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# Improving Laundry Plant Energy Efficiency

## A Study Done for the Department of Defense

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To comply with Presidential Executive Order 12759, which requires federal facilities to increase industrial/process energy efficiency 20 percent by the fiscal year 2000 (FY00) in comparison with FY85, the Department of Defense must improve the efficiency of its laundry facilities. Army laundry managers presently reduce utility consumption by using setback timers on equipment and lights, disconnecting or disabling unused equipment, installing occupancy sensors in seldom-used areas, and replacing worn out conventional equipment with more efficient models.

This study surveyed Army laundry facilities to determine and characterize their current condition and utility consumption. Those facilities were compared with commercial facilities of similar size, and alternative facility designs using advanced technologies were developed. This study concluded that it is still in the government's interests to own and operate military laundry facilities. However, to isolate waste and inefficiency, Army laundries must supplement current practices by consistently monitoring their energy and utility consumption. It was also concluded that Army laundry facilities can significantly improve efficiency by adding advanced technologies to increase utility savings by further reducing energy and water consumption, and production costs required to process laundry.

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## Foreword

This study was conducted for the Office of the Deputy Undersecretary of Defense, Environmental Security, Conservation and Installations under Military Interdepartmental Purchase Request (MIPR) No. DSAM20076, dated 29 March 1993. The technical monitor was Millard Carr, OASD-I(EE).

The work was performed by the Utilities Division (UL-U) of the Utilities and Industrial Operations Laboratory (UL), U.S. Army Construction Engineering Research Laboratories (USACERL). Martin J. Savoie was the USACERL principal investigator. William B. Scholten is associated with Science Applications Information Corporation (SAIC). George A. Williamson is employed by Thompson Engineering & Consulting, Inc. (TEC). Special acknowledgment is given to Claude Rudd, Charles Brown, and Victor Fiol, of HQ, U.S. Army Aviation and Troop Command, Weapon Systems Manager for Clothing and Services, Fort Lee, VA. Special acknowledgment is also given to the Department of Defense (DOD) laundry personnel who helped gather data and provided tours of their laundry facilities. Martin J. Savoie is Acting Chief, CECER-UL-U, John T. Bandy is Operations Chief, and Gary W. Schanche is Chief, CECER-UL. The USACERL technical editor was William J. Wolfe, Technical Resources.

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# Contents

|                                                    |           |
|----------------------------------------------------|-----------|
| <b>SF 298</b>                                      | <b>1</b>  |
| <b>Foreword</b>                                    | <b>2</b>  |
| <b>List of Tables and Figures</b>                  | <b>5</b>  |
| <b>1 Introduction</b>                              | <b>9</b>  |
| Background                                         | 9         |
| Objectives                                         | 10        |
| Approach                                           | 10        |
| Scope                                              | 10        |
| Metric Conversion Factors                          | 11        |
| <b>2 DOD Laundry Facilities</b>                    | <b>12</b> |
| Typical Plant Overview                             | 12        |
| Participating Installations                        | 12        |
| DOD Laundry Data                                   | 14        |
| Commercial Laundry Data                            | 15        |
| Comparison of Commercial and DOD Laundry Data      | 16        |
| Summary                                            | 19        |
| <b>3 Technology Review</b>                         | <b>38</b> |
| Conventional Technologies                          | 38        |
| Advanced Technologies                              | 41        |
| Companies/Organizations                            | 45        |
| <b>4 Laundry Process Models</b>                    | <b>57</b> |
| Comparison With Military and Commercial Facilities | 57        |
| Small Facilities (510,000 lb/year)                 | 59        |
| Medium Facilities (1,800,000 lb/year)              | 60        |
| Large Facilities (5,000,000 lb/year)               | 60        |
| <b>5 Conclusions and Recommendations</b>           | <b>80</b> |
| <b>References</b>                                  | <b>82</b> |

|                    |                                                                |     |
|--------------------|----------------------------------------------------------------|-----|
| <b>Appendix A:</b> | DOD Laundry Survey .....                                       | 83  |
| <b>Appendix B:</b> | Summary of Commercial and Military Laundry Data .....          | 87  |
| <b>Appendix C:</b> | Commercial Laundry Data Collection Summary and Survey Form ... | 92  |
| <b>Appendix D:</b> | Reprints of Selected Laundry Articles .....                    | 99  |
| <b>Appendix E:</b> | Model Laundry Operations .....                                 | 111 |

#### **Distribution**

## List of Tables and Figures

### Tables

|    |                                                                                                    |    |
|----|----------------------------------------------------------------------------------------------------|----|
| 1  | DOD installations participating in the DOD laundry plant energy efficiency improvement study ..... | 13 |
| 2  | Laundry equipment manufacturers .....                                                              | 46 |
| 3  | Energy, water, and steam use by washers and extractors .....                                       | 47 |
| 4  | Energy, water, and steam use by dryers, flat work ironers, and presses ...                         | 48 |
| 5  | Equipment list for a medium conventional model facility .....                                      | 58 |
| 6  | Equipment list for a medium high efficiency model facility .....                                   | 58 |
| B1 | Commercial laundry energy data .....                                                               | 88 |
| B2 | Commercial laundry nonenergy data .....                                                            | 89 |
| B3 | Military laundry energy data .....                                                                 | 90 |
| B4 | Military laundry nonenergy data .....                                                              | 91 |

### Figures

|   |                                                                     |    |
|---|---------------------------------------------------------------------|----|
| 1 | Typical laundry plant layout .....                                  | 20 |
| 2 | DOD laundry facility annual energy consumption .....                | 20 |
| 3 | DOD laundry facility annual energy cost .....                       | 21 |
| 4 | DOD laundry facility electricity consumption (kWh/yr) .....         | 21 |
| 5 | DOD laundry facility nonelectric energy consumption (MBtu/yr) ..... | 22 |
| 6 | DOD laundry facility total energy consumption (MBtu/yr) .....       | 22 |

|    |                                                                            |    |
|----|----------------------------------------------------------------------------|----|
| 7  | DOD laundry facility electricity consumption (kWh/lb) .....                | 23 |
| 8  | DOD laundry facility nonelectric energy consumption (kBtu/lb) .....        | 23 |
| 9  | DOD laundry facility total energy consumption (kBtu/lb) .....              | 24 |
| 10 | DOD laundry facility electricity cost (\$/yr) .....                        | 24 |
| 11 | DOD laundry facility nonelectric energy cost (\$/yr) .....                 | 25 |
| 12 | DOD laundry facility total energy cost (\$/yr) .....                       | 25 |
| 13 | DOD laundry facility water consumption (gal/yr) .....                      | 26 |
| 14 | DOD laundry facility water consumption (gal/lb) .....                      | 26 |
| 15 | DOD laundry facility water cost (\$/yr) .....                              | 27 |
| 16 | DOD laundry facility personnel (number/million lb processed) .....         | 27 |
| 17 | Commercial laundry facility electricity consumption (kWhr/lb) .....        | 28 |
| 18 | Commercial laundry facility nonelectric energy consumption (kBtu/lb) ..... | 28 |
| 19 | Commercial laundry facility total energy consumption (kBtu/lb) .....       | 29 |
| 20 | Commercial laundry facility total water consumption (gal/lb) .....         | 29 |
| 21 | Commercial laundry facility personnel (number/million lb processed) .....  | 30 |
| 22 | Electricity consumption comparison .....                                   | 30 |
| 23 | Electricity consumption comparison, expanded scale .....                   | 31 |
| 24 | Nonelectric energy consumption comparison .....                            | 31 |
| 25 | Nonelectric energy consumption comparison, expanded scale .....            | 32 |
| 26 | Total energy consumption comparison .....                                  | 32 |
| 27 | Total energy consumption comparison, expanded scale .....                  | 33 |
| 28 | Water consumption comparison .....                                         | 33 |
| 29 | Water consumption comparison, expanded scale .....                         | 34 |

|    |                                                                                  |    |
|----|----------------------------------------------------------------------------------|----|
| 30 | Electricity consumption .....                                                    | 34 |
| 31 | Nonelectric energy consumption .....                                             | 35 |
| 32 | Total energy consumption .....                                                   | 35 |
| 33 | Water consumption .....                                                          | 36 |
| 34 | Personnel comparison .....                                                       | 36 |
| 35 | Personnel comparison, expanded scale .....                                       | 37 |
| 36 | Milnor centrifugal extractor .....                                               | 49 |
| 37 | American washer extractor .....                                                  | 50 |
| 38 | Challenge Pacesetter dryer .....                                                 | 50 |
| 39 | Central flat work ironer .....                                                   | 51 |
| 40 | Ajax utility garment press .....                                                 | 52 |
| 41 | Ajax double buck cabinet bosom, body and yoke press .....                        | 53 |
| 42 | Laundry automation systems .....                                                 | 54 |
| 43 | Milnor continuous batch washer schematic .....                                   | 55 |
| 44 | Ludell direct contact water heater .....                                         | 56 |
| 45 | Electricity consumption comparison with model facilities .....                   | 62 |
| 46 | Nonelectric energy consumption comparison with model facilities .....            | 62 |
| 47 | Total energy consumption comparison with model facilities .....                  | 63 |
| 48 | Water consumption comparison with model facilities .....                         | 63 |
| 49 | Energy flow diagram for small, conventional/high efficiency model facility ..... | 64 |
| 50 | Layout for small, conventional/high efficiency model facility .....              | 65 |
| 51 | Energy flow diagram for small, super high-efficiency model facility .....        | 66 |
| 52 | Layout for small, super high-efficiency model facility .....                     | 67 |

|    |                                                                            |    |
|----|----------------------------------------------------------------------------|----|
| 53 | Energy flow diagram for medium conventional model facility .....           | 68 |
| 54 | Layout for medium, conventional model facility .....                       | 69 |
| 55 | Energy flow diagram for medium, high-efficiency model facility .....       | 70 |
| 56 | Layout for medium, high-efficiency model facility .....                    | 71 |
| 57 | Energy flow diagram for medium, super high-efficiency model facility ..... | 72 |
| 58 | Layout for medium, super high-efficiency model facility .....              | 73 |
| 59 | Energy flow diagram for large, conventional model facility .....           | 74 |
| 60 | Layout for large, conventional model facility .....                        | 75 |
| 61 | Energy flow diagram for large, high-efficiency model facility .....        | 76 |
| 62 | Layout for large, high-efficiency model facility .....                     | 77 |
| 63 | Energy flow diagram for large, super high-efficiency model facility .....  | 78 |
| 64 | Layout for large, super high-efficiency model facility .....               | 79 |

# 1 Introduction

## Background

Presidential Executive Order 12759 requires federal facilities to increase industrial/process energy efficiency 20 percent by the year fiscal year 2000 (FY00) in comparison with FY85. Where energy improvements can yield sufficient payback, the Department of Defense (DOD) may help installations fund energy-saving measures through its Energy Conservation Investment Program (ECIP), which is available to installations through the Facility Energy Management Program (FEMP) of each military branch. U.S. Navy facilities have begun to actively acquire state-of-the-art equipment and have already successfully modernized their laundry technologies. U.S. Air Force facilities have responded by contracting out nearly all of their laundry processing. Many U.S. Army facilities, however, have not yet modernized their laundry facilities for several reasons. Army laundry managers often find that established recordkeeping and acquisition procedures can complicate the process of quickly acquiring new equipment to keep their facilities up to date. For example, most Army installations do not meter energy use by individual buildings or utility areas, so Army laundry managers do not receive or have access to utility bills pertaining to their work areas. This makes it impossible to isolate specific incidences of energy over-consumption or waste, and hard to document needed justifications for new equipment purchases.

Most DOD laundry managers express concern with the performance of their operations and a desire to improve the performance and efficiency of their plants. In spite of acknowledged problems associated with outdated equipment and insufficient data, laundry managers presently reduce utility consumption by using setback timers on equipment and lights, disconnecting or disabling unused equipment, installing occupancy sensors in seldom-used areas, and replacing worn out conventional equipment with more efficient models. Army laundry facilities need to supplement these practices by adding advanced technologies to increase utility savings by further reducing energy and water consumption, and to decrease production costs by reducing the amount of labor required to process laundry.

## Objectives

The objectives of this study were to: (1) determine and characterize the condition and utility consumption of DOD laundry facilities; (2) compare those facilities with commercial facilities of similar size, and; (3) provide DOD with alternative facility designs using advanced technologies that can increase the efficiency and cost-effectiveness of military laundry operations.

## Approach

1. DOD laundry facilities were reviewed and characterized to establish a baseline for operating conditions, utility use, equipment type and condition, and production rates. Project Fact Sheets (surveys) were sent to 28 DOD laundry facilities with data collection forms to determine energy use, annual production, and operating conditions (Appendix A). Survey information was supplemented with site visits to selected DOD laundry facilities.
2. The collected data were entered into a spreadsheet and graphically analyzed.
3. The Science Applications International Corporation (SAIC) was contracted to collect data on commercial laundry facilities and on currently available advanced laundry equipment.
4. SAIC developed models of laundry facilities of the size and type required by DOD. These models provided the basis to compare conventional DOD laundries with commercial facilities using advanced laundry technologies.
5. Based on these comparisons, recommendations were formulated for modernizing DOD laundry facilities to achieve efficiencies in production, energy use, labor, and utility consumption comparable to those in the commercial sector.

## Scope

The information gathered in this study applies specifically to DOD laundry facilities. However, the results of this evaluation may also be helpful in equipment selection and operation, and in determining the real potential for utility (energy, water, and sewer) and cost savings in Veterans' Administration and commercial laundry facilities.

## Metric Conversion Factors

Metric conversion factors for the U.S. standard units of measure used in this report are given below:

|         |   |                                      |
|---------|---|--------------------------------------|
| 1 cu ft | = | 0.028 m <sup>3</sup>                 |
| 1 gal   | = | 3.78 L                               |
| 1 lb    | = | 0.453 kg                             |
| 1 psi   | = | 6.89 kPa                             |
| °F      | = | (°C × 1.8) + 32                      |
| 1 Btu   | = | 2.928 × 10 <sup>-4</sup> kilowatt hr |

## 2 DOD Laundry Facilities

### Typical Plant Overview

In the typical laundry facility (Figure 1\*), items are unloaded and then sorted into batches of similar goods. The batches of laundry are then washed in a single-batch or a continuous-batch washer. After the wash cycle is complete, excess water is extracted from the batch. The extraction process can be performed in the washer or in a separate piece of machinery known as an extractor. In the extractor, the goods are either spun or squeezed to drive out excess water before drying. After extraction, the batch is taken to a dryer for additional water removal. The tumbling action of the dryer also loosens and fluffs the laundered items. After drying, items of clothing are usually pressed and flat work, such as towels and linens, are ironed and folded. The laundering process can be automated so that laundry workers only load the soiled goods onto a conveyor after sorting, program the laundry cycle, and transport the cleaned goods from the dryer to stations for pressing, ironing, and folding.

The typical DOD laundry plant includes rows of washer-extractors, dryers, and presses as well as two flat work ironers. Batches are transported between the stations in the laundry plant in laundry carts, on conveyors, and on overhead rail systems. Steam is often used to supply heat to the presses and ironers and to heat water for the washers. Dryers are often direct-fired gas units, but steam and electricity are sometimes used to provide heat in dryers.

### Participating Installations

Table 1 lists the installations that participated in the DOD Laundry Plant Energy Efficiency Improvement Study and the type of laundry operation at each installation.

Table 1 documents a movement by DOD installations to contract laundry operations. Cuts in funding for facilities' maintenance and personnel often make it appear easier for a facility to monitor a contract for laundry operations than to actually run the

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\* All figures are included at the end of their corresponding chapters.

laundry facility. The uncertainty for many base laundries was discussed by Claude Rudd, Laundry and Dry Cleaning Specialist at Fort Lee, VA, in an interview published in *Laundry News* (September 1993):

The Army will continue to look at and study the most cost-effective method of laundering and processing goods on each individual facility. They will attempt to determine whether it is economically feasible to continue operating those facilities as they have been.

However, the Veterans Administration has conducted many cost comparisons on its laundry facilities and has shown that it is usually cheaper to maintain in-house operations than to pay for contracted service.

'In at least 95 percent of the cases, we win out in the cost comparisons by a pretty significant margin,' said Gerard Schroko, director of the A-76 program in the VA's Department of Operations (*Laundry News*, February 1993, p 1).

**Table 1. DOD Installations participating in the DOD laundry plant energy efficiency improvement study.**

| Installation                              | Type      |
|-------------------------------------------|-----------|
| Eglin AFB, FL †                           | GOGO*     |
| Fitzsimmons AMC, CO                       | COCO**    |
| Fort Bliss, TX †                          | GOGO      |
| Fort Bragg, NC                            | COCO      |
| Fort Campbell, KY †                       | GOCO***   |
| Fort Dix, NJ †                            | GOCO      |
| Fort Eustis, VA                           | COCO-GOGO |
| Fort Gordon, GA †                         | GOCO      |
| Fort Hood, TX †                           | GOGO      |
| Fort Huachuca, NM †                       | GOCO      |
| Fort Jackson, SC †                        | GOCO      |
| Fort Knox, KY †                           | GOCO      |
| Fort Leavenworth, KS                      | GOGO      |
| Fort Leonard Wood, MO                     | GOCO      |
| Fort Lewis, WA                            | GOGO      |
| Fort Ord, CA                              | COCO      |
| Fort Polk, LA †                           | GOCO      |
| Fort Richardson, AL                       | GOCO      |
| Fort Riley, KS                            | GOCO      |
| Fort Rucker, AL                           | GOCO      |
| Fort Sam Houston, TX                      | GOGO      |
| Fort Stewart †                            | GOCO      |
| Great Lakes NTC, IL †                     | GOGO      |
| Jacksonville NAS, FL †                    | GOGO      |
| Orlando NTC, FL †                         | GOGO      |
| Presidio of SF, CA                        | GOCO      |
| Walter Reed AMC, DC †                     | GOCO      |
| West Point, NY †                          | GOCO      |
| * Government-owned, government operated   |           |
| ** Contractor-owned, contractor-operated  |           |
| *** Government-owned, contractor-operated |           |
| † Site visited by researchers             |           |

Nevertheless, DOD laundry managers expressed a strong commitment to providing quality, timely service to their customers. Installation laundry personnel contacted for this study volunteered much needed data and willingly provided tours of their plants and overviews of the operations.

## DOD Laundry Data

Survey data revealed some anomalies that proved it difficult to identify specific trends in utility (electricity, natural gas, oil, water, sewage) usage and cost. For example, varying utility rates directly contribute to variances in facility operating expenses. However, utility use is often not metered at the installation laundry. Instead, the utility consumption and bills were estimated from formulas several years old that no longer accurately reflect current utility consumption due to changes in equipment efficiency, operational procedures, base-wide utility use, and annual production.

Figure 2 shows the total energy consumption (MBtu/yr) for 15 installations by total production (pieces per year). Figure 3 shows the total energy cost (\$/yr) for these installations, again arranged by total production. Figure 4 (electric energy), Figure 5 (nonelectric energy), and Figure 6 (total energy) show the expected general trend of energy consumption increasing as production increases. Nonelectric energy consumption is the sum of natural gas, oil, and steam consumption for each facility. Figures 2, 5, and 6 show that nonelectric energy consumption is much more significant (from 88.0 to 98.4 percent) than electricity consumption in DOD laundries. The variability of the data demonstrates the need for precise metering and recording of energy consumption at DOD facilities.

Figure 7 (electric energy), Figure 8 (nonelectric energy), and Figure 9 (total energy) show normalized energy consumption on a per-pound basis plotted against annual production. The scatter in the energy consumption data on these three plots indicates varying rates of energy consumption, normalized per pound of laundry processed, among similarly sized laundry facilities. These survey results reinforce the need for improvements in energy consumption monitoring and equipment modernization efforts in DOD facilities. Note that the increase in energy consumption per pound of laundry processed for small facilities is not unexpected due to the effect of economies of scale. Additionally, the scattered data makes it difficult to develop a reliable model for predicting laundry facility energy consumption.

Figure 10 (electric energy cost), Figure 11 (nonelectric energy cost), and Figure 12 (total energy cost) show a significant degree of variability in the cost of utilities for similarly sized facilities throughout DOD, attributable to differences in equipment,

energy consumption monitoring, and local utility rates. Electric energy costs ranged from 7.7 to 38.4 percent of total energy expenditures in DOD laundries. Figure 13 shows the general trend of annual water consumption increasing with annual production for the DOD facilities. Normalized water consumption (Figure 14) shows that DOD laundry facilities use approximately 5 gal of water per pound of laundry processed regardless of annual production. Figure 15 reveals the effect of varied utility rates on annual water cost. Some of the facilities' utility costs are based on metered billing while others' are billed as a percentage of total consumption for the entire installation. Sewage production (in gallons) is approximately 20 percent lower than water consumption. This is largely due to water loss during drying and from steam leaks.

The number of laundry personnel per million pounds of laundry processed for the DOD facilities (Figure 16) indicates that smaller plants may require more operators than large plants. The need for more employees in smaller plants may be due to the fact that larger facilities are able to employ labor-saving technologies, such as continuous batch washers, that the smaller plants cannot support. Efforts to implement meters and accurately monitor utility consumption in DOD facilities could result in energy savings (and cost reductions) by revealing inefficient processes that cannot be identified without utility consumption data. Appendix B (Tables B3 and B4) give the data plotted in Figures 2 through 16 in spreadsheet form.

## Commercial Laundry Data

Results from a late 1992 survey of commercial facilities were furnished by the Uniform and Textile Service Association.\* The consistent nature of the commercial laundry data indicates acquisition of the data via a more precise system of utility consumption monitoring than exists in the DOD due to the fact that the commercial laundry facilities must operate economically and remain competitive in the marketplace. Though annual utility costs were not included in the commercial laundry data set, it is obvious that the commercial facilities must pay similar rates to DOD facilities for their utilities, with rates varying with location. Figures 17 through 20 show commercial laundry data for normalized consumption of electricity, nonelectric energy, total energy, and water. Figure 21 gives the number of laundry personnel per million pounds of laundry processed for the commercial facilities. The next section compares the commercial and DOD laundry data.

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\* (Formerly [1993] the Institute of Industrial Launderers), 1730 M St. NW., Suite 610, Washington, DC 20036, tel. 202/296-6744.

## Comparison of Commercial and DOD Laundry Data

The surveys of 22 commercial laundries and 21 military laundries yielded data that included annual energy consumption, annual water consumption, and number of plant personnel. Survey results for the military facilities were obtained by USACERL. These data are for the entire physical plant of the laundry facilities and therefore include energy used for building lighting, domestic water heating, heating, and cooling. A search for facilities having data limited specifically to equipment was unsuccessful. Rarely, if ever, is any of the equipment individually metered. Appendix C summarizes the efforts undertaken to acquire commercial facility data and includes a copy of the commercial laundry survey form.

Data from the commercial laundry surveys were entered into a spreadsheet for analysis. Electricity use, nonelectric energy use, water use, and the number of personnel employed were examined as a function of production. Resource use was normalized on the basis of the amount of laundry processed (per pound). Appendix B (Tables B1 and B2) include the spreadsheet data and computational results. For each quantity analyzed, the scatter in normalized use is too great to show any significant trend with production rate. Commercial and military facility resource use were compared based on average values. The military facilities with the two lowest production rates (facilities P and Q) as well as military facility D, with a production rate near the low end of the range, all show much higher consumption than the remaining military facilities. A similar result applies to the commercial facility with the lowest production rate, facility DGA. In the sections that follow, graphs of the results for all the facilities are presented, followed by graphs of results for all facilities except the "high value" facilities discussed above (P, Q, D, and DGA). The elimination of the high value data allows the use of an expanded scale for the ordinate of the graph, thereby providing better resolution to the plotted results.

### ***Electricity Use***

Figure 22 shows the reported electricity use. The weighted average of the electricity use of the military facilities is 0.137 kWh/lb, 11 percent higher than the 0.123 kWh/lb for the commercial facilities. The electricity consumption is below 0.4 kWh/lb of goods laundered for all but three facilities, military facilities P and D, and commercial facility DGA. Figure 23 shows the electricity use of all facilities with electricity use rates below 0.4 kWh/lb. The weighted average of the electricity use of these military facilities is 0.105 kWh/lb, 12 percent lower than the 0.119 kWh/lb for the commercial facilities.

### ***Nonelectric Energy Use***

The nonelectric energy is the sum of the energy content in natural gas (1000 Btu/scf), oil (145,000 Btu/gal) and steam (1000 Btu/lb). Steam use is not reported for the commercial facilities. However, it seems unlikely that any of the commercial facilities would purchase steam from an external source. Rather, they would generate their required steam internally from purchased natural gas- or oil-fired boilers, so that any steam energy use would be included in the reported fuel use. Five military facilities report purchased steam use in addition to natural gas and/or fuel oil. Only one commercial facility reports any oil use as opposed to five military facilities.

Figure 24 shows the reported nonelectric energy use. The weighted average of the nonelectricity energy use of the military facilities is 8.67 kBtu/lb, 160 percent higher than the 3.34 kBtu/lb for the commercial facilities. The nonelectric energy consumption is below 20,000 Btu/lb for all but two facilities, military facilities P and D. Figure 25 shows the nonelectric energy use of all facilities with use rates below 20 kBtu/lb, except commercial facility DGA. Commercial facility DGA is excluded from the results so that the same facilities are represented as in the other "expanded scale" graphs. The weighted average of the nonelectric energy use of these military facilities is 7.48 kBtu/lb, 129 percent higher than the 3.27 kBtu/lb for the commercial facilities.

### ***Total Energy Consumption***

The total energy is the sum of the energy content in natural gas (1000 Btu/scf), oil (145,000 Btu/gal), steam (1000 Btu/lb), and Electricity (3413 Btu/kWh). Figure 26 shows the total energy use. The weighted average of the total energy use of the military facilities is 9.14 kBtu/lb, 143 percent higher than the 3.76 kBtu/lb for the commercial facilities. The total energy consumption is below 25,000 Btu/lb for all but two facilities, military facilities P and D. Figure 27 shows the total energy use of all facilities with use rates below 25 kBtu/lb, except commercial facility DGA, which is excluded from the results so that the same facilities are represented as in the other "expanded scale" graphs. The weighted average of the total energy use of these military facilities is 7.84 kBtu/lb, 114 percent higher than the 3.67 kBtu/lb for the commercial facilities.

### ***Water Use***

Figure 28 shows the reported water use. The weighted average of the water use of the military facilities is 5.35 gal/lb, 101 percent higher than the 2.66 gal/lb for the commercial facilities. The water consumption is below 10 gal/lb for all but two facilities (military facility D and commercial facility DGA). Water consumption data

for military facility P was not available. Figure 29 shows the water use of all facilities with use rates below 10 gal/lb. The weighted average of the water use of these military facilities is 3.62 gal/lb, 40 percent higher than the 2.58 gal/lb for the commercial facilities.

### **Comparison With Other Data**

The results of surveys of "four large chain companies" were reported in *Textile Rental* (June 1992, pp 28-32). Appendix D includes a copy of this and other articles of interest. The results were aggregated by region into "north" and "south," so as not to reveal the identity of the individual companies or facilities. A comparison of results from 1991 with those from 1984 showed "a significant reduction in natural gas/fuel oil use and water consumption" and that "use of electricity has increased slightly."

Figure 30 shows the average electricity consumption results of the *Textile Rental* surveys and the surveys analyzed in this study. The averages of all facilities analyzed here are labeled "All" and the expanded-scale averages, excluding the "high value" results from the commercial and military data, are labeled "Reduced Set." Similarly, Figure 31 shows the average nonelectricity consumption results of the *Textile Rental* surveys and the surveys analyzed here; Figure 32 gives the average total energy consumption results. Figure 33 shows the average water consumption results. The weighted average electricity consumption of the commercial and military facilities analyzed here are higher than the average electricity consumption reported for 1991 in the *Textile Rental* article. The weighted average nonelectric energy consumption of the commercial facilities analyzed here ranges from 3.27 kBtu/lb to 3.34 kBtu/lb, which falls within the range of the average fuel consumption reported in the *Textile Rental* article (3.06 kBtu/lb to 4.54 kBtu/lb). The weighted average nonelectric energy consumption of the military facilities analyzed here ranges from 7.48 kBtu/lb to 8.67 kBtu/lb, more than double the nonelectric energy consumption of the other groups shown. Similarly, the weighted average total energy consumption of the military facilities analyzed here ranges from 7.84 kBtu/lb to 9.14 kBtu/lb, more than double the total energy consumption of the other groups shown in recent years. The weighted average water consumption for the commercial facilities analyzed here is within the range of the average water consumption reported in the *Textile Rental* article, while that of the reduced set of military facilities is higher by a factor of about 1.5.

### **Personnel**

Figure 34 shows the reported number of personnel. The weighted average of the number of personnel for the military facilities is 13.97 per million pounds, 76 percent higher than the 7.94 per million pounds for the commercial facilities. The number of

personnel is below 40 per million pounds of goods laundered for all but three facilities, military facilities P and Q, and commercial facility DGA. Figure 35 shows the number of personnel of all facilities with personnel rates below 40 per million pounds. The weighted average of the personnel use of these military facilities is 12.70 per million pounds, 65 percent higher than the 7.71 per million pounds for the commercial facilities.

## Summary

To summarize, the total energy consumption of the commercial facilities considered is significantly lower than that of the military facilities studied. The nonelectric energy consumption of the military facilities is much greater than that of the commercial facilities, while the electric energy consumption of the military facilities is slightly lower than that of the commercial facilities. This result is not surprising, since the commercial facilities use more advanced technologies. The implementation of advanced technologies and electronic control mechanisms can significantly reduce consumption of nonelectric energy, but requires slightly more electricity to operate. Automated systems also require fewer operators. In this instance, increasing electricity consumption by a small percentage yields a significant payback via conservation of other energy sources, water, and labor. Military facilities can become more cost-effective in their operation and duplicate the performance of commercial facilities by implementing advanced technologies.

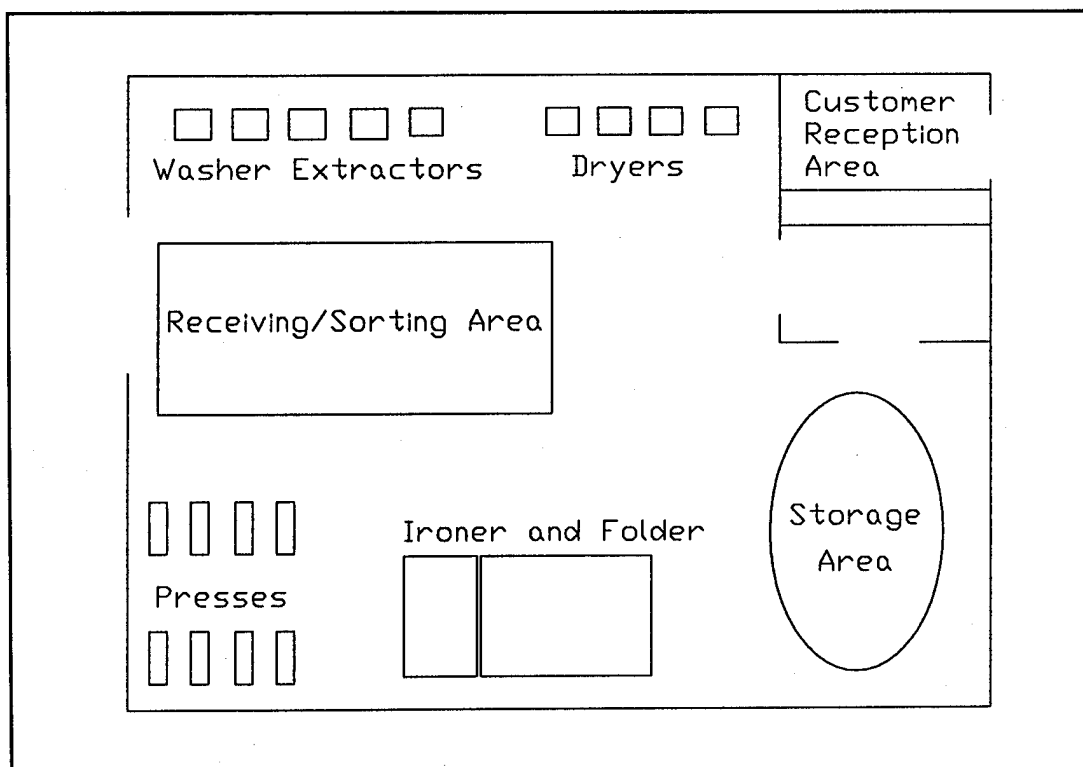


Figure 1. Typical laundry plant layout.

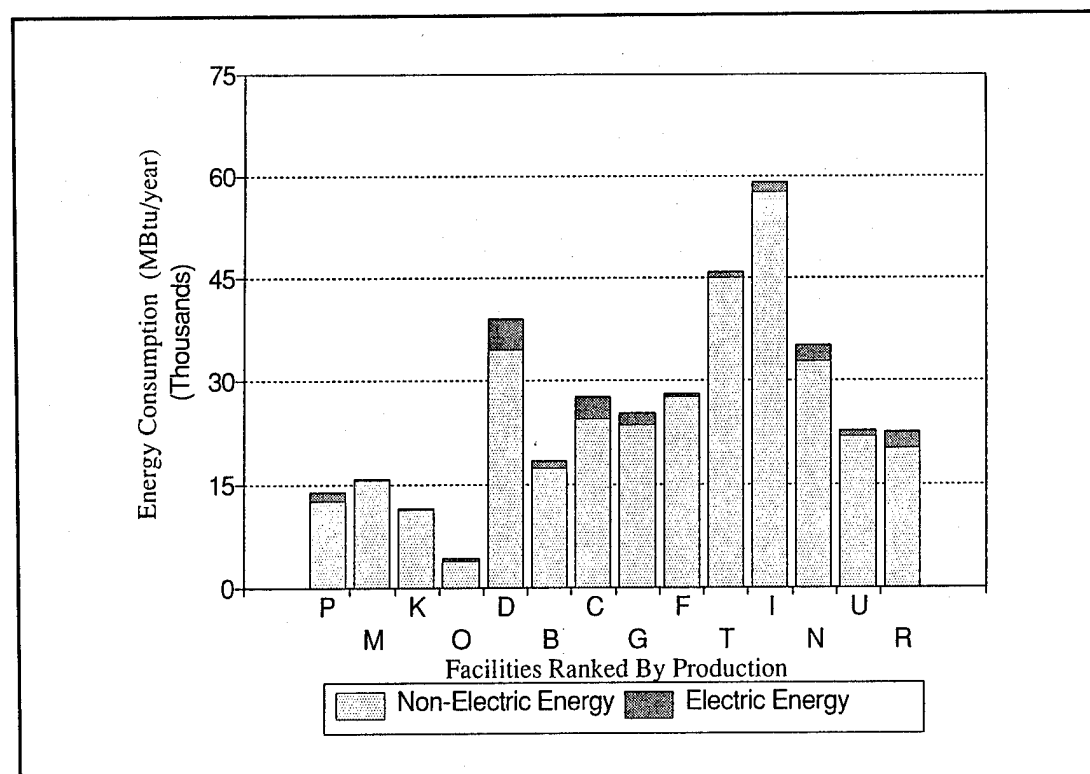


Figure 2. DOD laundry facility annual energy consumption.

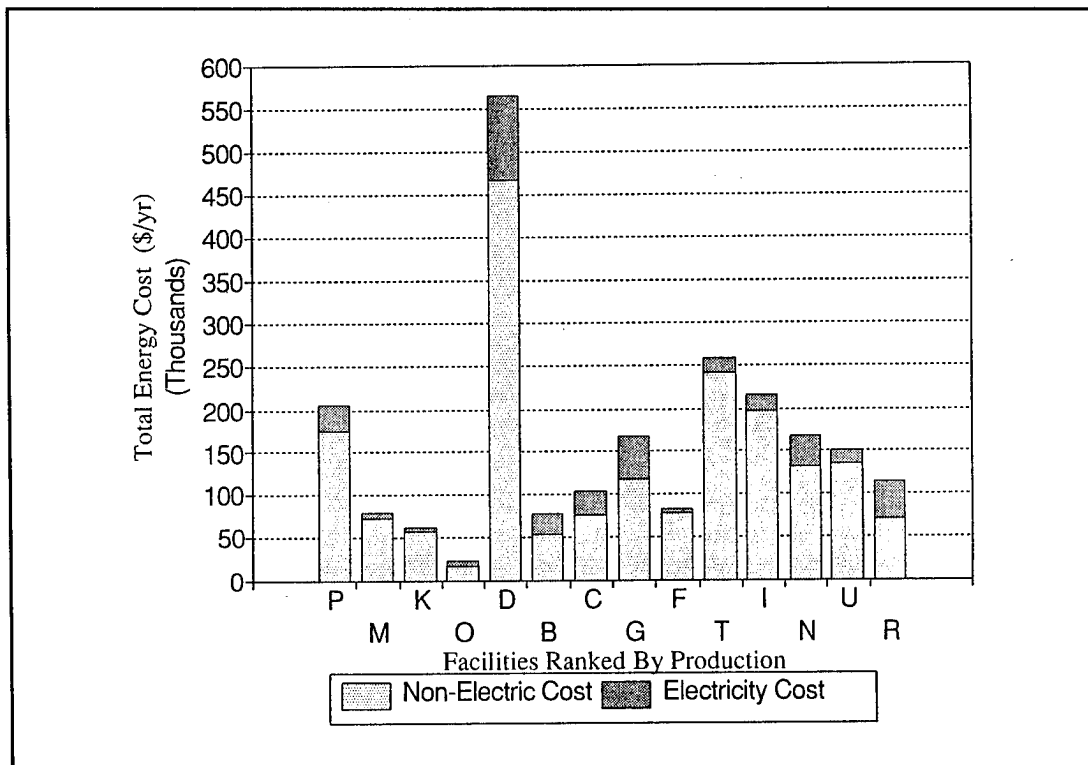


Figure 3. DOD laundry facility annual energy cost.

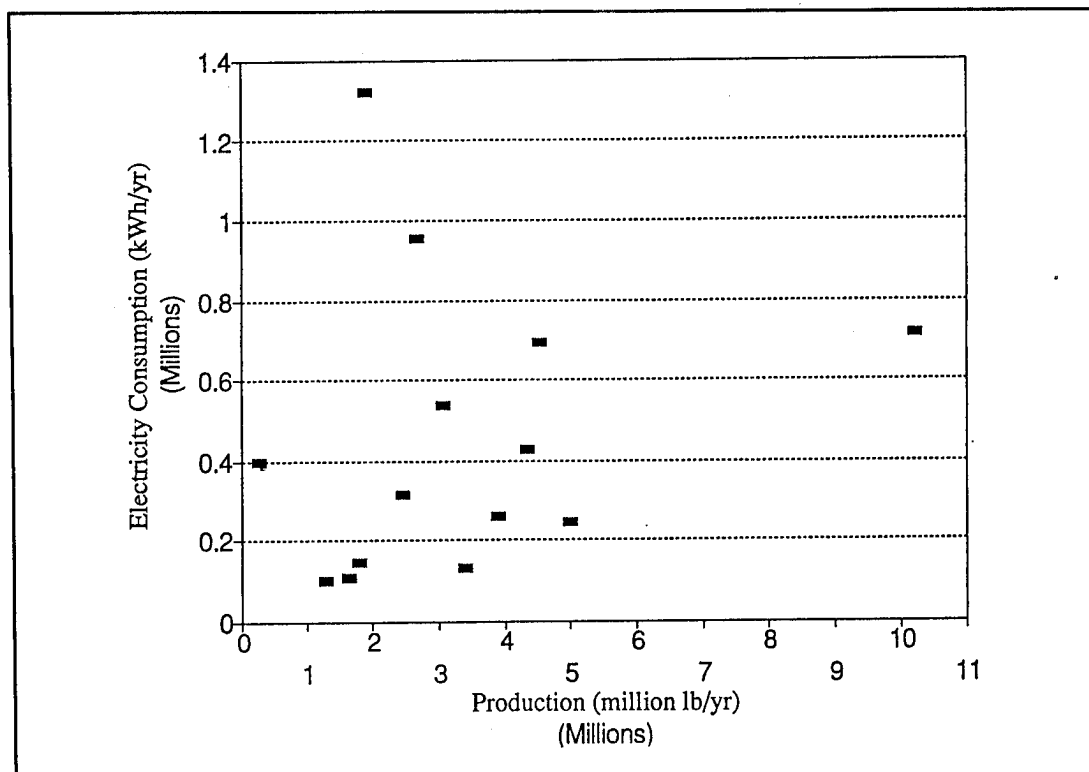


Figure 4. DOD laundry facility electricity consumption (kWh/yr).

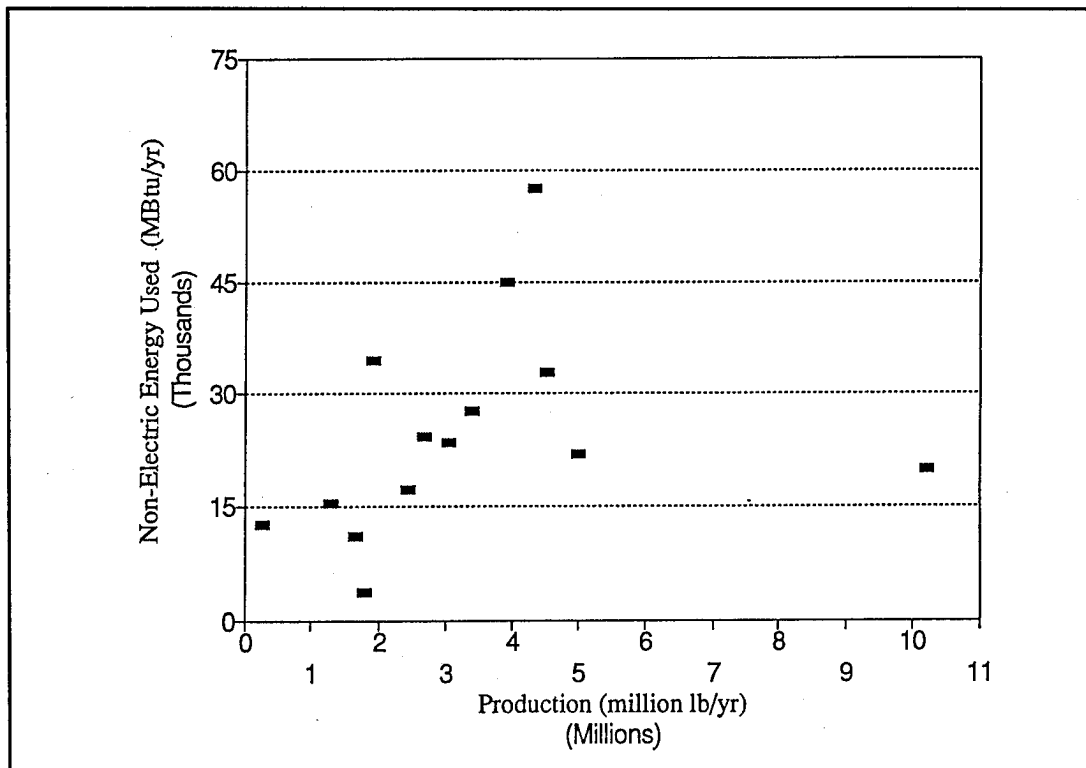


Figure 5. DOD laundry facility nonelectric energy consumption (MBtu/yr).

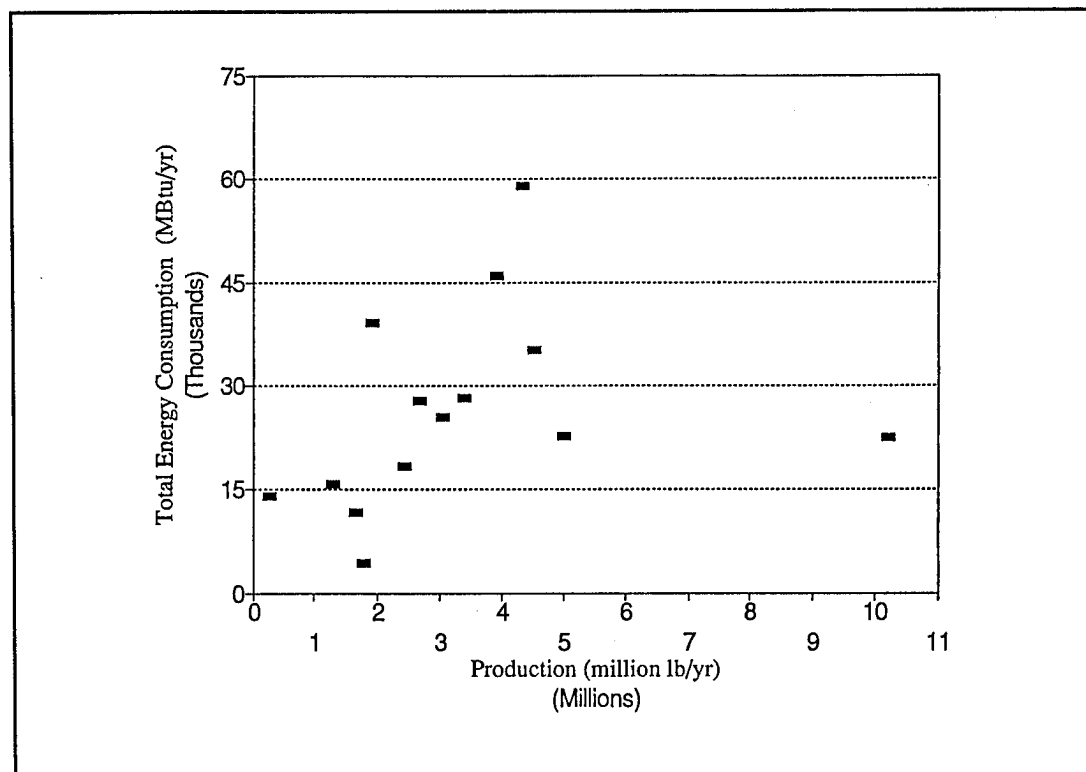


Figure 6. DOD laundry facility total energy consumption (MBtu/yr).

