Absolute Zero Defect – A Challenging Target

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Abstract: Absolute Zero Defect (AZD) is a concept which means no defectives product or service to be ever conceived, designed, developed, produced and provided to customers both inside as well as outside an enterprise system on any scale of measurement. At present, at Zero Defect (ZD) level, it is assured that no defective product or service is delivered to external customers outside the enterprise. Total Quality Management (TQM) philosophy of 'Continual Quality Improvement' (CQI) and analogy techniques used provide the base of assimilating the AZD concept and its scales. This paper also discusses the paradigm shift from 'ZD' concept to 'AZD' concept and scales. CQI of all business functions (marketing, finance, HR, production and sale/purchase etc), processes and its management system under TQM Philosophy can result in reduced rejections, scraps, reworks and failures. Wastages and losses show inefficiencies in the entire system of a business; input supplies, transformation and distribution channels. The cost of variables of recurrent nature of failures will have a higher impact than one time cost variables. This phenomena leads to higher production cost which reduces the margin of profit and compromises on competitive position in today's world market of open trade house under World Trade Organization (WTO) protocols. CQI of all business functions and processes under TQM philosophy is the best emerging approach for quality management and improvement of any enterprise. A large number of improvement tools, techniques and systems under TQM philosophy have been evolved and others are being researched. The aim is to first reduce and then completely eliminate rejections, reworks, scraps and failures (both internally as well as externally) in an enterprise. However, the problem arises in quantitative measuring and monitoring scale. Presently, the defects counting is done out of 100 on H (Hundred) scale only. This H scale gives misconceiving and deceiving impression as far as the quantitative impact of low percentage defective products is concerned. In fact, a small fraction in term of percent may involve a huge quantity of defectives when measured in a mass scale production (involving huge quantities) and recurring systems, like process industries. This deception of low percentage defectives usually result in accepting it as a norm due to 'Process Natural Variability' ( ) of a production system. Industrialized countries have already started CQI of all business functions and processes to achieve the AZD level. They have developed a new and broader scale for measuring defectives, called M (Million) scale. A new scale of measuring defectives is called T (Thousand and Trillion) scale, is the next stage. Still, these scales may not be suitable for future era of precise and perfect production and provision of products and services.

Application of AZD concept and its scales is not limited by size and type of enterprises for carrying improvements in its business functions and processes. A number of merits can be claimed from AZD concept and its related scales. However, this AZD concept presents challenges to all stakeholders; scholars, researchers, practitioners and even industrialists. They have to formulate and develop strategies, tools, techniques and systems to achieve the ultimate aim of absolute zero non-conformity within as well as outside the enterprise. This shall lead to provision of defect free products and services to the society at large.

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1. Introduction

Literature is quite rich on the subject of 'Continual Quality Improvement (CQI)' process under Total Quality Management (TQM) philosophy, but lacks measuring and monitoring scales beyond percentage. Quality of products and services is a prime requirement of every customer (Evan & Lindsay, 1999). Precision and accuracy is demanded, thus its provision becomes a challenge for all stakeholders. CQI is required in all business functions, processes and activities as they generate wastes, reworks, scraps and failures. The small percentage of inefficiencies and non conformances are considered as a norm in industry and ignored to reduce it (Womack

& Jones, 2003; Besterfield et al, 1999 & Feigenbaum, 1961). As such, economy is drained into waste every moment through defective functions, processes and operations (Saleem Ud Din, 1995). Such losses are more visible in high recurring processes (process industry) and mass production (manufacturing industry) when its cost is accumulated on daily, weekly, monthly or yearly basis. These losses increase the cost of production of products and provision of services, thus reducing the margin of profit. Ultimately, the enterprise becomes non-competitive in the open trade house under 'World Trade Organization' (WTO) regime.

CQI of all business functions and processes through TQM philosophy is need of the hour. A large number of strategies, tools, techniques and systems have been evolved over a period of time which proved beneficial whereas others are in the process of research, development and validation. The aim of these strategies, tools, techniques and systems is to reduce and even eliminate the non conformities in all facets of production and provision of products and services (Vincent & Ross, 1995).

