ptc®

HOW ENGINEERING CAN BE YOUR QUALITY GAME-CHANGER

ENGINEERING: GROUND ZERO FOR QUALITY AND BUSINESS RISK

Most quality failures don't start on the factory floor. They start earlier, often with small engineering decisions that seem minor at the time but compound as products move from design into manufacturing and, ultimately, the field.

An overlooked requirement or an unvalidated design assumption can quietly introduce risk. Left undetected, those issues surface later as production disruptions, service incidents, or customer failures, when they are far more expensive and far more visible.

Quality is a business driver that directly impacts cost, speed to market, and customer satisfaction. When issues originate in engineering, they don't stay contained; they delay launches, increase costs, and put customer outcomes at risk. The most effective place to control those outcomes is upstream, where products are defined, validated, and engineered.

THE REAL COST OF QUALITY

Quality directly affects three outcomes industrial leaders care most about: **cost control, speed to market, and customer trust**. Competition amplifies the stakes. Industrial buyers have more options than they did even a few years ago, and quality failures make switching easier. When quality breaks down, the impact rarely stays contained. It multiplies across the business.

A well-established principle in quality management, known as the 1-10-100 rule, illustrates this clearly. A defect identified during engineering may take only hours to correct. If that same issue reaches manufacturing, costs increase roughly tenfold due to scrap, rework, and production disruption. When defects escape to the field, costs can be 100 times higher, driven by service interventions, replacement parts, customer downtime, and reputation damage.

Quality-related issues, including rework, scrap, warranty claims, and recalls, are estimated to account for 15–20% of annual sales revenue for many manufacturers.

For producers of mission-critical industrial equipment, the stakes are higher still. Unplanned downtime can cost upwards of a million dollars hourly, depending on the application. At that scale, a single escaped defect can outweigh the cost of entire engineering programs.

Quality also influences speed. Late-stage defects delay launches, force reactive changes, and inject instability into supply chains. Organizations that engineer quality upstream move faster, not because they cut corners but because they prevent last-minute surprises.

Most importantly, quality underpins trust. Industrial customers expect products that perform reliably, meet requirements, and hold up in real-world conditions. Once that trust erodes, it is difficult to regain. Engineering teams are best positioned to prevent that outcome by designing quality in from the start instead of trying to inspect defects out later.

WHY ENGINEERING STILL MISSES CRITICAL QUALITY ISSUES

Most industrial leaders already recognize that quality issues originate in engineering. What's missing is a scalable, upstream way to stop them.

Today's environments remain disconnected. Engineering, manufacturing, quality, and service teams often rely on fragmented systems, leading to siloed data, limited traceability, and weak feedback loops. Validation practices vary widely, and lessons learned in service rarely make it back into future designs.

The problem is widespread. 93% of manufacturers report having critical data trapped in siloed systems (Frost & Sullivan), making it difficult to connect requirements, designs, test results, and field performance in meaningful ways.

Traditional quality approaches, such as manual audits, downstream inspections, and reactive corrective actions, cannot keep pace with the complexity of today's products. Organizations understand where failures originate, but struggle to implement prevention at scale.

THE SOLUTIONS THAT TRANSFORM ENGINEERING-LED QUALITY

UNIFIED, CENTRALIZED DATA REPOSITORY

Engineering-driven quality starts with a single, authoritative source of product truth. When product data is traceable across the lifecycle, from design through enterprise systems, manufacturing, supply chain, and quality, teams can identify risk earlier and prevent problems before they propagate.

In practice, product definitions, structures, and configurations stop living in separate places. This is the foundation of an Integrated Product Engineering (IPE) approach, where mechanical, electrical, and software design data stay connected in a single, governed thread. Design intent flows into accurate, lifecycle-managed bills of material, simplifying change and configuration control. Rule-based configuration further reduces the risk of variant errors that undermine quality.

Quality processes are embedded directly into this foundation. Failure Mode and Effects Analysis (FMEA), corrective and preventive actions (CAPA), nonconformances, deviations, waivers, and root cause analyses are centrally stored and linked to engineering bills of material and process plans. When requirements or nonconformances change, those relationships remain intact, supporting faster resolution, fewer escapes, and higher first-pass yields.

