PennState College of Engineering | ARCHITECTURAL ENGINEERING

A Case Study in Production Improvement: Thompson Electric Company

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Summary

The pursuit of continuous improvement with a parallel valuing of people seemed to be instilled in the essence of Thompson Electric Company (TEC). Thompson has instilled and standardized this in their approach to projects, under their self-titled “Thompson Production Management.” Their approach streamlines their project management efforts through internally developed software tools that streamline the planning, structuring, prefabrication, and tracking of in-progress work. Paralleling this efficiency is a strong value for people, both on the customers they serve and their employees and field workforce. Their strong investment in training and mentoring shows through the retention and promotion of the apprentices that have moved through their leadership training into field or project leadership within the firm. Beyond thoughtful approaches, Thompson emphasizes the use of prefabrication to reduce the uncertainties of projects, using standard overhead racks and in-wall assemblies to reduce the planning effort of foreman when beginning new projects, allowing them to put more effort and thought into the unusual project aspects of any given project. Thompson is continuing to move forward while working to maintain standards and consistency across its three primary locations and fabrication facilities.

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Company Overview

Thompson Electric is a regional electrical contractor in the Midwest with major offices in Sioux City, Iowa, Omaha, NE, and Sioux Falls, SD. The company was founded nearly 100 years ago by Alfred Thompson, and his principles of community engagement are still lived in the current culture and day-to-day relationships engendered in the local communities where Thompson operates. As Thompson grew and developed into a multi-office location, they have been working to provide consistency in the quality and service they provide to their electrical construction automation and robotics, life safety and systems, IT and Software and Electrical Safety.

Delivery methods

Most of the construction work undertaken is in the commercial buildings sector, ranging from retail space to school projects, with some industrial work included. Most of the construction project work they engage in is through competitive bidding practices for the general contractor- led work, with some direct client relationships for some of the regional industrial firms.

Construction scopes

Thompson covers a wide range of scopes and services within their projects, ranging from the typical underground, overhead, and interior work typical to electrical construction. Their service arm covers an array of commercial, industrial, and energy sector projects, including hospitals, schools, food processing, and diverse multi-tenant buildings from condominiums to retail work. The controls and automation extend beyond typical commercial low voltage and data work for commercial buildings into the automation and robotics that are becoming more commonplace in industrial settings.

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Thompson is a union contractor, actively engaged with the local IBEW in their areas. They are involved in the training programs offered to apprentices, as well as parallel outreach to K-12 schools to introduce the idea of trade work for younger students.

Case Study Process

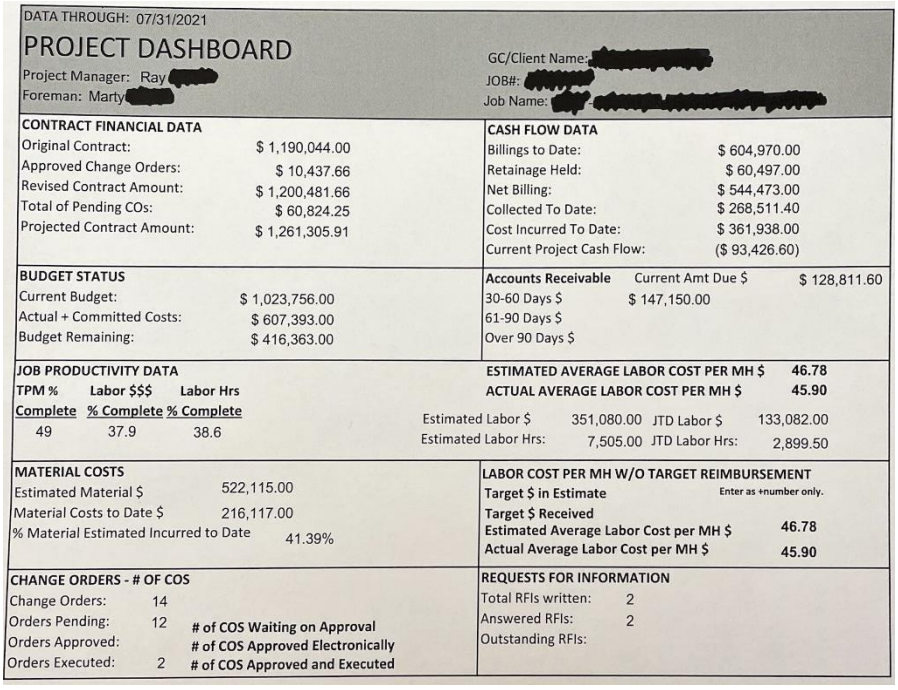
In late July 2022, the investigators of the Penn State Research Team conducted a site visit, performed interviews, and observed the operations at three construction projects for Thompson Electric's office in Sioux City, IA. The notes from the interviews and observations were reviewed to identify themes and the alignment of observed practices with lean principles. Following the visit, the case study was documented and shared with personnel at Thompson Electric for validation. The case study document contains the description of how the behaviors and approaches to lean are implemented at Thompson to support their construction operations.

