

LABORATORY REPORT

**TESTING OF THE LA-MAN
CARBON MONOXIDE FILTER SYSTEM**

SUBMITTED TO:

**LA-MAN CORPORATION
PO BOX 337
100 SOUTH COUNTRY ROAD 300E
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1.0 INTRODUCTION AND SUMMARY

Texas Research Institute, Inc (TRI) has conducted testing on the La-Man Model 820 carbon monoxide filtering system (10-inch cartridges) for its ability to produce Type J. Grade D breathing air according to the Compressed Gas Association (CGA) specifications. The test air was deliberately altered to non-Grade D specifications by the addition of carbon monoxide (CO) to 100 parts per million (ppm).

During the initial testing when temperatures ranged from 18-21 degrees Celsius, CO levels reached 65ppm after 22 hours, indicating a dependency upon temperature of the filter unit's efficiency of removal of CO. However, relative humidity was considered to be well within an acceptable range. The filter unit system was then moved indoors to stabilize and raise the temperature to within operating range of the catalyst.

The test protocol was to filter the test air containing 100ppm CO for 100 hours at a flow rate of 12 SCFM and an operating pressure of more than 100 psi to the system inlet. A reduction in pressure was created by an orifice plate within the filter unit situated at the filter inlet. The purpose of the pressure reduction with the orifice plate was to drop the relative humidity to within the working range of the filter unit.

The fixed orifice produced a pressure drop from 120 to 90 psi and a concomitant drop in relative humidity from 55-75% to 40-60%. Under these conditions with a consistent 100 ppm CO concentration supplied to the filter system, operation of the filter unit continued for at least 75.5 hours. The outlet gas reached a maximum of 17.4 ppm during this period. Testing continued from 75.5-100 hours. No samples were analyzed from hours 76-91, due to overnight operation of the filtering system. At hour 91.5, CO levels had reached 31.2 ppm in the outlet air. Additional samples were taken throughout the remaining 100-hour test, with a final reading of 33.1 ppm.

A system shutdown occurred at hour 75 for ten minutes due to a blown gasket in the La-Man Extractor Model 110. The extractor was replaced with a Speedaire catch-bowl, Model 2Z329A. Samples taken immediately following the down time showed no significant system variance of CO output or removal from the sample previous to the system shutdown.

2.0 METHODS AND PROCEDURES

The apparatus for conducting the test is presented schematically in Figure 1. Compressed air was supplied by a Speedaire Model #5Z017 compressor with an approximate 50-gallon tank. The two-stage compressor is direct drive from a 5HP single-phase motor and is advertised as capable of delivering 17.5 SCFM at 100 psi. The compressor oil recommended by the supplier and used in the test

as Dayton SAE 30 compressor oil. Water removal was accomplished by constant seepage from the bottom of the compressor and/or La-Man Model 110 extractor and Speedaire catch-bowl collector in the airline before regulation of 120 psi into the system. Large volumes of water were routinely extracted throughout the 100 hours, indication that the air was wet.

Compressed air was routed to the test apparatus through a 240 ft ½ inch diameter flexible hose to the La-Man Extractor (110), then to a regulator and finally to a junction proximal to a one-liter stainless steel bomb used for mixing. Carbon monoxide was metered into the junction using a constant flow control valve and verification of flow rates was a Brooks rotometer. The source of CO was a tank of 100% CO regulated at 1600 Kpa.

After the mixing chamber, a second “T” junction was used to route the CO/air mixture to the filter system and to a valved, air-transfer fitting for obtaining samples for the gaseous analytes (total hydrocarbons, CO, CO₂). Downstream from this fitting was an inline sampling filter for determination of oil mist and particulates in the inlet air.

After the sampling site, air was routed through a La-Man Model 107 extractor and then through the filter. Just before and at the bottom of the filter, air was routed to a three-way valve and to a housing containing a Vaisala Model HM114Y combination temperature and humidity probe. The housing had a controlled small leak to allow air to flow past the probe, yet maintain the desired operation pressure. The three-way valve permitted testing of the air before and at the interior of the filter unit’s bottom section. Pressure gauges were placed before and after the filter to monitor operating pressure. During the test the pressure inside the filter was 90 psi and 15 psi exiting the filter. After exiting the filter, the air was routed to the outlet-sampling site for collection of samples for gaseous analytes and oil mists and particulates. Lastly, air was exhausted through a Brooks Model 12-1110-24 rotometer.

