RECENT J. (2026), 79:022-029
https://doi.org/10.31926/RECENT.2026.79.022

# How to Certify a Defence Contractor According DIN 2303 Requirements

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**Abstract**
The article is reviewing the necessary developments regarding certification and quality assurance activities within armour steel welded products. The commitment to the standards and especially to DIN 2303 is underlined. As stipulated in welding standards for every armour welded product, quality requirements must be compass before manufacturing defence products on a regular basis. The quality system validation and the manufacturing system compliance to the standards, third party, customer and/or authorities must be certified. The quality system must be assessed starting with ISO 9001 and following ISO 3834 standard series requirements and followed by the specific requirements underlined within DIN 2303. The results of these analyses emphasize the importance of the quality management system certification by a third party. A certified system is supporting the success of defence product development and manufacturing. These are highlighting the company professionalism and will increases the company's competitiveness and profitability. These conclusions could be a starting point for companies in strengthening their management to drive product innovation and business growth. The general pattern from the idea to the certification itself is based on knowing and implementing the standard requirements according to ISO 9000, ISO 9001, ISO 19011, ISO 3834 series, EN 1090 series and DIN 2303. The purpose of this article does not consist in building an exhaustive list of standards but a pattern of milestones to be followed and passed to reach the quality management system certification. Many other standards and specific documents are involved in the certification process endeavour in accordance with the company portfolio.

**Keywords**
defence; welding; armour; EN 3834; DIN 2303

## 1. Introduction

Increasing of defence domain nowadays it is involving more investments in companies and people. International and national companies are investing more and more in defence area due to international situation. Europe, NATO and Romanian government are investing in national and international defence contractors to fulfil the actual market demands. The development of armoured vehicles specifically among defence industry products, heavily depends on advancements in armour materials and welding technologies. Companies' objectives must be aligned with the market demands and within the company the objectives are assumed by each department. In this article the focus will be placed on quality management system and especially on welding process as detailed in Figure 1.

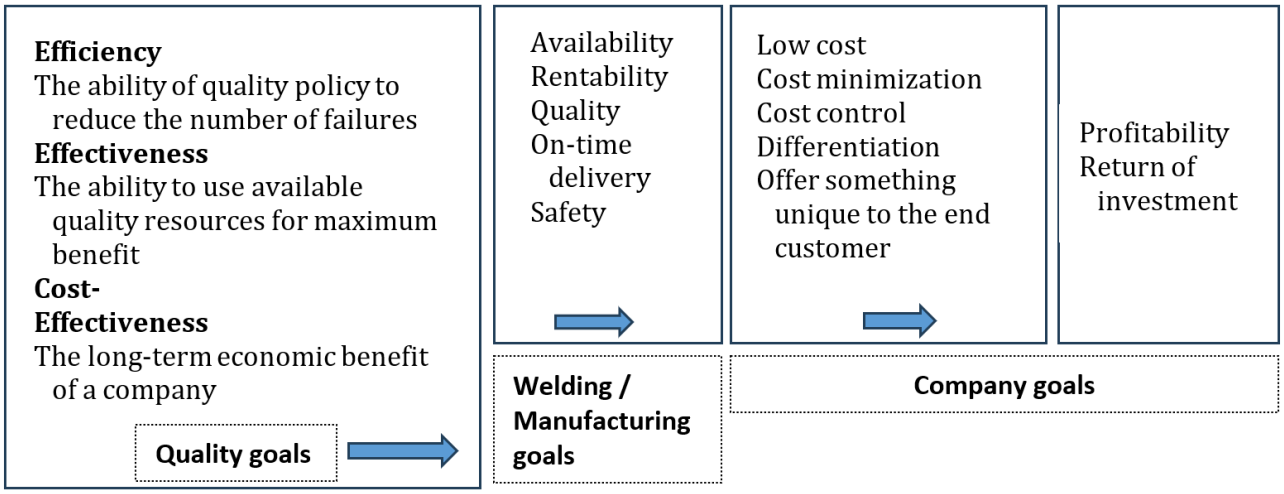


Fig. 1. Connection between quality and profitability [1]

## 2. Quality Management System Upgrade

This paper it is providing guidance through the certification process based on requirements and recommendations described within specific standards. If applied appropriately, provides confidence in the manufacturer company capability to deliver products that conform to customer contract requirements. Additional requirements apply to NATO contracts, e.g. as specified in AQAP-2110 NATO.

