

Technology **Drives** **Kenworth** *to Excellence*

Assemblers at Kenworth's Renton, WA, factory use high-tech tools to build world-class trucks.

Most people traveling along an interstate highway at 70 mph assume that all trucks look the same. But, many commercial drivers would beg to differ. They claim that one truck stands out among all the rest: Kenworth. The 81-year-old brand is considered by many truckers to be the "world's best."

build products faster, better and more efficiently than its competition.

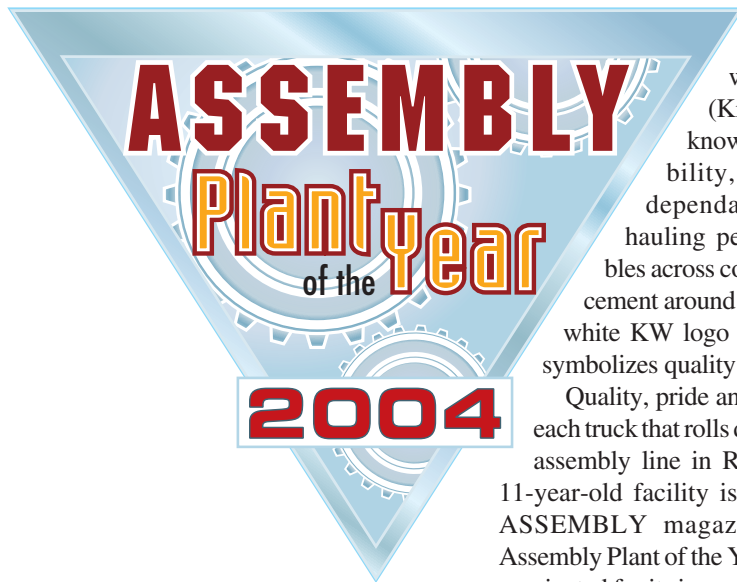
Kenworth views itself not as a truck company that uses technology, but rather as a high-technology company that builds trucks. Employees at the 270,000-square-foot Renton plant are using a variety of leading-edge tools to improve operating efficiency and boost bottom-line profitability.

"The plant strives to lead not only within our company, but also within the industry as a whole," says Doug Baugh, plant manager. "Our focus is an initiative called break-through performance, which is characterized by 'possibility thinking.'"

"Possibility thinking encourages us to look inside and outside the industry to determine better ways to conduct our business," adds Joe Zitzelberger, director of manufacturing development. "The end result is to implement means or methods to increase truck quality through continuous improvement. To help gauge our industry leadership, over 16 major benchmarking studies were conducted in the past year alone."

Because of its product innovation and reliability, Kenworth is recognized as the industry leader for heavy-duty trucks. In fact, this year, the company received the prestigious J.D. Power and Associates award for highest ranking in customer satisfaction among vocational segment Class 8 truck owners.

Kenworth traces its roots to 1923, when Seattle entrepreneurs Harry Kent and Edgar Worthington developed a rugged four-cylinder "Western truck for Western work," such as climbing



Vehicles made by Kenworth Truck Co. (Kirkland, WA) are known for their reliability, durability and dependability. Whether hauling perishable vegetables across country or a load of cement around town, the red and white KW logo on the front grill symbolizes quality to truckers.

Quality, pride and passion go into each truck that rolls down Kenworth's assembly line in Renton, WA. The 11-year-old facility is the recipient of ASSEMBLY magazine's inaugural Assembly Plant of the Year award. It was nominated for its innovative use of information technology to reduce production costs, increase productivity, improve safety, shorten time to market, and enhance product quality and yields.

Kenworth, a division of PACCAR Inc. (Bellevue, WA), has been aggressively applying information technology to improve the way it assembles custom-engineered, build-to-order trucks. The company has developed and implemented a variety of high-tech tools on the plant floor to

■ **By Austin Weber**
Senior Editor



For more than 80 years, Kenworth vehicles have been a common sight on the highways and byways of America. Photo courtesy Kenworth Truck Co.

steep hills and traversing mountain forests. In 1933, Kenworth became the first American truck manufacturer to install diesel engines as standard equipment. The company also developed the industry's first sleeper cabs.

