

ElectronicsIQ.

Information Quarterly from Linde Electronics.

THE LINDE GROUP

Linde



September 2014

Welcome to ElectronicsIQ, the quarterly update from Linde Electronics. In this issue, we will explore why quality is such a business priority. More precise and demanding technologies carry higher uncertainties, meaning that it is essential that customers know precisely what they are getting and that what they are getting is exactly what they need.

This issue will look at how quality fits into the Linde Electronics strategy, the significance of quality at Rogue Valley Microdevices, the rising importance of metrology and process control, and Linde Electronics' preparations for the new ISO 9001:2015 standards.

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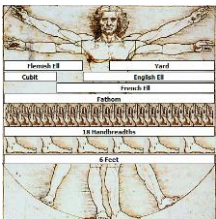
Linde Electronics Perspective on Quality

The industry must overcome technological and cost limits to stay on track with Moore's Law. The challenges of doing this are driving customer demands for holistic quality systems. Holger Kirchner, Head of Linde Electronics, shares his perspective on this and how quality fits into the overall strategy of Linde Electronics. [Read more](#)



Quality at Rogue Valley Microdevices

Jessica Gomez, Co-owner, CEO, and Founder of Rogue Valley Microdevices, talks about how quality is everything in her foundry business. Quality of products and in how they work with customers and resolve problems is what keeps customers coming back. [Read more](#)



Emerging Requirements for Electronic Materials Product Quality and Metrology

The technology changes in semiconductor processing and demands for higher-purity and better-characterized electronic materials have driven the need for advanced analytical metrology. In response to stringent emerging requirements, Linde Electronics is expanding its analytical capabilities to enable broad spectrum characterization of EM products. [Read more](#)

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Linde Electronics Process Control Systems

Driving a high performance organization (HPO) to achieve Leading status in the industry requires establishing more cost-effective Process Control Systems with linkage to higher-level business results. To that end, Linde Electronics is in the progress of implementing a system capable of real-time monitoring and reporting, across the supply chain, for the production of specialty gases. [Read more](#)



Linde Electronics Leading in Meeting New ISO 9001:2015 Standards

Quality is an overarching, pervasive, ongoing practice in a business that cares about its customers, its employees, its suppliers, and its many stakeholders. This is at the heart of the highly anticipated and distinctly current and modernized ISO 9001:2015 Quality Management Systems standard: a complete change to integrating quality and business standards. The Linde Electronics team is planning now for the new requirements, which formally launch in September 2015. [Read more](#)



My Life at Linde

We speak to Patricia Clarke, Technical Programs Manager, ESG SHEQ, Linde Electronics and Specialty Gases, about what motivates her to get out of bed in the morning and her proudest achievement at Linde. [Read more](#)



You Tell Us - Back Talk

What are your top ten quality challenges for 2015? We want to know! [Read more](#)

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Linde Electronics Perspective on Quality Interview with Holger Kirchner, Head of Linde Electronics

Q. How does quality fit into the overall strategy of Linde Electronics?

A. Quality is one of the three pillars—along with Safety and People—that make up the foundation of the Linde Electronics strategy. Each of these three pillars cannot be seen in isolation: they are interconnected. In the center of all of our programs is the customer...without them there is no business. We have to continuously add value to their business and improve the quality of service.



To demonstrate that the focus is clearly on Quality in our business, when I took over the reins of Linde Electronics, I changed the reporting structure so that the Head of Quality reports directly to me. To ensure the organizational focus, the Electronics global management team and I very frequently review the progress of our quality targets in all aspects of the business.

The ISO 9001: 2015 standards call for organizations to view quality as the job of every group and not just the quality manager's job. We are putting this view into practice. Quality is a theme throughout all of our work streams and is an emphasis in every part of our business.

Q. What is the core of the Quality strategy for Linde Electronics in the near- to mid-term?

A. We want to ensure that we remain a preferred partner with our customers and a strong Quality strategy is a primary way to do that. We are addressing the increasing need of the most dynamic industry leaders for a holistic Quality system. We envision this as an interlinked and comprehensive system to cover the entire supply chain from raw material supply to the delivery of our final products at the point of use in our customers' fabs. Metrology, fingerprinting analysis, continuity planning, and the continuous improvement of process stability are some of our top priorities in near- to mid-term.

