2022 Webasto Elevation Testing

by

Redpoint Conversions

in conjunction with

VMACS

Contact Information and Credentials

Redpoint Conversions is a custom campervan conversion workshop and service center located in Flagstaff, Arizona. Redpoint Conversions holds Webasto training credentials and is certified as a Specialist in service and repair of Webasto Air Top 2000STC, EVO40/55, and Thermo Top Heaters. Visit them online at www.redpointconversions.com.

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Located in Chesapeake, Virginia, VMACS, Inc. has been in business since 2001 working with climate control systems typically found in off road construction equipment. VMACS, Inc. is also an authorized Distributor of Webasto Thermo & Comfort North America, stocking genuine Webasto heater kits and parts for vehicles of all types. Visit them online at www.vmacs.net.

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Overview:

This testing protocol was performed on Webasto Airtop 2000 STC gasoline air heaters at an elevation of 6400' in Flagstaff, Arizona. The goal of this test was to qualitatively compare carbon buildup on the combustion chambers (CC) and burner inserts (BI) after set time periods between a factory heater "out of the box" to a heater professionally adjusted to 6400' elevation. The heaters were operated side-by-side for 8 to 12 hours per day and generally set to a temperature just above ambient room temperature using a rheostat controller. This temperature setting mimics real world applications of the heater cycling on and off to meet consumer demands. At intervals of approximately 50 hours throughout the test, an exhaust gas analyzer (EGA) reading was taken for 2 minutes to supply quantitative data.

Testing Equipment:

Equipment used for this test included a Bridge Analyzer 900403, which analyzes carbon monoxide (%), carbon dioxide (%), oxygen (%), and hydrocarbon (ppm) content using non-dispersive infra-red along with electro-chemical sensors. The Bridge Analyzer 900403 also calculates air/fuel ratio (AFR), Lambda (a stoichiometric equivalent to the air/fuel ratio), and the combustion efficiency (Comb. Eff.). A PC diagnostic software was used to analyze raw data from the Bridge Analyzer 900403. A Webasto PC diagnostic tool (part #1320920A) was also used to monitor heater operations.

Testing Setup:

This testing protocol used Webasto Airtop 2000 STC gasoline air heater kits from VMACS, Inc. (parts #90-3-0003 and #90-3-0004) installed on a test bench inside an insulated workshop. An intake silencer kit (part #98141A) with a length of 2' tubing was installed, as well as an exhaust muffler kit (part #1320488A) with a length of 3' tubing. A rheostat controller was used to set the thermostat temperature. Fuel for this test was regular unleaded 89 octane gasoline.

Summary:

Over the testing period, the unadjusted "factory" heater accumulated more carbon than the heater adjusted for 6400' elevation. After 336 hours of runtime, the unadjusted heater began to show major signs of patchy carbon buildup while the adjusted heater only had a small amount of uniform carbon buildup. This scattered carbon buildup in the unadjusted heater CC was likely due to higher concentrations of carbon buildup in the BI, which altered the air flow into the CC. Following 744 hours of runtime, the unadjusted heater had exceptional carbon buildup both around and between the CC fins, while the adjusted heater began to show patchy buildup, similar to the 336 hour unadjusted heater.

