Applying Lean Thinking to Improve Processes in Low Volume/High Complexity Industry: Part I

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Abstract

Low-volume/high-complexity industries are known for their unique designs and custom products, which require extremely flexible manufacturing processes. Implementing Lean principles is the best way to enhance flexibility and achieve success by offering the "best price in the market" and "fast delivery." However, the application of Lean principles depends on the type of production layout and business. Continuous production processes and variable production processes have distinct demands and targets. Applying the same Lean terminology to both industries can result in losses in terms of inventory, safety stock, pull systems, and takt times. This paper aims to address the common problems faced by low-volume/high-complexity industries and demonstrate how Lean techniques and thinking can resolve them. This paper aims to explain the cost benefits resulting from process improvement in the Volume-1 case study. It further explores process improvements in different complex areas, providing a clearer explanation of how lean thinking transforms complex processes into flexible ones. The focus on improving the paint and shipping processes stems directly from customer feedback regarding quality non-conformances and new customer development. Additionally, special process audits by new customers have influenced this focus. To illustrate the practical benefits of Lean thinking in industrial development and highlight the differences between low-volume/high-complexity industries, we will examine the industrial painting process. Industrial painting involves a range of complex tasks, including storing, mixing, spraying, testing, data availability, tools arrangement, inventory management, climate control, paint estimation, spray procedures, measuring devices, lighting quality, and layout optimization for smooth product flow. Jones Metal Inc. serves as an excellent example of a high-volume/complex industry. Improving process quality and maintaining acceptable performance levels are crucial for the success of any organization. Lean thinking provides an opportunity to enhance process flexibility for successful organizations. This paper first explains the current processes of the complex industry and then demonstrates how lean thinking contributes to the development of these processes.

Keywords
Flexible manufacturing processes, Continuous production processes, Process improvement, Lean principles, Industrial painting.

1. Introduction
Low volume/high complexity industries face challenges with procedures due to the customization and varying manufacturing processes involved. These processes encompass cutting, molding, shaping, pressing, punching, bending, welding, painting, and more. Hence, implementing Lean manufacturing tools like kaizen and control boards becomes essential in such industries. To illustrate this concept, we can examine Jones Metal Inc., located in Mankato, Minnesota, as an example. Jones Metal Inc. excels in sheet metal processing and specializes in complex processes with low volume production. Their expertise lies in crafting unique custom-built sheet metal products for companies worldwide. However, consistently manufacturing products with different procedures, quality standards, and testing requirements poses a significant challenge. Therefore, continuous process improvement based on demand is crucial. The focus is on the paint process in Jones Metal Inc. with the objective of improving the process using lean methodologies. Furthermore, the process costs and savings due to lean process improvements are discussed as well as the reduced quality defects due to the combination of a six-sigma project with the lean processes. Using Six Sigma tools and ANOVA analysis, we can identify the root causes of paint quality issues. This process aligns well with the principles of Lean methodology.

1.1 Objectives
1. How may Lean concepts be used to increase flexibility and achieve success in low volume/high complexity industries?

2. How might the concepts of lean manufacturing be applied to raise the standard of goods and services in low volume, high complexity industries?
3. How can the use of lean concepts be adapted to the particular requirements of low volume/high complexity industries?
4. What are the most effective ways to apply Lean concepts in low-volume/high-complexity industries?
5. What are the cost benefits of implementing Lean principles in low-volume/high-complexity industries?

2. Literature Review

From 1992 to 2002 there was a revolutionary change in lean applications, which made companies change their processes with the use of improved technology. There were several billion-dollar companies that incurred huge losses due to unnecessary inventories and safety stock (Womack and Jones 2003). This paper focuses on the process improvement of a complex process that encompasses wash-painting and shipping. It highlights the application of lean principles and the significant results they can yield. A typical lean process involves the following steps:

1. Identified value: The current value of the product is identified by walking the process backward from the customer. The current state of the process is also checked to identify waste (Muda).
2. Value Stream Mapping: To identify waste and value-added processes, the process is mapped using value stream mapping. This analysis helps identify non-value-added processes. A time study is conducted to ensure accurate value streaming.
3. Creating Flow: Based on the value streaming analysis, areas for improvement are identified in terms of quality, process time, and costs. New process improvements are then implemented to improve flow. A thorough analysis is performed to determine the next steps (McCarthy and Rich 2015).
4. Establishing Pull: A pull system is introduced in the shipping area for a specific customer, and a pull situation is also created in the paint area. Implementing this system in custom shops can be challenging due to uncertainties related to customer demands. However, by adopting cell manufacturing and strategic placement of supermarkets, a flexible system can be created, meeting customer requirements and providing a future state map for improvement (Liker and Franz 2011).
5. Striving for Perfection: While perfection may not be achievable, continuous improvement projects are carried out to seek perfection. These projects aim to identify areas for improvement and make ongoing enhancements.

The problems with the current process at the paint shop are analyzed using various methods such as Six Sigma DMAIC, design of experiments, and lean methodologies. The choice of analysis method depends on the type of processes and products being examined. The following describes the paint shop technical data on the floor of Jones Metal:

- Paint matrix: Technical data availability plays a major role in speeding up the paint process. This data is needed to identify the supplier's paint used for a specific job, including the primer, catalyst, and reducer mix ratios. It also includes the recommended number of mills and the customer's thickness requirement. The current process involves a paint chart that consolidates information to simplify the process. However, there are issues with the current system. It lacks flexibility to accommodate changes in customer requirements or updates, as well as the introduction or discontinuation of new paints by suppliers.
- File tech sheets: Each primer, paint, catalyst, and reducer are accompanied by technical data sheets and safety data sheets. Consolidating all the tech sheets in one location is beneficial. However, finding the correct data sheet from the collection is time-consuming. Therefore, organizing the data sheets with relevant information and filing them is a lean thinking approach from 5S. This practice proves particularly valuable in industries with intricate and adaptable processes.
- Simple data charts: Building simple data charts saves time, simplifies life, and enhances process flexibility, as discussed in Lean Solutions by James P. Womack. Searching for parts or multiple data entries in a large inventory is time-consuming and complex, increasing the likelihood of human errors. To address this, consolidate all the data into one sheet and keep a hard copy for quick reference. These charts, known as simple data charts, are an integral part of continuous improvement (kaizen) for streamlining processes.
- Procedure plan for Chemical Treatment: Preparing the surface is essential before painting. Chemical treatment removes grease, rust particles, and debris. A procedure plan and control plan for this process are beneficial, eliminating the need for operators to call supervisors when problems arise. These plans also help new employees streamline the process.
- Paint inventory-shelfing: Inventory needs to be shelved using two principles: FIFO (First In First Out) and tagging. Problems arise in inventory storage, especially with FIFO, often referred to as FIFE (First in first expired). Without tracking expiration dates, there can be significant losses in customer satisfaction and paint quality due to expired products. Additionally, expiration dates may change upon opening the

paint can, highlighting the importance of tracking all paints using a simple process plan. Shelf tagging is necessary to easily locate inventory and reorder stock.

