Designation: ~~E2691 – 11~~ E2691 – 16

Standard Practice for Job Productivity Measurement[1]

This standard is issued under the fixed designation E2691; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Job Productivity Measurement (JPM) measures both construction productivity differential on an ongoing and periodic basis and average productivity over the life of the construction project.

JPM calculates the ratio of output per unit of input: how much work—Construction Put In Place (CPIP)—was produced by how many labor hours. Additionally, JPM is an early warning signal for construction performance. It measures ongoing productivity changes, trends, and anomalies resulting from changes on a construction jobsite, which enables contractors, project managers, supervisors, and foremen to react and improve productivity as the construction project unfolds.

1. Scope

1.1 Based on the UNIFORMAT II format for organizing building data, established in Classification E1557, and depending on the level where measurement is applied (industry, total job, or building element), JPM measures construction productivity at three levels: task, project, and industry (shown in Fig. 1). By comparing labor hours used against CPIP, JPM allows for unified measurement of established building elements (according to the UNIFORMAT II format. This practice establishes a process for measuring construction job productivity by comparing labor usage to CPIP.

1.2 JPM measures labor productivity of the installation processes on a construction job.[2]

1.3 CPIP is measured with input from the labor performing the installation, utilizing elements of statistical process control (SPC) and industrial engineering.

1.4 JPM takes into account the difficulty of installation at any given point on a job.

1.5 JPM evaluates relative productivity changes using trend monitoring.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E631 Terminology of Building Constructions
E833 Terminology of Building Economics
E1557 Classification for Building Elements and Related Sitework—UNIFORMAT II
E1946 Practice for Measuring Cost Risk of Buildings and Building Systems and Other Constructed Projects
E2166 Practice for Organizing and Managing Building Data
E2587 Practice for Use of Control Charts in Statistical Process Control

2.2 *ASTM Manual:*[4]

MNL 65 Application of ASTM E2691 Standard Practice for Job Productivity Measurement

3. Terminology

3.1 *Definitions*—For definition of ~~terms~~ general terms related to building construction used in this practice, refer to Terminology E631 ~~and~~ ; and for general terms related to building economics, refer to Terminology E833.

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.81 on Building Economics.

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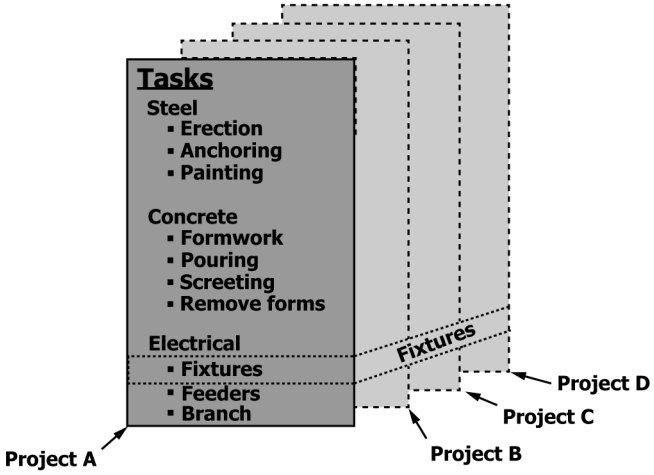
[2] JPM is based on the application of Job Productivity Assurance and Control (JPAC), which has been used in industry for more than fifteen years, resulting in 20 to 30 % improvement in productivity for contractors using it.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from ASTM International Headquarters. Order MNL65-EB.



Measurement at the **task** and **project** level (above) aggregate to provide measurement at the industry level (below).

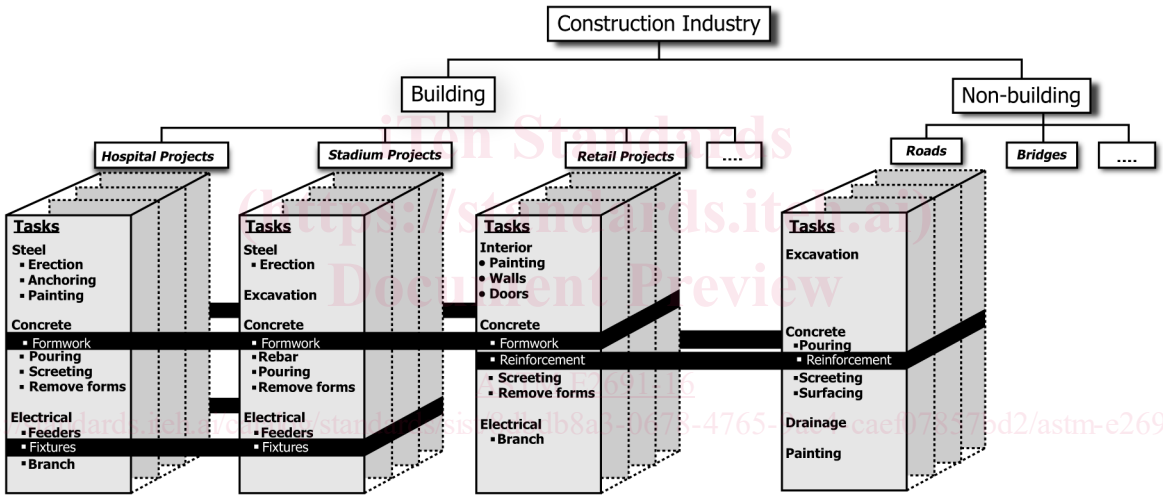


FIG. 1 Measurement of Productivity at the Industry, Project, and Task Level

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baseline labor hour budget, n*—a budget of direct labor hours created at the onset of a new construction project that approximates how many hours will be spent on any defined part of the project.

