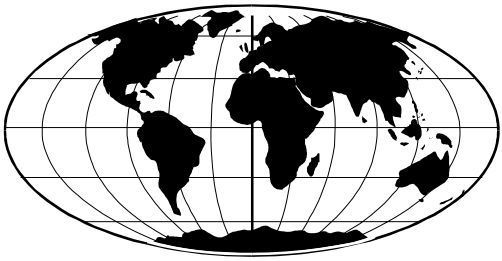
Reflow Tracker
User Manual

for use with

insight software version 1.2

Issue 2



Datapaq is the world's leading manufacturer of process temperature-monitoring instrumentation. The company maintains this leadership by continual development of its advanced, easy-to-use Tracker systems.

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European Community Electromagnetic Compatibility Directive (89/336/EEC)

The following product types manufactured by

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comply with the requirements of the European Community Electromagnetic Compatibility Directive (89/336/EEC)

Products

Datapaq 9000 Thermocouple Data Logger

Standards Applied

EMC Susceptibility	EN50082-1 IEC801-2 (8kV) IEC801-3 (3V/m) IEC801-4 (1kV)
EMC Emissions	EN50081-1 EN55022 Class B

User manuals are available in other languages. Contact Datapaq for details.

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Introduction

Datapaq Reflow Tracker, incorporating Insight software, is a complete system for monitoring the temperature profiles of products within reflow soldering ovens; accurate data acquisition and powerful analysis techniques are combined with flexibility and ease of use. The Reflow Tracker system's power and flexibility make it a perfect tool for process temperature monitoring, from commissioning and troubleshooting to process optimization, ensuring consistent quality of product and maximum efficiency.

Reflow Tracker is equally useful for other soldering applications such as vapor phase, wave solder, curing ovens and rework stations.

Current temperature characteristics can quickly be compared with previously stored reference curves to detect operating abnormalities – and innovative analysis techniques help in identifying problems, fine tuning the process and reducing running costs. The telemetry option allows full monitoring of temperatures in real time while a job is actually passing through the oven.

Powerful printing facilities allow the user to generate and customize reports, including any or all of the analysis results or raw temperature data.

Additionally, the **Rapid Oven Setup** module (if purchased – not covered by this manual), enables users to rapidly and accurately set up their ovens for new products and/or new solder formulations by predicting the recipes that should be used to achieve given temperature profiles.

This manual contains information for all Reflow Tracker users, from novice to experienced. The chapters are arranged in logical order explaining the Reflow Tracker system and the sequence of events in setting up and conducting a temperature profile run. There is also guidance on setting up the Insight software; complete information on using the software is contained in the online Help system available when it is installed.

Software – how to install, remove and run the Insight software.

Hardware – describes the system's data logger, thermal barrier and thermocouple probes.

Running a Temperature Profile – all the stages of obtaining a profile, from positioning probes to downloading the data into the software.

Using Telemetry – using serial (hard-wired) or radio telemetry to see your profile developing as the run is taking place.

Troubleshooting – error messages, and how to test the logger and probes.

Software

Datapaq Insight requires the following minimum computer specification.

- Pentium II™ processor 300 MHz.
- 32 Mb RAM.
- Monitor resolution 1024 × 768, 256 colors; Rapid Oven Setup option (available separately) requires high color (16-bit).
- 20 Mb free hard disk space.
- CD-ROM drive.
- 1 free serial port.
- Microsoft Windows™ 95, Windows 98, Windows NT 4.0 or above, Windows 2000, Windows ME or Windows XP.
- Microsoft Internet Explorer 4 or above.

Installation

When installing in Windows NT, ensure you are in Administrator mode.

For most systems, installation will start automatically on placing the Insight CD in the drive. (If installation does not start, click the Windows Start button and select Run; browse to your CD drive, and run Setup.exe.)

Follow the on-screen instructions. You will need your license number to hand, which is to be found on:

- Your license agreement.
- The inside of the CD case.
- The outside of the system packaging.

Removal

From the Windows Start button menu, select Settings and then Control Panel. Double-click Add/Remove Programs, select Datapaq Insight and click Add/Remove.

Using the Software

Full details on using the Insight software are contained entirely within its online Help system: access this by clicking Help, and then Contents, on Insight's main

menu. Then, within Help, click on Contents headings and topics to expand and read them.

You may also click the Help button in any dialog – or press the F1 key – to bring up help information relevant to the task being performed.

Hardware

The Reflow Tracker system hardware comprises:

- Data logger (including communications lead and charger).
- Thermal barrier.
- Thermocouple probes.

Additionally, if the radio-telemetry option has been purchased:

- Transmitter module for data logger.
- Receiver.

A typical Reflow Tracker system (without radio telemetry) shown with a laptop PC.

Data Logger – the Datapaq 9000

Combining data acquisition and storage and a computer interface in a single housing, the Datapaq 9000 data logger is microprocessor-based and powered by

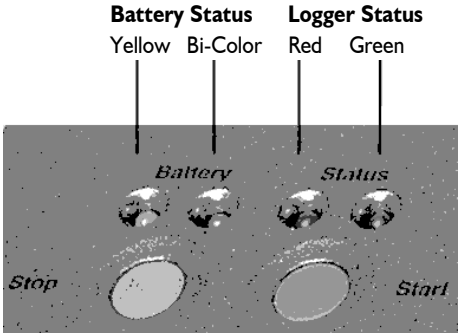
a rechargeable battery. Loggers for type K probes are available in versions with 3, 4 or 6 channels, a low or high temperature measuring range, and narrow or standard width – and for type T probes in 6-channel, standard-width form.

All Datapaq 9000 loggers have on-board storage based on 9,557 points per channel, providing totals of 28,671 points (3-channel logger), 38,228 points (4-channel) or 57,342 points (6-channel); the memory released by unused probes can be re-allocated to the active probes by turning them off in the Insight software. See Appendix 1 (p. 38) for detailed logger specifications, and p. 28 for details of telemetry hardware.

Versions of the Datapaq 9000 data logger.

Logger LEDs

The Datapaq 9000 logger is equipped with two sets of LEDs: two LEDs show the status of the battery, and two show the status of the logger and its memory.



Battery Status LEDs

Yellow	Bi-Color	Meaning
Flashing every 5 seconds	Off	Battery low: recharge now
On	Off	Battery on trickle charge
On	Red	Battery on fast charge
On	Green	Battery fully charged
Flashes 3 times	Off	Hall-effect switch has been triggered at start/end of data acquisition

Logger Status LEDs

Red	Green	Meaning
5 flashes, alternating with green LED	5 flashes, alternating with red LED	Logger successfully reset
Flashing, alternating with green LED, at sample interval	Flashing, alternating with red LED, at sample interval	Logger awaiting trigger
Flashing together with green LED	Flashing together with red LED	Probe 1 is above trigger temperature and cannot trigger, *or* logger is awaiting connection of Hall-effect switch
Off	Flashing at sample interval	Logger acquiring data
Off	Flashes rapidly 5 times	Data transferred from logger to PC
Flashes 5 times	Off	Connection between communications lead and logger has been made
Flashing every second	Off	Serious internal error
Flashing every 5 seconds	Off	Logger has data in memory which have not been downloaded

Communications Lead

An RS232 serial interface cable provides communication between the data logger and your computer.

Battery Charger

Two versions of the battery charger are available: the standard version for off-line data acquisition or hard-wired telemetry; and a low-noise version for radio telemetry. Both can deliver a full charge to the logger's battery in less then 2 hrs.

