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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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August 1983
Final Report

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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.

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METRIC CONVERSION FACTORS

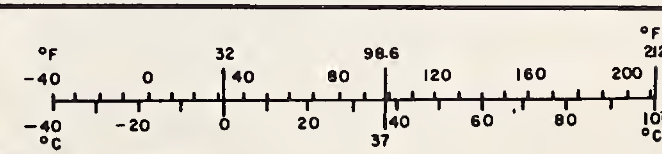
Approximata Conversions to Metric Measuras

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	squsrs centimeters	cm^2
ft^2	squars fsst	0.09	square metsrs	m^2
yd^2	squere yards	0.8	square meters	m^2
mi^2	squsre miles	2.6	squere kilometers	km^2
	ecrss	0.4	hectarss	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teespoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gellons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit tempereture	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measuras

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectarss (10,000 m^2)	2.5	scres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (axact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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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.

<u>Cost of Products Sold and Other Operating Charges</u>

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.

<u>Standard Product Costs</u>

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.)

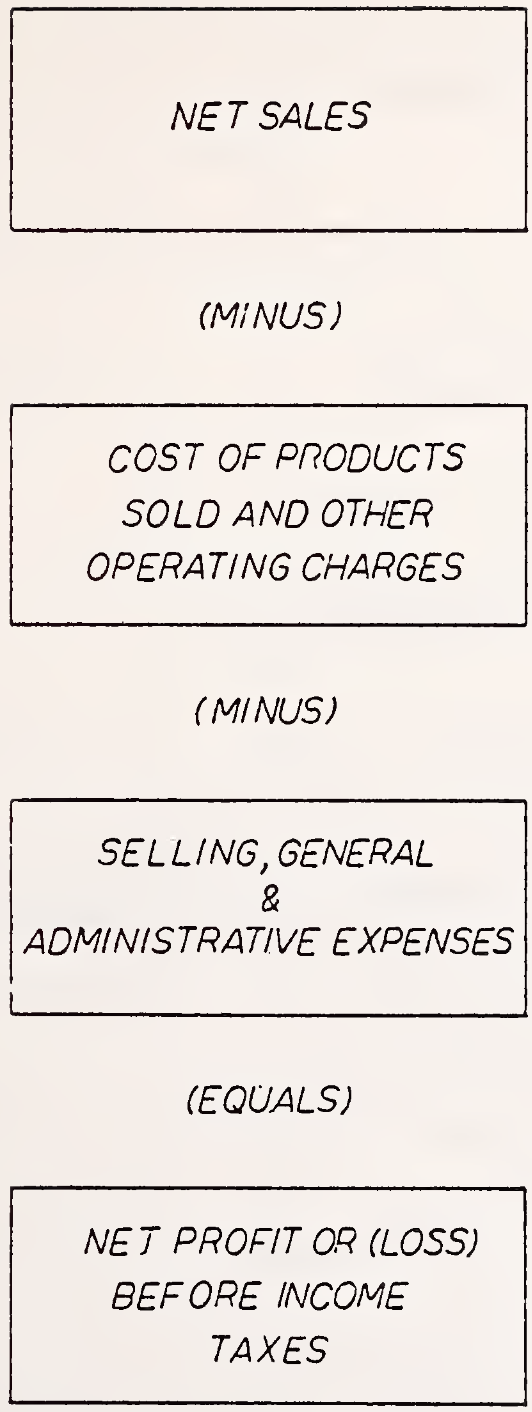

FIGURE 2-1. ELEMENTS OF A TYPICAL MANUFACTURING COMPANY'S INCOME STATEMENT

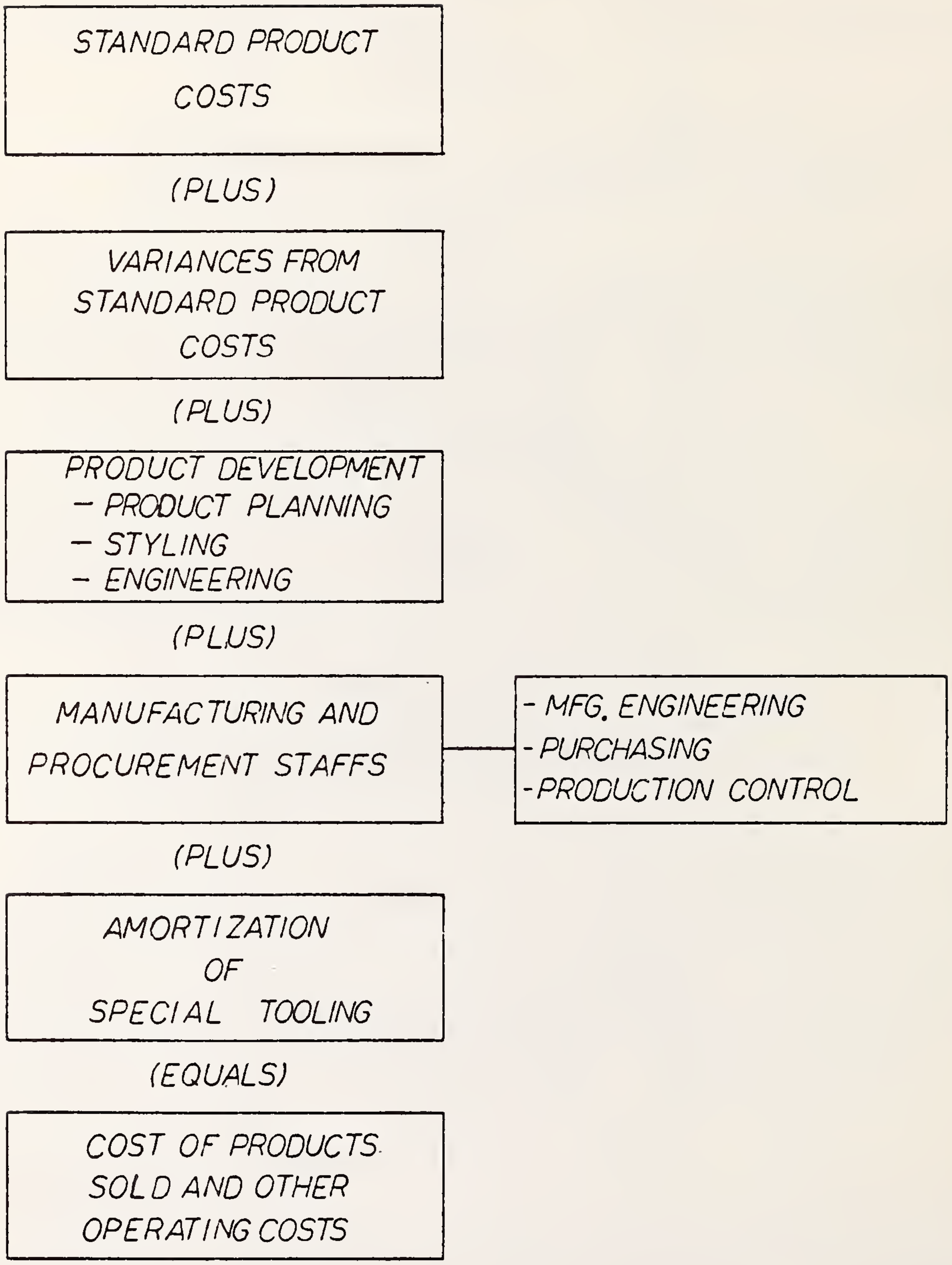

FIGURE 2-2. ELEMENTS OF COSTS OF PRODUCTS SOLD AND OTHER OPERATING CHARGES

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

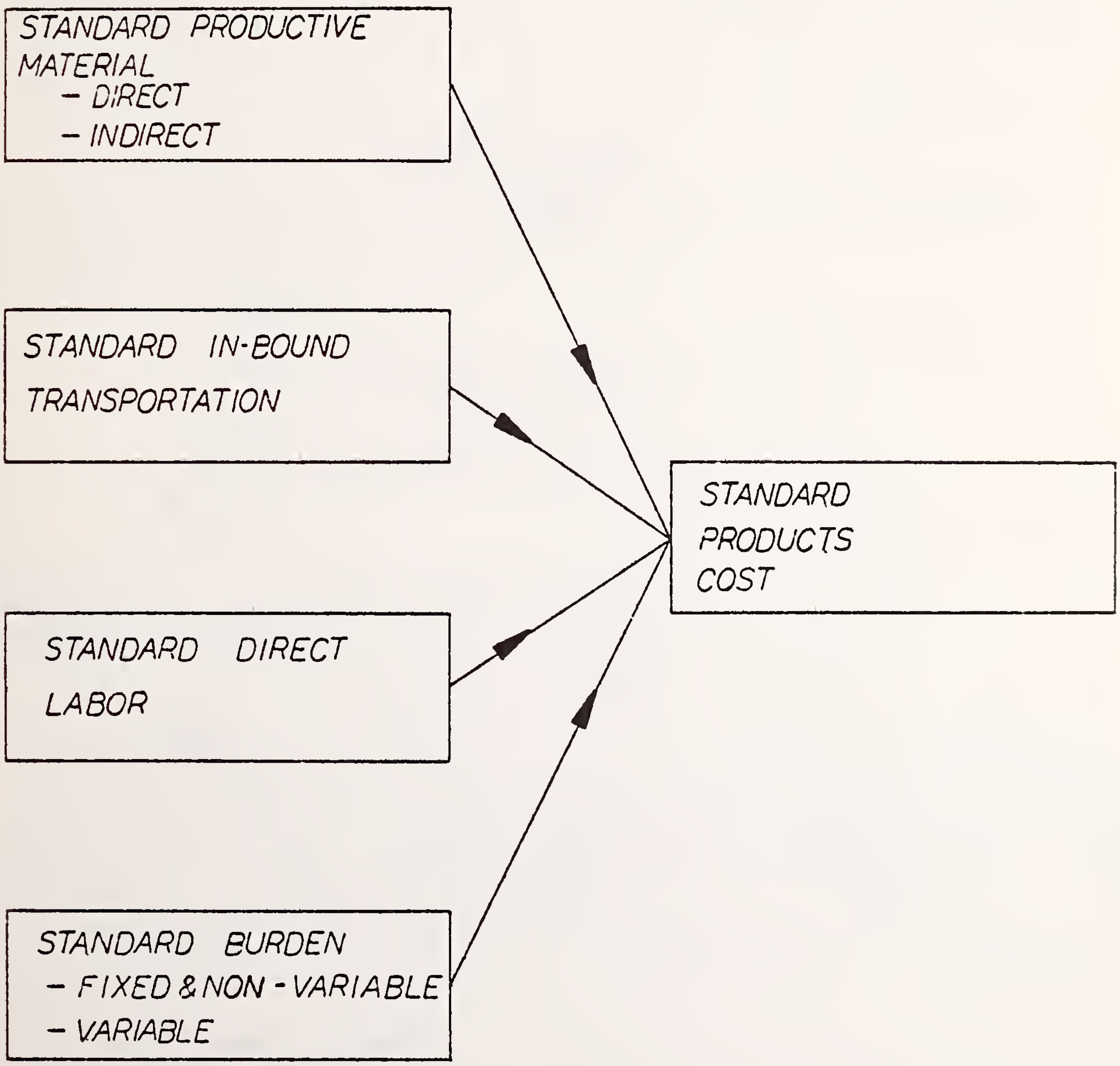

FIGURE 2-3. ELEMENTS OF STANDARD PRODUCT COSTS

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.

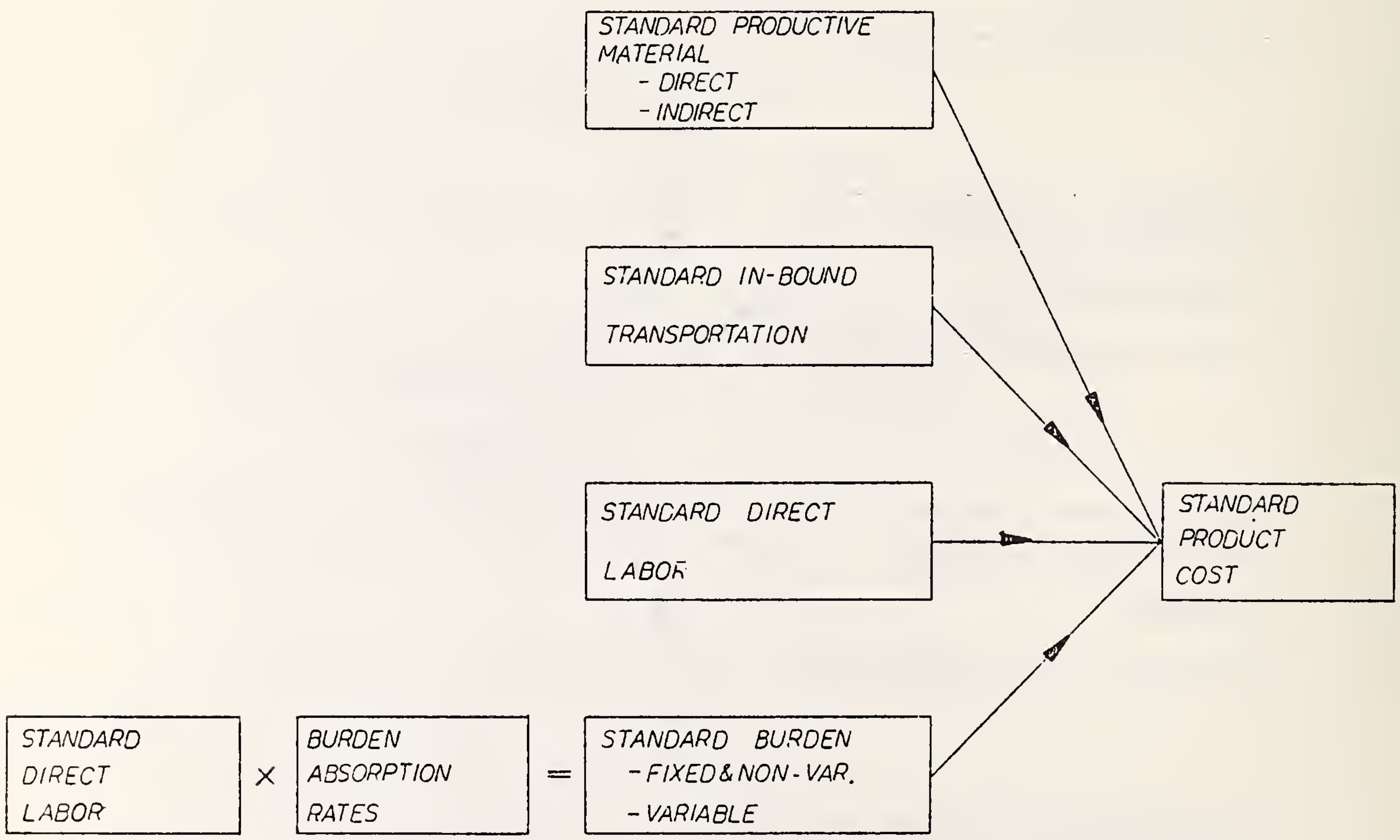

FIGURE 2-4. APPLICATION OF PLANT BURDEN RATE TO STANDARD PRODUCT COSTS

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

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* 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.

