Standard Work: Holding the Gains

Robert W. Hall

"Standard work" is an old-fashioned, underappeciated industrial term. Similar concepts are implied by other words and phrases: Procedures, SOPs, protocols, test specifications, codes, menus, programs, clinical paths, recipes, and so on. However, above all, standard work — the real thing — is disciplined replication of a process.

Standard work seldom captures media attention — not even industrial media attention. Most process improvement stories emphasize how an improvement was made, not how it was standardized and maintained, just like the discoverer of a new drug is lionized while the poor bloke who proved it out with the 27th clinical trial remains anonymous.

The concept of standards is so basic that we don't give it much thought. Standard sounds and symbols are the basis of human communication. In business, standard operating procedures became popular with the rise of railroads and manufacturing. Early in the 20th century standard procedures were considered a mark of efficient organization — a well-managed bureaucracy.

In a traditional bureaucracy, standards are set by staff or analysts. Others follow them. In a flattened, "high-performance" organization, the people that do the work are more likely to participate in the development of their own standards. This difference is important emotionally. It also distinguishes "lean" manufacturing from mass production or "conventional" manufacturing.

In addition, minimal standards for many kinds of work are set by various certifications, accreditations, and regulations. Good Manufacturing Practice (GMP) for the food and drug industries is a prime example. However, compliance with external standards may distract people from fundamentally improving their own processes themselves and consolidating the gains with self-developed standard work.

Standard work sounds about as exciting as the Dewey Decimal System. Students don't demand fundamental courses on standard work, although if pressured for compliance, they will scramble to learn something like ISO 9000. In industry, both the value and the difficulty of standard work are chronically underestimated. But in sports, its importance is easily recognized.

For example, year after year, John Wooden, the legendary UCLA basketball coach, drilled his teams on fundamentals so thoroughly that winning the NCAA championship was within grasp at the beginning of each season. (Wooden was described as "so square he could be divided by four," but he won more NCAA basketball titles than any other coach.) During pre-season practice, a new player once blurted that he was happy to be learning the "fine points of the game." Wooden icily replied, "Young man, first you must learn the fundamentals, and learn them better than anyone else we play."

Historically, standard work connoted procedures for clerks and production operators, not for "higher level" staff and management. That status rift still creates animosity about standard work in an age when much of it (but far from all) has become "menu driven" by computer systems. Willy-nilly, everyone that taps into an on-line system complies with menu standards if they do no more than get cash from an ATM machine.

Standard Work = Prediction and Control

Standard work strives for process repeatability: Same result, same method, same amount of time. Machines are obviously more repetitive than humans. A welding robot doesn't waver laying a bead along its programmed path. However, a different kind of robot, a programmed answering system, does not handle customer phone inquiries graciously. We acquire a tolerance for them, but an affection, never. "Rules" for human interaction aren't the same as for machines and production.

The late W. Edwards Deming defined management of any process as "the ability to predict and control," a deep insight concealed in a dull phrase. It is one of Deming's most valuable contributions, and the accompanying box copy is based on it.[1]

If a process is repetitive, standardization assures the same result time after time. Discovering how to achieve high repeatability, or a near 100 percent yield, from a low-waste process may be done through "engineered problem-solving," process capability improvement, Kaizen Blitz,SM continuous improvement, or other means. However, holding the gains requires standard work. In the box copy, this approach is represented by Level 2, which is where most of us are today.

On the other hand, Level 3 presumes the ability to uniquely combine standardized process modules. The time-honored approach is assembly-to-order from an inventory of options. However, forecast accuracy never being perfect, a large inventory is frequently short of something needed to complete assembly. With reduced lead times and one-piece flow, options can be built to order, not pulled from stock. In some cases, companies can ease into Level 3 by engineering to order and delivering the same day, a practice now generally limited to standard parametric calculations, like Andersen Windows, which develops the instructions for a custom-sized window using configurator software.

