On 25 Feb 2018 Joe D'Agostino posted a discussion about two different thermostats along with a photo of both participating in a 'sauce-pan' test. One of the thermostats had a lower temperature rating along with a smaller valve diameter, while the other 'Packard 160 °F' item had a higher temperature rating and larger diameter. Joe posed a question about whether the 'non- Packard' thermostat could be restricting coolant flow, and potentially contribute to a hotter running engine. During the past nine months I have been attempting to put some numbers to this question, and can say unequivocally that the answer is ***maybe***, and the value of 20 °F warmer is likely with the smaller thermostat. The difficulty with this investigation is that the position of the thermostatic valve is difficult to instrument, so a bit of educated guesswork and assumptions are required to flush-out an answer.

The thermostat I started with is a standard 'over the counter' item, 2 ½ inch outer diameter (marked 63mm), with a temperature rating of 160 °F. I bought these from O'Reilly's, so I will refer to this as the O'Reilly's thermostat, but I'm sure every major retailer will have something quite similar. This thermostat looks a lot like the one on the left in Joe's picture.

The configurations I've tested so far are:

- The O'Reilly 160 °F thermostat as purchased
- The O'Reilly 160 °F thermostat modified to have an increased flow area
- No thermostat

There are two pieces of information we should obtain from a sauce-pan test . . . not just the 'cracking' temperature, but also the temperature to achieve a 'full-open' area.

All of the thermostats had a 'cracking temperature' very close to the 160 °F rating. It took approximately 20 °F more to achieve the 'full-open' position. These are circular valves, so 'full-open' is achieved when the disk has moved a distance of approximately d/4 away from the seat (1/4 inch for the O'Reilly, likely 3/8 inch for the Packard). If your engine's coolant temperature is running 20 °F, or more, above the rated temperature of the thermostat, then the valve is likely 'full-open', and the coolant temperature will rise and fall based on engine power, road speed, and outside air temperature. This would be true to a lesser extent if the coolant temperature is between the 'cracking' temperature and the 'full-open' condition . . . in addition to the variables I've listed another variable would be the ever changing thermostat flow area where the coolant temperature is between the two 'sauce-pan' values determined before.

[The bad news is I'll be gibber-jabbering a lot of numbers for a while, but the good news is there are charts at the end of this discussion that draws perhaps a clearer picture of this investigation.]

The Swiss cheese modification details:

The O'Reilly thermostats have a valve diameter of 1 inch (probably 25mm), and based on the flange diameter of 2 ½ inch, that small 1 inch opening doesn't look large enough to do the job. I've modified one of the O'Reilly units to include 4 – 3/8 inch diameter holes, plus 4 – 1/4 inch diameter holes . . . that's in addition to the 1 inch diameter operating valve (see photograph 1 below). While I've never measured an original Packard thermostat, photographs in various manuals suggest an operating valve diameter something in the order of 1 ½ inch diameter, but I'll defer to other forum members for details of the OEM thermostat.

Photograph 1 – The Swiss cheese 'O'Reilly' thermostat modified with 4 – 3/8 and 4 - 1/4 inch holes. This will increase the flow area by approximately 81% over the unmodified geometry of a 1 inch diameter valve.

For purposes of comparison I will quote areas without applying the (π/4) term. First it's the same for all circular areas, and second the purpose of this data is to draw a comparison, not the exact square inches of flow area. The pseudo flow area data is included in the following table.

Area Comparison Table

Configuration	Minimum Area	Maximum Area
O'Reilly one inch	0	1
O'Reilly modified	0.81	1.81
Packard original	0	2.25

Multiply the tabulated reference areas by 0.785 (π/4) to convert to in² units

This data is also presented graphically at the end of the discussion.

When did I use each thermostat?

The un-modified O'Reilly unit was my 'go to' cool weather (below 80 °F) configuration. It consistently produces coolant temperatures of 160 – 180 °F, with excursions to 190 °F and higher. The car ran so frequently at 180 °F and above I thought the thermostat was actually a 180 unit. My logged data in this configuration is limited, but that's a limitation of me not recording the outside air temperature each time I drove the car. I'll correct that then the 'cool' weather returns, but from what I've seen in the data so far a 1 inch diameter thermostat will be marginal, perhaps extremely marginal, when the temperature is above 80 °F. My experience with another type of car is: once the thermostat is wide open the coolant temperature will increase about one degree for every degree of outside air temperature, so I would expect coolant temperature above 200 °F, with higher excursions, when the air temperature reaches 100 °F.

