

**DT968B
ONE PASS
TEMPERATURE
CONTROLLER
MANUAL**

DT968B ONE PASS TEMPERATURE CONTROLLER

The Model DT968B is a Microprocessor based Constant Flow Temperature Controller. It monitors temperature utilizing a Type J thermocouple sensor and controls the continuous liquid discharge temperature from an instantaneous heater with a special automatic reset power control algorithm. Numerous status and alarm functions are incorporated to monitor various system parameters.

The unit may be either operated in MANUAL or AUTOMATIC modes. In the MANUAL mode, the basic power setting may be directly selected. In the AUTOMATIC mode, the unit will determine the required power based on the FLOW SENSOR input.

A built-in 20 amp, photoisolated, solid-state power controller is used to control the heater. This allows the microprocessor to maintain the most accurate temperature possible without any concern for excess cycling. The power controller contains a zero cross detection scheme. This insures that no RFI (Radio Frequency Interference) is generated when the load is switched on and off.

An independent high limit circuit is provided. It is powered by an isolation transformer that draws power from the primary side of the master relay. The sensor is a Type J thermocouple. This circuit shuts off the internal master relay should an over temperature condition occur.

Twelve discrete LEDs are utilized to indicate system and display status as well as annunciate various alarms. A 12 key membrane switch is incorporated in the facepanel to allow for user setup and adjustment of the system.

Two numeric displays are utilized to allow the viewing of both the Process Temperature and the Flow Rate simultaneously. Additionally, each of the displays has multiple diagnostic and setup functions that may be activated by the keyboard or by the Microprocessor during various setup and alarm conditions.

The microprocessor section consists of two circuit boards, one for display and the other for control. The control board contains two transformers and provides the isolated DC supplies (+5 and +12 volts) necessary to run the system. In addition, it contains an instrumentation amplifier, A/D converter, EEPROM memory and the microprocessor. The display board contains all of the seven segment and LED displays as well as the audio transducer.

MODES*****

The six primary status modes are indicated by LEDs on the faceplate and are marked NORMAL, STANDBY, ALARM, SETUP, HEAT and AUTO.

NORMAL - This mode is the normal condition for the system. It indicates that the system is operating within the defined parameters.

STANDBY - This mode is a standby condition for the unit. It allows all normal monitoring and timing functions, but disables the heater. The only way to exit this mode is by depressing the 'RETURN' key. NOTE: For safety, the unit always starts up in this mode initially or after a power failure. When in this mode the process display reads "Hold".

ALARM - The various alarm conditions are activated by many sources and annunciated by both the displays and audio tone. The mode indicator shows that an alarm has occurred and that the system is still performing under the special conditions required by that alarm. The only way to exit this mode is to clear the alarm.

HEAT - This LED is illuminated whenever the heater is on. Note that when the unit is near the setpoint, the LED will continually cycle on and off.

SETUP - This is the setup mode. When in this mode the 'SETUP' key causes the controller to step through the parameters. The following is a table of the displays that will appear:

<u>CODE</u>	<u>DESCRIPTION</u>	<u>SETTING RANGE</u>
PS	Process Setpoint	0.0 to 100.0 °C.
IS	Inlet Temp. Setpoint	0.0 to 100.0 °C.
AP	Available Power	0.0 to 50.0 KW.
PP	Percentage Power	0 to 100%
DB	Dead Band	0.0 to 5.0°C.
HI	High Alarm Setpoint	0.0 to 100.0 °C.
LO	Low Alarm Setpoint	0.0 to 100.0 °C.
LF	Low Flow	0.0 to 5.0 GPM
AC	Access Code	0000 to 9999
CR	Cycle Rate	0 to 5 Seconds.
PR	Power Reset	0 to 199 Seconds.
CA	Calibration	±9.9°C.
RC	Reset Offset	(Test Program Only)
OC	On Count	(Test Program Only)
SN	Flow Sensor Number	0 = Test Only. 1 = Chem-Tec, MAO-500-T-20-C-AA. 2 = Signet MK507. 3 = Signet 2536, 1/2" Pipe. 4 = Signet 2536, 3/4" Pipe. 5 = Signet MK507-2. 6 = Signet MK507-3.