Overview of Production Improvement Implementation

The purpose of the case study is to learn from the processes, practices, and methods implemented in the operations of MEP trade contractors. Thompson had a strong emphasis on planning and tracking work. They used this process to learn from their past projects and get better on each consecutive project.

Thompson Production Management

In an effort to standardize and streamline the production management on projects, Thompson developed an in-house application for organizing the collection of project production plans and weekly production updates across projects. Titled Thompson Production Management, or more commonly TPM, the software is accessible online. At the start of a project, each field leader would re-structure the information from the estimate to align the production plan with the project schedule, with a target of no task holding more than 250 hours. On a weekly basis, the field leader uses their iPad to update the status of all active tasks with the status of the installation. This, in turn, feeds the overall project management that



DATA THROUGH: 07/31/2021

PROJECT DASHBOARD

Project Manager: Ray [redacted]
Foreman: Marty [redacted]

GC/Client Name: [redacted]
JOB#: [redacted]
Job Name: [redacted]

CONTRACT FINANCIAL DATA

Original Contract:	$ 1,190,044.00
Approved Change Orders:	$ 10,437.66
Revised Contract Amount:	$ 1,200,481.66
Total of Pending COs:	$ 60,824.25
Projected Contract Amount:	$ 1,261,305.91

CASH FLOW DATA

Billings to Date:	$ 604,970.00
Retainage Held:	$ 60,497.00
Net Billing:	$ 544,473.00
Collected To Date:	$ 268,511.40
Cost Incurred To Date:	$ 361,938.00
Current Project Cash Flow:	($ 93,426.60)

BUDGET STATUS

Current Budget:	$ 1,023,756.00
Actual + Committed Costs:	$ 607,393.00
Budget Remaining:	$ 416,363.00

Accounts Receivable Current Amt Due $ $ 128,811.60

30-60 Days $	$ 147,150.00
61-90 Days $	
Over 90 Days $	

JOB PRODUCTIVITY DATA

TPM % Complete	Labor $$$ % Complete	Labor Hrs % Complete
49	37.9	38.6

ESTIMATED AVERAGE LABOR COST PER MH $ 46.78
ACTUAL AVERAGE LABOR COST PER MH $ 45.90

Estimated Labor $ 351,080.00 JTD Labor $ 133,082.00
Estimated Labor Hrs: 7,505.00 JTD Labor Hrs: 2,899.50

MATERIAL COSTS

Estimated Material $	522,115.00
Material Costs to Date $	216,117.00
% Material Estimated Incurred to Date	41.39%

LABOR COST PER MH W/O TARGET REIMBURSEMENT

Target $ in Estimate Enter as +number only.
Target $ Received
Estimated Average Labor Cost per MH $ 46.78
Actual Average Labor Cost per MH $ 45.90

CHANGE ORDERS - # OF COS

Change Orders:	14	
Orders Pending:	12	# of COS Waiting on Approval
Orders Approved:		# of COS Approved Electronically
Orders Executed:	2	# of COS Approved and Executed

REQUESTS FOR INFORMATION

Total RFIs written:	2
Answered RFIs:	2
Outstanding RFIs:	

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incorporates material purchasing, prefabrication hours, cash position, and billing information that are used in the overall project tracking. In addition to having the information housed through the app for input and sharing, the company has standardized a brief dashboard that extracts the status of the key indicators. The dashboard serves as an instrumental resource for project reviews.

The standardization of the application and reporting across multiple offices allows for clarity and consistency of information used. When personnel works across offices on projects they are intimately familiar with the tools and processes, allowing them to focus on the project and tasks, rather than learning custom processes or tools used in different locations.

