Accurate Time Standards in Less Time

Robert E. Duvall

In a job shop operation where tasks are nonrepetitive, setting work standards for each job can cost more in analysts' time than can be saved in operations. Here's one company's solution to setting —

ACCURATE TIME STANDARDS IN LESS TIME

by Robert E. Duvall
Elliott Company

The advantages of time standards in controlling the costs of repetitive, large-volume production operations are well known. Standard time measurement is less widely used, however, in job shops and other work situations involving the performance of a large number of tasks that are only infrequently repeated. The problem, of course, is that determining accurate time standards can cost more in industrial engineering time than the application of the standards saves in labor time.

At Elliott Company, a division of Carrier Corporation, we have, we think, solved this problem by using "slotted" time standards, standards based upon a range of time rather than upon stopwatch precision. Although slotted standards lack the pinpoint accuracy necessary for control of high-volume operations, we have found them satisfactory for many of the less repetitive tasks performed in our plant — and economical to install and maintain. Initially greeted with skepticism, the technique has proved acceptable to union personnel as well as to management.

Work measurement program

Four years ago, Elliott Company, a producer of turbines, compressors, ejectors, condensers, and industrial strainers, recognized a

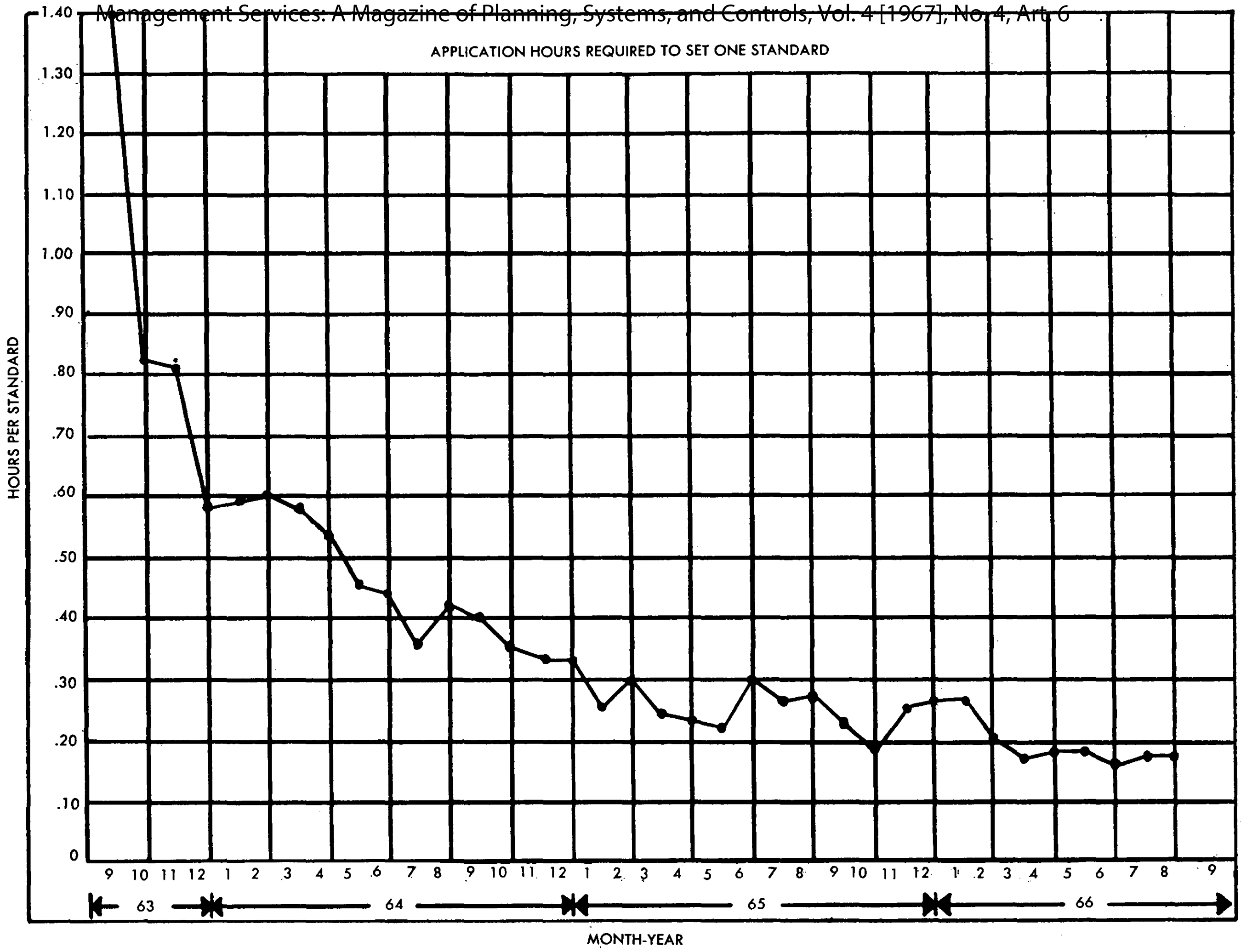


EXHIBIT I

need to increase the effectiveness of manufacturing methods. Labor productivity had to be improved if costs were to be lowered and profits increased. The decision was to institute a work measurement program to establish accurate, understandable, and consistent time standards for direct labor.

