

**APPENDIX D. MANUFACTURING COST ASSESSMENT - BILL OF MATERIALS**

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## APPENDIX D. MANUFACTURING COST ASSESSMENT - BILL OF MATERIALS

The manufacturing cost assessment methodology used to evaluate the cost of increasing the efficiency of clothes washers is a detailed, component-focused technique for rigorously calculating the manufacturing cost of a product (direct materials, direct labor and some overhead costs). Figure D.1 shows the three major steps in generating the cost of manufacturing clothes washers.



**Figure D.1 Manufacturing Cost Assessment Approach**

### D.1 BILL OF MATERIALS (BOM)

The first step in the manufacturing cost assessment was the creation of a complete and structured bill of materials (BOM) from the disassembly of the two baseline and six high efficiency models. The washers were dismantled and each part was characterized according to weight, dimensions, material and quantity.

The BOM incorporates all materials, components, and fasteners with estimates of raw material costs and purchased part costs. Assumptions on the sourcing of parts and in-house fabrication were based on industry experience, information in trade publications and discussions with manufacturers. Interviews and plant visits were conducted at major manufacturing facilities to ensure accuracy on methodology and pricing.

Cost estimates for raw materials and purchased components were drawn from Arthur D. Little's manufacturing databases and supplemented with information obtained from manufacturer and supplier sources. Adjustments to the cost estimates for purchased parts and raw materials were made, as appropriate, to include price discounts typically available at the purchase volumes in question. Figure D.2 is a section from the structured bill of materials of one baseline clothes washer. This section of the structured bill of materials lists the part number (defined during disassembly), description, material category, sourcing category (fabricated or vended), quantity, dimensions, weight, percent of scrap in processing, and estimated material cost.

| 1.00        | <b>Tub &amp; Basket Assembly</b>            |                |       |           |       |       |        | Weight (lbs) |              |         |                   |
|-------------|---|----------------|-------|-----------|-------|-------|--------|--------------|--------------|---------|-------------------|
| Part No.    | (Final Assy. 1388.00/1800.00) - Description | Category       | V (?) | #         | Width | Thkns | Length | Steel        | Other        | Scrap % | Material Cost, \$ |
| 1.01        | Tub   | Plastic        |       | 1         | 22.5  | 0.09  | 22.5   |              | 5.520        |         | 3.31              |
| 1.03        | Water Level Box                             | Plastic        |       | 1         | 2.75  | 0.085 | 1.75   |              | 0.066        |         | 0.04              |
| 1.02        | Tub to Suspension Seal                      | Rubber         |       | 1         | 0.6   | 0.03  | 5.2    |              | 0.036        |         | 0.02              |
| 1.07        | Beach Tube                                  | Rubber         |       | 1         | 0.6   | 0.09  | 5.2    |              | 0.036        |         | 0.02              |
| <b>1.30</b> | <b>Basket Assembly</b>                      |                |       |           |       |       |        |              |              |         |                   |
| 1.20        | Basket                                      | Enameled Steel |       | 1         | 20.5  | 0.055 | 18     | 13.500       |              | 15      | 4.13              |
| 1.22        | Lint Collector                              | Plastic        |       | 1         |       |       |        |              | 0.475        |         | 0.29              |
| 1.21        | Basket Balancing Ring w/Water in it         | Plastic        |       | 1         | 20.5  | 0.09  | 2      |              | 1.400        |         | 0.84              |
| 1.49        | Upper Agitator Assembly                     |                |       |           |       |       |        |              |              |         |                   |
| 1.50A       | Fabric Dispenser - Top                      | Plastic        |       | 1         | 3.81  | 0.05  | 1.6    |              | 0.108        |         | 0.05              |
| 1.50B       | Fabric Dispenser - Cup                      | Plastic        |       | 1         | 3     | 0.05  | 5.5    |              | 0.074        |         | 0.03              |
| 1.50C       | Fabric Dispenser - Bottom                   | Plastic        |       | 1         | 4     | 0.06  | 5      |              | 0.148        |         | 0.07              |
| 1.51        | Clutch Cover                                | Plastic        |       | 1         | 3.25  | 0.05  | 0.9    |              | 0.030        |         | 0.02              |
| 1.52        | Clutch Cover Seal                           | Rubber         |       | 1         | 3.15  |       | 0.16   |              | 0.010        |         | 0.01              |
| 1.75        | Lower Agitator Assembly                     |                |       |           |       |       |        |              |              |         |                   |
| 1.60        | Bottom Agitator Bearing                     | Plastic        |       | 1         | 2.95  | 0.26  |        |              | 0.016        |         | 0.01              |
| 1.59        | Bottom Agitator                             | Plastic        |       | 1         | 13.5  | 0.15  | 13     |              | 1.816        |         | 0.82              |
| 1.58        | Upper/Lower Agitator Bearing                | Plastic        |       | 1         | 2.6   | 0.05  | 0.775  |              | 0.016        |         | 0.01              |
| 1.57        | Upper Agitator                              | Plastic        |       | 1         | 3.75  | 0.01  | 11.5   |              | 0.934        |         | 0.42              |
| <b>1.85</b> | <b>Agitator Clutch Assembly</b>             |                |       |           |       |       |        |              |              |         |                   |
| 1.56        | Clutch Body                                 | Plastic        |       | 1         | 2.63  | 0.08  | 2.265  |              | 0.052        |         | 0.02              |
| 1.55        | Ratchet Stops                               | Plastic        |       | 4         | 0.4   | 0.15  | 0.9    |              | 0.016        |         | 0.01              |
| 1.54        | Clutch Bottom Cover                         | Plastic        |       | 1         | 1.75  | 0.05  | 0.4    |              | 0.006        |         | 0.00              |
|             | <b>Sub-Totals</b>                           |                |       | <b>22</b> |       |       |        | <b>13.50</b> | <b>10.79</b> |         | <b>10.12</b>      |

**Figure D.2 Structured Bill of Materials**

## D.2 FABRICATION PROCESSES

After each detailed BOM was completed, the major manufacturing processes were identified. These processes are listed in Table D.1.

