HBC-43
Hot Bonding Controller

Operators Manual

May, 2006

Note:

Throughout this manual, several important keys have been referred to by an abbreviation.
i.e. ¿ Refers to the Enter key
[ESC] Refers to the Escape key
‾, -, ¬ & ® Refers to the Cursor keys

Once you are familiar with the HBC-43 software, it will only be necessary to be prompted with a brief description of each of the operations to get the heat cycle going.
For further details on each topic, follow the chapter headings or references.

1.   Heaters and thermocouples (Chapter 5)

1.1   *Place as many thermocouples and heaters on the patch area as required. Note which heaters and thermocouples are associated.*
1.2   *Connect all thermocouples to the input connectors.*
1.3   *Connect the heater power leads to the power outlet sockets.*

2.   Cable connections (Chapter 4)

2.1   *Connect the 3-phase or single phase power lead to the master power input socket and zones 4-6 power if necessary.*
2.2   *Turn on the circuit breakers for all the heater zones that are connected (Always include #1, Master)*
2.3   *Connect the power leads to the computer power pack.*
2.4   *Plug the power pack into the computer.*
2.5   *Connect the "Computer" lead from the control case to the computer serial port.*
2.6   *Connect the printer lead from the computer to the printer (optional).*

3.   Turn on the main supply power switch on the wall.

4.   Turn on the computer and start the HBC-43 program.

*Enter your **operator name** and **password**. If starting the program for the first time the Operator name will be "Default" and the password will be "password".*

5.   Select a heat cycle. (Chapter 6)

*Edit a pre-designed cycle if necessary from the **Zone Temperature Profiles** screen (**Control Functions Menu, F3**), or go straight to the next step by configuring the system using an existing cycle.*

6.   Configure the thermocouple / zone layout by drawing the Repair Map (Main Menu, F3).

Current Thermocouple Configuration (Chapter 5)
    *6.1 Click the **Add Heater** button.*
    6.2 Draw the zone heater shape(s). Select the desired zone number or press OK to select the next available zone.
    *6.3 Click on the **Add Thermocouple** button and click where the thermocouple is to be placed for the zone. Select the desired thermocouple number or press enter to select the next available thermocouple.*

*6.4 The **Update Configuration** button will automatically transfer the configuration to the **Thermocouple and Zone Parameters** screen. Use this screen to fine-tune the configuration.* (Tie Stages, PID numbers, Chapter 16)

<u>Vacuum</u>

*6.5 Use the **Control Functions Menu, Vacuum / Pressure Setup** (F8/F2) screen to configure the vacuum pump and alarms.*

7.   Select Start Heat Cycle (F5) from the main menu.

*7.1 Check that all required heater zones are **Enabled**. (If not, [ESC]. back to the **Repair Map** window).*

*7.2 Select the cycle by clicking **Select Profiles** or pressing **Select Profile** (L). The temperature profiles were setup earlier in the #6 (**F8/F3**).*

*7.3 Select required zones by using the cursor keys. (Normally use **Enabled Zones**) and then "S" or **¿**.*

7.4 Change the cycle description if necessary, and press ¿ to continue.

*7.5 [ESC] out of the **Cycle Setup** screen, back to **the Start Cycle** window.*

7.6 Press "S" to continue the starting procedure.

*7.7 Enter **Item** being repaired, and **Part No**.*

7.8 Select the adhesive type to use the automatic cure cycle.

*7.9 Press "S" to go to the **Immediate / Auto** window. ¿ ?(Immediate mode) will start the cycle.*

7.10 Press any key to confirm each automatic temperature / time if required.

8.   Monitor the Repair Progress (Chapter 9)

*8.1 Select **Repair Map** (F3) from the main menu.*

*8.2 Select **Temperature Graph** (F2) from the main menu.*

8.3 All enabled zones can be selected from the Temperature Graph screen by pressing the desired zone number, 1 to 6.

*8.4 Select **Status All Thermocouples** (F1) for a table of temperatures.*

9.   Alarms

If alarms occur because of temperature deviations on warm up, check the Process Log (F7) screen. Entering the screen will accept the alarm and silence the horn.

The HBC-43 series is a feature-packed hot bonding controller system built to suit the requirements of today's aviation and bonding industries.

It is based on a versatile electronic / vacuum control case and a notebook computer as the operator interface. The computer and printer are stored in a separate case the same size as the HBC-43 control case. To operate the hot bonding controller, the computer can be placed on a bench or desk up to 100m away from the control case.

A communications cable is used to communicate between the computer and the control case.

The system is capable of running two independent tasks at the same time. The same keys are used to access the configuration of both tasks. The tasks are enabled from the Main menu by pressing either the 1 or the 2 keys.

The HBC-43 programme takes full advantage of the technology of the current notebook PC's. It uses the **high-resolution colour screen** to clearly identify the set point temperature, hottest temperatures, coldest temperature, vacuum set point and vacuum levels.

The repair temperature graph cycles can be saved and **printed later**. The alarm messages and data logs are also saved for later reference.

In addition, a thermocouple / zone **map of the repair** can be created and a **digital photograph** can be linked to the internal database. Both of these can be saved along with the temperature profile of a repair and can be retrieved for later examination for quality control records.

The thermocouples are grouped into the zones using the Thermocouple and Zone Configuration screen. All the enabled zones are scanned for the hottest thermocouple (or the average temperature, if available from the Thermocouple and Zone Parameter screen) to determine the temperature to be used for control of the zone. The hottest thermocouple / average temperature in each zone and the coldest thermocouple in the task are plotted on a graph. An open circuit thermocouple will automatically be removed from control.

The vacuum can be monitored. The **vacuum levels can be displayed** on the PC on either the graph, map or table screens.

The **adhesive curing characteristics can be programmed** into the computer so that the guess work is taken out of curing time. The curing stage time is adjusted automatically if an adhesive is nominated as the temperature cycle is started.

If a zone is needed to provide some background heat into a repair, any of the zones can be controlled in the manual mode using the local control on the control case.

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3.1 Hardware Specifications

NATO Stock Number is **4920-66-133-3912**

The central or main component of the HBC-43 is the control case. In addition, the computer and optional printer are stored in an identical rugged transport case.
The control case contains: –

- The main microcomputer
- Thermocouple reading circuitry
- Heater control
- Vacuum control pump

Number of T/C inputs:	16
Thermocouple type:	Type K
Temperature range:	Up to 300°C (600°F)
Accuracy:	+/- 1°C
Number of heater zones inputs:	6
Type of controlled output:	Phase angle SCRs to operate infra-red heater lamps or mats
Heater current (max.):	10 Amps
Heater power:	17.4kW total at 240VAC supply (2.4kW per zone)
Power supply safety protection:	Earth leakage circuit protection on each heater
Vacuum sources:	Air operated ejector pump, down to -80 kPa
Air supply:	150 to 800 kPa (Normal operation 500kPa) 200 l/m
Mains voltage supply:	Single phase or 3-phase 210 to 265VAC 50/60 Hz (phase to neutral)
Power:	10 Watts for controller plus heater power
Safety switch:	Earth leakage detector on each zone (30mA)
Environmental Rating:	Operating Temperature -25°C to 55°C Relative Humidity 5% to 95% (non-condensing)
Degree of Protection:	IP65 with the case closed IP30 with the case open

Case Sizes:	Computer/Printer:	220 mm high by 520 mm deep by 620 mm wide
	Control:	220 mm high by 520 mm deep by 620 mm wide
	Accessory Case Size:	320 mm high by 520 mm deep by 835 mm wide

Weight:	Computer/Printer:	15 kg
	Control:	22 kg
	Accessory Case:	40 kg

3.2 Operational Specifications

Number of simultaneous tasks:	2 (Repairs independently started and monitored)
Temperature control:	0 to 300 °C, PID

Display of temperatures:

Mapping — **Custom drawn map of the repair showing the Zone / Thermocouple positions & temperatures. Colour coded tags show the hottest / coldest temperatures**

Graph — **A graph shows the control temperature for each zone. The operator can select on 1 graph: Control temperature for each zone, coldest thermocouple for the repair, set point temperatures and the vacuum. Data is included for stage / elapsed time and estimated finish time and zone power level. Graph includes a zoom and pan feature.**

Table — **A colour-coded table shows the temperature of all thermocouples with colour coding of the hottest, coldest, control, low and high thermocouples.**

Selection of control T/C:	Control will be from the **highest** temperature of the thermocouples in each zone.
Selection of acceptance T/C:	Any thermocouples can be nominated as acceptance thermocouples. The acceptance thermocouple will be plotted on the graph. The soak time can be automatically adjusted based on the temperature of the acceptance thermocouple.
Zone control:	Multiple zones within a job can be **tied** at the beginning of each stage or one zone can be nominated as the master with the other zones set to **follow** the master.
Display modes:	Imperial or metric
No. of ramp / soak control stages:	Six
Temperature ramp rates:	0.5 to 10.0 °C per minute in 0.1 degree increments
Cycle profile:	Up to six ramp / soak stages each cycle
Cycle duration:	6 x 2000 minutes per stage in one minute increments

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Cycle memory:	Up to 100 pre-programmed cycles
Heater / T/C configuration:	Selectable on the keyboard or automatically selected from the repair map.
Operator controls:	Remote from control case using notebook PC Local manual/automatic power control on control case
Hard copy of data:	Available any time during or after the end of the cycle in colour or b&w including:
Map	**Zone / thermocouple positions & temperatures and the hottest / coldest temperatures, process log.**
Graph	**Operator selected temperature / vacuum graph including zoom views, plus:** **Time of day, zone number, zone status, control T/C number, acceptance T/C number, stage number, set point, run time, vacuum level and job data**
Other screens	**Other items can be printed during or after a run including:** **Adhesive profiles, Alarm report, Process log and Temperature profile.**
Storage of finished cycle:	Completed run is saved on the hard disk or direct to a network drive or removable media if available. Other related files can be linked to the saved job such as- **Pictures** **Text documents**
Import and Export	Files can be imported or exported in text format that could be read by **MS WordÔ** or **MS ExcelÔ** format including: **Temperature profiles and previous temperature graphs.**
Retrieval of previous runs:	Selected by part number, operator, adhesive, job description or date / time. Data retrieved includes: **Zone temperature / vacuum graphs, repair map, alarms and warning messages, pictures and documents. Graphs can be exported to ExcelÔ.**
Manual power output over-ride:	Auto-manual over-ride on each heater output
Alarm identification:	On screen display and hard copy print

Alarm status: Temperature deviation
                                 Thermocouple burnout
                                 Thermocouple reversed
                                 Vacuum over / under condition
                                 Heater mat failure
                                 Hardware failure
                                 Communication failure

Alarm indication: Audible – Tone generator in control case
                                          – PC speaker

Power fail re-start: Re-start at last point
                                 (Cycle data is stored on disk every 15 seconds)

4.1 Installing the Software

Insert the Novatech Controls HBC-43 installation CD into the CD drive in the PC.
The Setup Wizard will start running.

Select Components
The drop down box gives the operator three options:
1. Full Installation
Installs the HBC-43 control program and overwrites the saved temperature profiles, default program settings and the adhesive profiles.
2. Upgrade Current Installation
Overwrites the current version of the program but leaves the saved temperature profiles, default program settings and the adhesive profiles unaltered.
3. Custom Installation
This allows the operator to select the components that will be installed.

The past jobs data base is never destroyed.

Fig. 1 Installation Screens

Select Start Menu Folder
Use **Novatech Controls** folder by clicking **Next.**

Select Additional Tasks
The two options allow the operator to start the program from an icon on the desktop and / or from an icon in the Quick Launch area of the Windows™ start bar.

Ready to Install
Confirms the installation details. Click Install to complete the installation.
A tick in the **Launch Novatech Controls HBC43** tick-box will launch the HBC-43 program on completion of the installation.

Remove the HBC-43 CD from the computer and store it in a safe place.

4.2 Turn the Computer On

Allow the computer to start running Windows™.

The batteries will always start the computer if they are charged, however to use the computer for any extended period (> 30 minutes), always use the power adaptor.

Use the IEC lead supplied to connect the mains outlet on the HBC-43 control box (Computer Power) to the computer power adaptor. Plug the power adaptor into the computer.
Connect the computer to the control case ("Computer" connector) using the serial port (9 pin 'D' connector).

When the program is started for the first time the factory installed Operator / Password to gain access to the program is:

      Operator: Default
      Password: password
Note: The entry is case sensitive. The password must be between 6 and 32 characters.

This will log the user on with the authority of a **Manager**. For further details of the password system see chapter 22, **Operators and Passwords**.

Fig. 2 Start Screens

If the computer cannot communicate with the control case within a few seconds the following screen will be seen –

If the HBC-43 control case is not communicating with the PC the power output will be inhibited from the zone outputs unless the zones are switched to **Manual** power control.
If communications between the PC and the control case are lost during a temperature cycle both the PC and the control case will sound an alarm.

After the operator has been authorised the program will continue on with the start up splash screen and to look for the HBC-43 control case connected to the nominated port. The "Version #.#.#" at the top of the splash screen shows the version of the computer software. The report at the bottom of the splash screen during the start up shows the version of the software running in the control case, and which control cases have been found on the network.

A status box at the bottom of the **Main Menu** screen will report the status of the connection. Dots will be seen following the word "Connecting" until communication is established.

4.3 Using the Menus on the Computer

The function keys or the cursor keys can be used to select the menu functions. The [ESC] key is always used to exit back to the previous menu.
The tab key or the enter key can be used to move between the fields within a menu function.

A prompt line has been provided at the bottom of the some screen showing the selection of keys available for the current cursor position.

A pointing device such as a mouse or mouse pad can also be used with the program, however once an operator is familiar with the program it will be generally quicker to use the keys.