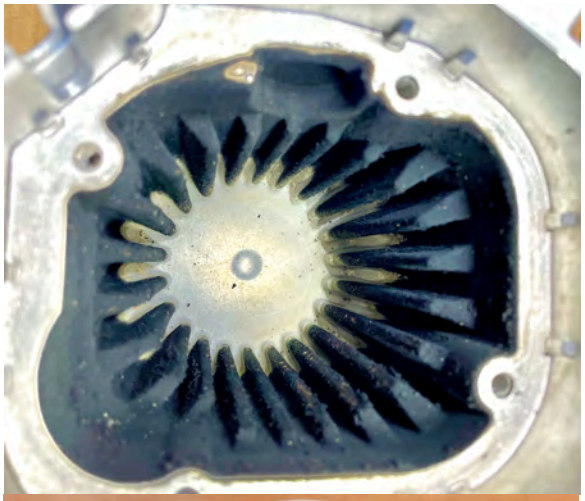
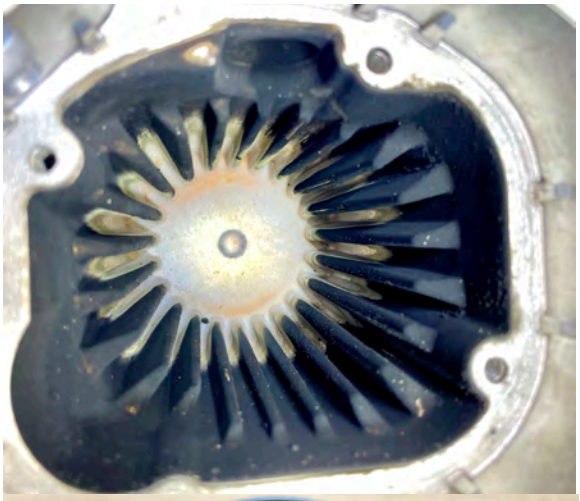
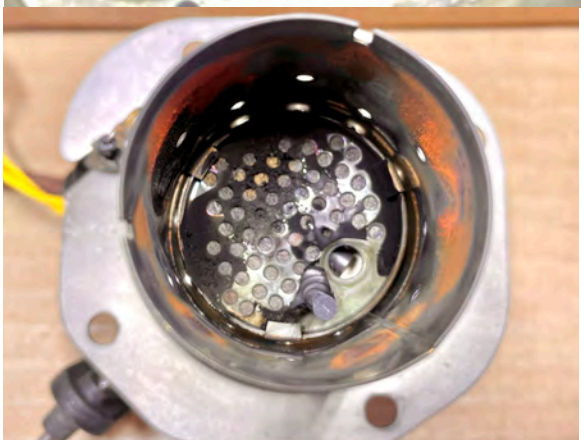
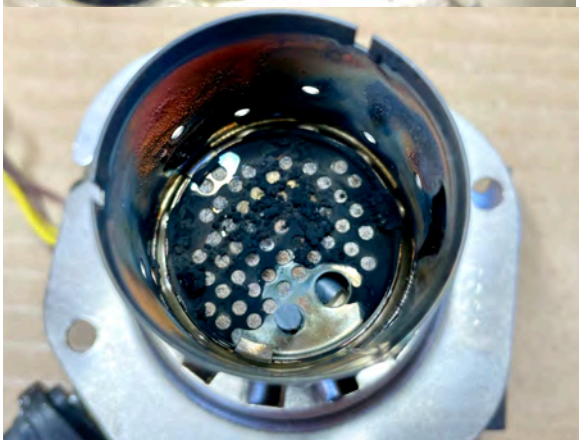
Hours	Unadjusted	Adjusted
72	Low carbon buildup	Low carbon buildup
216	Medium carbon buildup	Low carbon buildup
336	High carbon buildup	Medium carbon buildup
744	Very High carbon buildup	High carbon buildup

The EGA data showed both heaters to be in good working condition throughout the duration of the test. However, since these heaters cycle on and off, an accurate EGA reading became difficult; further testing may be required to confirm the quantitative data or draw any conclusions from the data. There were also no fault codes in either heater during the duration of this testing protocol.

In conclusion, an unadjusted heater clearly accumulates carbon faster when operated at higher elevations when compared to a professionally adjusted heater. Although the adjusted heater curtails carbon buildup and extends the time between cleaning maintenance, it does not entirely mitigate carbon buildup. **If the heater will be operating at higher elevations, we recommend to have the heater professionally adjusted to the operating elevation and to have your heater serviced accordingly.**

72 Hour Test

(January 6, 2022 - January 22, 2022, average ambient air temp. 75.7°F)