Standard formulas developed

H. B. Maynard and Company, Inc., a consulting firm specializing in work measurement, was hired in 1962 to institute a measured day work program utilizing MTM (Methods Time Measurement) and USD (Universal Standard Data).

(Methods Time Measurement has been described in previous issues of MANAGEMENT SERVICES [see "Controlling the Costs of Keypunch Operations" by Richard Paulson, November-December '65, p. 35, and "How Hanes Hosiery Uses Clerical Work Measurement" by Thomas G. Eshelman, March-April '66, p. 37]. Briefly, it is one of several predetermined motion times systems for setting standard times to perform a task. It provides a set of established time values, originally determined by time and motion study, for the basic motions required to perform common tasks in industry. The analyst studies the operation performed, breaks it down into its component motions, and assigns time values from the tables. Master Standard Data is a simplification of MTM that reduces the number of motions tabulated and combines some of them.)

Twelve industrial engineers were trained and tested in MTM. In the first year of the program 43 standard data formulas were developed for various operations such as machining, fitting, welding, burning, rolling, and miscellaneous assembly. Application of the standard data formulas to specific jobs in the Elliott Company started in August, 1963.

Analysts improved rapidly

During the first month of standard data application (September, 1963) every standard produced or operation measured required an average of 1.4 man-hours of industrial engineering time. This extremely high average resulted in part from the standards analysts'