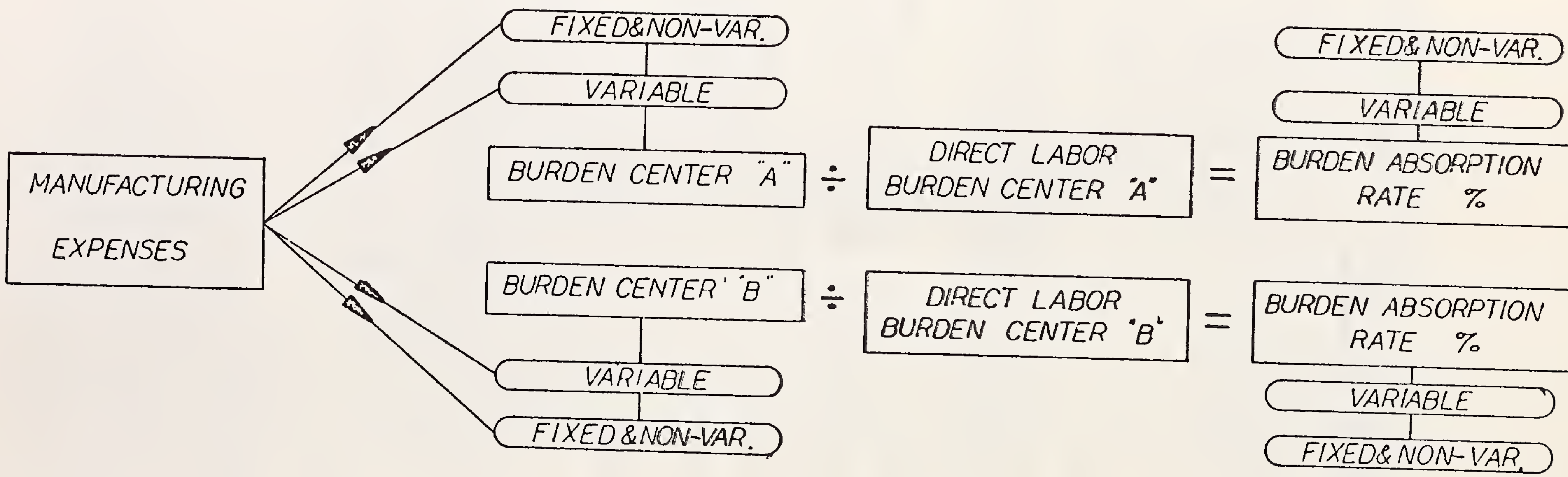


FIGURE 2-5. METHODOLOGY EMPLOYED IN DEVELOPING PLANT BURDEN ABSORPTION RATES

- 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.

TABLE 2-1. MANUFACTURING EXPENSES BY EXPENSE CATEGORY

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

* 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 non-productive 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.

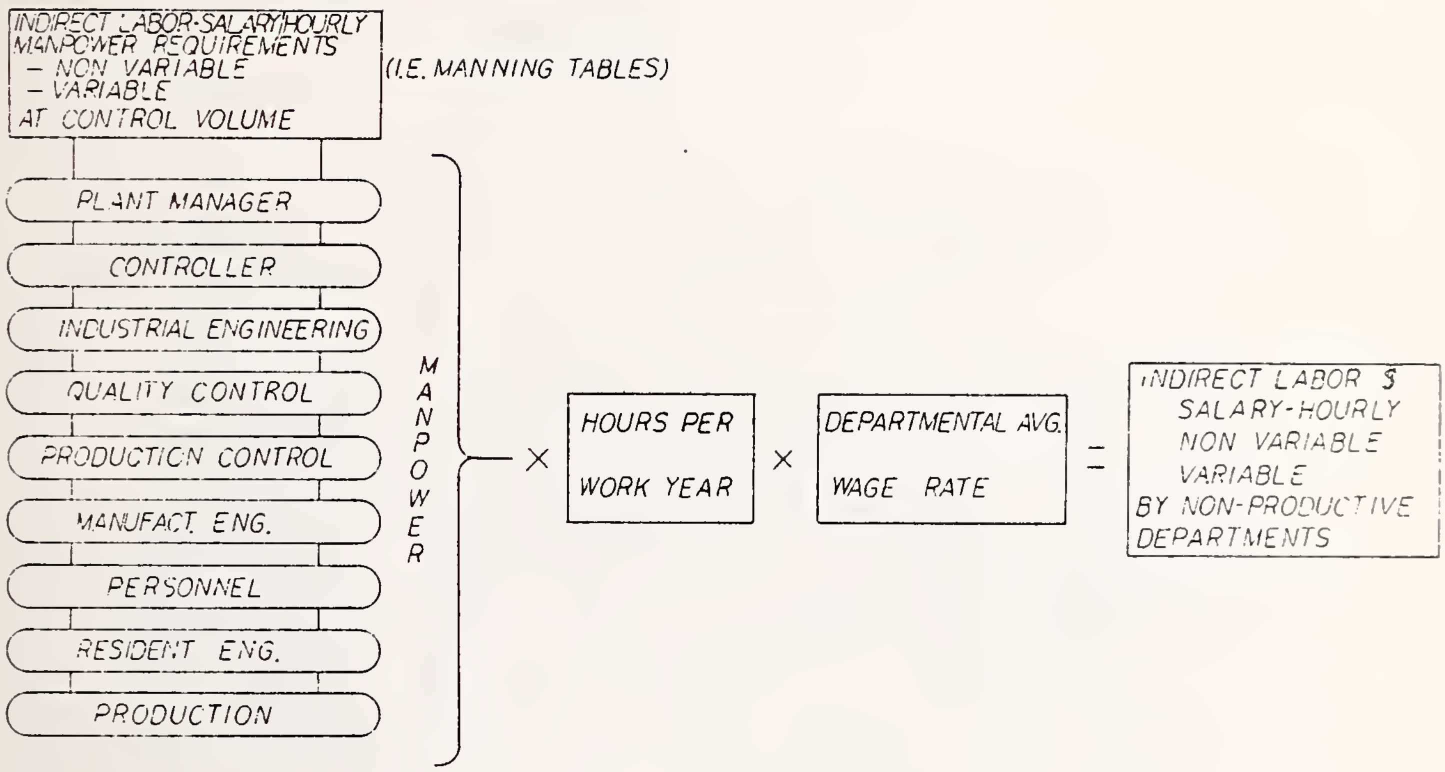


FIGURE 2-6. CALCULATION OF INDIRECT LABOR DOLLARS

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

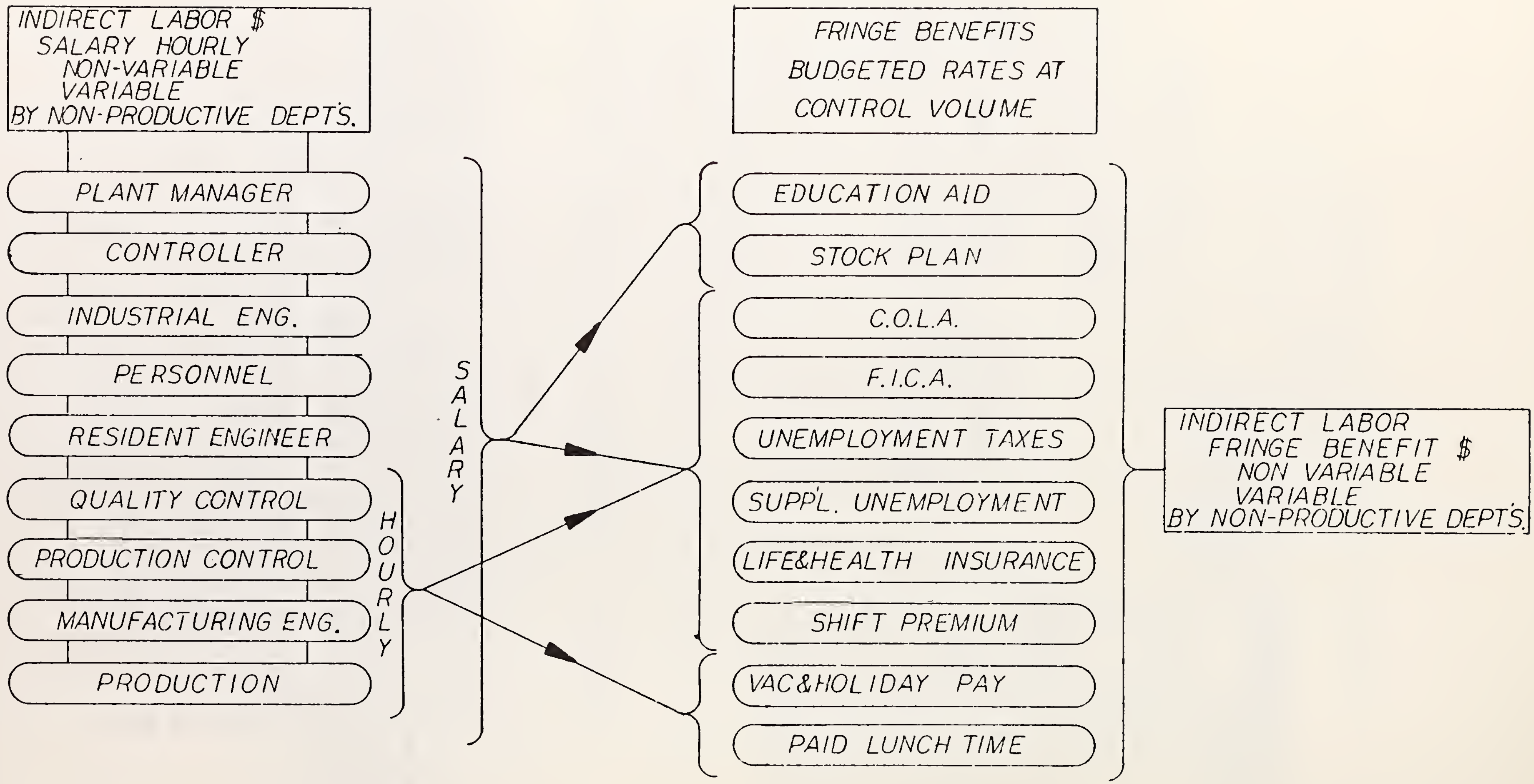


FIGURE 2-7. CALCULATION OF INDIRECT LABOR FRINGE BENEFITS

- 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

* 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 non-variable and variable standard burden.