Going much beyond this requires standardization at a more micro level — standardizing the prediction and control of materials and processing conditions in combinations never before produced. At Level 3 the ideal is for the prototype itself to be the product. For most companies, that's strictly "Star Wars," but the closer that models represent process reality, the less trial and error that is needed to make a product. Current approaches to Level 3 create a unique outcome from combining a

The Three Stages of Achievement Through Standard Processe Three Stages of Achievement Through Standard

The advance of standardization generally moves upstream according to the process model below:

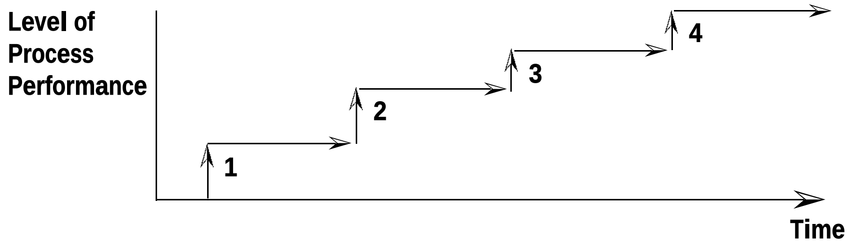
Predictions (Level 3) → **Processes (Level 2)** → **Outcomes (Level 1)**

Level 1: Standardized Outcome Only: This is the level achieved by build-to-print, as in customized house building or fabrication to print in a model shop. Two different sets of craftsmen working to the same print (the prediction) will achieve nearly the same outcome using somewhat different processes, but there is a long history of "as built" deviating from "as drawn," and with "as drawn" deviating from "as really wanted" or "as needed." When closely compared, two different houses built to the same plan will not be identical in every detail for many reasons: customer requests, drawing interpretation, available tools and material, measurement inaccuracy, and so on. That's variance. When pressed for identical outcomes, different processes can achieve it through copious feedback during the build process, otherwise known as "engineering it in" or "inspecting it in."

Level 2: Standardized Processes: The same operations are done the same way each time using the same methods, tools, material, layout, and process sequence, so the same outcome is more likely, but it is not guaranteed. The history of methods standardization, SPC, fail-safe — then "six-sigma" processes and beyond — has been dedicated to removing sources of variance from processes. One goal is a process so repeatable that it is unnecessary to stop material movement for inspection. Instead the process itself is monitored by fail-safe methods so that it self-corrects, as necessary, as it goes. A second goal of this level of achievement is to remove waste from processes so that standard, repetitive performance times are likewise attained. The only drawback is the time, skill, and resources needed for process learning and refinement.

Level 3: Standardized "Predictive" Methods: A standard process is designed and achieved directly from the outcome prediction (an engineered plan) so well that it works the first time. This is engineer-to-order without the need to prototype, test, or make special tools. It is only done today within a limited range of technology — some kinds of printed circuit boards, pneumatic systems packages, cosmetic attachments, and the like. However, the predictive ability of most engineering and process models remains limited. If much of the testing and refinement of a complex product is unnecessary, design of a flow process to make it remains more in the trial-and-error era. This level of standardization is a 21st century challenge made more difficult by other 21st century challenges of life-cycle design.

The Value of Standard Work



Four stages of process improvement are labeled above. At the end of each stage, standard work, or standardization, is the final phase of improvement that stabilizes the process at its new level until a new round of improvement is made.

Figure 1. *Adapted from: Hall, Robert W.;* Continous Improvement Concepts*, research report of the Association for Manufacturing Excellence, 1987, 16 pp.*

standardized base of product or process modules. For example, an Application Specific Integrated Circuit is generally made by adding uniqueness to a standard design already laid on the same wafer, an obviously ticklish process.

Standard Work and Process Variance

Standard work prevents variance from reappearing in processes — the heart of Stage 2 in the box copy. At a work station, standard work may be represented by an instruction sheet that summarizes activity of operators and equipment, step-by-step. It may pop up on a computer screen when a bar code is scanned. Standard work information tells people — or machines — what to do. The information can specify methods to achieve time, quality, safety, and environmental requirements. But standard work isn't documentation; it's actual execution of processes to obtain a predicted outcome.

