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## FACILITY[1]

| | |
|---|---|
| **Name of the facility** | *Short name and complete name (Original language and English translation)Le banc expérimental des Vignières, Les Vignières Experimental Bench* |
| | *URL address* |
| **Location of the facility** | *Country : France* |
| | *Postal address* 4790 Route des *Vignères* - 84250 LE THOR |
| | *UTM coordinates: Latitude/Longitude* |
| **Start date** | *Year since the facility has been operative 1995* |
| **Type of facility** | *Short description: Experimental benches for static and moving fires : acquisition systems (National Instruments data), visible video images, FLIR infra-red images, Campbell weather data* |
| **Keywords** | *Experimental fires, Laboratory, Mediterranean wildland fuels* |
| **Scientific characteristics** | *Scientific objectives: Behaviour of no-slope, up-slope and down-slope surface fires, Impacts on surface fire behaviour of fuels particles, bulk density, fuel load, fuel moisture content, width of the fuel bench* |
| | *Interest for users:* |
| | *Particularities in comparison to similar facilities:*<br>*Moving fires bench can be tilted from 0° to 30°, fires behaviour can be analysed from -30° to +30°. Wind effect can not be studied on this bench*<br>*Static fires bench allows to register the characteristics of the flame and of the plume depending of the the fuel characteristics (nature, fuel load, fuel moisture content, bulk density)* |
| | *Research projects in the frame of which the facility is used (include web site address)* FIRESTAR (www.eufirestar.org), EUFIRELAB (www.eufirelab.org), FIRE PARADOX (www.fireparadox.org |
| **Technical characteristics** | *Detailed description of instrumentation*: see attached file |
| | *Measured parameters*: see attached file |
| | *If there is any file, map or images relevant about this infrastructure, please attach it (indicating here the name of the file): FR-FA-02.pdf* |

| SCIENTISTS AND/OR TECHNICIANS IN CHARGE OF THE FACILITY | |
|---|---|
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[1] *Note: This information could be published in the webpage of FORESTERRA.*

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| Continue | |
|---|---|
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| **Is the facility participating in a national or international Network?** | *Name (Original language and English translation)* |
| | *URL address* |
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**EUFIRELAB**

**EVR1-CT-2002-40028**

**D-07-09**

**http://eufirelab.org**

# EUFIRELAB:

## Euro-Mediterranean Wildland Fire Laboratory,

## a “wall-less” Laboratory

## for Wildland Fire Sciences and Technologies

## in the Euro-Mediterranean Region

## Deliverable D-07-09

## Les Vignières facilities:

## Presentation of the different benches and devices

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**Jean-Charles VALETTE**

**May 2004**

**CONTENT LIST**

## SUMMARY

This document details the characteristics of the two main experimental benches and the different acquisition systems of Les Vignères infrastructure, which has been briefly described in Deliverable D-07-09.

Chapters 2 and 3 are devoted to the experimental benches for static and moving fires.
After a precise description of the benches themselves, specifications of the installed sensors are detailed.
The classical procedures developed are presented.

The four latest chapters are devoted to the acquisition systems: National Instruments data (chapter 4), visible video images (chapter 5), FLIR infra-red images (chapter 6) and Campbell weather data (chapter 7).

## GLOSSARY

None

## LIST OF ASSOCIATED DOCUMENTS

None

# 1 INTRODUCTION

Deliverable D-07-02 presents the infrastructure dedicated to laboratory studies of fire behaviour develop by INRA-PIF in Les Vignères.

This infrastructure has been developed during the tenth last years for:

- verifying physical assumptions on fire behaviour,
- enriching the behaviour model based on a complete and physical approach with adapted sub-models,
- comparing the predictions of the model with the results of well-documented laboratory experiments.

Because wind effects are studied on different research infrastructures, some of them belong to EUFIRELAB members, we decided to focus on the slope effects in order to study convection driven fires.

This choice enables to compare the behaviour of horizontal, up-slope and down-slope surface fires.

It enables to define when the fire has a two dimensional behaviour; the main gradients follow:

- X axis, the direction of fire propagation, and
- Z axis, the local vertical.

It enables to determine when the slope angle induces a three dimensional behaviour, the gradients following Y axis, perpendicular to X Z plan, can no more be neglected.

The equipment of these infrastructure has been enriched progressively thanks national contracts, and overall several European contracts dedicated to this item in the framework 3rd, 4th and 5th frameworks programmes.

Since the beginning, this infrastructure has been opened to all INRA-PIF partners and some devices have been developed with them.

The EUFIRELAB project represents two opportunities for this infrastructure:

- to enrich or complete its different acquisition systems,
- to enlarge the panel of research teams which are invited to participate to dedicated series of tests,
- to include it in the EUFIRELAB Centre for technological development which is the fourth task of the work package WP7 dedicated to Wildland Fire Metrology.

The objective of this document is first of all to present in detail the infrastructure and explain how we are working.

It may induce new interests and efficient, and promising co-operations.

# 2 THE EXPERIMENTAL BENCH FOR STATIC FIRES

## 2.1 DESCRIPTION OF THE BENCH

Some images present this bench in chapter 3 of Deliverable D-07-02

### 2.1.1 The chamber

It is a 4-m cube:
- the top side is open: the smoke provided during the test exhausts through the smoke exhaust of the roof of the building (see Deliverable D-07-02, chapter 2)
- the front side is transparent (8-mm extruded polystyrene plate) so that fire behaviour can be monitored and video-recorded from outside, a double door (2 x 2 m) also in extruded polystyrene permits to enter the chamber before and after the test
- the three other sides are white woody walls.

### 2.1.2 Baskets

Cylindrical baskets contains the wildland fuel before and during the test (reference 6 in Figure 2-1).

They are constituted of two grids:
- external grid: 25 mm x 25 mm meshes of 1.8-mm galvanised-iron thread,
- internal grid: 13 mm x 13 mm meshes of 0.8-mm galvanised-iron thread

For including the diameter of the flame among the studied parameters, three types of baskets have been carried out.
Their characteristics are the following:

| Basket | Small | Medium | Large |
|---|---|---|---|
| Height (m) | 0,20 | 0,20 | 0,20 |
| Diameter (m) | 0,20 | 0,28 | 0,40 |
| Circumference (m) | 0,628 | 0,879 | 1,257 |
| Basal area ($m^{2)}$ | 0,0314 | 0,0616 | 0,1257 |
| Lateral area ($m^{2)}$ | 0,1257 | 0,1759 | 0,2513 |
| Total area ($m^{2)}$ | 0,1885 | 0,2991 | 0,5026 |
| Volume ($m^{3)}$ | 0,006283 | 0,012315 | 0,025133 |

The grids mask 21% de la total area of the basket.

Basket sizes have been chosen in function of the mass-to-volume ratios of the fuel:
- 20 kg $m^{-3}$ for the dead Pinus pinaster needles,
- 4 kg $m^{-3}$ for Excelsior (control).

### 2.1.3 Baskets holder

It is represented by reference 3 in Figure 2-1

Its 0.95-m cubic structure of aluminium angle-bars (20*20*2 mm) is on a 1-m square aluminium plate placed on the upper plate of the balance.

A square structure of aluminium angle-bars can be moved inside the main structure in order to adjust the level of the top of the basket to the surrounding equipment.
During the test it is fixed at 0.40 m above the aluminium plate and at 0.60 m above the ground.

This square structure supports two U-shape slide bars, parallel to the edges of the structure, which can be adjusted to the size of the baskets.

This square structure can also support a square iron plate (reference 6 in Figure 2-2):
- a centre hole is adapted to the diameter of the basket,
- its upper side is painted with a black (emissivity = 1) polyurethane paint in order to resist to temperatures up to 600 K.

### 2.1.4 Ignition devices

Like for the baskets, we developed three sizes of ignition devices (see following table).

| Ignition device | Small | Medium | Large |
|---|---|---|---|
| Dimensions | | | |
| Length (cm) | 25,5 | 35,5 | 45,5 |
| Width (cm) | 24,0 | 34,0 | 44,0 |
| Channel | | | |
| External diameter (cm) | 20,0 | 30,0 | 40,0 |
| Internal diameter (cm) | 18,5 | 28,5 | 38,5 |

For enabling fresh air to enter or not trough the bottom of the basket, we developed open and closed devices.

The devices are stored in the oven-drier for:
- ensuring that the woody plates will not dry during the test and increase artificially the weight loss rate,
- facilitating the ahlcool vaporisation are dry before the tests and enabling a sudden and regular ignition of the channel, along the basal circumference of the basket.

2.1.4.1 Closed device (reference 4 in Figure 2-2)

They are constituted of a 5-mm plate of ceramic fibres placed on a 15-mm woody (poplar) plate: the following table details their sizes.

In the centre of each device, a 2 cm x 0.5 cm channel is grooved in the woody plate, and is filled with very fine sand.

0.3-mm aluminium ribbon covers and protects the five sides of the woody plate.

The device is sliding in the U-shape slide bars.

2.1.4.2 Open device (reference 5 in Figure 2-2)

They are constituted of one ring and two parallel arms, tangent to the ring, covered by ceramic fibres.
As for the closed device, a channel (same dimensions) is grooved in the ring and filled with sand.
It is also sliding in the U-shape slide bars.

### 2.1.5 Vertical marks

They are represented by reference 11 in Figure 2-1

They are 4 m high, marked by 10-cm red and white strips, 80 cm both sides of the vertical symmetric plan of the bench.

They permit to assess the height and the width of the flame and of the plume either during the test (direct reading) or afterwards during the analysis of the video images.

## 2.2 SENSORS

### 2.2.1 Infra-red images

As indicated on Figure 2-3, infra-red camera is located on the left side of the bench and the “cold” and “hot” black bodies on its right side.
A temperature controller maintains the temperature of the “hot” blackbody at a fixed value.

With this installation the infrared camera “sees” through the flame or the plume of hot gases both black bodies and also the hot solder of thermocouples sensors located just in the symmetric plan of the bench.
Characteristics of the flame like transparency are deduced from pixels comparison

Information are given in chapter 6

### 2.2.2 Visible video images

They are taken from outside trough the extruded polystyrene facade by the Handy cam, which is described in chapter 5.

### 2.2.3 Weighting system

It is represented by references 1 and 2 in Figure 2-1

As indicated previously, a Sauter E12O balance and his composed of two parts:
- a weighting platform which supports the baskets holder, the ignition device and the basket,
- a remote unit.

The 0.5 m x 0.4 m weighting platform accepts up to 60 kg with an accuracy of 1 g.

The remote unit gathers:
- electro luminescent diodes for displaying the weight,
- a keyboard for tarring and resetting the balance,
- a digital output thanks a 20 mA current loop.

This digital output is connected to a digital / analogue converter Mettler GC47 and the digital transmission is asynchronic per character and at 2400 bits per second.

The digital / analogue converter:
- analyses the digital input signal and isolates three consecutive digits,
- provides an analogic output tension between 0 and 10 VDC covering the range 0 – 999 g (selector on mark 3) .

This output tension is collected, measured and treated by the data logging system:
- previously, the Orion data logger,
- since two years, the National Instruments data acquisition system described in chapter 4.

### 2.2.4 Thermocouples sensors

Based on the range of expected temperature, all the thermocouples sensors are K-type (Chromel - Alumel).

They are carried out with the welding machine) Soudax SD100 (see Deliverable D-07-02):

- naked mono-side 50 microns wires in order to get "hot" points with a characteristic response time of 0.1 sec,
- insulated mono-side 175 microns wires in order to get a satisfying mechanical resistance.

In a first step, 5-cm Chromel wire is welded to a 5-cm Alumel wire to get the "hot" point.

In a second step, 50-µ Chromel wire is welded to the 175-µ Chromel wire.

In a third step, 50-µ Alumel wire is welded to the 175-µ Alumel wire.

Each pair of Chromel and Alumel junctions are connected with mini connectors to shielded copper wires which are connected to the data logging system.

These Chromel-Alumel / Copper connections are located in an insulated connecting box in which a RTD platinum sensor delivers the internal temperature which will used by the data logging system as "cold" junction temperature.

### 2.2.5 Flux meters

These sensors which equipped the bench previously are now abandoned.

Energy released by the flame and/or the glowing material will be deduced from infrared images

## 2.3 DATA LOGGING SYSTEM

In the previous period, the thermocouples sensors and the balance were connected to Orion data logger and only specific thermocouples sensors were connected to the National Instruments data acquisition system.

Figure 2-4 shows these connections.

The K00 to K05 thermocouples sensors were scanned at high frequency (200 Hz, all of them every 5 milli-second) in order to be able to identify correlations between the signals collected at.

By analysing the signals of the K00-K01, K02-K03 and K04-K05 pairs it is possible to determine the time needed by a given "bubble" of hot gas to move from K00 to K01, or from K02 to K03 or from K04 to K05.

Knowing the distance (10 cm) between each thermocouple sensor of each pair, it is possible to determine the vertical component of the gas velocity and to study its vertical gradient.

Presently, the capacity of the National Instruments data acquisition system has been improved thanks EUFIRELAB project and all the sensors are connected to it.

This simplify the data analysis and enable to trigger simultaneously the launching of the data acquisition system and of the infra red images acquisition system.

## 2.4 ILLUSTRATIONS

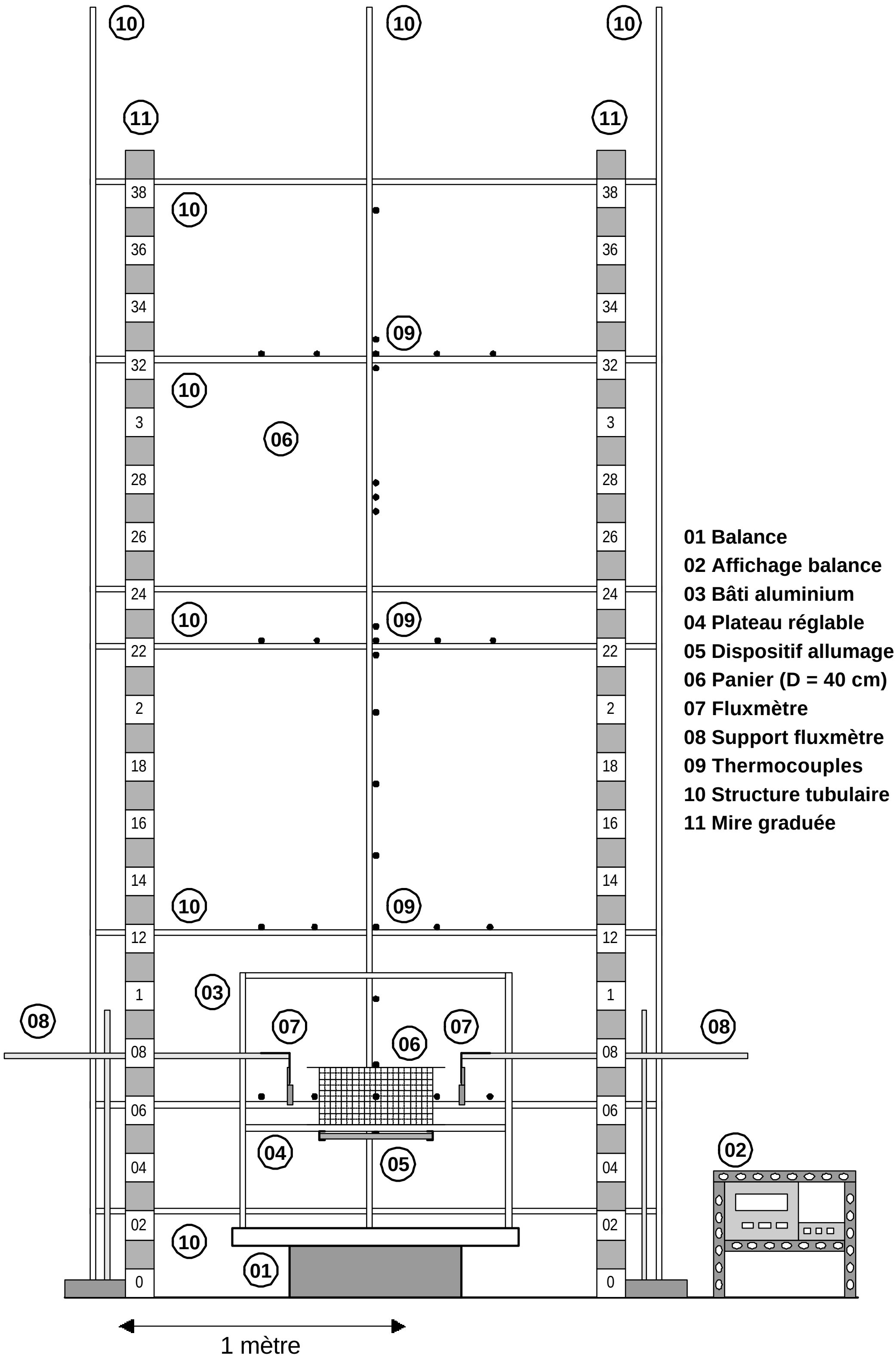
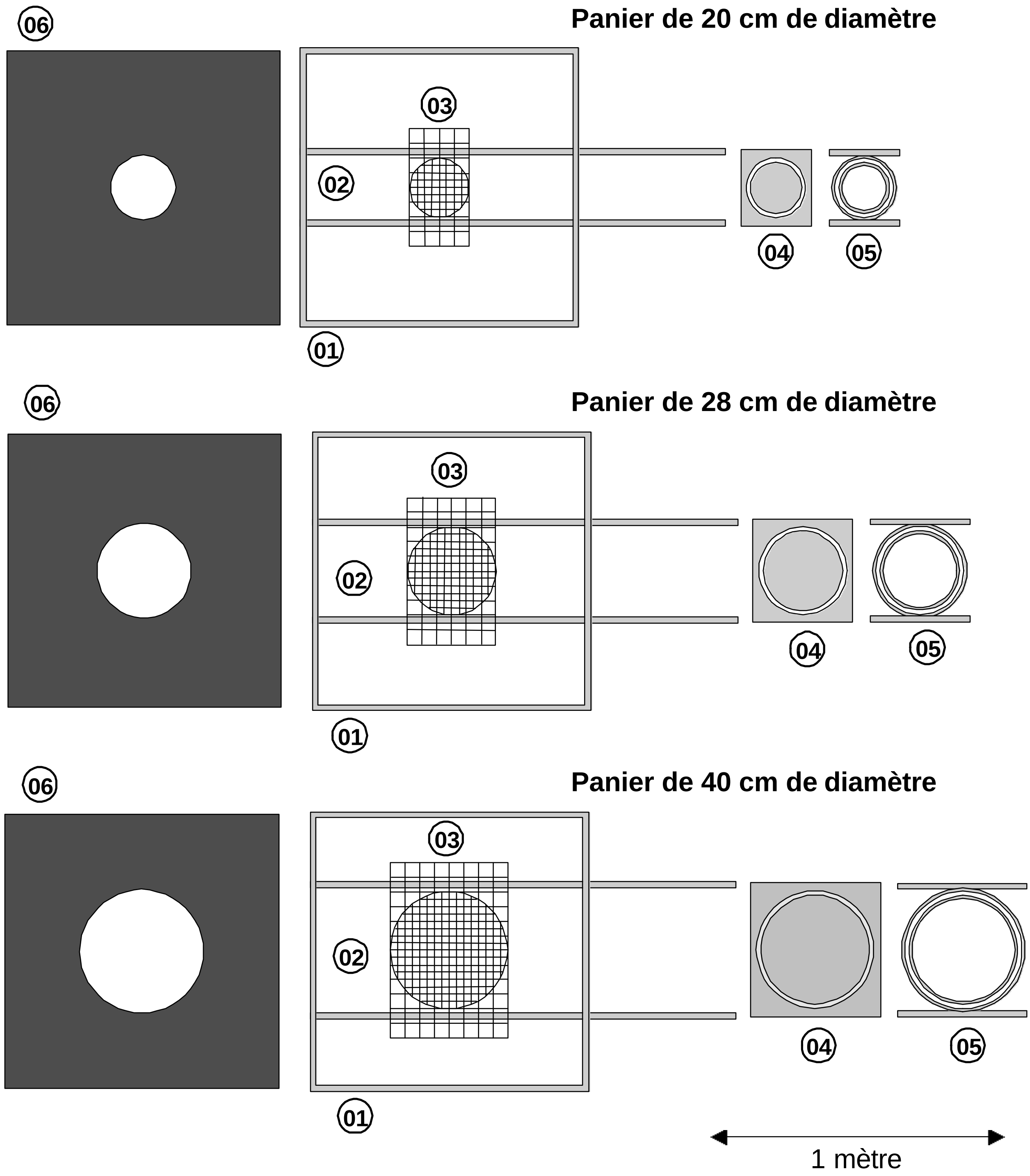



Figure 2-1: Location of the main components

| | | |
|---|---|---|
| 1 Balance: weighting platform | 2 Balance: remote unit (display and connections) | 3 Baskets holder |
| 4 Adaptable plate | 5 Ignition device | 6 Basket |
| 7 Flux meters | 8 Flux meters holders | 9 Thermocouples sensors |
| 10 Thermocouples sensors holder | 11 Vertical coloured marks | |