Q. What is driving these customer demands?

A. Our customers are facing unprecedented challenges in technology. As the industry drives toward 10 nm and 7nm technology nodes, higher uncertainty accompanies the necessarily more complex technologies, making a more fragile ecosystem for the entire production of chips. We need to meet customer requirements so that they are clear on what they receive from us and that what they receive from us is exactly what they need.

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There are many drivers:

- Manufacturers trying to overcome limits to stay on track with Moore's Law, unprecedented geometries in technologies and the need for more stringent controls, which drives the level of complexity and cost and makes yield even more important
- Risk from higher investments and operational costs
- Engineers not knowing how a specific impurity might impact performance: the challenge of the unknown. Not knowing is too much of a risk and is unacceptable. Things that are not analyzed become a threat because you don't know if any of those things might impact your technology and process. For example, impurities with no effect on older technology nodes possibly have an impact on yield, costs, and performance for next generation semiconductors.

Q. What are the challenges you foresee for Linde Electronics?

A. There are many challenges involved in meeting these new demands. Therefore we have to address:

- The increase in complexity of monitoring and ensuring process stability across the entire supply chain
- An increasing demand for people such as materials scientists, chemists, and process engineers

As we move toward smaller geometries, a holistic quality system is essential to ensure reliability and that what is delivered has certain characteristics. When you begin to apply a holistic quality system, the product offering becomes significantly expanded and becomes very different from what it was. We are in the process of upgrading our infrastructure and investing significantly to meet these requirements.

Such investments can only be made with a clear joint understanding between supplier and customer, with commitments on both sides to commonly agreed goals.

Q. What are the opportunities for Linde Electronics?

A. We have the opportunity to be of greater service to our customers and to be better partners with our customers. Along with delivering highly specialized and rigorously defined and measured products, we can give our customers peace of mind and the knowledge they need to make the right choices about what solutions they need.

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Quality at Rogue Valley Microdevices Interview with Jessica Gomez, Founder, CEO, and Co-owner

1. Tell me a little about Rogue Valley Microdevices and your role there.

I am the co-owner—along with my husband Patrick Kayatta—and Founder and CEO of Rogue Valley Microdevices, which has been in business since 2003 and is a MEMS foundry with a lot of the same types of equipment and materials as a semiconductor fab. We do contract manufacturing for customers with a wide variety of applications, including semiconductor, biotechnology, nanotechnology, and MEMS.



2. How important is quality to your products and services? How does quality directly impact you as a manufacturer?

Quality in this particular industry is really everything, especially for us. The quality of our products and services is what keeps our customers coming back. We put a lot of effort into making sure that everything at our facility has the highest level of quality—in products and in how we work with customers and resolve problems.

3. How do you establish a culture of quality?

We believe that a culture of quality comes from the top and starts with the people you hire, how you train them, and how you maintain standards. For example, we believe that how a box looks when a customer receives it is important; the labels, packaging, and organization of materials make an impression and indicate to the customer that we have an attention to detail and quality. When we first started, we evaluated what our competitors did and paid attention to and asked how we could separate ourselves from the competition and stand out—and attention to detail and quality is a primary way.

4. How has your attention to quality helped separate you from competition?

Our attention to quality instills a sense of confidence in our customers. If the customer has a good experience during the initial trial phase, the relationship continues. We ensure this by being consistent and attentive, by offering options to the customer, and by asking them if what we are doing is working for them.

We have worked really hard to be very consistent and to offer repeatable processes in our manufacturing. If a customer requests an old process, we can meet their request; this is very important to our customers. Also, we do a lot of work for customers in the R&D phase; they count on our reliability and repeatability so that they can continue their R&D work with confidence. Our ability to help customers as they move through development stages and into production separates us from our competitors. Our customers stick with us and we have a quality relationship with them throughout the lifecycle of the relationship. As the customer grows, we can help them find even larger facilities when needed. Because of our focus on quality and cooperation, 90% of our competitors work with us also. It helps everyone.

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5. What is the most important quality element for your business?

