipes (with agreement of water distributor)*
- *etc.*

The resistance of the earth electrode obtained in this way will depend on its shape, its location in the earth, and therefore the resistivity of the soil.

Concept of earth resistivity



The resistivity (ρ) of the earth is expressed in Ohm.meter (Ω.m).
This corresponds to the theoretical resistance in Ohms of an earth cylinder having a section of 1 m² and a length of 1 m.
Resistivity varies considerably depending on areas and type of soils, depending on the humidity and temperature factors (frost or drought increases it).

For example:

Type of earth	Resistivity (in Ω.m)
Marshland	from a few units to 30
Clayey soil	20 to 100
Humus	10 to 150
Jurassic marls	30 to 40
Clayey sand	50 to 500
Silica sand	200 to 3000
Bare stony soil	1,500 to 3,000
Stony soil overlaid with lawn	300 to 500
Soft limestone	100 to 300
Fissured limestone	500 to 1,000
Mica schists	800
Altered granites and clay	1,500 to 10,000
Highly altered granites and clay	100 to 600

Why measure soil resistivity?

- to choose, whenever possible, the location and shape of earth electrodes and earth networks before they are built,
- to provide for electrical characteristics of earth electrodes and earth networks,
- to optimization the construction costs of earth electrodes and earth networks (gain in time to obtain the desired earth resistance).

When should resistivity be measured?

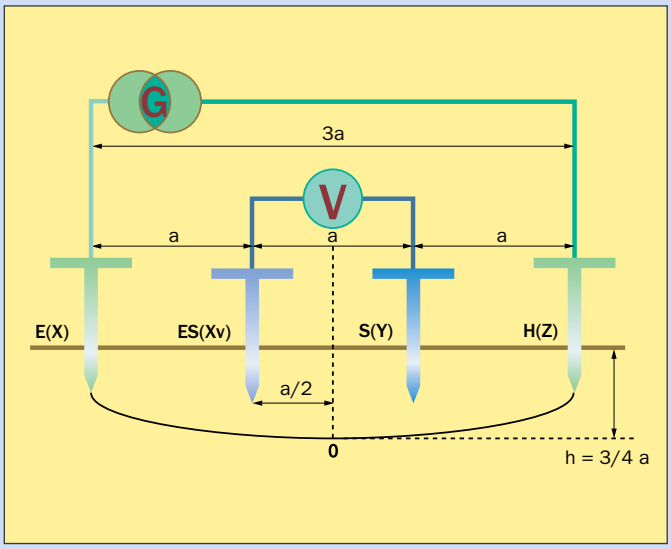
- on land under construction,
- for extensive tertiary buildings (or energy distribution substations) for which it is important to choose accurately the best earth electrode location.

Various methods can be used, but that most widely employed to determine soil resistivity is the WENNER "four electrodes" method.

Measurement principle:

Four electrodes are placed in line on the earth at intervals having a length a; Between the two end electrodes (E and H), measurement current I is injected by a generator.
Between the two central electrodes (S and ES), the potential ΔV is measured with voltmeter.

Note: the terms X, XV, Y and Z correspond to the name formerly used respectively for electrodes E, Es, S and H.



The measuring equipment used is a conventional earth Ohmmeter capable of injecting current and measuring ΔV.
The resistance value R read on the ohmmeter will allow the resistivity to be calculated by the following simplified calculation formula:

$\rho = 2\pi a R$

With ρ: resistivity in Ω.m at the point 0 or at a depth h = 3a/4
a: measurement base in m
R: value (in Ω) of resistance read on earth ohmmeter.

EDF recommends measurement with a = 4 m minimum.

Resistance measurement of an existing earth electrode

At present, we have a configuration in which the earth electrode already exists and for which we want to check that it corresponds correctly to safety standards.
Therefore we want to check that:

R earth < 50 Ω.

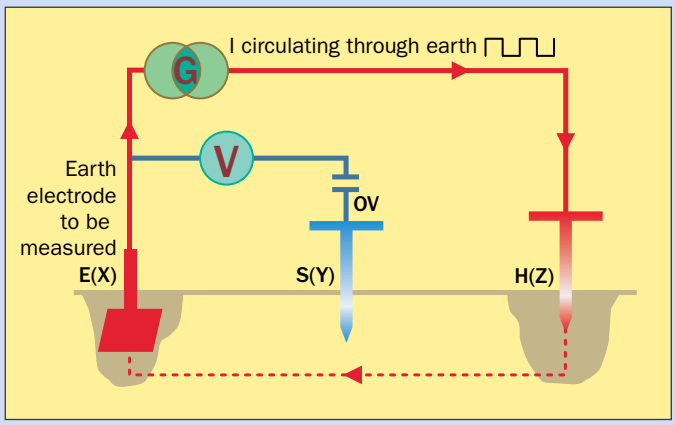
There are several methods that can be applied depending on the installation configuration.

Which method do we use?

Method according to configuration	Building in countryside with possibilities of sinking rods	Building in urban setting without possibility of sinking rods	Multiple parallel earth networks
62% method	■		
Triangle method	■		
62% variant method	■	■	■
PE phase loop measurement	■	■	
Earth clamp			■

Earth measurement principle

E is the earth electrode to be measured

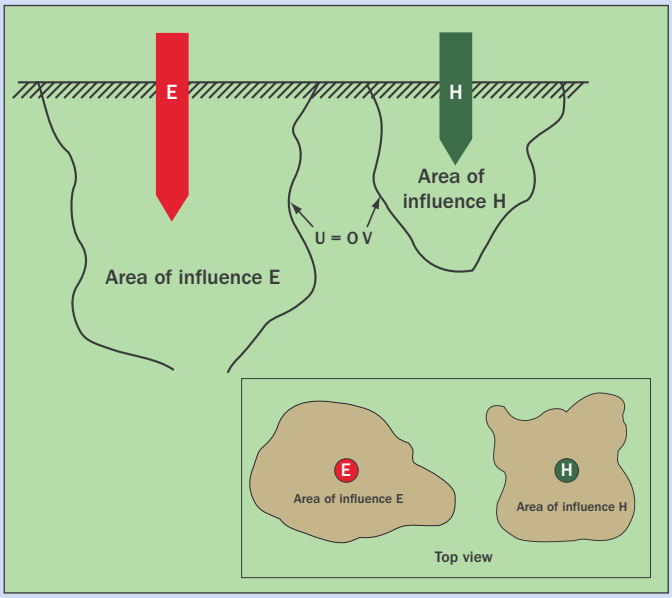


Using an appropriate generator G, AC current (i) at a constant level is made to circulate through auxiliary connector H referred to as the current injection connector with return via an earth connector E.
Voltage V is measured between connections E and the point in the earth where the potential is zero, using another auxiliary connector S referred to as the "0 V potential connection". The voltage quotient V measured in this way by the injected constant current (i) gives the desired resistance.

$R_E = U_{ES}/I_{EH}$

Important note:

The fault current flow is first through the earth electrode contact resistors. The further the distance of the earth electrode, the more the resistance number of the parallel contact will move toward infinity and establish an almost zero equivalent resistance.

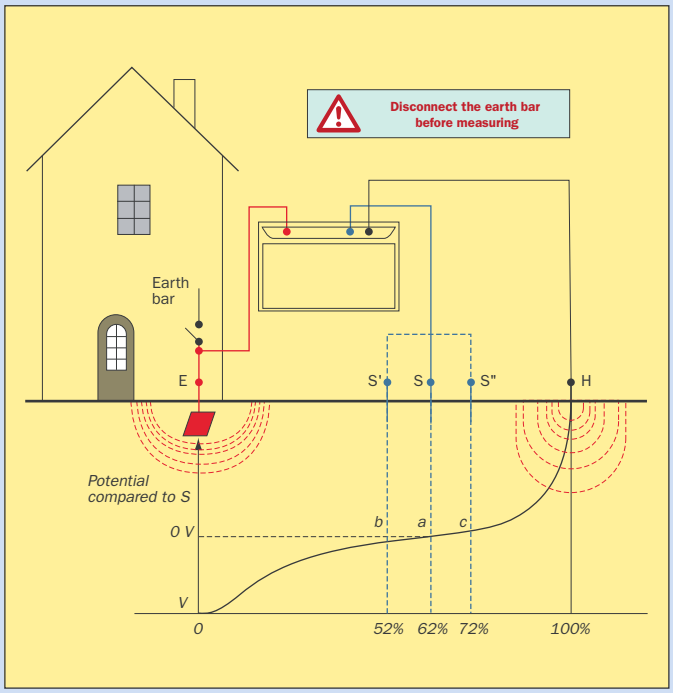


From this limit, whatever the fault current, potential will be zero.
Therefore, around each earth electrode through which current conducts, there is an area of influence whose shape and extent are not known.
During measurements, every endeavor will be made to set an auxiliary connector, referred to as the zero V potential connector, outside the influence areas of the auxiliary connectors through which the current conducts (i).

