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Investigating Sources Of Hexane Emissions

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THE SUBJECT OF this paper is, I'm sure, of as much interest to oil mill superintendents and operators, as it was to the Environmental Protection Agency. I hope that our research will be of some use to the vegetable oil industry. We understand that one company is making plans for recovering solvent where presently no attempt is being made, possibly due, in part, to our efforts.

Let me say just one thing about who we are and what we were doing. The Research Triangle Institute is a not-for-profit research group that was contracted with the U.S. EPA from approximately December 1978 through May 1980 to develop new source performance standards for volatile organic compounds (in this case hexane) and particulate emissions for the vegetable oil industry. Work was terminated in May of 1980 and no standards were developed or recommended. These standards were to affect only new plants or plants that underwent major reconstruction, but such a standard could have provided guidance to individual states in regulating both new and existing vegetable oil plants. This paper does not, however, represent EPA policy and the author is fully responsible for the presentation and interpretation of the data.

Testing Program Design

Early in the contract soybean mills were selected as the target industry. No testing was performed at other oilseed mills. However, those of you working with cottonseed, sunflower seed, or peanuts should find our results of interest, too.

The EPA testing program was designed to find out how much hexane was being lost at various points in the process. A meal sampling program was undertaken with the idea that a standard might be developed that would place a limit on the hexane content of the meal exiting the desolventizer-toaster (DT). As will be discussed in a moment, the meal sampling program did not provide data that accurately reflected solvent losses. It did, however, provide useful information on where hexane is being lost. Noel Myers (see report, July issue) visited most of these plants while we were collecting meal samples and should provide an idea in his paper of what can and is being done by companies to minimize solvent losses.

Meal Sampling and Analysis

EPA's Emission Measurement Branch (EMB), within the Office of Air Quality Planning and Standards (OAQPS), developed both a meal sampling routine and an analytical procedure based upon the work of Dupuy (1,2) and Wan et al. (3), the latter here at Texas A&M University. From June 18 through August 10, 1979, RTI and another EPA contractor visited eight soybean plants to collect meal samples. These eight soybean plants were sampled, each for seven hours, with triplicate samples taken hourly at each sampling point. The sampling points of interest were the meal discharges from the DT, meal dryer, meal cooler, and milling, plus appropriate points in the edible flour systems.

Earlier, solvent emissions tests had been performed at two plants: one during December 1978 and another during March 1979, when meal samples were also collected. The December 1978 meal sampling was neither as extensive nor as systematic as that described above, and the results are not considered to be valid, partly due to it being the first test and bugs needed to be worked out of the system.

Table I summarizes the testing program. A range of plant sizes and ages was selected. Three of the plants produced edible flour in addition to soybean meal. All but two plants are located in the Midwest, and all process only soybeans.

Table II summarizes the results of the meal sampling and analysis program. There is a weak statistical association between the overall reported losses of solvent and the measured solvent residue in the meal following the DT. This is believed to be more a reflection of the difference between reported loss and actual loss during sampling than a lack of association between meal residual

and overall plant solvent loss. The soybean companies provided solvent loss records that were based on a two-week to one-month average. Daily hexane inventories typically do not reflect usage. The two plants with the largest reported hexane losses are plants that produce edible soy flour. Plant D stands out from the others. This plant must not have been operating normally at the time of sampling. The hexane residual in the DT meal itself equals a solvent loss of nearly one gallon per ton of soybeans.

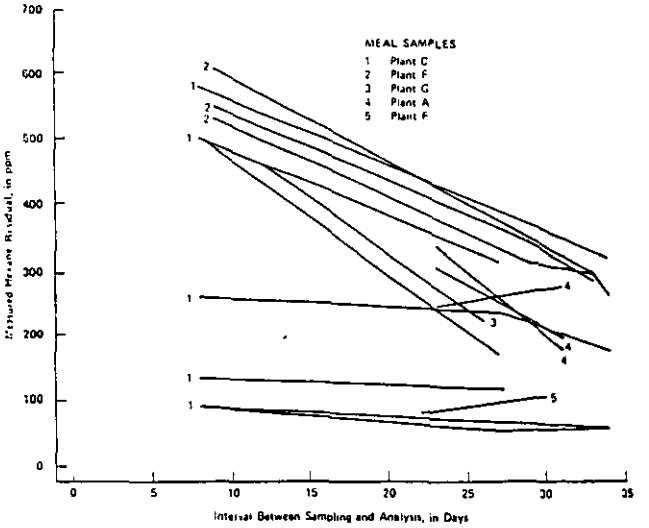
Before making any further judgement about these results one important fact must be mentioned. After the meal samples were collected they were then chilled and stored until analysis would be performed. The problem is that most samples were not analyzed for a month or more. We may have lost some valuable data because of the delay. However, I think we can salvage some information from these meal samples.