During testing, air samples were collected at the inlet and outlet sampling sites. Carbon monoxide, carbon dioxide, total hydrocarbons, oxygen, and methane were assayed by gas chromatography. Carbon monoxide is quantified reliably down to 1 ppm with as accuracy of +/- 2% or +/- 1 ppm, whichever is greater. Oil mist and particulates were determined by a gravimetric method using glass fiber filters to trap the oil mist and particulates.

3.0 RESULTS

Table 1 represents the results of the initial testing where low temperature was determined to have a detrimental effect upon efficiency of the catalyst. Table 2 and 2A and Figure 2 represent the results of the 100-hour experiment. A pre-system check without the controlled input of CO showed the filter unit to be outputting 1 ppm (ambient levels of CO indoors). Over the course of the 100

hours the output ranged from 4 to 31 ppm. The filter operated efficiently for a minimum of 75.5 hours meeting Grade D breathing air specifications.

Relative humidity was kept between 40-60 % as a result of the fixed orifice within the filter unit and the La-Man extractor (110) preceding the test system. This contributed to the successful functioning of the filter by preventing moisture from interfering with the filter catalyst. Excess moisture has been hypothesized for failure of the unit in previous tests.

Temperature was maintained between 20°C (68°F) to 30°C (86°F) throughout the test period and was attributed to the 240 feet of air hose between the compressor and the test system. Extreme temperature fluctuation was prevented by testing the filter indoors in a controlled environment.

Oil mist and particulate samples taken downstream of the after the filter unit showed that the filter removed oil mist and particulates over the test period. Concentrations of 0.15 and 0.40 mg/m³ in the upstream were removed less than <.005 mg/m³.

4.0 CONCLUSIONS

The La-Man Model 820 filtering system with ten-inch cartridges was shown to remove CO from compressed air containing 100 ppm CO. Under specified conditions the unit can operate effectively (i.e. remove CO to less than 20 ppm) for at least 75.5 hours. Maintaining a relative humidity below 90% and a temperature above 20°C (68°F) is considered important for the effective functioning of the filter unit. Relative humidity control was accomplished with a pressure drop across the filter by a fixed orifice on the filter. Temperature control was accomplished by having the system in a normally heated office building.

The unit as tested produced Type 1 Grade D breathing air from a non-Grade D source for 75.5 hours. Carbon monoxide was the only parameter that was out of the specification. The filter unit was not expected to remove out-of-spec CO₂, since this is the product of the catalytic CO oxidation. The removal of methane and total gaseous hydrocarbons was not tested: there Grade D test analytes may not be removed by the filter system. The filter was also effective in removing oil mists and particulates.