Kenworth was acquired by PACCAR in 1944. Today, the \$11 billion company also owns Peterbilt Motors Co. (Denton, TX), in addition to several leading truck manufacturers in Europe, such as DAF, Foden and Leyland.

PACCAR will be celebrating its centennial next year. The company was originally called Pacific Car and Foundry, and was a leading manufacturer of railroad rolling stock, such as refrigerated cars used for transporting fruit. The Kenworth Renton plant is located on the site of the company's former railcar factory, which closed in 1988.

Competitive Market

The trucking industry is the backbone of the U.S. economy. In fact, the American Trucking Associations (Alexandria, VA) claims that professional truck drivers account for 68 percent of all freight delivered in the United States. Many of those items arrive with Kenworth vehicles.

The Class 8 truck manufacturing

business is very competitive, because trucking is a cyclical industry. But, after several lackluster years, business is picking up due to the improving U.S. economy.

According to Standard & Poor's (New York), demand for heavy-duty trucks is up 40 percent this year. Global Insight Inc. (Waltham, MA) reports that orders for heavy trucks exceeded 96,000 units during the first three months of 2004, the best three-month performance since early 1998 and more than double year-earlier levels. In fact, PACCAR reported record revenues and net income for the first half of 2004. Replacement demand has been driving the market.

Swift Transportation Co. (Phoenix) recently ordered several thousand Kenworth trucks for its large fleet. In addition, Kenworth is currently processing a large order from Costco Wholesale Corp. (Issaquah, WA). To meet that growing demand, the Renton assembly line has seen steady production increases.

The Renton facility builds most of the trucks in the Kenworth product line. The other trucks are produced at Kenworth plants in Chillicothe, OH, St. Therese, QE, and Mexicali, Mexico.

Assemblers in Renton build a wide variety of trucks, such as aerodynamic models with sleeper cabins for long-haul applications; models with good visibility and maneuverability for short haul and urban delivery; and heavy-duty vocational models that are used as cement mixers and dump trucks.

"The Renton plant has the ability to manage an incredible variety of product," says Dave Stevens, director of manufacturing engineering. "The plant handles the maximum variation of our product line. Today, the fluctuation in content is greater than ever. And, vehicle technology is more challenging."

For instance, Stevens says vehicles now use a vast array of sophisticated electronics. Kenworth trucks can be equipped with navigation systems, satellite radio, collision avoidance warning systems, night vision systems and stability control braking systems, making the assembly process more complex.

"The data infrastructure required to handle these systems, and communicate with electronic control modules of major systems, is very sophisticated," explains Stevens. "Testing of electronics for reliability and interference is increasingly important, because so many systems,

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Many customers spec their trucks with stainless steel and polished chrome options. Photo courtesy Kenworth Truck Co.

from the engine to the transmission to the brakes, are electronically controlled.”

Engineers recently developed a cab harness electrical tester that is connected

to the cab electrical system while the cab is still on the trim line. “This allows us to do a functional test of all gauges, switches and lights to ensure the cab is ready for setting onto the chassis,” says Stevens. “The tester prompts the operator through a function validation sequence and generates a chassis-specific test report.” Information is also stored in a database that can be used for statistical analysis.

High-Mix Assembly Line

Kenworth vehicles assembled at the Renton plant include the:

- T600. This aerodynamic long-haul tractor is aimed at fleets eager to cut fuel consumption.

- T800. This truck features a set-back front axle to optimize payload potential and maneuverability. This popular vehicle accounts for more than

50 percent of the plant’s production.

- W900. This vehicle, featuring traditional long-nosed styling, is popular with independent truckers who consider

it to be the industry’s most classic design. Many customers usually spec their vehicles with stainless steel and polished chrome options.

In addition to over-the-road models, Kenworth is a leading manufacturer of off-highway trucks that are made for transporting heavy loads of commodities, such as coal or timber, in remote locations. Kenworth also has a long heritage of building trucks that haul equipment used for servicing oil fields in severe climates and terrain, ranging from Siberian tundra to Saudi Arabian sand dunes.

Many off-road trucks are equipped with special options, such as tandem steering, six-wheel drive, tubular bumpers, brush guards, extra fuel tanks and roof-mounted beacons, in addition to raised fuel tanks and brake chambers for greater ground clearance.

