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Inlet Heater for USCRN Weighing Precipitation Gauge

Mark E. Hall
Oak Ridge Associated Universities
NOAA Atmospheric Turbulence and Diffusion Division
Oak Ridge, TN

Edwin May
Consultant, NOAA/NCDC
Asheville, NC

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U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., U.S.Navy (Ret.)

National Climatic Data Center
Thomas R. Karl, Director

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1. Introduction

The U.S. Climate Reference Network (CRN) stations use a Geonor model T-200B weighing precipitation gauge. The weighing gauge allows the measurement of both liquid and solid precipitation. Early installations of CRN stations, some in harsh winter environments such as Alaska and Maine, indicated a need for some form of heater to keep the throat of the gauge free of snow when temperatures were within a few degrees, plus or minus, of freezing.

The NOAA Atmospheric Turbulence and Diffusion Division (ATDD) in Oak Ridge, TN has been tasked with installing and maintaining the CRN equipment. It was determined there was no commercially available heater available for the Geonor, so the engineers at ATDD modified a heater developed and tested (Wade and Cole, 2001)[1] at the National Center for Atmospheric Research (NCAR). This Technical Note describes the parts needed for the heater and the procedures used to install the heater.

2. Materials Required for the Geonor Heater System

The heater system consists of:

- 2 - Heating Elements (Minco, Model HR23937) wired in parallel
- 1 - Temperature Measurement Device (thermistor, YSI, Model 44003A)
- 1 - Bridge Resistor (Dale, 1002B13)
- 1 - Flat-4 automotive trailer connector
- 1 - Cable, Allied Wire and Cable #101220 (connects flat-4 connector to the datalogger)

The mounting of the heater(s) on the Geonor requires the following materials:

- 1 - 5 1⁄2 x 24 inch piece of Firestone TPO Quickseam Flashing (rubber roof seam material)
- 1 - 2 1⁄4 x 9 1⁄2 inch custom bent aluminum plate (mounted with 1/8 inch pop rivets)
- Silicone sealant
- White vinyl tape
- Solder and heat shrink or solder connectors

3. Description of the Geonor Heater System

Each of the heating elements is a 19.375 inch (492.1 mm) long by 4.5 inch (114.3 mm) high silicone resistive heater. The nominal resistance per heater is 5.1 ohms. The units are powered by 12 volts DC. Two heaters are used for each Geonor gauge with one heater mounted on the top inlet tube, and the second mounted inside the cover on the bottom of the inlet tube. These two elements are wired in parallel. The temperature sensing device is a 1K ohm at 25^{o}C NTC thermistor. The thermistor is wired in a bridge configuration with a 1K ohm fixed balance resistor.

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[1] Wade, C., and J. Cole, 2001: Final Report to CRN Management on the Snow Gauge and Wind Shield Evaluation Studies Conducted at NCAR from January to April 2001. NCAR Research Applications Program (RAP), 17 July 2001.

4. Installation Procedure

One heating element and the thermistor are mounted on the outside of the inlet of the precipitation gauge (see Figure 1, installing the outside heater strip, and Figure 2, installing the thermistor). The second heating element is mounted inside the cover on the portion of the inlet that extends down through the cover (Figure 3). A hole is drilled on the flared-out section of the Geonor casing approximately 2 inches below the straight portion of the inlet tube, and inline with where the thermistor is mounted. The wires for the external inlet heater and the thermistor are then fed through this hole, and the hole is sealed with silicone sealant. White roofing material (rubberized canvas) and white vinyl tape are used to cover and secure the externally mounted parts to the rain gauge heater, including the hole that was drilled to feed the wires through (Figures 4 and 5).

Figure 1: Installing the outside inlet heater strip.