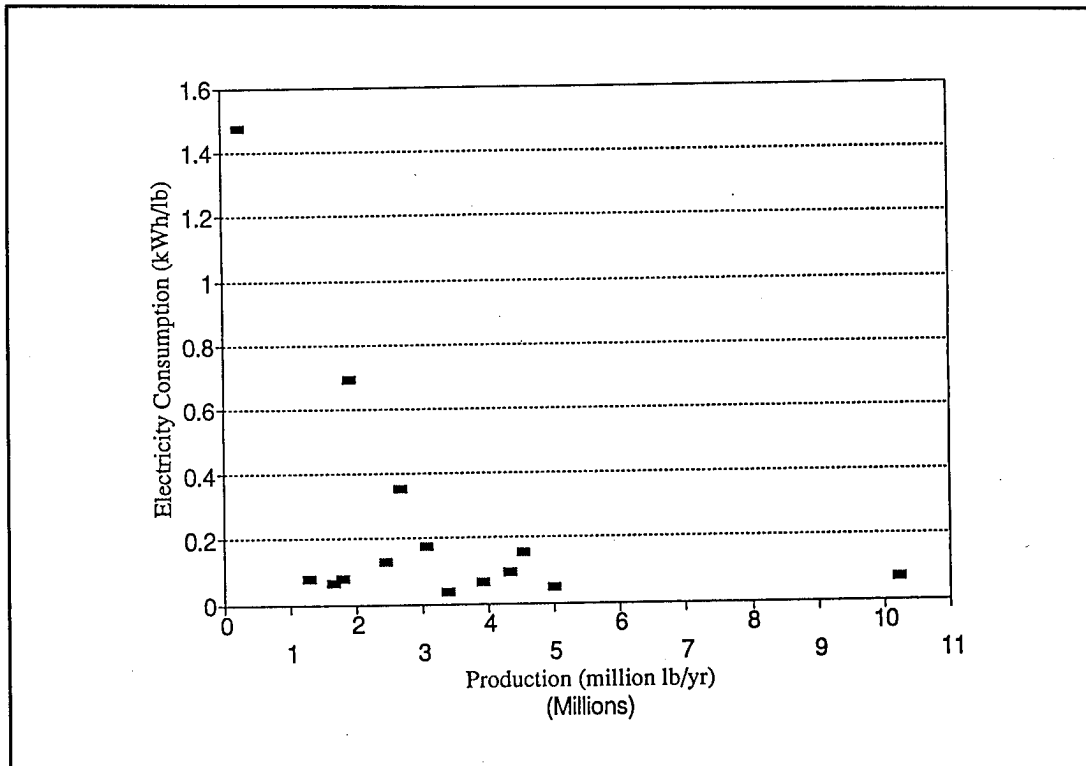


Figure 7. DOD laundry facility electricity consumption (kWh/lb).

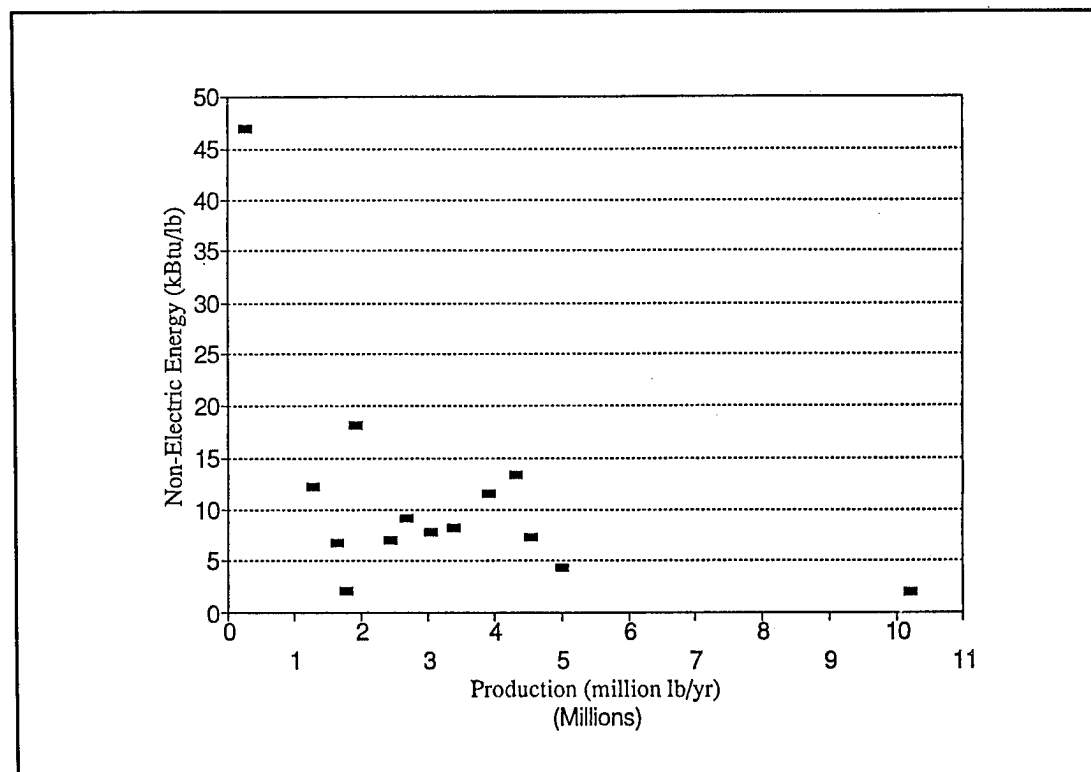


Figure 8. DOD laundry facility nonelectric energy consumption (kBtu/lb).

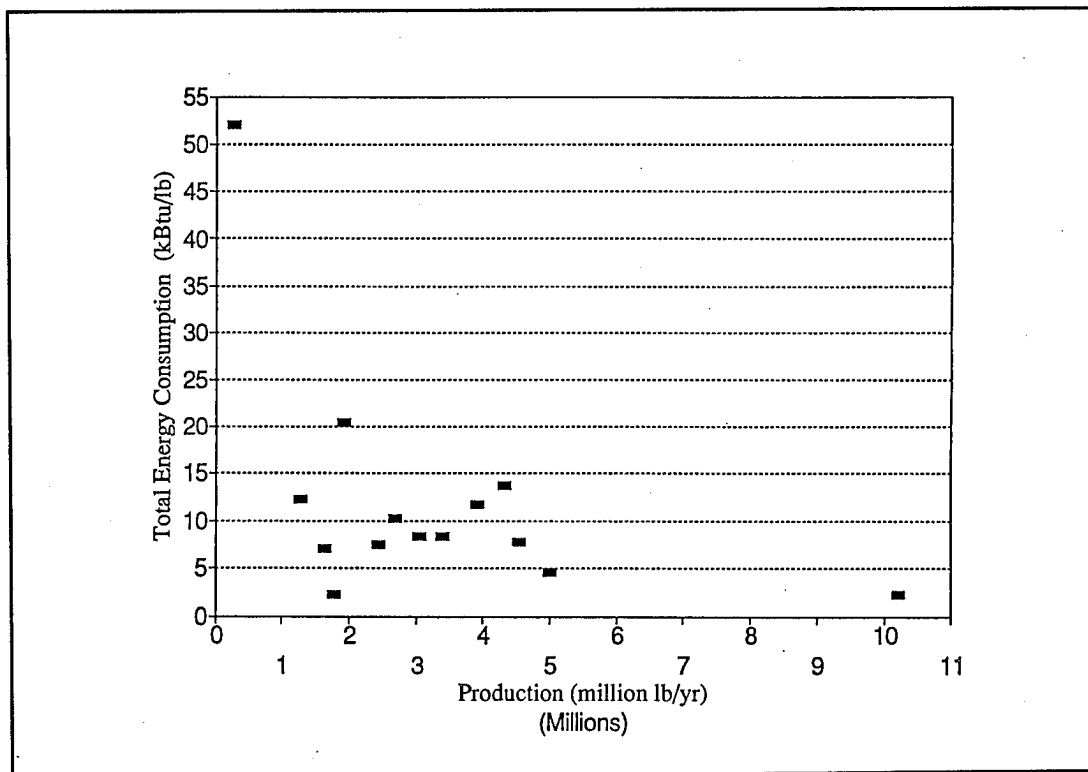


Figure 9. DOD laundry facility total energy consumption (kBtu/lb).

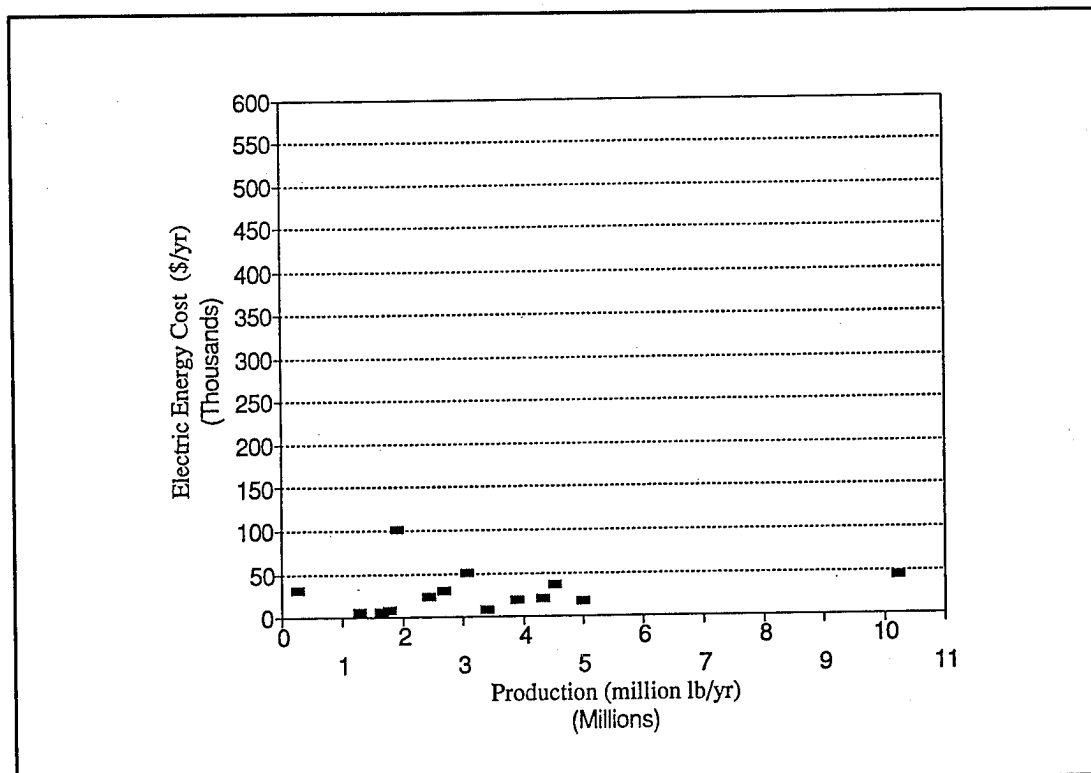


Figure 10. DOD laundry facility electricity cost (\$/yr).

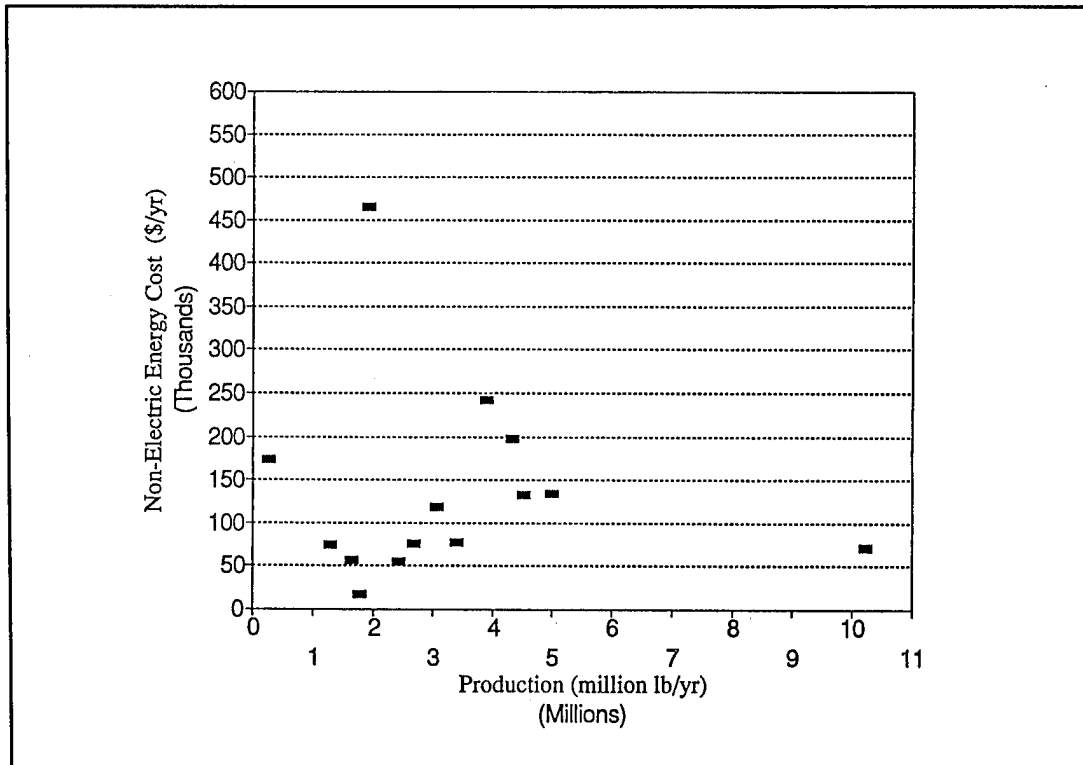


Figure 11. DOD laundry facility nonelectric energy cost (\$/yr).

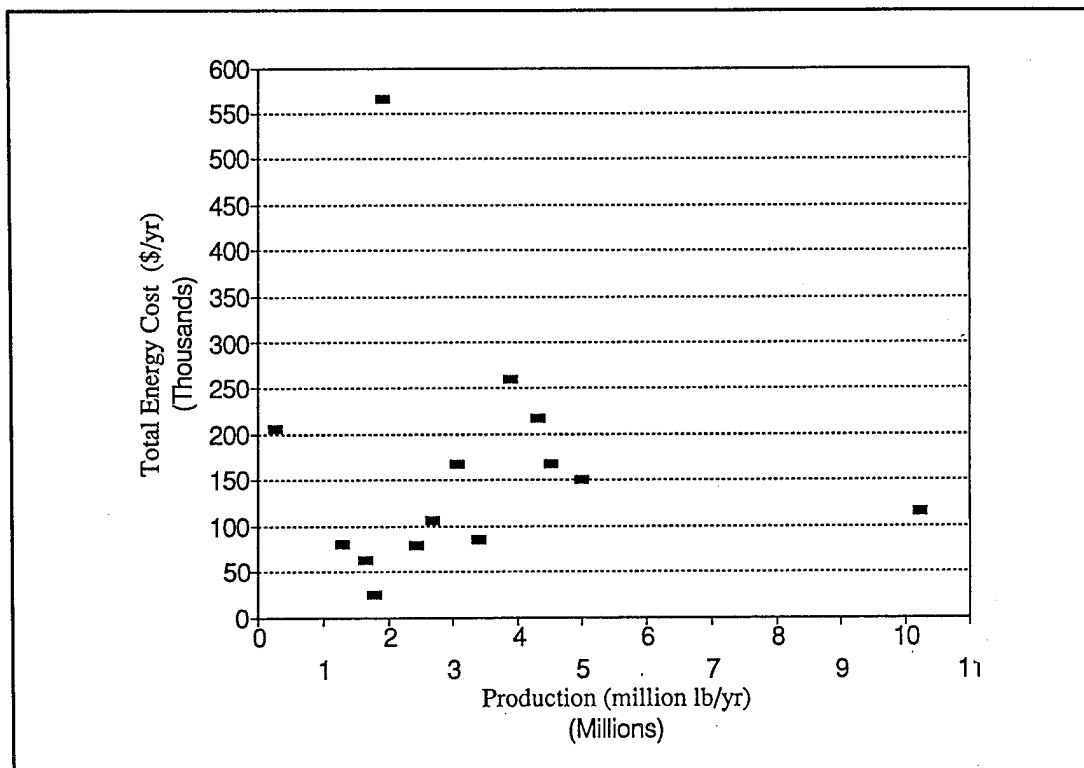


Figure 12. DOD laundry facility total energy cost (\$/yr).

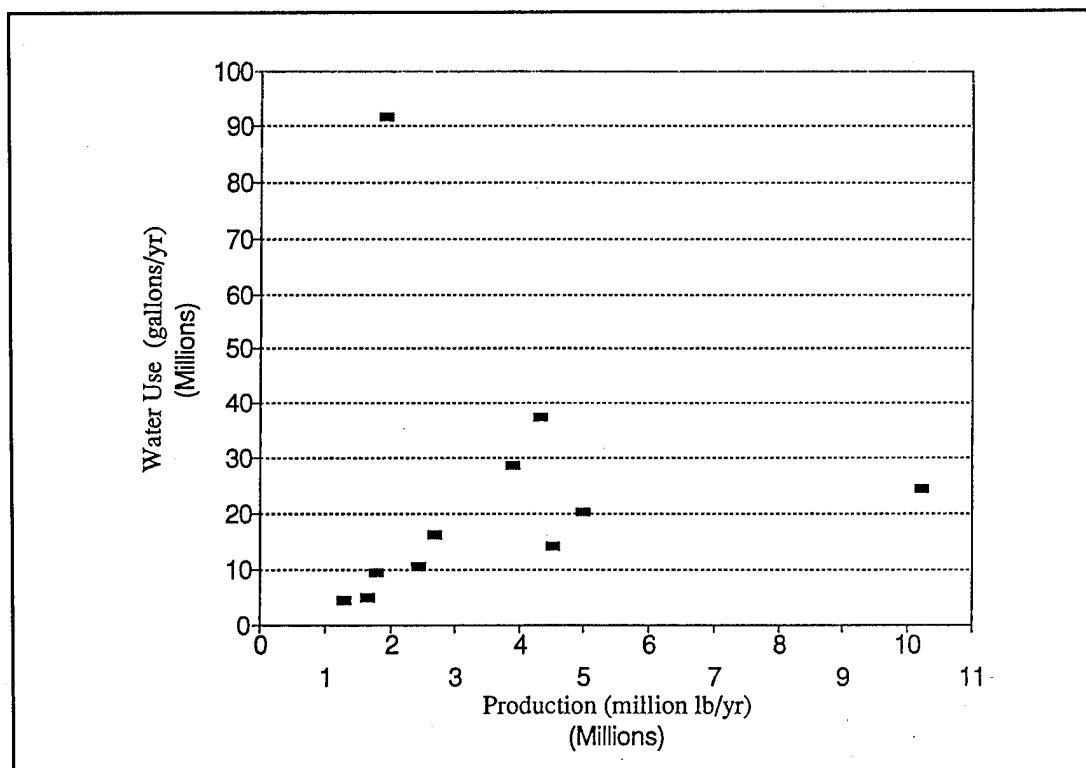


Figure 13. DOD laundry facility water consumption (gal/yr).

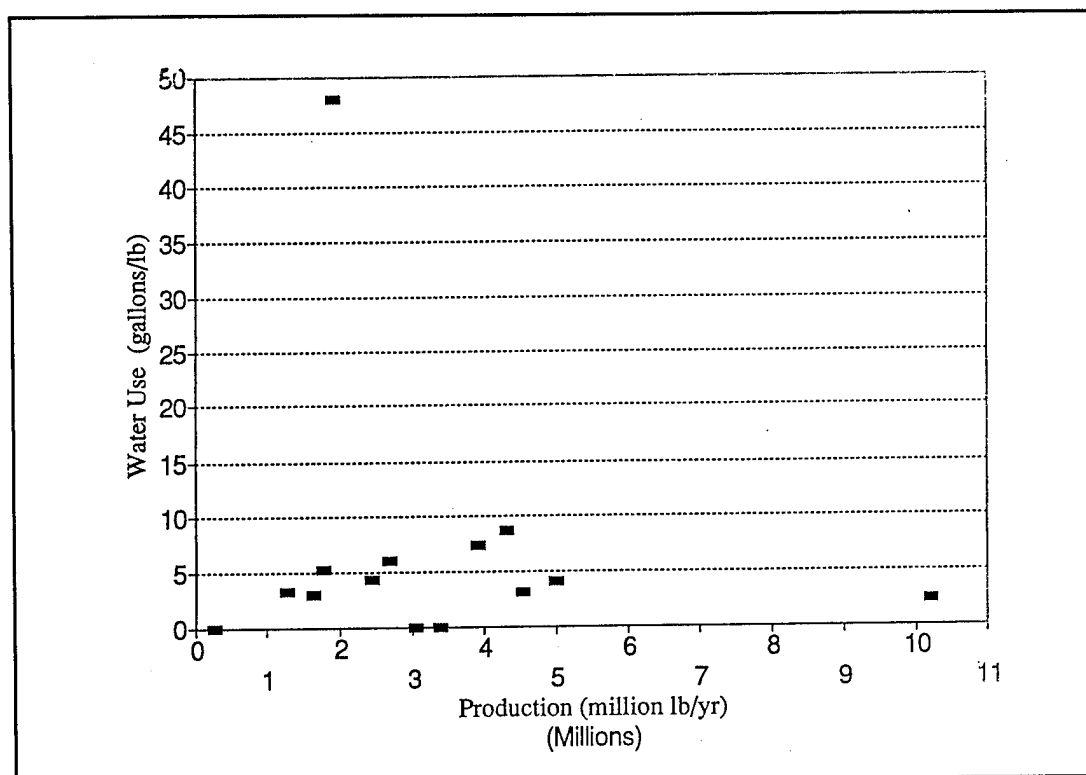


Figure 14. DOD laundry facility water consumption (gal/lb).

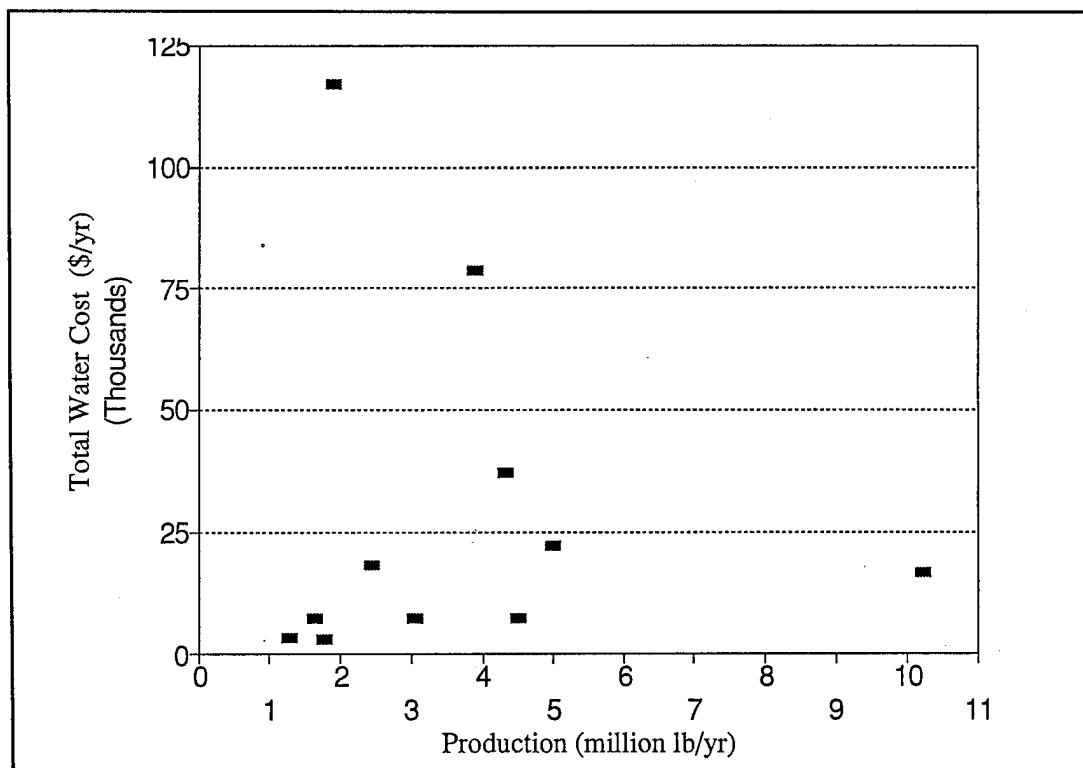


Figure 15. DOD laundry facility water cost (\$/yr).

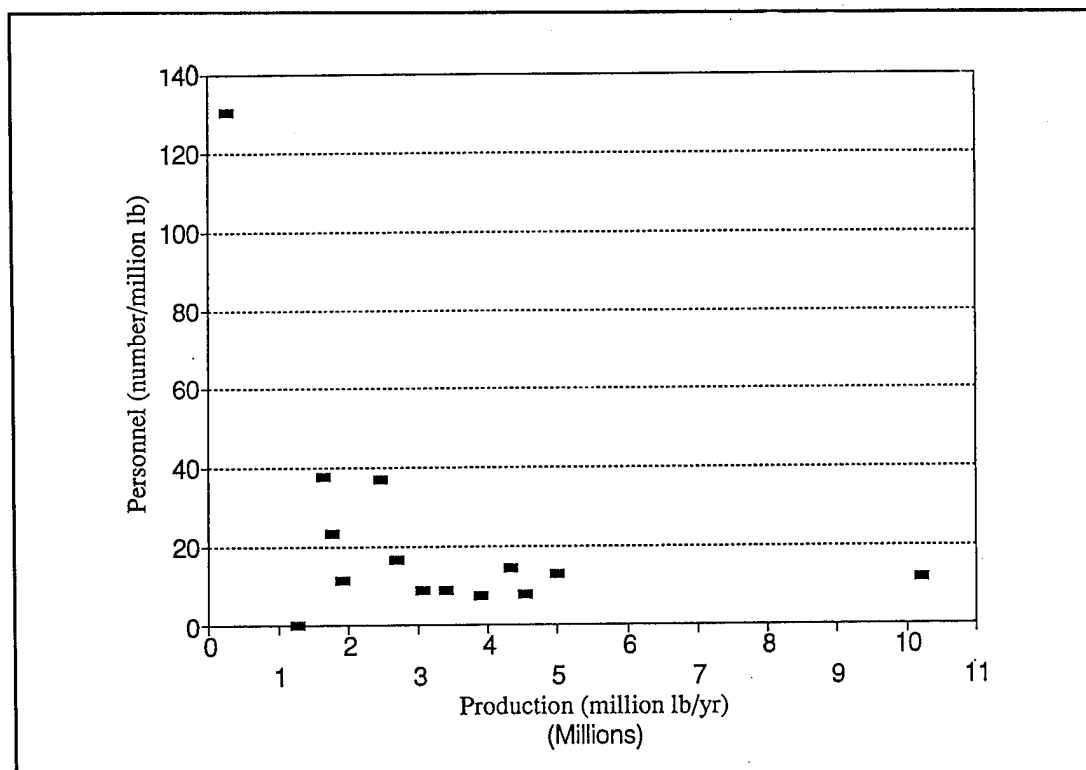


Figure 16. DOD laundry facility personnel (number/million lb processed).

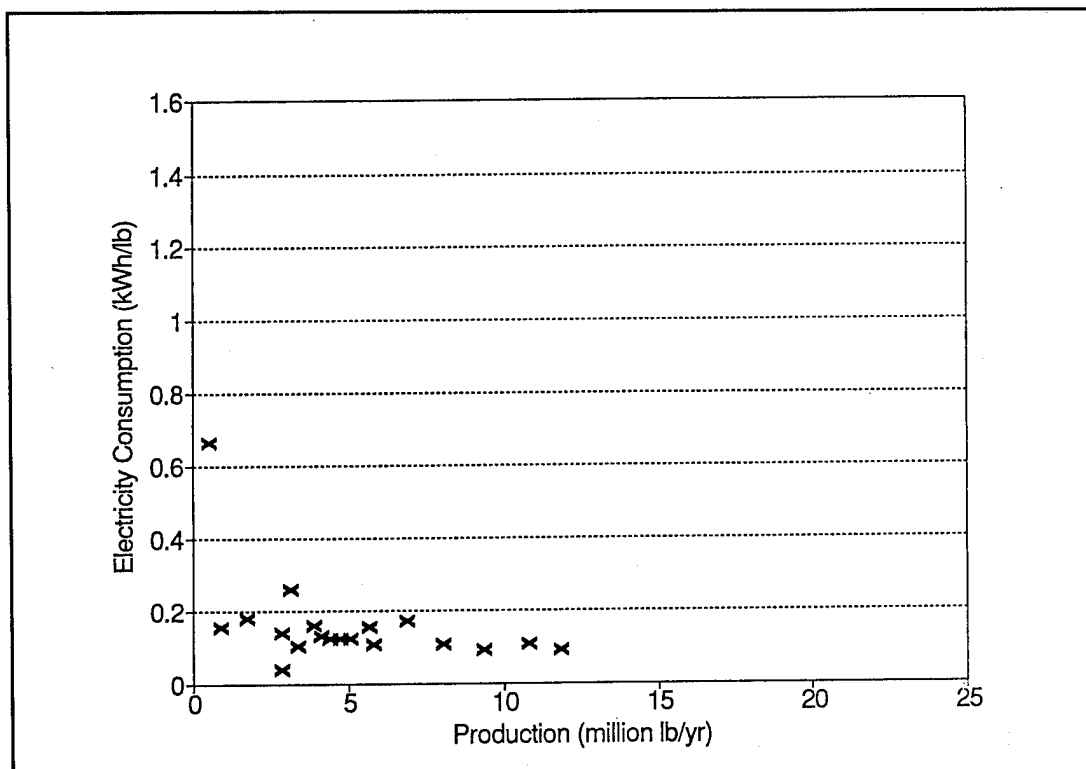


Figure 17. Commercial laundry facility electricity consumption (kWhr/lb).

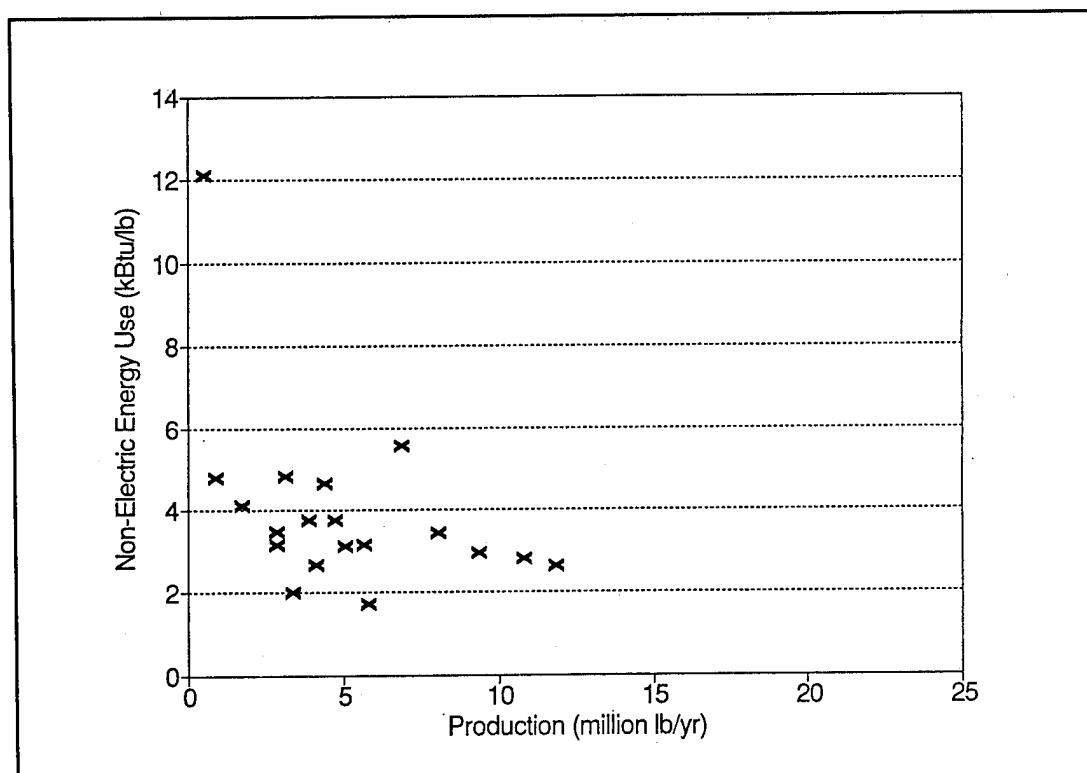


Figure 18. Commercial laundry facility nonelectric energy consumption (kBtu/lb).

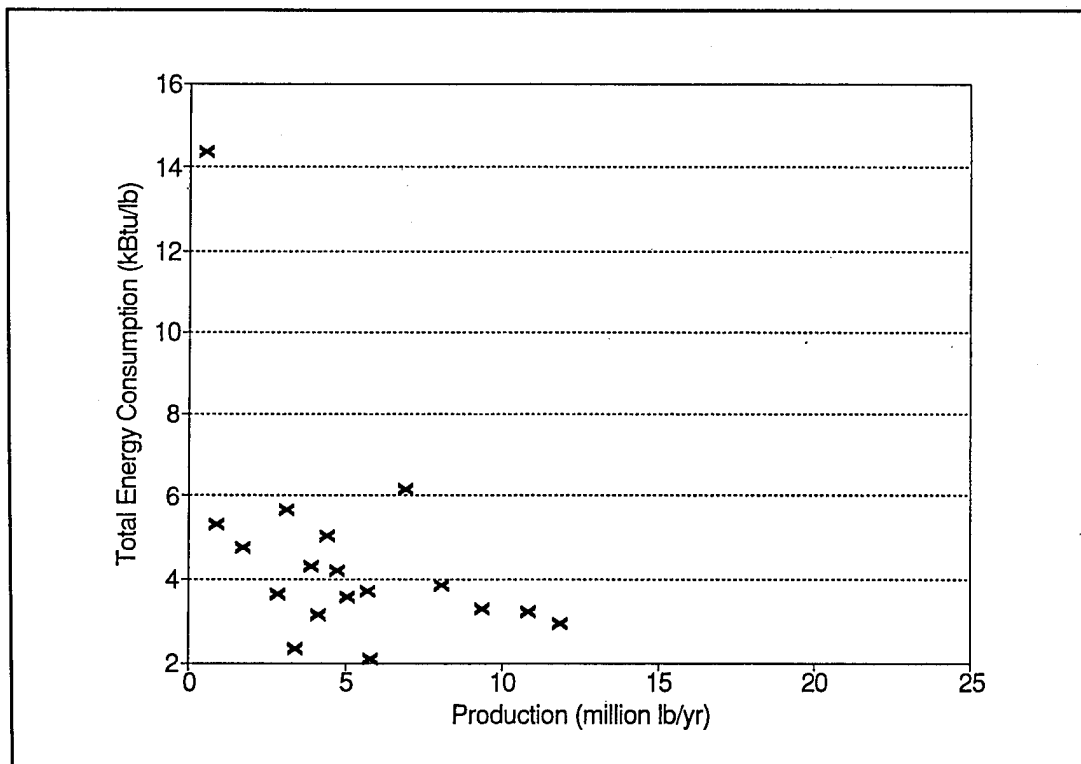


Figure 19. Commercial laundry facility total energy consumption (kBtu/lb).

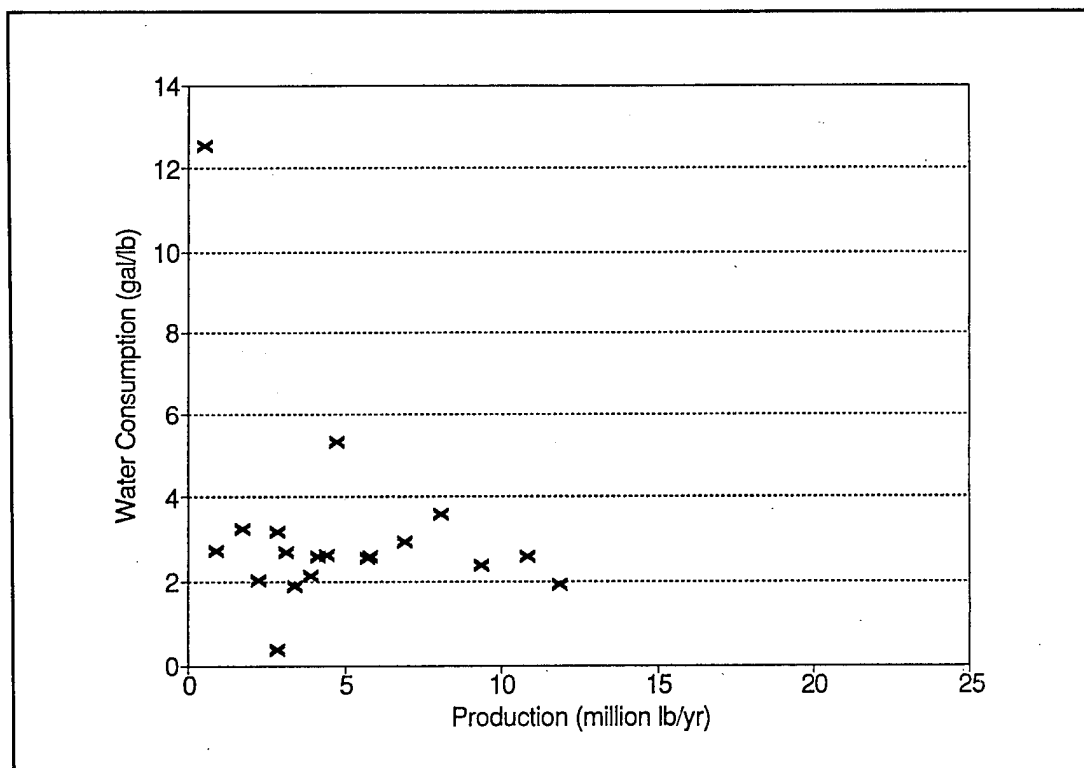


Figure 20. Commercial laundry facility total water consumption (gal/lb).

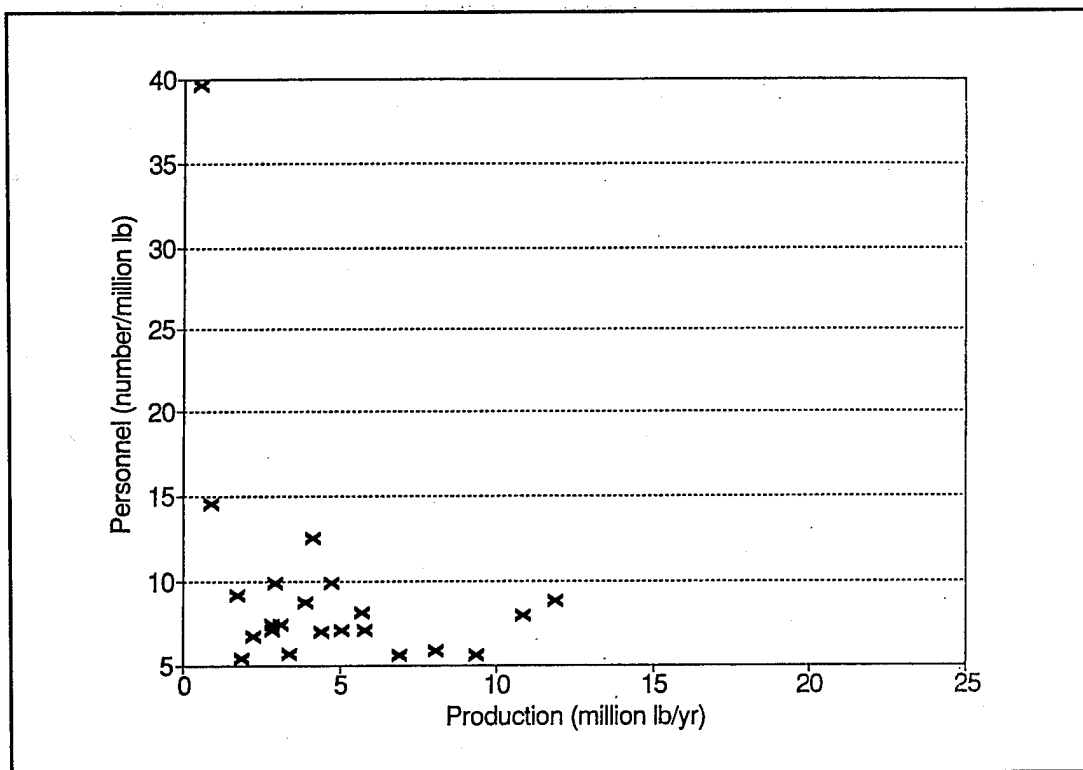


Figure 21. Commercial laundry facility personnel (number/million lb processed).

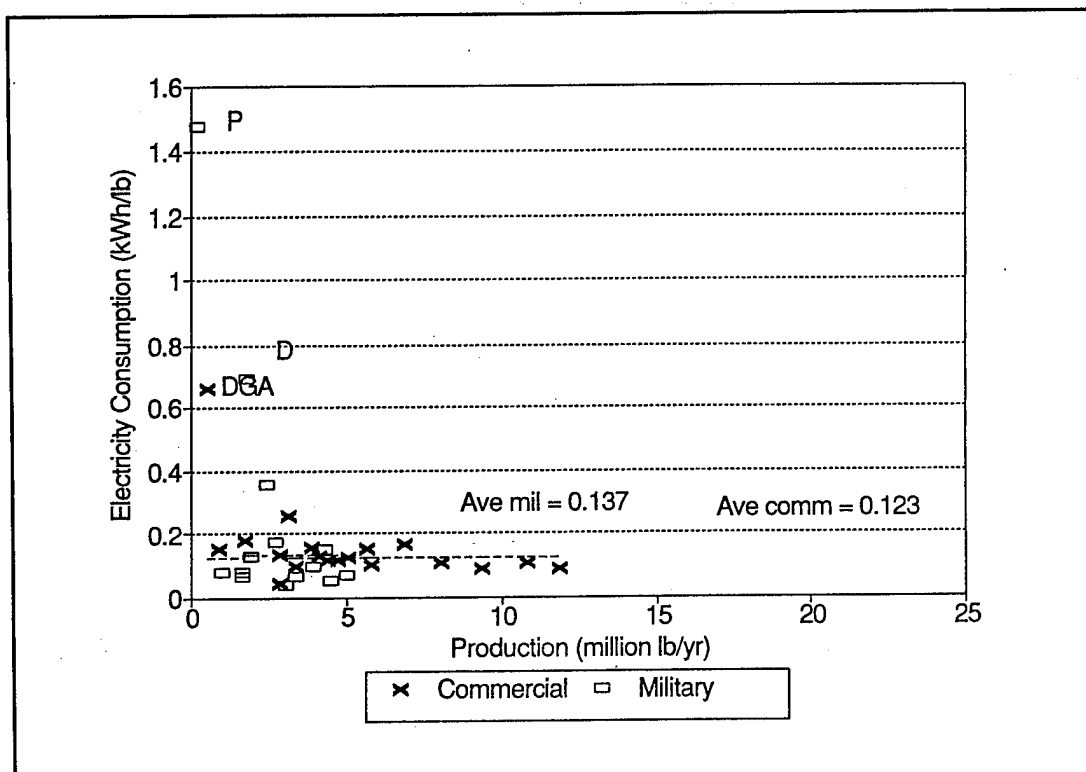


Figure 22. Electricity consumption comparison.

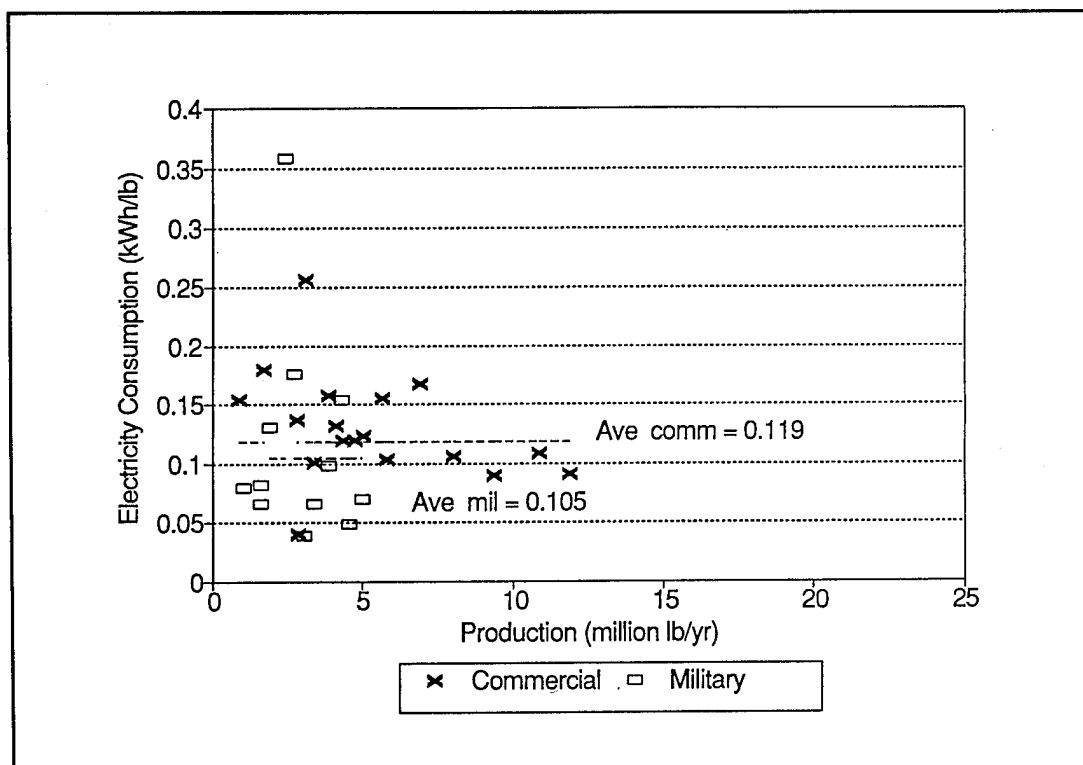


Figure 23. Electricity consumption comparison, expanded scale.