The battery charger specified for use with radio telemetry may also be used for standard off-line data acquisition or with hard-wired telemetry – but the standard charger ***must not*** *be used when communicating via radio telemetry.*

Battery charger model numbers are as follows:

	Europe	Japan	UK	US
Standard	CH0051A	CH0056	CH0050A	CH0055
Radio telemetry	CH0054A	CH0056	CH0053A	CH0055A

Thermal Barriers

The thermal barrier provides the thermal and mechanical protection necessary for the data logger to survive in the hostile environment of reflow, wave solder, vapor phase (requires thermal barrier TB2004) and curing ovens. Insulation based on ceramic powder covered with a PTFE-coated glass cloth provides the primary thermal protection. A range of barriers is available to fit different loggers and to suit different purposes; see Appendix 2 (p. 41) for detailed specifications.

Part of the range of Datapaq thermal barriers.

Thermocouple Probes

Thermocouple probes utilize the Seebeck effect, discovered in the nineteenth century, by which an emf is produced in any electrically conducting material that is not at uniform temperature. The actual voltage measured is proportional to the temperature difference between the thermocouple's 'hot' and 'cold'

junctions (the hot junction being the measurement junction, and the cold junction being the junction of thermocouple and measurement instrumentation).

The **probe kit** supplied with Datapaq's Reflow Tracker system includes one or both of the following sets of thermocouples:

- Flat, exposed-junction, PTFE-insulated, type K, ANSI MC96.1, higher-accuracy probes
- Flat, exposed-junction, glass-fiber-insulated, type K, ANSI MC96.1, higher-accuracy probes

and

- High-temperature tape.

A typical Reflow Tracker probe kit.

Thermocouple Specifications

Over the years, 'standard' thermocouples have been developed using materials chosen for sensitivity, linearity (consistency of sensitivity over the useful temperature range), price and availability. Current standards include types K, N, R, S and T, each type being identified by its connector color. Type K is the standard thermocouple probe for oven operation.

Probe Type	Temperature Range	Cable Insulation	Accuracy of Probes Supplied by Datapaq
K	-150°C to +1,370°C	Glass fiber or PTFE	0–1,250°C ±1.1°C or ±0.4%, whichever is greater

The presence of a probe on the product adds to the product's thermal mass, changing – however slightly – its rate of heating and cooling. To minimize the probe's thermal mass, and therefore its affect on the product, the type K probes supplied with the Reflow Tracker system are constructed from 0.2-mm wire.

Thermocouple Insulation

The practical operating temperature of the thermocouple probes is limited by the cable insulation material's temperature characteristics.

Probes insulated with **thin glass fiber**, impregnated with a silicone resin binder, are suitable for use at temperatures up to 500°C (932°F) continuously and 700°C (1,292°F) short term and **should be used if the probe cables could come into close proximity with infra-red heating elements**.

PTFE (polytetrafluoroethylene) is a robust, flexible, non-stick material suitable for general use at temperatures up to 260°C (500°F) continuously. It is the standard insulation for Reflow Tracker probes. Having a low thermal mass and therefore a quick response time, PTFE **should not be used when probe cables may be close to infra-red heating elements**.

WARNING

PTFE does not support combustion, but decomposes above 260°C producing small amounts of toxic fumes.

The important products from PTFE thermal decomposition are:

At Temperatures Greater Than	Product
400°C (752°F)	See note *
430°C (806°F)	Tetrafluoroethylene
440°C (824°F)	Hexafluoropropylene
475°C (887°F)	Perfluoroisobutylene
500°C (932°F)	Carbonyl fluoride *, which, in moist air, converts to the acid gas hydrogen fluoride

* May also be produced if PTFE tape is kept at 400°C (752°F) for an extended time.

Health Hazard Data

- Inhalation of decomposition products from PTFE can produce 'polymer fume fever', which has symptoms similar to influenza.
- There is no risk from ingestion or skin contact.
- There are no medical conditions generally aggravated by exposure to PTFE.

Emergency and First-aid Procedures

- If there is accidental contact with PTFE fumes, remove the person concerned to clean air.

Running a Temperature Profile

A temperature profile can be acquired by two means:

- **Without telemetry** – After the logger and product are sent through the oven, data is downloaded from the logger into the PC to be displayed and analyzed by the Datapaq Insight software.
- **Using telemetry** – As the logger gathers data from the product inside the oven, this is transmitted directly to the PC by a hard-wired connection (**serial telemetry**) or by radio transmitter/receiver (**radio telemetry**) . The temperature profile can be watched developing as it happens, i.e. in real time. See p. 27.

This chapter describes all the stages of obtaining a temperature profile for a PCB as it runs through the oven, without telemetry – from how and where to place the probes, to downloading the data into the software, ready to be analyzed.

Before running your PCB and the data logger through the oven you will use the Insight software to reset the logger, i.e. to prepare it for receiving fresh data. After the logger has been retrieved from the oven, you will use Insight again to download the profile data and save it to disk. The stages are as follows.

- Choose positions for and attach the thermocouple probes.
- Setup communication between the data logger and your PC (if this has not already been done for a previous profile run).
- Reset the data logger so that it is ready to receive fresh data; in the process of doing this you will also be able to set the sample collection interval and the method used to trigger the start of data collection, and to check the logger's battery status.
- Install the logger in its thermal barrier.
- Run the PCB and logger/barrier through the oven.
- Download the data from the logger into the Insight software.
- If necessary, set the oven start position within the data.
- Add any additional information that you wish to have recorded with the profile data.

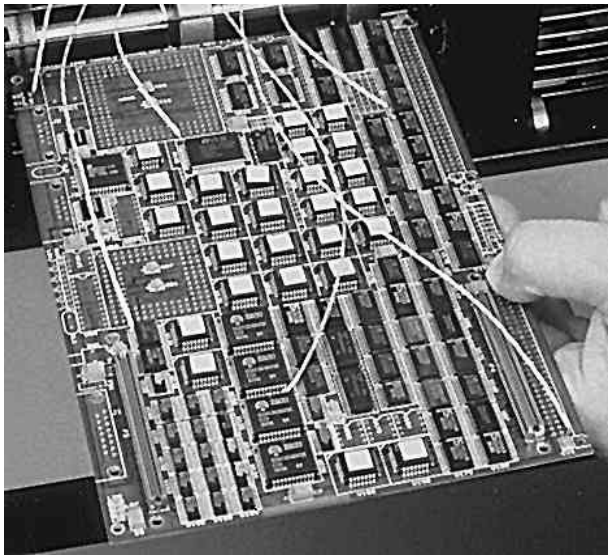
After this, Insight can be used to analyze the profile data as required.

Probe Location

Whatever the method of heating, the thermal mass of the PCB, its tracks and the components attached to them significantly influence the time taken for each physical element to attain a given temperature. Positioning of probes is thus crucial in ensuring that all key parts of the PCB attain reflow temperature.

Main Considerations

- Large ground planes absorb more heat and take longer to achieve reflow temperatures than narrow tracks.
- Large quad flat packs and ball-grid arrays absorb a lot of heat; they are also more susceptible to damage by thermal shock than most other components.
- Large surface-mount devices can shade the tracks to which they are to be soldered.
- The edges of the PCB heat more rapidly than the center.



Probes attached to the PCB and components.

Other Considerations

- Is the track density even? If so, the heating may be more uniform; if not, there may be localized hot and cold spots.
- Is the board double-sided? If so, it may have to go through the oven twice: the bottom of the board must be kept below reflow temperatures or

solderability could be lost, de-wetting experienced, and components could fall off.