Prefabrication Drivers and scopes

One of the key elements to differentiate Thompson's approach to production was their prefabrication shop operations. The shop operations, that originated in the Omaha office, were built up from scratch in an area with little other prefabrication work occurring. Thompson has been pursuing prefabrication for approximately 20 years and has consistently developed and standardized its work, with the rise of modeling and BIM as a boon to improve the reliability and visualization that allows them to be more successful in the implementation.

One of the main drivers for prefabrication was to reduce the overload of planning that occurs at the earliest stage of a project. With increasingly short timelines from the selection of the contractor to the start of work on-site, field leadership has a very short window to learn and plan a project. By targeting prefabrication on standard elements, the field personnel can focus in more detail on the site operations and unique aspects. Foreman can reduce the amount of time in takeoffs, labor planning, and purchasing requirements for those scopes. With site-specific challenges ranging from connecting to utilities, coordinating with the GCs schedule and other trades' work locations and sequences, the use of prefabrication removes a great deal of uncertainty, and the unique logistics that are needed for every new project – there is a great deal that needs to be figured out in a small amount of time.

Overhead conduit racks

Racking of overhead conduits was one of the focal points of the prefabrication efforts. The racking of multiple conduits onto the strut, with all thread or steel aircraft cable depending on the project

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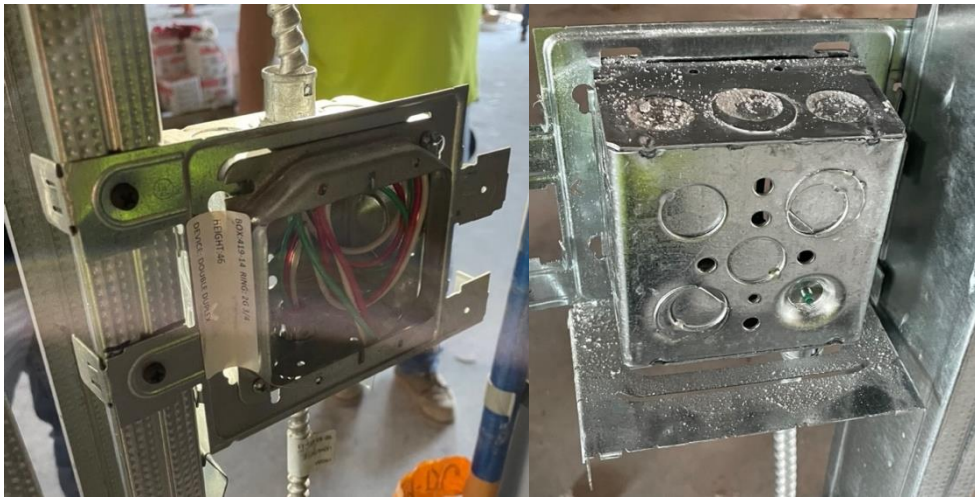
requirements, was commonly used to improve field installation rates. The racks were typically set at 10-foot lengths with two support struts, spaced five feet apart, as a size found to be manageable for a two-person crew. On one example project visited, the foreman cited installing an entire run of 10' racks across 120 feet of space within one day of work by a two-person crew. The project was a retail store with approximately 20' roof height.



In-wall prefabricated assemblies

The standardization of wall boxes for outlets, switches, and data allows for the pre-assembly of 5-7 pieces in the shop that are shipped to site in boxes labeled for the rooms. For receptacle boxes, the circuiting is considered and the middle of three receptacle boxes is pre-wired with MC cable, with the cable runs then pulled to the two adjacent boxes. The supports for the outlet boxes, lovingly nicknamed 'Corey boxes' after the prefab shop manager, were selected to support mistake-proofing in the installation and follow-on work by other trades. The tab alignment allows for two adjacent boxes to be fixed to the same metal stud while ensuring the boxes for receptacles or other devices are square and plumb. The tabs on the boxes ensure that they lock into 2x4 metal studs with a back dimension to brace them against the drywall behind them.

Underground (Omaha)

Some prefabrication of underground conduit runs was pursued. In one example project, they prefabricated multiple layers of conduit using HDPE panels with holes cut for each conduit. The tolerance on the openings allowed for some movement in each conduit for the connection to the next rack. In addition, they included a panel along the sides of the racks, akin to metal deck but with a light mesh, that allowed them to serve as forms for the duct bank that was cast when the racks were complete.