3.2.1.1 *Discussion*—

The budgeted hours are first assigned to the tasks on the project, and can be summed to determine budgeted hours for any cost code or for the entire project.

3.2.2 *control signal, n*—in construction, any series of data points which indicates deviation from the expected job progress in relation to labor, material, or finance, and indicates anomalies on the jobsite to the contractor, project manager, or job supervisor.

3.2.2.1 *Discussion*—

In the Job Productivity Measurement Standard Practice, a control signal identifies any deviation from the labor productivity reference point.

3.2.3 *labor productivity reference point, n*—a ratio calculated at the beginning of a construction project, for the hours needed to complete one percent of the construction, based on the baseline labor hour budget.

3.2.4 *non-installation hours, n*—labor hours spent on activities other than installation, removal, or erection of material on the jobsite including, but not limited to, hours spent on prefabrication, preassembly, job-layout, supervision, or job planning.

3.2.5 *observed percent complete, n*—a percentage number estimate, based on physical observation, that documents what portion of a jobsite task, cost code, or entire project has been completed.

3.2.6 *productivity differential, n*—in JPM, a measurement of the percent difference between the labor productivity reference point and the current labor productivity for the given timeframe.

3.2.6.1 *Discussion*—

In the Job Productivity Measurement Standard Practice, job productivity is defined as the rate of production over time, and measures the ongoing and periodic changes in productivity over time. If more hours are used than planned due to the difficulty of installation, errors, or rework, the job productivity differential will be negative. If fewer hours are used than planned, the job productivity differential will be positive.

3.2.7 *system productivity, n*—the ratio of the labor hours allocated to physical construction put in place,[5] over the total labor hours used for completion of the project.

4. Summary of Practice

4.1 This practice is organized as follows:

4.1.1 *Section 1, Scope*—~~Section~~Identifies ~~1, Scope—Identifies~~ coverage.

4.1.2 *Section 2, Referenced Documents*—~~Section~~Lists ~~2, Referenced Documents—Lists~~ ASTM standards referenced in this practice.

4.1.3 *Section 3, Terminology*—~~Section~~Addresses ~~3, Terminology—Addresses~~ definitions of terms used in this practice.

4.1.4 *Section 4, Summary of Practice*—~~Section~~Outlines ~~4, Summary of Practice—Outlines~~ the contents of this practice.

4.1.5 *Section 5, Significance and Use*—~~Section~~Explains ~~5, Significance and Use—Explains~~ significance of measuring job productivity and of using the JPM practice to do so.

4.1.6 *Section 6, Procedure*—~~Section~~Lists ~~6, Procedure—Lists~~ the steps for conducting JPM.

4.1.7 *Section 7, Data Sources and Assumptions*—~~Section~~Describes ~~7, Data Sources and Assumptions—Describes~~ raw data used in calculation of JPM.

4.1.8 *Section 8, Calculation of Labor Productivity Reference Point (LPRP)*—~~Section~~Describes ~~8, Calculation of Labor Productivity Reference Point (LPRP)—Describes~~ calculation of LPRP, using data gathered according to Section 7, and with output provided for Section 9.

4.1.9 *Section 9, Calculation of JPM*—~~Section~~Provides ~~9, Calculation of JPM—Provides~~ algorithms for determining JPM.

4.1.10 *Section 10, Report*—~~Section~~Describes ~~10, Report—Describes~~ various types of reporting output for JPM.

4.1.11 *Section 11, Applications*—~~Section~~Describes ~~11, Applications—Describes~~ where and how JPM information can be used.

4.1.12 *Section 12, Keywords*—~~Section~~Lists ~~12, Keywords—Lists~~ related words and phrases.

5. Significance and Use

5.1 JPM produces two measurements: construction production rate and productivity.

5.1.1 JPM measures the overall production rate by comparing CPIP to the time elapsed in the construction schedule.

5.1.2 JPM measures overall job productivity through a comparison of labor usage to a reference point.

5.2 JPM issues early warning signals for construction.

5.2.1 JPM identifies productivity deviations in the form of any gains or losses in productivity, and anomalies indicating a special cause, from the productivity reference point.

5.2.2 JPM measures the productivity changes to individual building elements (according to the UNIFORMAT II format for organizing building data, in Classification E1557) with the same methodology used for overall job productivity measurement.

5.2.3 JPM measures ongoing changes in labor usage.

5.3 JPM measures productivity wherever the labor is used in construction by:

5.3.1 Any contractor or construction manager directly or indirectly responsible for the productivity of the labor and its usage.

