Industrial Engineering
and Operations Research
ONAL POLLUTION PREVENTION CENTER FOR HIGHER EDUCATION

Case Study: Pollution Prevention as Continuous Improvement at Ford Motor Company

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Introduction

Seeing the benefits of preventing waste at the source, Phil Lawrence of Ford's Plant Engineering Office decided to develop a plant-level pollution prevention[1] program that could be implemented at Ford plants worldwide. To achieve this, measurables had to be defined, methodology developed, and importantly, senior management had to see the value in, and the benefits of, such a program.

Lawrence knew that waste prevention programs could result in the following:

- **Reduced operating costs.** These arise from the more efficient use of resources and raw materials, reduced maintenance requirements, and reduced waste handling and disposal costs.
- **Less detrimental environmental impacts.** Less waste equates to lessening environmental burden/impact.
- **Improved quality.** This is a natural outcome of analyzing the manufacturing process. As the process becomes better understood, it is easier to identify opportunities for improvement.
- **Safer workplaces.** While this is especially true if any of the waste materials are potentially hazardous, it is also important in management of materials such as oils, detergents, and packaging products.
- **Compliance with regulations.** As federal and local regulations dealing with pollution and worker safety become continually more strict, the company should aim to exceed these regulations and develop and implement processes and procedures that reduce their implications within Ford plants.

With these benefits in mind, Lawrence set out to develop an aggressive, plant-level pollution prevention program.

Background

In 1990, Ford's corporate Waste Minimization Directive was revised to focus primarily on pollution prevention. Workshops, seminars, and an action plan for implementation had been provided to manufacturing operations throughout the company. Although there were many "ad hoc" waste reduction successes at a variety of plants, implementation of a whole-scale, systems-approach process was inhibited by major issues surfacing at the plants, primarily:

- the time required to acquire data on process information, and
- a reluctance to authorize "upfront" money or human resources for "potential" opportunities.

To acquire management buy-in and demonstrate the efficacy of a pollution prevention program (both in waste reduced and dollars saved), Lawrence saw the need to develop a pilot project that would be representative of many Ford manufacturing plants. He requested participation from a machining plant and several company organizations and outside experts. The results of this project, along with the procedures/ processes developed, would be used to model a quality-oriented, plant level pollution prevention program for use throughout the company. The Livonia Transmission Plant agreed to participate in the study, and funding for the project was provided by Ford's Research Staff. To assist in the initial "pollution prevention opportunity assessment" and reduce the inhibitors to the program, Lawrence contracted a pollution prevention consultant to help assemble and organize much of the plant data.

His intent was for Ford personnel to learn the data collection and evaluation techniques used by the consultant, and then apply them to other plants within Ford. The Livonia Assessment Team (LAT) was developed with representatives from the consultant and various levels of Ford (see **Exhibit 1**).

The Livonia Transmission Plant is located in Livonia, Michigan, west of Detroit. In 1991, Livonia produced more than 1 million transmissions. (**Exhibit 2** details the plant layout.) Upon completion, these transmissions are sent to Ford assembly plants where the model "AODE" transmission goes into Broncos, F-150s, E-150s, Grand Marquis/Crown Victorias, Cougars, Thunderbirds, and Mustangs; the model "AXOD" is installed into Tauruses, Sables, and Lincolns. The transmission plant is part of the Transmission and Chassis (T&C) Division of Ford. T&C is in turn part of Powertrain Operations. Staff support is provided by members of the Environmental and Safety Engineering Staff's Environmental Quality Office.[2] Additional support comes from the Research Staff.

The Livonia Project

The pollution prevention opportunity assessment took place between October 1991 and February 1992. John Connor, Livonia Plant representative, coordinated the Livonia Assessment Team's work in the plant. A large part of the team's efforts were spent identifying and gathering relevant data. Unlike production or product quality data, which are often very detailed and readily available, data pertaining to wastes are widely dispersed about the plant and often unavailable to the level of detail needed for study. For example, the purchasing department is responsible for material input data, the wastewater treatment plant handles wastewater data, and the environmental engineer (in this case, Connor) handles manifested waste.[3] Because specific departments are not responsible for information on the quantity of wastes leaving their management area, such data is not routinely gathered. As a result, assumptions and extrapolations are a necessary part of the assessment. **Exhibit 3** shows an example calculation.

After five months of data collection and detailed plant and process evaluation, the team suggested 10 initial waste prevention opportunities representing nearly 5,000,000 lbs. of waste material and an annualized potential of $1.2 million. These wastes included solid and water waste , oils and manifested waste. (**Exhibit 4** provides a list of these initial recommendations.)

These results quickly came to the attention of the plant management, and an internal Livonia plant team was formed to verify the information and make the warranted process improvements. This plant team discovered several opportunities beyond those realized by the initial assessment team (exhibiting a potential savings of nearly 280,000,000 lbs. of wste with a potential value of $8.3 million a year). **Exhibit 5** summarizes the ongoing recommendations.[4]

Waste Prevention Opportunity Examples

Following are the 13 potential waste prevention opportunities identified by both the original LAT and the follow-up internal plant team. In some instances, the Ford engineers improved upon the consultant's suggestions; in others, they came up with an innovative solution of their own. In still other cases, they simply insisted on improvements from their suppliers and/or their own operations personnel.