- Cost estimation and coverage: There are two major problems in the current process: a lack of proper cost estimation for the painting process and inadequate guidance on the amount of paint needed for the proposed area. These issues are crucial for a flexible process. Without knowing the coverage, the required amount of paint cannot be determined for specific jobs or place accurate inventory orders. Consequently, forecasting becomes complex and time-consuming. Estimating costs is essential for billing the customer, and it falls within the paint department's responsibility to determine the cost of paint for each job.
- Paint room lighting conditions: The suitable lighting conditions for a paint booth are 400 Lux, while for the paint-testing area, it is 800 Lux. Several factors can decrease lighting conditions, such as over-spraying, long life of the lights, and their location. Over-spraying creates a layer on top of the lights, reducing Lux. The lifespan of the lights also affects their capacity. The location and height of the lights impact Lux in the spraying area. Regular measurement and maintenance of the lights are necessary to prevent quality problems and rework, which increase lead-time. Therefore, simplifying this complex process on a continuous improvement basis is crucial.
- Customer company expectations for future business: Customers expect these improvements because they do not want to pay for idle part sitting times, overhead times, and unnecessary processes. Some companies, like John Deere, can take the opportunity to improve processes at their suppliers' plants. However, most industries switch suppliers when they realize they are paying for unnecessary work done by the supplier company. Therefore, it is mandatory to simplify complex processes by applying lean methodologies, especially for small to mid-size industries.

3. Methodology

Creating or changing a process is a challenging task. First, the waste current process must be identified to determine areas for improvement. Next, a new lean process should be devised, emphasizing speed, simplicity, and cost-effectiveness. For a process to be considered improvement, it must enhance speed, efficiency, and cost-effectiveness while maintaining balance. However, if the speed is improved at a higher cost than budgeted, it cannot be considered a favorable improvement. Similarly, if a new process reduces costs by 50% but becomes more complex, it is not a desirable improvement. Complexity and human errors may result in rework, compromised quality, and delayed deliveries, offsetting the cost reduction benefits. Lean thinking offers an excellent solution for process development by eliminating waste (muda) and non-value-added events. The following are the processes proposed for each of the current process on the paint floor of Jones metal:

3.1 Building a paint matrix with flexibility for updates:

Creating a paint matrix for the paint shop is a significant task. The required data for painting is found in paint technical data sheets. In this case study, a chart is being built for 66 paint mixes. Before building the chart, certain clarifications are needed. Most spray paint mixes consist of paint (Part A), catalyst (Part B), and reducer. Some paints are ready to use. Each part requires priming before the final coat (topcoat). To complete this process, the mixing ratios for Part A, Part B, and the thinner need to be identified. The paints need to be categorized, such as epoxy, urethane, alkyd, and military, for easy access. The chart should be flexible, allowing the painters, purchasing department, and engineering department to add, update, and retrieve data. Columns such as paint code, description, routing code, inventory code, color code, supplier name, customer thickness requirement, primer specifications, and paint specifications should be included. This lean thinking eliminates the need for discussions between the purchasing, engineering, and painting departments and makes all the data available on the wall. This idea simplifies and clarifies the process without any additional costs. Table 1 displays a sample paint matrix. The main reason behind this improvement is the elimination of non-value-added events, making the complex process easier and clearer.

Table 1. Paint matrix tech data sheet

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JONES METAL

PAINT MATRIX

	Paint Code	Description	St RTR	INV	Color Code	Paint Supplier Name	Notes	Overall Thickness	Max. MILLS	Type
URETHANE	P100	Yellow Primer	SRP-P100	Z-P100-MIX	Buff Yellow	Diamond Vogel	Yellow primer only no top coat	1.0-2.0 mils	2.00	Urethane
	P111	CAT Yellow	SRP-P111	Z-P111-MIX	Cat Yellow	PPG	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P112	Pebble Gray **(Solar Gray top coat)**	SRP-P112	Z-P112-MIX	RAL 7032	Diamond Vogel	Paint inside and out (Pebble Grey is now being sprayed with SOLAR GRAY TOP COAT)	Min. 6.00 mils	2.00	Urethane
	P114	Waukesha Orange	SRP-P114	Z-P114-MIX	Waukesha Orange	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P115	Cummins Red	SRP-P115	Z-P115-MIX	Cummins Red	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P116	Ansi Gray	SRP-P116	Z-P116-MIX	RAL 7042	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P117	Cement Gray	SRP-P117	Z-P117-MIX	RAL 7033	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P118	Fire Red	SRP-P118	Z-P118-MIX	RAL 3020	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P119	Silver Gray	SRP-P119	Z-P119-MIX	RAL 7001	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P120	Cummins Beige	SRP-P120	Z-P120-MIX	Cummins Beige	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P121	Mid Gloss Black	SRP-P121	Z-P121-MIX	RAL 9005		Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P124	Brilliant Blue	SRP-P124	Z-P124-MIX	RAL5007	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P125	Traffic Blue	SRP-P125	Z-P125-MIX	RAL5017	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P127	Grey-White	SRP-P127	Z-P127-MIX	RAL 9002	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P128	Ivory (Used by Kohler)	SRP-P128	Z-P128-MIX	RAL 1014	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P129	MTU onsite Silver Gray	SRP-P129	Z-P129-MIX	RAL7001	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	2.00	Urethane
	P140	Cummins Red Primer	SRP-P140	Z-P140-MIX	Cummins Red	Diamond Vogel	Cummins Red Primer only No top coat	1.0 - 2.0 Mils	2.00	Urethane
	P150	Gray Primer	SRP-P150	Z-P150-MIX	Gray	Diamond Vogel	Gray primer only paint inside and out	1.0 - 2.0 Mils	2.00	Urethane
	P700	White **(INSIDE)**	SRP-P700	Z-P700-1-MIX	White	Commercial Performance	Inside white/outside gray	3.0 -4.0 Mils	2.00	Urethane
		Gray **(OUTSIDE)**		Z-P700-2-MIX	RAL 7042	Diamond Vogel		3.0 -4.0 Mils	2.00	Urethane
EPOXY	A100	White Primer	SRP-A100	Z-A100-MIX	White	Diamond Vogel	White primer only paint inside and out	Min 2.00 Mils	2.00	Epoxy
	A111	Kato Equipment Yellow (Cat yellow)	SRP-A111	Z-A111-MIX	Equipment yellow	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A112	Pebble Gray	SRP-A112	Z-A112-MIX	RAL 7032	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A113	Pure White	SRP-A113	Z-A113-MIX	RAL 9010	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A114	Ansi Gray	SRP-A114	Z-A114-MIX	RAL 7042	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A116	Flame Red	SRP-A116	Z-A116-MIX	RAL 3000	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A117	Light Gray	SRP-A117	Z-A117-MIX	RAL 7035	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A120	Green Gray	SRP-A120	Z-A120-MIX	RAL 7009	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A121	Grass Green	SRP-A121	Z-A121-MIX	RAL 6010	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A122	Brilliant Blue	SRP-A122	Z-A122-MIX	RAL 5007	Diamond Vogel	Paint inside and out	Min 6.00 Mils	2.00	Epoxy
	A417	Light Gray **(OUTSIDE ONLY)**	SRP-A417	Z-A417-MIX	RAL 7035	Diamond Vogel	Paint outside only	Min 6.00 Mils	2.00	Epoxy
MILITARY-ALKYD	K100	Military Green Primer	SRP-K100	Z-K100-MIX	Military Green		Paint inside and out	1.0 - 2.0 Mils	2.00	Military Alkyd/Other
	K111	Military Gray	SRP-K111	Z-K111-MIX	Military Gray	NCP coatings	Paint inside and out	Min 6.00 Mils	2.00	Military Alkyd/Other
	K113	Millitary White	SRP-K113	Z-K113-MIX	NCP	NCP coatings	Paint inside and out	Min 6.00 Mils	2.00	Military Alkyd/Other
	K411	Military Gray **(OUTSIDE ONLY)**	SRP-K411	Z-K411-MIX	Military Gray	NCP coatings	Paint outside only	Min 6.00 Mils	2.00	Military Alkyd/Other
	K700	Military White **(INSIDE)**	SRP-K700	Z-K700-1-MIX	White	NCP coatings	Inside white/outside gray	3.0 -4.0 Mils	2.00	Military Alkyd/Other
		Military Gray **(OUTSIDE)**		Z-K700-2-MIX	Military Gray	NCP coatings		Min 6.00 Mils	2.00	Military Alkyd/Other
MILITARY-EPOXY	H100	Green - 150 (Military green primer)	SRP-H100	Z-H100-MIX		sherwin williams	Primer-paint inside and outside	3.0 - 4.0 mils	4.00	Military epoxy polyamide
	H111	Haze gray - 151	SRP-H111	Z-H111-MIX		sherwin williams	Finishes-Paint inside and out	Min. 6 mils	3.00	Military epoxy polyamide
	H700	White - 152	SRP-H700	Z-H700-1-MIX		sherwin williams	white-inside(special instruction for location)	Min. 6 mils	3.00	Military epoxy polyamide
		Haze gray - 151		Z-H700-2-MIX		sherwin williams	Haze Gray-Outside(special instruction for location)	Min. 6 mils	3.00	Military epoxy polyamide
ALL OTHER CUSTOMERS	J001	Safety Yellow	SRP-J001	Z-J001-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J002	JLG Orange	SRP-J002	Z-J002-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J003	Repnet Purple	SRP-J003	Z-J003-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J004	SVT Blue	SRP-J004	Z-J004-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J005	Anderson Red	SRP-J005	Z-J005-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J006	AgChem Yellow	SRP-J006	Z-J006-MIX		Commercial Performance		3.0 -4.0 Mils	2.00	Epoxy
	J007	Carc Green	SRP-J007	Z-J007-MIX		PPG		3.0 -4.0 Mils	2.00	Epoxy
	J008	Carc Tan	SRP-J008	Z-J008-MIX		PPG		3.0 -4.0 Mils	2.00	Epoxy
	J009	High Heat Black	SRP-J009	Z-J009-MIX		PPG		1.0 - 2.0 Mils	0.00	Alkyd Enamel
	J010	Wilmar White	SRP-J010	Z-J010-MIX		PPG		3.0 -4.0 Mils	2.00	Epoxy
	J011	Cat Yellow Primer	SRP-J011	Z-J011-MIX		PPG		1.0 - 2.0 Mils	2.00	Urethane
	J012	Cat Yellow	SRP-J012	Z-J012-MIX		PPG		3.0 -4.0 Mils	2.00	Urethane
	J013	Cat Black	SRP-J013	Z-J013-MIX		PPG		3.0 -4.0 Mils	2.00	Urethane
	J014	Gray Primer	SRP-J014	Z-J014-MIX		PPG		1.0 - 2.0 Mils	2.00	Epoxy
	J015	Black Primer	SRP-J015	Z-J015-MIX		PPG		1.0 - 2.0 Mils	2.00	Epoxy
	J016	White Primer	SRP-J016	Z-J016-MIX		PPG		1.0 - 2.0 Mils	2.00	Epoxy
	J017	Gloss White	SRP-J017	Z-J017-MIX		PPG		3.0 -4.0 Mils	2.00	Epoxy
	J018	Gloss Black	SRP-J018	Z-J018-MIX		PPG		3.0 -4.0 Mils	2.00	Epoxy
	J019	Gloss Black	SRP-J019	Z-J019-MIX		PPG		3.0 -5.0 Mils	2.00	Epoxy
	J020	Signal Black	SRP-J020	Z-J020-MIX	RAL 9004	PPG		3.0 -5.0 Mils	2.00	Epoxy
	J021	FS 26307 Gray Epoxy	SRP-J021	Z-J021-MIX		sherwin williams		6 mils	2.00	Military epoxy top coat
	J022	ANSI 61 GRAY	SRP-J022	Z-J022-MIX	ANSI GRAY	PPG AMERCOAT		3 mils		

