ThermoBlade™

Low-Profile
Wireless 8-Channel
Thermocouple Monitor
for
Extreme Temperature
Environments

Revision A (02/2009)

Warranty

General Terms

Magna Systems, L.L.C. warrants this product to be free from defects in material and workmanship for a period of one year from the date of shipment. If this product is found to be defective during the warranty period, the product will either be repaired or replaced at Magna Systems' sole option.

To Use This Warranty

To exercise this warranty, write or telephone your local Magna Systems representative or contact Magna Systems headquarters in California. Detailed contact information may be found on the Magna Systems web site, www.magnasystems.net . You will receive prompt assistance and return instructions. Send the product, shipping prepaid, to the indicated service facility. The repaired or replacement product will be returned to you with shipping prepaid. The repaired or replaced product will be warranted for the remainder of the original warranty term or ninety days whichever is longer.

Limitation of Warranty

This warranty does not apply to defects or malfunctions resulting from modification or misuse of any product or part. This warranty does not apply to fuses or other circuit protection components, to batteries, damage from battery leakage or damage resulting from improper battery installation.

Entire Warranty

This warranty is the complete warranty and stands in lieu of any or all other warranties, expressed or implied, including any implied warranty of merchantability or suitability for a particular use. Magna Systems, L.L.C. shall not be liable for any indirect, special or consequential damages.

Symbols Used in This Manual

CAUTION Indicates potential for equipment damage or injury. Refer to procedures or instructions.

CAUTION Indicates potential risk of electrical shock. Take suitable precautions.

Regulatory Statements

Industry Canada Notice to Users

Operation is subject to the following two conditions: (1) This device may not cause interference and (2) This device must accept any interference, including interference that may cause undesired operation of the device. See RSS-GEN 7.1.5

FCC Notice to Users

Magna Systems has not approved any changes or modifications to the ThermoBlade™ made by the user. Antenna modification, antenna replacement or use of an antenna not approved by Magna Systems is not authorized. Any changes or modifications could void the user's authority to operate this equipment.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio / TV technician for help.

Battery Disposal

Please do not throw batteries in the trash. Used batteries must be disposed of in accordance with local regulation. For information about how to recycle batteries in your area, visit the Rechargeable Battery Recycling Corporation (RBRC©) at www.rbrc.org.

Important Safety Information

Electrical Shock Hazard

There are no hazardous voltages present in the ThermoBlade, however the American National Standards Institute (ANSI) states that a shock hazard exists when probes or sensors are exposed to voltages greater than 42 VDC or 42 V peak AC. In some applications thermocouples may be attached to objects or surfaces between which voltages in excess of the ANSI shock hazard standard exist. Despite the electrical isolation designed into the thermocouple assemblies, conditions may exist such that hazardous voltages could be conducted by attached thermocouples and present within the ThermoBlade. In such cases, users must handle the ThermoBlade in a manner consistent with the presence of hazardous voltages.

Exposure to Radio Frequency (RF) Energy

The ThermoBlade contains a radio transmitter and receiver. Whenever powered, the ThermoBlade will receive and emit radio frequency energy. The ThermoBlade is designed to comply with local regulatory requirements including those concerned with the exposure of human beings to RF energy.

Use of Rechargeable Batteries

Under conditions of heavy use it may be advantageous to use rechargeable batteries to power the ThermoBlade. Most rechargeable batteries, due to the chemical recombination process within the batteries, will vent non-corrosive gases to the ambient atmosphere. Ensure that the ThermoBlade is used with adequate ventilation when rechargeable batteries are used.

Explosive Environments

DO NOT USE THE ThermoBlade IN EXPLOSIVE ENVIRONMENTS.

Areas with potentially explosive atmospheres are often, but not always, posted. Such areas may include, but are not limited to, fueling areas, enclosed areas where fumes may accumulate (such as below decks on boats or areas near poorly ventilated gas powered appliances), chemical transfer or storage areas, laboratories, and areas when there are airborne particulates such as grain, dust, aerosolized paints or fine metal powders. DO NOT USE THE ThermoBlade IN SUCH AREAS. The installation or removal of batteries may cause sparks which could cause an explosion or fire.