Because of the large size and unique requirements of these trucks, the Renton plant builds them in a dedicated area of the factory. Kenworth offers two basic types of off-highway trucks, including the:

- C500. These trucks are designed

About the Award

The ASSEMBLY magazine “Assembly Plant of the Year” award was initiated earlier this year to showcase world-class production facilities in America, and the people, products and processes that make them successful. All manufacturers that assemble products in the United States were invited to nominate their plants.

The goal was to identify a state-of-the-art facility that has applied world-class processes to reduce production cost, increase productivity, shorten time to market or improve product quality.

An official nomination form was printed in several issues of ASSEMBLY; in addition, an online version appeared on the magazine’s Web site (www.assemblymag.com). Nominations were received from a diverse group of manufacturers that reflect the magazine’s demographics.

All nominees were evaluated by a group of independent experts and by ASSEMBLY’s editorial staff, based on the following criteria:

- Have assembly processes been improved through the use of new technology?

- Has the plant improved its performance by making more effective use of existing technology?

- Has the plant taken steps to reduce production costs?

- Have new or improved assembly processes resulted in increased productivity?

- Has the plant used assembly improvements to reduce time to market?

- Has the plant boosted bottom-line profits and competitive advantage?

- Did operators play a role in the successful implementation of new assembly strategies?

- Has a product been effectively designed for efficient assembly?

- Has the plant attempted to protect the environment and conserve natural resources?

As winner of the inaugural Assembly Plant of the Year competition, Kenworth Truck Co. (Renton, WA) received an engraved crystal award during a special presentation at the recent Assembly Technology Expo in Chicago. In addition, Kenworth received a commemorative banner to display inside its plant.



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Kenworth trucks are known for their reliability, durability and dependability. Photo courtesy Kenworth Truck Co.

for hauling heavy loads in both on- and off-road conditions.

■ 953. These extra-large trucks are built for demanding off-road desert applications and extreme payloads. They

feature large sand tires and heavy-duty axles, chassis and components.

No matter what type of vehicle they order, all truck operators are faced with the same challenges, such as rising fuel

prices, a shortage of qualified drivers and driver retention. To address these issues, Kenworth engineers are constantly searching for new innovations that help customers gain life-cycle cost advantages and retain drivers.

For instance, the company recently launched a lightweight rear-axle air-ride suspension system. The proprietary design produces a smoother ride and reduces maintenance. Kenworth has also introduced extended cabs for its popular T600, T800 and W900 vehicles. The new cabs increase interior space by 15 percent, which enhances driver comfort and provides additional storage space.

To maintain a competitive edge, Kenworth invests heavily in research and development. In fact, the company recently opened a state-of-the-art R&D center next to the Renton assembly plant. Engineers use rapid prototyping and a five-axis router to help speed the design process, enabling product enhancements 12 to 24 months faster than 10 years ago.

Sister Plant Is Also Impressive

Kenworth Truck Co. (Kirkland, WA) owns two assembly plants in the United States. In addition to its facility in Renton, WA, which is the recipient of the inaugural *ASSEMBLY* magazine Assembly Plant of the Year award, the company operates a plant in Chillicothe, OH, that is bigger, older and equally impressive.

The 30-year-old plant boasts more than 335,000-square-feet of space. More than 1,440 people work in the nonunion facility. The plant produces many of the same vehicles as Renton, in addition to the T2000, the newest Kenworth model. The truck blends weight-saving components, options and materials with leading-edge aerodynamics. For instance, it uses 20 percent fewer parts than other Kenworth models.

The T2000 is built using an automated assembly fixture, a robotic adhesive application system and an RFID-controlled conveyance system for assembly of the cab structure. "Design and manufacturing partnered to develop this extremely efficient assembly process," says Joe Zitzelberger, director of manufacturing development. As

a result, it takes nearly 50 percent less labor to assemble the cab-sleeper structure of a T2000, compared to the previous model.

The Chillicothe plant uses an employee-driven safety program to increase awareness and eliminate unsafe actions. A voluntary steering committee for the program is made up entirely of plant employees who set the program's goals and direction. Since the program's inception in 2001, the plant has seen a 29 percent decrease in work-related injuries and illnesses.