1

Previous Process: Use faulty reclaim system
Opportunity: Collect transmission fluids on AODE test stands

Type of Waste Generated:	Transmission fluid
Waste Prevented /Year:	20,000,000 lbs.
Savings /Year:	$4,000,000
Implementation Cost:	Not applicable[5]
Implementation Time:	3 months

Departments 306 and 307 both test AODE transmissions. These Departments access a Central System for transmission fluids. "Red" colored transmission fluid was showing up at the on-site wastewater treatment facility, and a root cause analysis pointed to Departments 306 and 307. First, there was leakage in the reclaim system's piping. Second, degraded screens and filters caused the fluid to overflow the system.

Process Improvement: Repairs and maintenance

The plumbing leaks were repaired, and the screens and filters were repaired or replaced. Further, screens and filters were put on a maintenance schedule to prevent future overflows. It was estimated that these adjustments have the potential to save Livonia $4,000,000 per year in reclaimed transmission fluids.

2

Current Process: Drain transmission fluid to on-site wastewater treatment facility
Opportunity: Collect fluids on test stands

Type of Waste Generated:	Transmission fluid in water
Waste Prevented / Year:	20,000,000 lbs.
Savings / Year:	$4,000,000
Implementation Cost:	$288,500
Implementation Time:	4 months

It has been estimated that 11,000,000 lbs. of transmission fluid from Department 406 and 270,000 lbs. of torque oil from Department 454 are lost to the on-site wastewater treatment facility each year. Some departments are set up to reclaim and recycle transmission fluids and/or other oils; however, the equipment does not always work as specified. For example, in Department 406, oils collected from the floor drainage system are pumped through a Hilco Oil Reclaimer. However, this reclaimer was not designed to provide continuous treatment of oil and/or transmission fluid containing high levels of water. It is estimated that inefficient oil reclamation costs for Department 454 are $175,425 per year.

Process Improvement: Use a portable oil/fluids reclamation system

In Department 406, the apparent solution was to "Activate AXOD reclaim unit." This involved replacing the float control valve and installing water-removing filters on the reclaim unit. Upon further investigation, it was determined that the reclaimer was obsolete — its outdated design made it impractical to repair. The present proposal, which is under evaluation, calls for an automatic, portable oil/fluid reclamation system that can be used in several departments. The system requires holding tanks in the various departments to maintain the oil/fluid until the reclaimer is available. This portable unit will remove water, dirt, dissolved gases, and impurities.

For Department 406, the reclaiming system is expected to save $167,054 per year in recycled transmission fluid, and deterred waste treatment requirements, maintenance, and filters. Extrapolated to the whole plant, the reclaiming system may have the potential to save Livonia $4,000,000 a year. Plant personnel are evaluating the full scope of this potential opportunity.

3

Current Process: Drain "carry-off" transmission fluid to wastewater treatment facility
Opportunity: Capture, reclaim, and reuse carry-off transmission fluid

Type of Waste Generated:	Transmission fluid in water
Waste Prevented / Year:	4,000,000 lbs.
Savings / Year:	$1,000,000
Implementation Cost:	$7,000 (prototype) $600,000 (plant-wide)
Implementation Time:	1 month

Departments 306 and 307 contain transmission test stands. Currently, test transmission fluid is allowed to drain to a subterranean trench where it goes to a sump that directs it to the plant's on-site wastewater treatment facility. It is estimated that up to a gallon (7.5 lbs.) of fluid per transmission tested is drained into wastewater treatment system.

Process Improvement: Pump to Central System 330

A procedure change would be implemented to collect carry-off transmission fluid that drips from test transmissions: the fluid would be drained from the collection pan on the transmission carrier, pumped through a treatment system that removes any water, and then pumped back through Central System 330 for reuse. The capture system would be prototyped in Departments 306 and 307 with successful performance resulting in a plant-wide implementation. The potential savings in reclaimed transmission fluid in Departments 306 and 307 may be in the range of $1,000,000 per year. Plant engineers are continuing this evaluation.

4

Current Process: Track the *number* of hydraulic oil additions to hydraulic systems
Opportunity: Implement hydraulic oil tracking system

Type of Waste Generated:	Hydraulic oil
Waste Prevented / Year:	2,467,213 lbs.
Savings / Year:	$880,000
Implementation Cost:	To be determined
Implementation Time:	3 months

Using the Plant Floor Information System (PFIS), it is currently possible to report when oil is added to a process machine. However, several limitations result from the current process:

- Some persons (oilers) who add oil to the systems do not record the oil additions in PFIS.
- Only the oilers report oil additions to PFIS (not machine or other operators).
- The actual amount of oil added can not be recorded in PFIS (it must be estimated).
- Run time is not recorded in PFIS (does the machine leak only when operating or all the time?).
- Oil usage by department is very difficult to determine.
- Directly piped oil holding tanks do not have automatic shutoffs (if technicians are pulled to another job, their tanks have the potential for overflow).
- Most plumbing drops (pipelines) and in plant oil delivery vehicles used by the oilers do not have meters to determine the amount of oil added, and many of the meters that are in place require maintenance to function properly.