While in SETUP mode, depressing either the 'up' or 'down' key will cause the display to advance or retard. Depressing the key once and releasing will allow the accurate setting

of the least significant digit. Holding either key down will activate the automatic, rapid incrementing or decrementing of the display. To exit this mode 'Return' is depressed. The Power Reset (PR) parameter adjusts the sampling period in tenths of minutes. Thus, smaller numbers create more rapid sampling.

The Calibration Adjustment (CA) parameter allows the elimination of various sensor and system errors. Thermocouple sensors are manufactured within a specific tolerance. The tolerance may lead to a difference between the actual temperature and the temperature displayed. This error coupled with the differential error caused by sheathing the sensor in materials such as Teflon® may cause a difference in the actual bath temperature and display temperature. This can simply be corrected by monitoring the bath temperature and utilizing the offset to add or subtract the appropriate number of degrees to bring the display into compliance with the actual temperature.

While in the Program mode, depressing the 'Save' key will cause the setup parameters to be written into the EEPROM memory. This is a permanent (10 year minimum life) memory that does not require battery backup. The save routine takes about two seconds to complete and is indicated by a series of dashes through the displays. This feature provides the O.E.M. with the ability to program their desired initial parameters prior to shipment. It then allows the user to modify these parameters for their exact requirements and permanently save the new parameters all from the keyboard.

ALARMS*****

There are six alarm LEDs. They are essentially visual annunciators of the system functions.

SYSTEM - This alarm is a catch-all indicator for the miscellaneous diagnostics. An example would be the malfunction of the EEPROM save routine. This would simply indicate to the user that something has gone wrong and he should either repeat the command or reset the unit.

CONTINUE HERE

NOTE:

This alarm will activate, if the FLOW drops below the Low Flow (LF) parameter setting. It lights the 'SYSTEM' LED. The process display will alternately flash the temperature and 'LF' for Low Flow.

SENSOR - This alarm is to indicate a defective "SENSOR". This indicates that the sensor is either open or not connected. Special circuitry has been incorporated to monitor the sensors for an open circuit. The processor continually monitors the input and if it detects an open sensor, it shuts off the heater output and activates the "SENSOR" alarm. The process display will alternately flash the temperature and "OP" for open sensor.

H LIMIT - This is "High Limit" alarm. The LED is wired directly to the high limit circuit and lights whenever the high limit turns the master relay off. Since it is powered by the high limit power supply it remains on even after the master relay has de-energized and shut the controller off. This alerts the operator that the system has shut down and why.

H TEMP - This is the "High Temperature" alarm. It is activated anytime the process temperature exceeds the high alarm setpoint. When activated, the process display alternately displays the process temperature and the code "HI".

L TEMP - This is the "Low Temperature" alarm. It acts like the "High Temperature" alarm, except it compares the process temperature to the low alarm setpoint. If the process temperature drops below the setpoint once it has initially come out of the warm-up mode, this alarm will be activated. In this case, the code "LO" is alternately flashed with the process temperature.

L LEVEL - This is the "Liquid Level" alarm. It monitors an optional remote liquid level sensing circuit and activates when a low liquid level is detected. The code "LL" is alternately flashed with the process temperature.

All of the alarms activate the audio tone as well as the alarm status LED and the individual alarm annunciator. The tone and the LEDs alternate on and off to draw attention to the alarm. As has been noted above, many of the alarms have additional visual displays to further define or draw attention to them.

KEYS*****

VIEW - This key is used to View the Process Setpoint and Programmed Process Time, when not in the Setup mode. It is a momentary key that will change displays to show the corresponding setpoints, as long as it is held down.

SETUP - This key is used to put the system into the SETUP mode and once in that mode, advance through the parameters.

Depressing the key once will place the unit into the SETUP mode. (Note: if the access code protection is selected, an additional step is required, see Access Code below). Depressing the key after entering the SETUP mode will allow the user to scroll through the SETUP parameters. To exit the SETUP mode, the RETURN key is depressed.