- Is it a multi-layer board? If so, it is likely to have more copper and so require more heat, but it may heat more evenly.
- Whether the oven heater elements heat the oven uniformly.
- Where infrared heating is used, the rate of heat absorption is influenced by the color and reflectivity of the material being heated, but it is generally restricted to one side of the PCB.
- Where convection heating is used, heat may be more evenly distributed but it may penetrate to both sides of the PCB.

Typical Probe Locations

- Locations likely to achieve the fastest rate of temperature increase, e.g. board edges and/or locations of components with low thermal mass.
- Locations having a high thermal mass which may require extra time to achieve reflow temperature.
- Locations shaded by large components, i.e. tracks under large quad flat packs and ball-grid arrays which may require extra time to achieve reflow temperature. Note that it may be necessary for cables to exit via a hole to the underside of the PCB.
- The underside of double-sided boards.
- Ideally, to ensure profiling is reliable and repeatable, test samples of each type of PCB with thermocouples permanently attached should be kept specifically for this purpose.

Due to drying and slight changes in color, the test sample PCB's thermal characteristics have a tendency to change slightly each time it passes through the oven. Any obviously discolored boards should be discarded and replaced.

Probe Attachment

Good thermal contact between probe and product is essential if the probe is to reflect accurately the product's temperature. Poor thermal contact will at best result in slowing the rate at which the product heats the probe, and at worst prevent the probe achieving the temperature of the element on which it is mounted.

Good Practice

- Ensure probe tips are clean before attaching them to PCB or component.

- Secure probes along their length to ensure they remain in position, cannot foul elements in the oven, do not thermally shade the product, and will not experience excessive temperatures by being too close to heater elements.
- Use glass fiber insulation when thermocouple cables will be in close proximity to infrared heating elements or experience temperatures in excess of 260°C (500°F).

Methods of Attachment

The following are the chief methods.

High-melting-point Solder

- Gives best repeatability but difficult to perform.
- Recommended for metal-to-metal attachment.

High-melting-point solder is used to attach thermocouples to the legs of components and to PCB tracks. It melts far enough above reflow temperature to ensure that the thermocouple remains in place.

To be successful, any low-melting-point solder must be removed, allowing high-melting-point solder to be applied directly to the metal to be joined. Use as little solder as possible, as follows.

1. Remove any low-melting-point solder. Clean the thermocouple then tin it using high-melting-point solder. Clean the component leg or PCB track to which the thermocouple will be attached. Tin it using high-melting-point solder.
2. Solder the thermocouple in place, using as little high-melting-point solder as is consistent with a satisfactory joint. Ensure the cable lies flat along the PCB.

SMA Adhesive

- Gives good results.
- Much easier to carry out than soldering, but adhesive needs to be cured.

The best results are obtained as follows.

1. Pre-form the thermocouple cable and hold it in place on the PCB with high-temperature tape, ensuring that the thermocouple tip is in good contact with the joint to be measured.
2. Place a small bead of SMA adhesive on the thermocouple tip.
3. Follow the manufacturer's specification to ensure correct curing of the adhesive: most SMA adhesives are heat-cured and this can be achieved by running the PCB once through the oven before the first data-collection run.

High-temperature Adhesive Tape

- A temporary means of holding cables in position on the PCB. For one-off trials only.
- If used in conjunction with aluminum tape, forms a reasonable method of attachment if high-melting-point solder or SMA adhesive cannot be used.

High-temperature (Kapton) tape is recommended as a means of restraining thermocouple cables where they run over the PCB (see below) but not of fixing them to the measuring point. However, attachment is improved by using self-adhesive aluminum tape and deforming it to fit closely around the thermocouple tip; high-temperature tape placed over this will hold it in place during the profile run.

Restraining the Cable

The thermocouple cables must be routed from their points of attachment to the rear of the PCB to enable the data logger to follow the PCB through the oven.

1. Route the thermocouples from their points of attachment to the rear of the PCB.
2. Attach the thermocouple cables to the PCB at intervals, using high-temperature tape.

Communications Setup

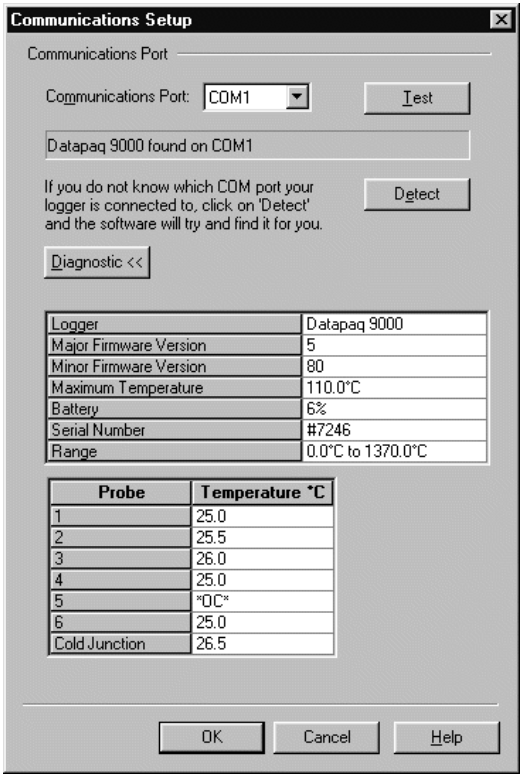
If the data logger is being connected to a PC for the first time, it is necessary to enable communication between them, i.e. to select the communication port to which the logger will be attached.

1. Using the communications lead supplied, connect the data logger to a free COM (serial) port on the PC (to minimize communications problems, connect the lead first to the PC and then to the logger). The red LED on the logger should flash five times to confirm that the connection between the communications lead and the logger has been made.

Typical sources of problems with establishing communication

- **Communications lead not fully inserted –** Check correct sockets are being used.
- **Wrong COM port selected –** Follow the procedure below to select the correct port.
- **Battery not charged –** Recharge the battery, ensuring the charging LEDs are illuminated.
- **Damaged communications lead or connectors –** Check for breaks and other damage. Replace the lead.

2. On the Insight software's menu bar, select Logger > Comms Setup to open the Communications Setup dialog.



The Communications Setup dialog with Diagnostic section expanded.

3. Select the number of the communications port to which the logger is connected, or click Detect to auto-detect it.
4. Click Test.

If the logger is detected, its type and the COM port to which it is connected are displayed.

SHORTCUT

Pressing F4 on the keyboard opens the Communications Setup dialog, looks for the COM port currently in use, and displays the port number and logger type (equivalent to clicking Detect in the dialog).

For more information on the logger in use, click the Diagnostic button which now appears. Additional data shown cover firmware version, maximum

permitted internal logger temperature, battery charge status, serial number and temperature recording range. Current temperature of the probes (updated once a second) is also shown – or open circuit (*OC*) if no probe is attached; the temperature of the thermocouple cold junction is effectively the current internal temperature of the logger.

Resetting the Data Logger

The data logger needs to be reset, as follows, before it can receive fresh data.

The procedure described here uses the Insight software's Logger Reset dialog.

If you are less sure of the process, you can instead use the Logger Reset Wizard to guide you, step-by-step, through this stage of running a profile: click on the Insight toolbar, or select Tools > Wizards from the menu.

Any data stored in the logger but not yet analyzed must be downloaded before proceeding, as resetting the logger will permanently erase all data stored in it.