With the current reporting mechanism, it is extremely difficult to oil waste, which is important to determine the value of waste minimization opportunities.

Process Improvement: Track the *amount* of hydraulic oil added to hydraulic systems

Rectifying the limitations identified above will help Livonia track and minimize the quantity of hydraulic oil used. A preliminary Pareto chart of the 21 top-dollar hydraulic oil use locations showed they used 287,664 gallons annually. Roughly two-thirds of this amount is considered excessive. Thus, the Livonia engineer sees a potential savings of nearly $200,000 for these 21 machines. Extrapolated to the entire plant, the Livonia engineer believes the $880,000 figure is attainable.

To achieve this, PFIS must be modified so it can provide the necessary tracking information: all oil additions, their amounts, and the time of the addition. The ability to track oil usage by department will also be beneficial. To determine the amount of oil added, meters must be installed on both the oilers' trucks and on direct drops. The installation of automatic shutoff mechanisms will immediately reduce some wasted hydraulic oil. And lastly, with the functionally robust reporting procedures in place, Livonia's engineering personnel will be able to effectively identify and rank the largest oil users. With this information, they will be able to prioritize those machines and hydraulic systems that provide the most significant cost savings for the plant. Plant engineers are continuing to investigate alternative oil-tracking processes.

5

Current Process: Discharge rinse water to the on-site wastewater treatment facility
Opportunity: Reclaim rinse water in anodizer room

Type of Waste Generated:	Rinse water
Waste Prevented / Year:	192,720,000 lbs.
Savings / Year:	$539,419
Implementation Cost:	$278,500
Implementation Time:	3 months

Currently, all rinse-water systems in Department 469 are supplied by city water. Spent/diluted acids used in process along with this water are discharged to the on-site wastewater treatment facility.

Process Improvement: Recycle rinse water

A reverse-osmosis recycling system specified by Livonia's plant engineering department will recycle city water and process water continuously at 50 gallons per minute. This will reduce city water used in the rinse process by 98%, reduce waste water volume by 90%, and enable nearly 100% of the acids to be recycled back into the plating bath.

The cost savings have several components:

Savings = recycled process city water
+ wastewater treatment deterred
+ recycled chemicals
+ reduced maintenance
+ reduced scrap

The overall potential savings are estimated to be $539,419 per year.

As the system recycles rinse water, it eliminates all suspended contamination. This reduced contamination is expected to improve product-quality. A cost evaluation is being conducted for this project.

6

Current Process: Use city water in cooling tower
Opportunity: Cool down and reuse mill water

Type of Waste Generated:	City water
Waste Prevented / Year:	175,564,800 lbs.
Savings / Year:	$240,734
Implementation Cost:	$ 60,000
Implementation Time:	2 months

Department 294 performs a deburring operation that includes cooling of the product. Currently, a Niagara cooling tower is used to perform this cooling function. For every minute the tower operates, it uses 60 gallons of city water, which is discharged to the on-site waste water treatment facility.

Process Improvement: Install heat exchanger for cooling and reusing mill water

A heat exchanger with a self-cleaning system can achieve the necessary cooling without employing city water. The self-cleaning system allows the use of mill water that can be totally recycled without waste treatment. This self-cleaning component of the heat exchanger system has been developed by the Livonia engineer.

This reduction in city water usage is calculated at 21,945,600 gallons. At $0.01 per gallon, this equates a $219,456 savings per year in city water. Reductions in electricity usage equate to another $12,070 per year. Additionally, the heat exchanger is easier to maintain — maintenance savings are projected at $9,208 per year. Total potential savings from this process improvement are $240,734 per year. This project has been implemented at the plant.

7

Previous Process: Supplier/service contractor reports operating conditions to engineering department
Opportunity: Manage and track water soluble machining oil (coolant)

Type of Waste Generated:	Soluble oil (coolant)
Waste Prevented / Year:	375,000 lbs.
Savings / Year:	$192,234
Implementation Cost:	within supplier contract
Implementation Time:	<1 month

A water-soluble machining oil (coolant) is used to "flood" the cutting tools that machine the transmission components. This water-soluble oil serves as a lubricant as well as a coolant for the tooling and production part during the machining process. It also helps to carry away the chips, turnings, and cuttings that are removed from the product during machining. Often, coolant for several machines is supplied by one large central "coolant" system (20,000 to 50,000 gallons). Modern Treatment Company was responsible for assessing the central systems' performance standards and reporting their condition to the plant's engineering department.