ISO 3834-2 standard is pointing the supplier company to the standard requirements but is also underlining the importance of the contract between customer and supplier. When referenced in a contract, AQAP-2110 NATO shall apply to all the processes necessary for the supplier to fulfil the contractual requirements [2].

Acquirer governmental and/or NATO organisations, enter into a contractual relationship with a supplier company, defining the product and quality requirements and supplier organisation acts in a contract as the provider of products to the acquirer or customer [2].

The quality management system it's setting the relations and the interactions between the elements of an organization to establish policies, objectives and processes to achieve the company objectives as presented in Figure 2.

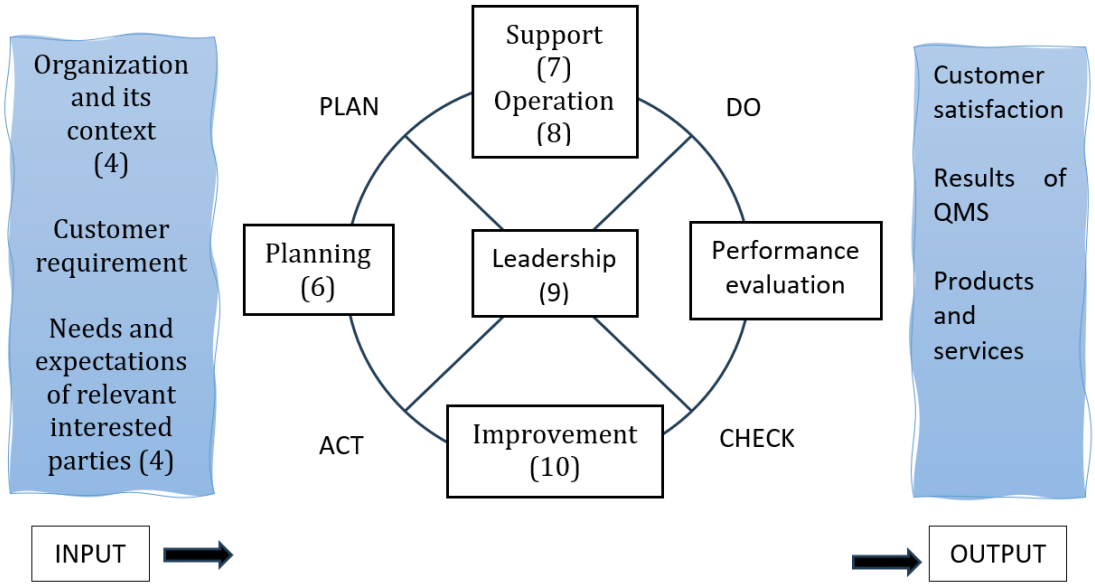


Fig. 2. QMS structure in accordance with PDCA cycle [3, 4]

Note:

- A management system can address a single discipline or several disciplines, e.g. quality management.
- The management system elements establish the organization's structure, roles and responsibilities, planning, operation, policies, practices, rules, beliefs, objectives and processes to achieve the company strategical objectives.
- The scope of a management system can include the whole of the organization, specific and identified functions of the organization, specific and identified sections of the organization, or one or more functions across a group of organizations [5].

In Figure 3 is presented a typical audit process, starting with information collection process until it's ending by drawing the conclusions and the audit report.

During information review, the auditors should decide whether the available data provides sufficient objective evidence to demonstrate that requirements are being met, such as being:

a) complete (all necessary content is covered by the documented information);
b) correct (the information is in accordance with applicable standards and regulations);
c) consistent (the documented information is consistent in itself and with related documents);
d) current (the available data are up to date) [5].

