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Application of Plant Manufacturing Burden to Standard Product Costs and Cost Estimates Related to Vehicle Teardown Studies

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Booz Allen and Hamilton, Inc. Transportation Consulting Division 4330 East-West Highway Bethesda MD 20014

August 1983 Final Report

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U.S. Department of Transportation

National Highway Traffic Safety Administration

Office of Research and Development Office of Vehicle Research Washington DC 20590

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16. Abstract		

The automotive industry's uses of competitive vehicle teardown studies are described and recommendations for more effective use of teardown data in vehicle weight reduction are presented. This report also relates the development and application of plant manufacturing burden to standard product costs and cost estimates developed from automotive vehicle teardown studies.

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#### PREFACE

The information contained in this report is based on the experience of Harbour and Associates, a Detroit based consulting firm whose members are retired manufacturing and financial executives from the automotive industry.

The report was prepared for the U.S. Department of Transportation, Transportation Systems Center, under Contract No. DOT-TSC-1609. The work was sponsored by the National Highway Traffic Safety Administration's Office of Vehicle Research, NRD-13. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Transportation Systems Center.

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METRIC CONVERSION FACTORS

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## 1. INTRODUCTION

Currently, the U.S. Department of Transportation, Transportation Systems Center (DOT/TSC) has contracts to have domestically built cars dismantled and estimates of tooling, material and processing costs and weight prepared for selected components. For each component, two cost and weight estimates are prepared:

- One based on the material the component is presently made from
- The other assuming the component is made from a substitute light weight material.

The two estimates are then compared and cost justified weight reduction potentials are identified. The problem is that the contractors who are preparing these estimates have not specified the production volumes and manufacturing processes that they assumed. Also, processing costs are not broken down into direct labor, burden and other cost elements.

Production volumes and the level of automation included in the manufacturing process, significantly effects the direct labor and burden elements of component product costs. Therefore, knowledge of assumed production volumes and manufacturing processes and a definitive breakdown of processing costs i.e., direct labor, burden, etc. are essential to making valid and meaningful cost/weight comparisons.

The objectives of this report are to:

- Define plant manufacturing burden, describe the development of burden rates and their application in a standard product cost system
- Describe the automotive industry's uses of competitive vehicle teardown studies
- Recommend guidelines for more effective use of teardown study data in weight reduction studies.

The material presented in this report is based on the knowledge and experience of retired auto industry executives in manufacturing and finance. The material includes narrative descriptions supported by block diagrams and where appropriate, cost charts.

#### 2. PLANT MANUFACTURING BURDEN

As described in the previous chapter, plant manufacturing burden is extremely important for a realistic estimation of component costs. In fact, it is one of the key elements that comprise standard product costs which in turn is one of the elements of "cost of products sold and other operating charges" reported on a typical automotive manufacturing company's income statement.

This chapter of the report provides an overview of the concept of plant manufacturing burden as used in the automotive manufacturing industry. The purpose of the chapter is to provide the reader with a basic understanding of plant manufacturing burden and its importance in estimating standard product costs. The material presented in this chapter and the next serves as the basis for the recommendations presented in Chapter 4.

The chapter is divided into three sections, as follows:

- Role of Plant Manufacturing Burden in Standard Product Costs
- Methodology Employed by Automotive Manufacturers in Developing Plant Burden Absorption Rates
- Sensitivity of Plant Manufacturing Burden to Production Volume and Level of Automation.

#### ROLE OF PLANT MANUFACTURING BURDEN IN STANDARD PRODUCT COSTS

This section describes the role of plant manufacturing burden in developing standard product costs starting with a look at the elements of a typical manufacturing company's income statement.

### Elements of A Typical Manufacturing Company's Income Statement

Automotive manufacturing companies generally publish the financial results of operations annually. These results typically include, but are not necessarily limited to, the following broad classifications of income and expenses (see Figure 2-1):

- Net sales
- Costs of products sold and other operating charges
- Selling, general and administrative expenses
- Net profit (or loss) before income taxes.

Note that no mention is made of plant manufacturing burden costs. Nonetheless these costs are reflected within the categories listed in Figure 2-1 as will be shown in the following sections. The category of interest in Figure 2-1 is the costs of products sold and other operating charges.

#### Cost of Products Sold and Other Operating Charges

Figure 2-2 expands upon the expense category costs of products sold and other operating expenses. As shown in the figure, costs of products sold and other operating expenses usually consist of the following broad categories:

- Standard product costs
- Variances from standard product costs
- Product development costs
- Manufacturing and procurement staff costs
- Amortization of special tool costs.

Standard product costs are based on standards which remain unchanged for a model year. Variances from standard product costs are segregated into variance accounts and are recorded in the period incurred. Standard product costs are used for progressive accounting through raw material, in-process and finished products inventories and for cost of products sold. As will be shown in the next section, plant burden is one of the elements of standard product costs.

#### Standard Product Costs

Figure 2-3 shows the key elements that comprise standard product costs. As shown, standard product costs are comprised of:

- Standard direct material
  - Direct material
  - Indirect material (adhesives, cements, paint sealers, solder, etc.)

# NET SALES

(MINUS)

COST OF PRODUCTS SOLD AND OTHER OPERATING CHARGES

(MINUS)

SELLING, GENERAL & ADMINISTRATIVE EXPENSES

(EQÜALS)

NET PROFIT OR (LOSS) BEFORE INCOME TAXES

FIGURE 2-1. ELEMENTS OF A TYPICAL MANUFACTURING COMPANY'S INCOME STATEMENT



FIGURE 2-2. ELEMENTS OF COSTS OF PRODUCTS SOLD AND OTHER OPERATING CHARGES

- Standard in-bound transportation
- Standard direct labor
- Standard plant burden
  - Fixed and non-variable
  - Variable.



# FIGURE 2-3. ELEMENTS OF STANDARD PRODUCT COSTS

Of particular importance in Figure 2-3 is plant standard (i.e., manufacturing) burden. Plant standard burden consists of manufacturing expenses incurred for the maintenance and operations of a manufacturing facility, exclusive of direct labor, productive material and in-bound transportation. As shown in Figure 2-4, plant standard burden is determined by multiplying standard direct labor by a burden absorption rate. The methodology employed by the automotive industry in developing this rate is the subject of the next section.



# FIGURE 2-4. APPLICATION OF PLANT BURDEN RATE TO STANDARD PRODUCT COSTS

# METHODOLOGY EMPLOYED BY AUTOMOTIVE MANUFACTURERS IN DEVELOPING PLANT BURDEN ABSORPTION RATES

Figure 2-5 provides a very simplified description of how companies distribute manufacturing expenses and arrive at burden absorption rates. Note that all of the hundreds of categories of expenses are basically split into two categories: variable and fixed/non-variable. Very simply, variable costs are those items which will change substantially when production volume or plant utilization changes. Fixed/ non-variable are those items which are essentially constant whether the company is fully utilizing the facility or not.