Not Vacuum Compatible

The ThermoBlade is not vacuum compatible. Do not use the ThermoBlade in vacuum as this could damage the ThermoBlade and / or contaminate your vacuum chamber and associated hardware.

Table of Contents

Care of Your New ThermoBlade

DO NOT EXPOSE YOUR ThermoBlade TO ANY OF THE FOLLOWING-

Liquids
Don't immerse your ThermoBlade in water or expose it to cleaning solvents, fuels, or other liquids.

CAUTION

Extreme Heat or Cold
Avoid temperatures outside of the operating range of -200ºC to 427ºC (-328ºF to 800ºF).

ALWAYS BE SURE TO OPERATE WITHIN THE TIME vs TEMPERATURE LIMITS GIVEN IN TABLE 1 ON PAGE 8. PROLONGED EXPOSURE TO EXTREME TEMPERATURES WILL DAMAGE THE ThermoBlade.

Microwaves or Intense RF Energy
Do not place your ThermoBlade in a microwave oven or expose it to direct radio frequency (RF) energy such as from a RF power transmitter.

Extreme Dust or Dirt
Don't expose your ThermoBlade to extreme dust, dirt, sand, or environments containing metal particles.

Shock
Do not expose your ThermoBlade to mechanical shock in excess of a three (3) foot drop or vibration in excess of 10 g's.

Cleaning
Dirt and dust can be removed from the outside of the ThermoBlade by wiping with a damp cloth. In addition, the ThermoBlade may be cleaned with hot water or steam spray, but AVOID SPRAYING DIRECTLY INTO THE THERMOCOUPLE SLOT. Do not clean the ThermoBlade with abrasive pads or cleansers as this may remove or blur the markings on ThermoBlade surfaces. Do not use solvents to clean the ThermoBlade.

Calibration
Your ThermoBlade comes factory calibrated and does not require any initial calibration before use. The ThermoBlade has an automatic re-calibration alert which will be displayed through the DataLink software when re-calibration is required. Should the re-calibration message appear, please follow the instructions displayed.

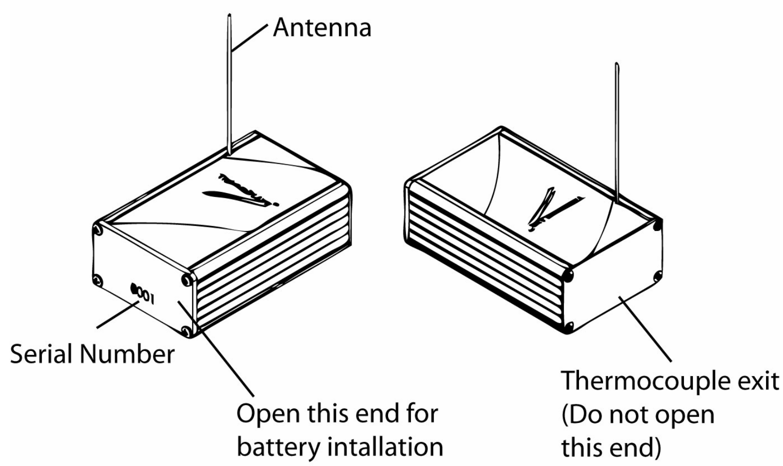
Maintenance & Service

The only user maintenance operation is battery installation or replacement which is described in the Getting Started section of this manual. The ThermoBlade should always be used with its cover installed. The ThermoBlade has no user serviceable parts and does not require any adjustment by the user.

Getting Started

The figure below shows two different views of your new ThermoBlade. Your ThermoBlade has been designed to provide accurate thermocouple based temperature measurements while requiring almost no user intervention.

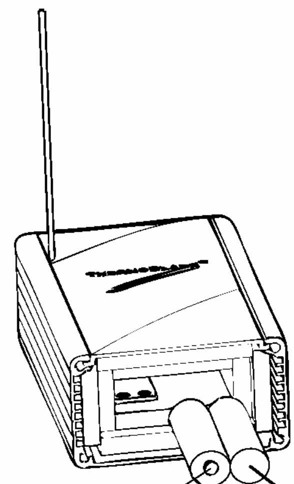
Users typically perform two types of operations while using the ThermoBlade, namely, battery installation or replacement and installation of a TC-Bridge, each described below.



