Advanced Energy®

250W Model 1314 Precision Calorimeter

User Manual

February 2023 1314-900 Revision BA

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Safety Information and Precautions

The following safety information applies to both operation and service personnel. Safety precautions and warnings may be found throughout this instruction manual and the equipment. These warnings may be in the form of a symbol or a written statement.

> ⚠ **CAUTION:**
>
> DO NOT USE IN EXPLOSIVE ENVIRONMENTS!
>
> The 1314 is not designed for operation in explosive environments.

> ⚠ **WARNING:**
>
> DO NOT OPERATE WITHOUT COVERS!
>
> This device should be operated with all panels and covers in place. Operation with missing panels or covers could result in personal injury.

Terms in this Manual

> ⚠ **CAUTION:**
>
> CAUTION indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury, and/or property damage. CAUTION is also used for property-damage-only accidents.

> ⚠ **WARNING:**
>
> WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury, and/or property damage.

DANGER:

DANGER indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. DANGER is limited to the most extreme situations.

NOTE statements identify best practices or tips for efficiency.

Terms on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols as Marked on Equipment

CAUTION – RISK OF DANGER

DANGER – Risk of Electric shock

Earth ground terminal

Frame or Chassis terminal

Alternating current

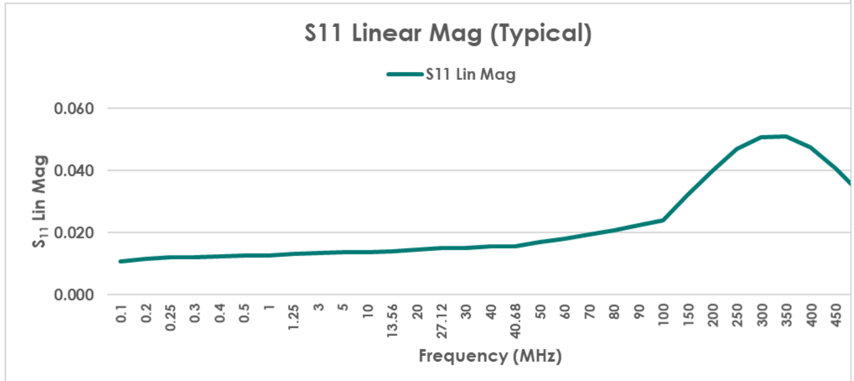
2

Product Overview and Specifications

Specifications

Measurement Ranges	Specification
Frequency (MHz)	50 Hz to 3000 MHz
Power (W)	10 W to 250 W
Connector Type	Type N (female)
Basic Accuracy	0.3 W + 0.3% Rdg[1, 2, 3]
Power Requirements	
Calorimeter	100 – 240 VAC, 1.5 A
Chiller	100 – 240 VAC, 9.4 A
AC Power Source (optional)	104 – 127 VAC, 10A[4]
AC Power Standard (optional)	100 – 240 VAC, 10A[4]
Physical Dimensions (Approximate)	
Calorimeter	4” height, 19” width, 23” depth (not in optional rack)
Chiller	7” height, 19” width, 28” depth (not in optional rack)
AC Power Source (optional)	6” height, 17” width, 23” depth[4]
AC Power Standard (optional)	5” height, 9” width, 16” depth[4]
Coolant Flow Rate	1 gallon (3.75 Liters) per minute nominal
Drift	< 50% of uncertainty over 48 hours
Input Impedance	50 Ω nominal
Communication	Ethernet
Cooling Fluid	25% DOW-Therm SR-1, 75% distilled water
Operating Temperature	68 to 86 °F (20 to 30 °C)

Specifications (continued…)

Storage Temperature	14 to +122 °F (-10 to +50 °C)[5]
Warranty	1-year Parts & Workmanship for AE-TEGAM-manufactured components
S11 Linear Magnitude (Typical)	Typical < 0.025 at *f* < 100 MHz, and <0.1 at *f* >= 100 MHz  Figure 1: Typical S_{11} Linear Mag Performance

Optional System Components (contact your AE-TEGAM representative for more information).

AC Source	Required for routine calibration of the Calorimeter.
AC Power Meter	Required for routine calibration of the calorimeter.
Rack (Single/Dual Bay)	Options available based on specific configurations.
P/C	For control of calorimeter and ancillary equipment.
Other	Contact TEGAM for further details and options.

[1] Average of ten (10) consecutive points taken 25 seconds apart, where the standard deviation of those points is < 0.05 W.
[2] The 1314 is intended for use as a primary standard. Measurement repeatability and uncertainties will vary among laboratories depending upon various factors, including ambient environment, user experience, and elapsed time since the most recent system calibration. TEGAM will provide guidance where possible, but users are ultimately responsible for establishing their own measurement uncertainties consistent with the laboratory's capabilities.
[3] Optional items required to achieve specifications listed. Must use recommended options.
[4] Example based on optional equipment (Keysight 6811B source and Yokogawa WT310E AC standard) . Other options are available.
[5] Assumes proper preparations are followed prior to storage, including draining the coolant system.

Product Overview

Figure 2: Model 1314 250W Precision Calorimeter (in optional rack w/PC)

The model 1314 is a precision calorimeter that can provide highly accurate RF power measurements up to 250 W in the 50 Hz to 3 GHz frequency range, and is traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or other recognized National Metrology Institutes, by comparison to equipment and standards maintained in the laboratories of AE-TEGAM Inc. The calorimeter design is based on first principles of fundamental physics in the following way. If we know a calorie is a defined as the amount of energy in the form of heat to raise the temperature of a certain mass of liquid by a given amount, then conversely, if we know the temperature rise and the mass of the liquid, we can determine the amount of heat and therefore, the amount of energy applied to the liquid. The calorimeter utilizes these fundamental relationships to precisely measure input power in the form of RF energy.

The physics definition of Work is also related to heat by being defined as energy in transition and work per unit time is power. We can then expand the concept of a calorie to include the rate at which this heat energy is delivered to the mass of the substance to directly derive power, which can then be equated to the more useful watt terminology describing our applied RF energy. One joule (or 1 BTU) of heat equals .239 calories (or 778 ft-lbs) of work, and 1 joule/sec (or 1 BTU/hr) has its electrical equivalent to 1 watt (or .293 W).

