AP42 Section: **9.2.3 Orchard Heaters**

Title: **Comments and background information from 1979 update (latest)**

Supporting Calculations

1. Particulate

Data from testing by Valentine, Fisher, & Tomlinson (V.F.T.)

Personal communication - Jack Nakai

from UC Riverside
UC Davis
Smith-Emery Company

2. SO_x

144 S lb/1000 gal = 0.144 S lb/gal

Pipeline Heater

$(0.144\,S)(0.9\ \text{gal/hr})^{*} = 0.13\,S$

Lazy Flame

$(0.144\,S)(0.75\ \text{gal/hr})^{*} = 0.11\,S$

Return Stack

$(0.144\,S)(1.0\ \text{gal/hr})^{*} = 0.14\,S$

Cone Type

$(0.144\,S)(\quad\ \text{gal/hr})^{*} = 0.14\,S$

* Fuel usage rate used in Pacific Northwest Emission Factor Book

3. CO

disregard MASCO data until better support

Values 4.8
11.3
4.0
8.4
5.9
3.1
37.5 ÷ 6 = 6.2 lb/heater hr

Valentine, Fisher, Jamieson

4. HC

from Air Pollution in Ventura County

Evap losses in Heaters

2 gal (early March – mid November)

× 7.1 lb/gal

14.2 lb

½ gal (mid Nov – early March)

× 7.1 lb/gal

1.8 lb

16 lb/heater/year

5. NO_x – negligible as per "Air Pollution in Ventura County"

Sheu - Y-1 Vaporizer with Return Stack

PARTICULATE EMISSIONS OF ORCHARD HEATERS IN GRAMS/MIN

Fuel lb./hr.	Oper. Pr. psi	Masco*	Doubleco	Sheu*			Mobil Oil
				Return Stack	Large Cone	230-A	Tree Heet*
2.5				BHM	BHM	.06	
3.0				"	.04	.06	
3.5				.02	.03	.06	
4.0				.02	.03	.07	
4.33	50	.045					
4.5				.02	.03	.15	
5.0			.25	.03	.03	.24	
5.5				.04	.04	.5	
5.67	75	.033					
6.0			.65	.04	.05	.7	
6.5			1.0 or >	.05	.17	.9	
6.84	125	.057					
7.0				.07	.2	1.1	
7.5				.18	.4	AHM	
8.0				.37	.7	AHM	
							.38**

* Masco - By UC Riverside
Sheu - By UC Davis
Tree Heet - By Smith-Emery

**Solid Block (no fuel control)

BHM - Below Heater Minimum

AHM - Above Heater Maximum

Received from
Ted Waka

Emissions Sim/Impinger

Fuel lb/Hr	Masco	Return Stack	Large Cone	Lazy Flame	Spot Heater & Nozzle Fired	Tree Heat
2.5				.06 TW		
3.0			.04 TW	.06 TW		
3.5		.02 TW	.03 TW	.06 TW		
4.0		.02 TW	.03 TW	.07 TW		
4.33	0.045 TW					
4.5		.02 TW	.03 TW	.15 TW		
5.0		.03 TW	.03 TW	.2 TW		
5.23		.04 TW	.04 TW	.5 TW	0.066 [2]	
5.5						
5.67	0.033 TW					
5.79					0.076 [5]	
6.0	0.131 [7]	.04 TW	.05 TW	.7 TW		
6.24					0.043 [1]	
6.5		.05 TW	.17 TW	.9 TW		
6.84	0.057 TW					
7.0		.07 TW	.2 TW	1.1 TW		
7.5		0.18 TW	0.4 TW		0.009 [6]	
8.0		0.37 TW	0.7 TW			
8.7					0.033 [3]	
10		0.495 [4]			-	
						0.38 TW