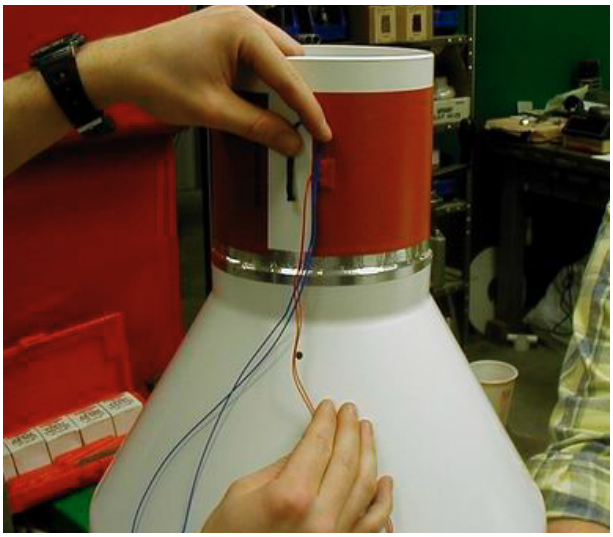

Figure 2: Installing the thermistor.

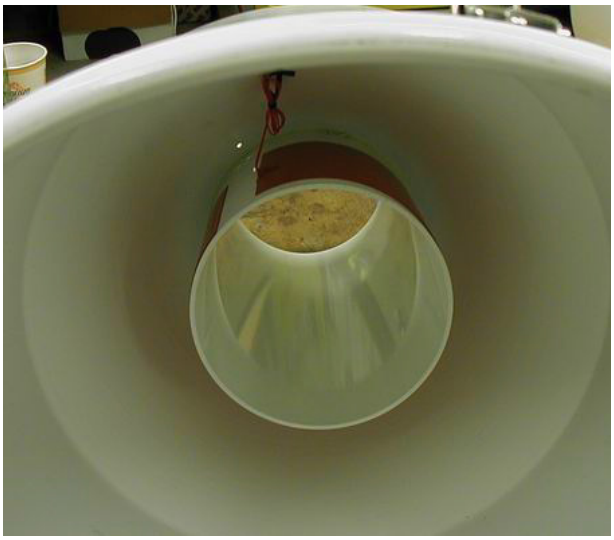

Figure 3: Heater strip mounted on bottom of the inlet tube inside the Geonor cover.

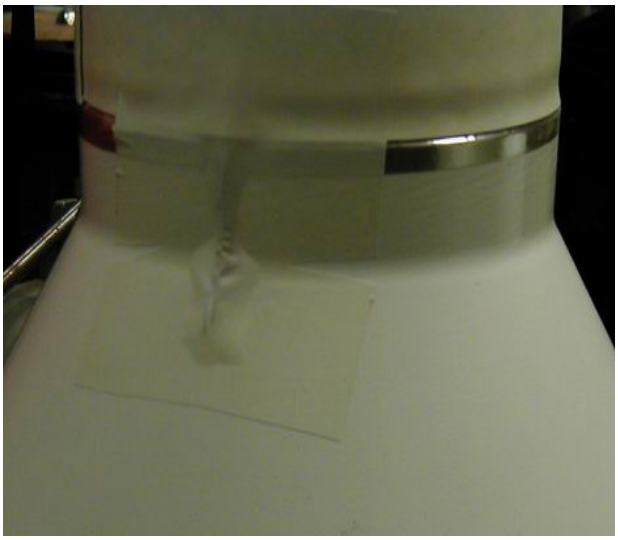

Figure 4: Exterior of the gauge with the waterproof roofing material and white vinyl tape applied.

The wires from the two heater strips and the thermistor are spliced into a regular flat-4 automotive trailer type connector (Figure 6 & 7). Holes are drilled into the side of the Geonor cover in which to mount the protective metal wire cover (Figure 8).

Figure 5: Finished exterior of the gauge with the heater installed and covered.