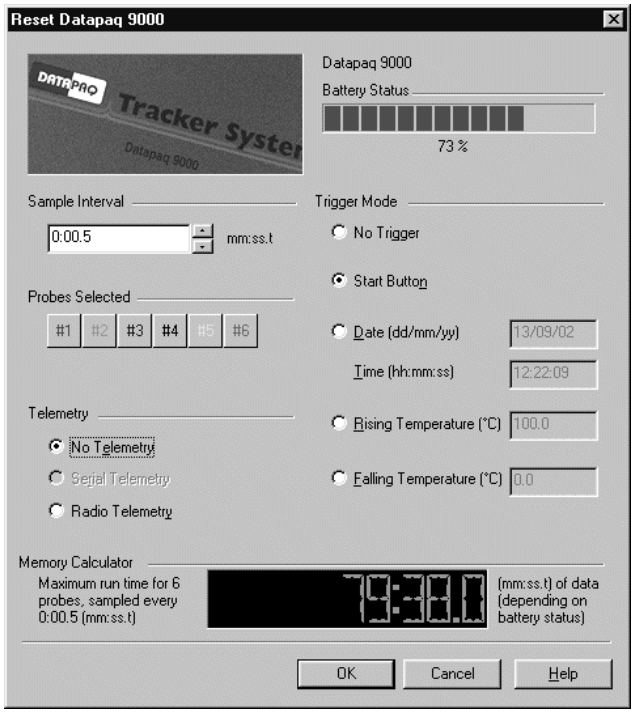
1. Use the communications lead supplied to connect the data logger to a free COM (serial) port on the PC (to minimize communications problems, connect the lead first to the PC and then to the logger). The red LED on the logger should flash five times to confirm that the connection between the communications lead and the logger has been made (if it does not, see 'Communications Setup', p. 19).
2. Open the Logger Reset dialog (click on the Insight toolbar, or press function key F2, or select Logger > Reset from the menu bar) and specify your reset options.

   Sample Interval Set the time which is to elapse between each set (sample) of data points (one data point for each probe) that the logger will collect. The shorter the sample interval the better you will be able to record short-term variations in your temperature regime – but the total recording time available to you will be reduced, and the data will take longer to download to the PC after the run.

   Probes Selected To conserve memory in the logger, click on the relevant buttons to deselect those probes which will not be used. The number of probes available and the logger memory size are dependent on the logger used. *Probe 1 must always be one of those selected.*

   Telemetry Select 'No Telemetry'.

   Memory Calculator Calculates the maximum time for which the logger can collect data, given the sample interval, the number of probes, and the logger's memory size. The time available may be further limited by the level of battery charge.



The Logger Reset dialog set for a run without telemetry.

Battery Status The charge indicator gives both the current percentage of full charge held by the logger battery, and a color-coded report:

GREEN Sufficient charge to perform a run.
YELLOW May be enough charge for a run, but battery getting low.
RED Insufficient battery charge: recharge immediately.

The battery charge level will not be displayed if the logger is on charge: disconnect the charger to verify battery status.

The logger's nickel-metal-hydride batteries discharge slowly even when not in use and will need charging if left for more than three weeks. With the Datapaq 9000 logger a full charge can be completed in two hours.

If in any doubt, abort the procedure by clicking Cancel, and recharge the logger.

Trigger Mode Select here a means to start the logger recording data.

No Trigger Data-recording starts immediately the reset is complete and the communications lead has been disconnected from the logger.

Start Button After reset, data-recording starts when the logger's green start button is pressed and held for 1 second.

Date and Time Data recording starts at a specified date and time. The current date appears by default.

Rising Temperature Data-recording starts when the temperature of probe no. 1 rises to the specified value. (If rising or falling temperature trigger mode is set, the logger records data from the time it is disconnected from the PC – but, once the trigger temperature has been reached, the logger keeps only a maximum of 60 data points before the trigger point and discards any others.)

Falling Temperature Data-recording starts when the temperature of probe no. 1 reaches the specified value as it is falling.

3. After clicking OK, the logger is reset and a message box confirms the sample interval and trigger mode you have set.
4. Disconnect the communications lead from the logger; the logger's status LEDs briefly flash red and green alternately to confirm logger reset.

Installing the Logger in the Thermal Barrier

Ensure the thermal barrier has cooled sufficiently since its last use.

The logger in place in its thermal barrier.

1. Plug the thermocouples into the logger's numbered sockets. If you are using a process file, ensure that the probe/socket numbers on the logger correspond to those used to define probe numbers and locations in that file (see the Insight software for an introduction to process files: press function key F1, or

select Help > Contents from the menu bar, and click the section 'Process Files: Oven, Recipe, Product').

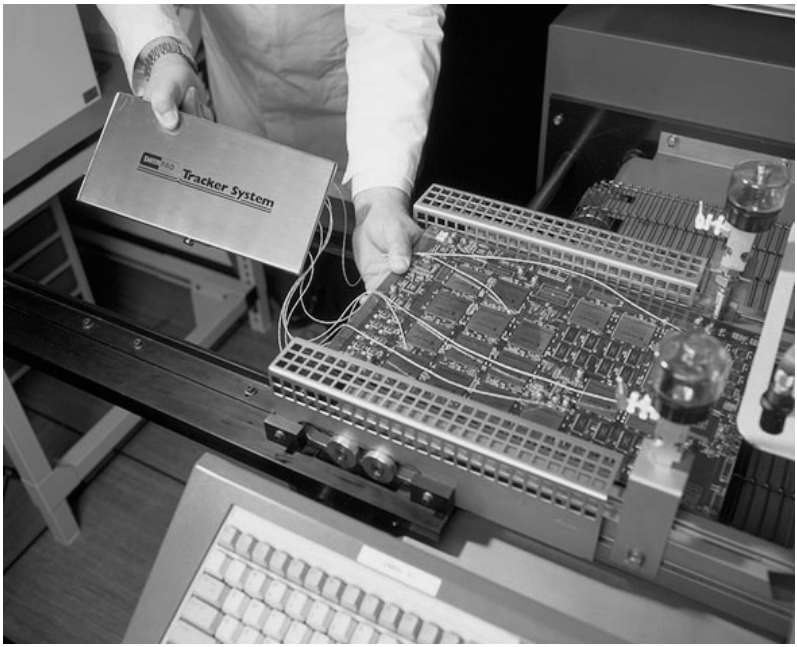
2. Ensure the barrier's mating surfaces are clean and undamaged. A good seal between thermal barrier and thermocouple cables is essential if the data logger is to be protected. Put the logger in place in the barrier, laying the thermocouple cables across the sealing material to exit the barrier at the cutout, ensuring they lie side by side and do not cross other cables.
3. If the trigger mode is Start Button, press and hold the start button for about 1 second until the green LED starts to flash at the sample interval.
4. Close the lid ensuring a good seal around the thermocouple cables.

Placing the System in the Oven

SAFETY

You should discuss the use of the Tracker System with your Health and Safety Officer. Wear appropriate protective clothing.

1. Place the instrumented PCB on the oven's conveyor with the thermocouple cables towards the rear.



An instrumented PCB on its way into the oven (to the right), with the data logger following behind.

2. As the board travels towards the oven feed the thermocouple cables carefully, ensuring they do not foul the oven.
3. Load the logger and thermal barrier onto the conveyor some distance behind the PCB to ensure their thermal mass does not affect the PCB's heating and cooling.

Removing from the Oven and Downloading Data

Recover the system from the oven as soon as the run is over.

*The thermal barrier – and the logger – will be **hot**. Use protective gloves.*

Failure to remove the data logger from the hot thermal barrier could damage the logger.

