ELECTRONICS INTERNATIONAL INC.

Accurate CHT
Measurements

7/31/14 By Ron Roberts

www.buy-ei.com

Electronics International manufactures a number of CHT probes. The list is as follows:

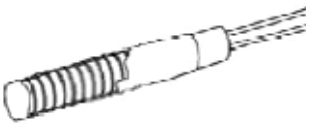
1. **P-100** - Ungrounded, screw-in
2. **P-101 Ungrounded** - Military style, bayonet
3. **P-101 Grounded** - Screw-in, bayonet, small brass tip
4. **P-101 MG** - Grounded, military style, bayonet, small brass tip
5. **P-102** - Ungrounded, surface measurement, under the spark plug
6. **P-102 -3/8** - Ungrounded, surface measurement, under a heater in the well

The CHT Boss that provides the threaded CHT well is casted into the cylinder head and measures approximately 1.0 inch in diameter and 1.35 inches long. The wall at the back of the CHT well is at the bottom of the combustion chamber / top of the cylinder wall.

Our tests and 35 years experience have shown the temperature in the well, all the way to the outside surface, operates at nearly the same temperature (within approximately 6 degrees F). This does not include the back wall of the well. The CHT Boss was designed to be significantly large enough to conduct the heat with little temperature gradient (temp loss along the length of the boss). This allows the following types of probes to operate with consistent results:

Rochester 3080, Resistive element

This probe incorporates a resistive bulb that is insulated from the brass body. The sensing wire is wrapped around an insulating mandrel or core and one end of the wire is grounded to the body. Temperatures are measured over a one inch section of the probe. This probe is currently used in tens of thousands of aircraft.



*Resistive Bulb

Alcor AN5546-1, RTD CHT Probe

This probe incorporates a resistive thermal device (RTD) to measure CHT's. The RTD is ungrounded (insulated) from the sheath and measures temperatures over an area just back from the tip.

Electronics International's P-101 Ungrounded probe makes contact with the wall at the back of the CHT well. The measuring junction is 0.15 inches back from the probe tip and is very small with a radius of 0.025 inches. The stainless steel sheath surrounding the junction insures heat is not conducted away from the measuring junction resulting in accurate measurements of well temperatures. We see little to no difference in the measured temperature between this probe, our P-100 CHT probe and the other probes listed above.

There have been some recent tests by Cub Crafters that indicate some types of CHT probes (similar to our P-101 Grounded probe) read higher temperatures. These types of probes measure a small section (.040" radius or smaller) right in the middle and at the back wall of the well. This is the closest to the 4,000 degree F combustion temperature you can measure in the well. If the temperatures are actually hotter in the center of the back wall, these probes will be displaying higher CHT readings than the older standard CHT probes. We will be performing tests to see if this is actually the case.

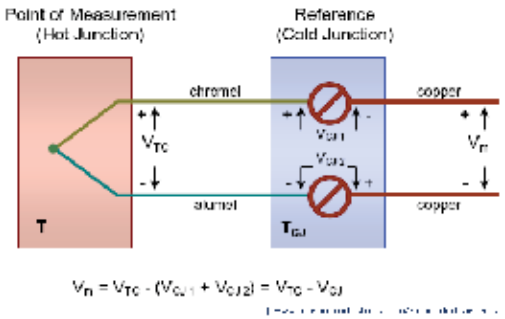
Inconsistent high CHT readings have been a problem in the past. Years ago CHT's were measured under the spark plug. These measurements were 25 to 50 degrees hotter than CHT well measurements (see appendix A). The cylinder head wall at the spark plug is not thick enough to stabilize the heat conducted by the plug and the top of the cylinder head. This resulted in inconsistent and higher CHT readings. We would see as much as 50°F difference in CHT measurements between the top and bottom spark plugs and the temperatures were always hotter than the well.

Insight's comment on their Gasket CHT Probe:
"Note that the spark plugs in some engines may run 50 to 100 Fahrenheit degrees hotter than the thermowell."

The intent of the CHT well is to provide consistent and stable CHT readings. Significant temperature gradients in the CHT well would defeat this intent. For this reason the CHT Boss has significant mass to provide consistent temperature over its length.