**01 Support réglable du plateau de combustion**

**02 Rails du dispositif d'allumage**

**03 Panier**

**04 Dispositif d'allumage (air freiné)**

**05 Dispositif d'allumage (air libre)**

**06 Plaque de tôle**

Figure 2-2: Detailed structure of the ignition device with the three baskets

01 Adaptable holder of the ignition device

02 U-shape slide bars

03 Basket

04 "Closed" ignition device

05 "Open" ignition device

06 Iron plate

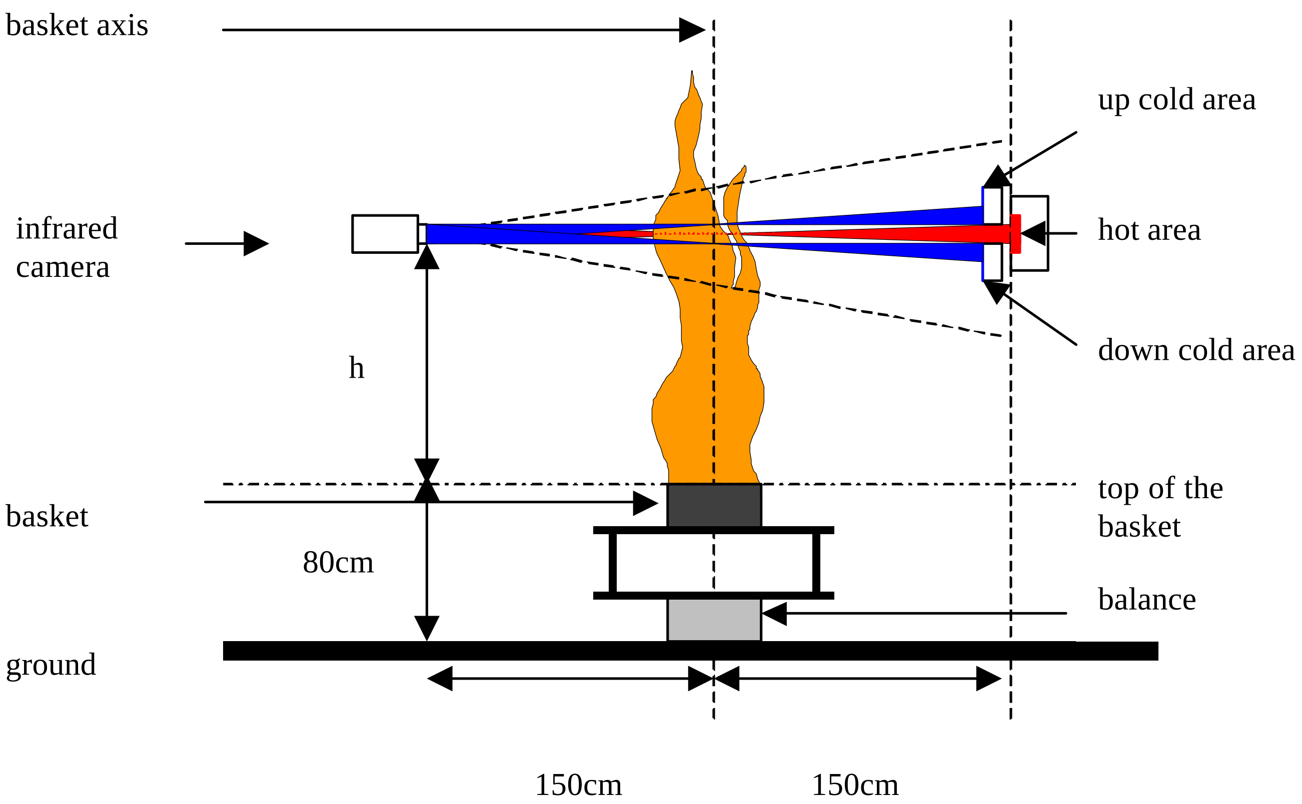



Figure 2-3: Scheme of the experimental device

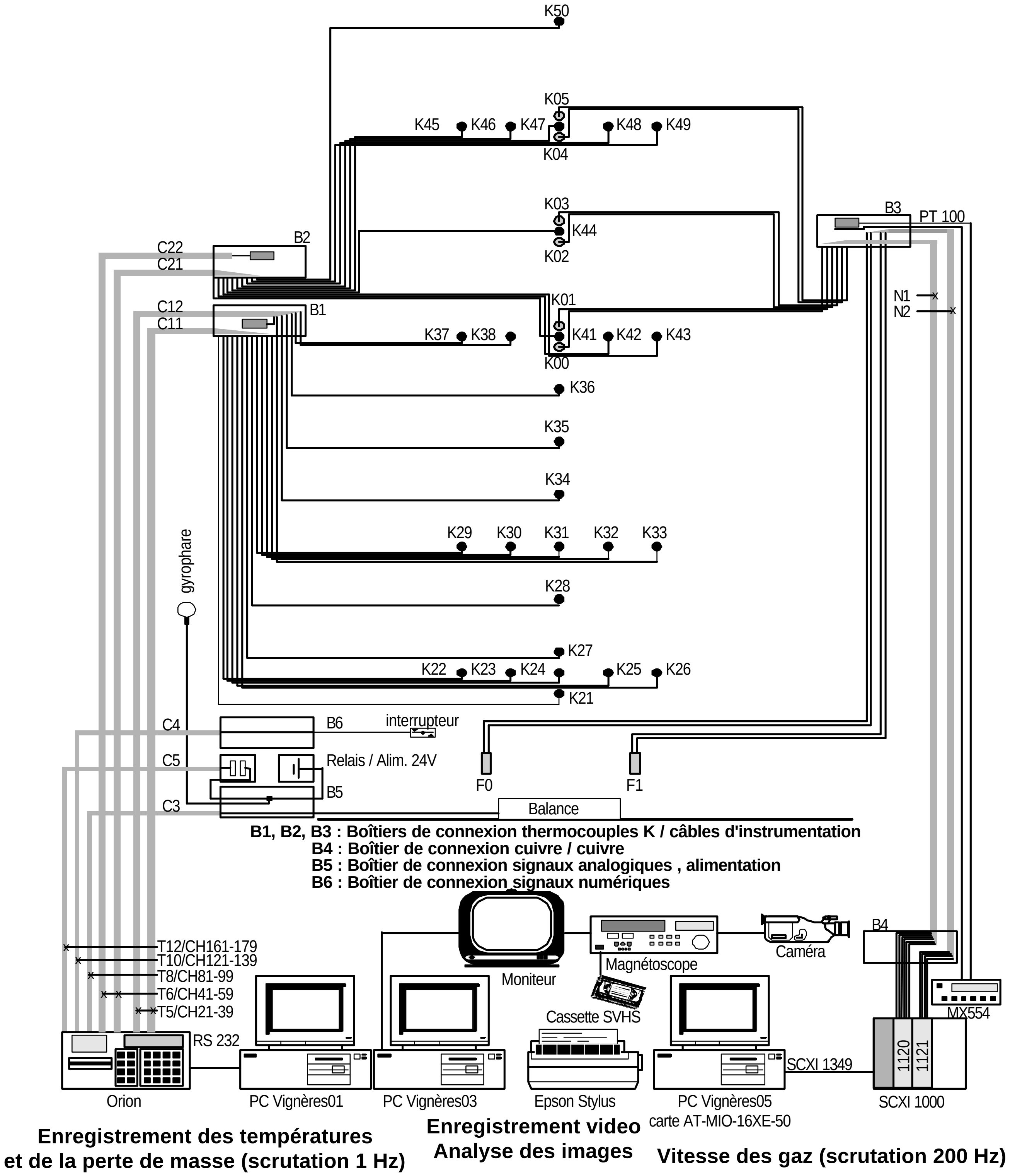



Figure 2-4: Scheme of the connections of the bench to the different data and images acquisition systems
B1, B2 and B3: Connection boxes: Chromel/Alumel – Copper
B4: Connection box Copper – Copper
B5: Connection box for analogue signals
B6: Connection box for digitised signals

Temperatures and weigh loss are scanned at 1 Hz (all the sensors every second) by Orion data logger

Thermocouples sensors K00 to K05 are scanned at 200 Hz (the six sensors are measured every 5 milliseconds by National Instruments data acquisition system

Nowadays all the sensors are conected to the National Instruments data acquisition system and Orion data logger is abandoned

## 2.5 PROCEDURE

We have developed a general procedure for carrying out tests on this bench.

It has to be adapted in order to satisfy the specific objectives of a given series of tests.

### 2.5.1 Studied factors

Three common factors are related to the bench:

- type of fuel family
- size of the basket
- entrance or not of air at the bottom of the basket.

For a given fuel type, we often cross the three levels of factor 2 and the two levels of factor 3.

2.5.1.1 Type of fuel family

Fire behaviour depends on the physical characteristics of the fuel particles, mainly their mass-to-volume ratio and their surface-to-volume ratio.

*We classically use dead Pinus pinaster and dead Pinus halepensis* needles ad Excelsior as control.

It is possible to use other types of fuel, but the baskets should be adapted in case the fuel particles are so small that they fall down through the finest mesh: the side of the basket must remain transparent and allow the entrance of air.

2.5.1.2 Size of the basket

For safety and technical reasons, it is not suitable to reduce the size of the smaller basket or enlarge the size of the larger one.

2.5.1.3 Entrance of air in the “burner”

The “closed” ignition device is suitable for very fine fuel particle like Excelsior or grasses, the dynamic of the fire is lower, the size of the flame ad of the plume is compatible with the bench and the building, the duration of the combustion process is log enough for collecting enough data during the stabilised period.

It is also adapted to study the fire behaviour close to ground level.

The “open” ignition device is necessary for quite all burning conditions with Pinus sp needles.

It is adapted to study the fire behaviour a few centimetres above the ground.

### 2.5.2 The test sheet

2.5.2.1 General information upon the test

Date of the test: DDMMYY format
Test number: YYMMDDNN format
Fuel type
Oven-dried fuel load in grammes
Size of the basket
Open or Closed ignition device

2.5.2.2 Wildland fuel

Wildland fuel is pre-dried in the oven at 60°C during at least 24 hours

The needed quantity of fuel is taken from the oven and weighted before preparing the test.

More fuel is stored outside the oven in the same preparation conditions.

A sample is taken from this mass of fuel in order to determine the moisture content of the fuel just before the test: 24 hours at 60°C.

Moisture content is expresses on oven-dried material (grams of water per hectogram of oven-dried material.

2.5.2.3 Air characteristics in the experimentation hall

Atmospheric pressure is measured just before ignition and express in hPa.

Air temperature and moisture content are measured by the RTD Pt 100 1/3 DIN and ROTRONIC-HYGROMER C94 sensors of the portable weather station.

They can also be deduced from the indication of the fixed psychrometer placed close to the bench:

- air temperature at the “dry” bubble thermometer Ts
- temperature of the water-saturated air “humid” bubble thermometer Tm

Both are expressed in °C

Air moisture content is deduced by applying the following equations:

:

$$\mathbf{EWTS = 6{,}107 \times (1 + (2^{0,5} \times Sin((2 \times Pi / 360) \times (Ts / 3))))^{8,827},}$$

$$\mathbf{EWTM = 6{,}107 \times (1 + (2^{0,5} \times Sin((2 \times Pi / 360) \times (Tm / 3))))^{8,827},}$$

$$\mathbf{ETS = EWTM - (Vt \times (Ts - Tm)).}$$

EWTS : tension of saturating vapour at temperature Ts in hPa.
EWTM : tension of saturating vapour at temperature Tm in hPa.
ETS : correction of EWTM by psychrometric constant Vt = 0,79 when ventilation is natural.
Air moisture content is equal to **100 x (ETS / EWTS)** and expressed in %
Saturation deficit is the difference between EWTS and ETS in hPa.

#### 2.5.2.4 Other observations

S-VHS tape number and location of the test on the tape, format HH:MM:SS

Value displayed by the balance at the end of the test.

Start and end dates (format HH:MM:SS) of the National Intruments session

Quantity of ahlcool used for ignition

#### 2.5.2.5 Infrared camera parameters

Sampling frequency: 50 images/s.
Range of measurement: depends on the type of test of the level of measurements 0-500°C or 350-1500°C (brightness temperature).
Calibration was done before each test, and was disabled during the tests.
The atmospheric parameters were updated before each test in the data logging software of the camera (Thermacam Researcher): atmospheric temperature, ambient temperature, and air humidity.

### 2.5.3 Different steps of a test

Before each daily series
- Verify the bench
- Activate the data acquisition system
- Verify the thermocouples and repair if necessary

Before each test
- Prepare the test sheet
- Prepare the data acquisition, and create the data files
- Prepare the fuel for filling the basket and for determining its moisture content
- Fill the basket by respecting the homogeneity of its porosity
- Verify the video camera and the infra-red camera
- Install the basket on its holder
- Extract the ignition device from the oven and install it on the holder
- Weigh some fuel for determining its moisture content and enter the sample in the oven
- Launch the video camera
- Reset the weight platform
- Note the climatic parameters
- Spread ahlcool regularly in the channel of the ignition device
- Insert the ignition device under the basket
- Reset the weight platform
- Ignite the ahlcool

During the test
- Announce loudly the starting of the test
- Simultaneously, launch the data acquisition system and the infra red camera
- Observe the combustion

After each test
- Stop the data acquisition system and the infrared camera
- Stop the visible video images acquisition
- Read the value displayed by the balance after extinction of the embers
- Save the data files
- Weigh the unburned material
- Clean all the components of the bench and prepare for the following test
- Repair the broken thermocouples sensors
- Verify and complete the test sheet

The following day
- Weigh the oven dry material and determine the fuel moisture content
- Complete the test sheet
- Archive the data files, the infra red images files and digitise the video tapes

# 3 THE EXPERIMENTAL BENCH FOR MOVING FIRES

## 3.1 DESCRIPTION OF THE BENCH

Views and scheme are available in deliverable D-07-02.

### 3.1.1 Platform

The platform is rectangular: 4 m width and 10 m long.

The metallic structure is covered by two layers:

- a woody floor constituted by *Pinus pinaster* jointed laths (200 cm x 7 cm x 2.7 cm)
- a cellular concrete floor constituted by jointed flags (60 cm x 50 cm x 5 cm)

These two layers ensure stability and avoid artificial fuel preheating which could modify fire behaviour.

The burning zone is 3 m x 9 m and surrounded by numbered red and white strips.

The burning area must be included in the burning zone, depending of the objectives of the series of test.

### 3.1.2 Horizontal marks

Four series of numbered red and white strips surround the burning zone (see Figure 3-1).

They are used:

- during the preparation of the test to located the burning area on the platform and the elementary areas for evaluating the fuel bed depth
- during the test to locate the fire front
- after the test, to locate the elementary areas where unburned fuel and ashes are collected for estimating the consumption ratio
- during the video images analysis, for locating the fire front spatially.

### 3.1.3 Cotton threads

In order to monitor the front line propagation, fine cotton threads are tighten parallel to Y axis and just on the top of the fuel bed.

The thread is so fine that it is cut by the fire as soon as it is reached by the fire front.

The thread is so tighten that it is possible to select the image corresponding to the event.

The threads are tighten:

- from 0.00 to 2.00, every 0.25 m
- from 2.00 to 9.00, every 0.50 m.

### 3.1.4 Grid

A grid (10-mm iron rods and a mesh of 0.25 m x 0.25) is located in a XZ plan at 0.25 m from the median plan of the platform.

The limits of the cells are aligned with the horizontal marks.

It is used for locating the base and the tip of the fire front seen from the side when each cotton thread is are cut by the fire front.

The grid supports the thermocouples sensors and the insulated Chromel – Alumel wires.

### 3.1.5 Metallic structure

3-cm square iron bars support the grid and the device for side view images

### 3.1.6 Catwalk

In order to ensure the security of the experimentalists a 1-m metallic catwalk surrounds the platform when it is horizontal.

They can prepare the test, verify and replace the thermocouples sensors and clean the platform in complete safety.

During a test, internal rule forbids the experimentalists to stay on the catwalk because:

- a general rule restricts the presence of experimentalists in the experimentation hall only in case of emergency,
- when the platform is tilted, there are no protection along the internal side of the catwalk

### 3.1.7 Connections boxes

The insulated connection boxes (eighteen connections and a RTD platinum resistance per box) are located below the platform:

- inputs: Chromel – Alumel wires
- outputs: Copper wires.

Specific plugs permit to replace easily broken thermocouples sensors.

### 3.1.8 Lifting oil jack

The oil jack permits to tilt the platform at the required slope angle.

This double-effects jack controls up and down movements of the platform and safety switches are activated for stopping the platform at 0° and 30°.

Emergency switches are located in the experimentation hall and in the observatory room in case of necessity.

### 3.1.9 Fire security

As indicated in deliverable D-07-02, specific attention is paid to this danger.

In case of emergency, the platform can be dropped directly from the observation room and the two permanent fire-hose point can be activated by the experimentalists.

No auto-extinguishing system has been installed yet.

## 3.2 SENSORS

They are connected to the National Instruments data acquisition systems described in the specific chapter 4.

### 3.2.1 Thermocouples sensors

They are identical to those used on the bench for static fire (see paragraph 2.2.4).

Their fragility induces many problems and requires a great attention from the experimentalists specifically when they are preparing the test.

Figure 3-1 indicates the location of the sensors:

The grid is placed at Y = 1.25 m so that the "hot" points of the sensors are exactly in the XZ median plan of the platform (Y = 1.50 m).

The classical configuration is the one represented on the Figure 3-1:

- 6 sensors along 7 verticals (V1 to V7) at 6 levels
- level 0 = just on the top of the fuel bed (0.05 m)
- level 1 = 0.25 m above the platform
- level 2 = 0.50 m above the platform
- level 3 = 0.75 m above the platform
- level 4 = 1.00 m above the platform
- level 5 = 1.50 m above the platform

Depending of the specific objectives of the tests, these levels can be modified in order to collect more accurate information in a given range of Z values.

It is also possible to locate some other sensors along Y lines, perpendicular to the X axis of the platform at level 0 in order to collect more information in XY plan (see Figure 3-1).

### 3.2.2 RTD platinum resistances

Like on the other bench, connecting boxes equip DESIRE bench.

They are located under the platform, Chromel – Alumel wires cross the platform and access directly to the insulated boxes,

Adapted plugs ensure the quality of the connections between Chromel – Alumel and coppers wires.

In each box, a RTD platinum resistance delivers the temperature of the connection, which is used by the data acquisition system as "cold" temperature.

### 3.2.3 Weight loss

On this bench, it is not presently possible to monitor and record this parameter with constraint gauges.

When we built the bench, the cost of accurate sensors was not compatible for our budget.

The maximum fuel load (81 kg = 3 $kg.m^{-2}$ x 27 $m^2$) was too low, compare to the total weight of the bench (the tara) to be monitored correctly with accessible measurement devices.

Presently, the weight loss rate is evaluated from the surface burnt per unit of time and from the consumption ratio, but the approach is not satisfying.

This must be improved in the future.

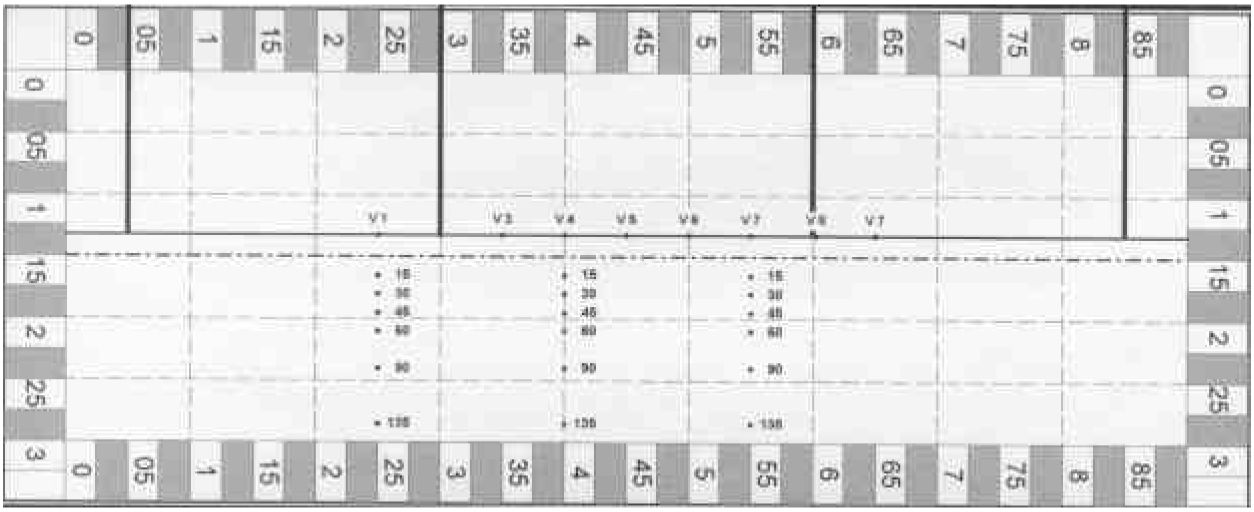


Figure 3-1: Location of the thermocouples sensors (view from above in XY plan)

## 3.3 INFRARED IMAGES ACQUISITION SYSTEM

The system based on FLIR components is described in the specific chapter 6.

For using it on DESIRE bench, we developed specific components, mainly:

- attachment arms to fix the camera on the bench and to avoid that the tilting of the platform modify the scene “seen” by the camera
- thermal marks to be able to localise the part of the platform “seen” by the camera.

This lead also to elaborate a specific procedure.

### 3.3.1 Attachment arms

Specific attachment arms (Figure 3-2)was used to fix the camera above the platform:

- a square grip fixed to the metal structure of the bench.
- a swivel grip fixed to the camera.

This connection allows a complete rotation of the camera in the three dimensions.

The camera is located so that the median axis of the burning area covers exactly the vertical axis of the image (Figure 3-3).

This accurate location is necessary to determine the relationships between the XY co-ordinates of the image and those of the platform: the trapezoidal shape of the image must be transformed in a rectangular one.

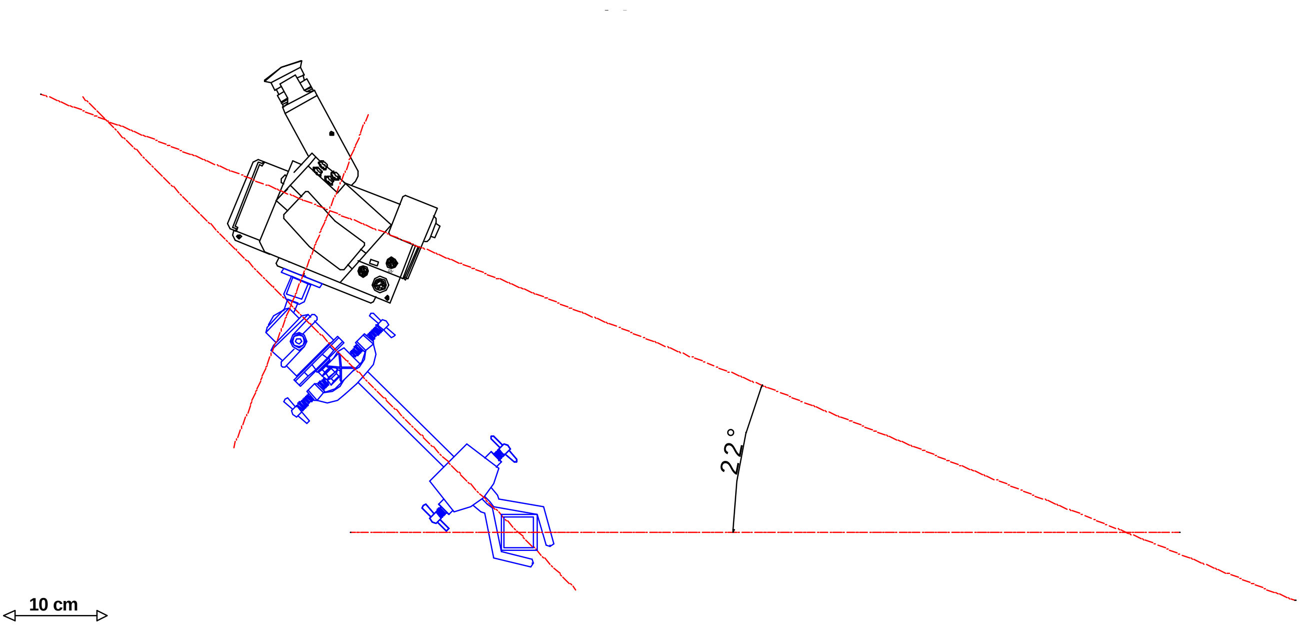



Figure 3-2: Attachment arm (blue) used to adapt the camera (black) to the DESIRE bench. The angle between the optical axis and the X-axis of DESIRE is 22°.

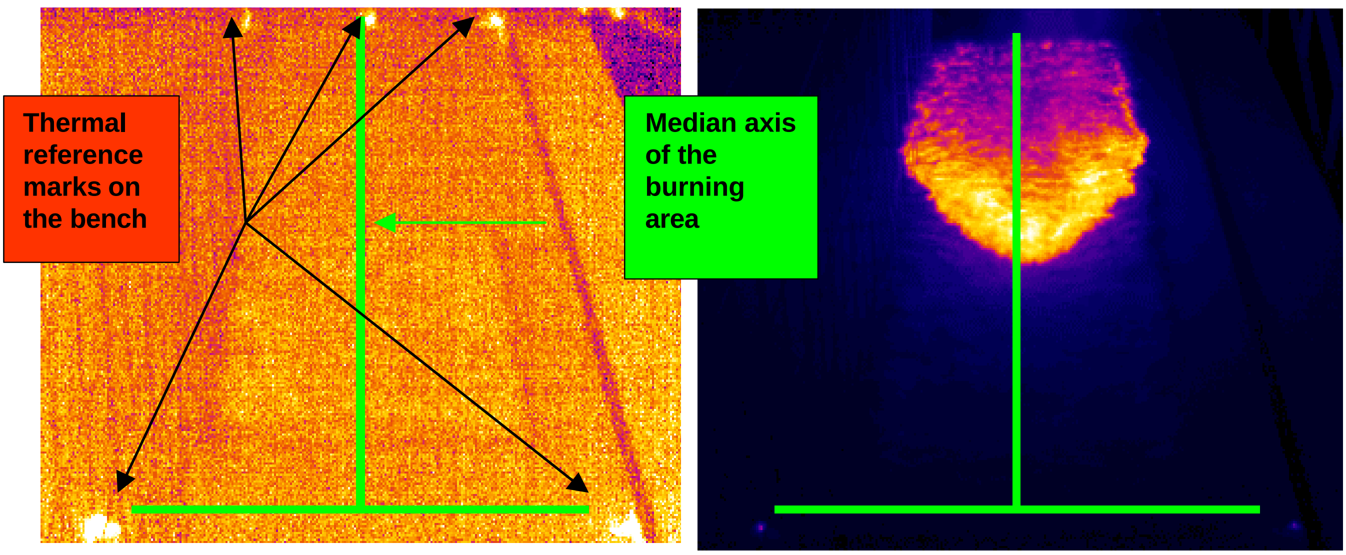



Figure 3-3: IR image, before and after the fire, the camera is in the median axis of the fire, centred in the image

### 3.3.2 Thermal marks

Thermal marks (three crossed strips of ruffled aluminium sheet and a candle at the centre of the cross) delimit on the platform the area "seen" by the IR camera (Figure 3-3, Figure 3-4 and Figure 3-5)

Because of the presence of soot (emissivity quite equal to 1) in the flame of the candle, this flame generates thermal radiation, which is scattered by the ruffled aluminium, and "seen" by the IR camera.

For avoiding any problems during the image analysis, the width of the strips is equal to three pixels of the IR image.

For ensuring stability of the candle, mainly during up-slope fires, each candle is stuck with hot wax on the aluminium crosses.