The modified O'Reilly thermostat has revealed a few interesting details. With an outside air temperature of 68 °F the 'cracking' temperature of the thermostat could not be achieved under lightly loaded conditions (that is an important data point because the valve should have been closed and therefore I know the flow area would be provided by the added holes). At the same outside air temperature a moderate power level did produce the 'cracking' temperature, but just barely. Since the minimum area of the modified thermostat is essential 81% of the un-modified maximum area I have presumed that under the same conditions (68 °F, moderate power) an unmodified 1 inch 160 °F thermostat would be 81 % open. On an 85 °F day with the modified thermostat installed, moderate engine load hit the full-open valve position (180 °F), but again fell-back to 172 °F (something like 1/2 open) with lighter engine load. Both of these flow areas would be greater than the area of the unmodified 1 inch diameter item (181% & 131% respective). This data suggests the coolant temperature on an 85°F day with an unmodified O'Reilly thermostat would be above 180 °F.

During the summer months I normally remove the thermostat and 'take what I get' for coolant temperature. Now, now this is when the minimum temperature of the day is still close to 100 °F, so it doesn't take long to warm to full operating temperature, and purging water from the lubrication oil will not be a problem. Based on the 2 1/2 flange diameter the area would be 6.25 on our referenced area scale, but since the upper radiator hose has an inside diameter of something in the order of 1 1/2 inch, my guess is the flow area of interest is close to the original Packard design (2.25 on the same area scale). Again not a lot of logged data yet, but I would say this configuration reduces the coolant temperature by 8 – 10 °F versus what would occur with the modified O'Reilly configuration (1.81 on the same area scale). I've run without a thermostat on a 105 °F day and could keep the coolant temperature between 185 – 195 °F by modulating the engine load.

With respect to running without a thermostat:
I'm not data rich in this configuration, but the data I have on the '48 Packard aligns with the reams of data I've collected on another car. I must await an outside temperature of 80 °F (in Phoenix, that's likely to be October) to complete the picture on what to expect in that configuration. I'm forecasting 160 – 170 °F on an 80 °F day with no thermostat. I would reserve 'no thermostat' operation to those days when the outside air temperature is at, or above, 80 °F.

I do not subscribe to the notion 'the water goes so fast it can't cool-down'. With all else being equal, the lowest coolant temperature will be achieved with the thermostat removed . . . however if the original thermostat has a valve diameter of 1 ½ inch the difference will be small . . . as the upper radiator hose is likely a close second in restricting the coolant flow.

Coming full circle, I think Joe would see a difference between a smaller thermostat valve area, and if it was on an 85 °F day that difference could be in the order of 20 °F (the Packard thermostat would likely be between 160 – 170 °F, while the smaller thermostat would be producing coolant temperature at, or near, 190 °F).

I would like to add that those of us that conduct 'sauce pan' tests, the valve full-open temperature is equal to, if not more important, to the 'cracking' temperature. The full-open temperature will likely be the minimum coolant temperature observed during mild weather. If my results are typical, a 160 °F, 1 inch diameter thermostat will produce a coolant temperature no less than 160 °F, but more likely a coolant temperature of 180 °F, and if the OAT is on the high side or the engine power elevated the coolant temperature will be 10 to 20 °F above the thermostat full-open temperature. We should know what temperature this is, and the 'sauce pan' test is the means to gather that information. The owner of the car will know that a 160 °F thermostat is installed, but the coolant temperature is never close to that rating. Under these conditions the owner may draw a conclusion that there is a deficient component in the coolant system . . . and he/she would be correct! It's the diameter of the thermostat that is elevating the coolant temperature . . . at least that's my opinion.

At the end of this discussion there is a graphic depiction of the data collected while the O'Reilly modified thermostat was installed. This would be all of the data points below 92 °F outside air temperature. The singular data set located at 105 °F outside air temperature would be when there was no thermostat installed. Note that the 'no thermostat' configuration is not wildly different than any of the other data, other than the increased flow area seems to have reduced the maximum coolant temperature . . . which would be quite normal, and consistent with heat transfer as I know it.

