tion • ISA5.2, Binary Control Logic Diagrams for Process Operations • ISA5.4, Instrument Loop Diagrams • ISA5.5, Graphic
agrams • ISA5.8, Measurement & Control Terminology Review Subcommittee • ISA5.9, Controller Algorithms and Performance

Tales from the trenches by ISA volunteers setting the standard for automation

Compiled by Renee Bassett

The ISA-95 Enterprise-Control System Integration standards

First published in 2000. As told by Chris Monchinski, 2019–20 Vice President, ISA Standards & Practices Department.

ISA-95 from its inception sought to solve an important issue in our industry: normalizing the integration practices between isolated enterprise and control systems and, in doing so, reducing costs and increasing success rates for these efforts.

The ISA95 committee began its work by surveying existing standards and common practices. The reference models it found for integration from enterprise to control were fragmented, lacking in detail, and quite dated.

The ISA-95 Part 1 and 2 standards ultimately define only primary data exchanges between enterprise and control. In doing so, the standards have also defined an entire framework of models to describe enterprise and control system applications, operations, and functions.

Contributors and contacts

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More information: https://www.isa.org/standards-and-publications/isa-standards

The concept of vertical levels of an enterprise, where key operations and applications interoperate in common time horizons and with common purpose, was adopted. Levels helped to define logical integration boundaries.

A lot has been discussed in recent years regarding the concept of levels, as many have observed that computing power, storage, and communications protocols have allowed a wider array of devices and systems to be connected. ISA-95 levels have always been logical boundaries that allow a practitioner to define boundaries that subsequently support the integration between systems. Viewed this way, all integration efforts begin with a definition of logical boundaries and operational space—a concept universal and still relevant to any integration effort today.

The ISA-95 equipment hierarchy model, an often-referenced model in manufacturing, expanded on an early physical hierarchy model in ISA-88 and demonstrated its universality across discrete, continuous, and logistics industries. Another key concept introduced in ISA-95 Parts 1 and 2 is the process segment, which provides a logical grouping of resources, personnel, equipment, and materials to support dynamic views of operational data—a key for supporting scheduling and resource planning activities between business planning and operational domains.

Although the ISA-95 standard title is "Enterprise to Control," ISA-95 Parts 3 and 4 formally defined the level 3 space, creating the term "manufacturing operations management" and creating complex models for resource management, quality test data management, and the representation of resource routing.

ISA-95 further evolved when Part 2 was revised to recognize the importance of equipment as a class of resources separate from a new resource type, the asset model, which facilitated new adoption of the standard for integrating production and maintenance activities.

The Part 5 standard expanded on this collection of objects and logical exchanges by contributing a transactional representation of ISA-95. Finally, we cannot overlook that the development of Business to Manufacturing Markup Language (B2MML), spearheaded by Dave Emerson and the XML-WG, encouraged the adoption of ISA-95, helping organizations, vendors, and solutions integrators realize the potential of following this industry standard to accelerate interoperability.

A "standard" can be thought of as a collection of the best ideas from across industry, and of course it helps to form those ideas around a solid architecture. The ISA-95 standards find robust adoption in manufacturing both as a reference architecture and as a facilitator of successful integration efforts.

I began my participation with ISA-95 at its earliest development, during the creation of ISA-95 Part 1. I had the fortunate opportunity to work closely with J. Keith Unger and Dennis Brandl. They both had just emerged from the successful creation and ongoing industry adoption of the ISA-88 standards. I have been the cochair of ISA-95 since 2011.

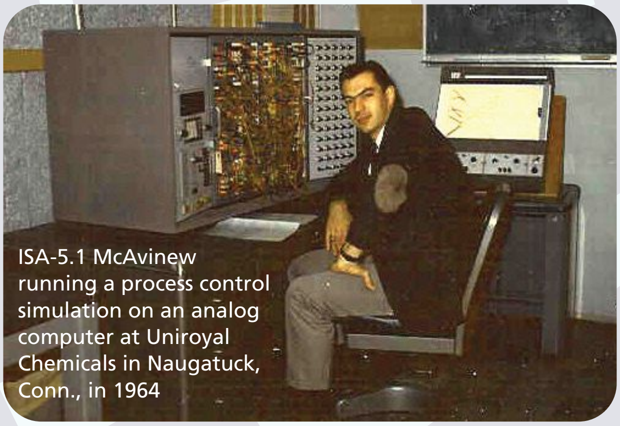
Perhaps the most challenging part of maintaining a successful standard is knowing when to adopt changes so that it remains effective and valuable to industry. Recent revisions to ISA-95 Parts 2, 4, and 5 (2018) were spearheaded by our Process Centric Messaging Working Group, led by Charlie Gifford. This group sought to reduce the complexity and granularity inherent in ISA-95 message exchanges by introducing the operations event model, which allows for a collection of data with common context to be exchanged as a single message.

ISA-95 Part 6 (Messaging Service Model) and Part 7 (Alias Service Model), put forth first as technical reports by Dennis Brandl and Alan Johnston (MIMOSA), were also driven by the real-world needs of practitioners. Most recently, the ISA95 committee is poised to release a new Part 8, which will define a framework for developing an ecosystem of "ISA-95 ready" profiles that can be adopted by integration scenario or industry type.

ISA-5.1, Instrumentation Symbols and Identification

Originally published in 1984. As told by Tom McAvinew.

The use of ISA-5.1, *Instrumentation Symbols and Identification*, originally published in 1984, is in general quite widespread. That is because it is important to consistently identify instrumentation in project documents used for specifying, purchasing, tracking, installing, and eventually maintaining them.



