

4-1920

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Harold A. Eppston

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### Recommended Citation

Eppston, Harold A. (1920) "Process Costs," *Journal of Accountancy*: Vol. 29: Iss. 4, Article 3.  
Available at: <https://egrove.olemiss.edu/jofa/vol29/iss4/3>

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# Process Costs

BY HAROLD A. EPPSTON

## INTRODUCTORY

The general manager of an aeroplane motor company informs the cost department that he desires the costs of valve guides by operations. He believes that if he has information of this type he will be enabled to cut the costs by changing the number or order of the operations. But before he can do this he must have costs by operations each month so that he can form his judgments from the changing costs.

Heretofore the cost department found costs for valve guides by jobs.

The cost department welcomes the opportunity for changing the method of costing because the job-order method of costing was unsatisfactory on account of the peculiarities of the production. Because the war programme production in the department where valve guides were made was continuous—day and night shifts worked ceaselessly. The valve guides went from machine to machine in a steady stream. It became impossible to associate each lot of valve guides with a job. The jobs were issued in lots of twenty, but many valve guides would be scrapped or spoiled before completion. As a result there was much guesswork in showing the quantities finished or spoiled on each job. When valve guides came from the last operation to which job did they belong? The question becomes more difficult to answer when we consider that things like the following took place:

A valve guide on operation number 10 is defective. The operative sends it back to operation 2 for correction and at the same time continues working on the rest of the valve guides covered by the job. It is almost certain that the identity of that valve guide will be lost.

Because of the employment of a new man on operation number 5, valve guides begin to accumulate near his machine. The men at operations numbers 6, 7 and subsequent operations are held up.

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The foreman gives orders that the valve guides go to operations numbers 6 and 7, then back to number 5, so as to keep everyone working. Here, too, the identity of the valve guides as to jobs is sometimes lost.

In the face of these facts a cost by operations or a process cost was welcomed by the cost department.

#### *Physical inventory.*

As has been already mentioned the costs of valve guides had been kept by jobs. The change from job costs to process costs takes place October 1st. At midnight September 30th the night shift is stopped and an inventory is taken. Results are as follows :

TABLE I

#### INVENTORY: VALVE GUIDES, OCTOBER 1

<i>Oper. number</i>	<i>Job number</i>	<i>Quantity</i>
1	234567	20
1	234566	5
2	234566	14
3	234567	20
4	234569	15
4	234570	4
5	234570	13
6	234579	20
7	234576	18
8	234578	22
9	234572	24
10	234573	19
		<hr/>
	Total.	194

A glance at the inventory will show how unsatisfactorily the job-order system operated in this case. On operation No. 8 there are 22 valve guides. The job started with only 20. It appears that some unidentified valve guides were thrown against that job. A similar condition exists with operation No. 9 and it is probably true of the rest though not apparent from the quantities.

#### *Book inventory.*

The cost department clerks pull from their files the open jobs on valve guides. They find the following jobs with the following charges against them.

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TABLE II

<i>Job number</i>	<i>Quantity ordered</i>	<i>Material</i>	<i>Labor</i>
234566	20	\$ 80.50	\$ 79.01
234567	20	80.50	80.20
234569	20	80.50	82.11
234570	20	80.50	86.07
234571	20	80.25	90.01
234573	20	80.25	112.28
234572	20	80.25	99.09
234576	20	80.30	120.30
234578	20	80.30	122.11
234579	20	80.30	120.06
Totals .....	200	\$803.65	\$991.24

The differences between quantities ordered and quantities present at physical inventory are the spoiled pieces and, of course, errors due to allocating valve guides to the wrong jobs.

It will be noticed that job 234571 shows a material and labor charge; yet there are no valve guides for this order in physical inventory. This is probably due to carelessness already described. The identity of the valve guides belonging to this order has been lost and they have undoubtedly been picked up by other jobs.

*Operation labor costs.*

To gather costs in the new way, the cost department orders the shop clerks to count all valve guides as they leave each operation and put the quantities on the job labor card of the operative.

The summaries of these job labor cards for October show the following:

TABLE III

*LABOR COSTS, OCTOBER*

<i>Operation number</i>	<i>Quantity</i>	<i>Amount</i>
1	20	\$ 18.75
2	25	20.01
3	20	22.02
4	20	18.98
5	18	20.09
6	17	28.03
7	18	29.05
8	19	24.07
9	20	22.17
10	20	25.18
		Total. \$228.35

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### *Material charges.*

Summaries of requisitions show that 21 rough valve guides were delivered to the valve-guide department for machining.

### *Summary of material issued to work in process October.*

Twenty-one rough valve guides at \$4.50 = \$94.50.

### *Overhead.*

The overhead for the valve guide department was \$456.70 or 200% of the direct labor. The same rate was used in previous months.