Valentine, Fisher & Tomlinson

1. Spot Heaters - Yakima, Washington
   1/7/70

2. Floden, Inc. - Yakima Wash Nozzle Fired
   1/9/70

3. Braders Heaters, Inc. - Yakima, Wash
   1/7/70

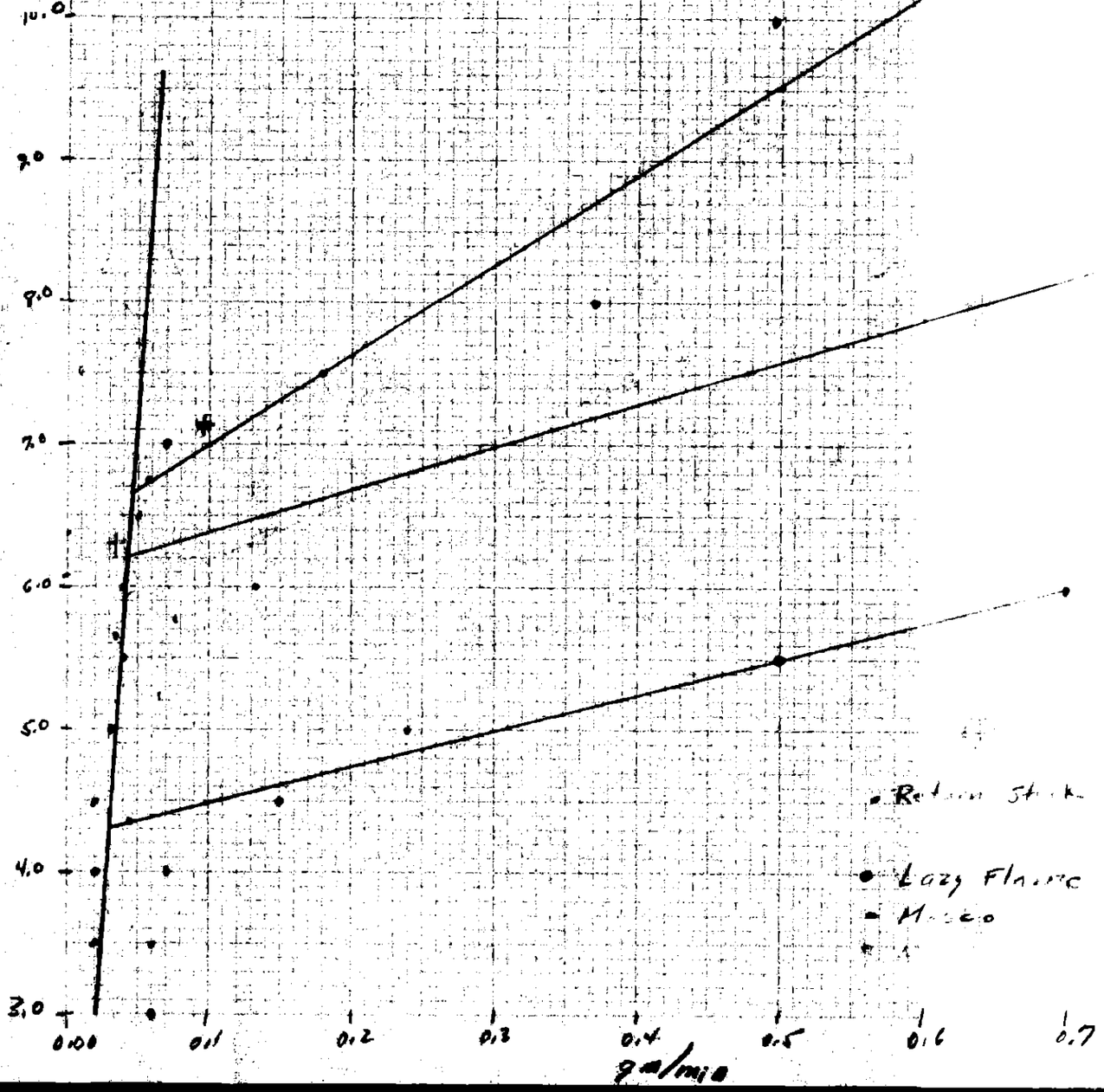
4. Spot Heaters (Return stack oil bath fired)
   1/8/70