Phillips B. Crosby coined the concept of 'Zero Defect (ZD)' (Crosby, 1979 and Vincent & Ross, 1995). This concept was well received by the industries. Initially, they measured the defectives on a scale of 100 (let us call it H scale). The problem with this scale is that it gives misconceiving, dubious and deceptive impression where wastages are represented by a small percentage. Such a small percentage of defectives is usually taken for granted as a norm due to 'Process Natural Variability (σ)' in an industry and is ignored to act upon. However, the total quantity of defectives produced by high recurring functions and processes on daily, weekly or yearly basis usually result in huge quantity. These defectives increase the cost of production and have severe impact when transferred to the society. Genichi Taguchi (Besterfield et al, 1999 p. 373) has already mentioned the transfer of such losses to the society by defining quality in his concept of 'Loss Function' and asserted that "*the loss imparted to society from the time a product is shipped. Societal losses include failure to meet customer requirements, failure to meet ideal performance, and harmful side effects.*" This means that a process may show a low defective percentage; however, if its production rate and scale are high, then the total defective produced will be a huge quantity and cannot be ignored. Suffering from such defectives products / services will be enormous when transferred to a society.

Most traditional companies believe that 99.73 (±3 σ) is a very good quality. It may be true by historical and traditional standards. However, consider what 99.73% good quality would mean in everyday life of a large society (quantitatively) in an industrialized country of the world, like the United States of America (Nawar, 2005);

- *"Unsafe drinking water once per week*
- *No electricity for nearly one hour per month*
- *500 wrong surgical procedures per week*
- *2 short or long landings at most airports each week*
- *20,000 wrong drug prescriptions per year*
- *2,000 lost articles of mail per hour"*

From this data, it can be safely asserted that perhaps 99.73% is not so good quality. World-class companies offer products to their customers with 99.9999998% (±6 sigma) accepted quality. From a statistical point of view, this means that they are offering ±6-sigma quality, which has 3 – 4 defective Parts Per Million (PPM) on M scale (Nawar 2004 – 2005; Evans & Lindsay, 2005 and Henderson & Larco, 1999). This is close to zero but not absolute zero as discussed in AZD concept presented here.

2. A New Challenge

Measuring the defective products and services on a scale of percentage - 100 (H scale) has become a norm in most industries of the world but it did not satisfy the leading industrialized countries as they have embarked upon the journey of CQI of all business functions and processes under TQM philosophy long time ago. They have challenged the H scale and developed another M scale for quality measurement (Moosa, 2000). The reason for developing M scale is that small fraction of defectives shown on a scale of 100 is usually deceiving, thus usually ignored in industries to correct upon. This H scale cannot appreciate the huge defective quantity being produced which is invisible behind the small percentage. For example, a small wastage of 1 % on H scale would seem negligible and may be ignored as a norm for process natural variations. However, the same 1% when projected on scales of Thousand (TH), Million (M) or Trillion (T) reveals a huge quantity of defectives of 10, 100, and 1000 respectively and will attract attention of every one in an enterprise as well as in the society (Vincent & Ross, 1995 and Besterfield et al, 1999). This huge quantity of defective products and non conforming services are supplied to the target market on hourly, daily, weekly or yearly basis. Such defective quantity is even more alarming if worked out for processing industry, like Chemical, Oil and Pharmaceutical etc where mass production is a routine.

The new M scale developed much suited and adopted by some industrialized countries, like Japan, to measure defectives in all business functions and processes. This M scale has almost replaced the H scale in some of the industrialized countries of the world. These industrialized countries are now mastering the M scale by using different quality improvement tools, techniques and systems; including Quality Control Circles, Statistical Quality Control Tools, Statistical Process Control Tools, Robust Design, Quality Functions Deployment and Six Sigma technique etc (Jackson & Jones, 1996 and Evan & Lindsay, 1999). The impact of only one improvement tool, Six Sigma, on quality and productivity is shown in Figure 1. As the value of 'Process Natural Variability (σ)' reduces, less defectives are produced, hence, the quality (with more number of sigma accommodated within accepted tolerance limits) and productivity improves.