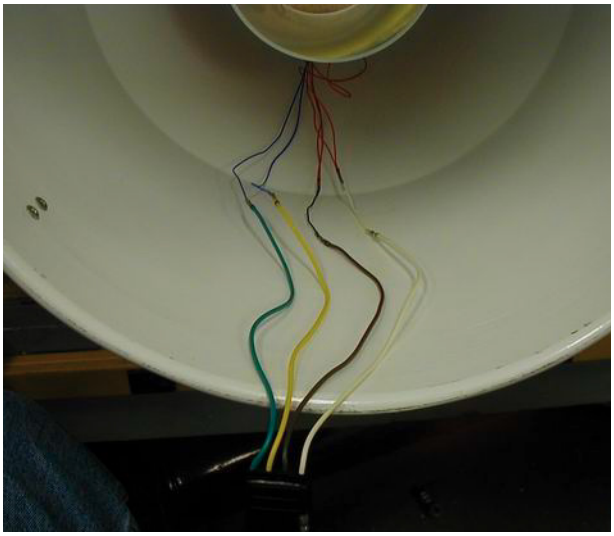

Figure 6: The wires from the two heater strips and the thermistor are connected to a coupler.

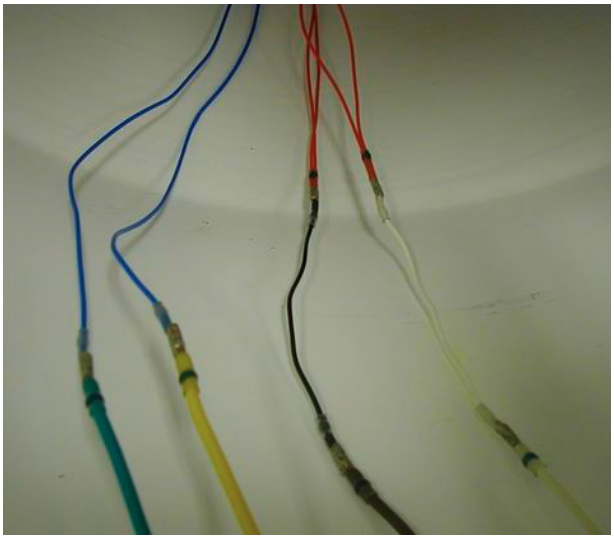

Figure 7: Wire connections from the heater strips and thermistor to the flat-4 coupler.

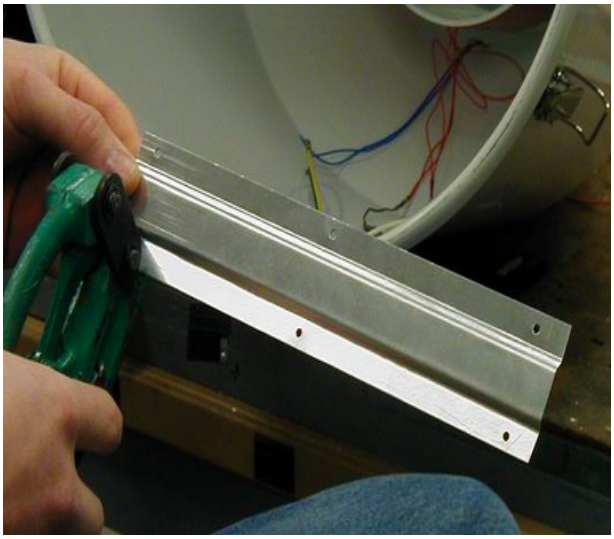

Figure 8: The metal protective wire cover is prepared for installing.

The metal wire guard is pop-riveted to the inside wall of the Geonor cover (Figure 9), running vertically down a line from the hole drilled earlier through which the exterior heater wires were fed. This completes the physical installation of the heater elements, thermistor, and the wiring in the Geonor housing (Figure 10). A custom cable (Weico, Inc.) is used to connect the power to the heater and the thermistor to the data system, and a custom built circuit is used to switch the power to the heater on and off based on the outside temperature.