From a technical standpoint, process control is extremely important. We have very well established processes and know very intimately what our equipment set is capable of and what its limitations are. We do that by collecting accurate data. We haven't implemented statistical control, but do analyze the data coming from our toolset and look at results from previous runs and make sure we are providing repeatable, consistent processes.

We don't make our own products so change control comes from our customers when they have something that they want to modify. We have a process to support them in that. In the long-term, we are in the process of moving toward ISO certification for Tier 3. We implemented it from the beginning and it is a part of how we do things.

On-time delivery is incredibly important for our customer base. A lot of what we do is short-loop. We put a lot of emphasis on making sure we give reliable process time, do a lot of pre-scheduling, and do what we can to make sure we have on-time delivery.

6. What processes do you use?

In addition to the above, our processes include traceability and we are working toward ISO certification.

7. What challenges do you experience with maintaining quality?

The only challenges we have with our supply chain—and these are rare—are on-time delivery. To head off this challenge, we always try to have two qualified suppliers for materials. Costs are always a concern. We try and keep our costs reasonable without compromising quality. We have traceability for all of our incoming materials and know what materials are used for which wafers and which batches.

We're the only semiconductor facility from Sacramento to Eugene so finding qualified people can be difficult. It takes six months to a year to fully train someone. The technicians in the fab are handling a lot...a lot of different projects...the thoroughness takes time to develop.

8. How does Linde stack up to other suppliers?

We really appreciate all of Linde's support. Linde is one of our top tier suppliers and is wonderful to work with, always supportive, and always available. One of the Linde manufacturing facilities is close to us and we have a great relationship with those people; it is wonderful. If we have a question or need something, they are there. We interface with them in community work and have a great working relationship with them.

From a product standpoint, we have never had an issue of anything coming from Linde. Linde—when it was BOC Edwards—was the first company that would deliver gases to our location. That is really appreciated. It is great to have a supplier that is as safety focused as Linde and can answer questions and be supportive to us.

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9. Have you met the Linde Electronics quality teams? What was your impression?

No, we haven't. We've never had an issue and haven't had the need for them to get involved.

10. Do you think that most suppliers meet today's needs? What about needs five years from now?

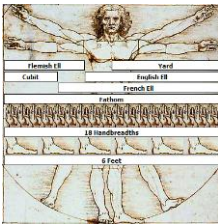
I think that most suppliers are meeting customers' needs or else they aren't doing well. Things have gotten increasingly competitive and that drives innovation and better customer service and quality. I don't know how things will be five years from now. I'm hoping that things will continue to go well and we won't have another dip in the industry as in 2008-2009, a tough time for everyone. This industry is up and down and it is hard to predict.

11. What major changes do you see in the future for quality within the semiconductor industry?

As things get smaller, people will get more demanding. Also, biomems and nano trends may necessitate different tiers of quality.

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Emerging Requirements for Electronic Materials Product Quality and Metrology by Dr. Atul Athalye, Head of Technology, Linde Electronics



In order to keep pace with Moore's Law, semiconductor market leaders have had to adopt increasingly challenging technology roadmaps, which are leading to new demands on electronic materials (EM) product quality for leading-edge chip manufacturing.

Critical process steps in high-volume semiconductor device manufacturing at aggressive feature sizes require stringent control of variability. For a silicon wafer with 100 or more advanced logic chips, each with up to 4 billion transistors and billions of connections:

- Essentially **all** the transistors and connections have to work as intended on **each** chip and
- The process has to be repeatable from wafer to wafer while chip production proceeds at rates of up to 50,000 wafer starts per month through a fab!

Variation among otherwise identical transistors on a chip will lead to poorer overall chip performance and must be minimized. This issue is exacerbated by the fact that critical feature sizes on the latest semiconductor devices are now several thousand times smaller than the thickness of human hair.