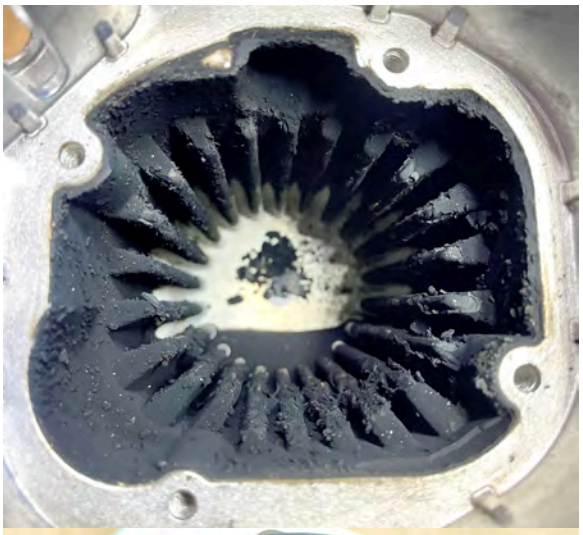
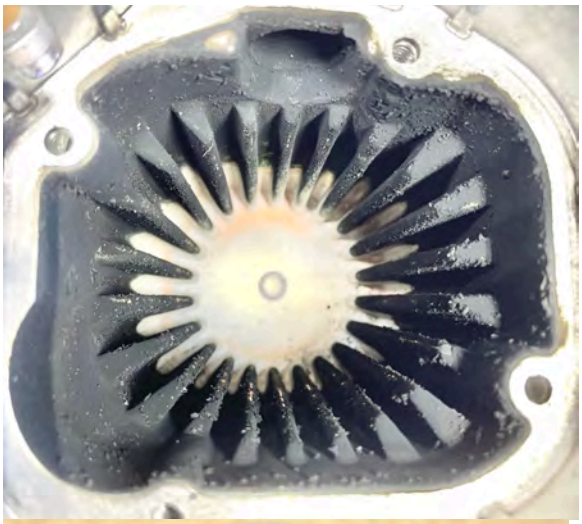
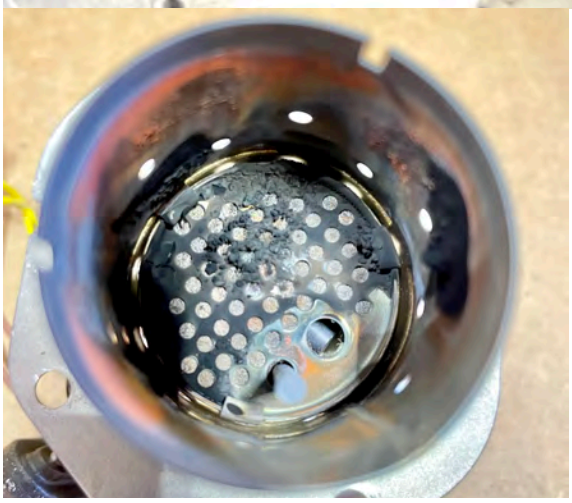
Unadjusted	Adjusted
	
	

	Start — Final	Start — Final
CO%	0.62% — 2.40%	0.04% — 0.26%
CO_2%	10.31% — 13.74%	10.76% — 12.71%
O_2%	7.18% — 1.02%	7.17% — 4.2%
HC (ppm)	625.71 — 6.97	2.69 — 1.82
Lambda	1.374 — 0.980	1.450 — 1.213
AFR	20.20 — 14.36	21.31 — 17.83
Comb. Eff.	94.06 — 92.56	99.78 — 99.02

Minor buildup of carbon on both the combustion chambers (CC) and the burner inserts (BI). The unadjusted CC had slightly more carbon buildup on the fins, while the adjusted CC had a thin, uniform coating of carbon.