A step-by-step discussion of the methodology employed by the automotive industry for developing plant burden absorption rates as displayed in Figure 2-5, is described in the following sections:

- Estimation of manufacturing expenses (step 1)
- Allocation of manufacturing expenses to burden centers (step 2)
- Calculation of direct labor (step 3)
- Calculation of standard burden absorption rates (step 4)

#### Estimation of Manufacturing Expenses

As shown in Figure 2-5, the first step in the methodology involves the estimation of plant manufacturing expenses. Manufacturing expenses consist of indirect salary and hourly labor and related fringe benefits budgeted at control volume\* and other manufacturing expenses indirectly related to the maintenance or operation of the manufacturing facility, also budgeted at control volume.

Personnel of the following departments are considered indirect labor:

- Plant Manager
- Controller
- Industrial engineering

<sup>\*</sup> Control volume is a selected annual production volume level based on marketing studies, to provide a uniform and conservative base for formulating plans, evaluating performance and for use in developing standard product costs.





Personnel

•

- Resident engineering •
- •
- Quality control Production control •
- Manufacturing engineering •
- Production-foreman, clerks, etc.

Other manufacturing expenses generally are:

- Maintenance materials
- Perishable tools •
- Spoilage and rework
- Supplies
- Communications
- Postage
- Purchased services
- Fuel costs
- Utilities
- Overtime premiums
- Insurance
- Taxes-real and personal property
- Depreciation-machinery, equipment, furniture, and fixtures.

The following sections describe the methodologies employed in calculating indirect labor dollars and benefits and other manufacturing expenses. A summary of these expense items by category (i.e., fixed/non-variable and variable) is shown in Table 2-1. Note that many of the expense items fall into more than one expense category.

	Expense Ca	ategory
Expense Item	Fixed Non-Variable	Variable
<pre>Indirect labor dollars Indirect labor benefits Maintenance materials Perishable tools Spoilage and rework Supplies Communications Postage Purchased Services Fuel Costs Utilities Overtime Premium Insurance Taxes-real and personal     property Depreciation-machinery,     equipment, furniture and     fixtures</pre>	X X X X X X X X X X X X X X X	X X X X X X X

# TABLE 2-1. MANUFACTURING EXPENSES BY EXPENSE CATEGORY

\* Primarily fixed.

## Calculation of Indirect Labor Dollars

An overview of the methodology used in calculating indirect labor dollars is shown in Figure 2-6. As shown, indirect manning tables developed by industrial engineering for various production volume levels are used to determine non-variable and variable manpower requirements of the nonproductive departments which support the productive departments. These manpower requirements are then multiplied by the annual number of workhours and the departmental average wage rate to arrive at the non-variable and variable indirect labor dollars. Using this methodology indirect labor dollars for both salaried and hourly workers are determined.



# FIGURE 2-6. CALCULATION OF INDIRECT LABOR DOLLARS

Calculation of Indirect Labor Fringe Benefits

Figure 2-7 is an overview of the methodology used by the auto industry in calculating indirect labor fringe benefits. Simply speaking, indirect salary and hourly labor dollars at control volume are multiplied by the latest actual fringe benefit rates to arrive at non-variable and variable fringe benefits at control volume.

As shown in the figure, typical benefits are:

- Education aid
- Stock plan
- Cost living
- F.I.C.A.
- Unemployment taxes



CALCULATION OF INDIRECT LABOR FRINGE BENEFIT'S FIGURE 2-7.

- Supplemental unemployment funds
- Life and health insurance
- Shift premium
- Vacation and holiday pay
- Paid lunch time.

# Calculation of Other Manufacturing Expenses

Other manufacturing expenses such as maintenance materials, perishable tools, supplies, fuel costs, utilities, depreciation, etc. are usually calculated based on experience and/or industrial engineering standards.

# Allocation of Manufacturing Expenses to Burden Centers

Returning back to Figure 2-5, the next step in developing burden absorption rates is to allocate the manufacturing expenses determined in Step 1 to burden centers. Presented below is a discussion of the burden centers and allocation of manufacturing expenses in four types of plants:

- Stamping
- Engine
- Foundry
- Assembly.

These four plants are discussed because they are representative of the major types of manufacturing operators employed in the automotive industry.\*

Definition of the Burden Centers in a Stamping Plant, Engine Plant, Foundry and Assembly Plant

A burden center is either a productive department or a collection of productive departments engaged in the production of one or more common products. For each burden center, there exists a single standard burden absorption rate. The following are the burden centers in a stamping plant, engine plant, foundry and assembly plant:

• Stamping Plant. A stamping plant generally has four productive departments: large press, small press, repair and assembly. Since each department is engaged in producing different products, each department is a separate burden center. Due to the cost of equipment, floor space required and higher level of automation, the large press

<sup>\*</sup> Engine plant represents the machining operation while a foundry represents the casting operation.

department typically has a higher fixed and variable burden absorption rate than the other three departments.

- Engine Plant. An engine plant generally has two final burden centers, machining and engine assembly. The machining burden center in turn is comprised of the following eight intermediate burden centers:
  - Cylinder Blocks
  - Cylinder Heads
  - Crankshafts
  - Camshafts
  - Pistons
  - Connecting Rods and Caps
  - Intake and Exhaust Manifolds
    - Water and Oil Pumps.

These eight intermediate burden centers are required for costing of parts produced for service requirements.

- Foundry. Normally all productive departments in a foundry are engaged in producing the same product. Thus, one plant-wide burden center is normally all that is required. However, since some castings which have been in storage, must be recycled through the cleaning process before shipment, there are frequently two burden centers in a foundry; mold/casting and cleaning.
- Assembly Plant. A car assembly plant has six productive departments: body, paint, trim, chassis final assembly and quality assurance. Since all productive departments are engaged in producing the same products a single burden absorption rate is utilized for the calculation of fixed and nonvariable and variable standard burden.

Allocation of Variable and Non-Variable Indirect Labor and Fringe Bencfits

With the exception of an assembly plant in which there is one plant-wide burden rate, non-variable indirect labor dollars and fringe benefits are allocated to the burden centers in stamping plants, engine plants and foundries, as follows (see Figure 2-8):

• The plant manager, controller, industrial engineering, personnel and resident engineering departments' indirect labor and fringe benefit dollars are allocated in direct proportion to the relationship each burden center's direct labor is to the total plant direct labor dollars.

- For the quality control, production control, and manufacturing engineering departments which are specifically assigned to support productive departments in specific burden centers, the applicable indirect labor dollars and related fringe benefit dollars are allocated on a specific manning basis.
- For the indirect labor manpower of the quality control, production control and manufacturing engineering departments which are not assigned to support specific productive departments, the applicable indirect labor dollars and fringe benefit dollars are allocated to the burden centers on the basis of the floor space occupied by the productive departments in burden centers.
- Production personnel are usually assigned to support productive departments in burden centers and as such the applicable indirect labor dollars and related fringe benefit dollars are allocated on a specific manning basis.



FIGURE 2-8. ALLOCATION OF INDIRECT LABOR AND FRINGE BENEFIT DOLLARS TO BURDEN CENTERS IN STAMPING PLANTS, ENGINE PLANTS AND FOUNDRIES Allocation of Other Manufacturing Expenses

Budgeted fixed/non-variable and variable other manufacturing expenses at control volume are allocated to the burden centers in a stamping plant, engine plant and foundry on the following basis:

- Maintenance materials, perishable tools, spoilage and rework supplies, communications, postage and purchased services are allocated on the basis of actual usage and/or industrial engineering studies.
- Fuel costs and utilities are allocated on the basis of the floor space occupied by the productive departments in the burden centers.
- Overtime premium is allocated in direct proportion to the relationship each burden center's direct labor is to the total plant direct labor.
- Depreciation of machinery and equipment specifically identified as being used by productive departments is allocated to the appropriate burden center. Depreciation on other machinery and equipment, furniture, fixtures, buildings, insurance and taxes are allocated on the basis of the floor space occupied by productive departments in each burden center.