4.4 Main Menus

Notes on Using the Menu screens

The program functions accessible via the menu system have been split into two groups.
  - ➢ **Main Menu**
  - ➢ **Control Functions Menu**

When the program first starts, the **Main Menu** is displayed and provides access to the most common of the functions that are required to run a repair cycle.
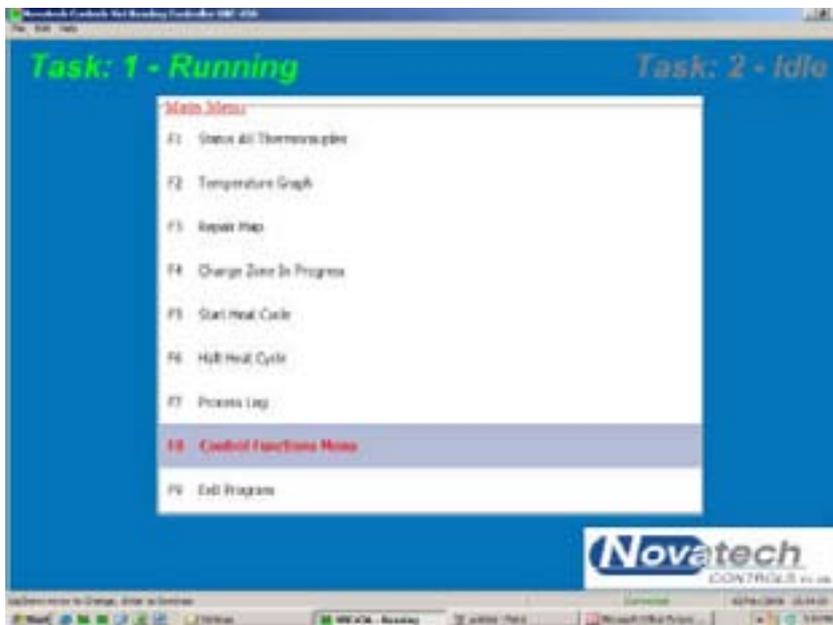
Fig. 3a   Main menu screen
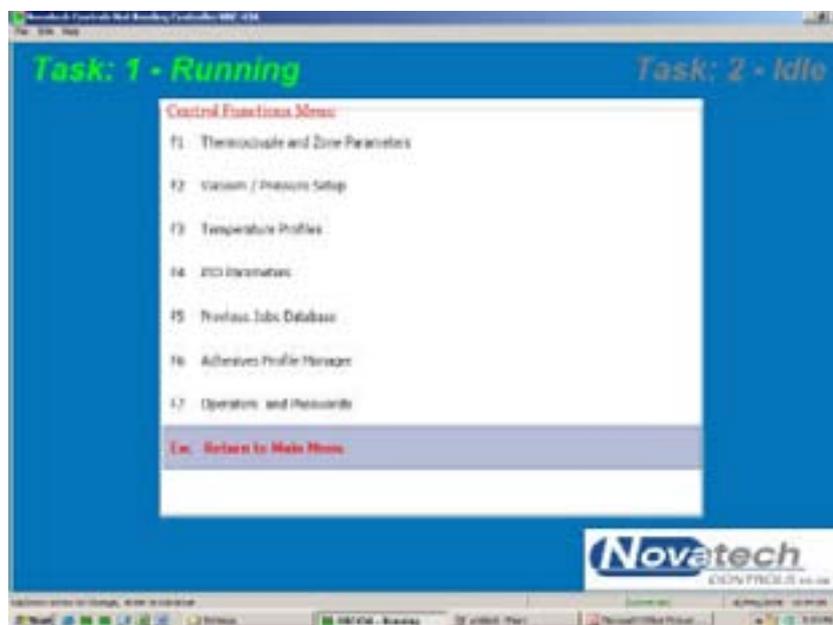
Fig. 3b   Control Functions Menu

The **Control Functions Menu**, which is displayed when F8 is pressed in the **Main Menu**, provides access to functions that are used to configure a heat cycle or to save and recall completed cycles.

1. To select a function either -
   1. Press the corresponding function key. (i.e. In the **Main Menu**, Function key F3 will select Repair Map)
   2. Use the up/down cursor keys to highlight the required function.
      Press the ↵ key.
   3. Double click with the pointing device, either an external mouse or the built in touch pad.

2. To access the **Control Functions** menu, press the F8 key, and then press a function key as shown in the Control Function menu.

3. To return from a function to the Main Menu, press [ESC].

All operations are accessible using the keyboard or the pointing device (except the drawing of the repair map needs the pointing device).

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5. CONFIGURING THE THERMOCOUPLES AND ZONES

> **NOTE:** It is possible to configure two tasks in the HBC-43 software. Use the 1 and 2 keys while in the Main Menu to swap between tasks.

5.1 Thermocouples and Zones

The configuring of the thermocouples in the zones that they are physically mounted in can be done two ways:

      Repair Map
      Thermocouple / Zone Configuration table
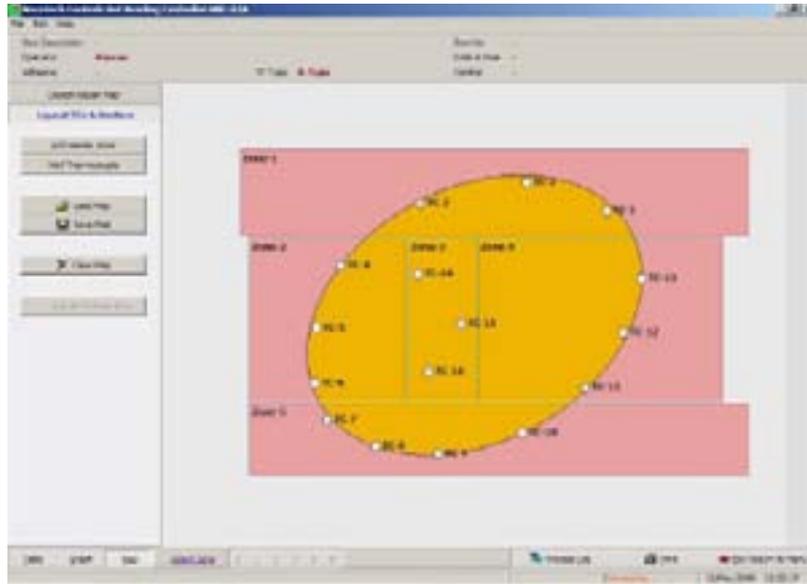
Fig. 4a   Thermocouple / Zone Configuration using the Repair Map
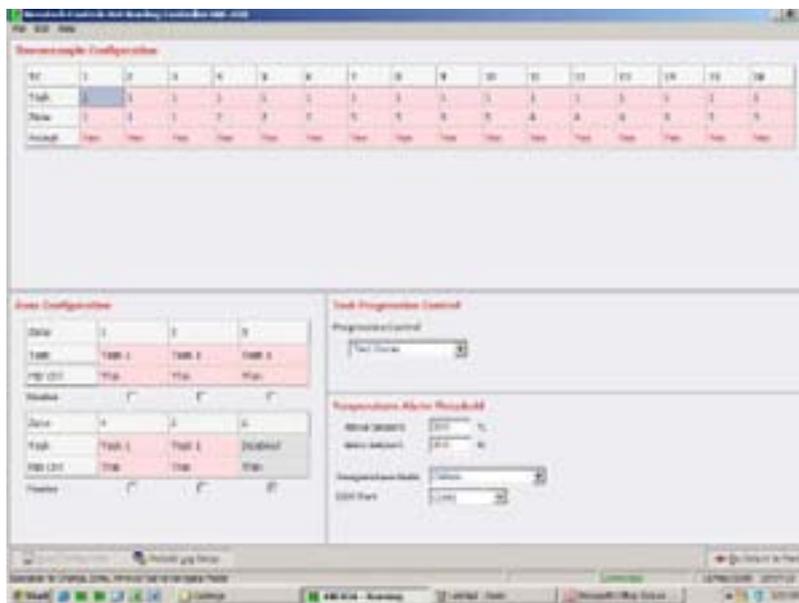
Fig. 4b Thermocouple / Zone Configuration using the Thermocouple Table

(Main Menu, Repair Map)
The repair map is the easiest way to assign the thermocouples to the zones.
Firstly a repair shape is drawn. The zones and thermocouples are then placed on top of the repair in approximately the same position as they are on the actual repair.

Features of the repair map –
- A zone that has been placed on the repair map can be moved and reshaped any time until the task has been started.
- A zone or a thermocouple can be removed by right-clicking on a zone or thermocouple to bring up an item specific menu.
- A thermocouple can be selected / deselected as an acceptance thermocouple by right-clicking on the thermocouple to bring up the menu.
- The last map layout will be restored when the computer is turned on the next time.
- Using the "Update Configuration" button will transfer the map into the zone / thermocouple configuration table.
- After a map has been created the table can still be viewed and edited until a job is started.   However, if after editing, the map does not match the table, a warning will be shown when starting a job or entering the map screen.
- The map will be saved when a repair is completed and can be recalled later.

It is important that –
- The thermocouples are placed within the area of the zone that they are to be controlling.
- A thermocouple placed outside all zones will still be monitored and can be selected as an acceptance thermocouple but will not be used for the control of a zone.

NOTE: When a repair cycle is running, the map can be used to monitor the temperatures. The temperature of each thermocouple is displayed attached to the thermocouple position. If a thermocouple is above or below the set point the temperature flag will change colour.

It is necessary to use the pointing device to create the repair map.

To create a repair map:
1. Select **Repair Map** from the **Main Menu (F3)**
2. Click the **Design Repair Map** tab.
3. Select the shape of the repair (either Ellipse or Round Rectangle)
4. If **Round Rectangle** selected, use the **Horizontal** and **Vertical** slide bars to shape the corners of the rectangle.
5. Use the **Repair Angle** to rotate the **Ellipse** or **Rectangle** (Windows™ 2000 and later).
6. Click the **Layout TC's & Heaters** tab.
7. Place the heaters over the repair shape by clicking the **Add Heater Zone** button.

NOTE: Place the cross where the top LH corner is required. Press & hold the LH mouse button and drag the bottom RH corner of the heater to the required position.

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8. Place a thermocouple by clicking the **Add Thermocouple** button.

NOTE: Individual heaters and thermocouples can be deleted by <u>right</u> clicking the item.
Use the <u>left</u> button to drag and re-shape the heaters and move thermocouples.

When the layout is complete click the **Update Configuration** button to transfer the layout to the **Thermocouple & Zones Parameters** table. If further changes are required simply use the F3 (**Repair Map**) key from the Main Menu.

5.1.2 Thermocouple Table

(**Control Functions Menu, Thermocouple & Zone Parameters**)
This screen can be used to configure the program to match the repair configuration. It can be created from the **Repair Map**. See chapter 5.1.1. The table changes will be save when exiting the screen. Selections are generally made by pressing the **space bar**.

Features of the Thermocouple Table –
- The screen uses colour-coding to quickly identify the zones and the tasks. **Task 1** is coloured **pink** and **task 2** is coloured **blue**. Disabled thermocouples and zones are grey.
- To place a thermocouple in a zone toggle (using the space bar) the **Zone** cell in the appropriate thermocouple column and make sure that the zone selected for the thermocouple is in the correct task. A zone can be disabled from the task row in the **Zone Configuration** table.
- In addition to the thermocouple / zone configuration this screen allows the operator to select the highest / average temperature control, zones tied / follow mode etc.

NOTE: Although this screen allows the operator to change the configuration of zones and thermocouples, a change in this screen will not update the **Repair Map**. It is better to make any changes from the **Repair Map** screen and then let the computer update the thermocouple table automatically.

NOTE: After a temperature cycle has been started it is not possible to change the temperature / zone configuration except to change the:
       PID values
       Acceptance status of a thermocouple
       Remove a thermocouple

Use the tab and the cursor keys to navigate around the screen, and the space bar to change a selection. The prompt line shows the available keys for each cell.

Thermocouple Configuration
The table shows the association of the tasks, zones and thermocouples. A thermocouple in the task can be enabled as an **Acceptance** thermocouple from the **Accept** row of the table. A thermocouple shown as **None** in the **Zone** row is enabled but will not be used for control of any zone. It can still be monitored or used as an Acceptance thermocouple.

5.1.3 Zone Configuration
This table allows the operator to link the zones into a task and set the PID group. The actual PID numbers are set in the **PID Parameters** screen (Control Functions Menu, PID Parameters).
The PID option is a convenient way to allow for different thicknesses of the structure being patched. There are three sets of PID values selected with the space bar. They can be individually set in the **PID Parameters** screen (Control Functions Menu, PID Parameters).

5.1.4 Task Progression Control
The control of a zone during a cycle run can be selected to be from the hottest thermocouple that is enabled for the zone.

If a thermocouple goes open circuit during a run cycle the program will automatically display it as "**o/c**" (open circuit) in the **Status All Thermocouples** screen, and will disable it from zone control.

If an individual thermocouple appears faulty, or you want to remove it from control of that zone, it can be disabled during a run by unplugging it. Within 2 seconds it will be recognised as open circuit and removed from control of the zone.

The HBC-43 software incorporates a **Guaranteed Soak** function. This means that the soak times will automatically extend to make sure that the heater is within the **Dev** level set in the **Zone Temperature Profiles** screen (default is +/-5°C, 0°C will disable the automatic soak extension) for the required time for each soak period.

The **Progression Control** sets the way the set point temperature is generated.
If **None** is selected the set point for each zone within a task will progress to the next stage in a temperature cycle independently of all other zones in the task.

If **Tied Zones** is selected the program will synchronise the start time of each of the ramp stages of the temperature cycle. The soak time of a zone that has completed the soak time before another zone will automatically extend to make sure that all zones start the next ramp at the same time. If one zone is slower to respond than another, they may get out of step. Tying the stages will hold the faster zones in the soak stage until the slower zones catch up.