216 Hour Test

(January 28, 2022 - February 18, 2022, average ambient air temp. 69.8°F)

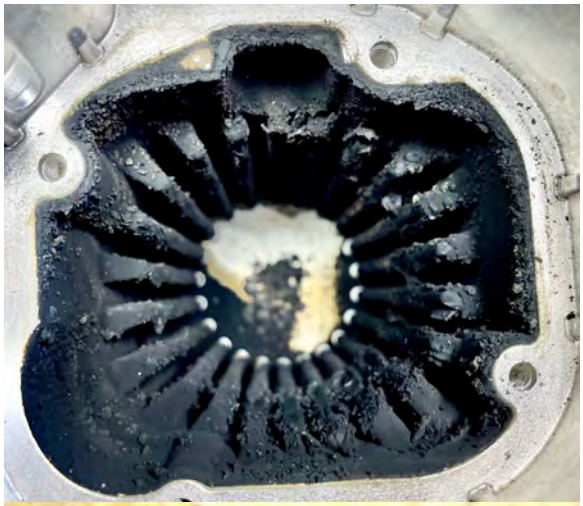
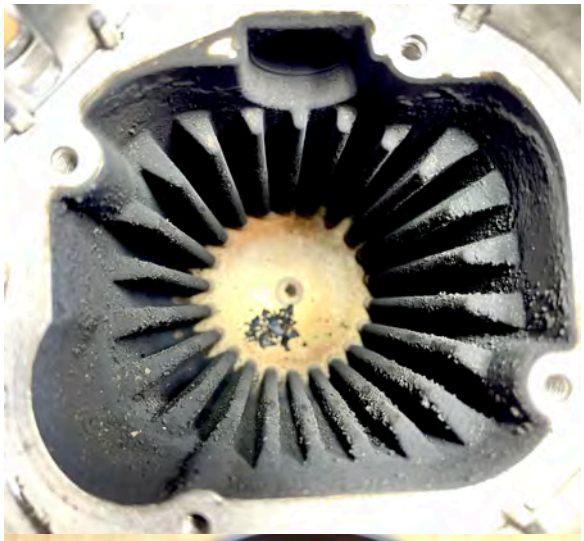
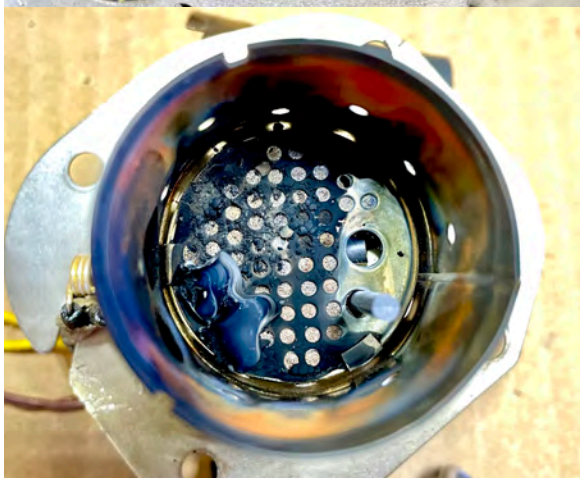
Unadjusted	Adjusted
	
	

	Start	Final	Start	Final
CO%	0.42%	0.44%	0.11%	1.09%
CO_2%	14.68%	14.65%	13.67%	14.36%
O_2%	1.91%	1.29%	3.55%	1.47%
HC (ppm)	13.74	8.88	13.60	13.17
Lambda	1.073	1.045	1.170	1.033
AFR	15.77	15.36	17.19	15.18
Comb. Eff.	98.55	98.52	99.53	96.44

The unadjusted CC showed more carbon buildup on the fins, while the adjusted CC continued to show slight carbon buildup that was uniform on and between the fins. Both BIs began to show signs of slight carbon buildup on the burner mat.

