Novatech Systems

HBC-43
Hot Bonding Controller

Operators Manual

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Note:
Throughout this manual, several important keys have been referred to by an abbreviation.

ie.	¿	Refers to the Enter key
	[ESC]	Refers to the Escape key
	ALT	Refers to the Alt key (ie. ALT F1 means to hold down the Alt key when the function key F1 is pressed)
	¯, - , ¬ & ®	Refers to the Cursor keys

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1. Getting Going Fast

Once you are familiar with the HBC-43, 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, follow the chapter references written in bold type.

- **1 Heaters and thermocouples**

  1.1 Place as many thermocouples and heaters on the patch area as required.

  Note which heaters and thermocouples are associated.

  1.2 Connect the heater power leads to the power outlet sockets.

  1.3 Connect all thermocouples to the input connectors.

- **2 Cable connections**

  2.1 Connect the 3 phase power lead to the master input socket.

  2.2 Turn on the circuit breakers for all the heater zones that are connected.

  2.3 Connect the power leads to the computer power pack & the printer.

  2.4 Plug the power pack into the computer.

  2.5 Connect the RS232 lead to the computer 9 pin COM1 port.

  2.6 Connect the printer lead from the computer to the printer.

- **3** Turn the 6 manual/auto power switches to auto.
- **4** Turn on the main supply power switch on the wall.
- **5** Turn on the computer.
- **6** Select a heat cycle from the main menu.

  Edit a pre-designed cycle if necessary from the **Heat Cycle Set-Up (ALT F1)** screen, or go straight to the next step, configure the system, using an existing cycle.

· **7** Configure the system to match your current thermocouple/heater set up in **Systems Parameters (ALT F2)** from the main menu.

Current Thermocouple Configuration

7.1 Select the zone in which each thermocouple is mounted (1 to 6).

7.1 Enable all the thermocouples inputs that are connected to thermocouples (yes/no).

7.2 Select from these thermocouples, or others, the thermocouples to be used for monitoring the lowest temperature areas. (For automatic adhesive curing)

Zone Control

7.3 Enable all the output heater zones that are connected to heaters (yes/no).

7.4 Select the PID settings for each enabled heater zone (usually PID No. 1).

7.5 Tie the stages of all of the enabled zones together to synchronise the cycle stage start times.

Vacuum

7.6 Select the alarm vacuum levels, and the maximum vacuum temperature change over point. Enable the external vacuum transducers being used .

7.7 Use the default settings for Data Log period(15) and Communications port(1).

· **8** **Select Start Heat Cycle (F4)** from the main menu.

8.1 Check that all required heater zones are enabled, “YES”. (If not, [ESC]. back to the **System Parameters** window).

8.2 Select required zones by typing 'S'. (Normally use “Enabled Zones”).

8.3 Select the cycle number that was set up in the **Heat Cycle Set Up** earlier, press ¿ .

8.4 Change the cycle description if necessary, press ¿ .

8.5 [ESC] out of the **Cycle Set Up** screen, back to the **Current Program** window.

8.6 Press ¿ to accept the cycle.

8.7 Enter “Operator” name, ¿ , and “Item” being repaired, ¿ , and “Part No.”.

8.8 Press ¿ to go to the **Immediate/Auto** window. ↵ (Immediate mode) will start the cycle at the start of the next minute.

8.9 Select the adhesive type for auto soak extension or “None”, and ¿ .

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

· **9** Select **Individual Zone Performance (F2)** from the main menu.

9.1 Select the heater zone you wish to monitor (1 to 6). All other zones can be selected from the individual zone screen by pressing the desired zone number, 1 to 6.

· **10** If alarms occur because of temperature deviations on warm up, check the **Alarm Reports** (F6) screen. [ESC] will accept the alarm and silence the horn.

2. Specifications

2.1 Operational Description

Display of 16 temperature inputs:	Simultaneous, °C
Display of control temperatures:	Colour coded, graphic display of six states for up to 12 hours. These states include: *open circuit T/C, T/C OK, at set-point, cold, hot* and *off, control T/C, coldest T/C*
Temperature control:	0 to 400 °C, PID
Selection of control T/C:	Each T/C can be nominated by zone. Control will be from the highest temp. in each zone
Selection of acceptance T/C:	Any T/C can be nominated as an acceptance T/C. The coldest T/C will be plotted. The soak time can be automatically set.
Accuracy:	+/- 1 °C
Temperature ramp rates:	1 to 9.99 °C per minute in 0.01 degree increments
Cycle duration:	0 to 12 hours in one minute increments
Cycle profile:	Up to six ramp / soak stages each cycle
Memory:	Up to 100 pre-programmed cycles
Heater configuration:	Selectable on the keyboard
Hard copy of data:	Available automatically during cycle including: *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 name* Available on request from the keyboard: *Graph of temperature and vacuum/pressure for current cycle*
Storage of finished cycle	Completed run is saved on the hard disk and on floppy disk for backup
Retrieval of previous runs	Selected by part number, operator, adhesive, job description or date/time
Manual power output over-ride:	Auto-manual over-ride on each heater output
Alarm identification:	On screen display and hard copy print
Watch-dog timer:	Alarm in case of computer or software failure
Alarm status:	Temperature deviation Keyboard settable: T/C burnout, vacuum over pressure condition.
Alarm shutdown / re-start:	Selectable from the keyboard: re-start from beginning, resume control from the last point
Power fail re-start:	Re-start at last point (Cycle data is stored on disk every minute)

2.2 System Specification

Number of thermocouple inputs:		Sixteen (K type thermocouples)
No. of ramp / soak control stages:		Six
Number of controlled outlets:		Six
Type of controlled output:		Phase angle fired SCRs to operate infra-red heater lamps or mats
Power to controlled outlets:		240V, 10A, 2.4KW per outlet, 17.4 kW total or 110V, 10A, 1.1 kW per outlet, 7.8 kW total
Vacuum source:		Air operated ejector, down to -80 kPa
Power supply safety protection:		Earth leakage circuit protection on each output
Case:		Three transportable cases, Computer/Printer Control system Accessories (Heater mats, cables etc.)
Power requirements:		Two 3 phase outlets 415 or 220V, 50 / 60 Hz
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 Size:	30 kg

2.3 Hardware Description

- One notebook computer with VGA active matrix colour screen, Pentium processor, 2 GB hard disk, 64MB RAM, CD ROM, 3.5” floppy disk drive
- One control case providing for 16 thermocouple inputs, 2 vacuum transducers, 6 outputs for power control, and one alarm sounder
- Six phase angle fired Triac circuits to operate heater mats or infra-red lamps, 10 Amp with earth leakage safety breakers
- One Cannon color bubble jet printer with single sheet auto paper feeder
- One set of pressure & (two) vacuum gauges, pressure regulator, vacuum transducer and ejector type vacuum pump requiring a 60 psi air supply
- Twenty heater mats of various sizes
- One set of accessories comprising eight heater leads, 100 metres of thermocouple wire, quick connect hoses, two sniffer valves and two sniffer vacuum gauges

3. Software Description

The software running on the computer provides a complete control system interface to the user. There are screens that show all the temperatures in table form or a graph of the way the heater has followed the set point. Temperature profiles can be user designed or automatically set using the published adhesive specifications.
The heaters and thermocouples are configured in the System Parameters screen.
The hottest thermocouples for each heater are automatically selected for the PID control, and the coldest thermocouple is graphed and logged to assure reliable temperature control.
User settable alarm conditions for the temperatures and vacuum/pressure levels are monitored.
Alarm conditions are displayed on the screen and printed for a hard copy.
The graph can be printed at any time on a color bubble jet printer.
As the run is finished the temperature/vacuum/time graph can be saved to hard disk and floppy disk and can be retrieved for later examination for quality control records.

3.1 Turn The Computer On

When the computer is turned on, the HBC-43 software will automatically load and start running.

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.
Use the RS232 lead to connect the computers serial port on the rear of the computer (9 pin 'D' connector) to the HBC-43 control box.

If there was a cycle running and not halted when the computer was turned off the previous time, you will be prompted -

The program will default to halting the current cycle if neither key is pressed within 15 seconds

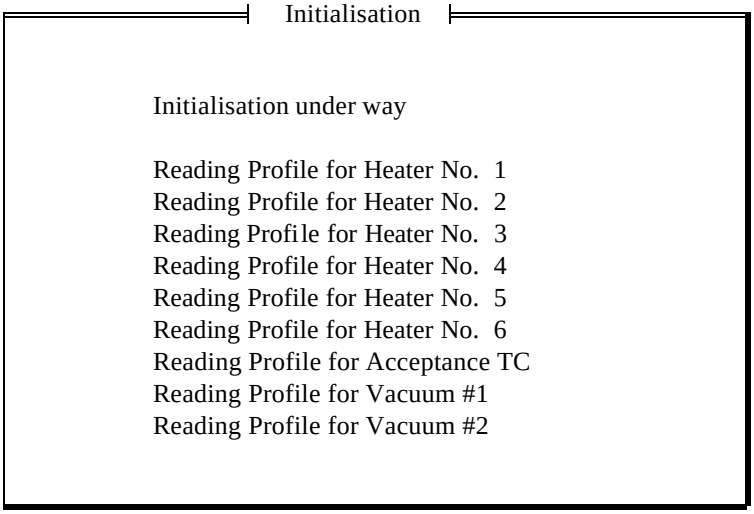


Fig. 1 Start up screen

If the HBC-1 interface circuit board inside the HBC-43 does not respond to the serial communications within 10 seconds, the computer will flash the message-

COMMs - Failure To Start

Press any key to continue. Continuous attempts to restart communications will be made. Beeps will be heard from the computer until communications is established. The power output will be inhibited from the HBC-1 interface circuit board.
If this message is displayed, check the cable from the HBC-43 control box (RS232, 4 pin socket) to the serial port on the rear of the computer (9 pin 'D' connector). For further information, see the trouble shooting guide at the end of this manual.

Note:
If the power adaptor is **not** plugged into the external power socket in the top of the computer, or the mains power is **not** plugged into the computer power adaptor, the batteries in the computer will only last ½ an hour. The computer will go into stand-by mode until the power is connected to the computer.
See the Operators Guide for further information.

