Minitab® Case Studies

# Using Six Sigma to Reduce Scrap, Rework, and Costs at Tenneco

Tenneco manufactures clean air and ride performance products for cars, trucks, and commercial and agricultural vehicles for customers in more than 100 countries. The company operates 14 engineering centers and 90 manufacturing facilities worldwide, with a global process excellence program to help the company meet continuous improvement goals and drive innovation.

"Our manufacturing facilities produce high-quality products and systems using state-of-the-art manufacturing processes and advanced optimization tools," says Dan Wolfe, Lean Six Sigma Master Black Belt and Master Black Belt Manager for North America at Tenneco. "Tenneco employs Six Sigma and Lean extensively to assure consistent levels of quality for our customers and to improve efficiency across all of our facilities."

As part of a Six Sigma initiative to reduce scrap and rework, a team at the company's Litchfield, Mich., facility used Minitab Statistical Software to assess and optimize their processes for manufacturing steel tubing for vehicle exhaust systems.

## The Challenge

While the Tenneco Litchfield plant manufactures steel tubing for exhaust systems of various sizes, the 2.5-inch size had the highest levels of "scrap," or defects. Tubing identified as scrap typically split at some point during the production process, either at one of the seams or flares, or when being sized. The project team, which included a Tenneco Master Black Belt and Black Belt, process owners, and engineers, set a goal to reduce the scrap rate for 2.5-inch tubing by 50 percent.

TENNECO

**ORGANIZATION**

Tenneco

**OVERVIEW**

- Global provider of clean air and ride performance products for cars, trucks, and commercial and agricultural vehicles
- Operates 90 manufacturing facilities and 14 engineering centers on six continents
- Nearly 29,000 employees worldwide
- Annual revenues of more than $8.4 billion

**QUALITY CHALLENGE**

Reduce 2.5-inch steel tubing scrap rate by 50 percent at Tenneco's Litchfield, Mich., facility.

**PRODUCTS USED**

Minitab® Statistical Software

**RESULTS**

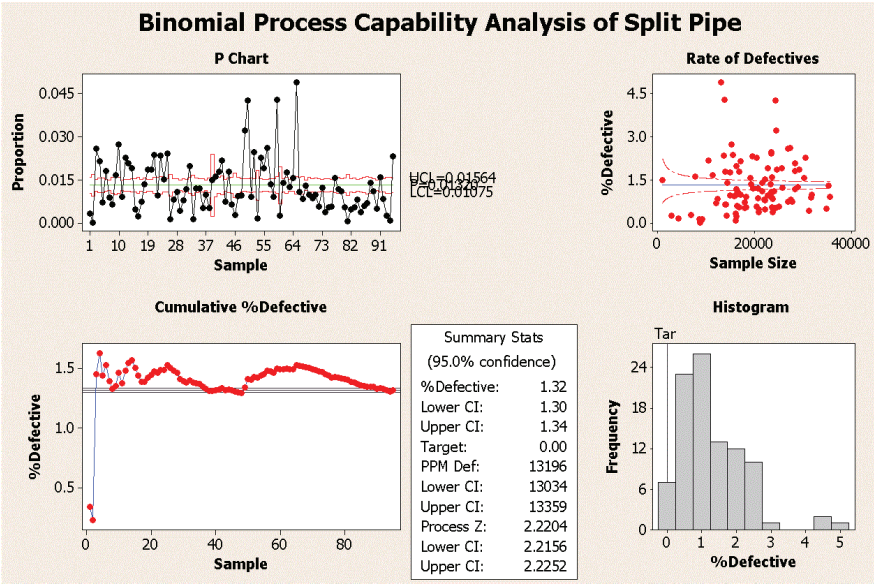
- Reduced 2.5-inch steel tubing scrap rate by 50 percent
- Improved the efficiency of both internal and external customer departments
- Improvements implemented at sister facilities

Using Minitab to analyze their data helped a Six Sigma project team at Tenneco reduce scrap rates for steel tubing used in vehicle exhaust systems.

# How Minitab Helped

The Tenneco team followed the DMAIC approach to complete their Six Sigma project, which divided their effort into five phases—define, measure, analyze, improve, and control. As part of the define phase, the team created detailed process maps to outline the steps involved in manufacturing exhaust pipes. They even consulted an external supplier with expertise in some of the more technical aspects of the process to help them highlight areas for improvement.