**Table D.1 Major Manufacturing Processes**

| <b>Fabrication</b>                         | <b>Finishing</b> | <b>Assembly / Joining</b>         |
|--|------------------|-----------------------------------|
| Fixturing                                  | Washing          | Adhesive Bonding                  |
| Stamping / Pressing (Large, Medium, Small) | Powder Coating   | Spot Welding                      |
| Brake Forming                              | Enameling        | Seam Welding                      |
| Cut & Shearing                             | Deburring        | Integral Fastner (i.e. clinching) |
| Machining                                  |                  | Other Fasteners                   |
| Injection Molding (Large, Medium, Small)   |                  | Press Fitting                     |
| Casting                                    |                  | Inspection & Testing              |

Information on equipment and tooling costs, typical processing cycle times, and materials used for fabrication were obtained from the ADL manufacturing databases. Equipment suppliers were contacted for further details concerning equipment capabilities and processing parameters (cycle times, scrap rates, etc.). The fabrication process cycle times were directly entered in the BOM and linked to the specific parts being fabricated. Each part had a processing time and labor cost assigned based on an overall labor rate.

Figure D.3 contains an excerpt of the non-assembly processing times (seconds per process) associated with each component listed on the left. This section of the model has all the processes listed in Table D.1, but for brevity a single page was presented in Figure D.2. Figure D.3 is from the equipment summary section, which includes total equipment and summarized labor requirements for each fabrication process.

In addition to the process time and labor costs associated with fabrication, labor times for assembly associated with each part is included.

| 1.00            | <b>Tub &amp; Basket Assembly</b>                   |                  |             |                       |                      |                    | Weight (lbs)        |                    |                   |                        |
|-----------------|--|------------------|-------------|-----------------------|----------------------|--------------------|---------------------|--------------------|-------------------|------------------------|
| <b>Part No.</b> | <b>(Final Assy. 1388.00/1800.00) - Description</b> | <b>Fixturing</b> | <b>Wash</b> | <b>Powder Coating</b> | <b>Enamel Baking</b> | <b>Large Press</b> | <b>Medium Press</b> | <b>Small Press</b> | <b>Brake Form</b> | <b>Cut &amp; Shear</b> |
| 1.01            | Tub  |                  |             |                       |                      |                    |                     |                    |                   | 1.0                    |
| 1.03            | Water Level Box                                    |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.02            | Tub to Suspension Seal                             |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.07            | Beach Tube   |                  |             |                       |                      |                    |                     |                    |                   |                        |
| <b>1.30</b>     | <b>Basket Assembly</b>                             |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.20            | Basket   | 40.0             |             |                       | 4.0                  |                    | 10.0                |                    | 30.0              | 2.0                    |
| 1.22            | Lint Collector                                     |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.21            | Basket Balancing Ring w/Water in it                | 5.0              |             |                       |                      |                    |                     |                    |                   |                        |
| 1.49            | Upper Agitator Assembly                            |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.50A           | Fabric Dispenser - Top                             |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.50B           | Fabric Dispenser - Cup                             |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.50C           | Fabric Dispenser - Bottom                          |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.51            | Clutch Cover                                       |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.52            | Clutch Cover Seal                                  |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.75            | Lower Agitator Assembly                            |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.60            | Bottom Agitator Bearing                            | 2.000            |             |                       |                      |                    |                     |                    |                   |                        |
| 1.59            | Bottom Agitator                                    |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.58            | Upper/Lower Agitator Bearing                       |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.57            | Upper Agitator                                     |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.85            | <b>Agitator Clutch Assembly</b>                    |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.56            | Clutch Body  |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.55            | Ratchet Stops                                      |                  |             |                       |                      |                    |                     |                    |                   |                        |
| 1.54            | Clutch Bottom Cover                                |                  |             |                       |                      |                    |                     |                    |                   |                        |
|                 | <b>Sub-Totals</b>                                  | <b>62.0</b>      |             |                       | <b>4.0</b>           |                    | <b>10.0</b>         |                    | <b>30.0</b>       | <b>3.0</b>             |

**Figure D.3 Fabrication Process Cycle Time Estimates**

### **D.2.1 Assembly Processes**

In the final step of the cost assessment, assembly times and associated direct labor costs were estimated. Assembly cycle times were primarily derived from reversing the disassembly of the selected tear-down clothes washers. The assembly sequence was built into the structured BOM, culminating with final assembly, testing and packaging.

Once the cost estimates for each machine were finalized, a detailed summary was prepared for relevant components, subassemblies and processes. The BOM and manufacturing process summaries provide detailed direct material, direct labor, indirect material, and investment costs. Indirect labor costs were estimated by subtracting the direct labor hours, determined from the bottom-up analysis, from the current average total labor hours per unit (1.8 hours). The current average labor content was derived from a top down analysis of several household laundry equipment manufacturing plants and conforms with data from the 1992 Census of Manufacturers.