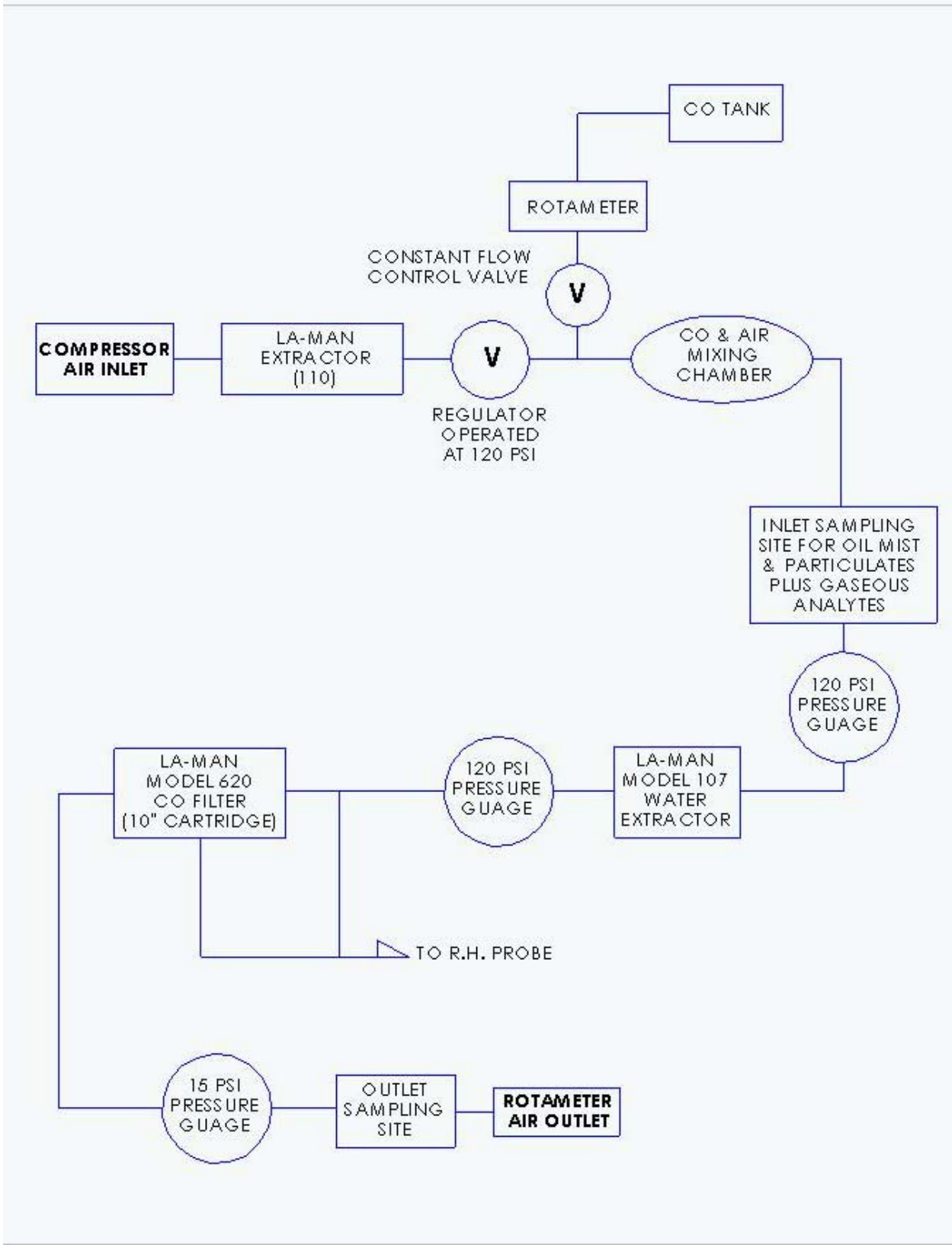


Figure 1 – Test Apparatus Schematic

TABLE 1

Time (Hrs)	RH IN (%)	RH OUT	TEMP IN C°	TEMP OUT C°	THC IN (ppm)	CO IN (ppm)	CO2 IN (ppm)	% O2 IN	THC OUT (ppm)	CO OUT (ppm)	CO2 OUT (ppm)	% O2 OUT	% CO REMOVAL
0.0	90.8	1.0	18.2	17.7	4.8	84.6	351.0	20.9	5.1	5.2	443.0	20.9	94%
0.5	90.8	11.0	19.0	17.8	5.6	92.8	348.0	20.9	4.9	3.5	451.0	20.9	96%
1.0	90.7	6.2	19.0	18.1	5.5	103.0	345.0	20.9	4.9	3.7	461.0	20.9	96%
1.5	89.4	7.7	20.9	19.7	4.9	112.0	352.0	20.9	5.4	5.1	472.0	20.9	95%
4.0	90.7	7.4	21.2	20.0	7.7	105.0	341.0	20.9	5.2	6.3	461.0	20.9	94%
5.0	90.2	8.3	20.5	19.2	5.7	101.0	346.0	20.9	4.8	8.9	448.0	20.9	91%
6.5	90.0	8.8	19.1	17.8	5.9	113.0	321.0	20.9	5.3	14.6	468.0	20.9	87%
21.0	89.8	12.0	20.4	19.1	5.2	137.0	377.0	20.9	5.6	65.0	447.0	20.9	53%
22.0	90.4	14.2	18.2	17.2	5.3	116.0	380.0	20.9	5.4	72.0	444.0	20.9	38%