1. Open the thermal barrier. Placing it on a cold surface will increase its rate of cooling. (An additional thermal barrier should be purchased if insufficient time is available to allow it to cool between test runs.)
2. If data acquisition has to be stopped manually, press and hold the stop button until the red and green status LEDs are on simultaneously. A flashing red LED indicates data stored in the logger but not yet downloaded to the PC.
3. Remove the logger from its thermal barrier and connect it to the PC with the communications lead. The red LED on the logger should flash five times to confirm that the connection between the communications lead and the logger has been made.
4. Open the Logger Download dialog (click  on the toolbar, or press function key F3, or select Logger > Download from the menu bar) and wait while the data is downloaded to the PC. For an explanation of any error messages generated during this process, see Troubleshooting (p. 35).

If you see the message
Logger stopped due to going over temperature
the data logger's maximum-permitted internal temperature has been exceeded, and it may have suffered damage. Contact Datapaq for advice. The reason for the excessive temperature, which may be the result of process operational problems or the use of an inappropriate thermal barrier, must be resolved before further profile runs take place.

5. The Select Process dialog then appears in order that you may choose a **process file** to apply to the results. If the process file and its components have been given names, these are shown when the process file is selected. Click No Process if you do not want to apply a process file.

If you will normally not wish to apply a process file to the results, you can opt not to have the Select Process dialog displayed immediately after a download (from the menu bar, select Tools > Options > Process File); a process file may still be applied subsequently.

6. The newly downloaded data then appear on screen and can be displayed (numerically and graphically), analyzed and printed as you wish; see Insight's online Help system. Save the data as a 'paqfile' (select File > Save or Save As).

You can set alarms to be triggered during a logger download, to warn you of incomplete data recorded during the profile run (from the menu bar, select Tools > Options > Run Alarms).

Specifying Oven Start

If you have not applied a process file, or if the process file you applied did not specify that the **oven start position** be adjusted, you may want to adjust the oven start position now: from the menu bar, select Process > Adjust Oven Start.

This can be valuable as it permits different paqfiles, i.e. data from different temperature profile runs, to be compared with each other. If you do not wish to adjust the oven start at this point, you may still do so at any time subsequently.

For an explanation of oven start, and how to adjust it, click Help in the Adjust Oven Start dialog.

Completing the Documentation

On the menu bar, select Edit > Notes to enter the operator's name and any **additional information** you may wish to record about the profile run. This will be saved with the paqfile and will also appear in your **printed report** (select File > Print Options).

Information about the logger and the data-collection process for the paqfile (including time/date, trigger mode and maximum internal logger temperature) can be seen in the **Paqfile Properties dialog** (select File > Properties, or right-click on the graph and select from the pop-up menu).

*For further features of the **Insight software** – particularly data analysis and the use of process files – see the online Help system (on Insight's menu bar, select Help > Contents).*

Using Telemetry

In addition to the standard off-line analysis, real-time analysis by **hard-wired (serial) telemetry** is a standard feature of Datapaq Insight software in version 1.2 and later. Optional transmitter and receiver modules for the system also allow **radio telemetry** to be used.

Radio-telemetry modules for Reflow Tracker.
1: Receiver 2: Datapaq 9000 data logger 3: Transmitter

Thus, as the logger and PCB pass through the oven, data being gathered by the logger is transmitted directly to the PC, and the temperature profile can be watched developing as data is received, i.e. in real time. Viewing and analyzing the temperature data while, for example, a PCB is being reworked on a rework station, enables decisions to be made as the job is actually in progress.

By following the procedure in this chapter, you will use the Logger Reset and Logger Download dialogs to run a temperature profile using serial or radio telemetry.

After the run is completed, the received data can be saved as a new paqfile. However, as data is also stored internally in the logger during the run, it may be

preferable instead (for a radio-telemetry run) to download the data from logger to PC after the run is finished and to save that as the final paqfile. This means there is less chance of the paqfile having missing data points due to losses in transmission.

Running a profile in real time is performed essentially as is a normal (non-telemetry) run (p. 15), but, in addition:

- *For radio telemetry*, a **transmitter** is fitted to the logger, and a **receiver** is connected to the PC.
- *For serial telemetry*, the **communications lead** is left attached to the logger.
- A **process file** can be applied before the run starts in order that the data can be understood more readily as it appears on screen.
- While the run is in progress, the **real-time display** of incoming data can be customized as preferred, incoming data packets can be checked individually, and the logger's status can be checked.

See 'Running a Temperature Profile' for information on the preparatory stages of **probe location and attachment** (p. 16) and **communications setup** (p. 19).

Changing Transmitter/Receiver Frequency

For detailed **transmitter** specifications, see Appendix 1 (p. 40).

The **receiver** has a signal-strength meter and no external controls. It passes the received telemetry data directly to the PC via the communications lead.

Frequency allocations are defined by national and international regulations. The default frequency may be acceptable, but – if this frequency is already in use by another device in the vicinity, or if the level of interference found during testing is unacceptable – an alternative frequency can be selected. Tuning of transmitter and receiver is carried out by re-setting their internal DIP switches, as follows.

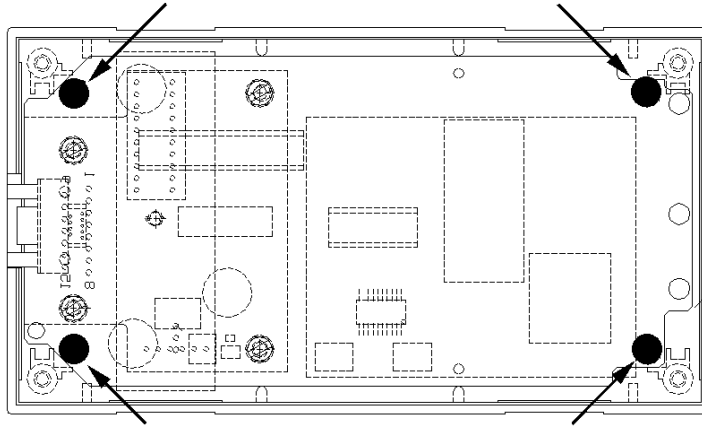
Transmitter and receiver must both be tuned to the same frequency.

Transmitter

1. Carefully remove the 'Remove To Set Freq' label on the underside of the transmitter.
2. Set DIP switches in accord with the new frequency; see tables (below) for the switch settings. *Note that, although transmitter and receiver must be tuned to the same frequency, their DIP switch settings are different*.
3. Attach a new 'Remove To Set Freq' label.

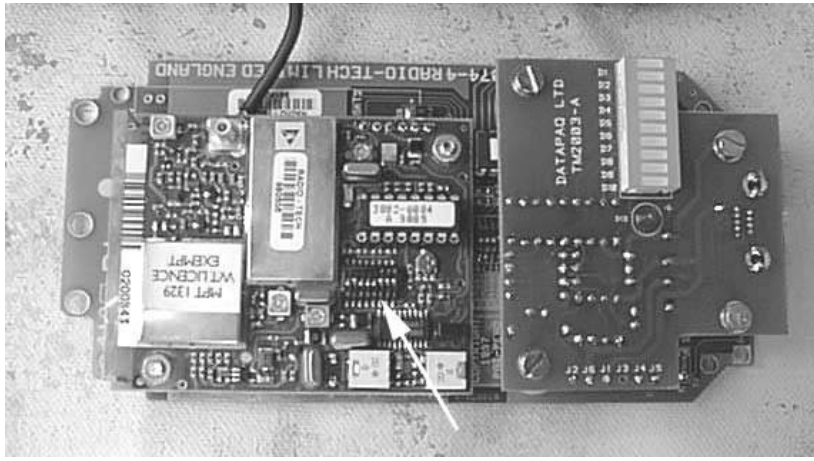
Receiver

1. Unscrew four screws from the base of the receiver and remove its cover.
2. Remove the four PCB retaining screws and carefully rotate the PCB.