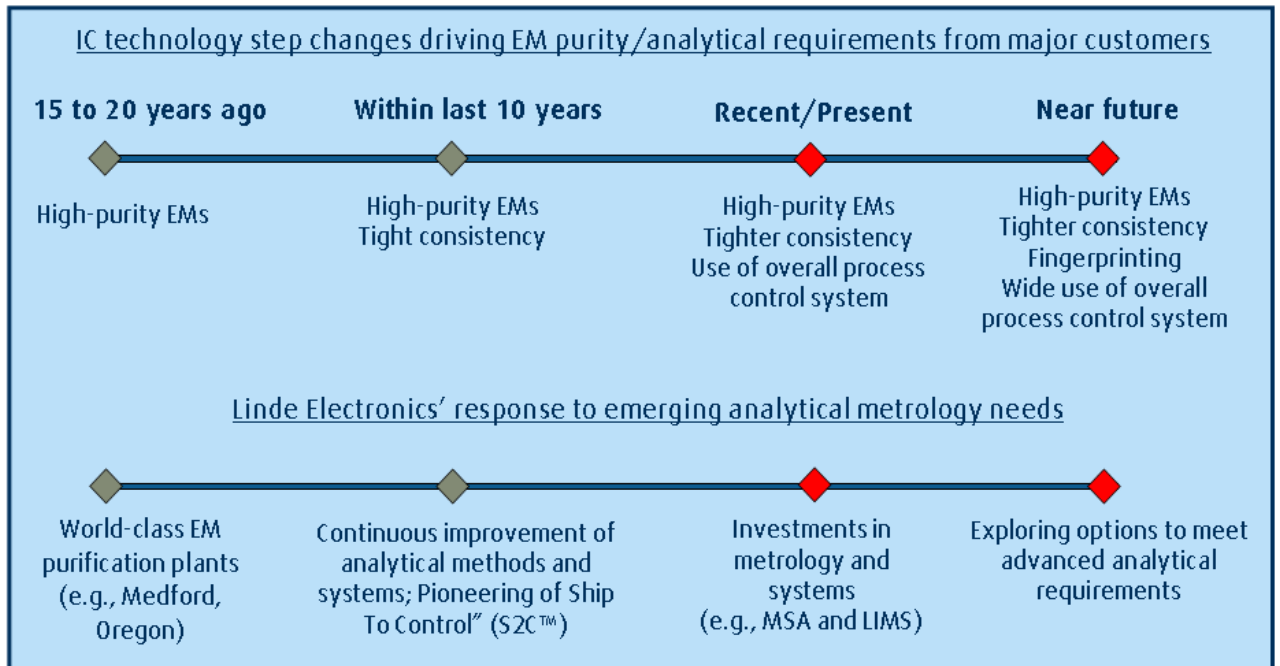
Variation in the form of a process excursion—when something unexpected happens in the manufacturing process—can also be very expensive. A starting wafer has a typical cost of \$120. After the wafer has been subjected to several hundred process steps over a period of six to eight weeks, the investment in the finished wafer can be of the order of \$1,000 to \$4,000. However, based on the selling price of the chips, this same finished wafer can represent a value of as much as 10 times the processing cost in terms of the revenues it can bring in for the chip maker!

Major industry players have pointed out that even trace contaminants—including those that are not specified on a standard Certificate of Analysis—can cause measurable shifts in semiconductor processes and affect chip performance as device geometries continue to shrink. There can sometimes be a lag of several days to weeks in the detection of problems during wafer processing. Small problems not detected early in the supply chain of the IC chip fab will increase exponentially in impact as value is added during wafer processing and can reportedly cause lost revenues of hundreds of millions of dollars in a worst-case scenario.

Given that EM products are a critical input in wafer processing, it is easy to see how the quality of EM products becomes increasingly important for chip manufacturers at leading technology nodes. Apart from focusing on major assay components, which are the impurities detailed in a Certificate of Analysis (CoA), some customers are also asking that minor assay components or other trace impurities must be controlled for critical materials used in advanced device manufacturing. EM suppliers usually only look for specified impurities and do not carry out a broad spectrum analysis due to the additional costs involved.

The need for tighter and more extensive control on gas purity now demands broad spectrum characterization. When carried out on product to be supplied to a customer, such "fingerprinting" can help us detect and measure impurities not formally specified on the CoA, but which could be present in the EM product and impact IC chip manufacturing processes where the EM product will be used. Broad spectrum characterization is also sometimes required to be carried out reactively in more of a forensic setting, e.g. when something goes wrong with a product during its use in a fab.