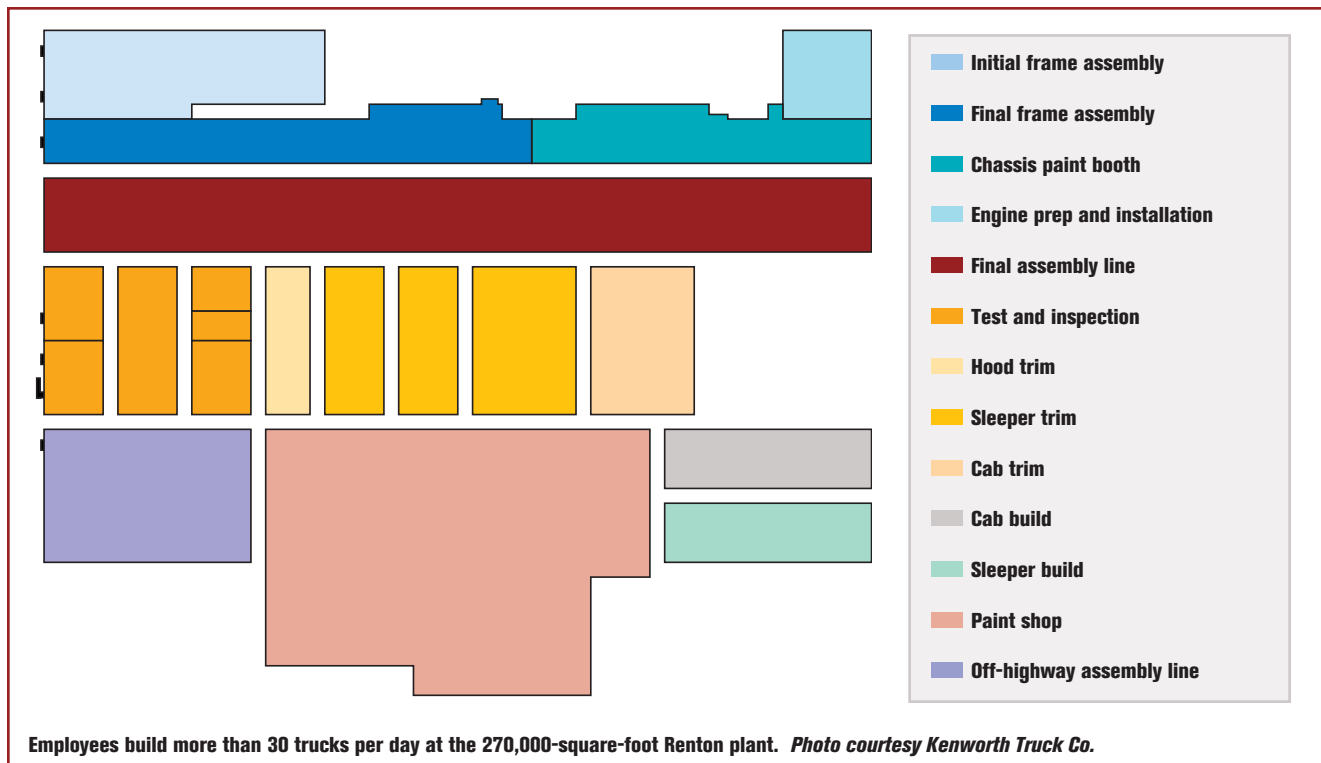
Employees also conduct quality audits on a representative sample of completed trucks, using a weighted scoring system. Evaluation results are monitored daily and corrective actions are immediately fed back to operators. Quality is validated three times annually via a product audit. During the past 3 years, there has been a 50 percent improvement in scores. At the same time, the plant has shifted its focus from "inspecting in" quality to making quality the responsibility of every employee. As a result, the number of quality assurance personnel has decreased by 33 percent.

To ensure predictable delivery to the customer, the plant introduced a new metric in 2003 that measures the time from scheduled chassis start to delivery at the transport company. Kenworth has set a target of 3 days for this turnaround. Last year, systems improvements resulted in an 18 percent reduction in warranty cost.

The plant also has implemented numerous initiatives to reduce in-house inventory and increase inventory turns. In 2003, the main warehouse was eliminated and additional docks were added as the plant moved toward one-touch material handling. Inventory turns increased by 14 percent last year.