3.2 Creating data sheet file with contents and all necessary data:

After acquiring the paint matrix, it is crucial to obtain technical data sheets from vendors for cross-referencing and resolving quality problems. The data sheet file should include all paint data, such as customer requirements, paint shelf-life charts, storage instructions, sustainability charts, and a table of contents. Categorizing and tagging everything is essential for quick data retrieval. It is a quick and easy process for painters to access data regarding dry times, viscosity, and mixing instructions. However, electronic gadgets are prohibited in paint spraying and storing areas according to OSHA rules. Therefore, maintaining a technical data file is the best process improvement. Lean thinking eliminates the need to search for data sheets, making the process simple and efficient. The results highlight the differences between continuous production lines and custom product lines in terms of lean thinking. This process clearly demonstrates that lean thinking simplifies complex processes, resulting in time and cost savings.

3.3 Simple data charts for faster process:

These data charts are hard copies available near the computer desks, displaying inventory and routing codes. The chart reduces searching time, ensuring a fast process. Repeatedly searching for parts consumes valuable time. Thus, a simple data chart is necessary. A simple data chart has been created for quick reference which can be found in the tech sheets data file and on the engineers' desk. When searching for inventory, the paint code needs to be entered in the search box. Otherwise, one would have to sift through thousands of parts. This code provides a simple and quick reference, ensuring consistency between the paint code on the floor and the routing code. Table 2 depicts the simple data chart created.

Table 2. Simple data chart

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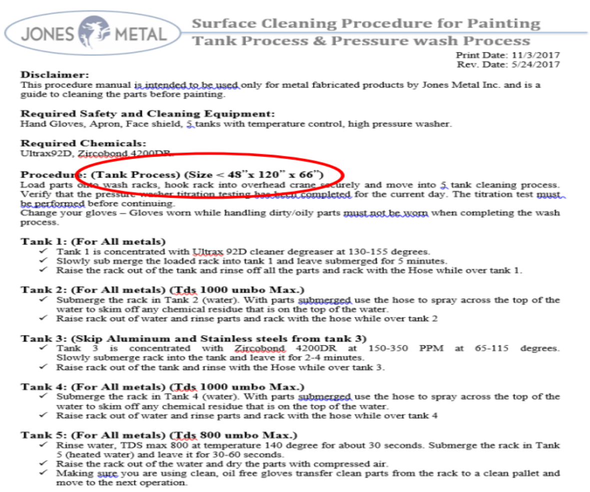
GLOBAL SHOP PAINT CODES