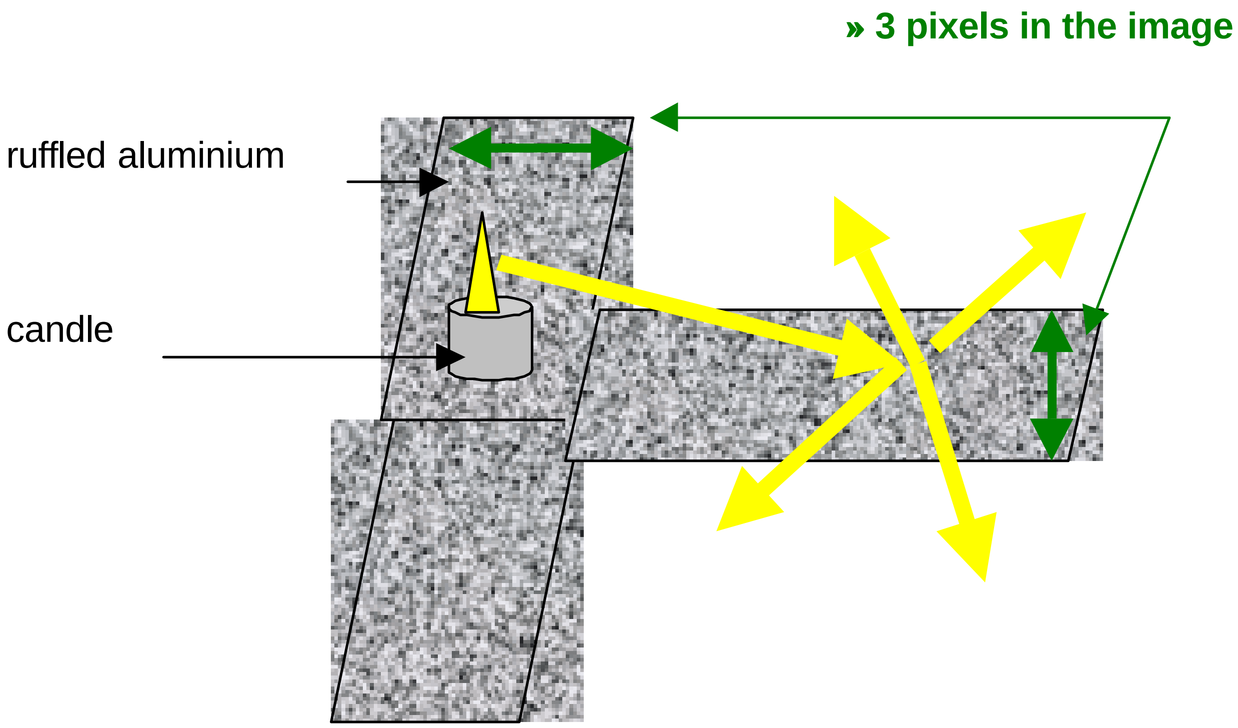



Figure 3-4: Scattering of the candle lights (T shape example)

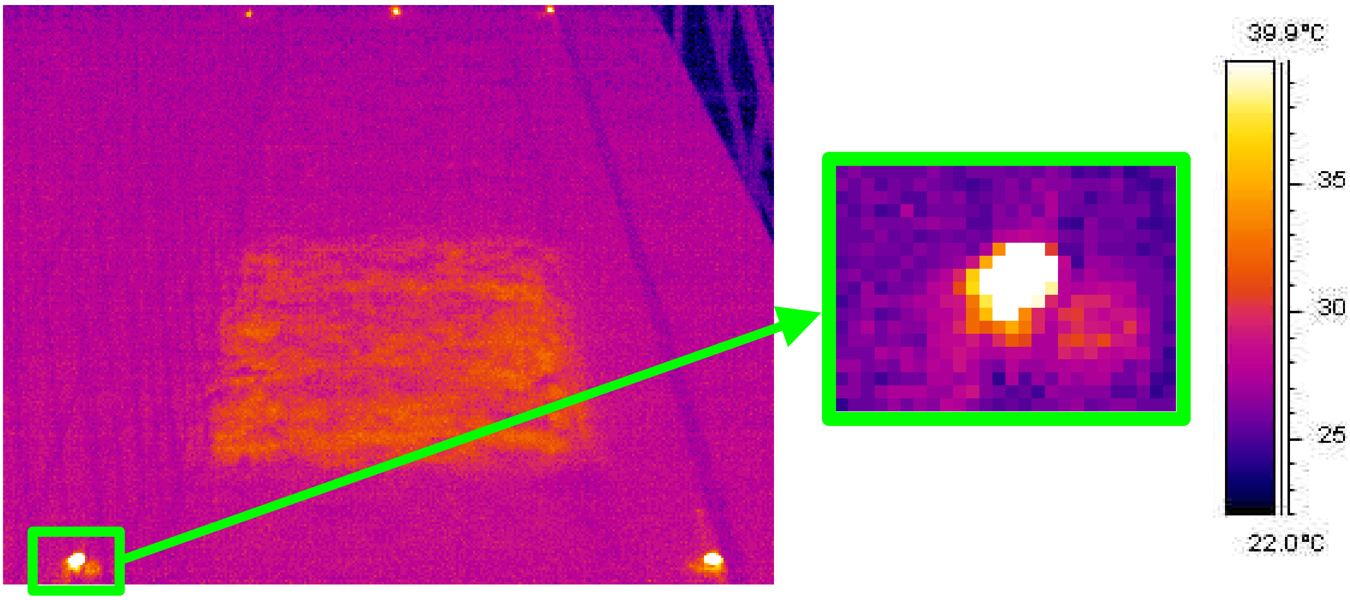



Figure 3-5: IR image of the thermal reference with the 0-500°C filter

### 3.3.3 Location of the IR camera, of the fuel bed and of the thermal marks

This chapter concerns only the specific procedure related to the IR camera; chapter 3.4 details the procedure for carrying out a test on DESIRE bench

Three factors are included in this procedure:
- the slope angle alpha, between 0 and +30°: this specific procedure has been elaborated for up-slope fires; it should have to be adapted for down-slope fires
- the view configuration in fact back view and front view: in case of side view, no specific procedure is needed because the angle between the optical axis and the Y-axis of DESIRE is nul.

The following table summarise the two locations of the IR camera and of the corresponding sizes of the fuel bed for two values of the slope angle: these co-ordinates should be adapted for other slope angles

| View configuration | Slope | Co-ordinates of the IR camera lens | DESIRE co-ordinates of the fuel bed | | Corresponding area |
|---|---|---|---|---|---|
| | | | Xmin to Xmax | Ymin to Ymax | |
| Back view | 0° | X = 0.5, Y = 0.75, Z = 2.2 | 4 m to 5.5 m | 0.25 to 1.25 m | 1 x 1.5 = 1.5 m² |
| Back view | 20° | X = 0.5, Y = 0.75, Z = 2.2 | 4 m to 8.5 m | 0.25 to 1.25 m | 1 x 4.5 = 4.5 m² |
| Front view | 0° | X = 8.5, Y = 0.75, Z = 2.2 | 3 m to 4.5 m | 0.25 to 1.25 m | 1 x 1.5 = 1.5 m² |
| Front view | 20° | X = 8.5, Y = 0.75, Z = 2.2 | 0.5 m to 5 m | 0.25 to 1.25 m | 1 x 4.5 = 4.5 m² |

Figure 3-6 shows the location of the thermal marks and of the fuel bed in fourth configuration (front view x 20°)

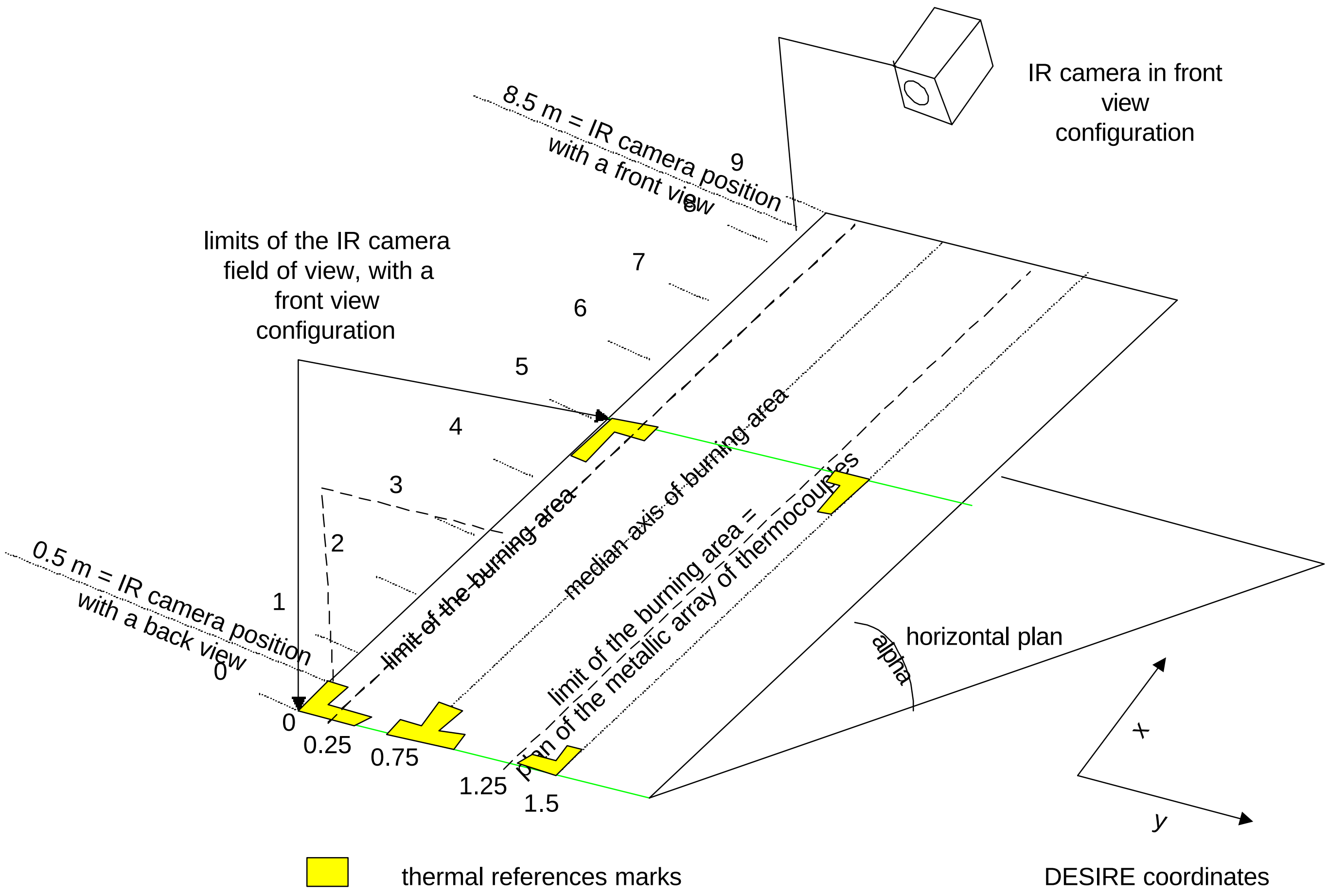
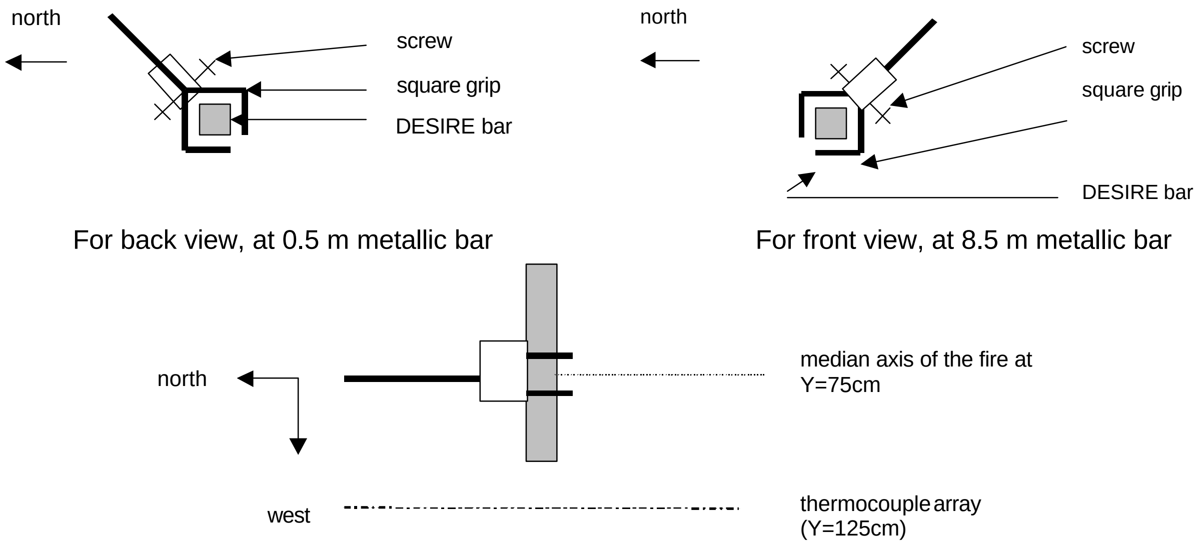



Figure 3-6: Experiment scheme

### 3.3.4 Camera and attachment arm




For back and front view, locate the arm at Y = 0.75

Figure 3-7: Location of the attachment arm on the metallic structure of the bench

### 3.3.5 Thermal marks

The following table summarises the XY co-ordinates of the thermal marks for the two configurations. In case of modification, these co-ordinates must be re-calculated.

| Marks | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Co-ordinates | X | Y | X | Y | X | Y | X | Y | X | Y |
| Back view | 4.00 | 0.00 | 4.00 | 1.50 | 9.00 | 1.50 | 9.00 | 0.00 | 9.00 | 0.75 |
| Front view | 0.00 | 0.00 | 0.00 | 1.50 | 5.00 | 5.50 | 9.00 | 0.00 | 0.00 | 0.75 |

### 3.3.6 Adjustment of the camera

Use the camera viewfinder, settling of the attachment arm to have all the marks in the image: auto-focus in such a way that the candles are sharp.

Use the –40/120°C temperature range and settle the image dynamic to obtain a maximum contrast: the coldest point in black, and the hottest (the candles) in white.

Use the profile tool of the camera and set the arm to have two low candles on the same horizontal line and the up middle one horizontally centred in the image.

### 3.3.7 Adjustment of ThermaCAM Researcher

In ThermaCAM Researcher (TR), some parameters are required to perform the temperature calculation.
- object emissivity = 1 (blackbody emissivity).
- distance to the object = 6.5 m (distance from the centre of the lens to the centre of the area delimited by the marks).
- ambient temperature = atmospheric temperature = dry temperature given by the hygrometer.
- relative humidity given by the hygrometer.

TR estimates the atmospheric transmission from the atmospheric temperature, the distance to the object, and the relative humidity.

Select the camera filter:
- 350-1500 °C in back view for embers analysis
- 0-500 °C in front view for pre-burnt fuel analysis

Turn off the shutter during the experiment.

### 3.3.8 Typical recording sequence

Activate the shutter one time to calibrate the camera
Up date the above parameters
Take and save one image just before ignition
Trigger the IR camera with the data acquisition systems in order to merge their time bases.

## 3.4 TEST PROCEDURE

We develop a general procedure which must be adapted to the type of test carried out.

This general procedure is detailed here below by chronological order.

### 3.4.1 Before the test

#### 3.4.1.1 Fuel bed preparation

Sort the collected fuel in order to obtain an homogenous material.

Weigh and put in containers the needed amount of fuel per elementary area on the basis of the required fuel load expressed in oven-dried material.

For technical reason, the elementary area is 1.5 $m^2$, and two containers are needed to contain the fuel.

Spread regularly the fuel on the platform in order to obtain a regular fuel bed; if necessary suppress the clusters.

Place a sample of fuel close to the platform; it will be used for determining the actual moisture content.

#### 3.4.1.2 Fuel bed depth

Measure the fuel bed depth in three points randomly distributed inside each elementary area of 1.5 $m^2$

Depending on the width of the burning area, the mean depth of the fuel bed will be calculated on the basis of:

- 18 measures if the burning area is 1 m width
- 36 measures if the burning area is 2 m width
- 54 measures if the burning area is 3 m width

An adaptable experiment sheet has been elaborated therefore.

#### 3.4.1.3 Cotton threads

Tighten the cotton threads parallel to Y axis:

- 9 threads every 0.25 m from 0.00 to 2.00,
- 14 threads every 0.50 m from 2.00 to 9.00.

Pay attention that each thread is just on the top of the fuel bed.

#### 3.4.1.4 Thermocouples sensors

Remove the protecting cap and verify visually the state of each sensor.

Replace the broken ones

Adjust the location of the hot points in X, Y and Z directions

#### 3.4.1.5 Climatic conditions

Collect air temperature and air moisture content on the weather station (chapter 7.1.3) or air temperatures at the psychrometer (chapter 2.5.2.3)

#### 3.4.1.6 IR acquisition system

Activate it and follow the procedure indicated in chapter 3.3

#### 3.4.1.7 Data acquisition system

Verify the data acquisition programme, mainly characteristics of each channel and scan frequency

Verify that each sensor indicates ambient temperature.

In case of dysfunction, the system emits an alarm.

Replace the dysfunctioning sensors

Create on the hard disk of the specialised PC the folder under which the data files will be stored, format YYYY-MM-DD-NN (year-month-day-number).

Open the main data file

#### 3.4.1.8 Visible video images acquisition system

Verify the connections between the cameras, the video-recorders and the monitors

Note the location of the tape format HH-MM-SS (hour-minute-second) and verify that the empty place on the tape is long enough for recording the next test.

If necessary, replace the tape by a new one, it is not possible to change the tape during a test without loosing information

#### 3.4.1.9 Fuel moisture content

Weigh the sample dedicated for this purpose and insert it in the oven-drier.

It will stay in it during at least 24 hours at 60°C.

It will be weighted and its moisture content will be calculated and expressed over oven-dried weight.

#### 3.4.1.10 Platform tilting

Verify that no tools are remaining on the platform.

If necessary activate the oil jack in order to tilt the platform up to the required slope angle.

### 3.4.2 During the test

#### 3.4.2.1 Ignition

The test leader verifies that all the participants and all the systems are ready.

The specialised experimentalist launches the video images acquisition system in order to record some images just before the ignition.

The specialised experimentalist constitutes the ignition line with ahlcool, 10 ml per meter.

The test leader orders the ignition and launches the infra red images and data acquisition systems with an external trigger in order to obtain simultaneous files, as soon as the ignition line is ignited.

The experimentalist leaves the experimentation hall

#### 3.4.2.2 Fire behaviour monitoring

Each time a cotton thread is cut, the time is noted and the base and the tip of the most advanced flame of the fire front are pointed on the chart.

The experimentalist in charge of the video images acquisition system adjust the cameras in order to obtain the most useful images.

Any event which occurs during the test is noted

### 3.4.3 After the test

As soon the fire reaches the end of the burning area, the different acquisition systems are stopped and the corresponding files are closed.

The protecting caps of the thermocouples sensors are put again.

Unburned fuel and ashes are collected on four elementary areas of 0.25 $m^2$ and weighted.

Consumption ratio is calculated on the basis of the initial fuel load.

Remaining fuel and ashes are removed from the platforms.

Platform is prepared for the next test.

# 4 DATA ACQUISITION SYSTEM

## 4.1 TERMINAL BLOCKS

### 4.1.1 SCXI-1328 high-accuracy isothermal terminal

This terminal is dedicated for connections to a small numbers of connections, a mixed of data inputs and excitation channels.

The SCXI-1328 high-accuracy isothermal terminal block consists of a shielded board with screw terminal to connect to the SCXI module input connector.

It as a high-precision thermistor; and an aluminium isothermal plate minimises the temperature gradients across the screw terminals when thermocouples are measured.

It has 18 screw terminals for easy connection.

One pair of screw terminals connects to the SCXI module chassis ground.

With the SCXI-1120, the remaining eight pairs of screw terminals are for signal connection to the eight module inputs.

With the SCXI-1121, four pairs of screw terminals are for the four module inputs and four pairs are for the module excitation channels.

### 4.1.2 SCXI-1321 offset-null and shunt-calibration terminal

This terminal is dedicated for the measurement of four-wire platinum RTDs, which are measuring the temperature inside the different connecting boxes of the experimental benches.

In fact, these connecting boxes are “remote cold junctions” were thermocouples wires are connected to copper wires.

The SCXI-1321 terminal block has a shielded board with supports for connection to the SCXI-1121 module.

In addition to the 18 screw terminals, the SCXI-1321 has circuitry for offset-null adjustment of Wheatstone bridges, and a shunt resistor for strain-gauge shunt calibration.

### 4.1.3 SCXI-1303 32-channel isothermal

The SCXI-1303 32-channel isothermal terminal block is a shielded board with screw terminals that connect to the SCXI-1102C module and other SCXI-1100 modules.

The SCXI-1303 has a high-accuracy thermistor, cold-junction temperature sensor, and an isothermal copper plane to minimise the temperature gradients across the screw terminals when thermocouples are measured.

The terminal block has 78 screw terminals for easy connection.

32 pairs of screw terminals connect to the 32 differential inputs of the SCXI modules.

One pair of terminals connects to the chassis ground pins of the module.

Three terminals connect to the SCXI module OUTPUT and AOREF pins and to the SCXI bus guard.

All the other terminals are reserved for future use.

The terminal block has a pullup resistor connected between CH+ and +5V and a bias resistor connected between CH- and chassis ground.

These resistors help for detecting open thermocouples (saturation of the module amplifier output).

Figure 4-2 shows the SCXI-1303 signal connections

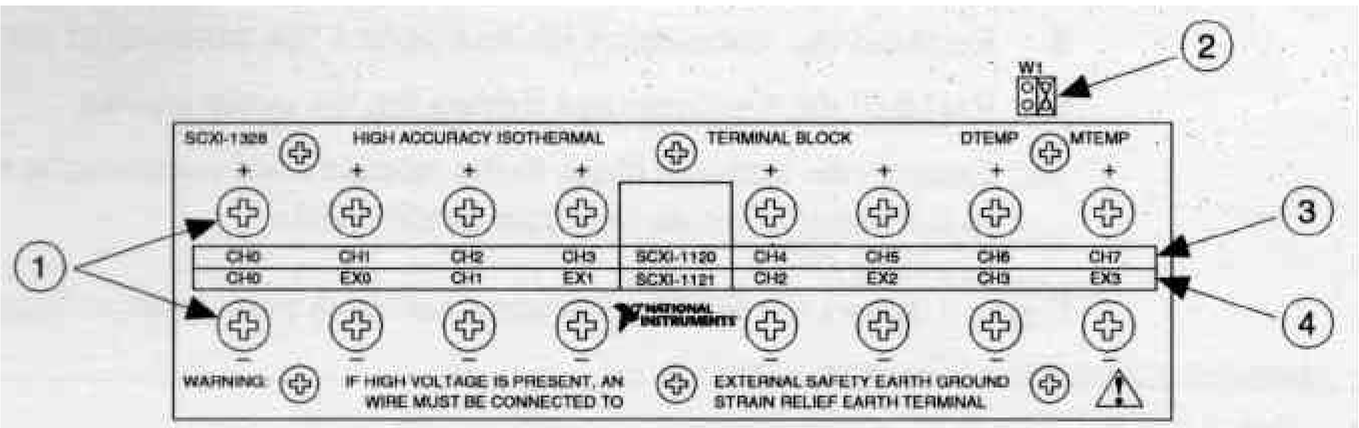



Figure 4-1: SCXI-1328 signal connections

1: Screw terminals 2: Berg connector W1
3: Channel labelling or SCXI-1120 4: Channel labelling or SCXI-1121

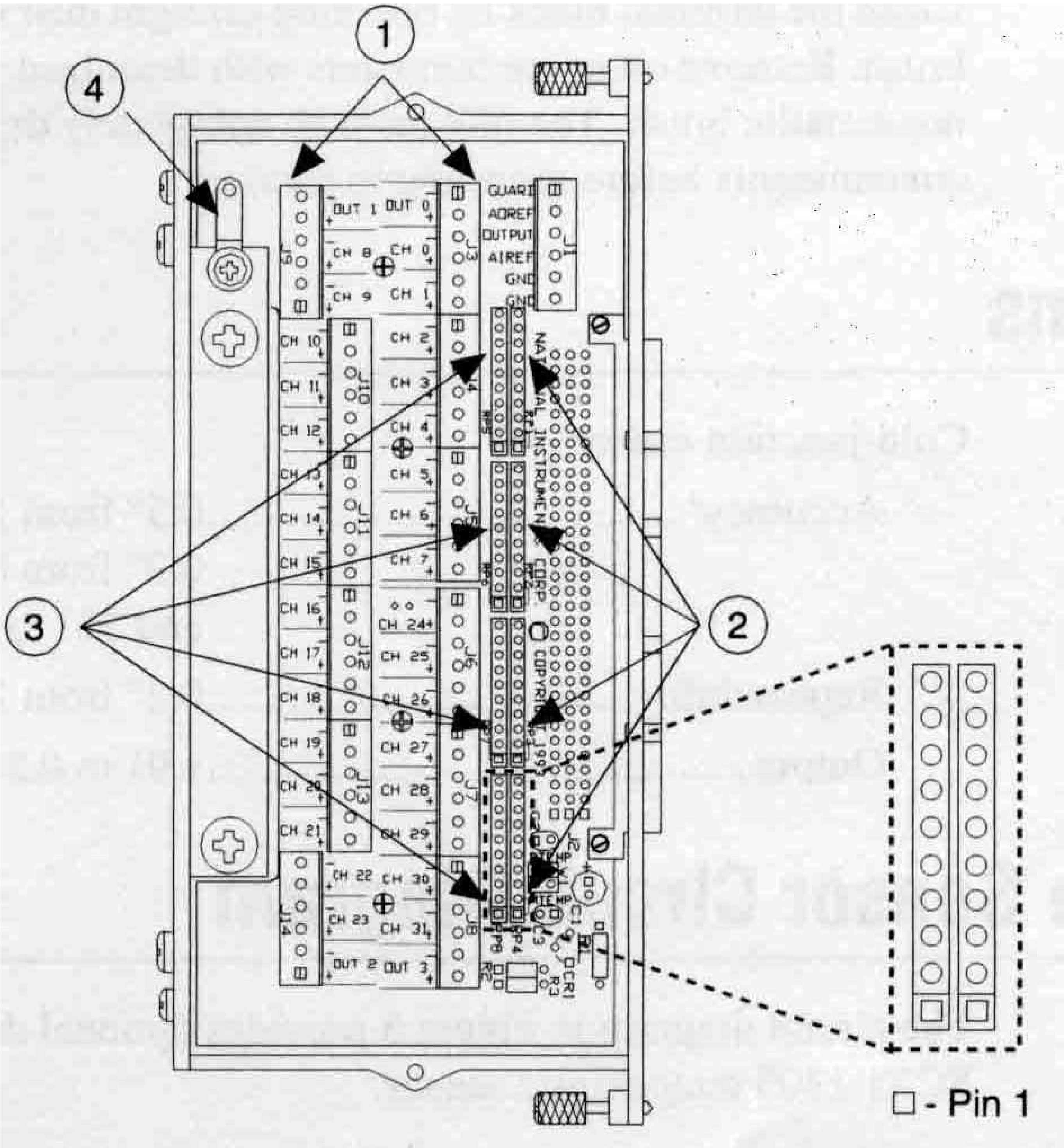



Figure 4-2: SCXI-1303 signal connections

1: Screw terminals
2: Bias resistor networks
3: Pullup resistor networks
4: Product name

## 4.2 INPUT MODULES

### 4.2.1 SCXI-1102C

This 32-channel thermocouple amplifier module is associated with the SCXI-1303 terminal block.