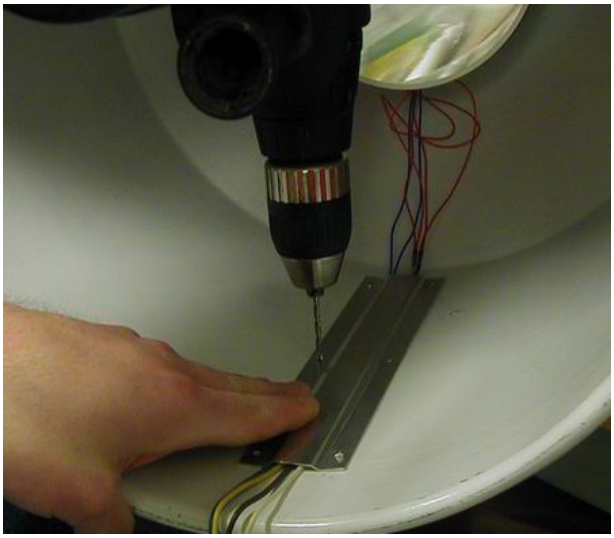

Figure 9: The metal protective wire cover is mounted to the inside wall of the Geonor cover.

Figure 10: Completed installation.

5. Operation of the Geonor Heater System

The normal site heater operation scenario (for sites with AC power) energizes the heater under the following conditions:

The temperature is between -5 and +2^{o}C (with a 1 degree dead band from 2 to 3^{o}C) if the battery voltage is greater than 12.2 volts (this would turn off the heater if the AC power is off and the system is running on battery backup).

At Barrow, AK the heating cycle was modified after it was noticed that rime ice was building up on the gauge at air temperatures below -5^{o}C (at this time there has not been any indication that this was a problem at any other site). The cycle was modified to eliminate the -5^{o}C low temperature shutoff; however, the heating cycle is only on for 2 minutes each 15 minute period. The upper temperature control point was also increased to +5^{o}C.

Another change was made in the heater control program at Canaan Valley, WV, which is a solar powered site where battery conservation is an issue. The heating cycle is only allowed to turn on the heater if the average depth received by the three Geonor wire sensors has increased more than 0.1 mm in the previous 15 minute period. This allows the heater to run during precipitation events, but not during periods when the temperature is within the control values, but there is no precipitation occurring. The performance of these settings is still under evaluation. Early performance was encouraging enough to make this program change at the Whiskeytown, CA solar site during the December 2003 annual maintenance visit.

The effect of the heater on keeping the inlet of the Geonor gauge open can be seen by the before and after pictures that follow. Figure 11 is a photo of the Geonor gauge inlet of the CRN station at Barrow, AK where the inlet is completely clogged and capped by rime icing, while Figure 12 shows the same site after the program was modified as discussed above.

Figure 11: Barrow, AK Geonor inlet (blocked and capped by rime ice) with AC site program.

Figure 12: The Barrow, AK Geonor inlet after program change.