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

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.

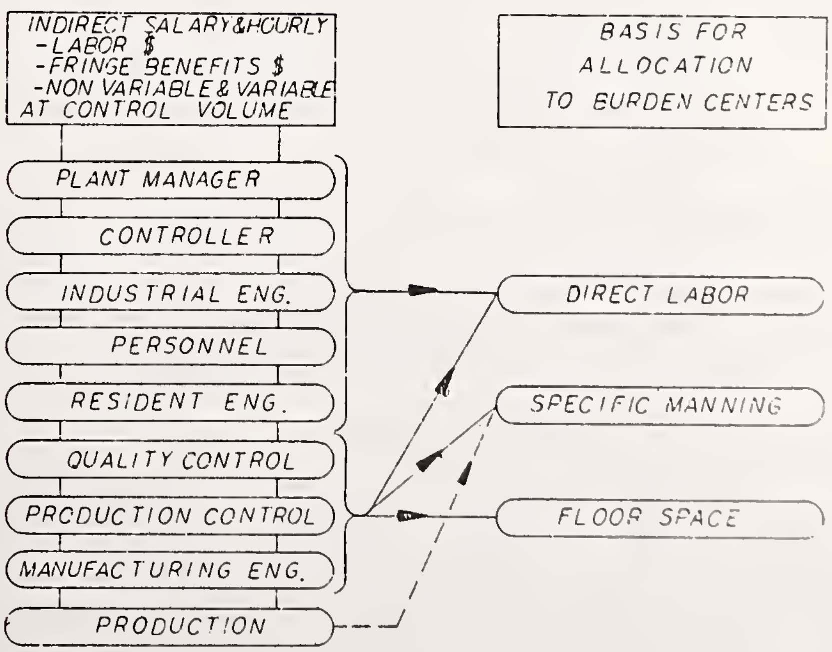


FIGURE 2-8. ALLOCATION OF INDIRECT LABOR AND FRINGE BENEFIT DOLLARS TO BURDEN CENTERS IN STAMPING PLANTS, ENGINE PLANTS AND FOUNDRIES

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.

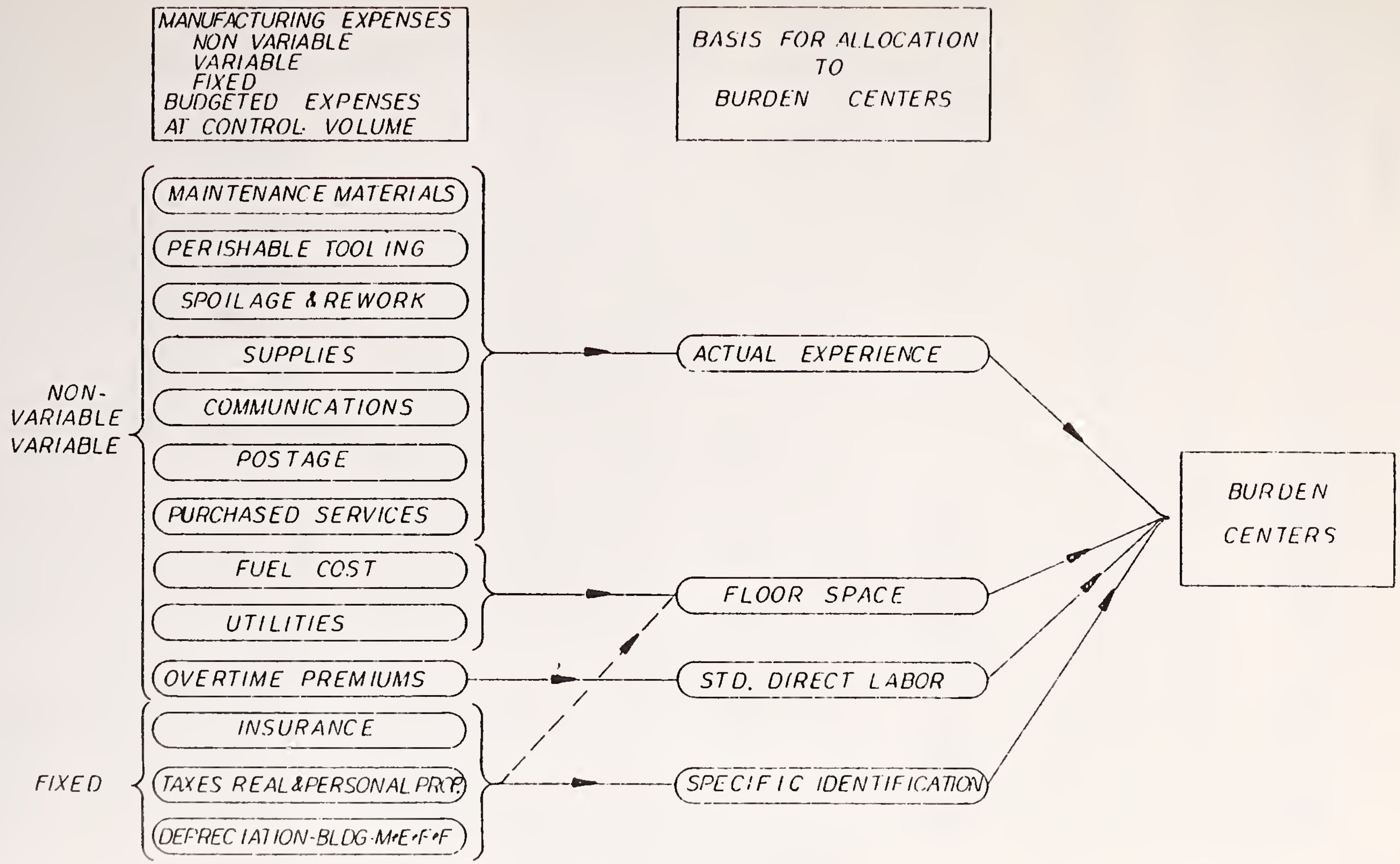


FIGURE 2-9. ALLOCATION OF OTHER MANUFACTURING EXPENSES TO THE BURDEN CENTERS IN A STAMPING PLANT, ENGINE PLANT AND FOUNDRY

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.

- Relief Time: 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.