An overview of this allocation scheme is shown in Figure 2-9.

Budgeted fixed/non-variable other manufacturing expenses at control volume are all allocated to the one plant-wide burden center in an assembly plant.

#### Calculation of Direct Labor

Following allocation of the fixed/non-variable and variable manufacturing expenses, the next step in the methodology is to calculate the standard direct labor for each of the burden centers. The calculation of standard direct labor is based on time standards established by industrial engineering studies. The estimates are for the manufacture (i.e., fabrication and assembly) of products in a specific facility utilizing a specific manufacturing process. Thus, the estimates are facility/plant specific.





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Direct labor time standards generally include:

- Base Work: Time allowed for the work content generated by product design and manufacturing process.
- Insystem Repair: Time required to make repairs during the manufacturing process.
- Line Balance: Time lost because of the inability to assign work to every operator for a full 60 minutes.
- <u>Relief Time</u>: Time each operator is relieved from assigned operations. This is usually specified in labor agreements.

In addition to the above, in a car assembly plant, direct labor time standards also include car conditioning time. This is defined as the time required to make repairs after completion of the manufacturing process but before release of the vehicles for shipment.

As shown in Figure 2-10, the product of direct labor time standards for each department engaged in producing a common product, the average departmental wage rate and control volume equals the productive department's direct labor dollars. Direct labor dollars are also allocated by burden center as shown by way of example for a stamping plant in Figure 2-11.



FIGURE 2-10. CALCULATION OF DIRECT LABOR DOLLARS



# FIGURE 2-11. SUMMARIZATION OF DIRECT LABOR DOLLARS BY BURDEN CENTER FOR A STAMPING PLANT

# Computation of Plant Burden Absorption Rate

The final step of the methodology is to calculate the plant burden absorption rate for each burden center. This is accomplished by dividing the manufacturing expenses allocated to each burden center by the direct labor applicable to each burden center. The resulting percentage is the plant burden absorption rate for each burden center. Separate burden rates are calculated for fixed/non-variable and variable expenses.

Figure 2-12 summarizes the methodology used in computing burden absorption rates as applied to a stamping plant. As shown, separate burden absorption rates are computed for:

- Large press
- Small press
- Repair
- Assembly.

In an engine plant separate burden absorption rates would be developed for the two final burden centers—machining and engine assembly—and the eight intermediate burden centers cylinder blocks, cylinder heads, crankshafts, camshafts, pistons, connecting rods and caps, intake and exhaust manifolds, and water and oil pumps. In a foundry, two separate burden centers would be developed—mold/casting and cleaning and one plant-wide burden would be developed for an assembly plant.



## FIGURE 2-12. CALCULATION OF STANDARD BURDEN ABSORPTION RATES

As described previously, when calculating standard product costs, the standard direct labor dollars incurred in manufacturing a product is multiplied by the standard burden absorption rate applicable to the burden centers through which the product was processed. This results in a dollar value for the manufacturing expenses or burden applicable to the product.

When a product is processed through multiple burden centers, the burden applicable to the product is computed for each burden center by applying the absorption rate for the burden center to the direct labor dollars incurred in processing the product through the burden center. Standard cost is determined by summing standard in-bound transportation, standard direct labor and standard plant burden.

#### SENSITIVITY OF PLANT MANUFACTURING BURDEN TO PRODUCTION VOLUME AND LEVEL OF AUTOMATION

This section presents information which demonstrates the effects that production volume and level of automation has on direct labor and plant manufacturing burden costs. It is important to study how burden rates may vary since this is one of the reasons for discrepancies in piece cost



# FIGURE 2-11. SUMMARIZATION OF DIRECT LABOR DOLLARS BY BURDEN CENTER FOR A STAMPING PLANT

## Computation of Plant Burden Absorption Rate

The final step of the methodology is to calculate the plant burden absorption rate for each burden center. This is accomplished by dividing the manufacturing expenses allocated to each burden center by the direct labor applicable to each burden center. The resulting percentage is the plant burden absorption rate for each burden center. Separate burden rates are calculated for fixed/non-variable and variable expenses.

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When a product is processed through multiple burden centers, the burden applicable to the product is computed for each burden center by applying the absorption rate for the burden center to the direct labor dollars incurred in processing the product through the burden center. Standard cost is determined by summing standard in-bound transportation, standard direct labor and standard plant burden.

## SENSITIVITY OF PLANT MANUFACTURING BURDEN TO PRODUCTION VOLUME AND LEVEL OF AUTOMATION

This section presents information which demonstrates the effects that production volume and level of automation has on direct labor and plant manufacturing burden costs. It is important to study how burden rates may vary since this is one of the reasons for discrepancies in piece cost estimates developed for identical components by different contractors. To illustrate this sensitivity, the manufacturing process, production volumes, direct labor manpower and plant manufacturing burden for a hood panel outer, hood panel inner, hood assembly and four-cylinder engine are described for the following scenarios:

- Hood panel outer and inner
  - Fully automated press line
  - Partially automated press line
  - Manually operated press line
- Hood assembly
  - Fully automated assembly operations
  - Manual assembly operations
- 4-Cylinder Engine
  - Non-automated manufacturing process
  - Automated manufacturing process

#### Hood Panel Outer and Inner and Hood Assembly

This section describes the manufacture of a hood panel outer, hood panel inner and hood assembly. All three parts are made in a stamping plant. The section is divided into the following parts:

- Description of Hood Panel Outer and Inner Manufacturing Scenarios
- Description of Hood Assembly Manufacturing Scenarios
- Calculation of Direct Labor and Plant Manufacturing Burden for Each Scenario.

Description of Hood Panel Outer and Inner Manufacturing Scenarics

Figures 2-13 and 2-14 graphically depict the manufacture of a hood panel outer and a hood panel inner respectively for the following three manufacturing methods:

• Fully Automated Press Line. This is depicted at the top of Figures 2-13 and 2-14. In a fully automated press line mechanical arms exist between each press for the transfer of the sheet metal stamping from one press to another thus eliminating





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the need for manpower between presses to load and unload the presses. The presses are equipped with automatic rolling bolsters for quick die changes, and mechanical transfer arms permit the maximum utilization of the presses' cycle time. Automatic die change features permit the changing of dies in five to ten minutes versus five to six hours for manual die changing.

- Partially Automatic Press Line. This is depicted in the center of Figures 2-13 and 2-14. In this type of operation mechanical arms are used for unloading the presses, but manpower is required for loading the presses. Dies are manually changed.
- <u>Manual Press Line</u>. This is depicted at the bottom of Figures 2-13 and 2-14. In a manual operation, manpower is used both to load and unload presses and to change dies.

For each manufacturing method, the figures show the manpower requirements and production rate. Note that the production volumes are higher when a fully automated manufacturing process is utilized.