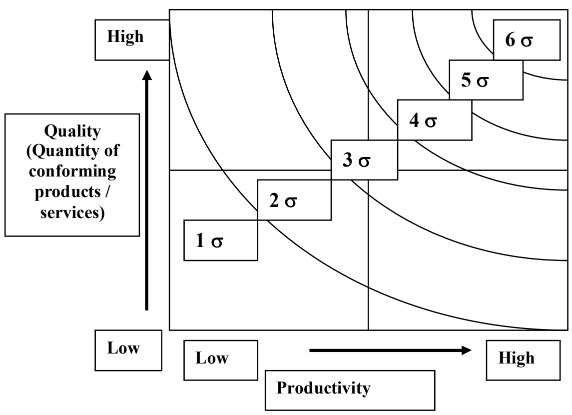


Figure 1. Quality versus Productivity at Different Number of Sigma within Quality Limits.

Defects and cost effect associated with different number of sigma (Rawoof, 1999) are also shown in Table 1, which depict higher quality and reduced cost of rejections.

Competitive positions associated with different number of sigma (Evan & Lindsay, 1999) are shown in Table 2. More the number of sigma within acceptable quality limits will guarantee better competitive position of an enterprise in the world market.

The impact of CQI on all business functions and processes shown in Figure 1, Table 1 and Table 2 is encouraging. When losses are reduced, the cost of rejection also reduces, thus improve Quality and Productivity. This improvement requires a new scale, called T (Trillion) Scale. However, once this scale is developed and adopted, it will confront with the same problem of deception, thus ignoring huge quantity of defectives invisible behind the small fraction percentage on H scale when checked on a larger scale. This small fraction of defective will become more visible and challenging as it draws the attention of all concerned. Hence, the M and T scales will no more be relevant and suitable for measuring CQI of all business functions and processes in far future. Their further projection into a new zone, frame of reference and scales will be required.

Table 1. Defectives and its Cost Effect Associated with Different Number of Sigma within Acceptable Tolerance Limits

Number of Sigma	Defectives PPM	Productivity (Yield %)	Cost of Defective Quality (Percent of Sale Value)
2 σ	308,537	69.2	25 – 35
3 σ	66,807	93.3	20 – 25
4 σ	6,210	99.4	12 – 18
5 σ	233	99.98	4 – 8
6 σ	3.4	99.99966	1 – 3

Table 2. Competitive Positions Associated with Different Number of Sigma within Acceptable Quality Limits

Number of Sigma within Acceptable Limits	Competitive Position of a Company
1 σ	Not Competitive
2 σ	Not Capable
3 σ	Average
4 σ	Healthy
5 σ	Superior
6 σ	World Class

3. AZD Analogy Techniques

Analogies are used to easily comprehend the ultimate concept of AZD datum level. These analogies include; 'Absolute Zero Temperature' used in physical sciences and the 'Included Angle Concept' on concentric circles. The 'Absolute Zero Temperature' is analogous to conceiving zero defectives, both inside as well as outside the enterprise, where as the 'Included Angle Concept' highlight the quantitative impact of low percentage defectives in a mass production scenario on different AZD scales of measurement.

3.1 Analogy Technique # 1

The first analogy of AZD concept can be made with a physical science phenomenon of absolute temperature. When temperature of a physical object is reduced, the motion of electrons decreases. As the temperature further drops, the electrons fall to a lower energy level but still revolve and do not come to a complete rest. This is analogous to ZD concept of Crosby (1979) achieved through final inspections by dispatching defect free products or offering the services to the external customers. However, the rework, rejection and back tracking of work continue inside the enterprise but no defective product / service left the enterprise for external customers (outsiders). This situation is depicted in Figure 2.