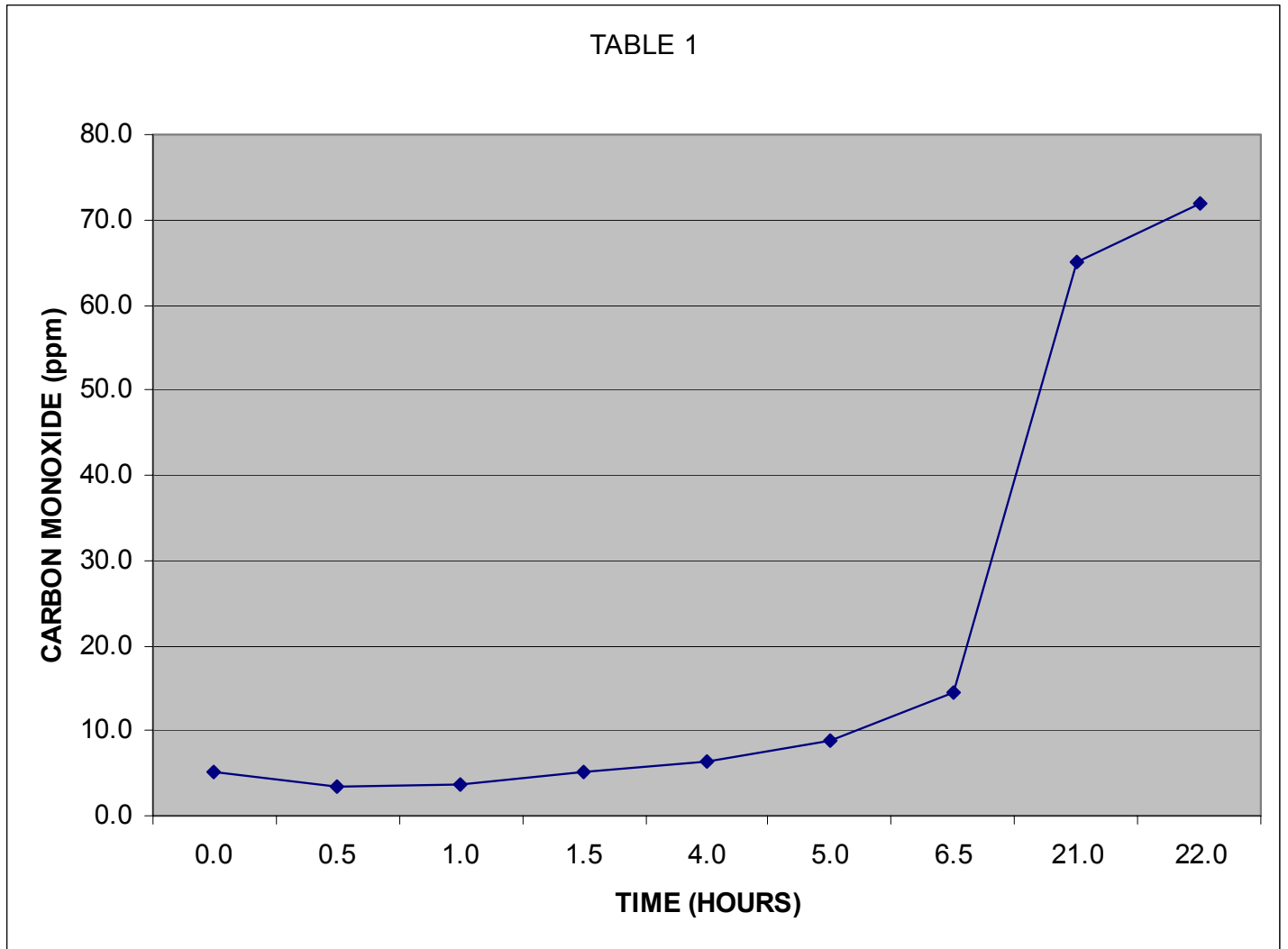


TABLE 2

Time (Hrs)	RH IN (%)	RH OUT (%)	TEMP IN C°	TEMP OUT C°	THC IN (ppm)	CO IN (ppm)	CO2 IN (ppm)	% O2 IN	THC OUT (ppm)	CO OUT (ppm)	CO2 OUT (ppm)	% O2 OUT	% CO REMOVAL
0.0	72.1	44.0	22.4	22.0	5.6	103	349	20.9	5.0	4.4	456	20.9	96%
0.5	72.0	45.1	22.4	21.9	5.8	105	350	20.9	5.0	4.4	466	20.9	96%
1.0	72.4	45.6	21.2	21.6	5.4	107	352	20.9	5.3	5.5	470	20.9	95%
1.5	47.3	47.5	21.1	20.6	5.1	106	350	20.9	5.0	5.9	468	20.9	94%
2.0	77.3	50.3	21.7	20.2	5.2	107	348	20.9	5.1	6.0	472	20.9	94%
3.0	71.2	48.0	22.2	21.8	5.0	101	347	20.9	4.7	5.6	459	20.9	94%
17.5	67.1	50.7	22.0	21.4	4.6	115	357	20.9	4.4	10.7	459	20.9	91%
19.5	70.0	47.2	24.8	24.3	4.9	113	355	20.9	4.9	11.8	456	20.9	90%
21.5	65.4	48.5	23.9	23.6	5.3	107	346	20.9	5.0	11.9	456	20.9	89%
23.5	61.3	44.4	26.1	25.7	5.1	104	342	20.9	4.7	11.5	449	20.9	89%
25.5	55.3	42.2	27.3	27.0	4.6	96	343	20.9	4.7	10.7	438	20.9	89%
43.5	56.9	42.2	23.6	23.3	5.6	119	359	20.9	5.1	16.7	468	20.9	86%
45.5	57.8	44.0	24.4	24.0	5.4	117	356	20.9	5.2	16.2	466	20.9	86%