Various measurement methods

Line measurements method referred to as "62%" (two rods)

This method requires the use of two auxiliary electrodes (or rods) for current injection and for 0 V potential reference. The position of the two auxiliary electrodes compared to the earth connection to be measured E(X) is of particular importance.
For the measurement to be accurate, the potential reference auxiliary connector(s) must not be installed within areas of influence of earth E and H created by the circulation of current (i).
Field statistics have revealed that the ideal method of guaranteeing the highest measurement precision consists in placing rod S at 62% of E on straight line EH.
Then, we ensure that the measurement varies little by moving rod S by ± 10% (S' and S") either side of its initial position, always on straight line EH.
If the measurement varies, it means that (S) is in an area of influence and the distances will have to be increased and measurements started over.
For the measurement obtained to be correct, rod H for the earth electrode to be measured must be at least 25 meters away.

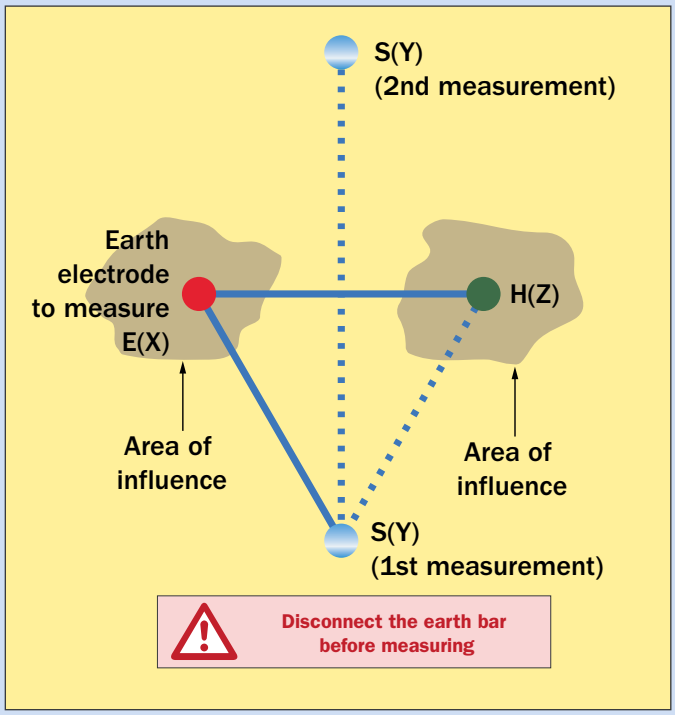


The triangular measurement method (two rods)

This method also requires the use of two auxiliary electrodes (or rods) and is used when the previously described method is impossible to use (because the alignment cannot be obtained or an obstacle prevents sufficient distance from H).
Further, it should not be considered as a reference method because it is less accurate than that of the "62%" method:

- *earth electrode E and rods S and H form an equilateral triangle (when possible)*
- *make the first measurement by placing S on one side and a second placing S on the other.*

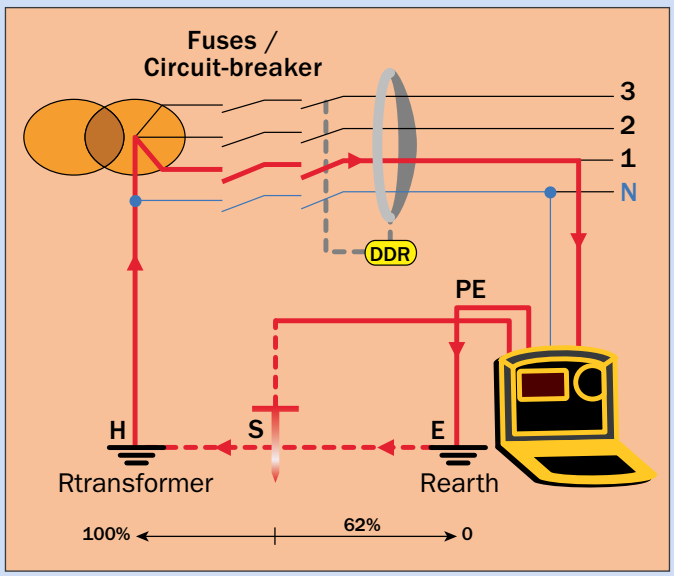
If the values obtained differ considerably, rod S is in an area of influence, in which case it will be necessary to increase the distances and start the measurements again.
If the values found are similar to within several %, the measurements can be considered correct.



However, this method gives uncertain results. Even when the values found are similar, it means that the areas of influence may be overlapping.
To check, start the measurements again and increase the distances.

62% alternative method (one rod)

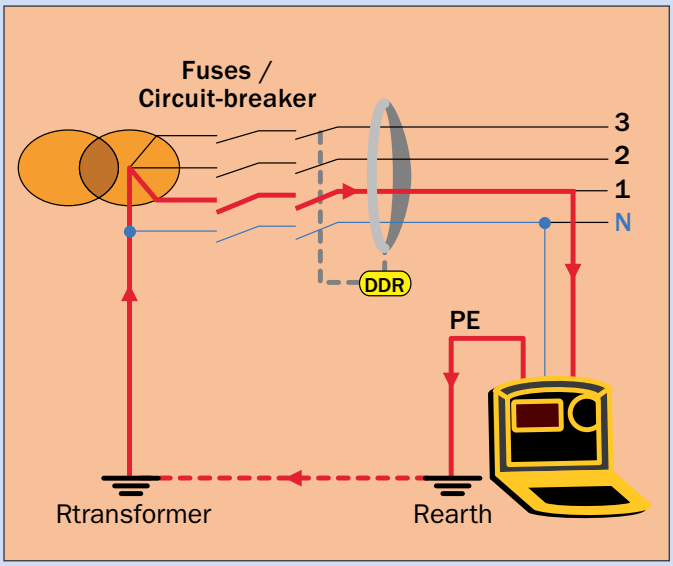
(using a TT or a loaded IT scheme only)
This method does not require the disconnection of the earth bar, and only calls for a single auxiliary rod (S).
Here, the rod H consists of the earth of a distribution transformer, and rod E consists of the PE conductor accessed on the protection conductor (or earth bar).



The measurement principle is the same as for the 62% method: rod S will be positioned in such a way that the distance S-E equals 62% of the overall distance

(between E and H). Therefore, S will be located normally in the neutral "O V reference earth" area.
The measured voltage divided by the injected current gives the earth resistance.
The differences with the 62% method are:
- *The measurement supply is from the network and no longer from batteries or cells.*
- *A single auxiliary rod is needed (S rod) making it faster to prepare the measurement.*
- *There is no need to disconnect the building earth bar. This represents a gain in time and guarantees maintained installation safety during measurement.*

Phase-PE loop measurement *(TT scheme only)*
In town, the earth resistance measurement is often difficult when the auxiliary rod method is used because there is no way of setting up rods because of a lack of space, concrete surfaces, etc.
In this case, in the urban environment, loop measurement does not require the installation of a rod and connection is simply to the power supply network (mains connector).
The loop resistance measured in this way also includes the earth to be measured, the earth and the internal resistance of the transformer and that of the cables. All these resistances are very low, and the measured value is an earth resistance value by excess.

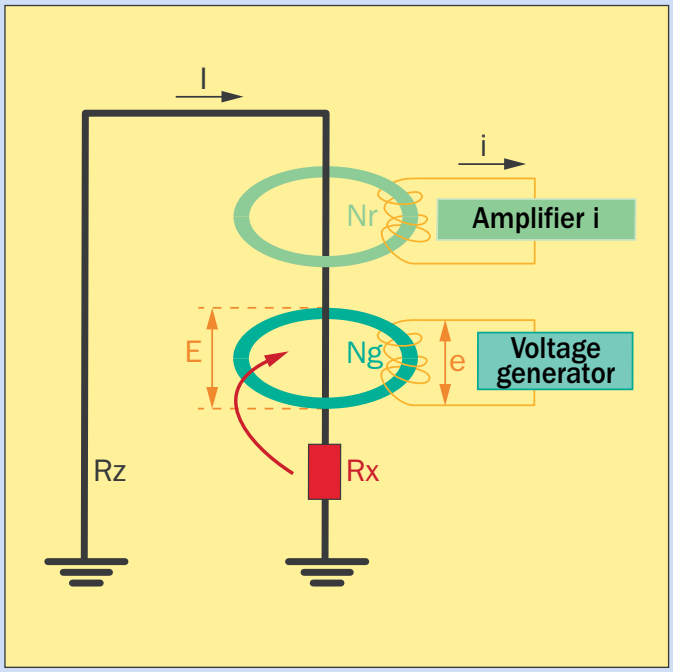


The real earth value is therefore less than: **R measured > R earth**
The measurement error (by excess) induced by this method is likely to improve safety.
Standard NF C 15-100 considers that the loop resistance value (earth resistance by excess) can be taken into consideration instead of the earth resistance, to satisfy rules concerning protection against the risks of indirect contact.