	Paint Code	Description	St RTR	INV	Color Code	Paint Supplier Name	Notes	Overall Thickness	Customer
URETHANE	P100	Yellow Primer	SRP-P100	Z-P100-MIX	Buff Yellow	Diamond Vogel	Yellow primer only no top coat	1.0-2.0 mils	Kato Engineering
	P111	CAT Yellow	SRP-P111	Z-P111-MIX	Cat Yellow	PPG	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P112	Pebble Gray **(Solar Gray top coat)**	SRP-P112	Z-P112-MIX	RAL 7032	Diamond Vogel	Paint inside and out (Pebble Grey is now being	Min. 6.00 mils	Kato Engineering
	P114	Waukesha Orange	SRP-P114	Z-P114-MIX	Waukesha Orange	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P115	Cummins Red	SRP-P115	Z-P115-MIX	Cummins Red	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P116	Ansi Gray	SRP-P116	Z-P116-MIX	RAL 7042	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P117	Cement Gray	SRP-P117	Z-P117-MIX	RAL 7033	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P118	Fire Red	SRP-P118	Z-P118-MIX	RAL 3020	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P119	Silver Gray	SRP-P119	Z-P119-MIX	RAL 7001	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P120	Cummins Beige	SRP-P120	Z-P120-MIX	Cummins Beige	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P121	Mid Gloss Black	SRP-P121	Z-P121-MIX	RAL 9005		Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P124	Brilliant Blue	SRP-P124	Z-P124-MIX	RAL5007	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P125	Traffic Blue	SRP-P125	Z-P125-MIX	RAL5017	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P127	Grey-White	SRP-P127	Z-P127-MIX	RAL 9002	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P128	Ivory (Used by Kohler)	SRP-P128	Z-P128-MIX	RAL 1014	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P129	MTU onsite Silver Gray	SRP-P129	Z-P129-MIX	RAL7001	Diamond Vogel	Paint inside and out	3.0 -4.0 Mils	Kato Engineering
	P140	Cummins Red Primer	SRP-P140	Z-P140-MIX	Cummins Red	Diamond Vogel	Cummins Red Primer only No top coat	1.0 - 2.0 Mils	Kato Engineering
	P150	Gray Primer	SRP-P150	Z-P150-MIX	Gray	Diamond Vogel	Gray primer only paint inside and out	1.0 - 2.0 Mils	Kato Engineering
	P700	White **(INSIDE)**	SRP-P700	Z-P700-1-MIX	White	Commercial Performance	Inside white/outside gray	3.0 -4.0 Mils	Kato Engineering
		Gray **(OUTSIDE)**		Z-P700-2-MIX	RAL 7042	Diamond Vogel		3.0 -4.0 Mils	Kato Engineering
EPOXY	A100	White Primer	SRP-A100	Z-A100-MIX	White	Diamond Vogel	White primer only paint inside and out	Min 2.00 Mils	Kato Engineering
	A111	Kato Equipment Yellow (Cat yellow)	SRP-A111	Z-A111-MIX	Equipment yellow	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A112	Pebble Gray	SRP-A112	Z-A112-MIX	RAL 7032	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A113	Pure White	SRP-A113	Z-A113-MIX	RAL 9010	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A114	Ansi Gray	SRP-A114	Z-A114-MIX	RAL 7042	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A116	Flame Red	SRP-A116	Z-A116-MIX	RAL 3000	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A117	Light Gray	SRP-A117	Z-A117-MIX	RAL 7035	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A120	Green Gray	SRP-A120	Z-A120-MIX	RAL 7009	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A121	Grass Green	SRP-A121	Z-A121-MIX	RAL 6010	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
	A122	Brilliant Blue	SRP-A122	Z-A122-MIX	RAL 5007	Diamond Vogel	Paint inside and out	Min 6.00 Mils	Kato Engineering
MILITARY-ALKYD	A417	Light Gray **(OUTSIDE ONLY)**	SRP-A417	Z-A417-MIX	RAL 7035	Diamond Vogel	Paint outside only	Min 6.00 Mils	Kato Engineering
	K100	Military Green Primer	SRP-K100	Z-K100-MIX	Military Green		Paint inside and out	1.0 - 2.0 Mils	Kato Engineering
	K111	Military Gray	SRP-K111	Z-K111-MIX	Military Gray	NCP coatings	Paint inside and out	Min 6.00 Mils	Kato Engineering
	K113	Millitary White	SRP-K113	Z-K113-MIX	NCP	NCP coatings	Paint inside and out	Min 6.00 Mils	Kato Engineering
	K411	Military Gray **(OUTSIDE ONLY)**	SRP-K411	Z-K411-MIX	Military Gray	NCP coatings	Paint outside only	Min 6.00 Mils	Kato Engineering
	K700	Military White **(INSIDE)**	SRP-K700	Z-K700-1-MIX	White	NCP coatings	Inside white/outside gray	3.0 -4.0 Mils	Kato Engineering
		Military Gray **(OUTSIDE)**		Z-K700-2-MIX	Military Gray	NCP coatings		Min 6.00 Mils	Kato Engineering
MILITARY-EPOXY	H100	Green - 150 (Military green primer)	SRP-H100	Z-H100-MIX		sherwin williams	Primer-paint inside and outside	3.0 - 4.0 mils	Kato Engineering
	H111	Haze gray - 151	SRP-H111	Z-H111-MIX		sherwin williams	Finishes-Paint inside and out	Min. 6 mils	Kato Engineering
	H700	White - 152	SRP-H700	Z-H700-1-MIX		sherwin williams	white-inside(special instruction for location)	Min. 6 mils	Kato Engineering
		Haze gray - 151		Z-H700-2-MIX		sherwin williams	Haze Gray-Outside(special instruction for locatio	Min. 6 mils	Kato Engineering
ALL OTHER CUSTOMERS	J001	Safety Yellow	SRP-J001	Z-J001-MIX		Commercial Performance		3.0 -4.0 Mils	
	J002	JLG Orange	SRP-J002	Z-J002-MIX		Commercial Performance		3.0 -4.0 Mils	
	J003	Repnet Purple	SRP-J003	Z-J003-MIX		Commercial Performance		3.0 -4.0 Mils	
	J004	SVT Blue	SRP-J004	Z-J004-MIX		Commercial Performance		3.0 -4.0 Mils	
	J005	Anderson Red	SRP-J005	Z-J005-MIX		Commercial Performance		3.0 -4.0 Mils	
	J006	AgChem Yellow	SRP-J006	Z-J006-MIX		Commercial Performance		3.0 -4.0 Mils	
	J007	Carc Green	SRP-J007	Z-J007-MIX		PPG		3.0 -4.0 Mils	
	J008	Carc Tan	SRP-J008	Z-J008-MIX		PPG		3.0 -4.0 Mils	
	J009	High Heat Black	SRP-J009	Z-J009-MIX		PPG		1.0 - 2.0 Mils	
	J010	Wilmar White	SRP-J010	Z-J010-MIX		PPG		3.0 -4.0 Mils	
	J011	Cat Yellow Primer	SRP-J011	Z-J011-MIX		PPG		1.0 - 2.0 Mils	
	J012	Cat Yellow	SRP-J012	Z-J012-MIX		PPG		3.0 -4.0 Mils	
	J013	Cat Black	SRP-J013	Z-J013-MIX		PPG		3.0 -4.0 Mils	
	J014	Gray Primer	SRP-J014	Z-J014-MIX		PPG		1.0 - 2.0 Mils	
	J015	Black Primer	SRP-J015	Z-J015-MIX		PPG		1.0 - 2.0 Mils	
	J016	White Primer	SRP-J016	Z-J016-MIX		PPG		1.0 - 2.0 Mils	
	J017	Gloss White	SRP-J017	Z-J017-MIX		PPG		3.0 -4.0 Mils	
	J018	Gloss Black	SRP-J018	Z-J018-MIX		PPG		3.0 -4.0 Mils	
	J019	Gloss Black	SRP-J019	Z-J019-MIX		PPG		3.0 -5.0 Mils	
	J020	Signal Black	SRP-J020	Z-J020-MIX	RAL 9004	PPG		3.0 -5.0 Mils	
	J021	FS 26307 Gray Epoxy	SRP-J021	Z-J021-MIX		sherwin williams		6 mils	Military epoxy
	J022	PSX 700 Series ANSI 61 Gray Epoxy	SRP-J022	Z-J022-MIX	ANSI 61 GRAY	PPG Amercoat		6 mils	Jones Metal Box Works