The **Follow Zones** mode can be used where one zone is slower than others and it is required that all zones are kept at the same temperature. The temperature of the slow zone can be used as the set point temperature of the faster zones so that the temperature of all the zones will exactly follow the same temperature profile.
To use the **Follow Zones** mode, select **Follow Zones** from the **Zone Heater Profile Control** section of the **Thermocouple & Zones Parameters** screen and then start the temperature profile as described in chapter 8. If the temperature of one zone is unable to keep up with the set point temperature, select the slow zone as the **Master** in the **Zone Configuration** section of the **Thermocouple & Zones Parameters** screen. The slow zone will still attempt to follow the original programmed set point, but the other zones will follow the actual temperature of the slow zone.

5.1.5 Temperature Alarm Threshold
The values set in the **Above Set Point** and **Below Set Point** boxes determine the levels at which the **Thermocouple High Temperature** and **Thermocouple Low Temperature** alarms are triggered. The temperature boxes in the **Repair Map** screen and the **Status All Thermocouples** screen will change to **dark blue** and **red** at these trigger points. The temperature boxes in these screens will also change to **light blue** and **pink** when the temperature exceeds half of the trigger values.

The temperatures can be displayed in either Centigrade or Fahrenheit.
The serial **Com Port** of the computer used to communicate with the HBC-43 control case can be set as COM1, COM2 or COM3, or whichever serial ports are available.

5.2 Vacuum / Pressure setup
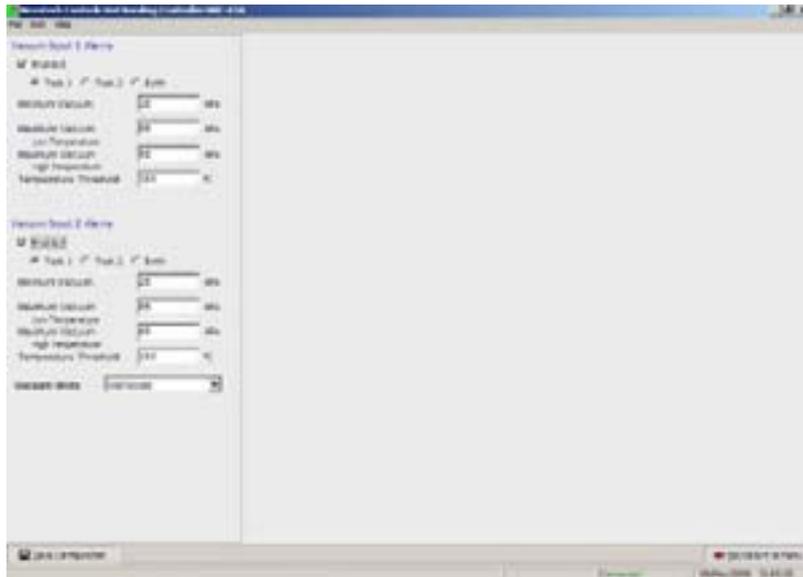
Fig. 5   Vacuum / Pressure Setup Screen

There are 2 inputs to allow for 2 external vacuum transducers. The inputs are designed to accept a transducer that has the range -100 to 0 kPa, with a 4-20mA output.

Either or both of the inputs can be **Enabled**. When enabled, the HBC-43 will alarm if the vacuum is not within the limits set on this screen. A graph of the vacuum level of each sensor can be shown on the **Temperature Graph** screen. The external inputs must be **Enabled** before the measurement will be displayed or graphed.

The **Maximum Vacuum, Low Temperature** and the **Maximum Vacuum, High Temperature** settings allow the operator to be warned when the temperature has risen above the **Temperature Threshold** and that the vacuum should be adjusted back to a lower level.

The vacuum can be displayed in Kilopascals (kPa), Inches Hg, Atmospheres or bars.

See chapter 9.4, **Monitoring the vacuum / pressure** for more details.

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There are 100 heat cycles stored on the hard disk that can be edited and renamed before starting a cycle.

Select the **Temperature Profiles** from the **Control Functions** menu.

You will be prompted for a cycle number. Page up, page down and the cursor up and down can be used to view the list of cycle descriptions available.

A new cycle description can be entered by using the tab key to highlight the **Edit Description** line or press "S", Alt S or Enter to continue to the edit screen.

The **Temperature Profiles** screen has a graph on the left and a table on the right. The line of text above the graph is the description of the cycle.
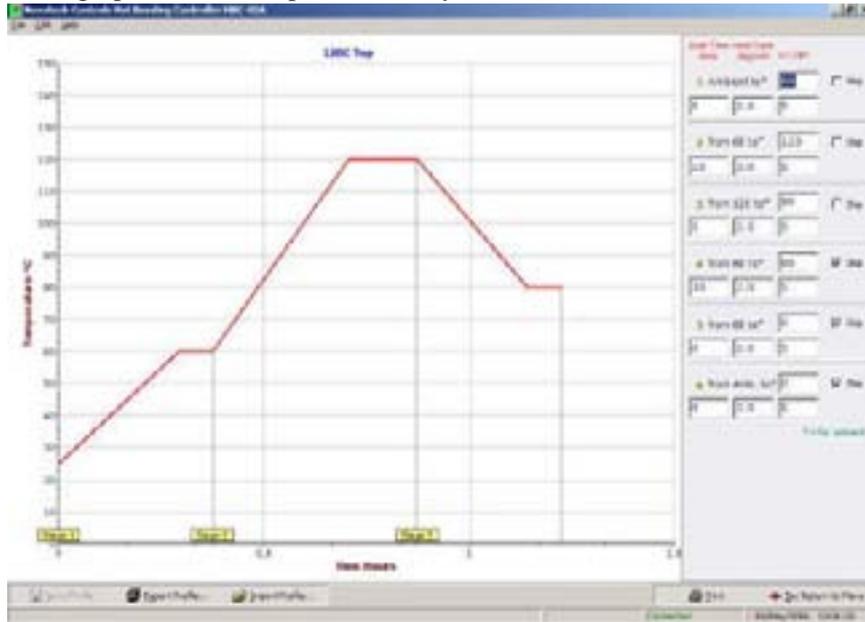
Fig. 6   Temperature Profiles Screen

Use the Tab key, cursor keys or the mouse to move to the data point you wish to change, and type the new value. Use the [ESC] key to take you back to the main menu screen. A prompt dialog box will appear when exiting this screen if changes have been made.

The 5 cells in each stage are:
1. Target temperatures.
2. Soak time, 0 to 2000 mins (33 hours) per stage, with a maximum of 200 hours for a complete cycle.
3. Heat / cool rate in °C/F / minute, 0.5 to 10.00.
4. Deviation temperature for the guaranteed soak function, 1 to 10°C/F (0 to disable the guaranteed soak feature).
5. The controlled vacuum level for this stage of the cycle. The automatic control of the vacuum is not available if **Pressure** is selected on the **Vacuum / Pressure Setup** screen.

NOTE: Any stage can be skipped if the **Skip** tick box is ticked. Use the mouse and the left click or the tab key to move to the tick box and the space bar to select / deselect the skip.

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7.1 Introduction

The HBC-43 control case is supplied with a vacuum pump. The pump is turned on and off using the **PUMP** rotating valve on the control case. Adjusting the **PUMP PRESSURE** regulator sets the pump vacuum level. The air supply pressure should be between 400 and 600kPa to the control case.

At the control case, the air supply pressure can be monitored on the **PUMP SUPPLY** gauge, and the vacuum level can be monitored on the **VACUUM** gauge. Provision has been made for two external vacuum sensors that can be connected directly to the repair vacuum bag. These sensors can be logged and graphed with the temperature profile. See **Main Menu**, **Temperature Graph**.

High and low vacuum alarm levels can be set. For more details of the PC screen that controls the vacuum alarms see chapter 5.2, **Vacuum / Pressure Setup** in which there is a description of the screen that is available from the **Control Function Menu**.
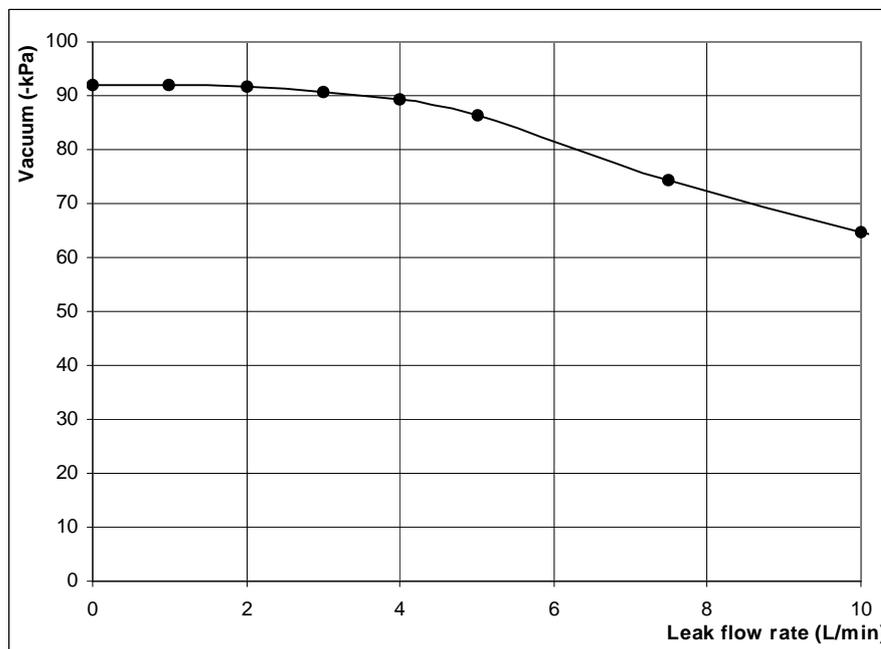

Fig. 7   Pumping Rate of the Vacuum Pump

The graph shows the relationship of the vacuum pressure to the volume of an air leak into the bonded repair bag.

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8.1 The easiest way to get a selected cycle running

If the heater zones and thermocouples have already been configured in the **Thermocouple and Zone Parameters** screen, the procedure is:

1. Select the **Task** by pressing **1** or **2** from the main menu. (The selected task will be highlighted in green)
2. Select **Start Heat Cycle (F5)** from the main menu.
3. From the table screen, press the "**L**" key, to select a pre-recorded temperature cycle.
4. Press **¿**, to choose the default (**Enabled Zones**) or select the required zone number.
5. Scroll through the list of cycle recipes until you find the one you want to run or type the number in the **Cycle No.** box followed by a **¿**. Change the **Description** if required or **¿** to continue.
6. The operator now has the option to edit the time / temperatures of the selected cycle. The changes entered this way will not be saved to disk for any future runs. The changes to the temperature profile will only be used for the running of this cycle. Press [ESC] to continue, and **¿** to save changes.
7. Press "**S**" to enter the details of the work being done. Use the tab key to toggle between the fields. The **Description** and **Item number** must both have an entry or the task cannot be started.
   The operator is given the option to have the computer automatically monitor the cycle that has been selected against the known adhesive characteristics.
   Confirmation of the changed parameters will appear for each zone that is selected.
8. Press the **¿** key to start the temperature cycle.

To monitor the cycle in progress, go to the **Repair Map**, **Temperature Graph** or the **Status All Thermocouples** screen (See chapter 9.1).

8.2 The Start Cycle Screen details

The **Start Cycle** screen shown below provides a summary in tabular form of the cycles last used for each of the heater zones.

Fig. 8   Start Cycle Table Screen

This screen provides a table of data for all of the heater zones.
The top line shows the zone number.
The second line shows whether or not the heater is enabled for that heater zone.
The remaining lines on the screen show the set points, soak times and the heat rates for each of the six heater zones.

The functional keys available on the **Start Heat Cycle screen** are: -
"D"   *Edit*
After the cycle has been selected, fine tuning of the cycle for one or more of the zone profiles may need to be done. Pressing the "D", and selecting the heater zone number, key will take you to the edit screen for that heater. This edit facility is now the same as when selected from **Change Zone In Progress (F4)**.

"L"   *Select Cycle*
Press the "**L**" key to select a different temperature profile to be run for any of the zones.

"C"   *Copy*
Press the "**C**" key to copy the temperature profile from one zone to another zone.

"S"   *Start*
Press the "**S**" key to continue the cycle start process. You will be prompted with a window to enter the –
*   Description of the item to be bonded
*   Item number

Fig. 9   Start Cycle Table Screen warning message

If the button **Start Bonding Cycle** does not appear in the bottom right hand corner of the table screen the reason will be identified in the button position. Messages include:

Message in the button	*Reason and the solution*
Not Connected	The PC is not communicating with the HBC-43 control case. Check that the communication cable between the HBC-43 and the PC has been installed correctly.
Zone x not ready	One of the nominated zones does not have any thermocouples associated with the zone. Check the Repair Map layout, and that the thermocouples are operating correctly (not o/c).
No enabled zones	No zones have been associated with the task. Check the Repair Map layout.
Task active	The task is running already. Use the Halt Heat Cycle function from the Main Menu to stop the heat cycle.

Fig. 10   Start cycle screen data entry

After the above two fields have been entered, an optional adhesive can be entered.

The adhesive entry facility allows the HBC-43 software to check the temperature cycle being started and warn the operator if the temperature is outside the recommended limit of the adhesive.

Fig. 11   Start cycle screen, Automatic Adhesive Selection Parameters

The adhesive monitoring feature also allows the HBC-43 software to automatically adjust the soak time during the soak stage if any part of the repair does not reach the cure temperature.

After the **Start Bonding Cycle** button has been clicked the bonding cycle will be started. To monitor the progress of the cycle see chapter 9, **Monitoring the Operation**.