During the past year, the Chillicothe plant has integrated Six Sigma principles. These efforts have yielded a 6 percent improvement in per truck assembly efficiency and a 46 percent reduction in per truck scrap. "While the numbers are impressive, it is truly the flexibility and dedication of the Kenworth Chillicothe workforce that has made these results possible," says Zitzelberger.

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The new facility also features a design-visualization room where engineers wear special 3D goggles to view real-sized images of trucks projected on a 16-by-20-foot screen. Engineers can rotate or flip the virtual truck, or peer at it from any angle, to test new designs and evaluate potential assembly challenges.

“Trucking is a very competitive business, so our customers demand higher reliability from our products,” says Jim Bechtold, chief engineer. “Our design engineers not only work on new products, but on ways to make existing products more productive and reliable. Engineering for reliability is a philosophy that filters down from the very top at Kenworth, to the people who actually assemble the truck.”

Earlier this year, the Federal Motor Carrier Safety Administration (Washington, DC) implemented a new hours-of-service rule that makes dependable uptime more important than ever. Under the new rules, the clock starts ticking as soon as drivers go on duty and continues counting up to 14 hours, whether they are driving or waiting at a loading dock. This puts more pressure on drivers and their equipment to make on-time deliveries.

“Truck deliveries and unloading are scheduled down to the minute, so if a driver shows up late, it costs everyone money,” says Bechtold. “That’s why running a reliable truck is so important—it helps maximize uptime and productivity, and minimize unexpected repairs.”

Custom-Built Vehicles

Kenworth prides itself on providing trucks that meet each customer’s unique



Tablet PCs are used on the plant floor to capture accurate production information and make better business decisions. Photo by Austin Weber

requirements. Every vehicle is custom-engineered, from bumper to taillight. Each truck is built any way customers want it, with multiple configurations to choose from.

“We use a production process that enables any model to be produced at any time, as opposed to a batch process,” says Zitzelberger. “Every truck coming down the assembly line is different. Customers specify many different options to meet their application. This means that the assembly teams need to be well trained and adapt to the changing assembly requirements.”

Zitzelberger claims that Kenworth offers more job-specific, factory-installed options than any other manufacturer. Customers can also select add-on features, such as pusher axles and hydraulic tanks.

Sleepers range from 38-inches to 86-inches, each equipped with numerous interior appointments and features. In addition, there is a wide variety of chrome and polish options, such as polished battery boxes, tool boxes, fuel tanks and exhaust stacks.

“Given the custom product expected by our customers, the integration of engineering and plant floor technologies is a

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Kenworth also builds trucks for demanding off-road applications such as logging (above) and oil field service (below). Photos courtesy Kenworth Truck Co.

must," says Zitzelberger. "We build 10 different truck models. The manufacturing engineering groups work closely with employees and our information technology group to identify methods that enhance plant performance."

The assembly process begins when a buyer selects features at one of 281 Kenworth dealerships in the United States. Specifications, such as the size

and brand of diesel engine, are transmitted electronically to the Renton plant, where engineers review the order. Kenworth engineers often suggest a different component, such as a specific transmission, to better suit the customer's intended use.

Once the order is approved, Kenworth suppliers, such as Caterpillar Inc. (Peoria, IL) and Cummins Inc. (Columbus, IN),



Kenworth views itself not as a truck company that uses technology, but rather as a high-technology company that builds trucks. Photo courtesy Kenworth Truck Co.

receive details of the order over an electronic network. Axles, engines, frames, radiators, seats, tires and other components are sequenced and delivered several times a week to minimize inventory.

In 2003, production lead time was 5 to 8 weeks from point of order to point of delivery. Production time is based on customer demand, current market conditions and order backlog. Each step is evaluated for non-value-added activities using Six Sigma methodologies.

One-touch material handling practices, starting with shipments from suppliers, have led to record efficiencies, such as a 13 percent reduction in material handling hours. Warehousing space within the Renton plant has been reduced by 71 percent, freeing up floor space for value-added activities. "The relationships and partnering with our suppliers are an inherent part of our success story," claims Baugh.

A material logistics planning system allows ordering by standard quantities. Use of returnable containers allows for more efficient use of trailer space and line-side part presentation.

"This is allowing more material to be delivered line-side, reducing the need for traditional warehouse space," says Baugh. "Also, extensive use of line-sequenced major components has resulted in similar inventory reductions. All of this is resulting in less warehouse stocking and increased use of satellite staging areas for fast flow movement of components from dock to point of use."