Fifteen triplicate samples were analyzed at different times. For example, there were a few DT samples analyzed about eight or nine days after the samples were collected. Other samples taken at the same time and place were analyzed three to four weeks later and almost without exception those analyzed later showed lower hexane residuals. As you can see in Figure 1 there appears to be a definite trend downwards with time. Another interesting observation is those samples with higher initial residuals showed a more dramatic loss, or reduced detection, of hexane after additional storage.

EPA and another contractor investigated this apparent degradation of hexane in soybean meal and found under laboratory conditions that the hexane was not lost after storage periods of a month or more. There was not a problem of leaking bottles. They concluded that something about the solvent extraction and desolventizing process itself created certain conditions where the hexane was modified or bound to the meal so that it was not detected under analysis.

This discussion about analysis and sampling is meant to support the idea that the residuals reported in Table 2 are probably lower than the actual levels. How much below the actual levels

FIGURE 1:
Effect Of Storage On Measured Hexane Residual
(triplicate samples analyzed after different storage periods)



we cannot say. However, we should be able to make some reasonable judgements about what the test results mean. Additional information that we should look at, along with the meal residuals data, are the hexane emission results. The vents sampled were the 1) main vent following a mineral oil scrubber, 2) the dryer exhaust stack, and 3) the cooler exhaust stack. We are fairly confident that the results reflect the actual levels found at the time of testing.

Table 3 does show a few things, I believe. First of all, the main vent when properly sized and controlled by a mineral oil system does not contribute greatly to the overall solvent losses. Unfortunately, there were some sampling equipment problems with

TABLE I — Summary Of Soybean Plant Tests

Plant	Approximate Size Tons/Day	Time of Visit	Meal Samples	Stack Sampling, Hexane	Waste Water Samples	Oil Samples
A	<1,000	Summer 1979	X			
B	<1,000	Summer 1979	X			
C	1,500-2,000	Summer 1979	X			
D	>2,500	Spring 1979	X	X	X	X
E	>1,000	Summer 1979	X			
F	>1,000	Summer 1979	X			
G	1,500-2,000	Summer 1979	X			
H	1,500-2,000	Summer 1979	X	X		X
I	1,500-2,000	Summer 1979	X			
J	>1,000	Winter (1978-79)	X	X	X	

TABLE II — Meal Sampling Results

Plant	Reported Hexane Loss (gallons/ton seed)*	Total Number of Samples Per Site	Average Measured Hexane Levels, PPM In Soybean Meal						
			DT	Dryer	Cooler	Milling	Flash Desolventizing	Cooling	Final Edible
A	0.3	21	220		110	95			
B	1.75	21	390	360	345	55	1,760	1,165	
C	0.4	21	265		110	80			
D	0.85	15	3,265	1,665	1,500	930			
E	2.2	21	415	240		165	495		225
F	0.9	21	95a			105a	3,800b/575c	495	55
G	0.9	21	265		235	155			
H	0.3	21	170	105	105	95			
I	0.5	21	880	600	695	415			
Jd	0.75	6	890	665	585				

a Only 3 samples collected. b Post flash tube, 15 samples. c Post full desolventization, 6 samples. d Many fewer samples, great variation in duplicate samples.

*Provided by soybean plant representative.

NOTE: Conversion Factor—100 ppm = 0.03 gallons of hexane residual/ton of soybean processed.

testing the main vent at Plant H and the resulting data for the main vent are not presented for they are invalid.

The dryer vent data are critical to understanding where hexane is lost. Again the testing program had shortcomings in that one plant could not be tested for dryer hexane emissions due to operating and design features. Looking at the results from Plants J and D we see greatly different estimates of hexane emissions. I believe these emission are in proportion to the amount of hexane that is being carried out of the DT. Plant D had high levels of hexane in DT meal. This implies that the DT was not effectively removing the hexane and would also explain why so little hexane was found in the main vent, given that the two solvent recovery systems at Plants J and D are designed for equal efficiencies. All cooler vents showed little hexane being driven off the meal in the cooler.

TABLE III — VENT STREAM TEST RESULTS

(Gallons Solvent Emitted/Ton Soybean)

MAIN VENT (following mineral oil scrubber)

Plant J	Plant H	Plant D
0.02	Sample problems	0.01
0.03	No reportable data.	0.01
0.05		0.01
0.05		0.02
0.04 avg.		0.01 avg.