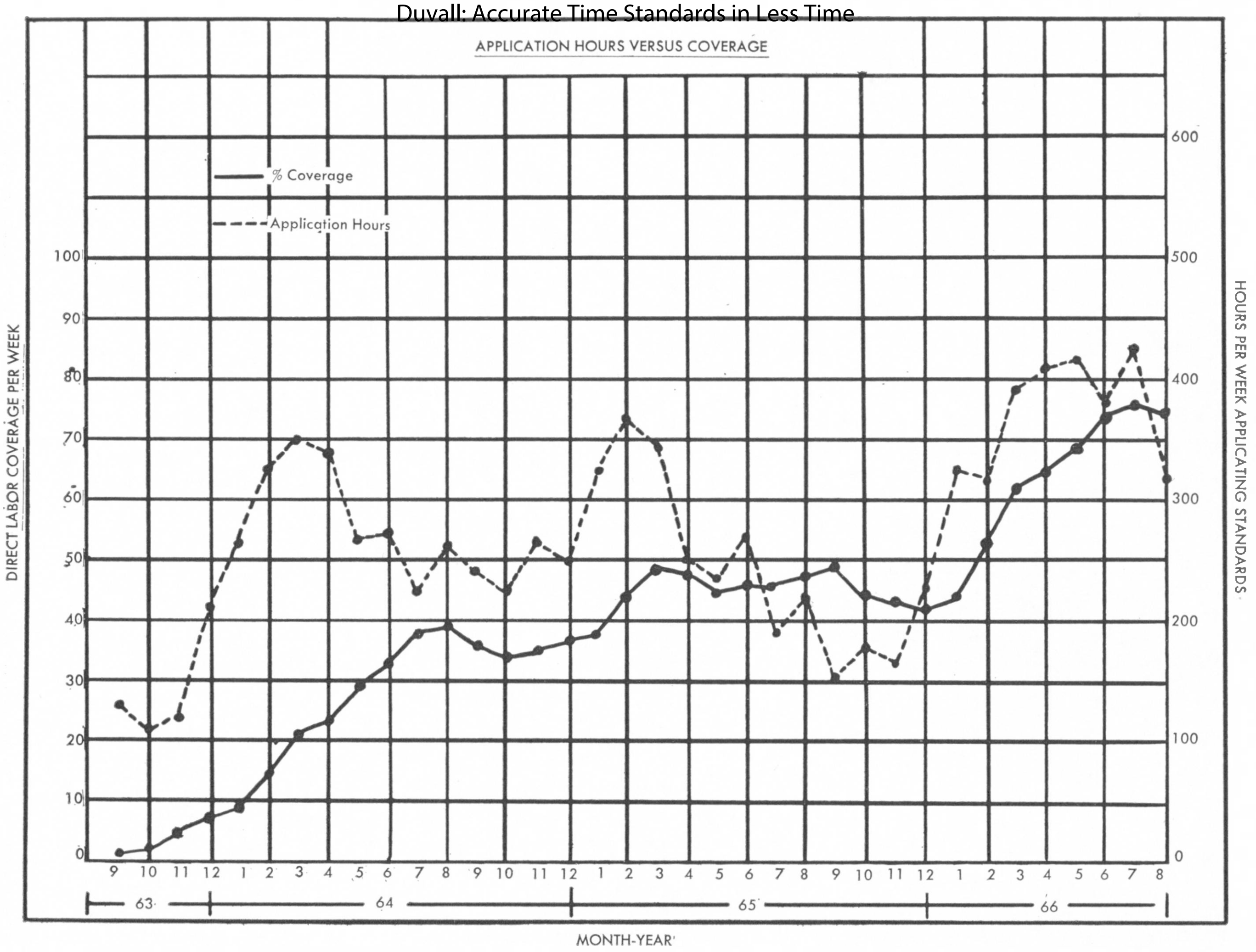


EXHIBIT 2

lack of experience and in part from the fact that they were working only on machining standards, which had to be set with great precision.

Improvement was rapid, as Exhibit 1 on page 43 shows. In October, 1963, the average time per standard had been reduced to .82 hours; in December, 1963, to .58 hours; by July of 1964, to .35 hours.

In the same period coverage (defined as the number of direct labor measured hours divided by the sum of the direct labor measured hours and the direct labor unmeasured hours) increased by an average of 4 per cent a month. This trend is shown in Exhibit 2 on this page. In the first eleven months of application, coverage was increased to 38 per cent. Then it started to level off.

ROBERT E. DUVALL is section manager of the industrial engineering department at Elliot Company, Jeanette, Pennsylvania, where he has been responsible for part of the standards development program described in this article. In the past he has served as industrial engineer with U.S. Steel Corporation, Gary, Indiana; Scaife Company, Oakmont, Pennsylvania; and Jones and Laughlin Steel Corporation, Pittsburgh Works. Mr. Duvall received his B.B.A. degree from Westminster College, New Wilmington, Penna., in 1958.

Problem of economics

Progress had been impressive during the first year of the work measurement program. Now, however, we had hit something of a plateau. Coverage was still well below our goal of 80 per cent. At the same time the total number of industrial engineering application hours had reached 350 hours a week, the equivalent of having nine industrial engineers doing nothing but setting time standards.

Variety of tasks problem

The total number of application hours could not be increased substantially without additional staff, an investment that might well make the whole project uneconomic. It was obvious that the time required to set one standard had to be cut still more. Yet we had already attained most of the bene-

Standard Time Ranges

Time Grouping #1

Standard Hours	Time Range Min.	Max.	Standard Hours	Time Range Min.	Max.
.018	0	.028	3.150	2.860	3.470
.032	.029	.037	3.830	3.480	4.200
.043	.038	.049	4.630	4.210	4.090
.057	.050	.065	5.610	5.100	6.180
.075	.066	.086	6.800	6.190	7.490
.106	.087	.122	8.280	7.500	9.090
.140	.123	.161	10.000	9.100	11.200
.185	.162	.213	11.700	11.300	12.300
.245	.214	.281	12.900	12.400	13.600
.323	.282	.372	14.300	13.700	15.000
.428	.373	.492	15.800	15.100	16.600
.569	.493	.651	17.400	16.700	18.300
.750	.652	.862	19.100	18.400	20.100
1.000	.863	1.099	21.100	20.200	22.200
1.210	1.100	1.320	23.200	22.300	24.400
1.460	1.330	1.600	25.600	24.500	26.900
1.770	1.610	1.940	28.200	27.000	29.600
2.150	1.950	2.350	31.100	29.700	32.600
2.600	2.360	2.850			

EXHIBIT 3

fit to be expected as the effect of the learning curve.

Our problem lay in the job shop nature of much of our work. Our production requires the performance of a large number of miscellaneous, nonrepetitive, low-volume tasks. For example, on one day (August 29, 1966) our time reporting system showed that approximately 3,750 different operations were performed in the plant. These operations, which were spread over 210 different work centers or types of work, constituted 5,700 direct labor hours, or an average of 1.52 hours per operation.

An example

To dramatize the problem, let us assume that Elliott Corporation is a complete job shop and that no job is ever repeated. There are 30,000 direct labor hours expended per week, and the average time to complete one operation in the shop is 1.52 hours. If the time required for an industrial engineer to set a standard were .35 hours, to obtain an 80 per cent coverage goal we would need more than 5,000 industrial engineering man-hours for setting standards, or the equivalent of more than 120 industrial engineers. This example is unrealistic, but it does show how uneconomical a measured day work program could be.

Actually, only about 12 per cent of all the direct labor operations in the plant are never repeated. Furthermore, only about 5 per cent of the total direct labor operations at any given time need to be revised by methods improvements and to have their standards updated. Even so, once the initial standard-setting job had been completed, we would need the equivalent of more than 800 standard application hours or more than 20 men per week to maintain 80 per cent coverage at a standard-setting time rate of .35 hours.

