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Auditing Program for Effective Energy Conservation

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ABSTRACT

Mallinckrodt Chemical Works has developed and is using a special audit format to identify conservation opportunities for all its utilities. Manufacturing, Utilities, R & D, and Engineering personnel are collected together for several days during which time a process or operation is subjected to an intense analyses of its utilities consumption, a brain-storming of conservation ideas, and then an "on-the-spot" engineering analysis of the economics and feasibility of each idea. This technique is a fast, comprehensive way to assess conservation potentials while committing the attention of those operating groups that can implement the ideas.

INTRODUCTION

In this period of uncertain energy supplies and escalating energy costs, many corporations have established formal conservation programs. These programs have taken various forms, but all of them require that conservation opportunities be specifically identified before money and effort can be spent to implement them.

In manufacturing, and specifically in the chemical industry, the general techniques for achieving improved energy usage are well known. The problem, then, is to identify those parts of an operation or process where the techniques can be economically applied. One method, of course, is to assign an engineer to the task and let him systematically measure steam flows, power input, etc.; develop conservation ideas; then test them in depth for viability. This is thorough but it has two failings. The engineer focuses only one mind and one set of experience on the problem. Second, the ideas are his - not those of the operating group - and getting them implemented requires that the "not invented here syndrome" be successfully overcome.

This paper describes an alternate technique - one that draws on the experience and creativity of several technical disciplines; that is quick and versatile; that not only generates ideas but immediately tests their value; and that relies heavily on the operating personnel so that they are committed to the results.

AUDIT FORMAT

The major ultimate objective of the Energy Conservation Audit is, of course, to reduce energy use. But the Audit itself, as conducted at Mallinckrodt Chemical Works, is dedicated to the objectives listed in Table 1.

An important subordinate result of the audit is an assessment of the vulnerability of the product or operation to problems caused by the energy shortage. For example, if the add-on energy required to manufacture the product is relatively low (less than 10,000 BTU/lb.), then the product is somewhat secure from the impact of rising fuel costs. Or, if the process uses interruptible natural gas, then it may be vulnerable to shutdown if there is no alternate fuel.

Table 1

Objectives of Energy Audit

1. Identify conservation opportunities for all major and minor utilities.
2. Estimate the financial and non-financial benefits of the ideas.
3. Establish a working list, by priorities, of opportunities to implement.
4. Identify future vulnerabilities caused by the energy shortage.
5. Estimate the add-on energy requirement per pound of the product.

To achieve these objectives, a formalized audit format has been devised, and the entire procedure is outlined in a manual used by the participants. The manual defines the procedural steps to be followed, and it contains "rule-of-thumb" calculation techniques to help in the economic evaluations. Further, it has conservation ideas and the data required to evaluate the ideas for every major unit operation or type of equipment found in Mallinckrodt's plants, as the examples in Table 2 show.

Table 2

Typical Conservation Ideas

Dryers, Gas Fired

a. Opportunities:
   1) Use of proper air-fuel mixture
   2) Heat recovery from stack gases
   3) Increased insulation
   4) Decreased moisture in product feed
   5) Hot product discharge
   6) Reduced operating temperature
   7) Increased gas/solid contact
   8) Recycled hot air

b. Required data:
   1) Orsat analysis and stack temperature at discharge from burner box
   2) Fuel consumption (or burner data)
   3) Total gas flow
   4) Discharge gas temperature
   5) Dryer design drawing
   6) Outside surface area
   7) Surface temperature
   8) Insulation thickness
   9) Discharge air humidity
   10) Product flow rate
   11) Product moisture
   12) Drying curve
   13) Feed moisture

There are eight major steps in the conduct of an audit, and they are managed by one person acting as the leader.

First, he must coordinate with the various departments, especially operations, to determine which process or operation is to be audited. Then he must resolve an extremely important issue - who shall participate. The ultimate success of the audit is directly proportional to the quality and experience of the participants, and the leader should seek the best people available from operations, R & D, engineering, and utilities. The total number of participants should vary between four and eight, and each should be prepared to commit his time totally to the audit.

Recruiting of personnel, setting of a time and place for the audit, and completion of other preliminary details, represent a complicated logistics problem, with plant emergencies, competing priorities, and variations in enthusiasm coming into play. These factors will ultimately require about twenty per cent of the leader's time investment in the audit.