Note: For a TN or IT (loaded) scheme, loop impedance measurement will allow short-circuit current calculation and therefore, the correct sizing of the protection devices.

Earth clamp measurement
Some electrical installations have multiple parallel earth connections, in parallel in some countries in the world where earth is "distributed" to each user by the energy supplier.
In buildings with sensitive electronic equipment, a grid of earth conductors leading to multiple earth electrodes will obtain an earth plan without any equipotential defect.

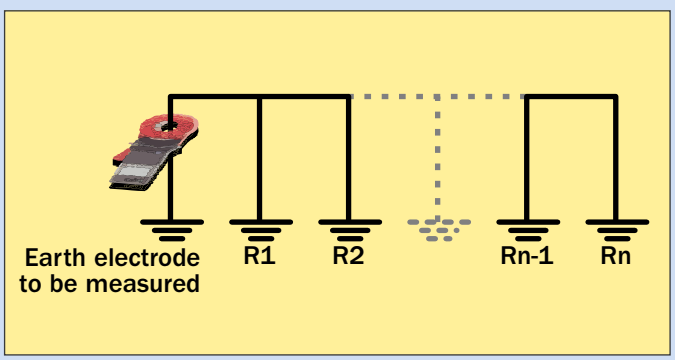
For this type of network, speed and safety of the testing processes can be optimized by an earth connection. In this case, there is no need to isolate the installation (by opening the earth bar) or to sink rods.
Simply clamping the cable on the earth electrode will give an indication of the earth value and the current circulating through that point.
An earth clamp consists of two windings: a generator winding and a receiver winding.



✓ *The "generator" winding of the clamp develops alternating voltage at a constant level E around the enclosed conductor; current* ***I = E / R loop*** *then circulates through the resistive loop.*
✓ *The "receiver" winding measures this current.*
✓ *When E and I are known, the loop resistance can be worked out.*
This is the case of a parallel earth network. Considering that "n" resistors in parallel are equivalent to a resistance R_{aux} of a negligible value, we can measure the local earth value R_x:

R loop = R_x + R_{aux} (where R_{aux} = resistance equivalent To R_1 ... R_n in parallel)

Since **R_x >> R_{aux}**, we obtain **R loop # R_X**



The earth clamp is used for earth resistance measurements:
- *on MV/LV transformers,*
- *on buildings with Faraday cages*
- *on telecommunications lines*
- *and for "underground earth" loop continuity.*

Coupling measurement

Strong coupling between two earths can have disturbing consequences regarding personal and/or equipment safety.

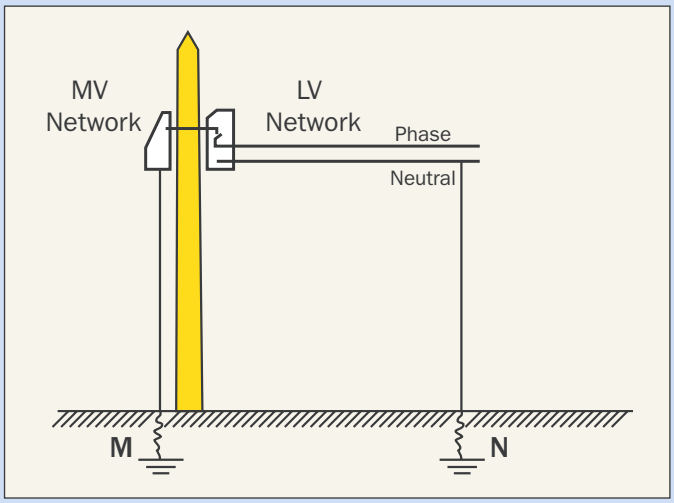
The outflow of fault current via the earth M of an MV network can cause the earth potential to rise, and therefore the neutral earth of the LV network, endangering the lives of people and the equipment using LV networks.

If lightning strikes an MV/LV transformer, the instant potential increase can amount to several kV.

The method to be used is that of in-line measurement referred to as the "62%" method.

The setting out of the auxiliary rods H (current return) and S (potential reference) shall be chosen in such a way as to ensure:

- *that coupling does not occur with the earth electrode to be measured while complying with the distances indicated in the following diagram,*
- *the earth potential reference validity.*

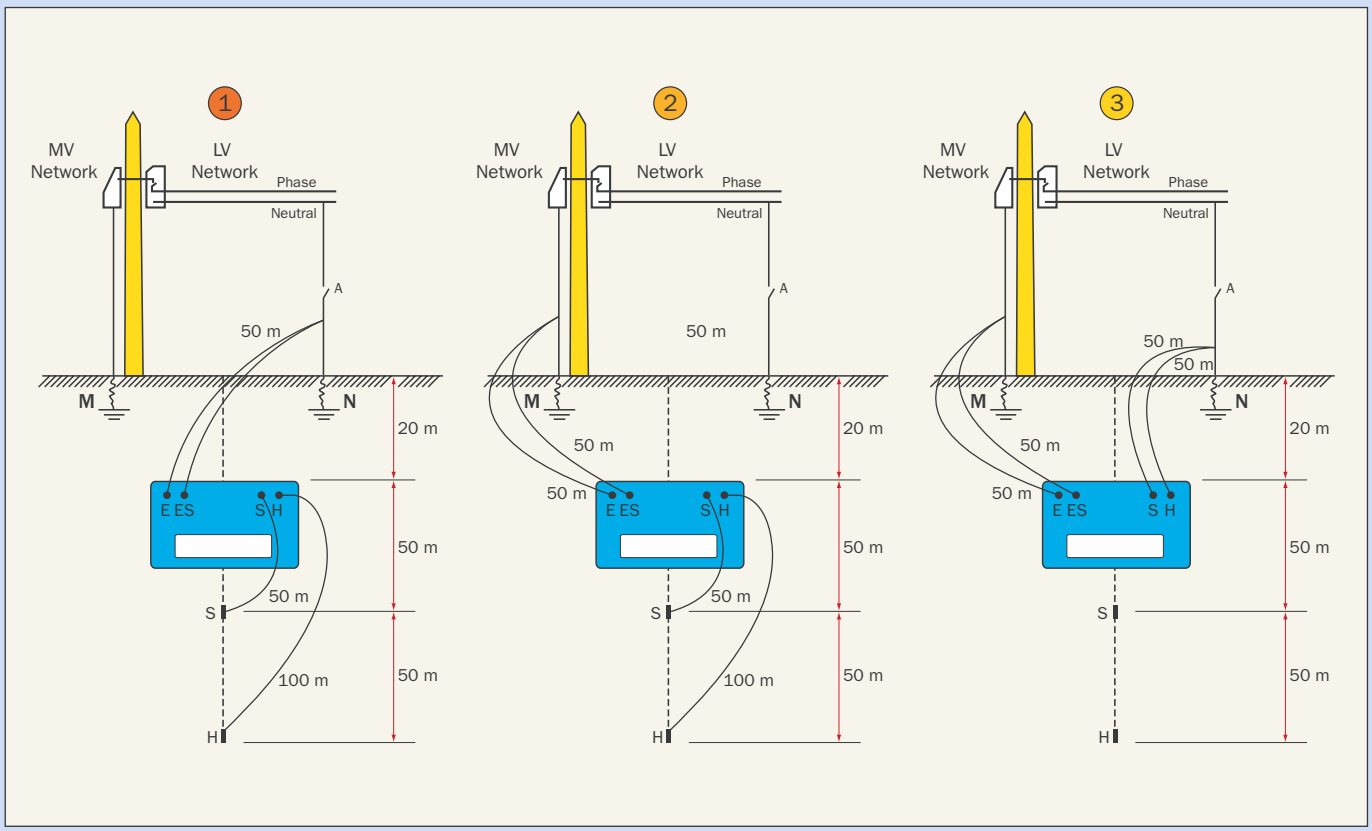


The coupling measurement is made as follows:

1) - Disconnect the Neutral from the LV network (open A)* (1)
   - Connect E and ES to N (LV neutral earth) using two 50 m cables
   - Connect S to the first rod with a 50 m cable
   - Connect H to the second rod with a 100 m cable
   - Place the meter between M and N at 20 m from their center line
   - Make the neutral earth connection resistance measurement: R neutral

   (the opening of point A will be necessary to allow coupling measurement of the first neutral earth connector)*
2) - As above but with E and ES connected to M (MV network earth connection) (the LV neutral is still disconnected) (2)
   - Make the earth electrode resistance measurement: RGrounds
3) - Connect E and ES to M (MV earth connection) using two 50 m cables
   - Connect S and H to N Earth or LV Neutral) using two 50 m cables
   - Make the RGrounds/Neutral measurement (3)
4) - Calculate the coupling:
   R Coupling = [R Earths + R Neutral - R Earths/Neutral] /2
5) - Calculate the coupling factor: **k = R coupling/R Earths**
   - This coefficient must be < 0.15 (EDF directive)

Important: remember to connect A back again



Coupling measurement method

Our solutions for your earth measurements

Depending on the configuration of the installation to be tested (urban area, possibility of sinking rods, earth network), you will probably prefer one measurement method to another.