Turning the ThermoBlade ON
The ThermoBlade is powered by two (2) AA type batteries which are installed in the battery pocket. THERE IS NO ON / OFF SWITCH. To turn the ThermoBlade ON, simply install the batteries as shown in the diagram using the procedure below.

CAUTION

Installing batteries in the wrong direction will damage the ThermoBlade. Please double check the orientation of the batteries during the installation process.



Battery Installation Procedure-

1. Remove the four screws that secure the end plate to the main ThermoBlade body.
2. Separate the end plate from the ThermoBlade so that the battery area is clearly visible.
3. Inspect the battery pocket area and note the battery orientations indicated.

NOTE: BATTERIES ARE INSTALLED IN OPPOSITE ORIENTATIONS

4. Slide both batteries into the pocket in the correct orientation. Do not puncture the insulation material protection.
5. Replace the end plate and making sure the battery contact aligns with two batteries. Carefully position any excess wire above the PCB assembly.
6. Push the base plate in place such that the screw holes and mounting holes properly align and the insulation fits into the recess in the mating ThermoBlade insulation and seals the unit.
7. Once oriented, hold the base plate in position and re-secure it to the ThermoBlade using the four (4) screws that were previously removed.

Once the batteries are installed, the ThermoBlade is ready to take measurements using the GateWay Network Access Point and your DataLink software.

Using the TC-Bridge

To measure the temperature distribution across a conveyorized oven, the ThermoBlade may be used with a TC-Bridge installed. The TC-Bridge has been designed for easy installation before beginning a measurement and rapid removal once a measurement has been completed.

TC-Bridge Installation Procedure-

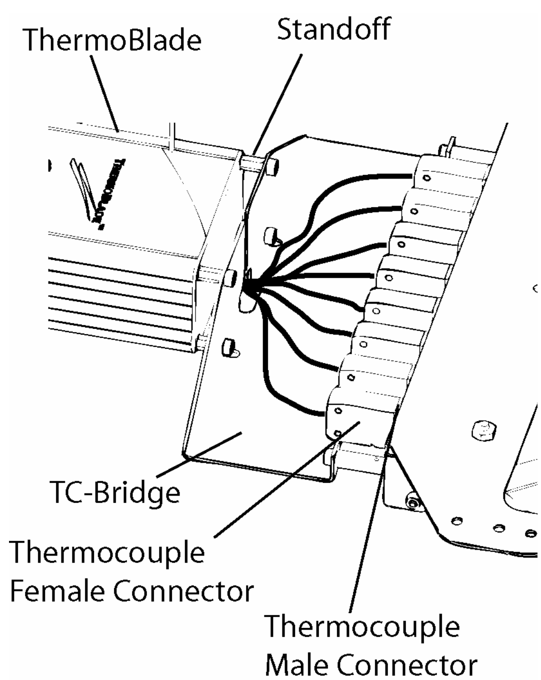
1. Replace four pan-head screws on the end plate of ThermoBlade with four standoffs, each of which is 0.375 inch long.

2. Position thermocouple wires through the TC-Bridge slot.

3. Align the mount holes of TC-Bridge with the four standoffs on ThermoBlade.

4. Install the four socket-head screws to connect TC-Bridge with ThermoBlade.

5. Connect eight thermocouple female connectors on ThermoBlade with the eight thermocouple male connectors on TC-Bridge.



CAUTION- POSSIBLE BURN HAZARD

After exposure to elevated temperatures the TC-Bridge and ThermoBlade will be **HOT**! To avoid burns, be sure to wear protective clothing before touching a hot TC-Bridge and or ThermoBlade.

Care of Thermocouples

CAUTION !

DESPITE THE ELECTRICAL ISOLATION PROVIDED BY DESIGN, IF THE THERMOCOUPLES ARE ATTACHED TO OBJECTS WHICH HAVE HIGH VOLTAGES PRESENT THE ThermoBlade™ MAY PRESENT A SHOCK HAZARD. HANDLE THE ThermoBlade™ IN A MANNER CONSISTENT WITH THE PRESENCE OF A SHOCK HAZARD.

To measure temperature, each ThermoBlade uses a set of permanently attached thermocouples or a ThermoAdapter / thermocouple assembly. Thermocouples are devices comprised of two wires made from different metals which have been joined at one end. Because of the dissimilar metals, thermocouples generate a small temperature dependent voltage.

