Background Report Reference

AP-42 Section Number: 9.11.1

Background Chapter: 4

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Title: Five Point Process Efficiency

G. Anderson

Crown Works Company

1976

AP-42 Section ____
Reference ____
Report Sect. 4
Reference 1

CROWN IRON WORKS COMPANY

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x 62

May 22, 1979

Ms. Audrey McBath
EPA Mail Drop 14
Research Triangle Park, NC 27711

Dear Ms. McBath:

Here is the copy of "5-Point Processing Efficiency..." as you requested; please distribute copies to others at EPA if you wish. Also enclosed is a copy of my April 17, 1978 letter which is in response to the draft copy of "Control Techniques...". If it is of consequence to you I feel that points numbered 2, 3, 4, 8, 10, 11, 14, and the paragraph immediately following point 14, are the most significant and unresolved issues.

Please call if we can help you again!

Sincerely,

George Anderson

George Anderson
Chief Engineer

GA/sp

Enclosure

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April 17, 1978

Ms. Kerri Brothers
United States Environmental Protection Agency
ESED, CPB (MD-13)
Research Triangle Park, NC 27711

Dear Ms. Brothers:

Thank you for sending the draft copy of "Control Techniques Guideline for the Manufacture of Vegetable Oils", prepared by Pedco Environmental. We have reviewed the draft and find it to be very comprehensive and of generally excellent quality. Although technical details, percentages of streams, etc. tend to vary according to equipment design and operator technique, the draft copy is a very good general engineering primer for the oilseed processing industry!

As is hopefully the intent of the draft copy, it has elicited a few comments. They are as follows.

1. On page 2-25, mention is made that "Two types of continuous solvent extractor predominate..." followed by descriptions of the (1) vertical basket machine (no longer in production to my knowledge) and of the (2) rotary cell, deep-bed machine. Our machine fits neither category, and yet it is highly significant in number of plants, current sales, tonnage processed, etc.--as noted on our enclosed listing of plants. I also enclose a copy of NPFA #36, 1974, which describes this machine on page 36-47 and 48. I doubt that our competitive colleagues would appreciate a detailed discussion of items we feel to be advantageous, but in the interests of balance and state-of-the-art, the aforementioned sentence could be corrected and a short paragraph introduced to cover a "continuous shallow-bed, rectangular loop extractor" which has no baskets or cells and has a stationary, self-cleaning screen.

2. Adsorption by carbon beds has been used on vent gas and has proven sufficiently hazardous as to be removed in all cases I am aware of in our industry. Enclosed is a reprint from an article which discusses this danger. While vent gas necessarily passes through the explosive range in adsorption, dryer and cooler gases ordinarily would not. However, considerable hazard would exist if a desolventizer-toaster were to mistakenly dump hexane-laden meal in the dryer. The prospect dampens my enthusiasm for some of the suggested control techniques, especially on older plants. (Draft copy page references: 1-3, 3-10, 6-1, 6-2.)

3. Incineration of 3,000-30,000 CFM from dryer and cooler vents seems risky in the case of a malfunction of the D.T. I have seen where an operator in an older plant had misguidedly run a D.T. with no "sparge steam" input for long enough prior to my arrival to cause visible hexane vapors on the ground in the vicinity of the D.T. discharge! Excess D.T. pressure or improper design can cause similar, but less dramatic free-vapor discharges continually! Precautions can be taken--but what risk is ever-present? (Page reference: 1-3, etc. See also 2-33.)

4. I presently have heard of only one meal cooler still operating with a bag-filter on the air discharge, and it is said to be at a very low air flow-to-cloth ratio, steam-traced, and "supposedly successful". I also know one other case where a filter caused endless trouble and was removed, but it was not a wholly desireable installation because of the treatment of other meal system, low volume, relatively cool air streams, in the same system. Certainly the dilution of dryer (or cooler) air to lower the R.H. would require heated air and significant expense in steam consumed. (Reference page 3-11.)

5. In combination, preceeding comments 2, 3, and 4 are probably a major reason that "no attempt is made to control solvent emissions from the desolventized flakes or meal". (Reference page 3-4.) Strictly speaking competent operators do make the attempt by the only proven and inherently safe means in wide use: Proper D.T. design and operation. Technology as described may prove feasible to improve on this emission, but operator reluctance to be the guinea-pig is quite logical.