Slotted standards

This was better than our hypothetical example but still too much. As a result, we came to the conclusion that instead of trying to set pinpoint standards for every operation it would be more practical, in the case of the less significant, less frequently repeated operations, to base the standards upon a "range of time" in which the

The total number of application hours could not be increased substantially without additional staff—an investment that might well make the whole project uneconomic. It was obvious that the time required to set one standard had to be cut still more.

work of a given operation could be performed by a qualified operator.

The "slotting" concept was originally developed in 1953 in connection with the development of a system of time standards for maintenance work. (Maintenance work differs from high-volume production work in that the method of performing a maintenance task varies from job to job while a worker on a high-volume production job will use the same method every time.) Two basic principles were employed to make slotted standards economical and feasible:

Time-range groups established

Range of Time – Instead of being expressed as exact times, standards are expressed as ranges of time. At Elliott Company two time-range groups were established.

One group is intended for use with operations where the time per piece is relatively small, such as flame cutting, shearing, etc. This group, shown in Exhibit 3 on page 45, has fourteen ranges of time from 0 to 1 hour, twelve ranges from 1 to 10 hours, and eleven ranges from 10 to 33 hours. The standard hour deviations from the time group mean are approximately ±15 per cent, ±10 per cent, and ±5 per cent, respectively.

The second time-range group, shown in Exhibit 4 on the left, is used for operations where the time per piece is high – fit, tack, weld, and heavy assembly. This group has fewer time ranges; it has twenty time ranges up to the 32-hour time-range maximum, as compared to the 37 time ranges in the first group.

Benchmark Jobs – Typical jobs are given carefully engineered, accurate standards and are used to create "slots" or "pigeon holes" into which other, related jobs can be fitted. These typical jobs, called "benchmark jobs," are chosen primarily on their ability to encompass a job that is representative of the parts made, the operations performed, and the variations encountered.

EXHIBIT 4

Standard Time Ranges

Time Grouping #2

Standard	Time Range (Hours) Minimum	Maximum
0.1	0.00	0.15
0.2	0.15	0.25
0.4	0.25	0.50
0.7	0.50	0.90
1.2	0.9	1.5
2.0	1.5	2.5
3.0	2.5	3.5
4.0	3.5	4.5
5.0	4.5	5.5
6.0	5.5	6.5
7.3	6.5	8.0
9.0	8.0	10.0
11.0	10.0	12.0
13.0	12.0	14.0
15.0	14.0	16.0
17.0	16.0	18.0
19.0	16.0	18.0
22.0	20.0	24.0
26.0	24.0	28.0
30.0	28.0	32.0
34.0	32.1	36.0
38.0	36.1	40.0
42.0	40.1	44.0
46.0	44.1	48.0
50.5	48.1	53.0
56.0	53.1	59.0
62.0	59.1	65.0
68.0	65.1	71.0
75.0	71.1	79.0
83.0	79.1	87.0
91.0	87.1	95.0
100.0	95.1	105.0

During the initial operation all standards are established by worksheet calculations. As the benchmark file is being built up, the standards analyst begins to compare the work he is calculating with that already calculated and slotted. At this point the benchmarks can take one of two forms:

Single major variable

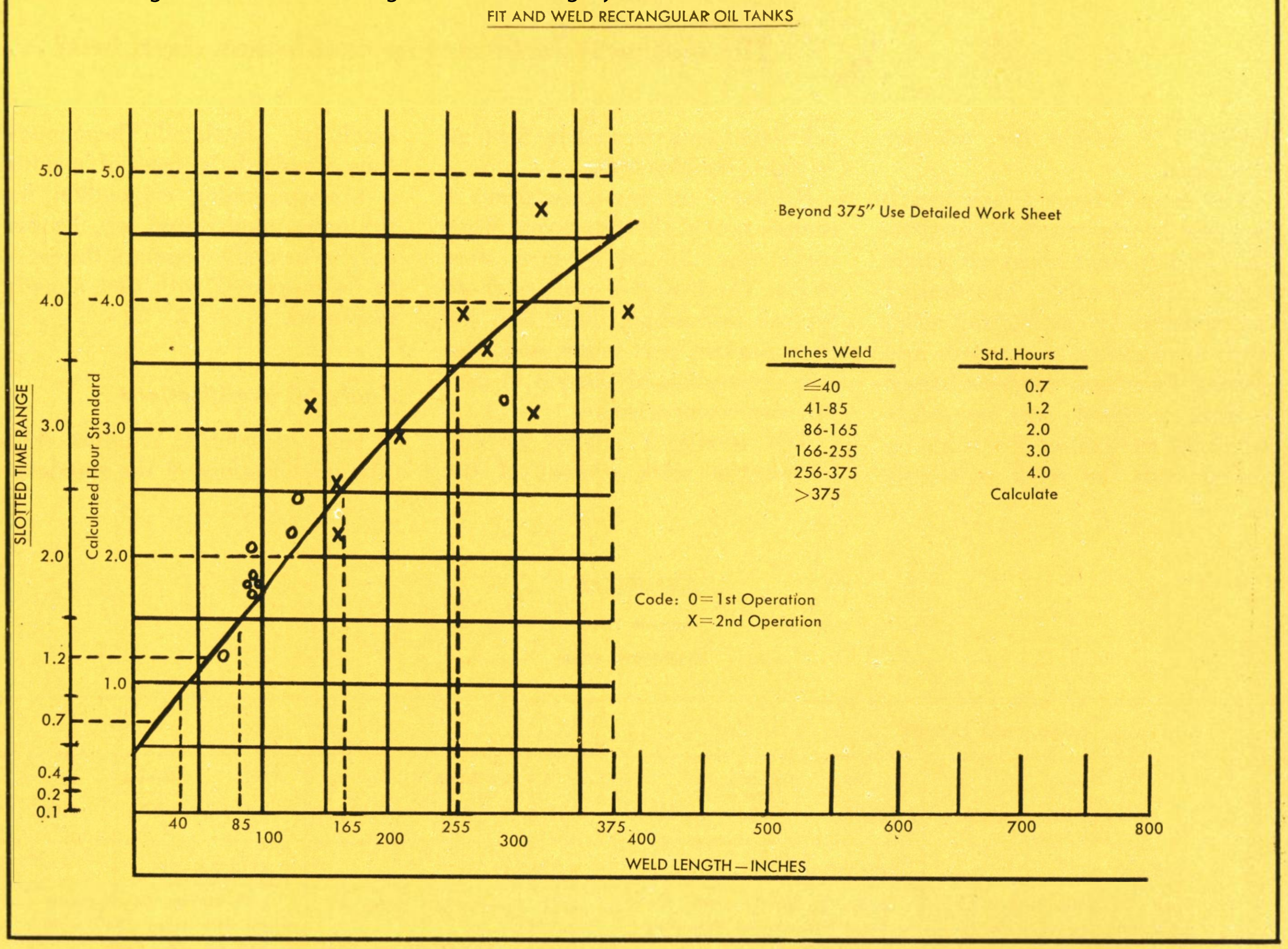
If a single major variable exists, then the job times are plotted on a chart against the variable, as shown in Exhibit 5 on page 47, to determine whether a logical curve can be established. For example, the variable found for the fitting and welding of oil tanks and baseplates was found to be the total length of weld. These products were grouped and a curve was drawn. Then the time ranges were superimposed on the curve to broaden it and let the highs and lows average out.

These standards are applied only to the two normal fit and weld operations of building an oil tank. Operation 1 is welding the bottom and the two ends plus burning openings and fitting nozzles and brackets. Operation 2 is fit and weld to complete all remaining items.

For ten different oil tanks the total calculated standard for Operation 1 is 21.33 hours, and the total slotted standard is 22.2 hours. The total calculated standard for Operation 2 is 29.31 hours, and the total slotted standard is 28 hours. These calculations are shown in Exhibit 6 on page 47.

Work content comparison

The total deviation of the first operation is +4 per cent, and the total deviation of the second operation is —4 per cent. The total cumulative deviation of the slotted times is 99.9 per cent, or within the validity limit of ±5 per cent within a 40-hour pay period. Deviations of individual standards of as much as ±30 per cent can be permitted so long as the cumulative



Calculation of Benchmarks by Major Variable Analysis

EXHIBIT 5

EXHIBIT 6

Calculation of Benchmarks by Work Content Comparison

DERIVATION OF DATA

FIT, TACK & WELD—RECTANGULAR OIL TANKS

		First Operation			Last Operation			
Part No.	Op. No.	Calc. Std.	Weld Lgth.	Slotted Std.	Op. No.	Calc. Std.	Weld Lgth.	Slotted Std.
670702-20	70 & 80	1.70	70″	1.2	110	2.15	164″	2.0
670739-17	60	1.77	88″	2.0	90	2.55	160″	2.0
670604-20	70	1.70	91″	2.0	100	3.40	136″	2.0
670605-20	70	1.80	92″	2.0				
670633-20	70 & 80	1.75	92″	2.0	130	3.65	272″	4.0
670737-20	80	2.07	92″	2.0	—	3.92	260″	4.0
825271-20	70 & 80	2.14	122″	2.0	130	2.97	206″	3.0
670607-20	90 & 100	2.47	126″	2.0	130	3.08	316″	4.0
825269-24	80 & 90	2.72	173″	3.0	140	4.69	321″	4.0
670843-28	80	3.21	296″	4.0	100	3.85	392″	*
815487-39	100 & 110	4.92	764″	*	140	7.52	544″	*
670822-17					100	2.90	196″	3.0
	Totals	21.33		22.2		29.31		28.0

$$\frac{22.2}{21.3} = 1.04 \qquad \frac{28.0}{29.3} = .96$$

$$\frac{50.2}{50.6} = .999$$

*Not Covered by Graph—Outside Validity Limit

The slotting is performed by establishing clear, brief . . .

deviation is within the ±5 per cent limit.

