The Wireless

August 2023

The Garden City Amateur Radio Club

PO Box 482 • Garden City, MI 48135-9998

Next Meeting:
Tuesday, Sept. 19, 2023, 7:00pm
Garden City Presbyterian Church
1841 Middlebelt Rd.
Garden City, MI 48135

Hope you are having a great summer. As we start to move in to the end of summer, it's time to start thinking about all those great fall activities again: kids going back to school, trips to the donut, err, cider mill, and of course the first GCARC meeting of the fall. I'm not looking forward to the air getting colder or the days getting shorter, but I am looking forward to seeing everyone at our first meeting on September 19. Don't forget to bring a friend.

A reminder from our Treasurer:

I will begin collecting 2024 dues at the September meeting. The current fee is $17.00. Please bring exact change if payment is by cash. Checks to GCARC also will be accepted. Dues can be paid in person during meetings or by mail to our P.O. Box listed above. Please mention our club to prospective new members who may be interested in joining.

73.
Richard Zarczynski / AC8FJ
GCARC Treasurer

Scouts learning Search and Rescue techniques from Scott, WT8S at Trail To Eagle.

Congratulations to Dennis, KE8YRZ/AG

Mat-Matics # 118
Henry 2K-Classic Valve Operation
Part 4 – Seal Temperatures

-Mat Breton, N8TW

This is the fourth and final article in a series on my studies into the behavior of my linear amplifier with respect to proper operation of the Eimac 3-500Z power tubes. Besides the prelude (measurement of my household service voltages), the articles are:

Article 1: Series Overview
Article 2: Henry 2K-Classic 3-500Z Filament Inrush Current
Article 2: Henry 2K-Classic 3-500Z Plate & Filament Voltages
Article 4: Henry 2K-Classic 3-500Z Seal Temperatures

Key to the proper operation of any vacuum tube is … well … the vacuum. And significant leakage of air into the vacuum will reduce or destroy the performance of the vacuum tube. Very little gas passes through the glass or metal on a tube: most will leak at the "seals" … where metal and glass are bonded together. Repeated dissimilar expansion of the materials is what can damage the glass to metal seals, causing air leakage into the tube. The tube usually has a limited ability to "getter" (or absorb) small amounts of air leakage, but after a certain point the tube will be unusable and unrepairable. In tubes that are operated properly (voltage and current), it appears that seal leakage is one of the primary reasons that tubes become inoperable.

About the seals: Because glass and iron/steel have such a dissimilar CTE (coefficient of thermal expansion), an intermediate material is used between them. This material will need be able to bond to both glass and metal, have a cte to match the glass, and yet be able to absorb the mismatch to the metal. Originally a material called Kovar™ was invented, a special metal alloy. Since then other materials have largely displaced Kovar, but the name is often used to describe this group of materials (much like Kleenex™ for tissues).

There are two sets of seals, and therefore seal temperatures, on the 3-500Z: the anode (or plate) seal on the top of the tube, and 5 pin seals on the bottom of the tube. Eimac specifies a different maximum seal temperature for each type:

Anode (top) Seal: Maximum 225 degC
Pin (bottom) Seals: Maximum 200 degC

The US Military did a lot of studies on receiver and transmitter tube leakage back in the day. I read one study where they found the Kovar would withstand a 200 degree rise (from 25 deg ambient to 225 deg) for more than 50,000 cycles before the seal began to degrade. As the maximum seal temperature rose, the number of cycles before leaking became significant would drop. I would not be surprised if something like this was the basis for the above figures.

Anode Heat Generation: Heat is generated in the anode of a power tube by the electrons from the cathode striking the anode at high velocity (kinetic energy). The heat generated in the 3-500Z anode exits the tube in two different ways: radiated (infrared radiation through the glass tube) and conduction (up the anode "bar" and through the glass seal at the top). Since the tube contains a vacuum there is no "direct" convection from the anode. In the 3100V grounded-grid application of the Henry, the plate dissipation should be about 400W maximum plate disappation.. Since my amp operates at about 3300V, I feel I should protect for 500W max dissipation (the max the tube is rated for). In the stock Henry design, some of the heat in this anode rod is coupled into a steel anode "cap" which is attached by a hex screw. It then couples into a finned aluminum radiator element.