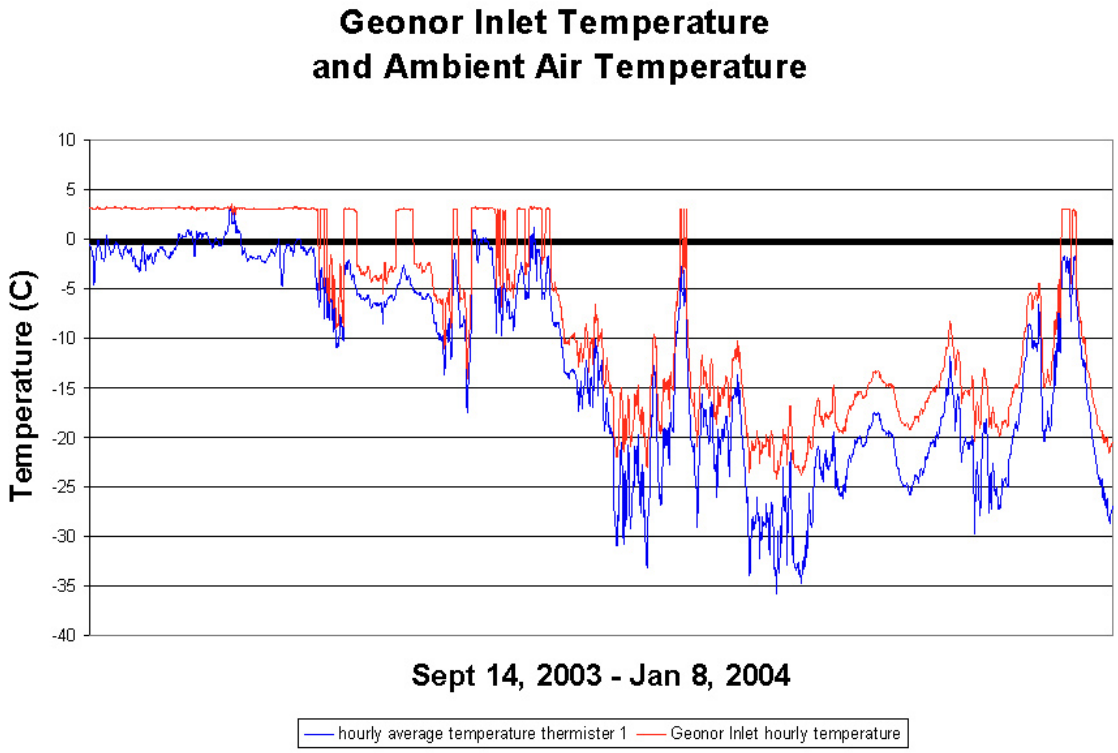

Figure 13: Graph of ambient air temperature and Geonor inlet temperature for the CRN Geonor gauges at Barrow, AK for the period 9/14/03 - 1/8/04.

6. Wiring Diagrams

Wiring diagrams relating to the connection of the Geonor heater system to the CR23X datalogger and the control circuit are attached in the following figures. Figure 14 is the schematic showing the terminal blocks used in the CSI 23X for the connection of the heater system. Figure 15 is the schematic showing the wiring connection of the heater system to the datalogger, and includes details of the custom made relay module. Figure 16 shows a wiring schematic for the temperature control thermistor.