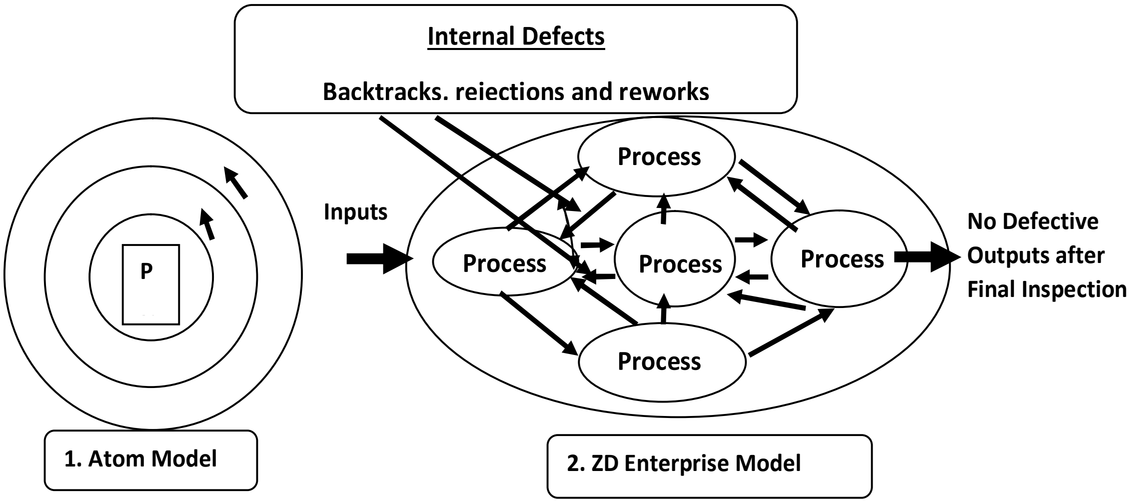


Figure 2. Activities at ZD Level

Lowest temperature is required to cease the motion of electrons in an atom. This situation is possible at 'Absolute Zero Temperature' which is minus 273 ^{0}K or minus 460 ^{0}R for water. This is analogous to the AZD concept that freezes all non conforming activities both inside as well as outside the enterprise. This analogy is described in Table 3.

This analogy of 'Absolute Zero Temperature' of physical science can be taken as guidelines to comprehend and achieve AZD level in industry where no waste, rejections, reworks, scraps, failures and other non conformities are conceived, designed, developed, produced or dispatched both inside as well as outside the enterprise. The AZD scales of H, TH, M and T can be used for measuring the quality improvement objectives which are set to reach the ultimate aim of 'Absolute Zero Defect Datum Level' of non conformities. For this purpose, different scales are used for measuring different levels of CQI under TQM philosophy. Activities of a lean enterprise at AZD datum level (total zero defectives) is depicted as shown in Figure 3.

At AZD enterprise model, there will be no Muri (overburden of an individual, processor or system), Muda (unwanted waste or fat) and Mura (unevenness or unbalanced loading or scheduling) (Nawar, 2005). Hence, the enterprise becomes absolute lean.

3.2 Analogy Technique # 2

The second analogy presented here is to highlight the quantitative impact of defectives products produced from the viewpoint of 'Included Angle Concept of Concentric Circles'. This phenomenon of 'Included Angle Concept' is shown in Figure 4. Each concentric circle represents an AZD scale, from a smaller to a larger one in the outward direction. These AZD scales can be of 100, 1000, 10,000 and 100,000 values and so on. For example, one defective on the inner smallest scale represents 10 defectives on the next higher scale and 100 defectives on the next highest scale and so on. As the circles move from insides outward, the field / area covered by the same included angle increase which is analogous to the quantity of defective products produced at mass scale.

Table 3. The Absolute Zero Temperature Analogy

S/No.	Temperature Range	Motion of Electrons in Water	Analogous Activities in an Enterprise
1	0 ^{0}C	Atom freeze to move but only motion of electrons slow down inside the atom	ZD (no defective products or services are sent outside the enterprise by screening at the final inspection) but internal rework / defectives still being produced)
2	Absolute 0 ^{0}C (- 460 ^{0}R or – 273 ^{0}K)	Electrons freeze to move in an atom	AZD (no defective product / service is conceived, designed, developed, produced or delivered both inside as well as outside the enterprise)

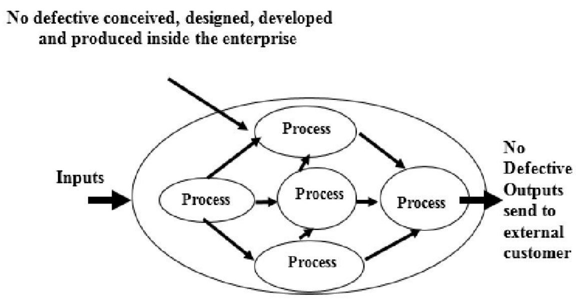
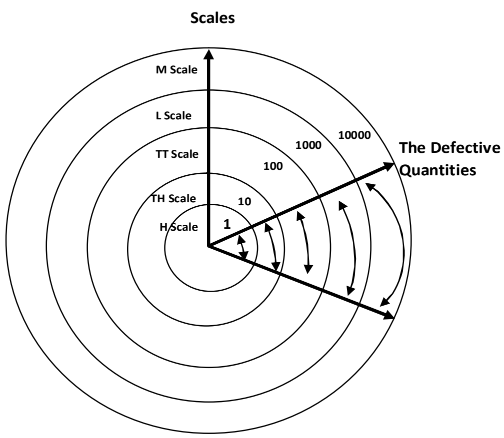