To further evaluate the current process, the team performed a process capability analysis in Minitab using data collected on the number of defects. The analysis showed the team that the proportion of defectives were quite variable with an average defective rate of 1.32 percent.

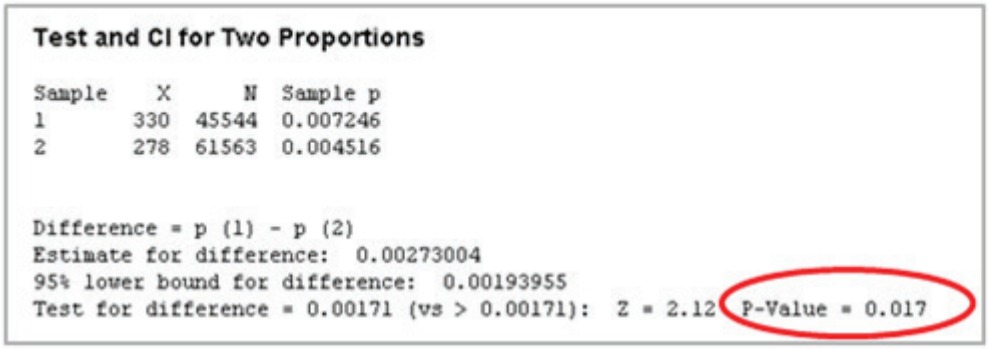



The project team at Tenneco performed process capability analysis in Minitab at the onset of their project to assess process variation.

Now that they had a clearer understanding of their process, the team met to rank areas where improvements could be made—including tool wear and alignment, temperature at the weld zone, setup, pressure, and inspection. The team then collected data for each of these potential improvement areas, such as continuous temperature data from the welding process, and set out to use statistical analysis to identify which areas they should focus on to reduce scrap rates.

They used Minitab to perform various hypothesis tests, including two proportions tests, to evaluate if new tooling would affect scrap rates, or if utilizing manufacturer recommended settings for tool setup would have an impact.

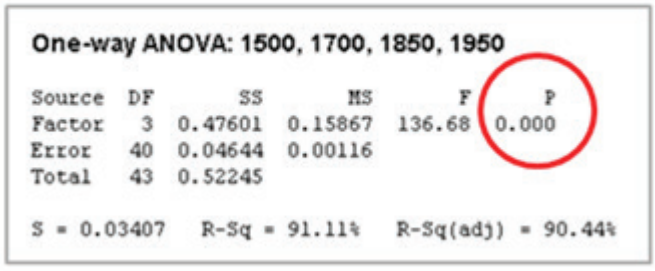
The team also conducted an analysis of variance (ANOVA) in Minitab to evaluate the importance of weld zone temperature on tubing expansion, since tubing that expanded was more prone to defects. This type of analysis assesses the importance of one or more factors by comparing the response variable means at the different factor levels. In this case, the different factor levels were the various temperatures (1500°F, 1700°F, 1850°F, 1950°F).



**Test and CI for Two Proportions**

| Sample | X | N | Sample p |
|---|---|---|---|
| 1 | 330 | 45544 | 0.007246 |
| 2 | 278 | 61563 | 0.004516 |

Difference = p (1) - p (2)
Estimate for difference: 0.00273004
95% lower bound for difference: 0.00193955
Test for difference = 0.00171 (vs > 0.00171): Z = 2.12 P-Value = 0.017