8.3 Halt Heat Cycle

Selecting this screen will stop the temperature profile for the selected task.
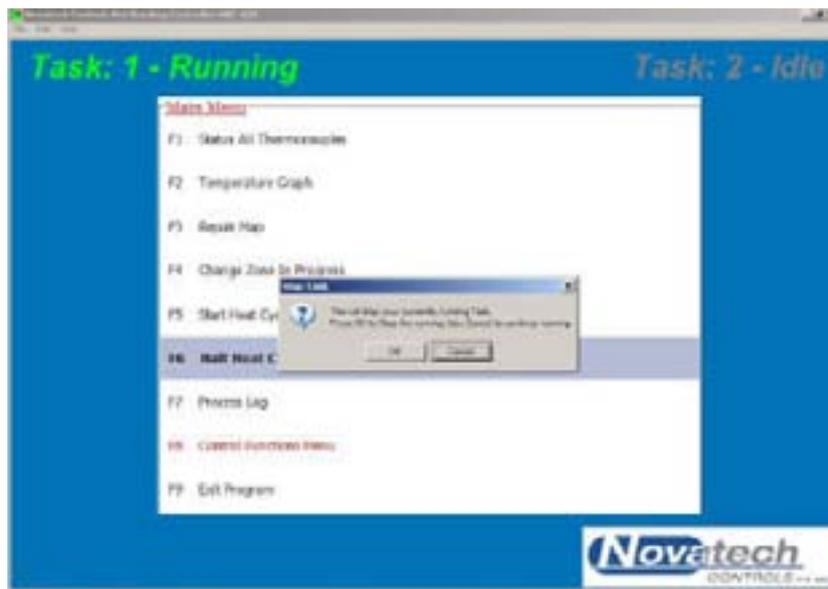
Fig. 12a Halt current task screen

If the task is not running the following dialog box will be shown
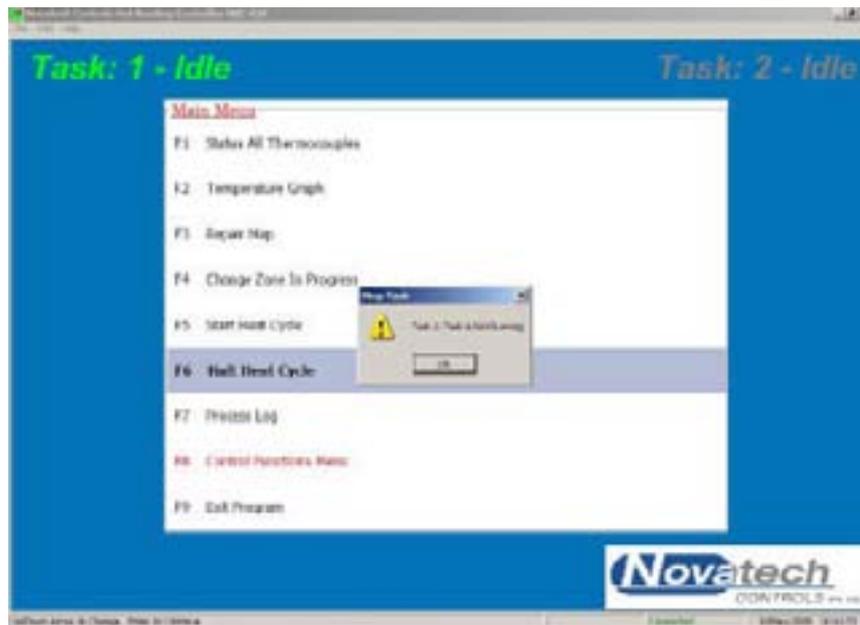
Fig. 12b The current task is not running

If a task is stopped before the cycle has been completed **or** if the temperature cycle is left to complete the whole cycle, the following dialog box will be shown.
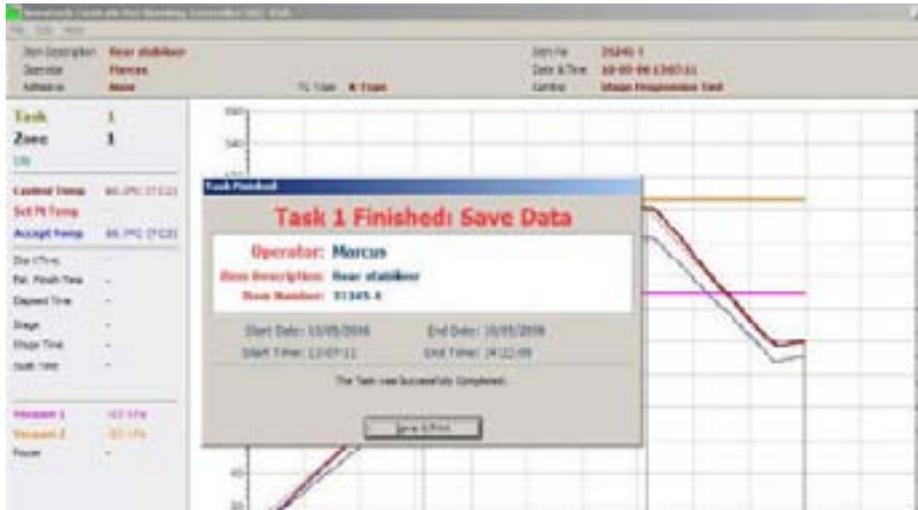
Fig. 13a The task has been stopped / completed

There is no choice; the profile must be saved. An unwanted task can be deleted by someone logged in as a manager from the **Previous Jobs Database** screen.

Fig. 13b The task has been stopped / completed

If the printer is not connected when the task is finished the graphs / map / process log can be printed later by recalling the job from the **Previous Jobs Database** screen.

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CONTROLS

NOTE: It is possible to configure two tasks in the HBC-43 software. Use the 1 and 2 keys while in the Main Menu to swap between tasks.

After the temperature cycle has been started the temperature of the repair can be monitored from three screens. Either the temperature of an individual zone can be shown as a graph or all the thermocouples can be shown grouped in numerical order and grouped in zones.

An additional feature of the HBC-43 hot bonding controller is the ability to create a map of a repair. The map can be used to recall the physical layout of a previous repair, but can also be used to monitor the hot and cold areas of the repair. For further details see chapter 9.3, **Repair Map**.

9.1 Status all Thermocouples

This screen displays-
> The current operating status of all of the thermocouples and zones
> The start time and cycle run time
> The vacuum level of both remote transducers
> The ambient temperature
> The temperature of the power controller heat sink

Fig. 14   Status All thermocouple's screen

It can be seen that the two tasks are clearly identifiable by the colour coding of the Zone number column. Pressing "A" will toggle all the acceptance thermocouples on / off.

The **TC** column identifies the thermocouple in each zone. From the legend on this screen it can be seen that the hottest thermocouple number in each <u>zone</u> is shown **in red**. The coldest acceptance thermocouple in each <u>task</u> is shown in **blue**.
If the **Actual** temperature is within <u>half</u> of the **Temperature Alarm Threshold** limits (set in the **Thermocouple and Zone Parameters** screen) of the set point temperature, the temperature will be shown in black. Otherwise the temperature cell will be either light blue, pink, dark blue or red.

The two **Stage** columns show which part of the temperature cycle is being run for each zone.

The **Cold Junction** temperature is measured inside the control case on the thermocouple connector strips and is used for the thermocouple cold junction compensation.

The **Heatsink** temperature should not be allowed to go over 70°C. This will only be likely if the ambient temperature is over 45°C and all six zones are driving heaters at over 80% duty cycle.

The **Vacuum1** and **Vacuum2** show the measurements taken by the external vacuum sensors.

9.2 Temperature Graph

A graph of all the zone control temperatures can be graphed together. Any of the zone temperature graphs can be selected by using the keys shown at the bottom of the graph.
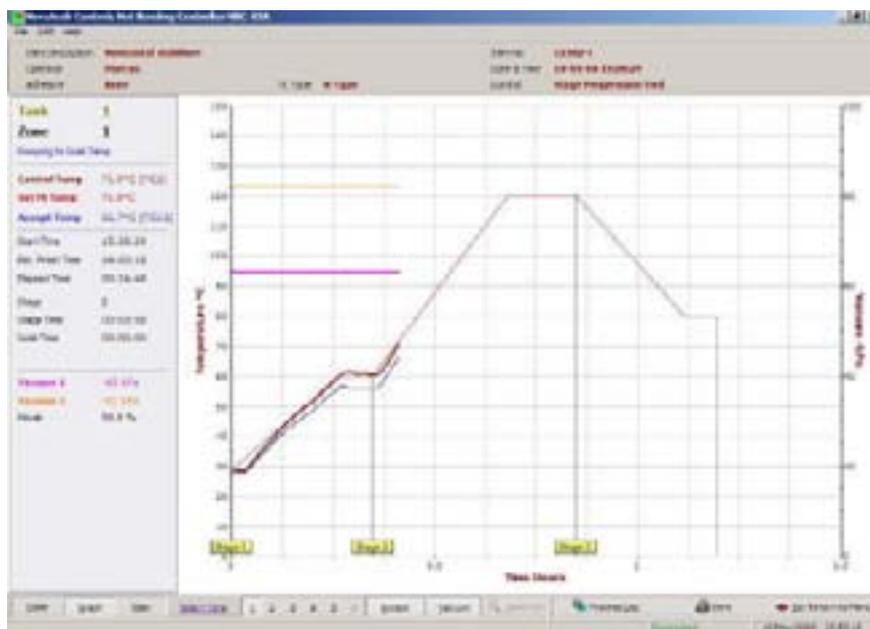
Fig. 15   Temperature Graph Screen (with Vacuum Scale)

9.2.1 Navigating Around the Temperature Graph

Details of any part of the graph can be examined by zooming up on the graph. Hold the left mouse button down while pointing to the top-left corner of the area you want to zoom in on. Drag the mouse to the bottom-right corner of the area and release the mouse button. The graph will be redrawn to fit the zoom area. Pressing the Z key or clicking the Zoom Out button will return the graph to the full screen.

The area being graphed can be moved by holding the right mouse button down while pointing in the mid area of the graph.

9.2.2 Temperature Graph Details

The screen shows a graphical profile of the temperature (and vacuum if selected) for the selected zone. The top of the screen shows:
1. The identification of the operator and the task
2. The selected adhesive (None, FM73 etc.)
3. Confirmation of the thermocouple type selected in the control case.
4. The status of the vacuum pumps. These buttons can be used to switch the pumps on and off.

In the left panel of the screen is:
1. The selected task (selected from the Main menu)
2. The selected zone (selected with the number keys 1 to 6)
3. The status of the zone (Running, Idle, Ramping, Soaking)
4. A soak progress bar when soaking is in progress
5. The actual temperature being used for the control of this zone (highest in the zone).
6. The current set point temperature for this zone
7. The acceptance thermocouple (the coldest thermocouple enabled as an acceptance thermocouple)

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8. The time that the task was started
9. The estimated finish time of the task. This time will reflect the changes produced by the **Automatic Adhesive Soak Extension** and the **Guaranteed Soak** functions
10. The elapsed time. The length of time for which the task has been running
11. The stage number of the temperature cycle that is currently running
12. The time that the current ramp or soak has been running. The soak time will not commence until the actual temperature is within 5°C (default limit) of the soak temperature. For further explanation of Guaranteed Soak, see chapter 23, **Glossary of Terms**.

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13. The vacuum 1 and vacuum 2 pressures are measured in the repair by external sensors plugged into the sensor inputs
14. The percentage of full power being sent to the heater for this zone

The **RED** profile shows the set point temperatures that have been calculated and sent to the temperature controller. The actual set points will vary from the selected cycle profile when the **Guaranteed Soak** control and the **Automatic Adhesive Soak Extension** operate.

Superimposed on this, will be the actual temperature profile verses time for the current process as it has been running. This is the hottest or average temperature (as selected) for this zone.

The **blue** trace records the acceptance thermocouple temperature.
> i.e. The lowest temperature of all the thermocouples nominated as acceptance thermocouples on the **Thermocouple and Zone Parameter** screen.

From the main **Temperature Graph (F2)** screen, you have several option keys:

> **NOTE:** The three buttons on the left of the control bar (Table, Graph and Map) are common to the three monitoring screens (**Status all Thermocouples**, **Temperature Graph** and the **Repair Map**)

1) Pressing **T** provides immediate access to the **Status all Thermocouples** screen without going through the **Main Menu**.

2) Pressing **G** provides immediate access to the **Temperature Graph** screen without going through the **Main Menu**.

3) Pressing **M** provides immediate access to the **Repair Map** screen without going through the **Main Menu**.

4) Pressing the **Z** key will **zoom** back to the full screen view of the graph. **Zooming up** to take a more detailed look at any area of the graph can be achieved by dragging the mouse over the desired area from top left to bottom right.

5) Pressing the **P** key will **print** the screen. This will provide an immediate hard copy of the temperature / vacuum profile, and numerical data.

6) Any of the other heater zones with this task can be displayed simultaneously from the main **Temperature Graph** screen by simply pressing the zone number (1 to 6).

7) The **Acceptance** graph can be switched on or off with the **A** key.

8) Pressing the **V** key will switch on and off a vertical scale and two traces for the vacuum transducers on the graph. The scale is from zero to full scale of the vacuum transducer.

9) The [ESC] key from any screen will return you to the Main Menu screen.

9.3 Repair map

This is the most useful screen to monitor the performance of a heat cycle at a glance. The temperature of all the thermocouples can be seen superimposed onto a map of the repair.

The heaters can be set to an approximate shape and thermocouples placed in position as selected by the operator. Once the temperature profile has been started, the temperature tags will be attached to each thermocouple.

If a thermocouple is not within the temperature alarm thresholds (default settings are 2.5°C or 5°C, set in the **Thermocouple and Zone Parameters** screen) of the set point temperature the background of the temperature tag will be set to light-blue / pink or dark-blue / red. Using this method a cold or hot area of the repair will stand out at a glance.