Standard work is often established by a computer protocol. For instance, a standard transaction menu on a point-of-sale terminal guides a store clerk through recording a sale and taking payment. The menu may even prompt the clerk to say thank you or to stimulate an impulse purchase. In many plants, computer screens tell operators what to do at critical points — if they pay attention.

However, operators ignore much information available to them for the same reason that basketball players can't review the playbook during a game. They go with whatever they know, however they actually do it. That is, the execution of standard work methods can be "fail-safed" in various ways, but it also has to be learned.

In practice, work has not been standardized if a "once-improved" process has to be completely flowcharted anew to be sure what is actually taking place. Likewise, work is not standardized if workers on different shifts do not actually agree *in practice* how the same tasks should be done. The telltale sign is one person adjusting the process differently from another, and not just for ergonomic reasons, like adjusting the seat after another driver has driven a car.

Standard Work and Process Improvement

Standardization of work is the last step of the four-step Deming Circle: Plan, Do, Check, Act. A multi-day Kaizen Blitz℠ generally covers only the first three phases of the Deming Circle: Plan-Do-Check, and check ends with a demonstration. After the intensive portion of a Kaizen Blitz,℠ "Act" assures that a process can continue to operate as demonstrated, or better. "Act" is finished only when all the follow-up activity to support a new method is done, and it has been learned well enough to endure a few crises. Then it has become standard work.

The development of standard work is part of an improvement process, as shown conceptually in Figure 1. Three messages are represented by the figure. First, without standard work in several forms, operator instructions, fail-safe methods, 5S, and so on, gains are not likely to be held. Second, without consistent, balanced performance measures, it is easy to chase different measurements around in circles while making trade-offs. Real process improvement boosts at least one prime performance indicator without any decrement in others. Third, the gains from each successive improvement effort often decrease as the process approaches its potential.

Once achieved, standard work is a platform from which the next level of advance can be achieved. Even when a process has maxed out near its upper performance level with the current technology, standard work is necessary to prevent regression.

Do-It-Yourself Standard Work: The Toyota System

Toyota has long regarded the most difficult, time-consuming phase of developing the Toyota Production System to be people learning to standardize their own work *themselves*. To do it, workers must understand standard work and want to do it. The staff must also understand what it is in order to support the workers' effort.

Taiichi Ohno, the leader responsible for the development of the Toyota Production System, considered the preparation of your own work procedure to be a key part of the system. During World War II skilled workers left Toyota Motor Company in droves and went to the battlefront. Most were replaced by unskilled workers. Just as in the United States, the need for work instructions and

The Elements of Standard Work

Here are two different historical lists:

Conventional "Four Ms"	Taiichi Ohno
Man (any human)	Takt time
Machine	Work sequence
Material	Standard Inventory
Method (includes information or software)	

Specification of an outcome, or a quality specification, is implied, and in many cases, a layout diagram is also part of the description of standard work. Ohno seems to have assumed that people would understand these inclusions by common sense.

Figure 2.

rapid job training was acute.

Ohno told the new workers to write their work instructions themselves. There was a method in this madness. To write their own instructions, the workers had to thoroughly learn the job to which they were assigned by talking with experienced operators, toolmakers, engineers, or anyone who could show them what to do. Ohno