Therefore, the fundamental calorimetric relationship between electrical power in watts and the thermal quantities measured inside the calorimeter are temperature rise ΔT (°C), rate of mass flow (gm/sec) and specific heat of the transfer medium cp (J/gm-°C):

$$\text{Watts} = \text{J/sec} = \text{mass flow rate (gm/sec)} \times \Delta T\ (^\circ\text{C}) \times \text{specific heat (J/gm-}^\circ\text{C)}$$

The system design utilizes the absolute flow method which means it measures the absolute flow within the system keeping it nearly constant in order to determine ΔT. A basic absolute flow calorimeter system in general is typically comprised of a liquid cooled RF load with a closely coupled thermopile, circulating pump/heat exchanger, and signal conditioning circuits with a display. The 1314 block diagram is shown in Figure 2. To begin, RF energy is converted to heat energy inside a RF load containing a circulating coolant flow. The heat energy is dissipated in the coolant, carrying this heat away in the coolant. The fluid circuitry causes the coolant to come in contact with the heat sensing surfaces of a closely coupled thermopile located between the load coolant inlet and outlet and thereby senses the temperature rise across the coolant and produces a DC voltage. The resultant voltage is not proportional to the absolute temperature of the coolant but to the difference in temperatures of the coolant streams. The entire heated coolant stream is involved in the measurement, not just a fraction. Since temperature is read out as a difference (rather than an absolute quantity) within the thermopile, the only absolute measurement required is the rate of flow made by the flow meter- and this can be made reasonably accurately. More importantly, if the flow meter is highly repeatable, the minor absolute flow measurement errors can be calibrated out with extreme accuracy. A chiller then removes the heat picked up by the fluid and exhausts it to the ambient air. The cooled fluid is then recirculated back to the load in a closed loop. The DC voltage from the thermopile and the flow meter output pulses are fed into a signal conditioning board and then on to a display, calibrated in RF watts (also available on the remote computer interface for automated system configurations). Thermistors are utilized on both the input and output water pipes to sense the absolute temperatures of the water stream at their respective points and are then used to compensate for errors introduced in the specific heat and gravity characteristics of the system fluid as a function of temperature. To allow for some variability in the flow rate for the system, an adjustable flow valve is made available, and is inserted in series with a fluid line connecting the inlet stream directly to the outlet stream. This valve is normally set to produce a flow rate of .5 GPM for the system, as this is the recommended minimum flow rate required by the RF load to achieve the system specification of 250 watts.

Figure 3: Block Diagram

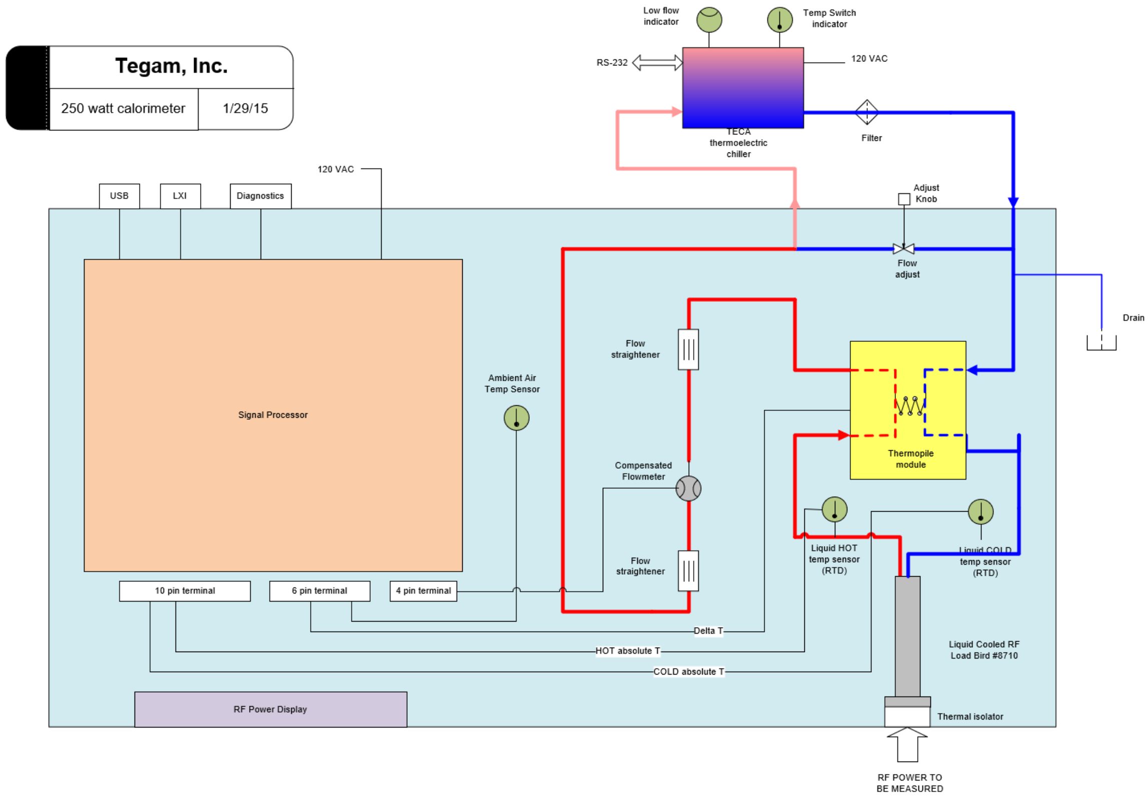
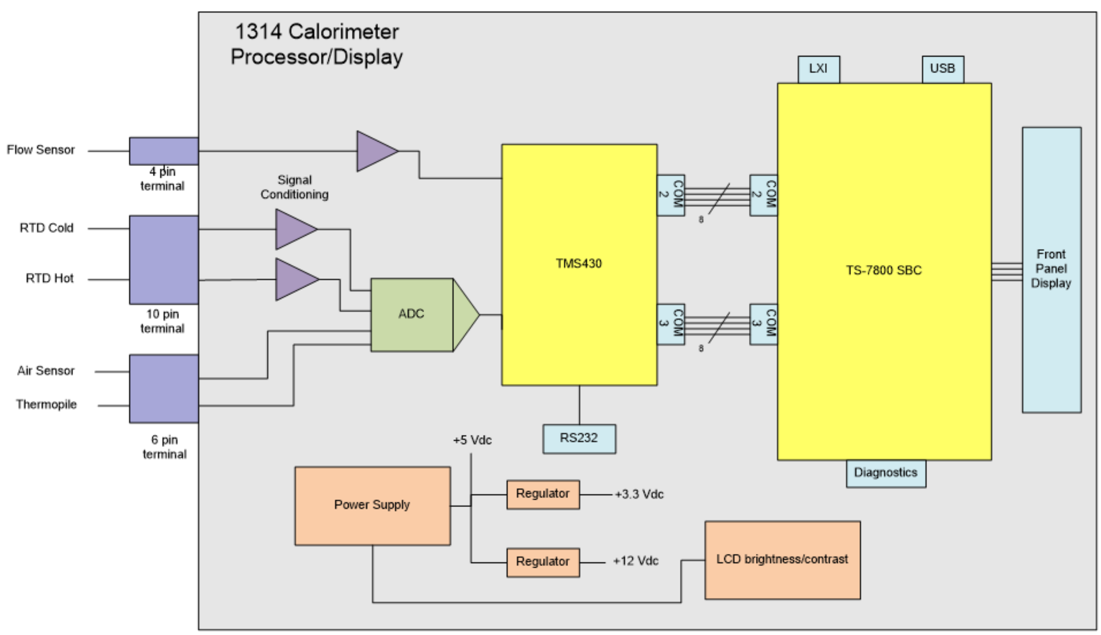