Thus, technology changes in semiconductor processing and demands for higher-purity and better-characterized electronic materials have driven the need for advanced analytical metrology. These and related changes are shown in the evolving roadmap of EM product quality below.



In response to these stringent emerging requirements, Linde Electronics is expanding its analytical capabilities to enable broad spectrum characterization of EM products.

In addition to the need for more advanced analytical technology, the EM supplier community is focusing on implementing a robust overall process control management system that leverages tools such as Statistical Quality Control (SQC), Statistical Process Control (SPC), measurement system analysis (MSA), and automated laboratory information management systems (LIMS) in response to the evolving customer requirements to control variability.

[NOTE: Patricia Clarke addresses these techniques in her article entitled "Linde Electronics Process Control Systems."]

As seen above, a full understanding of the electronic materials supply chain is required for successful introduction of new EM products and for their continued use in critical manufacturing steps in a fab. Achieving this also requires collaboration and trust between the supplier and the fab customer.

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Linde Electronics Process Control Systems

by Patricia Clarke, Technical Programs Manager, ESG SHEQ, Linde Electronics and Specialty Gases

Driving a high performance organization (HPO) to achieve Leading status in the industry requires establishing more cost-effective Process Control Systems with linkage to higher-level business results. To that end, Linde Electronics is in the progress of implementing a system capable of real-time monitoring and reporting, across the supply chain, for the production of specialty gases.

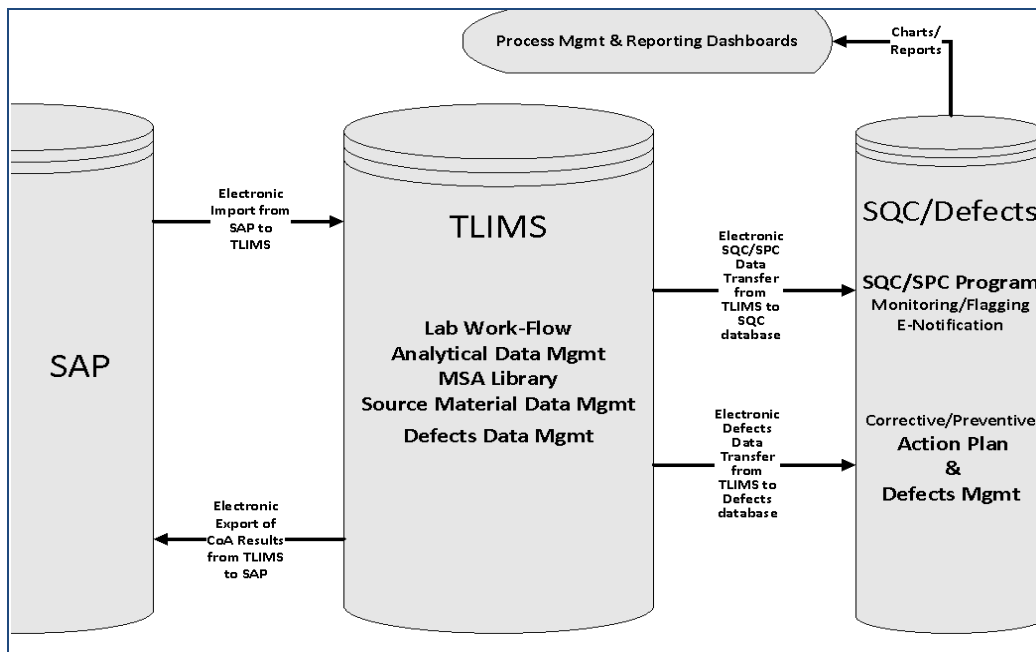
Automating our processes allows us to allocate a larger percent of our resources toward continuous improvement and strategic efforts: business continuity planning, improved cost management, improved productivity and traceability.

Critical Systems For Successful Materials Manufacturing



An increasing number of customer quality requirements is now mandatory to sustain current business and/or support new business opportunities. Automating our process control systems allows us to achieve efficient response times, more visible quality control across product supply chains, improved tracking and traceability speed for supply chain routing – leading to improved customer confidence in Linde products and increased customer scores.

Linde Electronics has developed the TLIMS/SQC System. This system includes an information management database plus SQC/SPC software and delivers connectivity with SAP, electronically pulling order information from SAP to TLIMS and pushing CoA data from TLIMS to SAP.