### *Final inventory.*

The inventory of valve guides in process at midnight October 31st is as follows:

TABLE IV

<i>Operation</i>	<i>Quantity</i>
1	20
2	18
3	18
4	20
5	13
6	19
7	17
8	19
9	24
10	19
Total.	187

### *Spoiled pieces.*

Summaries of spoiled pieces received by salvage department show:

TABLE V

<i>Pieces scrapped</i>	<i>Operation number</i>
1	5
4	6
3	8
Total.	8

### *Material costs.*

#### SOLUTION

From the inventory of valve guides at October 1st, it will be noticed that 194 valve guides were in process. From the book inventory of valve guides October 1st it will be found that against

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those jobs in process had been charged 200 valve guides—the total material value being \$803.65.

The fact that 200 had been charged to process and 194 are present at the time of physical inventory indicates that 6 valve guides were spoiled prior to the time when the physical inventory was taken. Hence the material cost for the 194 valve guides on hand October 1st is \$803.65—thus letting the pieces still good bear the cost of those defective.

Furthermore, the summaries of requisitions show that 21 rough valve guides (value \$94.50) were delivered to process during October and that 187 valve guides are left in process October 31st. That eight valve guides were spoiled during October and 20 valve guides were finished during October may be ascertained from the facts given. Material costs are found as follows:

TABLE VI

*Material Costs—Valve Guides*

	<i>Quantity</i>	<i>Unit</i>	<i>Value</i>
Inventory 10/1.....	194	\$4.1425	\$803.65
Charges in October.....	21	4.5000	94.50
	<hr/>	<hr/>	<hr/>
Total .....	215	\$4.1728	\$897.15
Spoiled in October.....	8	.....	.....
	<hr/>	<hr/>	<hr/>
Adjusted* .....	207	\$4.3341	\$897.15
Inventory 10/31.....	187	4.3341	810.47
	<hr/>	<hr/>	<hr/>
Cost of finished pieces.....	20	\$4.3341	\$ 86.68

\* Good pieces bear cost of spoiled pieces.

*Labor costs.*

To ascertain the labor costs by operations for October, it is necessary to distribute over the different operations the labor charges accrued against the valve guides on hand October 1st. How these charges have accrued and what proportion belongs to each operation cannot be determined by the job-order system of costing. Hence, to obtain costs there must be resort to an arbitrary method of prorating such labor over the different operations.

Two methods suggest themselves: first, to prorate the labor

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on the basis of facts determined by a time study; second, to prorate the labor on the basis of the actual cost facts of the next period. The latter method is usually the more accurate and it is used here.

Turning back to operation labor costs, we find that the labor costs for October were as follows:

*TABLE VII*

<i>Operation</i>	<i>Labor Costs, October</i>		<i>Unit operation cost</i>
	<i>Quantity</i>	<i>Amount</i>	
1	20	\$18.75	\$ .9375
2	25	20.01	.8004
3	20	22.02	1.1010
4	20	18.98	.9490
5	18	20.09	1.1161
6	17	28.03	1.6488
7	18	29.05	1.6139
8	19	24.07	1.2668
9	20	22.17	1.1085
10	20	25.18	1.2590
Totals.		\$228.35	\$11.8010

With the above information as to unit costs for October it becomes possible to prorate over the operations the balance of labor in process October 1st. But first it is necessary to trace the history of the inventory of October 1st over the several operations. The following illustrates how this is done:

From the inventory, valve guides, October 1st, we find the following:

*TABLE VIII*

<i>Inventory October 1st</i>	
<i>Operation</i>	<i>Quantity</i>
1	25
2	14
3	20
4	19
5	13
6	20
7	18
8	22
9	24
10	19
Total. 194	

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It is evident that the valve guides on operation No. 10 must have passed through the previous nine operations. Those on operation number 9 must have traveled through the previous eight operations, and so on.

The following table shows the history of the above inventory by operations:

**TABLE IX**

*Inventory Valve Guides by Operations, October 1st*

0	1	2	3	4	5	6	7	8	9	10
25										
14	14									
20	20	20								
19	19	19	19							
13	13	13	13	13						
20	20	20	20	20	20					
18	18	18	18	18	18	18				
22	22	22	22	22	22	22	22			
24	24	24	24	24	24	24	24	24		
19	19	19	19	19	19	19	19	19	19	0
194	169	155	135	116	103	83	65	43	19	0

The above table merely shows that the 19 pieces on operation number 10 had passed through the 9 previous operations, etc. As a result the inventory of October 1st is shown by operations.

Assuming, as already indicated, that the operation costs prior to October 1st were identical with those of October, we can get a table as follows:

**TABLE X**

*Bases of Prorating Labor Over Operations October 1*

Operation	Quantity	Unit	Total	%
0	194	.....	.....	.....
1	169	\$ .9375	\$158.44	16.2
2	155	.8004	124.06	12.7
3	135	1.1010	148.64	15.2
4	116	.9490	110.08	11.3
5	103	1.1161	114.96	11.8
6	83	1.6488	136.85	14.0
7	65	1.6139	104.90	10.7
8	43	1.2668	54.47	5.5
9	19	1.1085	21.06	2.6
10	0	1.2590	.....	.....
Total....	...	\$11.8010	\$973.46	100.0



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It will now be noticed that if the costs of labor by operations for the period prior to October 1st were identical with such costs for October the total amount above \$973.46 would be equal to the inventory of labor October 1, 1919. However, by looking back we find that the inventory of labor at October 1st was \$991.24, or \$17.78 more than the above. This difference exists because the operation costs prior to October 1st must have been greater than those of October. This difference, therefore, must be prorated over the amounts already set against the operations at October 1st.