6. The miscella entry to a vacuum stripper is typically on the order of 95% oil, which does not calculate out the same as is implied in the statement "Approximately 80 to 90%...evaporated in the first stage and second stage..." (Page reference 2-29.)

7. Full press operation typically does not attain 2-4% oil in commercial press-cake, but rather 4-6% with new equipment on common seed products. Higher percentages are often noted with worn presses or with difficult seeds. (Page reference 2-21.)

8. Two items are difficult to measure: Hexane trace concentration in a steamy, dusty airstream such as a dryer vent, and hexane trace concentration in D.T. meal. In the first case, the electronic noses available either decay or plug up frequently, and in the second, the "best" scientific methods characteristically have given nonsense results or inconsistent results by several orders of magnitude. Presumeably, it can be done, but I am not aware of fully reliable and quantitatively accurate technology for either case. (Reference page 1-3, 6-3.)

9. On the figure, item 7 is called "Desolventizer-toaster condenser" in our parlance and "excess vapor condenser" in some cases. The term "evaporator condenser" is usually reserved for item 11. (Reference page 2-7.)

10. Reference 4, page 2-30, suggests fugitive losses can be ten (10) times as high on small plants. In re-reading my article, I cannot justify ten times and come up with a factor closer to three (3) to five (5) times. This disparity comes from the fact that in my article, it is not clearly stated (in the footnote by an asterisk) that the 0.60 to 0.90 losses of a good small plant are total plant losses, not only fugitive losses.

11. Reference 17, page 4-7, it should be qualified that an 85% or greater reduction is possible only when a significantly poor D.T. is replaced!

12. I believe in actual average operation, oil will carry less than this amount...but your survey probably has more data on which to base an estimate. (Reference pages 2-8, A-2.)

13. Waste water is not strictly proportional to solvent flow. It comes largely from excess desolventizing steam and is more related to finished meal flow. (Reference pages 2-8, A-2.)

14. Consider emphasis on monitoring only total plant solvent loss for possible regulation. Virtually all losses end up in the air, and rather simple techniques could reduce uncertainty.

In my personal opinion, economic incentives (perhaps through fixed, graduated economic penalties for excess operating losses) are more conducive to genuine cooperation and progress than are threats of legal action or forced cessation of operation. Perhaps this difference is best reflected in the possible substitution of the word "implimentation" for the existing word "enforcement" with accompanying changes in emphasis. I realize this is not under the immediate control of the authors...but the report may wish to encourage, in form or word, its own means of application.

That completes our collective comments for the present. Hopefully they may be evaluated for possible modification of the final draft. Once again, in these comments it should be noted that the draft copy represents a great deal of very solid effort and that we have come up with very few comments to improve upon it.

Our major concern is that the net result be an accurate portrayal of the problem, that it include a complete discussion of the benefits, practicality, and hazards of control methods, and that it encourage a practical, flexible and simple method of monitoring by both industry and, if necessary, government.

Thank you for the opportunity to comment.

Yours truly,

George E. Anderson
Chief Mechanical Engineer

GEA/ls

cc: Mr. Donald Henz, Pedco Environmental, 11499 Chester Rd., Cincinnati, OH 45246

5-Point Processing Efficiency For Best Results With Known Handicaps

BY
GEORGE ANDERSON
Crown Iron Works Company
Minneapolis, Minnesota

This paper deals with the usual, reasonable modern system for the extraction of soybeans, and all of my data will deal most directly with soybeans; however, the same data usually will work in nearly identical fashion for cottonseed direct extraction, and may need only minor adjustments for application with other oilseeds.

In particular, I am presenting some material which I hope will be of use to the superintendent when the general manager asks why the residuals have risen to 1.5 per cent oil in the meal, and the solvent loss has passed above 1.5 gallons per ton. With this material, the superintendent should be able to defend himself, proving his operation is a brilliant success, but suffers from the obvious handicaps of his aging and undersized equipment. Of course, I doubt that any manager has ever believed or properly appreciated such an excuse; typically they react to such reasonings by observing that their data says a plant should always run at twice capacity, at .6 per cent residual oil, and at .6 gallons per ton of solvent loss.—George Anderson.