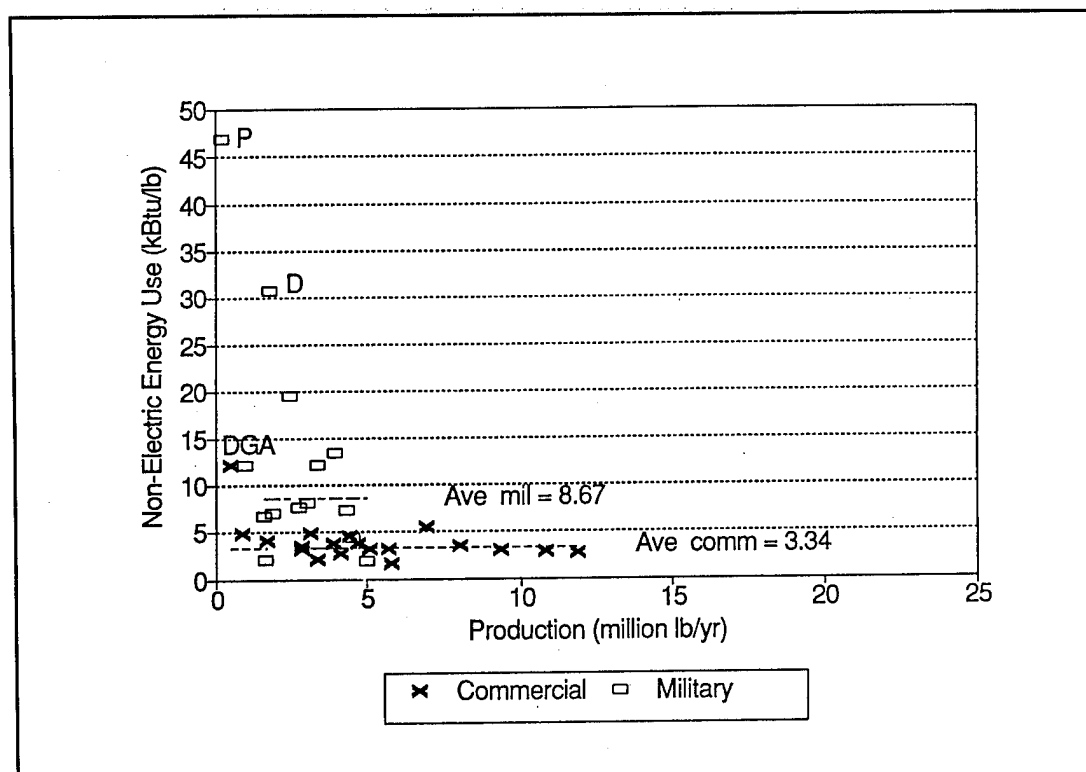


Figure 24. Nonelectric energy consumption comparison.

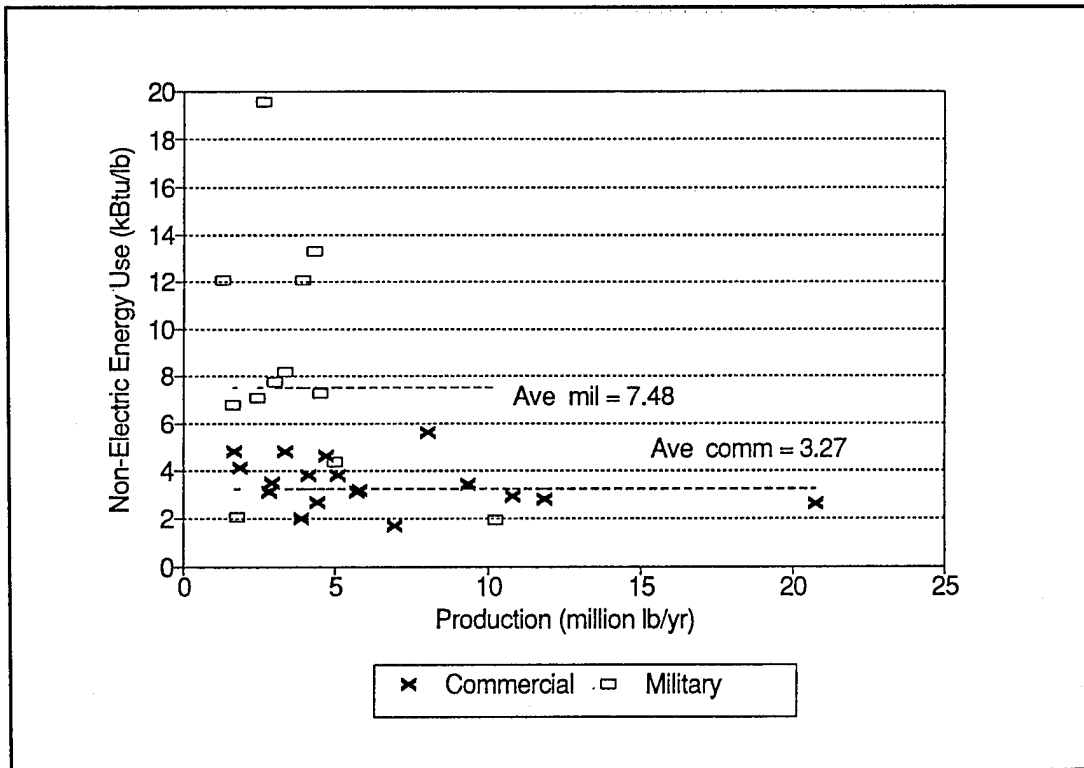


Figure 25. Nonelectric energy consumption comparison, expanded scale.

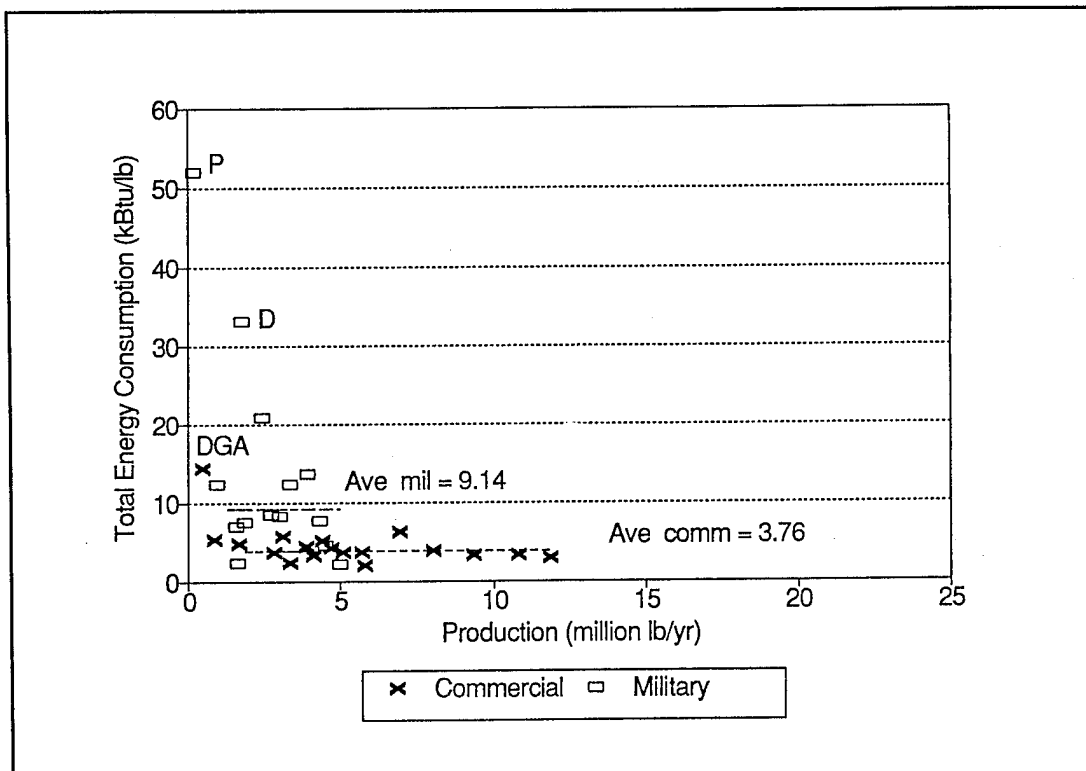


Figure 26. Total energy consumption comparison.

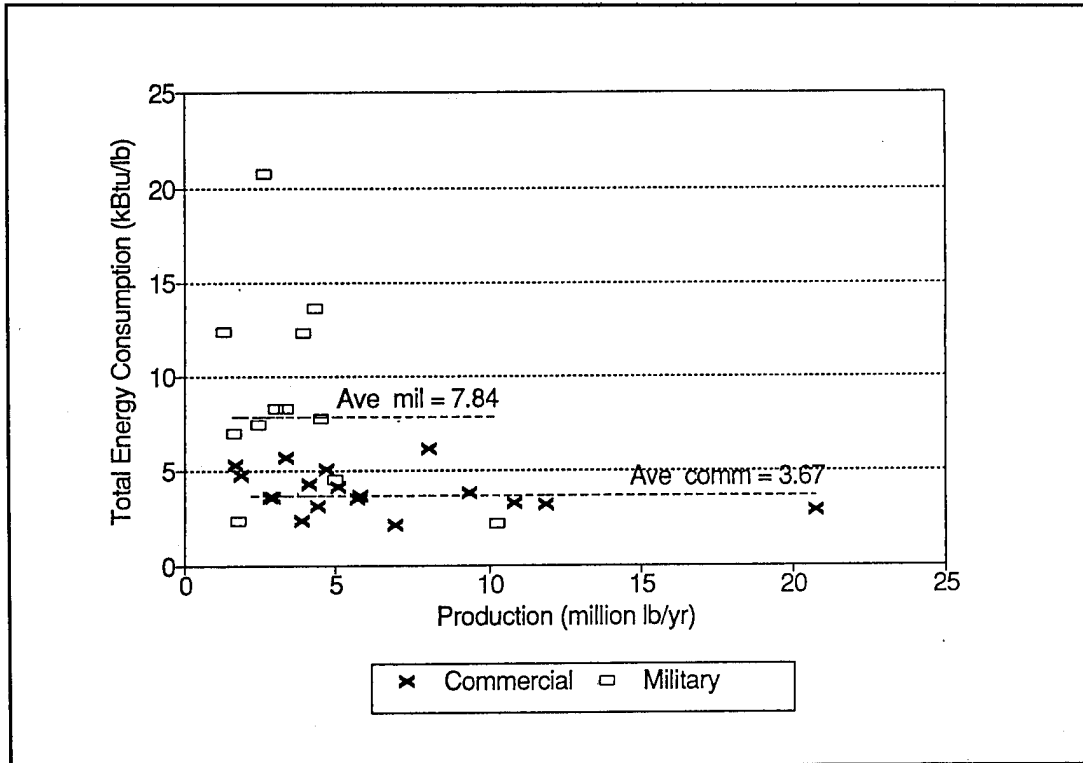


Figure 27. Total energy consumption comparison, expanded scale.

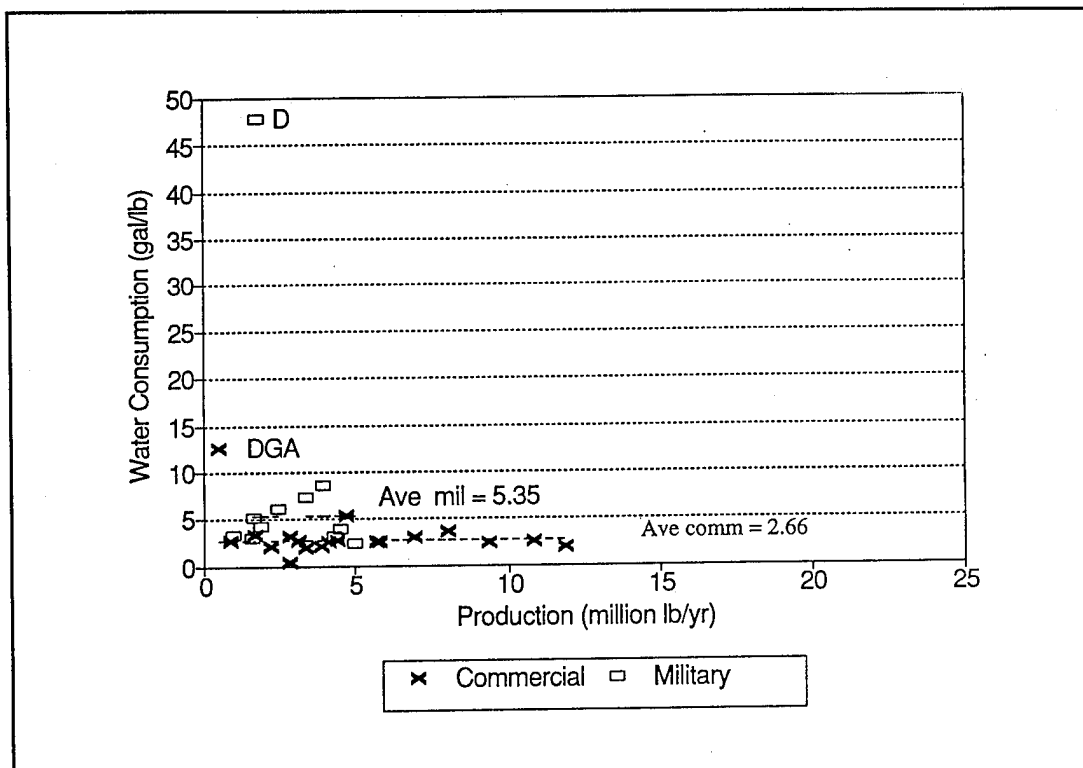


Figure 28. Water consumption comparison.

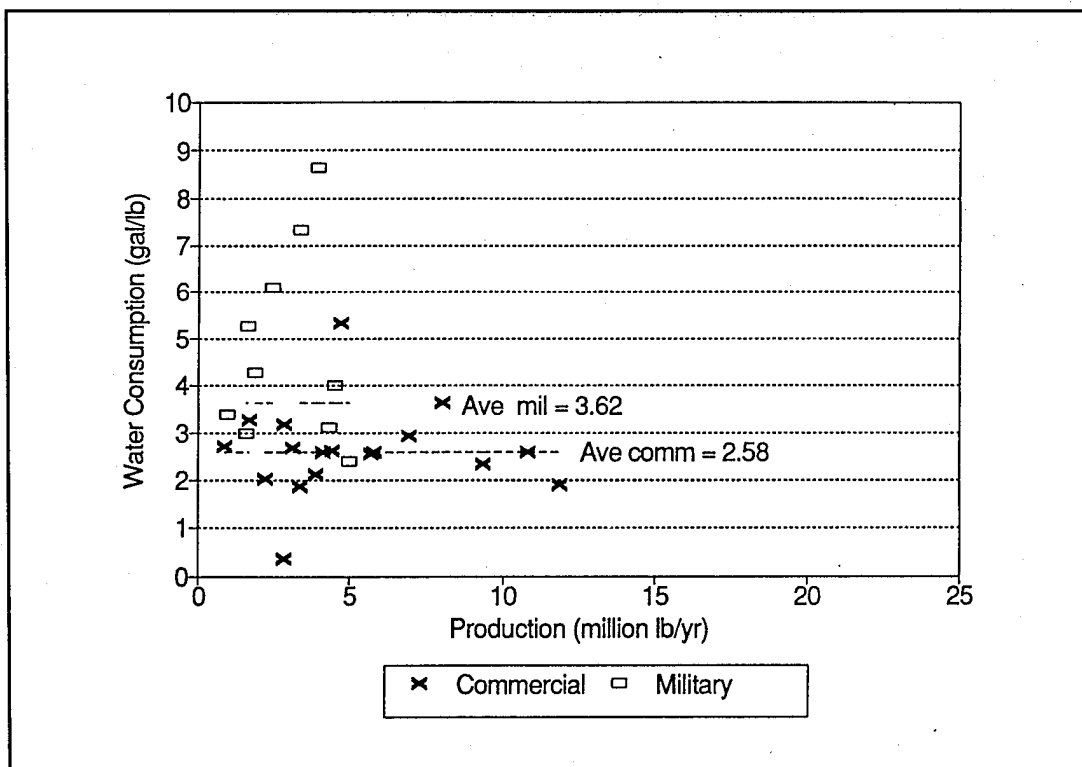


Figure 29. Water consumption comparison, expanded scale.

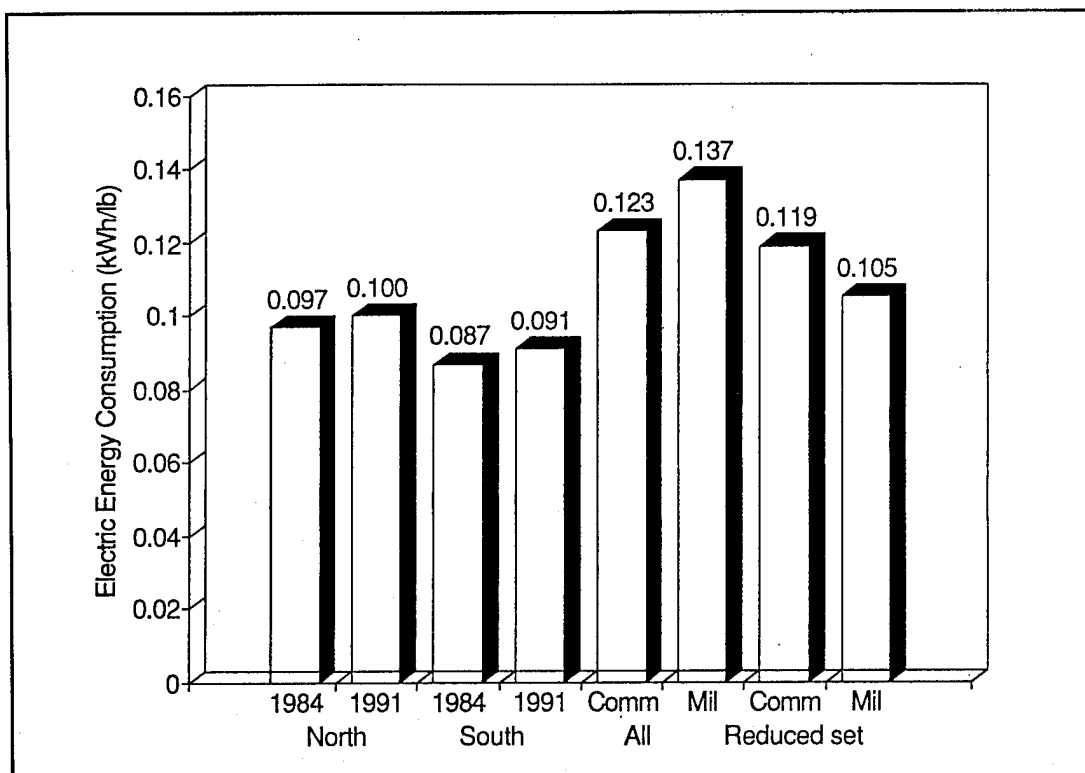


Figure 30. Electricity consumption.

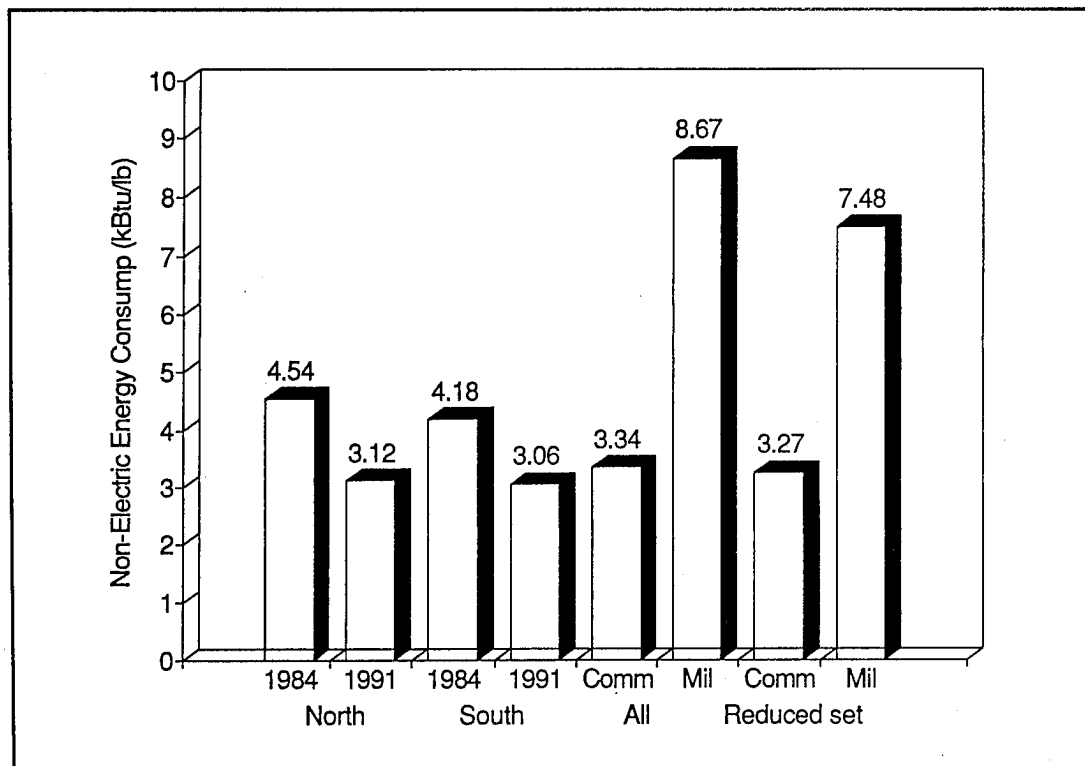


Figure 31. Nonelectric energy consumption.

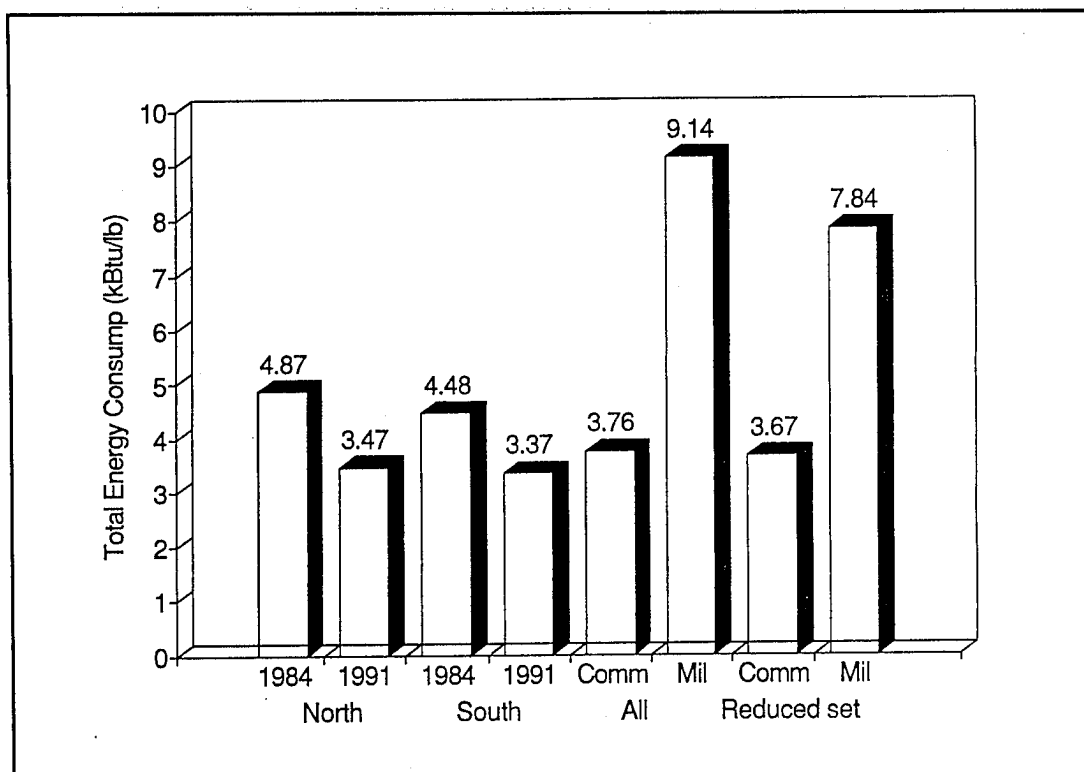


Figure 32. Total energy consumption.

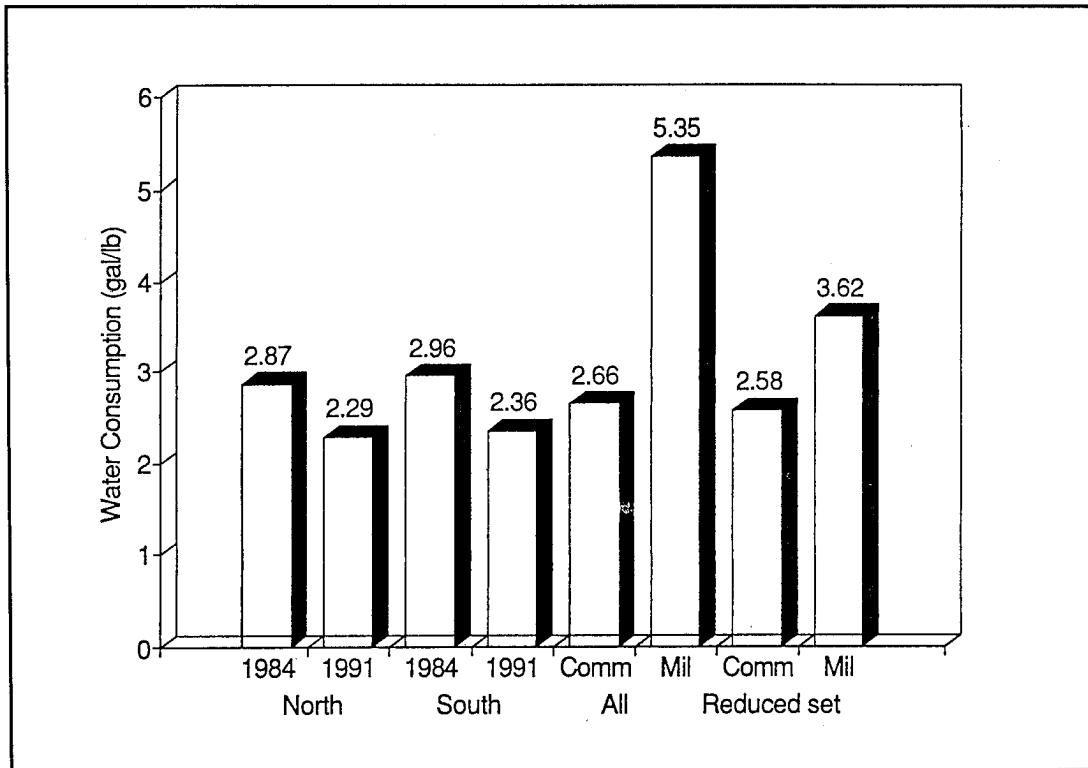


Figure 33. Water consumption.

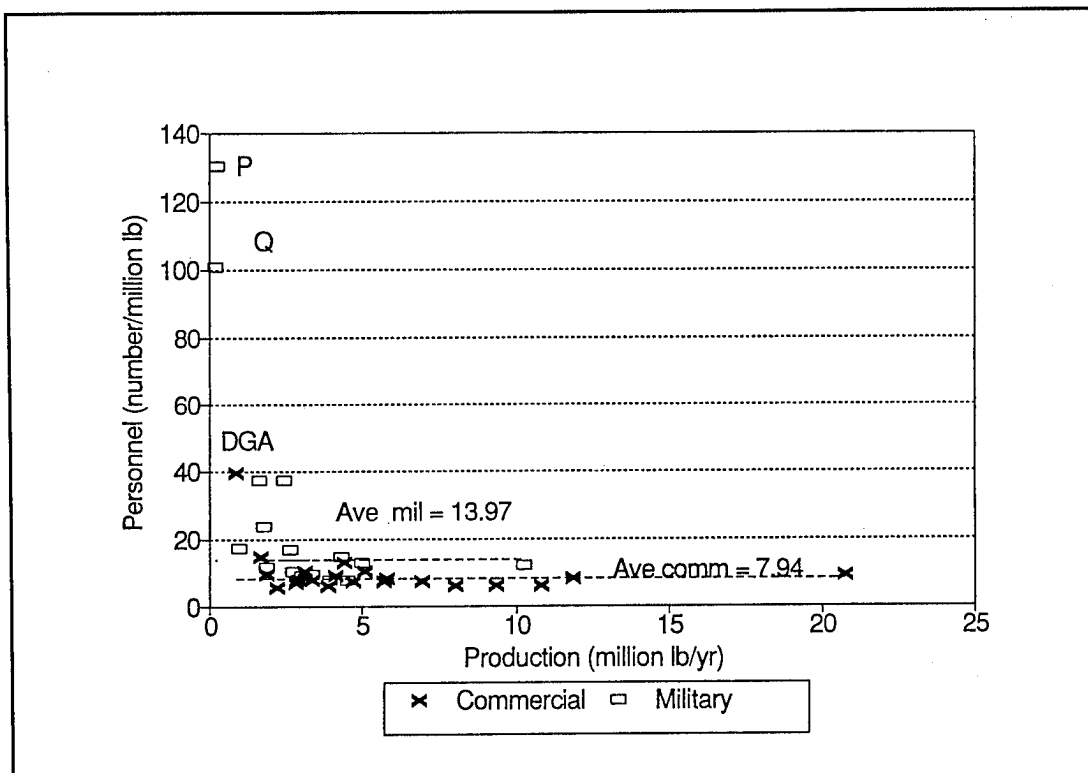


Figure 34. Personnel comparison.

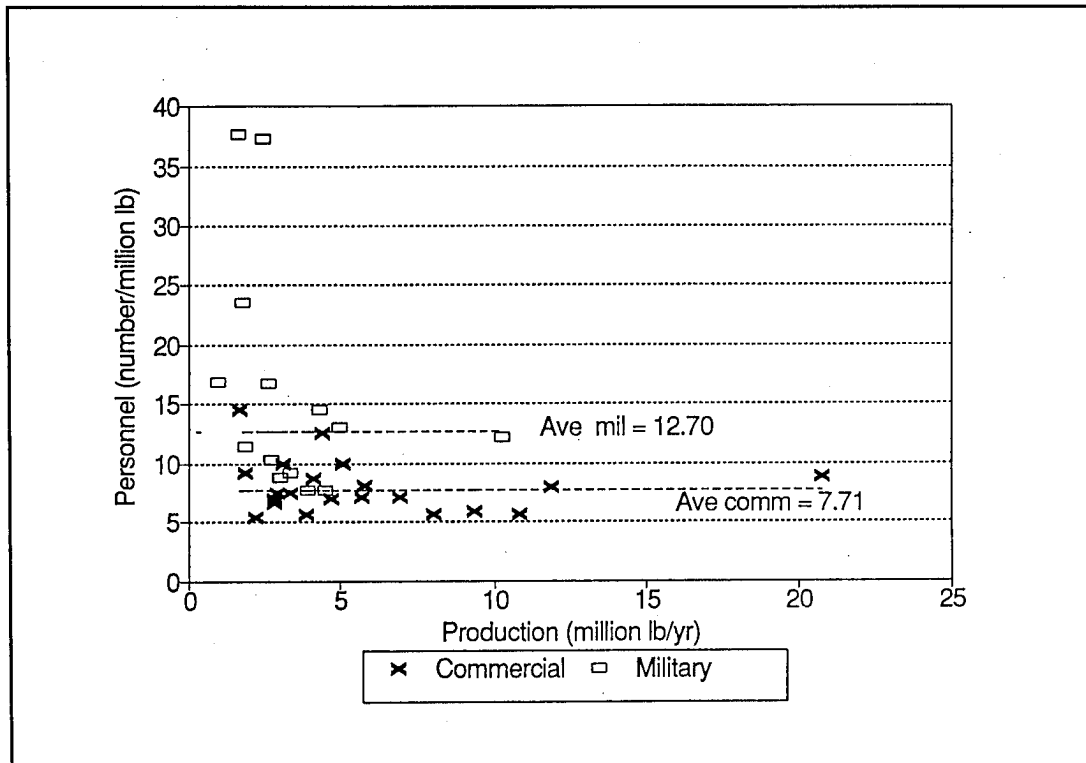


Figure 35. Personnel comparison, expanded scale.

## 3 Technology Review

### Conventional Technologies

#### *Unloading Batch Washers*

An unloading batch washer washes and rinses one batch of laundry at a time. After washing, the batch must be removed and transferred to an extractor to continue the process. Many units can be tilted to permit easier loading and unloading. Modular installation is common since it permits simultaneous processing of different types of goods with various degrees of soiling.

#### *Batch Extractors*

An extractor removes most of the water from a freshly washed batch of laundry before the laundry goes to the drying or finishing stages. Various methods of extraction may be used, such as spinning to force the water out by centrifugal force, squeezing in a flexible container, or compressing with a hydraulically or pneumatically operated piston in a porous cylindrical container. Loads from more than one washer can be combined in the extractor operation, and loads from more than one extractor can be combined in the drying operation. Figure 36 shows a centrifugal extractor.

#### *Washer Extractor*

A washer extractor combines the washing and extracting operations into a single machine similar to a household automatic washing machine. Extraction is accomplished by spinning. Multiple speeds are available in both the wash and extraction operations to accommodate fabrics of varying delicacy. Many units can be tilted to permit easier loading and unloading. Modular installation is common, permitting flexibility in handling different types and amounts of loading. Loads from more than one washer extractor can be combined in the drying operation. Figure 37 shows a sample washer extractor.

## ***Dryers***

Dryers provide the final drying to the laundry before the finishing and ironing stages by blowing a hot gas mixture through a rotating drum (tumbler) containing the goods to be dried. Heat for drying can be provided directly by combustion of natural gas, or indirectly with a fluid such as steam, hot water, or a thermal fluid. In a direct-fired dryer, the hot exhaust gases from the combustion process are blown through the dryer. In an indirect system, a heat exchanger is employed to transfer heat from the fluid to the hot air blown through the dryer. Figure 38 shows a tumbler dryer. Where further drying beyond extraction is not required, dryers may be used without heat as tumblers, to loosen and fluff caked goods.

Energy reducing features used in dryers include exhaust gas recirculation, exhaust gas economizers, automatic detection of exhaust humidity to shut off the dryer when goods are sufficiently dry, insulation of the entire unit to retain heat in the dryer, and gravity unloading instead of pneumatic unloading with hot drying air. The lower limit of energy use for a dryer system employing all of these energy conservation features is about 1700 Btu/lb of water removed.

## ***Flat Work Ironers***

Flat work ironers are used to press flat goods such as bed linen, tablecloths, towels, etc. The main components of a flat work ironer are the chest(s) and the roller(s). The chest has a highly polished steel surface formed to the contour of the roller, and is hollow to admit steam or a thermal fluid to heat the polished steel surface to the proper temperature for drying and ironing. The roller is made of a perforated steel cylinder and is covered with a porous, heat-resistant padding and cloth. Ironing is accomplished by rolling the goods with the roller against the heated polished steel surface. The water removed from the goods is drawn to the inside of the hollow roller and exhausted out the end. In comparison with the handheld household flatiron, the roller thus performs the function of the ironing board while the heated steel surface performs the function of the iron. Figure 39 shows a flat work ironer.

Steam-heated ironers operate at maximum pressures of about 125 psia, which limits the temperature of the ironing surface to about 300 °F. Thermal fluid ironers can operate at higher temperatures, (about 400 °F) and can therefore be run at higher speeds. At the higher temperatures, more accurate control is needed to avoid scorching the goods. Both steam and thermal fluid are recirculated to the boiler or heater for reuse.

## ***Presses***

Presses are used to iron irregularly shaped goods such as shirts, blouses, and pants. The main components of a press are the buck and the head. The head has a highly polished steel surface formed to the contour of the buck, and is hollow to admit steam or a thermal fluid to heat the polished steel surface to the proper temperature for drying and ironing. The buck is a padded form on which the item to be pressed is placed. In comparison with the hand-held household flatiron, the buck performs the function of the ironing board while the head performs the function of the iron.

Utility presses have bucks that resemble household ironing boards, with flat or slightly rounded pressing surfaces. The head is contoured to match that of the buck. The garment is placed on the buck, and the head is pressed into contact with the garment. Figure 40 shows a utility garment press.

Shirt and blouse presses use a standing buck, which is dressed with the garment, and the chest closes in around it. Bucks come in different sizes and shapes that are interchangeable in the press. The inside of the buck may be pressurized with compressed air to stretch the garment to a smooth shape during the pressing operation. A porous buck and heated air may also be employed so that the hot air flowing through the garment speeds up the drying process. Figure 41 shows a double buck press.

## ***Material Handling Systems***

Material handling systems perform multiple functions of sorting, storage, and transportation of goods between the various stages of the laundering process. Material handling systems range from fully manual to fully automated. In general, as the degree of automation increases, the energy (electricity) requirement increases while the labor (number of personnel) requirement decreases. Manual systems typically consist of canvas laundry carts that are manually loaded, unloaded, and wheeled from station to station. The process is automated with conveyors, rails, and pneumatic tubes, either singly or in combination.

Conveyors can be used to transport goods to and from washers, extractors, dryers, and finishing systems. Loading and unloading can be automated through various schemes, including providing loading hoppers on tops of the machines and tilting machines to permit emptying by gravity. Figure 42 shows material handling systems featuring carts and conveyers.

Rail systems reduce required floor space by carrying goods overhead in slings. Slings, which remain as a unit throughout the washer-extractor-dryer process, are porous bags containing sorted loads of goods. This provides a convenient sorting, storage, and transportation system. If goods must be temporarily stored because of lack of machine availability, they can be kept at ceiling level, which does not interfere with personnel access to the operation. Empty slings are collapsed for storage, reducing the required rail space to a minimum. Rail systems are generally the most energy efficient of the transportation systems.

Pneumatic tubes, or *negative air systems*, are used for automatic transport from the delivery truck to the initial sorting and dispatching area and from the sorting area to the washer. When used from sorting area to washer, there is generally a "buffer" storage box of one-load capacity, which serves to minimize washer loading time. In these systems a large (25 to 60 hp) blower is used to pull the goods through a cylindrical duct to a screen box for sorting. Negative air systems are not particularly energy-conserving; their primary advantage over other transport systems is in lower first cost, installation cost, and maintenance cost. Most negative air systems are semi-automatic.

## Advanced Technologies

### *Ozonation*

The use of ozone for laundry cleaning is one of the most recent developments in the industry. The ozone-based process was developed to provide a viable cleaning method for space applications where a limited supply of resources was available to the astronauts. The process involves creating and injecting an ozone-air mixture into the wash fluid. The ozone enhances the cleaning process in several ways. The ozone oxidizes calcium and magnesium ions and contributes to the oxidation of organics to a more soluble state, promoting precipitation of the organic oxide. Washwater is recirculated through the ozone generator during the wash cycle. Overall, the action of the ozone extends the life of the detergent, decreases the amount of detergent needed, reduces the demand for water, and shortens the wash cycle time. The reduction in quantities of water and chemicals used in the wash cycle leads to a reduction in the amount of wastewater produced and a decrease in sewer expenditures. The use of extra electricity to operate the ozone generator is offset by the decrease in wash cycle time and hot water consumption. Wash cycle energy cost savings of 18 percent and chemical savings of nearly 30 percent have been predicted for systems using the ozone process.

Industry studies (Institute of Industrial Launderers [IIL] Ozone Washing Task Force, 1992) have shown that the use of the ozonation process may result in a reduction of chemical use, water consumption, and wash time while sacrificing a varying degree of cleaning capability (depending on the type of soil in the fabric). Studies also demonstrated that ozone cleaning did not exhibit any adverse effects on color retention. It has been noted, however, that ozone may accelerate the fading of some fabrics, such as dyed acetate fabrics. Also, fabric strength was not significantly affected during the ozone cleaning tests. Additional studies to investigate the effect of varying concentrations of ozone on the cleaning process have been planned by various organizations.

Ozone is also useful in removing odors from fabrics. The odor-causing substance is neutralized via oxidation by the ozone molecules. Everyone working with ozone systems must be cautious, because concentrations as low as only one part per million have toxic effects on humans. Symptoms of exposure to ozone include headache, dry throat, irritation of respiratory passages, and burning eyes. Exposure to extremely high concentrations of ozone can be lethal. Ozone, though colorless, can be detected by sensors and has a distinct odor detectable to humans. Workers should evacuate the area when dangerous levels of ozone are present.

### ***Microwave Dryers***

The success of microwave technology for cooking created interest in the possibility of microwave drying. The process of using microwaves for drying fabrics has been, and continues to be, tested to determine its effectiveness, efficiency, and safety. Initial tests revealed problems with heating and arcing of metal (snaps, zippers, buttons, rivets), which damaged the fabric being dried and presented the possibility of ignition. Subsequent testing has shown that a drying process involving microwaves and heated air may be more efficient than conventional drying. Also, drying with microwave energy occurs at a lower temperature than conventional drying, allowing the consumer to dry delicate fabrics without shrinkage or other damage. The problem of arcing and overheating certain materials may be eliminated by controlling the intensity of the electric field strength in the dryer. Near the end of the drying cycle, the field strength in the dryer increases as the humidity level decreases, causing an increase in the possibility of overheating materials in the dryer. Incrementally decreasing the power from the microwave emitters as the humidity of the exit air decreases near the end of the drying cycle would, conceivably, lessen the possibility of overheating and arcing. The production of microwave dryers for general use will be feasible when the overheating and arcing problems have been solved.

### ***Continuous Batch Washers***

In a continuous batch washer (CBW), each step of the wash/rinse process takes place in a separate module of the machine. The goods are automatically transferred between the modules on the appropriate schedule. The amount of chemicals and water added to each module is controlled by a preprogrammed microprocessor. The laundry operator must enter the programming code for the type of goods being laundered (whites, colors, towels, etc.) and the machine then washes the batch. Since the modules operate simultaneously, several loads of goods can be in different stages of the process at the same time. Time savings occur because the CBW operates continually, with one batch following directly after another through the modules, eliminating the necessity of waiting for draining and refilling a single cylinder as in the case of a conventional batch washer. Clean water is fed to the machine at the final rinse module, and then is transferred through the row of modules in a "counterflow" direction to the goods. This ensures the cleanest possible goods at the end of the process. Water is recycled through the system to extend the life of the chemicals, reduce water consumption, and reduce energy requirements for water heating. CBWs use less water and energy than batch washers. Figure 43 shows a CBW schematic.

CBWs are used in laundry plants today in Europe, North America, and elsewhere. The process was developed to accommodate energy, water, and labor problems experienced in Europe. Environmental restrictions, water and energy shortages, and increases in the cost of energy, water, and labor have created a need for more efficient laundry systems throughout the world. CBWs answer the need for more efficient, less costly, and reliable equipment technology. The quality of cleaning occurring in a CBW is equal to or better than that achieved in a conventional batch washer. In most, if not all, CBW installations, the goods are automatically transferred through the entire laundering process to the final finishing stages. Labor savings occur because the only labor required is to load the CBW feeder and enter the proper programming code.

### ***Thermal Fluid Systems***

Thermal fluid systems provide an alternative to steam/hot water systems for providing thermal energy. Flat Work ironers are the most common application of thermal fluid systems in laundry facilities. These systems may also be used to provide energy for heating water, presses, and air (space heaters and dryers). The thermal fluid systems, when properly operated, require less maintenance than steam systems and may be more energy efficient due to the elimination of losses associated with steam blowdown, deaeration, and trap leaks. Corrosion problems common to steam systems are not present in thermal fluid systems. Thermal fluid systems do not require steam traps, water treatment chemicals, or deaeration. Thermal fluid spills or leaks are treated

like lubricating oil leaks and the thermal fluid can be combined with used oils for recycling. Steam systems are usually operated at temperatures as high as 350 °F and a pressure of 125 psi while thermal fluid systems can safely operate at temperatures as high as 450 °F near atmospheric pressure. A small amount of pressure is created by the pump that circulates the fluid. Thermal fluid systems can use a cold-sealed expansion tank or inert gas blanketing to prevent oxidation of the fluid. Safeguards should also be taken to prevent degradation of the fluid via overheating, especially during equipment shutdowns or power failures. Oxidation and degradation of the fluid will decrease the system's performance and could even damage the system. A licensed operating engineer is required in many states by operations employing high pressure steam systems. The thermal fluid systems usually do not require a licensed operating engineer, a factor that significantly reduces labor costs.