Chauvin Arnoux offers a full range of products to meet your needs and demands.

	Resistivity Measurement	EARTH MEASUREMENT			Coupling measurement
		62% method Triangle method	62% alternative	L-PE loop measurement	
C.A 6421 C.A 6423		■			
C.A 6425 TERCA 2	■	■			■
C.A 6115N			■	■	

C.A 6421/6423/6425

Stand-alone and reliable (measurement validation by self-diagnosis), the earth testers (C.A. 64521/6423) and resistivity/coupling testers (C.A 6425) were designed for use in the field: sealed site-adapted casing and display legibility. Analogue (C.A 6421) or digital, they make it possible to make measurements using traditional rod methods.

Measurement range:

C.A. 6421: *from 0.5 to 1,000 Ω (log scale)*

C.A. 6423/6425: *from 0.00 to 2,000 Ω (3 automatic ranges)*

Reader Service No. 7

TERCA 2

EDF-approved, TERCA 2 is a reference for measuring earth, respectively and coupling information under difficult conditions (spurious voltages, high telluric current, etc.). The tester offers many advantages such as test current selection, direct reading of measurement on large display and automatic testing of measurement conditions.

Equipment range:

2 Ω to 20 kΩ (5 ranges)

Rechargeable built-in battery using internal charger.

Reader Service No. 8

C.A 6115N

With the possibility of 14 different measurements (insulation, continuity, phase rotation, RCD), this installation tester is the most complete in its generation. In particular, it is capable of earth measurements using the 62% alternative method (single rod) or loop measurements, without causing the differentials to cut out.

Reader Service No. 9

"Single rod measurement" range: *from 0.15 Ω to 10 kΩ*

"Loop" range: *from 0.08 Ω to 200 Ω (resistance and impedance)*

Built-in battery rechargeable by internal charger.

Memory capacity 800 measurements.

C.A 6410/6412/6415: Earth clamps

For a multiple parallel earth network forming several successive loops, earth clamps offer the advantage of fast earth testing safely by simple clamping.

C.A 6412 and 6415 also allow the measurement of leakage current flowing into the earth.

C.A 6415 also offers an alarm function (if a threshold is exceeded) and a recording function (memory capacity 99 measurements).

"Resistances" range: *from 0.10 Ω to 1200 Ω*

"RMS current" range: *from 1 mA to 30.00 A*

Batteries or rechargeable cells.

Reader Service No. 10

Concentrate your energies!

CCT is a Multifluid Remote-readable Metering Pulse Receiver, the latest of the Enerdis communicating products for energy metering and management. Its eight pulse inputs, its considerable memorization capacity and its universal digital output, combined with a compact design and simple operation make it the highest performance tool on the market for the remote operation of a pulsemeter or the monitoring of digital signals.

Enerdis has been developing, manufacturing and marketing energy management systems and supervision apparatus for more than ten years. **CCT** draws on this experience in the areas of measurement, testing and metering of electricity.

This product gathers and stores, in real time, pulses from various energy meters (electricity, water, gas, thermal energy, compressed air, etc.) or digital signals (circuit-breaker state, alarm tripping, door opening), transmitting them via its RS 485 digital output toward a supervision system (with the possibility of using the **WinThor** supervision and energy management software). The type of meter unit m^3, m^3/h, kWh, MWh) is programmable.

With CCT, meters communicate

Controlling and optimizing energy consumption means regularly monitoring a great number of meters. Using **CCT**, any meter with a pulse transmitter, whether electromechanical or electronic, can be read automatically, reliably and quickly. With eight pulse inputs and its RS 485 Modbus/Jbus digital output, **CCT** keeps constant track over long distances of the changing meter indexes. This remote reading also enables users to improve efficiency while devoting more time to the investigation and optimization of their consumption.

Using pulses supplied by the meters, the **CCT** can memorize, for each of the inputs, the last twelve monthly meter indexes and the general meter index. It also records real time values making it possible to re-establish the load curves. 4,032 mean values can be memorized for each of its eight inputs over a time programmable from 1 to 60 minutes (i.e. 28 days self-sufficiency for 10 minutes integration or 168 days for 60 minutes integration) and synchronized on internal or external pulses.

Queried via its RS 485 Modbus/Jbus digital output at a distance, **CCT** restores consumption figures, giving users far more pertinent information than a simple index reading.

CCT completes the range of ULYS electronic meters

Enerdis has re-established its position as the main player on the modular meter market with the recent launch of its **ULYS** electronic meter range. Single or three-phase, single or double tariff, with active and reactive energy metering, all these meters have a pulse output. Combined with these meters and the **WinThor** energy monitoring and management software, **CCT** offers users a global and complete solution for monitoring and managing all their meter points.

CCT, a real surveillance agent

Each of the eight inputs of the **CCT** can be programmed (via **SESAME**) as an digital signal monitoring input. When a change of state occurs at an input, **CCT** memorizes the date and time of the beginning and end of the event (circuit-breaker state, alarm tripping subscribed power overrun, tariff changeover, process start, door opening). It memorizes the last 50 changes of state for each of its eight inputs.

CCT, a universal tool

In addition to the fact that this single device allows analysis of meter signals and memorizes major events, it is totally adapted to user requirements. Using our **SESAME** configuration software, each input can be programmed for every possible type of unit (m^3, m^3/h, kWh, MWh), pulse weight, communication parameters (address, speed, parity). The user can also choose the initialization values of the metering indexes.

CCT comes with an RS 485 two-wire Modbus/Jbus digital output. This communication protocol is recognized by all the leaders in the world of industry and logic control, offering easy and rapid integration of **CCT** into any supervision system on the market.

Regulatory meter synchronization

For particularly precise consumption analyses, it becomes necessary in some cases to synchronize load curve power demand calculations (more often referred to as the top 10 min) with the regulatory meter point. **CCT** is programmed to select, for each input, a synchronization by an external signal or by a **CCT** internal clock.

A 24 V DC integrated power supply

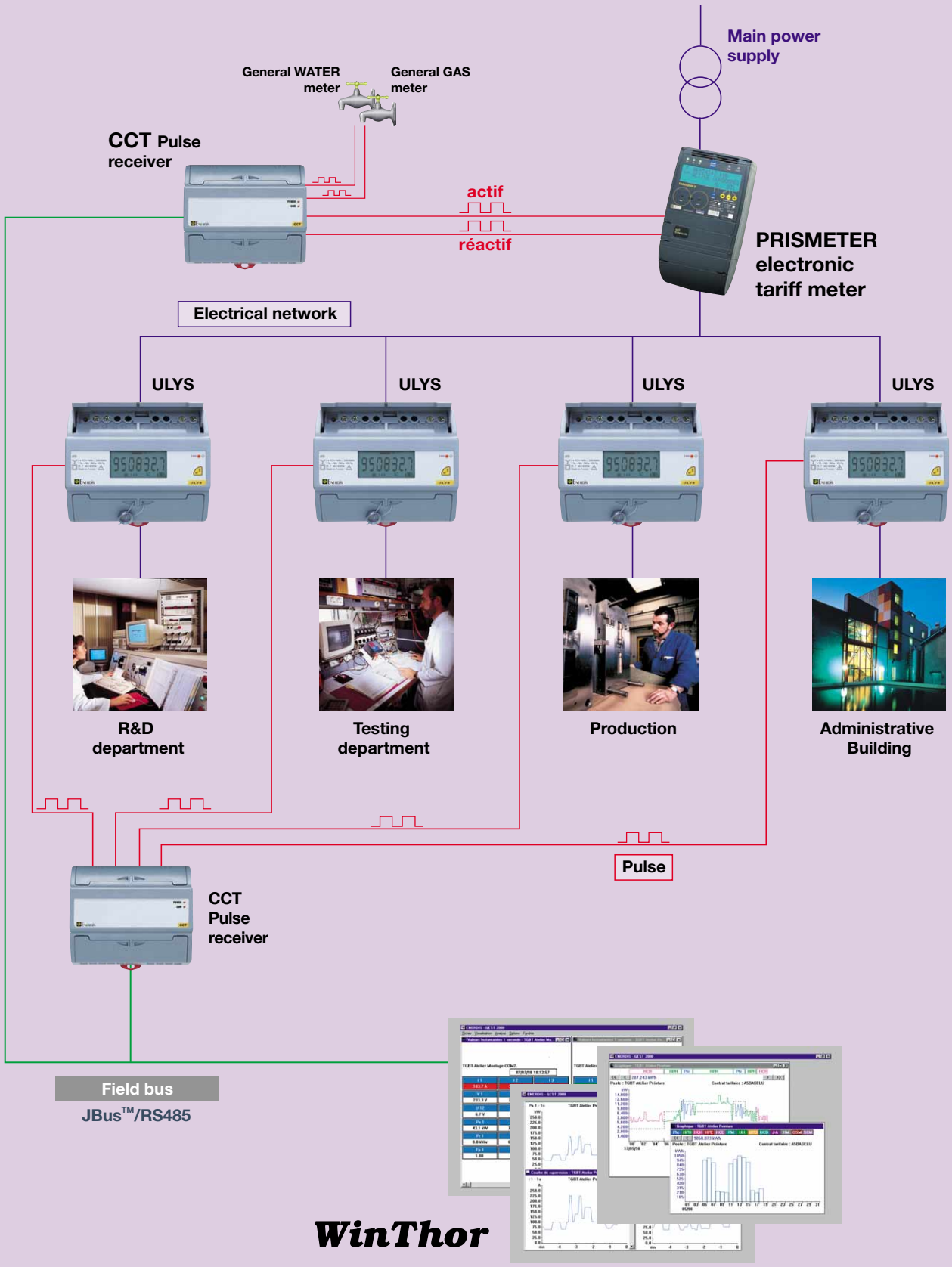
On **CCT**, there are two terminals providing access to the 24 V DC power supply used for activating signals from the meter pulse transmitters.