Fig. 16   Repair Map Screen

In addition to colour coding of the actual temperatures the control thermocouple circle, the hottest thermocouple in the zone is set to red and the acceptance thermocouple circle is set to blue.

When the repair is finished, the repair map is also saved. When a repair temperature profile is retrieved for later examination the position of the heaters and thermocouples will also be available.

9.4 Monitoring the vacuum / pressure

9.4.1 On the control case…
The HBC-43 has the ability to monitor the vacuum being applied to a repair. Two sockets on the control panel (VACUUM 1 and VACUUM 2) are able to read a 4-20mA signal from external transducers.

The scaling of the transducers -100 to 0 kPa represented by 4-20mA. -100 kPa produces 4mA.

There are two gauges mounted on the control panel in the control case. These allow the incoming air supply pressure and the vacuum pressure at the vacuum pump to be monitored. They are intended for approximate indications only. For a more accurate measure of the vacuum in the repair use the external vacuum sensors.

9.4.2 On the notebook PC …
The measurement of vacuum is displayed on the three monitoring screens (Status All Thermocouples, Temperature Graph and Repair Map). It can also be graphed on the Temperature Graph screen.

The external vacuum inputs must be **Enabled** on the **Vacuum / Pressure Setup** screen before they will be displayed or graphed.

10. CHANGING A RUNNING TEMPERATURE PROFILE

The actual heat cycle currently being run may be altered while the run is still in progress without stopping the cycle. Select **Change Zone in Progress (F4)** from the main menu. An edit box will appear for selection of heater zone of control. Select the zone number between 1 & 3 (or optionally up to 6) that you wish to modify, and press **¿** or click on OK.
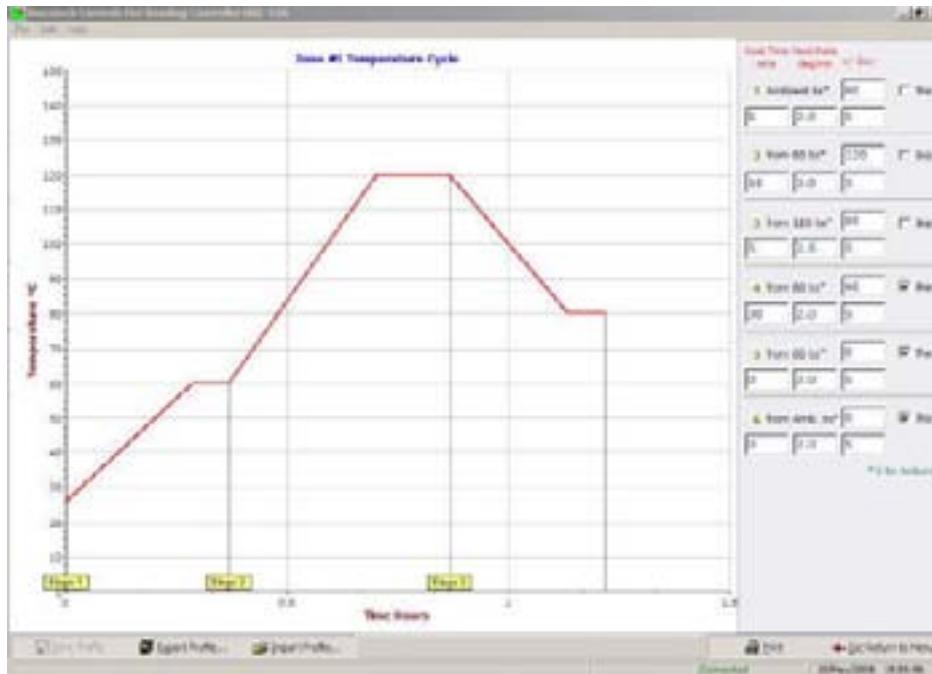

Fig. 17   Change zone in progress screen

The graph on the left of the screen will show you the shape of the temperature profile being used. The table of temperatures and times on the right define the shape of the profile. The table may be edited, and the result can be seen immediately on the graph.

Logically only the part of the profile that has not yet been reached can be changed.
The following table shows what can be changed after a job has been started:

	Ramp rate	Soak temperature	Soak time
When ramping	Not changeable	Changeable	Changeable
When soaking	Not changeable	Not changeable	Not changeable
A stage that has not yet started	Changeable	Changeable	Changeable
A stage that has been completed	Not changeable	Not changeable	Not changeable

   For example, the target temperature of a stage may be changed if the set point is still ramping up to the soak temperature. The ramp rate, target temperature and soak time can be changed of a stage that has not been started.

The prompt line at the bottom of the screen shows the options:

'S' Save profile
Save the current profile changes.

'X' Export profile
Export the current profile to the hard disk, removable media or a network drive.

'I' Import profile
Import the current profile from the hard disk, removable media or a network drive.

'P' Print
Prints the table and the graph.

[ESC] to accept / exit the screen

NOTE: Changing the profile of one heater zone will not affect the other zones.

For more details on editing the shape of the graph see chapter 6, **Creating a Temperature Cycle**.

The **Process Log** screen is available from the **Main Menu**, F7.

The screen provides a periodic report of a repair with a record of all the **process messages** that have occurred during a task and all the **alarm messages**. The process log file is one of the files that is saved with the repair and can be recalled and printed later.

Entering the **Process Log** screen will accept any new alarms and stop the **audible alarm** from the HBC-43. When the alarm messages have been assessed press the [ESC] key to exit the screen. Clicking the **Accept Active Alarms** button will also silence the alarm if the screen is open when an alarm occurs.

> **NOTE:** The new messages are at the bottom of the screen and it may be necessary to scroll through to the last messages.
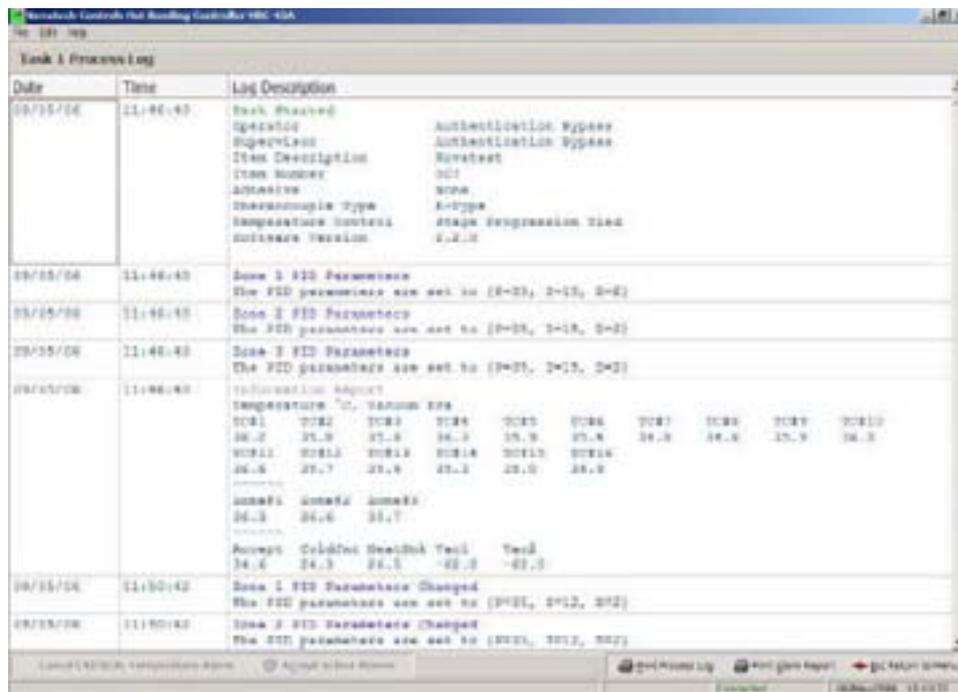
Fig. 18   Alarm and process reports screen

The **Cancel CRITICAL Temperature Alarm** button will allow the job to be restarted after the heaters have been turned off as a result of an extreme over temperature in any zone. This may have occurred because the thermocouples are not listed in the correct zone or because of a component failure in the HBC-43. (See chapter 11.2.5 for more details)

The "**P**" key can be used to print an alarm report of all the alarms, process messages and status reports for the current job or it can be viewed / printed later from the **Previous Jobs Database** screen using the **View Log** button.

The "**A**" key can be used to print an alarm only report from the full log report.

11.1 Process Log

An alarm is silenced by entering the **Process Log** screen. This screen is accessed from the **Main Menu** by pressing the **F7** key or using the mouse. It can also be accessed from any of the three monitoring screens (Status all Thermocouples, Temperature Graph, Repair Map) by clicking the **Process Log** button at the bottom of the screens.

The **L** key is a shortcut key to the Process Log screen from the monitoring screens. The Esc key will take you back to the monitoring screen that you came from. The Process Log button will flash when a new alarm occurs.

The HBC-43 software will record all events that occur during a repair. The following is a list of some of the possible process messages that are saved to the log file:

- Start task* / Stop task* / Resume task* / Finish task*
- Finish adhesive soak stage
- Periodic log
- Zone PID parameters changed
- Thermocouple control state changed
- TC acceptance stage changed
- TC Disabled
- Zone cycle changed
- Supervisor login/logout.

* - These log types also cause a periodic data log to be added to the process log file simultaneously.

11.2 Alarm List

In the same way as the process log records the messages during a repair the alarm messages are also recorded. Some of the alarm messages are:

11.2.1 Thermocouple Temperature High/Low
- Triggered by any control thermocouple that drifts more than the Temperature Alarm Threshold degrees from it's zone set point

11.2.2 Thermocouple Open Circuit / Reversed
- Triggered by any open circuit thermocouple.
- Prevents the affected thermocouple from being used as a control or acceptance.

11.2.3 Acceptance Temperature Low (only used when an adhesive has been selected)
- Triggered after 5 minutes if the acceptance temperature is below the minimum adhesive cure temperature during soak
- Will only trigger once the zone control temperature comes within the deviation range of the zone set point.
- Will re-alarm automatically after 5 minutes of being accepted if the conditions are not cleared.

11.2.4 No Acceptance Thermocouple (only used when an adhesive has been selected)

- Triggered if no acceptance thermocouple is found in a soak stage while attempting to automatically extend the soak time based on an adhesive profile
- Will only trigger once the zone control temperature comes within the deviation range of the zone set point.
- If the cause is unaddressed, it will cause the soak time to fail automatic soak extension based on the acceptance temperature.
- No soak extension will occur.

11.2.5 Critical Temperature Error

- Triggered if any control thermocouple reads significantly above the zone set point
- Significant temperature error is deemed to be 20C for a set point temperature <130°C, or 10°C for a set point temperature >130°C
- Instantly disables ALL heater outputs
- All heaters will be turned off and will only be re-started if a Supervisor or a Manager presses the CANCEL Critical Alarm button on the Process Log screen.
  (See Chapter 22, Operators and Passwords, for how to log on and off)

11.2.6 Heater Fail Alarm

- Triggered by a heater output running at 100% power for 60 seconds

11.2.7 Heatsink Temperature Error

- Triggered by the heatsink temperature reading over 70°C.
- Does not stop the heater operation

11.2.8 High/Low Vacuum Alarms

- Manual Mode - Triggered as soon as the external vacuum readings are outside the vacuum alarm parameters.
- Alarm conditions for each of the two vacuum sensors act independently for each of the two tasks
- Will re-alarm automatically after 60 seconds of being accepted if the conditions are not cleared.

In addition to the actual alarm message, the date and time of the message is also recorded.

11.3 Periodic Data Logging

The periodic data log keeps a record of the repair at predetermined intervals.

A variety of process parameters can be included in the periodic log that can be configured by using the **Periodic log Setup** button at the bottom of the screen.
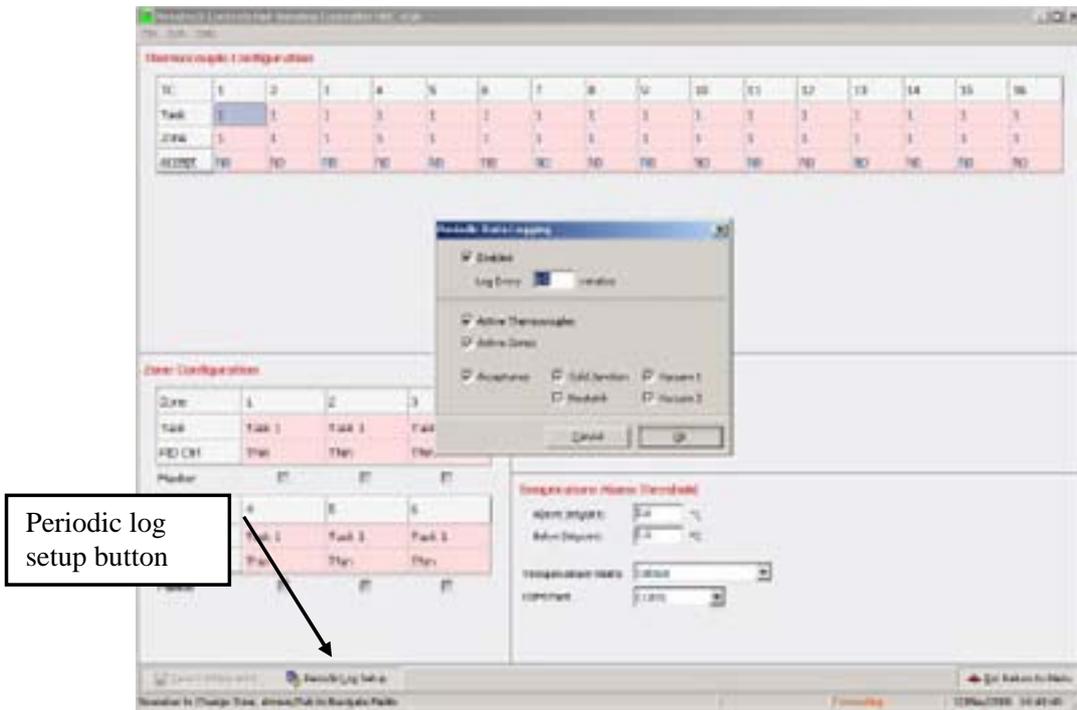
Periodic log setup button

Fig. 19 Status log options screens

When the log occurs, the selected values can be seen on the **Process Log** screen and can be printed or exported from that screen.