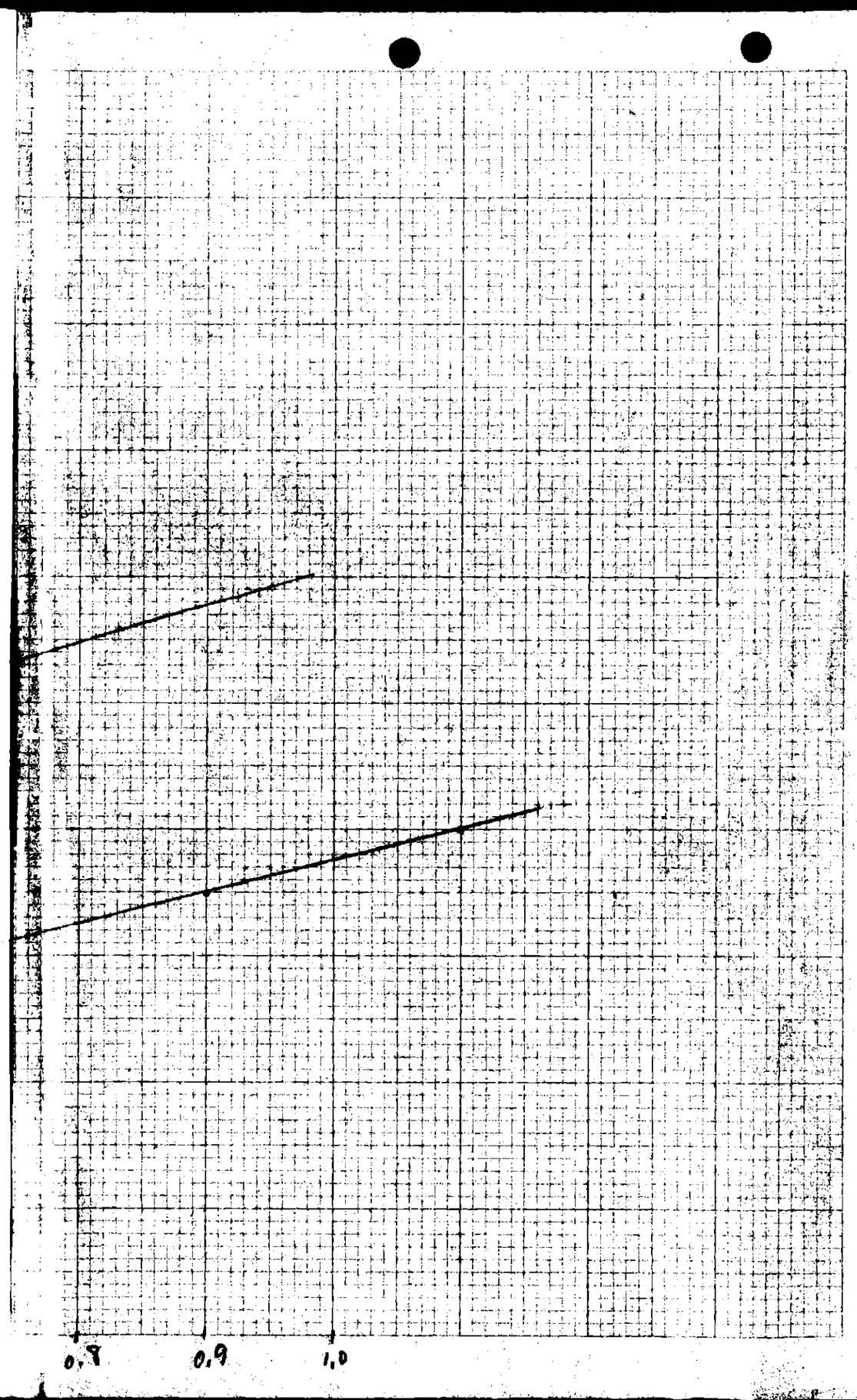
5. Spot Heaters - Yakima
   1/6/70

6. Orchard Rite Nozzle Fired
   1/7/70

7. Masco Junior - Manhassat Specialty Co.

Orchard Heater Emissions





x		y = mx + b	$(y_i - (mx_i + b))^2$
.07	7.0	7 - .07m - b	$49 - 14b + b^2 - .98m + .14mb + .0049m^2$
0.18	7.5	7.5 - .18m - b	$56.25 - 15b + b^2 - 2.7m + .36mb + .0324m^2$
0.39	8.0	8 - .39m - b	$64 - 16b + b^2 - 5.92m + .74mb + .1369m^2$
0.5	10.0	10 - .5m - b	$100 - 20b + b^2 - 10m + 1.0mb + 0.25m^2$
			$269.25 - 65b + 4b^2 - 19.6m + 2.24mb + .4242m^2$