IT IS seldom true in any field of effort that everything is ideal. In the oilseed extraction business there is often the continual pressure to process above rated capacity, to continue in spite of mechanical breakdown, to process without the most modern or efficient equipment or to operate on less than ideal raw material. In all cases, production must strive to do the best job possible and to do so they must have a good idea of what is possible at a given production level with known handicaps, and what could be done to achieve better results. My grandfather, who passed on some time ago at age 86, wrote poetry during his later years for publication in various small, specialized news periodicals. I remember one concluding verse to a poem which dealt with racing sailboats, but really was meant to apply in any situation; the verse went as follows: "Any man can win with the wind at his back, but cheers to the man who can win on a tack".

I am not, myself, usually or primarily involved with plant operation. I have spent about six months total, out of the last eight years or so, in the operation of plants, usually during new plant start up supervision or in some form of advisory capacity in an older plant.

Most of my time is spent in the design and layout of extraction machinery. Consequently, I have much to learn about the details of long-term operations in comparison to the experienced superintendent or seasoned operator. However, I have collected or calculated the data I give below from books, from experience, and from operators, and arranged much of it in what I hope will be seen as a simplified and easily usable format.

Much of available information is hearsay, or it is spread out through many complex and seldom used references. If the information is not convenient and is not absolutely vital, it tends to be forgotten. The following, then, is a point by point discussion of several aspects of solvent extraction, and in several of the discussion points I have hopefully included such ready-to-use information. My intention is to show some of the costs involved in wasteful situations, and to establish some criteria with which the superintendent and manager can evaluate their success in usual circumstances.

I—SAFETY

Lets begin our point-by-point discussion with the importance of safety in operations. Many good guidelines exist as to plant layout, equipment specifications, fire and explosion prevention, and the like. One of the most widely known and recommended booklets is NFPA #36, entitled "Solvent Extraction", provided by the National Fire Protection Association. Another general guide is the well-known OSHA standards. These basics of property and equipment safeguarding and personnel safety are essential, and I think most companies are aware of them and try to follow them. However, I am most concerned with the often casual attitude of personnel to day-to-day personal safety and the development of safe working habits.

Many times while visiting mills I have watched plant personnel, on occasion the most valuable men in terms of experience, enter a machine which is not positively locked out of operation, dip a hand in a moving conveyor to take a sample, or take some equally unnecessary chance. In one case I remember a general manager mentioned that he had recently stepped off a 36-inch diameter, v-belt sheave only seconds before someone out of his sight started the attached 40 HP motor. Much less happy endings can and do occur, and of course there are consequences for the company as well as for the man involved and his family. We probably all have taken our share of foolish chances, and must keep this in mind and impress the need for safe working habits on the personnel we associate with. It only takes a second to lose the services of a valuable employee, hopefully only temporarily.

II—EFFICIENT USE OF RESOURCES

A second production factor which is of importance to profitability is the efficient use of facilities, electrical power, steam, water and other resources. To place the costs of waste in some economic perspective, each 100 horsepower wasted costs about $14,000 per year in electrical energy plus any installation and maintenance costs. Each 1000 pounds per hour of steam wasted in a typical operation will cost somewhere between $15,000 and $34,000 per year, depending on the cost of fuel for the boiler and whether variable costs other than fuel are included.

Efficiency depends upon several factors. First of all, the equipment must be efficient in design and adequate in size so as to operate in the most efficient capacity

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range. For example, it is quite possible and occasionally demonstrated that an old, small desolventizer-toaster will have insufficient meal retention in the sparge or desolventizing decks, and a great deal of steam will bypass the meal and go directly to the condensers; some excess of solvent may go out in the meal as well. On a 1000 ton per day plant, a temperature rise of from 170 degrees normal temperature to 185 degrees, measured at the DT main vent, can indicate a 3,900-pound-per-hour steam waste or excess, at a cost of $90,000 per year, (unless some steam heat is recovered in the first stage evaporator). As another example, a D.T. which uses 35 RPM sweeps would in some cases do as well at 15 RPM, which might save over half the drive horsepower; if 75 horsepower is saved, that is $10,000 per year. In every case, of course, the savings hoped for in a modification to use less power must be balanced against the cost of the modification and must be carefully designed to avoid undesired side effects such as unreliability or operational complexity.