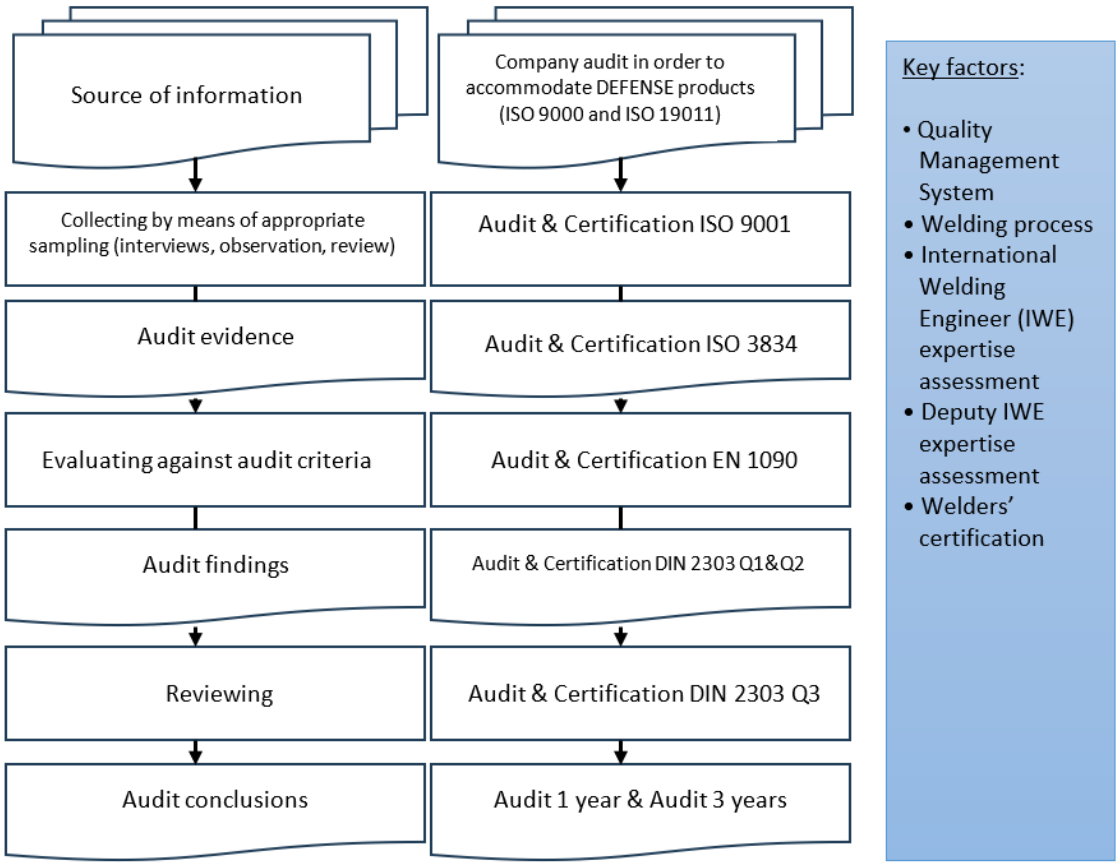


Fig. 3. Overview of a typical process of collecting and verifying information [6]

## 3. Welding Process Approach

### 3.1. ISO 3834 Series Summary

Having the foundation of the manufacturing company QMS set with ISO 9001 implemented and following ISO 9000 and ISO 19011 guidance, the company can move forward and closer to the objective.

The next step should be the analysis of ISO 3834 series requirements and acting for implementation. Military products must meet high quality standards in production and maintenance because of the static and dynamic loads to which they are subjected, their range of operation, the increased safety requirements placed on such products, and the substantial need for reliability. As defined by these standards, welding, brazing and thermal spraying are considered to be special processes. The quality requirements of the products cannot sufficiently be proved later. The ISO 3834 series is to be applied to the above-mentioned processes by analogy.

ISO 3834 series define the complete quality requirements for fusion welding of metallic materials in both workshops and on assembly sites and is presented in Table 1.

Table 1. EN 3834 standard series [7, 8]

| Standard | Definition | Part | Details |
|---|---|---|---|
| ISO 3834-1 | Quality requirements for fusion welding of metallic materials | Part 1 | Criteria for the selection of the appropriate level of quality requirements |
| ISO 3834-2 | | Part 2 | Comprehensive quality requirements |
| ISO 3834-3 | | Part 3 | Standard quality requirements |
| ISO 3834-4 | | Part 4 | Elementary quality requirements |
| ISO 3834-5 | | Part 5 | Documents with which it is necessary to conform to claim conformity to the quality requirements of ISO 3834-2, ISO 3834-3 or ISO 3834-4 |
| ISO 3834-6 | | Part 6 | Guidelines on implementing the ISO 3834 series |