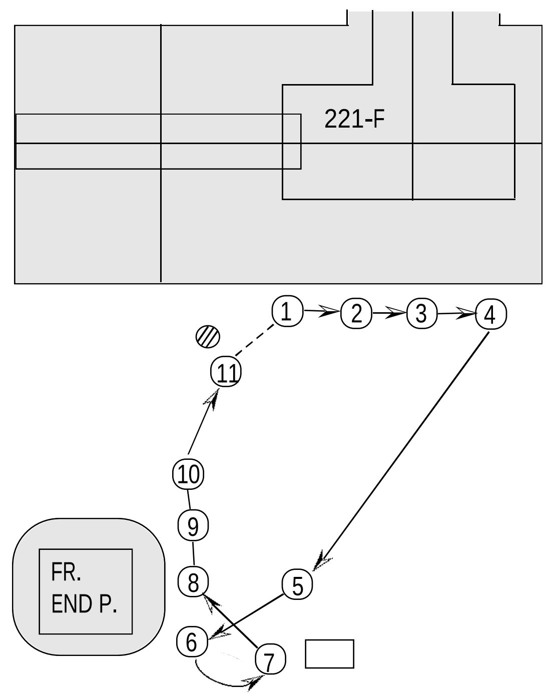
Work Instruction Form

PART NAME: Outer Panel (D)	STANDARDIZED WORK SHEET	ISSUE DATE	10-19-87
PROCESS NAME: Outer Panel Sub-Assembly Respot		SECTION	BODY ASSEMBLY

FROM: Set Side Panel Outer Sub-Assembly Into 221-F

TO: Set Front Post Sub-Assembly on Temporary Stand

Seq. #	WORK SEQUENCE	Work	Walk	Total
1.	Set side panel outer sub-assembly into 221-F	10”	—	10”
2.	Push auto clamp button	2”	—	2”
3.	Manual spotweld	20”	—	20”
4.	Push auto unclamp button	2”	—	2”
5.	Obtain front end post	2”	3”	5”
6.	Set into 216-F (front post fixture)	3”	—	3”
7.	Obtain patch and rope hook	2”	2”	4”
8.	Set into 216-F	10”	—	10”
9.	Manual spot weld front end post	12”	—	12”
10.	Unload 216-F	10”	—	10”
11.	Set front end post sub-assy. on temp. stand	2”	3”	5”
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
Total		75”	8”	83”



Quality Check	Safety Check	Cycle Time	Std. Stock	Tact Time
3 + 10	N/A	83”	One	83”

Figure 3. *A dated standard work instruction sheet from a Toyota operation before standard work had really been achieved. This one came from TABC and originally appeared in* Target, *Summer Issue, 1988. Standard work is important enough to Toyota that the company no longer releases work sheets for publication. Note the takt time in the lower right corner.*

notes that a good set of work instructions cannot be finished at a desk. They have to be checked out on location. You don't just "write up" standard work; you "work it out" by trying it.[2]

People can seldom "closely follow a recipe" as they work — especially if they don't really understand the recipe. Documentation does not assure standard work, and documentation of effective standard work is not always neat or complete. The "customers" for documentation and other standardizing methods are the people doing the work, not a manager, technical expert, or quality auditor.

People writing their own work instructions tend to keep them simple. They can test their effectiveness by checking whether another worker of the same skill level can follow them and perform work the same way.

People who write their own work instructions must somewhat understand the context and "whys" of the work. To do that, they must ask questions, and staff need to answer the questions, which is very different from the mind set that operators should be compensated for performing work that someone else defines. A work culture in which the staff sees the operators as "major customers" is not easy to sustain.

Specific work instructions assume that basic job skills have been mastered, and that general work rules are habitual. General rules are documented and used for instructing new hires, after which knowledge of them is assumed. Then the task instructions at a work station are limited to the essentials needed to perform them. Anything needed for reference during a given cycle of work should be easily visible and understandable within that work cycle. Like actors, people can follow cues and prompts if they have first "learned their lines."

Elements of Standard Work

There is no rigid formula for standard work. Everyone must develop a methodology to replicate their own processes. Many IE or kaizen forms can be used as models for operative instruction sheets, and achievement of standard work also depends on fail-safe, prompts, 5S, visibility, work flow control, and other practices that are part of the total work environment.

Figure 2 shows a couple of historical lists for describing work, one from Ohno and the "4Ms" that date from Frederick Taylor's time. Note that Ohno includes takt time as an element of standard work. In the Toyota system, each schedule comes with a takt time. The workers devise standard work to meet the takt time, and if they cannot do it, management has to help resolve the problem. Figure 3 shows an old Toyota work instruction sheet.