#### Description of Hood Assembly Manufacturing Scenarios

In a similar fashion to Figures 2-13 and 2-14, Figure 2-15 graphically depicts two different approaches to hood assembly. The top part of the diagram depicts the automated approach to hood assembly common in the U.S. In this approach, the individual operations (i.e., adhesive application, corrosion spray, etc.) are automated but the transfer of parts from one operation to the next is manual.

The bottom part of the diagram depicts the manual approach to hood assembly common in Japan. In this approach, the manufacturing operation is manual, but the transfer of parts is made via a carousel. In Japan, hood assembly is normally carried out in the assembly plant geared to a single assembly line (i.e., the hood assembly line serves as a feeder line to the vehicle assembly line). Thus, the hood assembly and vehicle assembly lines have the same production rates--60 units per hour. In contrast, as shown in Figure 2-15, the production rate of hood assemblies in the U.S., using the automated approach is much higher since it is not tied to a specific assembly line. In the U.S., it is common





MANUAL



PCS PERHR. - 60

Z ASSY

Z I/SIDE PANFL

MANPOWER

FIGUPE 2-15. TWO DIFFERENT APPROACHES TO HOOD ASSEMBLY

I. O/SIDE PANEL ADHESIVE

2. CÓRROSION SPRAY 3. MARRIAGE 4. HEMMING FIXTURE 5. MANUAL WEL D 6. TURN OVER for a stamping plant to build and assemble hoods for more than one assembly line.\*

Calculation of Direct Labor and Plant Manufacturing Burden for Each Scanario

To demonstrate the sensitivity of direct labor and plant manufacturing burden to production volume and level of automation, Tables 2-2, 2-3 and 2-4 are provided, as follows:

- Table 2-2 calculates the burden absorption rates for a hood panel inner and a hood panel outer for each of the three manufacturing scenarios described earlier. Also provided are the total direct labor and annual production volume (bottom of table) from which piece cost estimates can be determined.
- Table 2-3 calculates the burden absorption rates for a hood assembly for each of the two manufacturing scenarios described earlier. As in Table 2-2, direct labor and annual production volume are also provided.
- Table 2-4 summarizes the direct labor and manufacturing burden costs per piece for a hood panel inner, hood panel outer and hood assembly for each scenario using the information provided on Tables 2-2 and 2-3.

Note that the absorption rates for the hood panel inner and hood panel outer were computed for a large press burden center and the hood assembly for the assembly burden center (i.e., the production departments in the plants where the parts are made).

The manufacturing expenses included in Tables 2-2, 2-3 and 2-4 are estimates based on the information presented in Figures 2-13, 2-14 and 2-15 and do not apply to any other manufacturing operations or components. The following significant effects on direct labor and burden are illustrated by the information contained in the Figures 2-13 through 2-15 and Tables 2-2 through 2-4:

• Direct labor and burden piece costs are the lowest and the burden absorption rates are the highest when a fully automated manufacturing process is utilized.

<sup>\*</sup> Using their approach, Japan is able to minimize inventory levels and costs.

TABLE 2-2. CALCULATION OF BURDEN ABSORPTION RATES FOR HOOD PANEL INNER AND OUTER

LARGE PRESS BURDEN CENTER

			TYPE OF	F PRESS LI	ZE				
	FULLY A	UTOMATED		PARTIALI	LY AUTOMATI	D	MANUP	IL I	
			EXPEI	NSE AMOUNT					
	FIXED & NON-VAR.	VARIABLE	TOTAL	FIXED & NON-VAR	VARIABLE	TOTAL	FIXED & NON-VAR	VARTABLE	тОТАТ.
DIRECT LABOR			\$2,240			\$5,100			\$7,340
INDIRECT LABOR									
SALARY HOURLY	\$1,559 1.517	\$776 2.915	\$2,3354.432	\$1,559 1.415	\$ 776 2.719	\$2,3354	\$1,559 1.415	\$ 776 2.719	\$2,335
FRINGE BENEFITS									1
SALARY-INDIRECT	549	277	826	549	277	826	549	277	826
HOURLY-INDIRECT	1,227	2,361	3,588	1,145	2,203	3,348	1,145	2,203	3,348
HOURLY-DIRECT		1,813	1,813		4,130	4,130		5,940	5,940
MAINTENANCE	571	476	1,047	532	445	677	511	423	934
PERISHABLE TOOLS	14	96	112	14	96	110	14	96	110
SPOILAGE & REWORK		1,106	1,106		1,084	1,084		1,084	1,084
FUEL	246	14	260	246	14	260	246	14	260
SUPPLIES	116	455	571	116	455	571	116	455	571
UTILITIES	876	139	1,015	784	122	906	767	98	865
OTHER EXPENSES	533	67	630	533	97	630	533	97	630
OVERTIME PREMIUM		27	77		171	171		171	171
TAZES & INSURANCE	1,022		1,022	829		829	757		757
PENSIONS	836	1,171	2,007	911	1,476	2,387	962	1,706	2,668
DEPRECIATION	21,900		21,900	19,395		19,395	16,785		16,785
WORKMENS COMP	108	126	234	108	170	278	118	202	320
TOTAL	\$31,074	\$11,901	\$42,925	\$28.136	\$14.235	\$42,371	\$25,477	\$18,261 \$	41.738
BURDEN &	1,387%	531%	1,918%	5528	279%	831%	3478	2228	569%
TOTAL DIRECT LABOR HOOD OUTER PANEL			\$59.500			000.1513		[ S	005 500
HUOD INNER PANEL ANNUAL VOLUME			45,000			104,000			49,000
HOOD OUTER FANEL HOOD INNEE PANEL			868,000 965,000			530,750 627 250		5	30,750
69 - C ( 01 6 53 5 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5			nontror			061170		2	1 11001 17

TABLE 2-3. CALCULATION OF BURE	DEN ABSOI	RPTION H	WATES FC	R HOOD-	ASSEMBLY	7	
HOOD ASSEMBLY							
	IYF	E OF LI					
	AL	TOMATE		~1	MANUAL		
		Ê	PENSE	AMOUNT			
	FIXED ≁ NON-VAR.	VARIA BLE	TOTAL	FIXED + NON-VAR.	VARIABLE	TOTAL	
DIRECT LABOR			\$139,000			\$ 61,830	
INDIRECT LABOR - SALARY	\$ 44,180	\$ 22,000	\$ 66,180	\$ 19,630	\$ 9,770	\$ 29,400	
- HOUALY FRINGE BENEFITS	40,000	77,000	117,000	17,830	34, 320	52,150	
INDIRECT - SALARY	15,400	7,760	23,160	6,840	3,450	10,290	
	32,400	62,370	94,770	14,440	27,800	42,240	
MAINTENANCE	15,360	112,590	28,180	6,840	50,080	50,080	
PERISHABLE TOOLS	066	2,810	3,200	170	1,240	1,410	
SPOILAGE → REWORK		31,260	31,260		019.61	069,61	
r uel Supplifs	0 \$ 6 , 9 4 0	400	7,340	0.100	170	3,270	
UTILITIES	3,240	12,760	16,000	1,460	5,740	7,200	
OTHER EXPENSES	11,500	2,500	16,000	6,015	1,115	1,130	
		5,000	5,000		2,200	2,200	
	14,700		14,700	3,470		3,470	
PE NOIONS	36,420	43,580	80,000	16, 300	19,540	35,040	
	294,000		294,000	69,400		69,400	
WORNMENS COMP.	4,150	4,850	000'6	1,840	2,160	• • 000	
	\$ 543,210	\$ 401, 340	944,550	\$ 177,375	178,855	156,230	
ANNUAL WOLLINE	1166	2891	6801	2871	2891	5761	
ANNUAL VULUME			597,600			119,520	
						•	