**One-way ANOVA: 1500, 1700, 1850, 1950**

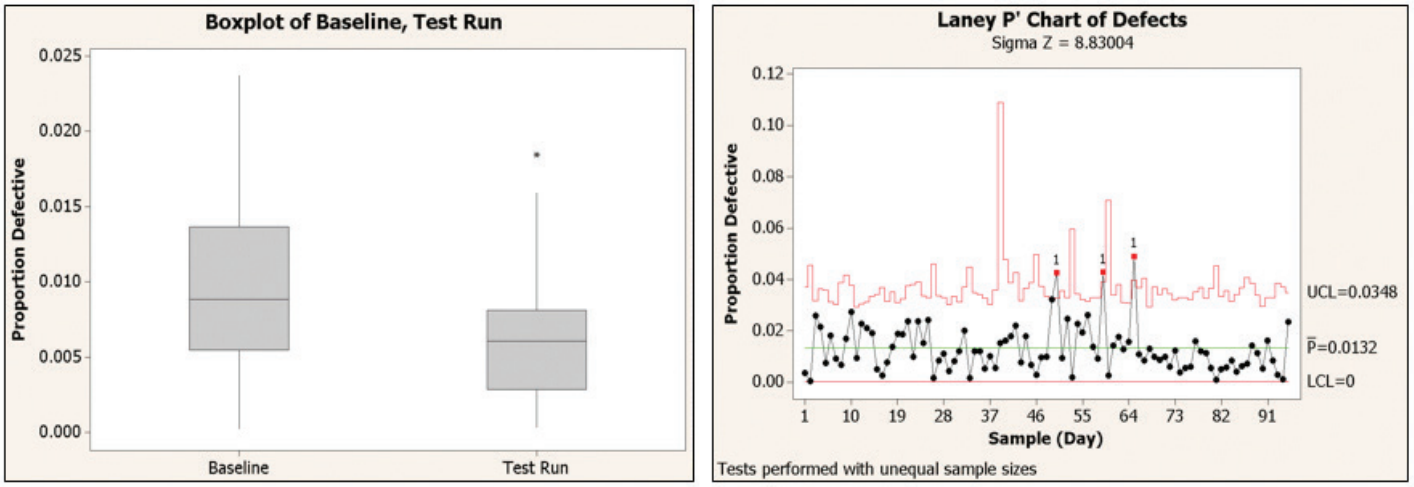
| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Factor | 3 | 0.47601 | 0.15867 | 136.68 | 0.000 |
| Error | 40 | 0.04644 | 0.00116 | | |
| Total | 43 | 0.52245 | | | |

S = 0.03407 R-Sq = 91.11% R-Sq(adj) = 90.44%

The team conducted a two proportions test in Minitab (top left) to evaluate if utilizing manufacturer recommended settings for tool setup would impact scrap rates. They also performed an ANOVA (bottom right) to analyze how different weld zone temperatures would impact defects related to tubing expansion.

"The Minitab analysis confirmed that we should focus our efforts on making improvements to the tooling, as well as standardizing tooling setup procedures and weld zone temperatures," says Peter Malefyt, Senior Engineer and Black Belt at Tenneco's Litchfield facility. "This is just one example of how we use Minitab to help us analyze data and derive solutions for process improvement."

The team validated these improvement opportunities with small production runs. Minitab boxplots and control charts allowed the team to easily see the outcome of the test runs, and performing Gage R&R analysis on their measurement systems allowed the team to be confident in the data they collected. Their analysis of data from the test runs further validated the opportunities they had outlined for improvement.




Minitab boxplots and control charts helped the project team analyze data from test production runs and validate improvement opportunities with easy-to-read visualizations of their data.

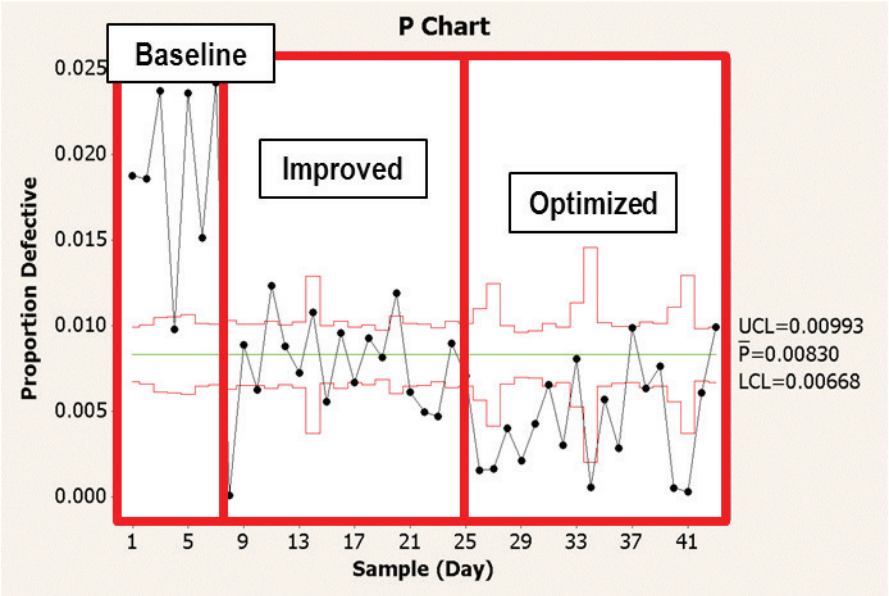
"With Minitab graphs, we're able to communicate what are often complex statistical findings in an easy-to-understand way that's relevant to everyone in our organization," Malefyt says.

