MANUAL

for the

Computer-Interfaced Temperature Controllers

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DRAFT -- DRAFT

Known Problems:

Section 1.2.4	need to check parameters check manuals	
Section 1.2.5	need to check parameters check manuals	
Section 1.2	need to add newer devices (see GEO)	
Chapter 3	need to update (see GEO) check functioning of **TLOG** and **STOPLOG**	
Appendix A	need to update (see GEO)	

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CHAPTER 1

TEMPERATURE CONTROL AT IPNS

1.1 OVERVIEW OF AUTOMATED TEMPERATURE CONTROL

Each of the temperature controllers used at IPNS has a number of adjustable parameters. Most of these parameters need be changed only occasionally (for example - the 'gain' and 'reset' values used in the control equation). However, for each controller there are three parameters which must be set each time you use the device via the instrument computer. These three are the SET POINT, UPPER LIM, and LOWER LIM parameters.

Each temperature control device has two 'logical' thermometers. One of these is labeled the 'control' thermometer and one is labeled the 'measurement' thermometer, and these function differently in the automated-temperature-control software. The CTL SENS and MEAS SENS parameters, respectively, are used to assign these logical thermometers to actual 'physical' thermometers (eg - thermocouples number 1 and number 2). Either of the logical thermometers can be assigned to either of the physical thermometers, or both of the logical thermometers can be assigned to a single physical thermometer. The controller operates to drive the temperature measured on the 'control' thermometer to the value specified by the SET POINT parameter. The temperature measured on the 'measurement' thermometer is compared to the UPPER LIM and LOWER LIM, and if so, data acquisition is allowed to proceed. Data acquisition is suspended whenever the temperature at the 'measurement' thermometer falls outside this specified range.

Normally the physical thermometer most closely thermally connected to the control heater is assigned as the 'control' thermometer, to provide good feedback for control stability. The physical thermometer located on or nearest to the sample is usually chosen as the 'measurement' thermometer.

Before you start any Runs with automatic temperature control, you may want to change one or more of the controller parameters. Section 1.2 provides the information necessary to do this for any of the temperature control devices supported at IPNS. Once all the device parameters have been set to their desired values, this process should not have to be repeated very often. Most of these parameters will retain their same values from Run-to-Run for a number of Runs.

Once the parameters are set as desired, you may want to start one or more Runs with automated temperature control. Chapter 2 describes how to do this. Chapter 3

discusses how to read the temperature and describes the temperature-logging capabilities.

1.2 SETTING DEVICE PARAMETERS

1.2.1 The **TEM** Command

The command

TEM

allows the user to change parameters in the parameter file (file DEVICE.TBL - see below) for the controller. After this command the computer will prompt

ENTER SETPOINT AND LIMITS ONLY (S), CHANGE OTHER
CONTROLLER PARAMETERS (C), OR EXIT (E) ?

If you enter a **C** at this point, the computer will step through a list of parameters with their current values. (See the section on the appropriate controller below for a description of parameters and allowed values.) If you enter a different value for one of these parameters, this new value will be stored in the parameter file. If you do not wish to change the current value for a given parameter, just hit the **<return>** key. At the end of the parameter list the computer will print out the current parameter values and will again respond with the above prompt.

If you enter **E** after this prompt, the TEM program will exit. The most recently entered values for the parameters will be stored in the parameter file.

If you enter **S** after this prompt, the computer will ask you to input values for a SET POINT and UPPER and LOWER LIMITS (see below for definitions). When you have input these values, the program will save them in the parameter file, will download all controller parameters to the controller, and will wait until a period of time (DELAY parameter) has elapsed after the temperature was first within the limits. During this waiting stage the program will keep a record of the temperature-time profile in the file (name)TEMP.LOG. At the end of this wait the TEM program will exit.

1.2.2 The Displex Controller Parameters

The operation of the Displex controllers is described in the manual "Instruction Manual for Series 5500-APD-K Microprocessor-Based Temperature Indicators / Controllers". The newest version of this manual that we have has revisions through Aug. 1983. This version should be used, as earlier versions contained numerous errors.

Only the Series 5500-APD-K controllers are computer interfaced. Earlier Displex controller models do not permit such interfacing. Temperature sensors used with all the 5500-APD-K controllers are chromel vs gold thermocouples. Later versions of the 5500-APD-K controllers allow temperature readout to two decimal places. The computer software always prints out the temperatures to 2 decimal places, but if one of the older controllers is in use, the last decimal place will not be meaningful.