Figure 3. AZD Enterprise Model



Legend for AZD Scales

H – Hundred (100) L - Lac (100,000)
TH – Thousand (1000) M - Million (1,000,000)
TT – Ten Thousands (10,000)

Figure 4. Included Angle on Concentric Circles Analogy (Zoom-Out Effect)

Also, the sector area increases for the same included angle when projected outward from the origin of the concentric circles (zoom out effect) generate higher defectives when represented on a higher scale.

As the defectives quantity on the inner scale decreases due to the application of CQI processes of TQM philosophy, the included angle also decreases. Hence, the quantity on the outer scales decreases proportionately (Zoom-In effect). If the process of CQI continues, the defectives will further drop to zero values on all AZD scales of measurement. Thus, the included angle will become zero on all concentric circles to represent a straight line. This is called 'AZD Datum Level' (Total Zero Defectives) as shown in Figure 5.

4. The AZD Scales Defined

Conventionally, efforts are directed to provide defect free products or services to the external customers (outward focus), where as internally, rework, rejection and back track of defectives continue as a norm in an enterprise. The new paradigm shift presented in this AZD concept and its scales is to cease the inception and transformation of non conformities both inside as well as outside the enterprise. Here, the focus has shifted inside (inward focus) to the defect free inception, design, development, production and dispatch of products or provision of services within an enterprise.

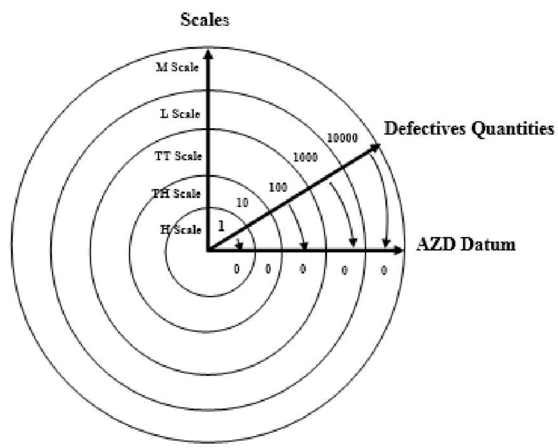


Figure 5. Included Angle Analogy (Zoom-In Effect)

The AZD concept is supported by the scales defined as "AZD scales of reference are used to measure continuous quality improvement of all activities under TQM philosophy to completely freeze defective, deficient, non-conforming, over and unwanted products and services at inception, design, development, production and delivery stages of an enterprise".

5. Application and Implementation of AZD Concept and its Scales

The application of AZD concept and its measuring scales is neither limited to size nor type of enterprise. As such, it is applicable to every enterprise of manufacturing and service sectors. However, the need for application of different scales arises to measure the CQI of all business functions and processes for different levels of quality improvement achieved.

The implementation process of ZD concept and its measuring scale (H) already exist in manufacturing and service industries that was initiated by Philosophy B. Crosby (1979). However, a paradigm shift has occurred through development of AZD concept and its scales under the CQI approach of TQM philosophy. A new M scale is presently being used by a few industrialized countries of the world. Adopting a new scale (TH, L, M or T) depends upon the quality improvement rate and stage of implementation in all business functions and processes of an enterprise.

It is logical to conclude that only a few industrialized countries, like Japan would reach the AZD datum first, as they are closing the gap at a faster rate than the rest of the industrial community.

The AZD concept and its scales have emerged from the same origin of reference as used in ZD concept and H scale. However, the evolutionary development of AZD concept and its quality measuring scales have given a new frame of reference to the CQI initiatives.