$$\frac{\partial f}{\partial m} = -19.6 + 2.24b + \cancel{.35}\ 0.85\,m$$

$$\frac{\partial f}{\partial b} = -65 + 8b + 2.24m$$

$$\frac{\partial f}{\partial m} = 0 \qquad 2.24b + \cancel{.35}\ .85\,m = 19.6$$

$$\frac{\partial f}{\partial b} = 0 \qquad 8b + 2.24m = 65$$

$m = 6.3$

$b = 6.36$

$y = mx + b$

$y = 6.3x + 6.36$

.3
1.1
1.4
3
5.6
11.4

.3
1.1
1.4
3
5.6
11.4

.0025
.0209
.04
.16
.49
.7211

x	y	dev: $y - mx - b$	
0.05	6.0	$6 - .05m - b$	
0.17	6.5	$6.5 - .17m - b$	
0.2	7.0	$7 - .2m - b$	
0.4	7.5	$7.5 - .4m - b$	
0.7	8.0	$8 - .7m - b$	

$$\frac{\partial f}{\partial m} = -22.8 + 3.04b + 1.44m$$

$$\frac{\partial f}{\partial b} = -70 + 10b + 3.04m$$

$$\frac{\partial f}{\partial m} = 0 \qquad 3.04b + 1.44m = 22.8$$

$$\frac{\partial f}{\partial b} = 0 \qquad 10b + 3.04m = 70$$

$$m = 3$$

$$b = 6.09$$

$$y = 3x + 6.09$$

Particulate Emissions from Oxford Heaters

Emissions — lb/hr/100 Acres

120
100
80
60
40
20
0

0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

Fuel Usage Rate — Mgal/hr

Spot - Yakima (V.F.I.

10 lb/hr

552 SCFM

0.35 % CO

$\rho = \frac{PM}{RT} = \frac{(1)(28)}{(0.73)(530)}$

$\rho = 0.072$

$w = (60)(0.0035)(552)(0.072) = 8.4$ lb CO

10 lb/hr Fuel

Spot - Yakima (VFI)

5.79 lb/hr

453 SCFM

0.30 % CO

$w = (60)(0.0030)(453)(0.072) = 5.9$ lb/hr

5.79 lb/hr

Orchard Rite (VFI)

7.5 lb/hr

482 SCFM

0.15 % CO

$w = (60)(0.0015)(482)(0.072) = 3.12$ lb CO

7.5 lb/hr

Sweet - Yakima (V 1 1)

448 SCFM

6.24 lb/hr

CO 0.25 %

wt : (60)(0.0025)(448)/(0.0772) = 4.8 lb CO

6.24 lb/hr

Wenatchee - Penco (V F 1)

437 SCFM

.823 lb/hr

CO 0.6 %

wt = (60)(0.006)(437)(0.0772) = 11.3 lb CO

5.23 lb/hr

Moxee - Finley Biomass (V F T)

467 SCFM

8.7 lb/hr

CO 0.2 %

wt = (60)(0.002)(467)(0.0772) = 4.0 lb CO

8.7 lb/hr

Results of tests with Masco Heater in burning tower at Riverside, each test 45 minutes.

Operating pressure lbs.	Fuel used lbs.	Particulate				Hydrocarbon		Carbon Monoxide	
		Sample volume cu. ft.	g/min.	µg/cu.ft.	µg/cu. meter	Steady state conc. ppm	Pounds/ton fuel used	Steady state conc. ppm	Pounds/ton fuel used
50	3.25	123	.045	25	880	1000	1.0	10	30
75	4.25	129	.033	17	600	1500	1.9	15	41
125	5.12	136	.057	27	940	1000	1.0	10	25

Received from Ted Wakai from E F DARLEY UC, RIVERSIDE

Masco

	fuel rate lb/hr	[illegible] lb/lb fuel	lb/hr
CO	4.33	30	0.065
	5.67	41	0.016
	6.83	25	0.085

Masco Jumper (VF-1)

6.0 lb/min fuel

[illegible] CO

532 SCFM

wt = (60)(0.000028)(532)(.072) = 0.0646 lb CO

Source	Fuel Rate lb/hr	Fuel Rate Gal/hr	Emission Rate lb/hr CO
Spot - Yakima	6.24	0.88	4.8
Nozzle - Fuel Flodin	5.23	0.74	11.3
Nozzle - Fuel Broders	8.7	1.23	4.0
Spot - Yakima	10	1.41	8.4
Spot Yakima	5.79	0.82	5.9
Orchard Rite	7.5	1.06	3.1
Masco	4.33	0.61	0.06
	5.67	0.80	0.02
	6.83	0.96	0.08
[illegible] Yuma	6.0	0.85	0.05