Model-based practices further strengthen this foundation. Fully annotated 3D models are reused downstream, preserving design intent and reducing interpretation errors. Design changes automatically flow across dependent teams, minimizing rework and late-stage surprises.

FULL PRODUCT AND REQUIREMENTS TRACEABILITY

Modern products span mechanical, electronic, and software domains, and quality depends on keeping them aligned. Unified, end-to-end traceability links requirements to designs, tests, changes, and compliance artifacts throughout the lifecycle—connecting customer and regulatory requirements directly to engineering decisions and verification outcomes.

This visibility allows teams to understand risk and change impact earlier, before issues reach manufacturing or the field. Mapping requirements to test coverage and design dependencies reduces rework and supports audit-ready compliance for regulated environments. Core quality workflows, like failure analysis, CAPA, and root-cause analysis, stay directly connected to requirements and changes, making quality oversight continuous rather than episodic.

AI further strengthens requirements and traceability by reducing manual effort and improving clarity early in the lifecycle. Intelligent assistance can help accelerate requirements authoring, automatically generate test cases from requirements, and flag ambiguous or inconsistent language that often leads to downstream defects. By improving the quality of requirements and test coverage upfront, teams reduce rework, close gaps earlier, and maintain stronger alignment between engineering intent, verification results, and compliance evidence as products evolve.

Systematic product line engineering further supports this approach, allowing organizations to manage variation across families of products without sacrificing consistency or quality.

SIMULATION-DRIVEN DESIGN AND VALIDATION

Thanks to simulation, validation no longer has to wait until the end of development. By applying simulation throughout development, not just at final verification, teams can identify structural, thermal, and performance issues earlier, when changes are less costly and more effective. This continuous approach reduces late-stage surprises and downstream corrections.

Generative design expands these capabilities and empowers engineers to explore alternatives informed by real constraints, materials, and manufacturing processes. AI-assisted optimization helps surface higher-quality, lighter, and more reliable designs before physical prototypes or production runs begin.

Quality improves earlier. And development moves forward with fewer corrections.

CONNECTED SERVICE DIGITAL THREAD

Quality does not end at product launch. Real-world performance data offers some of the most valuable insight for continuous improvement.

A connected service digital thread feeds field data—including failures, operating conditions, and service history—back into engineering. Engineers can analyze how products behave in practice and address design issues that traditional testing may miss.

Service teams also benefit directly. Technicians gain access to current design revisions, 3D models, tolerances, and specifications alongside asset history and maintenance context. This reduces guesswork and supports more accurate repairs.

The result is faster resolution, higher first-time fix rates, improved uptime, and stronger customer trust.

AI-enabled service tools extend this further into day-to-day execution. Conversational interfaces allow technicians to quickly access asset information, work instructions, and service history in context without navigating complex systems. This reduces cognitive load in the field, improves repair accuracy, and shortens time-to-resolution while ensuring service actions stay aligned with engineering intent.

THE TECHNOLOGIES THAT DEFINE ENGINEERING QUALITY

Engineering-led quality depends on a small set of technologies that connect data, enforce traceability, and establish a strong product data foundation across the lifecycle.

- **PRODUCT LIFECYCLE MANAGEMENT (PLM)**
  for managing product structures, configurations, and change across mechanical, electrical, electronic, and software domains
- **APPLICATION LIFECYCLE MANAGEMENT (ALM)**
  for governing requirements, risk, testing, and compliance
- **QUALITY MANAGEMENT SYSTEMS (QMS)**
  integrated directly into engineering workflows
- **COMPUTER-AIDED DESIGN (CAD) AND SIMULATION TECHNOLOGIES**
  for early validation and optimization
- **SERVICE LIFECYCLE MANAGEMENT (SLM) PLATFORMS**
  that close the loop between field performance and design
- **AI CAPABILITIES APPLIED ACROSS THE LIFECYCLE**
  to reduce part duplication and data inconsistency, improve requirements authoring and test quality, surface risk earlier, and support more effective service execution in the field

This is the foundation of PTC's **Intelligent Product Lifecycle:** a closed-loop system powered by structured product data, where information flows across disciplines and decisions improve over time. AI supports this lifecycle by helping teams interpret data, spot risks earlier, and prevent issues rather than chasing them.