The program has been designed to run under Windows™ 98, NT4, 2000 or XP.
When closing the HBC-43 program follow the standard procedures for the Windows™
operating system that is on the PC.

Stop any tasks that are running and follow the prompts to save the data for later review.

Close the HBC-43 program by pressing the **F9** key from the **Main Menu** or double click on
the **Exit Program** line in the main menu.
Press **¿** to quit the program or use the tab key and then **¿** to cancel the closure.

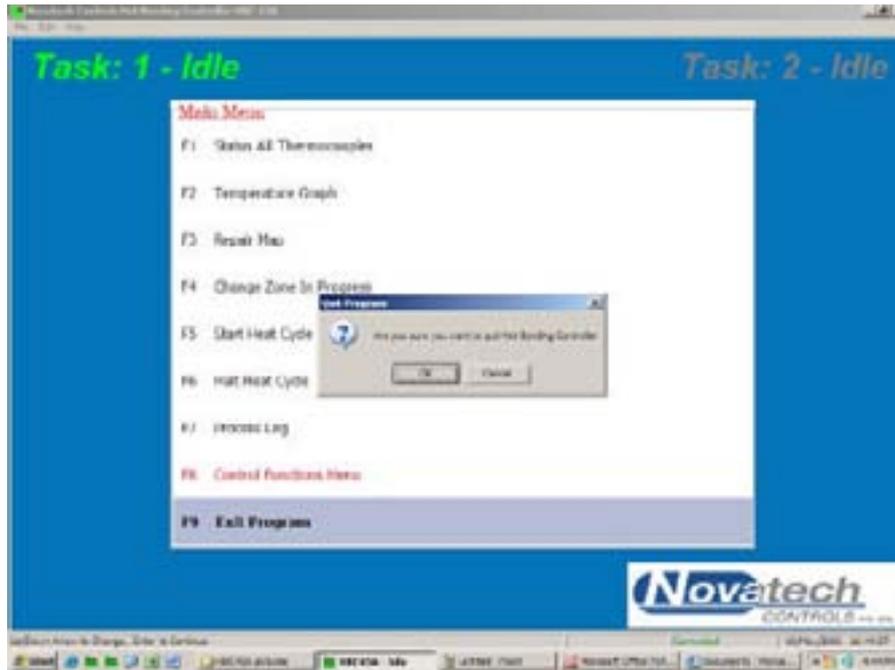Then follow the shut down procedure for Windows™.

Fig. 20 Closing the Program

NOTE: All active jobs must be stopped before the operator can close the program.

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13.1 Introduction

The cure cycle can be automatically set, based on the time / temperature data on particular common adhesives types. A Manager can add additional adhesives by using **Control Functions** menu, **Adhesives Profile Manager**.

As a temperature cycle is started, the highest temperature soak stage can be set to the correct time and temperature for the selected adhesive. In addition, the soak time can be automatically adjusted to the correct cure time for the coldest part of a repair (the coldest acceptance thermocouple).

13.2 Controlling a repair to match the Adhesive Characteristics

During the running of the cycle, the coldest of the acceptance thermocouples is plotted on the **Temperature Graph** screen. The temperature of the acceptance thermocouples is analysed during the cure stage of the cycle. The correct soak time required to cure the adhesive is calculated and automatically adjusted. There will be a process log report made of the soak time entered into the process log screen at the end of the soak time.

The report is recorded on the **Process Log** screen in both cases.
The report will show –

> ➢ zone number,
> ➢ extended soak time (calculated),

13.3 Entering a New Adhesive

If it is necessary to use an adhesive that is not already in the default list of adhesives in the HBC-43 program, another adhesive can be added. The **password** requirements of the program will only allow modifications to the adhesives to be done by a **Manager**.
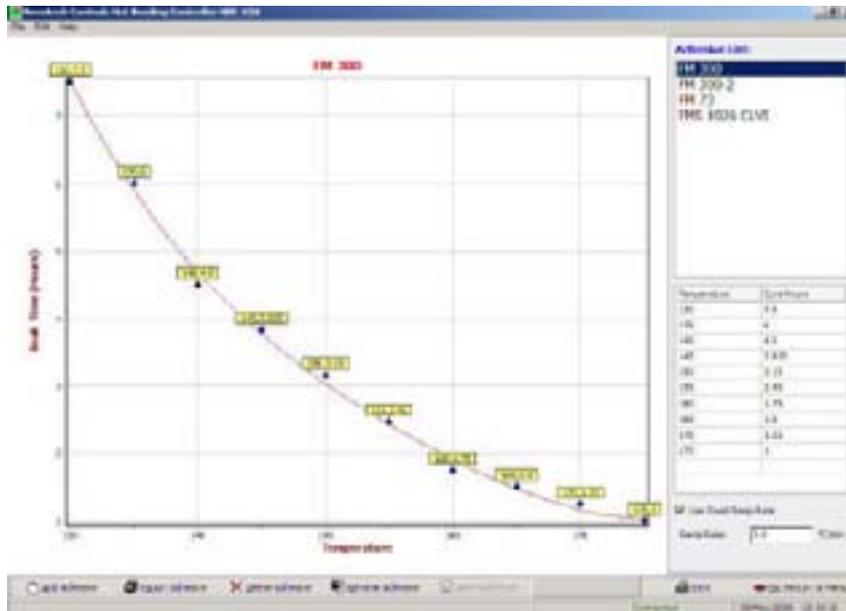For further details see chapter 22, **Operators and Passwords**.

Fig. 21 Entry of Adhesive Data

The adhesive screen cannot be accessed while a temperature cycle is running.

Adhesive characteristics are added to the program by entering the time / temperature data points from the time / temperature curing characteristics chart. A minimum of 5 data points should be used. The points should be spread evenly through the graph.

If the points are not correctly entered, an error message will appear at the bottom of the graph-

Please Check Graph for Potential Errors

This message will appear if the program deems that there is an entry error, although it will not prevent the profile from being used.

A graph of the data will automatically be drawn as the points are entered showing a line of best fit through the data points. The data points can be entered in any order and additional points can be added to the end of the table.

The buttons at the bottom of the screen provide the following functions –

Add Adhesive	Add another adhesive from • Data point entry • Imported from a file • Duplicated from an existing adhesive
Export	Export the adhesive in a form that can be saved or e-mailed to another HBC-43 user
Delete	Delete the selected adhesive
Rename	Rename the selected adhesive
Save	Save the adhesive files
Use Fixed Ramp Rate	If the tick box is ticked the ramp rate for all stages of the job will use this rate for all stages of the job.
Print	Print the graph and coefficients of the selected adhesive
Esc Return to Menu	Return to the Control Functions Menu

The HBC-43 control case has a method of controlling the heater outputs from the control case in the event of a failure of the PC during a temperature cycle. Each of the six heater outputs has an associated toggle switch and control. They are mounted on the control panel of the HBC-43 control case.

NOTE: If the HBC-43 is not being used with MANUAL control of the heaters the switched must be kept in the AUTO position, otherwise extreme temperatures may occur.

Always check the switch position before starting a temperature cycle.

When the switch is in the MANUAL position the power to the heaters can be set on the control knob anywhere between 0 and 100%.

The Hot Bonding Controller program has the ability to save and recall jobs to and from a database storage system in the PC.

While a task is running the PC saves the zone temperature data, vacuum data, repair map, data logs and process events to the hard disk. As a task is finished, these files are compressed and saved back to the hard disk. If a file is linked to a task after the repair has been finished (for example pictures of the finished repair) a linked file is also compressed and saved in the task record file. The size of a typical repair file will be about 10k without any linked files.

> **NOTE:** The linked file itself is saved in the compressed file.
> If this task file is exported it *will* include all other documents in the exported file.

A database of the compressed files is assembled and can be accessed through the **Control Functions Menu**, **Previous Jobs Database**.

15.1 The concept of a backup system

The database feature allows the record of the jobs to be saved on removable media (ie. USB flash drive, flash memory card, floppy disk, CD, DVD, external hard drive etc.) or transferred to a larger computer for backup on a hard drive or Zip / tape backup system.

The backup to network system will consist of the following steps –
* Allow the computer to save each job as it finishes to the hard disk, or to removable media.
* Transfer the jobs at a regular interval (ie. **every week**) to a network server that has backup facilities. Individual jobs can be transferred to removable media for temporary storage.

The computer saves the following information –
* Date / Time as the job is started
* Operator name
* Item description
* Part number
* Adhesive profile, if selected
* A **graph** containing the following –
  ➢ Set point temperature profile
  ➢ Hottest temperature of each zone
  ➢ Thermocouple type
  ➢ The coldest temperature of the repair
  ➢ The vacuum profile
* All alarm reports
* All supervisor / operator changes and automatic interventions
* A **map** of the repair with thermocouple and zone positions
* Files that are linked to the repair such as **digital photographs**

15.2 Saving the current job when finished

As each repair is finished the computer will save a copy of the temperature profile of the job, the map and the log file to the hard disk.

> **NOTE:** A procedure should be implemented to make sure that past jobs are not lost. The completed job files should be exported to a safe place on a regular basis.

15.3 Retrieving a previous job

Any of the jobs previously run can be recalled by searching the database.
The search can be based on –

➢ Operator
➢ Adhesive
➢ Job part number
➢ Job description
➢ Date / time

Fig. 23 Review Previous Jobs Menu

The recalling of a repair will allow access to the temperature / vacuum information that was
saved as the repair was finished as listed in figure 23. The hottest temperatures are graphed
for each zone and the coldest temperature for the repair is also shown. Parts of interest in the
graph can be expanded to show the detail as described in the chapter 9.2.1.

The map of the repair is recalled and can be re-examined as shown in figure 16.

Digital photographs of the repair can also be recalled.

15.4 Adding a Linked File to a previous job

Digital photographs and other file types can be linked to a repair history.

For example a photograph of the finished repair or a description of the surface preparation
written in Microsoft™ Word can be linked to the repair.

From the **Review Previous Jobs** menu, select (highlight) the repair to which you want to link
a file. Click the **Add Link** button at the bottom of the screen. When the **Open** dialog box
opens up, use the Files of Type window to select the type of file you want to include in the
repair (i.e. Picture, document, spreadsheet). Use the **Look In** window to find the file that you
want to link to the repair. Click the file and then click **Open**.

When reviewing a previous repair, select the repair you want to recall. Any linked files will be listed in the lower panel of the screen. Double-click the link file to view them in an appropriate application program.

To view the temperature graph, repair map and the alarm and process log files, click the **View Record** button. The temperature graph of the repair will appear.
From this screen –
- ➢ The repair map can be viewed by clicking the **View Setup** button.
- ➢ The process log can be viewed by clicking the **View Log** button.

The number buttons on the bottom of the screen can be used to show / hide any of the zone graphs. The Accept and the Vacuum buttons will show / hide the acceptance thermocouple and vacuum graphs.

The Export button will allow the temperature graph to be saved as a text table so that it could be viewed in detail, graphed in an application program such as Excel or e-mailed.

At the bottom of these screens the Print button can be used to keep a hard copy of the temperature graph and the repair map. The process and alarm log file will be opened in WordPad™ and can be printed from this program.

15.5 Transferring a job file to another HBC-43 computer
Repairs done using another HBC-43 computer can be exported to another computer.

Each repair record is a compressed file that contains three separate files. These files are –
Config.txt	Graph of the temperature and vacuums
Log.txt	All alarm messages, warnings, operator changes and data reports
Repair.map	Repair map showing the physical layout of the repair

When the compressed file is transferred, the files are placed in date order in the list of previous jobs and can be viewed using the **Previous Jobs Database** menu.

The job can be exported by clicking the **Export Record** button on the bottom of the **Previous Jobs Database** screen (or pressing the "x" key). Select the folder that you want to save the job in. The file name can be changed before saving.

The exported job can be imported into another computer from the **Previous Jobs Database** menu by –
1. Clicking the **Administrative Tasks** button
2. Click the **Import Single Record** button on the dialog box that will appear after step 1

Leave the ticks in the first and the last tick boxes (**Prompt before Overwriting** and **Re-index Database Automatically**)
3. Select the folder and the record that you wish to import
4. Click the **Open** button
5. Click **Done** when the **Database Administrative Tasks** dialog box reappears

The file will be imported into the data base and can be viewed from the **Previous Jobs Database** menu.

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16. TUNING THE CONTROLLER USING THE PID VALUES

16.1 Background

There are 3 considerations when the controller calculates the P, I and D values:

P is for   PROPORTIONAL,   measured in °C or °F (current display units)
I is for   INTEGRAL,   measured in seconds
D is for   DERIVATIVE,   measured in seconds

P	The distance the repair temperature is from the set point temperature.
I	The time the repair has been away from the set point temperature.
D	The rate at which the repair temperature is varying compared to the set point temperature.

The term PID refers to the three values used to calculate -
  The *power* required to get the *actual temperature* of the thermocouple
    equal to the *set point temperature*.