### ***Direct Contact Water Heaters***

In a fuel-fired (as opposed to electric) water heater, water is heated from the hot exhaust gases of the fuel combustion process. In a conventional heater, the water and exhaust gases are physically separated by some configuration of solid walls (e.g., shell-and-tube, fire-tube, or water-tube). In direct contact water heaters, the water is placed in direct contact with the exhaust gases. The contact occurs in a packed tower configuration, in which the water is injected at the top of the tower (typically through spray nozzles or a ring-type manifold) with the exhaust gases flowing upward through the packing. As thin films of water trickle down the packing, they pick up heat through direct contact with the rising exhaust gases. The direct contact heat transfer process is very efficient, with the exhaust gases typically at a final exit temperature within 20 °F of the entering water temperature. At the low exhaust gas exit temperature, the water vapor in the exhaust gases has been condensed and added to the water supply—an additional bonus. Efficiencies greater than 99 percent are claimed. Figure 44 shows a sample direct contact water heater.

In steam-generation boilers, a direct contact heat exchanger having essentially the same configuration as the direct contact water heater described above can be used in the exhaust stack to preheat the boiler feed water. In a well-tuned boiler, this can decrease the fuel requirements by 20 percent compared to a system with no exhaust heat recovery.

### ***Waste Water Heat Recovery and Rinse Water Reuse***

In a wastewater heat recovery system, thermal energy in the wastewater from wash-and-rinse operations is used to preheat the incoming supply water. This is accom-

plished with a liquid-liquid heat exchanger located between the water supply and wastewater lines.

Rinse water reuse can also be incorporated with waste heat recovery to reduce water usage. In this system, relatively uncontaminated final rinse water is collected and reheated for use in the first washing stages of operation. The amount of reusable water available depends on the type and level of soiling in the laundry. Typical water savings range between 20 and 30 percent. Filters are included to removed solid contaminants from the reclaimed rinse water. If a plant already has a wastewater heat recovery system, no additional energy savings are provided with a rinse water reuse system.

### **Companies/Organizations**

Table 2 lists manufacturers of various types of laundry equipment. Table 3 lists resource use requirements for washers and extractors. Table 4 lists resource use requirements for dryers, flat work ironers, and presses. Manufacturers should be contacted directly for updated laundry equipment, specifications, and product availability.

Table 2. Laundry equipment manufacturers.

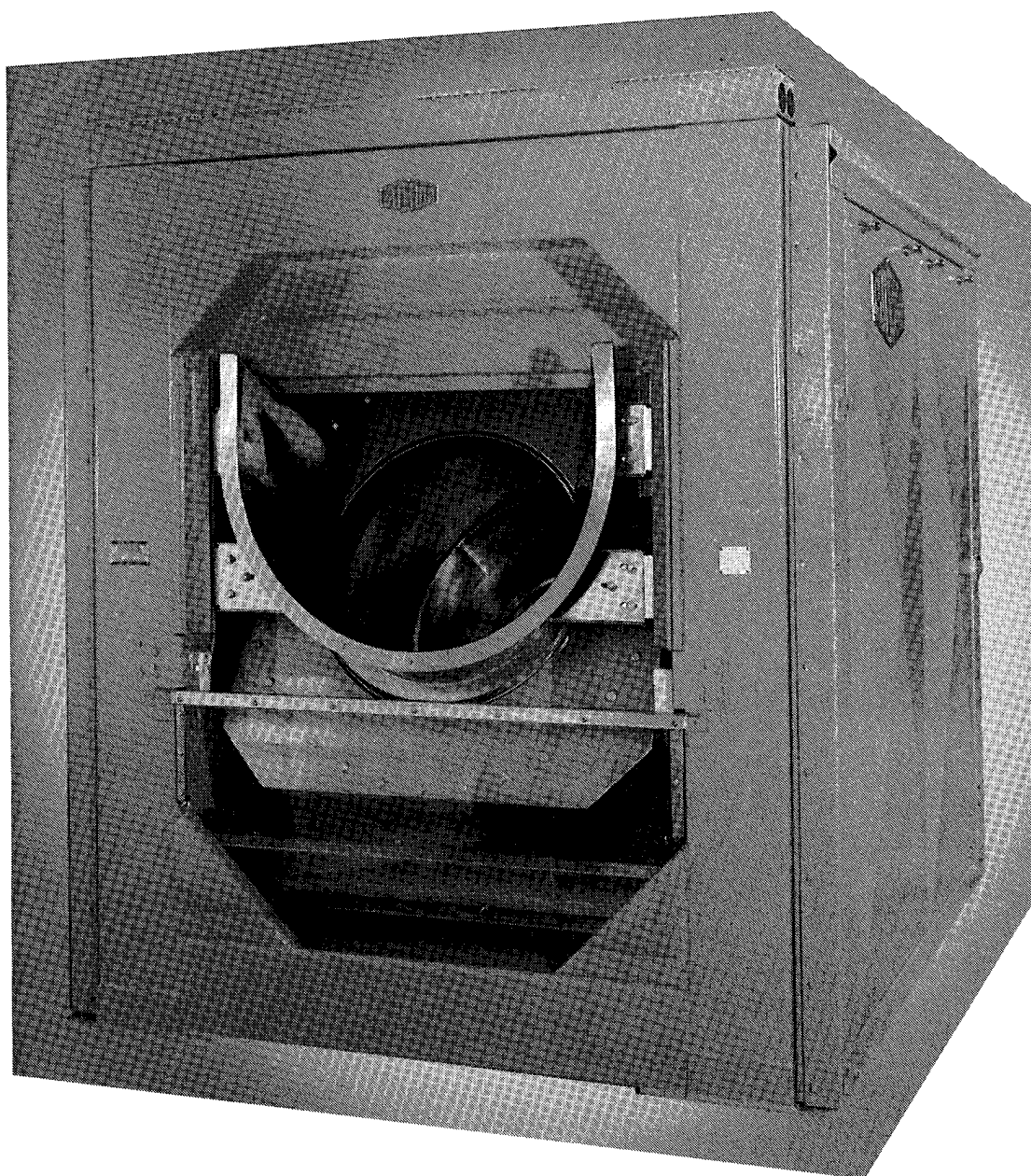
| Company Name                                | Water Heating Equipment | Sorting Systems | Wash Room Equipment                   |                   |                                 |                             | Dryers                    |          |                         |                         | Flat Work Systems | Presses | Material Handling Systems      |                      |
|---------------------------------------------|-------------------------|-----------------|---------------------------------------|-------------------|---------------------------------|-----------------------------|---------------------------|----------|-------------------------|-------------------------|-------------------|---------|--------------------------------|----------------------|
|                                             |                         |                 | Continuous Batch Washer (CBW) Systems | Washer Extractors | Batch Washers; Batch Extractors | Waste Water Energy Recovery | Gas; Steam; Thermal Fluid | Electric | Lint Collection Devices | Energy Recovery Devices |                   |         | Rail Systems; Conveyor Systems | Negative Air Systems |
| American Dryer                              |                         |                 |                                       | ✓                 | ✓                               | ✓                           | ✓                         | ✓        |                         |                         | ✓                 |         | ✓                              |                      |
| American Laundry Machinery                  |                         |                 |                                       | ✓                 | ✓                               | ✓                           | ✓                         |          |                         |                         |                   | ✓       |                                |                      |
| Ajax                                        |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         |                   | ✓       |                                |                      |
| Boewe Passat                                |                         |                 |                                       |                   | ✓                               |                             | ✓                         |          |                         |                         |                   |         |                                |                      |
| G.A. Braun                                  |                         |                 |                                       | ✓                 |                                 |                             | ✓                         |          | ✓                       |                         | ✓                 |         |                                |                      |
| Brim Laundry Machinery                      |                         |                 |                                       |                   | ✓                               |                             |                           |          |                         |                         | ✓                 |         |                                |                      |
| Central Finishing Systems                   |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         |                   |         |                                |                      |
| Cissel Manufacturing                        |                         |                 |                                       |                   |                                 |                             |                           | ✓        |                         |                         |                   |         |                                |                      |
| Clean Cycle Systems Division of Techni-Quip |                         | ✓               |                                       |                   |                                 |                             |                           |          | ✓                       | ✓                       |                   |         | ✓                              |                      |
| Ekola Engineering                           |                         |                 |                                       |                   | ✓                               |                             |                           |          |                         |                         |                   |         |                                |                      |
| Ellis                                       |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         |                   |         |                                |                      |
| Energenics                                  |                         |                 |                                       |                   |                                 |                             |                           |          | ✓                       | ✓                       |                   |         |                                |                      |
| Forenta                                     |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         |                   | ✓       |                                |                      |
| Huebsch Originators                         |                         |                 |                                       |                   |                                 |                             | ✓                         | ✓        |                         |                         |                   |         |                                |                      |
| Jensen                                      |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         | ✓                 |         |                                |                      |
| Kemco Systems                               | ✓                       |                 |                                       |                   |                                 | ✓                           |                           |          |                         |                         |                   |         |                                |                      |
| Lavatec                                     |                         |                 |                                       |                   | ✓                               |                             | ✓                         |          |                         |                         |                   |         |                                |                      |
| Ludell Mfg.                                 | ✓                       |                 |                                       |                   |                                 | ✓                           |                           |          |                         |                         |                   |         |                                |                      |
| Pellerin Milnor                             |                         |                 |                                       | ✓                 |                                 |                             | ✓                         |          | ✓                       |                         |                   |         | ✓                              |                      |
| Speed Check Conveyor                        |                         | ✓               |                                       |                   |                                 |                             |                           |          |                         |                         |                   |         | ✓                              |                      |
| Thermal Engineering of Arizona              | ✓                       |                 |                                       |                   |                                 | ✓                           |                           |          |                         | ✓                       |                   |         |                                |                      |
| Unipress                                    |                         |                 |                                       |                   |                                 |                             |                           |          |                         |                         |                   | ✓       |                                |                      |
| Washex/Sinking ELX Group                    |                         |                 |                                       | ✓                 |                                 |                             |                           |          |                         |                         |                   |         |                                |                      |
| White Automation                            |                         | ✓               |                                       |                   |                                 |                             | ✓                         |          | ✓                       | ✓                       |                   |         | ✓                              |                      |

Table 3. Energy, water, and steam use by washers and extractors.

| Table 3. Energy, water, and steam use by washers and extractors.                                                                                                             |              |         |                 |                 |                   |            |                 |                 |         |                  |              |              |        |                  |              |              |       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------|-----------------|-----------------|-------------------|------------|-----------------|-----------------|---------|------------------|--------------|--------------|--------|------------------|--------------|--------------|-------|
|                                                                                                                                                                              | CBW Systems  |         |                 |                 | Washer Extractors |            |                 |                 |         | Batch Washers    |              |              |        | Batch Extractors |              |              |       |
|                                                                                                                                                                              | Boewe Passat | Lavatec | Pellerin Milnor | Washex/ Senking | American Laundry  | G.A. Braun | Pellerin Milnor | Washex/ Senking | Lavatec | American Laundry | Boewe Passat | Brim Laundry | Ellis  | American Laundry | Boewe Passat | Brim Laundry | Ellis |
| Capacity (lb/hr)                                                                                                                                                             | 880          | 1100    | 2000            | 1100            | 300               | 300        | 300             | 300             | 450     | 1200             |              | 1200         | 1200   | 2400             |              | 2400         |       |
| Cycle Time (min)                                                                                                                                                             | 30           | 30      | 30              | 30              | 50                | 50         | 50              | 50              | 50      | 40               |              | 40           | 40     | 5                |              | 5            |       |
| Electricity Use (kWh/hr)                                                                                                                                                     |              |         | 42.4            | 14.2            | 5.7               |            | 6.0             | 6.5             |         | 1.7              |              |              |        | 10               |              | 10           |       |
| Max Electric Draw (kW)                                                                                                                                                       |              |         | 60.6            | 15.6            | 13.5              |            | 16.9            |                 | 21      | 20               |              |              |        | 15               |              | 15           |       |
| Water Use (gal/lb)                                                                                                                                                           | 1.1          | 1.1     | 1.1             | 1.1             | 3.5               | 3.5        | 3.5             | 3.5             | 3.5     | 3.5              |              | 3.5          | 3.5    |                  |              |              |       |
| Water Temp. (° F)                                                                                                                                                            | 90           | 90      | 90              | 90              | 70-170            | 70-170     | 70-170          | 70-170          | 70-170  | 70-170           | 70-170       | 70-170       | 70-170 |                  |              |              |       |
| Steam Use (lb/lb)                                                                                                                                                            | 0.6          | 0.6     | 0.65            | 0.5             | 1.5*              |            |                 | 1.5*            |         |                  |              |              |        |                  |              |              |       |
| Steam Press. (psia)                                                                                                                                                          | 75           | 75      | 75              | 70              | 100               |            |                 |                 |         | 80               |              |              |        |                  |              |              |       |
| Steam Temp. (° F)                                                                                                                                                            | 320          | 320     | 320             | 300             | 335               |            |                 |                 |         | 325              |              |              |        |                  |              |              |       |
| Expected Lifetime (years)                                                                                                                                                    | 15           | 15      | 15              | 15              | 15                |            |                 |                 |         | 15               |              |              |        | 15               |              |              |       |
| Number in Use—USA                                                                                                                                                            | 60           | 75      | 245             | 30              |                   |            |                 |                 |         |                  |              |              |        |                  |              |              |       |
| Number in Use—Worldwide                                                                                                                                                      | 500          | 500     | 630             | 400             |                   |            |                 |                 |         |                  |              |              |        |                  |              |              |       |
| Steam use in washer extractors depends on the temperature of hot water available. 1.5 lb of steam/lb of laundry is typical for raising the temperature of 2 baths by 100 °F. |              |         |                 |                 |                   |            |                 |                 |         |                  |              |              |        |                  |              |              |       |

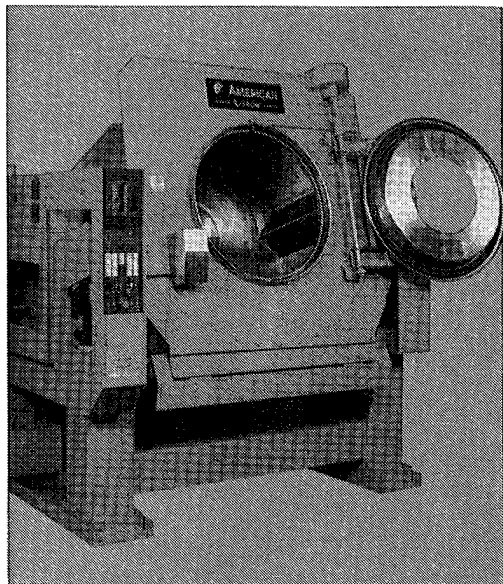
\* Steam use in washer extractors depends on the temperature of hot water available. 1.5 lb of steam/lb of laundry is typical for raising the temperature of 2 baths by 100 °F.



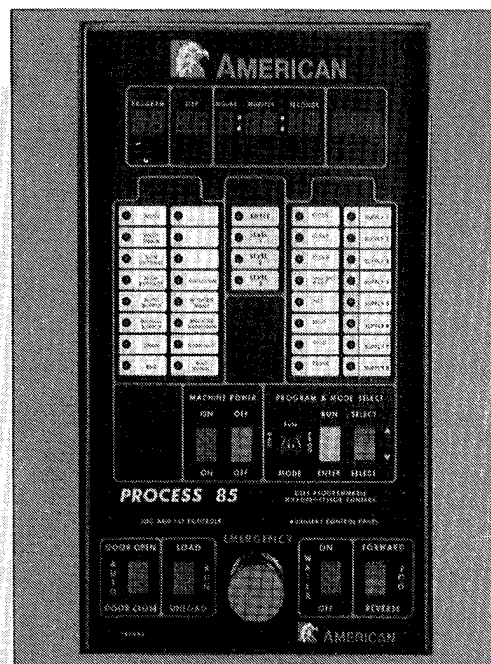


(Source: Pellerin Milnor Corporation, 1992. Reprinted by permission.)

**Figure 36. Milnor centrifugal extractor.**



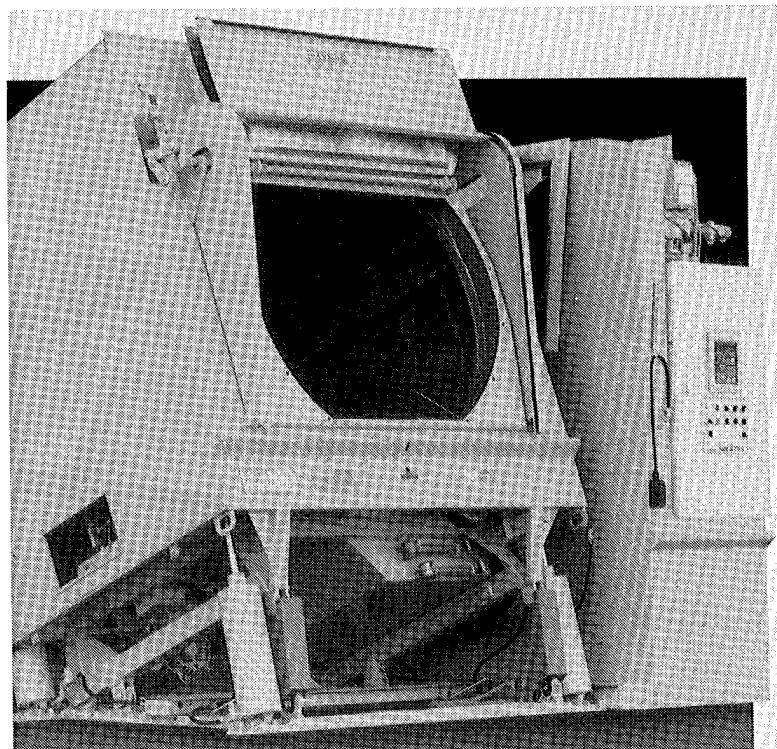
Large open-area cylinder of 450 L-tron takes a true 450 Lb. load.



Process 85 Microprocessor Control monitors all washer/extractor operations.

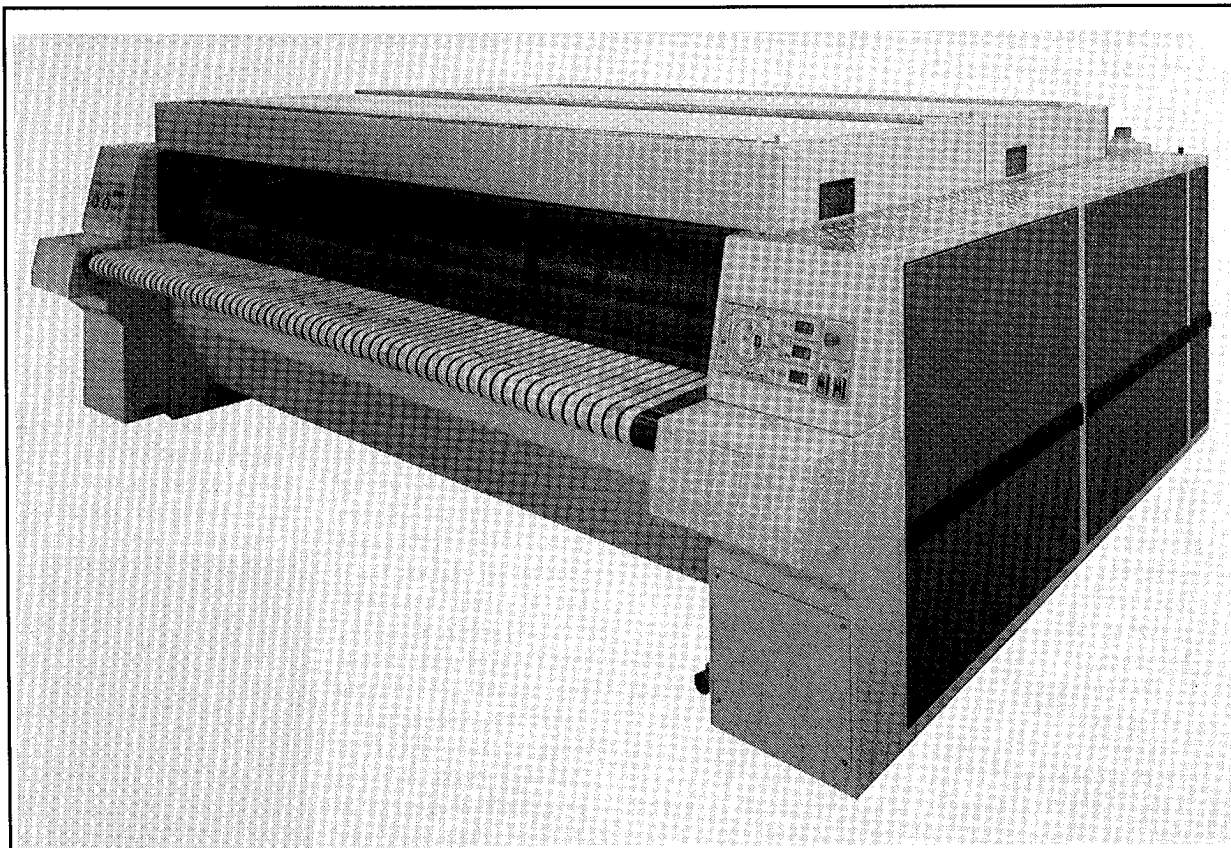
(Source: American Laundry Machinery, Inc. Reprinted by permission.)

**Figure 37. American washer extractor.**



(Source: Challenge Industries, Inc., 1992. Reprinted by permission.)

**Figure 38. Challenge Pacesetter dryer.**



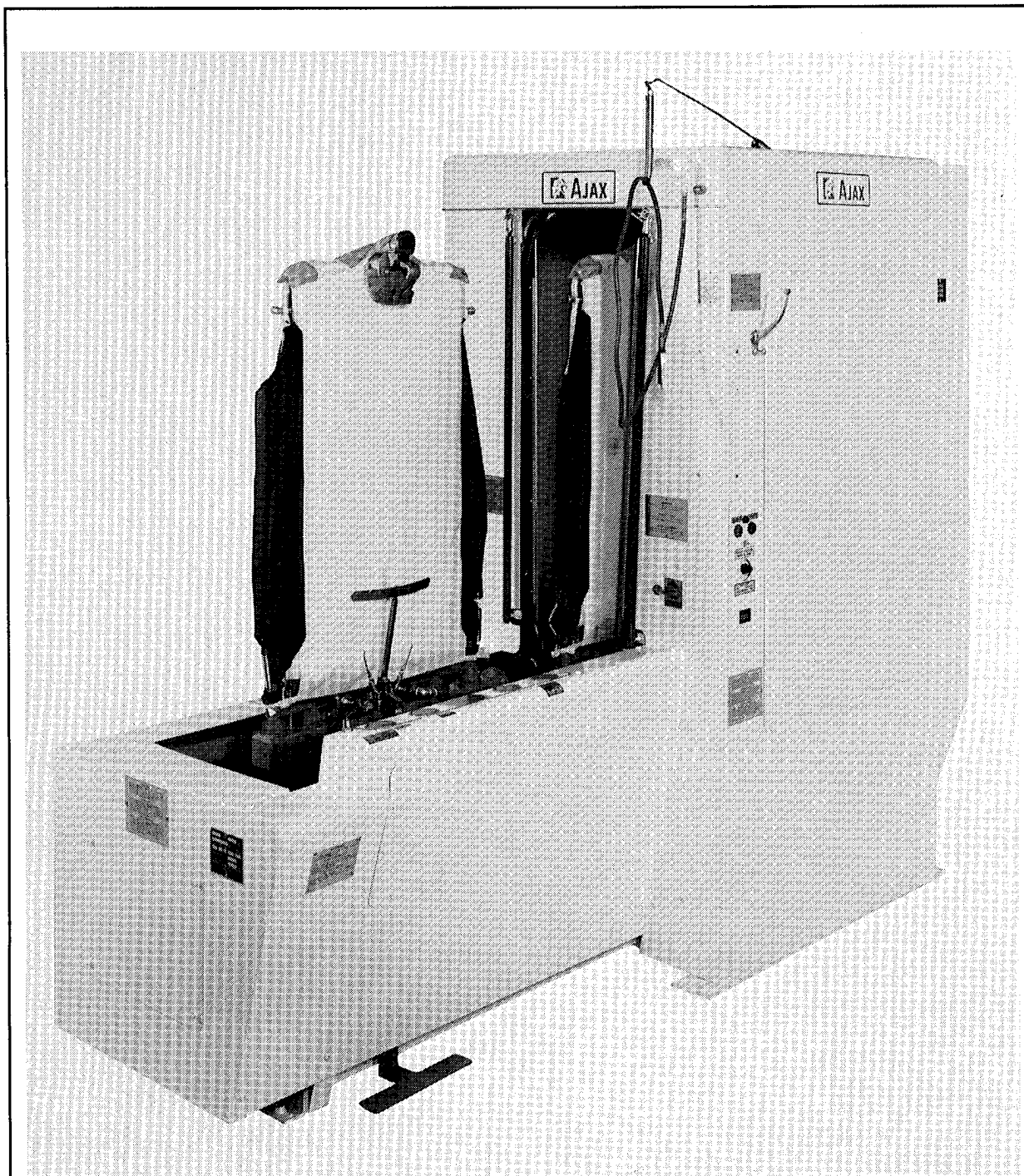
(Source: Central Finishing Systems. Reprinted by permission.)

**Figure 39. Central flat work ironer.**



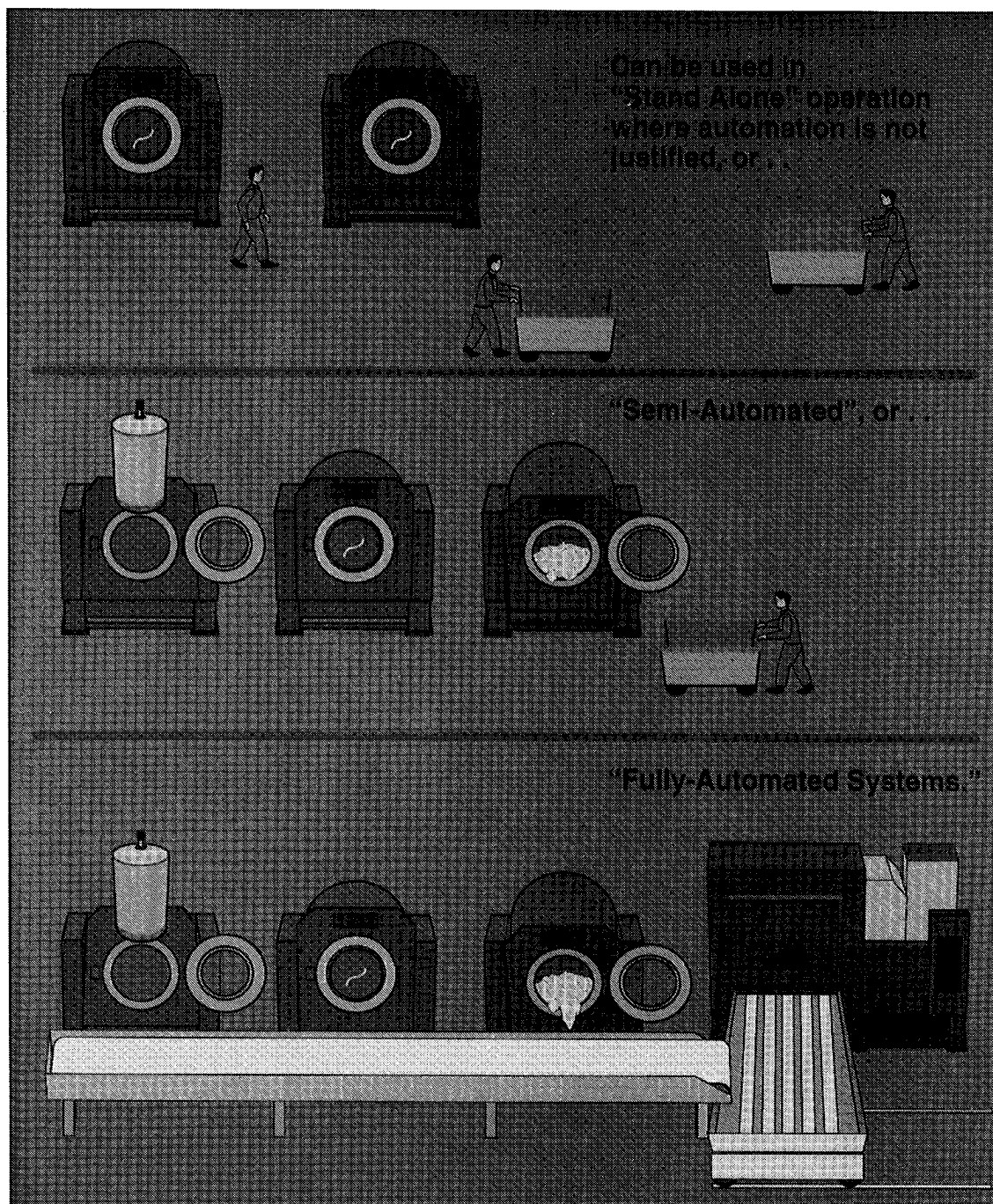
(Source: Ajax Division, American Laundry Machinery, Inc. Reprinted by permission.)

**Figure 40. Ajax utility garment press.**



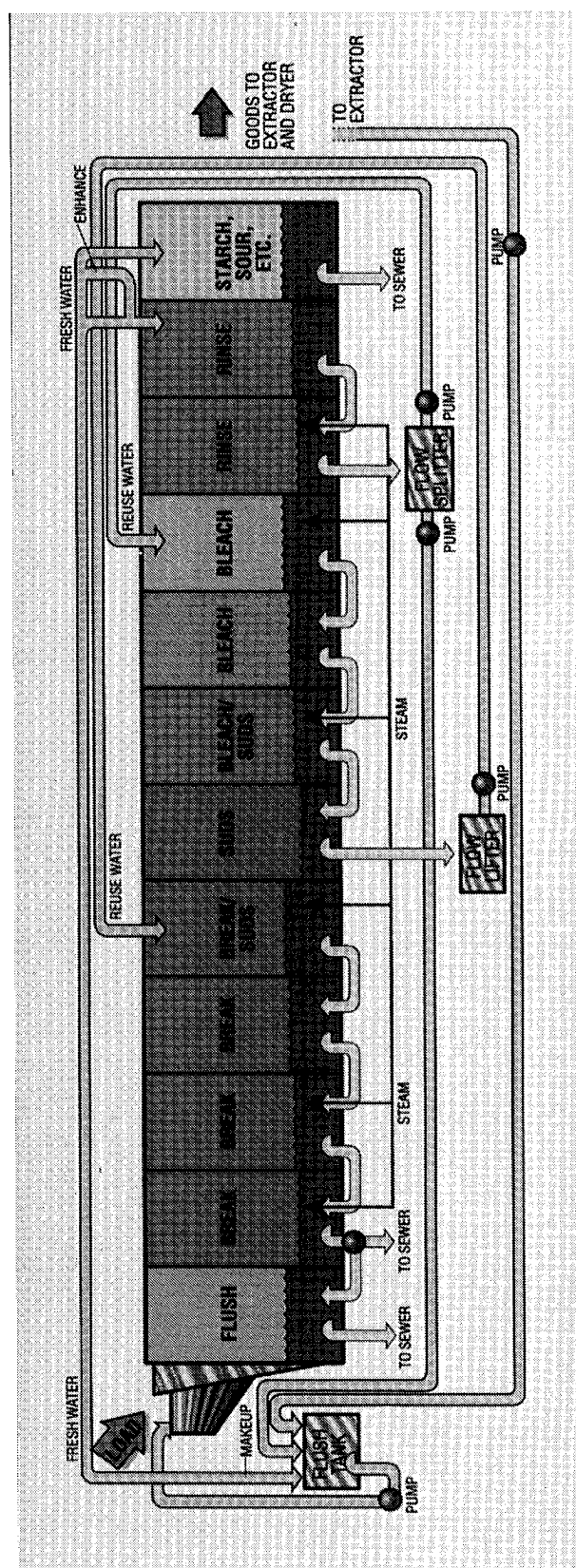
(Source: Ajax Division, American Laundry Machinery, Inc. Reprinted by permission.)

**Figure 41. Ajax double buck cabinet bosom, body and yoke press.**



(Source: American Laundry Machinery, Inc. Reprinted by permission.)

Figure 42. Laundry automation systems.



(Source: Pellerin Milnor Corporation, 1993. Reprinted by permission.)

**Figure 43. Milnor continuous batch washer schematic.**

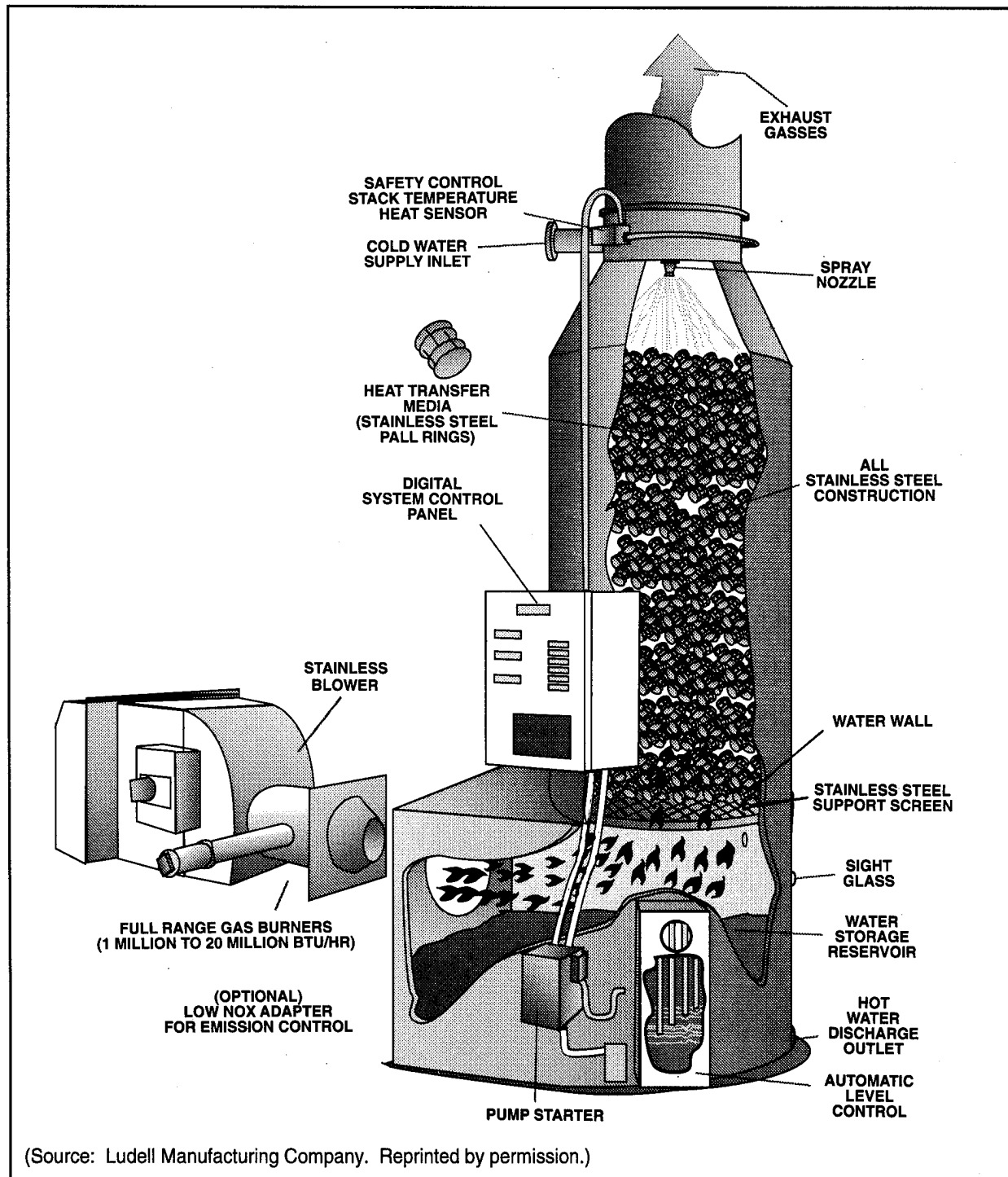


Figure 44. Ludell direct contact water heater.

## 4 Laundry Process Models

Model laundry facilities were developed to provide a way to compare conventional laundry facilities with those using more advanced technologies. The model facilities, sized according to production in pounds per year, are categorized as: less than 1,000,000 lb/year (small); 1,000,000 to 3,000,000 lb/year (medium); greater than 3,000,000 lb/year (large). Three models were developed for each of three size ranges. The models include a conventional facility similar to the existing DOD facilities, a high efficiency facility, and a super (ultra) high efficiency facility. Most DOD installations maintain equipment inventory lists of model, capacity, and age information for laundry facilities. The equipment lists from DOD laundry facilities generally reflect those found in the conventional model facilities. Tables 5 and 6 list equipment for medium conventional and medium high efficiency model facilities. Appendix E contains predicted energy and water consumption data, predicted utility cost data, and proposed laundry operating timetables for conventional, high efficiency, and ultra high efficiency (designated SOA2) laundry models.

### Comparison With Military and Commercial Facilities

Figure 45 shows predicted electricity consumption for the model facilities and electricity consumption for the commercial and military facilities. The predicted electricity consumption for the conventional model facilities agrees with that reported for both commercial and military facilities. The predicted electricity consumption for the high efficiency and super high efficiency models is slightly higher than that reported for both commercial and military facilities. This may be due, in part, to increased use of electricity in advanced control systems.

Figure 46 shows predicted nonelectric energy consumption for the model facilities and nonelectric energy consumption for the commercial and military facilities. The predicted nonelectric energy consumption for the conventional model facilities agrees with that reported for military facilities. The predicted nonelectric energy consumption for the high efficiency and super high efficiency models falls within the range reported for commercial facilities. These findings support the field observations of conventional (older) equipment at military facilities and newer (modern) equipment being used in commercial laundries.

**Table 5. Equipment list for a medium conventional model facility.**

| Item | Description                      |
|------|----------------------------------|
| A    | Sorting conveyer                 |
| B    | Soil storage rail                |
| C    | 400-lb washer extractor          |
| D    | 200-lb washer extractor          |
| E    | 100-lb washer extractor          |
| F    | Peristaltic pump supply system   |
| G    | 200-lb gas-fired dryer           |
| H    | 100-lb gas-fired dryer           |
| J    | Spreader feeder                  |
| K    | 8-roll super sylon ironer        |
| L    | Double lane primary/cross folder |
| M    | Flow rack                        |
| N    | Small piece folder               |
| P    | Small piece folder               |
| R    | 70-hp dual-fired boiler          |
| S    | Deaerator return system          |
| T    | Water softener                   |
| U    | 10 hp air compressor             |
| V    | Gas-fired hot water heater       |
| W    | Air dryer                        |
| X    | Double buck shirt press          |
| Y    | Sleeve                           |
| Z    | Collar cuff press                |
| AA   | Utility press                    |
| BB   | Clean take-away conveyer         |

**Table 6. Equipment list for a medium high efficiency model facility.**

| Item | Description                                                    |
|------|----------------------------------------------------------------|
| A    | 9-chamber, 50-lb, mini-continuous batch washer                 |
| B    | Single stage system press                                      |
| C    | C.B.W. system shuttle conveyer                                 |
| D    | C.B.W. system 100-lb dryers                                    |
| E    | 200-lb dryer                                                   |
| F    | 150-lb gas-fired dryer                                         |
| G    | 75-lb gas-fired dryer                                          |
| J    | 125-lb solid mount washer extractor                            |
| K    | 50-lb washer extractor                                         |
| L    | 200-lb washer extractor                                        |
| M    | Two roll 32-in. (or 27-in.) steam-heated ironer                |
| N    | Two-lane combination primary/single lane crossfolder w/stacker |
| P    | Small piece folding table w/cart dumper                        |
| P1   | Blanket folding table w/dumper                                 |
| Q    | Four-station spreader feeder                                   |
| R    | Clean work take-away conveyer                                  |
| S    | 10-hp air compressor w/tank                                    |
| T    | Compressed air dryer                                           |
| U    | Water softener w/brine tank                                    |
| V    | Gas-fired water heater                                         |
| W    | 70-hp gas/oil-fired steam boilers                              |
| X    | Boiler return system                                           |
| Y    | Five-pocket loading conveyer                                   |
| Z    | Cart dumper (shown w/cart)                                     |
| AA   | Domestic washer                                                |
| BB   | Domestic dryer                                                 |
| CC   | Garment steam finisher (tunnel)                                |
| DD   | Combination quarter/french small piece/gown folder             |

Figure 47 shows predicted total energy consumption for the model facilities and total energy consumption for the commercial and military facilities. The predicted total energy consumption for the conventional model facilities falls within the range reported for military facilities. The predicted total energy consumption for both high efficiency and super high efficiency models falls within the range reported for commercial facilities. Again, these findings support the field observations of conventional (older) equipment in service at military facilities and newer (modern) equipment in service at commercial laundries.

Figure 48 shows predicted water consumption for the model facilities and water consumption for the commercial and military facilities. The predicted water consumption for the conventional model facilities falls within the range reported for military facilities. The predicted water consumption for both high efficiency and super high efficiency models falls within the range reported for commercial facilities. Again, these findings support the field observations of conventional (older) equipment in service at military facilities and newer (modern) equipment in service at commercial laundries.

### **Small Facilities (510,000 lb/year)**

Due to equipment size limitations, the conventional facility and the high efficiency facility for the smallest size range (less than 1,000,000 lb/year) are essentially the same and are represented identically. Therefore, only two options, a conventional/high efficiency model and a super high efficiency model, were actually presented for the small facility modeling. Figure 49 shows annual utility usage and Figure 50 a conceptual layout for the small conventional/high efficiency laundry. Figure 51 shows the annual utility usage for the small super high efficiency model, and Figure 52 shows the conceptual layout for the small super high efficiency laundry. Small military facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 27.6 percent by using modern, super high efficiency equipment at the cost of only a small (4.6 percent) increase in electricity use. The electricity use increases because modern controls and energy conservation equipment designed to reduce nonelectric energy consumption consume more electricity than conventional equipment with more rudimentary controls. A reduction of 3.7 percent in water consumption can be expected when upgrading conventional small facilities with super high efficiency equipment. The reduction in water and nonelectric energy are achieved via the addition of a wastewater heat reclamation system and an ozone generator.

### **Medium Facilities (1,800,000 lb/year)**

Figure 53 presents the annual utility usage for the medium conventional model and Figure 54 shows a possible layout for the medium conventional laundry. Figure 55 shows the annual utility usage for the medium high efficiency model, and Figure 56 depicts a possible layout for the medium high efficiency laundry. Figure 57 shows the annual utility usage for the medium super high efficiency model and Figure 58 depicts a possible layout for the medium super high efficiency laundry. Medium military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 44.5 percent by employing high efficiency equipment while increasing electricity use by only 1.3 percent. Most of the reduction in energy and water use is due to the addition of the continuous batch washer.

Medium military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 53.7 percent by employing modern, super high efficiency equipment while increasing electricity use by 7.0 percent. The additional energy savings realized in the super high efficiency plant are attributed to the addition of wastewater heat reclamation and an ozone generator. A reduction of 51.1 percent in water consumption can be realized when upgrading medium conventional military facilities with high efficiency or super high efficiency equipment. The medium super high efficiency model yields a greater reduction in nonelectric energy consumption than the medium high efficiency model, but provides no additional reduction in water consumption since water use is already minimized by the continuous batch washer.

### **Large Facilities (5,000,000 lb/year)**

Figure 59 presents the annual utility usage and Figure 60 shows a possible layout for the large conventional laundry. Figure 61 shows the annual utility usage and Figure 62 shows a possible layout for the large high efficiency laundry. Figure 63 shows the annual utility usage and Figure 64 shows a possible layout for the large super high efficiency laundry. Large military laundries with older conventional equipment and controls could reduce nonelectric energy consumption by 62.2 percent by employing high efficiency equipment while increasing electricity use only slightly (1.2 percent). Most of the reduction in energy and water use is due to the addition of the continuous batch washer system.

Large military laundry facilities with older conventional equipment and controls could reduce nonelectric energy consumption by 69.7 percent by using modern, super high efficiency equipment while increasing electricity use by only 8.5 percent. The

additional energy savings realized in the super high efficiency plant are attributed to the addition of wastewater heat reclamation and an ozone generator. Upgrading large conventional military facilities with high efficiency equipment can reduce water consumption by 58.1 percent. The addition of super high efficiency equipment may yield a 58.7 percent reduction in water consumption.