Efficient operation also depends upon steady operation. During shutdowns and even during periods of continual minor production fluctuations there is a loss of efficiency. A plant can waste solvent, power, man-hours, ruined seed, production volume, operator morale, and all other desirables during downtime. Downtime and fluctuations also represent increased changes of operator error resulting in additional downtime or injury. To avoid downtime, it is necessary to establish a good preventive maintenance schedule, to have standby machinery or personnel at critical points wherever possible, to have reliable and easily operated equipment, to arrange the equipment in an easy to control and fully accessible layout, to have all-hour repair capability, and to have personnel trained in smooth operation and habits of general cleanliness.

The skillfully run plant of any age usually will reflect planning and neatness in all phases and will tend to "make it look easy" in spite of a few sleepless nights and the occurence of many of the common problems.

III—SOLVENT LOSS

The third major point of profitable operation is solvent loss. Solvent loss is undesirable for a variety of reasons including safety, pollution control, and supply shortage; however, its most important aspect is the cost of the wasted solvent.

At a plant flowrate of 1000 tons per day an excess loss of one-half gallon per ton will amount to about 160,000 gallons per year at a cost of roughly $65,000.

Where does the solvent escape to? Shown below is a table which lists the most common reasons for solvent loss and gives some idea of the amount typically lost in each area:

Reason For Solvent Loss:	Good	Fair	Poor
Meal desolventizing	.20	.40	1.20
Oil flash	.02	.06	.15
Water discharge	.02	.05	.20
Vent gas discharge (with mineral oil absorption)	0.6	.20	.75
Storage "breathing"*	0.1	.03	.07
Vapor leaks*	.02	.06	.15+
Liquid leaks*	.02	.06	.15+
Startups/shutdowns*	.02	.06	.15
Downtime*	.02	.06	.15
Approximate Totals	0.39	0.99	2.97

* In smaller plants, these items are proportionately worse and a good plant may be expected to have losses of from 0.60 to 0.90.

Some of these areas are as follows: Some part of the solvent entering the desolventizer-toaster will not be effectively removed by the steam, and will go out with the meal; I am quite sure I have seen plants where in excess of one gallon per ton is, or had for some time, been continually lost in this fashion. Usually the cause is a combination of insufficient meal volume in the D.T. sparge deck and poor D.T. venting such that solvent vapors reach the lower decks and then are forced out under pressure with the meal. Even in a good D.T. it is doubtful that solvent loss is ever negligible.

A second place where some solvent is always lost is in the oil; however, the desolventization of oil in the typical stripping column is not a difficult process, the laboratory tests on oil are generally quite frequent, and therefore this is usually a small loss. A third place where solvent is lost is in the waste water, most of which is condensed from the excess desolventizing steam from the D.T. If any care is taken at all to heat the water above 170 degrees F. prior to discharge to the system, and to collect the vapors, this is also a negligible loss. Perhaps the second largest reason for solvent loss is the vent gas discharge to atmosphere. Even with a properly operated mineral oil absorption system there will often be a faint odor of solvent in the vicinity of the vent discharge. With the mineral oil system, losses might be as low as .06 gallons per ton, or as high as .2 gallons per ton; if the system is obviously run very poorly, it would be quite possible to lose over .75 gallons per ton. If there is no mineral oil system, and only a refrigerated condenser, operating at about 40 degrees F, losses of .35 gallons per ton might be possible. If only a 75 degree condenser is operating, expect losses of over 1.0 gallon per ton—and remember that this is from this one source only, and must be combined with other plant losses!

Another source of loss is in the so-called "breathing" of storage tanks, the slight pressurization during filling or during hot afternoon hours, and the slight vacuum during emptying or cool evenings. With the pressure changes air is taken in and solvent laden air is vented out with each cycle. This loss is usually minor and can be kept quite small by the use of special venting of the storage tanks, either silver painting or buried tanks, and by the avoidance of excessive filling or emptying of any process tanks which contain solvent or miscella.