This module is for the signal conditioning of the thermocouples, high-bandwith volt and milivolt sources, 4 to 20 mA current sourcesn and 0 to 20 mA process-current sources.

It has 32 analog input channels and one cold-junction ensor channel.

On each channel, the module has a three-pole lowpass filter with a 10 kHz cutoff frequency.

Each channel also has an amplifier with a selectable gain of 1 or 100.

SCXI-1102C inputs can be multiplexed to a single output, which drives a single data acquisition device channel.

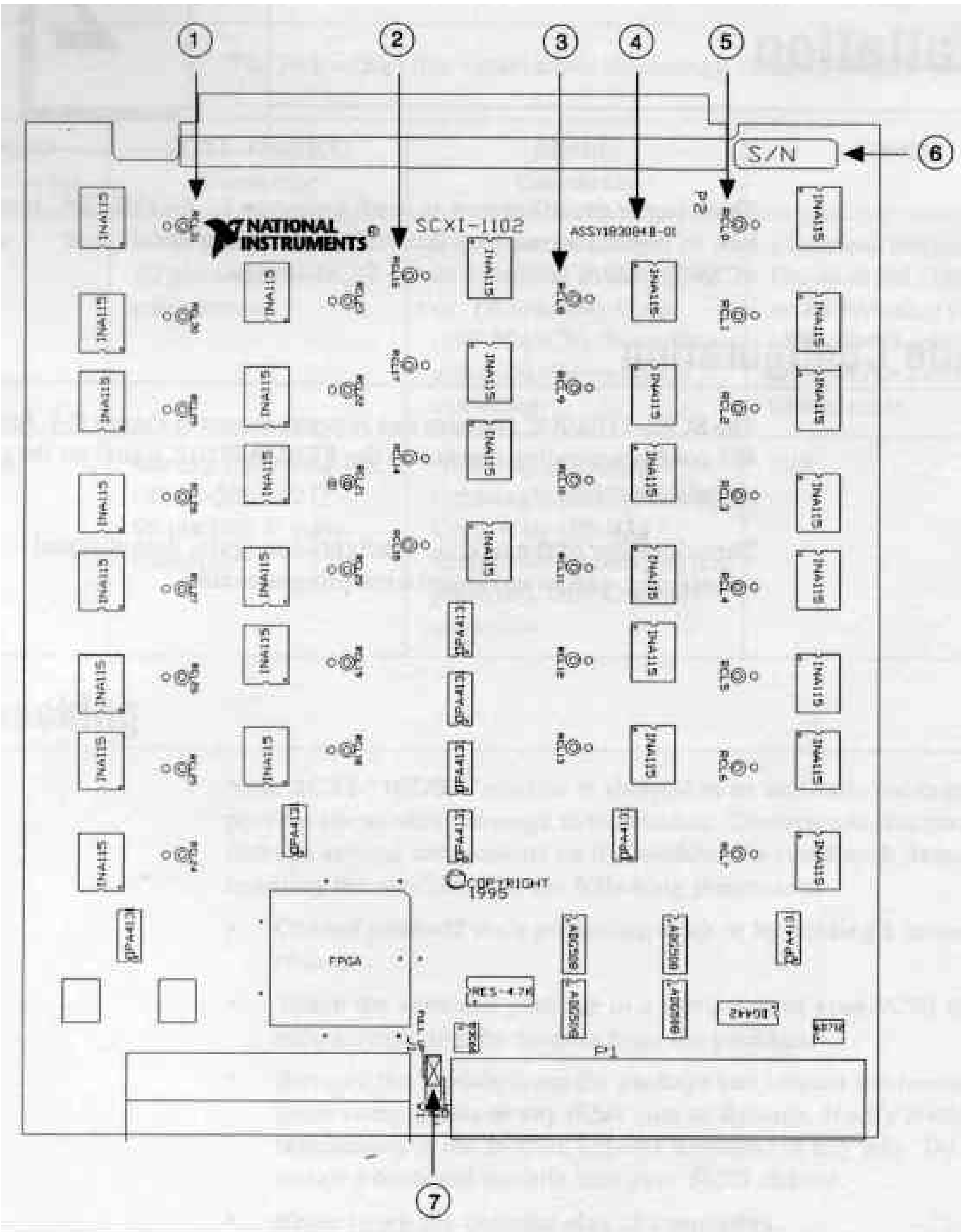



Figure 4-3: SCXI-1102C module parts locator diagram

1: Channels 24 to 31 2: Channels 14 to 23 3: Channels 8 to 13
4: Assembly number 5: Channels 0 to 7 6: Serial number
7: Position Pullup (one single chassis) / No pullup (several chassis) jumper

### 4.2.2 SCXI 1120

The SCXI-1120 is a class I module consisting of eight iisolated input channels.

This module is for the signal conditioning of the thermocouples, volt and milivolt sources, 4 to 20 mA current sources and 0 to 20 mA process-current sources.

If external excitation is provided, thermistors, RTDs and strain gauges can also be measured.

It can operate in two output modes (we used only the second one):

- in parallel output mode with all eight input channels connected in parallel to eight data acquisition board channels, or
- in multiplexed output mode with all eight channels multiplexed into a single data acquisition boeard channel.

This module is associated with the SCXI-1328 terminal block.

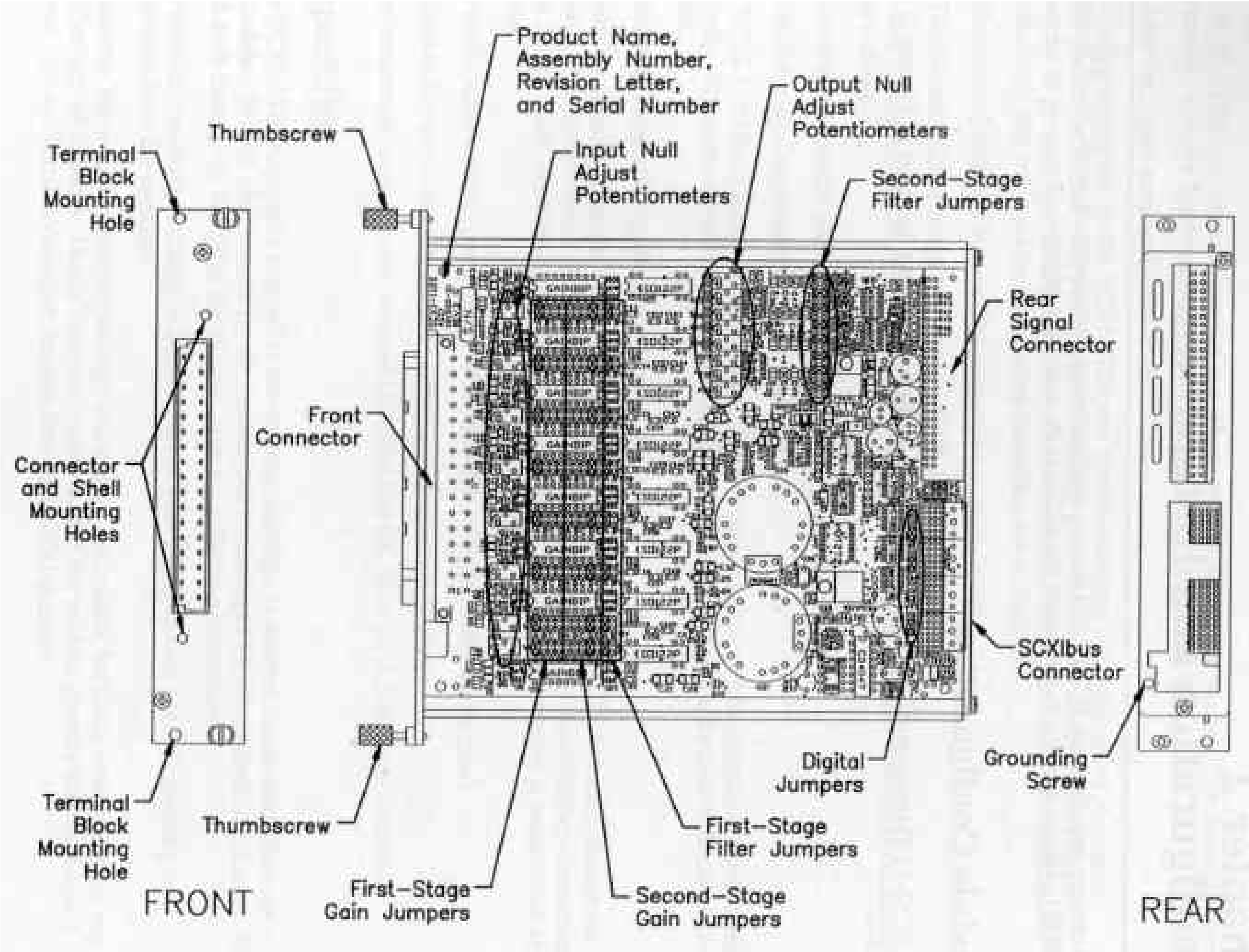



Figure 4-4: SCXI-1120 General parts locator diagram

### 4.2.3 SCXI-1121

This module consists of four isolated input channels and four isolated excitation channels.

This module is for the signal conditioning of the thermocouples, volt and milivolt sources, 4 to 20 mA current sources and 0 to 20 mA process-current sources.

It can operate in two output modes (we used only the second one):

- in parallel output mode with all eight input channels connected in parallel to eight data acquisition board channels, or
- in multiplexed output mode with all eight channels multiplexed into a single data acquisition boeard channel.

This module is associated with the SCXI-1321 terminal block.

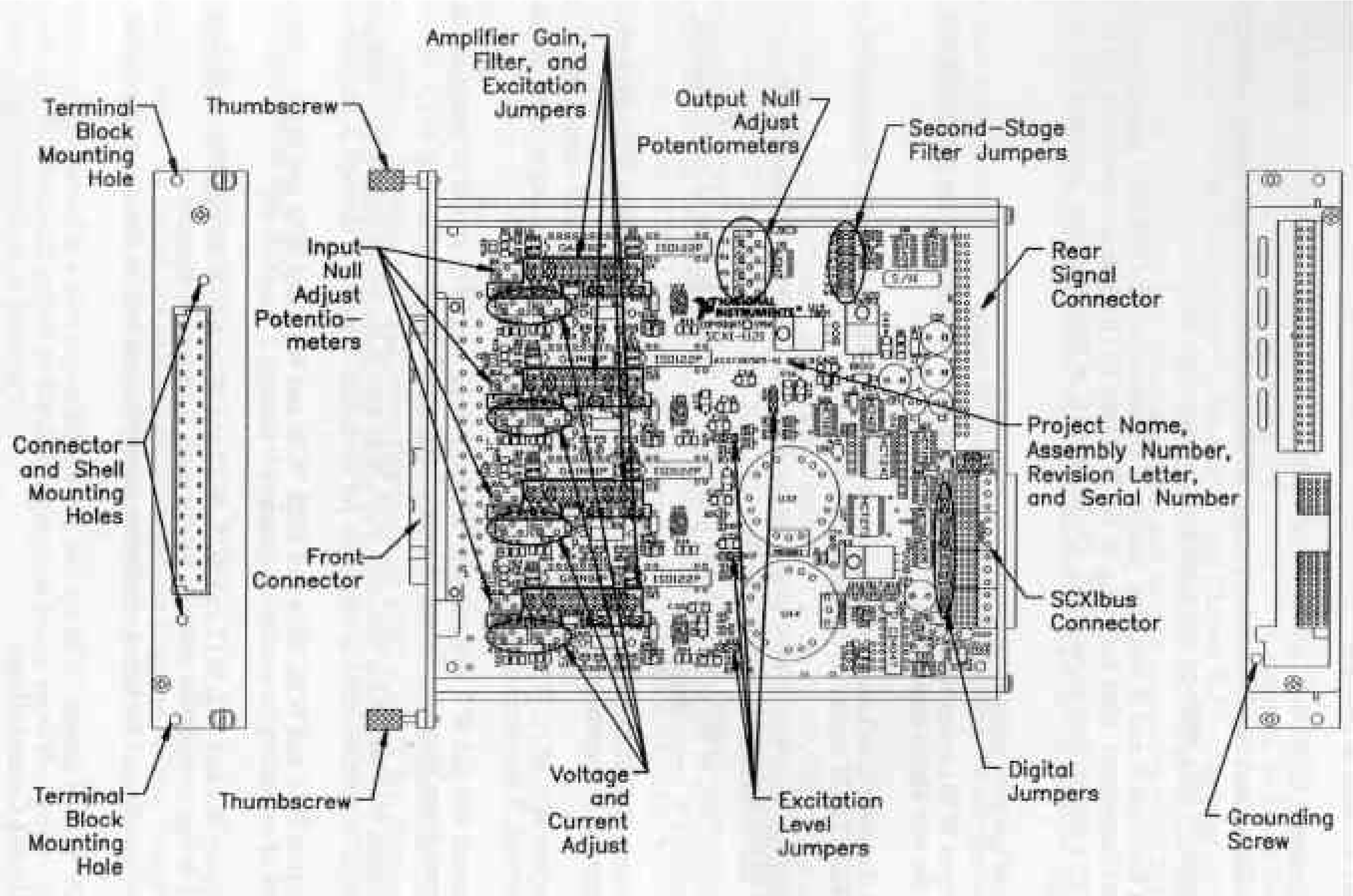



Figure 4-5: SCXI-1121 General parts locator diagram

### 4.3 SCXI-1000 CHASSIS

This chassis has four-slots for connecting up to four SCXI modules and is powered by 230 VAC.
It supplies a low-noise environment for signal conditioning, supplying power and control circuitry for the modules.
It is a general-purpose chassis and can be used with all the SCXI modules.

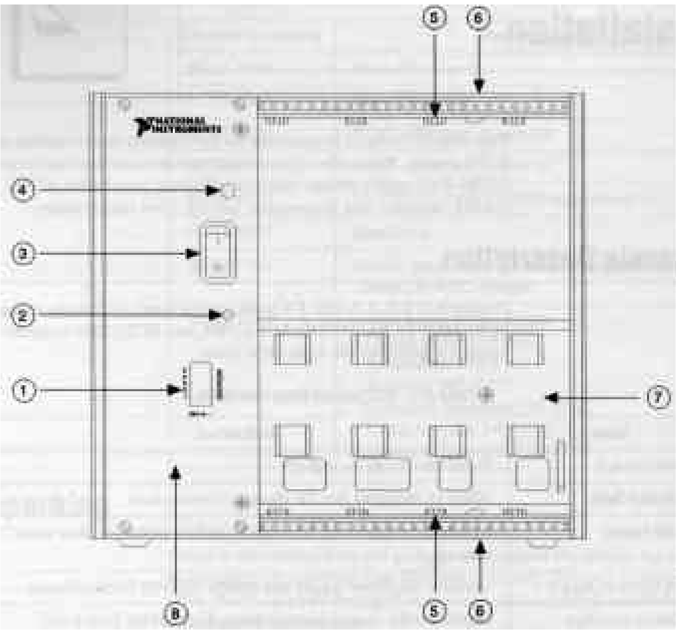


Figure 4-6: SCXI-1000 front view diagram

1: DIP switches
2: Reset button
3: Power switch
4: Indicator light
5: Modules guides
6: Threaded strips
7: Back plane
8: Slot 0/ Power supply

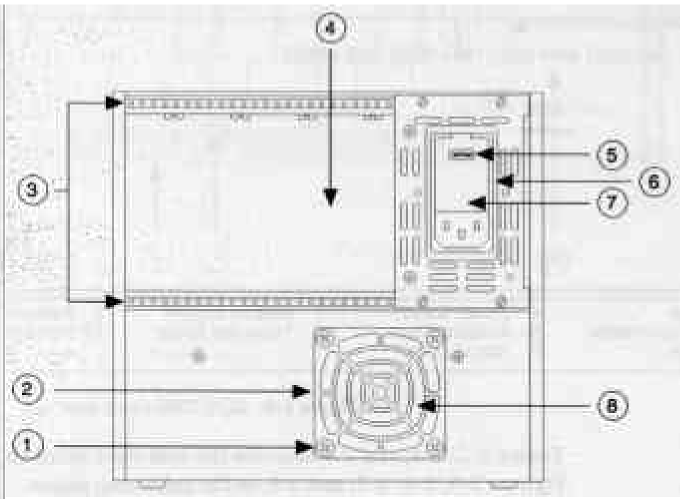


Figure 4-7: SCXI-1000 rear view diagram

1: Four fan screws
2: Fan and filter
3: Threaded strips
4: Connector space
5: Voltage selection
6: Power entry module
7: Fuse (concealed)
8: Backplane fuses

Our system is triggered manually in order to start the data acquisition system and infra red acquisition images system simultaneously: the high frequency scan (around 200 Hz) needs such an accuracy.

### 4.4 SCXI-1349 SHIELDED CABLE

This cable ensures a low-noise, long distance connection between the SCXI-1000 chassis and the AT-MOI-16XE-50 board.

Our cable is 2 m long with a 68-pin female connector at each end and an adapter board must be plugged to the rear signal connector

## 4.5 AT-MOI-16XE-50 DATA ACQUISITION BOARD

This data acquisition board belongs to the AT E series which is completely Plug and Play compatible multifunction analog, digital, and timing input / output boards for personal computers.

Because it has no DIP switches, jumpers or potentiometers, it is easily configured and calibrated using software.

It uses the National Instruments system timing controller for time-related functions: three timing groups that control analog input, analog output, and general-purpose counter/timer functions, and that include a total of seven 24-bit and three 16-bit counters and a maximum timing resolution of 50 nanoseconds.

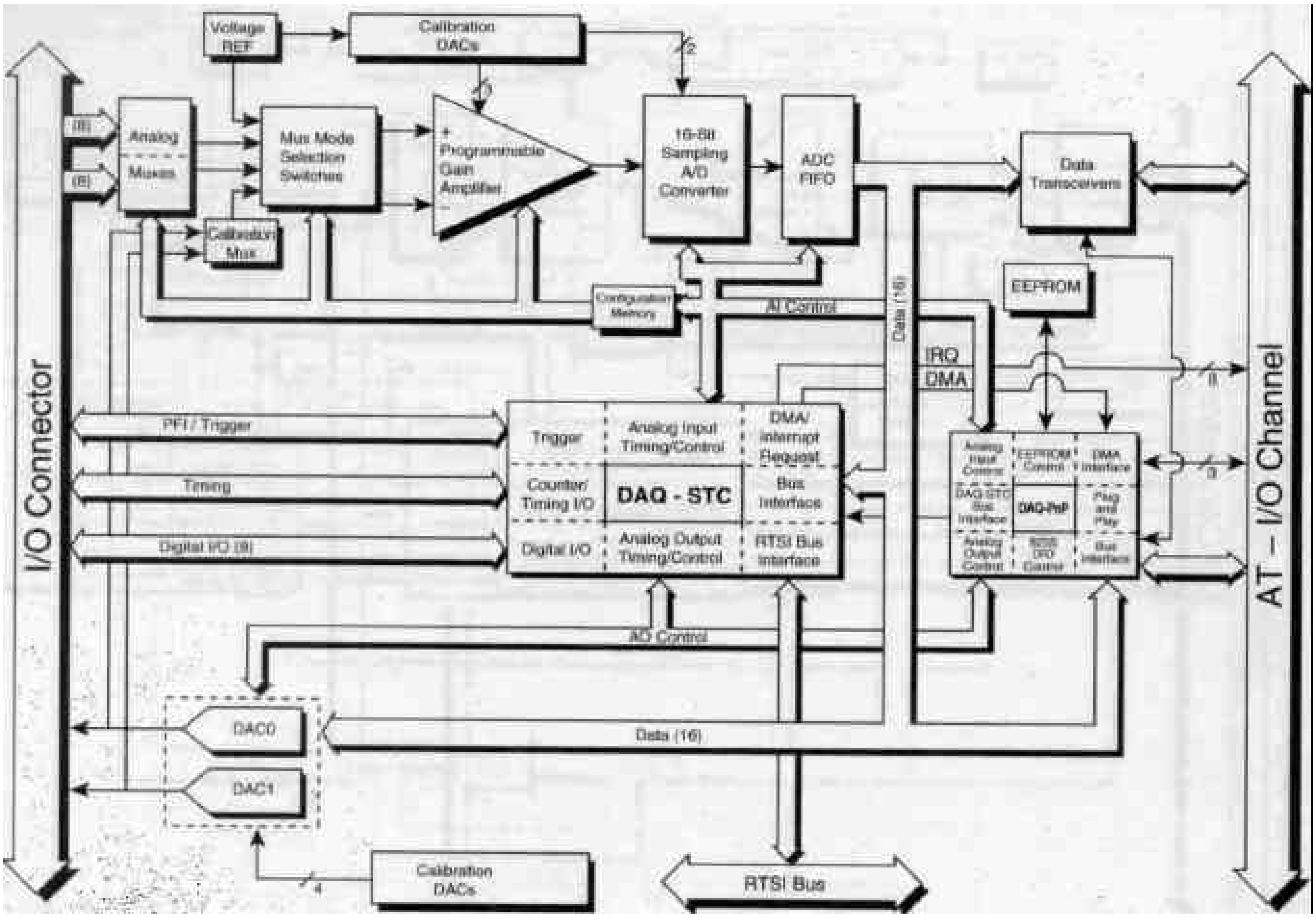



Figure 4-8: Data acquisition block diagram

### 4.6 SOFTWARES

For carrying out the data acquisition, we are using two softwares developed by National Instruments:

- Measurement Automation Explorer for fixing the characteristics of the data acquisition board based on the characteristics of the different hardwares,
- LabVIEW version 6.1 for managing the data acquisition itself.

The following scheme presents the relationships between these two softwares and the data acquisition hardwares.