The following table illustrates how this may be done:

TABLE XI

<i>Inventory of Labor October 1 by Operations</i>					
Operation	Quantity	Total	%	Adjustment	Final
0	194	.....	....	....	.....
1	169	\$158.44	16.2	2.88	\$161.32
2	155	124.06	12.7	2.26	126.32
3	135	148.64	15.2	2.70	151.34
4	116	110.08	11.3	2.01	112.09
5	103	114.96	11.8	2.10	117.06
6	83	136.85	14.0	2.49	139.34
7	65	104.90	10.7	1.90	106.80
8	43	54.47	5.5	.98	55.45
9	19	21.06	2.6	.46	21.52
10	....	.....	....	....	.....
Total.. .....		\$973.46	100.0	17.78	\$991.24

Now it is possible to get the true labor costs for October. But first it is necessary to obtain a statement showing the defective pieces by operations. This statement (table XII) has the same relation to table V as table IX has to table VIII.

TABLE XII

<i>Statement of Defective Pieces by Operations, October</i>											
0	1	2	3	4	5	6	7	8	9	10	Total
1	1	1	1	1							
4	4	4	4	4	4						
3	3	3	3	3	3	3	3				
8	8	8	8	8	7	3	3	0	0	0	Total

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The following statement shows the labor costs for October:

TABLE XIII

*Final Labor Costs by Operations, Valve Guides, October*

Operation	Inventory Quantity	October 1 Amount	Changes in Quantity	October Amount	Total Inv. & Quan- tity	Changes Amount	
0	194	.....	21	.....	215	.....	
1	169	\$158.44	20	\$18.75	189	\$177.19	
2	155	124.06	25	20.01	180	144.07	
3	135	148.64	20	22.02	155	170.66	
4	116	110.08	20	18.98	136	129.06	
5	103	114.96	18	20.09	121	135.05	
6	83	136.85	17	28.03	100	164.88	
7	65	104.90	18	29.05	83	133.95	
8	43	54.47	19	24.07	62	78.54	
9	19	21.06	20	22.17	39	43.23	
10	0	0	20	25.18	20	25.18	
<hr/>							
Total	194	\$973.46	21	\$228.35	215	\$1201.81	
<hr/>							
Adj. Spoil- age	Ad- justed Quan- tity	Amount	Unit Cost	Inventory Octo- ber 31 Quantity	Octo- ber Amount	Com- pleted Quan- tity	October Amount
<hr/>							
8	207	.....	.....	187	.....	20	.....
8	181	\$177.19	\$.9789	161	\$157.61	20	\$19.58
8	172	144.07	.8376	152	127.32	20	16.75
8	147	170.66	1.1609	127	147.44	20	23.22
8	128	129.06	1.0079	108	108.90	20	20.16
7	114	135.05	1.1846	94	111.36	20	23.69
3	97	164.88	1.6998	77	130.88	20	34.00
3	80	133.95	1.6744	60	100.46	20	33.49
0	62	78.54	1.2668	42	53.21	20	25.33
0	39	43.23	1.1084	19	21.06	20	22.17
0	20	25.18	1.2500	0	0	20	25.18
<hr/>							
8	207	\$1,201.81	\$12.1783	187	\$958.24	20	\$243.57

Reference to table XIII will show that both quantities and values check mathematically—that is, the inventory October 1st, plus charges for October, less deductions for spoilage, equals the total inventory October 31st, plus cost of finished pieces. This is true both of quantities and values.

To obtain overhead costs in this case all that is necessary is to set up a table similar to table XIII and multiply all values by 200%. However, if the overhead rate varied from one cost period to another the table would have to be worked out in detail.

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The following is a summary of the costs per valve guide finished during October:

*TABLE XIV*      *Summary—Cost Per Valve Guide, October*

<i>Operation</i>	<i>Material</i>	<i>Labor</i>	<i>Overhead</i>	<i>Total</i>
0	\$4.3341	\$ .....	\$ .....	\$ 4.3341
1	.....	.9789	1.9578	2.9367
2	.....	.8376	1.6752	2.5128
3	.....	1.1609	2.3218	3.4827
4	.....	1.0079	2.0158	3.0237
5	.....	1.1846	2.3692	3.5538
6	.....	1.6998	3.3996	5.0994
7	.....	1.6744	3.3488	5.0232
8	.....	1.2668	2.5336	3.8004
9	.....	1.1084	2.2168	3.3252
10	.....	1.2590	2.5180	3.7770
10	\$4.3341	\$12.1783	\$24.3566	\$40.8690