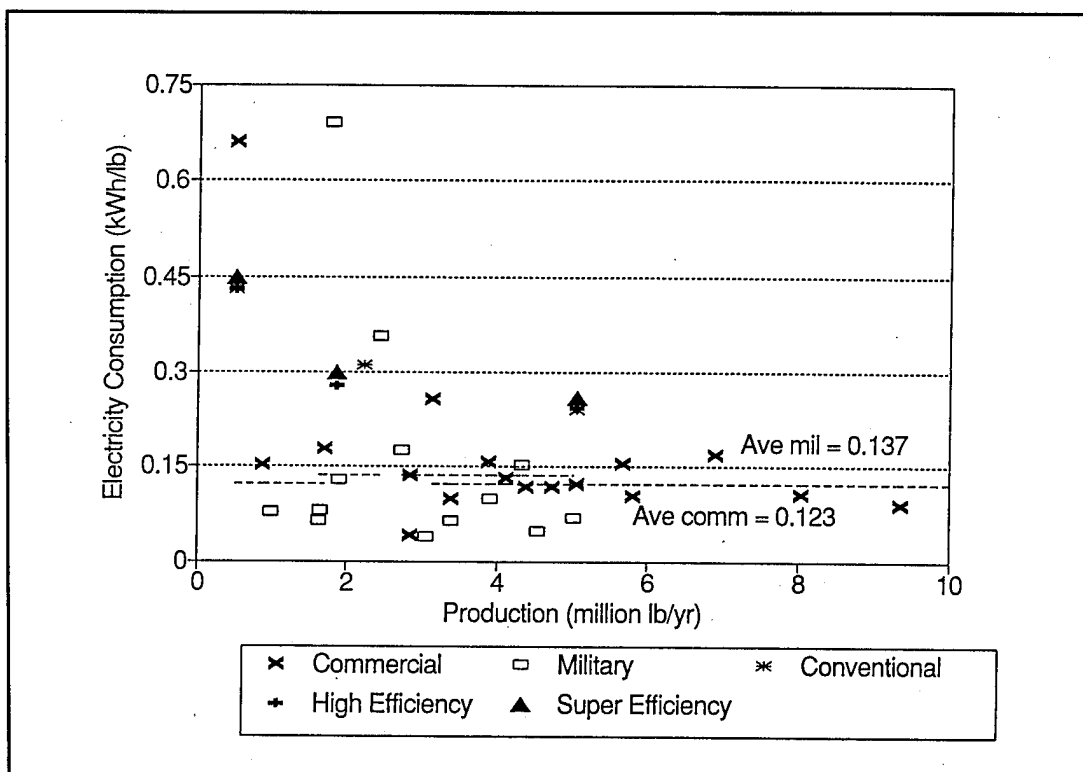


Figure 45. Electricity consumption comparison with model facilities.

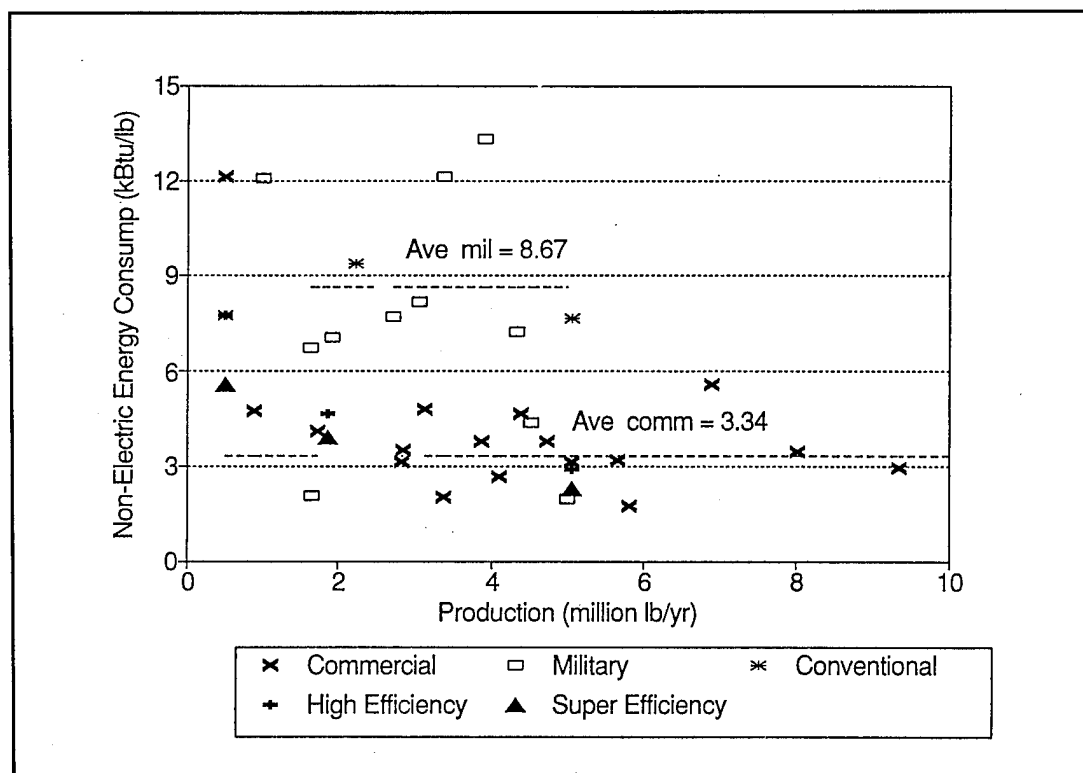


Figure 46. Nonelectric energy consumption comparison with model facilities.

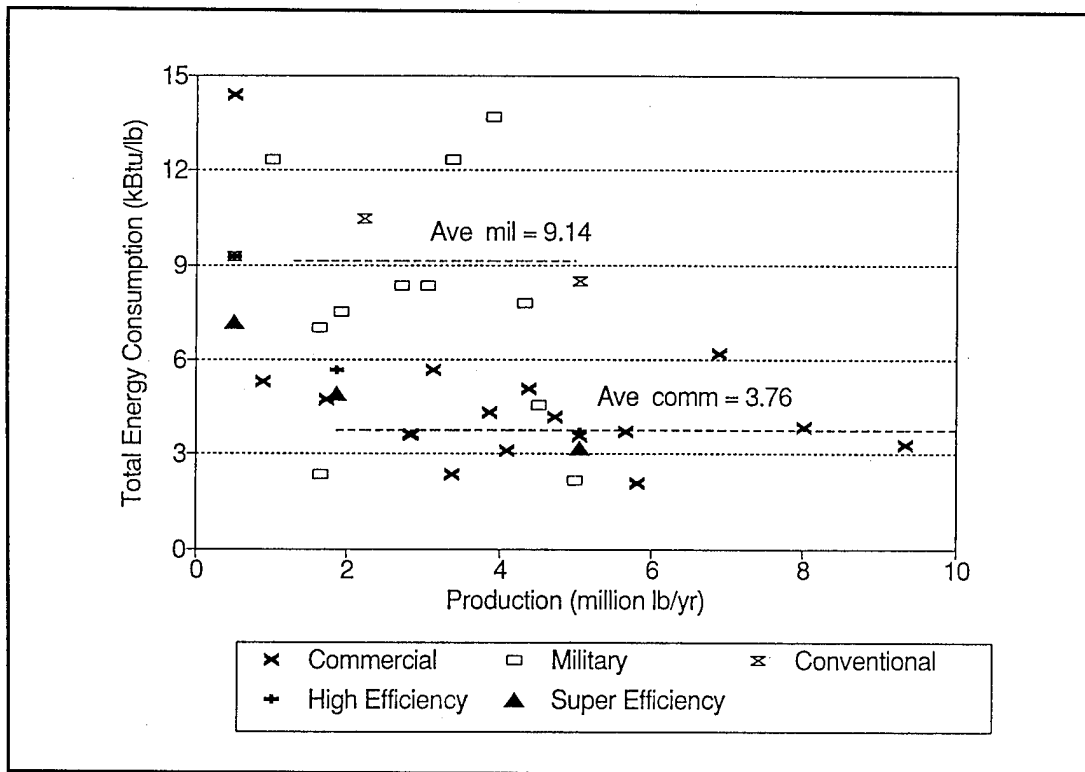


Figure 47. Total energy consumption comparison with model facilities.

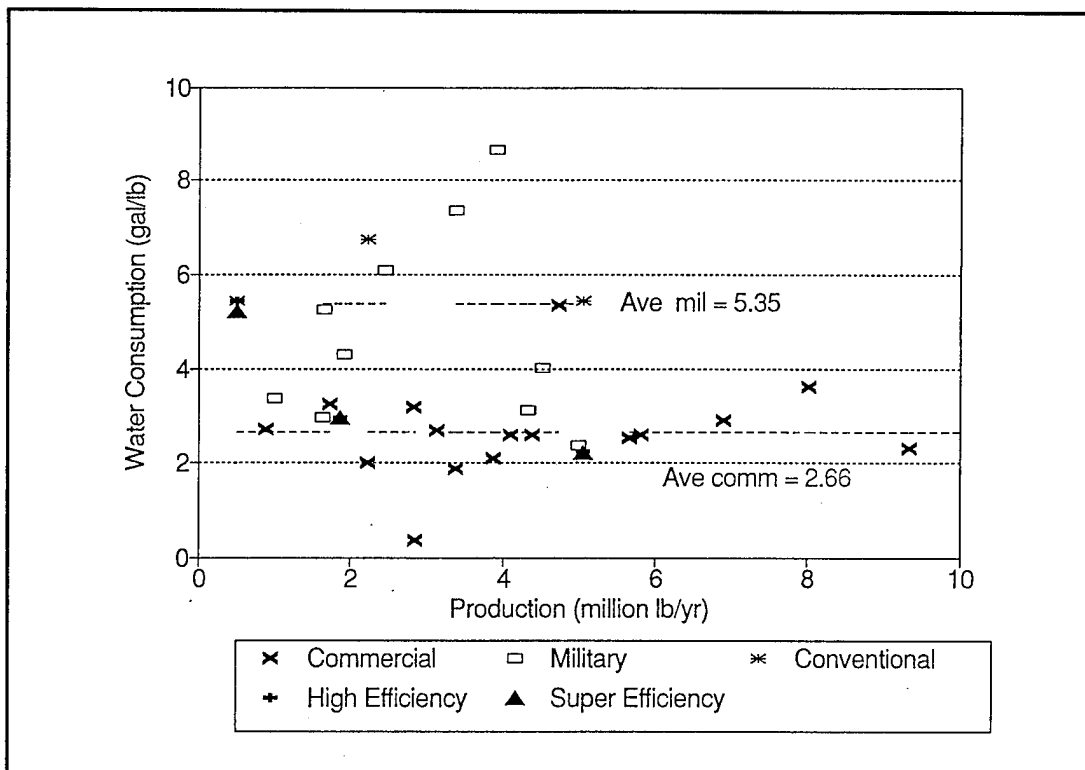


Figure 48. Water consumption comparison with model facilities.

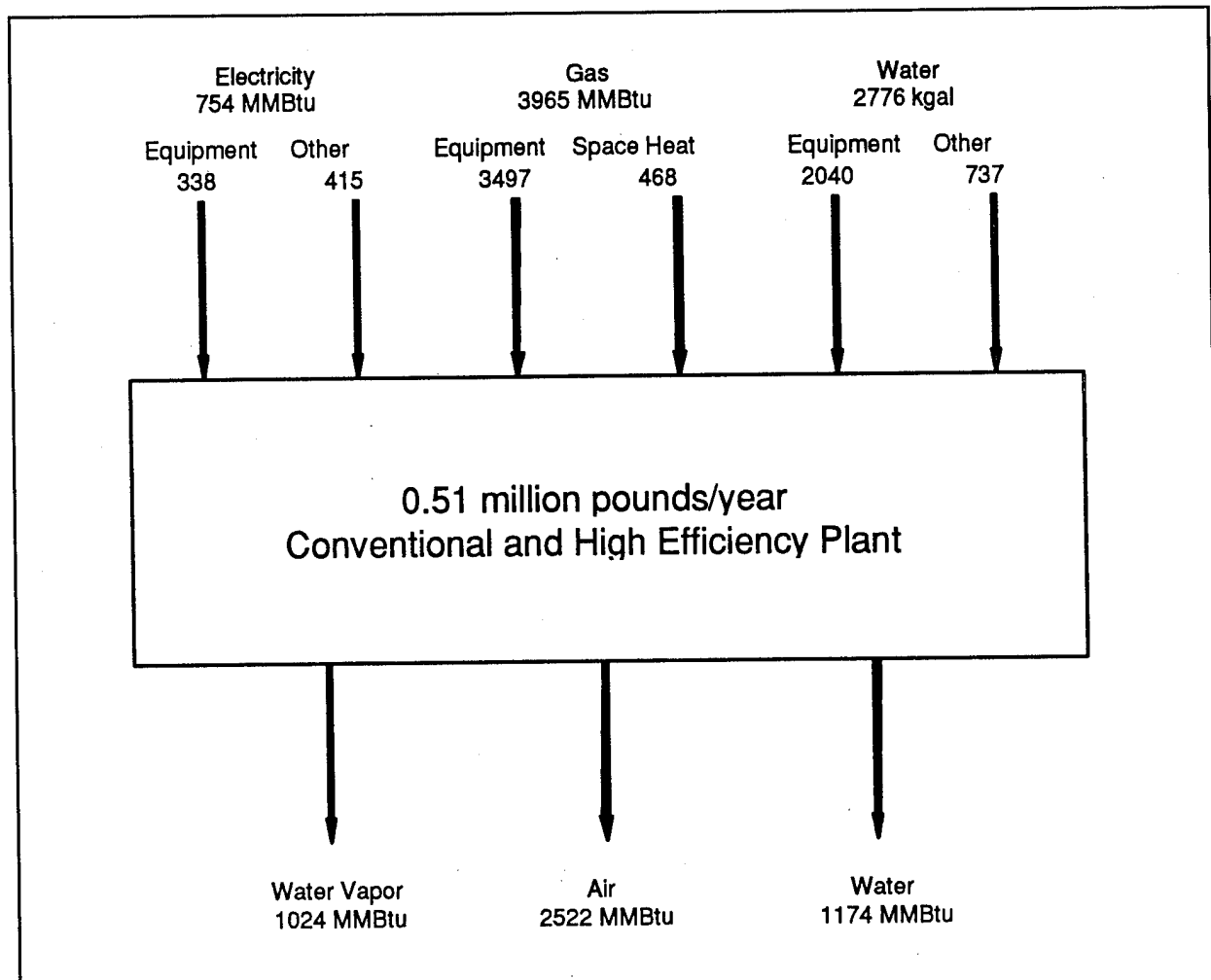
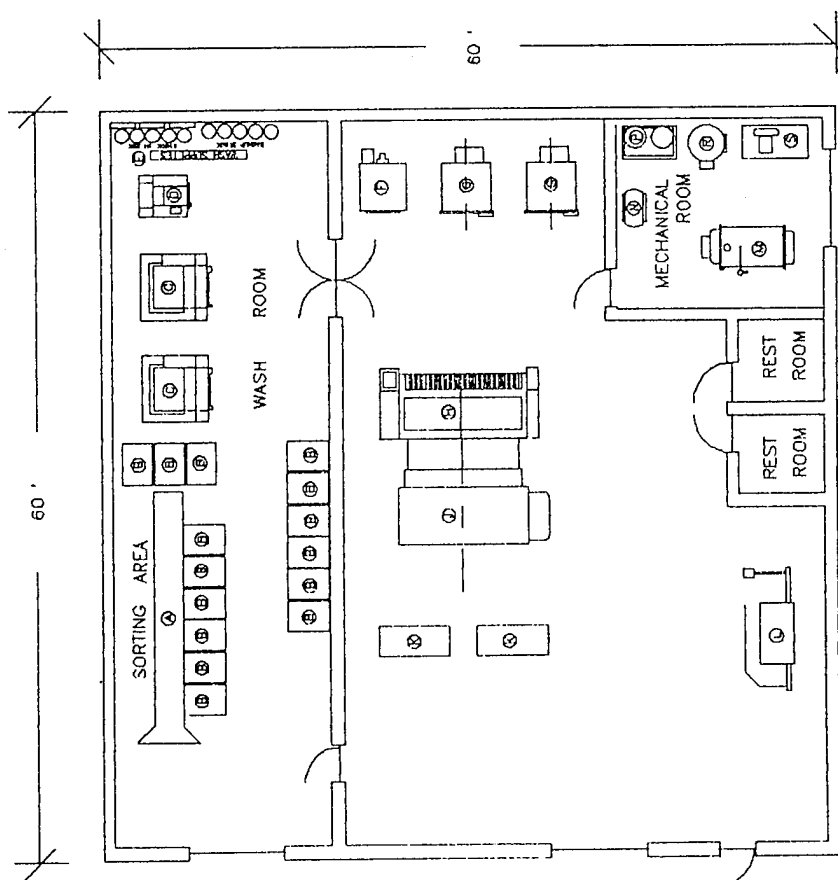


Figure 49. Energy flow diagram for small, conventional/high efficiency model facility.

## EQUIPMENT LIST

- A. MANUAL SORTING TABLE.
- B. CART 30 X 42 X 28.
- C. 125 LB. WASHER EXTRACTOR.
- D. 85 LB. WASHER EXTRACTOR.
- E. PERISTALTIC PUMP SUPPLY SYSTEM
- F. 110 LB. GAS FIRED DRYER.
- G. 150 LB. GAS FIRED DRYER.
- H. SINGLE ROLL 24" IRONER.
- I. DOUBLE LANE PAINTER/CROSS FOLDER.
- J. SMALL PIECE FOLDING TABLES 30" X 72"
- K. STEAM AIR TUNNEL GARMENT FINISHER (250 / HR.).
- L. 15 HP DUAL FIRED STEAM BOILER.
- M. DEAERATOR RETURN SYSTEM.
- N. WATER SOFTENER.
- O. GAS FIRED HOT WATER HEATER.
- P. 10 HP. AIR COMPRESSOR.
- S.

[illegible]

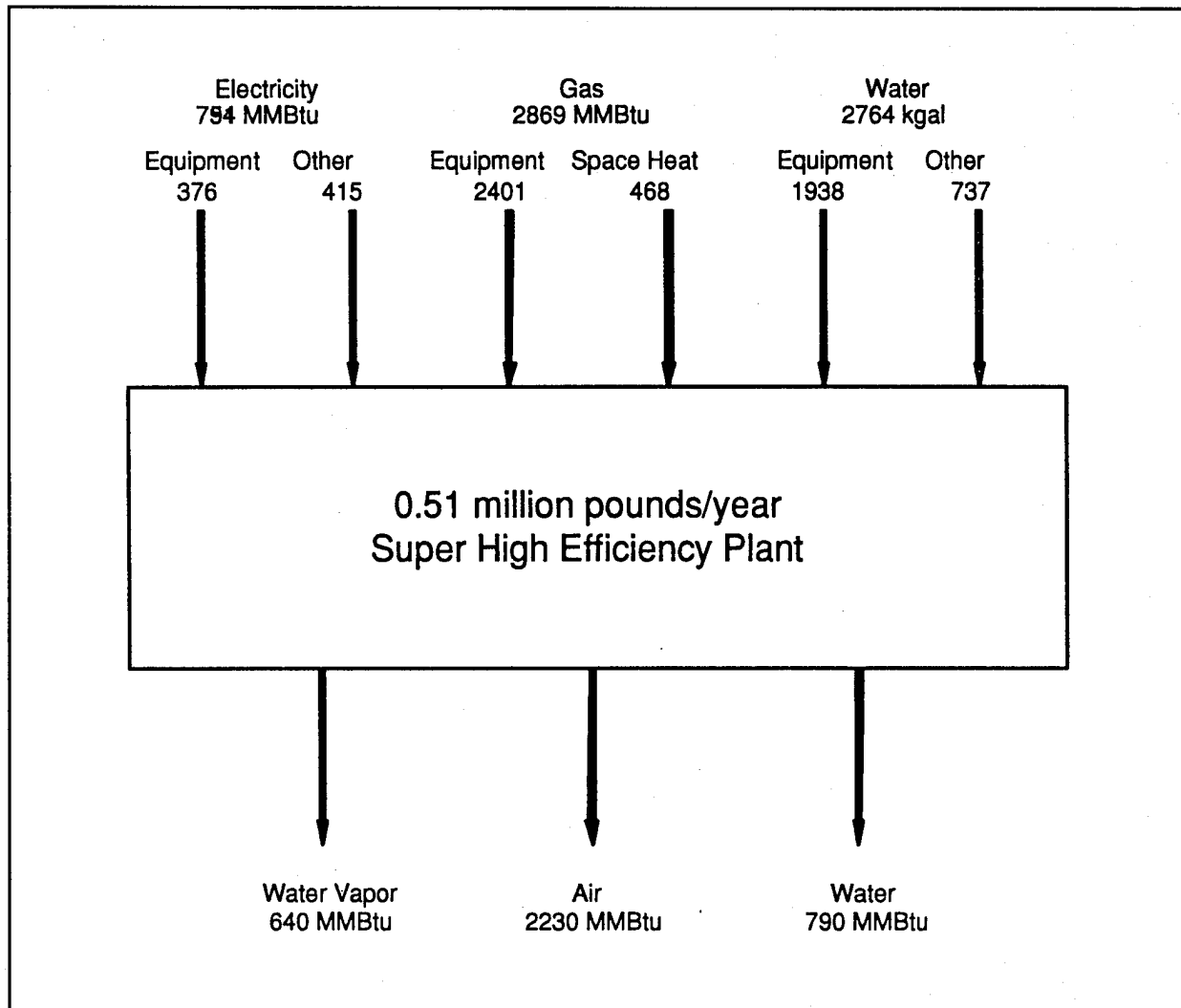


Figure 51. Energy flow diagram for small, super high-efficiency model facility.

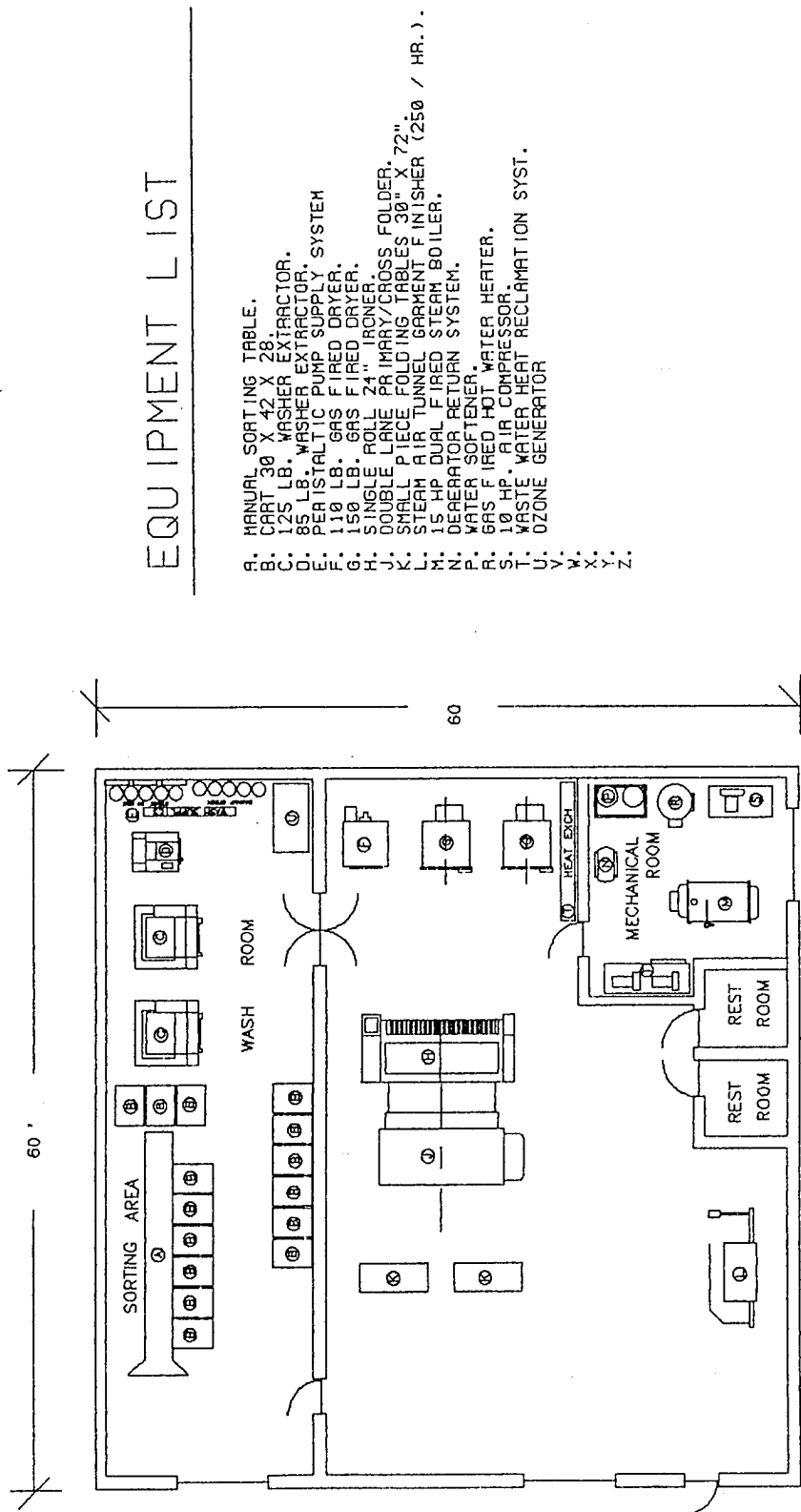


Figure 52. Layout for small, super high-efficiency model facility.

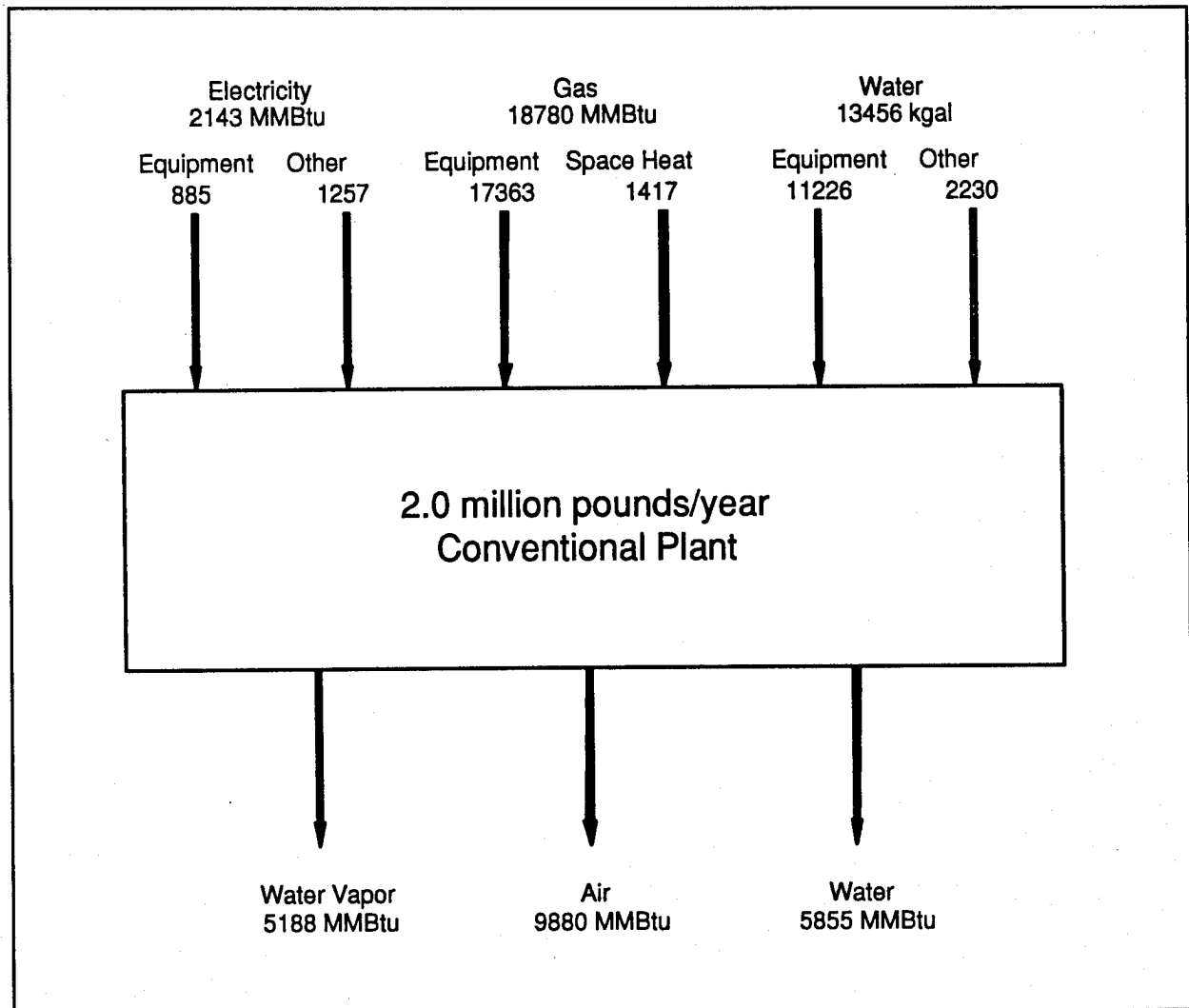


Figure 53. Energy flow diagram for medium conventional model facility.

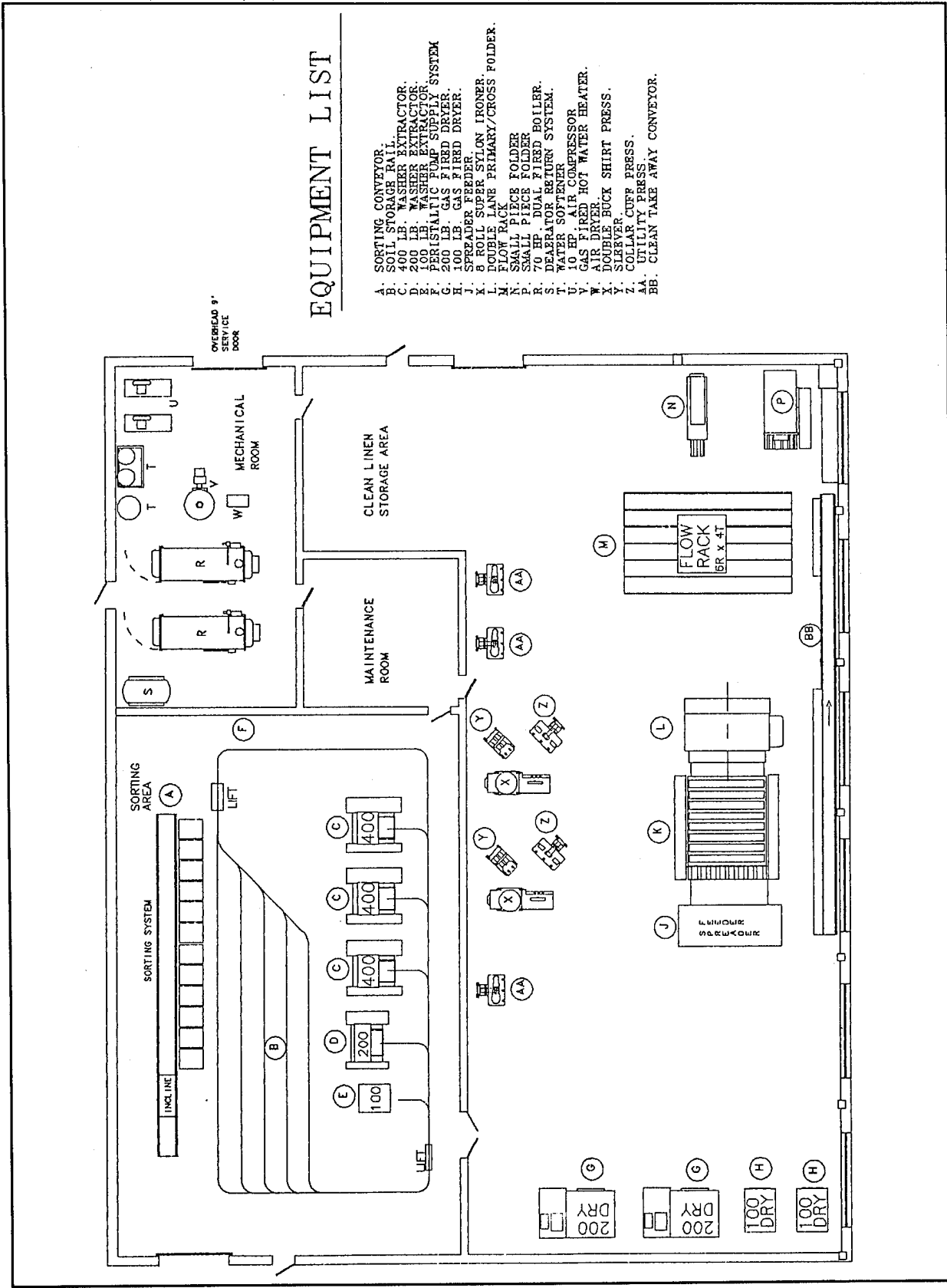


Figure 54. Layout for medium, conventional model facility.

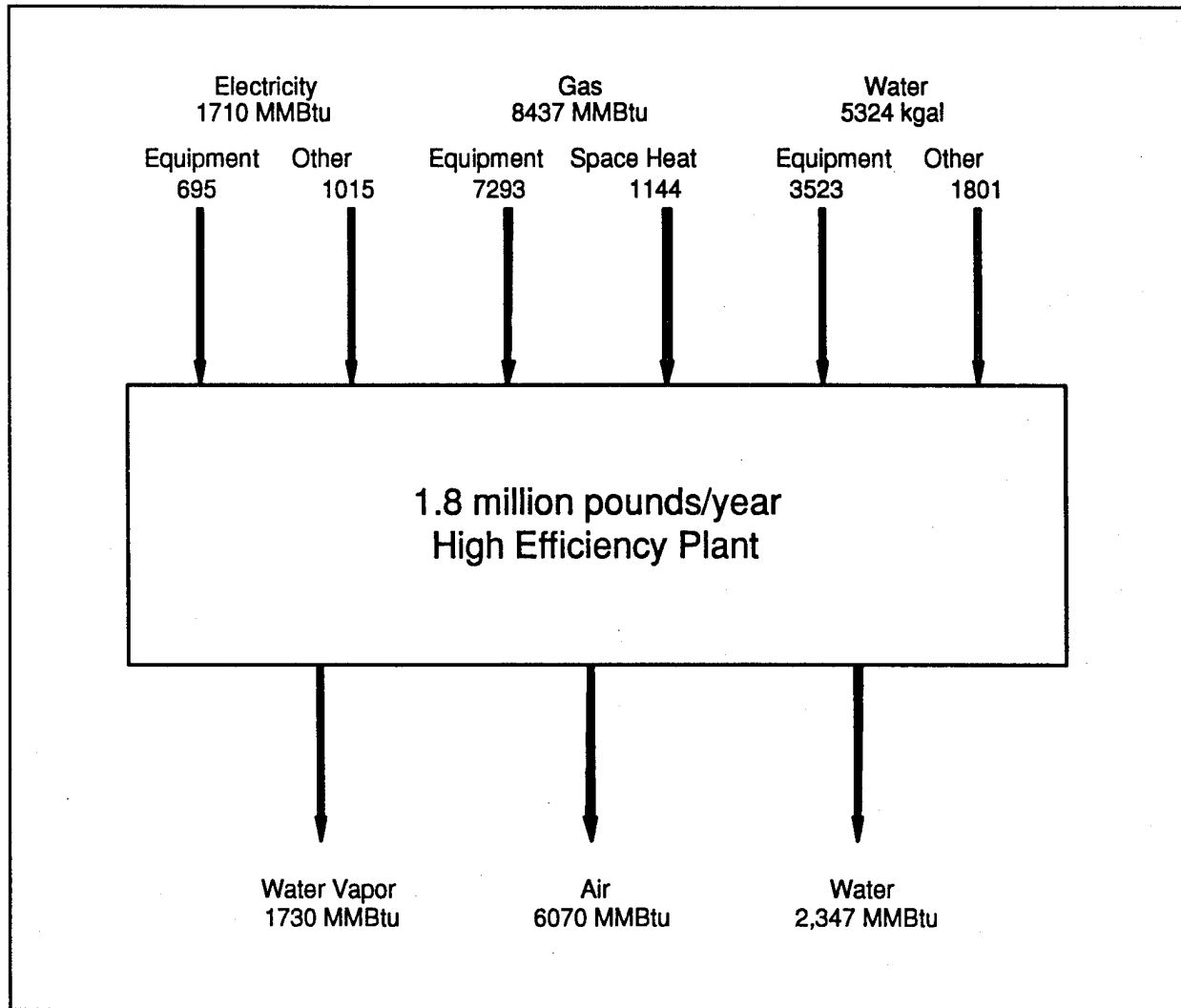
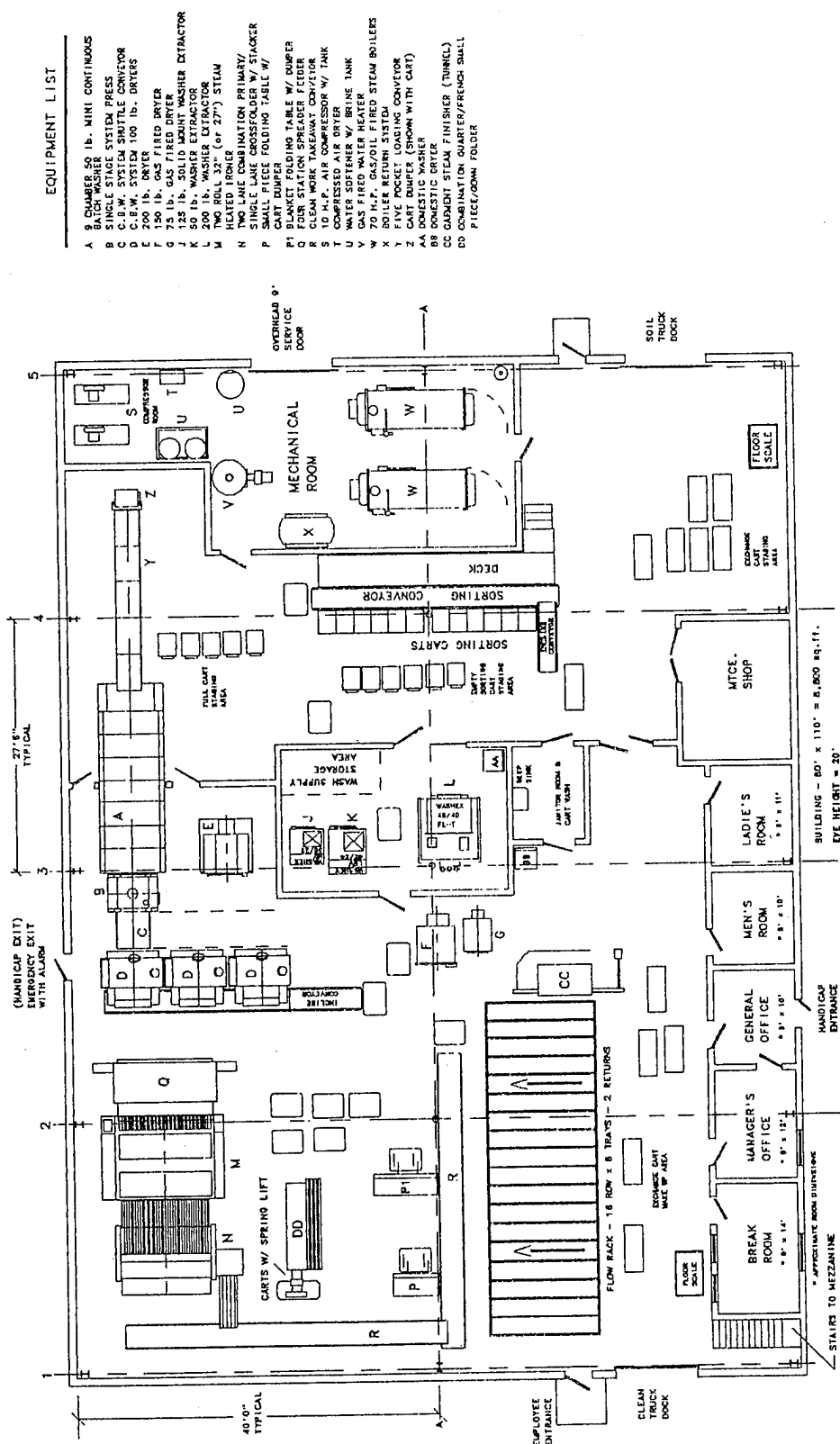


Figure 55. Energy flow diagram for medium, high-efficiency model facility.



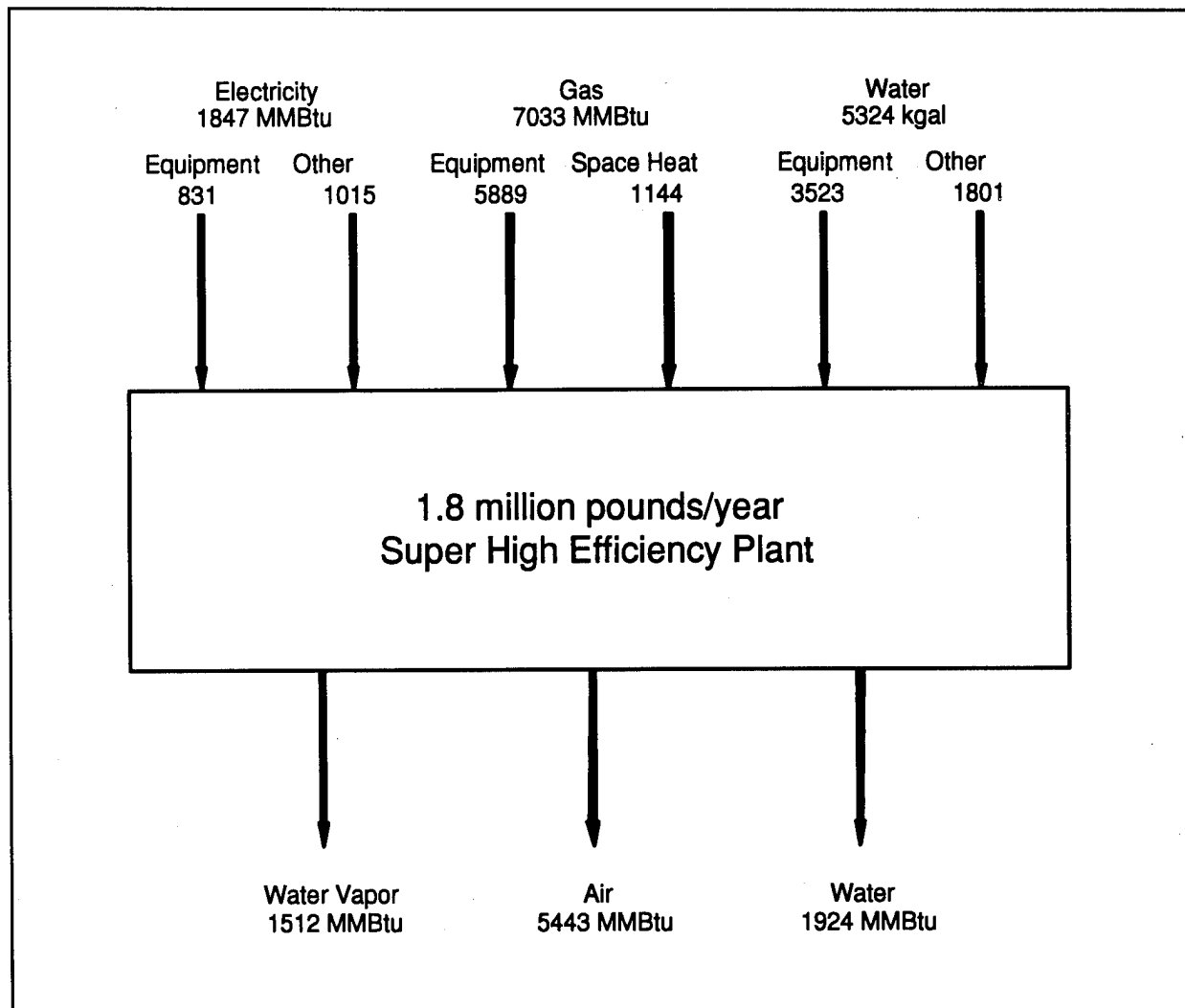


Figure 57. Energy flow diagram for medium, super high-efficiency model facility.

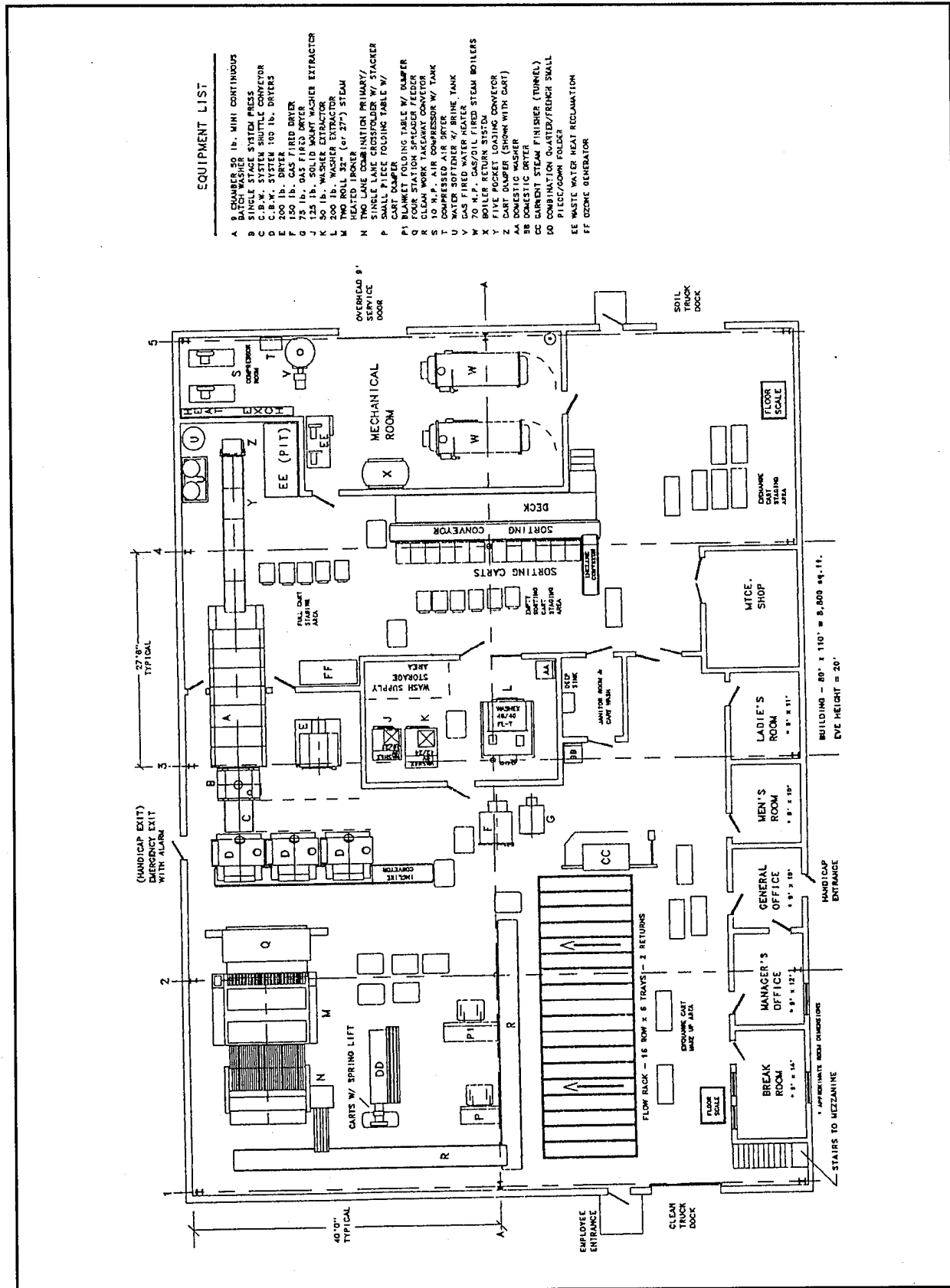


Figure 58. Layout for medium, super high-efficiency model facility.