The Displex controller is interfaced to the instrument computer via an RS232 cable which leads from the computer to the instrument. This operates at 300 baud (currently) and is treated as an ordinary terminal line by the VMS terminal driver. In order for RS232 communications to work with these controllers, the RS232 cable must have an adapter in which the 'send' and 'receive' wires are interchanged (pins 2 and 3). These adapters should normally be left connected to the controllers. Also, power line grounds have been disconnected in the controllers, as otherwise ground loops occur when the RS232 cables are connected.

The parameters for the Displex controllers (device number 4) have the following ranges and meanings:

Parameter	Range	Meaning
SET POINT	0. - 300.	Set point temperature in degrees K.
UPPER LIM	any value	Maximum value of measured temperature (degrees K) for which data acquisition is allowed.
LOWER LIM	any value	Minimum value of measured temperature (degrees K) for which data acquisition is allowed.
DELAY	-99999. to +99999.	Delay time in minutes between initial reaching of desired temperature and start of data acquisition. If this delay time is preceded by a minus sign (-), the delay will occur each time TEM is invoked (eg - whenever a new Run is started). If this delay time is not proceeded by

a minus sign, the delay will occur only if the current temperature does not fall within the new temperature limits.

CTL SENS	1 or 2	Number of sensor to be used for control.
MEAS SENS	1 or 2	Number of sensor to be used for measurement.
SP RATE	0.10 - 50.	Maximum rate (degrees K/minute) at which controller can change set point.
PROP	0 - 99	'Proportional' coefficient in the control equation.
INT	0 - 99	'Integral' coefficient in the control equation.
DERIV	0 - 99	'Derivative' coefficient in the control equation.

A reasonable, but not fully optimized set of control parameters is

        SP RATE = 50
        PROP = 25
        INT = 5
        DERIV = 60

1.2.3 The MICRICON (Furnace) Controller Parameters

        The operation of the MICRICON controllers is described in the manuals "82300 MicRIcon User Manual" and "Model 82322 MicRIcon Intelligent Distributed Controller". The newest versions we have are dated 1982, and these are missing the section on computer interfacing. However this section has been added to some copies.

        The MICRICON controller is interfaced to the instrument computer via an RS232 cable which leads from the computer to the instrument. This operates at 300 baud (currently) and is treated as an ordinary terminal line by the VMS terminal driver.

        At present we have 3 different MICRICON chassis and 5 different I/O boards which can be put in these chassis to interface to different types of sensors. These I/O capabilities (identified by board serial number) are:

   1.   SN 101384 --- Model 82330-I1(K75)-I2(K75)-O1(O3)-O2(O3)
         Channel 1 -- Type K thermocouple, -20 to 750 C, 0.1 C resol.
         Channel 2 -- Type K thermocouple, -20 to 750 C, 0.1 C resol.

2.   SN 101737 --- Model 82330-I1(K25)-I2(K25)-O1(O3)-O2(O3)-R(2)
     Channel 1 -- Type K thermocouple, -20 to 1350 C, 1 C resol.
     Channel 2 -- Type K thermocouple, -20 to 1350 C, 1 C resol.

3.   SN 101739 --- Model 82330-I1(K25)-I2(K25)-O1(O3)-O2(O3)-R(2)
     Channel 1 -- Type K thermocouple, -20 to 1350 C, 1 C resol.
     Channel 2 -- Type K thermocouple, -20 to 1350 C, 1 C resol.

4.   SN 113711 --- Model 82332-I1(K25)-I2(K75)-O1(O3)-O2(O3)-T(W)
     Channel 1 -- Type K thermocouple, -20 to 1350 C, 1 C resol.
     Channel 2 -- Type K thermocouple, -20 to 750 C, 0.1 C resol.

5.   SN 114668 --- Model 82330-I1(S32)-I2(MV50=0/100%))-O1(O3)-O2(O3)-
     T(W)-SP15
     Channel 1 -- Type S thermocouple, -20 to 1760 C, 1 C resol.
     Channel 2 -- 0 to 50 millivolts, readout in % of full scale.