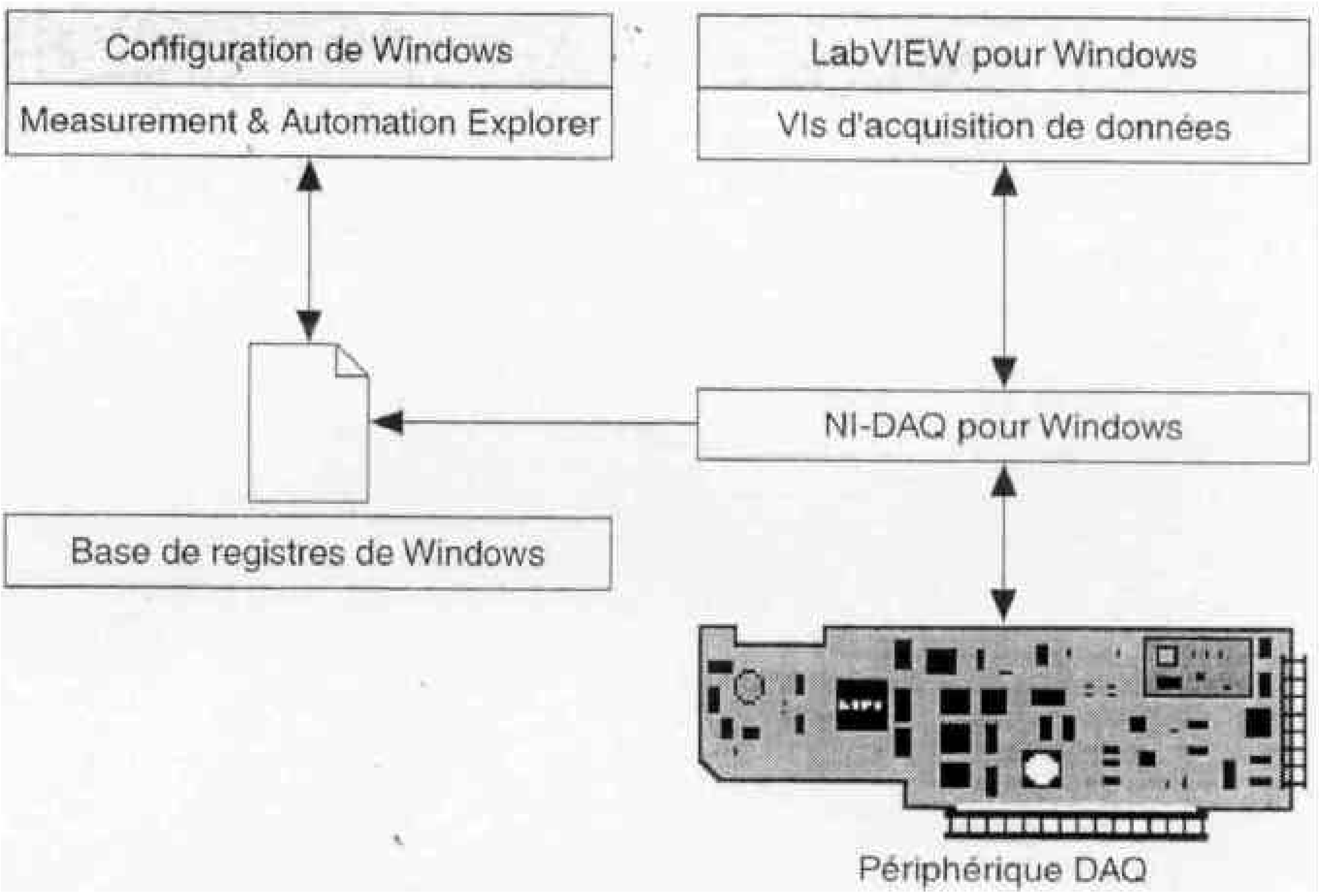



Figure 4-9: Relationships between Measurement and Automation Explorer, LabVIEW and the data acquisition hardwares

| | |
|---|---|
| Configuration de Windows | Windows configuration |
| Base de registres de Windows | Windows registers base |
| LabVIEW pour Windows | LabVIEW for Windows |
| VIs d'acquisition de données | Virtual Instruments for data acquisition |
| NI-DAQ pour Windows | NI-DAQ for Windows |

### 4.6.1 Measurement Automation Explorer

The version of the software we have, is running under Windows environment and is dedicated for:
- configuring the components of the data acquisition system described here above,
- adding new channels, new interfaces (terminal blocks, modules and chassis) and new virtual instruments,
- diagnosing the system in order to identify the sources of problems,
- displaying peripherals and devices connected to the system,
- planing the softwares up-dating

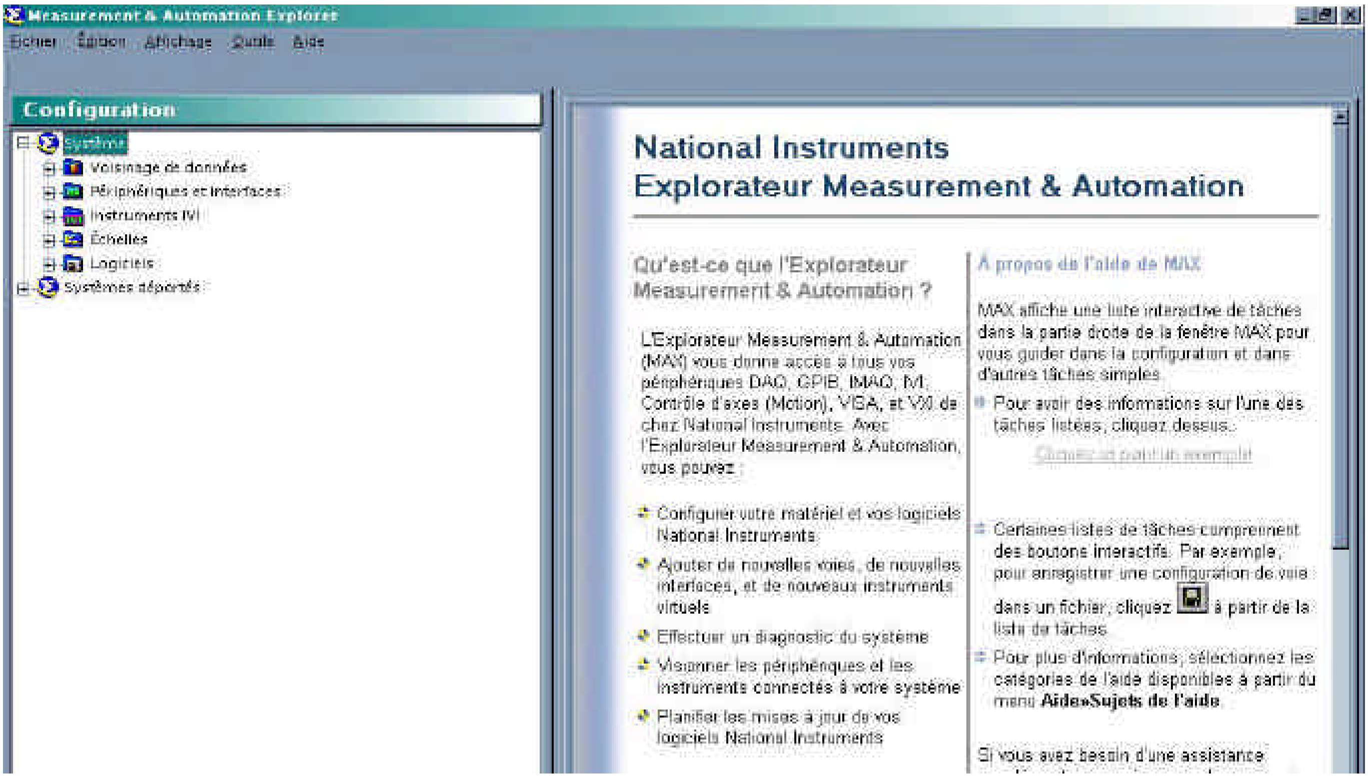



Figure 4-10: Home page of Measurement and Automation Explorer (French version)

### 4.6.2 LabVIEW 6.1


Figure 4-11: LabVIEW home page

LabVIEW is a graphical programming language which uses icons instead of lines for creating applications.

Contrary to textual programming languages, where instructions determine the code execution, LabVIEW uses a data flow programming mode, in which data determine the code execution.

We use LabVIEW for realising a user interface with tools and objects.

The user interface is named “Front view”.

Then we add a code, contained in the diagram, with graphical representation of the functions for controlling the objects of the front view.

If everything is correctly organised the diagram looks like an organising map.

LabVIEW’s programmes are named virtual instruments or VIs, because they are looking and functioning like physical instruments.

Each VI uses functions which manipulate data from the user interface or from other origins, display this information or copy and paste them to other files or computers.

A VI has three components:

- the front view: user interface
- the diagram: it contents the graphical source code and defines its functionality
- the connecting border and the icon: they identify the VI in order to include it in an other VI; the included VI is a sub-VI which corresponds to a sub-routine in textual programming modes.

## 4.7 OTHER INFORMATION

In order to get more information connect to National Intruments web site

http://www.ni.com

# 5 VIDEO IMAGES ACQUISITION SYSTEM

## 5.1 FIXED AND MOBILE CAMERAS

### 5.1.1 The two “fixed” cameras

Fixed cameras (references 33 and 34 in the scheme) are single board CDD colour cameras LDH 0380 (linked to the VT-14A video switch by Y/C wires, they need AC current 12 volts.

They have a electric zoom ( 5.5 to 72 mm) with an automatic diaphragm in order to regulate the light level on the CDD sensor: the electric zoom is controlled from the command desk by the VT-14A video switch.

Their technical specifications are the followings:

| | |
|---|---|
| Power supply | 12 – 28 VAC via system connector |
| Video sensor | 1/3 inch |
| Resolution | 480 TV lines |
| Sensitivity | 1 lux |
| Video output | 1Vpp into 75 Ohms |

Each camera is fixed on a rotating turret (Pan and Tilt 560) which moves the camera in two perpendicular plans (left-right and up-down): this enables to cover all the bench and to follow the fire propagation during the test: the movement of the turret is controlled from the command desk.

| | Pan | Tilt |
|---|---|---|
| Movement (°) | 10 to 350 | +20° to 90° |
| Speed (° per sec) | 6 | 3 |
| Torque (kg.cm) | 35 | 70 |

### 5.1.2 The “side view” camera

Because the two “fixed” cameras provide only front and back view of the fire front, we decided, in the framework of EUFIRELAB project to complete the installation with a third camera for providing side views.

Due to the constraints of the experimental bench for moving fire, we selected a CDD colour video camera XC-555P.

It is a, ultra-small colour camera module that utilises a ½ type Charge Coupled Device with 380 000 effective pixels.

A built-in super hole accumulated diode sensor allows high sensitivity.

Using the CCD Iris function, the shutter speed is adjusted automatically for ensuring the most appropriate level of image signal.

An adapted lens is mounted in order to optimise the focal distance.

The other technical specifications are identical to those of the “fixed” cameras.

The “side view” camera is fixed to a rail parallel to the length of the bench: presently is it located in a given place before the test; in the future the movement of the camera will be controlled from the command desk in order, if necessary to follow the fire propagation.


Figure 5-1: Type of image from the side view camera

### 5.1.3 The “handy” camera

We have also a handy camera in order to collect other view from this bench, to collect images from the experimental bench for static fires and during outside experimental fires for the same purpose: to constitute images bases of our experiment, analyse afterwards these images, and to store and archive them.

Therefore, and because our handy camera records on HI8 tape, we connect it to the video recorder as indicated in the following chapter.

Figure 5-2: Video camera recorder CDD-VX1E, HI8 handycam PRO

### 5.2 VIDEO-RECORDERS

Theoretically, the video recording permits to look at the test just after it to collect information about the test that we did not note during it or for calculating parameters like “instantaneous” fire velocity, or to compare several tests and to create archives which can be replicate and share with partners.

Therefore, we decided to equip les Vignères with professional video-recorders using S-VHS tapes, which were in 1997 the safest way (and compatible with our budget) to archive the images: we selected Panasonic AG-7355-E.

Unfortunately, after many series of observations and measures on fixed images, we observed a degradation of the quality of the images.

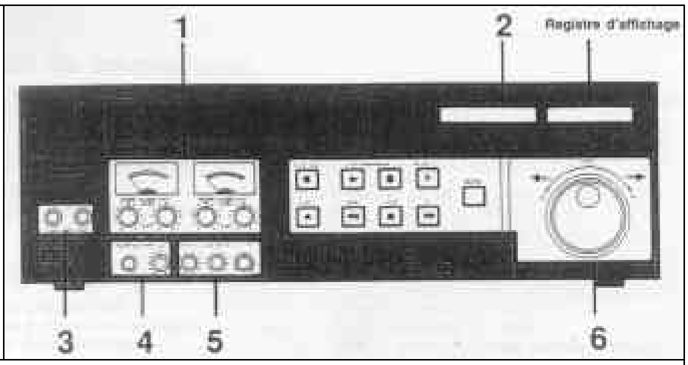
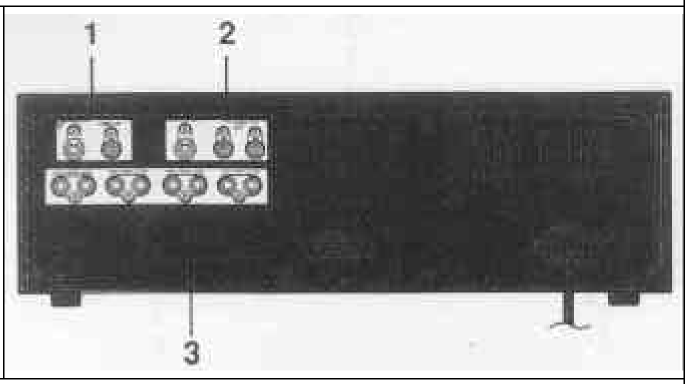
Consequently, we decided to create numerical files from selected sequences in order to be able to store them on CD and more recently, on DVD

The procedure is described in Deliverables D-07-09

So, we are able:

- to work several times on the images afterwards without degrading their qualities
- to replicate the tapes for sharing them with partners, specifically in the framework of EUFIRELAB

The series of figures here below present the front and back facades of the video-recorder.

| | |
|---|---|
| 1: Audio levels adjustment<br>2: Lighting indicator for S VHS mode<br>3: Microphone plugs<br>4: Header plugs<br>5: Image levels adjustment<br>6: Main commandes: On / Off, Backwards, Tape begining, Tape end, Image selection “image per image” |  |
| Figure 5-3: Video recorder, front view | |
| 1: Video input connections<br>2: Video output connections<br>3: Audio input and output connections |  |
| Figure 5-4: Video recorder, back view | |



In order to replicate a tape, the two video-recorders must be connected as indicated on figure 5-6as

For copying HI8 tape from the “handy” video camera on S-VHS tape, the “handy” camera replaces the “reader” video recorder.

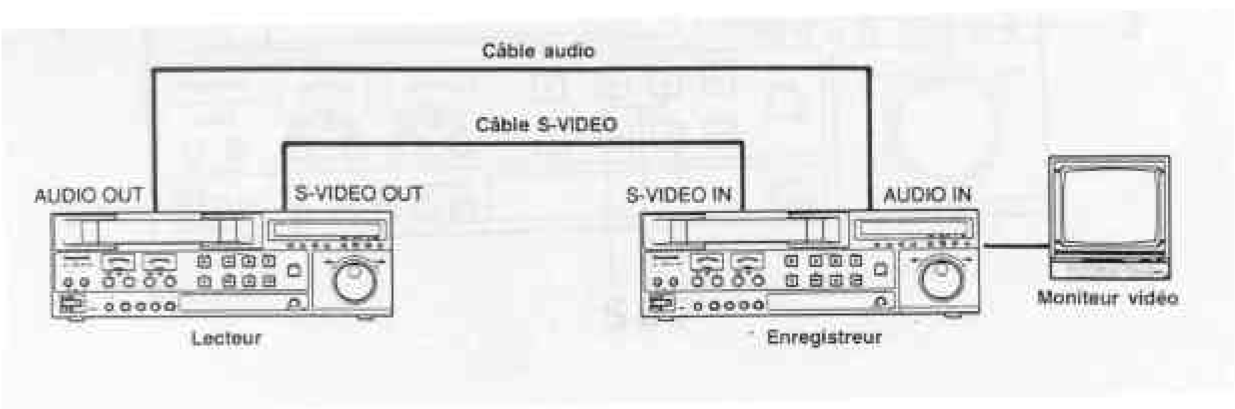



Figure 5-5: Connection between two video recorder to create archive tapes
(Lecteur = reader, Enregistreur = writer)

## 5.3 VIDEO MONITORS

The colour video monitors Panasonic TC 1470Y are compatible with the video recorders and are dedicated to display the images during the test: the person in charge of the video network adjust the images according what it is displayed.

They were used afterwards for selecting “image per image” images from previous experiments, for measuring directly on the screen some characteristics.

Since we create the numerical files, this use is abandoned.

### 5.3.1 Specifications

| | |
|---|---|
| System | Interlaced, PAL / SECAM / NTSC 3.58 / NTSC 4.43 |
| Power Source | 220 – 240 volts, 50 hertz |
| Power Consumption | 85 watts |
| Picture tube | 34 cm diagonal |
| S-Video input | Y signal 1.0Vp_p, C signal 0.285Vp-p, 75 ohms or High Impedance, MINI DIN 4P type connector |
| S-Video output | Y signal 1.0Vp_p, C signal 0.285Vp-p, 75 ohms or High Impedance, MINI DIN 4P type connector |

### 5.3.2 Presentation

The two following images present the front and rear views of the monitor.

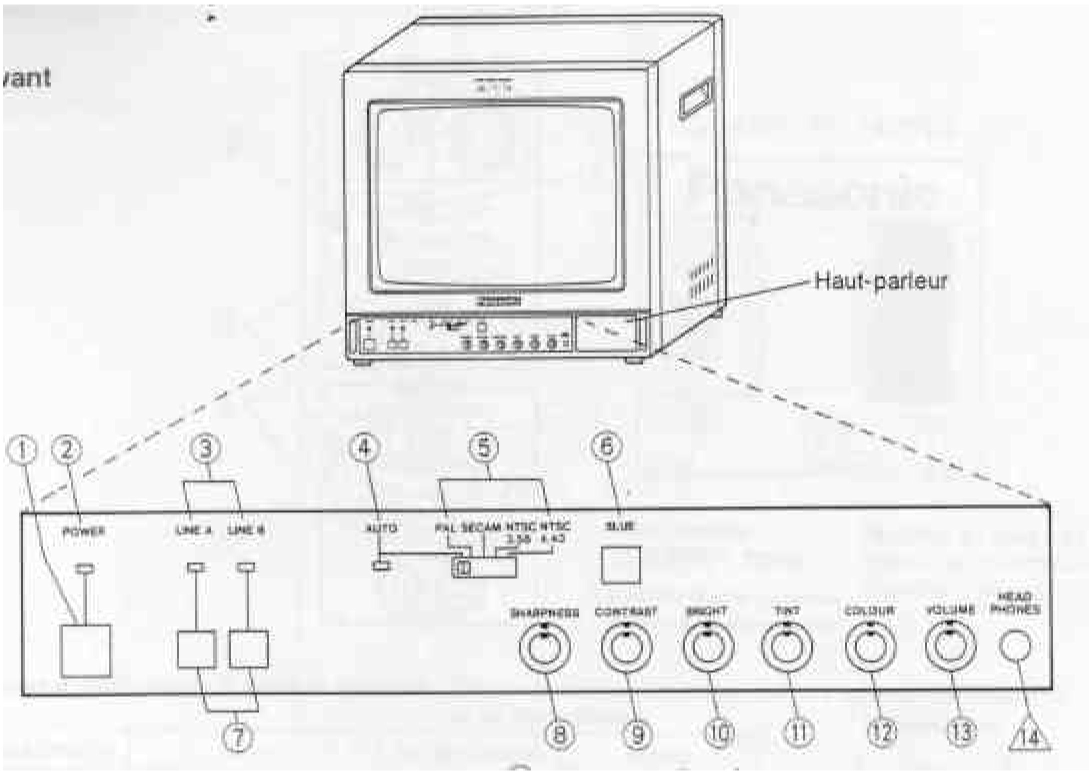



Figure 5-6: Video monitor, front view

| | | | |
|---|---|---|---|
| 1: Power Switch ON/OFF | 2: Power indicator: will light when the power is ON | 3 Input indicators: will light when the appropriate input is selected | 4: Auto indicator: will light when the TV system selector is in AUTO mode |
| 5: TV System Selector Switch: normally set at AUTO, it can be modified to the appropriate position | 6: Blue Only Switch: depress for observing blue signal using EBU colour bar display for adjusting chrominance and hue | 7: Input Selector Switches: either Line A or Line B (see rear view) | 8: Sharpness control: soft to sharp |
| 9: Contrast control: decrease or increase | 10: Brightness control: dark to bright | 11: Tint control: red to green | 12: Colour control: low to high |

13 and 14 are dedicated for Audio use only

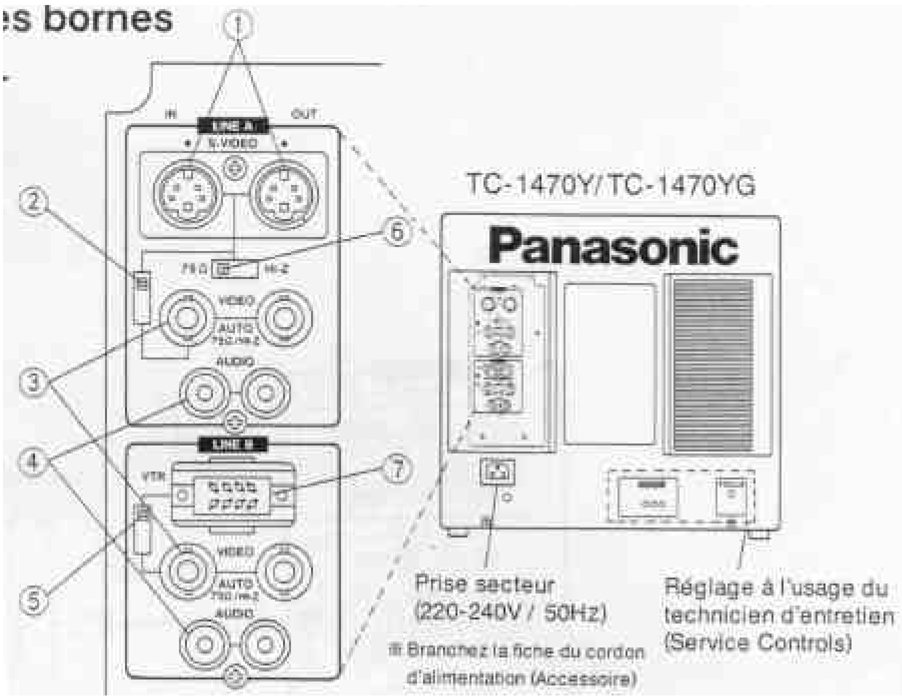



Figure 5-7: Video monitor, rear view

1: S-Video Input/Output terminal (4 pin): Luminance signal and chroma signal input / output terminal

2: Video / S-Video Switch: always in S-Video position

6: S-Video Impedance Switch: set to HI-Z when the S-Video output is used (the monitor is inside the network), set to 75 Ohms when just the S-Video input terminal is used (the monitor is at the end of the branch of the network (see figure 5-1)

The Sony monitor dedicated to the “mobile” video camera has the same characteristics, except that it can not be connected in Video mode (no Line B).

## 5.4 VITEC MPEG PROFILER

### 5.4.1 Main characteristics

It is a PCI encoding card designed for Windows 2000, and uses the latest technology in MPEG compression.

Its video specifications are:
- video standard: PAL but also NTSC and SECAM
- encoding standard: MPEG-1, MPE-2 but also half D1, 2/3 D1 and full D1
- video encoding bit rate: 2 to 15 Mbits/s for MPEG-2 and 100 kbps for MPEG-1
- file format: video elementary
- VDC, XVCD, SVCD and DVD compliant
- constant and variable bit rate
- calibration hue, saturation, brightness and contrast
- digital prefiltering
- all video resolution supported

### 5.4.2 Procedure for creating a numerical file

#### 5.4.2.1 Step 1

Connect the video recorder to the video monitor and the video monitor to the input plug of the card.

Activate MPEG profiler version 2.4 software: the home page is displayed

Click on the upper left icon, the installed encoding card(s) is displayed

Validate the selection by a double click on the green icon just before the name of the encoder


Figure 5-8: MPEG profile software home page

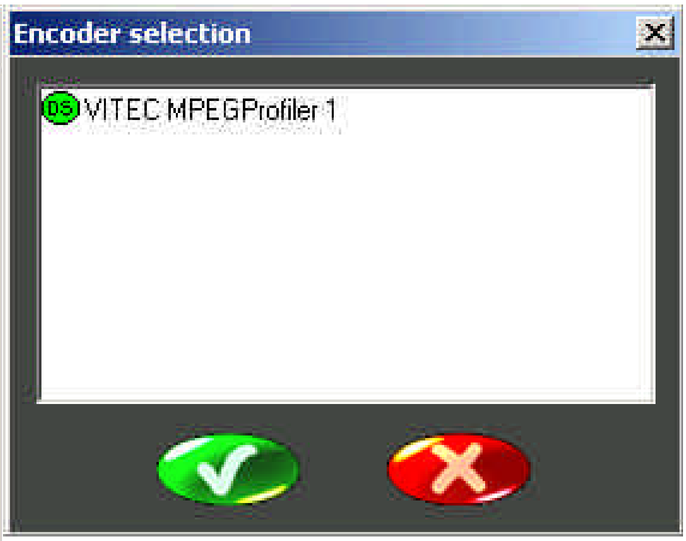


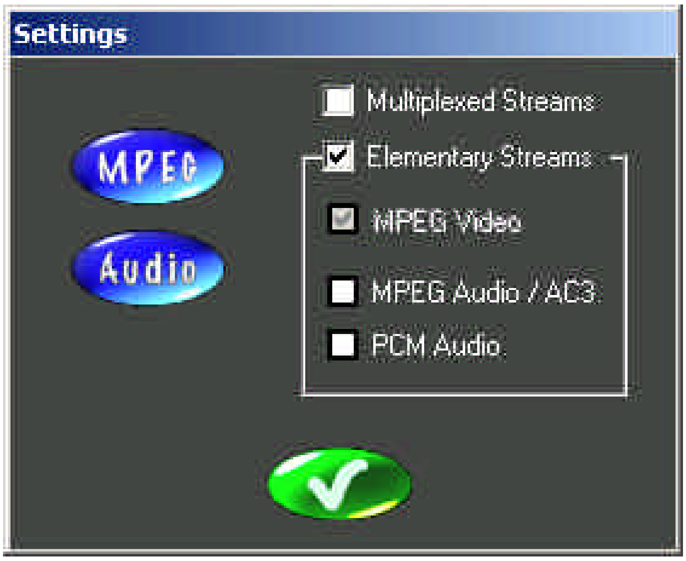

Figure 5-9: Encoder selection menu

### 5.4.2.2 Step 2

Click on the “tools” icon, in the upper line of the home page.