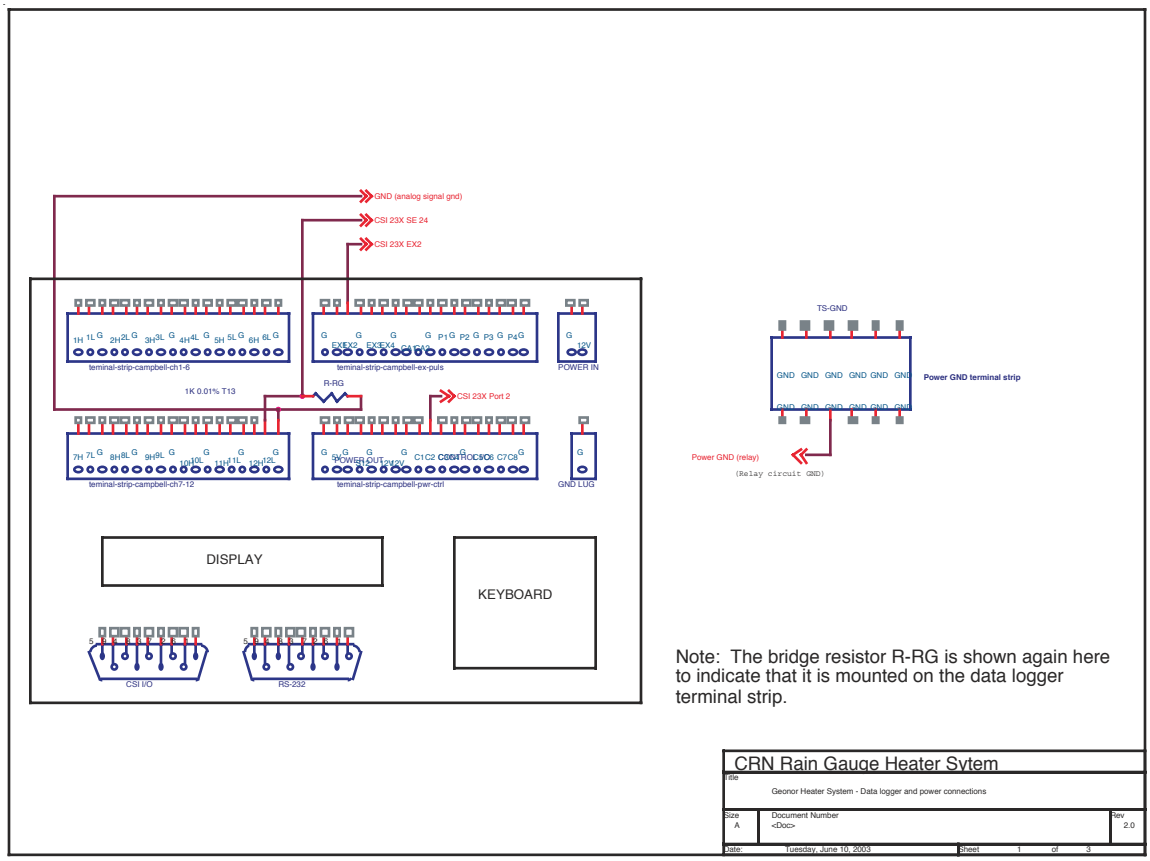

Figure 14: The terminal blocks used in the CSI 23X datalogger for the heater connections are shown in this schematic. The Bridge Resistor R-RG is also shown.