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TABLE 2-4. SUMMARY OF DIRECT LABOR AND BURDEN COSTS PER PIECE HOOD PANEL INNER, HOOD PANEL OUTER AND HOOD ASSEMBLY

OR												
TOTAL DIRECT LAB & BURDEN	\$1.41	2.33	2.41		1.01	1.58	1.60				1.80	3.52
TOTAL	\$1.34	2.08	2.05		.96	1.41	1.36				1.57	3.00
COSTS VAR.	\$ .37	.70	.80		.27	.47	• 5 3				06.	1.50
 BURDEN F.N.V.	76.\$	1.38	1.25		.69	.94	. 83				.67	1.50
TOTAL	1,918%	831%	569%		1,918%	831%	569%				680%	576%
KATE VAR.	531%	279%	222%		531%	279%	222%				391%	287%
BURDEN F F.N.V.	l,387%	552%	347%		1,387%	552%	347%				289%	289%
DIRECT LABOR	\$ .07	.25	.36		. 05	.17	.24				.23	. 52
	HOOD - OUTER PANEL FULLY AUTOMATED	PARTIALLY AUTOMATED	MANUAL	HOOD - INNER PANEL	FULLY AUTOMATED	PARTIALLY AUTOMATED	MANUAL	TOTAL DIRECT LABOR	ANNUAL PRODUCTION	HOOD ASSEMBLY	AUTOMATED	MANUAL

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 Fixed expenses are higher and direct labor is lower when a fully automated manufacturing process is utilized.

Note that piece cost estimates (direct labor plus burden) can vary by as much as 95 percent depending on the production volume and manufacturing operation.

It should also be noted that when the production volume required is less than can be obtained from utilizing a fully automated manufacturing process, the direct labor and manufacturing burden piece costs would increase significantly due to the under-utilization of the available production capacity.

## 4-Cylinder Engine

In a similar manner to the hood panel inner/outer and hood assembly, Tables 2-5 through 2-8 and Figure 2-16 describe the sensitivity of direct labor and plant manufacturing burden to production volume and level of automation as follows:

- Table 2-5 compares the manpower requirements for two different approaches to manufacturing a 4cylinder engine—a non-automated approach and an automated approach
- Figure 2-16 provides explanations for the differences in manpower requirements for the two approaches shown in Table 2-5
- Tables 2-6 and 2-7 calculate the burden absorption rates associated with the non-automated and automated processes of manufacturing a 4-cylinder engine, respectively
- Table 2-8 summarizes the direct labor and burden costs per engine using the information provided on Tables 2-6 and 2-7.

Again, the manpower and manufacturing expenses included in Tables 2-6, 2-7 and 2-8 are estimates based on the engine machining processes described in Figure 2-16 and do not apply to any other manufacturing operations or components.

Note that separate burden rates are calculated in Tables 2-6 and 2-7 for the eight intermediate burden centers (cylinder blocks, cylinder heads, crankshafts, camshafts, pistons, connecting rods and caps, intake/exhaust manifolds and water/oil pumps) and two final burden centers (machining and assembly). As in the previous example, the following

# TABLE 2-5. COMPARISON OF MANPOWER REQUIREMENTS FOR NON-AUTOMATED AND AUTOMATED 4-CYLINDER ENGINE MANUFACTURING PROCESSES

	MANUFACTURIN	G PROCESS	
PRODUCTIVE DEPARTMENT	NON-AUTOMATED	AUTOMATED	MANPOWER DECREASE
Cylinder Blocks	88	66	22
Cylinder Heads	64	48	16
Crankshafts	93	70	2 3
Camshafts	73	56	17
Pistons	21	16	5
Connecting Rods & Caps	56	42	14
Intake/Exhaust Manifolds	37	28	9
Water & Oil Pumps	56	42	14
Total Machining	488	368	120
Assembly & Testing	387	296	91
Total Direct Labor	875	664	211
Indirect Labor - Hourly	645	484	161
- Salary	330	256	74
Total Indirect Labor	975	740	235
Total Manpower	1,850	1,404	446
Total Hours Per Engine	8.88	6.74	2.14

HIGH SPEED MACHINING LATHES AND GRINDERS FOR CONNECTING ROD AND HIGH SPEED MACHINING AND GRIND-SECTIONS TO COMPENSATE FOR ANY AUTOMATIC GAGING AND ASSEMBLY MATIC INSPECTION STATIONS FOR HIGH SPEED TRANSFER LINE WITH ING FACILITIES WITH AUTOMATIC ONE SECTION BEING DOWN. AUTO-LOADED AND TRANSFERED BETWEEN HIGH SPEED TRANSFER LINE WITH IN BANKING BETWEEN ALL MAJOR CYLINDER BORES AND AUTOMATED SPEED OIL HOLE DRILLING. ALL OPERATIONS ARE AUTOMATICALLY LOAD, INSPECTION AND GAGING MAIN BEARING JOURNALS. HIGH MECHANICAL SPEEDS & FEEDS. OF CONNECTING RODS & CAPS. MECHANICAL SPEEDS & FEEDS. ASSEMBLY FOR BEARING CAPS. AUTOMATED OPERATIONS. EQUIPMENT. CONNECTING ROD AND BLOCK MACHINING PROCESS AND ASSEMBLY ø 22 MEN **CRANKSHAF**'F **23 MEN** 14 MEN MACHINING 5 MEN ASSEMBLY PISTONS 1 1 CAP MAIN BEARING. HIGH SPEED OIL HOLE ALL MANUAL INSPECTION OPERATIONS DRILLS, ALL MANUALLY LOADED AND GRINDERS FOR CONNECTING ROD AND HIGH SPEED MACHINING LATHES AND MECHANICAL SPEEDS AND FEEDS.NO MANUAL ASSEMBLY OF WELSH PLUGS TRANSFERED BETWEEN OPERATIONS. HIGH SPEED TRANSFER LINE WITH HIGH SPEED TRANSFER LINE WITH IN-LINE BANKING STATIONS AND OF CONNECTING RODS AND CAPS. MANUAL GAGING AND ASSEMBLY AUTOMATIC GAGING EQUIPMENT. MECHANICAL SPEEDS & FEEDS. NON-AUTOMATED HIGH SPEED MACHINING AND GRINDING FACILITIES WITH AND MAIN BEARING CAPS.