The parameters for the MICRICON controllers (device numbers 3,9,10) have the following ranges and meanings:

Parameter	Range	Meaning
SET POINT	-20.0 - 750.0 -20. - 1350. -20. - 1760. check individual controller	Set point temperature in degrees C.
UPPER LIM	any value	Maximum value of measured temperature (degrees C) for which data acquisition is allowed.
LOWER LIM	any value	Minimum value of measured temperature (degrees C) for which data acquisition is allowed.
DELAY	-99999. to +99999.	Delay time in minutes between initial reaching of desired temperature and start of data acquisition. If this delay time is preceded by a minus sign (-), the delay will occur each time TEM is invoked (eg - whenever a new Run is started). If this delay time is not proceeded by a minus sign, the delay will occur

		only if the current temperature does not fall within the new temperature limits.
CTL SENS	1 or 2	Number of sensor to be used for control.
MEAS SENS	1 or 2	Number of sensor to be used for measurement.
SP RATE	> 0	Maximum rate (degrees C/minute) at which set point is changed.
GAIN	0. - 128.	'Proportional' coefficient in the control equation. No control action occurs if GAIN=0.
RESET	.0 - 60.23	Related to 'integral' coefficient in the control equation.
RATE	0. - 8.5	Related to 'derivative' coefficient in the control equation.
HIOUT LIM	-99.9 - 99.9	Maximum output power in percentage of full scale (negative values are for time-proportional output).
FILTER	0. - 5.	Digital filter settings. 0. Means digital filter is not used (see manuals for other settings).
CONTROL	0. or 1.	Control type. 0. means reverse control (output power goes down as temperature goes above set point), 1. means direct control (output power goes up as temperature goes above set point).
TP-CYTM	0.,4.,8.,17., 34.,68.,136.	Time-proportioning cycle time. 0. means this feature is not used (see manuals for other settings).
SEL ADAPT	0. or 1.	Select-Adaptive. 0. means this feature is disabled, 1. means it is enabled.
GAINS 1 • • GAINS 5	.1 - 128.	These are values for the GAIN parameters at the 5 select-adaptive points (0%, 25%, 50%, 75%, and 100% of the full controller range). The controller linearly interpolates between these values when select-adaptive is enabled.

RESETS 1	.0 - 60.23	These are values for the RESET parameters at the 5 select-adaptive points (0%, 25%, 50%, 75%, and 100% of the full controller range).
•		
•		
RESETS 5		The controller linearly interpolates between these values when select-adaptive is enabled.

1.2.4 The MICRISTAR (Furnace) Controller Parameters

The MICRISTAR controller is interfaced to the instrument computer via an RS232 cable which leads from the computer to the instrument. This operates at 300 baud (currently) and is treated as an ordinary terminal line by the VMS terminal driver.

The parameters for the MICRISTAR controller (device number 20) have the following ranges and meanings:

Parameter	Range	Meaning
SET POINT	-20.0 - 750.0 -20. - 1350. -20. - 1760. check individual controller	Set point temperature in degrees C.
UPPER LIM	any value	Maximum value of measured temperature (degrees C) for which data acquisition is allowed.
LOWER LIM	any value	Minimum value of measured temperature (degrees C) for which data acquisition is allowed.
DELAY	-99999. to +99999.	Delay time in minutes between initial reaching of desired temperature and start of data acquisition. If this delay time is preceded by a minus sign (-), the delay will occur each time TEM is invoked (eg - whenever a new Run is started). If this delay time is not proceeded by a minus sign, the delay will occur only if the current temperature does not fall within the new temperature limits.
CTL SENS	1 or 2	Number of sensor to be used for control.

MEAS SENS	1 or 2	Number of sensor to be used for measurement.
SP RATE	> 0	Maximum rate (degrees C/minute) at which set point is changed.
GAIN	0. - 128.	'Proportional' coefficient in the control equation. No control action occurs if GAIN=0.
RESET	.0 - 60.23	Related to 'integral' coefficient in the control equation.
RATE	0. - 8.5	Related to 'derivative' coefficient in the control equation.
HIOUT LIM	-99.9 - 99.9	Maximum output power in percentage of full scale (negative values are for time-proportional output).
FILTER	0. - 5.	Digital filter settings. 0. Means digital filter is not used (see manuals for other settings).
CONTROL	0. or 1.	Control type. 0. means reverse control (output power goes down as temperature goes above set point), 1. means direct control (output power goes up as temperature goes above set point).
TP-CYTM	0.,4.,8.,17., 34.,68.,136.	Time-proportioning cycle time. 0. means this feature is not used (see manuals for other settings).

1.2.5 The LFE (Furnace) Controller Parameters

The LFE controller is interfaced to the instrument computer via an RS232 cable which leads from the computer to the instrument. This operates at 300 baud (currently) and is treated as an ordinary terminal line by the VMS terminal driver.

The parameters for the LFE controller (device number 12) have the following ranges and meanings:

Parameter	Range	Meaning
SET POINT	-20.0 - 750.0	Set point temperature in degrees C.