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Typically manually operated and separately managed, TLIMS/SQC System integrates and electronically links the following processes:

- Data management and OQC-to-IQC traceability
- Incoming raw/source material (IQC) data management
- Control limit management across supply chain (IQC, IPQC, OQC)
- SQC/SPC monitoring, flagging, and e-notification across supply chain (IQC, IPQC, OQC)
- Defects/CONQ management and reporting

There are many benefits to doing this:

EXAMPLES	FORMER	NEW
Cost management	Minimum visibility (quarterly/monthly reporting) Lagging response times	Real-time visibility (daily/hourly) Leading response times
Excursions/Defects management	Customer inquiry/complaint or quarterly SQC packs	Early, real-time internal notification and response
Resource allocation	Response to customer inquiries/complaints	Response to internal Linde system notifications
Tracking/Traceability	Hours/days to retrieve information	Minutes to retrieve information

Our customers have given us very positive feedback on this system so far. Here are some examples of what they have been saying about the TLIMS/SQC System:

- "We recommend regular monitoring of SPC trends as well as implementing SPC rules to ensure targets are met and maintained. TLIMS is an excellent tool to provide this capability, including real-time SPC monitoring, electronic data connectivity plus instrument management and validation."
- "An integrated LIMS system is critical to providing real-time process monitoring, necessary to protect our interests, and therefore our confidence in Linde. We see this as a key component to maintaining and growing new business with Linde."
- "In the semiconductor industry, it is critical to have real-time SPC data to identify concerns and potential problems in the process so that we can provide our customers with the best quality product as possible. We expect our suppliers to be aligned and have the same capabilities to fully support us as a key customer."

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Linde Electronics Leading in Meeting New ISO 9001:2015 Standards

By Jody Alt, Head of Quality, Linde Electronics

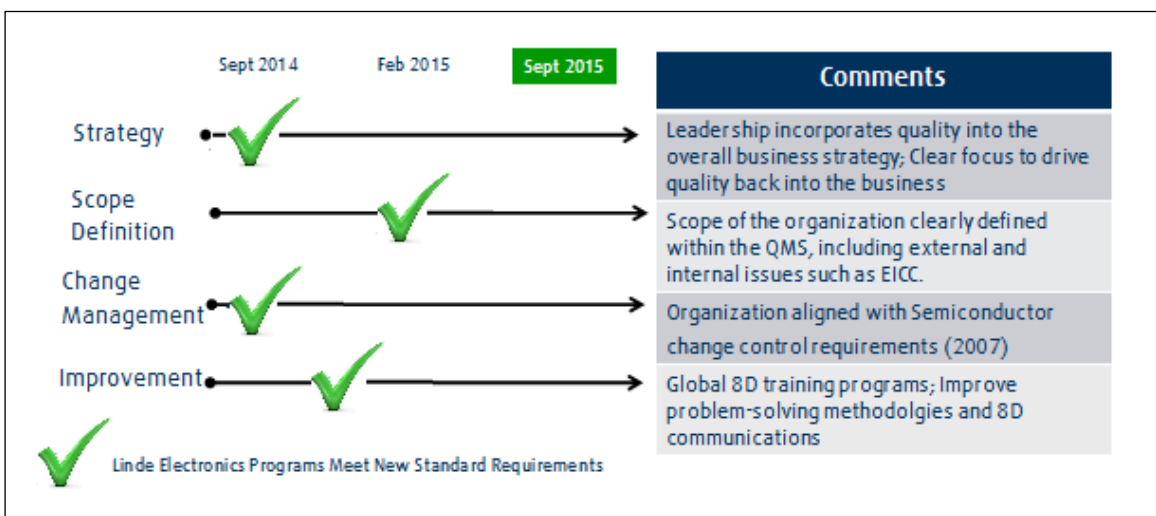
Cynthia A. Montgomery, Harvard Business Professor, says: "What's been forgotten is that strategy is not a destination or a solution. It's not a problem to be solved and settled. It's a journey. It needs continuous, not intermittent, leadership."