AUTOMATED AND AUTOMATED 4 CYLINDER ENGINE MANUFACTURING PROCESSES FIGURE 2-16. EXPLANATION OF DIFFERENCES IN MANPOWER REQUIREMENTS FOR NON-

FIGURE 2-16. EXPLANATION OF DIFFERENCES IN MANPOWER REQUIREMENTS FOR NON-AUTOMATED AND AUTOMATED 4 CYLINDER ENGINE MANUFACTURING PROCESSES

	АИТОМАТЕD	HIGH SPEED LATHES AND GRINDERS WITH AUTOMATIC LOADERS AND AUTOMATICALLY TRANSFERED BETWEEN OPERATIONS.	HIGH SPEED TRANSFER LINE WITH MECHANICAL SPEEDS AND FEEDS. IN LINE AUTOMATIC BANKING STATIONS AUTOMATIC INSPECTION STATIONS AND PARTIALLY AUTOMATIC HEAD ASSEMBLY.	HIGH SPEED TRANSFER LINES WITH MECHANICAL SPEEDS AND FEEDS. ALL AUTOMATIC LOAD AND UNLOAD FACILITIES.	ENGINE ASSEMBLY WITH SUBSTANTIAL AUTOMATIC ASSEMBLY DEVICES.	AUTOMATIC TESTING WITH COMPLETE DIAGNOSTIC FACILITIES.		
סיוטייטי	PROCESS	CAMSHAFT AND ACCESSORY SHAFTS - 17 MEN	CYLINDER HEADS - 16 MEN	INTAKE/EXHAUST MANIFOLDS - 9 MEN	ASSEMBLY - 77 men	TESTING - 7 MEN	ALL OTHER - 21 MEN	
E W	NON-AUTOMATED	HIGH SPEED LATHES AND GRINDERS ALL MANUALLY LOADED AND TRANS- FERED BETWEEN OPERATIONS.	HIGH SPEED TRANSFER LINE WITH MECHANICAL SPEEDS AND FEEDS. MANUAL INSPECTION AND CYLINDER HEAD COMPONENT ASSEMBLY. MANUAL IN-LINE BANKING STATIONS.	HIGH SPEED TRANSFER LINE WITH MECHANICAL SPEEDS AND FEEDS. ALL MANUAL LOAD AND UNLOAD.	ENGINE ASSEMBLY WITH NO MAJOR AUTOMATION. PRINCIPALLY MANUAL ASSEMBLY.	SEMI-AUTOMATIC TESTING		

BECAUSE OF IMPROVED MACHINE REDUCED MAINTENANCE REPAIR INSPECTION BECAUSE OF MORE REDUCED MATERIAL HANDLING HANDLING, INSPECTION AND ENGINEERING, CONTROLLER, MANPOWER RESULTING FROM MORE AUTOMATIC TRANSFER REDUCED QUALITY CONTROL REDUCED SUPERVISION OF DIRECT LABOR, MATERIAL CONVEYORS AND DEVICES. MAINTENANCE MANPOWER. AUTOMATIC INSPECTION PERSONNEL AND OTHER REDUCED INDUSTRIAL CLERICAL MANPOWER. AUTOMATED DIAGNOSTICS. STATIONS. • • • • • TOTAL REDUCTION INDIRECT LABOR INDIRECT LABOR PROCESS - 161 MEN - 446 MEN - 74 MEN HOURLY SALARY NON-AUTOMATED

FIGURE 2-16. EXPLANATION OF DIFFERENCES IN MANPOWER REQUIREMENTS FOR NON-AUTOMATED AND AUTOMATED 4 CYLINDER ENGINE MANUFACTURING PROCESSES

 TABLE 2-6.
 CALCULATION OF BURDEN ABSORPTION RATES 

 4-CYLINDER ENGINE NOW-AUTOMATED HANJFACTURING PROCESS

					(\$000				a de la segura de la segura de				
BURDEN				BURDEN	C	ENTERS		ALI	LOCATION				
CATEGORY	FIXED & NON-VAR.	VARI- ABLE	TOTAL	CYL. BLOCK	CYL. HEAD	CRANK SHAFT	CAM- SHAFT	PISTONS	CONN. KODS	INT/ EXH.	WATER DIL PUMPS	TOTAL MACH- INING	ASSY. & TEST
INDIRECT LABOR SALARY HOURLY	\$ 4,711 3,108	\$4,019 8,120	\$8,730 11,228	\$1,632 1,099	\$1,080 810	\$1,227 1,244	\$ 708 926	\$ 289 266	\$ 738 720	\$ 296 : 464	\$345 \$ 703	6,315 6,242	\$2,415 4,986
FRINGE BENEFITS SALARY-INDIRECT	1,639	1,398	3,037	302	222	326	254	73	195	127	192	1,691	1,346
HOURLY-INDIRECT	2,437	6,367	8,804	876	644	944	735	212	566	368	557	4,902	3,902
HOURLY-DIRECT		11,073	11,073	1,101	810	1,188	924	266	711	463	703	6,166	4,907
MAINTENANCE	920	2,239	3,159	766	480	500	230	67	289	94	79	2,535	624
PERISHABLE TOOLS	;	2,447	2,447	614	385	401	185	78	222	76	62	2,033	414
SPOILAGE & REWORK	1	2,107	2,107	529	332	345	159	67	200	65	54	1,751	356
FUEL	1,847	484	2,331	529	332	345	159	67	200	65	54	1,751	580
SUPPLIES	192	1,152	1,344	332	208	216	100	42	126	41	35	1,100	244
UTILITIES	2,215	1,943	4,158	677	612	638	294	124	369	120	100	3,234	924
OTHER	1,643	520	2,163	492	309	322	148	63	186	61	50	1,631	532
OVERTIME PREMIUM	348		348	44	32	48	38	11	28	19	28	248	100
PENSIONS & INS.	9,217	1	9,217	917	674	989	770	221	592	385	585	5,133	4,084
TAXES	1,700	ł	1,700	427	268	279	128	54	161	52	44	1,413	287
DEPRECIATION	16,123	-	16,123	4,047	2,537	2,641	1,217	515	1,527	498	412 1	3,394	2,729
WORYMENS COMP.	2,023		2,023	201	148	217	169	49	130	85	128	1,127	896
DIRECT LABOR	248,123	\$41,869	\$13,754	\$14,885 \$1,368	\$9,883\$	11,870	\$7,144	\$2,494 \$330	\$6,970\$ \$ 883	3,279\$4	,131\$( 872 \$	60, 666 \$ 7, 659	29, 326 <u>\$6, 095</u>
BUPDEN ABSOPPTION PATE	350%	3043	6543	1,089%	9818	80.48	622%	7528	789%	569%	47.18	7928	481%

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TABLE 2-7. CALCULATION OF BURDEN ABSORPTION RATES -4-CYLINDER ENGINE AUTOMATED MANUFACTURING PROCESS