5.3.2 Any contractor or construction manager conducting self performance on any portion of the construction job.

5.3.3 Any contractor or construction manager supervising labor performance on any portion of a construction job.

6. Procedure

6.1 Establish a baseline labor hour budget (BLHB) for the scope of the construction job being measured using a Work Breakdown Structure (WBS) and reference to the UNIFORMAT II classification (Practice E1557).

[5] Construction put in place is defined in the C30 series report from the U.S. Census Bureau on "Value of Construction Put in Place," http://www.census.gov/.

6.2 Evaluate the BLHB for appropriate level of detail.

6.3 Establish the labor productivity reference point (LPRP).

6.4 Once any labor hours are expended on the job (even before installation commences, with activities such as planning, layout, pre-assembly), begin tracking the JPM.

6.5 Report the JPM productivity differential and review the results for signals of special causes[6] impacting the productivity.

7. Data Sources and Assumptions

7.1 There are four data sources required for the calculation of JPM:
7.1.1 An estimate of the scope of construction to be put in place (see 7.2).
7.1.2 The BLHB developed from a work breakdown structure (WBS) (see 7.3).
7.1.3 Expended labor hours (see 7.4).
7.1.4 CPIP, measured by observed percent complete (see 7.5).

7.2 The estimate of the labor required for installation is established prior to establishing the BLHB.
7.2.1 Profit on the project is calculated based on estimated labor cost with given labor hours; therefore, the BLHB must not exceed the estimated labor hours.

7.3 A WBS comprised of cost codes and tasks is needed to establish the BLHB as described in Section 8.
7.3.1 The UNIFORMAT II classification (Practice E1557) provides a format for creating a WBS by defining a hierarchy of building elements; Practice E2166 provides a practice for organizing building data based on UNIFORMAT II.[7]
7.3.1.1 JPM users managing several contractors or subcontractors have subcontractors reporting JPM for each of the major group elements and group elements defined in UNIFORMAT II.
7.3.1.2 Contractors and subcontractors directly managing installation report JPM for major group elements, using cost codes similar to the individual elements from UNIFORMAT II. For example, the cost codes for an electrical contractor include service and distribution, lighting and branch wiring, communication and security systems, and special electrical systems, as shown in Fig. 2.
7.3.2 Establish cost codes that will remain standard across all jobs within the company. Use a maximum of 20 cost codes. Seven to twelve cost codes are effective for most applications.[8] Reference the descriptions listed as individual elements in Section 3 of UNIFORMAT II for creating cost codes.
7.3.3 Depending on the application level of JPM, tasks are defined by either UNIFORMAT II, or when applied at the project level, are generated and described individually as a subset of each cost code.
7.3.4 A partial example of a WBS based on UNIFORMAT II is shown in Fig. ~~2~~3, where UNIFORMAT II Level 2 and 3 are shown for an electrical contractor, and detailed tasks have been assigned to Level 3 for the Service and Distribution.
7.3.5 The WBS includes tasks for both installation and non-installation activities.
7.3.5.1 Non-installation activities include, but are not limited to, planning, layout, pre-fabrication and assembly, and supervision.
7.3.5.2 Non-installation hours are included as tasks within the cost codes to which they apply.
7.3.6 The baseline labor hours are assigned to the lowest level tasks of the WBS, establishing $BLHB_{Task}$ for each task.

7.4 On the project level application of JPM, labor hours expended are reported in each cost code. This method of time reporting must be consistent with time reported for payroll purposes. Hours are not reported for any level lower than the cost codes in the WBS. In other words, hours are not collected or reported by individual activities.

7.5 CPIP is the observed completed portion of each task (observed percent complete), contributing to the total completion of that task, based on effort expended.

NOTE 1—Observed percent complete will take into account the difficulty of installation of each task. For example, the first five hundred feet of a one thousand foot pipe installation could be a straight run, giving observed percent complete of fifty percent. The second five hundred feet of the installation could be more difficult, requiring more labor hours. Therefore, the ratio of construction put in place to labor hours spent will not be a linear relationship. In this example, the first five hundred feet could use 250 out of 1000 hours, where the second five hundred feet could use 750 out of 1000 hours.

8. Calculation of Labor Productivity Reference Point

8.1 The WBS created in 7.3 is used to create the BLHB, which is then evaluated and used to establish the initial LPRP.

8.2 Create a BLHB for the job.

[6] As defined by Practice E2587, a special cause (or unassignable cause) is a factor that contributes to variation in a process or product output that is feasible to detect and identify. In JPM measurement, the factor contributes to variation in productivity or deviation from the productivity reference point.
[7] UNIFORMAT II is limited to building construction, whereas JPM applies to all types of construction, including roads and bridges, tunnels, dams, and railroads.
[8] For reasons similar to those listed in 6.1.3 of Practice E1946, 20 elements provides an appropriate level of detail for measuring job progress without oversimplifying the JPM, or placing undue burden on the field labor for tracking required for the JPM.