Some solvent will also be lost due to vapor leaks. This can occur for one of two reasons: either the leak allows air to enter the system, and the air carries some solvent out through the vent system, or the leak allows solvent vapor to exit directly to atmosphere when the plant is momentarily under pressure—or in some plants, when the plant is continually under pressure. This can be very insignificant in a fairly tight plant kept under slight vacuum; however, it can be well over .15 gallon per ton if the plant is less tightly under pressure. It should be noted that pulling too large a vacuum is often as troublesome as not pulling any, because the high vacuum may periodically pull large gulps of air which will then blind the condensers for a few moments, causing the possibility of cycling of the plant vent system from vacuum to pressure, with a resulting solvent loss and operator confusion. Liquid leaks are obviously another potential reason for solvent loss. The potential for loss is unlimited in this case, except of course for the actions of plant personnel in attending to the little drips and seals and valve stems and worn elbows which appear from time to time. It should be noted that a drip each second from any source is likely to amount to 1000 gallons in a year, at a cost of $400.

Last, but not least, we have some loss of solvent due to shutdowns, downtime, and startups. Naturally, solvent loss, on a gallon-per-ton-processed basis, is rather poor and in fact becomes meaningless during downtime because some losses continue, and there is no tonnage produced! However, actual gallons lost per day may be surprisingly high during these shutdowns and downtime situations. Often there is a great deal of solvent lost because plant vapor seals are not as effective without meal in the system; sometimes large volumes of air are swept through the system either intentionally or because it cannot be helped; on occasion the system is completely purged and steamed free of solvent, and the normal leaks and storage losses continue during downtime.

Summarizing all of the various losses of a plant, it seems that a very well run and well designed large plant could run with a total loss of about .39 gallons per ton; a smaller plant, less than 800 tons per day capacity, might do well to run with .60 gallons per ton. A poor result might be well over 1.2 gallons per ton, and dismal results of over 4.0 gallons per ton have at times been noted.

IV—RESIDUAL OIL

The fourth, and in this presentation, final point concerning profitable operation of a solvent extraction plant, is the topic of residual oil content of the meal produced. This is important because the oil left in the meal is sold for the lower price per pound of the meal, and also because the higher oil content of the meal will result in a lower protein percentage in the meal, which could at times be important. Once again, this topic will involve some data, shown at bottom of page, entitled "Residual Oil Control in Solvent Extraction of Soybeans".

The basic requirements for low residual levels are fairly simple, but in practice are overlooked surprisingly frequently. Preparation of the oilseed is highly important, with special emphasis on proper conditioning and flaking; it is important to produce thin, uniform flakes with as few fines as possible, and then convey them to the extractor with a minimum of damage. There must be little or no bypassing of the flaking rolls by pieces of cracked soybean, and the flakes must not vary substantially from the desired thickness. Then, the extractor must be properly designed and adjusted to give a thorough, countercurrent washing in stages, without "channeling" of miscella or solvent through only a part of the bed. The drainage must be as good as possible so as to remove the miscella rapidly as it becomes oil laden in order to remove as much as possible of the final miscella wash prior to discharge to the desolventizer-toaster.

The final hexane wash must be very evenly distributed so as to wash off all of the final miscella, because any miscella left in the meal will leave its oil behind with the meal as desolventizing takes place.

Finally, the extractor must be large enough to allow sufficient extraction time to attain low residuals. This time will vary somewhat with the type of machine, but with the Crown extractor on soybeans, we like to have in excess of 30 minutes of useful time, or wash and final drain time, corresponding to about 38 minutes time for the chain to make a complete revolution through the machine. With different products, the time for extraction is often greater.

On our table "Residual Oil Control", you will find five tables of data, the first of which relates the effects of extractor residence time and flake thickness on residual

RESIDUAL OIL CONTROL IN SOLVENT EXTRACTION OF SOYBEANS

BASIS: 160°F, 10¼% moisture conditioning; 138°F solvent; Crown extractor residuals measured in spent flakes and calculated on 12½% moisture meal basis; practical commercial-scale residuals.