3.2 Main Menu

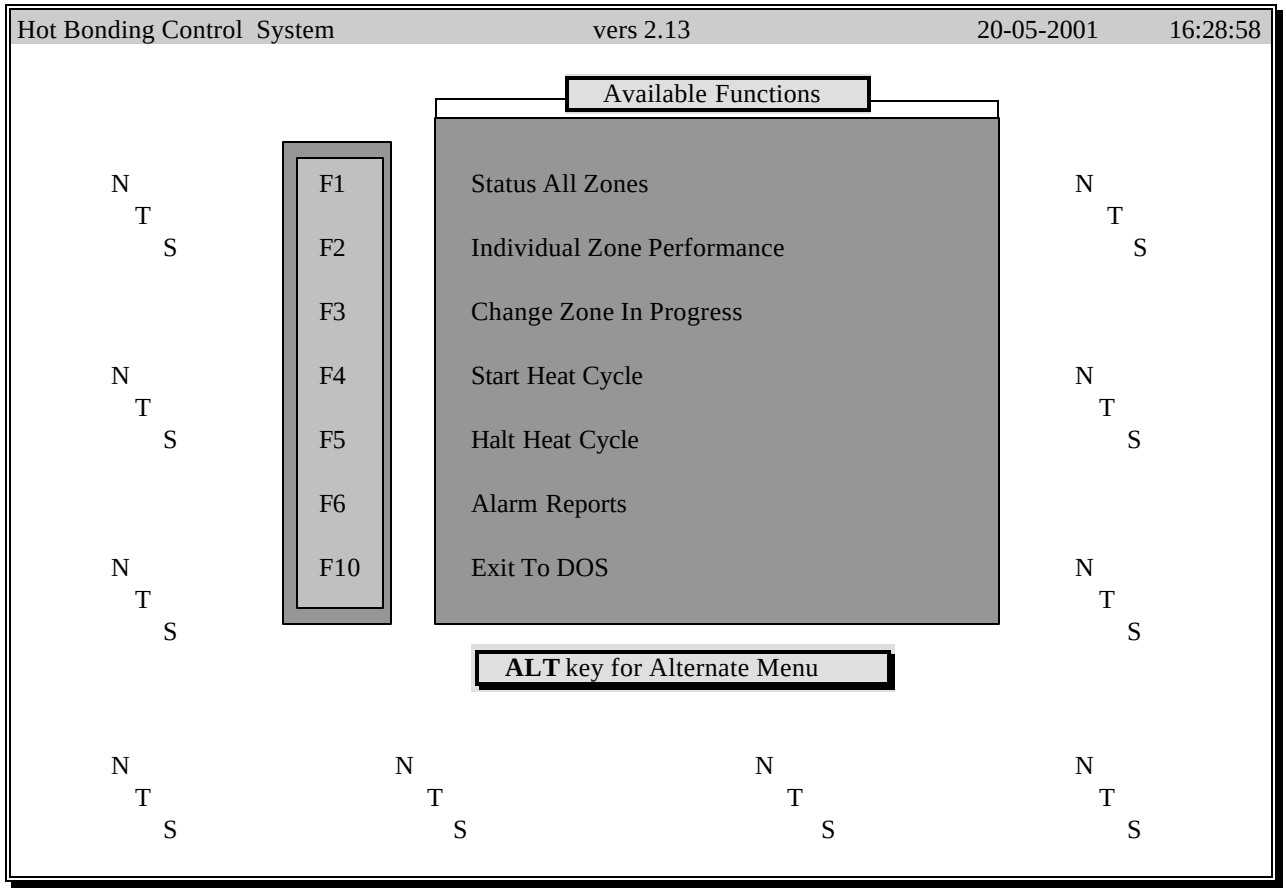


Fig. 2A Main menu screen

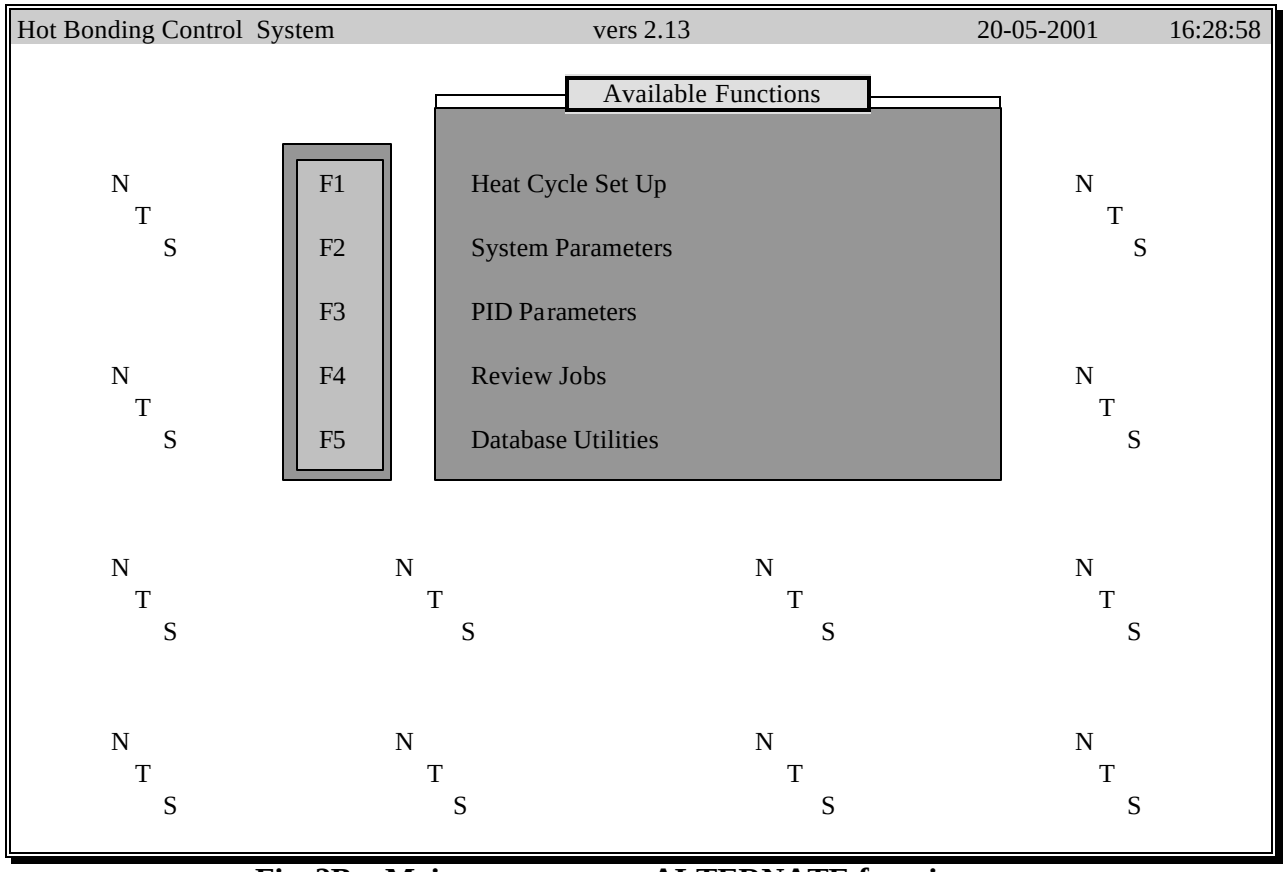


Fig. 2B Main menu screen, ALTERNATE functions

Notes on Using the Main Menu

The program functions accessible via the menu system have been split into two groups.

When the program first starts, the menu displayed provides access to the most common of the functions that are required to run a heat treatment cycle.

The ALTERNATE menu, which is displayed when the ALT key is held down, provides access to functions that are used to set up a heat cycle or to save and recall completed cycles.

1. To select a function either -
    1. Press the corresponding function key
        ie. Function key F3 will select “Change Zone In Progress”
    2. Use the up/down cursor keys to highlight the required function.
       Press the ↵ key.
2. To access the ‘Alternate Menu’, hold down the Alt key, and then press a function key.
3. To return from a function to the Main Menu, press [Esc].

3.3 Status all Zones:

On this screen is display- The current operating status of all of the heaters or zones of control
The ambient temperature
The temperature of the power controller heat sink
The vacuum level of both remote transducers
The start time and cycle run time

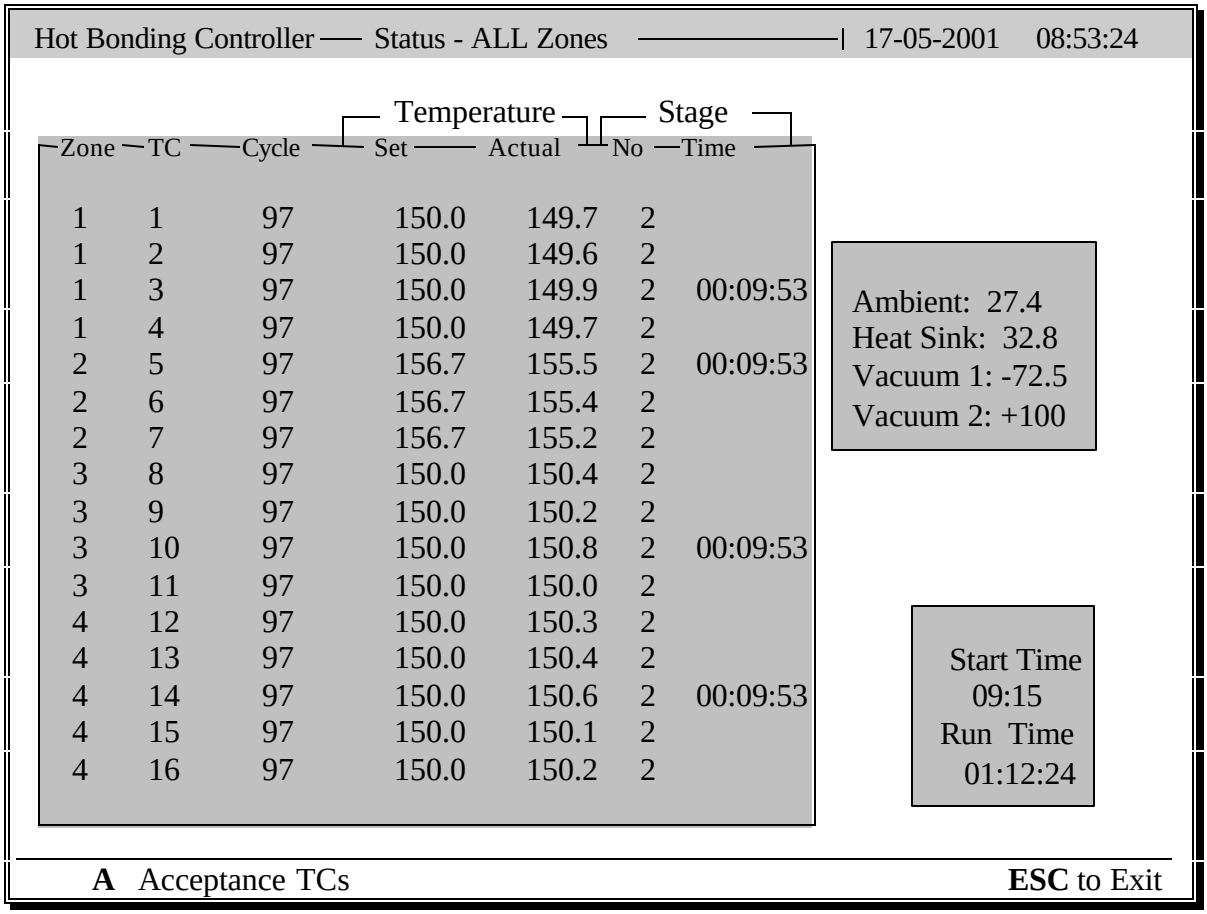


Fig. 3 Status All Zones screen

3.3.1. *Main Box*
The main box shows each zone with its associated thermocouples.
Columns are provided for :
1) Zone number (Heater output)
2) Thermocouple input number
3) Temperature
   3A) Set point temperature
   3B) Actual temperature
4) Cycle stage
   4A) Stage number currently running
   4B) Time this stage has run

3.3.1.1 Zone number
Each zone is listed in numeric order if it is enabled from the **System Parameters** screen. There is one line for each thermocouple associated with the zone.

3.3.1.2 Thermocouple input number
Each thermocouple is listed under the zone it is associated with in the **System Parameters** screen.
The computer will automatically select the hottest thermocouple to use as the control sensor. The thermocouple input being used to control each zone is displayed in **red**.
If acceptance thermocouples are selected from the System Parameters screen, one thermocouple number will be displayed in **blue**. This will be the coldest sensor.

3.3.1.3 Set Point Temperature
This column shows the current set point for each zone and thermocouple. The set point is determined by the cycle that was selected to run, and the stage of that cycle currently being run.

3.3.1.4 Actual Temperature
This column shows the actual temperature for each zone and thermocouple.
Color coded information/warnings are displayed in this column.

Color	**Meaning**	**Solution**
Black on white	Normal	Normal
White on blue	Actual temperature is below the set point by between 2.5°C and 5.0°C	The temperature control will adjust the power level automatically.
Flashing white on blue	Actual temperature is below the set point by more than 5.0°C	The temperature control will adjust the power level automatically.
White on red	Actual temperature is above the set point by between 2.5°C and 5.0°C	The temperature control will adjust the power level automatically.
Flashing white on red	Actual temperature is above the set point by more than 5.0°C	The temperature control will adjust the power level automatically.
Flashing red on white “o/c”	The thermocouple is open circuit	Repair the thermocouple or Disable the thermocouple in the System Parameters screen.

The Actual Temperature display is also used to indicate an abnormal condition of the of the temperature reading electronics in the control case.

Abnormal Temp.	**Probable cause**	**Solution**	
460.0	The ambient temperature and the heatsink temperature are too far apart.	Check the ambient and heatsink RTD temperature sensors.	
470.0	The calibration memory module has - Not been initialised. or It has lost all calibration data.	Perform a full calibration. **	
480.0	The check sum in the calibration memory is incorrect.	Put the HBC-43 into calibration mode. Type "FINISHED". Check the calibration accuracy. **	
490.0	The active memory check has failed.	Replace the bridge rectifier BR4 on the HBC-1-3 PCB.	
500.0	The temperature has been read as >400°C.	The thermocouple is probably open circuit or not connected. It will need to be re-enabled in the **System Parameters** screen.	

** NOTE: Refer to the Novatech Systems, HBC-43 "Routine Calibration and Operational Check" manual. RAAF reference AAP 7656.032-2M.

The table above shows the possible abnormal temperatures that may be displayed for one or all the Actual Temperatures and the suggested solutions. For further information check with either Novatech Systems, or the calibration authority.

3.3.1.5 Stage number
This column shows the stage of the cycle that is currently being run.
There are six stages in every temperature cycle. Each stage has been programmed with a ramp and a hold section. See **Heat Cycle Set Up** for more details.

3.3.1.6 Time this stage has run
As soon as the stage of a cycle is started, this time will be displayed in minutes and seconds. It will appear once in the table for each zone on the control thermocouple row.

3.3.2 *Ambient/Heat sink/Vacuum Box*
3.3.2.1 The ambient temperature is measured on the thermocouple terminal strip. The same sensor is also used for cold junction compensation for the thermocouples.

3.3.2.2 The heat sink temperature is a measure on the finned aluminium SCR heat sink block on the top panel of the control box. It should never be allowed to rise above 80°C. Under normal operating conditions it will be very close to the ambient temperature. Reducing the power load of the heaters will reduce the temperature.

3.3.2.3 Vacuum 1 & 2
The vacuum as measured by the two remote transducers is displayed here.
A value of between -100 to 0 kPa is acceptable. About -60 kPa is normal.
A value of +100 means the transducer is either not connected or is not functioning.

3.3.3 *Start time & Run time*
3.3.3.1 The start time is simply the time of day that the cycle was started. This is important when automatic start was used.

3.3.3.2 The run time is the total elapsed time since the cycle was commenced. It will include time incurred because of the guaranteed soak feature. See Glossary of Terms for further explanation.

3.3.4 From the main **Status All Zones** (F1) screen, you have two option keys:

1) Pressing the 'A' key will show only the thermocouples that have been nominated as ACCEPTANCE thermocouple from the **System Parameters** screen. A second press will toggle the other thermocouple's back on.
2) The [ESC] key from any screen will return you to the main menu screen.

3.4 Individual Zone Performance:

3.4.1 *Normal View*
This is the most useful screen to monitor the continuing performance of a heat cycle.
When selected from the main menu, this screen will show an edit box for selection of zone of control.
Types a zone number between 1 & 6 and press ↵.