3.4 Creating chemical treatment process procedure for reference:

Chemical treatment is important before painting a metal part. The procedure typically depends on the type of metal and the customer's requirements. However, a procedure plan is needed to simplify the complex process and provide a quick reference. This procedure plan explains the safety equipment, required chemicals, and procedure. At Jones Metal, we perform two types of chemical treatment: pressure washing and tank processing. Therefore, we need two different procedures based on part size. The sample procedure clearly explains the processes and requirements. The picture shows the part sizes that can fit in the tanks. If the part size is larger than the mentioned size, then it should be pressure washed. This procedure plan ensures that everyone can follow the same procedure and provides easy reference. This improvement saves time, improves efficiency, and is cost-effective. Therefore, it is a perfect lean improvement to make complex processes more flexible. Figure 1 displays the surface cleaning procedure for painting.



JONES METAL — Surface Cleaning Procedure for Painting
Tank Process & Pressure wash Process

Print Date: 11/3/2017
Rev. Date: 5/24/2017

Disclaimer:
This procedure manual is intended to be used only for metal fabricated products by Jones Metal Inc. and is a guide to cleaning the parts before painting.

Required Safety and Cleaning Equipment:
Hand Gloves, Apron, Face shield, 5 tanks with temperature control, high pressure washer.

Required Chemicals:
Ultrax92D, Zircobond 4200DR.

Procedure: (Tank Process) (Size < 48"x 120" x 66")
Load parts onto wash racks, hook rack into overhead crane securely and move into 5 tank cleaning process. Verify that the pressure washer titration testing has been completed for the current day. The titration test must be performed before continuing.
Change your gloves – Gloves worn while handling dirty/oily parts must not be worn when completing the wash process.

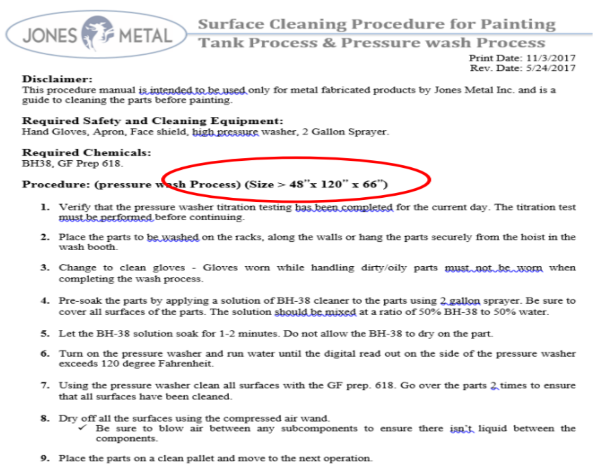
Tank 1: (For All metals)
- ✓ Tank 1 is concentrated with Ultrax 92D cleaner degreaser at 130-155 degrees.
- ✓ Slowly sub merge the loaded rack into tank 1 and leave submerged for 5 minutes.
- ✓ Raise the rack out of the tank and rinse off all the parts and rack with the Hose while over tank 1.

Tank 2: (For All metals) (Tds 1000 umbo Max.)
- ✓ Submerge the rack in Tank 2 (water). With parts submerged use the hose to spray across the top of the water to skim off any chemical residue that is on the top of the water.
- ✓ Raise rack out of water and rinse parts and rack with the hose while over tank 2

Tank 3: (Skip Aluminum and Stainless steels from tank 3)
- ✓ Tank 3 is concentrated with Zircobond 4200DR at 150-350 PPM at 65-115 degrees. Slowly submerge rack into the tank and leave it for 2-4 minutes.
- ✓ Raise rack out of the tank and rinse with the Hose while over tank 3.

Tank 4: (For All metals) (Tds 1000 umbo Max.)
- ✓ Submerge the rack in Tank 4 (water). With parts submerged use the hose to spray across the top of the water to skim off any chemical residue that is on the top of the water.
- ✓ Raise rack out of water and rinse parts and rack with the hose while over tank 4

Tank 5: (For All metals) (Tds 800 umbo Max.)
- ✓ Rinse water, TDS max 800 at temperature 140 degree for about 30 seconds. Submerge the rack in Tank 5 (heated water) and leave it for 30-60 seconds.
- ✓ Raise the rack out of the water and dry the parts with compressed air.
- ✓ Making sure you are using clean, oil free gloves transfer clean parts from the rack to a clean pallet and move to the next operation.



JONES METAL — Surface Cleaning Procedure for Painting
Tank Process & Pressure wash Process

Print Date: 11/3/2017
Rev. Date: 5/24/2017

Disclaimer:
This procedure manual is intended to be used only for metal fabricated products by Jones Metal Inc. and is a guide to cleaning the parts before painting.

Required Safety and Cleaning Equipment:
Hand Gloves, Apron, Face shield, high pressure washer, 2 Gallon Sprayer.

Required Chemicals:
BH38, GF Prep 618.

Procedure: (pressure wash Process) (Size > 48"x 120" x 66")

1. Verify that the pressure washer titration testing has been completed for the current day. The titration test must be performed before continuing.
2. Place the parts to be washed on the racks, along the walls or hang the parts securely from the hoist in the wash booth.
3. Change to clean gloves - Gloves worn while handling dirty/oily parts must not be worn when completing the wash process.
4. Pre-soak the parts by applying a solution of BH-38 cleaner to the parts using 2 gallon sprayer. Be sure to cover all surfaces of the parts. The solution should be mixed at a ratio of 50% BH-38 to 50% water.
5. Let the BH-38 solution soak for 1-2 minutes. Do not allow the BH-38 to dry on the part.
6. Turn on the pressure washer and run water until the digital read out on the side of the pressure washer exceeds 120 degree Fahrenheit.
7. Using the pressure washer clean all surfaces with the GF prep. 618. Go over the parts 2 times to ensure that all surfaces have been cleaned.
8. Dry off all the surfaces using the compressed air wand.
   - ✓ Be sure to blow air between any subcomponents to ensure there isn't liquid between the components.
9. Place the parts on a clean pallet and move to the next operation.

Figure 1. Surface cleaning procedure

3.5 Paint inventory sorting and applying FIFO:

Applying the FIFO (First In First Out) method is an important process for warehouses to track material expiration dates. This is especially important for paints, which tend to expire more quickly after opening. Therefore, it is mandatory to label paints with an expiration date after they are opened. To do this, a tagging process was created, which begins by creating a shelf-life tag. The shelf-life tag contains the manufacturing date, which is the order date, and the expiration date, which is the actual expiration date with seal. The open date must be written immediately after the seal is broken and the new expiration date. This process will be easier when computers and scanners are used, but electronic devices should not be used in the chemical warehouse because it is highly flammable. Figure 2 shows the paint shop life tagging instructions.