I have assumed that the Packard original thermostat once 'full-open' would perform somewhat like the 'no thermostat' characteristic. This assumption is based on the flow area of the upper radiator hose, and that restriction would be in-place whether a thermostat was installed, or not.

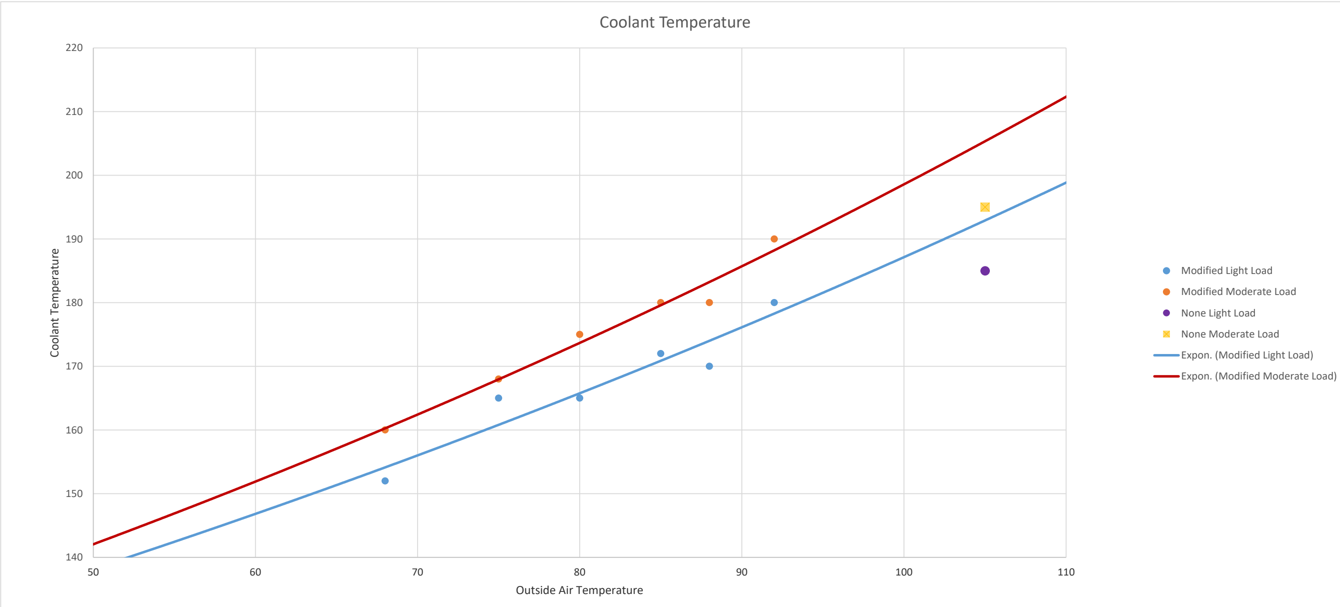
Also note the effect on the cooling system performance by the amount of load on the engine. My reference to ‘light load’ is operation at approximately 30 - 35 mph, with no grade, while ‘moderate load’ is approximately 50 mph, on a grade. That grade is enough to demand a good amount of throttle to maintain constant speed and is along the way home, so it’s unavoidable, but it does make a good built-in test condition. My experience is the coolant temperature will have increased approximately 10 °F when the car reaches the end of the three mile long grade. The last portion of the trip home is a leisurely 30 - 35 mph, 1 ½ mile drive . . . this time down-hill. The coolant temperature will return to the ‘light load’ temperature during this short segment.

So far that’s all I’ve got, I’m awaiting the weather to cool-down to the low 80’s to collect data at the low end of the ‘no thermostat’ configuration.