Figure 4: Signal Processing Block Diagram



3

Installation and Set-Up

Unpack the Shipment and Inspect the Contents

Each calorimeter is put through a series of electrical and mechanical inspections before shipment to the customer.

1. Upon receipt of your instrument unpack all the items from the shipping carton.
2. Inspect for damage that may have occurred during transit. Report any damaged items to the shipping agent. Retain and use the original packing material for reshipment if necessary.
3. Inspect the carton for the following items:

Table 1: Packing List

Item	Part Number
Model 1314 Precision Calorimeter	1314-300
Technical (Operation and Maintenance) Manual	1314-840(CD) or 1314-900(Printed)
Chiller	1314-389
Calibration Certificate with Data	n/a
Software	HPC-CAL
Calibration Cable	1314-252
Optional Accessories	Various

Control the Installation Environment

Normal calibration laboratory practice dictates the environment should be closely controlled. This minimizes errors introduced by temperature and humidity changes. A nominal temperature of +23ºC (+73.4ºF) provides a good working condition. A tolerance of ±1ºC gives an ideal temperature spread. Controlled temperatures also stabilize the aging process of the standards.

Check the Location Where the Unit Will Be Installed

1. Make sure the surface is level. An unbalanced system rack can produce faults and/or inaccuracies.

2. Select a spacious area with good airflow. Avoid placing the unit next to heat producing equipment or in locations subject to drafts or sudden changes in temperature. Free flowing air through the intake and outlet gratings on the rack are important. Notice the red and blue arrows depicting air flow in Figure 4 below.

Figure 5: Airflow

3. Lock caster wheels once location is determined.

Fill the Coolant Reservoir

> ⚠ **CAUTION:**
>
> Never operate cooling pump dry! Severe damage will occur.
>
> Never apply AC or RF power to the unit until proper coolant levels and sufficient air flow are established.

> ⚠ **CAUTION:**
>
> Use only pure distilled water in the coolant mix.
>
> Do not fill the unit with de-ionized water, flammable fluids, corrosive fluids, explosive, or any other hazardous fluids.

1. Disconnect the main power cord!

2. Remove the reservoir filler cap. It is located on the upper left side of the front panel of the chiller.

Figure 6: The Location of the Reservoir Filler Cap

3. Using a clean funnel, fill the chiller reservoir with a mixture of 25% DOW-Therm SR-1 and 75% pure distilled water. Avoid splashing coolant onto electrical components. The DOW-Therm provides a corrosion-prevention system that will extend the life of your calorimeter's load and plumbing. Additionally, factory test data was taken with this mix and any change will result in calibration that is not repeatable to the factory test. Do not exceed 25% coolant, as the specific heat of coolant is lower than water and temperature rise will be excessive. DO NOT USE AUTOMOTIVE COOLANT. Automotive coolant uses unknown and/or inadequate corrosion protection systems that may be incompatible with materials in your calorimeter

4. Add a drop of ordinary dishwater detergent or other biocide inhibitor to the distilled water to prevent organic growth within the calorimeter's cooling system.

   Adding a growth inhibitor is good practice whenever the unit is being filled from a dry state and when use is infrequent,

5. Replace the reservoir filler cap, and make sure that it is tight.

   The cap is unvented, so you can locate the unit either above or below the load.

Establish Communication with the 1314

1. Connect the 1314 ethernet port into a network hub on the same network as the computer.

   Note: The TEGAM Program Iguana Manager can be used to upload all updated system initialization files to the 1314 through these communication interfaces (cables) if the system is not intended to be setup for automated measurements.

2. Connect the power cable located at the bottom of the unit into an appropriate power source (see specifications section).

Figure 7: Front Panel

3. Turn on the 1314 by pressing the power button located in the lower left front panel area of the unit. It takes a minute or so for the unit to fully power up, so patience is needed.

   When the 1314 is ready for further commands, it will display a power measurement value and a frequency setting value. It will be necessary to find the Ethernet address assigned to the unit under the softkey "setup".

4. Once the Ethernet address is displayed, open the TEGAM Iguana Manager program located on the computer and type in the address under the "communication port" tab in the main menu.

   The program will confirm that communication has been established by displaying the identical information currently displayed on the front panel display of the 1314.

5. Once communication has been established, proceed to the parameter list shown in Appendix A and check the following parameters to display their real time data being streamed from the 1314:

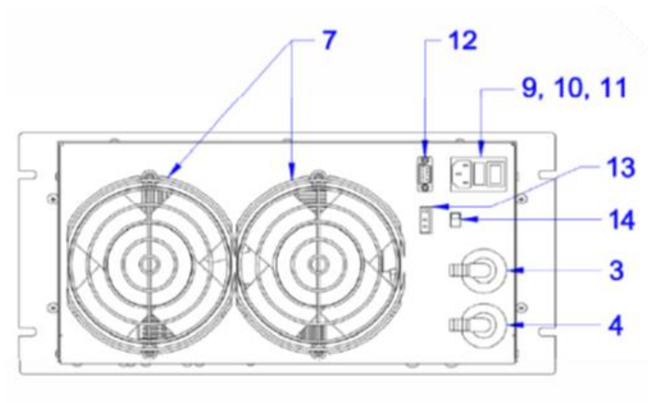
- **RTD_TEMP_PRE**
- **RTD_TEMP_POST**
- **THERMISTOR**
- **FLOWRATE (GPM)**
- **THERMOPILE**

The RTDs and ambient values should now display real time data of values close to the current laboratory environment (typically ~ 25C). The thermopile should display a value close to 0 (typically .0009 or so) as there is no temperature differential taking place yet with no fluid or flow present. The flowrate should display 0 as there is no fluid present and the pump has not been turned on yet. This flowrate value will guide you to establishing the proper flowrate once the pump has been turned on. The unit is now ready to prime the pump and the proper flowrate will be adjusted to a value of .5 to .55 GPM using the flow adjust knob on the rear of the 1314 unit as described in the next section.