& TEST 2,930 3,742 1,048 532 117 3,100 338 3,212 \$1,946 3,704 656 428 352 580 252 972 681 535% ASSY. \$6,440 \$2,867 3,439 56,160 \$24,590 \$ 435 \$ 654 \$5,777 \$ 4,600 3,680 4,650 INING 1,632 \$5,030 2,143 1,755 1,751 1,132 3,394 147 855 4,688 1,316 3,894 MACH-2,659 1,662 15,772 972% TOTAL ALLOCATION 276 527 486 149 416 528 106 50 51 17 441 98 WATER PUMPS 83 67 54 54 36 525% OIL ŝ 237 349 99 277 350 126 /TNI MAN. 99 80 65 65 42 12 293 62 586 64 658% 61 ЕХН ŝ CONN. 589 \$663 RODS 548 129 186 446 1,798 970% 422 533 303 244 200 200 387 17 189 98 151 S PISTONS 232 200 130 170 606 \$2,289 \$252 57 160 202 83 67 67 43 37 908% 102 63 9 64 CENTERS S SHAFT CAM-696 725% \$567 709 195 160 159 308 148 1,434 \$80,750 \$14,340 \$9,410 10,996 6,379 103 22 594 130 201 561 241 151 \$ 881 3,110 SHAFT 346 345 223 669 28 749 328 164 \$ 755 \$1,111 989% 977 934 708 894 524 322 253 422 CRANK ŝ 1,246% 858 2,987 609 643 309 19 509 315 (000\$) 607 504 406 333 332 214 112 172 481 HEAD CYL. ŝ BURDEN BLOCK 1,396% 4,765 \$1,294 825 655 530 529 493 26 692 \$10,377 \$ 1,027 827 803 646 342 502 **15**2 234 1,025 CYL. 1,536 8,430 2,364 6,610 8,354 3,315 2,571 2,107 2,331 1,384 4,366 2,164 264 6,994 2,000 18,984 \$6,976 TOTAL 778% VARI-ABLE 6,096 1,057 4,780 8,354 2,107 520 \$3,039 2,571 1,184 \$34,582 2,351 484 2,039 333% 1 ł 1 Plant NON-VAR. FIXED & \$46,168 2,334 1,307 1,830 200 2,327 2,000 1,847 1,644 6,994 1,536 264 18,984 \$3,937 964 1 1 445% Total BURDEN HOURLY-INDIRECT BURDEN ABSORPTION SALARY-INDIRECT SPOILAGE & REWORK PERISHABLE TOOLS OVERTIME PREMIUM FRINGE BENEFITS HOURLY-DIRECT PENSIONS & INS. INDIRECT LABOR WORKMENS COMP. DEPRECIATION DIRECT LABOR MAINTENANCE CATEGORY UTILITIES SUPPLIES SALARY HOURLY OTHER TAXES RATE FUEL

SUMMARY OF DIRECT LABOR AND BURDEN COSTS PER ENGINE TABLE 2-8.

			NON-AUTOM	ATED			AUTOMA	TED			
		DIRECT		BURDE	Z	LABOR &	DIRECT	BU	R D E 1	Z	LABOR &
BURDEN CENTERS		LABOR	F.N.V.	VAR.	TOTAL	BURDEN	LABOR	F.N.V	VAR.	TOTAL	BURDEN
Cylinder Blocks	-Cost -Rate	\$3.42	\$21.51 629%	\$15.73 460%	\$37.24 1,089%	\$40.66	\$ 2.57	\$22.13 861%	\$13.74 535%	35.87 1,396%	\$38.44
Cylinder Heads	-Cost -Rate	2.52	14.11 560%	10.61 421%	24.72 981%	27.24	1.89	14.36 760%	9.18 486%	23.54 1,246%	25.43
Crank Shafts	-Cost -Rate	3.69	16.36 443%	13.33 361%	29.69 804%	33.38	2.78	16.21 583%	11.29 406%	27.50 989%	30.28
Camshafts	-Cost -Rate	2.87	9.42 328%	8.45 294%	17.87 622%	20.74	2.20	8.98 408%	6.98 317%	15.96 725%	18.16
Pistons	-Cost -Rate	. 83	3.45 416%	2.79 336%	6.24 752%	7.07	.63	3.38 537%	2.34 371%	5.72 908%	6.35
Conn.Rods & Caps	-Cost -Rate	2.21	9.63 436%	7.80 353%	17.43 789%	19.64	1.66	9.50 572%	6.61 398%	16.11 970%	17.77
Intake/Exhaust Manifolds	-Cost -Rate	1.44	4.22 293%	3.98 276%	8.20 569%	9.64	1.09	3.93 361%	3.24 297%	7.17 658%	8.26
Water/Oil Pumps	-Cost -Rate	2.18	5.05 231%	5.29 243%	10.34	12.52	1.64	4.44 271%	4.16 254%	8.60 525%	10.24
Total Machining	-Cost -Rate	19.16	83.76 437%	67.98 355%	151.74 792%	170.90	14.48	82.94 574%	57.53 398%	140.47 972%	154.92
Assembly & Test	-Cost -Rate	15.25	36.60 240%	36.75 241%	73.35 481%	88.60	11.50	32.54 283%	28.97 252%	61.51 535%	72.93
Total Plant	-Cost Rate	\$34.41	\$120.36 350%	\$ 104.73	\$225.09	\$259.50	\$25.96	\$115.48 445%	\$86.50	\$201.98 778%	\$227.94
Annual Productio	n Volume			399,840						399,840	

significant effects on direct labor and burden are illustrated by the information contained in the tables:

- Direct labor and burden piece costs are the lowest and burden absorption rates are the highest when an automated manufacturing process is utilized.
- Fixed expenses are higher and direct labor is lower when an automated manufacturing process is utilized.

The important point of the tables, however, is that total piece cost (labor plus burden) can vary by as much as 22 percent depending on the production volume and manufacturing process assumed.

# 3. DESCRIPTION OF THE AUTOMOTIVE INDUSTRY'S USE OF COMPETITIVE VEHICLE TEARDOWN STUDIES

The automotive industry has for many years used competitive vehicle teardown studies as a basis for comparative value analysis. This chapter of the report describes:

- The objectives of the teardown studies conducted by the automotive industry
- The methodology employed by the automotive industry in performing these teardown studies
- The analysis and use of the vehicle teardown study data by the automotive industry

## OBJECTIVES OF TEARDOWN STUDIES CONDUCTED BY THE AUTOMOTIVE INDUSTRY

Competitive vehicle teardown studies consist of a part by part dismantling of two or more competitive vehicles and a comparison of the parts, components and assemblies of these vehicles in terms of product design, manufacturing process, variable manufacturing costs and weight. The objective of the studies is to provide information for use in planning, styling, engineering and manufacturing competitive vehicles.

## METHODOLOGY EMPLOYED BY THE AUTOMOTIVE INDUSTRY IN PERFORMING VEHICLE TEARDOWN STUDIES

In performing the vehicle teardown studies defined above, the auto industry essentially follows a three step approach:

- In the first step, the manufacturer conducting the study selects one of its vehicles and one or more comparable vehicles of competing manufacturers for the teardown study.
- In the second step, preliminary data are collected on the vehicles. This involves photographing and weighing the vehicles intact.

• In the third and final step, the vehicles are dismantled so that the design and weight of various parts, components and assemblies can be determined.

In carrying out this third and final step, the vehicles are dismantled into twenty basic components, as follows:

- Seats
- Trim panels
- Carpets
- Headlining
- Instrument panels
- Glass
- Engine electrical
- Transmission
- Torque converter
- Rear axle
- Suspension
- Drive shafts
- Wheels
- Tires
- Ornamentation
- Grills
- Bumpers
- Lamps
- Cross members.

This leaves the body with integral sealers, sound deadening and paint which is weighted. The above components are also weighed, further disassembled and then weighed again.