Level 1 Major Group Elements	Level 2 Group Elements	Level 3 Individual Elements
A SUBSTRUCTURE	A10 Foundations	A1010 Standard Foundations A1020 Special Foundations A1030 Slab on Grade
	A20 Basement Construction	A2010 Basement Excavation A2020 Basement Walls
B SHELL	B10 Superstructure	B1010 Floor Construction B1020 Roof Construction
	B20 Exterior Enclosure	B2010 Exterior Walls B2020 Exterior Windows B2030 Exterior Doors
	B30 Roofing	B3010 Roof Coverings B3020 Roof Openings
C INTERIORS	C10 Interior Construction	C1010 Partitions C1020 Interior Doors C1030 Fittings
	C20 Stairs	C2010 Stair Construction C2020 Stair Finishes
	C30 Interior Finishes	C3010 Wall Finishes C3020 Floor Finishes C3030 Ceiling Finishes
D SERVICES	D10 Conveying	D1010 Elevators & Lifts *D1020 Escalators & Moving Walks* D1090 Other Conveying Systems
	D20 Plumbing	D2010 Plumbing Fixtures D2020 Domestic Water Distribution D2030 Sanitary Waste D2040 Rain Water Drainage D2090 Other Plumbing Systems
	D30 HVAC	D3010 Energy Supply D3020 Heat Generating Systems D3030 Cooling Generating Systems *D3040 Distribution Systems* D3050 Terminal & Package Units D3060 Controls and Instrumentation D3070 Systems Testing & Balancing D3090 Other HVAC Systems & Equipment
	D40 Fire Protection	D4010 Sprinklers D4020 Standpipes D4030 Fire Protection Specialties D4090 Other Fire Protection Systems
	D50 Electrical	D5010 Electrical Service & Distribution D5020 Lighting and Branch Wiring D5030 Communications & Security D5090 Other Electrical Systems
E EQUIPMENT & FURNISHING	E10 Equipment	E1010 Commercial Equipment E1020 Institutional Equipment E1030 Vehicular Equipment E1090 Other Equipment
	E20 Furnishings	E2010 Fixed Furnishings E2020 Movable Furnishings
F SPECIAL CONSTRUCTION & DEMOLITION	F10 Special Construction	F1010 Special Structures F1020 Integrated Construction F1030 Special Construction Systems F1040 Special Facilities F1050 Special Controls and Instrumentations
	F20 Selective Building Demolition	F2010 Building Elements Demolition F2020 Hazardous Components Abatement

FIG. 2 One Section of the UNIFORMAT II Classification of Building Elements (Practice E1557), Shown as a Format for Creating a WBS

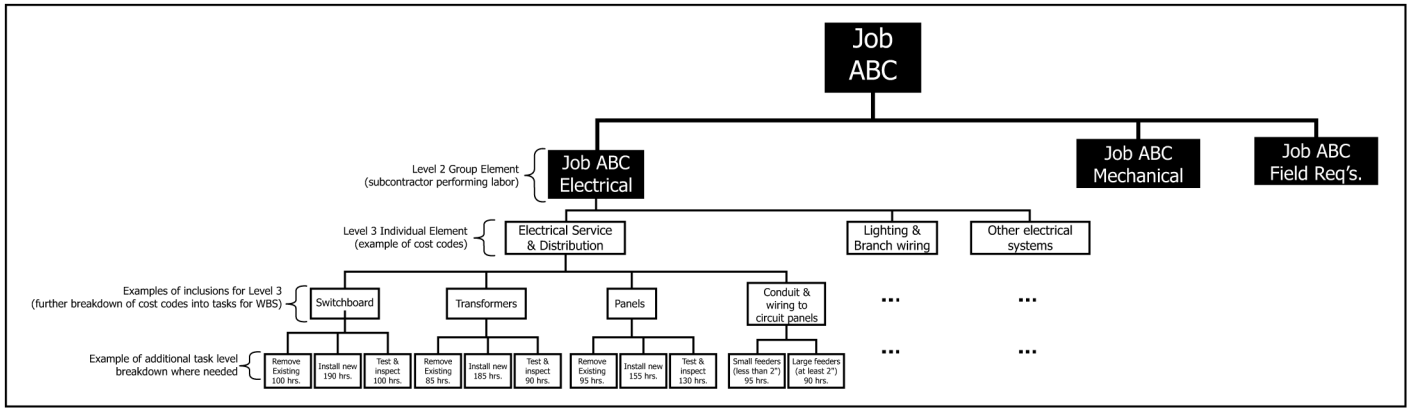


FIG. 3 Partial WBS for Electrical Subcontractor, Based on UNIFORMAT II

8.2.1 Data from 7.3.6 provides budgeted labor hours for each task in the WBS. Use either the budgeted labor hours specific to a job based on company past practice or, if that data is not available, use an industry standard reference point such as R.S. Means Cost Estimating guide (**1**).[9]

8.2.2 Determine the BLHB for each cost code by summing the BLHB for each task within the cost code at the lowest level of the WBS, according to Eq 1:

$$BLHB_{CostCode} = \sum_{Tasks} BLHB_{Task} \tag{1}$$

8.2.3 Determine the BLHB for the total job by summing the hours budgeted in each cost code, as shown in Eq 2.

$$BLHB_{Job} = \sum_{CostCodes} BLHB_{CostCode} \tag{2}$$

8.2.4 The summed cost code hours comprise the total direct labor budget for the job. An illustration of a conversion from the WBS into a BLHB is shown in Table 1.