High-Tech Tools

Information technology plays a significant role in the assembly process at Renton. For instance, conventional build paper has been computerized into a chassis image. The chassis image system is a user-friendly application with computer stations strategically located along the assembly line. Operators run a daily build query that provides them with specific parts for their specific area of assembly.

Assemblers frequently access electronic engineering diagrams and bills of material. "By eliminating the need to

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sort through multiple pages of build paper, the opportunity to install the wrong part or miss a required part is lessened," says Baugh. "This online version provides more time for employees to concentrate on the quality of their work."

In July, Kenworth unveiled another new shop floor software program, in conjunction with Microsoft Corp. (Redmond, WA). This Web-based tool serves as an online encyclopedia of information on every truck assembly task with a click

of a button. Employees can click on a button and find out the specifics of their job or a specific task.

The Web-based tools work together to enable production staff and management to monitor work-in-process in the plant. They also allow inspectors to capture information on the assembly line where they can resolve problems prior to the completion of the manufacturing process.

A series of "quality gates" are located throughout the Renton plant. Mechanical quality is checked on the main line, just before the cab is attached to the chassis; at the cab trim exit; and at the end of the main assembly line. Paint quality is checked on the main paint line, just before the cab is released to the trim line.

"By creating a real-time production database with our systems, we are able to prioritize efforts through trend analysis and make faster quality advancements," claims Zitzelberger. He says the software application has dramatically improved the way engineers interact and communicate with operators on the plant floor.

"Benefits include easy access and the ease of adding useful information, such as posting content, in a structured manner," adds Stevens. "There is a greater willingness to share lessons learned and training documentation by a wider audience due to the user friendliness of the software."

On the plant floor, assemblers, quality improvement technicians, material coordinators and line managers are



Since the Renton plant opened in 1993, it has built more than 80,000 heavy-duty trucks. Photo courtesy Kenworth Truck Co.

using tablet PCs. The devices are more commonly used in the health care and insurance industries, but they have numerous benefits on the plant floor. They give users the ability to write directly on a portable, handheld screen with an electronic stylus.

Tablet PCs allow Kenworth to capture more accurate information in a



An assembler installs a wiring harness in the cab of a Kenworth truck. Many vehicles are equipped with state-of-the-art tools, such as navigation systems, satellite radio, collision avoidance warning systems, night vision and stability control braking systems, making assembly and testing more complex. Photo by Austin Weber

real-time environment. "Having accurate information faster, whether it is quality information like mil thickness on a painted surface, or part delivery, we make faster business decisions every day," says Stevens.

New Production Tools

Kenworth engineers constantly search for new ways to increase productivity and improve customer satisfaction. "By implementing key capital investments in produc-

tion technology and computerized applications on the production floor, we are better able to focus resources where they add the best value," explains Zitzelberger.

Over the past few years, an extensive effort has been undertaken to record torque control throughout the Renton plant, which uses hundreds of threaded fasteners to build trucks. Substantial investments have been made in direct current tooling on critical fastening applications at the plant. All tools have been networked with a program so that run-down information can be accessed, torque values trended, and predictive maintenance performed as required. This application allows manufacturing engineers to electronically monitor and report on all DC tools within the plant.

"The DC tools provide superior torque control over traditional air-powered assembly tools," claims Stevens. "The technology allows us to control torque at Six Sigma levels or higher. This investment has also allowed us to use different fastening strategies to ensure not only that the correct torque is applied to a given fastener, but also the correct clamp load, which ultimately is what is important."

The electronic controls also enable error proofing. The tools automatically adjust themselves, based on specific chassis configurations.

Kenworth has installed DC electric tools throughout the Renton plant, most notably in the motor department where most of the drivetrain components are

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Because of the large size and unique requirements of off-road trucks, the Renton plant builds them in a dedicated area of the factory. Photo courtesy Kenworth Truck Co.

installed. “The most expensive portion of a truck is the drivetrain,” notes Bechtold. “Technology is applied to these assembly processes to ensure that these critical components are assembled accurately to the supplier-prescribed torque specifications.

“Applying technology to ensure accuracy of our critical assembly processes has further enhanced our product quality,” adds Bechtold. “The DC tools produce an extremely high and reliable CpK to eliminate the need to inspect for correct torque values. They have improved our control of clamp load on mechanically fastened joints.”