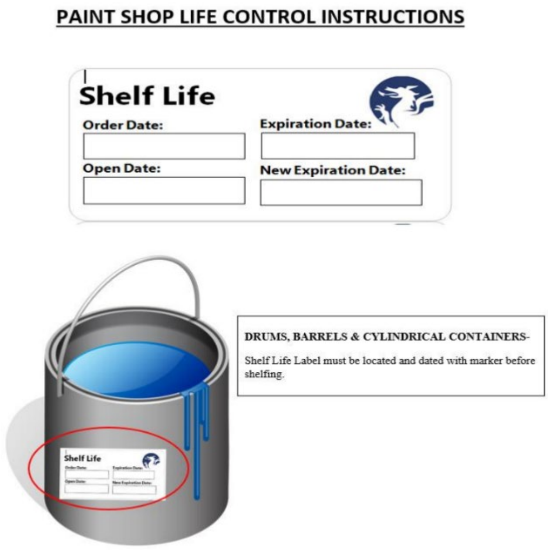


Figure 2. Tagging instructions

3.6 Invented shelf-life chart:

Table 3 shows the new shelf-life chart with the expiration dates for closed and open containers. This makes the tagging process easier, as the expiration dates are not printed on the paint boxes. Therefore, it is important to maintain a chart. This process adds value to the product by reducing time, making it a perfect lean process.

Table 3 . Shelf-life chart

Shelf Life Chart

	Part Number	Description	Supplier	Closed Container Shelf Life	Opened Container Shelf Life
PRIMER	04488WEP-4	OFF WHITE EPOXY PRIMER	HENTZEN	24 MONTHS	12 MONTHS
	EPX-904	GRAY EPOXY PRIMER	COMMERCIAL PERFORMANCE	24 MONTHS	12 MONTHS
	EPX-908	BLACK EPOXY PRIMER	COMMERCIAL PERFORMANCE	24 MONTHS	12 MONTHS
	EPX-950	WHITE EPOXY PRIMER	COMMERCIAL PERFORMANCE	24 MONTHS	12 MONTHS
	N-8330	GREEN ALKYD PRIMER	NCP COATINGS	12 MONTHS	6 MONTHS
	PG-0255	GRAY URETHANE PRIMER	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	PG-3235	YELLOW URETHANE PRIMER	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	SPU75953	SPU 75953 YELLOW PRIMER	PPG	12 MONTHS	6 MONTHS
	E90H226	MIL-DTL-53022 EPOXY PRIMER	SHERWIN WILLIAMS	12 MONTHS	6 MONTHS
	N10G350	MIL-DTL-24441D EPOXY POLYAMIDE	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	N10G450	Military	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
PAINT	N-5113	WHITE ENAMEL	NCP COATINGS	24 MONTHS	12 MONTHS
	AUE100 C9405	GLOSS BLACK	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 0130-10250	SVT BLUE	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 0130-91001	WILMAR WHITE	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 61310	JLG ORANGE	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 71781	ANDERSON RED	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 81496	SAFETY YELLOW	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 92121	WHITE	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE100 51264	REPNET PURPLE	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE360 32048	PEBBLE GRAY	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	AUE360 81774	AGCHEM YELLOW	COMMERCIAL PERFORMANCE	48 MONTHS	12 MONTHS
	B62 WZ111 RAL3000	FLAME RED	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62TZ104 RAL6010	GRASS GREEN	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62TZ104 RAL6010	BRILLIANT BLUE	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62 WZ111 RAL7009	GREEN GRAY	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62 WZ111 RAL7032	PEBBLE GRAY	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62 WZ111 RAL7035	LIGHT GRAY	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62 WZ111 RAL7042	ANSI GRAY	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	B62 WZ111 RAL9010	PURE WHITE	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	F78XXH14348-4347	CUMMINS BEIGE	SHERWIN WILLIAMS	24 MONTHS	12 MONTHS
	HHB-900	HIGH HEAT BLACK ENAMEL	PRO PAINT INC	NA	NA
	IG-1280 RAL5007	BRILLIANT BLUE	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	IG-1280 RAL5017	TRAFFIC BLUE	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	IG-1281	SILVER GRAY & IVORY	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	IG-1282	CEMENT GRAY	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	IG-5283	CUMMINS RED	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	MLN8045	CARC GREEN	AUTO BODY SPECIALTIES	12 MONTHS	6 MONTHS
	MLN8048	CARC TAN	AUTO BODY SPECIALTIES	12 MONTHS	6 MONTHS
	N-7411	MILITARY GRAY ENAMEL	NCP COATINGS	24 MONTHS	12 MONTHS
	SPU72726	CAT BLACK	PRO PAINT INC	12 MONTHS	6 MONTHS
	SPU72739	CAT YELLOW	PRO PAINT INC	12 MONTHS	6 MONTHS
	VLX19396-02	ANSI GRAY	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	VLX19664-04	WAUSKESHA ORANGE	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	VLX19395-07	Solar Gray	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	Pinnacle 460	SILVER GRAY	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	IG-0280 RAL5007	BRILLIANT BLUE	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	KI20980-0316	Kato Equipment yellow	DIAMOND VOGEL	24 MONTHS	12 MONTHS
	KI22165-0217	Pebble gray	DIAMOND VOGEL	24 MONTHS	12 MONTHS
	KI22166-0217	Ansi gray	DIAMOND VOGEL	24 MONTHS	12 MONTHS
	KI22225-0317	Light gray	DIAMOND VOGEL	24 MONTHS	12 MONTHS
	N10A351	Haze gray	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	N10W352	white	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	AUE 370	GLOSS BLACK	SHERWIN WILLIAMS	48 MONTHS	12 MONTHS
	AUE 370	signal Black	SHERWIN WILLIAMS	48 MONTHS	12 MONTHS
	F92SAA26307	Gray epoxy	SHERWIN WILLIAMS	24 MONTHS	12 MONTHS
CATALYSTS	04489CEH-4	CATALYST		24 MONTHS	12 MONTHS
	EPX901	CATALYST		24 MONTHS	12 MONTHS
	GXH1080	CATALYST	PPG	6 MONTHS	6 MONTHS
	IG-0245	CATALYST	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	V93V227	CATALYST	SHERWIN WILLIAMS	24 MONTHS	12 MONTHS
	N10V350	CATALYST	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	N10V450	CATALYST	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	AUE-101	CATALYST	PRO PAINT INC	24 MONTHS	12 MONTHS
	B60VZ70	CATALYST	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	GXH1080	CATALYST	PPG	6 MONTHS	6 MONTHS
	GHX1086	CATALYST	PRO PAINT INC	24 MONTHS	12 MONTHS
	IG0260	CATALYST	DIAMOND VOGEL	48 MONTHS	12 MONTHS
	V66-V29	CATALYST	SHERWIN WILLIAMS	24 MONTHS	12 MONTHS
	MULT-E-PDXY 180 REGULAI	CATALYST	DIAMOND VOGEL	24 MONTHS	12 MONTHS
	N10V351	CATALYST	SHERWIN WILLIAMS	36 MONTHS	12 MONTHS
	V93V228	CATALYST	SHERWIN WILLIAMS	24 MONTHS	12 MONTHS
REDUCER	JR-506	MEDIUM REDUCER	PRO PAINT INC	72 MONTHS	72 MONTHS
	TOLUENE	REDUCER	DIAMOND VOGEL	72 MONTHS	72 MONTHS
	N-3023 Xylol	REDUCER	DIAMOND VOGEL	72 MONTHS	72 MONTHS
	R-130	REDUCER		72 MONTHS	72 MONTHS

3.7 Create paint coverage and cost estimator:

Finding a calculator that could provide the data on the required gallons of paint to cover a part and the cost of the paint was a real challenge. This calculator would make the process faster by allowing parts to be ordered just in time. Otherwise, parts would need to sit on the floor for 5 days (lead time) waiting for paint from the purchasing department. The coverage calculator would also be useful for maintaining the right amount of safety stock. Cost estimation makes the process very accurate, saving the industry a lot of money by providing accurate numbers that account for overspray and waste. Part 2 discusses more about paint shop cost savings after lean thinking. Figure 3 shows the multi-step cost estimator, which can be used for more customized results for any paint mix. The calculator considers the following factors: percentage of solids, coverage for a gallon with 1 mil thickness, gallon price, cost per square foot of part A, ratio of part B, cost of part B, ratio of reducer, cost of reducer, and total cost per square foot with 1 mil thickness. The total cost can be multiplied by N number of mills based on customer requirements. This process has been continuously improved to create a single-step cost estimator. This is extremely easy to use and has tons of background data. The main goal of this calculator is to find coverage and cost in 1 second. This sheet is easy to update and add more paints.