Typically 30 AWG T-type (Cu-Constantan) thermocouples which have a temperature measurement range from -270ºC to 400ºC (-454ºF to 752ºF) are used, however for higher temperature measurements K-type (Nichrome / Alumel) thermocouples with a temperature measurement range from -270ºC to 1372ºC (-454ºF to 2502ºF) may be used. The use of 30 AWG diameter wire tends to provide a good compromise between ease of handling and thermal performance. Due to its single, solid wire construction thermocouple wire tends to be stiff and thicker gauge wire becomes difficult to handle while thinner wire tends to break easily. The 30 AWG wire should be handled with some care; mechanical stresses, such as pulling on the wire, should be avoided if possible.

Unless otherwise specified, the thermocouples that come with your ThermoBlade are Teflon® insulated and will withstand temperatures up to 370ºC. Teflon® is a thermoplastic and will melt above ~ 370ºC. Thermocouple wires can be easily cleaned by wiping with a wet cloth or paper towel. Since Teflon® is chemically inert, solvents may be used to clean only the thermocouples in cases where contaminating materials persist.

TIP: *If your ThermoBlade has a ThermoAdapter / thermocouple assembly you can make network initialization easier if you install the thermocouples before starting to test. During network initialization, DataLink checks for open thermocouples so having the thermocouples connected to the ThermoBlade speeds the initialization step.*

Once the ThermoBlade is powered, mounted, and thermocouples have been connected the ThermoBlade is ready to record temperature data.

Turning the ThermoBlade OFF / Replacing the Batteries
During routine use it should not be necessary to turn the ThermoBlade OFF and so THERE IS NO ON / OFF SWITCH. However, if it is anticipated that the ThermoBlade will not be used for an extended period, it may be desirable to remove the batteries from the ThermoBlade. To remove or replace the batteries, please use the same steps found in the battery installation procedure.

Into The Oven (or Freezer) We Go!

Now that the batteries have been installed and DataLink is recording data, the ThermoBlade is ready for the oven (or freezer). The key question at this point is- ***how long can the ThermoBlade stay in the oven or freezer?***

The ThermoBlade has been designed to have the broadest operating temperature range possible; however, batteries limit the internal operating temperature to a maximum of ~ 80ºC. The batteries will fail if used above this temperature limit.

In Table 1 we give the high temperature exposure duration (time limit). The second column presents the maximum exposure time for a ThermoBlade. It is assumed that the ThermoBlade is initially at room temperature (22ºC or ~ 72ºF).

Table 1: High temperature exposure time limit versus environmental temperature

Temperature ºF (ºC)	Maximum exposure time
375 ºF (191 ºC)	25 minutes
425 ºF (218 ºC)	20 minutes
475 ºF (246 ºC)	15 minutes

Making Accurate Temperature Measurements

It seems that making accurate temperature measurements should be simple, but experience tells a different story. Accurate temperature measurements are made by understanding the factors that can effect the measurement and controlling or eliminating them.

One of the most important factors in making accurate temperature measurements is good thermal contact. To make an accurate measurement, the thermocouple needs to be in intimate thermal contact with the measurement point. In achieving intimate thermal contact air is your enemy. Air is an excellent thermal insulator and even a small air gap between the measurement point and the thermocouple can produce a significant error. Air can be excluded from the region between the thermocouple and the measurement point by using a thermally conductive adhesive or by using appropriately designed attachments.

It is also important to consider the effect that the measurement set up has on the accuracy of the measurement. For example, the addition of thermal mass to the measurement point will slow its thermal response, while the addition of thermally insulating material which impedes normal convective or radiative heat transfer will lead to inaccuracies too. In other cases, when measuring at low temperatures, even the thermal conductivity of the thermocouple itself can lead to an inaccurate measurement by introducing a heat source into the low temperature system.

In other measurement configurations, chemical corrosion and time may conspire to thwart a previously accurate measurement. At elevated temperatures chemical reactions proceed more quickly and since thermocouples depend on the properties of the dissimilar metals comprising the thermocouple, the corrosion of one or more thermocouple wires can give rise to inaccurate measurements.