	-20. - 1350. -20. - 1760. check individual controller	
UPPER LIM	any value	Maximum value of measured temperature (degrees C) for which data acquisition is allowed.
LOWER LIM	any value	Minimum value of measured temperature (degrees C) for which data acquisition is allowed.
DELAY	-99999. to +99999.	Delay time in minutes between initial reaching of desired temperature and start of data acquisition. If this delay time is preceded by a minus sign (-), the delay will occur each time TEM is invoked (eg - whenever a new Run is started). If this delay time is not proceeded by a minus sign, the delay will occur only if the current temperature does not fall within the new temperature limits.
CTL SENS	1 or 2	Number of sensor to be used for control.
MEAS SENS	1 or 2	Number of sensor to be used for measurement.
SP RATE	> 0	Maximum rate (degrees C/minute) at which set point is changed.
GAIN	0. - 128.	'Proportional' coefficient in the control equation. No control action occurs if GAIN=0.
RESET	.0 - 60.23	Related to 'integral' coefficient in the control equation.
RATE	0. - 8.5	Related to 'derivative' coefficient in the control equation.

CHAPTER 2

AUTOMATIC TEMPERATURE CONTROL DURING RUNS

2.1 ENTERING SETPOINTS AND LIMITS

A control setup program allows the user to set the temperature set point and limits which will be different for each Run. This program can be invoked in either of two ways:

1.   By answering **Y** when the computer prompts

       CONTROL PARAMETERS (Y/N) ?

       while the user is setting up a Run with the **NEW** command.

2.   After the Run has been set up, by entering the command

       CTL$_\Delta$run-number

       where run-number is the number of the Run for which control parameters are to be entered. This method can be used either to make the initial entry of temperature control information for this Run (provided the Run has never been started), or to change previously entered control information for this Run (provided the device name(s) and the number of devices are not changed). Previously entered control information can be changed even for a Run which has been started and stopped.

In either case, the program will display a list of the allowed devices for this instrument, ask the user for the name(s) of the device(s) he wishes to use, and for each device the user specifies will prompt the user for the values of those device parameters which may change from Run-to-Run. In the case of the temperature controllers, these parameters are SET POINT, UPPER LIM, and LOWER LIM. The names of the devices to be used and these new parameter values will be stored in the Run File, and will then automatically be used, along with the other device parameters, the next time this Run is started.

2.2 READING THE CONTROL PARAMETERS FOR A RUN

Once control information has been entered in the Run File, this information can be displayed using the command

PRUN$_\triangle$CONTROL$_\triangle$run-list

where 'run-list' is a list of Run numbers. This information is also displayed as part of the **PRUN** command for **HEADER** or **RUN**.

2.3 DURING A RUN

If a temperature controller is selected as a controlled device, then when this Run is started the TEM program will be spawned to download the controller parameters and wait for equilibrium. Data acquisition is allowed to start only after a wait (DELAY parameter) after the measured temperature first gets within the specified limits (UPPER LIM, LOWER LIM). Data acquisition will be suspended whenever the measured temperature is outside the user-specified limits, and will be resumed whenever it gets back inside these limits.

CHAPTER 3

OTHER FEATURES

3.1 READING THE TEMPERATURE

The command

RDT

returns the current measured temperatures at the control and measuring thermocouples. Temperatures are specified in Kelvin for the Displex controllers and in Celsius for the furnace controllers.

3.2 RETRIEVING THE TEMPERATURE-TIME PROFILE

The temperature-time profile at the measuring thermocouple at 60-second intervals is stored (either by the temperature control program running after the **TEM** command or at the start of a Run, or by the Run monitoring program) in the file DATADIR:(name)TEMP.LOG, where (name) is the four-character instrument name for your instrument. (Instruments with three-character names such as SCD have a numeral 0 thru 9 appended to these three characters to form a four-character instrument name; eg - SCD0.) This file can be printed out using one of the print queues for your instrument computer (see the User Manual). It can also be copied to another directory for later analysis.

All the temperature-logging data are appended to the end of this file. If the controller is a type that supports only one thermocouple (LFE), then each record (line) in the file contains the time of the first point in that record, followed by ten temperature points (fewer in some cases) corresponding to approximately 60-second intervals, and finally the date. In this case the format of each record is

(Time),   (Temperatures),   (Date)
1X,8A1   1X,10F7.2   1X,9A1)

For all the rest of the controllers, two lines are printed every ten minutes. The first of these lines contains the time of the first point and temperatures measured on thermometer number 1 in the format

(Time),   (Temperatures)
1X,8A1   1X,10F7.2

The second lines contains the thermometer and controller numbers, followed by the ten temperatures for thermometer number 2, and finally the date. The format is

(Thermom/Controller)   (Temperatures),   (Date)
2X,'T2,C',I1   3X,10F7.2   1X,9A1

The controller number which follows the 'C' in this line takes on the following values (1 = DISPLEX, 2 = MICRICON, 3 = LFE, 4 = LFE 2012-13, 5 = MICRISTAR).