In addition to the above, sections are cut into one side of the vehicle to reveal construction of roof rails, headers, "A" post, "B" post, roof, doors, hood, deck, etc. The other side of the vehicle is left intact. Comparable disassembled parts of the teardown vehicles are mounted in the following major groups:

- Body
- . Glass
- Ornamentation
- Instrument panel
- Grille and lamps
- Interior trim
- Chassis
- Engine
- Electrical
- Brakes
- Wheels and tires

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- Transmission
- Drive components
- Suspension
- Other.

The compariable vehicle parts are then compared in terms of design and weight.

## ANALYSIS AND USE OF THE VEHICLE TEARDOWN STUDY DATA BY THE AUTOMOTIVE INDUSTRY

Using the design/weight data from the vehicle teardown studies, cost estimates of material, labor and variable burden are prepared for each part being compared. This is done on the basis that all parts under comparison were manufactured in the same facility and that the manufacturing processes were at the same level of automation and were produced in the same volume.

For comparison purposes, the vehicle of the manufacturer conducting the teardown study is considered to be the base vehicle. The cost and weight estimates of the competitors' parts are then compared with the cost and weight estimates of the base vehicle parts to determine whether a differential exists. Summary charts comparing the cost and weights of the comparable parts are also prepared for the following major groupings:

- Body
- Instrument panel
- Chassis
- Brakes
- Drive components
- Glass
- Grill and lamps
- Engine
- Wheels and Tires
- Suspension
- Ornamentation
- Interior trim
- Electrical
- Transmission
- Other.

As the final step in the analysis, the product planning, styling, product engineering and manufacturing groups of the company review the cost and weight comparisons and examine the mounted parts to determine potential product improvement, cost and/or weight reduction areas. Further studies are made by these groups to determine the feasibility and desirability of making changes in product design and/or manufacturing processes to produce competitively priced vehicles and still retain features that will meet or beat competitors' products. In conducting all studies, consideration is given to the effect required changes will have on manufacturing facilities and processes and on other components or systems of the vehicle.

Upon agreement with all involved groups, changes are targeted for implementation either in the current model year as engineering changes and/or manufacturing process changes for incorporation in future model product plans.

# 4. <u>RECOMMENDED GUIDELINES FOR USE OF TEARDOWN</u> STUDY DATA IN WEIGHT REDUCTION PROGRAMS

As mentioned in the introduction, the U.S. Department of Transportation currently has contracts to have domestically built cars and trucks dismantled and estimates of tooling, material and processing costs prepared for selected components. Cost and weight analyses are also prepared for these components and for substitute light weight materials. The purpose of these studies is to identify cost justified weight reduction potentials. The problem is that assumed production volumes, manufacturing processes and a breakdown of processing costs into direct labor and burden elements are not provided to support the cost estimates. Consequently, whether these weight reduction potentials are truly cost effective cannot be completely ascertained.

This chapter of the report presents guidelines recommended for use by DOT/TSC contractors when performing teardown studies in support of vehicle weight reduction analyses. The guidelines are based on information presented previously in Chapters 2 and 3 of this report, and if implemented, should result in an improvement in the conduct of existing and future studies. The chapter is divided into the following parts:

- Restatement of the problem
- Summary of recommended guidelines.

#### RESTATEMENT OF THE PROBLEM

If the two estimates were based on the same volumes and manufacturing processes using the same level of automation the difference would be the cost savings or penalty to manufacture the component from different materials in similar manufacturing environments. The reduction in weight of the component could be translated into a decrease in fuel consumption. Thus weight reduction potentials could be identified for further study. However, without details of the production volumes, manufacturing process, direct labor and burden costs, a meaningful comparison of the teardown cost estimate with a manufacturer's cost cannot be made and differences cannot be reconciled.

#### SUMMARY OF RECOMMENDED GUIDELINES

First, it is recommended that the teardown contractor and the U.S. Department of Transportation agree on the cost elements to be included in the calculation of plant manufacturing burden. The following are examples of the type of expenses that should be included:

- Indirect labor and related fringe benefits for the following non-productive departments which support productive departments:
  - Plant manager's office
  - Controller
  - Industrial engineering
  - Quality control
  - Manufacturing engineering
  - Personnel
  - Resident engineering
  - Production.
- Manufacturing expenses
  - Maintenance
  - Perishable tools
  - Spoilage and rework
  - Fuel
  - Supplies
  - Overtime premium
  - Utilities
  - Other expenses.
- Fixed Expenditures
  - Taxes real estate and personal property
  - Insurance property plant and equipment
  - Depreciation buildings, machinery, equipment, furniture and fixtures.

Second, it is recommended that the teardown contractor's piece cost estimate be supported by details of production volume; description of manufacturing process; direct labor manpower; and hourly pay rate and number of annual work days per man. Piece cost estimates should be detailed as to direct labor, fixed and non-variable burden, variable burden and productive materials. Figures 4-1 and 4-2 are examples of the type of cost estimate and manufacturing process sheets that should be submitted in support of each piece cost estimate.

MANUFACTURING PROCESS SHEET	OMPONENT: MANUFACTURING OPERATIONS	ESCRIPTION I DIAGRAM (IDENTIFY OPERATIONS, MANFOWER, HOURLY PRODUCTION KATE, AND LEVEL OF AUTOMATION)
	COMPC	DESCI 1. 5. 7.

FORMAT FOR RECOMMENDED MANUFACTURING PROCESS SHEET FIGURE 4-1.

COST ESTIMATE SHEET	
PART DESCRIPTION:	DATE:
MATERIAL SPECIFICATIONS:	VEHICLE:
TYPE:	
BLANK SIZE:	
WEIGHT: GROSS: NET:	MANUFACTURING PROCESS:
PRODUCTION SPECIFICATIONS:	(DETAILS ATTACHED)
ANNUAL VOLUME:	
PRODUCTION RUN:	
PRESS LINE SIZE:	
PRESSES PER LINE:	
PIECE COST ESTIMATE	
MATERIAL:	COST PER LB.
DIRECT LABOR:	MINUTES PER PIECE: HOURLY WAGE RATE:
BURDEN - VARIABLE:	\$ OF DIRECT LABOR:
FIXED & NON-VARIABLE	% OF DIRECT LABOR:
TOTAL BURDEN:	% OF DIRECT LABOR:
NOTE: BURDEN SHOULD ONLY INCLUDE MANUFACTURING EXPENSES	S INCURRED AT THE PLANT LEVEL.SELLING,
GENERAL AND ADMINISTRATIVE, PRODUCT DEVELOPMENT,	MANUFACTURING AND PROCUREMENT,
AMORTIZATION OF SPECIAL TOOLS AND IN-BOUND TRANSE	PORTATION SHOULD NOT BE INCLUDED
IN BURDEN.	
FIGURE 4-2. FORMAT FOR RECOMMENDED (	COST ESTIMATE SHEET

Finally, it is recommended that further study be conducted when a comparison of the cost and weight estimates for the teardown component and the component manufactured from lighter weight materials indicates a cost justified weight reduction potential. This study should determine the effect the change in materials has on:

- The manufacturing facilities and processes
- The weight distribution of the vehicle;
- The structural strength of the new component and of the vehicle as a whole.

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# APPENDIX - REPORT OF NEW TECHNOLOGY

The work performed under this contract, while leading to no new inventions, has led to recommendations for more effective use of vehicle teardown study data in automotive weight reduction studies and cost analysis.

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