The second form a benchmark can take is work content comparison. This is used when no single major variable exists. The slotting is performed by establishing clear, brief descriptions of the jobs and slotting them into ranges of time. A new standard can be established by comparing the work required with the work previously calculated and covered by a range of time (benchmark).

Exhibit 7 on this page shows a sample spread sheet of layout work up to the .51- to .90-hour time range. The listing of each of these typical benchmark jobs has the part number, part name, and concise description of the job to permit easy comparison.

The standards analyst already knows the work content of the carefully calculated benchmark time standard. Instead of making a time-consuming calculation for the new, unmeasured job, he has only to mentally compare the work to be measured with that already measured.

Analysts' qualifications

This, of course, requires skill. The qualifications of the standards

EXHIBIT 7

Spread Sheet

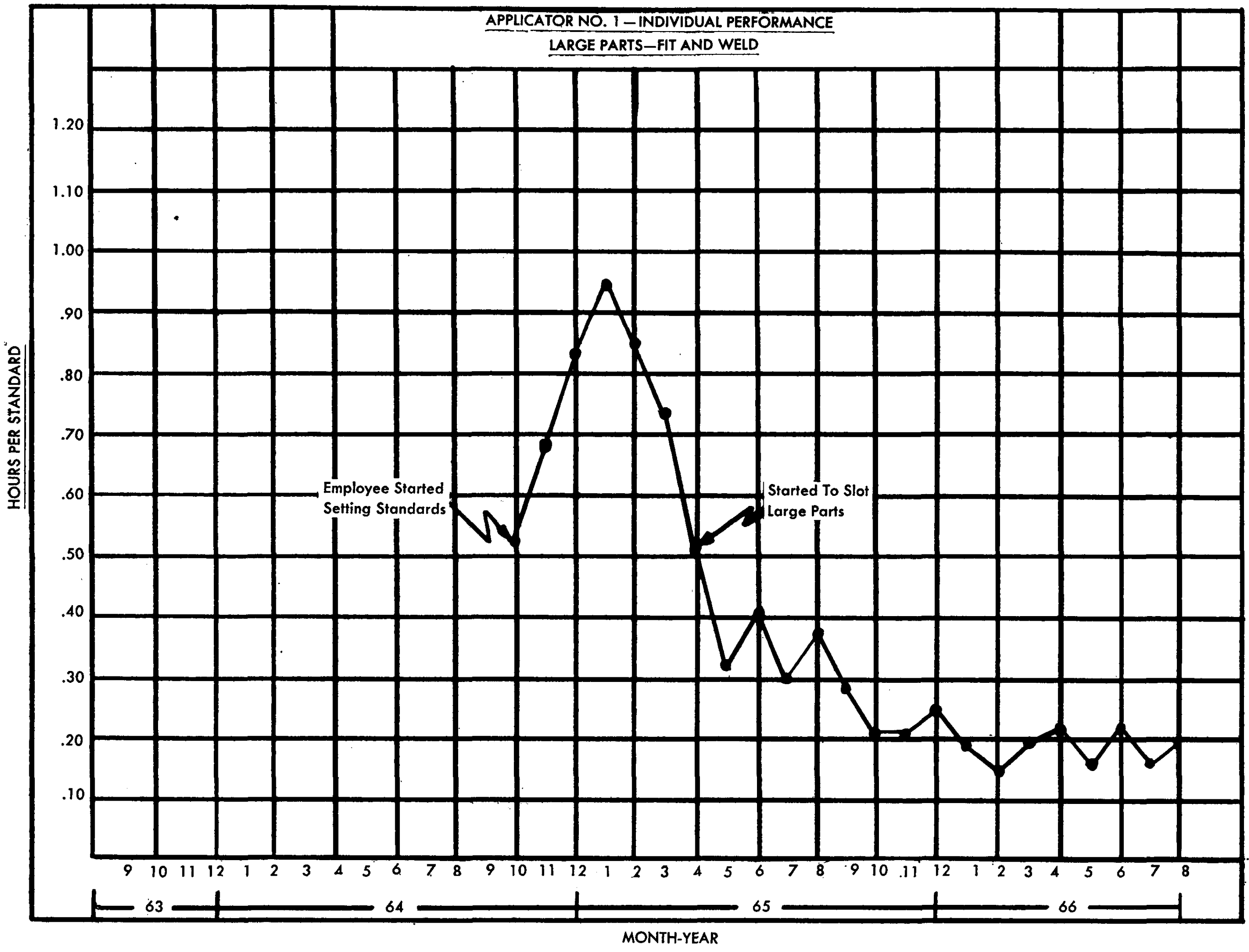
Benchmark Jobs

Task Area: TANK SHOP LAYOUT

Group (0) 0.10 (0.15)	Group (.151) 0.20 (.25)	Group (.251) 0.4 (.50)	Group (.51) 0.7 (.90)
831970-3 Spec. Shipping Brace—2½ x 2½L—56″ Lg.—L/o for ∠ Shearing plus, Order out 2 parts. S.U. = .17 Ea.Pc. = .137	636669-41 L/O Gauge Bar for Oil Level Indicator 1 Hole plus 1 Bend Line S.U. = .17 Ea.Pc. = .19	411260-11 L/O Flange—32″ O.D. x 24″ I.D. S.U. = .17 Ea.Pc. = .27	411260-SA01 L/O Nozzle Development— All Strt. Lines 154″ x 38″ S.U. = .17 Ea.Pc. = .84