ISO 3834-2 chapter 5 is requesting the manufacturer to analyse the contract requirements. The manufacturer shall review the contract requirements and any other requirements, together with any technical data provided by the purchaser or internal data when the construction is designed by the manufacturer [8]. The manufacturer shall determine that all information necessary to perform the manufacturing operations is complete and available before work begins. The manufacturer shall confirm its capability to meet all requirements and ensure adequate planning of all quality-related activities. The requirements review is conducted by the manufacturer to verify that the scope of work is within its capability to perform, that sufficient resources are available to meet delivery deadlines, and that the documentation is clear and unambiguous. The manufacturer shall ensure that any differences between the contract and previous bid data are identified, and that the purchaser is informed of any resulting changes in schedule, cost, or technical conditions.

The manufacturing company decision will be to choose which standards and to what extent will apply for achieving the right certification appropriate for fulfilling the business objectives.

### 3.2. EN 1090 Series Summary

Hereafter EN 1090-2 study and implementation will follow for business competences extent and capabilities validation. EN 1090-2 is part of EN1090 series which is presented in Table 2.

Table 2. EN 1090 standard series [7, 9]

| Standard | Name | Part | Details |
|---|---|---|---|
| EN 1090 | Execution of steel structures and aluminium structures | 1 | Requirements for conformity assessment for structural components |
| EN 1090 | | 2 | Technical requirements for the execution of steel structures |
| EN 1090 | | 3 | Technical requirements for the execution of aluminium structures |

EN 1090-2 specifies requirements for execution of steel structures, to ensure appropriate levels of mechanical resistance and stability, serviceability and durability. Following this standard is implicating the fact that the work is carried out with the necessary skill and adequate equipment and resources to perform the work in accordance with the execution specification and the requirements of this European standard [9]. Once more the manufacture has to decide which standards and to what extent are recommended for his business certification.

### 3.3. DIN 2303 Summary

Welding according to DIN 2303 is a requirement of the German Armed Forces. The quality of welding processes is paramount, particularly in safety-critical areas such as defence technology. Since the quality of weld seams cannot be improved retrospectively, it must be guaranteed during the production process, necessitating strict standards. Additionally, the quality of a welded product cannot be sufficiently determined non-destructively during the process.

DIN 2303 outlines the requirements for manufacturing and repair companies engaged in welding work on defence technology products. This standard specifies minimum requirements for quality assurance systems and describes a method of qualifying manufacturers of military products. It does not apply to commercially available products that can be used in both civilian a military application without significant modifications being made [10, 11].

DIN 2303 classifies companies into four manufacturer qualification classes based on material and safety requirements. These classifications depend on the type of product, the materials used, and any specific additional requirements as shown in Table 3.

Each classification comes with corresponding quality standards that must be met. Focus on this article will be on class Q3:

- Class Q1, Q2, Q4: see details in DIN 2303
- Class Q3 applies to companies that process armouring materials that must comply with the specifications of the Bundeswehr Technical Delivery Conditions.

Table 3. Classes and requirements [10, 11]

| Class of manufacturer qualifications | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| Requirements depending on the type of defence technology product | General requirements | Special requirements | Armour function | Airworthiness |
| Inclusion of | - | Class Q1 | Class Q1 | - |
| Additional specific requirements | - | VG95105<br>BV1050 | TL 2350-0003<br>TL 2350-0008 | Aviation standards of the series<br>DIN 29…<br>DIN 65… |
| Quality requirements to be fulfilled | ISO 3834<br>Quality requirements for fusion welding of metallic materials | | | |
| | ISO 3834-3<br>Standard quality requirements | ISO 3834-2<br>Comprehensive quality requirements | | |

DIN 2303 classifies defence components into four classes according to their function and type of stress. The requirements for load-bearing capacity, safety and usability vary depending on the component class.

Simplified description of the component classes is presented in Table 4:

- Component class 1: This class includes defence technology products with high stresses and high safety significance, etc. It requires the most stringent quality control and material requirements;
- Component class 2, 3, 4: for details see DIN 2303.