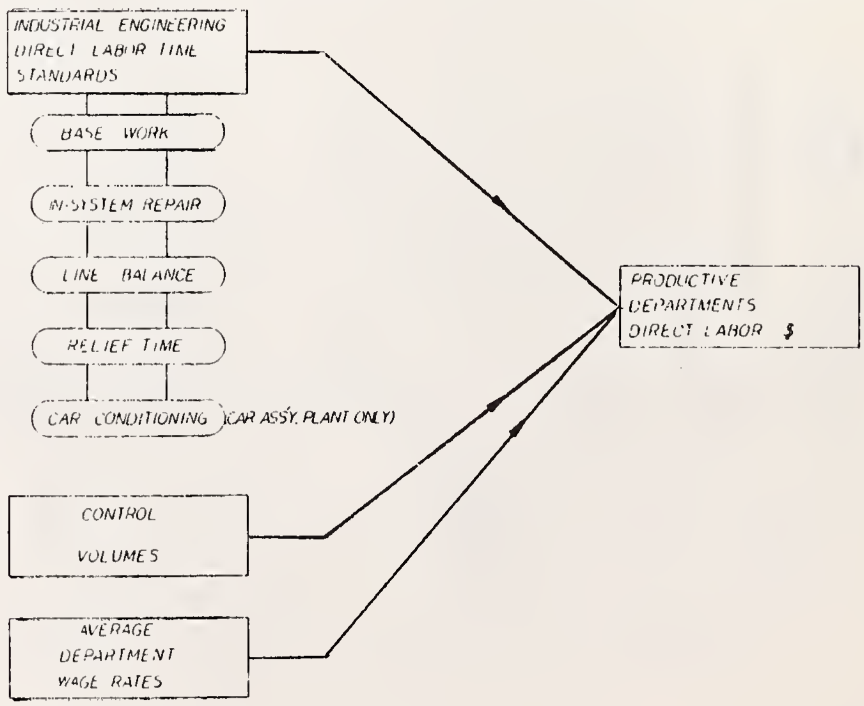


FIGURE 2-10. CALCULATION OF DIRECT LABOR DOLLARS

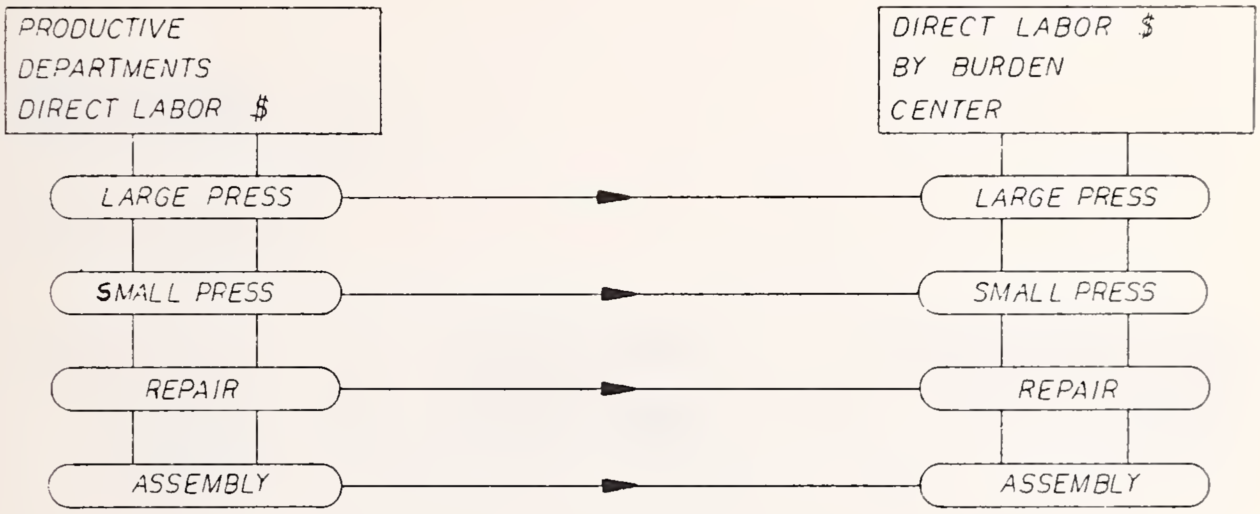


FIGURE 2-11. SUMMARIZATION OF DIRECT LABOR DOLLARS BY BURDEN CENTER FOR A STAMPING PLANT

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.

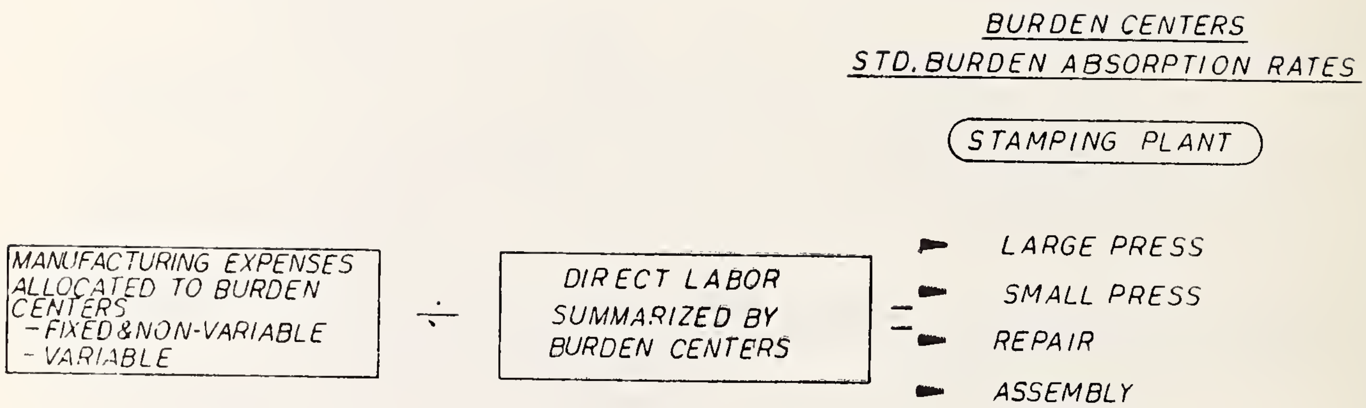


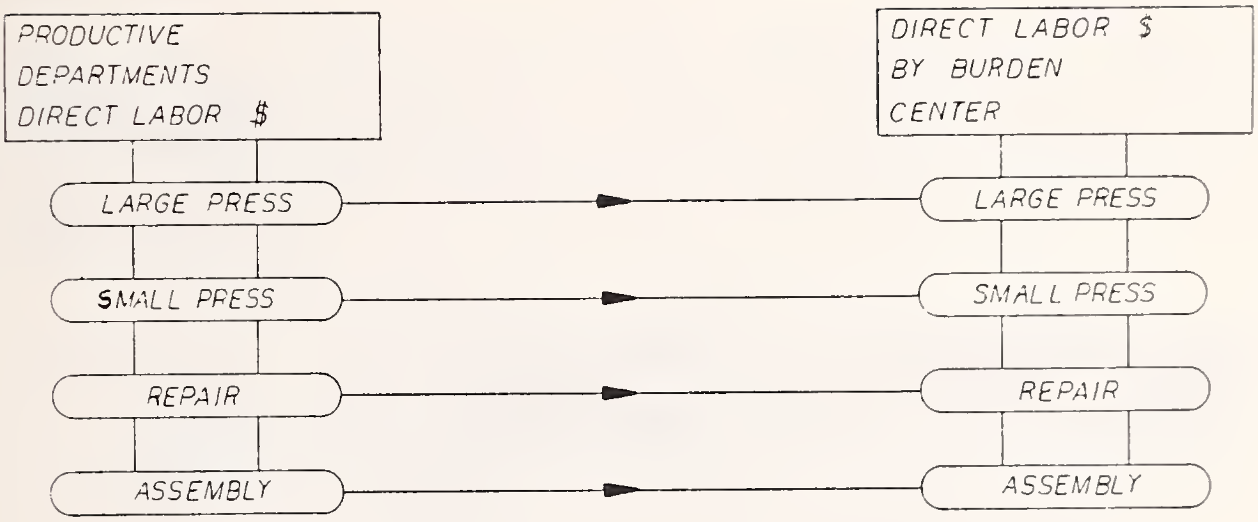
FIGURE 2-12. CALCULATION OF STANDARD BURDEN ABSORPTION RATES

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



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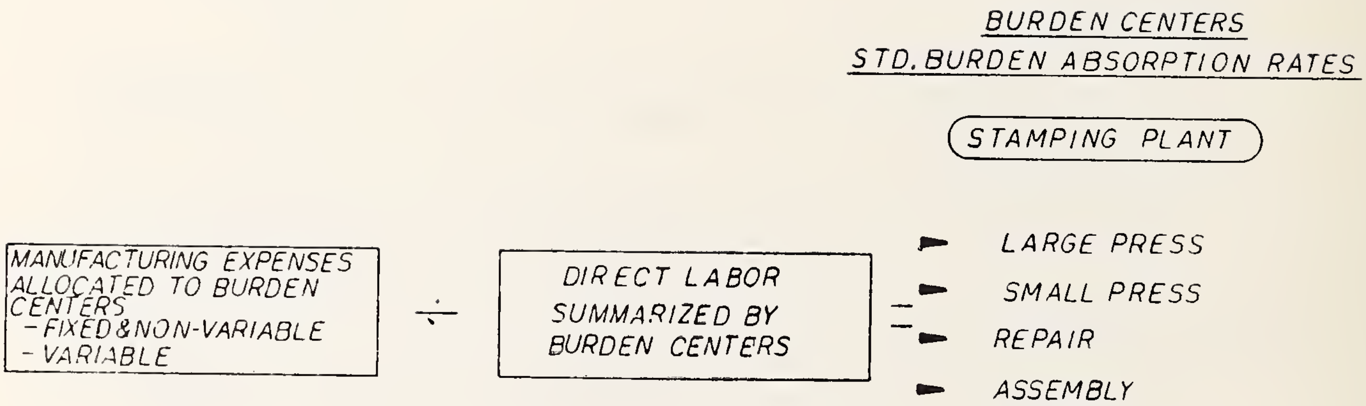