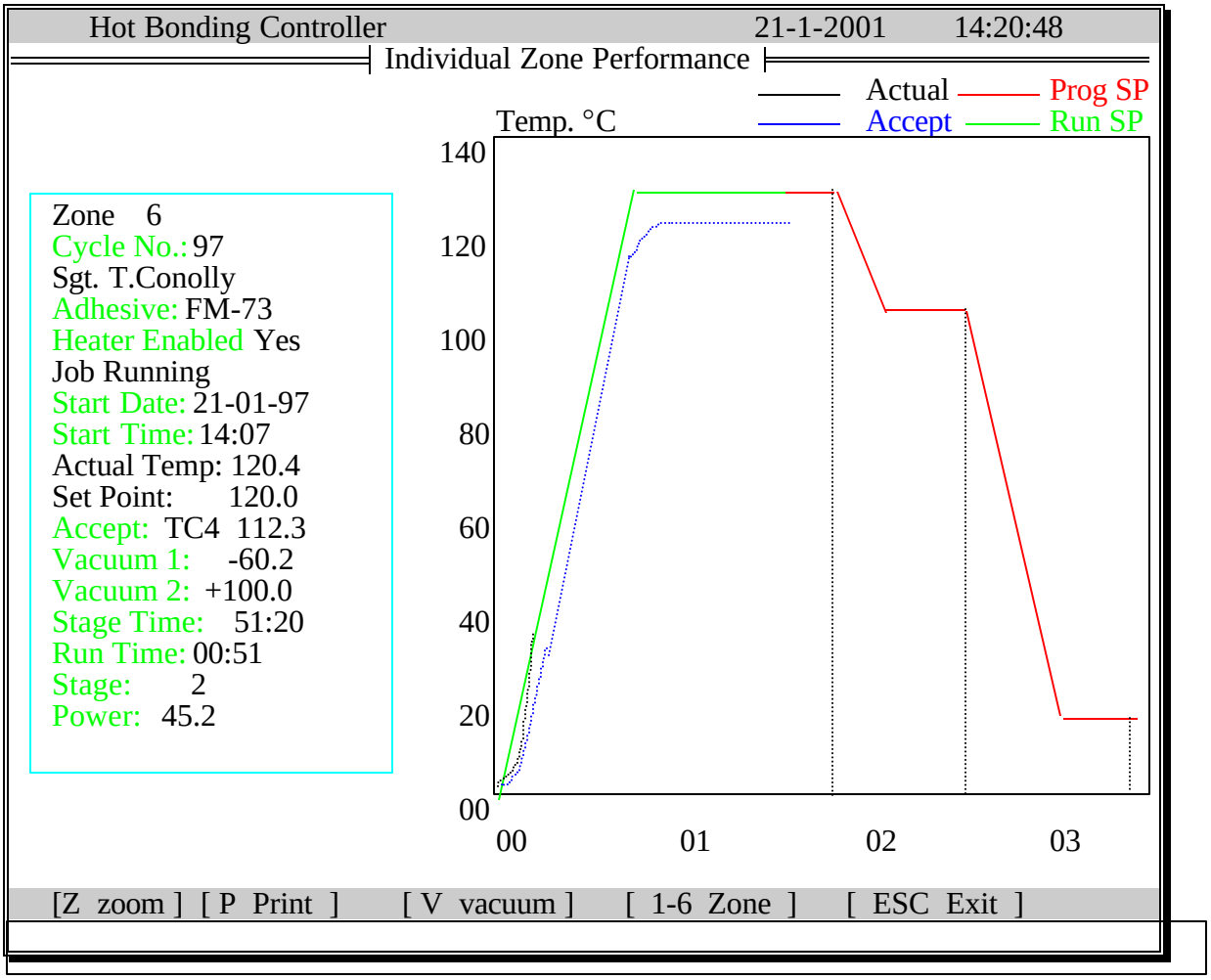


Fig. 4 Individual Zone Performance Screen

The screen provided shows a graphical profile for that zone of control and a window on the left hand side of the screen with data, which describes the current performance of the zone of control.

In this window the information provided is :

1) The selected heater.
2) Program number running for that zone of control
3) Whether or not the heater for that zone of control has been enabled by the operator.
4) Current operating status which can be- Job Running
   No jobs Running
   Waiting to Start
5) The date and time when this cycle was started. These fields are particularly important if the job has been started automatically on date and time.
6) The actual temperature for the control thermocouple for this zone.
7) The current set point for this zone.

8) The time that the current stage (either ramp or soak) has been running. The stage time will not commence until the actual temperature gets within 2.5°C of the soak temperature. For further explanation of Guaranteed Soak, see Glossary of words.
8) The run time. The length of time for which the cycle has been running.
9) The stage number that the cycle currently timing. This number can be from 1 to 6.
10) The percentage of full power being sent to the heater for this zone.

On the right hand side of the screen is a temperature/time graph.

The **Green** 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 operates.

The **Red** profile is the predicted set points as calculated from the cycle selected.

Superimposed on this, will be the actual temperature profile (**white**) verses time for the current process as it has been running.

The **blue** trace records the acceptance thermocouple temperature.
ie. The lowest temperature of all the thermcouples nominated as acceptance thermocouples on the **System Parameter** screen.

As the temperatures are being measured, the graph of actual and set point temperatures will up date on the screen every second. If a graph is re-drawn, using a zone number or going to another menu screen, the graph will be re-drawn from temperatures acquired on the minute readings. For this reason, there may be up to a one minute mismatch in the traces of the graph.

From the main **Individual Zone Performance (F2)** screen, you have several option keys:

1) Pressing the 'Z' key will get a **Zoom** and **Zoom Review** screens of the graphical profile. The ¿ key will return you to the main **Individual Zone Performance** screen. See the next page for further detail.

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

3) Pressing the 'V' key will toggle on and off a vertical scale and two traces for the vacuum/pressure transducers on the graph. The scale is from zero to one atmosphere of either vacuum or pressure. (See Fig. 5)

4) Any of the other heater zones can be displayed immediately from the main Individual Zone Performance screen by simply pressing the zone number (1 to 6).

5) The [ESC] key from any screen will return you to the main menu screen.

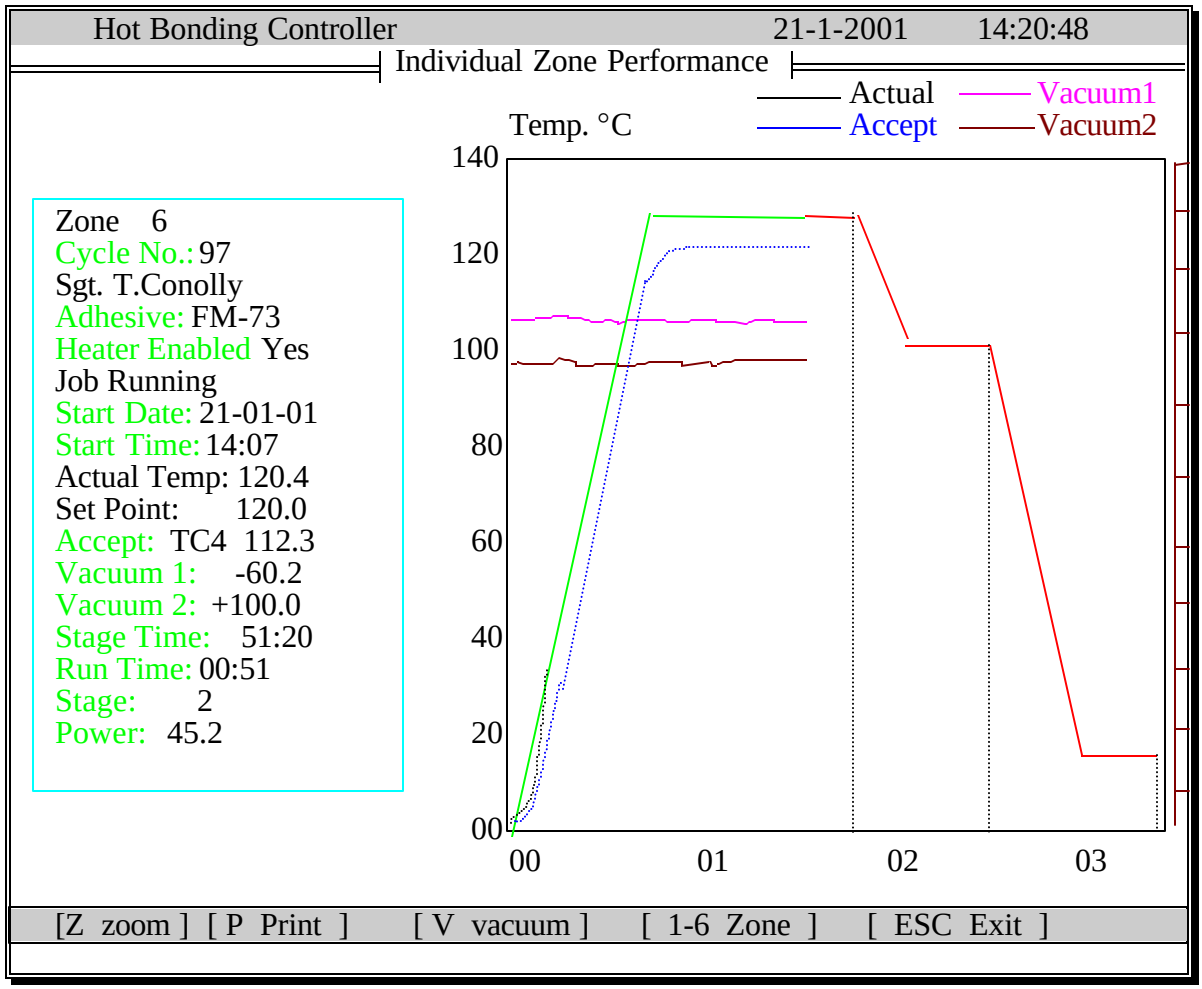


Fig. 5 Individual Zone Performance Screen, with Vacuum/Pressure scale

From the main **Individual Zone Performance (F2)** screen, one of the option keys is -

Pressing the 'V' key will toggle on and off a vertical scale and two traces for the vacuum/pressure transducers on the graph. The scale is from zero to one atmosphere of either vacuum or pressure. (See Fig. 5)

3.4.2 ***Zoom*** *screen*

Enter the 'Zoom' mode by pressing the ← key while in the 'Individual Zone Screen'.

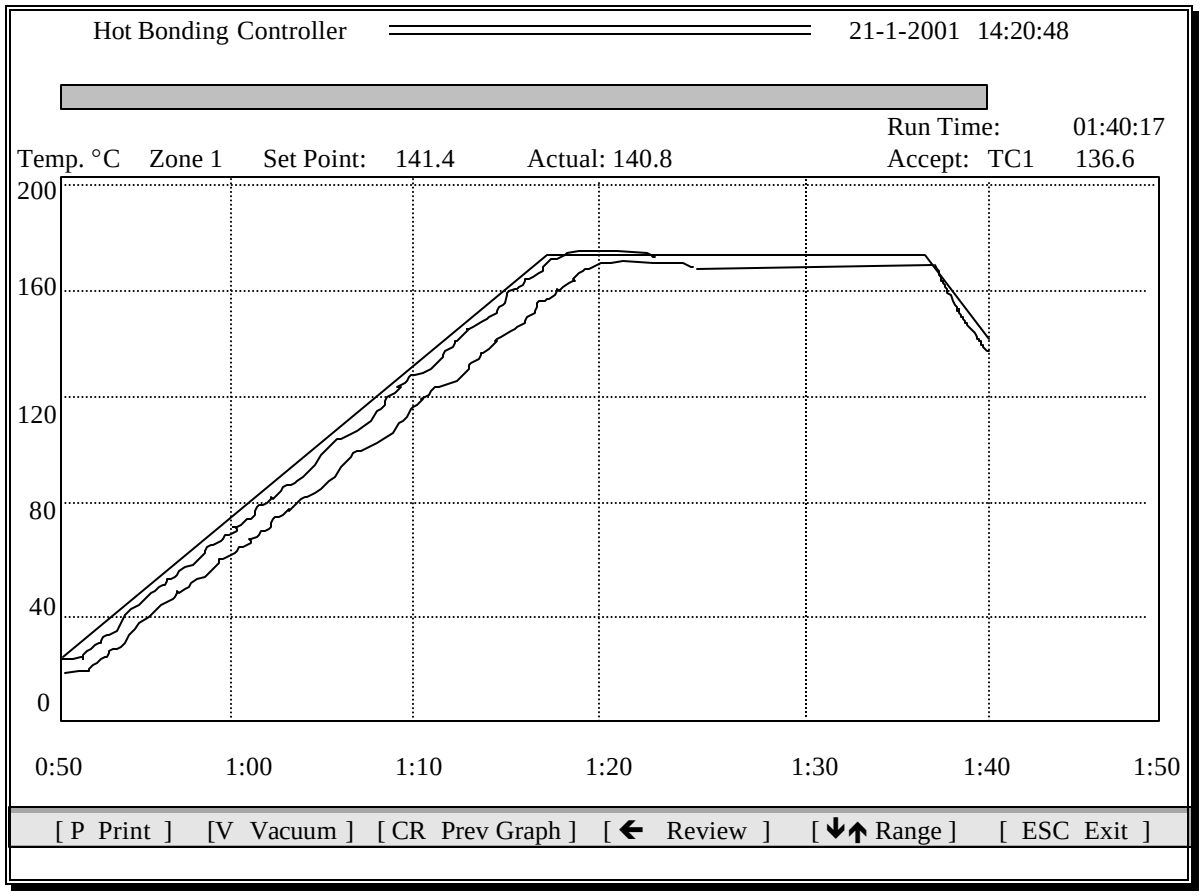


Fig. 6 Individual Zone Performance, Zoom screen

From the main **Zoom screen**, you have several option keys:

1) Pressing the 'P' key will print the screen. This will provide an immediate hard copy of the temperature/vacuum profile.

2) Pressing the 'V' key will toggle on and off a vertical scale and two traces for the vacuum/pressure transducers on the graph. The scale is from zero to one atmosphere of either vacuum or pressure.

3) CR will return to the full profile graph.

4) ← (left cursor key) will take you to the **Zoom Preview** screen. See the next page for further details.

5) Pressing either up or down cursors keys (↓↑) will move the temperature scale in 50° steps to allow closer examination of the temperature.

6) [ESC] will take you back to the main menu.

3.4.3 *Zoom screen, with the temperature scale expanded*

Enter the 'Zoom' mode by pressing the ↓ or ↑ key while in the 'Individual Zone Screen'.