Besides the basic "4Ms" of a process description, standard work and work instruction sheets for specific tasks should address each of the following concerns:

Quality: Conformance quality and often, customer-perceived quality as well.

Time: Must fit within takt time or the necessary leadtime.

Health and Safety: Anything beyond the normal work area rules.

Ecology: Again, any action needed beyond the normal work area rules.

Using general guidelines and some examples created for their kind of work, operators (and others) can learn to design their own work procedures themselves, sometimes in teams, and try them out. Obviously, the work instructions at some stations must be initiated by engineers or staff with a deeper understanding of the technology than the operators. However, if the operators complete the standard work instructions themselves, they should then understand it.

Advancing a workforce to this level of standard work takes time and acceptance within the work culture. That's why Toyota regards the development of standard work as the most difficult, time-consuming stage in making work flow. See Figure 4.

The Benefits of Standard Work

Once standard work has been achieved, a Toyota workforce is not only able to sustain one-piece flow, they

Stages in Discrete Manufacturing Process Development

1. Start-up, or "traditional" manufacturing
2. Organize a flow of work
3. Standardize work or standardize methods: Assure process quality
4. "Pull system" methods: self-correcting flow control introduced to processes
5. Small lot sizes: improved efficiency
6. Lot size = 1: high flexibility.

Note: These six stages are based on one of the explanations Toyota has used to explain the development of the Toyota Production System. Note that Toyota does not think that one-piece flow can be truly captured without the development of standard work. The stages are food for thought, but they do not represent a Bible for implementing lean manufacturing in every context.

Figure 4. *Source: TABC, Long Beach, CA*

can rapidly redeploy equipment to do something different — flexibility. A tremendous asset is operators and support staff that can quickly learn a new set of tasks, refine a process, and reduce it to standard work in a flow.

As a result, Toyota and most of its suppliers in Japan have long had a monthly "kaizen" with every major change of the automotive schedule. It's called distributed production planning. Each department, team, or work station receives a new takt time (if necessary) and the proposed mix to be run for the next month. They have 3-5 days to convert the takt time, quality specs, space, and inventory allowance for each work area into standard work. New improvement ideas may be tried out and included. When the schedule starts, the plant is expected to meet the time and quality requirements of standard work in the first hour.

Coupled with all of Toyota's other "lean" practices, standard work allows the company to run several car platforms on one assembly line, for instance — one reason why Ohno referred to the Toyota Production System as a step beyond large-scale production. Some other Japanese companies do something similar in the homeland plants. Elsewhere in the world, running multiple platforms of vehicles on one line is considered a great challenge — or impossible. In financial terms, the Toyota Production System allows the company to concentrate assets while maintaining a broad product line, and thus maintain a low breakeven point at the same time.

The Intel Version

Intel's production system is very different from Toyota's, but in its own way, Intel is more rigorous than Toyota in using standard work. Intel also builds on established process platforms using a practice called "Copy Exactly!" (The exclamation mark is part of the name.) When building a second semiconductor plant to fab a chip already in production, the equipment, conditions, settings, measurements, documentation, operators' activities, and controller codes are copied exactly — no deviations.

With this discipline, as soon as the cloned plant is loaded and chips begin to come out, the new plant is able to match the yield and output of the original. There's no long debugging process. From that time onward, process improvement is done by a disciplined process with all the same plants in lock step.

When a fab plant is built or modified for a new chip design, no more of the process than is necessary differs one whit from the processes in an established one. This production strategy is supported by Intel's version of modular product design. Each new, faster chip has been a disciplined, modular change from the last generation. Using this strategy Intel beat competitors to market with new generations of "X86" chips for about ten years running.

Of course, at some point Intel must jump to a different learning curve —- rebuild a big chunk of the accumulated standard process platforms. A major change will occur as the industry changes from 200mm to 300mm wafers. Then Intel will try to tear through new learning curves and establish a new set of standard process platforms before competitors can.