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As described previously, when calculating standard product costs, the standard direct labor dollars incurred in manufacturing a product is multiplied by the standard burden absorption rate applicable to the burden centers through which the product 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 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 Scenarios

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

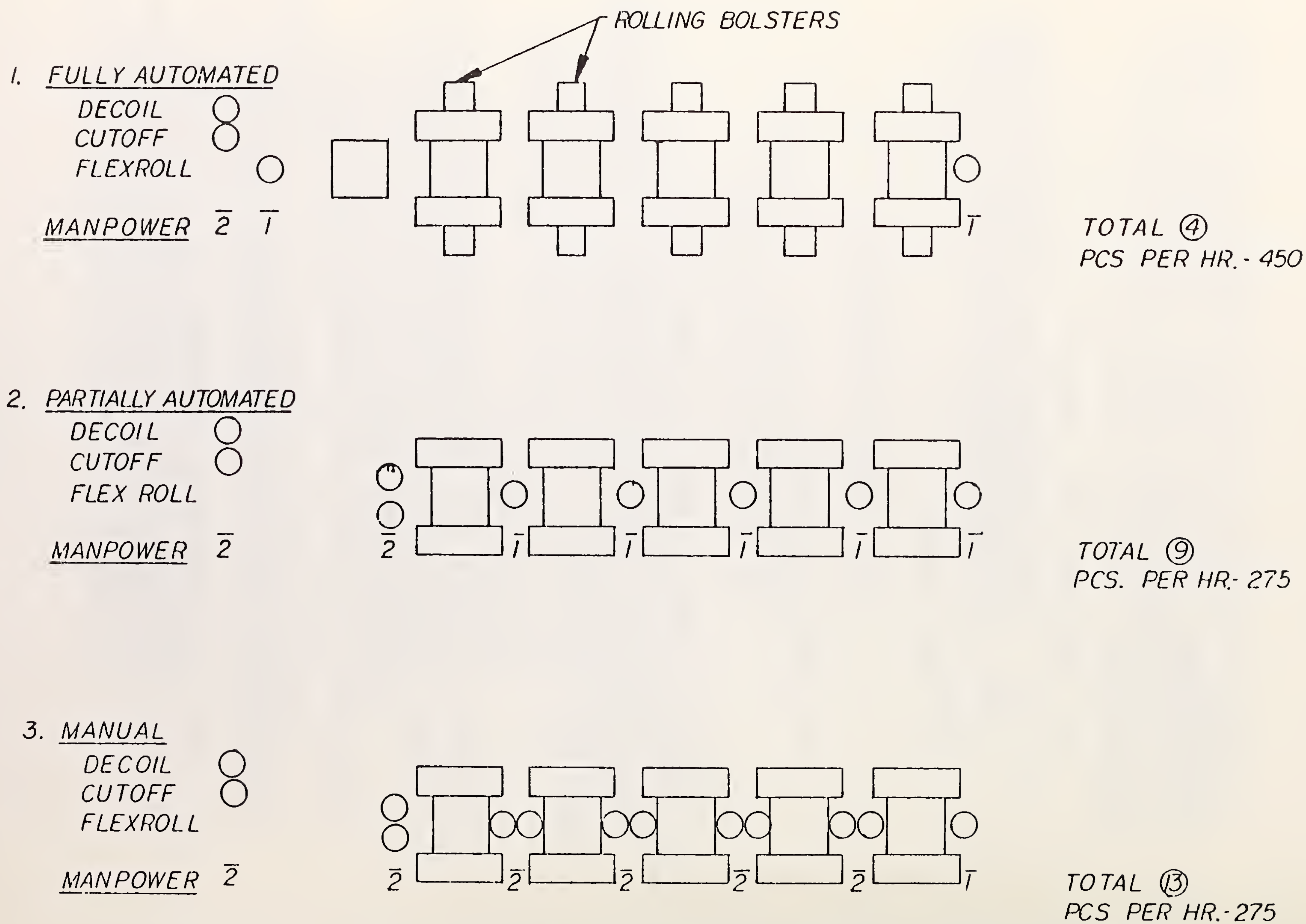

FIGURE 2-13. THREE DIFFERENT APPROACHES TO STAMPING A PANEL HOOD-OUTER

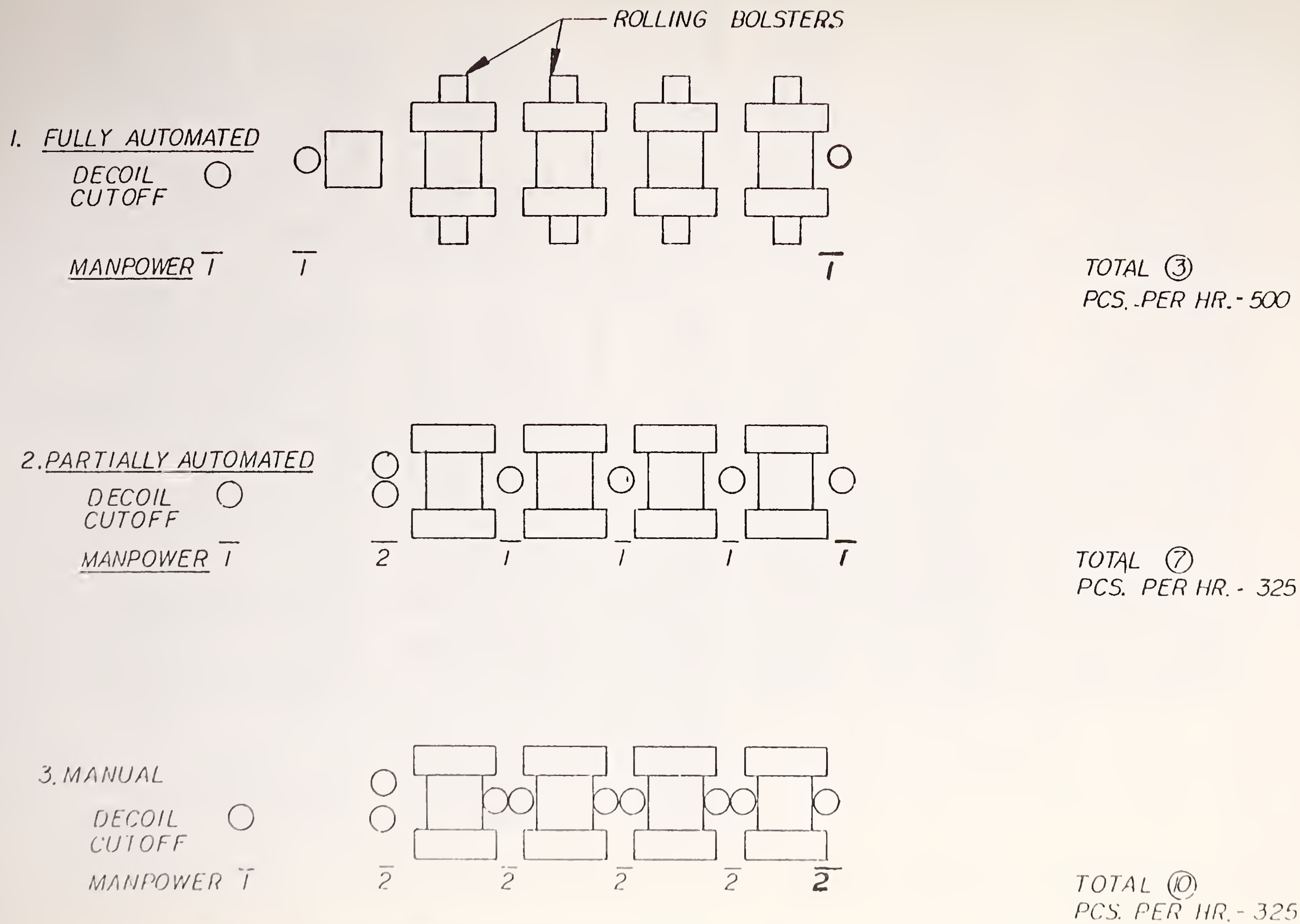

FIGURE 2-14. THREE DIFFERENT APPROACHES TO STAMPING A PANEL HOOD-INNER

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.