336 Hour Test

(April 14, 2022 - June 7, 2022, average ambient air temp. 74.5°F)

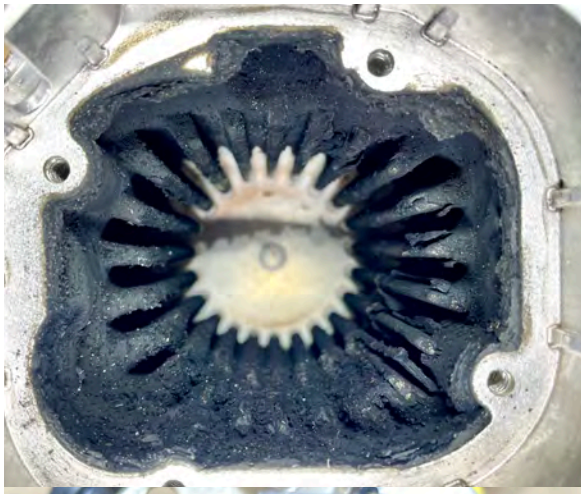
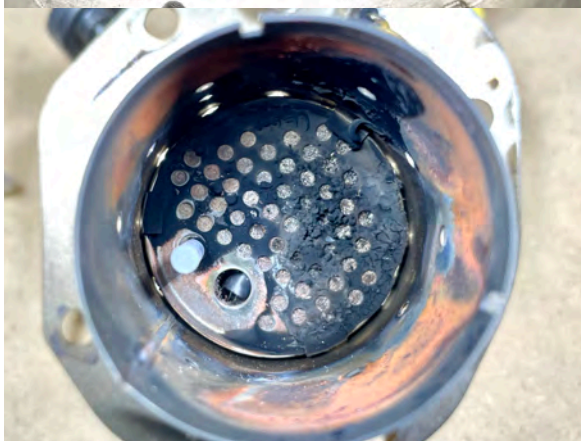
Unadjusted	Adjusted
	
	

	Start	Final	Start	Final
CO%	0.14%	0.20%	0.08%	0.12%
CO_2%	12.66%	13.34%	12.91%	12.50%
O_2%	4.20%	2.99%	3.69%	4.42%
HC (ppm)	14.98	0	0	0.30
Lambda	1.215	1.142	1.189	1.236
AFR	17.87	16.79	17.47	18.16
Comb. Eff.	99.38	99.26	99.64	99.51

Considerable amounts of carbon buildup formed in the unadjusted CC around the fins as well as larger segments of carbon buildup on the BI burner mat. The adjusted CC continued to show uniform coverage of light carbon on and between the fins. The adjusted BI showed minimal additional buildup of carbon.

744 Hour Test

(January 18, 2022 - April 14, 2022, average ambient air temp. 61.8°F)

Unadjusted	Adjusted
	
	

	Start	Final	Start	Final
CO%	0.18%	0.10%	0.09%	0.15%
CO_2%	13.33%	12.93%	12.50%	12.30%
O_2%	3.59%	4.13%	4.82%	4.70%
HC (ppm)	3.24	17.39	3.51	2.79
Lambda	1.170	1.210	1.255	1.254
AFR	17.24	17.77	18.45	18.43
Comb. Eff.	99.31	99.54	99.63	99.39

The 744 hour test showed the unadjusted CC with extensive carbon buildup around the fins. The unadjusted BI also showed carbon buildup around the sides and on the burner mat. The adjusted CC showed continued carbon buildup around the fins, but still having gaps between most all fins. The BI showed a very small amount of carbon buildup on the burner mat.

Interpreting Air-Fuel Ratios and Emissions*

The relationship between the air-fuel ratio and exhaust gases monitored by the analyzer are:

- CO is lowest when the air-fuel ratio is nearly ideal because there is less O2 and C left over. This is due to more complete combustion occurring at stoichiometric ratios. Richer than ideal mixtures cause CO levels to increase; leaner mixtures have little effect.
- CO2 levels are highest when air-fuel ratios are close to ideal, and decrease when the mixture becomes richer or leaner.
- O2 levels are near zero when the air-fuel ratio is near stoichiometric, since most of the O2 consumed in combustion. It remains low with richer mixtures, and increases when the mixture leans out.
- HC is lowest when the air-fuel ratio is ideal because most of the fuel is consumed in combustion. Richer or leaner mixtures, or ignition problems cause HC to increase because of incomplete combustion.

*Source: https://www.bridgeanalyzers.com