The Intel process has a more integrated recipe than Toyota. The process modules are more interdependent, so no team can be turned loose to "kaizen a sub-process." At Intel, process change in a complex recipe is more like trying a mutation in a genetic code. A few mutations are beneficial; most aren't.

The Intel system also achieves standard work through rigorous discipline to replicate the process. Operators watch each other to be sure that they actually perform process steps the same way. Sometimes operators in different fab plants watch each other on closed circuit TV to be sure that they are copying exactly. But work in an Intel process cannot flow like Toyota's.

The Challenges of the Toyota System

As with any system, the strong points of the Toyota system are also its weak points. Toyota depends on close communication and "peopleware" more than software. Standard work takes human discipline. Most westerners prefer to invent their way around the discipline, or impose it through software.

For example, when Fujio Cho came to the United States, he found that Americans were less amenable to standard work the Japanese way (lifetime perfection as an ideal) than Japanese. Instead they were more interested in making the work less stressful using ergonomics and systems aids. (Once one of Taiichi Ohno's understudies, Cho was president of Toyota Motor Manufacturing North America for several years before returning to Japan.)

Smartly used, ergonomics improves productivity and quality as well as decreasing work stress and strain. Workers are more likely to standardize an easy work method than a difficult one. As a result of its foreign experience, Toyota now stresses ergonomics much more in Japan. But ergonomics and systems are not a substitute for standard work — attention to making each job — and the overall process of which it is a part — both repeatable and efficient.

This is not a small issue. Our instinct is to make our own work easier without recognizing how it makes other's work harder, or for how it complicates the overall flow of work.

A second weak point of the Toyota system, even in Japan, is that it depends on a core of very experienced workers. Learning how to improve processes and hold the gains through standard work takes time. When expansion outruns the company's ability to develop experienced workers, Toyota begins to slip into the same problems as everyone else.

The Role of Standard Work

Mass production was characterized by breaking work down into tasks that require easily-developed skills, thus minimizing station-by-station labor costs, but sometimes at the expense of a fat overhead. Lean manufacturing is characterized by learning how to improve new processes and reduce them to standard work yourself, which is not a quickly-developed skill. Complex manufacturing is characterized by trying to make a product by any way possible to do it — back to Level 1 unless attention is paid to processes from the beginning.

The ability to simplify and standardize work depends on products and processes, including software, being conceptually designed for it. Complex processes are more difficult to break into separate modules that can be improved and standardized separately, then flow together. In many process industries, the process is a mass of interrelated variables, parts of which are not well understood. Intel is an example of a company that cannot follow the Toyota system, but that has achieved modular improvement and standardization of a complex process.

In almost any industry, if products must be "engineered and tested together," the process stays at Level 1, where neither flow nor standard work can ever quite be grasped. Constant attention is needed to design products and software having manufacturable, testable, and maintainable modules. It can be done the Toyota way or the Intel way.

Likewise, thinking that standard work can be achieved through cost pressure is illusory. For example, eliminating the cost variance from medical cases with the same diagnosis profile is an objective of managed care, but doctors are rebelling. Improvement and standardization of process modules on "clinical pathways" by those who do the work are more likely to lead to flow and standard work, and therefore to minimum cost.

Well-conceptualized and well-developed, standard work promotes process integration. The holy grail to pursue isn't the documentation of a mess, or the automation of complexity, but the ability to predict and control processes and their outcomes.

1. W. Edwards Deming, "A System of Profound Knowledge," *Actionline*, publication of the Automotive Industry Action Group, Vol. 9, No. 8, August 1990, pp. 20-26. (This was Deming's last article.)

2. Ohno, Taiichi, *Toyota Production System: Beyond Large-Scale Production*, translation published by Productivity Press, Portland, OR, 1988, pp. 20-21. (Originally published in Japanese by Diamond, Inc., Tokyo, 1978.)

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