File and - emission factors

KERN COUNTY HEALTH DEPARTMENT

1700 Flower Street
P. O. Box 997
Bakersfield, California 93302

OWEN A. KEARNS, M.D., M.P.H.
Director of Public Health
Air Pollution Control Officer

6.9
6.1

July 1, 1975

Charles C. Masser
National Air Data Branch
U. S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Dear Mr. Masser:

We have received the unedited corrections for AP - 42 and have a question regarding orchard heater emissions in Section 6.9-1. The emission factors for hydrocarbons have been changed to read lb/htr-yr, while the other pollutants still read lb/htr-hr. Is this correct? If so, what is a heater-year? Is it one heater burning continuously for one year or merely for one season?

Thank you for your immediate assistance in this matter.

Sincerely yours,

Owen A. Kearns, M.D., Health Officer
Air Pollution Control Officer

Larry Landis

Larry Landis, R.S.
Air Sanitation Chemist

LL:ld

I called 7/9/75 and left ... of Mr. Landis' question.

C Masser

SCHEU PRODUCTS COMPANY

P. O. BIN 1 • 297 STOWELL STREET • UPLAND, CALIF. 91786 • 714/982-8933

LELAND C. SCHEU
ALLYN B. SCHEU

March 27, 1969

Mr. Steve Molnar
State of California - County of Ventura
County Health Department
3147 Loma Vista Road
Ventura, California 93001

Dear Mr. Molnar:

Thank you for your letter of March 11th, requesting literature on our oil fired orchard heaters, carbonaceous discharge rate of heaters and list of discontinued heaters. I am enclosing a brochure illustrating our four conventional heaters. Also, I am enclosing a brochure illustrating our new automated heating system which will be going to market this coming year.

Of the four conventional heaters, only three are sold in California. The Sliding Cover Heater has practically been discontinued and is only sold where there are no air pollution regulations. The Return Stack, Large Cone and 230-A Stack Heaters have been manufactured for over 30 years. There have been no changes in the combustion chamber which would alter the combustion characteristics. Our more recent carbon emission tests were performed by the University of California at Davis by Arthur S. Leonard in 1950. A summation of these tests are as follows.....

Burning Rate in lb. Per Hour	Return Stack Heater Carbonaceous Output in Grams Per Minute	Large Cone Heater Carbonaceous Output in Grams Per Minute	230-A Heater Carbonaceous Output in Grams Per Minute
2.5	Below Heaters Min.	Below Heaters Min.	.06
3	" " "	.04	.06
3.5	.02	.03	.06
4	.02	.03	.07
4.5	.02	.03	.15
5	.03	.03	.24
5.5	.04	.04	.5
6	.04	.05	.7

Burning Rate in lb. Per Hour	Return Stack Heater Carbonaceous Output in Grams Per Minute	Large Cone Heater Carbonaceous Output in Grams Per Minute	230-A Heater Carbonaceous Output in Grams Per Minute
6.5	.05	.17	.9
7	.07	.2	1.1
7.5	.18	.4	Above Heaters Max.
8	.37	.7	Above Heaters Max.

The above figures were taken from a curve which was placed between various readings. Therefore, they are probably not accurate to the .01 of a gram, but probably more to a .02 of a gram.

As to the list of discontinued models, our line of heaters has not changed in the last 30 years. Prior to that there had been several other heater types manufactured, however, due to the number of years that have passed it would entail a great deal of research to obtain this list. The industry, of course, has produced and discontinued many heater models over the years. Again, this list would be time consuming to develop in that our records are somewhat incomplete as to happenings in the industry 20 to 30 years ago. I believe that probably your best source on all heaters used, whether discontinued or otherwise, would be the San Bernardino Air Pollution Office.

The National-Riverside Company, which you directed a similar request to, was acquired by us in about 1962. Their line of heaters, from that point forward, has been practically identical to ours. We have incomplete records on the company's heater models prior to that date.

As to the heaters illustrated in our Automated System brochure, this is a new system utilizing only the Return Stack and Large Cone Heaters. Our laboratory tests indicate these two heaters on the Automated System, as compared to their counterparts in the conventional heaters, have superior performance. As to carbon emission, as yet we have not confirmed these findings with an independent laboratory. This will take place in the very near future and when these results are confirmed, we will forward them to you.