Next, the leader meets with all the participants to define the purpose of the audit and to distribute data collection assignments. In addition to operating data, such as insulation thicknesses, flue gas analyses, etc., it is necessary to calculate the current and projected costs of the pertinent utilities. Further, it is important to identify direct utilities costs and "top-of-the-rate" costs since these will define potential savings.

About two weeks is allowed between the preliminary meeting and the audit for data collection, and if any participant is unfamiliar with the process, for plant tours. Although it is not important that all the participants, especially the leader, be thoroughly knowledgeable about the process, it is important that everyone has seen the area, the equipment, and the operation.

After the audit is held, the leader then prepares a report summarizing the conservation ideas that are worth implementing; the add-on energy consumption per pound of product; and the future vulnerabilities. This report then serves as the working document for a meeting between the leader and the management of the operating section. The main purpose of the meeting is to agree on the ideas that will be pursued further and who will be responsible for their management. Some ideas are procedural, and can be handled totally by manufacturing. Some require research and development. Most require capital investment and must ultimately be handled through the engineering groups. The responsibility for their implementation, however, passes from the leader to the operations management.

This, of course, is the end of the audit, but not the end of the formal program. Follow up is necessary to insure that the ideas come to fruition. Some may be abandoned after more in-depth engineering study, but the major danger is that the ideas may stagnate because of lack of attention.

These major steps of the program are summarized in Table 3.

The audit itself is conducted by the leader, who acts to short-circuit non-productive ideas, to minimize idle conversation, and, in general, to keep the group focussed on the objectives. The audit may last two or three days, and the effort is intense, so the leader must maintain good discipline and interest if the audit is to be successful. The steps of the audit itself are outlined in Table 4.

Table 3

Major Steps In Audit Process

1. Establish time and location
2. Identify participants
3. Hold preliminary meeting
4. Collect required data; tour facilities
5. Conduct the audit
6. Prepare summary report
7. Assign responsibilities for implementation
8. Follow-Up

Table 4

The Audit

1. Introductory Remarks
2. Overall Review of Flow Sheet
3. Step-Wise, In-Depth Review of Flow Sheet
    a. Identification of Utilities Usage
    b. Brainstorming for Conservation Opportunities
    c. Evaluation of Opportunities
4. Review of General Utilities Usage
5. Summarization
6. Identification of Future Vulnerabilities
7. Estimation of Product Add-On Energy Use

The introductory remarks include background information on the energy crisis as well as an appeal for creative openness - without cynicism or negativism - on the part of the participants.

Then the operating personnel review the total flow sheet for the operation, partitioned according to the steps defined in the preliminary meeting. This is followed by an in-depth consideration of each step. The total consumption of each utility is identified, with the leader noting this and subsequent ideas and calculations on easel paper, posting the critical sheets around the room for quick reference.

After an operating step is thoroughly reviewed, then the participants brain-storm conservation ideas, drawing from the ideas listed in the manual or using their own initiative. All the ideas are written down. Then the leader takes the group through a systematic analysis of each idea. The potential savings are calculated, using rule-of-thumb techniques and general engineering experience. The capital investment is estimated, too, and if the capital can be retired in five or less years, then the idea is further analyzed for other negative or positive benefits, for its probable duration, for its ease and timing of accomplishment, and, finally, for its technical practicality. This activity is time-consuming, and, with experience, the leader can avoid extensive analysis of marginal ideas.

After each operating step is reviewed, then the same analytical approach is applied to the general utilities usage of the physical area where the process is housed. This includes, for example, the heating and ventilating system, cooling towers, air pollution control equipment and lighting.

Depending on the operation, the leader may want to brain-storm major changes in the operation, such as basic changes in the process chemistry, and evaluate their conservation worth. This usually leads to long-term programs, but it helps focus immediate attention by the R & D and operating personnel on the energy implications of various fundamental process changes.

Usually toward the end of the audit, the leader works with the participants to develop the list of energy-oriented vulnerabilities. The last two tasks, summarizing the results and calculating the total add-on energy used by the product, can be done during the audit. However, these tasks can be done more efficiently later by the leader alone.

RESULTS

Each audit is likely to be different in scope and productivity. However, Tables 5, 6, and 7 present typical results from an audit of Mallinckrodt's process for manufacturing Barium Sulfate USP, a compound used for X-ray diagnostic purposes.