8.3 Evaluate the BLHB.

8.3.1 Calculate the contribution of each $BLHB_{Task}$ to its associated cost code, and to the overall job (Eq 3 and 4).

$$\text{BLHB Task Weight per Cost Code} = \frac{BLHB_{Task}}{BLHB_{CostCode}} \tag{3}$$

$$\text{BLHB Task Weight per Job} = \frac{BLHB_{Task}}{BLHB_{Job}} \tag{4}$$

8.3.2 Common practice has shown that a task representing more than 2.5 % of the total job will be difficult to visualize for reporting observed percent complete. If any $BLHB_{Task}$ is greater than 2.5 % of $BLHB_{Job}$, divide the task into more detailed tasks.

8.3.3 Continue to divide tasks as necessary and reallocate hours until each $BLHB_{Task}$ is less than 2.5 % of the $BLHB_{Job}$. Examples of BLHB task weightings are shown in Table 2, columns 4 and 5.

8.3.4 Calculate the LPRP for each cost code as the BLHB required for one percent of CPIP (Eq 5).

$$LPRP_{CostCode} = \frac{BLHB_{CostCode}}{100} \tag{5}$$

8.3.5 Calculate the LPRP for the total job by summing the $LPRP_{CostCode}$ of each cost code weighted by the $BLHB_{CostCode}$ as a portion of the $BLHB_{Job}$ (Eq 6).

$$LPRP_{Job} = \sum_{CostCodes} \left(LPRP_{CostCode} \cdot \frac{BLHB_{CostCode}}{BLHB_{Job}} \right) \tag{6}$$

NOTE 2—One percent of a cost code ($LPRP_{CostCode}$) is not equal to one percent of the total job due to the fact that each cost code has a different impact on the job and is therefore weighted against the total job. In other words, one percent completion of each cost code could be higher or lower than one percent completion of the job. The cost code weighting is done to ensure that JPM takes into account the difficulty of installation based on the cost code being measured. Eq 6 takes weighting of the cost code into account and is a summation of weighted $LPRP_{CostCode}$, and therefore will not be equal to the simple summation of all $LPRP_{CostCode}$.

8.4 Account for change orders.

8.4.1 The budgeted labor hours associated with change orders are added or subtracted from the BLHB, and are included in the calculation of the baseline productivity from the point at which they are recognized by the labor performing installation.

[9] The boldface numbers in parentheses refer to a list of references at the end of this standard.

TABLE 1 Calculation of BLHB Using UNIFORMAT II Classification and WBS

Column # → Row # ↓	1	2a	2b	3
1	(UNIFORMAT II Level 3 Individual Element) Cost Code	Tasks		BLHB
2	Electrical Service & Distribution	Main switchboard	Remove Existing Switchboard	100
3			Install Switchboard - Equip. Room 1	100
4			Install Switchboard - Equip. Room 2	90
5			Test & Inspect S. Board - Equip. Room 1	60
6			Test & Inspect S. Board - Equip. Room 2	40
7		Primary transformer	Remove Existing Transformers	85
8			Install Transformer - Equip. Room 1	95
9			Install Transformer - Equip. Room 2	90
10			Test & Inspect Transformer - Equip. Room 1	50
11			Test & Inspect Transformer - Equip. Room 2	40
12		Branch circuit panels	Remove Existing Panels	95
13			Install Panels - Equip. Room 1	80
14			Install Panel - Equip. Room 2	75
15			Test & Inspect Panels - Equip. Room 1	70
16			Test & Inspect Pane! - Equip. Room 2	60
17		Conduit & wiring to circuit panels	Small Feeders	95
18			Large Feeders	90
19	Total Budgeted Hours for Electrical Service & Distribution			1315
20	Lighting & Branch Wiring	Lighting Fixtures	Floor 1 - assemble	40
21			Floor 1 - install	95
22			Floor 2 - assemble	40
23			Floor 2 - install	95
24			Floor 3 - assemble	35
25			Floor 3 - install	80
26			Showroom track lighting - assemble	40
27			Showroom track lighting - install	80
28			Showroom sconces - assemble	25
29			Showroom sconces - install	70
30			Showroom lay-ins - assemble	65
31			Showroom lay-ins - install	90
32		Branch wiring and devices for lighting fixtures	Floor 1 - conduit	90
33			Floor 1 - wire	100
34			Floor 2 - conduit	90
35			Floor 2 - wire	100
36			Floor 3 - conduit	90
37			Floor 3 - wire	100
38			Showroom - conduit	100
39			Showroom - wire	90
40		Devices	Floor 1 - terminate	80
41			Floor 1 - trim	60
42			Floor 2 - terminate	80
43			Floor 2 - trim	80
44			Floor 3 - terminate	90
45			Floor 3 - trim	100
46			Showroom - terminate	70
47			Showroom - trim	80
48	Total Budgeted Hours for Lighting & Branch Wire			2155
49	Other Electrical Systems	Emergency generator	Equipment set	80
50			Equipment connection	90
51			Testing	20
52		UPS		50
53		Lightning and grounding protection system		90
54		Raceway system		100
55	Total Budgeted Hours for Other Electrical Systems			430
56	Site Lighting	Set poles		80
57		Wire and conduit for fixtures		100
58		Install fixtures		90
59	Total Budgeted Hours for Site Lighting			270
60	Total Budgeted Hours for Job			4170