CCT and WinThor

A specific driver has been developed to operate and utilize every possibility of the **CCT** for our **WinThor** monitoring and energy management software.

Reader Service No. 11

Example of electrical network monitoring and energy management



Metering energy flow within the context of deregulation

The recent deregulation of the energy market has lead to the creation of, among other things, a new player: electric transmission network management. This latter guarantees the continuity and the quality of public utilities made available to its new customers - producers on one side and consumers and distribution systems on the other. To complete its mission, this management must be able to access certain production and consumption information. Thus electric transmission network equipment needs to evolve so that the flow of electricity that transits this network can be metered.

New needs in electric transmission network metering

In 1996, the European Commission adopted a guideline which opened the electricity market to competition: European consumers will be able to eventually chose their own electricity supplier.

As a requirement for opening the energy market, electricity transmission had to be separated from its production by creating independent entities. A single electric utility management for the transmission of electricity is required in each country. This management is to be in charge of high and very high voltage lines (63kV to 400kV), all those that connect electric power plants, eligible industrial sites, electric networks, its new customers, and electrical networks in neighboring countries.

Thus our management's role is to invoice the cost of transmission to these new users, establish the variance between production and consumption forecasts and realizations, and set up their settlement.

Running an electric transmission system means ensuring, in real time, the balance between the consumers demand for electricity and the suppliers' supply. To ensure this balance, the network management needs to be able to do as needed with the energy reserves, using them as they rise or fall in relation to the direction of total imbalance noted. Even if the global balance between production and consumption can be maintained, this doesn't necessarily mean that the same production-consumption balance holds true for each of the suppliers. Thus detailed accounts need to be established a posteriori to identify the differences between the production-consumption results of each producer and then follow through with their financial regularization.

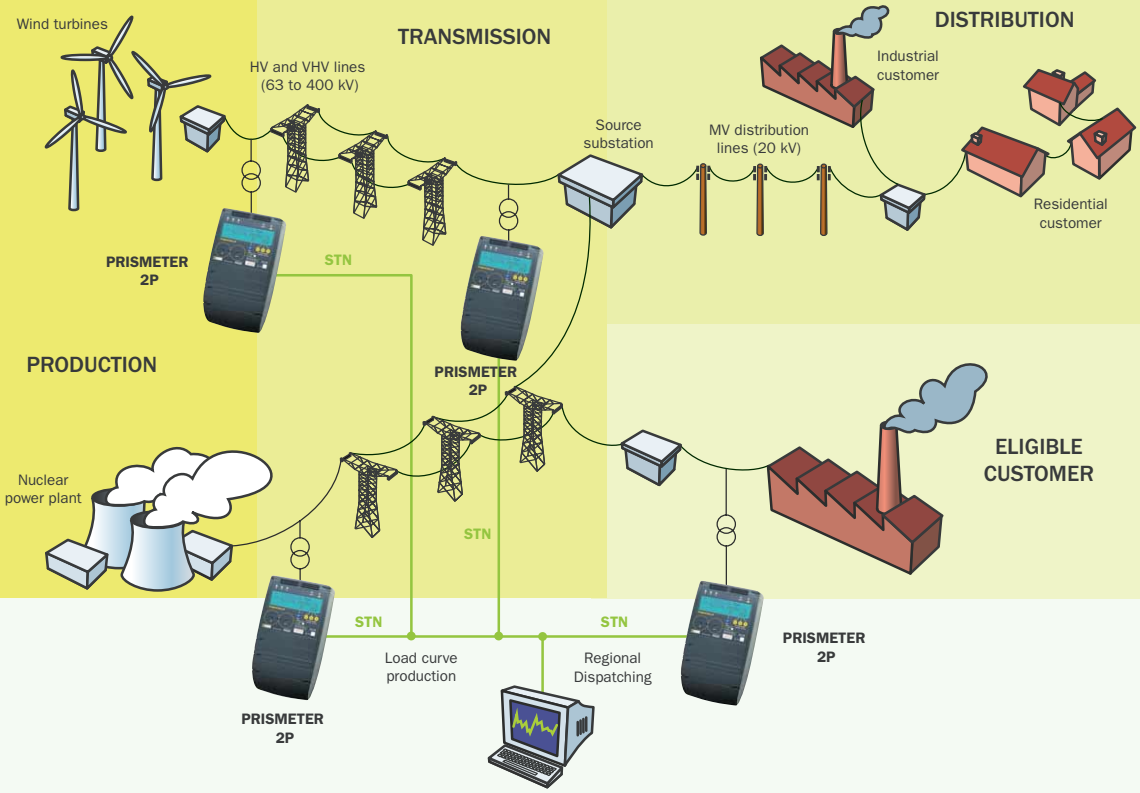
Furthermore, the network management ensuring the functioning of the electric transmission network needs to be paid for this service.

Metering improvements

Input and output points for a metering-equipped transmission system

In order to calculate and regulate variance in the product-consumption results on the one hand and transmission service invoice on the other, it is necessary to know the energy flow that transit the electrical transmission network. This is the reason why all production and consumption points connected to

Electric transmission system equipped with metering



an electric transmission utility need to be equipped with a remote-metering system. This remote-metering system requires 2 meters on each metering point to guarantee data metering without interruption.
On top of this, if one can choose one's supplier, this means that, in the client's metering structure, energy measurement must be separate from metering system installed by the energy supplier. The part that measures must be physically separate from the part that fixes the price.

Sophisticated metering systems

Among the elements of this system, remote servers, modified to actively and dynamically manage the double-meter system, have been installed in the seven regional dispatchings.
Data collected at this level is then transmitted to a server center where variance is calculated.
Other elements in the system, energy meters are installed in all of the transmission network's input and output points; they communicate data to the servers. Because they have an integrated communications port, programming and maintenance can be carried out on site.

Doted with features such as billing and real-time monitoring, these tools are highly robust (notably in electromagnetic environments) and reliable (with a very low failure rate).
Because large amounts of energy are being billed between different companies, it is important for the meters to be extremely precise. It is for this reason that transmission network metering is structured around four quadrants (import-export energy) which measure active energy with an accuracy class of 0.2S and reactive energy with class 2.

The meters are equipped with a switched telephone network (STN) modem so that the return of data can be carried out at a distance. Since as soon as they are placed in operation on their designated telephone line, these meters are linked up and accessible no matter their location.
Using radio-type clocks, local synchronization for these meters provide synchronized average powers which can be called upon and thus can reconstruct production and consumption load curves.

Reader Service No. 12

PRISMETER 2 meters on power transmission networks

The PRISMETER 2 meter comes in two mechanical formats: the 1/2 19" rack-mountable version for electrical cabinets and the surface-mounted version for metering panels.

In France, the PRISMETER 2 meter was chosen by the RTE, the power transmission management. Between October 1998 and February 1999, 800 PRISMETER 2 meters were installed on the transmission network. Their high metrological accuracy and features perfectly meet established terms and conditions.

Accuracy

The PRISMETER 2 meter is especially adapted for HV and VHV energy flow (energy production, interconnection, etc.). Because of its high metrological accuracy, it is destined for metering large quantities of energy. Reminder: it measures active energy with an accuracy class of 0.2S as per IEC 687 and reactive energy with class 2 as per IEC 1268.