The power can be varied from zero volts to full mains voltage on the heater mat. The amount of power required has to be continuously assessed to get the temperature to the set point, or to maintain the temperature at the set point.
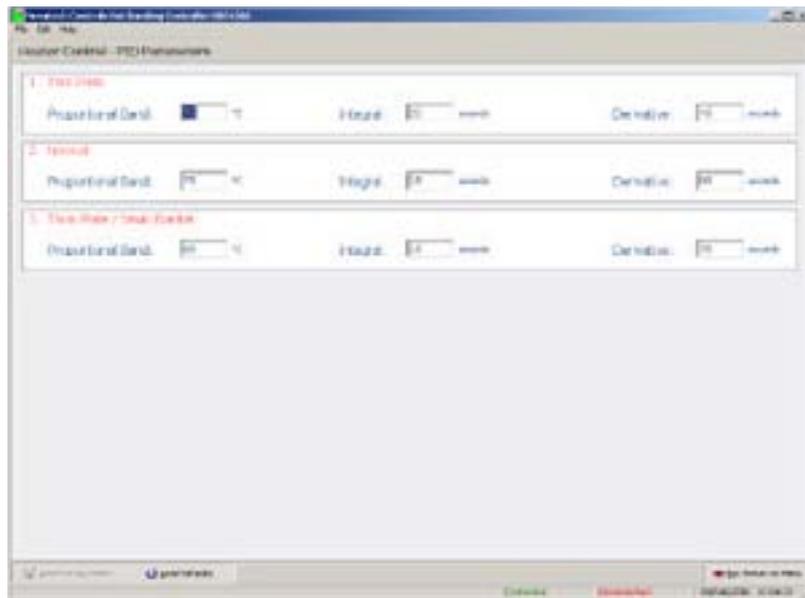
16.2 Changing the PID values

Fig. 24   PID parameters screen

NOTE:
Tuning a temperature controller takes time. Only change the values if you have no choice.
If you do change the PID, keep careful notes of the values and the temperature reactions.
Make sure you have waited long enough to let the system settle before taking the next action.

The PID values should not have to be changed. The values of –

	P	I	D	
Thin Plate	95	22	45	0.6mm aluminium plate
Normal Plate	75	18	60	2mm aluminium plate
Thick Plate	60	15	70	6mm aluminium plate

- have been found to control the temperature of the heaters within +/- 2°C of the set point.

16.3 Proportional Value

This is the most important term. The other two actions (I & D) could be turned off (a value of 0 will disable either I & D), and proportional action alone could control the temperature quite well. It sets the output proportional to the deviation of temperature above and below the set point. When the actual temperature is within this band, the controller will select a power level between off and full on.
The **larger** the number, the **smaller** the proportional effect.
Proportional action cannot be turned off.

P VALUE TOO SMALL
If the P value is too small, the controller will provide greater power variation for a small temperature variation. This will lead to instability in the patch temperature, and there will be a slow oscillation of the temperature over a few minutes. Increase the "P" value, and test the stability again.

P VALUE TOO LARGE
If the P value is too large, the temperature will not follow the ramps closely, and will not reach the soak temperatures. Decrease the "P" value, and test the control again.

16.4 Integral Value

This value is used to stop the temperature from settling just off the set point.
The **larger** the number, the **smaller** the integral effect.
A "0" will turn all integral action off. "1" is the largest or fastest action.

I VALUE TOO SMALL
The actual temperature will oscillate above and below the set point (slower than the proportional oscillation).
Increase the "I" value by 50% of the current value. If this does not reduce the oscillation of the temperature, set the PID values to the default values.

I VALUE TOO LARGE
The actual temperature will settle usually below the set point on a soak stage.
Halve the "I" value and let the controller settle down again for 15 minutes.

16.5 Derivative Value

This value is used to fine tune control. It modifies the power out in response to the rate at which the actual temperature is approaching the set point.

i.e. When the set point gets to the top of a ramp, but the power out is still set high, expecting a continuing ramp up. The D value will help stop over shooting of the soak temperature.

The **larger** the number, the **larger** the derivative effect.

A 0 will turn all derivative action off.

D VALUE TOO SMALL

The actual temperature will approach the soak temperature too slowly.

Before changing the "D" value, make sure you have a big enough blanket to heat the patch at the required rate.

Increase the "D" value by 20% of the current value.

D VALUE TOO LARGE

The temperature will be too slow to reach set point. Reduce the "D" value by 20% of the current value. If this does not produce smooth temperature control then set the PID values to the default values.

16.6 Tuning the PID values

The easiest way to get started on a repair is to use the default values that are set in the program and are shown in the table above (Chapter 16.2, Changing the PID Values). This requires that the job be assessed as Thin, Normal or Thick. The description of these jobs is also shown in chapter 16.2.

A more conservative approach, until more experience is gained with a new job, is to use proportion control only. This means turning off the integral and the derivative parts of the PID and setting the Proportional factor wide.

Set the following –

Proportional Band	60
Integral	0
Derivative	0

The result will be that the temperature of the zone will follow the set point smoothly but will be 5 to 10°C below the set point.

Introducing some integral action will bring the temperature much closer to the set point. Start with the following but increase the integral to 100 if cycling starts -

Proportional Band	60
Integral	50
Derivative	0

This will usually result in the temperature following the set point within 1 to 2°C.

To further improve the response to a sudden change in the set point such as when the ramp temperature reaches the soak temperature, a small derivative could be added. Try starting with –

Proportional Band	60
Integral	50
Derivative	4

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17.1 A zone does not heat up

Solutions:-
1. The zone has not been enabled on the **Thermocouple and Zone Configuration** screen.
2. The zone power **auto / manual** selection is not set to Auto in the control case Setup mode.
3. If the power output lamp is on, the blanket is probably faulty.
4. The heater is plugged into the wrong power outlet socket.
5. One of the thermocouples configured for that zone in the **Thermocouple and Zone Configuration** screen is actually in another zone.

17.2 A zone heats above the set point temperature

Solutions:-
1. The **auto / manual** selection is not switched to Auto on the control case.
2. One of the thermocouples configured for that zone in the **Thermocouple and Zone Configuration** screen is in another zone.
3. The PID control values are not set correctly. See Chapter 16, **Tuning the Controller Using the PID Values.**

17.3 The computer keeps 'Beeping'

Solutions:-
1. The **computer** communications cable is not connected to the computer.
2. The power is not on at the control case. Check the power leads, and the fuse inside the control case.

17.4 There are too many 'temperature too high / low alarms'

Solutions:-
1. Thermocouples and zones are configured incorrectly in the **Thermocouple and Zone Configuration** screen.
2. The incorrect PID number has been selected in the PID field of the **zone control** section in the **Thermocouple and Zone Configuration** screen.

17.5 The screen of the PC goes blank

Solutions:-
1. The PC battery has gone flat and the computer has gone into stand-by mode. Check the power and power pack leads.
2. The temperature / vacuum profile and process log / alarms will be saved and the job can be re-started.

17.6 The temperature does not control to the set point

Solutions:-

1. Check that the correct PID group is being used in the **Zone Control** section of the **Thermocouple and Zone Configuration** screen.

2. Change the PID values back to the default values of -

	P	I	D
Thin plate	15	80	5
Normal plate	15	70	10
Thick plate	25	100	5

Re-tune the controller PID values. See chapter 16, **Tuning the Controller Using the PID Values**.

17.7 A temperature is reading "o/c"

Solutions:-

1. The thermocouple may be open circuit or have a broken connector in the thermocouple plug.

17.8 The temperature in one zone goes high while the other zone goes low

The heaters and thermocouples may be in opposite zones.

Solutions:-

1. Check that the heaters are connected to the correct zone.

2. If this occurs, an alarm (Excessive Zone Temperature) will be active and heaters will be cut off automatically. They will be re-enabled if the **Cancel CRITICAL Temperature Alarm** button on the **Process Log** screens is pressed. The button can only be accessed by a Manager or a Supervisor.

17.9 There is a "Heater Fail" alarm

The heater has been running at 100% power level for more than one minute.

Solutions:-

1. Check which heater is nominated in the alarm. Make sure that it is connected to the correct zone.

2. Consider providing a secondary heat source for the area.

17.10 There is a "Thermocouple x Critically High" alarm

The temperature of a valid thermocouple is >20°C over the set point (for set points up to 130°C) or >10°C over the set point (for set points over 130°C).

Solutions:-

1. Check the solutions suggested in section 17.8 above.

2. A heater output control circuit has failed. Use another output if possible and have the HBC-43 serviced.

The accuracy of the Hot Bonding Controller is dependent on the electronics built into the control case. The electronics was designed to need very little maintenance or calibration. This has been achieved by the use of extremely stable voltage references, which are used in a continuous self-calibrating process, as well as built in self-checking processes. This is all scheduled and controlled by an internal microcomputer.

However for safety, the control box should be thoroughly checked by trained and competent personnel every year.

The annual check and calibration should include –
- Calibration of the thermocouple inputs.
- Calibration of the vacuum and pressure measuring electronics.
- Calibration of the external vacuum sensors.
- Checking of the zone power outputs.
- Operational check of the earth leakage detector.
- Physical and electrical check of the sockets and cables.

The software in the HBC-43 control case includes a restricted access calibration function. The entire calibration procedure is carried out using a PC and the HBC-43 control case. The calibration factors are stored in permanent memory in the control case. There are no potentiometer adjustments.

When the calibration check / adjustment is required, and a suitably trained organisation is not available, contact –
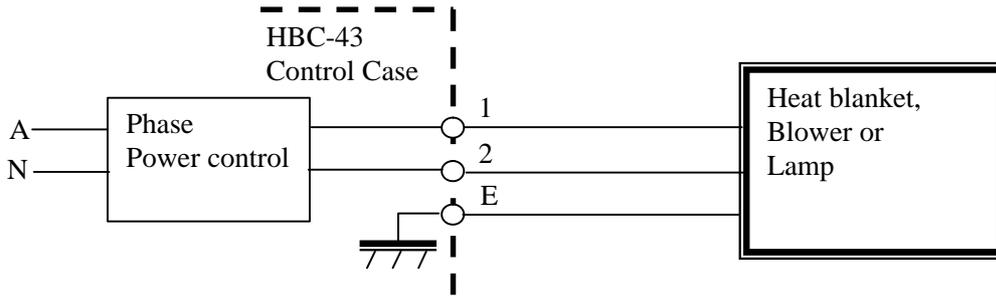
> **Novatech Controls Pty Ltd**
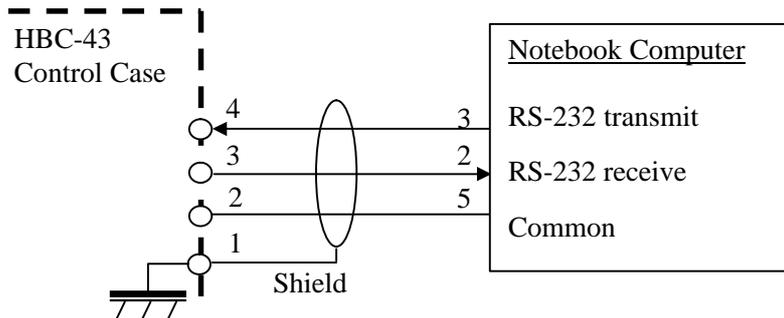> Tel   +61 3 9585 2833
> Fax +61 3 9585 2844
> www.novatech.com.au
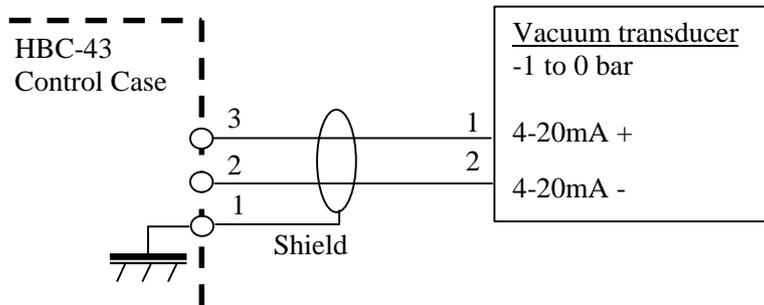
18.1 External Wiring

Heater outputs

HBC-43
Control Case

A — Phase
N — Power control

1
2
E

Heat blanket,
Blower or
Lamp

Serial communications

(Computer, RS232)

HBC-43
Control Case

4
3
2
1

Shield

Notebook Computer

3 RS-232 transmit
2 RS-232 receive
5 Common

Vacuum transducers

(Vacuum 1, Vacuum 2)

HBC-43
Control Case

3
2
1

Shield

Vacuum transducer
-1 to 0 bar

1 4-20mA +
2 4-20mA -

Mains power

HBC-43
Control Case

3 Phase Power

1 Active, phase 1 (White)
2 Active, phase 2 (Orange)
3 Active, phase 3 (Brown)
4 Neutral (Blue)
E Earth (Green/Yellow)

Novatech
CONTROLS

```
HBC-43                          Single Phase Power
Control Case
                     1
                                        Active (Brown)
                     2

                     3

                     4
                                        Neutral (Blue)
                     E
                                        Earth (Green/Yellow)
```
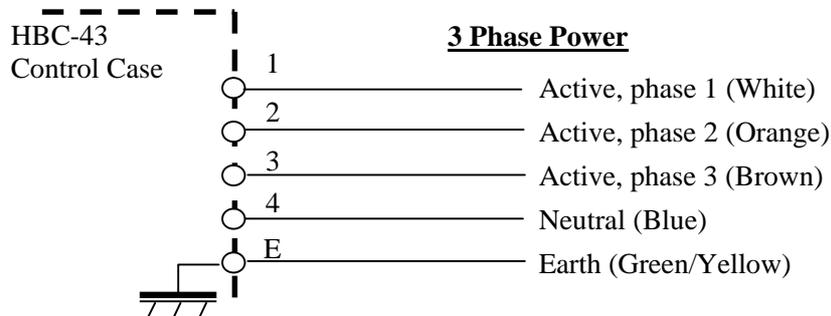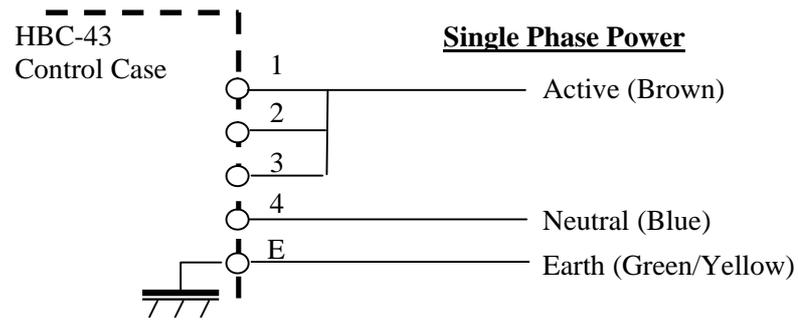
Note:
The cable colours may not always be the same as shown here

NOTE: This manual does not claim to have sufficient information to prepare and bond a patch. It must only be used as reference manual for the HBC-43 Hot Bonding Controller. For complete information on the bond process, please refer to the adhesive manufacturer, or the Training Notes.