So by understanding and controlling these and any other factors that affect your measurement you can make simple, robust and accurate temperature measurements. By allowing the selection of thermocouple material, insulation type, wire gauge and termination style you can readily optimize your measurement and avoid problems.

We hope that Magna Systems has furnished the tools you need to achieve your measurement goals and that our products provide value through simplicity, ease of use and accuracy.

Setting Up For Accurate Measurements
The ThermoBlade is designed to easily make accurate and repeatable temperature measurements utilizing up to eight (8) thermocouples manufactured

and tested by Magna Systems. Magna Systems manufactures thermocouples with three different termination types:

- Standard termination- designed for use in immersion applications
- Bare termination- used for surface temperature measurements
- Ring-Lug termination- designed for attachment using threaded fasteners

The design of these termination types has taken into account several factors that affect measurement accuracy. Among these factors are electrical isolation of the thermocouple itself, addition of minimal thermal mass, ensuring good thermal contact with the measurement point, maintaining good thermal conductivity between the measurement point and the thermocouple, and minimizing the insulating effect of thermocouple attachment.

The Standard termination will provide optimal results for immersion measurements. Immersion measurements are those in which the probe is immersed in the measurement environment. Typical examples of immersion measurements are:

- Measuring the temperature of the air flowing past a cooling fan
- Measuring the air temperature above a heatsink
- Measuring the temperature of a container of water by immersing the probe
- Measuring the temperature of a metal block by embedding a thermocouple probe in a hole in the block

The Standard termination is simply a thermocouple junction that has been encapsulated in a thin layer of Teflon® to provide electrical isolation, mechanical toughness, and make the thermocouple more chemically inert.

The Bare termination is the traditional bare wire thermocouple end. Bare termination is useful when thermocouples are soldered in place or when measuring the temperature of a surface.

CAUTION

Bare termination users should be aware that, because the ThermoBlade uses all solid state electronics, either all measurement points must be at the same electrical potential (voltage) or some sort of electrical insulation must be used to provide isolation between the channels.

To illustrate the use of the Bare termination, consider two typical applications, measurement of temperature on a sample printed circuit board (PCB) and temperature measurement on an electrically “live” heatsink where Kapton® tape is used to provide electrical isolation.

In the first case we are interested in measuring the temperature profile of a PCB sample during heating. To measure the temperature at various points on the bare board, we decide to use a high temperature solder to attach Bare thermocouple tips to the board. In this case, the board does not have any active components attached and all the ThermoProbe points are near ground potential. In this case, the high temperature solder provides good thermal conductivity and fills any voids, thus eliminating any air pockets.