The same can be said about the Quality Management System (QMS). A company cannot sequester quality to a quality department and then forget about it. It is an overarching, pervasive, ongoing practice in a business that cares about its customers, its employees, its suppliers, and its many stakeholders.

This is at the heart of the highly anticipated and distinctly current and modernized ISO 9001:2015 Quality Management Systems standard: a complete change to integrating quality and business standards.

This is seen particularly in the Context of the Organization, i.e., Clause 4.1: "The organization shall determine external and internal issues that are relevant to its purpose and its **strategic direction** and that affect its ability to achieve the intended results of its Quality Management System." Included in this are how an organization approaches its products, services, investments, and interested parties.

The Linde Electronics team is planning now for the ISO 9001:2015 requirements, which formally launch in September 2015. There are a significant number of changes to the new standard, and many of the clauses are more prescriptive than previous years. Although not all changes are addressed in this article, our high-level plans are outlined below:



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Linking QMS to Strategy

The Linde Group has a simple tagline: Leading. This is a guiding light for everything we do, including being ahead of the curve in meeting the ISO 9001:2015 standards. Linde Electronics global teams met early in 2014 to map out issues that are relevant to the business' strategic direction and affect the results of the QMS. To meet the directives of the 2015 standards, we determined ways to Integrate QMS back into the business so that QMS was not seen just as a "Quality Department" activity. We set in place detailed plans to improve products and services and meet the predicted ISO requirements, connecting the dots between departmental managers and their roles in quality. The detailed plans are linked to our business strategy and reviewed with our Executive Board.

Scope Definition

Many of the former documented requirements have been eliminated from the standard; however, one key step that organizations should take is defining the **scope** according to the Context of the Organization clause. This gives leadership the opportunity to frame the QMS to address the internal and external issues that impact the business' strategy.

Our teams are in the process of assessing our scope, and some of the issues being considered for the Linde Electronics scope, which reflect the needs of our electronics customers are:

Internal issues	External issues
Business strategy and its link to QMS	Technology changes
Advanced process control	Growing sustainability expectations
Upstream supplier management	Impact of regulatory changes

Managers at all levels in the organization have a major influence on the allocation of resources to support the quality management system. The new ISO standard focuses less on the activities of the quality department and encourages wider participation across the organization. This is a significant change—one that will make ISO certification more relevant to today's business environment.

Other Significant Changes in ISO 9001: 2015

- Expands focus to all interested parties, including government, employees, stakeholders, and internal/external customers
- Enhances emphasis on risk-based thinking
- Enhances emphasis on change control
- Standardizes numerical system all standards (ISO 9001, ISO 14001, etc.)
- Eliminates requirement to keep the seven documented procedures (alternative tools such as flow charts, check lists, and databases are acceptable)
- Exclusions no longer limited to design and development and may be declared within the scope as long as it does not impact conformity

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My Life at Linde

by Patricia Clarke, Technical Programs Manager, ESG SHEQ, Linde Electronics and Specialty Gases



How would you describe your role in 5 words?

Process Control across supply chain

What motivates you to get out of bed in the morning?

The next adventure and/or challenge that life has to offer... Life need not be easy, provided only that it is not empty...

Describe your colleagues in three words.

Determined. Resilient. Talented.

Tell us a little about your background – university, degree qualification etc.

- B.S. Chemistry – San Diego State University
- Minor Computer Science – San Diego State University
- Six Sigma Green Belt

What was it about Linde that made you join the company?

I joined Linde because of the intriguing challenges of the electronics industry and the opportunity to utilize my strengths.

How long have you been a part of the Linde team?

25 years

What does your role entail?

My role entails managing programs that maintain and improve Linde's Process Control Systems, upgrading and establishing more cost-effective Process Control Systems with linkage to higher-level business results, and preparing Linde for future customer requirements via Process Control Systems roadmap.

What has been your proudest achievement during your time at Linde?

I am most proud of my longevity, which has required me to adapt to the ever changing business requirements of the electronics industry.

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Back Talk



We'd like to hear from you. **What are your top ten quality challenges for 2015?**

Send your responses to electronicsinfo@linde.com.

In our next issue of ElectronicsIQ, we will summarize what you told us. We promise not to use your name or company name.

Thanks for taking the time. We hope to hear from you!