Engineering-led quality is not a standalone initiative. It is a core pillar of an intelligent, data-driven lifecycle strategy. When engineering, quality, manufacturing, and service share a unified digital foundation, quality becomes continuous rather than reactive.

HOW MANUFACTURING LEADERS ARE ENGINEERING QUALITY AT SCALE

Leading manufacturers are already applying engineering-driven quality principles to achieve measurable business outcomes—improving traceability, reducing rework, accelerating development, and lowering total cost of ownership.

- **AT VOLVO CONSTRUCTION EQUIPMENT (VOLVO CE)**, quality and traceability improvements started with connecting engineering data across previously siloed systems. By establishing a unified, product-centric digital foundation, Volvo CE improved cross-functional consistency and reduced late-stage issues tied to manual data handling and disconnected product structures.

  Outcome highlights include up to a 30% reduction in the cost of poor quality and up to a 40% reduction in duplicate parts, alongside improved collaboration across global teams and faster response to engineering changes.

  LEARN HOW VOLVO CE ESTABLISHED A LIFECYCLE-WIDE DIGITAL THREAD — **Learn How**

- **NIDEC GLOBAL APPLIANCE** leveraged integrated product development processes to improve quality while significantly accelerating time-to-market. By embedding quality earlier in engineering workflows and standardizing product data and change management across global teams, Nidec reduced development friction across thousands of product configurations.

  Measured results included a 48% reduction in time-to-market, a 40% decrease in costs related to non-quality, and a 284% increase in the number of large engineering projects delivered.

  SEE HOW NIDEC SCALES QUALITY WITHOUT SLOWING INNOVATION — **See How**

- **VAILLANT GROUP** enhanced product reliability by improving cross-functional collaboration and end-to-end lifecycle traceability. By replacing manual, spreadsheet-driven change processes with connected engineering workflows, Vaillant improved visibility into product maturity, requirements, and changes across teams.

  Documented outcomes include a 53% improvement in first-pass sample approval, a 28% faster engineering change implementation cycle, and a 16% reduction in rework, directly supporting higher quality and faster delivery.

  EXPLORE HOW VAILLANT IMPROVED QUALITY THROUGH LIFECYCLE TRACEABILITY — **Explore How**

Leading manufacturers are already applying engineering-driven quality principles to achieve measurable business outcomes—improving traceability, reducing rework, accelerating development, and lowering total cost of ownership.

- **WELBILT** reduced total cost of ownership and improved product quality by standardizing and scaling engineering processes across highly configurable product variants. By improving bill of material accuracy and change consistency across brands, Welbilt enabled mass customization without the quality and cost penalties typically associated with complexity.

Results included a 30% improvement in engineering change efficiency and a 30% increase in BOM and design accuracy, contributing to lower downstream costs and fewer production-related quality issues.

LEARN HOW WELBILT SCALES CUSTOMIZATION WHILE LOWERING TCO

Learn How

In practice, the impact shows up as engineering-driven quality delivering tangible, measurable impact when applied at scale: reducing risk, improving execution, and enabling organizations to grow complexity without sacrificing reliability.

MAKE ENGINEERING YOUR QUALITY ADVANTAGE

Quality is no longer something to inspect at the end of the process. It must be engineered from the start.

By unifying product data, strengthening traceability, validating designs earlier, connecting field feedback, and applying AI intelligently, engineering teams can become the primary drivers of quality, cost control, and customer trust.

Next steps:

- Speak with a quality and engineering expert to explore how engineering-led quality fits into your broader product lifecycle strategy.
- Subscribe to the industrials newsletter to stay informed on best practices and real-world success stories.

Need more information?

1146184 [E-book] How Engineering can be your Quality Game-Changer