Receiver with cover removed showing the four PCB retaining screws.

3. Set DIP switches in accord with the new frequency; see tables (below) for the switch settings. *Note that, although transmitter and receiver must be tuned to the same frequency, their DIP switch settings are different.*



The receiver's PCB: the bank of DIP switches is arrowed.

4. Re-assemble the receiver.

Frequencies available for use in EUROPE and their DIP switch settings
Settings for the transmitter (Tx) and receiver (Rx) are shown separately.

Frequency (MHz)		DIP Switch Settings							
		1	2	3	4	5	6	7	8
433.075	Tx	OFF	ON	ON	ON	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	ON	ON	OFF	ON
433.100	Tx	OFF	ON	OFF	ON	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	ON	OFF	OFF	ON
433.125	Tx	OFF	ON	ON	OFF	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	OFF	ON	OFF	ON
433.150	Tx	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	OFF	OFF	OFF	ON
433.175	Tx	OFF	ON	ON	ON	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	ON	ON	OFF	ON
433.200	Tx	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	ON	OFF	OFF	ON
433.225	Tx	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	OFF	ON	OFF	ON
433.250	Tx	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	OFF	OFF	OFF	ON
433.275	Tx	OFF	ON	ON	ON	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	ON	ON	OFF	ON
433.300	Tx	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	ON	OFF	OFF	ON
433.325	Tx	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	OFF	ON	OFF	ON
433.350	Tx	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	OFF	OFF	OFF	ON
433.375	Tx	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	ON	ON	OFF	ON
433.400	Tx	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	ON	OFF	OFF	ON
433.425	Tx	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	OFF	ON	OFF	ON
433.450	Tx	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	OFF	OFF	OFF	ON

Frequencies available for use in USA and their DIP switch settings
Settings for the transmitter (Tx) and receiver (Rx) are shown separately.

Frequency (MHz)		DIP Switch Settings							
		1	2	3	4	5	6	7	8
464.100	Tx	ON	ON	ON	ON	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	ON	OFF	OFF	ON
464.125	Tx	ON	ON	OFF	ON	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	OFF	ON	OFF	ON
464.150	Tx	ON	ON	ON	OFF	ON	ON	OFF	OFF
	Rx	ON	ON	ON	ON	OFF	OFF	OFF	ON
464.175	Tx	ON	ON	OFF	OFF	ON	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	ON	ON	OFF	ON
464.200	Tx	ON	ON	ON	ON	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	ON	OFF	OFF	ON
464.225	Tx	ON	ON	OFF	ON	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	OFF	ON	OFF	ON
464.250	Tx	ON	ON	ON	OFF	OFF	ON	OFF	OFF
	Rx	ON	ON	ON	OFF	OFF	OFF	OFF	ON
464.275	Tx	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
	Rx	ON	ON	OFF	ON	ON	ON	OFF	ON
464.300	Tx	ON	ON	ON	ON	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	ON	OFF	OFF	ON
464.325	Tx	ON	ON	OFF	ON	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	OFF	ON	OFF	ON
464.350	Tx	ON	ON	ON	OFF	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	ON	OFF	OFF	OFF	ON
464.375	Tx	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	ON	ON	OFF	ON
464.400	Tx	ON	ON	ON	ON	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	ON	OFF	OFF	ON
464.425	Tx	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	OFF	ON	OFF	ON
464.450	Tx	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
	Rx	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
464.475	Tx	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
	Rx	ON	OFF	ON	ON	ON	ON	OFF	ON

Resetting the Logger for a Run Using Telemetry

The data logger needs to be reset, as follows, before it can receive fresh data.

The procedure described here uses the Insight software's Logger Reset dialog.

If you are less sure of the process, you can instead use the Logger Reset Wizard to guide you, step-by-step, through this stage of running a profile: click on the Insight toolbar, or select Tools > Wizards from the menu.

Any data stored in the logger but not yet analyzed must be downloaded before proceeding, as resetting the logger will permanently erase all data stored in it.

1. *For a radio telemetry run only*, ensure that a transmitter is fitted to the logger: the transmitter module plugs into the end of the data logger, and is attached by two screws using the tool provided.
2. Use the communications lead supplied to connect the data logger to a free COM (serial) port on the PC (to minimize communications problems, connect the lead first to the PC and then to the logger). The red LED on the logger should flash five times to confirm that the connection between the communications lead and the logger has been made (if it does not, see 'Communications Setup', p. 19).
3. Connect the power supply (battery charger) to the communications lead, at the lead's connection near the COM port of the computer, and plug the power supply into a mains socket.

The battery charger used during radio telemetry must be the low-noise version (see p. 11).

4. Open the Logger Reset dialog (click on the Insight toolbar, or press function key F2, or select Logger > Reset from the menu bar), select serial or radio telemetry and specify your other reset options (see p. 21).
5. After clicking OK, the logger is reset and a message box confirms the sample interval and trigger mode you have set.
6. *For a serial telemetry run*, leave the communications lead connected to the logger, and click OK.
   For a radio telemetry run, disconnect the communications lead from the logger and connect it to the receiver which should be placed within 30 m of the logger/transmitter; the logger's red and green status LEDs then briefly flash alternately to confirm logger reset; click OK.
7. The Select Process dialog then appears in order that you may choose a process file to apply to the results. If the process file and its components have

been given names, these are shown when the process file is selected in the list. Click 'No Process' if you do not want to apply a process file. (A process file allows you to see the temperature profile in relation to the oven zones as the profile appears on screen during the run. See the Insight software for an introduction to process files: press function key F1, or select Help > Contents from the menu bar, and click the section 'Process Files: Oven, Recipe, Product'.)

Install the logger in the thermal barrier and **place the system in the oven** as described on p. 23.

Real-time Display During the Run

After the first few data packets have been received, the data starts to be displayed in the Graph and Analysis Windows, scrolling in real time as new data is received. You may change the way the data is displayed with the Axes tab of the Graph Options dialog (from the right-click menu, or from the main menu select View > Graph Options): under Telemetry, specify how much of the recently received data is displayed, and whether you wish to see only a certain temperature (y-axis) range, centered on a the latest data.

You may **zoom** the display as when viewing a paqfile (see the online Help system), except that:

- Double-clicking on the graph (or selecting Real Time Zoom from the View menu or right-click menu) shows only the most recently received portion of the data on the scrolling graph (see above).
- Saved zoom modes are not available.

If the **y-axis** is not set to be centered (see above), the default y-axis zoom changes as more data is received, in order to accommodate all received data.

To **move the graph** across the viewing area, hold Shift and drag the mouse pointer.

You may overlay one or more **tolerance curves** on the graph to compare with the data as it is being received (select View > Overlay). Other paqfiles cannot be overlaid.

You may adjust the **oven start** position while a real-time run is in progress (select Process > Adjust Oven Start).

Calculations shown in the **Analysis Window** for the chosen data analysis mode update continuously as new data is received. As for non-real-time runs, calculations are performed only on the currently zoomed area shown on the graph. However, if the graph is scrolling and showing just the most recently

received portion of the results, the analysis calculations will be performed as if on the full zoom view.