    Using these formats, you can read the data from this file if you want to process it with a program of your own.

3.3 STAND-ALONE TEMPERATURE LOGGING

    The temperature-time profile at the measuring thermocouple at 60-second intervals can be logged to the file DATADIR:(name)TEMP.LOG even when the TEM program is not running and no Run is active. To do this, type

TLOG

Logging will be in the format discussed above. To stop this logging, type

STOPLOG

*** NOTE ***: The TLOG program should not be left running when TEM is active or when a Run involving temperature control is running.

APPENDIX A

INSTALLATION

A.1 INSTALLATION CHECKLIST

To install a temperature controller at an instrument:

1.   Connect the controller to the RS232 terminal cable at the instrument. Note the terminal number on the label on this cable.

2.   Plug in the controller power cord and connect heaters and thermocouples.

3.   For Displex controllers, make sure the controller case is not grounded.

4.   Turn on the controller and verify that it is reading temperature correctly.

5.   Make sure the controller is set to 300 baud. For Displex controllers this is done from the front panel. Use the keys #, I/O to get into the I/O entry mode. The first entry will prompt 'BAUD' and should be set to 1 for 300 baud. Keep hitting 'ENTER' until you exit the I/O entry mode. For the MICRICON the baud rate is set on internal switches, and should be changed only by someone familiar with the units.

6.   In the case of the MICRICON controller, make sure the controller is set to the 'terminal' mode. This is also done with internal switches, and should be done only by someone familiar with the unit.

7.   Log in on the computer for the instrument in question.

8.   Using the EDT editor, modify the (name).ANC file to include the controller you are installing and the correct number of the terminal line to which it is connected. See the discussion of the (name).ANC file below for details about this step.

9.   Type in the command **TEM** and use the CHANGE OTHER CONTROLLER PARAMETERS option (enter a **C**) to check that controller parameters are set to the correct values in the parameter table (a **<return>** after a parameter prompt retains the parameter value displayed). Change any parameters as necessary. Then EXIT (enter an **E**). (See Chapter 1 for details about this step.)

10. Type in the command **RDT** and verify that the correct temperature is returned. This verifies that communication has been established with the controller.

The controller should now be completely installed and ready to operate from the computer.

A.2 FILE (name).ANC

This file, where (name) is the four-character instrument name, is contained in the logical directory INSTDIR:. It is a formatted, variable record length, sequential file created by the EDT editor. It's contents are specific to each instrument, and include one entry for each device currently allowed on that instrument. (Hence it must be changed using EDT whenever the configuration of available ancillary devices on that instrument is changed.)

Each device entry consists of one record in the format shown below:

(DEVNAM),   (DEVNO),   (SLTNO),   (SUBCH),   (MONIT)
5X,A16   2X,I4   3X,I5   3X,I5   3X,I2

DEVNAM is the name by which the device is to be known to the user (MICRICON, Howe Furnace, 300C Furnace, LFE, MICRISTAR, or DISPLEX for the temperature controllers).   DEVNO refers to the number of this device in the file DEVICE.TBL (DEVNO = 3 for the MICRICON, 4 for the Displex controller, 9 for the Howe Furnace, 10 for the 300C Furnace, 12 for the LFE controller, and 20 for the MICRISTAR controller - see the Instrument Manager Manual for the Data Acquisition System). SLTNO is the terminal line number used for this controller. SUBCH should be 0 for temperature controllers, and MONIT must be 1 for temperature controllers.

Table 1 shows a typical (name).ANC file (this one might be appropriate to the SAD instrument). This file states that the instrument has 3 ancillary devices: device CHANGER which uses CAMAC slot 11 and subchannel 1, device DISPLEX which uses logical terminal line TERM03 and is to be monitored during Runs, and device MICRICON which uses logical terminal line TERM03 and is to be monitored during Runs.

TABLE 1

TYPICAL ANCILLARY DEVICE CONFIGURATION
(file (name).ANC)

CHANGER	1	11	1	0
DISPLEX	4	3	0	1
MICRICON	3	3	0	1

Since the MICRICON and DISPLEX are never used at the same time, it is OK for them to both be assigned to the same terminal line.