47.5	65.8	45.8	25.6	25.3	5.0	108	351	20.9	4.7	14.7	452	20.9	86%
49.5	64.4	47.6	25.7	25.3	5.0	109	346	20.9	4.8	10.8	457	20.9	90%
51.5	64.6	47.7	24.3	23.9	4.6	111	347	20.9	5.3	13.4	447	20.9	88%
67.5	57.9	46.5	23.4	22.9	5.1	118	360	20.9	5.1	17.8	464	20.9	85%
69.5	58.5	45.6	26.8	26.2	5.4	115	361	20.9	5.3	17.1	466	20.9	85%
71.5	71.7	55.7	25.3	24.6	5.8	96.7	349	20.9	5.5	15.2	437	20.9	84%
73.5	67.5	54.3	28.2	27.8	6.7	91.1	348	20.9	5.2	15.1	438	20.9	83%
75.5	69.4	55.4	27.8	27.2	5.5	107	345	20.9	5.1	17.4	456	20.9	84%
91.5	68.1	56.5	25.1	24.6	5.7	110	367	20.9	5.5	31.2	448	20.9	72%
93.5	68.7	56.3	25.5	24.9	5.4	110	359	20.9	5.1	31.9	443	20.9	71%
95.5	69.1	57.2	23.2	22.9	4.9	105	349	20.9	4.8	24.7	445	20.9	76%
97.5	76.2	58.7	23.3	22.8	5.2	103	344	20.9	4.9	25.5	445	20.9	75%
100.0	75.4	59.6	23.7	22.6	5.0	107	348	20.9	5.8	33.1	428	20.9	69%

Table 2A

Sample #	Time (Hours)	Oil Mist & Particulate IN (mg/m3)	Oil Mist & Particulate OUT (mg/m3)	Cubic Meters (AIR)
1	2	0.15	<0.002	40
2	2	0.25	<0.002	40
3	2	0.34	<0.002	40
4	1	0.40	<0.005	20
5	1	0.32	<0.005	20
6	1	0.24	<0.005	20
7	1	0.36	<0.005	20