Table 5 clearly illustrates the relative cost of the various utilities used in this process. It also identifies the utilities cost per pound of product, which can be related to the total product cost. At 28,624 BTU/lb. $BaSO_4$, this product is energy intensive, and this alerts the operating personnel to the vulnerability of $BaSO_4$ USP to escalating steam costs and fuel shortages, and it gives impetus to implement the conservation ideas that were developed.

These ideas are in part illustrated in Table 6. The cryptic notes are indended to identify the scope of the idea; a more thorough description must be sought in the audit notes. The estimated five year savings are based on the sum of various utility savings. For instance "Return vac. quench H_2O to QW Tk." involves recycling quench water used in the barometric leg of a vacuum producer back to another process quench water tank where currently fresh water is heated to 80°C. The idea not only conserves steam, it also conserves water and reduces sewage treatment costs.

Some of the vulnerabilities are noted in Table 7. It was determined that a critical scrubber blower was made of a fiberglass-resin compound that had been in short supply, and it was determined that a spare should be immediately ordered. Barytes, the impure $BaSO_4$ used as the principal raw material in the process, is also used as a weighting agent in drilling mud used in oil fields; therefore, its procurement should be closely watched.

It has cost between \$2,000 and \$5,000 to conduct each audit. The Barium Sulfate audit cost \$3,700. It developed \$178,500/year in potential utilities savings.

TABLE 5

Examples of Results - $BaSO_4$ Audit

Total Utilities Cost - 1973 (USP Process)

Operation	Steam lb./Day	H_2O gal./Day	Elec. KW hr./Day	Comp.Air MCF/Day	Nat.Gas MCF/Day
Cooker	43,700	47,500	820	43.2	
Filter/Digest	38,400	30,600	330		
Filter/Reslurry	28,000	38,900	340		
Dryer	55,200		555	14.4	
$CaCl_2$ Conc.	213,600	6,000	260		
Proc. Exhaust		7,200	1,250		
Misc. Utilities			290		36.7 (winter only)
Total	378,900	130,200	3,845	57.6	36.7
1973 Cost	\$1.33/M lbs.	\$.225/M gal.	1.41¢/KWH	7¢/MCF	68¢/MCF
Daily Cost	\$504	\$29	\$54	\$4	\$10 (Avg. over yr.)

Total Daily Cost = \$601

¢/lb. $BaSO_4$ = 2.81

Total Equivalent Energy Use (USP Process)

Steam, Based on Boiler Feed:	27,276 BTU/lb. $BaSO_4$
Electricity:	620 BTU/lb. $BaSO_4$
Natural gas:	728 BTU/lb. $BaSO_4$
	28,624 BTU/lb. $BaSO_4$

TABLE 6

Examples of Results - $BaSO_4$ Audit

Conservation Ideas (USP Process)

Step	Opportunities	5-Year Savings	Required Capital
Cooker	Recycle LP steam, jets to QW Tk.	$35,000	$ 2,000
Cooker	Use electric vs. air vibrators	3,600	1,500
Cooker	Use 5% $CaCl_2$ as QW	61,200	10,000
Filter/Dig.	Return vac.quench H_2O to QW Tk.	17,500	2,000
Filter/Dig.	Eliminate one digest Tk.	21,300	1,000
Filter/Resl.	Heat wash H_2O-ht.exch. on Stg.2 jet	10,000	1,500
$CaCl_2$ Conc.	Recycle Filter M $CaCl_2$ as $CaCl_2$ make-up H_2O	46,000	15,000
$CaCl_2$ Conc.	Raise $CaCl_2$ to 35%	42,000	1,000
Misc. Util.	Recycle bldg. warm air	10,000	1,000

TABLE 7

Examples of Results - $BaSO_4$ Audit

Future Vulnerabilities

1. Barytes
2. Cardboard Containers
3. Filter Cloths (Cotton, Synthetic)
4. Nickel Agitators
5. Hastelloy Steam Blow Lines
6. Filter Agitator
7. Plastic Scrubber Blower

This is equivalent to a preliminary cost of 2% of the potential savings, which is considered a good investment. However, not all operations will prove as productive, and the cost of the audit cannot be lowered significantly without sacrificing the advantages of speed and multi-disciplined involvement. So some selection process should be used to identify the operations within a company that are likely to be most energy-inefficient.

In general, the audit program has been successful in identifying practical and economically justified conservation ideas. It has been modified slightly with experience, but it has proved to be a strong engineering-management tool.

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