Connect the Chiller and Prime the Coolant Pump

1. Connect the chiller serial cable to the PC USB port.
2. Ensure the supply outlet hose of the chiller is connected to a filter then the inlet of the 1314.
3. Make sure the outlet hose of the 1314 is connected to the return inlet of the chiller.
4. Locate the main power switch on the back side of the chiller, turn it ON.

Figure 8: Chiller Power Switch



3-Coolant Supply (OUT)
4-Coolant Return (IN)
7-Air Exhaust
9-On/Off Switch
10-Fuse (5 x 20 mm, slow blow)
11- AC Input
12-RS-232 port (Chiller Serial)
13-External RTD sensor connector
14-Internal/External RFD Switch

Figure 9: Back Panel Description

5. With the controller turned on, the fan will start to spin. The pump will energize, prime, and begin to move fluid.

   At first, the low light flow will flash on and off during the priming process. The system is capable of self-prime, establish flow and bleed excess air back into the reservoir without intervention.

6. When the pump is properly primed the orange light will be illuminated on the right side of the chiller display [PUMP SET].

Figure 10: Display indicating properly primed

7. Allow the pump to circulate liquid for at least 10 minutes in efforts to purge air from the system.

8. Look for trapped air bubbles.

   The gear pump inside the chiller flows so fast that air streams past the bleed block and can remain entrapped in the flow creating bubbles throughout the system. This is normal and can be mitigated by slowing the flow down using the flow valve adjust knob or by pinching either the inlet or outlet hose and observing the bubbles in the flow as they are encouraged to disappear using this technique. This isn’t as easy as it sounds so take your time. Otherwise, the system can be left to run for several hours and usually the bubbles will clear themselves out with time.

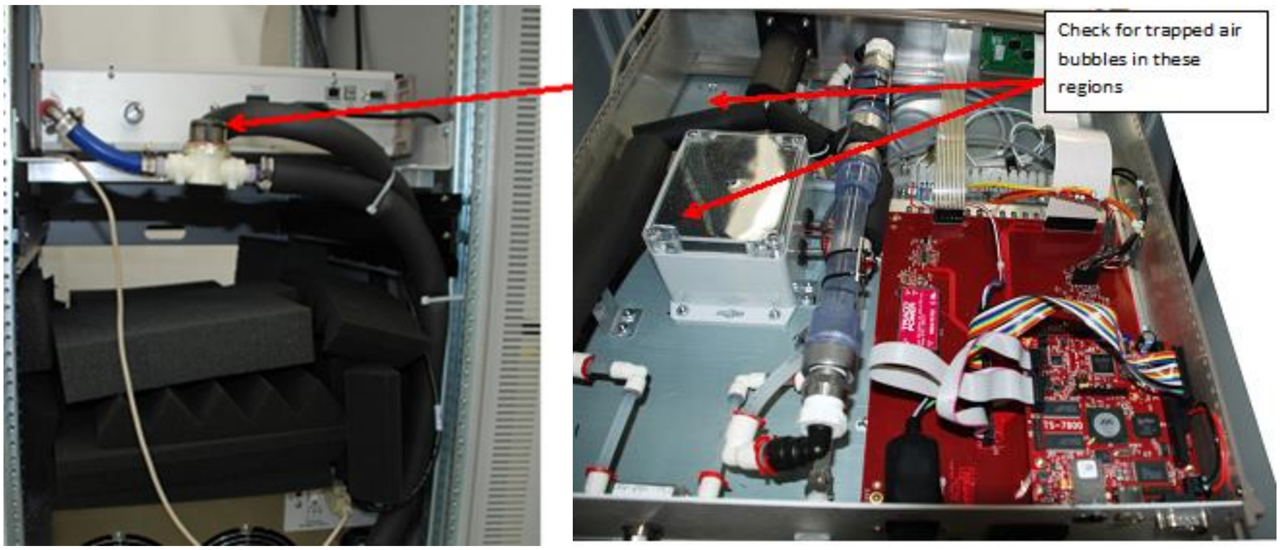


Figure 11: Look for trapped air bubbles

9. When the bubbles disappear the pump should be fully primed. The displayed flow valve from the Iguana Manager program should now display a value around .5 GPM. If not, adjust the flow adjust knob located in Figure 12 until 0.5 to 0.55 GPM is established.

Adjusting Coolant Flow

Figure 12: Flow adjustment knob

1. Use the adjusting knob to set flow rate.

The displayed flow rate will not change quickly due to the filtering taking place inside the 1314 but an increase or decrease can easily be detected when adjusting the knob. It typically takes about 30 minutes for the flow rate to reach a steady state value, so patience is needed here. Once the proper flow rate (> .5 GPM to ~.55 GPM) has been reached, little to no adjustment should be necessary in the future. Only add coolant to the reservoir to maintain the proper level. Replace reservoir cap and fill port cover. Observe the flow for some time after flow has been established, looking for any air bubbles in the clear PVC tubing and around the filter at the rear of the unit.

2. Check chiller display.

If there is insufficient (less than .05 GPM or .2 LPM) or no flow for 30 seconds all functions are disabled and only the low flow light and temperature display remain on. The priming sequence can be reinitiated by pressing the up and down arrow keys simultaneously. Repeat this step 3 to 5 times if needed. If the flow cannot be established proceed to next step.

Figure 13: Reinitiate Priming Sequence

3. If flow cannot be established on the entire system, this time replace the system tubing with a short loop and repeat step 2 to establish the flow. Then reintroduce the system tubing and load and repeat step 2. If there is still no flow, go to step 4..

4. Check the reservoir capacity and quick connects. If it works with a small loop but not in the system let's look there. Is there gunk in the lines somewhere? Is the filter clogged? Are all the lines properly connected? Is there a kink somewhere? Did it work for a while and then stop? Repeat step 3.