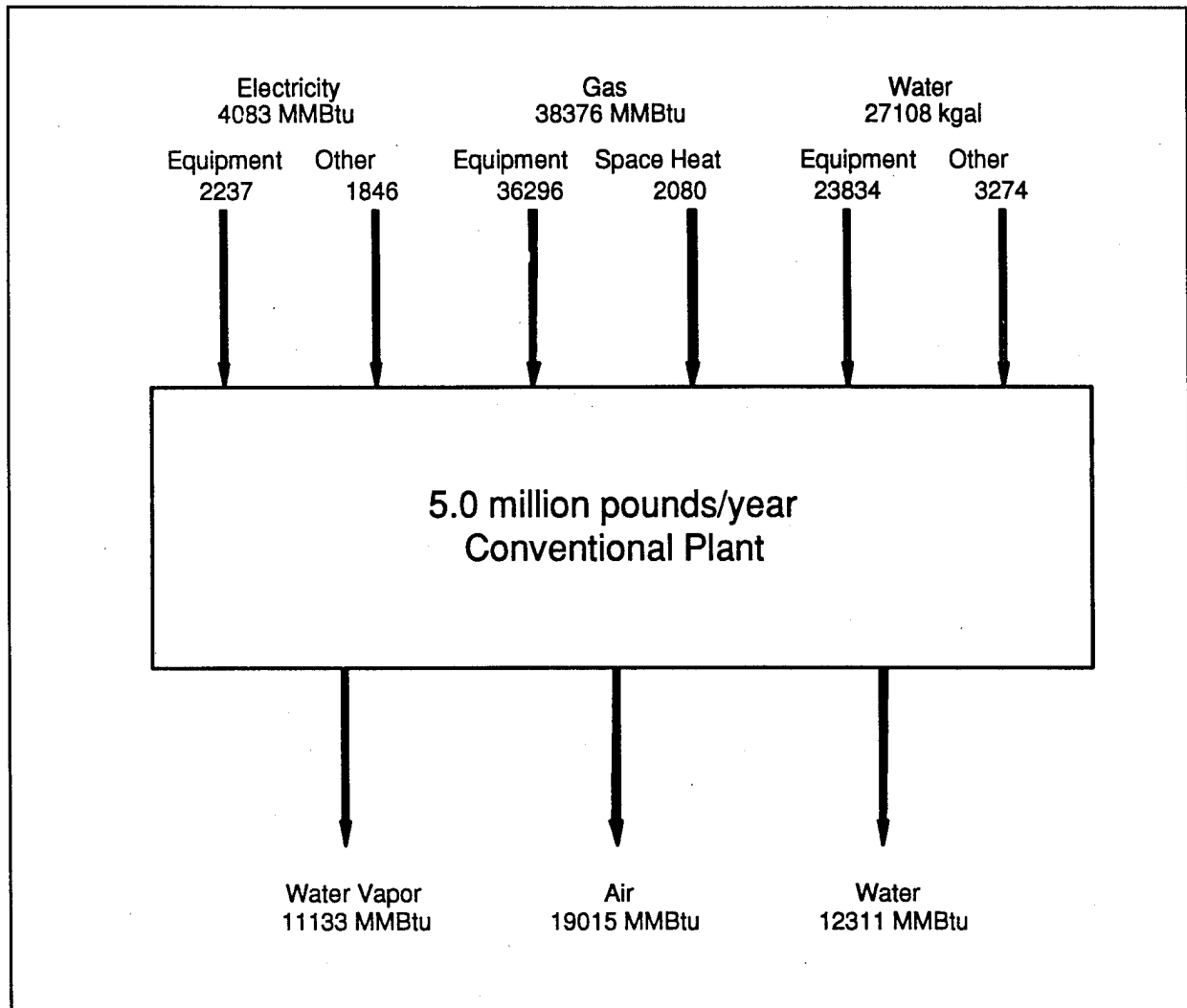
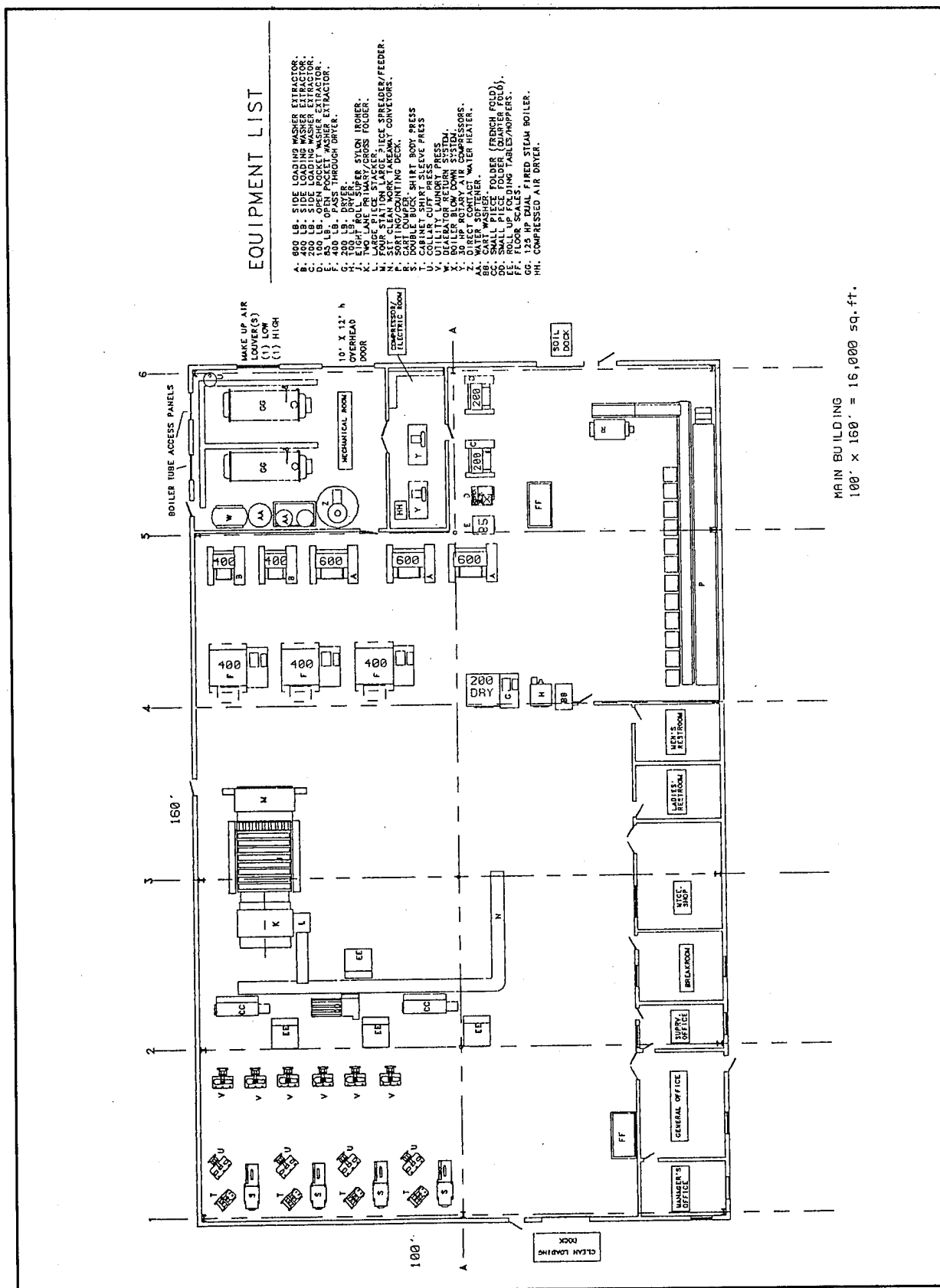


Figure 59. Energy flow diagram for large, conventional model facility.



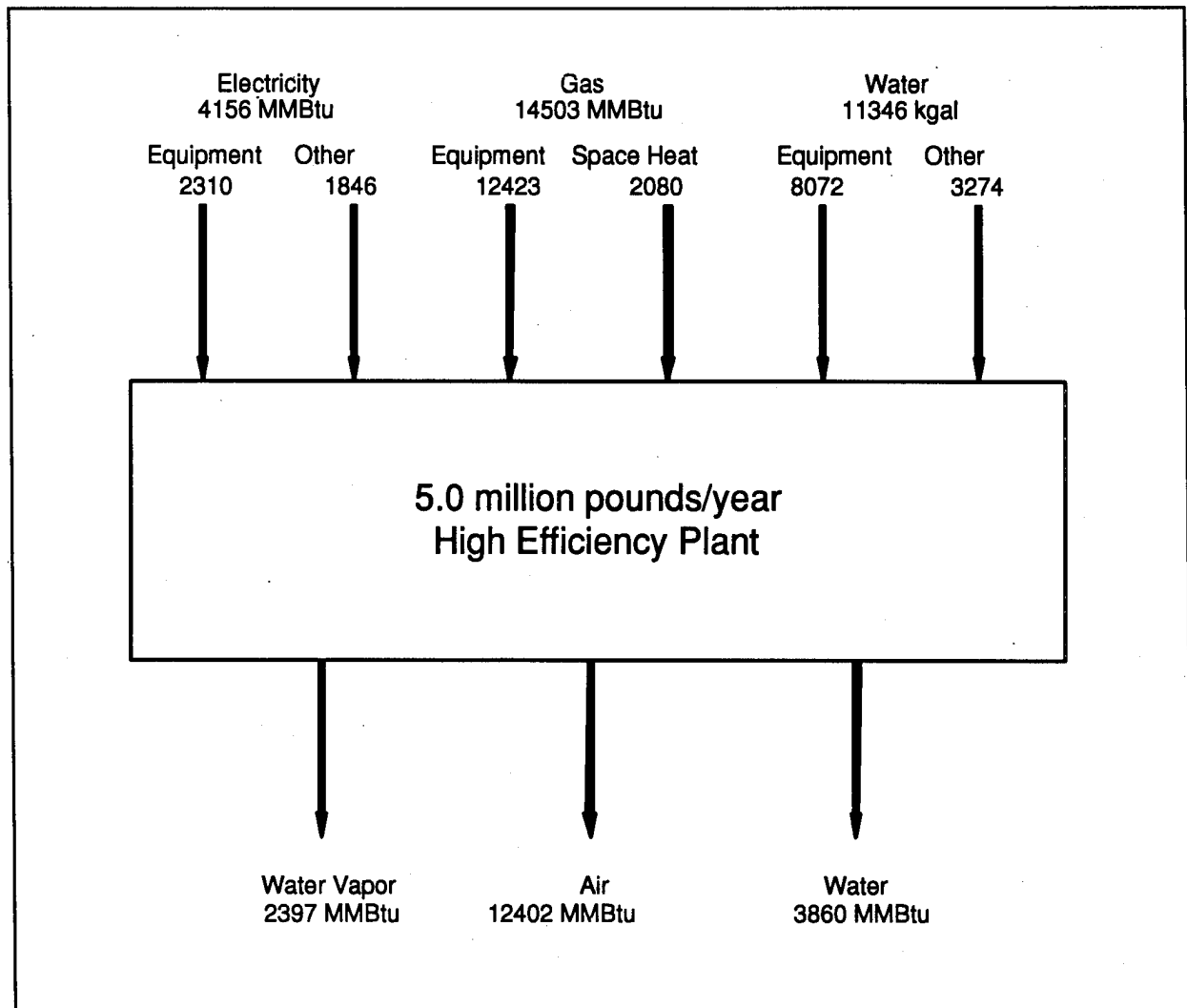
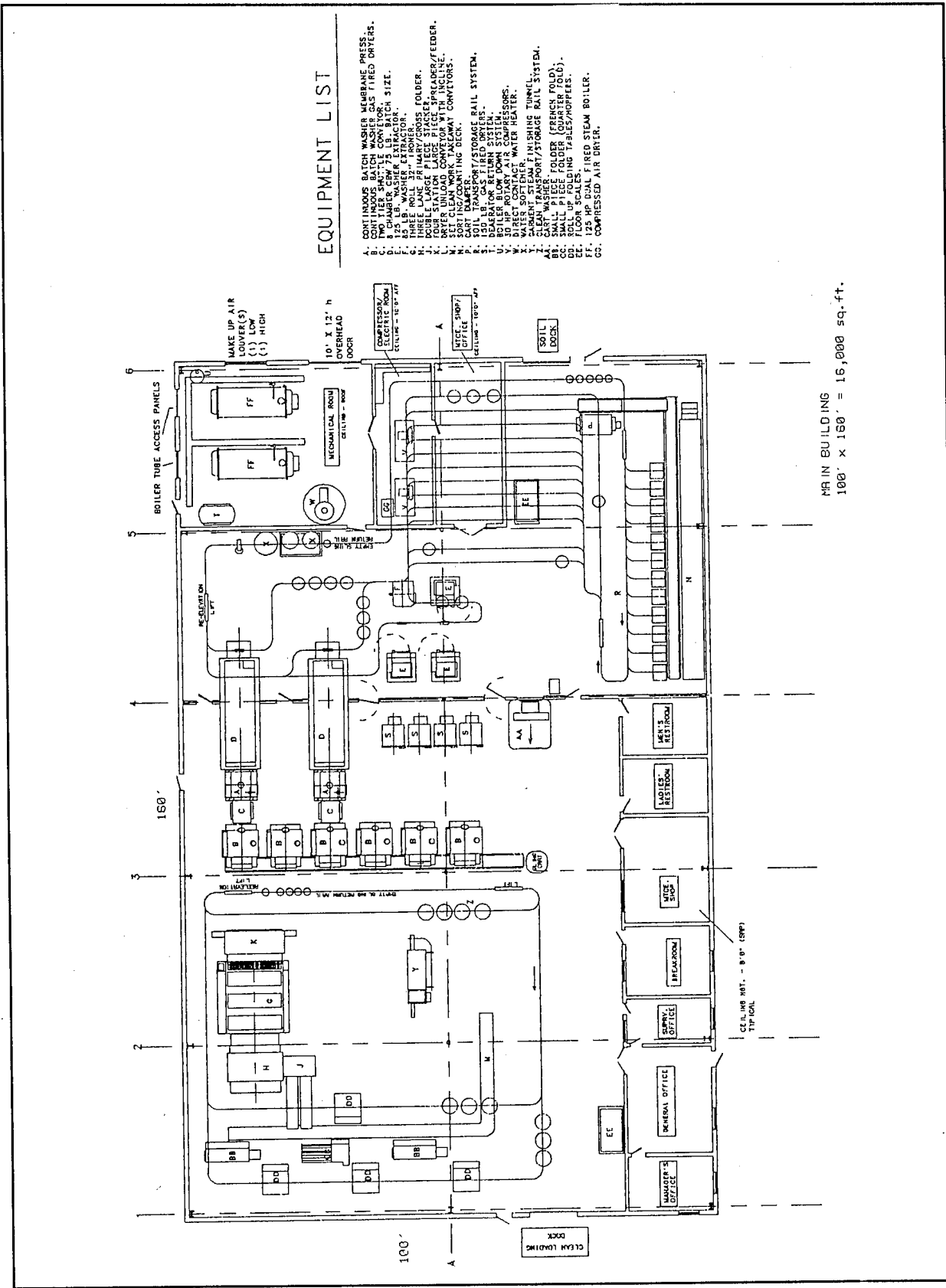


Figure 61. Energy flow diagram for large, high-efficiency model facility.



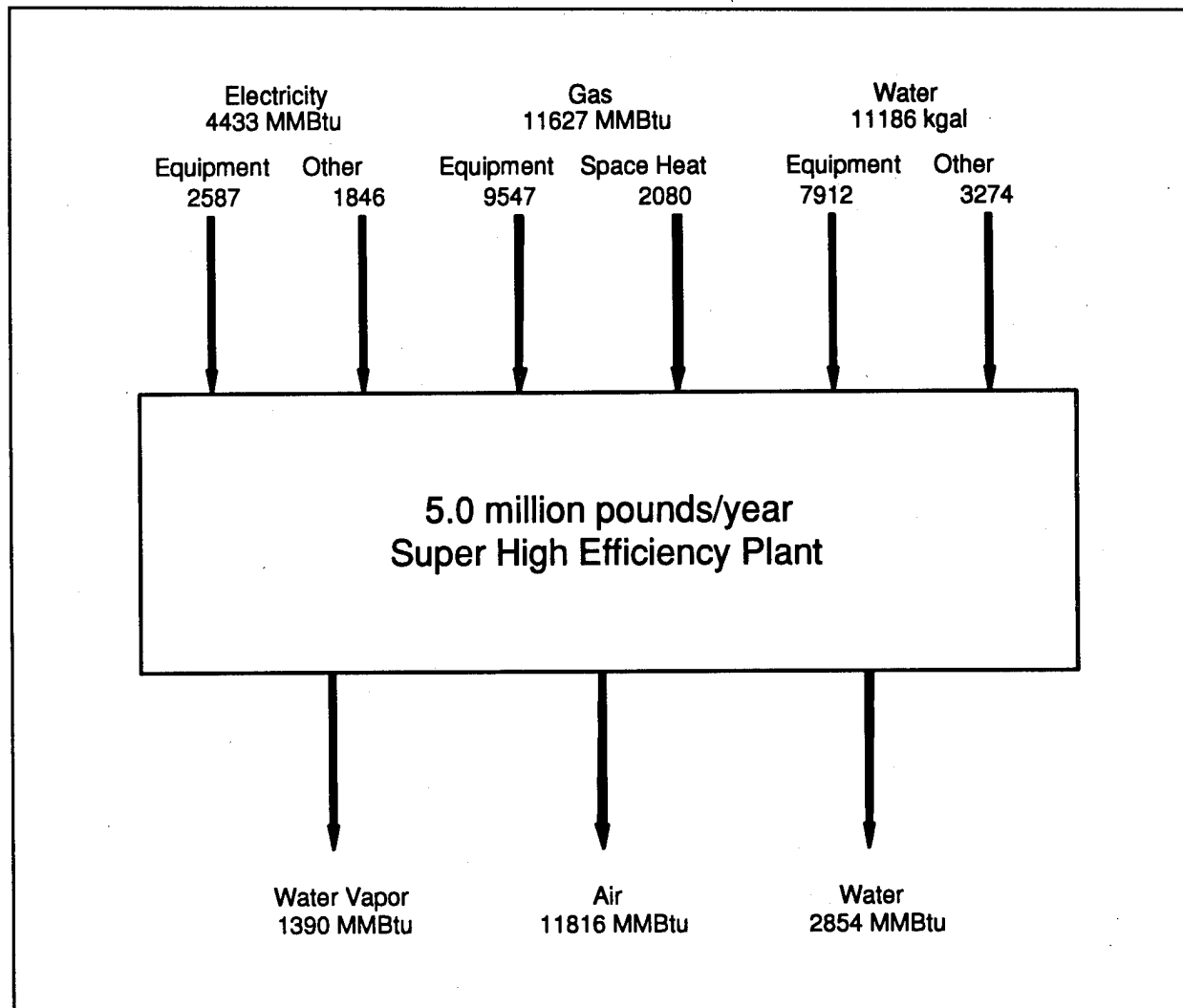


Figure 63. Energy flow diagram for large, super high-efficiency model facility.

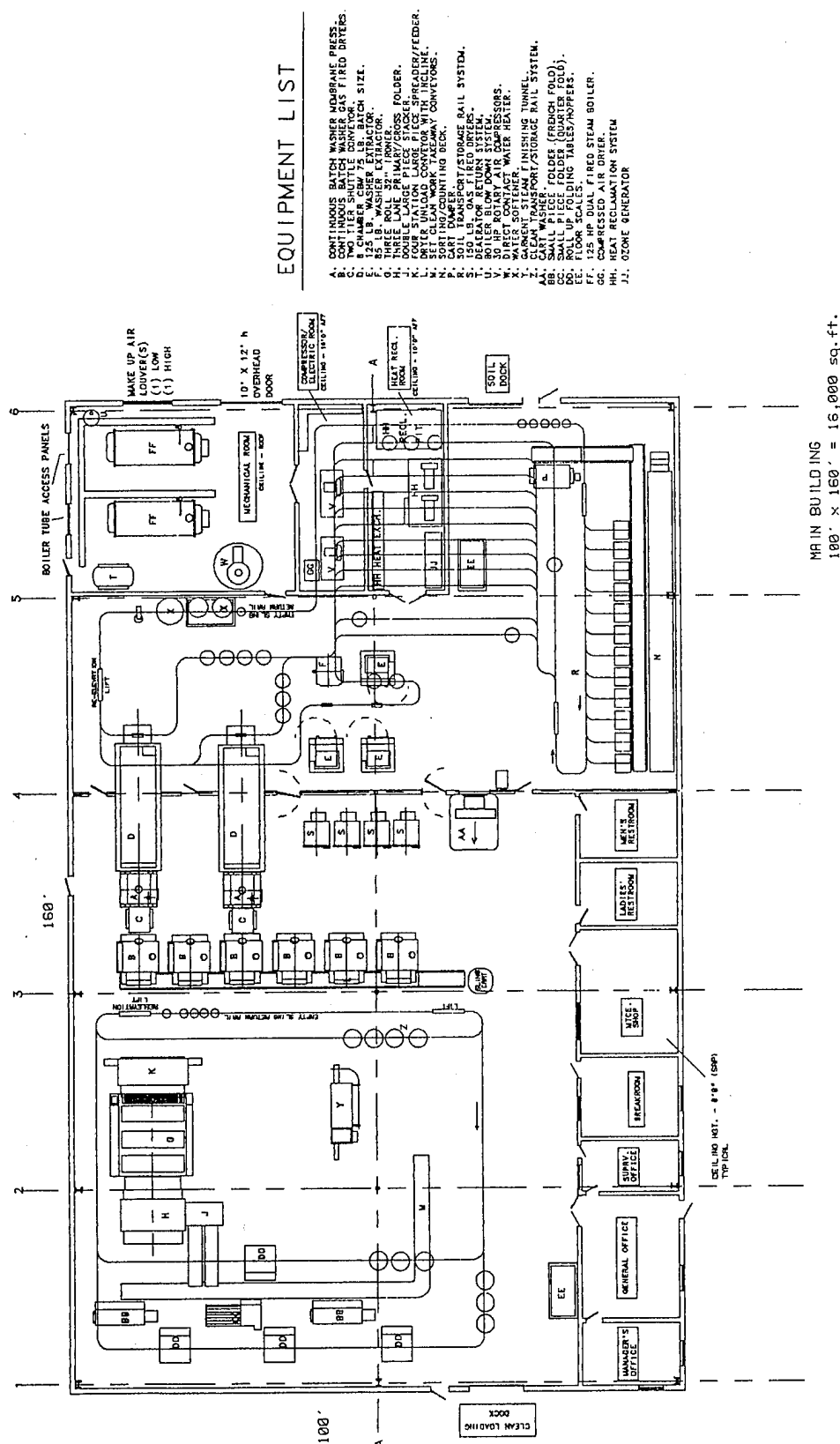


**Figure 64. Layout for large, super high-efficiency model facility.**

## 5 Conclusions and Recommendations

This study contacted personnel at 28 installations and sent surveys to determine energy use, annual production, and operating conditions at those DOD laundry facilities. Site visits were also made to several installations to visually inspect equipment and to review current operating practices. Data were entered into a spreadsheet and graphically analyzed. A preliminary data analysis revealed significant variations in the amount of energy consumed by DOD laundry facilities of comparable capacities. It was concluded that the scattering of data points may have resulted from any one or combination of several causes:

- inefficient equipment operation
- equipment in need of tuning or repair
- use of outdated equipment
- faulty utility-metering equipment
- lack of metering equipment.

Currently, utility consumption at DOD laundry facilities may not be monitored by personnel at the laundry site and is sometimes billed according to outdated formulas that assign an arbitrary percentage of installation-wide utility use to the laundry. Such outmoded billing formulas and spotty metering may inadvertently result in overspending on utilities. It is difficult to demonstrate or verify the effectiveness of conservation measures without past performance data for comparisons. It is therefore recommended that utility consumption in DOD laundries be accurately metered; this would greatly enhance the ability of managers to implement conservation methods.

When compared to the DOD laundry data, data on commercial laundry facilities showed that, on average, the military facilities studied used approximately 12 percent less electricity and 129 percent more thermal energy per pound of processed laundry than comparable commercial facilities. This apparent advantage in electricity savings is offset by the fact that electricity consumption typically ranges only from 9 to 15 percent of total energy consumption in commercial laundries. Average water consumption in the military laundries studied was 40 percent higher than that of the commercial laundries studied. Military laundries typically employed 12.70 people per million pounds of laundry processed as opposed to only 7.71 people per million pounds of laundry processed in commercial facilities.

Model laundry facilities were developed to be similar in capacity and function to DOD laundries, and were compared to both military and commercial laundry plants. The models for each of the three common size ranges included one model using standard equipment and two using state-of-the-art equipment and technologies to project optimal utility efficiencies. The models also indicate that commercial laundries appear to be operating more efficiently in terms of utility consumption than many DOD laundries.

Old equipment, such as has become common in DOD laundry facilities due to tight military budgets, is generally less efficient than newer equipment that employs recent technologies, and more difficult to repair due to scarcity of parts and lack of manufacturer support. At least in terms of its laundry facilities, the reduction in operations and maintenance funding has taken a toll on the DOD infrastructure.

This study concludes that the efficiency of DOD laundry facilities may be greatly improved by implementing modern energy management techniques, by obtaining new equipment, and by providing additional personnel training. It is recommended that DOD implement advanced water and energy conservation/recycling technologies as outlined in the alternative facility designs modeled in this study to allow its laundry facilities to become competitive with commercial laundries of similar production capacity. Modernization efforts can greatly enhance DOD facilities' ability to provide competitive, high-quality services to military personnel. It is therefore also recommended that individual installations should do appropriate cost analyses to determine whether laundry plant energy improvements qualify for funding assistance under ECIP. Since similar government-owned, government-operated facilities (belonging to the Veterans' Administration) are consistently competitive with commercial laundries, it is clearly in the best interest of the government to own and operate its own laundry facilities.

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## **Appendix A: DOD Laundry Survey**

**DOD LAUNDRY PLANT ENERGY EFFICIENCY STUDY**  
**ENERGY USE SURVEY**

CONTROL NUMBER \_\_\_\_\_

**IDENTIFICATION INFORMATION**

INSTALLATION \_\_\_\_\_

DATE \_\_\_\_\_

POC \_\_\_\_\_

POC PHONE # \_\_\_\_\_

OFFICE SYMBOL \_\_\_\_\_

COMMAND \_\_\_\_\_

ADDRESS \_\_\_\_\_

DOD BRANCH \_\_\_\_\_

CITY \_\_\_\_\_

LAUNDRY BLDG # \_\_\_\_\_

ZIP \_\_\_\_\_

TYPE OF LAUNDRY \_\_\_\_\_

**COMMENTS**

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CONTROL NUMBER \_\_\_\_\_

### PRODUCTION INFORMATION

| ANNUAL PRODUCTION (1 lb = 1 piece) | TYPICAL OPERATION                         |
|------------------------------------|-------------------------------------------|
| COMMERCIAL/FAMILY _____            | # DAYS/WEEK _____                         |
| HEALTHCARE _____                   | # HOURS/DAY _____                         |
| LINEN _____                        | # EMPLOYEES _____                         |
| RENTAL (UNIFORM) _____             |                                           |
| OTHER _____                        | PLANT OUTPUT (lbs/day) or (per day) _____ |
|                                    | DAILY AVE _____                           |
| TOTAL _____                        | MAX CAPACITY _____                        |

### ANNUAL OPERATING COSTS

| UTILITIES                        | USE   | \$/UNIT | COST  | ANNUAL COSTS   |
|----------------------------------|-------|---------|-------|----------------|
| ELECTRICITY (kWh)                | _____ | _____   | _____ | ENERGY _____   |
| NATURAL GAS (MCF)                | _____ | _____   | _____ | LABOR _____    |
| OIL (#) (Kgal)                   | _____ | _____   | _____ | SUPPLIES _____ |
| DOMESTIC H <sub>2</sub> O (Kgal) | _____ | _____   | _____ | OVERHEAD _____ |
| HOT H <sub>2</sub> O (Kgal)      | _____ | _____   | _____ | OTHER _____    |
| STEAM (Klbs)                     | _____ | _____   | _____ |                |
| OTHER (Sewer)                    | _____ | _____   | _____ | COST/lb _____  |

### ENERGY CONSUMING EQUIPMENT: WASHERS, DRYERS, IRONERS, PRESSES, ETC.

| EQUIPMENT<br>DESCRIPTION | # OF<br>UNITS | CAPACITY | ENERGY<br>SOURCE | PEAK<br>DEMAND<br>(amps, Btu/hr) | OPERATING<br>psi | °F    | YEAR<br>INST | **<br>STATUS |
|--------------------------|---------------|----------|------------------|----------------------------------|------------------|-------|--------------|--------------|
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |
| _____                    | _____         | _____    | _____            | _____                            | _____            | _____ | _____        | _____        |

\*STATUS\* 1-NORMALLY ON  
2-HOT STANDBY  
3-COLD STANDBY  
4-OUT OF ORDER

CONTROL NUMBER \_\_\_\_\_

## ENERGY CONSERVATION FOR LAUNDRY

|                                                                          | YES   | NO    |
|--------------------------------------------------------------------------|-------|-------|
| MICROPROCESSOR CONTROLS ON LAUNDERING EQUIPMENT                          | ___   | ___   |
| FULLY AUTOMATED (HANDS-OFF) WASHROOM                                     | ___   | ___   |
| RECOVER HEAT FROM DRYER EXHAUSTS                                         | ___   | ___   |
| PREVENTATIVE MAINTENANCE SCHEDULE                                        | ___   | ___   |
| ISOLATION VALVES FOR IDLE EQUIPMENT                                      | ___   | ___   |
| CONTINUOUS BATCH WASHERS                                                 | ___   | ___   |
| OZONATION SYSTEMS                                                        | ___   | ___   |
| THERMAL FLUIDS                                                           | ___   | ___   |
| DIRECT FIRED H <sub>2</sub> O HEATER                                     | ___   | ___   |
| WASTEWATER HEAT RECLAIMER<br>(IF YES, EXPLAIN-TEMPERED H <sub>2</sub> O) | ___   | ___   |
| OTHER ENERGY CONSERVATION METHODS USED                                   | _____ | _____ |
| OTHER NEW TECHNOLOGIES USED                                              | _____ | _____ |

## PLANT BOILER DATA

|        | BLR<br># | CAPACITY | FUEL<br>TYPE | OPERATING<br>psi | °F  | DIST.<br>MEDIA<br>(H <sub>2</sub> O, Water, Steam) | YEAR<br>INST | **<br>STATUS |
|--------|----------|----------|--------------|------------------|-----|----------------------------------------------------|--------------|--------------|
| BOILER | ___      | ___      | ___          | ___              | ___ | ___                                                | ___          | ___          |
| BOILER | ___      | ___      | ___          | ___              | ___ | ___                                                | ___          | ___          |
| BOILER | ___      | ___      | ___          | ___              | ___ | ___                                                | ___          | ___          |
| BOILER | ___      | ___      | ___          | ___              | ___ | ___                                                | ___          | ___          |

OPERATOR: 1. 24 HOURS 2. LAUNDRY TIME 3. ROVING 4. ON CALL

## ENERGY CONSERVATION FOR BOILER ROOM

|                                                                 | YES | NO  |
|-----------------------------------------------------------------|-----|-----|
| BOILER CONTROLS WORKING PROPERLY                                | ___ | ___ |
| STACK TEMPERATURE MEASURED                                      | ___ | ___ |
| CO <sub>2</sub> , CO, O <sub>2</sub> , NO <sub>x</sub> ANALYZED | ___ | ___ |
| PROPER BLOWDOWN OF BOILERS                                      | ___ | ___ |
| DAMPER CONTROLS WORKING PROPERLY                                | ___ | ___ |
| CONDENSATE RETURN SYSTEM<br>(IF YES, % RETURNED ___)            | ___ | ___ |
| TRAPS WORKING PROPERLY                                          | ___ | ___ |
| HOT WATER TANKS ARE SIZED ADEQUATELY                            | ___ | ___ |
| BOILER WATER IS CHEMICALLY TREATED                              | ___ | ___ |
| FUEL METERED                                                    | ___ | ___ |
| ELECTRICITY METERED                                             | ___ | ___ |
| WATER METERED                                                   | ___ | ___ |
| STEAM METERED                                                   | ___ | ___ |
| CONDENSATE RETURN RECOVERY TANK SIZED ADEQUATELY                | ___ | ___ |
| BANK/TURNDOWN @ OFF HOURS                                       | ___ | ___ |
| CHAIN VALVES FOR MAIN HEADERS                                   | ___ | ___ |

TYPE OF TRAPS \_\_\_\_\_

## **Appendix B: Summary of Commercial and Military Laundry Data**

Table B1. Commercial laundry energy data.

| Plant | Production<br>(Mlb/yr) | Annual Energy Use |                    |               |                |                    |                    |                 | Normalized           |                       | Annual Energy Cost (\$) |           |       |       |         |
|-------|------------------------|-------------------|--------------------|---------------|----------------|--------------------|--------------------|-----------------|----------------------|-----------------------|-------------------------|-----------|-------|-------|---------|
|       |                        | Electric<br>(kWh) | Nat'l Gas<br>(kcf) | Oil<br>(kgal) | Steam<br>(klb) | Non-Elec<br>(MBtu) | Electric<br>(MBtu) | Total<br>(MBtu) | Electric<br>(kWh/lb) | Non-Elec<br>(kBTU/lb) | Electric                | Nat'l Gas | Oil   | Steam | Total   |
| DGA   | 0.883650               | 583,040           | 10,708             |               |                | 10,708             | 1,990              | 12,698          | 0.660                | 12.118                | 53,406                  | 58,319    |       |       | 111,725 |
| RNM   | 1.715250               | 264,120           | 7,538              | 4,635         |                | 8,210              | 901                | 9,112           | 0.154                | 4.787                 | 20,717                  | 23,016    | 5,298 |       | 49,031  |
| POR   | 1.860227               | 333,800           | 7,693              |               |                | 7,693              | 1,139              | 8,832           | 0.179                | 4.136                 | 19,093                  | 25,067    |       |       | 44,160  |
| SUT   | 2.220400               |                   |                    |               |                |                    |                    |                 |                      |                       | 27,094                  | 31,126    |       |       | 58,220  |
| SCA   | 2.833814               |                   |                    |               |                |                    |                    |                 |                      |                       | 45,843                  | 40,860    |       |       | 86,703  |
| SIN   | 2.842447               | 387,420           | 8,945              |               |                | 8,945              | 1,322              | 10,267          | 0.136                | 3.147                 | 19,372                  | 33,265    |       |       | 52,637  |
| CNE   | 2.940979               | 119,160           | 10,269             |               |                | 10,269             | 407                | 10,675          | 0.041                | 3.492                 | 7,149                   | 48,263    |       |       | 55,412  |
| DCO   | 3.131316               |                   |                    |               |                |                    |                    |                 |                      |                       | 23,176                  | 44,094    |       |       | 67,270  |
| BCT   | 3.380010               | 869,400           | 16,245             |               |                | 16,245             | 2,967              | 19,212          | 0.257                | 4.806                 | 85,326                  | 67,573    |       |       | 152,899 |
| BND   | 3.870000               | 389,000           | 7,766              |               |                | 7,766              | 1,328              | 9,094           | 0.101                | 2.007                 | 30,315                  | 27,431    |       |       | 57,746  |
| BMA   | 4.107535               | 645,820           | 15,513             |               |                | 15,513             | 2,204              | 17,717          | 0.157                | 3.777                 | 73,551                  | 79,852    |       |       | 153,403 |
| INJ   | 4.386000               | 576,480           | 11,728             |               |                | 11,728             | 1,968              | 13,696          | 0.131                | 2.674                 | 67,168                  | 55,980    |       |       | 123,148 |
| GMI   | 4.724900               | 582,880           | 21,920             |               |                | 21,920             | 1,921              | 23,841          | 0.119                | 4.639                 | 50,643                  | 62,355    |       |       | 112,998 |
| DIA   | 5.050000               | 601,440           | 19,105             |               |                | 19,105             | 2,053              | 21,158          | 0.119                | 3.783                 | 33,095                  | 64,637    |       |       | 97,732  |
| FTX   | 5.668000               | 700,060           | 17,801             |               |                | 17,801             | 2,389              | 20,190          | 0.124                | 3.141                 | 52,983                  | 80,089    |       |       | 133,072 |
| SNY   | 5.799729               | 897,488           | 18,515             |               |                | 18,515             | 3,063              | 21,578          | 0.155                | 3.192                 | 105,316                 | 38,692    |       |       | 144,008 |
| LLA   | 6.904193               | 710,550           | 11,985             |               |                | 11,985             | 2,425              | 14,410          | 0.103                | 1.736                 | 47,631                  | 46,266    |       |       | 93,897  |
| CIL   | 8.030144               | 1,351,955         | 44,764             |               |                | 44,764             | 4,614              | 49,378          | 0.168                | 5.574                 | 130,934                 | 158,992   |       |       | 289,926 |
| HKY   | 9.358425               | 990,600           | 32,527             |               |                | 32,527             | 3,381              | 35,908          | 0.106                | 3.476                 | 30,263                  | 109,725   |       |       | 139,988 |
| WWI   | 10.839671              | 970,480           | 32,128             |               |                | 32,128             | 3,312              | 35,440          | 0.090                | 2.964                 | 75,874                  | 105,923   |       |       | 181,797 |
| COH   | 11.854879              | 1,279,936         | 33,490             |               |                | 33,490             | 4,368              | 37,858          | 0.108                | 2.825                 | 89,771                  | 108,429   |       |       | 198,200 |
| GNC   | 20.765405              | 1,882,684         | 54,576             |               |                | 54,576             | 6,426              | 61,002          | 0.091                | 2.628                 | 127,338                 | 147,634   |       |       | 274,972 |

Table B2. Commercial laundry nonenergy data.

| Plant | Production<br>(Mlb/yr) | Annual Water  |                        | Cost<br>(\$) | Annual Sewer  |              | Operating<br>Cost<br>(\$/lb) | Personnel |                         | Age (yrs) |     |      |       |
|-------|------------------------|---------------|------------------------|--------------|---------------|--------------|------------------------------|-----------|-------------------------|-----------|-----|------|-------|
|       |                        | Use<br>(kgal) | Normalized<br>(gal/lb) |              | Use<br>(kgal) | Cost<br>(\$) |                              | Number    | Normalized<br>(num/Mlb) | <2        | 2-5 | 5-10 | 10-20 |
| DGA   | 0.883650               | 11,093        | 12,554                 | 10,862       |               | 17,249       |                              | 35        | 39.6                    |           | x   |      |       |
| RNM   | 1.715250               | 4,633         | 2,701                  |              |               |              |                              | 25        | 14.6                    |           |     |      | x     |
| POR   | 1.860227               | 6,051         | 3,253                  | 5,915        |               | 9,352        |                              | 17        | 9.1                     | x         |     |      |       |
| SUT   | 2.220400               |               |                        |              |               |              |                              | 12        | 5.4                     |           |     |      | x     |
| SCA   | 2.833814               | 5,729         | 2,022                  | 8,526        |               | 14,198       |                              | 19        | 6.7                     |           |     | x    |       |
| SIN   | 2.842447               | 9,058         | 3,187                  |              |               | 20,400       |                              | 20        | 7.0                     |           |     | x    |       |
| CNE   | 2.940979               | 1,062         | 0.361                  | 319          |               | 1,169        |                              | 22        | 7.5                     |           |     |      | x     |
| DCO   | 3.131316               |               |                        | 4,235        |               | 11,473       |                              | 31        | 9.9                     |           |     | x    |       |
| BCT   | 3.380010               | 9,075         | 2,685                  | 18,985       |               |              |                              | 25        | 7.4                     |           |     | x    |       |
| BND   | 3.870000               | 7,294         | 1,885                  | 11,502       |               | 7,424        |                              | 22        | 5.7                     |           |     | x    |       |
| BMA   | 4.107535               | 8,655         | 2,107                  | 22,504       |               | 36,353       |                              | 36        | 8.8                     |           |     | x    |       |
| INJ   | 4.386000               | 11,308        | 2,578                  | 32,960       |               | 9,000        |                              | 55        | 12.5                    |           |     | x    |       |
| GMI   | 4.724900               | 12,338        | 2,611                  | 20,422       |               | 14,705       |                              | 33        | 7.0                     |           |     | x    |       |
| DIA   | 5.050000               | 26,945        | 5,336                  | 25,426       |               | 22,730       |                              | 50        | 9.9                     |           |     |      | x     |
| FTX   | 5.668000               |               |                        |              |               | 53,642       |                              | 40        | 7.1                     |           |     |      | x     |
| SNY   | 5.799729               | 14,714        | 2,537                  | 12,827       |               |              |                              | 47        | 8.1                     |           | x   |      |       |
| LLA   | 6.904193               | 17,771        | 2,574                  | 14,367       |               | 11,374       |                              | 49        | 7.1                     |           |     |      | x     |
| CIL   | 8.030144               | 23,418        | 2,916                  | 25,372       |               | 18,958       |                              | 45        | 5.6                     |           |     |      | x     |
| HKY   | 9.358425               | 33,839        | 3,616                  | 23,263       |               | 28,716       |                              | 55        | 5.9                     |           |     | x    |       |
| WWI   | 10.839671              | 25,395        | 2,343                  | 21,900       |               | 33,114       |                              | 61        | 5.6                     |           |     | x    |       |
| COH   | 11.854879              | 30,601        | 2,581                  | 52,262       |               | 41,157       |                              | 95        | 8.0                     |           |     |      | x     |
| GNC   | 20.765405              | 39,378        | 1,896                  | 26,738       |               | 32,044       |                              | 184       | 8.9                     |           |     | x    |       |

Table B3. Military laundry energy data.

| Plant | Annual Energy Use   |                |                |            |             |                 |                 |              | Normalized        |                    | Annual Energy Cost (\$) |          |        |        |         |
|-------|---------------------|----------------|----------------|------------|-------------|-----------------|-----------------|--------------|-------------------|--------------------|-------------------------|----------|--------|--------|---------|
|       | Production (Mlb/yr) | Electric (kWh) | Natl Gas (kcf) | Oil (kgal) | Steam (klb) | Non-Elec (MBtu) | Electric (MBtu) | Total (MBtu) | Electric (kWh/lb) | Non-Elec (kBtu/lb) | Electric                | Natl Gas | Oil    | Steam  | Total   |
| A     |                     |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| E     |                     |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| Q     | 0.197728            |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| P     | 0.268340            | 396,000        |                |            | 12,600      | 12,600          | 1,352           | 13,952       | 1.476             | 46.955             | 31680                   | 32328    |        | 141750 | 205,758 |
| S     | 0.384000            |                |                |            |             |                 |                 |              |                   |                    | 124372                  | 28524    |        |        | 152,896 |
| H     | 1.004805            |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| M     | 1.281383            | 102,640        | 15,479         |            |             | 15,479          | 350             | 15,829       | 0.080             | 12.080             | 6079                    | 73303    |        |        | 79,383  |
| L     | 1.624068            |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| K     | 1.647167            | 109,168        | 11,151         |            |             | 11,151          | 373             | 11,524       | 0.066             | 6.770              | 6168                    | 56760    |        |        | 62,928  |
| O     | 1.783559            | 145,934        | 3,598          | 0.515      |             | 3,673           | 498             | 4,171        | 0.082             | 2.059              | 7997                    | 16003    | 408    |        | 24,408  |
| D     | 1.911106            | 1,321,332      | 27,132         |            | 31,839      | 58,971          | 4,510           | 63,481       | 0.691             | 30.857             | 100322                  | 14297    |        | 452076 | 566,695 |
| B     | 2.440065            | 317,190        | 17,249         |            |             | 17,249          | 1,083           | 18,332       | 0.130             | 7.069              | 23686                   | 54490    |        |        | 78,176  |
| C     | 2.678258            | 957,353        | 20,372         | 27.912     | 28,005      | 52,424          | 3,267           | 55,692       | 0.357             | 19.574             | 29678                   | 22727    | 37280  | 15310  | 104,995 |
| J     | 2.716770            |                |                |            |             |                 |                 |              |                   |                    |                         |          |        |        |         |
| G     | 3.055382            | 538,920        | 23,649         |            |             | 23,649          | 1,839           | 25,488       | 0.176             | 7.740              | 50200                   | 117400   |        |        | 167,600 |
| F     | 3.384254            | 131,724        | 27,714         |            |             | 27,714          | 450             | 28,164       | 0.039             | 8.189              | 6860                    | 77567    |        |        | 84,427  |
| T     | 3.900000            | 259,140        | 31             | 325.500    |             | 47,228          | 884             | 48,112       | 0.066             | 12.110             | 18140                   | 17007    | 224595 |        | 259,742 |
| I     | 4.320640            | 425,440        | 33,550         |            | 24,129      | 57,679          | 1,452           | 59,131       | 0.098             | 13.350             | 19551                   | 22774    |        | 174413 | 216,738 |
| N     | 4.522857            | 694,500        | 32,845         |            |             | 32,845          | 2,370           | 35,216       | 0.154             | 7.262              | 35285                   | 132384   |        |        | 167,669 |
| U     | 5.000000            | 246,000        |                | 40.000     | 16,072      | 21,872          | 840             | 22,712       | 0.049             | 4.374              | 16064                   |          |        | 135163 | 151,227 |
| R     | 10.227355           | 717,000        | 19,703         | 2.844      |             | 20,115          | 2,447           | 22,562       | 0.070             | 1.967              | 44329                   | 69336    | 1943   |        | 115,608 |

Table B4. Military laundry nonenergy data.

| Plant | Production<br>(Mlb/yr) | Annual Water  |                        |              | Annual Sewer  |              | Operating<br>Cost<br>(\$/lb) | Personnel |                         | Age (yrs) |     |      |       |
|-------|------------------------|---------------|------------------------|--------------|---------------|--------------|------------------------------|-----------|-------------------------|-----------|-----|------|-------|
|       |                        | Use<br>(kgal) | Normalized<br>(gal/lb) | Cost<br>(\$) | Use<br>(kgal) | Cost<br>(\$) |                              | Number    | Normalized<br>(num/Mlb) | <2        | 2-5 | 5-10 | 10-20 |
| A     |                        |               |                        |              |               |              |                              |           |                         |           |     |      |       |
| E     |                        |               |                        |              |               |              |                              |           |                         |           |     |      |       |
| Q     | 0.197728               |               |                        |              |               |              |                              | 20        | 101.1                   |           |     |      | x     |
| P     | 0.268340               |               |                        |              |               |              |                              | 35        | 130.4                   |           |     | x    |       |
| S     | 0.384000               |               |                        | 10228        |               |              |                              |           |                         |           |     |      |       |
| H     | 1.004805               |               |                        |              |               |              |                              | 17        | 16.9                    |           |     |      |       |
| M     | 1.281383               | 4312          | 3.365                  | 3333         | 3448          | 2473         |                              |           |                         |           |     |      |       |
| L     | 1.624068               |               |                        |              |               |              |                              |           |                         |           |     |      |       |
| K     | 1.647167               | 4889          | 2.968                  | 7140         |               |              | 0.22                         | 62        | 37.6                    |           | x   |      |       |
| O     | 1.783559               | 9387          | 5.263                  | 2914         | 7509.6        | 4929         | 0.05                         | 42        | 23.5                    |           |     |      | x     |
| D     | 1.911106               | 91528         | 47.893                 | 117009       | 73224         | 78558        |                              | 22        | 11.5                    |           |     |      |       |
| B     | 2.440065               | 10476         | 4.293                  | 18169        | 8376          | 4821         |                              | 91        | 37.3                    |           |     |      | x     |
| C     | 2.678258               | 16315.7       | 6.092                  |              |               |              | 0.39                         | 45        | 16.8                    |           |     |      |       |
| J     | 2.716770               |               |                        |              |               |              |                              | 28        | 10.3                    |           |     |      | x     |
| G     | 3.055382               |               |                        | 7200         |               |              |                              | 27        | 8.8                     |           |     |      | x     |
| F     | 3.384254               |               |                        |              |               |              | 0.245                        | 31        | 9.2                     |           |     | x    |       |
| T     | 3.900000               | 28714         | 7.363                  | 78676        | 28714         | 110262       |                              | 30        | 7.7                     |           |     |      |       |
| I     | 4.320640               | 37339         | 8.642                  | 37092        | 29871.2       | 7635         | 0.43                         | 63        | 14.6                    |           |     |      |       |
| N     | 4.522857               | 14091.42      | 3.116                  | 7232         | 12682.28      | 17706        |                              | 35        | 7.7                     |           |     |      |       |
| U     | 5.000000               | 20080         | 4.016                  |              |               |              | 0.345                        | 65        | 13.0                    |           |     | x    |       |
| R     | 10.227355              | 24480         | 2.394                  | 16646        |               |              |                              | 124       | 12.1                    |           |     |      | x     |

## **Appendix C: Commercial Laundry Data Collection Summary and Survey Form**

### **Contacts with Local Laundering Facilities:**

#### ***Fairfax Hospital***

Energy use for the hospital is not separately metered. Visitors are not allowed into the laundry facility to avoid possible exposure to infectious organisms.