4 quadrants / load curve

The meter measures and records energy transiting in both directions (production / consumption). There are 6 energy indexes: active energy produced and active energy consumed, reactive energy produced and reactive energy consumed for which there is also inductive reactive energy and capacitive reactive energy. It records load curves (average power demands) over a programmable integration period of 1 to 60 minutes.

Time synchronization

Equipped with its own time-stamping clock for dating constituent elements of the load curve, the PRISMETER 2 is also fit with an input for synchronizing with an external signal.
Synchronization with an accuracy inferior to 100ms of the read load curve is carried out by connecting the installed meters to a time central receiving either radio or GPS satellite.

The PRISMETER 2 meter also comes with or without an auxiliary power supply, class 0.5S or 0.2S.

Remote-reading

A communicating meter, the PRISMETER 2 is equipped with a STN modem. In this way, metering points from the entire production (connected to a transmission system) are repatriated to regional dispatching servers remotely via a telephone line. This data is made available to customers (distributors and eligible industrials). It also has a Teleinfo digital output (2 wire bus) so that end customers carry out their own energy management.

Power quality

The PRISMETER 2 meter also provides optional qualimetry features, notably continuity measurement and recording (interruptions, voltage dips and surges, frequency, slow variations in voltage), and the supply's quality (current and voltage harmonics measurement up to the 40th order, unbalance measurement).

PRISMETER 2 has also been improved. In the event that a STN telephone line can not be installed, it is possible to connect it to an external GSM modem.
PRISMETER 2 is equipped with pulse transmitter outputs. The weight of the length of the 4 pulse outputs are programmable, which means that the client can adapt his system to suit his needs.

Reader Service No. 13

Protective sheaths for pyrometer assemblies

At the very heart of measurement, the temperature sensor is the sensitive element of a measurement process loop. Exposed to severe and repeated stresses, it must be robust and protected accordingly by a sheath to guarantee a minimum life duration.

There are many industrial processes involving temperature: heating, firing, heat treatment, fusion.
The measurement systems implemented to test and regulate temperature form a complete system known as a thermal process loop.
The temperature sensor is the sensitive part of this loop.

Exposed to harsh and repeated stresses, the temperature sensor must be accurately tailored to its application so to fulfil its function on a long-term basis. Obviously, this means that the temperature range to be resisted by the process and the process setpoint temperature is known, yet also depends on conditions specific to the process in question: chemical nature of the environment to be measured with its physical and mechanical demands.

Pyro-Contrôle Chauvin Arnoux, an expert in the production of industrial sensors, describes here the technological choices that contribute to the robustness and long life of a sensor.

Robustness

It is essential for a sensor to be robust. The process calls for much thought because there are many aspects involved.
What is the desired minimum life span of the sensor? In terms of time, what is the cost of replacing a sensor? If the sensor's protective sheath is doubled, how much gain can be generated in terms of the equipment utilization factor? All these parameters have to be taken into consideration when determining the type of protection and its life duration.

Naturally, the operating temperature first governs the choice of materials to be used in manufacturing a sensor protective sheath.
Industrial processes also affect pyrometer assemblies by abrasion, pressure, vibration or corrosion. The media can be reductive, oxidizing, acid, alkali or sulphurous.
Pyrometer assemblies therefore have to incorporate suitable materials like special steel, nickel-base alloys, sintered metals, composites, plastics, ceramics.

Good vibration resistance means taking the strength of the materials and the frequencies of these vibrations into consideration.

All the materials used in sensor construction must comply with this double-sided demand. Another element of robustness is resistance to thermal impact, often causing breakage or rupture, especially for ceramics.

Protection materials

Protective sheaths are designed to protect the sensitive part of the sensor from undesirable influences such as fluid pressure or flow speed, chemically or mechanically aggressive media or electrical influences. Each case means using a suitable material, possibly reinforced by a special coating. Protection can be obtained by a sheath lined with another sheath to deal with several different parameters at the same time.

Metal sheaths

Metals most often used are:
- dressed cast iron, pure iron,
- stainless steels up to 400 °C,
- refractory steels up to 1,300 °C,
- nickel-base alloys up to 1,350 °C,
- lined metal tubes,
- special metals, especially precious metals.

Dressed cast iron and pure iron

Dressed cast iron is used in aluminum and non-ferrous metal foundries, for instance zinc. Increasingly, they are being replaced by composite ceramic sheaths (see below).

Stainless steel

Stainless steel sheaths are essentially used for chemical installations. In addition to mechanical strength, the need for good chemical resistance to corrosion is an incentive to choose a material identical or similar to that of the installation itself for the protective sheaths. Welding capability should also be checked.

There are special prescriptions for installations handling food or pharmaceutical products. We might mention the more customary steels:
AISI 304L, AISI 316L and 316 TI.

Depending on the expected type of protection, protective sheaths can be built of many materials: refractory steel, stainless steel, alumina, ceramics

Refractory steels

These are used essentially for sheaths placed in ovens, fire boxes, salt baths. These sheaths are generally not exposed to solicitation caused by pressure or flow. They have to offer optimum resistance to high temperature oxidization.
The more frequently used are:
AISI 321 and AISI 446.

Pure nickel and high nickel content alloys

- Nickel-chrome or Inconel alloys
Inconels have a high nickel and chrome content, endowing them with resistance to oxidizing and reducing media. They are suited to high temperature corrective environments. Some alloys have exceptional fatigue resistance.
- Nickel-iron-chrome or Incoloy alloys
The presence of approximately 40% iron endows Incoloys with properties of resisting carbiding. They offer excellent resistance to high temperatures and to sulfur attack and corrosion.
- Nickel-copper or Monel alloys
Monels have a high copper content of around 30%. These alloys offer high mechanical strength, good welding capability and excellent resistance to corrosion in a vast range of temperatures and for different environmental conditions.
- Nickel-chrome-Molybdenum/Iron alloys or Hastelloy
Hastelloys are particularly effective in corrective, oxidizing and reducing media. Their versatility and resistance to fatigue mean that they are often used for fine chemical processes. Some are used for household refuse incineration.

Coated metal tubes

Metal sheaths coated with a material suited to

Coating	Properties	Examples of use
PTFE	Resists weak acids and alkalis. Mediocre heat conductivity.	Chemical installations without longevity demands.
Stellite	Very hard, resists high temperature abrasion. Coating deposited by welding.	Rotary furnaces, air containing abrasive powder.
Mild enameled steel	Good resistance up to 450°C but fragile on impact.	Zinc bath.

Coated metal tubes (Fig. 1)
Examples of coated metal tube applications

Material	Properties	Examples of use
Platinum and platinum-rhodium	Resists oxidization even at high temperature. Resists acids and alkalis.	Manufacturing of hydrofluoric acid. Glass and enamel baths.
Tantalum	Excellent resistance to acids and alkalis up to 300°C (exceptionally, 400°C).	Tantalum-coated pipes and boiler-making: for nitric acid; lactic acid, bromide, iodine.
Silver	Resists oxidization up to 400°C. Resists acid partially, e.g. phosphoric acid.	Silver-coated chemical installations.
Molybdenum	Resists temperature-reducing atmospheres.	Atmospheric ovens with the presence of hydrogen.
Kanthal	Presence of protective alumina coat offering properties of resistance to oxidizing and sulfur-bearing media.	Gas ovens.

Special metals (Fig. 2)
Examples of applications with precious metal sheaths

Coating	Properties	Examples of use
PTFE and polyamides	Resists weak acids and alkalis. Mediocre heat conductivity.	Electro-plating and acid baths.
PVC	Low resistance, maximum strength 100°C - Coating deposited by welding.	Applications without any particular requirements.

Plastic material sheaths (Fig. 3)
Examples of applications with plastic material sheaths

Cannes CADID for high temperatures starting from 500°C. The sensitive element: a pearl-type thermo-couple covered with metallic protection or a sheath of ceramic or alumina.

cope with the environment, offering good chemical resistance in addition to mechanical strength offered by the supporting tube *(Fig. 1)*.

Special metals

For cases where nickel-base steel and alloy is insufficient, special metal protection sheaths are used *(Fig. 2)*.

Non-metallic sheaths

Plastic sheaths

Plastics most often used are PTFE, polyamide and PVC *(Fig. 3)*.

Sheaths of ceramics and other amorphous materials

Operate essentially at high temperature when metals can no longer be used or do not offer sufficient life duration. Alumina or aluminum silicate ceramic sheaths are suitable for noble metal thermo-electric couples *(Fig. 4)*.

These sheaths are particularly sensitive to thermal shock: excessively fast entry into the hot zone will cause a thermal dilatation gradient that can break the sheath. On contact with dust at high temperature, vitrified deposits often form on their surface having a different thermal dilatation factor: excessively fast withdrawal could cause the sheath to shatter. Gas-tight sheaths are more sensitive to thermal shock.