If you wish to **view another paqfile** while the logger is in listen mode, i.e. while data is being received and viewed in real time, you must first stop real time mode (see 'Ending the Run', below).

While the run is in progress, you may use the **Real Time Tool** dialog to check the individual data packets as they are received, as well as the status of the logger (click  on the toolbar, or select View > Real Time Tool).

Ending the Run

You may wish to **end data-collection** when the logger is removed from the oven – or, by selecting Logger > Stop Real Time Mode, you may end or pause it while a telemetry run is still in progress. Data then continues to be collected by the logger, but it is no longer received in real time by Insight (download from the logger after the run is finished to retrieve the full data). The graphical and numerical data received up to that point remain on screen, available for viewing and analysis, and can be saved as a paqfile.

While the logger is still transmitting, you may **resume the collection of transmitted data** (select Logger > Logger Listen Mode). After the first few data packets have been received, the data starts to be displayed in the Graph and Analysis Windows. This second bout (and any subsequent bouts) of data-collection can also be ended and saved as a separate paqfile, as above.

If **Autosave** is enabled (select Tools > Options > General), the data being gathered is automatically saved periodically during a telemetry run. If the system fails during the run, the last-autosaved version of the data is displayed automatically when Insight is next run, and you may then choose to save it as a paqfile.

When the run is complete, **remove the logger from the oven and download the data**, as described on p. 24 (for a serial-telemetry run, instead of downloading the data stored in the logger, it should be adequate simply to save the data already received as a new paqfile).

Troubleshooting

Logger Communications Problems

- **Communications lead not fully inserted:** check correct sockets are being used.
- **Wrong COM port selected:** see Communications Setup (p. 19) to select the correct port.
- **Battery not charged:** recharge the battery, ensuring the charging LEDs are illuminated.
- **Damaged communications lead or connectors:** check for breaks and other damage; replace the lead.

Logger Download Error Messages

Error Message	Action
There are insufficient readings in the logger	Check trigger set point (time or temperature) Check data logger's battery for charge Check date/time settings on computer Check probes and their connections Reset logger and test probes (see 'Logger Diagnostics', p. 36)
Logger stopped due to going over temperature *	The logger's maximum-permitted internal temperature has been exceeded and it may have suffered serious damage: contact Datapaq for advice
Logger stopped due to low battery *	Replace or recharge the battery as appropriate, then repeat the profile run
Logger memory full	Data collection may have stopped before the run was completed: check the data collection period and sample interval before resetting the logger for another run (see 'Resetting the Data Logger', p. 21)

* Only if these alarms have been enabled (from the Insight menu bar, select Tools > Options > Run Alarms). Details of the alarm triggered will also appear on an Alarms tab in Insight's Analysis Window.

Checking the Data

Thermocouple probes are generally reliable, but damage resulting from inappropriate use or handling can produce erroneous readings. If you suspect that invalid data may have been introduced into your temperature profile (paqfile), select the View Data tab in the Insight software's Analysis Window to view the raw data as downloaded from the logger. The various types of invalid data which may be contained in a paqfile are shown in the analysis grid as follows.

OC	Open circuit.
NA	Data not available.
LO	Temperature measured was below the range of the logger.
HI	Temperature measured was above the range of the logger.
BZ	Data marker introduced by Hall-effect switch.
***	Calculation cannot be performed (not necessarily because the data are invalid). Does not appear in View Data analysis mode.

Probes with an intermittent open circuit may produce spiky, erratic profiles. Note that spikes are inevitable when probes are disconnected from a running data logger. Typical causes of invalid or interrupted data are:

- Start or stop trigger at the oven entrance or exit did not work. (See the *Rapid Oven Setup User Manual* for the setting-up of Hall-effect switch trigger magnets on the oven; in particular, check that the yellow logger LEDs flash when the switch passes the magnets – and ensure that, in the course of checking, the logger does not pass through the oven unprotected by its thermal barrier.)
- Thermocouple becoming detached from the logger.
- Faulty connection.

Readings which are inconsistent with those of other probes may be caused by a short circuit (see 'Logger Diagnostics', p. 36). The probe concerned must be replaced.

Logger Diagnostics

Running the data logger diagnostics provides information on the status of the logger and the means to test the thermocouple probes. Short circuits and open circuits may be revealed: these are sometimes intermittent, and can be a function of temperature and/or rate of change of temperature, or caused by bending the probe cable.

1. Connect the data logger to the PC (to minimize communications problems, connect the lead first to the PC and then to the logger). The red LED on the logger should flash five times to confirm that the connection between the communications lead and the logger has been made.
2. Connect a full set of thermocouple probes to the logger, leaving them at ambient temperature.
3. On the Insight software's menu bar, select Logger > Comms Setup to open the Communications Setup dialog.
4. Select the number of the communications port to which the logger is connected, or click Detect to auto-detect it.
5. Click Test.

6. If the logger is detected, the Diagnostic section of the dialog appears (see p. 20). The Temperature list box identifies all available probe channels, the indicated temperature or status, and the temperature of the internal cold junction.
7. Check that all probes are indicating the same temperature. Replace any showing *OC* (open circuit), or having inconsistent readings indicating an intermittent short circuit.
8. Place the probes into a bowl of hot water and check that all probes show a similar increase in temperature. Replace any showing ambient temperature as this indicates a short circuit. If any probe shows a temperature significantly less than ambient its plug may be incorrectly oriented in the logger socket.
9. Click OK to close the dialog.

Printing Problems

- Check correct printer selected: on menu bar, select File > Print Setup.
- Check printer cable connections.

Appendix 1: Data Logger Specifications – Datapaq 9000

Due to continuing product development, specifications of existing products are subject to change and additional products will become available. Contact Datapaq for latest information.

Data Loggers for Type K Probes

Low Range (-150 to +500°C), 4-channel

	Model DP9042A
Channels	4
Sample interval [1]	0.1–600 s
Time to fill memory [2]	From 200 s to battery limit (max. 100 hrs)
Accuracy	±1°C
Resolution	0.5°C
Manual trigger	Yes
Time trigger	Yes
Rising temperature trigger	Yes
Falling temperature trigger	No
Pre-trigger data stored	Yes
Memory capacity	8,000 data points
Battery	Rechargeable NiMH [3]
Battery life	Up to 100 hrs [2]
Length	149 mm (5.87 inches)
Width	106 mm (4.17 inches)
Height	12 mm (0.47 inches)

Low Range (-150 to +500 °C), Standard and Narrow Widths

	Standard Width **Model DP9061A**	***Narrow Width*** **Model DP9161A**
Channels	6	6
Sample interval [1]	0.1–600 s	0.1–600 s
Time to fill memory [2]	From 15 mins 55 s to battery limit (max. 100 hrs)	From 15 mins 55 s to battery limit (max. 100 hrs)
Accuracy	±1°C	±1°C
Resolution	0.5°C	0.5°C
Manual trigger	Yes	Yes
Time trigger	Yes	Yes
Rising temperature trigger	Yes	Yes

	Standard Width **Model DP9061A**	*Narrow Width* **Model DP9161A**
Falling temperature trigger	Yes	Yes
Pre-trigger data stored	Yes	Yes
Memory capacity	57,342 data points	57,342 data points
Battery	Rechargeable NiMH [3]	Rechargeable NiMH [3]
Battery life	Up to 100 hrs [2]	Up to 100 hrs [2]
Length	149 mm (5.87 inches)	165 mm (6.5 inches)
Width	106 mm (4.17 inches)	57 mm (2.24 inches)
Height	12 mm (0.47 inches)	21 mm (0.83 inches)