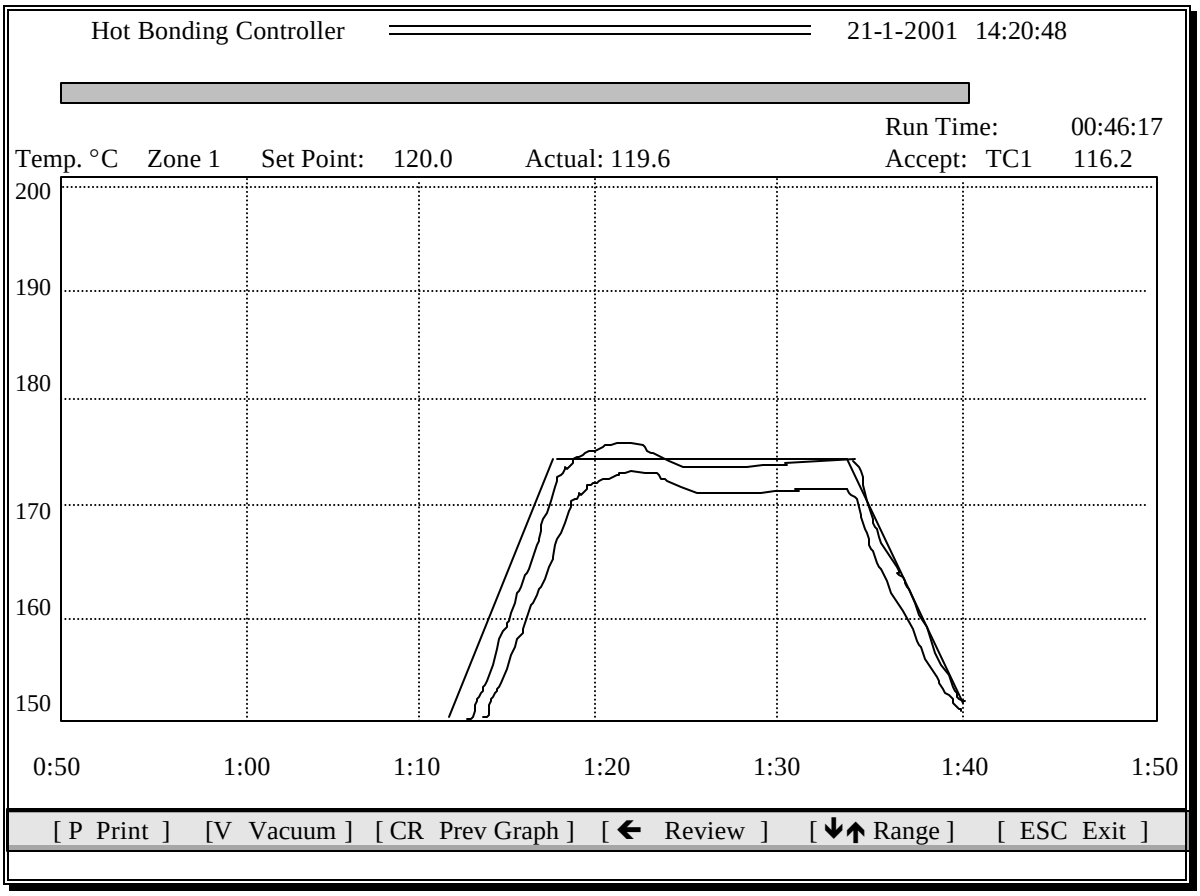


Fig. 6 Individual Zone Performance, Zoom screen, temperature scale adjusted

When either the up or down cursor keys is pressed in the **Zoom screen**, the temperature scale can be adjusted to view a 50° window of the temperature profile.

The option keys available when the temperature scale has been adjusted are the same as from the main **Zoom screen.**

Pressing either up or down cursors keys (↓↑) will move the temperature scale in 50° steps to allow closer examination of the temperature.

3.4.4 ***Zoom Review*** *screen*

Enter the ZOOM PREVIEW mode by pressing the ← key while in the 'Individual Zone Screen', and while in the 'Zoom Mode'.

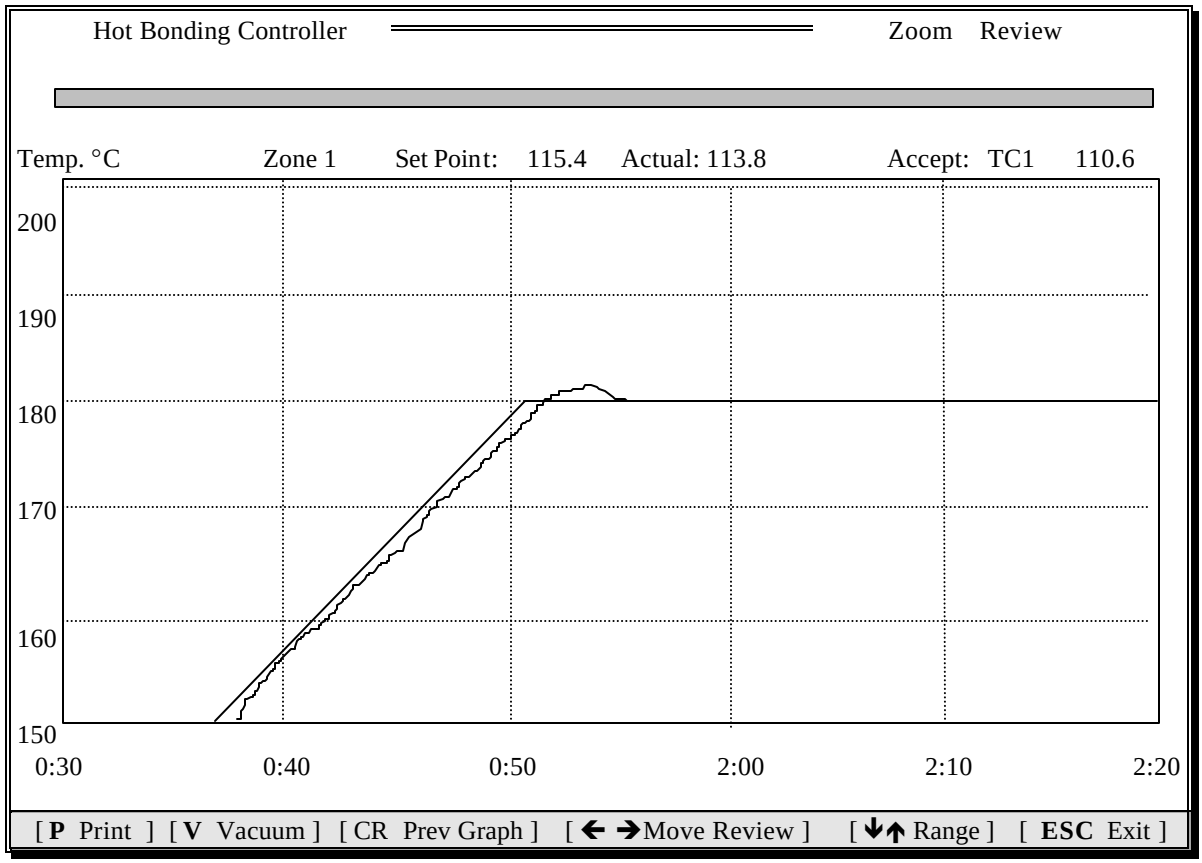


Fig. 7 Individual Zone Performance, Zoom, Preview Screen

From the main **Zoom Preview Screen**, you have several option keys:

1) Pressing the 'P' key will print the screen. This will provide an immediate hard copy of the temperature/vacuum profile.

2) Pressing the 'V' key will toggle on and off a vertical scale and two traces for the vacuum/pressure transducers on the graph. The scale is from zero to one atmosphere of either vacuum or pressure.

3) →← (left/right cursor keys) will move the display backwards and forwards in 30 minute intervals, always displaying 60 minutes of the profile.

4) ↓↑ (down/up cursor keys) will move the display backwards and forwards in 30 minute intervals, always displaying 60 minutes of the profile.

5) Pressing either up or down cursors keys (↓↑) will move the temperature scale in 50° steps to allow closer examination of the temperature.

6) [ESC] will take you back to the **Zoom** screen.

3.5 Change Zone in Progress:

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** from the main menu. An edit box will appear for selection of heater zone of control. Types the zone number between 1 & 6 that you wish to modify, and press ¿ .
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.
The prompt line at the bottom of the screen shows the two options:

E to edit the table
[ESC]. to accept/exit the screen

Note: Editing one heater zone will not affect the other zones.

The box above the graph shows :-

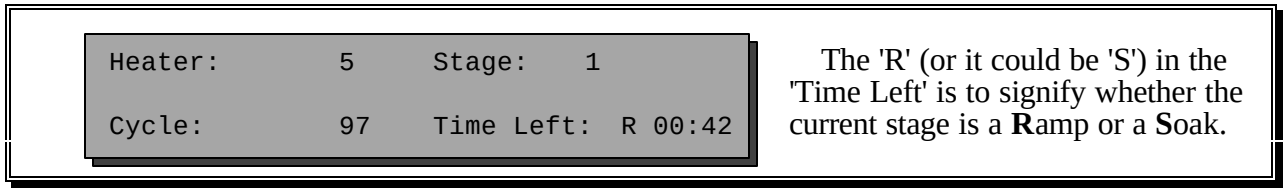


Fig. 8 Change Zone In Progress Information Box

The edit table to the right of the screen defines the graph shape :-

Stage	Temp		Mins	Heat Rate	+/- Dev.
1	0				NO
	to	100	30	2.00	5
> 2	100				YES
	to	120	30	3.00	5
3	120				YES
	to	220	30	2.50	5
4	220				YES
	to	180	30	2.50	5
5	180				YES
	to	100	30	2.00	5
6	100				YES
	to	0	30	2.00	5

Fig. 9 Change Zone In Progress Temperature Data Table

The " > " symbol to the left of the table points to the stage currently being run.

The "YES" or "NO" in the right hand column is an enable or disable flag for the vacuum/pressure alarms. Using the 'space bar' can toggle the flag. If "NO" is set here, the vacuum/pressure alarm will not occur for this stage of the cycle.

Pressing 'E' for edit will allow any of the values within a stage to be changed.

Highlight the value to be changed using the cursor keys. Typing over the current value will replace it in the table. The cursor keys or the ¿ key will move the highlight to the next table position, produce an update on the graph.
Use the [ESC] key to save the change(s) and exit back to the main menu screen.

3.6 Start Heat Cycle

3.6.1 ***The easiest way to get a selected cycle running :-***

Normally all the heater zones that were configured in the **System Control Parameters** screen will need to be started. The procedure is :-

1. Press the “S” key, to select the cycle.

2. Press ¿ , to choose the default (**Enabled Zones**).

3. Scroll through the alphabetic ordered list of cycle recipes until you find the one you want to run. Type the cycle number followed by a ¿ . Change the Description if required, as prompted, or ¿ to continue to continue.

4. You now have 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. They will only be used for this running of this cycle. Press [ESC] to continue.

5. Press ¿ to enter the operator name and particulars of the work being done. Use the tab key to toggle between the fields.

6. Press the ¿ key to go on. The **immediate/auto** window gives the user the option of starting immediately (on the turn of the next minute), or by selecting **Auto,** and by setting the start time, to do a delayed start. Press ↵ on the start mode required.

7. The operator is now given the option to have the computer automatically monitor the cycle that has been selected. If an **adhesive type** is chosen, the highest temperature soak stage will be set to the characteristics of the selected adhesive. Confirmation of the new time/temperature will appear for each zone that is selected.

8. To monitor the cycle in progress, go to the **Status All Zones** screen or the **Individual Zone Performance** screen.

3.6.2 *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.

```
 Hot Bonding Controller  ──────────────────────────────   27-05-2001
08:53:51
═══════════════════════════╡    Current Program╞═══════════════════════════
   Zone Number ....   1         2         3         4         5         6
   Zone Enabled ...  YES       YES        NO        NO        NO        NO
──────────────────────────────────────────────────────────────────────────

  Acceptance TC ...  0         0         0         0         0         0
 Stage Set Point .. 80 ± 5    80 ± 5    50 ± 5   100 ± 5   100 ± 5   100 ± 5
   1   Soak Time ..  5         5         5        30        30        30
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00
 Stage Set Point ..120 ± 5   120 ± 5    75 ± 5   120 ± 5   120 ± 5   120 ± 5
   2   Soak Time ..  5         5        10        40        40        40
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00
 Stage Set Point ..160 ± 5   160 ± 5   100 ± 5   160 ± 5   160 ± 5   160 ± 5
   3   Soak Time ..  5         5        15        50        50        50
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00
 Stage Set Point ..110 ± 5   110 ± 5   120 ± 5   200 ± 5   200 ± 5   200 ± 5
   4   Soak Time ..  5         5        20        60        60        60
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00
 Stage Set Point .. 90 ± 5    90 ± 5    75 ± 5   140 ± 5   140 ± 5   140 ± 5
   5   Soak Time ..  5         5        10        70        70        70
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00
 Stage Set Point .. 40 ± 5    40 ± 5    60 ± 5    60 ± 5    60 ± 5    60 ± 5
   6   Soak Time ..  5         5         5        80        80        80
       Heat Rate .. 9.90      9.90      2.00      2.00      2.00      2.00

──────────────────────────────────────────────────────────────────────────
   E - Edit      S - Select Cycle    C - Copy    CR ¿ - Accept     ESC - Exit
```

Fig. 11 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 third line shows the control thermocouple for that heater zone, and 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 **Start Heat Cycle** are :-

"E" ***Heater Zone Cycle Edit***

After the cycle has been selected, fine tuning of the cycle for one or more of the heater profiles may need to be altered. Pressing the "E", 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 Heater In Progress**.

"S" ***Select Cycle***

Press the "S" key to continue the cycle start process. You will be prompted with a window to either start just one zone, or all enabled heater zones. Use the up/down cursor keys to select the zone(s) required.
"Enabled Zones" will start all the zones that are enabled from the **System Control Parameters**, **Zone Control** panel. See section 3.9. Selected zones are shown with a "YES" in green at the top of the **Start Heat Cycle** screen.
Alternatively, moving the high light bar with the cursor keys will enable any one of the enabled heater zones.
Use cursor, page up/down keys to scan the 99 pre-recorded cycles in list. Type the cycle number and press CR to go on.

Change the description if required, as prompted, or ¿ to continue to start the cycle.
Enter the operator name and particulars of the work being done. Use the CR key to toggle between the fields. This identification will be printed on the hard copy reports during or at the end of the cycle.
Press the [ESC] key to go on.
The **immediate/auto** window will give you the option of starting immediately (on the turn of the next minute), or by selecting **Auto** (and setting the start date and time as prompted), do a delayed start.

"C" Copy zone
The copy command is used to copy the profile from one heater to another.
Use this if you want two heater zones to follow the same heater profile.

You will be prompted with a window :-
From Which Heater ?
Use CURSOR KEYS To Select

Use the left/right cursor keys to move the high light on the heater zone number. Press ¿.
You will then be prompted :-
To Which Heater ?
Use CURSOR KEYS To Select
Select the heater zone that you want to be the same as the one previous selected. Press ¿.
The data in the table for both zones that were selected will now be the same.

Note:
It is also possible to make several heater zones follow the same temperature profile by -
1. Enabling the required zones in the **System Parameters** screen
2. Starting all **Enabled Zones** from the **Start Heat Cycle** screen.