Before the heater blankets, thermocouples and release films can be assembled, the physical damage must be repaired, and the surface preparation must be carefully done.

      Surface Preparation comprises :-
      Cleaning the Surface
      Exposing Fresh Material
      Chemically Modifying the Metal Surface

Before starting the assembly stage, the HBC-43 controller and accessory equipment supplied with the controller should be checked to make sure it is complete and in operational condition. Heater blankets in particular should be checked for sharp creases in the pad or bared wires in the lead. Also check the blanket power extension leads and the thermocouples for frayed or damaged leads.

The actual bagging sequence involves the positioning of the heater blanket and thermocouple wires in the correct positions, the proper placement of bleeder cloths, breather cloths and release films, as well as the vacuum sealant tape, bagging film and vacuum sniffer ports.

19.1 Thermocouples

The thermocouple placement is extremely important to a successful bond. The HBC-43 has provision for 16 thermocouples.
The HBC-43 also allows for up to 6 heaters. If the area to be bonded spans areas with different thermal loading, more than one heater must be used.
i.e. The patch may go from honeycomb core to a structural member.

Determine how many heaters will be used, and where they will be placed. Between 3 and 6 thermocouples must be placed under each heater.
Place the thermocouples in positions that will show the extremes of temperature. Put some of the thermocouples in the centre area of the heater and others around the perimeter. The hottest thermocouple will automatically be selected to control the temperature to the set point, and the coldest thermocouple will be monitored to allow an extended soak to be calculated.

19.2 Release Film

During the cure cycle the adhesive will expand and melt. As it melts it flows. In order to prevent the adhesive from bonding to other elements of the lay-up, a release film is placed over the repair area and the thermocouples, overlapping the repair by about 50 mm. The film is usually made of Teflon and is capable of withstanding the temperatures of the heater blankets.
When the cycle is complete, the release film allows the bagging materials to be removed easily without them bonding to the repaired area.

19.3 Heater Blankets

The HBC-43 has provision for 6 heater blankets. Choose a heater blanket close to the size of the patch. If the patch has any heat-sink areas such as an attachment point, choose heater blankets to match the shape of the heat load. The HBC-43 will individually control the blankets to maintain the required temperatures.

The heat blanket is assembled straight over the release film to enable good thermal coupling to the repair.

19.4 Breather Cloth

Breather cloth is used to maintain an even vacuum over the whole patch area without 'close-off'. It is capable of withstanding pressures of up to 700 kPa.

There are different grades of cloth available designed for particular applications such as thin cloths for tight corners and small radii.

The cloth should extend past the edge of the repair by 100-150 mm if possible, so that the vacuum ports can sit over the cloth without any risk of them sitting on the heater blanket.

19.5 Vacuum Ports

There are usually two bleeder ports (or sniffer ports) installed through the vacuum bag film. The port comes in several parts. The base plate is placed on top of the breather cloth, under the vacuum bag film. The rubber seal and upper section is attached to the base plate after the vacuum bag has been stuck down with the vacuum bag sealant, by cutting a slot in the vacuum bag film long enough for the key tags to go through the film. The upper section is pushed through into the base plate and twisted to lock the parts together.

The valve section that is screwed to the upper section has a non-return valve. This allows the vacuum supply or the vacuum gauges to be disconnected from the lay-up without the vacuum being lost.

19.6 Bleeder Cloth

The bleeder cloth is used for absorbing excess resin from the repair.

For repairs that use film adhesives there is usually no need to absorb adhesives.

When 'pre-preg' materials or wet lay-up materials are specified, excess resin has to be removed to provide the correct fibre / resin ratio. The number of thicknesses, or plies, of the bleeder cloth that are used regulates the amount of resin that is absorbed. If there is too much absorption, the repair will be resin dry, and if not enough, the repair will be resin rich.

It is most important that both of these situations are avoided by using the correct amount of bleeder cloth.

19.7 Vacuum Bag Sealant

Vacuum bag sealant is used to provide an air lock between the inside of the vacuum bag and the atmosphere.

The sealant tape is laid down along the outer edges of the repair area, and encloses the entire lay-up and bagging-up materials. The sealant tape should be capable of withstanding the high temperatures of the cure cycle, and is easily removed from the panel when the repair is finished.

Sealant tape should never be re-used.

19.8 Vacuum Bag Film

The final part of the bagging-up procedure is the application of the bagging film.

The film is very thin and conforms easily to the shapes that may exist in some repairs. Once the air has been removed from the bag, and the vacuum is created, a leak test must be performed as follows -

1. Connect a vacuum pipe to one of the vacuum outlets on the control panel.
2. Make sure the vacuum transducer is connected to the other end of the vacuum pipe.
3. Test the ultimate vacuum by turning on the vacuum with the **VACUUM ON** air switch on the HBC-43 control case.
4. Note the vacuum obtained on the **Status all Thermocouples** screen for the **Internal Vacuum Sensor**. The vacuum will be about -70kPa with a supply line air pressure of 400kPa. Turn the vacuum off.
5. Connect one of the vacuum inlets onto one of the vacuum ports on the vacuum bag.
6. Connect the vacuum gauge to the other vacuum port.
7. Turn on the vacuum with the **VACUUM ON** air switch on the HBC-43 control case.
8. Work the vacuum bag sealant and the vacuum port seals until no air leaks can be heard, and the vacuum pressure on the computer screen shows the value obtained in step 4.
9. Hold the vacuum for several minutes.
10. Disconnect the vacuum pipe from the control panel.
11. Watch the vacuum reading for the **External Sensor** on the computer, and monitor the leak rate.
12. If the vacuum falls by more than 7kPa per minute it is not acceptable.
13. Re-work the vacuum bag sealant and the vacuum ports until the vacuum falls by less than 7kPa per minute.

There are two major functions that contribute to the successful repair of a bonded panel.
1. The vacuum allows the atmosphere to exert pressure to keep all the components of the patch evenly pressed together until the adhesive has cured.
2. The removal of chemicals that retard the curing rate, from within the adhesive. These vapours, referred to as 'volatiles', if not drawn out of the adhesive during the cure cycle, will cause porosity, which greatly reduces the strength of the joint.

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One of the most critical components in the bonding process is the thermocouple. If the two wires that make the thermocouple joint are not joined precisely, significant errors in the measurement of the temperature can occur.

The best way to create a thermocouple junction is to weld the two wires. This is best done using a TIG welder; do not use oxy / acetylene as the acetylene will pollute the thermocouple junction. If a TIG welder is unavailable then an oxy / propane mixture can be used but the junction will be inferior to a TIG welded junction.

The picture below shows how the two wires are positioned so that the conductors are pushing against each other and how the junction should look after the weld. The wires should not be twisted together nor should the junction look like a "blob" of metal.

Fig. 25 The lead on the right shows how the wires should be positioned prior to the welding process. The lead on the left shows a correctly welded junction.

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21.1 Bonding accessories

Accessories case
The accessory case has been designed to carry all the items required with the HBC-43 control case. The case is 840 x 510 x 290mm.

The standard configuration of the control case includes –
* 20 high quality silicon heater blankets of 10 different sizes, a 1m lead and connector

75 x 150 mm
50 x 300 mm
150 x 150 mm
50 x 450 mm
200 x 200 mm
150 x 300 mm
200 x 300 mm
300 x 300 mm
300 x 450 mm
450 x 450 mm

* 2 vacuum hoses, 5m long, fitted with a quick connect coupling, vacuum transducer, bag entry port and a bleed tap.
* Hand held thermocouple thermometer
* 2 External vacuum sniffer type 30 gauge with a bag entry port
* 2 of 15m 3-phase power lead
* 16 type 'K' thermocouple plugs, 100 metres of 24 gauge PTFE insulated thermocouple wire
* 6 heater extension cables, 3m long

Other configurations are also available, and the blanket quantity and sizes can be tailored to meet individual needs.

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Introduction

When the program is first installed a default user and password can be used to gain access to all parts of the program with Manager authority. If security is an issue, the default user should be removed and a new user installed.

The initial default access is gained by using –
        Operator =   Default
        Password =   password

The HBC-43 software has a protection structure built into the program. There are three levels of authority within the structure. The level determines the parts of the program that will be available.

Password protection…	Operator	Supervisor	Manager
Create users at all levels of authority			*
Delete or disable accounts			*
Create or modify the adhesive files			*
View and edit the adhesive characteristic screen			*
View the adhesive characteristic screen	*	*	*
Access to the **Operators and Passwords** screen		*	*
Create users at the operator level of authority		*	*
Create or modify the temperature profiles		*	*
Change a zone temperature profile while a task is in Progress		*	*
Access to the data base of previous jobs		*	*
Access to the vacuum control setup screen		*	*
Operational parts of the program	*	*	*
Change tasks	*	*	*
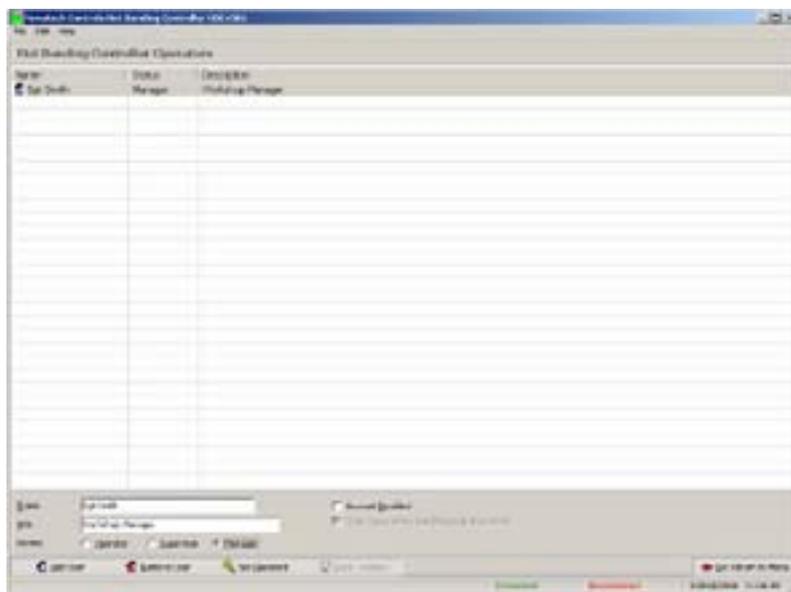
Fig. 26   Password protection screen

Creating a new User

Using the above screen, a Manager has the ability to –
     Create new users
     Select the authority level
     Disable accounts
     Change passwords

To add a new user, click the **<u>A</u>dd User** button at the bottom of the screen (or press Alt A). The Create New User dialog box will appear.

Enter the –
     User name
     User description
     Select access level
     Enter the password and password confirmation.
The password can be between 6 and 32 characters long and can contain any numbers, letters or punctuation.

If additional authority is required after a user has logged on, to gain access to a screen that the operator may not have access to, temporary access may be obtained by logging on a new Supervisor / Manager.

Use the **Supervisor Login…** under the **File** menu heading in the top left hand corner of the screen. Use the start up user name / password dialog box as used when starting the program. All changes in the operator are logged in the process log screen if a temperature profile is running.

To return to the original operator, click the **Logout** button in the top left hand corner of the screen.

Cycle
The recipe for the temperature profile is called the cycle. The cycle includes six stages. Each stage has a ramp and a soak stage.

Guaranteed Soak
If the actual temperature is not within the "**Dev**" temperature set in the **Temperature Profiles** screen (default setting is 5°C) of set point at any time during a soak stage, the soak time will frozen. This can cause the total cycle time to be extended beyond the calculated time by a few minutes, but guarantees that the zone will have the required time at the curing temperature.

Map (Repair Map)
The control program has the ability to draw, save and recall a map of the repair layout. See chapter 9.3, **Monitoring the Operation, Repair Map**.

Passwords
The passwords control access to some of the more sensitive parts of the program. See chapter 22, **Operators and Passwords**.

PID
The P, I and D (Proportional, Integral and Derivative) values are used to allow tuning of the HBC-43 temperature controller. See chapter 16, **Tuning the Controller Using the PID values**.

Ramp Rate
A temperature cycle is made up of temperature ramps and temperature hold times. The ramp rate is entered in degrees per minute. See chapter 6, **Creating a Temperature Profile**.

Soak Time
A temperature cycle is made up of temperature ramps and temperature hold times. The soak time is entered in minutes. See chapter 6, **Creating a Temperature Profile**.

Stage
The temperature cycle is broken up into 6 stages. Each stage has a ramp and a soak stage.

Zone
Each of the six heater power outputs provides a zone of control. Each zone is controlled individually, based on the thermocouples within the area of that heater blanket. There are six zones available with the HBC-43.

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