UP - In the SETUP mode, depressing the 'UP' key will cause the display to advance. Depressing the key once and releasing will allow accurate setting of the least significant digit. Holding the key down will activate the automatic, rapid incrementing of the display.

DOWN - In the SETUP mode, depressing the DOWN key will cause the display to

decrease. Depressing the key once and releasing will allow the accurate setting of the least significant digit. Holding the key down will activate the automatic, rapid decrementing of the display.

SIL - The alarm silence key is provided to allow for the elimination of the audio portion of the alarm as well as the portion of the alarm display that effects the process display. This essentially allows the unit to be returned to a functional condition where setpoints can be examined and reset without the interference of the special alpha displays. However, the alarm status and annunciator LEDs continue to flash to indicate the alarm and where applicable, the output to the heater is turned off to protect the equipment from any potential damage.

RETURN - This key is used to return the system from the SETUP mode, if in SETUP. If in 'HOLD', it will exit the HEATER HOLD mode.

SAVE - This key is only active in the SETUP mode and is used to permanently save the system parameters.

STANDBY - This key will put the unit into the HOLD mode. It disables the heater output. This mode is exited by either depressing the 'RETURN' key or a second depression of the 'STANDBY' key. Note: for safety, the unit always starts up in this mode initially or enters it after a power failure. When in this mode, the Flow Display reads 'HOLD'.

PWR - This key is utilized to toggle the internal electronic latch and master relay. This turns the main power to the controller ON and OFF.

AUTO/MAN - This key is used to toggle the system between the AUTO and MANUAL modes.

AUX 1 - This key is utilized to toggle the AUX 1 output ON and OFF.

AUX 2 - This key is utilized to toggle the AUX 2 output ON and OFF.

OPERATION*****

The controller has two basic modes of operation: MANUAL and AUTOMATIC. The mode determines whether the basic power setting for the unit is determined by a direct manual input or as a function of the FLOW SENSOR. The following discusses the difference between the two:

MANUAL MODE - This mode uses a specialized control algorithm for use with a instantaneous Liquid Heater. The control system can be thought of as a very sophisticated self-adjusting noise limiting variac. In essence, the direct power to the heater is adjusted to obtain the appropriate temperature rise for a specific flow.

The user should compute the power required to obtain the appropriate 'Delta T' across the

heater. This power estimate, in percent, is then directly placed in the 'PP' (Percentage Power) parameter. The desired setpoint is then set into the 'PS' (Process Setpoint) parameter.

When the unit is taken out of the HOLD mode, it will immediately apply the stipulated percentage power as a time percentage of the cycle rate utilizing the zero cross solid state relay output. For example, if the cycle rate is set to 2 seconds and the percentage power is set to 50%, the system will cycle ON for one second and OFF for one second on a continuous basis.

AUTOMATIC MODE - In this mode, a slightly more sophisticated control algorithm is used to control the instantaneous Liquid Heater. It employs the same basic technique as described in the MANUAL MODE, with the enhancement that the power output is automatically varied as a function of the flow.

From a computational viewpoint, the algorithm will determine the required KW to obtain a specific Delta T based on the following formula:

$$\text{KW} = \frac{\text{GPM} \times \Delta T^{\circ}\text{C}}{3.79}$$

This formula utilizes an Input Temperature parameter (IS) and the Process Setpoint temperature to calculate Delta T. The gpm is taken from the Flow Meter Reading and the KW is adjusted by time proportioning the ON time of the heaters ratioed to the time base set in the 'CR' (Cycle Rate) parameter. The only additional parameter that needs to be set for this automatic operation is the 'AP' (Available Power) parameter. This should be adjusted to the maximum output of the heater (e.g. 4.0 KW).

Once the initial settings are made, the unit will automatically vary the heater power directly with the flow. Thus, a consistent Delta T may be obtained across the heater for any flow readings within the range of the specific flow sensor.

MANUAL and AUTOMATIC modes, all of the following features apply:

The 'PR' (Power Reset) parameter may be utilized to automatically adjust the percentage power to compensate for errors in the initial computation, as well as variances in the system that might be caused by inlet temperature variations, line voltage variations, etc. In essence, this parameter allows the system to automatically monitor the difference between the Discharge Temperature and the Process Setpoint. If the temperature is low, it will continually tweak up the power until the output temperature is met. If the temperature is too high, it will continually turn down the power until the desired discharge is reached.