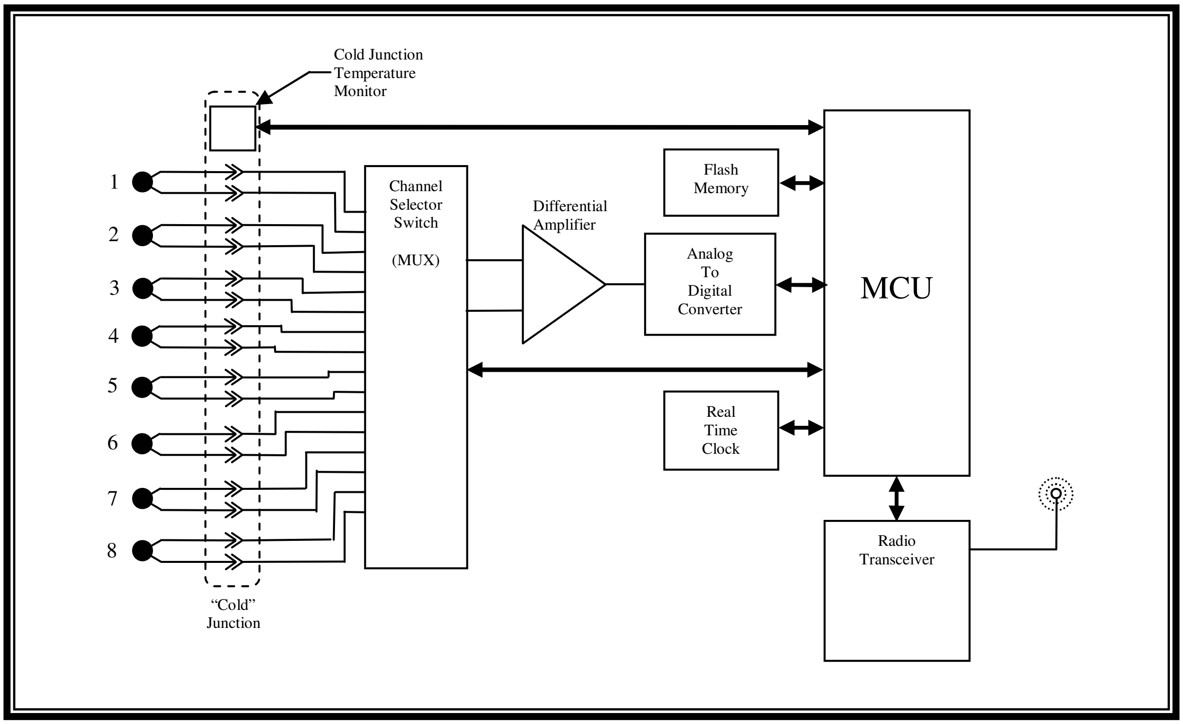
In the second case, we are interested in measuring the temperature distribution across the surface of a heatsink. The heatsink happens to be attached to a live component that is holding the heatsink at an elevated voltage. To be sure that there are no voltage differences between the ThermoProbe tips we choose to place a small piece of Kapton® tape onto the heatsink at each of the measurement locations, then we place the Bare termination ThermoProbe end and secure it to the heatsink with another piece of Kapton® tape. After placing the Kapton® tape over the Bare termination we are careful to press on the contact point to make sure that the tip is actually in contact with the heatsink / Kapton® tape and to remove as much air as possible from between the two layers of Kapton® tape.

The Ring-Lug termination is designed to meet the need to attach a thermocouple to a location where a threaded fastener is available. Typical applications of this type of termination include measurement of the temperature of a bolt-on style heatsink, measurement of the temperature of a motor or other applications where a temperature measurement at a fixed location is desired. In making this termination available, Magna Systems hopes to eliminate the frustration experienced when a bare thermocouple is clamped under the head of bolt and the pressure beaks the thermocouple or the thermocouple slips from under the head of the bolt. The Ring-Lug termination is comprised of a Standard termination that has been affixed in a specially selected ring lug. This construction allows the electrical isolation of the thermocouple while ensuring a good thermal connection to the measurement point.

Thermocouple assemblies having custom lengths or configurations are available either through the Magna Systems web site (www.MagnaSystems.net) or by contacting Sales at Magna Systems.

How the ThermoBlade Works

A simplified block diagram of the ThermoBlade with a thermocouple assembly attached is shown below.



To make a measurement, the microcontroller unit selects the desired thermocouple by sending control signals to the channel selector switch. The switch connects the selected thermocouple across the inputs of the differential amplifier. This low-noise, zero-drift amplifier magnifies the relatively small thermocouple voltage such that an effective measurement can be made. The amplified voltage is presented to the input of the analog to digital converter where it is converted to a digital code. The digital code is read by the microcontroller unit and stored in memory. In order to interpret the digital code representing the thermocouple temperature correctly, the "cold" junction voltage must be compensated. The ThermoBlade uses an integrated circuit temperature sensor to accurately measure the "cold" junction temperature and the microcontroller then performs software based compensation. The microcontroller then selects the next channel to be measured and the process is repeated as required. The radio transceiver is used to periodically transfer acquired temperature data to DataLink using the GateWay network access node. If, for any reason, the data is not transferred to DataLink, the ThermoBlade stores the data in the flash memory and transmits the data later. The ability to store over 20,000 data points and report them later means that no measurement data will be lost.

Judging the Accuracy of Your Results

Making good measurements isn't hard, but occasionally an unexpected result will crop up and it is useful to know how to judge the accuracy of your results.

Different errors can occur depending on the type of measurement attempted. Temperature measurements almost always involve temperature and time; in some cases a measurement of the "steady-state" temperature is important while in other cases we are interested in temperature transients.