8.4.2 Note reasons for change orders as part of the JPM.

9. Calculation of JPM

9.1 Evaluate the JPM periodically by collecting CPIP and expended labor hours, and comparing them to the LPRP.

9.1.1 Report the CPIP, measured by observed percent complete on each task, as shown in Table 3, column 6.

TABLE 2 Calculation of BLHB Task Weights per Cost Code and per Job

Column # → Row # ↓	1	2a	2b	3	4	5
1	(UNIFORMAT II Level 3 Individual Element) Cost Code	Tasks		BLHB	BLHB Task Weight per Cost Code	BLHB Task & Cost Code Weight per Job
2	Electrical Service & Distribution	Main switchboard	Remove Existing Switchboard	100	8 %	2.4 %
3			Install Switchboard - Equip. Room 1	100	8 %	2.4 %
4			Install Switchboard - Equip. Room 2	90	7 %	2.2 %
5			Test & Inspect S. Board - Equip. Room 1	60	5 %	1.4 %
6			Test & Inspect S. Board - Equip. Room 2	40	3 %	1.0 %
7		Primary transformer	Remove Existing Transformers	85	6 %	2.0 %
8			Install Transformer - Equip. Room 1	95	7 %	2.3 %
9			Install Transformer - Equip. Room 2	90	7 %	2.2 %
10			Test & Inspect Transformer - Equip. Room 1	50	4 %	1.2 %
11			Test & Inspect Transformer - Equip. Room 2	40	3 %	1.0 %
12		Branch circuit panels	Remove Existing Panels	95	7 %	2.3 %
13			Install Panels - Equip. Room 1	80	6 %	1.9 %
14			Install Panel - Equip. Room 2	75	6 %	1.8 %
15			Test & Inspect Panels - Equip. Room 1	70	5 %	1.7 %
16			Test & Inspect Panel - Equip. Room 2	60	5 %	1.4 %
17		Conduit & wiring to circuit panels	Small Feeders	95	7 %	2.3 %
18			Large Feeders	90	7 %	2.2 %
19	Total Budgeted Hours for Electrical Service & Distribution			1315	100 %	31.5 %
20	Lighting & Branch Wiring	Lighting Fixtures	Floor 1 - assemble	40	2 %	1.0 %
21			Floor 1 - install	95	4 %	2.3 %
22			Floor 2 - assemble	40	2 %	1.0 %
23			Floor 2 - install	95	4 %	2.3 %
24			Floor 3 - assemble	35	2 %	0.8 %
25			Floor 3 - install	80	4 %	1.9 %
26			Showroom track lighting - assemble	40	2 %	1.0 %
27			Showroom track lighting - install	80	4 %	1.9 %
28			Showroom sconces - assemble	25	1 %	0.6 %
29			Showroom sconces - install	70	3 %	1.7 %
30			Showroom lay-ins - assemble	65	3 %	1.6 %
31			Showroom lay-ins - install	90	4 %	2.2 %
32		Branch wiring and devices for lighting fixtures	Floor 1 - conduit	90	4 %	2.2 %
33			Floor 1 - wire	100	5 %	2.4 %
34			Floor 2 - conduit	90	4 %	2.2 %
35			Floor 2 - wire	100	5 %	2.4 %
36			Floor 3 - conduit	90	4 %	2.2 %
37			Floor 3 - wire	100	5 %	2.4 %
38			Showroom - conduit	100	5 %	2.4 %
39			Showroom - wire	90	4 %	2.2 %
40		Devices	Floor 1 - terminate	80	4 %	1.9 %
41			Floor 1 - trim	60	3 %	1.4 %
42			Floor 2 - terminate	80	4 %	1.9 %
43			Floor 2 - trim	80	4 %	1.9 %
44			Floor 3 - terminate	90	4 %	2.2 %
45			Floor 3 - trim	100	5 %	2.4 %
46			Showroom - terminate	70	3 %	1.7 %
47			Showroom - trim	80	4 %	1.9 %
48	Total Budgeted Hours for Lighting & Branch Wire			2155	100 %	51.7 %
49	Other Electrical Systems	Emergency generator	Equipment set	80	19 %	1.9 %
50			Equipment connection	90	21 %	2.2 %
51			Testing	20	5 %	0.5 %
52		UPS		50	12 %	1.2 %
53		Lighting and grounding protection system		90	21 %	2.2 %
54		Raceway system		100	23 %	2.4 %
55	Total Budgeted Hours for Other Electrical Systems			430	100 %	10.3 %
56	Site Lighting	Set poles		80	30 %	1.9 %
57		Wire and conduit for fixtures		100	37 %	2.4 %
58		Install fixtures		90	33 %	2.2 %
59	Total Budgeted Hours for Site Lighting			270	100 %	6.5 %
60	Total Budgeted Hours for Job			4170		