Adjusting the Set Point Temperature

After the correct flow rate of >0.5 GPM to ~0.55 GPM has been verified, the Set Point will need to be adjusted. To change the set point:

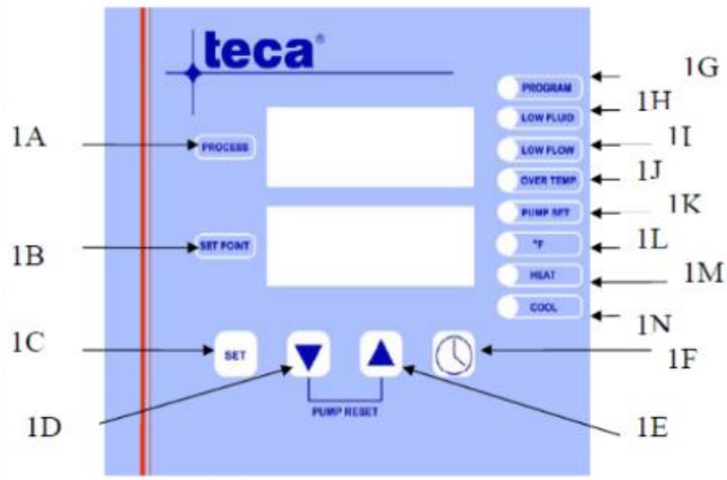
1. Press or push button for more than 1.5 s to begin modifying the set point.
2. Continue until the desired set point has been reached.
3. The new set point will be loaded automatically after a 2 second delay.
4. By pressing the clock symbol or SET it is possible to abort the modification.

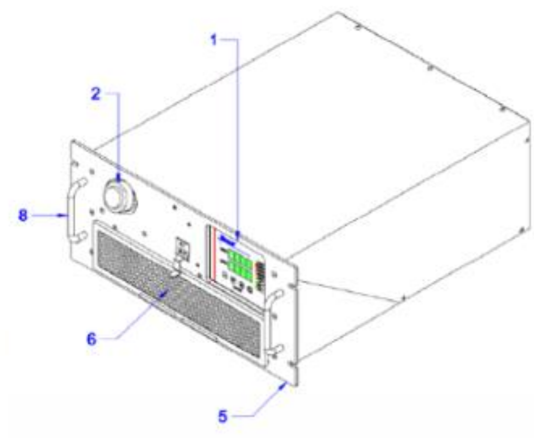
Figure 14: Change Set Point

Set the system set point to about 3 degrees or so less than the ambient temperature expected in the laboratory environment. In a typical case the set point is set to 20 degrees C when the normal lab ambient is 23 C. A more detailed explanation of the chiller front panel display is shown in Figure.15.

Figure 15: Front End Layout

Front Layout





1A	Process (or fluid) Temperature
1B	Set Point Temperature
1C	"Set" - Used in Programming
1D	"Down Arrow" - Adjust parameter (Temperature) down
1E	"Up Arrow" - Adjust parameter (Temperature) up
1F	"Clock Symbol" – Used for programming and initiating program
1G	This yellow light is ON when running a program
1H	This red light flashes when there is a low fluid level condition
1I	This red light flashes when there is a low flow condition
1J	This red light will be ON during an overheat condition and flash after recovery until manually reset.
1K	This light is ON when the pump is running. This light is OFF if the no flow condition has not been corrected or the system has not primed indicating a need to reset by pressing both arrow buttons.
1L	This light is ON when the controller is displaying degrees F.
1M	This light is ON when heating
1N	This light is ON when cooling.

Features and Settings

Over Temperature Safety

When an over temperature condition occurs the following will happen:

- The OVER TEMP light will be on.
- System heating and cooling will be disabled
- The pump reset function will be disabled
- If a program is running it will be placed in the "hold" mode

When the condition has cleared normal operation will resume. Heating and cooling will be enabled. It will be possible to reset the pump. The OVER TEMP light will flash until the over temperature condition has been acknowledged using the L.rS parameter in the Basic Mode.

Adaptive Fan Control

Adaptive Fan Control is a special feature designed to improve overall temperature control and user comfort while maintaining maximum performance when needed. The most evident characteristic is the reduced fan noise as the system approaches set point. The fan speed is directly related to the amount of cooling required. This feature has been factory preset. Changes, while not recommended, can be made within the "Set-Up Operator" mode described in detail found in the TC-4300 Operators Manual.

Chiller PID Settings

The PID temperature controller parameters (TC-4300) contained within the front panel display of the chiller can be individually set to optimize the time settling performance of the calorimeter. It has been previously determined through testing that the following parameters are optimal for achieving timely steady state readings from the calorimeter yet minimizing the amount of drift at a particular power level setting:

Table 2: Chiller PID Setting

Pb	it	d
6%	1.00	0.15

Although these values should remain in the chiller's memory indefinitely, should they become deleted or set to default values for any reason, please refer to the TC-4300 operator's manual to change them back to the above values.

4

Manual Operation

Once unit communications have been established, the correct flowrate set, air bubbles have been minimized, and the proper chiller set point have been set, the unit is ready to be calibrated with AC power.

⚠ **CAUTION:**

Never apply AC or RF power to the unit until proper coolant levels, coolant flow, and sufficient air flow are established. Even a short application of power to the load without coolant circulation WILL cause immediate damage to the load and can result in system failure.

If AC power supply loss to the unit could result in delayed input power cutoff (AC or RF), it is ADVISABLE to provide a dedicated power supply to the calorimeter to ensure a dependable and continuous flow.

⚠ **CAUTION:**

DO NOT APPLY MORE THAN THE MAXIMUM RATED AC OR RF TO THE LOAD.

USE ONLY DISTILLED WATER AS A SOURCE OF COOLANT

Always allow coolant to circulate at least 3 minutes after AC or RF input power is removed.

Warm Up

Permit the unit to operate at a minimum of approximately > 30 minutes prior to application of AC or RF power (this allows the gear pump to reach a steady state flow rate and to purge cooling system of any newly formed or remaining air bubbles). Once calorimeter/chiller reach equilibrium, calorimeter should soak at lab temp for ~ 2 hours before first calibration run to maintain the greatest precision possible. Manual dwell times at desired calibration power levels should be > 6 minutes (the temp control loop needs this minimum time to react and settle) and it is suggested to be 10 minutes. Otherwise in automatic mode, the time settling algorithm will control all the dwell times when calibration tests are run under the control of the software program.

Calibration

Calibration procedures are based on AC substitution. A source of AC power is applied to the load to simulate the heating effect of the unknown RF power and is measured using readily available AC power sources and measuring equipment. The accuracy of the AC power meter, known to be extremely accurate (on the order of approximately 0.1% or better) can then be transferred to the RF measurement since a well-designed RF load will respond nearly identically to either AC or RF power up to a specified high frequency limit.

Many calorimeters in use today express accuracy as a percentage of full scale, less load error. Only the power that is absorbed by the load is measured and displayed. All other power (reflected, etc.) is considered part of the load error and is not measured. This may be convenient for the manufacturer, but to achieve a more precise measurement, this load error can be characterized by determining the reflection coefficient of the RF load as a function of frequency and compensating for it at the frequency of interest. The 1314 unit automatically compensates for this error term by storing the RF load reflection data in memory and then applying it as a frequency correction term to obtain the final calibrated RF answer in watts.