Cathode Heat Generation: In the cathode, heat is generated by the filament current and voltage (P = E * I). In a cathode-driven (grounded-grid) amplifier this power consists of both the filament voltage generator, and the RF exciter power.

> Most is generated in the filament itself, but some is generated in the pin/socket interface, as well as the pin itself (which is a structure of several parts). If the contacts are not clean and functioning properly, the resistance in the pin/socket increases, and an increased share of the heat is generated locally in the pin.
> This heat is partially radiated by the filament, and partially conducted out by the two cathode pins in the bottom of the tube. The pins are "clamped" into to the tube socket, and airflow around the pins and the socket clamps hopefully provide the necessary convection to keep the seals cool.

Note: Compared to the amount of heat generated by the cathode and anode, the heat generated by the grid is very small. The grid absorbs some of the heat radiated by both anode and cathode. I would normally expect heat issues to the lower pins to occur on the cathode, and not the grid pins.

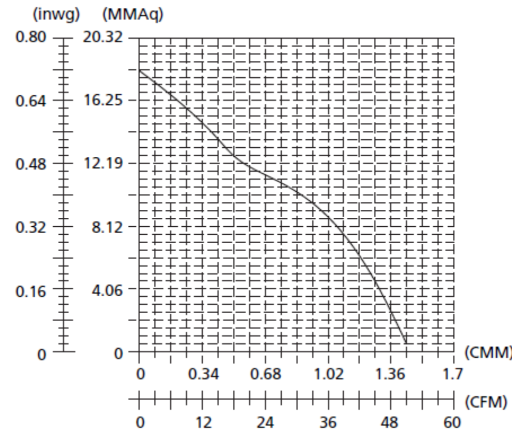
Misinformation on the web: There is a lot of misinformation on the web about anode seal (in particular) temperatures. One Youtube video from someone selling expensive replacement anode caps (https://www.youtube.com/watch?v=EoVCGFPvOuk)actually uses a 225 deg F temperature threshold, not a 225 deg C temperature threshold, making it look like his product is necessary and important. Thanks to Rich W8DOW for catching this! Other pieces of information include unsafe practices. Take care …

Measurement of the effective airflow: Since Eimac specified that if one were to keep 13CMF of air flowing past the tube a design would be OK (the seal temperatures would be below the limit). This assumes that the linear amp mfg replicated their setup, and that we can correctly measure the real airflow "past the tubes". While it is very difficult to directly measure the air flow pas the tubes, if you know the blower specifications and the pressure drop across the fan, you can at least make a calculated estimate. The fan in a Redmond #80239: there is no information on the web for this exact mfg/model, but locating similar one I obtained some specs. I also borrowed a manometer to measure the pressure drop between the inlet and outlet of the blower. Note that when I did this I completely disabled the high-voltage supply for safety.

CFM @ free air: 50 CMF (from the surrogate blower spec0

Estimated “Leakage”: 10% (air flow not going past seals/tube, my guestimate)

Measured blower backpressure: 0.268 in wg



Manometer (left), Backpressure-Flow Chart (right)

Calculated airflow for each tube: 42 (CFM)* 90% /2 (tubes) = 19 CFM/tube >> 13 CFM/tube minimum requirement. There appears to be a 46% design margin on my already conservative requirement of 13 CFM/tube.

There may be some problems with this calculation approach, primarily is the fact that Henry didn’t use 100% Eimac parts: they used lower priced ceramic tube sockets instead of the Eimac recommended high-airflow sockets (Johnson 122-275 vs Eimac SK-410). Additionally, we need to remember that my peak power will be higher than calculated by Henry due to the 240V input voltage design differences. By looking at the 3-500Z tube specs, I could expect an additional 25W or so of anode heat could be generated in normal operation.

Henry substituted a shorter anode/plate caps due to due space limitations in the RF chassis. I measured these caps and compared them to the original part specifications. Both are “transverse” flow (meaning the fins are horizontal, not vertical), but the ¾”, 6-fin Eimac was 7/8” tall … while the Henry cap is 1” in diameter and only ¾” tall. The Eimac design has about 5.8 in^2 of surface area, while the Henry design has about 5.9 in^2 of surface area … actually very close.