High Range (0 to +1,370°C), Standard Width

	Model DP9064A
Channels	6
Sample interval [1]	0.1–600 s
Time to fill memory [2]	15 minutes 55 seconds to battery limit (max. 100 hrs)
Accuracy	±1°C
Resolution	0.5°C
Manual trigger	Yes
Time trigger	Yes
Rising temperature trigger	Yes
Falling temperature trigger	Yes
Pre-trigger data stored	Yes
Memory capacity	57,342 data points
Battery	Rechargeable NiMH [3]
Battery life	Up to 100 hours [2]
Length	149 mm (5.87 inches)
Width	106 mm (4.17 inches)
Height	12 mm (0.47 inches)

High Range (0 to +1,370 °C), Narrow Width

	Model DP9037A	**Model DP9069A**
Channels	3	6
Sample interval [1]	0.1–600 s	0.1–600 s
Time to fill memory [2]	From 15 mins 55 s to battery limit (max. 100 hrs)	From 15 mins 55 s to battery limit (max. 100 hrs)
Accuracy	±1°C	±1°C
Resolution	0.5°C	0.5°C
Manual trigger	Yes	Yes
Time trigger	Yes	Yes
Rising temperature trigger	Yes	Yes
Falling temperature trigger	Yes	Yes
Pre-trigger data stored	Yes	Yes

	Model DP9037A	Model DP9069A
Memory capacity	28,671 data points	57,342 data points
Battery	Rechargeable NiMH [3]	Rechargeable NiMH [3]
Battery life	Up to 100 hours [2]	Up to 100 hours [2]
Length	236 mm (9.29 inches)	165 mm (6.5 inches)
Width	57 mm (2.24 inches)	57 mm (2.24 inches)
Height	12 mm (0.47 inches)	21 mm (0.83 inches)

Data Logger for Type T Probes

Range -190 °C to +400°C

	Model DP9066A [4]
Channels	6
Sample interval [1]	0.1–600 s
Time to fill memory [2]	From 3 mins to battery limit (max. 100 hrs)
Accuracy	±1°C
Resolution	0.5°C
Manual trigger	No
Time trigger	Yes
Rising temperature trigger	Yes
Falling temperature trigger	Yes
Pre-trigger data stored	Yes
Memory capacity	57,342 data points
Battery	Rechargeable NiMH [3]
Battery life	Up to 100 hours [2]
Length	149 mm (5.87 inches)
Width	106 mm (4.17 inches)
Height	12 mm (0.47 inches)

Notes

[1] 0.2 seconds to 10 minutes for hard-wired and radio real-time data acquisition.

[2] Dependent on sample interval.

[3] Nickel-metal-hydride.

[4] Telemetry possible by hard-wired (serial) connection only.

Transmitter

Frequency — EU 433.075–433.450 MHz; USA 464.100–464.475 MHz

Effective radiated power — 10 mW

Range — 200 m in open space, typically 30 m when in oven

Temperature range — 0–105°C (32–221°F)

Humidity — 85% RH non-condensing

Approved to national specifications:

EU I-ETS-300-220

USA FCC part 90, 1996, clause 90.217

Appendix 2: Thermal Barrier Specifications

Due to continuing product development, specifications of existing products are subject to change and additional products will become available. Contact Datapaq for latest information.

Barriers for DP9037A Data Logger (3-channel)

TB2006

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	20.5	12	10	9	8.5			

Dimensions Height 25 mm (0.98 inches) Width 78 mm (3.07 inches)
Length 302 mm (11.89 inches) Weight 0.65 kg (1.43 lbs)

TB2007

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	7.5	5.5	4.5	4				

Dimensions Height 18 mm (0.71 inches) Width 75 mm (2.95 inches)
Length 286 mm (11.26 inches) Weight 0.50 kg (1.10 lbs)

TB2011

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)			4					

Dimensions Height 16 mm (0.63 inches) Width 75 mm (2.95inches)
Length 286 mm (11.26 inches) Weight 0.30 kg (0.66 lbs)

Barriers for DP9042A, DP9061A and DP 9064A Data Loggers

TB2001

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	20.5	12	10	9	8.5			

Dimensions Height 25 mm (0.98 inches) Width 135 mm (5.31 inches)
Length 216 mm (8.50 inches) Weight 0.70 kg (1.54 lbs)

TB2002

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	7.5	5.5	4.5	4				

Dimensions Height 18 mm (0.71inches) Width 134 mm (5.28 inches)
Length 204 mm (8.03 inches) Weight 0.60 kg (1.32 lbs)

TB2003

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	45	25	20	18	15			

Dimensions Height 40 mm (1.57 inches) Width 162 mm (6.38 inches)
Length 216 mm (8.50 inches) Weight 1.45 kg (3.20 lbs)

TB2004

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	20.5	12	10	9	8.5			

Dimensions Height 25 mm (0.98 inches) Width 147 mm (5.79 inches)
Length 211 mm (8.31 inches) Weight 1.30 kg (2.87 lbs)

TB2015

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	24	14	11	9.5	8.5			

Dimensions Height 25 mm (0.98 inches) Width 133 mm (5.24 inches)
Length 210 mm (8.27 inches) Weight 0.70 kg (1.54 lbs)

TB2016

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	11	7	4	3.5	2			

Dimensions Height 18 mm (0.71inches) Width 133 mm (5.24 inches)
Length 210 mm (8.27 inches) Weight 0.55 kg (1.21 lbs)

TB2017A – for radio telemetry

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	24	14	11	9.5	8.5			

Dimensions Height 25 mm (0.98 inches) Width 132 mm (5.19 inches)
Length 259 mm (10.21 inches) Weight 0.85 kg (1.87 lbs)

TB2018A – for radio telemetry

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	11	7	4	3.5	2			

Dimensions Height 18 mm (0.71 inches) Width 131 mm (5.16 inches)
Length 259 mm (10.21 inches) Weight 0.75 kg (1.65 lbs)

Barriers for DP9161 and DP9069 Data Loggers

TB2008

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	7.5	5.5	4.5	4				

Dimensions Height 30 mm (1.18 inches) Width 75 mm (2.95inches)
Length 231 mm (9.09 inches) Weight 0.50 kg (1.10 lbs)

TB2009

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	20.5	12	10	9	8.5			

Dimensions Height 36 mm (1.42 inches) Width 83 mm (3.27 inches)
Length 235 mm (9.25 inches) Weight 0.70 kg (1.54 lbs)

TB2019A – for radio telemetry

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	11	7	4	3.5	2			

Dimensions Height 28 mm (1.10 inches) Width 84 mm (3.31 inches)
Length 324 mm (12.76 inches) Weight 0.65 kg (1.43 lbs)

TB2020

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	11		4	3.5	2			

Dimensions Height 28 mm (1.10 inches) Width 84 mm (3.31 inches)
Length 223 mm (8.78 inches) Weight 0.50 kg (1.10 lbs)

TB2021

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	24	14	11	9.5	8.5			

Dimensions Height 35 mm (1.38 inches) Width 84 mm (3.31 inches)
Length 223 mm (8.78 inches) Weight 0.65 kg (1.43 lbs)

TB2022A – for radio telemetry

Temperature (°C)	100	150	200	250	300	400	500	800
Duration (minutes)	24	14	11	9.5	8.5			

Dimensions Height 35 mm (1.38 inches) Width 84 mm (3.31 inches)
Length 324 mm (12.76 inches) Weight 0.70 kg (1.54 lbs)

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