Price of Paint mixture is here — Rev. Date 5/25/2017

URETHANE

INV	Description	Paint Mills	Price per sq. ft.
Z-P100-MIX	Yellow Primer	2.00	$0.46
Z-P111-MIX	CAT Yellow	4.00	$2.22
Z-P112-MIX	Pebble Gray (Solar Gray top coat)	4.00	$1.39
Z-P114-MIX	Waukesha Orange	4.00	$1.99
Z-P115-MIX	Cummins Red	4.00	$1.75
Z-P116-MIX	Ansi Gray	4.00	$1.37
Z-P117-MIX	Cement Gray	4.00	$1.79
Z-P118-MIX	Fire Red	4.00	$0.51
Z-P119-MIX	Silver Gray	4.00	$1.67
Z-P120-MIX	Cummins Beige	4.00	$3.40
Z-P121-MIX	Mid Gloss Black	4.00	$2.12
Z-P124-MIX	Brilliant Blue	4.00	$1.95
Z-P125-MIX	Traffic Blue	4.00	$1.96
Z-P129-MIX	MTU onsite Silver Gray	4.00	$1.63
Z-P140-MIX	Cummins Red Primer	2.00	$0.51
Z-P150-MIX	Gray Primer	2.00	$0.51
Z-P700-1-MIX	White (INSIDE)	4.00	$1.92
Z-P700-2-MIX	Gray (OUTSIDE)	4.00	$1.38

EPOXY

INV	Description	Paint Mills	Price per sq. ft.
Z-A100-MIX	White Primer	2.00	-
Z-A111-MIX	Kato Equipment Yellow (Cat yellow)	6.00	$1.79
Z-A112-MIX	Pebble Gray	6.00	$1.42
Z-A113-MIX	Pure White	6.00	#REF!
Z-A114-MIX	Ansi Gray	6.00	$1.45
Z-A116-MIX	Flame Red	6.00	#REF!
Z-A117-MIX	Light Gray	6.00	$1.41
Z-A120-MIX	Green Gray	6.00	#REF!
Z-A121-MIX	Grass Green	6.00	#REF!
Z-A122-MIX	Brilliant Blue	6.00	#REF!
Z-A417-MIX	Light Gray (OUTSIDE ONLY)	6.00	$1.41

Prices per 1 Gallon here

PRIMER

PART A

COST/GAL	Part number	Description	Supplier
$84.80	04488WEP-4	OFF WHITE EPOXY PRIMER	
$59.87	EPX-904	GRAY EPOXY PRIMER	
$59.88	EPX-908	BLACK EPOXY PRIMER	
$59.88	EPX-950	WHITE EPOXY PRIMER	
$79.31	N-8330	GREEN ALKYD PRIMER	
$52.04	PG-0255	GRAY URETHANE PRIMER	
$46.32	PG-3235	YELLOW URETHANE PRIMER	
$98.28	SPU75953	1E72732A YELLOW PRIMER	
$59.89	E90H226	MIL-DTL-53022 EPOXY PRIMER	SHERWIN WILLIAMS
$62.88	N10G350	MIL-DTL-24441D EPOXY POLYAMID	SHERWIN WILLIAMS
$56.85	N10G450	Military	SHERWIN WILLIAMS

PART B

COST/GAL	Part number	Description	Supplier
$84.80	04489CEH-4	CATALYST	
$35.31	EPX901	CATALYST	
$84.48	GXH1080	CATALYST	
$73.55	IG-0245	CATALYST	
$67.48	V93V227	CATALYST	SHERWIN WILLIAMS
$62.88	N10V350	CATALYST	SHERWIN WILLIAMS
$52.85	N10V450	CATALYST	SHERWIN WILLIAMS

PART A

COST/GAL	Part
$56.12	N-5113
$40.30	AUE100 C940
$64.90	AUE100 0130-
$41.05	AUE100 0130-
$82.30	AUE100 61310
$62.59	AUE100 71781
$60.63	AUE100 81496
$45.49	AUE100 92121
$62.64	AUE100 51264
$80.33	AUE360 3204
$109.00	AUE360 8177

Figure 3. Multi-step cost estimator

Figure 4 shows a single-step cost estimator. It works with custom formulas for each paint based on paint properties and technical data. The user simply enters the area of the part in square feet in the specified red cell and presses enter. All costs and paint volumes are instantly updated with the new number. The user then needs to find which paint is being used to obtain the correct values. This calculator eliminates many emails and communication processes, making everything a single step. A price update sheet is directly linked from the coverage sheet as background data to update new paint prices. A user guide shows the background formulas and explains how to use the calculator and how to update or change the paints. This is one of the best process improvements in the paint shop, saving a lot of money and making the process faster and simpler. Therefore, this process improvement is an excellent example of lean thinking.

ENTER TOTAL AREA IN Sq. foot -----> 1

Square inch to square foot converter: Enter your Sq. Inch --> 144 | In Sq. Foot ---> 1

URETHANE (P)

P100-YELLOW PRIMER

Order: Diamond Vogel			Gallons	Price / gallon	Each Costs
Primer	Part A	PG-3235	0.0078125	$46.32	$0.36
	Part B	IG-0245	0.001116406	$48.69	$0.05
	Reducer	TOLUENE	0.0015625	$11.98	$0.02
Paint	Part A	NA			0
	Part B	NA			0
	Reducer	NA			0
				Grand Total=	$0.43

P111-CAT YELLOW

Order: PPG			Gallons	Price / gallon	Each Costs
Primer	Part A	SPU75953	0.008547009	$98.28	$0.84
	Part B	GXH1080	0.000854701	$84.48	$0.07
	Reducer	NA			$0.00
Paint	Part A	SPU72739	0.007633588	$57.65	$0.44
	Part B	GXH1080	0.002061069	$84.48	$0.17
	Reducer	JR506	0.000763359	$31.84	$0.02
				Grand Total=	$1.55

P112-PEBBLE GRAY (Solar Gray top coat)

Order: Diamond Vogel			Gallons	Price / gallon	Each Costs
	Part A	PG-0255	0.0078125	$52.04	$0.41

EPOXY (A)

A100-WHITE PRIMER

Order: Diamond Vogel			Gallons	Price / gallon	Each Costs
Primer	Part A	NA		$0.00	$0.00
	Part B	NA		$0.00	$0.00
	Reducer	NA			$0.00
Paint	Part A				$0.00
	Part B				$0.00
	Reducer				$0.00
				Grand Total=	$0.00

A111-CAT YELLOW (Kato equipment yellow)