Correction of Error Terms

All of the error term parameters collected and analyzed by the 1314 are incorporated into four separate initialization files comprised of one file representing the actual reflection coefficient of the load, one characterization file that defines constants and dynamic correction terms specific to the design/construction of the calorimeter, one file representing the efficiency of the RF load to convert the electrical energy into thermal energy as a function of power and frequency, and one file of calibration constants defining the slope and intercept points of a piecewise linear approximation to a calibrated AC reference power source. These files are shown geographically in Figure 16 and are uploaded to the 1314 prior to making calibrated RF measurements.

Defining the parameters of the error terms contained within these files allows the system firmware to be flexible and adapt easily to situations where the load or fluid components may need to be changed in the future. When the calorimeter makes its final calculation of either calibrated AC or RF power, applicable error parameters are called and used to refine the final displayed power.

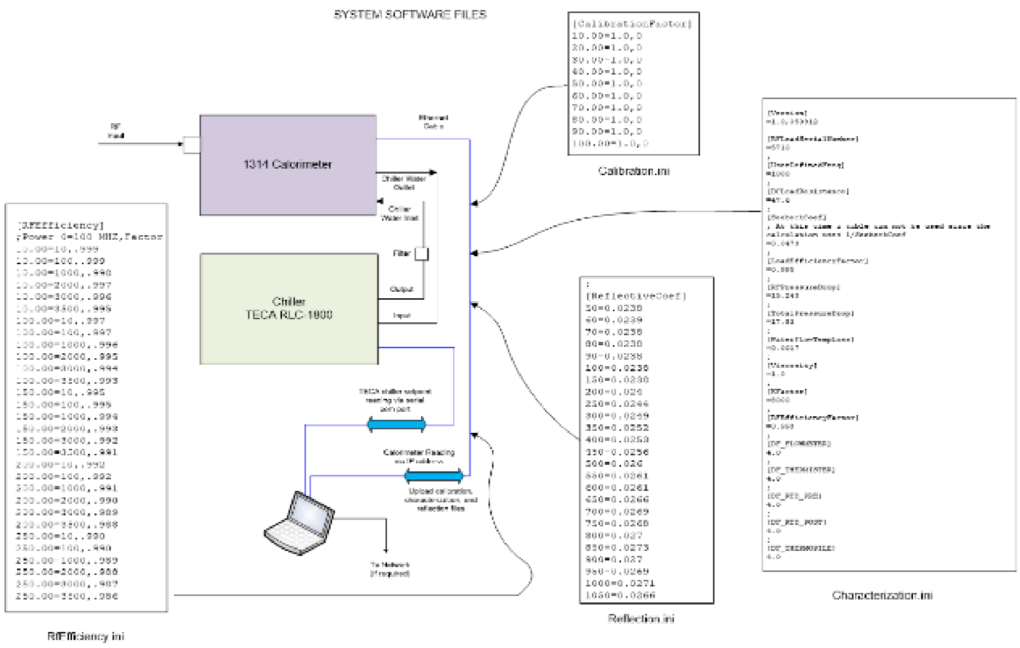


Figure 16: Software System Files

Manual AC Calibration Procedure

To calibrate a RF device using the 250 watt calorimeter, the calorimeter must first be calibrated against an AC power meter standard traceable to a governing authority i.e. NIST, etc. Configure the equipment setup as shown in Figure 17. Set the 1314 to read AC power by pressing the AC/RF soft key on the front panel display to AC.

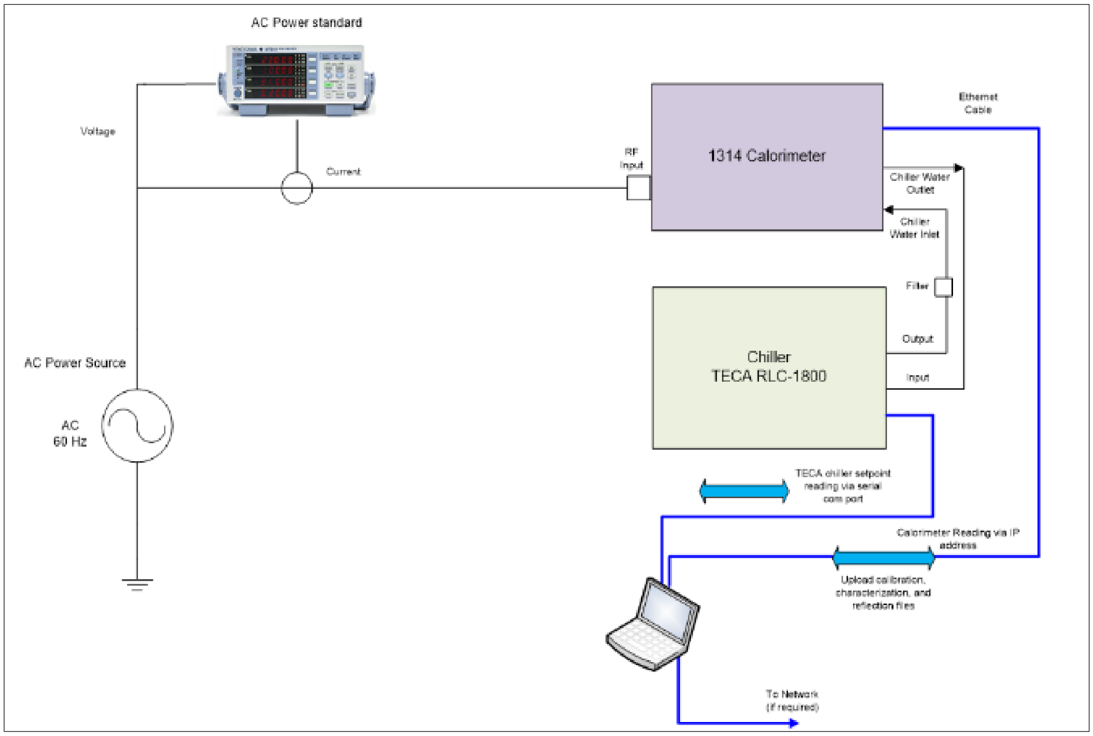


Figure 17: Manual AC Calibration Configuration

After confirming fluid is flowing properly in the calorimeter and the correct chiller set point has been entered, slowly apply AC power monitoring the total output power as read by the externally supplied AC power meter standard. When the desired calibration power level has been reached, continue to keep the power constant and allow the calorimeter to settle for >~ 6 minutes and then read the AC value in the front panel display. Repeat this process for as many power level points as desired for testing. When finished, shut off the AC source power to the input of the calorimeter and allow the coolant fluid to continue flowing through the load for a minimum of >3 minutes before shutting down the chiller supplying the coolant flow. At this point, you will have a table consisting of AC power applied versus AC power as read by the calorimeter. These points can then be manually input into the excel spreadsheet titled “1314 annual Calibration best fit algorithm” to generate the slopes (m’s) and intercepts (b’s) of the resulting piecewise linear approximation to the relationship between these two variables. Once these sets of m’s and b’s are collected for each power level, they can be transferred to the file titled “calibration.ini”. This file is then uploaded using the Iguana Manager to the 1314 and stored in its local memory. The calorimeter is now fully calibrated to proceed forward with RF input measurements.