The Renton plant has also been applying technology to streamline the flow of material to the assembly line. “The goal of our supply chain management effort is to continuously improve material availability for truck assembly through a pull system,” says Baugh.

Earlier this year, the plant began testing the use of radio frequency identification (RFID) technology. “It will enable us to quickly receive and locate parts throughout the production line and produce cost savings through dunnage reduction,” explains Baugh. The technology is currently used for product tracking and power-and-free conveyor management in the paint shop.

“RFID reduces the retrieval time of parts being painted,” adds Baugh. “It has proven to be more reliable than the optical-based sensor system it replaced.”

In addition, the Renton plant recently installed robots in the base and clear coat booths, which are used to automatically paint cabs, hoods and sleepers. The technology has improved the quality of the paint jobs and the cycle times. “This will pave

the way for increased throughput,” says Baugh.

People Power

Even with state-of-the-art technology, Kenworth relies heavily on people to ensure the quality and value of its products. “The employees of the Renton plant take great pride in the products they deliver to the market,” says Baugh. “Maintaining our leadership position in the industry drives us to continually decrease waste, as well as constantly evaluate ourselves to improve our in-plant processes.

“Although much of our marketing, sales and design engineering efforts are done at a separate location, the employees at the Renton plant are well integrated into all aspects of Kenworth’s business,” adds Baugh.

Six Sigma has been fully implemented at the plant as both a problem-solving methodology and a business strategy. The Six Sigma methodology is applied to production processes, quality control, new product introductions and transactional processes.

“Employees with demonstrated problem-resolution abilities from a diversity of backgrounds are trained in the theory and application of Six Sigma methodology as either black belts or green belts,” says Baugh. “They then



No matter what they haul, all truck operators are faced with the same challenges, such as rising fuel prices and driver retention. To address these issues, Kenworth engineers are constantly searching for new innovations that help customers gain life-cycle cost advantages. Photo courtesy Kenworth Truck Co.

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Every Kenworth vehicle is custom-engineered, from bumper to taillight, to meet customers' unique requirements. *Photo courtesy Kenworth Truck Co.*

lead cross-functional teams to resolve issues and continuously improve the facility's operations."

Kaizen events are another continuous improvement process for the facility. According to Baugh, these events, which focus on using a cross-section of employees, have eliminated non-value-added activities and generated significant savings by reducing inventory, scrap and dunnage, as well as relocating



The Renton plant has quality gates set up in strategic locations, such as at the exit of the paint shop oven. *Photo by Austin Weber*

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parts for easier access and reduced walking distances.

"The management team makes a conscious effort to ensure the workplace is a place where our employees want to come to work," adds Baugh. "Safety, communication, quality and increased productivity are the major focus areas."

Although the State of Washington has some of the country's most stringent ergonomic standards, the Renton plant has taken a proactive approach to addressing this challenge on the assembly line. In fact, last year, the facility received an Ergonomics in Action award from the Washington State Department of Labor and Industry for reducing hazards in material handling and production operations.

Assemblers use a wide variety of fixtures, tools and material-handling devices to eliminate fatigue and improve the work environment. For instance:

- A tilt fixture allows operators to easily manipulate the entire cab for ergonomic installation of rooftop-mounted components, such as lights, horns and antennas.

- A seat lift device uses an air-powered balancer to provide a weightless feel when transferring seats from the



Each truck on the Renton assembly line is different than the next. *Photo courtesy Kenworth Truck Co.*

returnable rack into the cab for mounting.

- An air cleaner lift device uses an electric-powered balancer to provide a weightless feel to the parts when they are being inserted onto the cab.

- Suspended torque tools use air balancers to provide a weightless feel to the tools, which reduces assembler fatigue and repetitive stress injuries.

"Our strategic long-term goals focus on breakthrough performance in quality, safety and performance metrics," concludes Baugh. "We continue to move forward with an aggressive plan to increase the use of technology to make the assembler's job easier, faster and safer. To maximize profits and improve productivity, the management team strategically submits capital funding and operating budget requests to focus project management on eliminating waste, improving plant efficiencies, reducing truck hours, improving quality and ensuring a safe work environment." **A**



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