#### ***Shady Grove Hospital***

Calls were unsuccessful in making contact with the appropriate person.

#### ***Virginia Linen, Landover, MD***

A spokesperson said it was against company policy for individual facilities to provide the type of information asked for. He referred us to their home office in Petersburg VA.

#### ***Virginia Linen, Petersburg, VA***

When asked if a survey form were available, several copies of the form were sent, with the hope of collecting data on different sizes of facilities. (A copy of the form sent is included at the end of this Appendix.) As of the last contact (12 April 1994), the forms had been received and turned over to the company president for disposition.

### **Contacts with Laundry Trade Associations:**

#### ***Uniform and Textile Service Association (UTSA) (formerly the Institute of Industrial Launderers)***

UTSA commissioned a survey of wastewater and energy use in member facilities. The survey was conducted in late 1992. Mr. Geoffrey A. Northey furnished copies of filled out surveys from 22 facilities, which provided the primary source of data for the

comparison of military and commercial laundry facilities presented in this report. A copy of an equipment list for one facility was also received from Mr. Northey. UTSA also markets a computerized maintenance management system that incorporates data on an equipment-by-equipment basis. It may be possible to obtain more detailed data from the users of this system, with proper permission and clearances.

#### ***International Fabricare Institute***

Mr. Ken Faig sent a copy of the March 1992 issue of *Special Reporter*. The title of the issue is "Getting the Most For Your Energy Dollar." The discussion focused on ways to conserve energy and water in the various items of laundry equipment. The only pertinent quantifying statement is "The energy cost for a pound of laundry is \$0.05." A copy of the article is included in Appendix D.

#### ***The National Association of Institutional Linen Management***

This organization referred the researchers to Mr. Chip Webster of Servicemaster Corp., who is associated with laundry layouts and management of over 200 facilities. Information of the type requested is confidential and cannot be released without the consent of each specific customer.

#### ***Textile Care and Allied Trade Association***

Is a small (two person) operation and does not collect any data pertinent to this study.

#### ***Textile Rental Services Association (TRSA)***

TRSA supplied a copy of an article titled "Industry Energy Consumption Drops, According to Survey," which appeared in the June 1992 issue of *Textile Rental* magazine. Results of energy and water use surveys of four large chain companies are presented. These results are compared with other available data in this report. A copy of the article is included in Appendix D. TRSA also has available a two-volume publication titled "How to Reduce Costs Through Energy Conservation."

## Commercial Laundry Survey Form

### LAUNDRY PLANT ENERGY EFFICIENCY STUDY ENERGY USE SURVEY

#### 1. PLANT/PRODUCTION DATA

| IDENTIFICATION AND PRODUCTION INFORMATION                                          |  |
|------------------------------------------------------------------------------------|--|
| FACILITY NAME                                                                      |  |
| DATE OF SURVEY                                                                     |  |
| TYPICAL OPERATION<br># Days/week<br># Hours/day<br>Time of operation (From.. to..) |  |
| NUMBER OF EMPLOYEES                                                                |  |
| PLANT OUTPUT (lbs/day)<br>Daily average<br>Maximum capacity                        |  |
| PLANT ANNUAL OUTPUT (lbs/year)                                                     |  |

#### 2. ANNUAL ENERGY CONSUMPTION AND COSTS

| ITEM                            | USE | \$/UNIT | COST |
|---------------------------------|-----|---------|------|
| ELECTRICITY (kWh)               |     |         |      |
| NATURAL GAS (MCF) <sup>1</sup>  |     |         |      |
| OIL ( # ) (gal)                 |     |         |      |
| DOMESTIC H <sub>2</sub> O (gal) |     |         |      |
| HOT H <sub>2</sub> O (gal)      |     |         |      |
| STEAM (lbs)                     |     |         |      |
| OTHER ( )                       |     |         |      |
| TOTAL ENERGY COST               |     |         |      |

#### 3. ANNUAL COSTS

| ITEM                          | COST |
|-------------------------------|------|
| ANNUAL DIRECT LABOR COST      |      |
| ANNUAL SUPPLIES COST          |      |
| ANNUAL MAINTENANCE LABOR COST |      |
| ANNUAL OVERHEAD COST          |      |
| OTHER                         |      |

<sup>1</sup> MCF - million cubic feet





## 6. ENERGY CONSERVATION MEASURES FOR LAUNDRY AND BOILER ROOMS

|                                                                 | YES | NO |
|-----------------------------------------------------------------|-----|----|
| LAUNDRY EQUIPMENT                                               |     |    |
| Microprocessor controls on laundering equipment                 |     |    |
| Fully-automated (hands-off) washroom                            |     |    |
| Heat recovery from dryer exhausts                               |     |    |
| Preventative maintenance schedule                               |     |    |
| Isolation valves for idle equipment                             |     |    |
| Continuous batch washers                                        |     |    |
| Ozonation system                                                |     |    |
| Thermal fluids                                                  |     |    |
| Direct fired water heater                                       |     |    |
| Waste water heat reclaimer                                      |     |    |
| BOILERS                                                         |     |    |
| Boiler combustion control system                                |     |    |
| Stack temperature measured                                      |     |    |
| CO <sub>2</sub> , CO, O <sub>2</sub> , NO <sub>x</sub> analyzed |     |    |
| Blowdown on boilers (Continuous/periodic)                       |     |    |
| Damper controls                                                 |     |    |
| Condensate return system (if yes, % return)                     |     |    |
| Boiler stack economizer                                         |     |    |
| Fuel metered                                                    |     |    |
| Electricity metered                                             |     |    |
| Water metered                                                   |     |    |
| Steam metered                                                   |     |    |

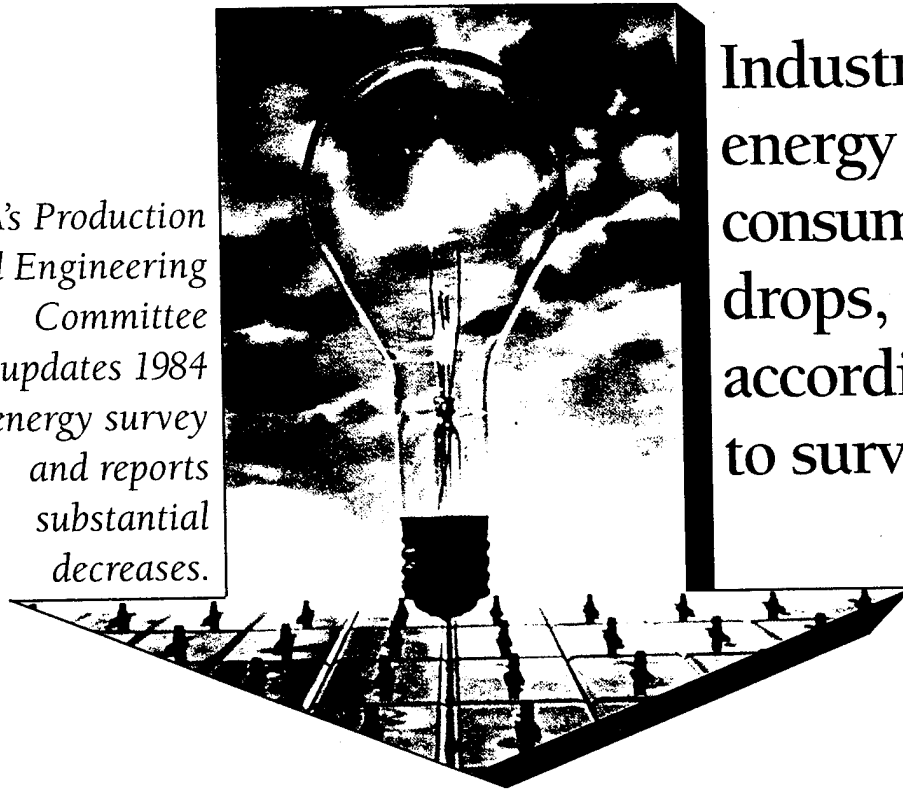
## LIST OF OTHER ENERGY CONSERVATION EQUIPMENT/TECHNOLOGY USED

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

## **Appendix D: Reprints of Selected Laundry Articles**

## "Industry Energy Consumption Drops, According to Survey," *Textile Rental* (June 1992)

TRSA's Production and Engineering Committee updates 1984 energy survey and reports substantial decreases.



Industry  
energy  
consumption  
drops,  
according  
to survey

Long regarded as an energy-efficient, recycling industry, textile rental appears to be making greater strides in this direction, according to a survey conducted in late 1991 by TRSA's Production and Engineering Committee. The survey of four large chain companies shows a substantial decrease in boiler and dryer fuel and water usage with a slight increase in electrical consumption compared with a 1984 industrywide survey.

For the recent survey, participating companies provided consumption data of three utilities by per pound of production for each of the geographical

regions in which they operate. To ensure confidentiality, company names and the areas for which each provided data are not reported. Instead, survey data have been compiled for two regions: northern and southern states.

TRSA's two prior energy surveys (1984 and 1982) also reported data according to these two major climatic zones, anticipating that plants in northern states would consume more energy than those in southern states. For this analysis, the geographical areas used in reporting data have been grouped according to Chart 1.

### Survey results

The data reflect a significant reduction in natural gas/fuel oil use (*Chart 2*) and water consumption (*Chart 4*) in both northern and southern plants. However, use of electricity has increased slightly (*Chart 3*).

These findings have been determined by taking averages submitted by the four companies and then averaging these figures again. Mathematically, this is not a proper procedure. However, the results provide benchmark figures against which rental operators can compare their own figures, and the improvement shown is of such a degree that it represents industrywide improvement—although possibly not to the same extent as the data show.

Considering the changes TRSA knows to have taken place in the industry, the data appear logical. For example, much of the older washing equipment has been replaced with more modern equipment that uses significantly less water. Most plant managers who still use the older equipment have adjusted their formulas to use less water, especially heated water. Much work also has been done to reuse water—both to recycle clean rinse water into the initial operation of subsequent loads and to

**Chart 1: Energy survey geographical regions**

| Geographical areas used by companies in reporting data | Regrouped into north/south regions                                                               |
|--------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| North<br>East<br>Northeast<br>Northwest<br>Midwest     |  North region |
| South<br>West<br>Southeast<br>Southwest                |  South region |

Chart 2: Natural gas and fuel oil consumption in Btu per lb. of production

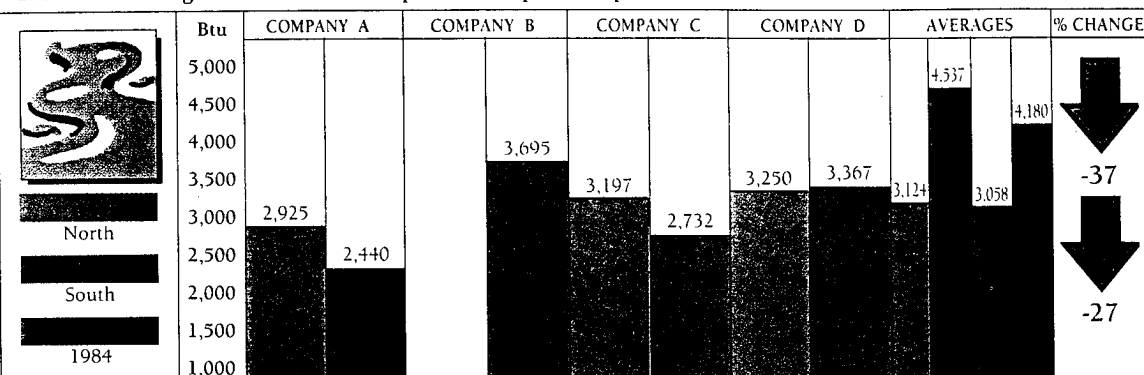


Chart 3: Electrical consumption in kwh per 100 lb. of production

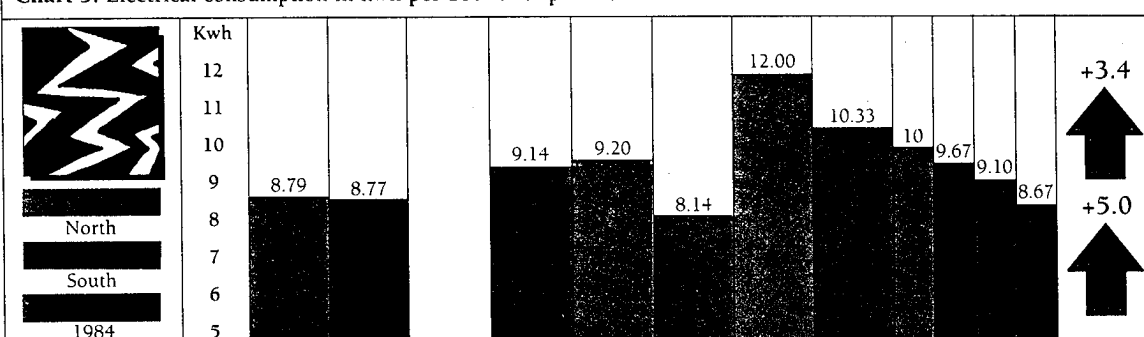
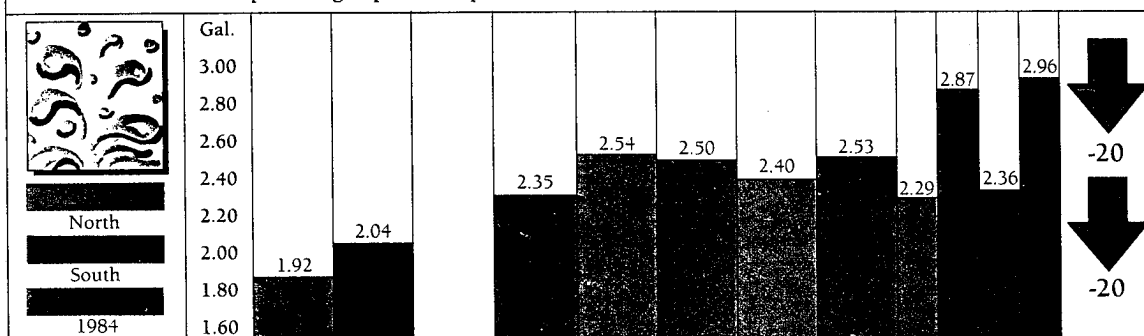


Chart 4: Water consumption in gal. per lb. of production



reclaim wastewater for processing and reuse.

The reduction in the amount of water used logically results in a corresponding reduction in the energy used to heat it. Recent improvements in the efficiency of some newer extractors result in shorter drying cycles in tumbler/dryers or, in some cases, bypassing the operation.

Some of these changes can be expected to increase costs in other areas. This is reflected in the higher electricity use to power the newer high-output washers and mechanical extractors and to light the plants. Many plants are operating more hours per day than in the

### Energy-saving publications available from TRSA

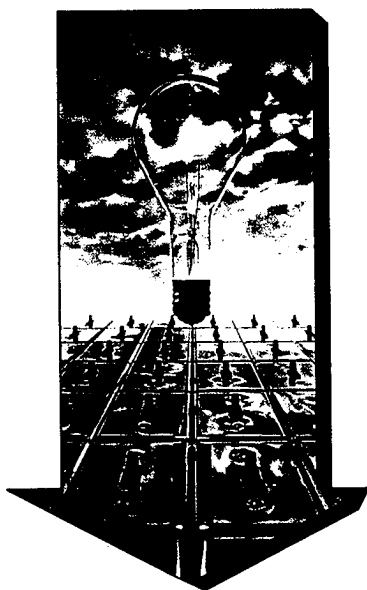
Two TRSA publications can help you identify energy-saving opportunities in your plants:

☐ **How to Reduce Costs Through Energy Conservation, Vol. I (#71301)**

This 24-page booklet describes how to reduce energy costs by checking specific energy use areas. Major categories featured are plant buildings, processes and equipment, electric power, and vehicle fuel conservation. Useful as a comprehensive checklist to survey all areas of energy consumption for possible savings.  
Member price \$5; retail \$10

☐ **How to Reduce Costs Through Energy Conservation, Vol. II (#71372)**

This 96-page book is a compilation of material on energy management and energy conservation techniques for specific kinds of plant equipment previously appearing in either *Textile Rental* magazine or TRSA newsletters. Vol. II should be used as a companion piece to Vol. I. Included in Vol. II is a chapter on monitoring and measuring energy consumption.  
Member price \$15; retail \$30



past to better use the fixed investment in plant and equipment.

### Comparing your energy consumption

Your plant's consumption of any of these three utilities may be better or worse than the consumption rates shown here for valid reasons. In addition to the factors mentioned, soil content can be a major determinant of the amount of heated water and energy used.

Also, the way you determine pounds of production can affect your consumption rate. TRSA's Production and Engineering Committee believes that pounds of production should be stated in terms of clean, dry weight calculated from pieces produced. That is the count of good pieces coming from the various finishing operations multiplied by a weight factor for each piece.

Another determinant of fuel consumption is the geographical location of the plant. Plants located in northern cities with cold climates can be expected to use significant amounts of fuel for space heating.

### How to get a handle on energy costs

With today's increased competition and low profit margins, you or your plant manager should regularly measure and record consumption of water, electricity, and gas/fuel oil on a per-pound basis. By comparing these rates with a benchmark rate, you can spot trends in consumption over time and take action when needed. The sidebar below offers some useful formulas for starting this process. If you have any questions about the survey, contact Clyde Blaco at TRSA.

## Tips for measuring energy consumption



### Water

Water consumption is usually expressed as gallons used. For any specific period of time:

$$\frac{\text{Gallons used}}{\text{Pounds produced}} = \text{Gallons per pound}$$

Therefore, if 22,024,000 gal. of water is consumed and 7,269,000 lb. of merchandise is processed during a set period of time, the consumption rate would be:

$$\frac{22,024,000 \text{ gal.}}{7,269,000 \text{ lb.}} = 3.0 \text{ gal. per lb.}$$

If your water company (or its meter) provides consumption data measured in cubic feet of water, convert the number of cubic feet consumed to gallons consumed. This is done by multiplying cubic feet by 7.48.

$$\text{Cubic feet of water} \times 7.48 = \text{Gallons of water}$$



### Electricity

Consumption of electricity is measured by the kilowatt hour—the amount of energy delivered by an hour-long flow of 1 kw of electric power. A 100-watt bulb burning for 10 hours will use 1 kw of electric energy (100 watts multiplied by 10 hours equals 1,000 watt hours, or a kilowatt hour).

Kilowatts can be converted to Btu by multiplying by 3,413.

Kilowatt hours should be related to pounds produced:

$$\frac{\text{Kilowatt hours used}}{\text{Pounds produced}} = \text{Kilowatt hours per pound}$$



### Natural gas/fuel oil

Natural gas consumption is measured in several ways. These, and their Btu equivalency, are shown in the following table:

| Unit of measurement | Btu equivalency |
|---------------------|-----------------|
| Therm               | 100,000         |
| 1 cu. ft. (CF)      | 1,000*          |
| 100 cu. ft. (CCF)   | 100,000*        |
| 1,000 cu. ft. (MCF) | 1,000,000*      |

For the most commonly used types of fuel oil, the Btu ratings are:

| Type of fuel oil | Btu equivalency  |
|------------------|------------------|
| No. 2 fuel oil   | 140,000 Btu/gal. |
| No. 5 fuel oil   | 148,000 Btu/gal. |
| No. 6 fuel oil   | 150,000 Btu/gal. |

To calculate the consumption rates for natural gas, fuel oil, or any other type of fuel, convert the quantity of fuel used into its Btu equivalency and then relate this to the pounds of production.

\*The number of Btu in a cubic foot of natural gas varies from place to place and from time to time, but 100 cu. ft. usually contains more than one therm (100,000 Btu). To obtain the exact Btu content of natural gas, contact the gas utility. The figures shown are usually close enough for monitoring fuel-usage rates.

The reason for making this conversion is that the Btu is the common denominator into which a known quantity of any fuel or electricity may be converted. A plant using a No. 2 fuel oil and natural gas can't add these consumption rates together without first converting them to a common denominator. By the same token, if a plant uses No. 2 fuel oil only and wants to compare its fuel consumption rate to that of another plant that uses natural gas only, conversion is needed to make the comparison.

For a plant that consumed 600 gal. of No. 2 fuel oil and 2,250,000 cu. ft. of natural gas to process 600,000 lb. of merchandise, the arithmetic involved in calculating the Btu per pound processed is as follows:

$$600 \text{ gal. of No. 2 fuel oil} \times \frac{140,000 \text{ Btu}}{\text{per gal.}} = 84,000,000 \text{ Btu}$$

plus:

$$2,250,000 \text{ cu. ft. of natural gas} \times \frac{1,000 \text{ Btu}}{\text{per cu. ft.}} = 2,250,000,000 \text{ Btu}$$

$$\text{Total number of Btu} = 2,334,000,000 \text{ Btu}$$

$$\frac{2,334,000,000 \text{ Btu}}{600,000 \text{ lb. processed}} = 3,890 \text{ Btu per lb. processed}$$

To simplify the division of such large numbers, move the decimal point five or six places to the left in the numbers above and below the line. Moving it five places to the left results in the following:

$$\frac{23.340 \text{ Btu}}{6 \text{ lb.}} = 3,890 \text{ Btu per lb.}$$

TRSA

**"Getting the Most for your Energy Dollar," *Special Reporter*, Vol 20, no. 2 (March 1992).**

# **INTERNATIONAL FABRICARE INSTITUTE** **SPECIAL REPORTER**

*The Association of Professional Drycleaners and Launderers*

12251 Tech Road, Silver Spring, Maryland 20904

(301) 622-1900

## Getting the Most For Your Energy Dollar

Each pound of drycleaning processed contains an energy cost of \$0.12 or \$0.27 for a two piece suit. The energy expense consisted of fuel, electricity, water, and sewage. One would expect the energy cost of a pound of laundry to be more expensive; however, it is considerably lower than drycleaning. The energy cost for a pound of laundry is \$0.05. The power consuming machinery and component parts in drycleaning raise the energy cost per pound.

According to the IFI cost survey, utility costs are about 5.5 to 6 percent of total sales. Anything which can be done to reduce the energy costs should have high priority.

### Fuel Conservation in the Power Plant

Conservation of fuel should always be a concern of good management from a cost standpoint even when a shortage of fuel does not exist. Proper boiler operation saves many dollars and, possibly, some costly breakdowns.

Your power plant transforms British Thermal Units (BTUs) of fuel into steam for heating water and use in machines that process work. Our purpose here is to talk about getting the most out of the BTU input. Many factors affect the efficiency of your boilers, regardless of the type of fuel you use.

If you burn oil, gas, or coal, how long has it been since the actual mixture of air and fuel has been checked? Insufficient air will cause incomplete combustion and a smoking stack. On the other hand, an excess of air will reduce the BTU transfer.

There is a large variance in the instruments used in different plants to measure the effectiveness of the boiler. Flue gas temperatures as well as constant CO<sub>2</sub>, and CO, and O<sub>2</sub> recorders indicate how well the boiler is transferring the BTU input into processing steam. If these meters are not available, many gas and oil companies will check your stack temperature and use an Orsat meter to determine if you have the proper mixture of air and fuel.

High stack temperatures are good indicators that scale is forming on the tubes, preventing proper heat transfer. Tube burn out and wasted fuel are a result of scale formation.

Correct treatment of the boiler feed water is most important and should be determined by a technician from one of the many companies supplying boiler treat-

ment compounds. Once you determine the needs for your particular boiler feed water, see that these needs are filled so scale will not accumulate in the boiler and tubes.

The amount of blow-down needed for your boiler will also be established in tests the boiler feed water technician can make. When plants use soft water, other factors such as pitting and corrosion will be a factor in boiler treatment compounds.

Check that all insulation originally designed for your boiler is in place and has not deteriorated or been lost. At the same time, check that all the steam headers and steam lines in the power plant are properly insulated, as the heat loss from the larger headers can be very great. Repack all steam valves that show leakage. Any flange joints in the larger headers should be checked for leaks and promptly repaired if any exist.

While the boiler plant is inspected internally and externally once a year by your insurance company, it is wise to check the boiler internally both on the fire side and water side semiannually to ensure against scale buildup, as well as leaks in the refractory and brick surfaces of the fire side of the boiler. Remember, soot on the tubes as well as scale in the drum and the tubes will cut down on heat transfer and boiler efficiency.

Boiler feed pumps should be checked for leaky packing as well as the temperature of the returning condensate. Pumps can only pump liquids and steam bind where the condensate is steam. Plants with steam heated hot water heaters usually run the condensate through a hot water tank before returning it to the condensate tank.

Trapping throughout the plant will have a great effect on the temperature of condensate return. If traps are not working properly, the temperature of the return condensate tank will be excessively high, causing lost steam through the tank vent to the atmosphere, plus the addition of excessive chill water to the condensate tank.

Start up and close down times can be very important in fuel conservation since most systems will have sufficient steam pressure to carry the load if the boiler is shut down 10 to 15 minutes before the plant ceases operation. Starting the power plant as late as possible before steam is needed for processing can also result in fuel savings. Every half hour of later starting or earlier close down will mean savings in fuel used over a period of a week.

Perhaps you need to run only one department on Saturday. Your piping should be arranged so that departments requiring steam can be isolated and you do not have to provide it for the entire plant. Likewise, where steam is required, just to heat the building during cold weather, the boiler should be run at low instead of high pressure to prevent costly "freeze ups" and also conserve the fuel needed for high pressure. Many plants have used a small boiler or space heater for this purpose, and have realized a savings in fuel.

In laundry operation, heat reclaimers can save many fuel dollars since waste water from the washroom contains many BTUs which can raise your incoming cold water temperature, say, 40 degrees. If it is possible to raise your incoming water 40 degrees, this is equal to  $\frac{1}{4}$  of the total heat required to raise 60° F water to 180° F. Since about 65 percent of the fuel burned is for heating water, you save many BTUs on the total heating bill. The initial cost of the heat reclaimer may seem high, but the savings in fuel dollars can make it a very profitable investment. If you have a heat reclaimer, be sure that it is kept clean so that maximum heat transfer from the waste water is obtained.

Hot water storage tanks and heaters should be inspected for scale, sludge, pitting, and corrosion. If you require 160° F hot water, you are wasting fuel when your controls allow this temperature to rise to 180° F. Hot water storage tanks and heaters should be insulated to conserve BTUs of the heated water.

Proper operation of all boiler controls should be inspected, such as boiler feed pump controls and low water cutoff controls. Operating personnel should be blowing down these controls at least twice daily to ensure proper operating water level in the boiler as well as ensure that the low water cutoff is operating properly should low water develop. The blow-down valves should not leak. Since they are exposed to the solids and sludge being blown from the boiler, these valves will often not seat correctly and allow a loss of steam. Safety valves should be seated tightly, not allowing them to sizzle and lose steam. The fire eye, the pressure control, and the low water cutoff are wired in series. Check all three. Failure in any of these operations will cause an immediate shut down of the burner.

Since air compressors are usually considered power plant equipment, all electrical wiring and controls should be inspected. Check water-cooled jackets for scale or other obstructions. Incoming air filters should be kept clean and air storage tanks should be drained daily to prevent the build-up of water in the air lines. Fins on the heads of air-cooled compressors should be kept free of lint and dirt to prevent overheating. It is wise to draw the incoming air for the compress from outside the building.

A preventive maintenance system can be very effective in saving energy and preventing breakdowns. It

ensures that each piece of power plant equipment is being checked for its needed maintenance, and provides a record of parts and maintenance time needed to keep the piece of equipment in proper running condition. This record indicates when replacement is necessary due to large repair bills, and also prevents expensive breakdowns.

The power plant checklist on page 3 should help you find energy losses.

## Insulation

Insulating all hot pipes is the first step in saving fuel and reducing the inside temperature of the plant. This has one of the best payback records of any equipment or supplies. The savings in fuel will pay for the insulation in three to six months. This kind of payback is hard to beat. Make sure that not only pipes but tanks requiring insulation are insulated.

## Steam Leaks

Steam leaks must be repaired as quickly as possible. Many of the leaks are from the packing gland around the stem of a valve. A fraction of a turn will stop the leak. Fittings and valves are often the source of leaks. Keep after the leaks as they will only get worse.

## Trapping

The first step to maximum steam utilization in steam-heated equipment is proper trapping. We recommend the use of individual traps on ironers to prevent short circuiting of some chests on the ironer as a result of the difference in condensing rates from the first to last chest.

To determine if a trap is working properly, check the temperature on both the inlet and outlet sides. Normally, the temperature will be considerably less on the discharge side. If it is not, you may have a blow-through condition which is causing less efficiency in the unit and will raise the temperature of the condensate, causing more flash steam at the receiver tank. This will usually mean that air and carbon dioxide gas are not being eliminated, which will cause corrosion and further reduction in efficiency as a result of the insulating effect of air in the steam. Checking traps for proper operation, particularly if you have not done so for a while, can improve the operating efficiency of the boiler. It will also save you money and fuel.

## Valves to Isolate Equipment

It has always been our recommendation that your finishing or ironing equipment have valves on both the steam lines and condensate returns so that, if necessary, one unit or one press can be turned off for maintenance purposes without having to disable other equipment.

### Checklist for Power Plant Operation

#### Boilers

- ☐ Are you getting the maximum efficiency in your BTU input compared to steam produced?
- ☐ All controls working properly
- ☐ Stack temperature correct—maximum 150 degrees over temperature of steam produced
- ☐ CO<sub>2</sub>, CO, and O<sub>2</sub> analyzed
- ☐ Proper blow down of boilers
- ☐ Damper controls working properly

#### Condensate

- ☐ Pumps working properly—no leaks
- ☐ Traps working properly—not overheating the condensate tank
- ☐ Condensate being returned to the boiler at the correct temperature

#### Piping and Valves

- ☐ Leaky valves repaired and repacked
- ☐ All lines insulated properly
- ☐ All steam leaks in pipe fittings and flange joints repaired

#### Hot Water Tanks

- ☐ All internal surfaces checked for scale and sludge, corrosion, and pitting
- ☐ All external surfaces properly insulated
- ☐ Operating controls functioning properly to maintain desired temperature
- ☐ Many hot water tanks have a separate coil to utilize the heat from the condensate before it goes to the condensate tank. If it does not have a coil, use a heat exchanger for this purpose

#### Boiler Treatment Compound

- ☐ Correct chemicals being used
- ☐ Proper injection system being maintained
- ☐ Daily log of test results
- ☐ Supervision by technician from manufacturer of chemicals being used

#### Heat Exchangers and Heat Reclaimers

- ☐ Check proper temperature rise on outgoing water line
- ☐ Heat reclaimers are kept clean and operating properly

#### Air Compressors

- ☐ Condition of all electrical wiring and controls
- ☐ Check discharge valves
- ☐ Check water-cooled compressor jackets for scale or obstruction
- ☐ Check air storage tank
- ☐ Check air inlet filters—draw air from outside the building

#### Log of Operation

- ☐ Fuel used
- ☐ Electricity used
- ☐ Steam produced
- ☐ Water used

#### Preventive Maintenance System for Power Plant

- ☐ Accurate, systematic checking of all power plant equipment
- ☐ Records of cost, parts, and labor for each piece of equipment

Even when this procedure is followed, we have seen instances where any number of presses are standing idle with full steam pressure applied.

When you have units which are not going to be used during the day, these valves should be turned off. This will save fuel and, especially in warm climates or in summer, will reduce the heat which requires additional ventilation or cooling to keep employees as comfortable as possible. Better planning can be the key to increased efficiency in fuel utilization. In multi-ironer plants the standard procedure is to heat up all the units even though one may not be used for several hours or perhaps not at all unless there is a breakdown. Usually an ironer can be warmed up in no more than an hour, yet many are heated from nine to ten hours per day and used only an hour or so or perhaps not at all. Turn those valves off and save money and fuel.

### Timers and Controls

Most newer types of finishing equipment have automatic controls or timers to govern the time the press is closed, or the time steam or air is applied. In many plants, these controls or timers have not been checked for the proper setting; they should be.

Where excessive time is used in these functions, your loss is a double-headed monster. If the air cycle is too long, your electricity bill goes up and you waste energy. The same goes for steaming cycles and press closed time—excessive steam is consumed. And in both cases, the operator efficiency is lowered as a result of the total elapsed time between cycles and/or pieces.

### Hot-head Presses

For maximum efficiency and utilization, presses should be kept clean. There is usually starch in items which are pressed in laundry departments and a certain amount of starch will adhere to the press polished surface and turn brown from the heat. This coating has an insulating effect and should be cleaned off with a non-abrasive cleaner and bronze wool. Steel wool should NOT be used as it will remove some of the polished finish.

### Tumblers

Many tumbler installations are not piped adequately because of a misunderstanding of the steam requirements for these rather simple machines. The average 32 to 50 pound rated tumbler will consume about four boiler horsepower per hour. Four tumblers will require more steam than a conventional six-roll ironer. These are relatively heavy steam users.

As long as the tumbler runs, it is pulling power from the boiler. The fan pulls air through the steam coil and

exhausts the air up the stack. Once the load is dry, this is a waste of time and money. It will also, on occasion, raise the temperature of the load to a point where some items will be ignited and you have not only wasted money and steam, but you have a claim for customer goods or you have burned up part of your inventory.

On tumblers that do not come equipped with timers, it is fairly easy to put kitchen timers on the units. In some cases, these can be wired into the electrical circuit, or they may only serve to sound a bell or a buzzer to remind the operator to remove the load. These should also be fixed so that they can be set for only an average drying time.

Tumblers which have lint traps in a drawer at the base of the unit should be cleaned out several times a day to keep a free flow of air and keep efficiency high. Clogged lint traps drop efficiency and raise operation costs. The steam coil should also be kept free of lint to prevent reduction of air flow through the fins of the coil. Keeping equipment running at peak efficiency is the key to maximum utilization of power.

Gas-fired tumblers should be tested to ascertain that proper pressure in the incoming gas supply is maintained. This is normally recorded as a certain amount in inches of water and should be regulated to the specification established by the manufacturer. Additionally, the fuel-air mixture should be checked for proper combustion. Normally the local gas company representative will check these for you.

If your gas tumbler does not have a sensing control for degree of moisture in either conditioning or drying loads, check to make sure the timers are being set for proper times. If your workload now consists of higher quantities of blends rather than cotton, you can probably reduce the timer settings. Also, check the time on fully dried loads as many plants over dry and this wastes fuel and reduces the total capacity of the tumbler.

### Flatwork Ironers

Besides the things mentioned elsewhere in this *Reporter* about ironers and trapping and turning off steam when it is not in use, there are several other checkpoints for conservation.

When the ironer will not be used for short periods of time (lunch hour), the pressure should be taken off and the machine should be stopped. This will give added life to aprons and padding, as well as save electricity. If the ironer is also equipped with a canopy, the exhaust motor can be turned off to prevent air being pulled from the chest area and exhausted to the outside atmosphere. This will save steam and electricity and maintain the temperature so the unit will be ready to pick up full production at the end of the lunch hour.

You should also examine the type and quantity of

### 15 Super Savers—Steam Usage Checklist

- ☐ Make sure pipes and hot water storage tanks are insulated.
- ☐ Check for steam leaks throughout the plant. Repack valves that are leaking.
- ☐ Check all traps for proper operation—replace or repair inoperative ones or those that are blowing through.
- ☐ Check equipment which is not being used to make sure such equipment is turned off. If individual valves have not been installed to accomplish this, put valves in as needed. Make sure that valves which are turned off are seated properly and not leaking steam into unused equipment.
- ☐ Check timers and controls for correct operation. Do not oversteam, overblow, or overdry in tumblers or presses.
- ☐ Check condition of press surface areas—keep clean and bright for better heat transfer.
- ☐ Check tumblers for adequate piping and ducting.
- ☐ Check timers and/or timing of drying and conditioning loads.
- ☐ Check lint traps for free air flows.
- ☐ Check steam coils for lint buildup—clean them as required.
- ☐ Check pressure of gas and combustion on gas-fired tumblers.
- ☐ Check ironers for pressure removal during periods of inactivity and make sure motors are turned off.
- ☐ Turn off vents in canopy when ironer is not in use.
- ☐ Check workload on ironer to be sure proper speeds are used.
- ☐ Check padding, covers, aprons, and mechanical condition for maximum production.

work being processed. If the workload has changed in nature, you may not have adjusted the speed to produce the maximum amount of work in the least possible time. The speed should be such that items will dry in one pass. If you have a quantity of items which have to be fed into the ironer twice to dry, you can save by reducing the speed. The second time through will usually be inefficient both in terms of handling and in fuel utilization since the item will be almost dry after the first pass and the second expends as much time and heat all over again. It is wasteful.

If your workload has a high percentage of blends and you are still using the conditioning tumbler, you should check to see if you can eliminate the conditioning and still maintain the same productivity.

Naturally, proper maintenance of the ironer's mechanical condition, padding, covers, and aprons will contribute to the overall efficiency and prevent waste of energy.

### Conservation of Electricity

Purchase power in many plants will be in excess of 25 percent of the amount spent for oil or gas. It is another important energy source to try to save as much as possible. A number of checkpoints follow.

Fluorescent lamps give much greater illumination per watt than incandescent bulbs and have a life expectancy of more than ten times the incandescent bulb. A 40-watt fluorescent tube produces more light than a 100-watt incandescent bulb for less than half the energy cost.

Heavy duty motors expend the most power when starting. Plants using centrifugal extractors should be

sure loads are carefully balanced before starting the extractor. This avoids having to stop and restart these large motors.

Multiple extractor starting times should be staggered so that the heavy draw on current it takes to start them all will not be on the line all at once. This will help to keep the demand rate at a lower level and save money on the power bill. This same idea will be beneficial for plants with multiple washer-extractors. Staggering the starting times will reduce the number of occasions when two or more will be going into extract at the same time.

Turn off all equipment as soon as possible after it is no longer needed. Plant shutdown at the end of the day should be made the responsibility of one individual or a number of people with definite procedures to make sure that everything no longer being used is turned off. Post signs, at doors to storage areas or other areas used only occasionally to remind people to turn out lights when leaving the area. Make a checklist of outdoor lights, signs, night lights, etc., to make sure these are not burning during daylight hours. Automatic dusk to dawn switches can be put on some of these circuits.

Clean or replace filters in equipment and ventilating systems. This will keep air flowing freely, thus the motors will use less current.

Eliminate excessive voltage drops. If expansions in the operation have included new equipment and existing lines have been extended for additional service, excessive line drops will cause motors and equipment to draw more current and run at higher ambient temperatures, causing inefficient operation.

Check machine loading procedures to ascertain that full loads are processed each time you operate your powered machinery. There is virtually no difference in power consumed with partial loads, but in order to handle the same total tonnage, partial loads will require more running time, use more energy, and cost more money.

Consider earlier starting times during summer months to take advantage of long cool mornings to reduce the need for ventilating and cool systems.

Check fill times in washroom operation. Frequently, a small reciprocating pump can boost water pressure to reduce total running time on automatic wash wheels or washer-extractors. Normally, the timer does not start until the wash level is reached, or rinse level, as the case may be. The pump will speed the fill time, shorten processing time, burn less energy, cost less money, and improve plant efficiency.

Check the length of time extractors are running. If you are handling large quantities of blends, you may be able to reduce the extract time and still get good extraction.

Check maintenance procedures to make sure equipment is in top operating condition. Equipment which does not get proper lubrication can put added drag on motors and require more energy.

## Water and Sewage Conservation

Conservation of water and supplies in a laundry washroom can bring multiple savings. Dollar savings can be applied against increased costs for other supplies. And careful use of water can affect savings in the energy needed to heat it.

Water rates have doubled and in some areas even tripled over recent years. Sewer service charges have skyrocketed. Our industry in some areas faces surcharges on water disposal. Just because water always seems to be there, we should not feel free to waste it. We must learn to practice water conservation methods, due to a constantly increasing demand for water and the problems of sewage treatment, sewer and water costs will climb in the months and years ahead.

One of the best ways to undertake these savings and to conserve water is to make a complete water survey of your plant. Your own plant engineers may be competent to conduct such a survey, or an outside consultant can do it for a fee. It will point out areas of savings and tell you the actual dollars and the gallons you can save.

Here are some things to consider in water conservation; many of the points covered here may suggest steps you should take.

Automatic controls on water flow can reduce human error. Floats or pressure controls in tanks or thermostatic valves in cooling circuits can signal water demand to start or stop the water flow when the machines are in use.