I hope the above information will supply most of your requirements. Sorry that I do not have the balance, however, if I can be of any further assistance in any way, please do not hesitate to contact me.

Sincerely yours,
SCHEU PRODUCTS COMPANY

Allyn B. Scheu

ABS:cf
Enclosure: OH-4; Automated Brochure

Hammarle

State of Maryland

DEPARTMENT OF HEALTH AND MENTAL HYGIENE
Neil Solomon, M.D., Ph.D., Secretary
ENVIRONMENTAL HEALTH ADMINISTRATION
610 N. HOWARD STREET • BALTIMORE, MARYLAND 21201 • Area Code 301 • 383- 3122/3147
2287

July 27, 1973

Director
Monitoring and Data
Analysis Division
Office of Air Quality
Planning and Standards
Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Dear Sir:

REFERENCE: AP-42 (April 1973)

Could you review the hydrocarbon emission factors given for orchard heaters in Table 6.9-1? It seems highly unlikely that the evaporative HC emissions would substantially exceed the fuel usage rate for orchard heaters given in Figure 6.9.2.

Very truly yours,

W D Kebschull

W. D. Kebschull
Public Health Engineer
Bureau of Air Quality Control

WDK:pmf

File AP-42 #6.9

February 5, 1979

Mr. Larry Landis
Kern County APCD
1601 H Street
Bakersfield, California 93302

Dear Mr. Landis:

Thank you for bringing our attention to errors in AP-42 section 6.9, "orchard Heaters". Present evaporative hydrocarbon emission factors are based on the weight of fuel consumed as shown in reference 1 of the section. Relevant parts of this reference are enclosed. We are aware that this method of estimation may not be totally accurate and, we will revise the emission factor when new data become available to us.

In the meantime, footnote 'f' to Table 6.9-1 is being revised to read:

> Reference 1. Evaporative losses only. Hydrocarbon emissions from combustion are considered negligible. If units are part of a pipeline system, evaporative hydrocarbon losses are negligible.

Also footnote 'c' refers to all sulfur oxides emission factors. These and any other revisions to this section will appear in supplement 10 to AP-42.

Sincerely yours,

Audrey McBath
Environmental Engineer
Source Analysis Section, AMTB

Enclosure

AMTB:SAS:AMACBATH:eb:rm.776NU:ext.5285:2/5/79

MIDWEST RESEARCH INSTITUTI
Suite 35
401 Harrison Oaks Boulevar
Cary, North Carolina 27513-241
Telephone (919) 677-024
FAX (919) 677-006

Date: April 13, 1995

Subject: Background Information for the Revision of AP-42 Section 9.2.3, Orchard Heaters
Review and Update of Food and Agricultural Sections, Chapter 9, AP-42
EPA Contract No. 68-D2-0159, Work Assignment 2-03
MRI Project 4602-03

From: Tom Lapp

To: Dallas Safriet
EMAD/EFIG (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

The current AP-42 Section 6.9, Orchard Heaters, was published in July, 1979 and was based, to a large extent, on information from Ventura County, California. Efforts were made to obtain more recent data to use as a basis for the update of the existing section. These efforts centered on the two States most likely to use orchard heaters to the largest extent, California and Florida. Each of these States was contacted to obtain any new emission test data that could be used to update the existing emission factors.

The Florida Department of Environmental Protection, (Ms. Tammie Egan), was contacted for any emission tests or other information available in Florida on emissions from these sources. According to this source, the general use of orchard heaters is illegal in Florida. They can be used if a special permit is obtained in advance but no special permits have been issued in recent years for this use. Ms. Egan suggested that we contact the State of Georgia for any information they may have. Orchard heaters are used to some extent in that State. We attempted to contact the source suggested by Ms. Egan but repeated telephone messages were not returned.

Mr. Richard Baldwin and Ms. Gennie McGaugh of the Ventura County, California Air Pollution Control District (APCD) were contacted for any more recent emission test data or emission information on orchard heaters. Ms. McGaugh stated that orchard heaters are used, on occasion, in Ventura County and supplied MRI with a copy of the agricultural fuel combustion appendix of the 1994 Ventura County Air Quality Management Plan. Mr. Baldwin, Air Pollution Control Officer for Ventura County APCD, has many years of experience with air quality regulations. He was not aware of any new information and suggested that MRI contact sources in the California Air Resources Board (CARB).