Table 1.—FLAKE THICKNESS

Thickness	Actual Flake Flow/Extractor Capacity			
	1.33X	1.00X	0.80X	0.60X
0.008"	0.40%	0.35	0.32	0.30
0.010"	0.60	0.48	0.40	0.35
0.012"	0.87	0.68	0.55	0.46
0.014"	1.20	0.93	0.78*	0.61
0.016"	1.60	1.23	1.03	0.81
0.018"	2.40	1.70	1.32	1.05

Table 2 — CRACKED BEAN BYPASS

% (WT.) Unflaked	Increase In Residual
0%	0%
0.5	0.10
1.0	0.20*
2.0	0.40
3.0	0.60

Table 3—EXTRACTION TEMPERATURE

Temperature (°F)	Increase In Residual
140	0%
130	0.05
120	0.11
110	0.24
100	0.44

Table 4—OIL CONTAMINATED SOLVENT

% Oil In Solvent	Increase In Residual
0	0%
0.5	0.25*
1.0	0.50
1.5	0.75
2.0	1.00

Table 5—SOLVENT RINSE EFFECTIVENESS

% Miscella Removed	Increase In Residual
100%	0%
90	0.20*
80	0.40
70	0.60
60	0.80

* EXAMPLE: 0.78 + 0.20 + 0.25 + 0.20 = 1.48% expected residuals in a plant with many significant problems.

oil, and the last four of which indicate the approximate effects of cracked bean bypassing of the flakers, extraction temperature, oil contaminated solvent and solvent rinse effectiveness. Note that we assume cracked beans have been conditioned to 160 degrees F. and 10½ per cent moisture, that solvent is normally at 138 degrees, that the residuals are measured in the spent flakes on a 12½ per cent meal basis, that a Crown extractor is in use, and that the results are felt to be practical to attain continually on a commercial basis and not an unusually good run.

To use this table, enter on Table 1 the actual average flake thickness being produced; it is important to spend some time in estimating this actual thickness average, because this is the usual place where errors are made. Measure the thickness of samples from both ends and the center beneath each set of flaking rolls and never assume the values on an hourly log are correct; that usual log entry showing .012 inch flakes was probably last checked in 1962! Once the real thickness is established, then in the table go across that row to the column which indicates the approximate level of capacity at which the extractor is being operated—one and one-third times its rated capacity, at its normal rating, at 80 per cent of rated capacity, or at 60 per cent of rating.

Where the flake thickness row and operating level column intersect in the first table is given a good approximation of the residual oil level to be expected if everything else is being run correctly. For example, with a flake thickness of .016 inches and an extractor running at about 60 per cent of its rated capacity, expect residuals in the spent flakes of about .81 per cent.

However, several things can also be wrong which could cause higher residuals, as indicated in the other four tables. If one flaker of four total has a single bad cheek-plate at the end of the rolls, it may well bypass one per cent of the cracks without flaking; according to Table 2 this will add roughly .2 per cent to the expected residuals. Similarly, if the extractor is operating with cool flakes or solvent so that the average extraction temperature is about 120 degrees, add another .11 per cent of residuals, because the cool temperature retards extraction.

If there is a chronic problem of oil being entrained in solvent vapors in the distillation system and entering the solvent supply such that the solvent is one-half per cent oil, add .25 per cent to our now suffering expectations. And if, for reasons of bad drainage of final miscella or because of maldistribution of the final solvent wash, the last miscella wash is not completely removed — say that only 80 per cent is removed—then add .4 per cent to our expectations.

With all of these problems, perhaps it would be more correct to say fears instead of expectations, and in this case we shall have to live with 1.77 per cent spent flake residuals until someone takes the time to adjust a few things in the plant!

* * *

CONCLUSION

Please note that in all of the data, the information is approximate and must be fairly general in application, that is to say that it may not fit prefectly with your experience. In some cases there may also be errors in my judgement in selecting of data from many, often conflicting, sources. But I feel that it is useful to the superintendent and to his general manager to have something to either try for or disagree with. It is important for the sailboat helmsman to know if indeed he is winning on his particular tack, or if he is merely going through motions and being passed in the night. If these notes can serve to help in any way, they have served their purpose.