Investigate the reuse of water. Water now discharged from compressor jackets and condensers used in drycleaning is reusable. When it is fed back to a cooling tower in an evaporative condenser, you can reuse the water.

Another water conserving program involves separating rinse water from sudsing water and reusing the rinse water for subsequent suds operations. The means for separating these wastes as they are dumped from the washers depend on the physical set-up of the washroom. Some ingenuity may be needed to work out a system for each plant. The ideal arrangement would be double gutters under the washers. A tilt board or chute connected to the control chart would direct the suds waste to the sewer gutter and the rinse water to the other gutter which leads to a rinse water holding tank. The rinse water could then be pumped as needed through a filter and then through added piping to any washer calling for water for sudsing.

This water would be soft, alkaline, and warm but would have to be heated by a coil in the tank or by steam injection in the piping or in the washer. A machinery manufacturer can apply a tilt chute and attach it to the controls to work in such a situation.

If two gutters are not available, some plants might prepare a small sump in back of the washer where a chute could dump one rinse. This would have to be pumped to a holding tank right away. Smaller washers with dump valves on a pipe could be fitted with a "Y" in the pipe and dump valve on each branch. One valve could open to discharge the suds waste to the sewer, the other could allow the rinses to flow to a holding tank.

Reusing rinse water for sudsing may save 40 percent of your water. This would mean nearly 40 percent savings on water costs, sewer rental, softening costs, and some heat.

Check for leaking dump valves. Improperly seating valves may allow water to leak out of the washer during washing or rinsing. If enough leaks out to affect the water level gauge, a valve may open admitting more water. This is wasted water. It dilutes the supplies and may require their replenishment. Moreover, it can cause poor washing or redeposition. The same problem results if water level gauges are incorrect and excess water is used in washing or rinsing. Rinse height of 12 inches instead of 10 inches in a 42 x 84 washer (or 300 pound washer-extractor) is equal to 16 gallons in each of four rinses of one wash cycle. This is equivalent to 64 gallons of water per load in a 300 pound machine. Six loads per day means 384 gallons per day, per machine—enough water per year to wash almost 30,000 pounds of work!

Check your meter readings over a period of time, or check the volume charge on your water bill. In a recent

survey of water usage, we found that most laundries were using between 2.5 and 3.5 gallons per pound of work processed. This figure is found by dividing the total gallons used per period (week, month, or year) by the weight of fabrics processed in the same period.

Some plants reported very unusual figures. Some indicated less than ½ gallon used per pounds of load. Other had usage figures of 10, 15, or 20 gallons.

**Continuous batch washers** or tunnel washers will save large amounts of water. They will use approximately 1½ gallons per pound of linen. Such washers are found in many hospitals doing large quantities of linen.

**Weigh loads** being prepared for the washroom—to ensure that the washers are neither underloaded nor overloaded. Accurate loading will utilize machine, manpower, and supplies at an efficient rate. If you underload washers you still use approximately the same amount of water in the wash formula. If you overload, you may find you have to do reruns on the work being processed.

From 50 to 60 percent of the boiler horsepower required in a plant is generally used to heat hot water. Review your formulas. Can they be altered to cut water consumption? Or can you use less hot water?

**Review formulas** to determine if extraction time can be reduced. The high volume of polyester in sheeting material should reduce extraction time approximately two-thirds from what it was previously run on all cotton.

## Extraction

Consider collecting water from centrifugal or squeeze-type extractors. You may economically recover 15 to 25 gallons of water here for every 100 pounds of laundry processed. Saturated moisture in a load is 0.2 to 0.3 gallon per pound, or 30 gallons per 100 pounds. A plant processing 30,000 pounds a week, then would gain 9,000 gallons of water a week.

**Check water levels** to be sure that you are getting what the formula calls for in the way of inches of water in the suds or rinse operation. By controlling this accurately, you may well save 8 to 10 gallons per inch in the amount of water used in each step of the wash formula.

**Check the condition** of the washing equipment. This may help to save water and supplies. Make sure

that all water connections are tight. Replace washers in leaky faucets. A faucet leaking at the rate of 200 drops per minute (this is a fast drip but not a steady stream) wastes the equivalent of 5,145.5 gallons in a year. This is not much money in terms of dollars, but this is enough water to wash about 1,500 pounds of fabric. Further, how many faucets, valves, and pipe joints are leaking this fast or faster?

**Post the formula** for each type of classification being run in that machine. Get a specific size cup or scoop to hold the quantity of supplies needed for each step in the formula. For example, if you need eight ounces of sour in a formula, get a container or scoop at a local hardware store that will measure out exactly that amount. Check all wash formulas, and be sure the proper portion of each supply is being used. If excessive amounts of supplies are used, you'll have to do additional rinsing. Do not use more suds or rinses than are necessary to provide a good wash.

**Check water hardness**, if your water source gives you water that is over 2.5 grains per gallon, a water softener should be used.

**Check and maintain** the incoming hot water range. In most plants, maintaining a range of 150° F to 160° F is acceptable. In a plant that may use a large amount of hotter water you can review whether this incoming water temperature should be increased. Generally, any special need for higher water temperatures can be met through the use of steam injection for the isolated case or the limited classification requiring the high temperature.

**Classify your loads** so as to minimize washing time and still get good washing. Except in the cases of extreme emergency for work flow pattern, never mix heavily soiled work with lighter soiled classifications in the same machine.

Keep a sufficiently high water pressure feeding the supply injectors of your washers. This could vary depending on the moment of demand. Some plants have installed a water injection tank to ensure pressure to flush in supplies.

Use the checklist on page 8 for checking your water and sewage conservation. The second chart on page 8 lists commonly overlooked energy savings.

### Water and Sewage Conservation Checklist

- ☐ Reuse of water
  - a) Cooling water to sewer (air conditioning, compressors)
  - b) Rinse water
  - c) Water from centrifugal and squeeze type extractors
- ☐ Leaks
  - a) Faucets
  - b) Valves
  - c) Connections
  - d) Dump valves
  - e) Steam leaks
- ☐ Modify existing washroom formulas
  - a) Reduce extraction time if possible
  - b) Use less hot water
  - c) Use proper formula for type and degree of soil
- ☐ Utilize washroom equipment at rated capacity
- ☐ Maintain water pressure to equipment
- ☐ Maintain proper levels in washers

### Energy Savings Overlooked in Many Plants

- ☐ Insulate all hot pipes and tanks
- ☐ Test steam traps for "blow through"
- ☐ Keep boiler burner in tune
- ☐ At night, set back temperatures where heat is kept in plant
- ☐ Check boiler for "coast down" and "start up time"
- ☐ Relocate air compressor intake to outside
- ☐ Install valves to isolate sections of the plant when not working
- ☐ Repair steam and condensate leaks
- ☐ Repair water leaks
- ☐ Repair air leaks

This bulletin was written by Ken Faig, Division Director—Education.

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## **Appendix E: Model Laundry Operations**

| EQUIPMENT 1/2 MILLION #/YR PLANT              | POWER<br>(Kw) | GAS<br>(MMBtuh) | WATER<br>(gal/hr) | STEAM*<br>(MMBtuh) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |
|-----------------------------------------------|---------------|-----------------|-------------------|--------------------|---------------|--------------|---------------|
| Manual Sorting Table                          |               |                 |                   |                    | 3500          | 300          | 186           |
| Laundry Cart 30" x 42" x 28"                  |               |                 |                   |                    | 4500          |              | 239           |
| 125 Lb. Washer Extractor                      | 11            |                 | 812               | 0.037              | 40000         | 3000         | 2120          |
| 85 Lb. Washer Extractor                       | 4.7           |                 | 288               | 0.013              | 10500         | 750          | 557           |
| Peristaltic Pump Supply System                | 0.3           |                 | 15                |                    | 5000          | 450          | 265           |
| 110 Lb. Gas Fired Dryer                       | 5             | 0.128           |                   |                    | 4200          | 400          | 223           |
| 150 Lb. Gas Fired Dryer                       | 2.5           | 0.045           |                   |                    | 15100         | 1000         | 800           |
| Single Roll 24" Ironer                        | 3             |                 |                   | 0.2                | 30800         | 2200         | 1632          |
| Double Lane Primary / Cross Folder            | 2             |                 |                   |                    | 28000         | 1600         | 1484          |
| Small Piece Folding Tables 30" x 72"          |               |                 |                   |                    | 1000          |              | 53            |
| Steam Air Tunnel Garment Finisher (250 / Hr.) | 7.2           |                 |                   | 0.132              | 30000         | 2600         | 1590          |
| 15 Hp. Dual Fired Steam Boiler                | 1             | 0.48            |                   |                    | 9400          | 800          | 498           |
| Deaerator Return System                       | 5             |                 | 5                 |                    | 2200          | 150          | 117           |
| Water Softener                                | 0.7           |                 |                   |                    | 6000          | 600          | 318           |
| Gas Fired Hot Water Heater                    | 0.5           | 1.2             |                   |                    | 11300         | 1000         | 599           |
| 10 Hp. Air Compressor                         | 11.1          |                 |                   |                    | 3800          | 350          | 201           |

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## DIRECT LABOR REQUIREMENT (FTE'S)

|                 |     |
|-----------------|-----|
| Sort            | 0.5 |
| Wash Room       | 0.5 |
| Dryers          | 0.5 |
| Folders/Ironers | 1.5 |
| S.P. Folders    | 1   |
| Garments        | 0.5 |
| Utility         | 0.5 |
| TOTAL           | 5   |

280#/Hr x 1820 Hrs / Yr = 509,600 #/Yr

# / Worked Hour

509,600 / (5 x 1820) = 56

\*Steam is generated by Boiler  
which is in Gas utility requirement

## EQUIPMENT 1/2 MILLION #/YR PLANT

| EQUIPMENT 1/2 MILLION #/YR PLANT              |  | Hour |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |  |  |
|-----------------------------------------------|--|------|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|--|--|
|                                               |  | 5    | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |  |
| Manual Sorting Table                          |  | X    |   | X | X | X |    | X  |    |    |    |    |    |    |    |    |    |  |  |
| Laundry Cart 30" x 42" x 28"                  |  |      |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |  |  |
| 125 Lb. Washer Extractor                      |  |      |   | X |   | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |  |  |
| 85 Lb. Washer Extractor                       |  |      |   | X |   | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |  |  |
| Peristaltic Pump Supply System                |  |      |   | X |   | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |  |  |
| 110 Lb. Gas Fired Dryer                       |  |      |   |   |   | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |  |
| 150 Lb. Gas Fired Dryer                       |  |      |   |   |   | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |  |
| Single Roll 24" Ironer                        |  |      |   |   |   |   | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Double Lane Primary / Cross Folder            |  |      |   |   |   |   | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Small Piece Folding Tables 30" x 72"          |  |      |   |   |   |   | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Steam Air Tunnel Garment Finisher (250 / Hr.) |  |      |   |   |   |   |    | X  | X  | X  | X  | X  |    |    |    |    |    |  |  |
| 15 Hp. Dual Fired Steam Boiler                |  |      |   | X |   | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Deaerator Return System                       |  |      |   | X |   | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Water Softener                                |  |      |   | X |   | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| Gas Fired Hot Water Heater                    |  |      |   | X |   | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |
| 10 Hp. Air Compressor                         |  |      |   | X |   | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |  |  |

| EQUIPMENT: 1/2 MILLION #/YR PLANT(SOA2)       |               |                 |                   |                    |               |              |               |  |  |
|-----------------------------------------------|---------------|-----------------|-------------------|--------------------|---------------|--------------|---------------|--|--|
|                                               | POWER<br>(Kw) | GAS<br>(MMBtuh) | WATER<br>(gal/hr) | STEAM*<br>(MMBtuh) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |  |  |
| Manual Sorting Table                          |               |                 |                   |                    | 3500          | 300          | 186           |  |  |
| Laundry Cart 30" x 42" x 28"                  |               |                 |                   |                    | 4500          |              | 239           |  |  |
| 125 Lb. Washer Extractor                      | 11            |                 | 770               | 0.037              | 40000         | 3000         | 2120          |  |  |
| 85 Lb. Washer Extractor                       | 4.7           |                 | 274               | 0.013              | 10500         | 750          | 557           |  |  |
| Peristaltic Pump Supply System                | 0.3           |                 | 15                |                    | 5000          | 450          | 265           |  |  |
| 110 Lb. Gas Fired Dryer w/Heat Reclamation    | 5             | 0.11            |                   |                    | 4200          | 400          | 223           |  |  |
| 150 Lb. Gas Fired Dryer w/Heat Reclamation    | 2.5           | 0.038           |                   |                    | 15100         | 1000         | 800           |  |  |
| Single Roll 24" Ironer                        | 3             |                 |                   | 0.2                | 30800         | 2200         | 1632          |  |  |
| Double Lane Primary / Cross Folder            | 2             |                 |                   |                    | 28000         | 1600         | 1484          |  |  |
| Small Piece Folding Tables 30" x 72"          |               |                 |                   |                    | 1000          |              | 53            |  |  |
| Steam Air Tunnel Garment Finisher (250 / Hr.) | 7.2           |                 |                   | 0.132              | 30000         | 2600         | 1590          |  |  |
| 15 Hp. Dual Fired Steam Boiler                | 1             | 0.43            |                   |                    | 9400          | 800          | 498           |  |  |
| Deaerator Return System                       | 5             |                 | 5                 |                    | 2200          | 150          | 117           |  |  |
| Water Softener                                | 0.7           |                 |                   |                    | 6000          | 600          | 318           |  |  |
| Gas Fired Hot Water Heater                    | 0.5           | 6.8             |                   |                    | 11300         | 1000         | 599           |  |  |
| 10 Hp. Air Compressor                         | 11.1          |                 |                   |                    | 3800          | 350          | 201           |  |  |
| Waste Water Heat Reclamation System           | 3             |                 |                   |                    | 27500         | 1950         | 1458          |  |  |
| Ozone Generation Equipment                    | 3             |                 |                   |                    |               |              | 0             |  |  |

232800 17150 12338

## DIRECT LABOR REQUIREMENT (FTE'S)

280#/Hr x 1820 Hrs / Yr = 509,600 #/Yr

0.5

Sort

Wash Room

Dryers

Folders/Ironers

S.P. Folders

Garments

Utility

TOTAL

# / Worked Hour

509,600 / (5 x 1820) = 56

\*Steam is generated by Boiler  
which is in Gas utility requirement

0.5

0.5

0.5

1.5

1

0.5

0.5

5

## EQUIPMENT 1/2 MILLION #/YR PLANT(SOA2)

|                                               | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-----------------------------------------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| Hour                                          |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| Manual Sorting Table                          |   | X | X | X | X |    |    |    |    |    |    |    |    |    |    |    |
| Laundry Cart 30" x 42" x 28"                  |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 125 Lb. Washer Extractor                      |   |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 85 Lb. Washer Extractor                       |   |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| Peristaltic Pump Supply System                |   |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 110 Lb. Gas Fired Dryer w/Heat Reclamation    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 150 Lb. Gas Fired Dryer w/Heat Reclamation    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Single Roll 24" Ironer                        |   |   |   |   | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Double Lane Primary / Cross Folder            |   |   |   |   | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Small Piece Folding Tables 30" x 72"          |   |   |   |   | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Steam Air Tunnel Garment Finisher (250 / Hr.) |   |   |   |   | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 15 Hp. Dual Fired Steam Boiler                |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Deaerator Return System                       |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Water Softener                                |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Gas Fired Hot Water Heater                    |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 10 Hp. Air Compressor                         |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Waste Water Heat Reclamation System           |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Ozone Generation Equipment                    |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |

| EQUIPMENT 2 MILLION # CONVENTIONAL       | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM<br>(MMBtu/h) | Hour |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
|------------------------------------------|---------------|------------------|-------------------|--------------------|------|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
|                                          |               |                  |                   |                    | 5    | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Sorting Conveyor                         | 3.2           |                  |                   |                    | X    | X | X | X | X | X  | X  |    |    |    |    |    |    |    |    |    |
| Soil Storage Rail                        |               |                  |                   |                    | X    | X | X | X | X | X  | X  |    |    |    |    |    |    |    |    |    |
| 400 Lb S/L Washer Extractors             | 40.65         |                  | 4927              | 0.18               |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 200 Lb S/L Washer Extractors             | 8.9           |                  | 775               | 0.026              |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 100 Lb O/P Washer Extractor              | 4.4           |                  | 410               | 0.014              |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| Peristaltic Pump Supply System           | 0.5           |                  | 25                |                    |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
| 200 Lb Dryer                             | 7.6           | 0.34             |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 100 Lb Dryer                             | 2.6           | 0.1              |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Four Station Large Piece Spreader/Feeder | 3             |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Eight Roll Super Sylon Ironer            | 13.1          |                  |                   | 0.93               |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Two Lane Primary/Cross Folder            | 2.9           |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Flow Rack                                | 0.25          |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Small Piece Folder (French Fold)         | 1.4           |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Small Piece Folder (Quarter Fold)        | 1.4           |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 70 HP Dual Fired Steam Boilers           | 3.9           | 2.1              | 24                |                    | X    | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Deaerator Return System                  | 3.3           |                  |                   |                    | X    | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Water Softener                           | 0.16          |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 15 HP Rotary Air Compressors             | 11.1          |                  |                   |                    | X    | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Direct Contact Water Heater              | 6.1           | 6.4              |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Compressed Air Dryer                     | 1.2           |                  |                   |                    | X    | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Double Buck Shirt Body Press             | 12.1          |                  |                   | 0.17               |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Cabinet Shirt Sleeve Press               | 7.97          |                  |                   | 0.12               |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Collar Cuff Press                        | 0.07          |                  |                   | 0.11               |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Utility Laundry Press                    | 0.11          |                  |                   | 0.13               |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Clean Take Away Conveyor                 | 3             |                  |                   |                    |      |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |

| EQUIPMENT 2 MILLION #/YR H.E. PLANT      | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM*<br>(MMBtu/h) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |
|------------------------------------------|---------------|------------------|-------------------|---------------------|---------------|--------------|---------------|
| 9 Chamber 50 lb mini CBW                 | 7.3           |                  | 956               | 0.47                | 157000        | 12000        | 8321          |
| Single Stage System Press                | 10.8          |                  |                   |                     | 70000         | 5000         | 3710          |
| CBW System Shuttle Conveyor              | 5             |                  |                   |                     | 26000         | 2200         | 1378          |
| CBW System 100 lb Dryers                 | 12            | 0.28             |                   |                     | 100000        | 7500         | 5300          |
| 200 lb Dryer                             | 0.3           | 0.23             |                   |                     | 24200         | 1500         | 1283          |
| 150 lb Gas Fired Dryer                   | 2             | 0.14             |                   |                     | 8300          | 600          | 440           |
| 75 lb Gas Fired Dryer                    | 0.8           | 0.07             |                   |                     | 2500          | 400          | 133           |
| 125 lb Solid Mount Washer Extractor      | 7.5           |                  | 372               | 0.033               | 16500         | 1600         | 875           |
| 50 lb Washer Extractor                   | 3.7           |                  | 150               | 0.013               | 7200          | 750          | 382           |
| 200 lb Washer Extractor                  | 6.7           |                  | 595               | 0.054               | 39500         | 1100         | 2094          |
| Two Roll 32" Steam Heated Ironer         | 10.3          |                  |                   | 0.82                | 90000         | 6500         | 4770          |
| Two Lane Combination Crossfolder/Stacker | 1.4           |                  |                   |                     | 28300         | 1200         | 1500          |
| Small Piece Folding Table w/ Dumper      | 0.4           |                  |                   |                     | 7000          | 500          | 371           |
| Four Station Spreader Feeder             | 2.1           |                  |                   |                     | 40100         | 1500         | 2125          |
| Clean Work Take Away Conveyor            | 1             |                  |                   |                     | 8000          | 1100         | 424           |
| 10 HP Air Compressor w/ Tank             | 11.1          |                  |                   |                     | 4700          | 800          | 249           |
| Compressed Air Dryer                     | 1             |                  |                   |                     | 1400          | 200          | 74            |
| Water Softener w/ Brine Tank             | 0.8           |                  |                   |                     | 8000          | 1000         | 424           |
| Gas Fired Water Heater                   | 2.1           | 1.05             |                   |                     | 11300         | 1000         | 599           |
| 70 HP Gas/Oil Fired Steam Boilers        | 2             | 1.78             |                   |                     | 43000         | 4000         | 2279          |
| Boiler Return System                     | 11.2          |                  | 75                |                     | 16000         | 1200         | 848           |
| Five Pocket Loading Conveyor             | 2.1           |                  |                   |                     | 12500         | 750          | 683           |
| Cart Dumper                              |               |                  |                   |                     | 2800          | 200          | 148           |
| Domestic Washer                          | 0.9           |                  | 50                |                     | 600           | 60           | 32            |
| Domestic Dryer                           | 0.7           | 0.003            |                   |                     | 400           | 50           | 21            |
| Garment Steam Finisher                   | 1.6           |                  |                   | 0.28                | 12000         | 1000         | 636           |
| Combination Small Piece Gown Folder      | 1.4           |                  |                   |                     | 17000         | 800          | 901           |

## DIRECT LABOR REQUIREMENTS (FTE'S)

|                          |    |                                |        |       |       |
|--------------------------|----|--------------------------------|--------|-------|-------|
| Soil and Wash Room       | 4  | 1.8 Million #/Yr               | 754300 | 54510 | 39978 |
| Flatwork and Folding     | 4  | 7 Worked Hours/day             |        |       |       |
| Cart Makeup and Delivery | 2  | #/operator Hr                  |        |       |       |
| Utility Person           | 1  | 1,800,000 / (11 x 1820) = 89.9 |        |       |       |
|                          | 11 |                                |        |       |       |

\*Steam generation requirement included in gas

## EQUIPMENT 2 MILLION #YR H.E. PLANT

|                                          | Hour |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |  |
|------------------------------------------|------|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|--|
|                                          | 5    | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
| 9 Chamber 50 lb. mini CBW                |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| Single Stage System Press                |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| CBW System Shuttle Conveyor              |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| CBW System 100 lb Dryers                 |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| 200 lb Dryer                             |      |   |   |   | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| 150 lb Gas Fired Dryer                   |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |  |
| 75 lb Gas Fired Dryer                    |      |   | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |  |
| 125 lb Solid Mount Washer Extractor      |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| 50 lb Washer Extractor                   |      | X | X | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| 200 lb Washer Extractor                  |      |   |   | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| Two Roll 32" Steam Heated Ironer         |      |   |   | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |  |
| Two Lane Combination Crossfolder/Stacker |      |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |  |
| Small Piece Folding Table w/ Dumper      |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Four Station Spreader Feeder             |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Clean Work Take Away Conveyor            |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| 10 HP Air Compressor w/ Tank             |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Compressed Air Dryer                     |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Water Softener w/ Brine Tank             |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Gas Fired Water Heater                   |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| 70 HP Gas/Oil Fired Steam Boilers        |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Boiler Return System                     |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Five Pocket Loading Conveyor             |      | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Cart Dumper                              |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Domestic Washer                          |      |   |   | X | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| Domestic Dryer                           |      |   |   |   | X | X  | X  | X  |    |    |    |    |    |    |    |    |  |
| Garment Steam Finisher                   |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |
| Combination Small Piece Gown Folder      |      |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |  |

| EQUIPMENT 2 MILLION #/YR H.E. PLANT(SOA2)  | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM*<br>(MMBtu/h) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |
|--------------------------------------------|---------------|------------------|-------------------|---------------------|---------------|--------------|---------------|
| 9 Chamber 50 lb mini CBW                   | 7.3           |                  | 956               | 0.47                | 157000        | 12000        | 8321          |
| Single Stage System Press                  | 10.8          |                  |                   |                     | 70000         | 5000         | 3710          |
| CBW System Shuttle Conveyor                | 5             |                  |                   |                     | 26000         | 2200         | 1378          |
| CBW System 100 lb Dryers W/Energy Recovery | 12            | 0.24             |                   |                     | 100000        | 7500         | 5300          |
| 200 lb Dryer W/Energy Recovery             | 0.3           | 0.2              |                   |                     | 24200         | 1500         | 1283          |
| 150 lb Gas Fired Dryer W/Energy Recovery   | 2             | 0.12             |                   |                     | 8300          | 600          | 440           |
| 75 lb Gas Fired Dryer W/Energy Recovery    | 0.8           | 0.06             |                   |                     | 2500          | 400          | 133           |
| 125 lb Solid Mount Washer Extractor        | 7.5           |                  | 372               | 0.033               | 16500         | 1600         | 875           |
| 50 lb Washer Extractor                     | 3.7           |                  | 150               | 0.013               | 7200          | 750          | 382           |
| 200 lb Washer Extractor                    | 6.7           |                  | 595               | 0.054               | 39500         | 1100         | 2094          |
| Two Roll 32" Steam Heated Ironer           | 10.3          |                  |                   | 0.82                | 90000         | 6500         | 4770          |
| Two Lane Combination Crossfolder/Stacker   | 1.4           |                  |                   |                     | 28300         | 1200         | 1500          |
| Small Piece Folding Table w/ Dumper        | 0.4           |                  |                   |                     | 7000          | 500          | 371           |
| Four Station Spreader Feeder               | 2.1           |                  |                   |                     | 40100         | 1500         | 2125          |
| Clean Work Take Away Conveyor              | 1             |                  |                   |                     | 8000          | 1100         | 424           |
| 10 HP Air Compressor w/ Tank               | 11.1          |                  |                   |                     | 4700          | 800          | 249           |
| Compressed Air Dryer                       | 1             |                  |                   |                     | 1400          | 200          | 74            |
| Water Softener w/ Brine Tank               | 0.8           |                  |                   |                     | 8000          | 1000         | 424           |
| Gas Fired Water Heater                     | 2.1           | 0.35             |                   |                     | 11300         | 1000         | 599           |
| 70 HP Gas/Oil Fired Steam Boilers          | 2             | 1.79             |                   |                     | 43000         | 4000         | 2279          |
| Boiler Return System                       | 11.2          |                  | 75                |                     | 16000         | 1200         | 848           |
| Five Pocket Loading Conveyor               | 2.1           |                  |                   |                     | 12500         | 750          | 663           |
| Cart Dumper                                |               |                  |                   |                     | 2800          | 200          | 148           |
| Domestic Washer                            | 0.9           |                  | 50                |                     | 600           | 60           | 32            |
| Domestic Dryer                             | 0.7           | 0.003            |                   |                     | 400           | 50           | 21            |
| Garment Steam Finisher                     | 1.6           |                  |                   | 0.28                | 12000         | 1000         | 636           |
| Combination Small Piece Gown Folder        | 1.4           |                  |                   |                     | 17000         | 800          | 901           |
| Waste Water Heat Reclamation System        | 10            |                  |                   |                     | 36500         | 2500         | 1935          |
| Ozone Generation System                    | 12            |                  |                   |                     |               |              | 0             |

## DIRECT LABOR REQUIREMENTS (FTE'S)

|                          |    |                                |        |       |       |
|--------------------------|----|--------------------------------|--------|-------|-------|
| Soil and Wash Room       | 4  | 1.8 Million #/Yr               | 790800 | 57010 | 41912 |
| Flatwork and Folding     | 4  | 7 Worked Hours/day             |        |       |       |
| Cart Makeup and Delivery | 2  |                                |        |       |       |
| Utility Person           | 1  | #/operator Hr                  |        |       |       |
|                          | 11 | 1,800,000 / (11 x 1820) = 89.9 |        |       |       |

\*Steam generation requirement included in gas

## EQUIPMENT 2 MILLION #YR H.E. PLANT(SOA2)

| EQUIPMENT 2 MILLION #/YR H.E. PLANT(SOA2)  |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    | Hour |  |  |  |  |  |  |  |  |  |  |  |
|--------------------------------------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|------|--|--|--|--|--|--|--|--|--|--|--|
|                                            | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |      |  |  |  |  |  |  |  |  |  |  |  |
| 9 Chamber 50 lb mini CBW                   |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Single Stage System Press                  |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| CBW System Shuttle Conveyor                |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| CBW System 100 lb Dryers W/Energy Recovery |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 200 lb Dryer W/Energy Recovery             |   |   |   |   | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 150 lb Gas Fired Dryer W/Energy Recovery   |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 75 lb Gas Fired Dryer W/Energy Recovery    |   |   | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 125 lb Solid Mount Washer Extractor        |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 50 lb Washer Extractor                     |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 200 lb Washer Extractor                    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Two Roll 32" Steam Heated Ironer           |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Two Lane Combination Crossfolder/Stacker   |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Small Piece Folding Table w/ Dumper        |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Four Station Spreader Feeder               |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Clean Work Take Away Conveyor              |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 10 HP Air Compressor w/ Tank               |   | X | X | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Compressed Air Dryer                       |   | X | X | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Water Softener w/ Brine Tank               |   | X | X | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Gas Fired Water Heater                     |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| 70 HP Gas/Oil Fired Steam Boilers          |   | X | X | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Boiler Return System                       |   | X | X | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Five Pocket Loading Conveyor               |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Cart Dumper                                |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Domestic Washer                            |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Domestic Dryer                             |   |   |   |   | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Garment Steam Finisher                     |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Combination Small Piece Gown Folder        |   |   |   | X | X | X  | X  | X  | X  | X  |    | X  |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Waste Water Heat Reclamation System        |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |
| Ozone Generation System                    |   | X | X | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |      |  |  |  |  |  |  |  |  |  |  |  |

| EQUIPMENT | 5 MILLION # CONVENTIONAL                 | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM<br>(MMBtu/h) |   | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-----------|------------------------------------------|---------------|------------------|-------------------|--------------------|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
|           | 600 Lb S/L Washer Extractors             | 40.6          |                  | 7400              | 0.247              |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 400 Lb S/L Washer Extractors             | 27.1          |                  | 3285              | 0.11               |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 200 Lb S/L Washer Extractors             | 17.8          |                  | 1548              | 0.052              |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 100 Lb O/P Washer Extractor              | 4.4           |                  | 410               | 0.014              |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 85 Lb O/P Washer Extractor               | 3.7           |                  | 320               | 0.011              |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 400 Lb Pass Through Dryers               | 69.3          | 3.36             |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
|           | 200 Lb Dryer                             | 7.6           | 0.34             |                   |                    |   |   |   | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | 100 Lb Dryer                             | 2.6           | 0.1              |                   |                    |   |   |   | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | Eight Roll Super Sylon Ironer            | 13.1          |                  |                   | 0.93               |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Two Lane Primary/Cross Folder            | 2.9           |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Large Piece Stackler                     | 0.25          |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Four Station Large Piece Spreader/Feeder | 3             |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
|           | Set Clean Work Takeaway Conveyor         | 3             |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
|           | Sorting/Counting Deck                    | 3.8           |                  |                   |                    |   | X | X |   |   |    |    |    |    |    |    |    |    |    |    |    |
|           | Cart Dumper                              | 4.1           |                  |                   |                    | X | X | X | X | X | X  | X  |    |    |    |    |    |    |    |    |    |
|           | Double Buck Shirt Body Press             | 24.2          |                  |                   | 0.34               |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Cabinet Shirt Sleeve Press               | 15.9          |                  |                   | 0.24               |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Collar Cuff Press                        | 0.14          |                  |                   | 0.22               |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Utility Laundry Press                    | 0.23          |                  |                   | 0.25               |   |   |   | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Deaerator Return System                  | 6.1           |                  |                   |                    | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Boiler Blow Down System                  | 0.16          |                  |                   |                    | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | 30 HP Rotary Air Compressors             | 29.7          |                  |                   |                    | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Direct Contact Water Heater              | 11.3          | 12               |                   |                    |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | Water Softener                           | 0.16          |                  |                   |                    |   | X | X | X | X | X  | X  | X  | X  |    |    |    |    |    |    |    |
|           | Cart Washer                              | 16.7          |                  | 20                |                    |   | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
|           | Small Piece Folder (French Fold)         | 2.8           |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
|           | Small Piece Folder (Quarter Fold)        | 1.4           |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
|           | Roll Up Folding Tables/Hoppers           | 0.95          |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
|           | Floor Scales                             | 0.4           |                  |                   |                    |   |   |   | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
|           | 125 HP Dual Fired Steam Boilers          | 4.2           | 2.9              | 75                |                    |   | X | X | X | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
|           | Compressed Air Dryer                     | 1.8           |                  |                   |                    | X | X | X | X | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |

| EQUIPMENT & MILLION #/YR H.E. PLANT      | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM<br>(MMBtu/h) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |
|------------------------------------------|---------------|------------------|-------------------|--------------------|---------------|--------------|---------------|
| CBW System Membrane Presses              | 33.8          |                  |                   |                    | 195700        | 10000        | 10372         |
| CBW System 150# Gas Fired Dryers         | 88.2          | 0.58             |                   |                    | 240000        | 19000        | 12720         |
| Two Tier Shuttle Conveyors               | 19.2          |                  |                   |                    | 92700         | 8000         | 4913          |
| 8 Chamber 75 Lb CBW's                    | 68            |                  | 2625              | 1.6                | 298000        | 21000        | 15794         |
| 125 Lb Washer Extractors                 | 13.2          |                  | 1400              | 0.08               | 60000         | 4500         | 3180          |
| 85 Lb Washer Extractor                   | 3.7           |                  | 318               | 0.02               | 10500         | 750          | 557           |
| Three Roll 32" Ironer                    | 14.7          |                  |                   | 1.25               | 133000        | 7500         | 7049          |
| Three Lane Primary/Cross Folder          | 2.9           |                  |                   |                    | 40000         | 1200         | 2120          |
| Double Large Piece Folder                | 1             |                  |                   |                    | 8000          | 600          | 424           |
| Four Station Large Piece Spreader/Feeder | 3             |                  |                   |                    | 40100         | 1500         | 2125          |
| Dryer Unload Conveyor with In-line       | 0.95          |                  |                   |                    | 6200          | 500          | 329           |
| Clean Work Takeaway Conveyors            | 3             |                  |                   |                    | 16500         | 1200         | 875           |
| Sorting/Counting Deck                    | 3.8           |                  |                   |                    | 66000         | 4500         | 3445          |
| Cart Dumper                              | 4.1           |                  |                   |                    | 10600         | 700          | 557           |
| Soil Transport/Storage Rail System       | 1.2           |                  |                   |                    | 390000        | 35000        | 20670         |
| 150 Lb Gas Fired Dryers                  | 10.4          | 0.38             |                   |                    | 30300         | 1800         | 1606          |
| Dewater Return System                    | 6.1           |                  |                   |                    | 22600         | 1800         | 1193          |
| Boiler Blow Down System                  | 0.16          |                  |                   |                    | 3200          | 250          | 170           |
| 30 HP Rotary Air Compressors             | 29.7          |                  |                   |                    | 30200         | 1800         | 1601          |
| Direct Contact Water Heaters             | 11.3          | 1.47             |                   |                    | 29500         | 2500         | 1564          |
| Water Softener                           | 0.16          |                  |                   |                    | 14300         | 1200         | 758           |
| Garment Steam Finishing Tunnel           | 9.96          |                  |                   | 0.4                | 51000         | 4200         | 2703          |
| Clean Transport Storage Rail System      | 1.2           |                  |                   |                    | 128000        | 10000        | 6784          |
| Cart Washer                              | 16.7          |                  | 20                |                    | 59000         | 4800         | 3127          |
| Small Piece Folder (French Folder)       | 2.8           |                  |                   |                    | 35500         | 1000         | 1882          |
| Small Piece Folder (Quarter fold)        | 1.4           |                  |                   |                    | 17700         | 500          | 938           |
| Roll up Folding Tables/Hoppers           | 0.95          |                  |                   |                    | 26000         | 750          | 1378          |
| Floor Scales                             | 0.4           |                  |                   |                    | 12800         | 1200         | 678           |
| 125 HP Dual Fired Steam Boiler           | 2.6           | 4.03             | 76                |                    | 65000         | 6000         | 3445          |
| Compressed Air Dryer                     | 3.6           |                  |                   |                    | 1400          | 200          | 74            |

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## DIRECT LABOR REQUIREMENT

|                            |    |                                  |
|----------------------------|----|----------------------------------|
| Floor Lead Person          | 1  | 7 Worked Hours / Day             |
| Soil & Wash Room           | 7  | 5 Days Per Week = 1 820 Hrs      |
| Flatwork/Folding/Finishing | 10 | #/Worked Hour                    |
| Cart Make Up And Delivery  | 4  | 5,000,000 / (1820 x 27) = 101.75 |
| Utility Persons            | 3  | * Steam is Generated by Boiler   |
| Garment Processing         | 2  | which is in Gas Requirement      |
| TOTAL                      | 27 |                                  |



## EQUIPMENT 5 MILLION #/YR H.E. PLANT(SOA2)

| EQUIPMENT                                  | 5 | 6 | 7  | 8  | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|--------------------------------------------|---|---|----|----|---|----|----|----|----|----|----|----|----|----|----|----|
| CBW System Membrane Presses                |   |   | X  | X  | X | X  | X  | X  | X  | 50 |    |    |    |    |    |    |
| CBW System 150# Gas Dryers W/Heat Recovery |   |   | X  | X  | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Two Tier Shuttle Conveyors                 |   |   | X  | X  | X | X  | X  | X  | X  | 50 |    |    |    |    |    |    |
| 8 Chamber 75 Lb CBW's                      |   |   | X  | X  | X | X  | X  | X  | X  | 50 |    |    |    |    |    |    |
| 125 Lb Washer Extractors                   |   |   |    | X  | X | X  | X  | X  | X  | X  | 50 |    |    |    |    |    |
| 85 Lb Washer Extractor                     |   |   |    | X  | X | X  | X  | X  | X  | X  | 50 |    |    |    |    |    |
| Three Roll 32" Ironer                      |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Three Lane Primary/Cross Folder            |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Double Large Piece Folder                  |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Four Station Large Piece Spreader/Feeder   |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Dryer Unload Conveyor with Incline         |   |   | X  | X  | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| Clean Work Takeaway Conveyors              |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Sorting/Counting Deck                      |   | X | X  | X  | X | X  | X  |    |    |    |    |    |    |    |    |    |
| Cart Dumper                                |   | X | X  | X  | X | X  | X  |    |    |    |    |    |    |    |    |    |
| Soil Transport/Storage Rail System         |   | X | X  | X  | X | X  | X  | X  | X  | X  |    |    |    |    |    |    |
| 150 Lb Gas Fired Dryers W/Heat Recovery    |   |   |    |    | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Deaerator Return System                    |   |   | X  | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Boiler Blow Down System                    |   |   | X  | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| 30 HP Rotary Air Compressors               |   | X | X  | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Direct Contact Water Heaters               |   | X | X  | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Water Softener                             |   | X | X  | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Garment Steam Finishing Tunnel             |   |   |    |    | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
| Clean Transport Storage Rail System        |   |   |    |    | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
| Cart Washer                                |   | X | X  | X  | X | X  | X  |    |    |    |    |    |    |    |    |    |
| Small Piece Folder (French Folder)         |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Small Piece Folder (Quarter fold)          |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Roll up Folding Tables/Hoppers             |   |   |    | X  | X | X  | X  | X  | X  | X  | X  |    |    |    |    |    |
| Floor Scales                               |   | X | X  | X  | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
| 125 HP Dual Fired Steam Boiler             |   |   | 50 | 70 | X | X  | X  | X  | X  | X  | 70 | 50 | 30 |    |    |    |
| Compressed Air Dryer                       |   | X | X  | X  | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
| Waste Water Heat Reclamation System        |   |   | X  | X  | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |
| Ozone Generation System                    |   |   | X  | X  | X | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |

% Indicates amount of average hourly utility usage.

## EQUIPMENT 6 MILLION #/VR H.E. PLANT(SOA2)

|                                            | POWER<br>(Kw) | GAS<br>(MMBtu/h) | WATER<br>(gal/hr) | STEAM<br>(MMBtu/h) | COST<br>PURCH | COST<br>INST | COST<br>MAINT |
|--------------------------------------------|---------------|------------------|-------------------|--------------------|---------------|--------------|---------------|
| CBW System Membrane Presses                | 33.8          |                  |                   |                    | 195700        | 10000        | 10372         |
| CBW System 150# Gas Dryers W/Heat Recovery | 88.2          | 0.49             |                   |                    | 240000        | 19000        | 12720         |
| Two Tier Shuttle Conveyors                 | 19.2          |                  | 2625              |                    | 82700         | 8000         | 4913          |
| 8 Chamber 75 Lb CBW's                      | 68            |                  |                   | 1.8                | 298000        | 21000        | 15794         |
| 125 Lb Washer Extractors                   | 13.2          |                  | 1330              | 0.08               | 80000         | 4800         | 3180          |
| 85 Lb Washer Extractor                     | 3.7           |                  | 300               | 0.02               | 10500         | 750          | 557           |
| Three Roll 32" Ironer                      | 14.7          |                  |                   | 1.25               | 133000        | 7800         | 7049          |
| Three Lane Primary/Cross Folder            | 2.9           |                  |                   |                    | 40000         | 1200         | 2120          |
| Double Large Piece Folder                  | 1             |                  |                   |                    | 8000          | 600          | 424           |
| Four Station Large Piece Spreader/Feeder   | 3             |                  |                   |                    | 40100         | 1800         | 2125          |
| Dryer Unload Conveyor with Incline         | 0.95          |                  |                   |                    | 6200          | 500          | 329           |
| Clean Work Takeaway Conveyors              | 3             |                  |                   |                    | 16500         | 1200         | 875           |
| Sorting/Counting Deck                      | 3.8           |                  |                   |                    | 85000         | 4800         | 3445          |
| Cart Dumper                                | 4.1           |                  |                   |                    | 10500         | 700          | 557           |
| Soil Transport/Storage Rail System         | 1.2           |                  |                   |                    | 390000        | 35000        | 20670         |
| 150 Lb Gas Fired Dryers W/Heat Recovery    | 10.4          | 0.32             |                   |                    | 30300         | 1800         | 1606          |
| Deaerator Return System                    | 6.1           |                  |                   |                    | 22500         | 1800         | 1193          |
| Boiler Blow Down System                    | 0.16          |                  |                   |                    | 3200          | 250          | 170           |
| 30 HP Rotary Air Compressor                | 28.7          |                  |                   |                    | 30200         | 1600         | 1601          |
| Direct Contact Water Heaters               | 11.3          | 0.63             |                   |                    | 29500         | 2500         | 1564          |
| Water Softener                             | 0.16          |                  |                   |                    | 14300         | 1200         | 758           |
| Garment Steam Finishing Tunnel             | 9.98          |                  |                   | 0.4                | 51000         | 4200         | 2703          |
| Clean Transport Storage Rail System        | 1.2           |                  |                   |                    | 128000        | 10000        | 6784          |
| Cart Washer                                | 16.7          |                  | 20                |                    | 59000         | 4800         | 3127          |
| Small Piece Folder (French Folder)         | 2.8           |                  |                   |                    | 35500         | 1000         | 1882          |
| Small Piece Folder (Quarter fold)          | 1.4           |                  |                   |                    | 17700         | 500          | 938           |
| Roll up Folding Tables/Hoppers             | 0.95          |                  |                   |                    | 26000         | 750          | 1378          |
| Floor Scales                               | 0.4           |                  |                   |                    | 12800         | 1200         | 678           |
| 125 HP Dual Fired Steam Boiler             | 2.8           | 3.8              | 75                |                    | 65000         | 6000         | 3445          |
| Compressed Air Dryer                       | 3.8           |                  |                   |                    | 1400          | 200          | 74            |
| Waste Water Heat Reclamation System        | 1.5           |                  |                   |                    | 45000         | 3000         | 2385          |
| Ozone Generation System                    | 24            |                  |                   |                    |               |              | 0             |

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## DIRECT LABOR REQUIREMENT

|                            |    |                                  |
|----------------------------|----|----------------------------------|
| Floor Lead Person          | 1  | 7 Worked Hours / Day             |
| Soil & Wash Room           | 7  | 5 Days Per Week = 1820 Hrs       |
| Flatwork/Folding/Finishing | 10 | #/Worked Hour                    |
| Cart Make Up And Delivery  | 4  | 5,000,000 / (1820 x 27) = 101.75 |
| Utility Persons            | 3  | * Steam is generated by Boiler   |
| Garment Processing         | 2  | which is in Gas Requirement      |
| TOTAL                      | 27 |                                  |

AVERAGE ANNUAL MAINTENANCE COST AND ACTUAL ANNUAL MAINTENANCE COST  
AS A PERCENTAGE OF PURCHASE PRICE VS. EQUIPMENT AGE

YEAR                      COST (%)                      AVG COST (%)

|    |   |      |
|----|---|------|
| 1  | 0 | 0    |
| 2  | 3 | 1.50 |
| 3  | 4 | 2.33 |
| 4  | 5 | 3.00 |
| 5  | 6 | 3.60 |
| 6  | 7 | 4.17 |
| 7  | 7 | 4.57 |
| 8  | 7 | 4.88 |
| 9  | 7 | 5.11 |
| 10 | 7 | 5.30 |
| 11 | 7 | 5.45 |
| 12 | 7 | 5.58 |
| 13 | 7 | 5.69 |
| 14 | 7 | 5.79 |
| 15 | 7 | 5.87 |
| 16 | 7 | 5.94 |
| 17 | 7 | 6.00 |
| 18 | 7 | 6.06 |
| 19 | 7 | 6.11 |
| 20 | 7 | 6.15 |

The average annual maintenance cost is based on the recorded maintenance costs from several facilities, and several different types of laundry equipment.

The cost does level out at 7% per year at an equipment age of 6 years.

The 10 year average of 5.3% is used in the maintenance cost calculation in the various plant equipment lists.

## USACERL DISTRIBUTION

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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