DRYER

Plant J	Plant H	Plant D
0.04		
0.03		
0.04	NOT	0.28
0.02	TESTED	0.50
0.02		0.36
0.03 avg.		0.38 avg.

COOLER

Plant J	Plant H	Plant D
0.03		0.03
>0.01	0.004	0.02
>0.01	0.005	0.004
0.01	0.005	0.001
>0.01	0.006	0.002
>.01 avg.	0.005 avg.	0.03 avg.

Interpretation

Returning to the meal sampling results and in light of the vent results I will attempt to make some judgements as to their meaning. The meal collected from the discharge end of the DT shows hexane contents ranging from 0.03 to nearly one gallon per ton. If we look just at those plants that appear to have been operating normally, i.e., throw out Plant D for the reasons mentioned earlier, and exclude plants that produce flour, the range is from .05 gallons to .25 gallons per ton. In other words, from 15 per cent to 50 per cent of the total reported loss was found in the meal exiting the DT. These estimates are probably low because of the storage problem already discussed. Thus, under steady state conditions, the meal is carrying away a sizeable portion of the total hexane loss, but probably not a great majority of the loss.

Another interesting point is the average percentage loss of hexane across the dryer. On the average, approximately one-third of the hexane residual was lost after passing through the dryer. This may not be too significant in terms of total solvent loss, but in the case of Plant D it was over four-tenths of a gallon, and this is confirmed by the nearly four-tenths of a gallon that was found at its dryer vent. So under conditions where the DT is not efficiently desolventizing, a large amount of hexane apparently will be driven off in the dryer. Not having studied the stacked cooker or even Schnecken tubes, as found in many cottonseed oil mills, I cannot say if this is likely to happen in these types of dryers, but I would assume hexane would continue to be driven off in significant amounts if DT's are not efficiently desolventizing.

Where is the remainder of the solvent going? If we can account for only 50 per cent of the hexane in the meal exiting the DT and another five per cent, let's say, coming from the vent system, there need to be other places where the hexane is lost. Some is not recovered from the oil, but our tests found only trace amounts in

the crude oil. Likewise, wastewater was tested at two plants and only traces were detected. There appears to be no reason for hexane to be lost via oil or wastewater under normal conditions in a well designed plant.

What remains is the contribution of fugitive emissions and shutdown or breakdown losses to overall plant losses. In our attempts to add up the admittedly crude estimates of hexane losses via meal, main vent oil, and wastewater, we assigned additional hexane losses of 20 to 25 per cent for fugitives and shutdown and breakdowns. It could be even higher, for all these assigned estimates should reflect well designed and operated solvent extraction mill.

A plant that is losing more than one gallon of hexane per ton of seed is definitely open for improvements in one or more of the following areas:

1) desolventizing,
2) vent system,
3) oil desolventizing,
4) maintenance of seals, gaskets, valve stems, etc.,
5) purging systems with solvent recovery.

I will leave to the engineers and plant managers the task of improving solvent recovery with plenty of help from escalating prices for solvent. I hope the information presented here will prove to be valuable.

REFERENCES

1. Dupuy, H.P., and S.P. Fore, JAOCS 47:231 (1970).
2. Fore, S.P. and H.P. Dupuy, Ibid. 49:129 (1972).
3. Wan, P. J. et al, Ibid. 54:542 (1977).

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Billy R. Lester Joins IMPCO

Effective July 1, Billy Lester joined the engineering staff of Industrial Metal Products of Phoenix, Arizona. Billy is the son of past IOMSA President Bill and Lela Lester.

Billy and his wife Beth along with their four children have resided in Phoenix for the past five years. Billy is a 1975 graduate of Texas Tech University in Lubbock and at the time of his graduation was employed by Plains Cooperative Oil Mill.

He first joined IMPCO in 1976 working on dust control system design. In 1978 Billy joined the engineering staff of Anderson Clayton Co., Oilseed Processing Division, in Phoenix. For the past three years, his responsibility has been in the area of air and water pollution control and was also involved with new project construction at the various ACCO mills.

In making this announcement Boyce Davis, president of IMPCO, said that he is very pleased to have Mr. Lester back with their company and that he will play a vital role in the company's growing involvement in the oilseed processing industry.

Secretary of Agriculture John R. Block has announced that the **Food Safety and Quality Service** will be transferred to the jurisdiction of **Assistant Secretary C.W. McMillan.** FSQS and the Agricultural Marketing Service will then be reorganized to emphasize the department's marketing functions. Under the reorganization, the commodity services program will move from FSQS to AMS, where it was located prior to 1977.