- Manual Press Line. 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

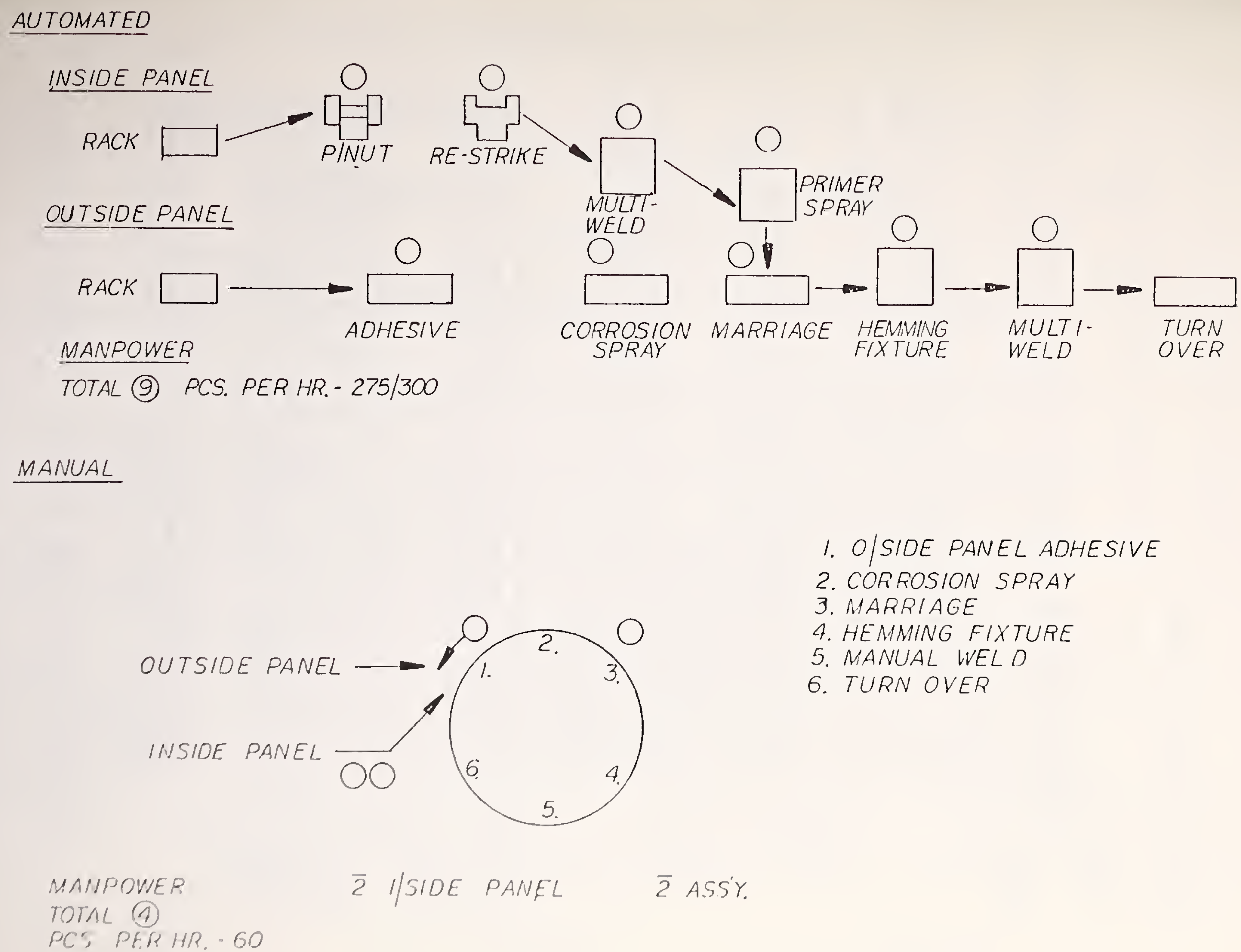

FIGURE 2-15. TWO DIFFERENT APPROACHES TO HOOD ASSEMBLY

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 Scenario

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.

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* 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 PRESS LINE — EXPENSE AMOUNT								
	FULLY AUTOMATED			PARTIALLY AUTOMATED			MANUAL		
	FIXED & NON-VAR.	VARIABLE	TOTAL	FIXED & NON-VAR.	VARIABLE	TOTAL	FIXED & NON-VAR.	VARIABLE	TOTAL
DIRECT LABOR			$2,240			$5,100			$7,340
INDIRECT LABOR									
SALARY	$1,559	$776	$2,335	$1,559	$ 776	$2,335	$1,559	$ 776	$2,335
HOURLY	1,517	2,915	4,432	1,415	2,719	4,134	1,415	2,719	4,134
FRINGE BENEFITS									
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	977	511	423	934
PERISHABLE TOOLS	14	98	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	97	630	533	97	630	533	97	630
OVERTIME PREMIUM		77	77		171	171		171	171
TAXES & 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%	552%	279%	831%	347%	222%	569%
TOTAL DIRECT LABOR:									
HOOD OUTER PANEL			$59,500			$134,000			$193,500
HOOD INNER PANEL			45,000			104,000			149,000
ANNUAL VOLUME									
HOOD OUTER PANEL			868,000			530,750			530,750
HOOD INNER PANEL			965,000			627,250			627,250

TABLE 2-3. CALCULATION OF BURDEN ABSORPTION RATES FOR HOOD-ASSEMBLY

HOOD ASSEMBLY

	TYPE OF LINE / EXPENSE AMOUNT: AUTOMATED			MANUAL		
	FIXED & NON-VAR.	VARIABLE	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
- HOURLY	40,000	77,000	117,000	17,830	34,320	52,150
FRINGE BENEFITS						
INDIRECT - SALARY	15,400	7,760	23,160	6,840	3,450	10,290
- HOURLY	32,400	62,370	94,770	14,440	27,800	42,240
DIRECT - HOURLY		112,590	112,590		50,080	50,080
MAINTENANCE	15,360	12,820	28,180	6,840	5,720	12,560
PERISHABLE TOOLS	390	2,810	3,200	170	1,240	1,410
SPOILAGE & REWORK		31,260	31,260		13,930	13,930
FUEL	6,940	400	7,340	3,100	170	3,270
SUPPLIES	3,240	12,760	16,000	1,460	5,740	7,200
UTILITIES	22,530	3,640	26,170	10,040	1,620	11,660
OTHER EXPENSES	13,500	2,500	16,000	6,015	1,115	7,130
OVERTIME PREMIUM		5,000	5,000		2,200	2,200
TAXES & INSURANCE	14,700		14,700	3,470		3,470
PENSIONS	36,420	43,580	80,000	16,300	19,540	35,040
DEPRECIATION	294,000		294,000	69,400		69,400
WORKMENS COMP.	4,150	4,850	9,000	1,840	2,160	4,000
	$ 543,210	$ 401,340	$ 944,550	$ 177,375	$ 178,855	$ 356,230
	391%	289%	680%	287%	289%	576%
ANNUAL VOLUME			597,600			119,520

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

	DIRECT LABOR	BURDEN RATE F.N.V.	BURDEN RATE VAR.	TOTAL	BURDEN COSTS F.N.V.	BURDEN COSTS VAR.	TOTAL	TOTAL DIRECT LABOR & BURDEN
HOOD - OUTER PANEL								
FULLY AUTOMATED	$ .07	1,387%	531%	1,918%	$ .97	$ .37	$1.34	$1.41
PARTIALLY AUTOMATED	.25	552%	279%	831%	1.38	.70	2.08	2.33
MANUAL	.36	347%	222%	569%	1.25	.80	2.05	2.41
HOOD - INNER PANEL								
FULLY AUTOMATED	.05	1,387%	531%	1,918%	.69	.27	.96	1.01
PARTIALLY AUTOMATED	.17	552%	279%	831%	.94	.47	1.41	1.58
MANUAL	.24	347%	222%	569%	.83	.53	1.36	1.60
TOTAL DIRECT LABOR								
ANNUAL PRODUCTION								
HOOD ASSEMBLY								
AUTOMATED	.23	289%	391%	680%	.67	.90	1.57	1.80
MANUAL	.52	289%	287%	576%	1.50	1.50	3.00	3.52

- o 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.