In the Settings windows:
- validate Elementary Streams, and
- suppress Audio selections in order to create only an images file.

Click on MPEG blue icon in order to determine the parameters in the different menus




### 5.4.2.3 Step 3

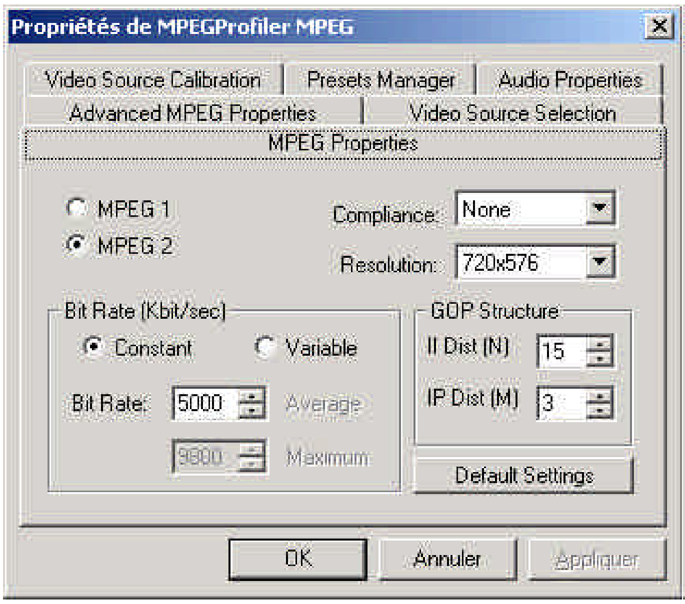



Figure 5-10: MPEG Properties menu

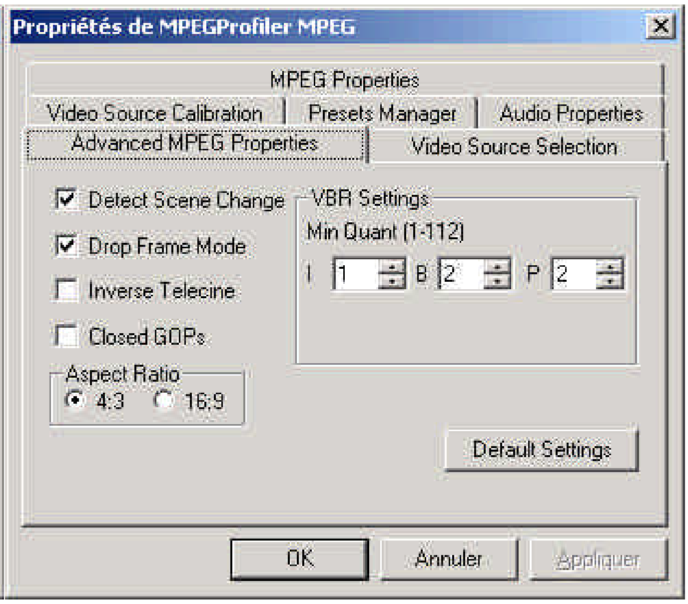



Figure 5-11: Advanced MPEG Properties

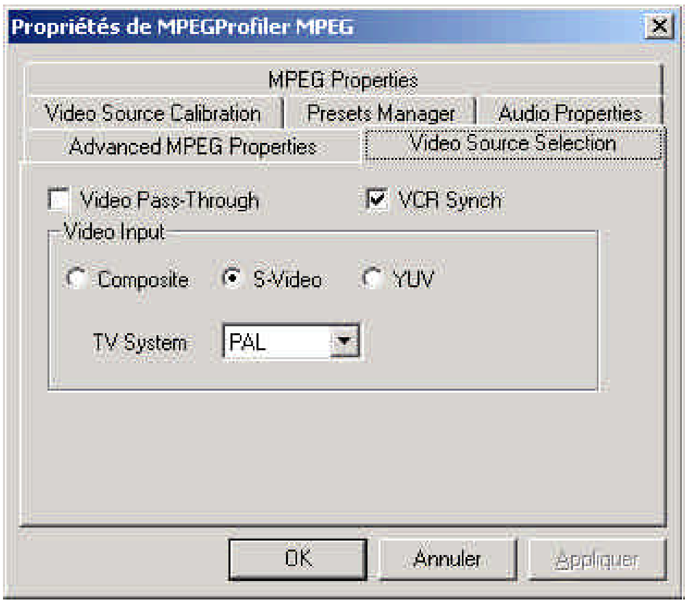



Figure 5-12: Video Source Selection menu

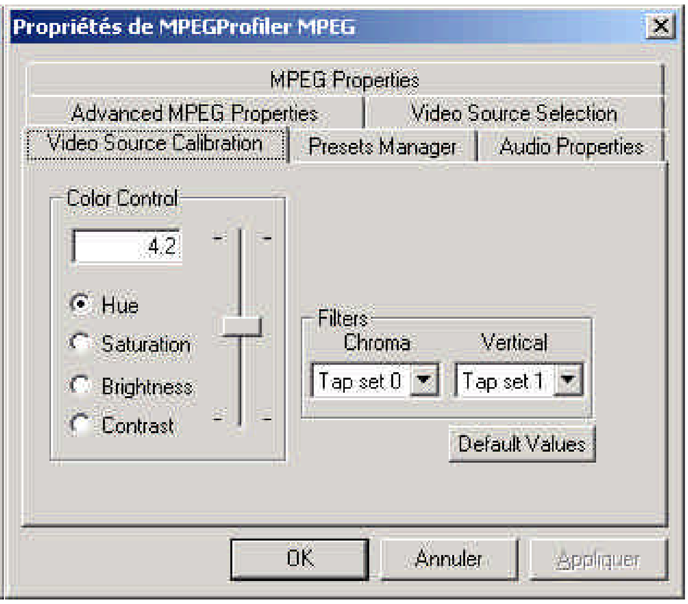



Figure 5-13: Video Source Calibration menu


Figure 5-14: Presets manager menu

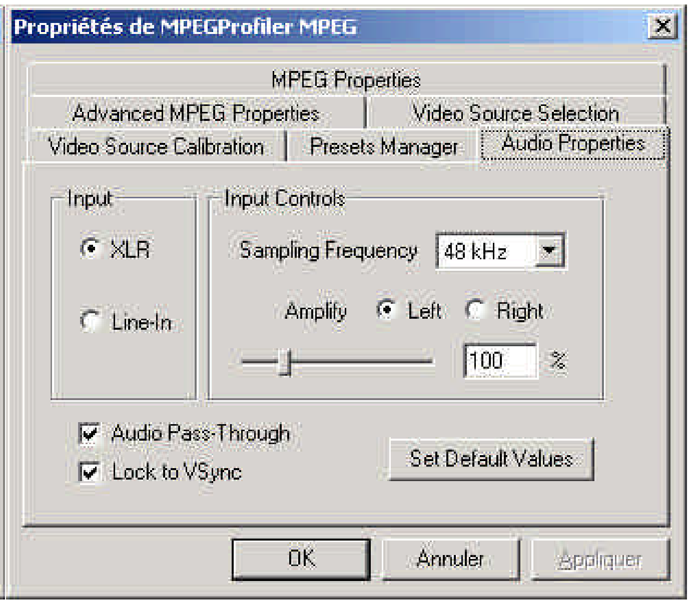
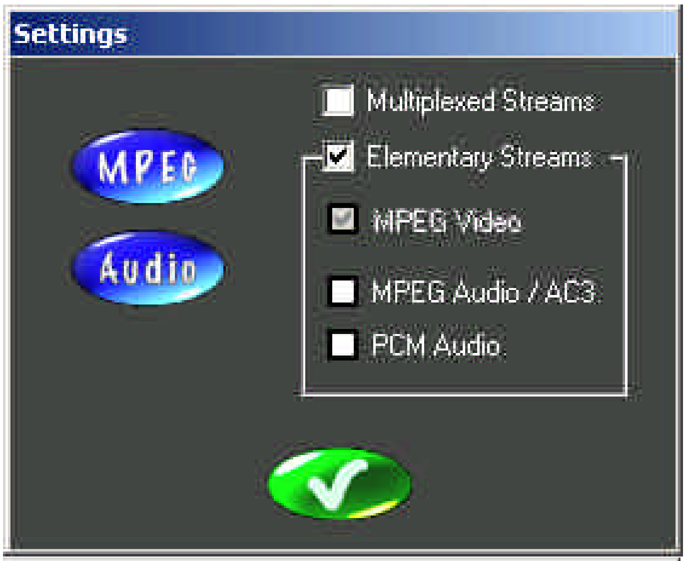



Figure 5-15: Audio Properties menu even if Audio selections are non active

Validate all the selections by clicking on the green icon.

The profile software home page is displayed

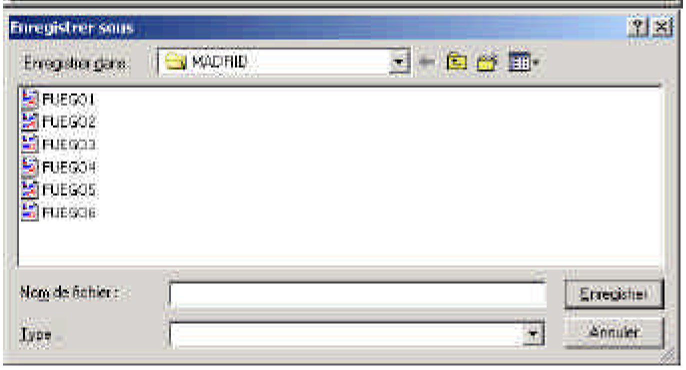



<u>5.4.2.4 Step 4</u>

Click on the upper right icon for entering the name of the numerical file and the storage folder

Validate by pressing on the Enregistrer (Record) button; the third grey button is lighted: the software is ready to create the numerical file

At the bottom of the profile software home page, enter an evaluation of the duration of the record (do not hesitate to indicate longer duration if you hesitate



## 5.4.2.5 Step 5

Before pressing the "red" button, verify that the connection between the video recorder and the computer is correct (see the corresponding chapter) and that the tape is at the right position.

Launch the operation, start the video recorder.

Wait until the operation is finish for stopping the operation by pressing on the right "yellow" button or until the indicated duration is over.

## 5.5 VITEC VIDEOCLIPMPEG2

The version 2.2 of this software permits to copy sequences of numerical images from an initial numerical file.

In the left screen, open an exiting numerical file, define the first and last images of the sequence that is to copied, and press the bottom right red icon.

In the right screen, press the bottom right red icon, the corresponding images are pasted in the second screen, and save the new file.

## 5.6 VITEC MPEG PLAYER

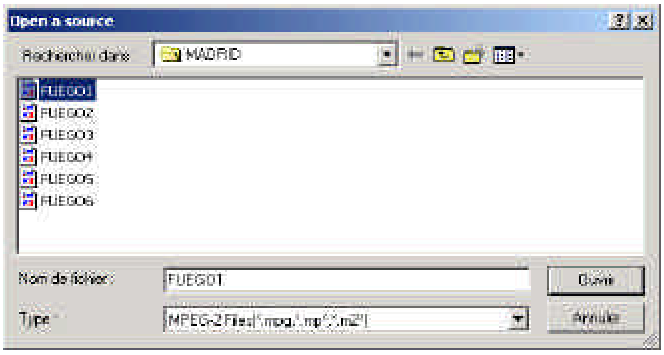
### 5.6.1 Procedure for visualising a numerical file

Activate VITEC MPEG Player software

Click on the Open a media icon (first left in the upper line)


Select the type to which belong the numerical file

Select the numerical file and click on Ouvrir (Open)




The first image of the file is displayed in the main screen.

Using the icons of the lower line of VTEC MPEG Player menu, the film can be displayed

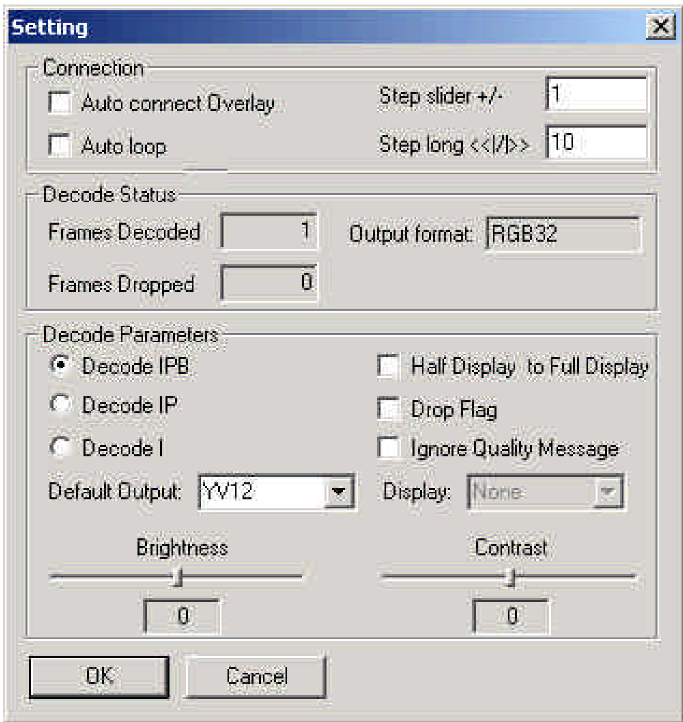
- Play or Pause the media: run or stop Decrement or increment position: display the next or previous image
- Go to first position: display the first image of the file
- Go to end: display the last image of the file Long decrement or increment position commands are used for displaying images at a regular step of 10 frames

Select play offers four possible rates for reading the numerical file.

### 5.6.2 Procedure for extracting images

Display the selected image using the image by image command

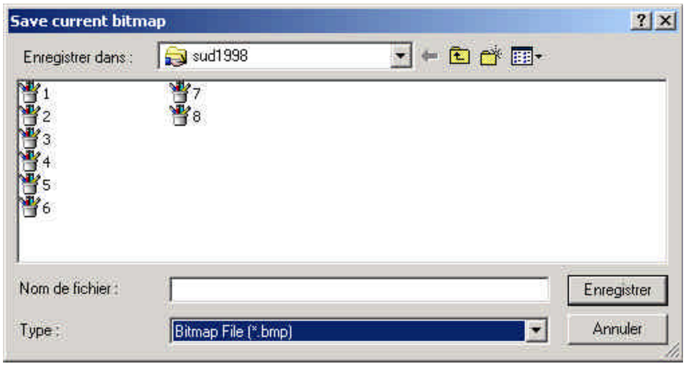
Click on Set and suppress the Auto connect Overlay activation



Press on the Save a picture button (red button at the bottom right


Enter the name of the file (Nom du fichier) and click on Enregistrer (Save)

A bmp file is created which can be uploaded afterwards with Photo Shop 7 software for creating a .jpg corresponding file.




## 5.7 OTHER INFORMATION

For more information, connect to VITEC web site: http://www.vitecmm.com

# 6 INFRARED IMAGES ACQUISITION SYSTEM

## 6.1 SC2000 CAMERA TECHNICAL SPECIFICATIONS

The main technical characteristics of the infrared camera FLIR SC2000 are:

(technical specifications in Annex A):
- IR-detector based on non-cooled micro-bolometer focal plane array (FPA),
- this technology works in the long wave spectral band (7.5 – 13 ìm spectral range),
- a built-in spectral filter reduces the influence of the atmospheric attenuation,
- the camera has a fully radiometric design with temperature measurement up to 1500 °C,
- three temperature ranges are available: –40° C to +120° C, 0°C to +500°C, 350°C to 1500 °C,
- its 14 bits digital output works in real-time,
- it can be used as a portable handhold camera, tripod mounted, operated locally or by remote control.

The Researcher HS system is used to perform high-speed image data acquisition at a sampling rate of 50 Hz.

More technical information are summarised in chapter 6.6

## 6.2 THERMACAM RESEARCHER SYSTEM

The following image reminds the complete ThermaCAM Researcher System (Figure 6-1).

This system is composed of:
- SC2000 Infra red camera,
- cable 194450 and extension cable 194267, for connecting the camera to 500 input port of the parallel interface
- parallel interface 1944441
- RS432 cable 194452 and RS232 cable 908618 for connecting the parallel interface to the PC07 (see Internal computing network in Deliverable D-07-02)
- power supply 194091 in 230VAC, connected to the pwr input port of the parallel interface
- external trigger in order to start simultaneously the data and the IR images acquisitions.

For technical reasons, the total length of cables 194450 and 194267 must be lower than 15 m (here 12.5 m).

For analogue reasons, the length of cable 908618 is limited to 1.8 m.

These major constraints induce specific adaptations when we used the ThermaCAM Researcher system on DESIRE bench.

We must move all the system in order to be close to the experimental bench for static fire during experiments on this bench.

Rechargeable batteries NiMH permit to use the camera disconnected from the system.

The software features are the same as ThermaCAM® Researcher but the hardware uses the System parts ThermaCAM® SC Parallel (see Figure 6-2):
- IC2-DIG16 frame grabber (inside the PC) from Imaging Technology Inc., USA
- a PCI-standardised card with a 44-pin DSUB cable fitting into the side of the Parallel Interface (PI) (3)
- a Parallel Interface (PI) 500/900 box (3).
- the PI - Camera Cable fits into the "Camera 500" connector of this box
- the IC2-DIG16 cable fits into the "RS422" connector.
- a serial cable links the desktop computer to the "RS232" connector
- a LEMO connector on the short side fits to a Power Supply 500 unit (5)
- the ThermaCAM® Researcher CD-ROM (not shown) including PC driver software
- a desktop computer (1) with an internal SCSI disk (2) (*external on the image*) for image storage

## 6.3 PROCEDURE

### 6.3.1 High frequency infra red images acquisition

Using the parallel interface, the system can acquire infra red images at a frequency up to 50 Hz.

Fix the camera on its support or tripod.

Connect the infra red acquisition board installed on PC07 to the RS432 output port of the parallel interface, using RS432 cable, for transferring the infra red images.

Connect the input/output serial port of PC07 to the RS232 output port of the parallel interface, using RS232 cable, for transferring instructions.

Connect the SC2000 camera to the 500 port of the parallel interface using cables 194450 and 194267.

Connect the external trigger to the trigger port of the parallel interface

Using the AC/DC transformer, connect the power supply to the pwr port of the parallel interface.

Turn the ON/OFF switch of the power supply on ON

Turn the ON/OFF switch of the camera on ON

Turn the ON/OFF switch of PC07 on ON

Activate the ThermaCAM Researcher software Figure 6-3)

Create a working session (.irs file) for adjusting the camera:
- parameters concerning the "object" such as emissivity, air temperature and humidity (Figure 6-4)
- characteristics of the output signal (Figure 6-5)
- measurement range 0-120°C, 0-500 °C, or 350-1500°C and focus (Figure 6-6)
- noise reduction : Off, Normal, High (Figure 6-7)
- sequence name and storage folder

Complete the working session by determining the analysis tools: points, square or circular areas, polygons, formulas.

Launch the infra red acquisition by using the mouse or the keyboard of PC07, or the external trigger for simultaneous launching of the infra red images and data acquisitions.

At the end of the acquisition, visualise and analyse the images, using or not the defined tools (Figure 6-8 and Figure 6-9)

An application designed, developed and implemented in Visual Basic 6.0 ensures automatic choice of the camera parameters, and recording of the infra red images (Figure 6-10 and Figure 6-11).

### 6.3.2 Low frequency infra red images acquisition

This procedure is dedicated for using the camera disconnected from the ThermaCAM researcher system.

It uses the following equipment:
- Green button for activating the camera
- Enter button for moving inside the graphic interface of the command software of the camera
- C button for cancelling the last selection in the menu of the command software of the camera
- A button for calibrating the camera or to adjust its focus
- S button for selecting an image or storing it on the storing board of the camera
- Joystick has several functions:
  - starting mode for focusing and zooming,
  - menu mode for selecting the appropriate function, or increasing or decreasing the values of the parameters
- Viewfinder whose focus can be adjust with a small wheel
- 12 VCC connector for the parallel interface
- Header
- Video connectors to monitor or video recorder

The procedure is as following.
- Fix the camera on its support or tripod
- Insert the battery in the camera
- Inset the memory card in the camera
- Activate the camera
- Adjust the focus of the camera
- Determine the parameters using the graphic interface of the internal software (object parameters, temperature range, filters, …)
- Determine the recording parameters on the memory card (frequency, images names, folder name)

Back to the laboratory:
- extract the memory card from the camera
- insert it in the PCMCIA card reader of PC07
- copy the images on its hard disk
- use the ThermaCAM Researcher software for visualising and analysing the images.

### 6.3.3 ThermaCAM Researcher software

It works under Windows 2000 environment.

Under laboratory conditions, it ensures the infra red images recording at real time and at high frequency (up to 50 Hz).

It has large functionality for visualising and analysing the recorded infra red images, using numerous tools (points, lines, areas, isotherms.

Results are displayed in different windows ad under different ways (tables, histograms, curves, profiles.

They can be stored under text format files.

Using OLE procedure, information and data can be extracted from the images for being included in .doc or .xls files (Word2000 and Excell2000) or used by Visual Basic software (Figure 6-10and Figure 6-11).