Process Improvement: Include provision for continuous improvement in contracted services

The Livonia engineer developed a new contract concept that holds the supplier, in this case, Modern Treatment, more accountable for the performance of the central coolant systems, and requires the supplier to provide continuous improvement by reducing the waste of soluble oil coolant. Under this new concept, the supplier is allocated a blanket 10,000 gallons per month of undiluted water-soluble oil to dispense throughout the plant. If oil usage exceeds 10,000 gallons, however, the plant's maintenance department budget must pay for the excess. To help explain oil usage, the supplier developed control charts for each central system and reports monthly oil usage and the reasons for discrepancies on the these charts. Additionally, the supplier prepares estimates for funding potential engineering solutions that are discovered as a result of improved process control practices.

It is estimated that this new service contract with the supplier will result in a 50,000-gallon annual reduction in the use of water-soluble oil at Livonia. A 15% per year improvement is the use of water-soluble oil is expected under the contract arrangement. This relates to a potential annualized cost savings opportunity of nearly $200,000.

8

Current Process: Allows for filter media waste to be placed in hoppers containing high-value scrap
Opportunity: Rewind filter media

Type of Waste Generated:	Aluminum, cast iron, and steel media
Waste Prevented / Year:	1,500,000 lbs.
Savings / Year:	$165,545
Implementation Cost:	$30,000 per rewinder
Implementation Time:	—

There are several chip separation systems throughout the plant that use roll-off of filter media to remove metal chips and fines from the water soluble coolants. On ten of these systems, the paper/cloth filter media is deposited in the hopper with the salvageable chips. The media material contaminates the aluminum chips and reduces their value by about $0.11 per pound compared to "clean" scrap chips. With 1,518,760 lbs. of chips produced a year, this equates to a savings opportunity of $165,545 per year for aluminum. A similar situation in the cast iron and steel areas may provide opportunity for another $49,125 in cost savings annually. Together, these account for a potential cost savings of $230,748 per year.

Process Improvement: Install media rewinders

Media rewinders will rewind the filter media and deposit only the chips in the hopper. This will allow the plant to receive the highest price for its scrap aluminum (without the $0.11 penalty for filter contamination). This added value will save the plant $165,545 per year. Because the cast iron and steel cost savings potential is comparable to the investment cost for each rewinder ($30,000 + labor), it was not cost-effective to make the equipment investment in that area. Plant engineers are proceeding to implement the opportunity in selected areas.

9

Current Process: Use of defective conductivity meters
Opportunity: Install new meters on parts washers

Type of Waste Generated:	Washer chemicals
Waste Prevented /Year:	263,560 lbs.
Savings /Year:	$91,525
Implementation Cost:	$49,500
Implementation Time:	To be determined

Washers are located throughout the Plant to wash dirt, oil, and metal chips off transmission parts. After operating for a period of time, these washers become contaminated with oils, chips, and other dirt. A cleaning schedule is maintained whereby the solution tank is discharged to the on-site wastewater treatment facility, and replaced with a fresh chemical/water solution (usually 2%). Because a washer is in operation, the chemical concentration decreases due to solution carry-off on the parts. The washers have conductivity meters to measure the concentration and control the addition of chemicals from adjacent drums. However, if the meters become "fouled" and do not work properly, the drum may be either emptied or underutilized. In many areas, chemicals are added manually. The cost differential on washer chemical usage attributed to faulty meter performance is $91,525.

Process Improvement: New meters; different chemicals

The installation of new conductivity meters would greatly reduce the variation in chemical usage and is expected to also improve product quality. Meters that can provide reduced fouling problems cost about $500 each ($49,500 for plant-wide implementation). If new meters are purchased, maintenance of the washers is critical to their successful use.

While new meters will reduce concentration variance (thus better insuring process quality), an open issue remains regarding the amount of chemical used/needed. With the introduction of meters, more chemical might be used in the aggregate.

Additional investigations are underway to (1) determine the effect of using smaller washers (with less waste per recharge) at certain locations, and (2) evaluate alternative chemicals that are less expensive and more compatible with conductivity monitoring.

10

Current Process: Change oil on set schedule
Opportunity: Implement oil analysis plant-wide

Type of Waste Generated:	Hydraulic spindle oil
Waste Prevented / Year:	102,490 lbs.
Savings / Year:	$34,720
Implementation Cost:	Not applicable
Implementation Time:	<1 month

The Preventative Maintenance Program requires changing, at specific time intervals, hydraulic spindle oil in process machines throughout the plant. This change is performed even when the oil quality is still within specification. While this form of maintenance prevents machine wear and assures a smooth-running process, it also generates a significant amount of waste oil.

Process Improvement: Analyze oil before change

On a test basis, Maintenance Area 1-South is analyzing the oil before making the required change. If the oil is still within specification, no oil change is performed, thereby saving oil and labor. An economic analysis of this operation resulted in the following conclusions:

- Oil analysis has deterred the annual disposal of 52,920 lbs. of clean oil in Area 1-South. The rest of the plant uses about as much oil as Area 1-South. Using the double size estimation factor, oil analysis throughout the plant would spare 102,490 lbs. of clean hydraulic spindle oil from early disposal each year.
- The potential cost savings associated with oil analysis are made up of several components: oil saved + oil disposal deterred + oil change labor saved + wastewater treatment deterred - lab fee - sampling labor.