Press the ¿ key to proceed with the starting of the heat cycle.

[ESC]
Press the [ESC] key if you want to abort the start cycle process and return to the main menu.

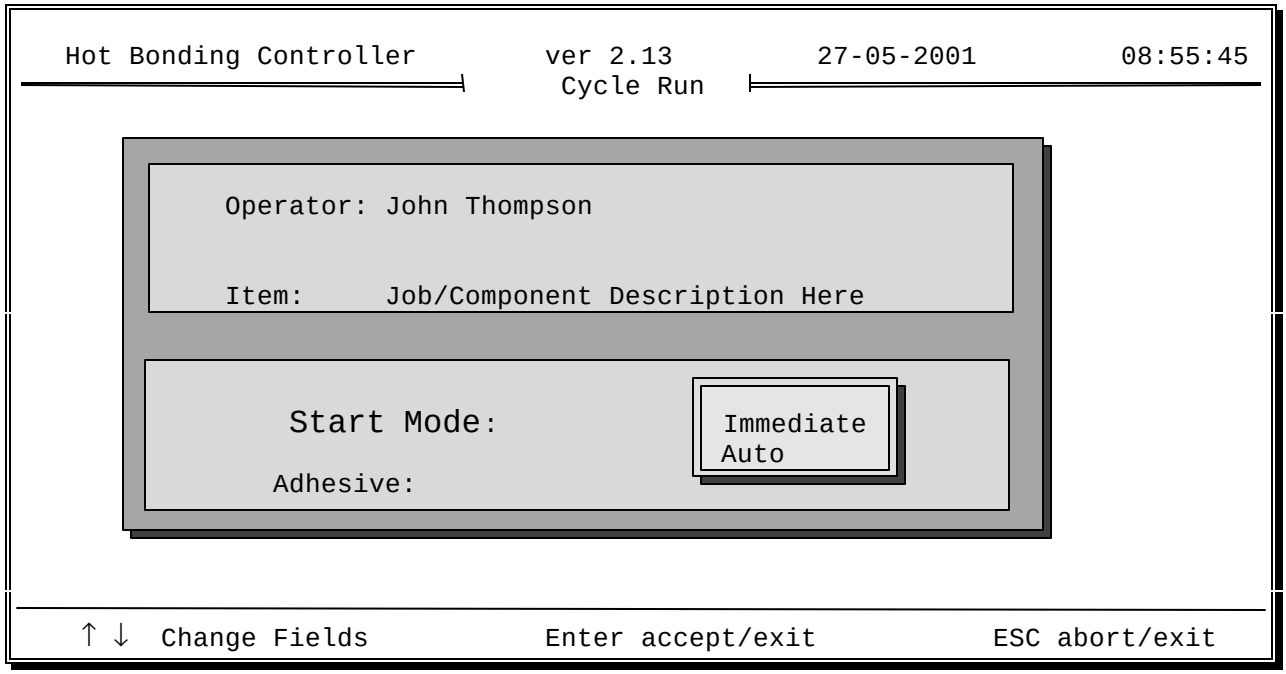


Fig. 12 Start cycle screen

3.6.2 ***Automatic Cure Cycle based on Adhesive Selection***

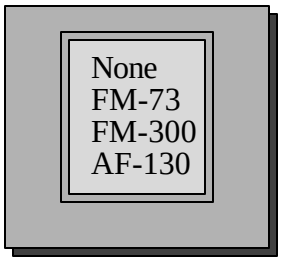


Fig. 13 Start cycle screen, Adhesive selection

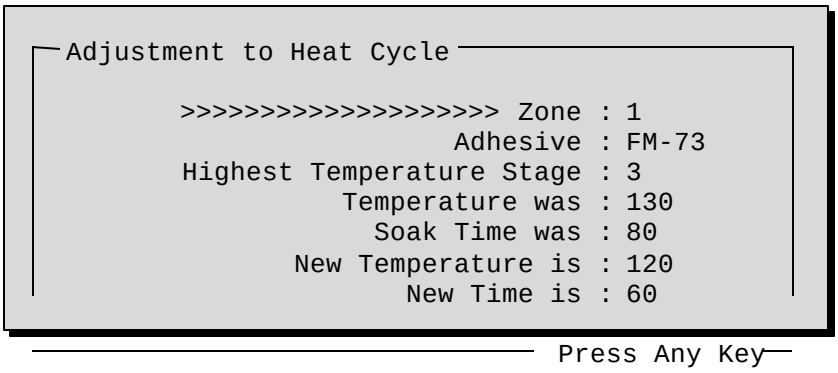


Fig. 14 Start cycle screen, Automatic Adhesive Selection Parameters

The cure cycle can be automatically set, based on the time/temperature data on particular common adhesives types.
The highest temperature soak stage will be set to the correct time and temperature for the selected adhesive.

During the running of the cycle, the coldest of the acceptance thermocouples is plotted on the **Individual Zones** screen. Fifteen minutes into the hottest soak stage, the acceptance temperature is used to calculate the soak time required to cure the adhesive. The change to the soak time is confirmed by a box that displays the new soak time. The computer beeper gives will give short warning bursts while the box is displayed on the -

(F1) Status All Zones screen.
(F2) Individual Zone screen, normal view
(F2) Individual Zone screen, zoom view

Pressing F3 will stop the beeper and remove the confirmation box.

(F1) Status All Zones screen.
If the **Status All Zones** screen is being displayed when the change of soak time is to be confirmed, a box will appear requesting the operator to either accept or reject the soak time extension.

A box will appear for each of the zones that require a soak time extension as they reach the 15 minute time into the soak stage, showing the current soak time and the new soak time.

(F2) Individual Zone screen, normal view and zoom view
If the extension has been applied to the zone currently being displayed, then the confirmation box will be displayed, the graphics profiling will stop, and the program will wait for the operator to Accept or Reject the soak time extension.

If there are other zones which also need their soak times extended, the box will display the relevant information for each of them in turn giving the operator the chance to accept or reject each soak time change.

If an extension is to be applied to a zone other than the one currently being displayed, then the new zone will be displayed before displaying the confirmation box.

3.6.3 *Automatic Cure Cycle, additional notes*

In addition to the confirmation box on the screen, a record of the soak time extension will be printed showing -

- zone,
- original programmed soak time,
- (recalculated) extended soak time,
- acceptance thermocouple temperature

If the operator rejects the extension then the previously programmed time will be restored.

If the operator does not respond before the soak goes into the extension time, then the program will print out a report which includes -

- original programmed soak time,
- (recalculated) extended soak time,
- actual soak time (as at time of rejection)

3.7 Halt Heat Cycle

When you select this option, the screen will display a message indicating the current operating status.
The messages which may be displayed are :

1. No Job In Progress
   Press any key to Continue .....

If there are no temperature profiles are currently being run, there is no job to **Halt**.

2. Job Waiting To Start
   Do you wish to HALT this Cycle ? (Y/N)

If the current job has been programmed for an **Auto** start at a later time, or if it is waiting for the turn of the minute to start an **Immediate** job, you will be prompted to either abort the job (Y), or cancel the **HALT** command (N). It is not necessary to press ¿ .

3. Job In Progress
   Do you wish to HALT this Cycle ? (Y/N)

The prompt is to get confirmation of the HALTing of the current job. Press 'Y' to halt the current job or 'N' to let the job continue. It is not necessary to press ¿ .

3.8 Alarm Reports

The computer keeps a record of the last 128 alarms. They can be viewed by entering this screen from the main menu screen. Use the cursor up/down and the page up/down to view all the alarms.
Using the [ESC] key to exit will accept any new alarms, and stop the **alarm sound**.

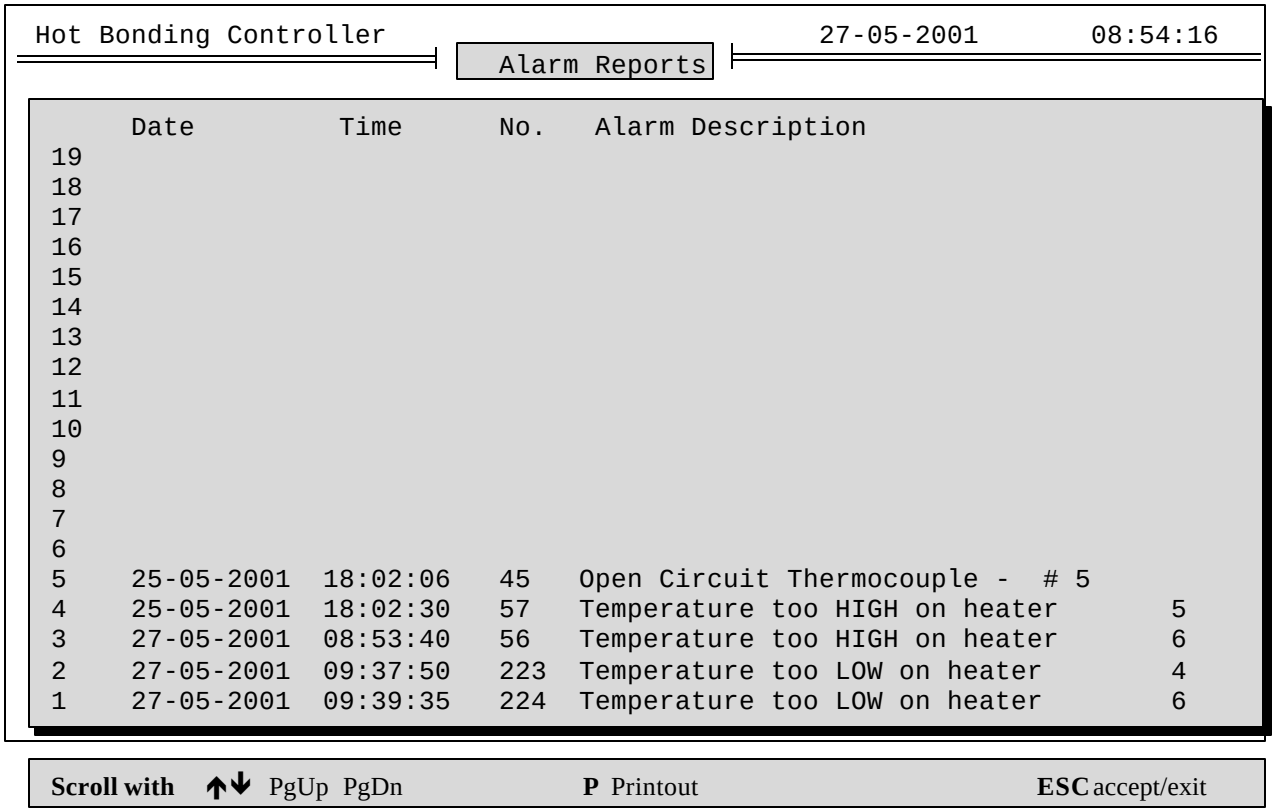


Fig. 16 Alarm reports screen

The 'P' key can be used to print an alarm report of all the alarms for the current job.

The alarm printout starts with -
the date and time,
the operator's name and job description,
the start date and start time,
the total run time,
and then one line for each alarm condition reported.

A sample of the alarm report is shown below.

Alarm Report 15-05-2001 21:45:32

Cpl John Thompson Part #AS0904-5

Started at: 15-01-2001 11:11 Run Time: 03:11:32

No.	Description	
1	Temperature too LOW on heater	4
2	Temperature too LOW on heater	3
4	Temperature too LOW on heater	1
5	Low Vacuum - # 2	

3.9 Exit To DOS

NOTE:
Always follow these instructions back to DOS before turning off the computer.

To leave the HBC-43 program, select **Exit To DOS** from the main menu.
You will be prompted for a confirmation. If you press 'Y', the computer will go back to the Disk Operating System.

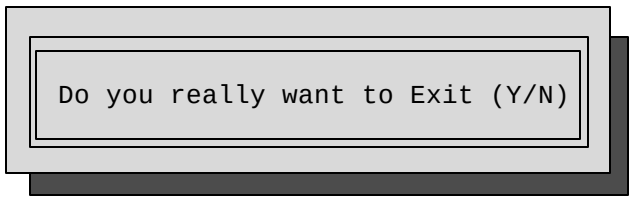


Fig. 18 Exit to DOS screen

To re-start the HBC-43 program from DOS, type 'Run' from any directory. The computer will start the program by checking for communications with the control box HBC-1 interface electronics. When it establishes communications, it will report the version number of the software running in the HBC-1 interface.

3.10 Heat Cycle Set-Up (Alternate Main Menu)

The 99 heat cycles stored on the hard disc can be edited before starting a cycle.
Select **Heat Cycle Set Up** from the main menu and press ¿ .
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.