I would like to push the coolant temperature below 180 °F, on a 110 °F day . . . and if I have to I will cut-back 10 mph on the speed going up the hill on the way home. I’m a rolling road block anyway, so slowing down below the speed limit won’t make much difference. Right now I’m forecasting no lower than 190 °F coolant temperature without a thermostat installed, so I guess I’ll have to bang away on the air side of the problem for a while, but at 40-50 mph the air flow through the radiator core shouldn’t be something I can make much improvement on, but I won’t know that until I try. Interestingly the 23rd series front bumper provided less open frontal air flow area than the 22nd series, I wonder if that was to improve something related to cooling, like ensuring the air enters the vertical section of the grill, or it was one of those ‘major engineering’ changes all of Detroit was known for. What I would like to know is Joe’s current experience with the ‘pusher’ electric fan. I’m considering that configuration as a potential modification to coax the coolant temperature down a bit when the really warm weather is upon us. I do have one of those ‘generator look alike’ alternators and a NAPA 3EH battery, so I think I can handle the extra electrical load without a problem. I would like to limit the coolant maximum temperature to about 180 °F then the outside air temperature is at or above 110 °F. My motivation for this is the engine begins to run rough after a short spell of idle at a traffic light when the engine is really warm. I suspect the carburetor temperature has hit a critical value for the low fuel flow and the onset of vaporization has set in.

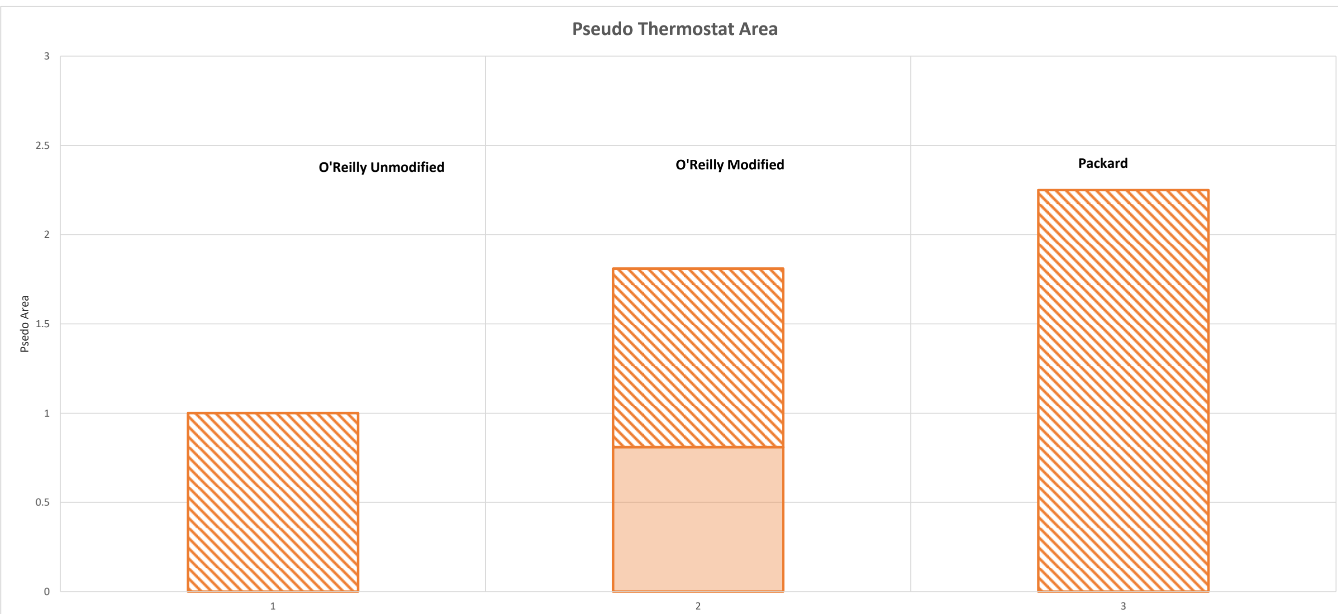
On the positive side, I’m getting quite handy making goose neck gaskets out of Cheerios boxes. Sorry, I didn’t add a sustained idle test point in this test series, perhaps later, but no guarantee since I’m not a fan of sustained operation at idle.

Logged coolant temperature data



The ‘no thermostat’ light load characteristic should parallel the blue line until about 92-94 °F. My expectation is the ‘no thermostat’ characteristic will drop away from the envisioned parallel line while the modified O’Reilly area is decreasing from 92-94 °F to 72-74 °F..

Thermostat operating area comparison



Cross hatching indicates the variable area section of each thermostat. Note the modified O’Reilly never is less than the ‘extra hole’ area.