Conversely, coarse-grain sheaths offer better resistance but have high porosity.

■ **Composite material sheaths** *(Fig. 5)*

Mechanical properties

■ **Mechanical strength**

The mechanical strength of steel decreases with temperature. In addition, corrosion and abrasion help decrease the effective sheath thickness. This should be taken into consideration during calculations. Ceramic sheaths also lose their strength at high temperature. Up to a given temperature, the strength characteristics vary relatively little, but beyond tend to become very quickly and emphatically depleted. This limits the range of use of ceramics to below this temperature setpoint (indicated by the suppliers).

■ **Resistance to corrosion and abrasion**

From the standpoint of chemical strength, the choice of a suitable material for the sheath calls for great attention. In aqueous solutions, an electric battery effect occurs (for instance, between the sheath and the boiler walls), always aggravating corrosion when the distance between the two reactive materials is small.

This gives us the following basic rule: the sheath must be manufactured from the same material as the equipment or from a more noble material from the electric standpoint.

It is possible to obtain data from steel manufacturers about the loss of weight (per cubic meter and year) and the resistance of refractory steel to oxidization. These values apply to calm air. The resistance to oxidization of chrome-nickel alloys comes from the adhering oxide coat which limits oxygen penetration. When this oxide coat is damaged, for instance if dust particles or sand are carried by the air flow, the damage will increase substantially. There is no way of setting valid values as a general measure. To improve abrasion resistance, suitable coatings are used on metal sheaths: stellite and shooping are typical examples, as are vacuum plasma processes. The latter allow a wide variety of coating materials to be used on a range of different substrates.

Quartz sheaths resisting acids and alkalis are used in the chemical world. They are insensitive to thermal impact and can be used to very high temperatures. They are also used in metallurgy. They guarantee purity compliance in semi-conductor manufacturing

Material	Properties	Examples of use
Ceramic 530	Resists up to 1,500°C; not very sensitive to thermal shock; porous.	Material most often used in metallurgy and heat treatment ovens, often used as double jacket.
Alumina 710	Resists up to 1,800°C; very sensitive to thermal shock; low porosity.	More current materials in metallurgy and heat treatment ovens, at high temperature than ceramic 530.
Quartz	Resists acids (except HF) and alkalis - Insensitive to thermal shock.	Steel bath up to 1,600°C. Semi-conductor ovens.

Sheaths of ceramics and other amorphous materials (Fig. 4)
Examples of application with ceramic material sheaths.

Material	Properties	Examples of use
Graphite	Electricity conductor; can be used to 1,800°C; mandatory to use insulating internal sheath such as alumina 710.	Aluminium foundry.
Nitride binder Silicone carbide	High mechanical strengh, good resistance to thermal impact - Resists oxidizing and reducing atmospheres - Max. Temperature 1,600°C.	Foundry work for aluminium, zamac, zinc and copper metals. Incineration furnaces.
Silicone nitride	Excellent corrosion resistance for non-ferrous metals. Max temperature 1,250°C.	Zinc bath.

Sheaths and composite materials (Fig. 5)
Examples of applications with sheaths of composite materials

Furnace mapping at Snecma

We met with Mr. FERBOEUF, in charge of the Snecma forge workshop, who gave us a particularly warm welcome and told us about his work: furnace metrology.
"Furnace mapping implies mastery over global quality and applies to the heat treatment of metal parts f/or aircraft engines."

Photo SNECMA

This forge furnace is "instrumented" for no-load mapping (empty furnace). All 27 temperature sensors are set out through the volume of the furnace (3.67 x 3.55 x 2 m) and connected to a measurement unit. No-load temperature consistency tests are run for four different temperatures (maximum 1,200°C). On completion of these tests, the furnace will be declared as conforming or not.

Heat treatment process control, especially the forging of materials used in the composition of aircraft engines, ensures quality and safety of the material and of the people being transported.
That is why SNECMA, over the years, has developed the concept of a manufacturing "instructions" specifying the ways of testing parts used in the composition of aircraft, and establishing references for the measurement instruments used for testing them.

Accuracy and consistency for a furnace holding temperature are two primordial elements governing quality and cost of the resulting heat treatment.

Why quality?

Because the mechanical characteristics obtained during tempering, for instance, depend on the temperature reached during heating at every point of the load, and any fault in accuracy and consistency will lead to variations in the properties obtained, and therefore dispersed quality.

Why the cost?

Because any reduction in temperature deviations between two points in a furnace enclosure will result in a decreased heating setpoint, and therefore, by stopping the superheating process, provide an energy saving.
At 1,000°C, saving a single degree makes for considerable economy.
In the long term, limiting the amount of overheating will also extend the equipment life duration.

Furnace mapping

Furnace mapping is an essential part of heat treatment process control.
Furnace and oven suppliers know how to meet specifications that stipulate the equipment "class".
The class of a furnace is the maximum difference between any two points in the enclosure. This means that a class 10 furnace is not supposed to generate more than 10°C deviation between all the points of the load.
This is only in theory. In practice, furnace mapping, with or without a load, is a way of checking.

Reception of a new furnace

Two types of mapping can be applied for certifying a furnace, checking compliance with the original specifications. The characteristics found will be used for writing up the acceptance report.
The acceptance report will be used for writing the procedure applicable to future mapping and determining the periodicity needed between two maintenance mapping processes.

These two types of mapping are:
- No-load reception mapping: empty furnace (see photo)
- Reception mapping with a load: furnace containing a correct amount of material.

Furnace maintenance

A new furnace mapping process is triggered on a due date, or by observing an anomaly on withdrawal from the furnace.
Effectively, at SNECMA, each part is measured thermally by a production agent using portable apparatus. If the measured temperature is abnormal, the fault is reported to Mr. FERBOEUF's Department, who will seek the defective composition in the furnace.
After repair, another mapping process is always run.

Temperature measurement and recording

The furnace to be tested is "instrumented".
With temperature sensors that are connected to a measurement unit.

No-load consistency testing

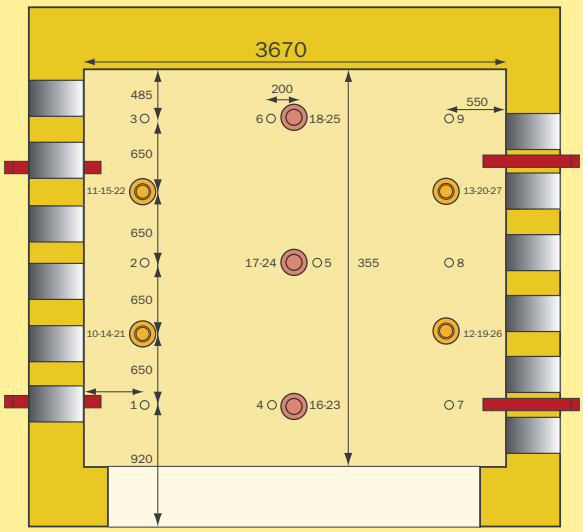
Temperature consistency tests are carried out at four different setpoint temperatures. The temperature values are chosen according to the furnace and the parts that will be treated in them.
- The process begins at ambient temperature with stabilization at a first temperature level. Stabilization may last several hours. The furnace is destabilized (e.g.: doors opened) for 30 minutes and another stabilization level is allowed for 30 minutes.
- Then, another increase to a second temperature level is requested. There is a one-hour stabilization waiting period, then the acquisition system records the values obtained by the temperature sensors for one hour. This is followed by 30 minutes' destabilization, followed by furthers stabilization for 30 minutes.
- Then the temperature is increased to the third level with the same cycle as before, and the temperatures are recorded for one hour.
- The fourth cycle is a reduction in temperature with return to the initial temperature value.
- The last temperature cycle consists in bringing the system back to max. temperature again and measuring the temperatures.

On-load consistency test

The test is run at two different temperatures according to a preset cycle and, for each temperature, the load tonnage will be modified.

A look at the Snecma group

Among the very biggest worldwide engine manufacturers, Snecma is alone in mastering such a complete range of propulsion technologies for civil and military and transport aircraft, helicopters, missiles, drones, satellites and space launch vehicles with a thrust range extending from 8 grams to more than 650 tons.



The thermocouple sensors are set out as follows:

- numbers 1 to 9 are placed on the base
- numbers 10 to 13 are placed on jacks at a height of 0.5 m
- numbers 14 to 20 are placed on jacks at a height of 0.7 m
- numbers 21 to 27 are placed on jacks at a height of 1 m.

Location of temperature sensors in furnace.
The temperature setpoint is obtained by gas heating diffused by burners.

"Consistency test" report

At SNECMA, the following information is recorded for each furnace: Name, volume characteristics, maximum load, temperature range, temperature class, name of the temperature recording equipment and metrological validity, a table of measurements*, general observations, quality decision.