Mr. David Todd is a member of the emission source testing group in CARB and told MRI that he was not aware of any emission test reports since the late 1970's. Mr. Wayne Clark, San Joaquin Unified Air Pollution Control District (SJUAPCD) in Fresno, was contacted and stated that orchard heaters are not used anymore in the SJUAPCD because of the prohibitive fuel costs to operate the heaters. In addition, he was not aware of any new test reports.

The 1994 agricultural fuel combustion appendix supplied by Ms. McGaugh addresses the estimated annual emissions for Ventura County resulting from fuel combustion in various agricultural categories. One category, CES 47233, is for orchard heaters. The 1994 annual estimate was derived using the existing 1979 AP-42 emission factors, Ventura County acreage and heater usage data, and National Weather Service data. The 1979 emission factors were used because more recent data are not available. According to this appendix, orchard heaters are typically used for 4 hours per night. During 1990, the heaters were used on four nights or an annual total usage of 16 hours per heater.

Recommendation: Information derived from Florida and California indicates that more recent emission test data are not available to update the 1979 emission factors currently published in AP-42, 4th Edition. In addition, information obtained from California and Florida indicates that usage of these heaters occurs for about 4 hours per night and the annual frequency of usage is very low, if any, and very sporadic.

It is recommended that the current AP-42 Section 6.9 be renumbered to Section 9.2.3 and included in the 5th Edition Supplement, without modification. If no additional data become available, the inclusion of this section in future editions should be reconsidered based on the overall annual usage frequency.

ACTIVITY 1
FUEL COMBUSTION
AGRICULTURAL

CES CATEGORY

47233 Orchard Heaters

DESCRIPTION

This activity is used to compile the combustion and evaporation of fuel oil from orchard heaters.

TOTAL ACTIVITY EMISSIONS

	TOC	ROC	NOx	TSP	PM10	SO_2	CO
Planning (tons):		0.0	0.0				
Annual (tons):	132.9	110.7	0.0	2.8	2.8	14.9	2,126.7

TEMPORAL DISTRIBUTION

Daily: Primarily nightime activity for four hours.
Weekly: Uniform activity seven days a week.
Annual: The annual activity is during the winter months, generally Nov. 15 - Feb. 15.

SPATIAL DISAGGREGATION: Agricultural Acreage

PROCESS RATE: (Heater-Year)

Annual
88,611

EMISSION FACTORS: (pounds per heater-year)

TOG = 3.0
ROG = 2.49

PM = 0.004 X 16 hrs = 0.064
CO = 3.000 X 16 hrs = 48.00
SOx = 0.021 X 16 hrs = 0.336

ORGANIC REACTIVE FRACTION: 0.8331 (Profile #504)

PM10 FRACTION: 0.9760

METHODOLOGY

The number of orchard heaters was derived from 1990 fruit and nut acreage data obtained from the University of California Cooperative Extension utilizing estimates on the number of heaters per acre and the percent usage of heaters provided by the agricultural commissioner. The

emissions were computed using emission factors from AP-42 and adjusted to reflect a yearly rate. The TOG emission factor is an ARB staff estimate.

ASSUMPTIONS

1. Heaters operate 4 hours per frost night. In 1990 heaters were used on 4 nights, thus 16 heater-hours per year.

2. Farm Advisor assumes 15 heaters/acre and 50 percent of total crop acreage protected with 20 percent of the protected acres using orchard heaters.

3. Total acres of fruit and nuts farmed in 1990 was 59,074.

REFERENCES

1. California Air Resources Board; "Methods for Assessing Area Source Emissions in California"; December 1982.

2. "Ventura County Cropland History 1973-1987"; University of California Cooperative Extension.

3. National Weather Service; "Annual Report of Fruit Frost Activities (1989-90 Season)."

Ventura County
Air Pollution
Control District

669 County Square Drive
Ventura, California 93003

~~805/654-2780~~
tel 805/645-1400
fax 805/645-1444

FAX

date: 2/15/95

pages to follow: 2

to: Tom Lapp

Midwest

from: Genie McGaugh

comments:

original will follow

original will not follow

FAX
916-
677-0065

Research:
John Holmes
916 445-0753

Source Testing:
Peter Venturini
916 445-0650