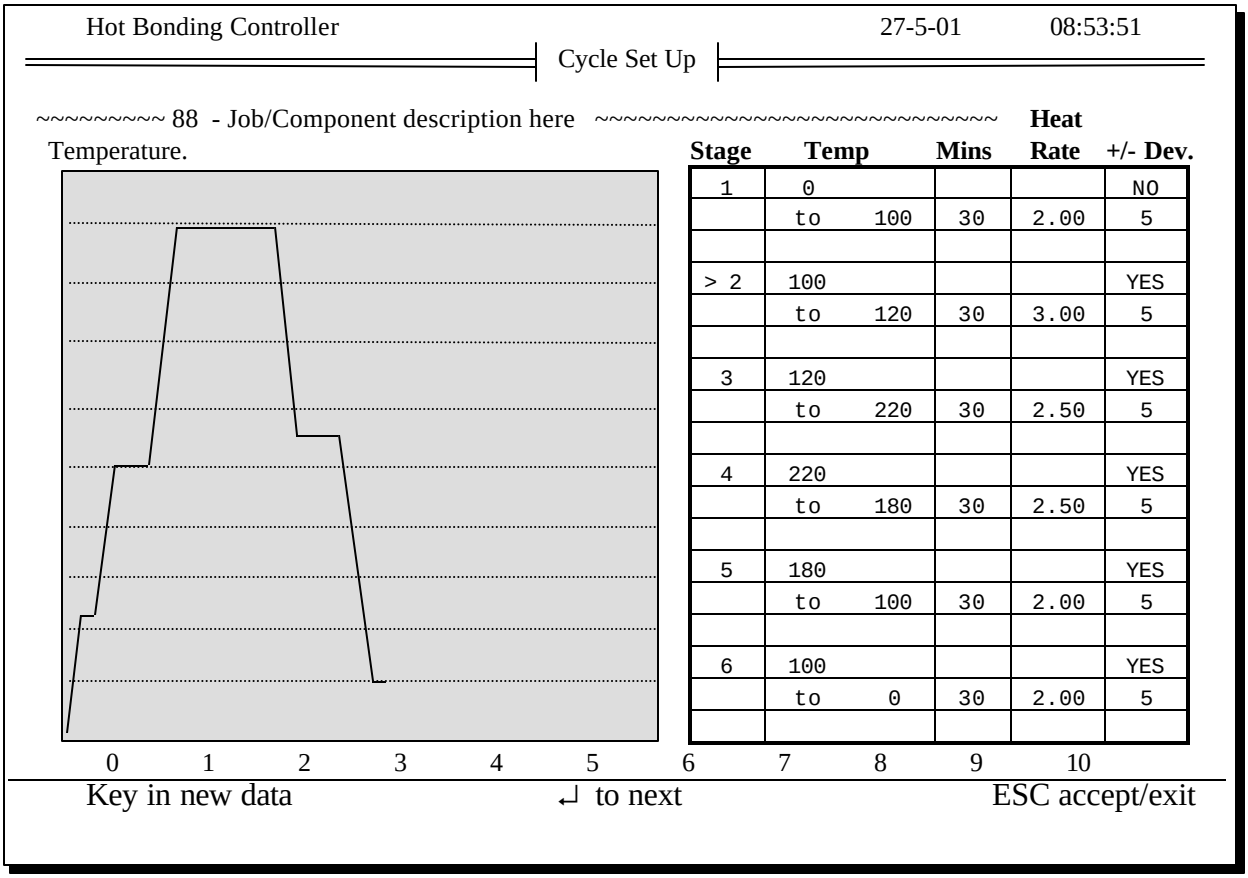
Choose the required cycle from the description column. Type the cycle number between 1 and 99, that corresponds to this description number, and press ¿ .
A new cycle description can be entered, or simply press ¿ to continue to the edit screen.

The **Cycle Set Up** screen, like the **Change Zone in Progress** screen, has a graph on the left and a table on the right. The line above the graph shows the cycle number that was selected, and description of that cycle.

Use the cursor keys to move to the data point you wish to change, and enter the value, or use the space bar to toggle "YES" and "NO". The ¿ key will move to the next entry field. Use the [ESC] key to take you back to the main menu screen. The table will be saved to the hard disk on exit.

The 5 columns are:

1) Stage number, 1 to 6.
2) Target temperatures.
3) Soak time, 0 to <720 mins (6 hours) per stege, with a maximum of 12 hours for a complete cycle
4) Heat/cool rate in °C/minute, 0 to 9.99
5) Vacuum/pressure alarm enable & Deviation alarm temperature, 1 to 99°C



Stage	Temp		Mins	Heat Rate	+/- Dev.
1	0				NO
	to	100	30	2.00	5
> 2	100				YES
	to	120	30	3.00	5
3	120				YES
	to	220	30	2.50	5
4	220				YES
	to	180	30	2.50	5
5	180				YES
	to	100	30	2.00	5
6	100				YES
	to	0	30	2.00	5

Fig. 10 Heat Cycle Set Up Screen

3.11 System Parameters (Alternate Main Menu)

This screen is used to configure the program to match your hardware.
There are three boxes :

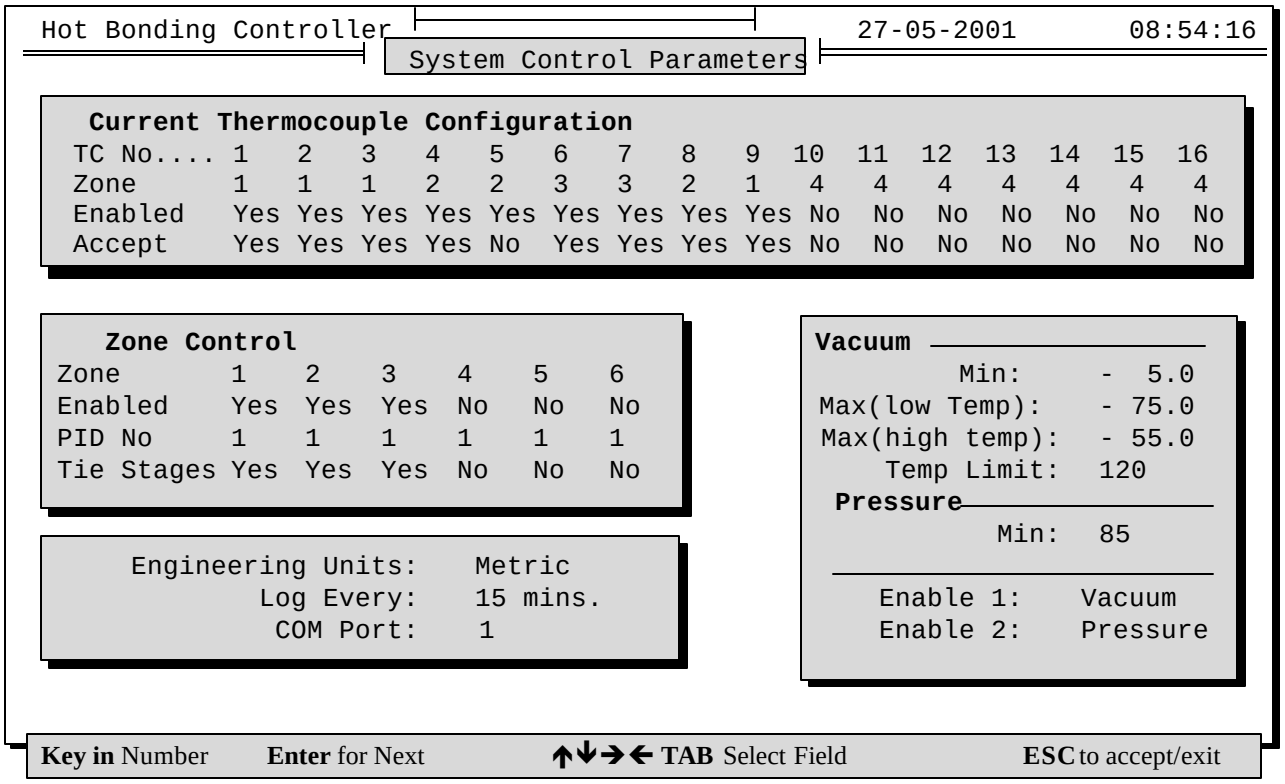


Fig. 15 System parameters screen

Current Thermocouple Configuration
Each thermocouple input must be nominated by the zone in which it is mounted. Use the cursor keys to move the high light to the **Zone** line, and to under the thermocouple number to be changed. Type in the new number.
Enable each thermocouple that is being used. Move the high light to the **Enable** line, and toggle the 'yes/no' with the space bar, for the correct thermocouple number.
The hottest thermocouple that is enabled from each zone will be used for control of that zone during a cycle run. A thermocouple input that is enabled but does not have a thermocouple connected, will display '**o/c**' (open circuit) in the **Status All Zones** screen.
If an individual thermocouple appears faulty, or you want to remove it from control of that zone, in can be disabled during a run.

Zone Control
Each zone that is to be controlled must be **Enabled**. Move the high light to the **Enable** line, and toggle the 'yes/no' with the space bar, for the correct zone number.
The PID number is a convenience option to allow for different thicknesses of the structure being patched. There are three sets of PID values. They can be individually set in the **PID Parameters** screen.
See section 3.11 (**PID Parameters**), and 8.0 (**Tuning the Controller Using the PID Values**).
The number for each zone is saved on disk. Generally the set number one of PID values should be used.
The **Tie Stages** will synchronise the start times of each of the soak stages of the temperature cycle.
Use the space bar to toggle the yes/no for the correct zone.
The soak times will automatically extend to make sure that the heater is within 2.5°C for the required time for each soak period.
If one zone is slower to respond than another, they may get out of step. Tying the stages will hold the faster zones until the slower zones catch up.

Miscellaneous Window

The temperatures can be displayed in either Centigrade or Fahrenheit.
The computer will print a report at the interval nominated in the '**Data Log Every:**' field.
The serial port used to communications to the control box can be set as either COM 1 or COM 2.

Vacuum Pressure Window

Alarm Levels, Vacuum
If the vacuum rises above the **Min Vacuum** level, there will be an alarm.
ie. If the vacuum rises to -40, and the **Min Vacuum** is set to -50, there will be a “Low Vacuum” alarm.

If the vacuum falls to below either of the **Max Vacuum** levels (low temp or high temp level), there will be a “High Vacuum” alarm.

The **Max (low temp)** level is used when the temperature of any of the control thermocouples are *below* the **Temp Limit** set in this box.

Alarm Levels, Pressure
If a pressure transducer is connected to one of the transducer inputs, it must be **‘Enable’**d as pressure. Only one alarm level is used for a pressure transducer (There is no MAX pressure alarm).

If the pressure falls below the **Min Pressure** level, there will be an alarm.
ie. If the pressure falls to 40, and the **Min Pressure** is set to 50, there will be an alarm.

The vacuum/pressure transducers option should be set to **None** if a transducer is not connected, to inhibit false alarms. Use the space bar when the **Enable** field is high lighted.
The options are -

None
Pressure
Vacuum

3.12 PID Parameters (Alternate Main Menu)

The power output level is set by a calculation using three components :-

Proportional: Temperature error of actual temperature from the set point temperature
Integral: The time and distance the actual temperature is from the set point temperature
Derivative: The rate at which the actual temperature is approaching the set point temperature

In most case, the values can be left at :-

Proportional Band: 25	Integral: 220	Derivative: 15

The **Proportional** value should always be between 10 and 100.
The **Integral** value should always be between 150 and 400.
The **Derivative** value should always be between 10 and 80.
A value of zero for either **Integral** or **Derivative** will disable them. Proportional control can never be disabled.

For convenience, three sets of PID values are saved. Select the set to be used from the **System Parameters** screen, **Zone Control** box.

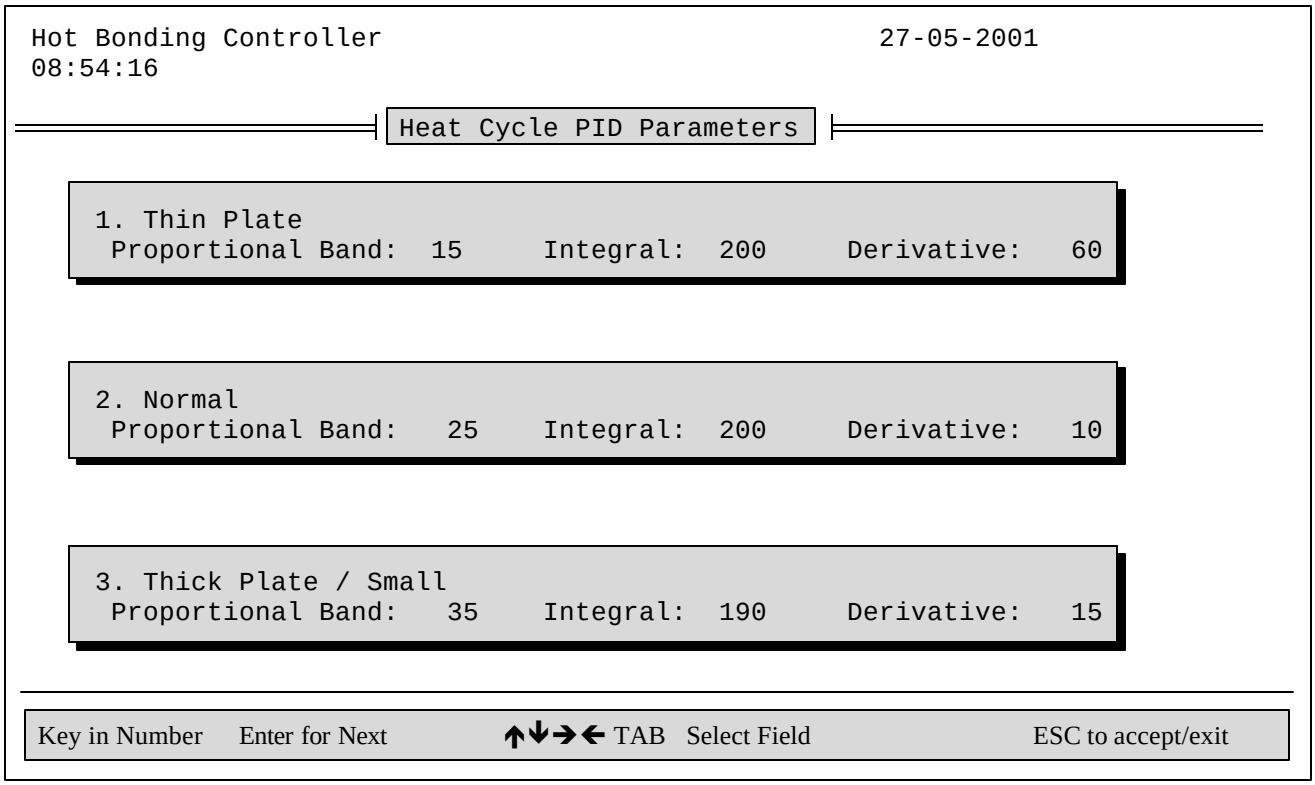


Fig. 17 PID parameters screen

These values will only need to be adjusted if :-

1.The temperature oscillates continuously over at least +/- 3°C. (Increase the Proportional value by 5 to 10)

2.The temperature is consistently more than 2°C from the set point when the set point has been constant for at least 10 minutes. (Reduce the Integral value by 10 to 40)

3.The temperature does not approach up to the soak temperature within 6 minutes after a ramp. (Reduce the Derivative value by 10 to 20)

The tuning of the PID values should only be done by an operator that has a knowledge of process control and the HBC-43.
An informed and experienced judgement must be made to determine the settings based on the contribution of :-
The size of the structure being heated
The size and power of the heating blanket
The set point temperature
The ambient temperature
The insulation around the structure

After any change is made to the PID values, monitor the **Individual Zone Performance** graph for the result of the change. Do not make another change for at least 15 minutes. After the values are changed, the new value will be saved on the hard disk, and used for all the following jobs.