## 6.4 ILLUSTRATIONS

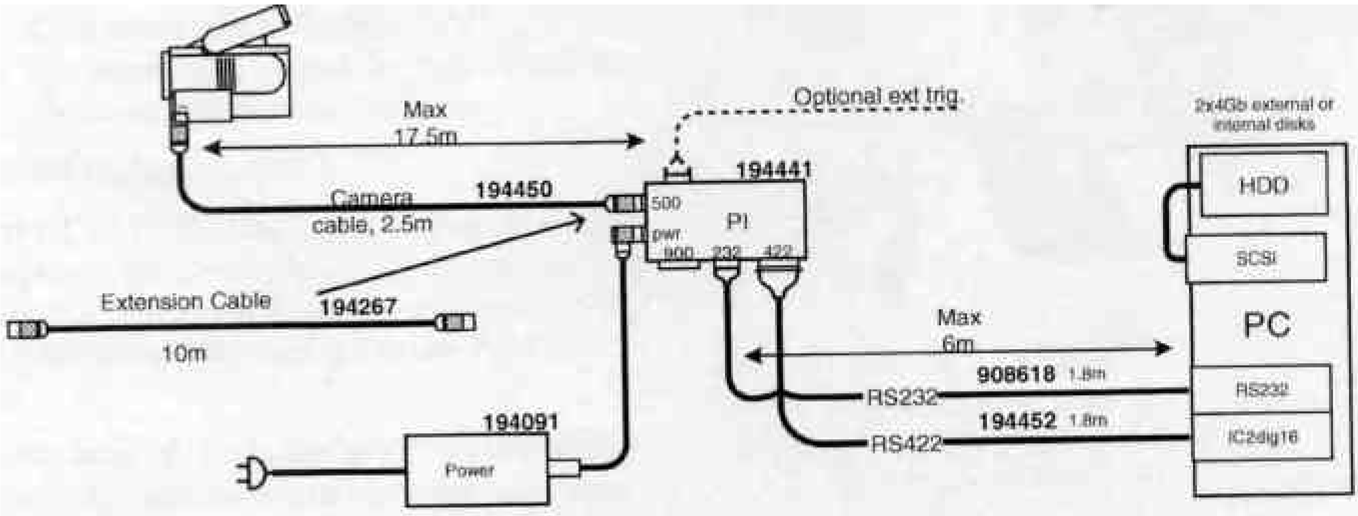



Figure 6-1: SC2000 ThermaCAM Researcher system


Figure 6-2: ThermaCAM® Researcher HS - ThermaCAM® SC parallel interface system

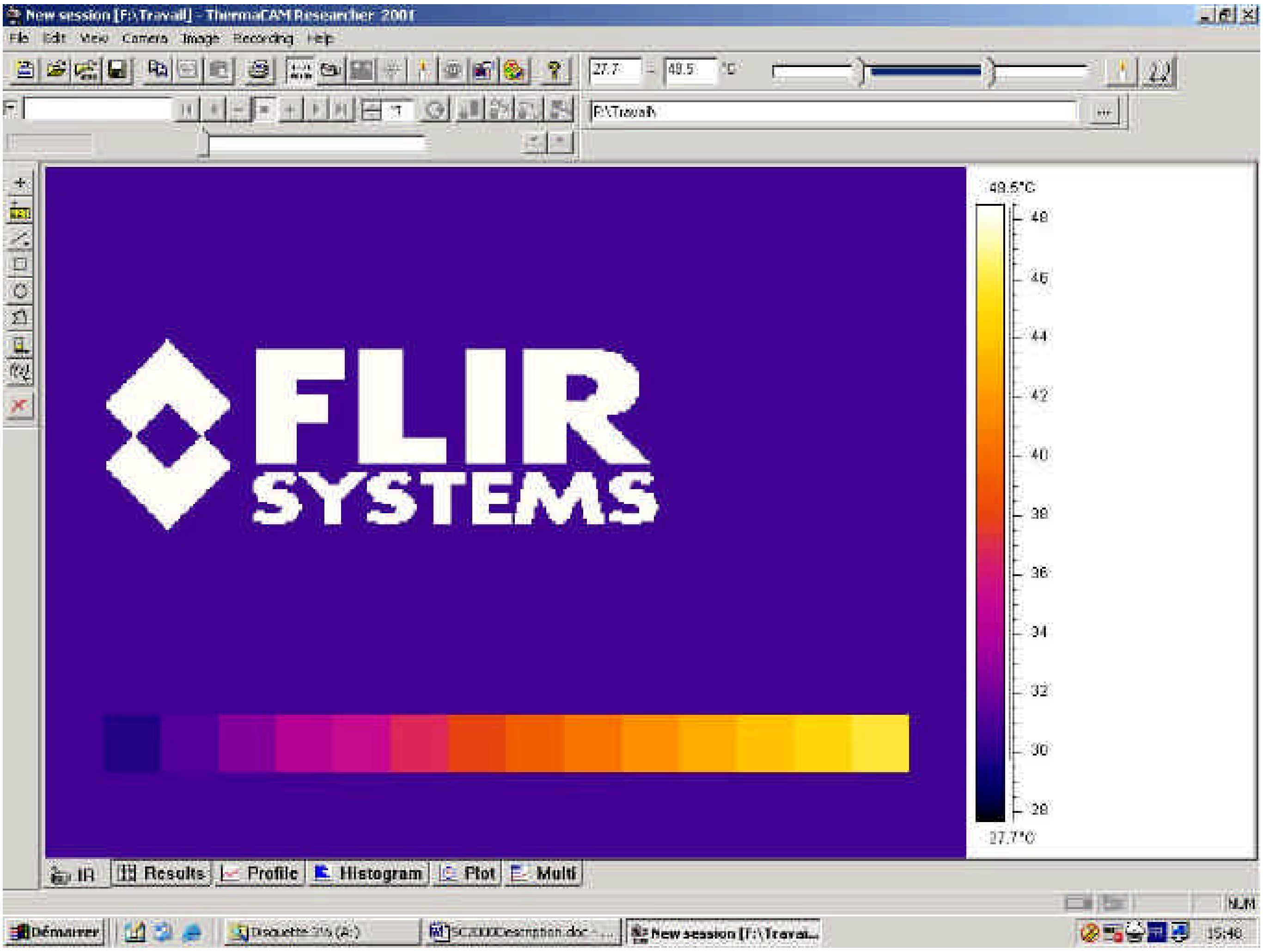



Figure 6-3: ThermaCAM researcher software home page

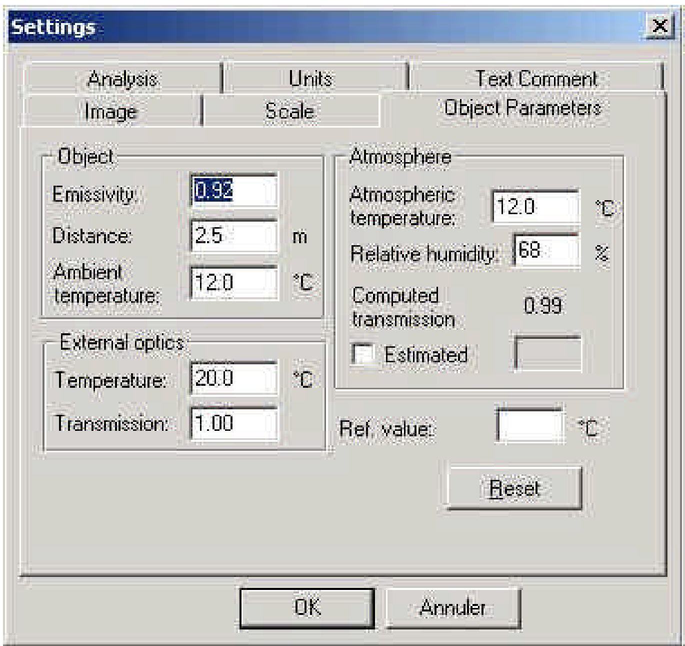



Figure 6-4: To select the object parameters

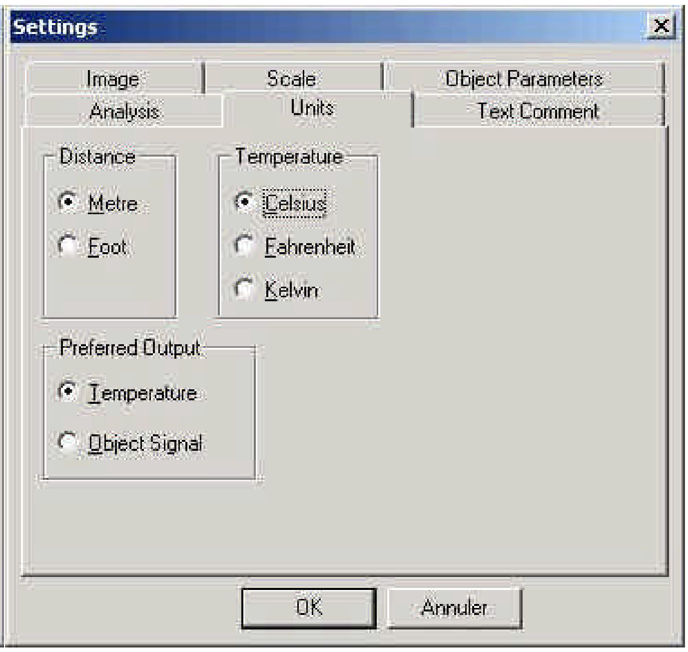



Figure 6-5: To select the units

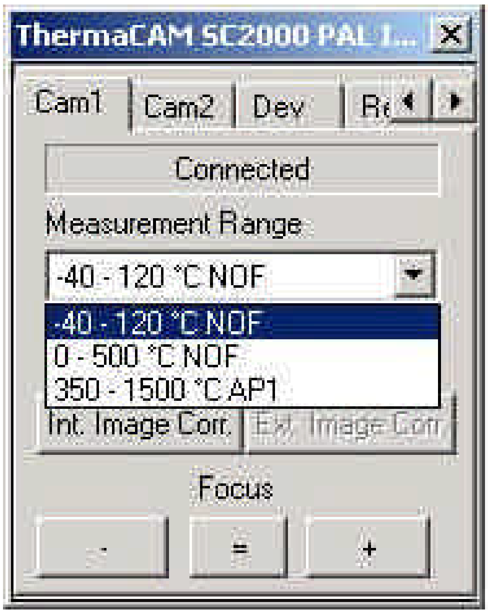



Figure 6-6: To fix the measurement ranges

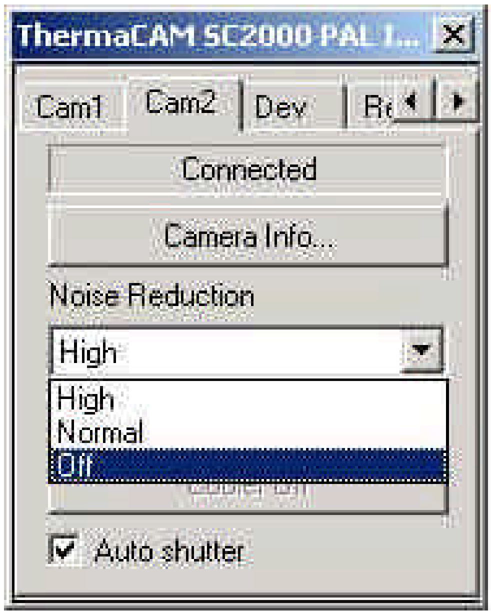



Figure 6-7: Noise reduction

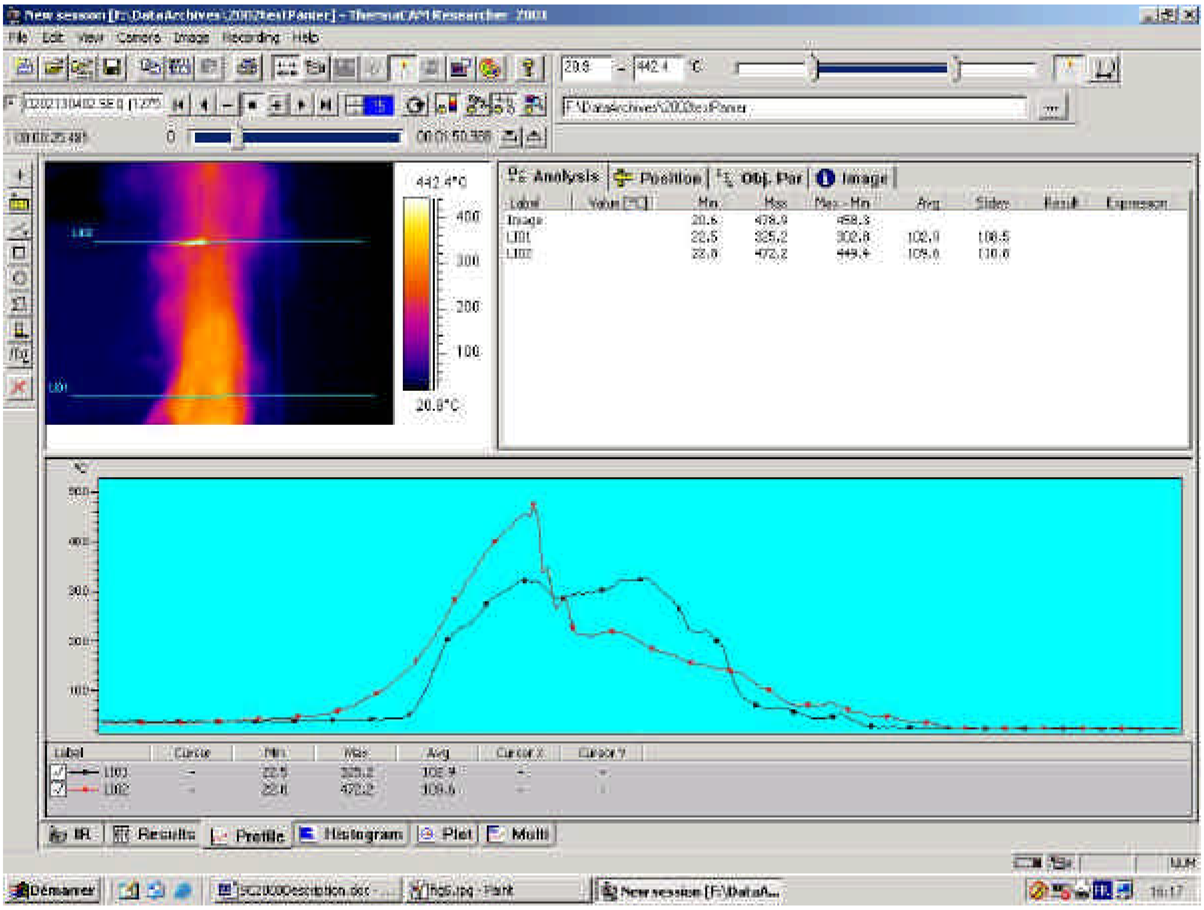



Figure 6-8: Temperature variation along lines 01 (blue) and 02 (red) located in the upper left fixed image

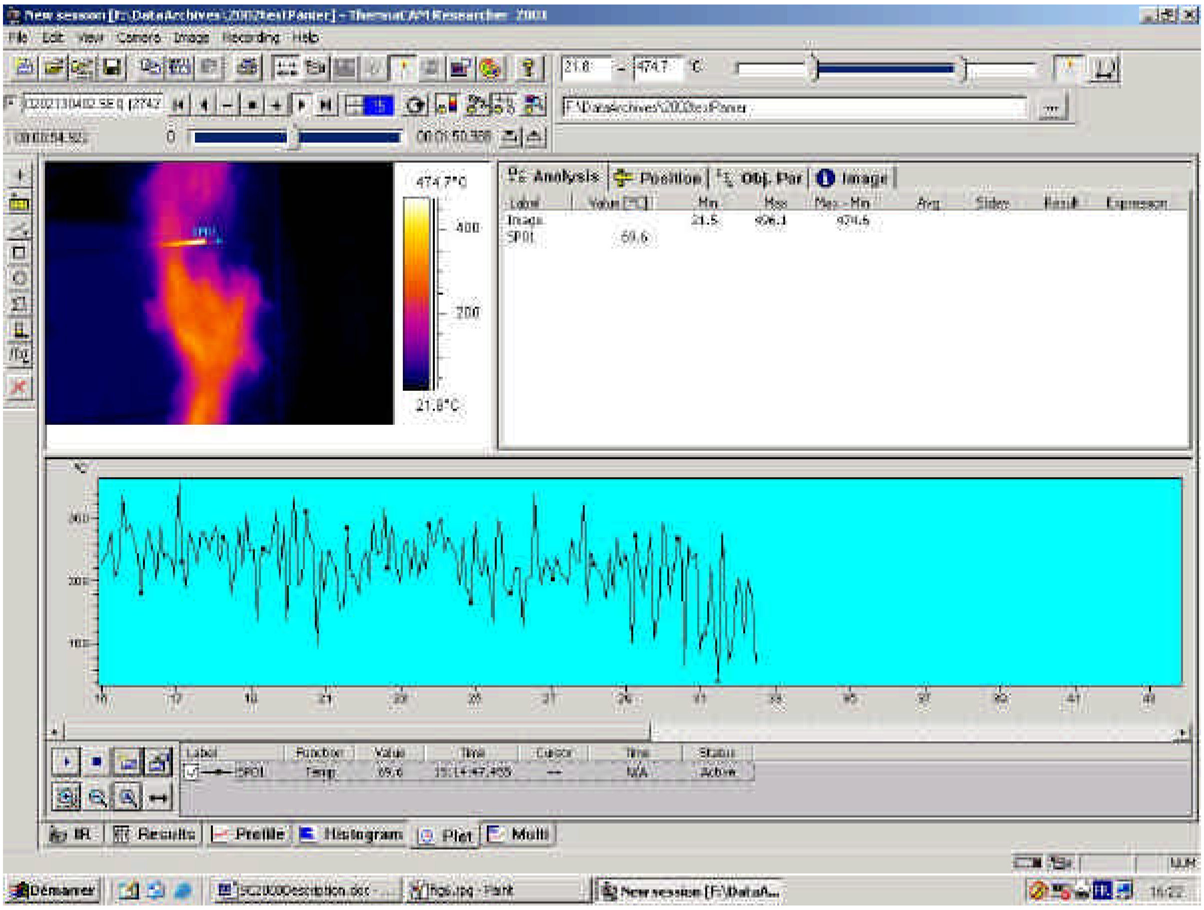



Figure 6-9: Temperature variation in the selected point SP01 versus time
SP01 is located in the upper left running image

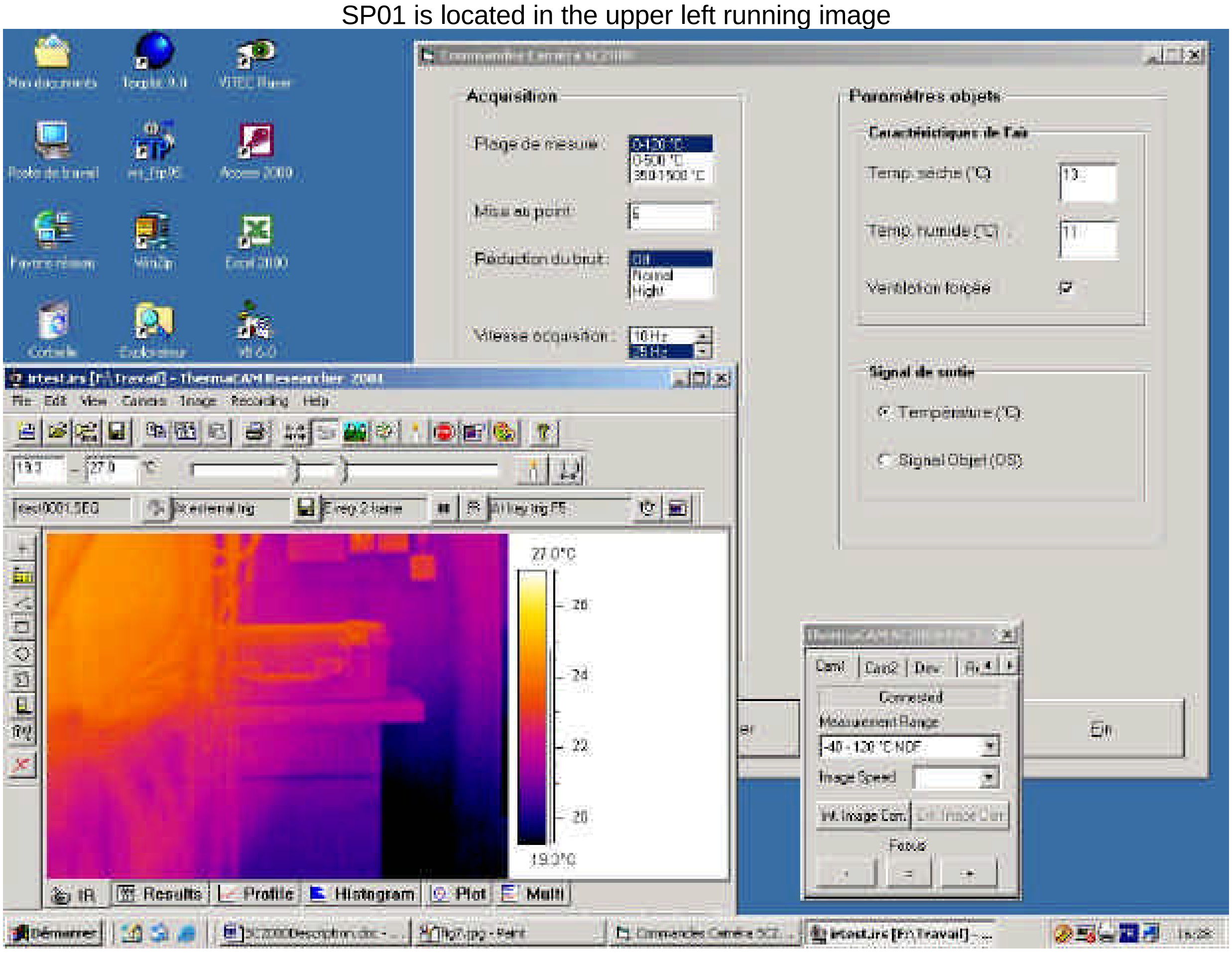



Figure 6-10: Visual Basic application for fixing the parameters

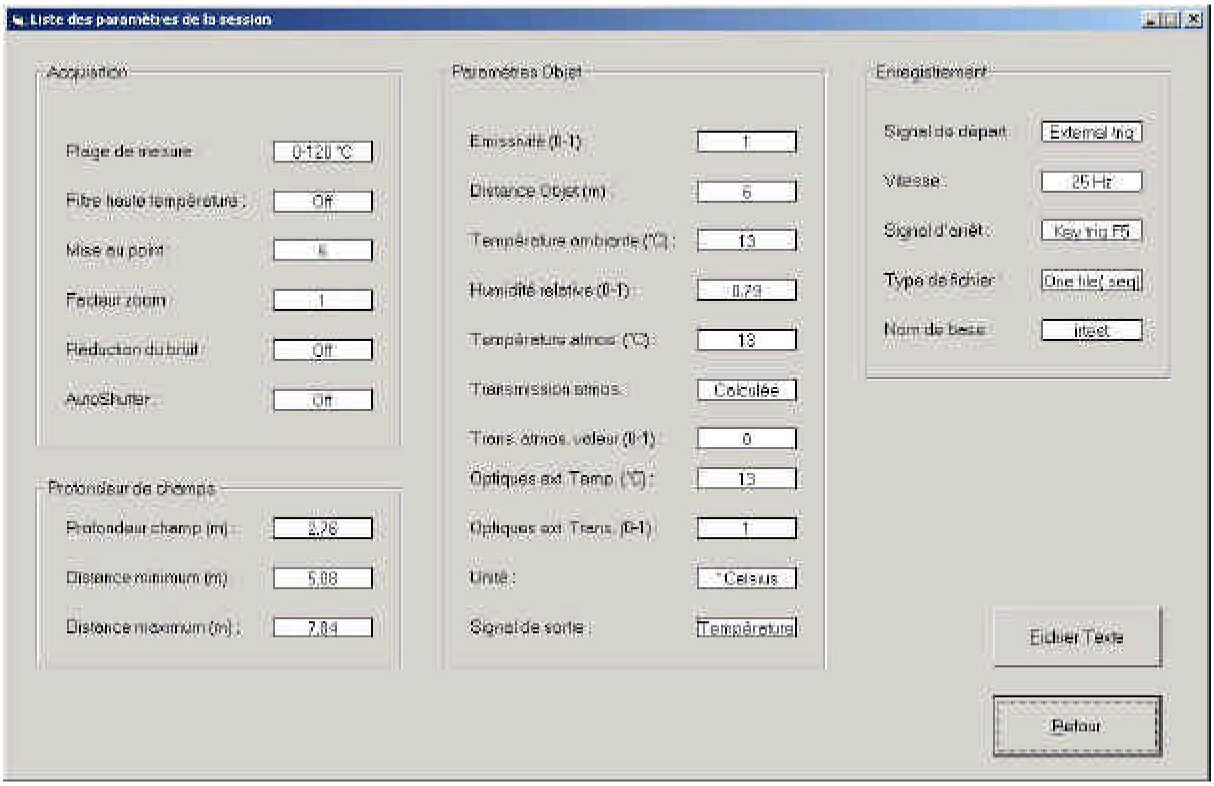



Figure 6-11: Visual Basic application for summarising all the parameters of the session

## 6.5 OTHER INFORMATION

For more information, connect to FLIR web site: [http://www.flir.com](http://www.flir.com)