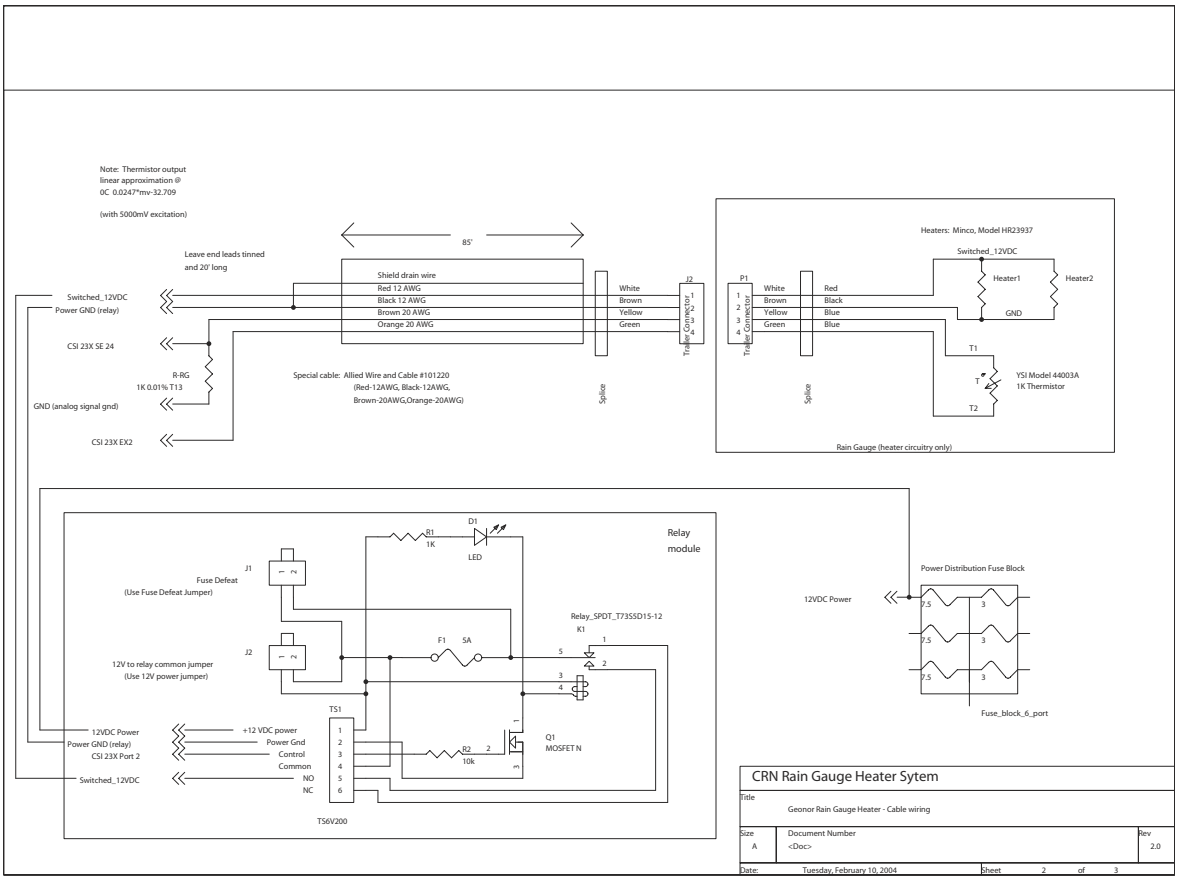

Figure 15: Wiring diagram showing wiring from the heaters and thermistor through the flat-4 connector and the special cable to connections on the CSI 23X terminal blocks. The bottom left portion of the figure details the Relay Module.

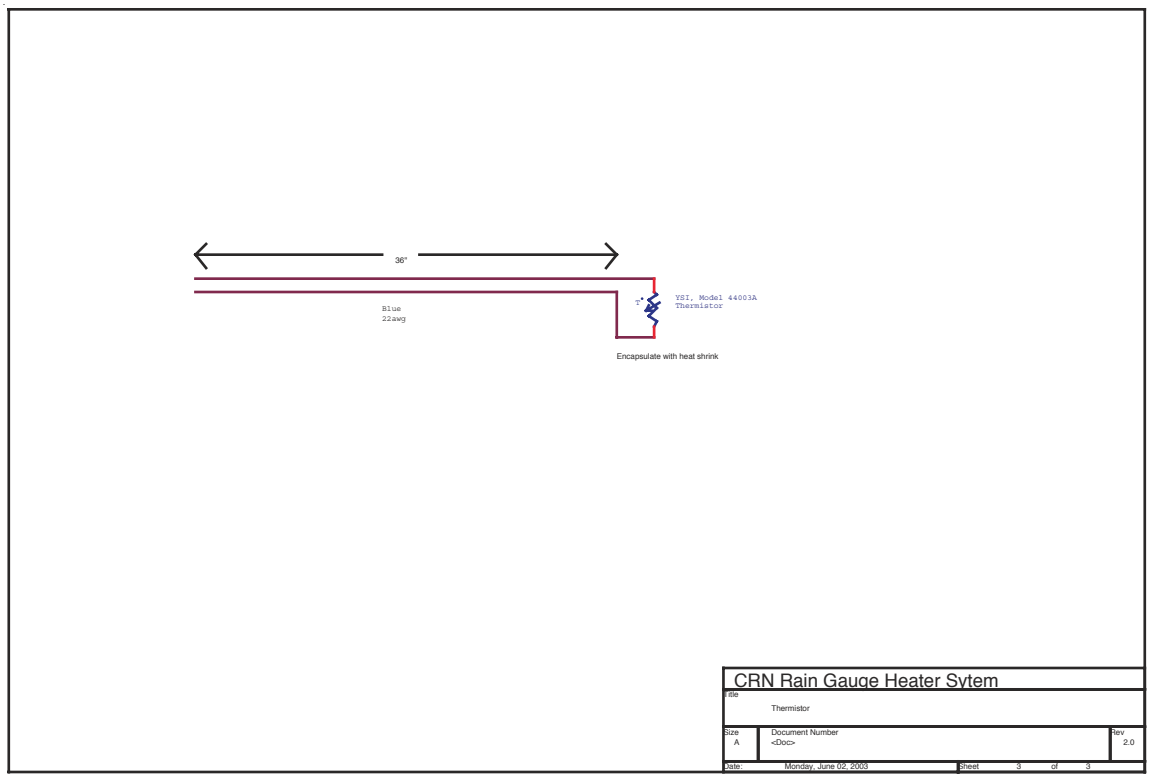

Figure 16: Schematic of the wiring for the temperature control thermistor used in the heater system.

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