Table 4. Component classes [10, 11]

| Component class | Technical details |
|---|---|
| BK1 | Applies to the manufacture of defence technology products or their individual components with high static or dynamic loads and high safety significance and/or high operational capability |
| BK2, BK3, BK4 | ...for details see DIN 2303 |

The manufacturer qualification of class Q3, in accordance with DIN 2303 is specifically intended for companies that manufacture components with armouring functions. These products must meet the highest safety standards, as they are exposed to unique threats in the military sector, including ballistic threats and explosives. Qualification for this class requires compliance with specific regulations, in particular the technical delivery conditions (TL 2350-0003 and TL 2350-0008). TL 2350-0003 outlines the specifications for the design, manufacture and testing (approval) of enclosures with armouring functions. This regulation specifies detailed technical requirements to ensure that the manufactured components provide the required protection in use [10, 11].

A special process test, which verifies the welding process, includes the production of three basic blast bodies. These must be manufactured by the company in accordance with the requirements of TL 2350-0003. The test pieces are then tested by the Weapons and Ammunition Technical Centre (WTD 91) to assess the weld seam quality. Only after successful testing can the company obtain approval to manufacture armour components. Components with an armouring function are generally assigned to the highest component class 1. This means that they are subject to high stresses and are of the utmost importance in terms of safety. The quality requirements and the necessary testing and approval procedures for manufacturers in this class are correspondingly strict. The “third party” play a central role in the approval process for manufacturers in accordance with DIN 2303. Their primary task is to ensure that companies meet the necessary quality and process requirements before receiving manufacturer approval [10, 11].

The requirements for qualified welding supervisors are also derived from the component classes. For instance, high component class 1 components require a welding engineer in accordance with DVS-IIW/EWF 1173 for welding supervision to ensure professional processing and quality assurance. If the welding engineer profile has to be analysed, it can be used ISO 14731.

Table 5 it's built based on the consideration mentioned along this paper until now (Q level, BK level, process type):

Table 5. Application field

| | | | | | |
|---|---|---|---|---|---|
| DIN 2303, Q1 | | Component class BK1 | ● | | |
| DIN 2303, Q2 | | Component class BK2 | | Welding | ● |
| DIN 2303, Q3 | ● | Component class BK3 | | Brazing | |
| DIN 2303, Q4 | | Component class BK4 | | Thermal spraying | |

### 3.4. Welding Materials Summary

To facilitate the understanding of having the right manufacturing system and the appropriate materials for manufacturing armour products in this paper are summarized information regarding defence specific filler and base metals (some examples existing on the market).

a) Filler material - Union X 90 – Bohler welding by Voestalpine – characteristics are presented in Table 6 and Table 7.

Table 6. Chemical composition of Union X90 – typical analysis [12]

| Filler Metal | C [%] | Si [%] | Mn [%] | Cr [%] | Ni [%] | Mo [%] |
|---|---|---|---|---|---|---|
| Union X90 | 0.10 | 0.80 | 1.80 | 0.35 | 2.25 | 0.60 |

Table 7. Mechanical properties of all weld metal – typical values (min. values) [12]

| Filler Metal | Condition | Yield strength $R_{p0.2}$ | Tensile strength $R_m$ | Elongation A ($L_0$=5$d_0$) | Impact energy ISO-V KV J | | Shielding gas |
|---|---|---|---|---|---|---|---|
| | | MPa | MPa | % | 20$^0$C | -60$^0$C | |
| Union X90 | u | 915 (≥890) | 960 (≥940-1180) | 20 (≥15) | 130 | ≥47 | M21 |
| | u untreated, as welded | | | | | | |

GMAW low-alloyed solid wire electrode – G 89 6 M21 Mn4Ni2CrMo, high strength, for joining of quenched & tempered and thermomechanical rolled fine-grained structural steels with yield strength of 890 MPa. Due to the micro-alloying concept, the weld metal is outstandingly tough with high-strength and good resistance to cold cracking at low temperatures when deposited with gas mixture. Used in crane and vehicle constructions for base metals as: S890Q, S890QL, S890QL1, S890MC.

b) Filler metal - Thermanit X – characteristics are presented in Table 8 and Table 9.