3.13 Review Jobs (Alternate Main Menu)

NOTE: *Review Jobs* functions are only available if a job is *NOT* running.

To enable complete records to be kept and recalled for later examination, without the use of hard copy print outs, each cycle is saved at the end of the cycle.

The *Review Jobs* function allows the operator to recall any job that has been run. The job can be found easily by searching for within a time period for –

Jobs run by the same operator
Jobs run with the same adhesive
Jobs with the same part number
Jobs with the same job description

or any job within a time period.

The data is saved during the temperature cycle every minute.

NOTE: When a previous job is retrieved the current temperature profile will be lost.

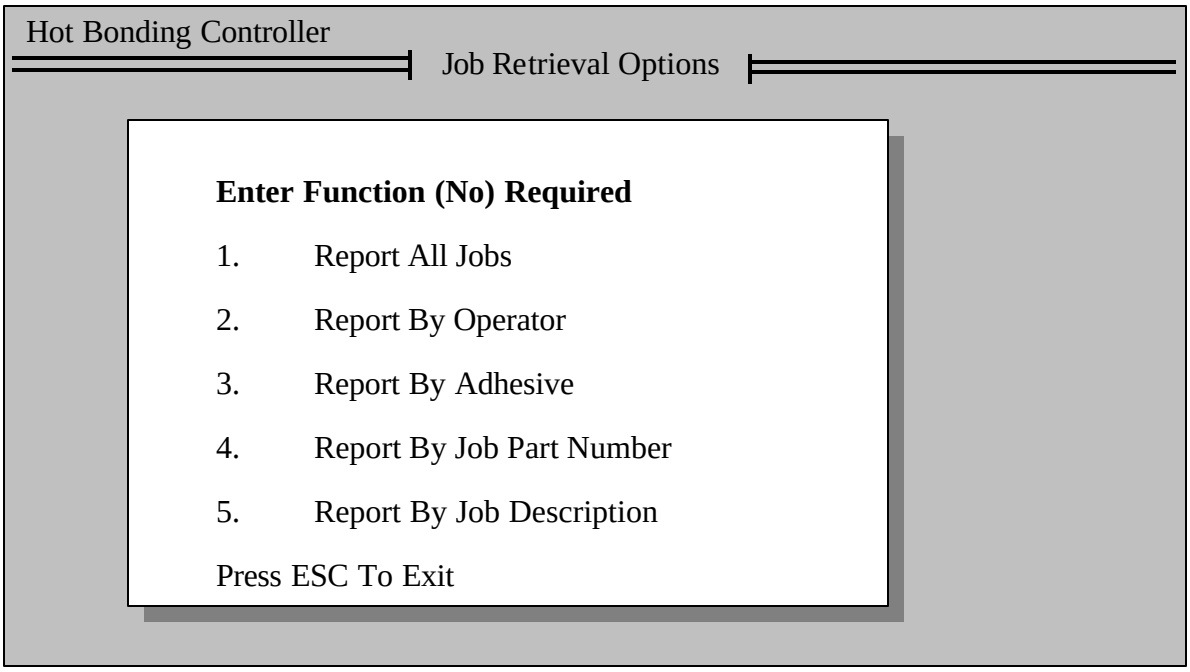


Fig. 18 Review job, Job retrieval screen

Press the number key corresponding to the search function required.

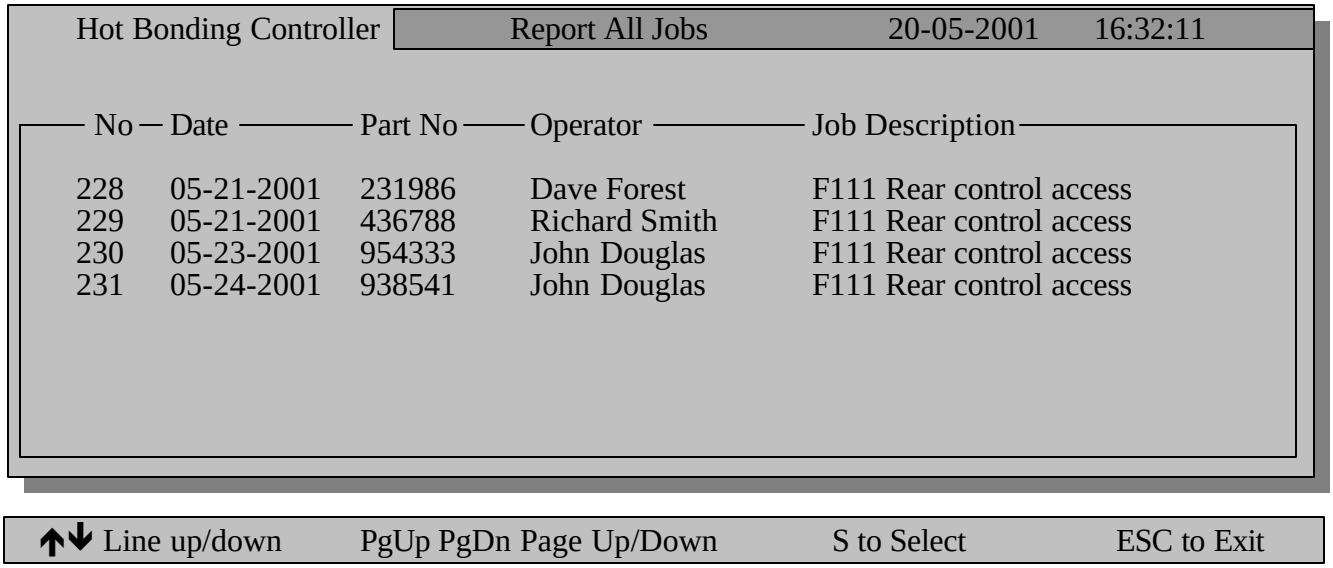


Fig. 19 Review job, Report all jobs screen

To select a job, press the ‘S’ key, and use the ↑↓ cursor keys.

Press the ¿ Enter key view the *Job Retrieval Data.*

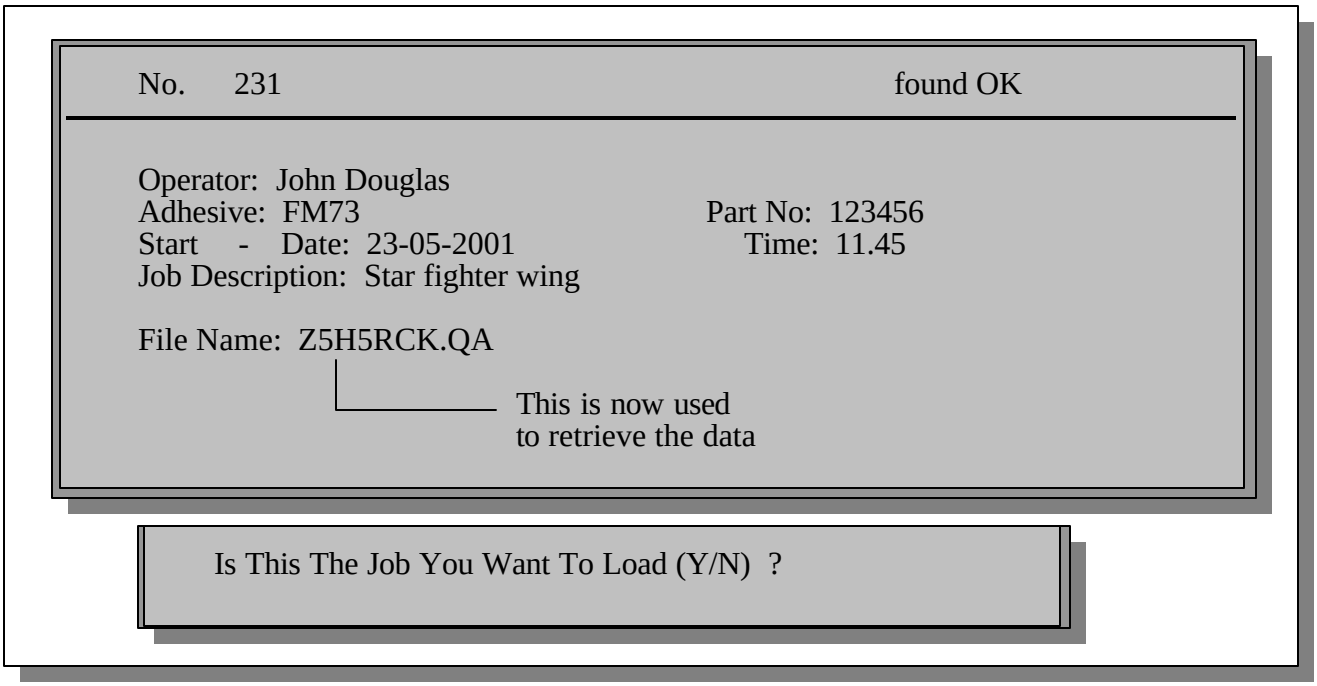
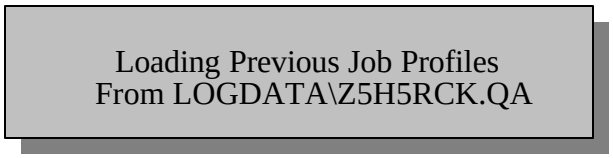


Fig. 20 Review job, Job retrieval data screen

Press either the ‘Y’ or the ‘N’ key in response to the question in the above screen. If it is not the correct job, pressing the ‘N’ key will return to the data base select screen.

While the job is being loaded from the hard disk, this box will appear. The loading takes about 20 seconds.



When the job has been successfully loaded the following box will appear.

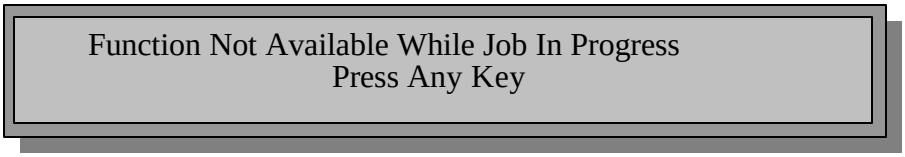
After the job has been loaded, the computer will return to the main menu. The F2 function key (*Individual Zone Performance*) can be pressed to view an zone the graph of the job that was loaded.
While in the *Individual Zone Performance* screen all the zoom features can be used to examine the graph more closely.

- Zoom
- Zoom screen with the temperature scale expanded
- Zoom review screen
- Zoom review screen with the temperature scale expanded

The graphs from all these screens can be printed.

3.14 Database Utilities (Alternate Main Menu)

NOTE: *Database Utilities* functions are only available if a job is *NOT* running.



If this prompt box appears, the job that is currently running must be *HALTED* before the *Database Utilities* will be available.

Pressing the F5 function key (*Database Utilities*) will only be necessary if some of the file in the database are corrupted. If this happens a prompt box will appear –

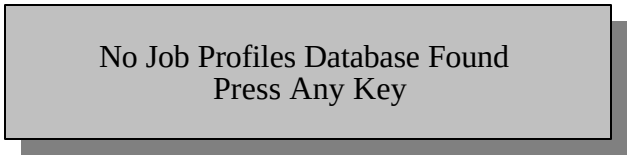


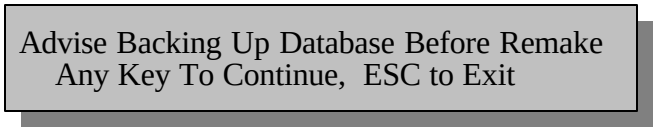
Fig. 21 Database error prompt box

If this prompt box occurs, contact Novatech Systems. Some of the file in the database have been corrupted and it may not be possible to recover the recorded jobs.

The options available in the database utilities are –

3.14.1 *Remake Index Files*

If the database file does not contain the same list of temperature files that are available on the hard disk, or if a job does not appear on the list of available retrieve jobs, it may be possible to recover the job by remaking the index file from the backup floppy disks.



The prompt box shown above will copy all the currently saved files to a backup directory when any key is pressed.

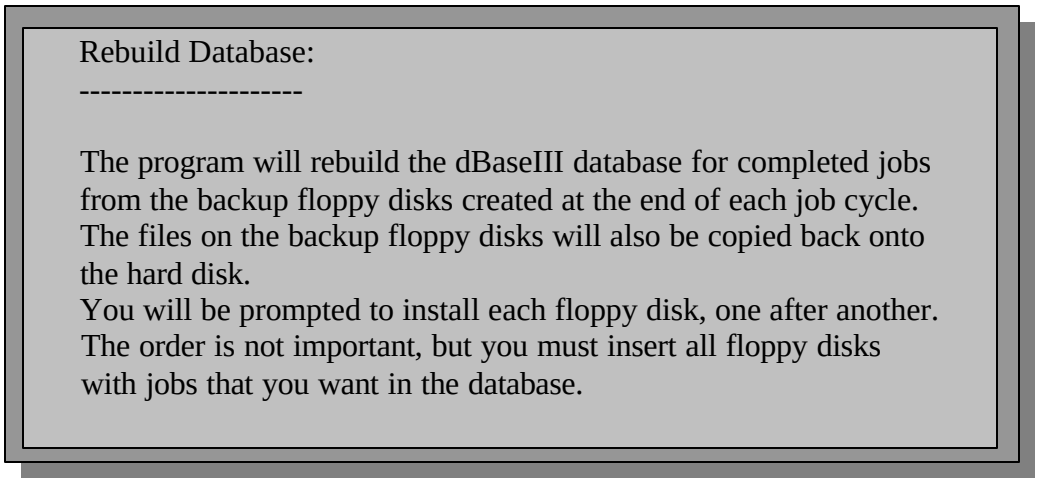
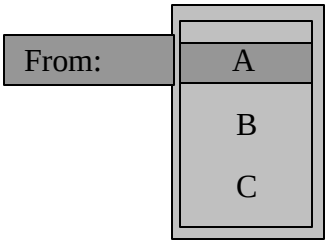


Fig. 22 Help box for *Remake Index* screen

Press ESC to exit the *Rebuild Database* function if a rebuild is not required.

Press ¿ Enter to continue.