The Dead Band (DB) setting may be utilized to establish a band around the process setpoint in which the reset action is disabled. This is utilized to minimize the hunting

effect caused by continuous reset. The band should be set in accordance with the acceptable tolerance levels for the specific application.

A special override feature has been incorporated to insure that major errors in the setting do not cause excessive discharge temperatures. Regardless of the Power and/or Reset settings, the heat output will be disabled, if the temperature exceeds the process setpoint by 5 degrees C. This parameter is totally independent of the High Alarm setpoint. The only difference is that the High Alarm sets off the alarms as previously described, whereas the internal override is a control feature. It should be noted that even though the 5 degree temperature limit has turned the heat off, the Power Reset, if selected, will continually turn the power down to try to bring the system into compliance.

FLOW - The unit contains the capability of monitoring a number of different FLOW SENSORS. The SENSOR NUMBER (SN) is selected in the SETUP stack.

In both the MANUAL and AUTOMATIC modes, there is a LOW FLOW (LF) parameter setting. This parameter allows the user to set an 'Annunciator Only Alarm Condition' based on the FLOW SENSOR input. It should be noted that this alarm does not have any function in the system, other than to alert the operator to the fact that there is a LOW FLOW condition. It does not directly inhibit the HEAT output.

In the MANUAL mode, the only function for the FLOW SENSOR is to provide the user with FLOW information and the 'Annunciator Only Low Flow' alarm.

In the AUTOMATIC mode, the FLOW input is utilized in the power computation and thus, has a direct bearing on the HEAT output.

It should also be noted that in the AUTOMATIC mode, if the FLOW drops below .4 gpm, that the HEAT is disabled, except when the MC507-2 sensor is selected.

BACKDOOR CODE*****

A special code has been incorporated into the software to insure factory access to all functions no matter what the customer has done with the access codes. This code is 333.

SPECIFICATIONS

TEMPERATURE RANGE	0.0 - 100.0 Degrees C.
TEMPERATURE RESOLUTION	0.1 Degrees C.
NOISE REJECTION	NMR - 60 db @ 60 HZ CMR -120 db @ 60 HZ
FLOW RANGE	0.0 to 25.0 gpm
FLOW RESOLUTION	0.1 gpm
MEASURING TIME	4 Conversions/Sec
DISPLAY	8, 0.56" High, 7 Segment, LED Uniplanar numerals. 12 Discrete LEDs (Red, Green, Amber).
ANNUNCIATOR	Audio Tone, ~ 2500 HZ
SETUP MEMORY	EEPROM, All Parameters
MEMORY RETENTION	10 Years w/o Power
SENSOR	Standard - Type J Thermocouple, Cold Junction Compensation, Up Scale Break Protection.
CONTROL	PID with Anti-Reset Windup.
ADJUSTMENT	Cycle Rate: 0 - 5 Sec. Power Reset (Integral): 1 - 199 Sec. Calibration Offset: + 9.9 Deg. C
OPERATING RANGE	0 to 50 Degrees C
STORAGE RANGE	-40 to 60 Degrees C
CONSTRUCTION	Enclosure - Kydex. Face - Lexan, Back Printed
SIZE	7 x 6 x 5.25 inches (HxWxD) 178 x 152 x 133mm
WEIGHT	< 4 Lbs. (1.8 kg)
CONNECTION	Rear, Screw-Type, 3/8 Inch Centers; T/C - Miniature, Type J, Jack.
OUTPUT	SSR, Optically isolated, zero cross, 20 Amp, 208 VAC. Relay: 1 HP, 250 VAC (optional) BUZ, HS: 20ma, 12 VDC (provided)
POWER:	(P/N 306874) 11 VA, 208 VAC ±10%, 50/60 HZ, or (P/N 306891) 11 VA, 120 VAC ±10%, 50/60 HZ, or (P/N 306890-24V) 11 VA, 24 VAC ±10%, 50/60 HZ.