<u>4-Cylinder Engine</u>

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 4-cylinder 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

PRODUCTIVE DEPARTMENT	MANUFACTURING PROCESS NON-AUTOMATED	AUTOMATED	MANPOWER DECREASE
Cylinder Blocks	88	66	22
Cylinder Heads	64	48	16
Crankshafts	93	70	23
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

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

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

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

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

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

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

TABLE 2-6. CALCULATION OF BURDEN ABSORPTION RATES — 4-CYLINDER ENGINE NON-AUTOMATED MANUFACTURING PROCESS

($000)

BURDEN	BURDEN CENTERS ALLOCATION												
CATEGORY	FIXED & NON-VAR.	VARI-ABLE	TOTAL	CYL. BLOCK	CYL. HEAD	CRANK SHAFT	CAM-SHAFT	PISTONS	CONN. RODS	INT/ EXH. MAN.	WATER OIL PUMPS	TOTAL MACH-INING	ASSY. & TEST
INDIRECT LABOR													
SALARY	$ 4,711	$4,019	$8,730	$1,632	$1,080	$1,227	$ 708	$ 289	$ 738	$ 296	$345	$6,315	$2,415
HOURLY	3,108	8,120	11,228	1,099	810	1,244	926	266	720	464	703	6,242	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	97	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	--	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	977	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	--	9,217	917	674	989	770	221	592	385	585	5,133	4,084
TAXES	1,700	--	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	13,394	2,729
WORKMENS COMP.	2,023	--	2,023	201	148	217	169	49	130	85	128	1,127	896
	$48,123	$41,869	$89,992	$14,885	$9,883	$11,870	$7,144	$2,494	$6,970	$3,279	$4,131	$60,666	$29,326
DIRECT LABOR			$13,754	$ 1,368	$1,006	$1,476	$1,149	$ 330	$ 883	$ 575	872	$7,659	$6,095
BURDEN ABSORPTION RATE	350%	304%	654%	1,089%	981%	804%	622%	752%	789%	569%	474%	792%	481%

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

($000)

BURDEN CATEGORY	Total Plant FIXED & NON-VAR.	Total Plant VARI-ABLE	Total Plant TOTAL	BURDEN CENTERS ALLOCATION CYL. BLOCK	CYL. HEAD	CRANK SHAFT	CAM-SHAFT	PISTONS	CONN. RODS	INT/ EXH MAN.	WATER OIL PUMPS	TOTAL MACH-INING	ASSY. & TEST
INDIRECT LABOR													
SALARY	$3,937	$3,039	$6,976	$1,294	$ 858	$ 977	$567	$ 232	$ 589	$ 237	$ 276	$5,030	$1,946
HOURLY	2,334	6,096	8,430	825	609	934	696	200	548	349	527	4,688	3,742
FRINGE BENEFITS													
SALARY-INDIRECT	1,307	1,057	2,364	234	172	253	201	57	151	99	149	1,316	1,048
HOURLY-INDIRECT	1,830	4,780	6,610	655	481	708	561	160	422	277	416	3,680	2,930
HOURLY-DIRECT	--	8,354	8,354	827	607	894	709	202	533	350	528	4,650	3,704
MAINTENANCE	964	2,351	3,315	803	504	524	241	102	303	99	83	2,659	656
PERISHABLE TOOLS	--	2,571	2,571	646	406	422	195	83	244	80	67	2,143	428
SPOILAGE & REWORK	--	2,107	2,107	530	333	346	160	67	200	65	54	1,755	352
FUEL	1,847	484	2,331	529	332	345	159	67	200	65	54	1,751	580
SUPPLIES	200	1,184	1,384	342	214	223	103	43	129	42	36	1,132	252
UTILITIES	2,327	2,039	4,366	1,025	643	669	308	130	387	126	106	3,394	972
OTHER	1,644	520	2,164	493	309	322	148	63	186	61	50	1,632	532
OVERTIME PREMIUM	264	--	264	26	19	28	22	6	17	12	17	147	117
PENSIONS & INS.	6,994	--	6,994	692	509	749	594	170	446	293	441	3,894	3,100
TAXES	2,000	--	2,000	502	315	328	151	64	189	62	51	1,662	338
DEPRECIATION	18,984	--	18,984	4,765	2,987	3,110	1,434	606	1,798	586	486	15,772	3,212
WORKMENS COMP.	1,536	--	1,536	152	112	164	130	37	98	64	98	855	681
	$46,168	$34,582	$80,750	$14,340	$9,410	10,996	6,379	$2,289	$6,440	$2,867	3,439	56,160	$24,590
DIRECT LABOR			$10,377	$ 1,027	$ 755	$1,111	$ 881	$252	$663	$ 435	$ 654	$5,777	$ 4,600
BURDEN ABSORPTION RATE	445%	333%	778%	1,396%	1,246%	989%	725%	908%	970%	658%	525%	972%	535%

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

BURDEN CENTERS		NON-AUTOMATED					AUTOMATED				
		DIRECT LABOR	BURDEN			LABOR & BURDEN	DIRECT LABOR	BURDEN			LABOR & BURDEN
			F.N.V.	VAR.	TOTAL			F.N.V	VAR.	TOTAL	
Cylinder Blocks	-Cost	$3.42	$21.51	$15.73	$37.24	$40.66	$ 2.57	$22.13	$13.74	35.87	$38.44
	-Rate		629%	460%	1,089%			861%	535%	1,396%	
Cylinder Heads	-Cost	2.52	14.11	10.61	24.72	27.24	1.89	14.36	9.18	23.54	25.43
	-Rate		560%	421%	981%			760%	486%	1,246%	
Crank Shafts	-Cost	3.69	16.36	13.33	29.69	33.38	2.78	16.21	11.29	27.50	30.28
	-Rate		443%	361%	804%			583%	406%	989%	
Camshafts	-Cost	2.87	9.42	8.45	17.87	20.74	2.20	8.98	6.98	15.96	18.16
	-Rate		328%	294%	622%			408%	317%	725%	
Pistons	-Cost	.83	3.45	2.79	6.24	7.07	.63	3.38	2.34	5.72	6.35
	-Rate		416%	336%	752%			537%	371%	908%	
Conn.Rods & Caps	-Cost	2.21	9.63	7.80	17.43	19.64	1.66	9.50	6.61	16.11	17.77
	-Rate		436%	353%	789%			572%	398%	970%	
Intake/Exhaust Manifolds	-Cost	1.44	4.22	3.98	8.20	9.64	1.09	3.93	3.24	7.17	8.26
	-Rate		293%	276%	569%			361%	297%	658%	
Water/Oil Pumps	-Cost	2.18	5.05	5.29	10.34	12.52	1.64	4.44	4.16	8.60	10.24
	-Rate		231%	243%	474%			271%	254%	525%	
Total Machining	-Cost	19.16	83.76	67.98	151.74	170.90	14.48	82.94	57.53	140.47	154.92
	-Rate		437%	355%	792%			574%	398%	972%	
Assembly & Test	-Cost	15.25	36.60	36.75	73.35	88.60	11.50	32.54	28.97	61.51	72.93
	-Rate		240%	241%	481%			283%	252%	535%	
Total Plant	-Cost	$34.41	$120.36	$ 104.73	$225.09	$259.50	$25.96	$115.48	$86.50	$201.98	$227.94
	-Rate		350%	304%	654%			445%	333%	778%	
Annual Production 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

- Transmission
- Drive components
- Suspension
- Other.

The comapariable 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. RECOMMENDED GUIDELINES FOR USE OF TEARDOWN 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

DATE:

COMPONENT: VEHICLE TYPE:

MANUFACTURING OPERATIONS

DESCRIPTION	DIAGRAM (IDENTIFY OPERATIONS, MANPOWER, HOURLY PRODUCTION RATE, AND LEVEL OF AUTOMATION)
1.	
2.	
3.	
4.	
5.	
6.	
7.	

FIGURE 4-1. FORMAT FOR RECOMMENDED MANUFACTURING PROCESS SHEET

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 INCURRED AT THE PLANT LEVEL.SELLING, GENERAL AND ADMINISTRATIVE, PRODUCT DEVELOPMENT, MANUFACTURING AND PROCUREMENT, AMORTIZATION OF SPECIAL TOOLS AND IN-BOUND TRANSPORTATION 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.

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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