The accuracy of a "steady-state" temperature measurement is essentially determined by good thermal contact and calibration. Calibration is handled by the processes we use at Magna Systems to provide ThermoBlade units that meet specification. We take care in the design and maintenance of our processes so that you may be confident that by using a ThermoBlade you are capable of making excellent and accurate measurements. The most likely issue then becomes the existence of intimate thermal contact at the measurement point. This can be checked by introducing a heat impulse near the measurement point and ascertaining that the thermocouple response is sufficiently rapid. A slow response or a response of insufficient amplitude indicates a lack of thermal conductivity between the measurement point and the thermocouple. This is often easily remedied by thermocouple reattachment.

When making measurements of thermal transients the most common worry is the thermocouple response time; is the thermocouple response fast enough to provide an accurate measurement of temperature versus time? To judge this, again a heat impulse may be used. By applying a thermal impulse or step function one can assess the thermocouple response time. This is most easily done by rapidly immersing the thermocouple in an environment at a different temperature while taking temperature data. The trace of temperature versus time for such a step function transient will give a good sense of the thermocouple thermal response time. When performing this test one must remember that the environment must be uniform such that the thermal mass of the thermocouple is insignificant. For example, if a thermocouple is suddenly immersed in hot water, it is important to move the thermocouple such that the water is stirred and that the water which is initially near the thermocouple is replaced with water at the elevated temperature. When using the temperature versus time trace to measure thermal response time, bear in mind that the initial transient will provide a more accurate measure of the response time than the later portions of the curve.

Troubleshooting

Symptom: ThermoBlade does not appear during network initialization.

Possible Problem- ThermoBlade may have depleted batteries.

Solution- Check to be sure the batteries in the ThermoBlade are still charged and replace as required.

Symptom: ThermoBlade does not read temperatures correctly.

Possible Problem- Wrong type of thermocouple specified in DataLink

Solution- Check thermocouple specification in the node configuration used for network initialization and revise as required.

Possible Problem- Thermocouple could be broken

Solution- Use the thermocouple continuity test feature in DataLink to test the thermocouple. If DataLink indicates that the thermocouple is broken, please contact Magna Systems for a replacement thermocouple.

Possible Problem- Temperature data is outside of the ThermoBlade's rated temperature range.

Solution- Use the thermocouple within the rated temperature range. If an extended temperature range is required, please contact Magna Systems for an extended range thermocouple.

Symptom: ThermoBlade drops out during data collection.

Possible Problem- ThermoBlade is too far from the GateWay or there is significant radio frequency interference.

Solution- Reposition the ThermoBlade closer to the GateWay.

Possible Problem- Sampling rate is too high.

Solution- Cancel test and set sampling rate to a longer interval (slower rate).

Possible Problem- Weak battery condition.

Solution- Cancel test and replace batteries.

Technical Specifications

Thermocouple Inputs-

Number of Channels: 8

Thermocouple Types: T-type standard (E, J, K, R & S available by special order)

Cold Junction Compensation: Automatic, software based

Thermocouple Input: Integral thermocouples or ThermoAdapter inputs

T-type Thermocouple Temperature Range: -270ºC to +400ºC

T-type Thermocouple Characteristics:

Accuracy*	Resolution
± 0.5ºC	0.1 ºC

*Errors are for the ThermoBlade only and do not include the thermocouple error

Monitoring & Data Recording-

Sampling rate user settable from days to 5 samples / second

All samples time stamped at acquisition

Programmable start time or start on command

Programmable test end time or end on command

Measurements stored or relayed in real-time

General Specifications-

Operating Environment: -200ºC to 427ºC (-328ºF to 800ºF)
5% to 95% Relative Humidity (non-condensing)

Vibration: 10 g (rms 20 Hz to 2000 Hz)

Shock: 3 foot drop

Power: Two AA style batteries

Battery Life: 1.5 yrs at 1 sample / min.

Time Accuracy: ± 1 min / month

Communications Interface: ISM band radio (868 / 915 MHz)
+5 dBm maximum TX power
RX sensitivity better than -100 dBm

Storage Temperature Range: -40 to 120 ºC

Weight: ThermoBlade only: ~ 500 gm (1.1 lbs.)

ThermoBlade with batteries: ~ 600 gm (1.32 lbs.)

Enclosure: Aluminum alloy (anodized)

Dimensions: (in inches)