Manual RF Calibration Procedure

Configure the equipment as shown in Figure 4.16. Set the 1314 to read RF power by pressing the AC/RF soft key on the front panel display to RF. After confirming fluid is flowing properly in the calorimeter and the correct chiller set point has been entered, slowly apply RF power monitoring the total output power as read by the externally supplied RF power meter standard serving as the DUT. When the desired calibration power level has been reached, continue to keep the power constant and allow the calorimeter to settle for >~6 minutes and then read the RF value in the front panel display. Repeat this process for as many power level points as desired for testing. The power levels desired do not need to necessarily match the calibrated AC power levels as the internal software to the 1314 will use the piecewise linear approximations derived from the calibration.ini file to interpolate between points if needed. When finished, shut off the RF source power to the input of the calorimeter and allow the coolant fluid to continue flowing through the load for a minimum of >3 minutes before shutting down the chiller supplying the coolant flow. The resulting power value differences obtained between the DUT and the calorimeter can now be used to adjust or correct the DUT readings resulting in a calibrated DUT device.

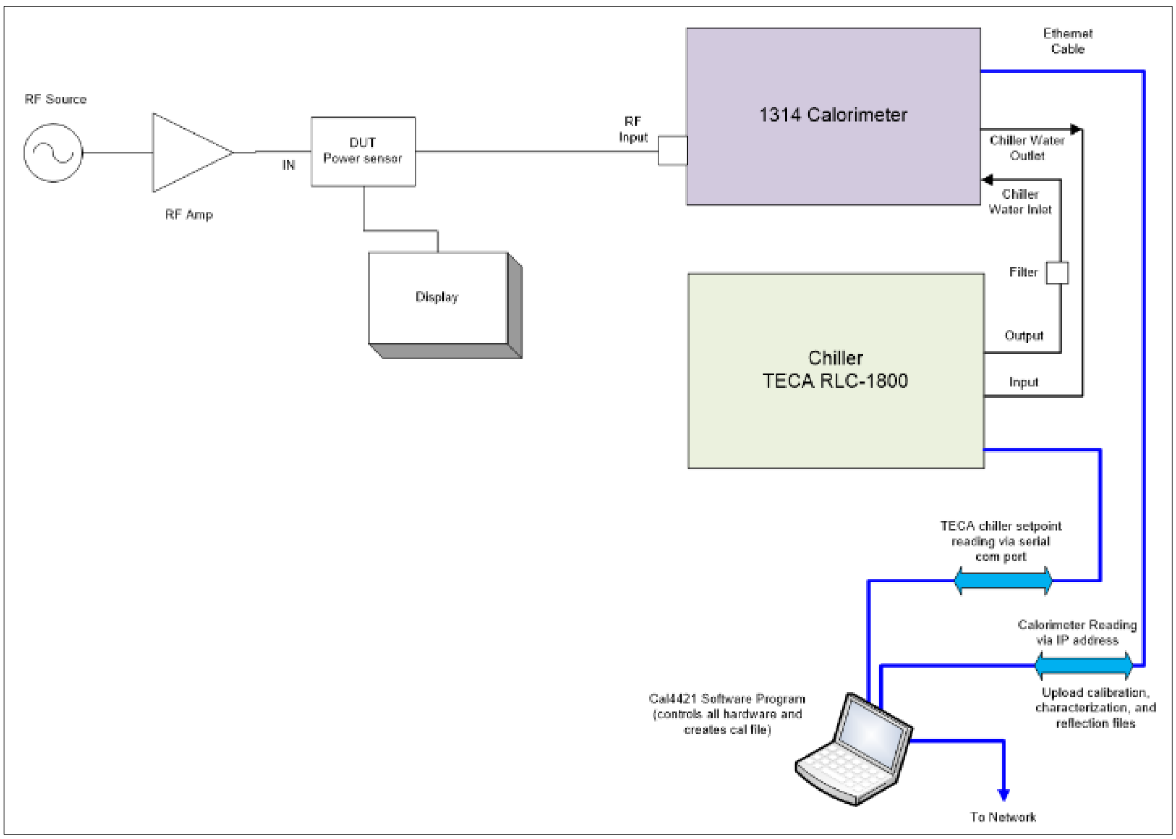


Figure 18: Manual RF Calibration Set-up

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Maintenance

Periodic Inspection and Servicing

> WARNING–This unit must be disconnected from all AC or RF power before any repairs are attempted. Any attempt to repair without disconnecting ac or RF power could be fatal.

The coolant reservoir should be checked each time the unit is used, add coolant when low. The life expectancy for the gear pump used inside the chiller is approximately 20,000 hours.

The following should be performed at intervals of one to six months depending upon usage:

- Remove cover to access internal components.
- Remove accumulations of dust, dirt, and other obstructions to air flow on the rack system.
- Inspect hardware and tighten as required.
- Check all coolant lines are clear of obstructions.
- Clean or replace strainer element (50 micron filtration needed) located between the chiller outlet and unit inlet barb.

  NOTE - If the pump has excessive noise or cavitation is taking place the strainer element should be checked.

- Clean air inlet, air outlet/fan filters on the chiller using a vacuum.

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Troubleshooting Guide

Unresponsive to power

If the unit fails to respond to either AC or RF power, check to see if the RF load is still functional.

1. Use an ohmmeter to check the DC resistance from the center pin to the outer shell on the N connector.

   The reading should be between 50 +/- 5 ohms and should not have deviated from the original value significantly (+/-.5 ohms) at the time of delivery.

If it becomes necessary to replace the load for any reason, the following can be performed by a qualified service provider, however, it is best to return the calorimeter to AE-TEGAM for repair:

1. Measure the DC resistance of the new load and enter the value into the characterization.ini file under “DCLoadresistance.”