Order: Diamond Vogel			Gallons	Price / gallon	Each Costs
Primer	Part A	NA		$0.00	$0.00
	Part B	NA		$0.00	$0.00
	Reducer	NA			$0.00
Paint	Part A	KI20980-0316	0.010526316	$86.47	$0.91
	Part B	MULT-E-PDXY 180 REGULAR C	0.005263158	$48.69	$0.26
	Reducer	N-3023 Xylol	0.001368421	$18.48	$0.03
				Grand Total=	$1.19

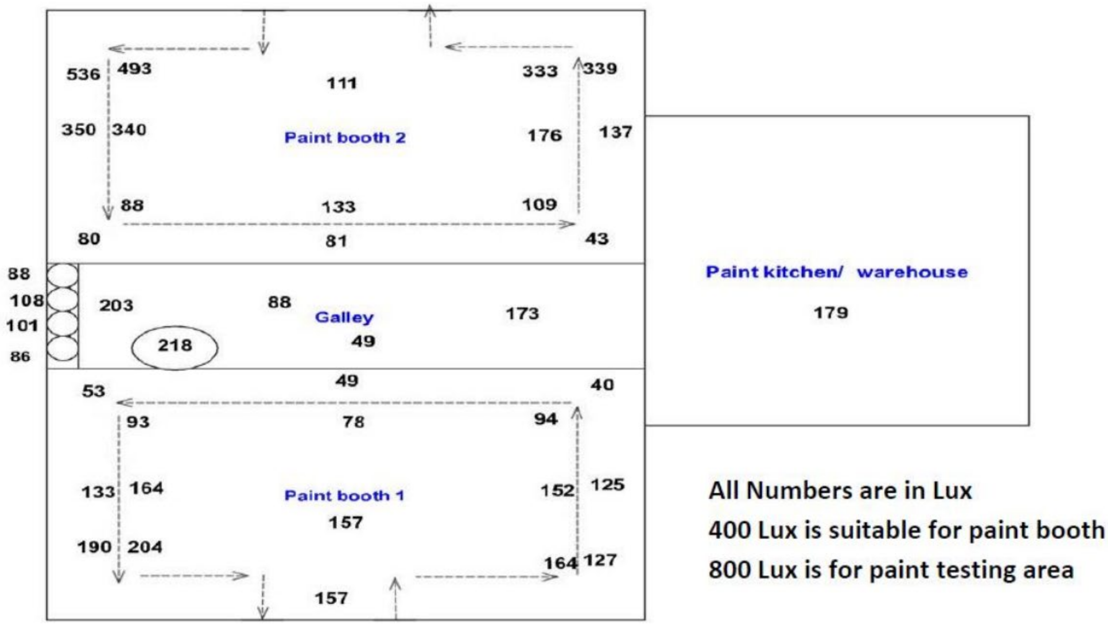
A112-PEBBLE GRAY

Order: Diamond Vogel			Gallons	Price / gallon	Each Costs
	Part A	NA		$0.00	$0.00

Figure 4. Single step cost and coverage estimator

3.7 Create paint coverage and cost estimator:

The current light status and locations should be known in order to restore the paint shop light. If the light capacity is 600 Lux, that does not mean that there are 600 Lux on the ground. Lux should be calculated on the part surface area. To do this, all of the paint line layout must be considered, and every point must be measured using a Lux meter. In this research, the Lux meter HDE Lx-1010B was used. This meter can provide accurate readings of +/- 5%. A current Lux plant layout was then created. Figure 5 shows the Lux report of the current layout. The arrows represent the paint line flow. Both sides of the line need to be measured because the painter will be spraying from both sides. Therefore, it is important for the painter to check every corner clearly.



Solution:

1. Restore all the screens of the lights. If possible add new LED tubes at paint exhaust area.
2. Add new lights in front of the exhaust at both the paint booths and top of the pots in galley

Figure 5. Lux report

The report explains the solution based on the requirement and the difference between the current lux level. In this case, new tubes need to be added and old ones restored. Therefore, the quality of the painting is improved, and rework is reduced at a lower cost. This is a good process improvement and an example of lean thinking.

3.7 Customer company expectations for future business:

Customer companies expect their suppliers to have processes that are not too complex, as this could lead to quality errors and extra overhead costs. Most companies, such as aerospace and motor vehicle companies, need very accurate parts, so they need to follow all procedures with flexibility, which reduces errors. Small to mid-size companies that want to win projects should follow the best procedures with the least possibility of errors. Lean manufacturing is the best way to make procedures easier, simpler, and more profitable.

4. Results and Discussion

4.1 Fast processing and on time delivery:

The lean thinking in Jones metal's paint shop led to a significant improvement in processing speed. More practical numbers will be discussed in Volume 2. The paint matrix and cost estimators saved costs and improved process speed. Expiration charts and shelf-life tags improved the FIFO process and quality. The 5S event played a major role in the improvement process, changing the entire warehouse layout to make it easier to store paints. All the spaces were used very well, and tools were standardized. The improvement in lighting Lux also increased quality.

4.2 Paint quality:
All the process improvements discussed in the case study were found to increase paint quality, both directly and indirectly. Improved quality led to profits and business improvements in the future.

4.3 Saves money:
Lesser money was spent on process improvement, and in most cases, no money was spent at all. This directly saved money in the form of less maintenance. Cost estimator and coverage charts saved direct money by purchasing the right amount and billing the customer the right amount. This also saved money on labor charges by making the processes faster by eliminating non-value-added time and sitting time.

4.4 More scope for business development:
After these improvements were made at Jones Metal Inc., the company won a project and qualified as a supplier for a well-respected company. This was due to the company's best procedures, failure processes, and ongoing improvement. Therefore, there is a lot of potential for future business development.

5. Conclusion
Lean thinking has increased flexibility, process speed, and cost savings (Womack et. al, 1990). The major difference between continuous production processes and custom product processes is the rate of improvement due to complexity. The rate of change is much slower for custom production due to unique designs and complex processes, but it still decreases complexity. The same changes in high-volume/continuous production plants give much better results. While applying lean methodologies, only a few have been applied because some do not work, such as pull. It is difficult to apply pull in more customized settings due to different paints, customers, and procedures. Lean thinking always makes changes towards flexibility regardless of the size of the industry, but there will be a difference in applying lean to complex and non-complex industries, and the development rate will also be different.

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Biographies

Dave Olson is an industry veteran with 30 years of experience in metal fabrication industry. His core competencies include Sales, Metal Fabrication, Laser Cutting, Sheet Metal, Lean Manufacturing, Product Development, Machine Tools, Sales Management, Quality Assurance, Water Jet, Saws, Press Brake, Robotic Welding, MIG welding, Spot Welding, Resistance Welding, Tube Bending, Tube Cutting, Plating, Painting

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Naim Islam is a professional science master's student, pursuing engineering management under the Department of Industrial and Manufacturing Engineering at Minnesota State University, Mankato. He completed his bachelor's degree in communications engineering from International Islamic University, Malaysia. Upon completing graduation, he worked as an IT assistant in Sydney, Australia and as a performance marketer in Dubai, U.A.E. During his work experience, he has handled process improvement and waste reduction projects in different applications. He is actively involved and interested in various research topics including quality assurance, supply chain management, Lean manufacturing, Lean-Six-sigma applications, project management, new product development, design of experiments, data analysis and statistics. He has registered with IEOM as a student member to be actively involved and learn more from the industrial/manufacturing sector.