TABLE 3 Reporting CPIP per Task as Measured by Physical Observation of Percent Complete on Each Task

Column # → Row # ↓	1	2a	2b	3	4	5	6
1	(UNIFORMAT II Level 3 Individual Element) Cost Code	Tasks		BLHB	BLHB Task Weight per Cost Code	BLHB Task & Cost Code Weight per Job	Observed % Complete
2	Electrical Service & Distribution	Main switchboard	Remove Existing Switchboard	100	8 %	2.4 %	100 %
3			Install Switchboard - Equip. Room 1	100	8 %	2.4 %	50 %
4			Install Switchboard - Equip. Room 2	90	7 %	2.2 %	20 %
5			Test & Inspect S. Board - Equip. Room 1	60	5 %	1.4 %	0 %
6			Test & Inspect S. Board - Equip. Room 2	40	3 %	1.0 %	0 %
7		Primary transformer	Remove Existing Transformers	85	6 %	2.0 %	95 %
8			Install Transformer- Equip. Room 1	95	7 %	2.3 %	5 %
9			Install Transformer - Equip. Room 2	90	7 %	2.2 %	0 %
10			Test & Inspect Transformer - Equip. Room 1	50	4 %	1.2 %	0 %
11			Test & Inspect Transformer- Equip. Room 2	40	3 %	1.0 %	0 %
12		Branch circuit panels	Remove Existing Panels	95	7 %	2.3 %	100 %
13			Install Panels - Equip. Room 1	80	6 %	1.9 %	80 %
14			Install Pane! - Equip. Room 2	75	6 %	1.8 %	50 %
15			Test & Inspect Panels - Equip. Room 1	70	5 %	1.7 %	0 %
16			Test & Inspect Panel - Equip. Room 2	60	5 %	1.4 %	0 %
17		Conduit & wiring to circuit panels	Small Feeders	95	7 %	2.3 %	90 %
18			Large Feeders	90	7 %	2.2 %	100 %
19	Total Budgeted Hours (col. 3); Weight per Cost Code (col. 4); Weight per job (col. 5); Cost Code % complete (col. 6)			1315	100 %	31.5 %	48 %
20	Lighting & Branch Wiring	Lighting Fixtures	Floor 1 - assemble	40	2 %	1.0 %	75 %
21			Floor 1 - install	95	4 %	2.3 %	20 %
22			Floor 2 - assemble	40	2 %	1.0 %	30 %
23			Floor 2 - install	95	4 %	2.3 %	5 %
24			Floor 3 - assemble	35	2 %	0.8 %	0 %
25			Floor 3 - install	80	4 %	1.9 %	0 %
26			Showroom track lighting - assemble	40	2 %	1.0 %	15 %
27			Showroom track lighting - install	80	4 %	1.9 %	0 %
28			Showroom sconces - assemble	25	1 %	0.6 %	15 %
29			Showroom sconces - install	70	3 %	1.7 %	0 %
30			Showroom lay-ins - assemble	65	3 %	1.6 %	0 %
31			Showroom lay-ins - install	90	4 %	2.2 %	0 %
32		Branch wiring and devices for lighting fixtures	Floor 1 - conduit	90	4 %	2.2 %	75 %
33			Floor 1 - wire	100	5 %	2.4 %	25 %
34			Floor 2 - conduit	90	4 %	2.2 %	45 %
35			Floor 2 - wire	100	5 %	2.4 %	5 %
36			Floor 3 - conduit	90	4 %	2.2 %	0 %
37			Floor 3 - wire	100	5 %	2.4 %	0 %
38			Showroom - conduit	100	5 %	2.4 %	100 %
39			Showroom - wire	90	4 %	2.2 %	100 %
40		Devices	Floor 1 - terminate	80	4 %	1.9 %	25 %
41			Floor 1 - trim	60	3 %	1.4 %	0 %
42			Floor 2 - terminate	80	4 %	1.9 %	0 %
43			Floor 2 - trim	80	4 %	1.9 %	0 %
44			Floor 3 - terminate	90	4 %	2.2 %	0 %
45			Floor 3 - trim	100	5 %	2.4 %	0 %
46			Showroom - terminate	70	3 %	1.7 %	0 %
47			Showroom - trim	80	4 %	1.9 %	0 %
48	Total Budgeted Hours (col. 3); Weight per Cost Code (col. 4); Weight per job (col. 5); Cost Code % complete (col. 6)			2155	100 %	51.7 %	20 %
49	Other Electrical Systems	Emergency generator	Equipment set	80	19 %	1.9 %	100 %
50			Equipment connection	90	21 %	2.2 %	100 %
51			Testing	20	5 %	0.5 %	50 %
52		UPS		50	12 %	1.2 %	100 %
53		Grounding		90	21 %	2.2 %	100 %
54		Special Raceway		100	23 %	2.4 %	100 %
55	Total Budgeted Hours (col. 3); Weight per Cost Code (col. 4); Weight per job (col. 5); Cost Code % complete (col. 6)			430	100 %	10.3 %	98 %
56	Site Lighting	Set poles		80	30 %	1.9 %	80 %
57		Wire and conduit for fixtures		100	37 %	2.4 %	65 %
58		Install fixtures		90	33 %	2.2 %	55 %
59	Total Budgeted Hours (col. 3); Weight per Cost Code (col. 4); Weight per job (col. 5); Cost Code % complete (col. 6)			270	100 %	6.5 %	66 %
60	Total Budgeted Hours for Job (col. 3); Observed%Complete for Job (col. 6)			4170			40 %