The savings for Area 1-South were determined to be $12,165 per year.

The machines that undergo several samples before requiring a change provide the greatest opportunity for savings. Conversely, some machines require a change almost every time they are tested; it is not economical to test them before changing hydraulic oil. By eliminating testing of those machines that do not demonstrate cost savings, Area 1-South would reduce costs by an additional $5,500 for a total of about $17,928. Based on the opportunity to double the savings by expanding the testing before oil change to a plant-wide program, the potential savings are about $35,000 per year. Plant personnel are continuing to evaluation of this suggestion.

11

Previous Process: Allows oil and foam spillover at turnings conveyor

Opportunity: Install shield in Central System 111

Type of Waste Generated:	Water soluble oil/coolant
Waste Prevented / Year:	614,250 lbs.
Savings / Year:	$17,035
Implementation Cost:	Not applicable
Implementation Time:	<1 month

System 111 had a problem with oil foam being carried out of the system on the chip conveyor. Observations showed that 50 gallons of water-soluble oil mixture (oil in water) were lost per hopper. With seven hoppers generated each day, Central System 111 lost 350 gallons of this machining fluid per day, or 91,000 gallons (614,250 lbs.) per year. At the typical 8% oil in water concentration, 7,280 gallons of oil were lost annually, totalling an estimated value of $17,035.

Process Improvement: Change type of soluble oil

The only place the oil foam contacts the conveyor is at the interface between the conveyor and the cutting oil surface. Originally, it was thought that a "shield" could be placed around the conveyor where it is in contact with the surface of the cutting fluid. This solution, however, proved infeasible. To effectively restrict the foam, the shield would also restrict the larger metal chips/turnings. Another solution was sought.

The solution was to eliminate the foam chemically rather than mechanically. A new soluble oil from a different supplier proved to foam much less than the soluble oil used previously. Further investigation showed that foam by itself did not account for all the oil loss in Central System 111. A root-cause analysis showed that the system's liquid level control was faulty. It was determined that the system-discharge valve was on, thus allowing soluble oil coolant that should have been recycled through the system to drain to the on-site wastewater treatment facility. The level control problem will be corrected, with a significant reduction in lost oil expected as a result.

12

Previous Process: Safety Kleen reclaim services

Opportunity: Eliminate non-operational part cleaners

Type of Waste Generated:	Solvent from part cleaners
Waste Prevented / Year:	12,000 lbs.
Savings / Year:	$12,000
Implementation Cost:	within supplier contract
Implementation Time:	<1 month

Part-cleaners are solvent-filled drums with removable sink basins above the drum. Safety Kleen provides the part-cleaners used throughout the plant and charges a fee each time the solvent is changed. The waste solvent leaves the plant as a manifested hazardous waste.

Previously, the Livonia engineer tracked the waste generated by these part cleaners and assigned cost/year and cost/department figures. Safety Kleen was responsible for assessing washer performance standards.

Process Improvement: Requirements for continuous improvement

The Livonia engineer developed a new contract that holds Safety Kleen more accountable for the performance of its parts cleaners, and requires it to show continuous improvement in the reduction of waste solvent. Safety Kleen was instructed to evaluate usage of each part cleaner station. From this evaluation, it identified cleaners that were not used or rarely used so they could be consolidated with other cleaner stations; then it developed a servicing schedule more in tune with actual usage. The Livonia engineer also created a new inspection form that requires a comprehensive inspection from Safety Kleen representatives.

This new relationship with Safety Kleen has resulted in an estimated reduction of 12,000-lb. of hazardous solvent waste, at a yearly savings of $12,000 to the plant. Further, Safety Kleen has agreed, through its contract, to reduce solvent waste volume by 15 percent per year and provide the plant with continuously improving services.

13

Current Process: Overflow of vacuum filter
Opportunity: Install baffle on Central System 111

Type of Waste Generated:	Water soluble oil/coolant
Waste Prevented / Year:	357,563 lbs.
Savings / Year:	$10,397
Implementation Cost:	$1,000
Implementation Time:	<1 month

Central System 111 has a problem with metal chips/turnings that clog up the port to the vacuum filter. This flow restriction causes the coolant level to back up and overflow the weir. The coolant falls into the trench and is drained to the on-site wastewater treatment facility. It is estimated that 25 percent (3,814 gallons per year) of the waste oil generated by System 111 can be attributed to such overflows. The waste coolant (at 8 percent oil content) is estimated at 47,675 gallons (357,563 lbs.) per year. This equates to $10,397 per year in lost value due to overflow.

Process Improvement: Install baffle

To eliminate the coolant overflow, metal chips/turnings have to be kept free of the port to the vacuum filter. To address this, a baffle (sheet metal elbows at the ends of the inlet trenches) will be installed at the inlet to the fluid tank; it will direct chips away from the vacuum filter outlet and toward the front of the conveyor. It should take less than a week to install this fix. Without turnings clogging the outlet, the controlled flow of coolant will be maintained in Central System 111.