** All the temperatures from the thermocouples are entered into a table.*

Other important information is also recorded, such as: regulation time, stabilization time, overrun time, stabilization max. and min. temperature, perturbation max. and min. temperature, stabilization minimum amplitude, rise time.

On completion of all these measurements, the furnace will be declared good or bad by the quality department.

Reader Service No. 15

Our tailor-made solutions

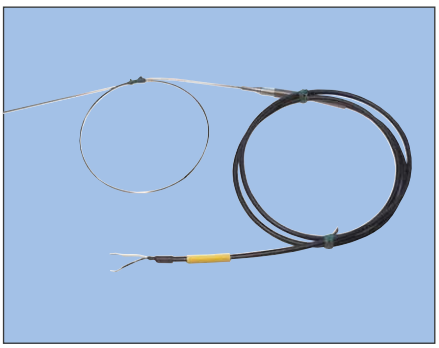
Pyro-Contrôle Chauvin Arnoux converts every measurement and test requirement concerning temperature into an industrial solution. In this particular application of "furnace mapping", it is competent to offer the full chain: sensors for measurement and the PYROTRACER modular system for recording and restoring data.

TEMPERATURE SENSORS:

The temperature sensors most often used in mapping applications are K type thermocouples lined with Inconel (resisting up to 1,150°C).

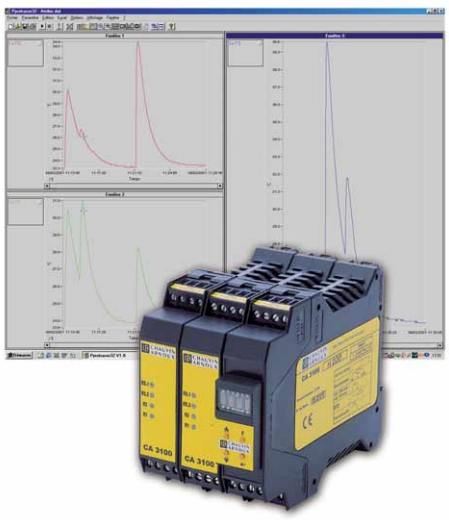
All our K thermocouples lined with Inconel are in class 1[1]. The extension cable is usually PVC insulated after binding with a shield braid and PVC sheath; other types of sheath are available on request, glass silk insulation, silicone sheathing or FEP.

[1] According to standard NF EN 61-515. [2] According to standard NFC 42-330.



TCG3 sensor: K type thermocouple lined with Inconel, PVC extension cable output.

DATA RECORDING AND ANALYSIS ON THE PC



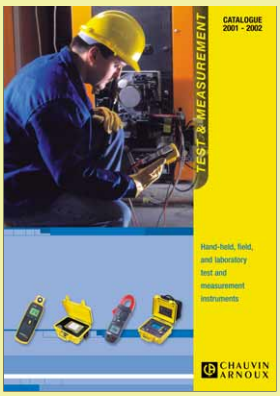
Pyrotracer:1 to 32 measurement channels. Easy data analysis directly on the PC.

This PC digital temperature recorder consists of the "Pyrotracer" software and digital transmitter modules of the C.A 3100 general-purpose input type. Between 1 and 32 modules can be connected, depending on the application.

These modules have an RS 485/Modbus protocol digital output.

Each channel has a low and a high alarm.
There are two available recording modes: batch mode or programmed starting and stopping in time and the "continuous" mode with constant data recording.

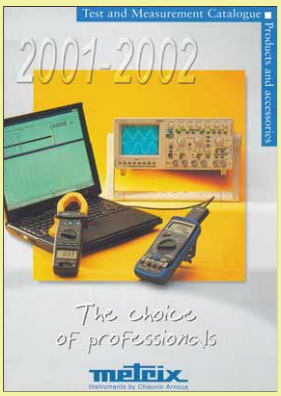
Reader Service No. 16



Chauvin Arnoux Test & Measurement

The complete and up-to-date product offer. Within the 32 illustrated pages of this 2002 catalogue, the Test & Measurement division presents metrology professionals with its full range of Chauvin Arnoux brand hand-held, field, and laboratory instruments: *Electrical testing and safety, Current measurement, Hand-held testers, Energy analysis, yet also LAN and telecommunications testing and Microwaves.*

Reader Service No. 17



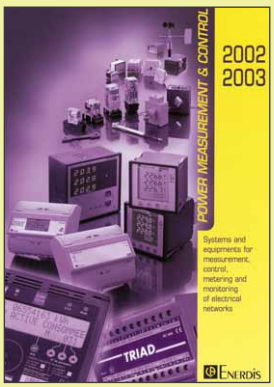
Metrix Test & Measurement

Within its habitual 32 color pages, Metrix presents its product range within selection tables. Set forth in a very clear way, comparisons between equipment are made using each's specifications. Photos of each of the multimeters, oscilloscopes, generators, power supplies, accessories, and other instruments are included to make the selection more simple.

Reader Service No. 18

Power Measurement & Control

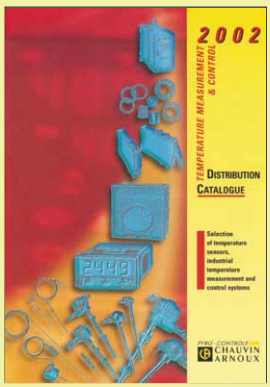
Within this 2002-2003 catalogue (126 pages), the Power Measurement & Control division presents its entire product offer sold under the CA Enerdis brand name, an offer intended for utilities and electricity companies, installers, switchboard operators, manufacturers, industrial firms, and engineering firms and public administration. This catalogue is particularly enriched by the ULYS electronic energy meter range designed for all sub-metering applications, the new NODUS D power monitors, and digital displacement measurement systems and meteorological measurement.



Reader Service No. 19

Temperature Measurement & Control

This 2002 catalogue presents the Pyro-Contrôle Chauvin Arnoux "standard product" offer. It includes a choice of sensors and temperature measurement and control systems, available at wholesalers - distributors specialized in "industrial process."



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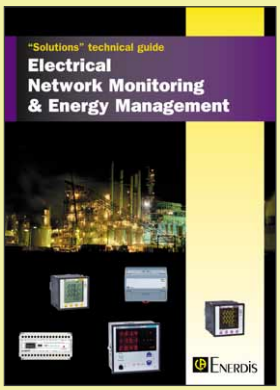

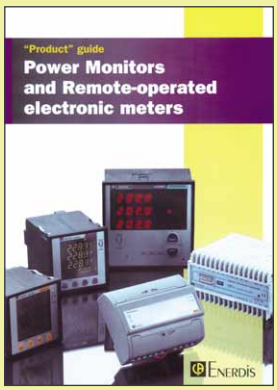

Two essential guides for a time marked by the deregulation and privatization of the energy market!

The "Product" guide presents the C.A Enerdis offer for requirements in measurement, metering, display and monitoring of electrical networks. This offer is structured around the **POWER** and **NODUS** power monitors, **CDT** remote-operated electronic meters, **CCT** pulse receivers, and **WinThor** energy management and monitoring software. To complement this guide, the "Solutions" guide re-examines your electrical installation's monitoring needs. It explains in detail the principle of an energy management system, the advantages of remote-reading indices, and the result analysis for taking corrective action.

Reader Service No. 21

Analogue oscilloscope

This 2-sided brochure presents our complete, reliable and uncompromising SINGLE-CHANNEL OSCILLOSCOPE: the X 4010. The well-known fact that it is very easy to use should not be allowed to eclipse its features: 10MHz bandwidth over the whole sensitivity range, 10 input ranges between 5 mV and 5 Volts per division, triggereing up to 30 MHz and indication by "TRIG" LED, XY mode at 1 MHz. Discover its other features in this complete document.

Reader Service No. 22

Multi-purpose voltage absence tester

Equipped with a modular casing comprised of interchangeable adapters and thin, full-safety test probes, the C.A 700 is astonishing in its ability to adapt to any type of electric cabinet and safety socket, accessing even hard-to-reach spaces.
With features including voltage detection, phase/neutral and continuity, the C.A 700 perfectly meets the European IEC 61243-3 standards. Discover its multiple applications in the sales literature.

Reader Service No. 23

Energy to save ?

ULYS

A new range of energy meters

The new range of ULYS meters provide a simple, rapid and economic solution to all of your electrical energy metering requirements on LV and MV networks.
Designed for industrial and services sector sites, this complete range of 6 meters has numerous assets:

Total IEC 61036 compliance
Classe 1

- For single-phase and three-phase networks, 60 mA to 90 A direct inputs or connection to 1 A and 5 A current transformers, 57.7 V to 400 V
- Display and configuration possible when the instrument is disconnected
- Single or dual-tariff active and reactive energy metering
- Measures the instantaneous and maximum power
- Zero-resettable metering for periodic energy management
- Programmable current/voltage ratios and pulse transmitters

The best in electrical equipment

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