448507-20 L/O Flange—9⅞″ O.D. x 3⅞″ I.D. S.U. = .17 Ea.Pc. = .10	831971-6 L/O 2 Holes in Lugs on 30″ Dia. x 15/16″ Plate S.U. = .17 Ea.Pc. = .19	411260-4 L/O Flange—59½″ O.D. x 48″ I.D. S.U. = .17 Ea.Pc. = .47	690812-5 L/O Plate & Location of 2 Hdls. + Flng. for Oil Tank Cover S.U. = .17 Ea.Pc. = .84
434055-2 L/O Flange—11⅞″ O.D. x 1½″ I.D. S.U. = .17 Ea.Pc. = .13		670739 L/O Form Template for Oil Tank Bottom S.U. = .17 Ea.Pc. = .43	815784-4 19 Blade Imp. 20″ O.D. 7½″ I.D. S.U. = .35 Ea.Pc. = .76
411260—9,10 Water Inlet Flange Order out 1 piece S.U. = .17 Ea.Pc. = .06		843100-1 Soleplate—3″ x 28″ x 24″ L/O 4 Str. Lines S.U. = .17 Ea.Pc. = .40	833748-4 15″ O.D. Flanged Brg. Hous'g. End Cover. 1 Temp., 1 Circle, 2 Strt. Lines, 1 Order out S.U. = .242 Ea.Pc. = .521
		448893-7 2″—150# Stm. Chest Assy. 4 Lines—2 Circles S.U. = .17 Ea.Pc. = .26	448916-4 14″ Noz. Ass'y., 1 Cplng., 8 Str. Lines, 1 Circle S.U. = .17 Ea.Pc. = .634
		843101-4 16″ x 16″ Centering Pin Holder—6 Str. Lines and 1 Circle S.U. = .17 Ea.Pc. = .50	448755-14 Flange 86″ O.D. 72″ I.D. S.U. = .17 Ea.Pc. = .589
		638810-3 Soleplate 78″ x 15″—4 Str. Lines S.U. = .17 Ea.Pc. = .425	448687-5 Man Hole Cover 6 Str. Lines, 4 Circles S.U. = .17 Ea.Pc. = .744

Task Area: TANK SHOP LAYOUT

. . . descriptions of the jobs and slotting them into ranges of time.



Time to Set Standards for Large Parts

EXHIBIT 8

analysts are among the most important ingredients of a slotting program. The analyst must have a thorough knowledge of the work on which he is setting a standard and be able to understand the application of the standard data. At Elliott Company most of the analysts are practical shop men who can visualize any job they are analyzing.