Developing a Pollution Prevention Program

The success of the Livonia Transmission Plant Waste Prevention Opportunity Assessment provided Phil Lawrence with an example project demonstrating that organized waste prevention initatives were a viable and fruitful activiies. The next step was to leverage this success and formalize a waste prevention process for dissemination to Ford plants worldwide.

To accomplish this, Bill Schneider, who had been actively involved in the Livonia Assessment Team, was requested by Lawrence to head an ad hoc team for the company's Hazardous Waste Minimization Committee. The team would focus on developing a Ford-specific waste minimization process based on the Livonia and other plant's experiences and Company Directive D-109, "Waste Minimization Program." With members of the LAT and environmental and process engineering personnel from other operations, Schneider reviewed the Livonia findings along with pertinent material from other corporations and the U.S. Environmental Protection Agency. While many publications existed on pollution prevention, this team had a priority to develop procedures/processes that would be extensions of Ford's existing Total Quality Program. The resulting guidebook, *Roadmap to an Effective Waste Minimization Program*, has been distributed to all Ford plants. **Exhibit 6** provides the major element of the process discussed in the guidebook. Following is a summary of the main ideas.

1. A plant-wide, cross-functional team should be set up to coordinate waste reduction efforts. The team can be either an existing plant team (e.g. a quality improvement team, process improvement team, etc.) or a new pollution prevention team created for addressing waste minimization opportunities. This team needs to include representatives from most, if not all, of the departments in the plant, including hourly employees and key suppliers. Specific internal or external experts can be invited to participate on an "as-needed" basis. It is essential that both senior plant management and line workers commit to the effort to reduce waste.

2. The most effective way to eliminate a specific waste at each level of plant operations is to utilize area-specific teams at each segment of the manufacturing process. These teams should be made up of people who already work on the process and include a member who has been trained in the specifics of pollution prevention.

3. The coordinating team for the plant begins the pollution prevention process by setting goals and carrying out a macroscopic analysis of plant operations focusing on waste streams (steps A and B below). The teams specific to the particular waste, (e.g., hydraulic oil) or area of the plant (e.g., Department 306) could then take over the planning and implementation of the pollution prevention plans relevant to that material or specific area of the plant.

The steps in the guidebook for implementing a plant pollution prevention program are listed here.

A. Identify Waste Streams

The coordinating team should start by identifying the process streams leading in and out of the manufacturing plant. Any material that does not contribute to the final product is a waste stream. The quantity of waste material produced by the plant must be measured so that the cost of each waste stream can be estimated. The costs of waste arising from each unit of a particular product, whether defective or not, should also be estimated. These costs can be used as factors in the production planning and costs analysis for the products being manufactured.

B. Establish Priorities

After determining what the waste streams are, it is essential to establish pollution prevention priorities on a plant-wide basis. The factors that affect this prioritization may include raw material cost, amount of waste produced, and environmental effects, among others. The priorities will be specific to the plant, and the overall pollution prevention objectives will be set by the coordinating team in cooperation with the individual departments or management areas. Once the priorities have been established, it is also necessary to set realistic goals and timelines for achieving them. As with all process improvement programs, pollution prevention requires a sustained, incremental effort if lasting change is to be achieved.

C. Focus On Waste Sources

After the macroscopic analysis of the waste streams has been completed and appropriate goals have been set, a more detailed analysis of each targeted waste stream is required. The source of each waste stream should be located. This will require extensive coordination within the plant, especially if the same waste material comes from several operations within the plant. Specialized ad hoc teams that will deal with each targeted waste should be formed at this time to carry out the detailed analyses. This process should begin on a plant-wide basis; from there, it should steadily become more focused, culminating in measuring waste from individual machines or parts of machines.

D. Develop Solutions

Once the targeted waste streams have been identified, options for reducing each stream have to be developed and screened. The options must deal with the waste directly rather than just switching to alternate means of disposal—after all, the aim is to reduce as much of the waste as possible through source/use reduction opportunities. When this is not possible, materials should be captured and reused and/or recycled where feasible. Only when other opportunities for material use have been determined to be unacceptable, should the waste be allowed to go to disposal.

An action plan should be developed from each option that is selected. The action plan should fulfill the goals set for the plant and must itself have verifiable goals. The plan should be implemented as soon as it has been approved by the coordinating team.

E. Verify Results

The efficacy of the pollution prevention program can be evaluated only if measurables have been used throughout the planning and implementation process. When it is time to verify the results, the goals can be compared to what has actually been achieved. Having a quantitative basis for evaluation will also be helpful in calculating monetary savings.

After evaluation, the plans that have been implemented should be adjusted as needed. A reevaluation of the process may reveal new insight that will prove to be beneficial for the overall system. This will enable the company to apply the plan to other facilities. The plans should be continued and enhanced after each evaluation. Following the "Plan, Do, Check, Act" method of Total Quality Management (TQM), the overall pollution prevention process should then return to the analysis phase.