9.1.1.1 Calculate observed percent complete per cost code, by summing the weighted percent complete per task item for the cost code (Eq 7).

$$Observed\%Complete_{CostCode} = \sum_{TasksforCostCode} (Observed\%Complete_{Task} \cdot BLHBTaskWeightperCostCode) \quad (7)$$

NOTE 3—For Eq 7, Observed%Complete is expressed as a percentage and can take any value between 0 and 100.

9.1.2 Report the hours expended by the labor on each cost code, as shown in Table 4, column 7.

9.1.3 Calculate current productivity per cost code[10] as the labor hours expended per observed percent of CPIP for each cost code, based on the labor hours expended and the observed percent complete per cost code (Eq 8).

$$CurrentProductivity_{CostCode} = \frac{LaborHoursExpended_{CostCode}}{Observed\%Complete_{CostCode}} \quad (8)$$

NOTE 4—Observed%Complete is expressed in whole numbers in Eq 8, taking a value between 0 and 100.

9.1.4 Calculate the productivity differential as the percent difference between the LPRP and the current productivity, for each cost code (Eq 9).

$$ProductivityDifferential_{CostCode} = \frac{(LPRP_{CostCode} - CurrentProductivity_{CostCode})}{LPRP_{CostCode}} \quad (9)$$

9.1.5 Determine the total job productivity differential by taking the weighted average of the cost code productivity differentials.

$$ProductivityDifferential_{Job} = \sum_{CostCodes} (ProductivityDifferential_{CostCode} \times BLBHCostCodeWeight) \quad (10)$$

9.1.6 Continue evaluation of LPRP on periodic basis.

10. Report

10.1 Report the productivity differential on each cost code and for the job on a Summary Sheet (Table 5), which includes all of the elements from Tables 1-4, and the productivity differential for one reporting period.

10.2 Graphically represent the productivity differential trend over time, with the 0 % line representing the LPRP.

10.2.1 When the productivity differential is above the line, interpret that the job productivity is better than planned according to the initial LPRP (Fig. 4).

10.2.2 When the productivity differential is below the line, interpret that the job productivity is worse than planned according to the initial LPRP (Fig. 4).

10.3 Plot the percent productivity differential from each JPM update on a line graph, to show the trend in the differential over time, on the job, and by cost code (Fig. 5).

11. Applications

11.1 Review productivity trends for early warning signals of deviations in the form of any gains or losses in productivity, and anomalies as shown in Fig. 6, from the productivity reference point to identify special causes. Any anomaly or deviation from the reference point is a special cause if it has any the following characteristics:[11]

11.1.1 Trends: 6 or more points in the same direction.

11.1.2 Shifts in the mean: 9 or more points in a row on one side of the mean with the rest of the points fall at the other side of the mean.

11.1.3 Extreme points: a point more than 3 standard deviations above or below the mean.

11.1.4 Alternating ups and downs (saw tooth pattern): 14 points alternating vigorously.

11.2 Missing data is a clear indication of lack of process control and requires immediate attention.

11.3 If anomalies do not show any of the above-mentioned behaviors, such deviations (productivity gains or losses) are typically referred to as common variation due to daily events on the construction jobsite.

11.4 Analyze the JPM trends for individual jobs.

11.4.1 *Total Job*—Observe the total job trend for presence of any special causes. If there are no special trends as identified in Fig. 5, then use the productivity deviation to establish if the job is ahead or behind the expected productivity reference point.

[10] Current average productivity per job can also be calculated as labor hours expended per job divided by the observed percent complete for the job. Although this calculation is not used for calculation of the productivity differential and tracking JPM, it is a by-product of the data collected for JPM. For example, using the numbers in Table 4, current average productivity for the job is 37.7 hours per observed percent of CPIP (that is, 1508 divided by 40 = 37.7; where 1508 is listed in line 60, column 7, and 40 is listed in line 60, column 6).

[11] Practice E2587 describes four signals of a shift in the process level which are suitable for manufacturing; the signals listed here are modifications which apply in construction, based on common practice of JPM.