NOTE: The floppy disks containing all the files of the past jobs will have to be inserted into the computer to rebuild the database.

If these disks are not available, **DO NOT PROCEDE !**

All the jobs that were backed up onto the hard disk will be erased if a rebuild if started !

If a rebuild is found to be necessary, select 'A' in the above prompt box and press the ¿ Enter key**.**

Insert the backup floppy disks as required. Check the available jobs in the *Preview Jobs* function (ALT F4).

4. Hardware Description

4.1 Control Case

The control box contains:-

- The HBC-1 interface circuit board
- The two HBC-3 input module circuit boards
- 6 single phase, 10Amp power output controllers
- 6 auto/manual power switches and controls
- An ejector vacuum pump
- Air supply on switch, pressure regulator
- Air supply pressure gauge, vacuum gauge

4.2 Accessory Box

The accessory box contains:-

- 20 heater mats of various sizes
- 2 three phase power leads
- 8 single phase heater extension leads
- 100 meters of type K thermocouple lead
- 2 vacuum transducers and leads
- 2 sniffer gauges and fittings
- 2 vacuum pipes
- 1 five meter exhaust hose

4.3 Computer/Printer case

The Computer/Printer box contains:-

- The computer (Notebook PC)
- Cut paper, color ink jet printer
- The computer and printer connecting cables
- A hand held temperature gauge

5. Assembly and Bagging

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 supplied by the Air Force.**

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

For details of these processes, please refer to Training Notes supplied by the Air Force.

Before starting the assembly stage, the HBC-43 controller and accessary equipment supplied with the controller should be checked to make sure it is complete. 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.

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.

ie. 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 bake to be calculated.

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 blanket.
When the cycle is complete, the release film allows the bagging materials to be removed easily without them bonding to the repair area.

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.

Breather Cloth
Breather cloth is used to maintain an even vacuum over the whole potch 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.

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 between the 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 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.

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 amount of resin that is absorbed is regulated by the number of thicknesses, or plies, of the bleeder cloth that are used. 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 is avoided by using the correct amount of bleeder cloth.

Vacuum Bag Sealant
Vacuum bag sealant is used to provide an air lock between 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.

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 'Air Supply' on/off switch.
4. Note the vacuum obtained on the **Status all Zones** screen. The vacuum will be about -70kpa with a supply line air pressure of 400kpa.
5. Connect a vacuum pump to one of the vacuum ports.
6. Connect the vacuum gauge to the other vacuum port.
7. Turn on the vacuum with the 'Air Supply' on/off switch.
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 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 all leaks are eliminated.

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 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.

6. Glossary of Terms

Guaranteed Soak
If the actual temperature is not within 2.5°C of set point, on the change of the minute, when a soak stage begins, the soak time will not be started. This can cause the total cycle time to be extended beyond the calculated time by a few minutes.

Cycle
The recipe for the temperature profile is called the cycle. It includes six stages, which each have a ramp and a soak.

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

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.

7. Trouble Shooting Guide

7.1 A zone does not heat up

Solutions:-
1. The zone has not been enabled on the **System Parameters** screen.
2. The auto/manual switch on the control box is in the manual position.
3. If the power output lamp is on, the blanket is faulty.
4. The heater is plugged into the wrong power outlet socket.
5. One of the thermocouples configured for that zone in the **System Parameters** screen is in actually in another zone.
6. Zones 4, 5 or 6 require the second 3 phase power lead into the control box.

7.2 A zone heats above the set point temperature

Solutions:-
1. The auto/manual switch on the control box is in the manual position.
2. One of the thermocouples configured for that zone in the **System Parameters** screen is in actually in another zone.
3. The PID control values are not set correctly. See Chapter 8, **Tuning the Controller Using the PID Values.**

7.3 The computer keeps 'Beeping'

Solutions:-
1. The RS232 communications cable is not connected to the computer.
2. The power is not on at the control box.

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

Solutions:-
1. The temperature deviation tolerance is set too small in the **Change Heater in Progress** screen.
2. Thermocouples and zones are configured incorrectly in the **System Parameters** screen.
3. The incorrect PID number has been selected in the PID field of the **System Parameters** screen.
4. The PID values being used are incorrect.

7.5 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.

7.6 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 **System Parameters** screen.
2. Change the PID values back to the default values of -

P	25
I	220
D	15

3. Re-tune the controller PID values. See chapter 8, **Tuning the Controller Using the PID Values**.

7.7 The temperatures are all reading 460° C

Solutions:-
The ambient temperature is extremely important because an error in the ambient temperature will cause the same error in all the thermocouple readings.
The ambient temperature and the heatsink temperature are checked regularly in the control case.

The thermocouple temperatures will all read 460°C if one of the following conditions exists.
1. The ambient temperature is not between 0°C and 65°C.
2. The heatsink temperature is not between 0°C and 85°C.
3. The ambient temperature is more that 10°C from the heatsink temperature.

Check that which of the above conditions exist. Check the 100 Ω RTD temperature sensors that are connected to both the thermocouple input connector block and the heatsink.

7.8 The temperatures are all reading 470° C or 480° C

Solutions:-
The calibration memory has been check and found to have lost the calibration factors, or the memory check sum is incorrect. The controller has gone into to a safe operating mode. Send the control box for a calibration check.

7.9 The temperatures are all reading 490 ° C

Solutions:-
The calibration memory has been check automatically and found to have been not operating.
The bridge rectifier BR4 on the HBC-1 PCB may have failed. Send the control box for repair and calibration.

7.10 A temperature is reading 500 ° C

Solutions:-
The thermocouple may be open circuit or have a broken connector in the thermocouple plug.
Also check that the input is enabled in the **System Parameters** screen.

7.11 Regular maintenance

The accuracy of the Hot Bonding Controller is dependant on the electronics built into the control case. Electronics was design to need very little maintenance by the use of extremely stable voltage references which are used in a continuous self calibrating process, which is all supervised by a micro computer.

However for safety, the control box should be checked every year.

When the calibration check/adjustment is required,

Contact – Novatech Systems
Phone (03) 9585 2833
Fax (03) 9585 2844
www.novatech.com.au

8. Tuning the Controller Using the PID Values

8.1 Background

P is short for PROPORTIONAL, measured in % of full scale range (400°C full scale)
I is short for INTEGRAL, measured in seconds
D is short for DIFFERENTIAL, measured in seconds

The term PID refers to the three values used to calculate -
The ***power*** required to get
a process variable (in this case the ***temperature of the patch***)
equal to
the desired value (in this case the ***set point temperature***).

The power can be varied from zero volts on the heater to full mains voltage on the heater mat in 256 steps. The amount of heat has to be continuously assessed to get the temperature to the set point, or to maintain the temperature at the set point.

There are 3 considerations when the controller calculates the P,I and D values.
1. The distance the patch temperature is from the set point temperature.
2. The time the patch has been away from the set point temperature.
3. The rate at which the patch temperature is varying compared to the set point temperature.

8.2 Changing the PID values

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.

NOTE:
There is provision for 3 sets of PID values to be saved in the HBC-43 program. Before you re-tune the controller, make sure the correct values are being used in the **Zone Control** section of the **System Parameters** screen, and the **PID parameters** screen.

The PID values should not have to be changed. The values of -
P 25
I 220
D 15
have been found to control the temperature of the heaters within +/- 1°C of the set point.

Proportional Value
This is the most important term. The other two actions (I & D) could be turned off (a value of 0 will disable both I & D), and proportional action alone could control the temperature quite well. It set a band of temperature above and below the set point. When the actual temperature is within this band, the controller will select a power level between full 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 too 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. Double 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. Halve the P value, and test the control again.

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 action.

I VALUE TOO SMALL
The actual temperature will oscillate above and below the set point.
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.
P = 25, I = 220, D = 15

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.

Differential 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.
ie. 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.
If the D value is increased, the P value will probably also have to be increased.
The **larger** the number, the **larger** the differential effect.
A 0 will turn all differential 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 big enough blanket to heat the patch at the required rate.
Increase the D value by 20% of the current value. The P value may have to increased as well.

D VALUE TOO LARGE
The temperature will be unstable. Reduce the D 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.
P = 25, I = 220, D = 15

9. Manufacture of the thermocouple

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

The simplest way to join the wires if a thermocouple welder is not available, is to use a joining piece known as a "**Quicktip**".

The quicktip is a tiny figure eight shaped piece of alloy. The two thermocouple wires are fed into the two holes so that they appear 2mm out the opposite side of the Quicktip. The Quicktip is then crushed to hold the two wires securely. A tool is available to crush it or a gentle pressure can be applied with smooth jawed pliers.

The Quicktips are available from

Temperature Controls
412 Moreland Road
Brunswick West
Victoria 3055

Phone (03) 9384 0444
Fax (03) 9384 0204

(Nominate the thermocouple type as type 'K', and the gauge as 24 to 30
Part number QT-128540)

10. Use of The Database of past jobs

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

10.1 The concept of a backup system

The database feature allows the record of the jobs to be kept on either a series of floppy disks or transferred to a larger computer for backup on hard disk/tape backup system.

The backup system will consist of the following steps–

- Allow the computer to save each job as it finishes on both the hard disk and the backup floppy disks.
- Label the backup floppy disks clearly with –
  - Date the disk was first used
  - Date the disk was filled
  - Which Hot Bonding Controller it was used on.
- Save the floppy disks as they are filled (about 10 jobs per disk) in a secure place. Keep the disks in date order.
- Set up a maintenance procedure that will guarantee that the hard disk copy of the files will be copied into the *'BACKUP'* directory at least **every week**. This will keep a dual copy of all the jobs.
- If a file in the database is corrupted, the *'BACKUP'* copy can be recalled using the *Restore Database'* function.
- If a backup is required, feed the backup floppy disks into the HBC-43 computer as requested in the program. (*Rebuild Entire Database*)

10.2 Saving the current job when finished

As each job is finished the computer will save a copy of the temperature profile of the job to the hard disk if required by the operator. Press the 'Y' key to save the job on the hard disk, and insert the latest backup floppy disk when requested by the program (or leave the disk in the computer).

Make sure the 'Write Protect Window' on the disk is closed.

Each floppy disk will hold between 10 and 14 jobs.

10.3 Retrieving a previous job

Any of the jobs previously run can be recalled by searching the database.

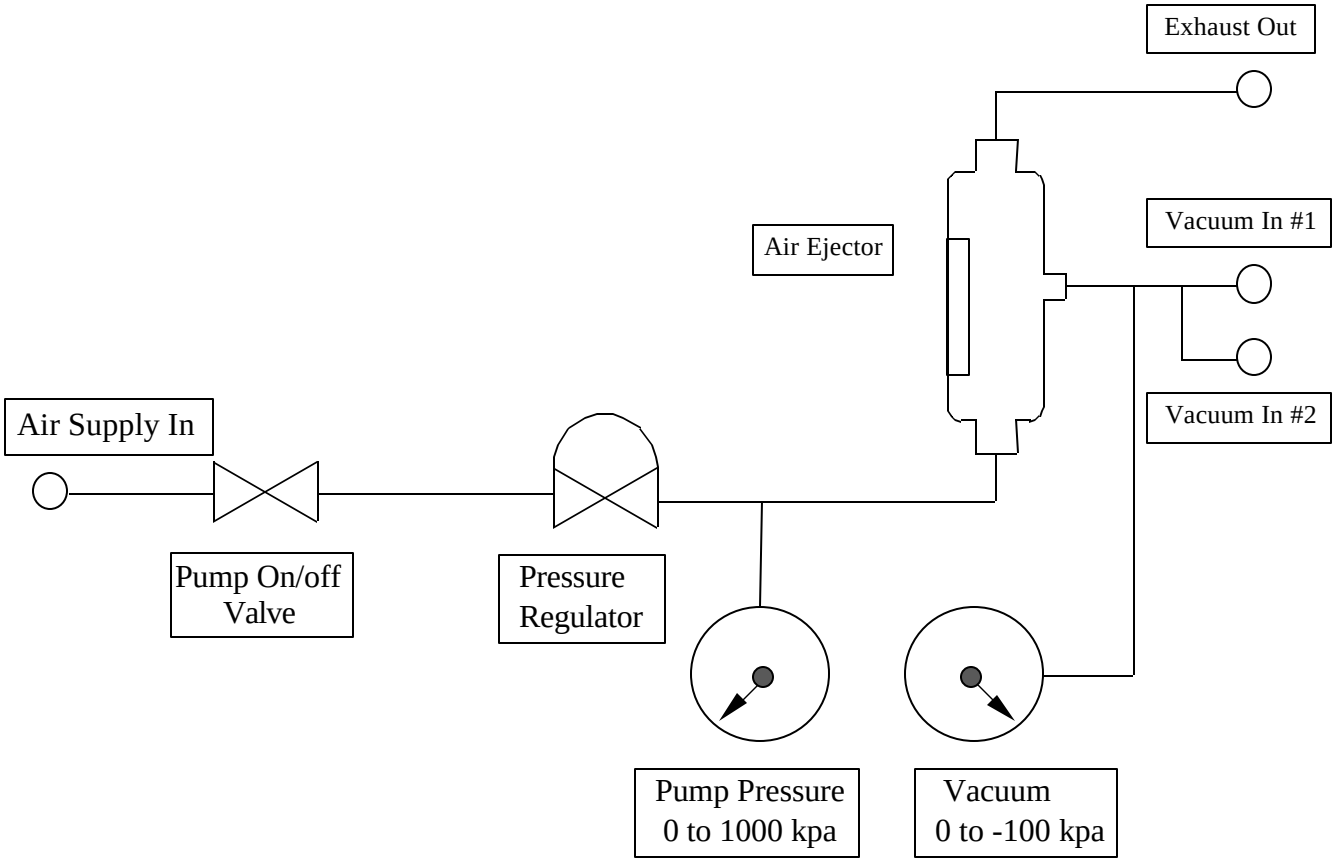
The search can be based on –

- Operator
- Adhesive
- Job part number
- Job description

And a time period can be nominated.

For full details of the *Retrieve Jobs* function, see chapter 3.13.

Appendix 1. Vacuum System Block Diagram.



Appendix 2. Electrical Block Diagram & Printed Circuit Board Schematics

Appendix 3. Control Case Component Identification