TQM employs continuous improvement to strive for the goal of zero defects. While some defects are inevitable, the goals of TQM drive companies to improvements they might not otherwise seek. Similarly, pollution prevention is a process of continuous improvement and assessment that should not be considered complete until all wastes have been eliminated from the plant.

ENDNOTES

[1] Many terms exist for pollution prevention, including waste minimization, waste reduction, and Total Quality Environmental Management (TQEM). Because the intent of these various programs is the same (only the way of affecting it is different), the term "pollution prevention" will be used in this case for clarity. TQEM can be viewed as the employment of TQM tools to address pollution prevention issues.

[2] As of this writing, the Plant Engineering Office's personnel and responsibilities have shifted to the company's Environmental Quality Office and the Plant Engineering Office has been disbanded.

[3] Regulations resulting under the federal Resource Conservation and Recovery Act (RCRA) require toxic wastes (as defined by RCRA) to be manifested (documented) upon removal from the site. The paperwork involved represents a large part of the environmental engineer's responsibility.

[4] As of December 1992, several of the projects are still under management review.

[5] Implementation costs relate to additional funding related to completing the project. As the process improvement can be made within the existing budget, there is no implementation cost associated with this opportunity.

Exhibits

EXHIBIT 1: LIVONIA ASSESSMENT TEAM

John Connor	Livonia Plant
Alan Amberg	Environmental Quality Office
Ron Burns	Transmission and Chassis Division
David Chock	Research Staff
Phil Lawrence	Plant Engineering Office
Jack Murray	Plant Engineering/Environmental Quality Offices
Mark Panetta	Truck and Chassis Division
Bill Schneider	Research Staff
Two consultants	Outside consulting firm

EHIBIT 2

LIVONIA TRANSMISSION PLANT LAYOUT

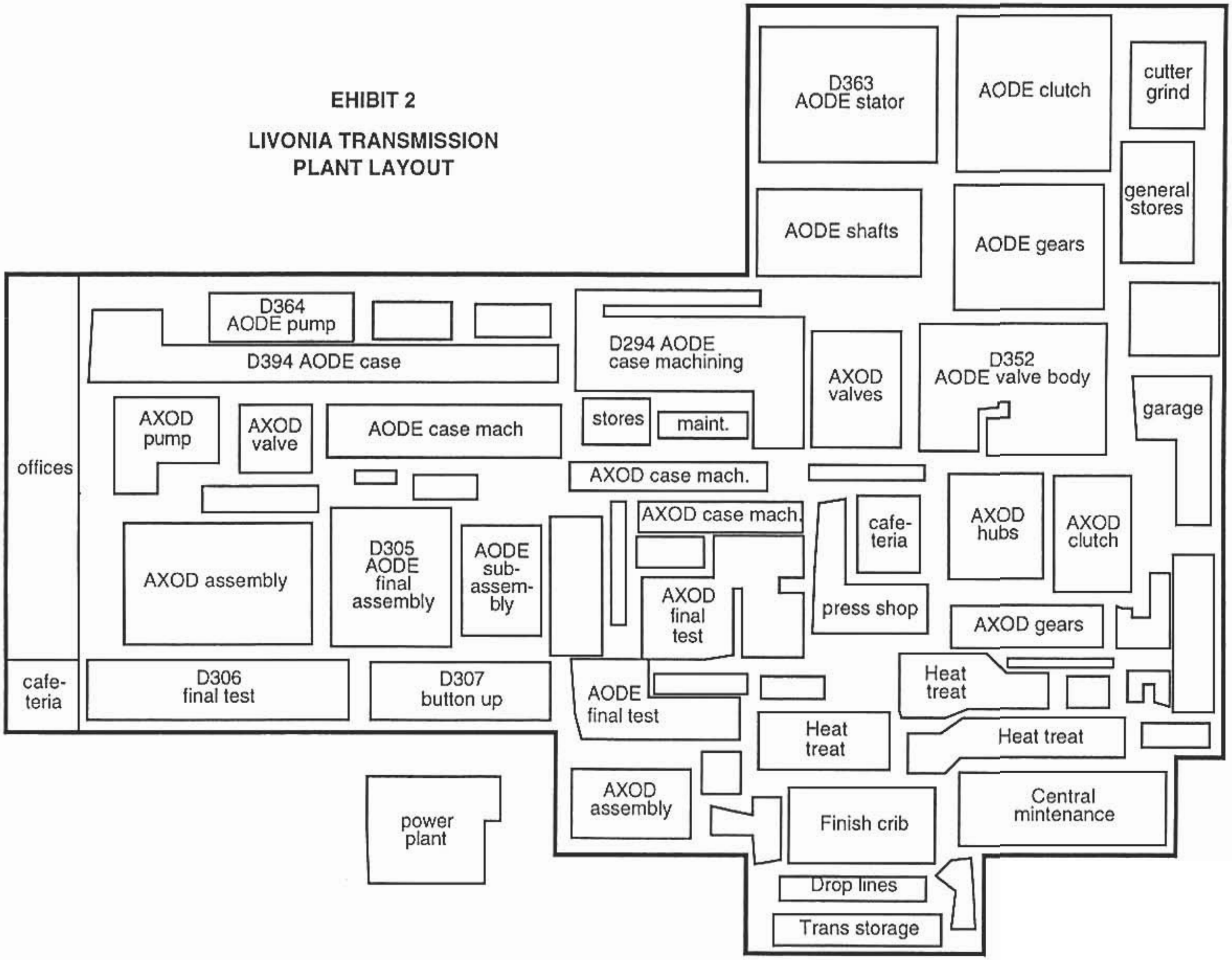

EXHIBIT 3:

WASTE CALCULATION

System 111 has a problem with oil foam being carried out of the system on the chip conveyor. Observations showed that 50 gallons of cutting fluid were lost per hopper. The system has been generating seven hoppers per day. Waste costs for the first six months of 1991 were calculated as follows:

7 hoppers/day X 50 gallons/hopper = 350 gallons/day

350 gallons/day X 130 days/6months = 45,500 gallons/6 months

45,500 gallons X 8% oil in cutting fluid lost = 3,640 gallons of oil wasted

Projected waste oil for one year: 2 X 3,640 = 7,280 gallons of oil

7,280 gallons of oil X $2.60/gallon = $18,928 per year

EXHIBIT 4:

INITIAL RECOMMENDATIONS

Waste Prevention Opportunities	Type of waste generated	Pounds/year prevented	savings/year
Activate AXOD reclaim unit	Transmission fluid	1,885,295	560,807
Oil tracking system	Hydraulic & spindle oil	307,470	104,160
Eliminate non-operational parts cleaners	Naphtha	26,055	18,760
Install media rewinders	Scrap metal & filter paper	1,360,100	230,748
Reduce rubbish contamination	Scrap metal	N/A	109,911
Install shield on Central System 111	Cutting fluid	614,250	17,035
Install baffle on Central System 111	Cutting fluid	357,563	10,397
Install new conductivity meters on washers	Washer chemicals	263,560	91,525
Update PFIS oil tracking	Oil	Unknown	Unknown
Needle bearing grease accountability	Greases	5,000	5,000
	TOTAL	4,863,709	1,271,783

EXHIBIT 5:

ONGOING RECOMMENDATIONS

Waste Prevention Opportunities	Type of waste generated	Pounds/year prevented	savings/year
Activate AXOD reclaim unit	Transmission fluid	11,000,000	$1,287,000
Collect fluids on test stands	Transmission fluid	20,000,000	4,000,000
Capture carry-off oil	Transmission fluid	4,000,000	1,000,000
Oil tracking system	Hydraulic & spindle oil	307,470	104,160
Eliminate no-operational parts cleaners	Naphtha	12,000	12,000
Install media rewinders	Scrap metal & filter paper	1,360,100	335,692
Reduce rubbish contamination	Scrap metal	N/A	109,911
Install shield on Central System 111	Cutting fluid	614,250	17,035
Install baffle on Central System 111	Cutting fluid	357,563	10,397
Install new conductivity meters on washers	Washer chemicals	263,560	91,525
Update PFIS oil tracking	Oil	Unknown	Unknown
Reclaim Anodizer rinse water	Rinse water	192,720,000	291,343
Install heat exchanger to cool mill water	City water	48,000,000	120,000
Reclaim cutting oils, broach oils, mineral oils	Misc. oils	592,000	80,300
	TOTAL	279,200,000	$8,300,000

EXHIBIT 6:

MAJOR WASTE PREVENTION PROGRAM ELEMENTS

Waste Minimization Start-up

1. Form a waste-minimization team (may be an existing plant team)
2. Set and communicate objectives

Know Your Waste Streams

1. *Identify* the waste streams
2. *Quantify* the waste streams
3. Determine the *cost* of the waste streams

Establish Priorities and Refine Goals

1. Base waste-reduction goals on initial survey
2. Establish timing for goals

Focus on Your Waste Sources

1. *Locate* waste sources and associated processes
2. *Measure* and *verify* waste quantities
3. Identify waste reduction *opportunities*

Develop Effective Solutions

1. Develop and screen options
2. Establish an action plan
3. Implement the action plan

Verify Results

1. Measure and verify waste reduction
2. Adjust as necessary
3. Return to initial survey phase

Discussion Questions

1) What are the benefits to Ford of reducing waste?

2) How do Total Quality Management principles relate to pollution prevention?

3) What data management techniques would improve the waste assessment process?

4) The case presented only describes improvements to *existing* processes. From a TQM standpoint, what might be done to *design* processes with the intent to prevent pollution?

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Your Input is Welcome!

We are very interested in your feedback on these materials. Please take a moment to offer your comments and communicate them to us. Also contact us if you wish to receive a documents list, order any of our materials, collaborate on or review NPPC resources, or be listed in our *Directory of Pollution Prevention in Higher Education.*

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