Table 8. Chemical composition of Thermanit X – typical analysis [13]

| Filler Metal | C [%] | Si [%] | Mn [%] | Cr [%] | Ni [%] |
|---|---|---|---|---|---|
| Thermanit X | 0.08 | 0.8 | 7.0 | 19 | 9.0 |

Table 9. Mechanical properties of all weld metal – typical values (min. values) [13]

| Filler Metal | Condition | Yield strength $R_{p0.2}$ | Tensile strength $R_m$ | Elongation A ($L_0$=5$d_0$) | Impact energy ISO-V KV J | |
|---|---|---|---|---|---|---|
| Thermanit X | | MPa | MPa | % | -60$^0$C | -110$^0$C |
| | u | 430 (≥370) | 640 (≥600) | 42 (≥35) | 60 (≥47) | (≥32) |
| | U untreated, as-welded – shielding gas Ar + 2.5% $CO_2$ | | | | | |

High-alloyed solid wire of G 18 8 Mn / ER307 (mod.) type for: dissimilar joints, armour plates, high

carbon and quenched and tempered steels, for joint welding of unalloyed / low-alloyed or Cr steels with high-alloyed Cr and CrNi-steels; welding of austenitic high manganese steels and with other steels etc.

c) Base metal - Armox® 500T (from SSAB) – characteristics are presented in Table 10 and Table 11. Benefits: 500 HBW hardness; for use in vehicles and buildings; superior workshop properties; hardness/toughness balance; combined penetration and blast protection.

Table 10. Chemical composition – typical analysis [14]

| Base Metal | C [max, %] | Si [max, %] | Mn [max, %] | P [max, %] | S [max, %] | Cr [max, %] | Ni [max, %] | Mo [max, %] | B [max, %] |
|---|---|---|---|---|---|---|---|---|---|
| Armox® 500T | 0.32 | 0.40 | 1.20 | 0.010 | 0.003 | 1.0 | 1.80 | 0.70 | 0.005 |

Table 11. Mechanical properties – typical values (min. values) [14]

| Base Metal | Thickness [mm] | Hardness [HBW] | Yield strength $R_{p0.2}$ [min MPa] | Tensile strength $R_m$ [min MPa] | Elongation $A_5$ [min %] | Impact energy ISO-V 10×10 [KV J] |
|---|---|---|---|---|---|---|
| Armox® 500T | 3.0 – 80.0 | 480– 540 | 1250 | 1450 - 1800 | 8 | 32 / - 40$^0$C |
| | 80.1 – 130.0 | 470 - 540 | 1200 | 1450 - 1800 | - | 20 / - 40$^0$C |

Armour steel belongs to the ultra-high tensile strength and hardness group of steels. The welding of armour steel is complicated due to the high percentage of carbon content in the base metal and the presence of faults in the form of cracks and pores in the weld metal zone, whereby fractures may be initiated in the weld metal. Austenitic filler material is traditionally used for armour steel welding because of hydrogen dilution improved in an austenitic phase. For heavy structural engineering, such as armoured military vehicles frequently being under the effects of impact and variable loads, mechanical properties of welded joints and the weld metal zone must be known. Due to variable loads, cracks created in the weld metal may easily propagate towards the sensitive fusion line, followed by their possible rapid growth [15].

Following step by step the recommendations and the requirements specified in the appropriate standards, the manufacturer company can achieve the right certification in armour steel welding.

Based on these certificates the company can handle and deliver defence industry products and processes according customer expectations.

## 4. Conclusion

Based on the actual geopolitical factors, international and national, the author is analysing the need of aligning QMS of a manufacturing company to the defence industry requirements.

This article analyses and details the steps that have to be implemented in order to adhere to the defence industry demands.

An example of quality management system has been built along this paper starting with the current status of a company and grow in step by step the necessary levels of knowledge and competences to be able to accomplish the final objective.

The author conceptualized the critical aspects within the main standards configured all of them in a matrix which will be able to sustain the manufacturing company to handle and deliver processes and products according defence industry high expectations.

Asses the QMS actual status in a defence contractor manufacturing system, establish the objectives and design the plan to achieve them. Critical thinking is crucial in this endeavour.

The general pattern from the idea to the certification itself is based on knowing and implementing the standard requirements according to ISO 9000, ISO 9001, ISO 19011, ISO 3834 series, EN 1090-2, DIN 2303 and specific documents regarding armoured vehicles.

In this paper the author synthesizes the key concepts applicable in this field in order to achieve an

improved, functional, adapted and certified quality management system which will be able to bring customer satisfaction through benchmark products and processes.

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