"The documentation and built-in help available for Minitab Statistical Software is the best we've ever used at Tenneco, which aids us immensely for training purposes," adds Wolfe.

Knowing where to focus their improvements, the team implemented solutions that would be most capable of achieving the scrap target. They also performed cost-benefit analyses to justify implementation costs. Solutions included incorporating a new measurement system and controls for the tooling, setting temperature parameters, and standardizing setup conditions.

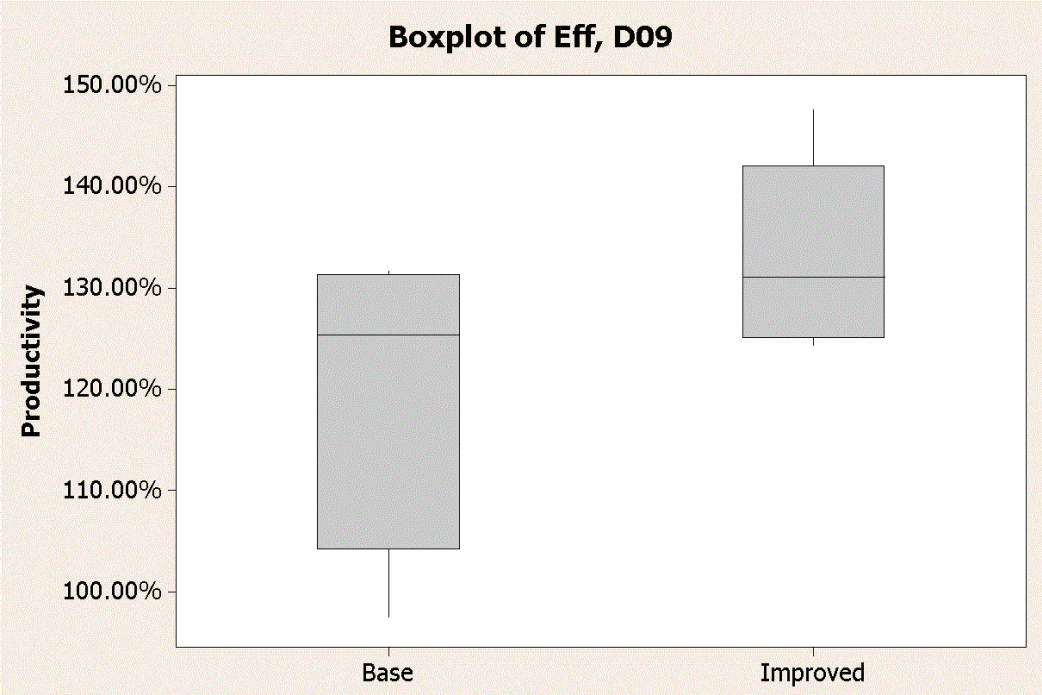
# Results

When they analyzed data collected after implementing the process improvements, the results confirmed the team achieved their goal of reducing scrap by 50%.




The project team created the control chart with stages above to show management how the process had changed throughout the implementation of improvements. The team was able to highlight three time periods—the process before it was improved (baseline), at the initial solution development (improved), and the optimized solution—all on one chart.

Additional benefits included efficiency improvements in both the internal and external customer departments that produce the steel tubing parts in the Litchfield plant.




The boxplot above shows the overall productivity level both before and after the improvement solutions were implemented for the departments responsible for producing the 2.5-inch steel tubing.

The project team has communicated their success to improvement teams at other Tenneco facilities that make different-sized parts or have similar production processes.

"This is where the impact of this project is much more than what our immediate numbers show," Malefyt says. "Tenneco manufactures many different sizes of steel tubing, and each of those processes, across all of our facilities, can implement these improvement activities."

The team members are quick to point out that theirs is just one out of a myriad of successful projects completed annually by Tenneco's global process excellence program.

"Minitab is an integral part of our Six Sigma training, and an integral part in the successful completion of DMAIC projects at Tenneco," says Wolfe.