   The DC load resistance value is also used as a reference value to determine the transmission coefficient for RF calibration.

   The DC load resistance values is used by the control feedback algorithm within the CalProg program to set the requested power on the 6811B (or other AC power source) under automated conditions (not under manual operation).

2. Next, upload the new file to the system program to ensure proper operation.

3. Measure any reflection coefficients desired specific to your application as a function of frequency of the new load using a vector network analyzer with the system coolant running inside the load.

4. Enter the list of frequencies versus reflection coefficients obtained into the reflection.ini file.

5. Then, upload the new file to the system program to ensure proper operation. Again, these values are used in determining the reflection coefficient for RF calibration.

It is good practice to measure the DC resistance of the load annually and chart the results to identify any significant trends taking place. A load will naturally increase very slightly in resistance as the carbon film becomes oxidized with age but any significant jumps in value (> +/- .5 ohms annually) is an indication of a potential pending failure.

Table 3: General Troubleshooting Guide

Symptom	Corrective Action
No power displayed	Check load DC resistance for possible failure
Power won’t settle or excessively long settling time	Check RF amp for possible power drifting Make sure chiller set point and PID parameters are correct
Flow rate much less than nominal	Check for blockage in fluid filter
AC calibrated power equals input power	Check calibration.ini file for proper values
RF calibrated power equals AC calibrated power	Check reflection.ini file for proper values
Extreme ambient temperature readings	Check for fan failure or inlet air blockage
No communication with 1314 Calorimeter	Check for proper IP address

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Appendix A

PARAMETER NOMINAL VALUES AND LIMITS

Field Values	Low Limit Value Reading	High Limit Value Reading	Units	Expected Values (250 watts @ 25°C ambient)
THERMISTOR	22	28	°C	26.45°
RTD_TEMP_PRE	20	24	°C	22.75°
RTD_TEMP_POST	20	26	°C	24.45
THERMOPILE	0	0.072	volts	0.066
WATERFLOW_TEMP_LOSS	0	0.002	°C	n/a
SPECIFIC_HEAT	4.18	4.1816	J/g-C	4.18017
GRAVITY	0.9972	0.9982	g/cm3	0.9976
VISCOSITY	0.5	100	mPa-sec	1
FLOWMETER	260	285	pulses/sec	268 to 272
K_FACTOR	8000	8000	pulses/liter	8000
FLOWRATE	0.5	.058	GPM	.51 to .55
FLOW_VOLUME	31.861	34.386	cm3/sec	33.14
MASS_FLOWRATE	31.784	34.302	gm_sec	33.06
SEEBECK_CONSTANT	0.04	0.06	volts/C	0.04
DELTA_T	0	1.8	°C	1.65
LOAD_EFFICIENCY_FACTOR	0	1	--	0.995
FRICTIONAL_WATTS	0	6	watts	4.9
RF_PRESSURE_DROP	15	25	psi	21.094
TOTAL_PRESSURE_DROP	20	30	psi	26.041
INPUT_POWER	-5	250	watts	220 to 260
RF_LOAD_DC_RESISTANCE	45	55	ohms	49.3
SERIAL_NUMBER_OF_RF_LOAD	0	100000	--	0
REFLECTION_COEFFICIENT	0	1	--	0.022
TRANSMISSION_LOSS_FACTOR	0	1	--	0.9992
CAL_FACTOR	-5	250	watts	250
RF_TRANS_LOSS_FACTOR	0	1	--	0.9992
RF_EFFICIENCY_FACTOR	0	1	--	0.9995
USER_DEF_FREQ	0	3500	MHx	0 to 3500
RFCALPOW	-5	250	watts	249.8
POWER_ADJ	-4	4	watts	n/a
T_PIVOT	23	27	°C	25
T_POWER	0.4	0.5	watts/°C	n/a
n/a = not applicable for model #1314				

Appendix B – Service Assistance

Returns for Repairs

Once you have verified that the cause for the Coaxial RF Power Standards malfunction cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA, (Returned Material Authorization), number. You can contact TEGAM customer service via the TEGAM website, www.tegam.com or by calling 440.466.6100 (All Locations) OR 800.666.1010 (United States Only).

The RMA number is unique to your instrument and will help us identify you instrument and to address the service request by you which is assigned to that RMA number.

Of even importance, a detailed written description of the problem should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or of a detailed description of the problem.

This description should include information such as measurement range, and other instrument settings, type of components being tested, are the symptoms intermittent, conditions that may cause the symptoms, has anything changed since the last time the instrument was used, etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use a copy of the Repair and Calibration Service form provided on the next page.

Once this information is prepared and sent with the instrument to our service department, we will do our part in making sure that you receive the best possible customer service and turnaround time possible.

Warranty

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of one year from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of 1 year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

To exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by TEGAM Inc. The calibration of this instrument is traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or other recognized National Metrology Institutes, by comparison to equipment and standards maintained in the laboratories of TEGAM Inc.

Document publishing dates may lag product changes.
Visit www.tegam.com to download the latest version of this manual.

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FX: 440.466.6110
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WEB: *http://www.tegam.com*

Storage and Shipment

CAUTION:

Do not store calorimeter or load where ambient temperatures fall below freezing.

Drain the calorimeter system of all coolant

1. Disconnect the inlet and outlet hoses from the chiller and 1314.

   The hoses may be removed without spilling any fluid from either the 1314 or chiller as all the hose connection ports have valves and prevent fluid from flowing when disconnected. Drain the individual hoses completely by removing the connectors on their respective ends.

2. Place a quick connect connector with an open hose end onto the return inlet of the chiller.

3. Put the end of the open hose into a vessel to collect the fluid and loosen the reservoir cap.

4. Tilt the unit about 30 degrees to drain as much fluid as possible.

   To completely empty the system put another connector and clean hose into the supply inlet on the chiller. Apply low pressure air (less than 10 psi) for a minimum of 5 minutes or until coolant is no longer expelled from the unit.

Repeat this procedure using the outlet hose port, and the input fluid port.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The completion of this form and including it with your instrument will expedite the processing and repair process.

RMA #:	Instrument Model #:
Serial Number:	Company:
Technical Contact:	Phone Number:
Additional Info:	

REPAIR INSTRUCTIONS:

☐ Evaluation ☐ Repair & Calibration
☐ Calibration Only ☐ Repair only
☐ Provide Data (May incur extra charge)

Detailed Symptoms:

Include information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent? Has anything changed with the application since the last time the instrument was used?, etc.