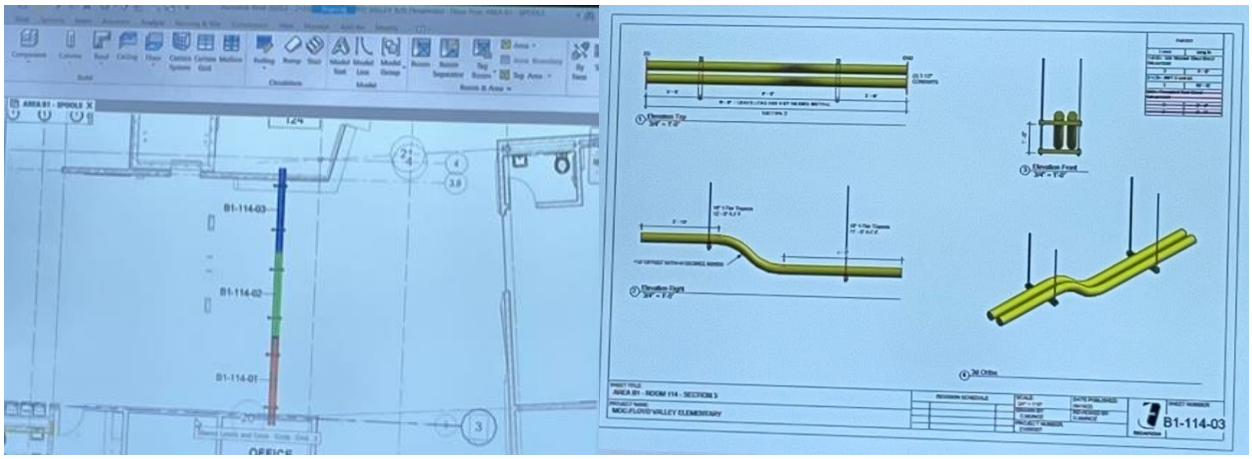
Wire spooling

In addition to the prefabrication of conduits and boxes, the prefabrication shop has developed a process for pre-spooling the necessary wires for each conduit run and corresponding circuit(s).

When used on site, the spooled wire is labeled and can easily be pulled, again reducing the likelihood of simple mistakes and re-work in the color, gauge, or number of wires needed in any given conduit or circuit.

Modeling process

The process for translating a new project's drawings into a 3D model for fabrication is a two-stage process. An initial work packaging step has a prefab and constructability review to identify and group conduit runs and circuits into a short list, based on the panel layouts and circuit locations. The circuiting list is handed off to a modeler to lay out each of the conduits runs in Revit, with the help of Evolve to support the bill of materials, couplings, rack, and related assemblies for the prefabricated run of conduit. The modeler works with the other trades from a given project to coordinate the layout and avoid system clashes, before spooling the modeling into sheets for fabrication in the shop. Each assembly, typically broken into 10' runs for overhead racks, are detailed in a single sheet.



BIM Box on site

For projects of appropriate size, job boxes with computers are sent to allow the foreman and crew to access the model as needed to understand and visualize the model and coordinated placement of racks amongst other MEP assemblies, particularly in congested assemblies.

Layout and scanning

In addition to the core modeling and spooling processes, the modeling process has the capacity related to laser scanning when working with existing structures to ensure accurate capture of as-built conditions when needed. Similarly, they have worked to integrate the model hanger information into a total station layout process to quickly push the

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information from the model into the field for timely installation of hanger supports during slab rough-in or roof installation.

Onboarding, leadership training, and pull-driven development planning

Thompson invests heavily in their people, with a strong emphasis on training. The training program follows three approaches. As electricians move to the end of their apprenticeship, Thompson has developed a program to teach them about the breadth of the business. Thompson positions the program as an opportunity to jumpstart the apprentices' path toward becoming field leaders, as well as ensuring they are fully aware of the resources and contacts across the company. The program runs for 9 months, typically starting in the fall. The group meets for 1-2 hours, based on the topic, with strong engagement from across the company, including meetings with the CEO, CFO, Safety Manager, Project Manager(s), HR Team, IT, and activities such as a bid-day exercise to understand the processes used to win work.