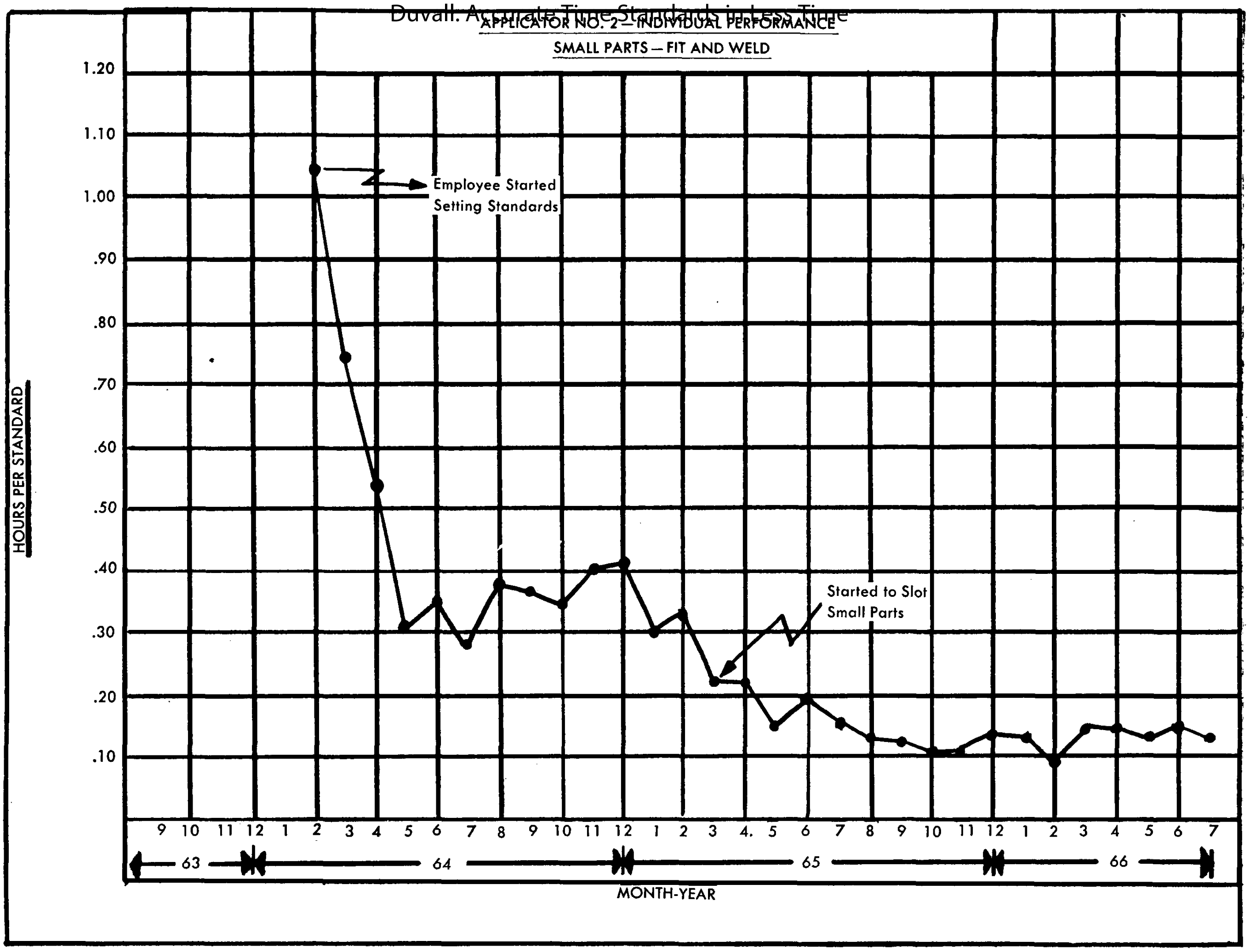
Results

The results have been highly satisfactory. As Exhibit 1 shows, by August 1, 1966, the time required to set one standard had been reduced to .16 hours. As of the same date (Exhibit 2) the coverage was around the 75 per cent level, with total application hours per week between 350 and 400 hours.

Exhibit 8 shown above and Exhibit 9 on page 50 give specific examples of the effect of slotting on the time to set standards. The standards analyst whose work is charted in Exhibit 8 is responsible for the establishments of standards for large parts fitting and welding. Before the slotting technique was installed in April, 1965, this man was calculating individual standards from a detailed worksheet and averaging .74 hours per standard. Now he is averaging .22 hours per standard, or an improvement of better than 300 per cent.

Easiest standards set first

This improvement is particularly striking because the less difficult standards were set first. The parts concerned are large parts, such as barometric condensers and ejectors, which can range from the size of a railroad car to the size of three railroad cars. Because of the



Time to Set Standards for Small Parts

EXHIBIT 9

size of these parts, the standard times for fitting and welding them will vary substantially, and so will the time to establish one standard. We set rates on the smaller fabrications first because they took less time and moved on to the larger units later. During the first month of application of slotted time standards the time to set one standard on large parts was reduced from .73 hours to .51 hours. Without slotting, the time required would have hovered around the average for the first six months of .76 hours.

The standards analyst whose work is illustrated in Exhibit 9 is responsible for establishing standards for small parts fitting and welding. When he started setting rates in March, 1964, his time to set one rate was extremely high. Improvement was immediately noticeable, as the result of the learning curve, and after the first three months his time had dropped to between .30 and .40 hours. There it remained until the introduction of slotting in March, 1965. Then the time was reduced to an average of .15 hours per standard, representing a better than 200 per cent improvement.

Conclusion

The slotting principle is not used on all operations at Elliott Company. Pinpoint accuracy is still required on many machining tasks. Slotted time standards are being used for fitting, welding, rolling, burning, shearing, and various miscellaneous assembly operations.

Introduction of the slotting technique has benefited people who perform several functions. The foreman in, say, the weld shop now has available a guide to how long it should take to do nine out of ten jobs. The standards analyst now is able to cover accurately approximately 90 per cent of the 4,000 hours of direct labor expended in the weld shop each week. The industrial engineer now has a practical method that enables him to develop realistic time standards in economical amounts of time.

The most important fact is that management has a work measurement program that is economical and still is accurate enough for scheduling, estimating, measuring, and planning. Slotting has sold itself to the Elliott Company.