6. The AZD Concept and its Scales – A Challenge

The AZD concept and its projected scales present challenges to all stakeholders like; quality scholars, researchers, proponents, practitioners and industrialist. The scholars and researchers have to further consolidate the AZD concept and its scales with more analogies, simulations and strategies. The practitioners and industrialists can help in the implementation process and practice of AZD concept and its scales to exhibit defects free products, services, enterprises and industries. They have to develop tools, techniques and systems to measure the CQI of all business functions and processes at different stages to achieve the ultimate aim of AZD Datum Level. Thus, cumulative efforts are required by all stakeholders in the 'Quality House' for the CQI of product and service systems to reach the AZD Datum Level of 'Total Zero Defective'. The CQI process can enhance the competitive position of any enterprise by reducing prices and increasing the margin of profit and market share by producing defect free products and services to the customer. Hence, it is a win – win situation for everyone in the integrated / holistic business system including; suppliers, manufacturers, distributors and customers (both internal as well external).

The journey towards AZD Datum is in progress by leading industrialized countries of the world like, Japan to reach to this point of quality excellence. Their aim is clear and they are following the right approach of focusing on implementing the AZD concept and its scales in all its business functions, processes and activities through CQI. The AZD conditions can be achieved when all wastes, losses, rejections, scraps, failures, over and unwanted production / provision of product / service both inside as well as outside their industries cease to exist.

The industry in developing and under developed countries should focus on the new paradigm shift from ZD to AZD concept and its scales. Thus, replaced the Phillip B. Crosby (1979) ZD concept and H scale with the new AZD concept and its L, TH, M, TT scales to measure the CQI in all business functions and processes.

6.1. Merits of AZD Concept and its Scales

Followings are the main advantages which are expected from the implementation of new AZD concept and scales.

- The AZD concept combines both the 'Inward Looking / Focus' concept (no internal defective products or services conceived, designed, developed and produced) with 'Outward Looking / Focus' concept (no defective products or services delivered to external customers).
- It will provide a new 'frame of reference' for measuring CQI under TQM philosophy.
- New direction and objectives for quality improvement will re-energize every enterprise system for competition in the open trade house of WTO regime.
- It will provide new scales for measuring defectives and non conformities of products and services in the CQI process because the existing H and M scales may no more be relevant and useable in future.
- It will keep the enterprises working towards 'a never ending process of CQI' with AZD scales to measure it at different stages of quality achievement.
- It will open a new horizon of measuring quality knowledge in every walk of industrial, social and economic life.
- It will open a new era for further research and practices of CQI concept.
- New quality tools and techniques are to be developed.
- The new millennium can be dedicated to the perfection of AZD concept and its scales.
- The ultimate results of AZD concept will be the availability of defect free products and services for easy transaction across the borders under WTO regime. This can also result in improve quality of life, socio-economic development and harmonized world community..

7. Conclusions

Reduction and elimination of rejections, scraps, reworks, failures, non conformities and over and unwanted production / provision are the main objectives of every enterprise. All these issues show inefficiencies and losses in the supply, transformation and distribution functions. If these non conformities are recurring in nature in a high volume production, it will have a bigger cost impact than the one time cost variables of low volume. Different strategies, tools, techniques and systems have already been developed for CQI process of TQM philosophy to reduce and even eliminate these losses and non-conformities.

Measure of defective products / services on H scale is in practice in most parts of the world.

However, this scale is deceptive and misleading when a small percentage of non conformity is involved. Industrialized countries, like Japan, have developed and mastered a new and broader scale of reference, called the M scale. T scale is the next projected scale for measuring quality improvement. However, these scales may not suffice for future and would require replacement into a broader zone and new frame of reference for measuring defectives. The logical ultimate of CQI scales' continuum is 'AZD Datum' Level or 'Total Zero Defectives'.

The analogies of AZD concept and its scales is a challenge for every scholar, researcher, proponent, practitioner and industrialist. Freezing the defectives products and services at inception, design, development, production and delivery stage shall result into defect free systems and industries. Cumulative efforts are required by all the stakeholders; researchers, scholars, industrialists and practitioners to reach this 'AZD Datum' of 'Total Zero Defective'. Major advantages can be claimed from the AZD concept with its associated scales at global level.

Industries in developing and under developed countries should follow the industrialized countries approach for quality improvement and its management system to shift from ZD to AZD concept and freezes all non conformities and losses at the point of inception, design, development, production and delivery both to internal as well as external customers.

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