Eimac HR-6 cap (left), Henry Cap (right)

Drake Caps (left), Aftermarket Caps (middle, right)

Because of the anode cap design change, I decided to also “measure” the anode seal temperature … but not the pin seal temperatures. Just to be sure …

Measurement of the anode seal: For all practical purposes it is impossible to directly measure the actual “seal temperature” since it is encapsulated in glass. From the description in the Eimac documentation one needs to assume they accounted for this, and what they are actually referring to is the closest measurement point to the seal temperature (the anode cap, and the cathode pin).

Safe measurement of the anode temperature is problematic due to both the mechanical design, the very high voltage, and the RF that is applied when transmitting. In lieu of direct measurement, Eimac recommends using a temperature sensitive marker on the anode that will change color/state when it reaches 225degC. Alternative methods I considered and rejected are Infrared sensing (target too small, shiny, access), thermocouple (high voltage, RF interference), and glass thermometer (mechanical access). Markel and Tempil are leading manufacturers of these products, although there are others. The trick is making sure you purchase the correct temperature marker/crayon.

I was able to purchase a Markal Thermomelt 225degC marker (model 86405) for $13.93. This marker puts a “chalk like” substance on the material to be measured. If the temperature passes the threshold it melts. The accuracy is +/- 1% (+/- 2.25degC). This is a lot of money for a single test, but a replacement set of “matched” tubes is over $700 right now.

Tempil Crayon (left), Anode Pin (middle), covered with temp stick (right)

Conclusions: Both my calculations and measurements indicate that that the anode seal temp is good, and my calculations indicate the pin seal temps are good. No need to do any mods as the Henry design is more than adequate (plenty of spare margin) in this respect: in this case good enough IS good enough. This testing cost me < $14 for the temperature stick (which I will volunteer out to others who want to do some measurements of their own linear amps).

Remember that deadly high-voltage is present inside of 3-500z linear amplifiers. I took specific precautions to protect myself, and I never defeated any interlocks or exposed myself to high-voltage (either directly or through test instruments).

The Amateur’s Code

by Paul M. Segal, W9EEA (1928)

The Radio Amateur is:

CONSIDERATE….. never knowingly operating in such a way as to lessen the pleasure of others.

LOYAL….. offering loyalty, encouragement and support to other amateurs, local clubs and the American Radio Relay League, through which Amateur Radio in the United States is represented nationally and internationally.

PROGRESSIVE….. with knowledge abreast of science, a well built and efficient station, and operation beyond reproach.

FRIENDLY….. with slow and patient operation when requested, friendly advice and counsel to the beginner, kindly assistance, co-operation and consideration for the interests of others. These are the hallmarks of the amateur spirit.

BALANCED….. Radio is an avocation, never interfering with duties owed to family, job, school or community.

PATRIOTIC….. with station and skill always ready for service to country and community.

Countdown to W4DXCC

September 29rd and 30th, 2023, Pigeon Forge, TN

The W4DXCC DX and Contest Convention is about 6 weeks out. We sure hope you're planning on joining us. We have another well rounded schedule of topics! Please visit our website for all the details and to purchase your tickets! Click here to go to the W4DXCC website

The W4DXCC Convention has MOVED to an upgraded hotel and convention center. We have negotiated a good rate for you. The Ramsey has about 80 rooms available but these rooms go fast. Call now)and make your reservations at the number below, tell them you want the " W4DXCC by SEDCO" rates.
865-428-2700

We'll be sending out more details including the schedule of activities Wednesday.
73!
The W4DXCC Planning Committee

2023 FINDLAY HAMFEST

Vendor set-up 6AM.
Doors open at 8AM.

SUNDAY, SEPTEMBER 10

Hancock County Fairgrounds
1017 E. Sandusky St., Findlay, OH 45840

41.036717
-83.631166

RAIN OR SHINE

FREE PARKING

$10 Admission
$20 Vendor Table ($15 additional tables)
$10 Flea Market Space
$15 Overnight fee

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Hancock County Fairgrounds