## 6.6 COMPLETE TECHNICAL INFORMATION

| | | **SC 2000** |
|---|---|---|
| THERMAL IMAGING PERFORMANCE | FIELD OF VIEW/MIN FOCUS DISTANCE | 24° x 18°/0.5 m |
| | SPATIAL RESOLUTION (IFOV) | 1.3 mrad |
| | THERMAL SENSITIVITY (NETD @ 30 C) | 0.1 C° at 30° C |
| | IMAGE FREQUENCY | 50/60 Hz non-interlaced |
| | DETECTOR TIME CONSTANT | 15 msec |
| | ELECTRONIC ZOOM FUNCTION | 4X continuous |
| | DETECTOR | Uncooled microbolometer FPA<br>320 x 240 pixels |
| | SPECTRAL RANGE | 7.5 to 13 µm |
| | FPA OPERATING TEMPERATURE | Room temperature |
| | START UP TIME | < 25 seconds |
| | DIGITIZING RESOLUTION | 14 Bits, 16,384 Levels |
| | IMAGE CORRECTION (NUC) | Internal and external |
| | LENS MOUNT | Bayonet |
| | LENS IDENTIFICATION | Automatic |
| IMAGE PRESENTATION | VIDEO OUTPUT FORMAT | 60hz - RS170 EIA/NTSC or 50hz - CCIR/PAL composite, and 14 bit digital video |
| | DISPLAY | Built-in, high-resolution colour LCD (TFT) viewfinder |
| | COLOR LCD FLAT PANEL EXTERNAL DISPLAY | Optional |
| MEASUREMENT | STANDARD TEMPERATURE MEASUREMENT RANGES | -40 to 120 °C / 80 to 500 °C / 350 to 1500 °C |
| | OPTIONAL TEMP RANGES | 350 to 2000 °C |
| | ACCURACY | +/- 2% or 2 °C |
| | IMAGE TEMPERATURE SPANS | Infinitely variable within a range, automatic or manual |
| | EMISSIVITY & BACKGROUND (AMBIENT) CORRECTION | Variable from 0.01 to 1.0 or select from listings in user-defined materials list |
| | ATMOSPHERIC TRANSMISSION CORRECTION | Automatic based on inputs for distance, atmospheric temperature, and relative humidity |
| | THERMAL READOUTS | °C, °F |
| | AMBIENT TEMPERATURE CORRECTION | Automatic – based on signals from 5 internal sensors |
| | OPTICS CORRECTION | YES, Automatic detection of lens in use |

| | | |
|---|---|---|
| FEATURES | IMAGE PRESENTATION | B/W and Colour |
| | # COLOR PALETTES | 8 |
| | USER DEFINED COLOR PALETTES | YES |
| | SPOTS | 3 movable |
| | AUTOSPOT (locates hottest or coldest pixel) | YES |
| | DELTA TEMPERATURE TO REFERENCE | YES |
| | DUAL SPOT DELTA TEMPERATURE | YES |
| | ISOTHERM: INTERVAL, ABOVE, BELOW, DUAL ABOVE, DUAL BELOW, SEMITRANSPARENT COLOR | YES |
| | PROFILE – HORIZONTAL OR VERTICAL | YES |
| | AREA (MAX; MIN; AVG), BOX OR CIRCLE | 1 |
| | REVERSE IMAGE POLARITY | YES |
| | TEMPERATURE LEVEL & SPAN SETTING | Manual or automatic |
| | CONTINUOUS AUTOMATIC SETTING OF TEMPERATURE LEVEL & SPAN | YES |
| | MANUAL LEVEL AND SPAN ADJUSTMENT | YES |
| | PCMCIA (PC-CARD) FLASH DIGITAL STORAGE CARD DRIVE | YES |
| | PCMCIA FLASH CARD STORAGE CAPACITY | 160 Mb (> 700 thermal images) |
| | THERMAL IMAGE FILE FORMAT | BMP and/or 14 bit digital storage |
| | THERMAL BMP DETAILS | Image only or image with screen graphics |
| | IMAGE ANALYSIS FROM PCMCIA | YES |
| | STORAGE TIME FOR 14 BIT IMAGE | <1.5 seconds |
| | ADJUSTABLE MEASUREMENT PARAMETERS FROM STORED IMAGES | YES |
| | ADJUSTABLE TIMED INTERVAL STORAGE | YES - up to 1 Hz |
| | CONTINUOUS STORAGE AT 5 Hz | Optional – ThermaCAM Researcher RT |
| | CONTINUOUS STORAGE AT 50/60 Hz | Optional – ThermaCAM® Researcher HS |
| | AUTO CAMERA PARAMETER ENCODING | YES – Includes header file with all radiometric data |
| | SAVE / RECALL CAMERA CONFIGURATION | YES |
| | IMAGE FREEZE | YES |
| | MULTI-LANGUAGE MENUS AND UNITS | Italian, English, French, German, Spanish, and Portuguese |
| | RS-232 SERIAL I/O INTERFACE | YES – Breakout box included |
| | REMOTE CONTROL HANDLE | OPTIONAL |
| | RS-232 IMAGE DOWNLOAD CAPABILITY | YES |
| | REMOTE CONTROL SOFTWARE | OPTIONAL – Achieved through ThermaCAM® Researcher |
| | REMOTE FOCUS | YES |
| | UPGRADABLE SYSTEM SOFTWARE | YES |
| | IN-FIELD VOICE ANNOTATION | 30 sec / image |
| | IN-FIELD USER DEFINED TEXT ANNOTATION | Pre-defined text selected and stored with the image. Up to 4 text fields/image |
| EXTERNAL CONNECTIONS | MULTI-FUNCTION CONNECTOR (External power, RS232, Video) | YES |
| | COMPOSITE VIDEO OUTPUT | YES |
| | HEAD-SET CONNECTOR FOR VOICE ANNOTATION | YES |
| | S-VIDEO OUTPUT CABLE | N/A |
| OPERATING ENVIRONMENT | OPERATING TEMP. RANGE | -15 TO +50 °C |
| | STORAGE TEMP. RANGE | -40 TO +70 °C |
| | HUMIDITY | Operating and storage 10 TO 95%, non-condensing |
| | SHOCK RESILENCE | Operational: 25G, IEC 68-2-29 |
| | VIBRATION RESILENCE | Operational: 2G, IEC 68-2-6 |
| | ENCLOSURE/PROTECTION | Metal case, IP54 IEC 529 |
| | EMI/RFI SHIELDING | YES |
| | ESD PROTECTION | YES |
| POWER | AC POWER ADAPTER | 110-240 V 50/60 Hz |
| | OPERATING VOLTAGE | 13 VDC, nominal (11.5 to 16 V) |
| | POWER CONSUMPTION | 13 watts |
| BATTERY SYSTEM | TYPE | 2 NiMh field replaceable |
| | BATTERY OPERATING TIME | 2 hours |
| | BATTERY CHARGING TIME | 1 hour |
| | BATTERY CHARGER | 110-240 VAC 50/60 Hz input, charges 4 NiMh batteries |
| | BATTERY BELT, 8 HOURS OPERATION | Optional |
| DIMENSIONS & WEIGHTS | CAMERA DIMENSIONS WITH STANDARD LENS | 220 x 130 x 140 mm (8.6 x 5.1 x 5.5 in.) |
| | TOTAL WEIGHT | 2.0 kg (4.4 lbs.), excluding battery 2.4 kg (5.3 lbs.) including battery |
| | TRIPOD MOUNT | 1/4"–20 |

# 7 METEOROLOGICAL DATA ACQUISITION SYSTEM

## 7.1 THE SENSORS

### 7.1.1 Wind speed

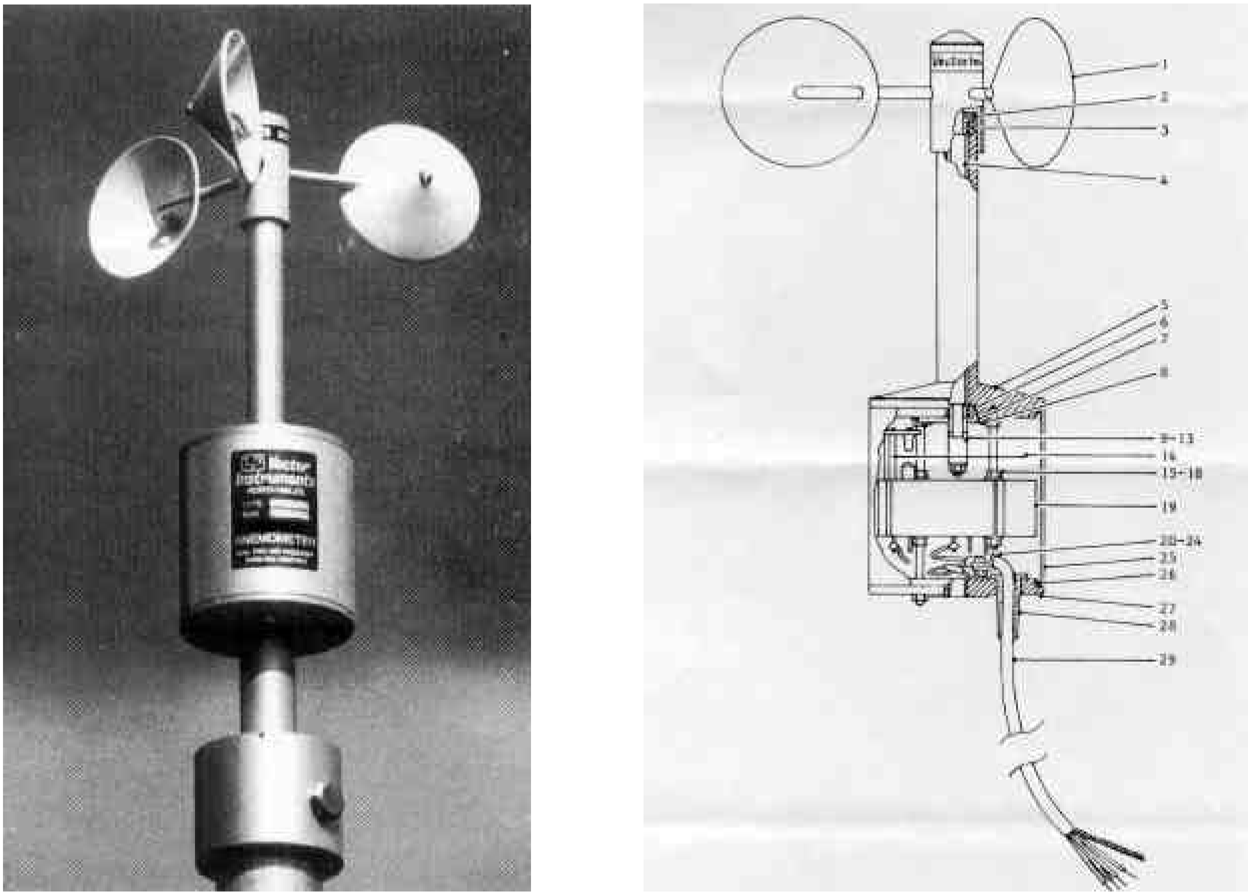



Figure 7-1: Vector anemometer

| | | |
|---|---|---|
| Range of operation | Threshold | 0.3 Kts (starting speed: 0.4 Kts, stopping speed: 0.2 Kts |
| | Maximum wind speed | 150 Kts (75 m/s) |
| | Standard measuring range | 0 to 150 Kts |
| Rotor | Type | R30, 3-cup rotor |
| | Distance constant | 2.3 m, 10% |
| Pulse Output | Rotor speed measurements | By interruption of optical beam |
| | Accuracy | 1% of reading (20 to 110 Kts),<br>up to 2% of reading (110 to 150 Kts), 0.2 Kts (0.2 to 20 Kts) |
| | Non linearity | 0.4% of full range output frequency |
| | Output range | 0 to 1500 Hz for 0 to 150 Kts (10 Hz per Knot) |
| | Resolution | 5.15 cm |
| | 5V pulse output | High 5V 5%, Low <0.2 v, min. load res: 0.2 Kohms<br>Rise/Fall time approx. 25 µs, duty cycle 50% |
| Analogue Output | Nominal Factory Calibration | 0 to 2.5 VDC for 0 to 150 Knots, single ended |
| | Output over range | 5 V 10% |
| | Overall non linearity | 0.9% full range output for 0 to 150 Knots |
| | Temperature coefficient | 2% of output relative to 15°C value (-30 to +40°C) |
| | Response time | 150 ms first order lag typical (as Porton A100) |
| | Effect of supply variation | 0.2% full range over full supply range |
| | Output ripple | Typically 13 mv peak to peak at pulse frequency |
| | Output resistance | Less than 500 Ohms |
| | Recommended load resistance | 1 MOhms for calibrated output, otherwise minimum 5 KOhms |
| General | Operating Temperature range | -30 to +70°C |
| | Supply voltage | 6.5 to 28 VDC |
| | Power-up time | 5 s |
| | Current consumption | 2 mA max, 1.6 mA typical |
| | Standard cable | 3 m log, 6 core screened 7/0.2 mm, PVC insulated |

### 7.1.2 Wind direction

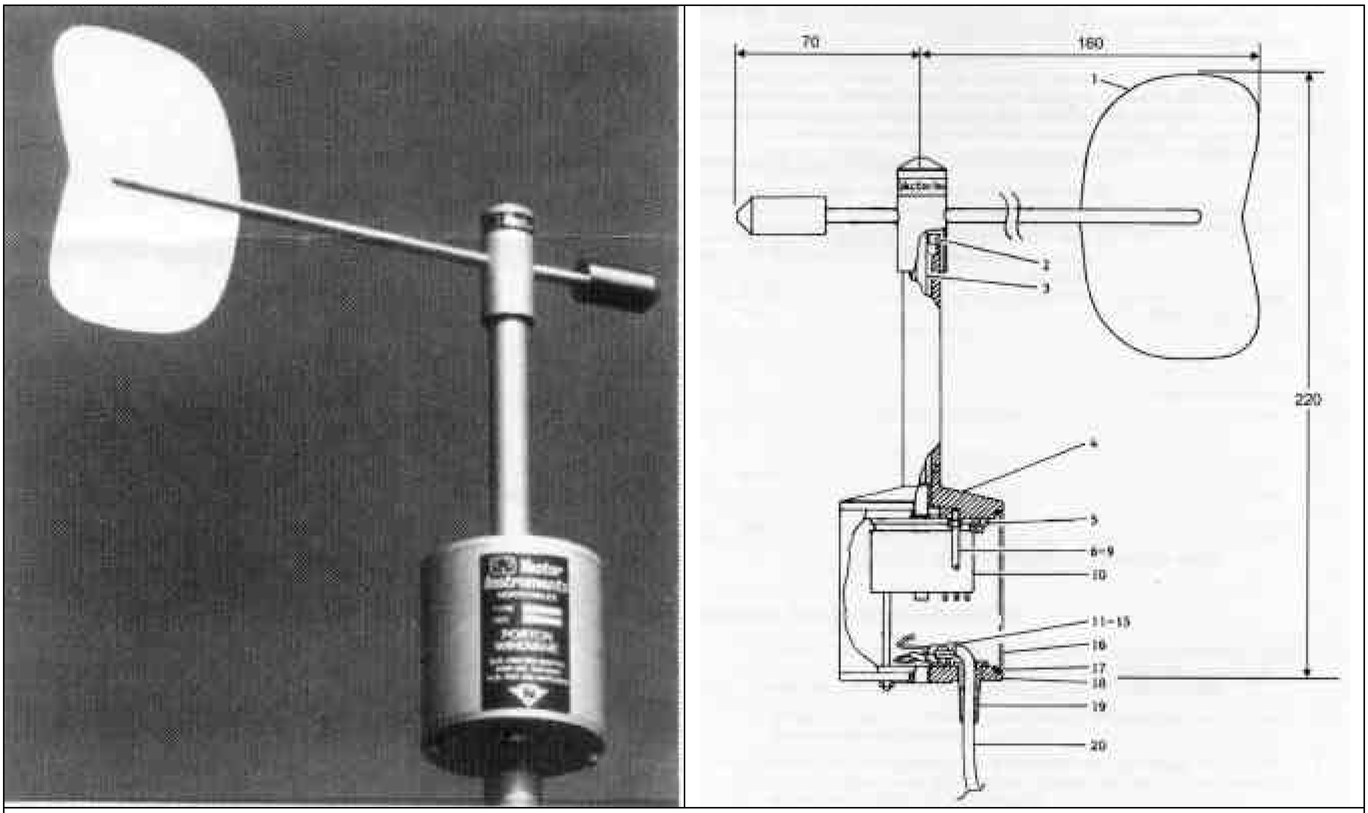
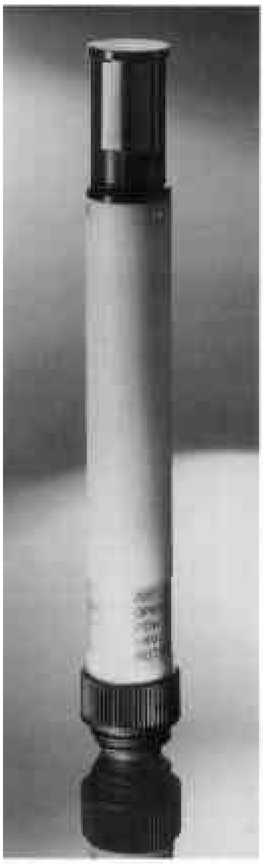



Figure 7-2: Vector wind vane (wind direction)

| | | |
|---|---|---|
| Range of operation | Maximum wind speed | Over 75 m/s (150 Knots) |
| | Range | 360° mechanical angle, full circle continuous rotation allowed |
| | Temperature range | -50 to +70°C |
| Performance | Threshold | 0.6 m/s (1.2 Knot), the vane will commence movement when aligned at 45°C to the flow |
| | Response | Damped natural wavelength: 3.4 m, Damping ratio: 0.2 m, Recovery distance: 0.51 m, Distance constant: 2.3 m |
| | Repeatability | 0.5° vane removed and replaced no measurable backlash movement during use |
| | Life of potentiometer | 5 x $10^{7}$ cycles ( 10 years typical exposure) |
| | Service interval | 4 to 5 years |
| | Accuracy | 3° in steady winds > 5 m/s, 2° obtainable following calibration |
| Electrical | Potentiometer resistance | 1000 Ohms 10% |
| | Maximum dissipation | 0.5 W, -50 to +20°C (de rate linearly to 0.25 W at 70°C |
| | Maximum wiper current | 50 µA, (20 mA absolute max) |
| | Supply voltage | 1 to 5 V (20 V absolute max) |
| | Case to potentiometer voltage | 72 V max (case or screen to any terminal on potentiometer |
| | Insulation resistance | > 50 MOhms |
| | Temperature coefficient of resistance | 50 x $10^{-6}$ per °C |
| | Electrical continuity angle | 357.7° 1.5° (2.3° gap at North) |
| | Electrical variation angle | 356.5° 1.5° (3.5° dead-band) |
| | Resolution | 0.2° |
| | Independent linearity | 0.25% (unloaded) |

### 7.1.3 Air characteristics



**Humidity sensor** ROTRONIC-HYGROMER C94

**Temperature sensor** RTD Pt 100 1/3 DIN

| | Humidity | Temperature |
|---|---|---|
| Operating ranges | 0 to 100 % RH | -40 to +60°C |
| Accuracy at 23°C | 1% RH from 5 to 95% RH, 2%RH if U<5% or U>95% | 0.3°C |
| Reproducibility | <0.5% RH | <0.1°C |
| Long term stability for humidity typical under normal conditions | 1% RH per year | |
| Time constants at 23°C and 1 m/s air movement | <10s | <15s |
| Adjustments points (potentiometers) | 10%, 35%, 80%, 100% limit HMAX | Tmin, Tmax |

### 7.1.4 Data logger Campbell CR10X

7.1.4.1 Desciption

The data logger CR10X is integrated in the portable weather station; a solar panel supplied electric power in order to be able to use the portable weather station everywhere, and specially as close as possible to the experimental plots.

Plugs 1H to 6L are dedicated to analog inputs for differential channels: H and L correspond respectively to high and low tensions.
In case of unipole connections, the measure concerns the difference of tension with the analog mass of the data logger, to 1H and 1L correspond inputs 1 and 2, to 2H and 2L correspond inputs 3 and 4, and so on

Plugs E1, E2 and E3 are excitation outputs and provide programmable tensions for bridge measurements. These tensions can be in AC or DC between –2500 mV and +2500 mV

Plugs P1 and P2 are dedicated for impulses counting, they are programmable too.

Plugs C1 to C8 are dedicated to numerical Inputs/Outputs. As inputs ports, they are use to measure externa signals: high conditions are between 3 and 5.5 V, low conditions are between –0.5 and 0.8 V. As outputs ports, they are used for controlling external devices.

AG plugs are analog mass and used as reference for unipole measurements

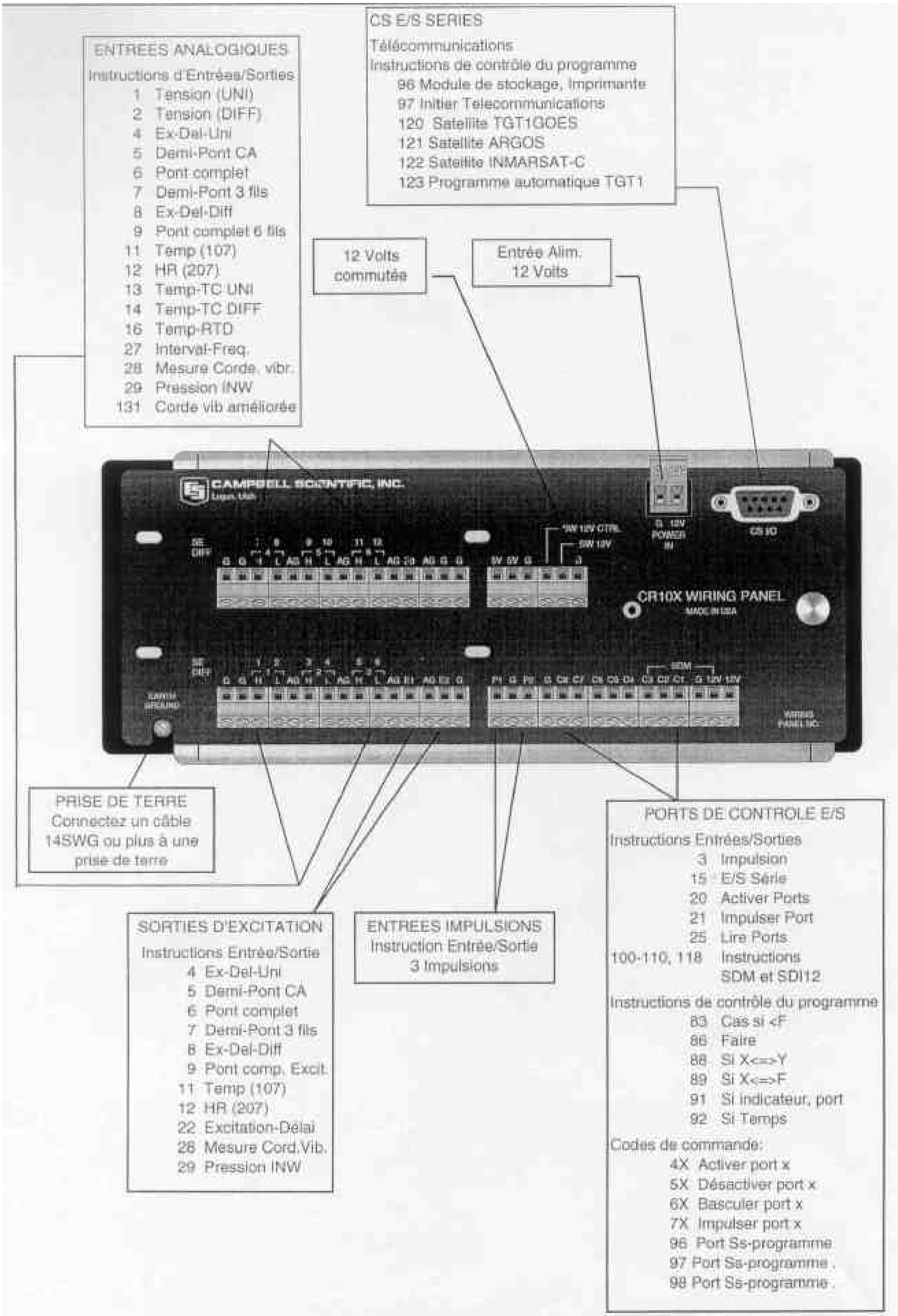
Plus 12V and G (ground) are used to provide electric power to the data logger. The other 12V and G plugs can be used for providing electric power to external devices which accept 12 V. G plugs can also be used for ground connection.

5V outputs are used for providing electric power to devices which accept this tension

Serial Inputs/Outputs port is used for connecting the data logger to the laptop for programming the characteristics of the sensors connected to the data logger and adjust the scan frequency at the required level. It is also used for downloading the data file stored internally.

7.1.4.2 Main specifications

| | |
|---|---|
| **Inputs / Outputs** | |
| Differential Analogue Channels | 6, each can be configured as 2 single ended channels; expandable with multiplexers |
| Maximum Input Voltage | 2500 mV |
| Analogue Voltage Resolution | to 0.33 µV |
| A/D Bits | 13 |
| Input Impedance | 20 GOhms |
| Input Bias Current | 10 nA max |
| Scan Rate | 64 Hz, one measurement with data transfer without interruption |
| Burst Mode | 750 Hz |
| Pulse Channels | 2, switch closure, high frequency square wave or low-level AC sine wave, expansion peripherals available |
| Excitation Channels | 3 switched voltage |
| Excitation voltage | 2500 mV |
| CAO Channels | 0 |
| Digital Ports | 8 I/O |
| Voltage requirements | 9.6 to 16 VDC |
| **Memory** | |
| Program Memory | 16 Kbytes active, 16 Kbytes auxillary |
| Data Storage | 62280 data points |
| Optional Data Memory | 1 million data points |
| **Current Drain** | |
| Quiescent | 1.3 mA typical |
| Processing | 13 mA |
| Measurement | 46 mA |
| **Temperature range** | |
| Standard | -25 to +50°C |
| Extended | -55 to 85°C |


ENTREES ANALOGIQUES
Instructions d'Entrées/Sorties
1 Tension (UNI)
2 Tension (DIFF)
4 Ex-Del-Uni
5 Demi-Pont CA
6 Pont complet
7 Demi-Pont 3 fils
8 Ex-Del-Diff
9 Pont complet 6 fils
11 Temp (107)
12 HR (207)
13 Temp-TC UNI
14 Temp-TC DIFF
16 Temp-RTD
27 Interval-Freq.
28 Mesure Corde. vibr.
29 Pression INW
131 Corde vib améliorée
CS E/S SERIES
Télécommunications
Instructions de contrôle du programme
96 Module de stockage, Imprimante
97 Initier Telecommunications
120 Satellite TGT1GOES
121 Satellite ARGOS
122 Satellite INMARSAT-C
123 Programme automatique TGT1
12 Volts commutée
Entrée Alim. 12 Volts
CAMPBELL SCIENTIFIC, INC.
CR10X WIRING PANEL
MADE IN USA
POWER IN
CS I/O
PRISE DE TERRE
Connectez un câble 14SWG ou plus à une prise de terre
SORTIES D'EXCITATION
Instructions Entrée/Sortie
4 Ex-Del-Uni
5 Demi-Pont CA
6 Pont complet
7 Demi-Pont 3 fils
8 Ex-Del-Diff
9 Pont comp. Excit.
11 Temp (107)
12 HR (207)
22 Excitation-Délai
28 Mesure Cord.Vib.
29 Pression INW
ENTREES IMPULSIONS
Instruction Entrée/Sortie
3 Impulsions
PORTS DE CONTROLE E/S
Instructions Entrées/Sorties
3 Impulsion
15 E/S Série
20 Activer Ports
21 Impulser Port
25 Lire Ports
100-110, 118 Instructions SDM et SDI12
Instructions de contrôle du programme
83 Cas si <F
86 Faire
88 Si X<=>Y
89 Si X<=>F
91 Si indicateur, port
92 Si Temps
Codes de commande:
4X Activer port x
5X Désactiver port x
6X Basculer port x
7X Impulser port x
96 Port Ss-programme
97 Port Ss-programme .
98 Port Ss-programme .