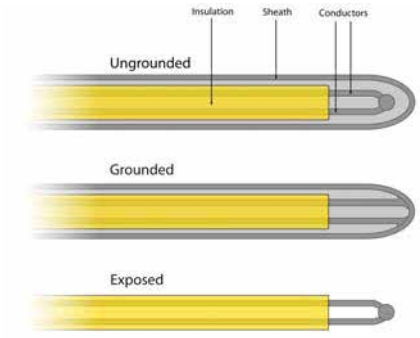
There are a lot of other reasons for inaccurate CHT readings.

1. Compensating Junction – Thermocouple (TC) wires require cold junction compensation at the terminating end of the wire. Some instrument manufacturers do not have compensation or they place the compensator in the instrument. As you climb, the temperature at the terminating end of the TC wire will decrease in temperature causing incorrect high CHT readings.



Electronics International instruments provide a temperature compensating diode located right at the terminating end of the TC wire. This insures accurate temperature measurements.

2. Grounded vs. Ungrounded Probes – Grounded CHT probes will pick up ground voltages and noise at the engine. This can cause shifts in temperature and jumpy readings. Some instrument manufacturers require the instrument to be grounded at the engine in order to reduce these problems. A 10mV signal at the engine, which is not uncommon, can result in a 30 degree shift in the CHT readings.



Most of Electronics International's probes are ungrounded and are not effected by ground loops, noise or voltage shifts. In addition, Electronics International incorporates common mode amps, differential inputs and filters to insure accurate and stable temperature readings for grounded probes.

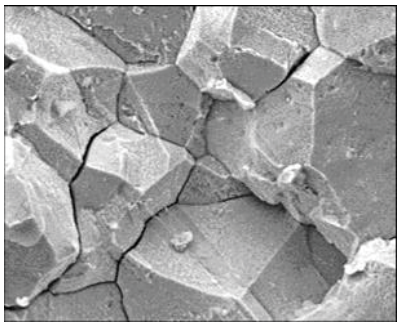
From Alcor Learning Center:

"**Why does it matter which kind of thermocouple is used?** Depending on the grounding situation in some digital instruments or aircraft/engine models, grounded probes can lead to electrical "noise" or interference in a digital instrument. Ungrounded thermocouples are easier to design and are used on amplified meters with circuits requiring that style to avoid this issue. Some digital engine monitors or aircraft models may specify the use of ungrounded probes while others allow grounded. If an ungrounded probe is required, it should be specified in the aircraft or Engine Monitor manual. Ungrounded probes can be used in place of grounded, but grounded should ***not*** be used in the place of ungrounded."

3. Type K vs. Type J CHT Probes - Type J probes have significant nonlinearity over their temperature range which can pose a challenge in producing accurate CHT readings. Some instrument manufactures calibrate at one set point and hope for the best.

Electronics International instruments use the more expensive type K probes because they provide a much more linear output and have a much higher temperature range. Also, we incorporate a map (similar to a polynomial) that produces accurate readings over a very wide temperature range (-60°F to 1700°F).

3. Impurities in the TC Junction – Some grounded probes weld the TC wire into the end of the probe. This can introduce impurities in the TC junctions causing inaccurate temperature readings and/or non-linearity. Also, the weld can produce fractures due to embrittlement in the chromel wire.



Electronics International uses ungrounded probes that do not have foreign metals introduced into the TC junction. This insures accurate and reliable temperature readings. Also, our grounded probes are not welded.

For the last 35 years Electronics International products have been used in hundreds of the type certificate projects, engine test stands, STC projects and FAA flight tests for both piston and turboprop aircraft.

Appendix A:
CHT Limits for the Spark Plug and Well Locations

FSO-470-A, 0-470-2

NOTE 1. Maximum permissible temperatures:

Cylinder head

525 F. (spark plug gasket)

475 F. (bayonet thermocouple downdraft cooling only)

NOTE 1. Maximum Permissible Temperatures:

Cylinder Head Models	/	Spark Plug Washer	/	Thermocouple Well Type
All except 0-223-A1 O-235, O-235-A, -AP O-235-B (O-235-2), - BP - C		525°F		500°F

NOTE 1. Maximum permissible temperatures are as follows:

Models	/	Spark Plug Gasket	/	Well Type
O-435-B		540°F		500°F
O-435, -A, -A2, -C, -C1, -C2; GO-435 GO-435-C2, -C2B, -C2B1, -D1; O-435-A3, -K, -K1, -C2D, -C2A,		525°F		500°F

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