In addition to the young leader program, Thompson has identified standard training they target for each of the major roles. For instance, as someone moves up into a project management role, they would be sent for leadership training, they would get more detailed training on the tools and software they are expected to use in that role, as well as other areas that may be identified for ensuring their success. The training can take many forms, ranging from online courses and e-tutorials for common software, workshops or training seminars, invited speakers to meet with key roles across all of the offices, and professionally offered programs through NECA and other industry groups.

The last area of training is an ongoing program to ensure all personnel is receiving the training and certifications they need. In conjunction with the company's annual reviews, supervisors are expected to work with HR and each employee to identify the skills and training, custom to that employee, to ensure they are meeting their roles and responsibilities as well as given the opportunity to grow into new roles as appropriate. This includes identifying key certifications and safety training for equipment, scaffolding, and other methods or jobsite-specific requirements. The program is finely balanced to allow HR to identify and offer the resources, but it is on each employee to 'pull' the training and resources and take responsibility for following through on completing the custom-defined plans.

Concluding Thoughts

Throughout the visit, it was clear that Thompson had put a great deal of thought and effort to reach its current operations. They are excelling in their current work and are on track with a consistent approach to small, incremental improvements with an eye out for innovative opportunities. The culture that has developed in the company is one of flat organizations and engagement from the field up to the highest leadership. When visiting job sites and the shop with the President, employees knew him by his first name and were quick to engage with a smile and quick discussion. While subtle, the emphasis on valuing people and their development seems to be at the core of Thompson's success. The company is not shy about investing in its people when the people have shown that they are ready and willing to meet their responsibilities and step into new roles.

Practices that support continuous improvement

- Regular engagement between the modeling, prefabrication team, and the foreman managing the field installation.
- Thoughtful engagement and career planning with all personnel, including standard leadership training for apprentices in their 5th year.
- Community engagement – Thompson has made themselves part of the communities in which they reside, with each PM expected to engage in the community group or service of their choice. This in turn highlights the company values to ensure cultural fit.

Common challenges and barriers

- Variations in codes and practices across regions make the standardization of some elements difficult – for example, the inspectors across regions may differ in allowing whips and wire pulling in the prefabricated assemblies
- Workforce shortage – it was noted at several different points that more electricians are needed to sustain the current work output
- Uncertainty – lack of planning across projects, particularly by some general contractors, still leads to competition to be 'first in' for installing a trades work. While the use of models for coordination of placement has helped in many instances, it is not consistently used.

Other Observations

Knowledge sharing - an ongoing challenge of any construction firm is how to best harness the array of knowledge distributed throughout its people and then find and apply that knowledge when and where it is needed. Thompson has developed common times for meetings, reviews, and continuous improvement opportunities but could expand the value of these meetings by thoughtfully targeting others to participate, and potentially take over the running of meetings as the process progresses. As a simple example, PMs meet with the Regional Vice President monthly to review projects. If these reviews included one or two other PMs (e.g., if two were back-to-back, or if young or upcoming PMs were invited to attend) the review process would allow for PMs to learn from each other, and the process could gradually shift to the PMs auditing each other's projects, with the Vice President serving as oversight and support.

Standard Process documentation – Thompson has gone to great lengths to develop and train its personnel in their roles and in the core processes. However, there was limited documentation for many of the processes that were performed. Capturing this information in clear steps, process maps, or simple checklists can serve to enshrine the more detailed methods, as well as key considerations or constraints that need to be reviewed at key steps. Standard Processes serve as tremendous tools for training in the "Thompson Way" that can build upon core information seen in NECA or other standard training modules, specific to software used, and introduce costs coding, reviews, or purchasing timelines.

Expand use of visual management – The organization of information was very thoughtful; technology was commonly used to speed the collection and analysis of information across projects and crews. However, the information when presented was commonly text-based– moving to simple and consistent visuals, whether bar charts for production, pie charts for labor breakdowns, lines graphs for trending both weekly and cumulative hours worked vs those budgeted, would make a significant improvement in how quickly personnel at all levels can grasp the information that is frequently shared. Similarly, incorporating visual indicators and organizational systems into job boxes and material storage can speed the time for

workers to step into the role of planning and installing work, rather than searching for tools and materials, as well as streamline the move from one project to another.

Acknowledgments

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