ISA-5.1 McAvinew running a process control simulation on an analog computer at Uniroyal Chemicals in Naugatuck, Conn., in 1964

Although often cited on project or site documents along with other standards, ISA-5.1 is often not followed completely—particularly regarding device identification tagging. Sometimes this is because a particular site may not have followed the standard in the past. Other times, operations personnel on a project may insist on using more phonetic tagging, rather than one of the basic tenets of ISA-5.1—that ID tagging be based on primary variable functional tagging.

My role with ISA-5.1 has been as a resource, based on my 50+ years of experience in the application of the standard for both operating and engineering design firms. None of this would have been possible without the tutelage of Marvin D. Weiss, one of the pioneers in process analytical instrumentation, who met a fresh-out-of-school chemical engineer with an interest in instrumentation and process control, then convinced him to join ISA in 1964.

The ISA-88 Batch Control standards

First published in 1995. As told by Dennis Brandl.

The ISA-88, *Batch Control* (series) standard, first published in 1995, introduced the ISA-88 model, recognized now as an object-oriented design pattern for defining automation. It has become the accepted standard for structuring automation projects.

Most major integrators, and all major automation vendors, support the ISA-88 model and use the models in their projects. We documented measurable benefits from applying the models, typically a 30 percent savings on the first project and up to 80 percent savings on follow-up projects due to the modular and reuse approach defined in ISA-88. Even today, work on Industry 4.0 and smart manufacturing initiatives use the ISA-88 equipment and recipe models as an integral part of their development efforts.

We found that once people learned how to apply the ISA-88 model, their personal productivity improved, and they became better engineers. The World Batch Forum, now part of MESA International, documented the greater than 30 percent improvement, in addition to throughput improvements in batch processes, better repeatability of processes, and higher product quality. These directly measurable improvements have been what has led to the widespread use of the ISA-88 series.

There were, on average, between 20 and 30 active participants in the development of the ISA-88 standard, and over 100 reviewers. Our meetings were at times raucous and noisy, but always focused on the goal of documenting the best-known practices.

My initial role in the committee was to help identify the "true-isms," the things that we could all agree on, such as "a unit only runs one batch at a time," and document what we agreed

ISA88 leaders circa 2007: front, Dennis Brandl, Dave Chappell; rear, Charlie Giffords, Lynn Craig, Keith Unger

to. Where we couldn't reach agreement, we came up with the words that describe the different possible implementations.

I started as a naive engineer but listened and learned. Eventually I became the editor of the different parts in the series, and for a time was committee chairman. Often, being chairman was "herding cats," but hopefully I kept us focused on the deliverables and away from the deeper "philosophical" questions that always seem to come up when engineers get together.

There were other major contributors, including Tom Fisher from The Lubrizol Corporation, Lynn Craig from Rohm and Haas, Bill Hawkins, Rick Bullotta, Leo Charpentier, Rick Mergen, Paul Nowicki, Keith Unger, Michael Saucier, and Joel Vardy. These were only a few of the experts involved, but many of the ISA88 committee members have gone on to become some of the icons of automation and batch.

The ISA-99 Industrial Automation and Control Systems Security standards

First published in 2007. As told by Eric Cosman, 2020 ISA President.

The ISA-99 standards helped to put industrial cybersecurity on the map, leading to today's high level of awareness.

It is easy to forget that the ISA99 committee existed and our work on the 62443 standards was happening before most of the current popular or higher-profile products and technologies were even available. Pioneers in the development of solutions in this area were also involved in the early activities of our committee. A notable example is Eric Byres, who went on to develop the Tofino industrial firewall.

Members of the ISA99 committee also provided expertise to the Automation Federation in its efforts to raise awareness with politicians and public policy members. This included the development of briefing papers and visits to Washington

D.C. Our committee has been working closely with the U.S. National Institute of Standards and Technology (NIST) and other groups in the public sector for almost 20 years. This included having a major role in shaping the NIST cybersecurity framework.

All of this attention and focus by industry has led to the creation of new types of jobs in industrial automation cybersecurity. There are now several very successful companies providing consulting and advisory services to asset owners in this area, some of whom employ members of our committee. The impact of ISA-99 has been to help increase understanding of the importance of automation in ensuring safe, reliable, available, and high-performing manufacturing and operations processes.

I was one of a small group of people who came together in a conference call on 18 September 2002 to discuss how ISA could best approach the growing need for and interest in standards and practices for industrial systems cybersecurity.

The Society had considered two basic approaches. The first was to direct all existing and future subject-specific standard groups (e.g., ISA-95) to examine if and how they should revise their standards to consider cybersecurity threats and vulnerabilities. The alternative was to create a new committee to develop one or more standards devoted to cybersecurity and promote the result as a "horizontal" standard that could be applied in a range of contexts.

ISA95 team in Sun Valley in 2012

The consensus was that the second option was preferred. This resulted in the chartering of the ISA99 committee with Bob Webb as managing director and Bryan Singer as committee chair. Bryan Singer and Keith Unger developed the initial committee description. A face-to-face meeting in Chicago on 22 October attracted almost 60 people. This was the first meeting of the committee. Those present approved the formation of three subcommittees to address scope and purpose; models and terminology; and research and liaison.

I have been a member of ISA99 since its formation. I joined to represent the chemical sector cybersecurity program of the American Chemistry Council (ACC), which had decided to avoid creating sector-specific standards and practices. I served as the cochair (with Evan Hand) of the work group that developed what became ISA-99.00.01-2007, which was the first standard in what became the 62443 series. I later took on the role of committee cochair, first with Bryan Singer and later with Jim Gilsinn. Many others who attended our first meeting are still contributing today—continuity that has contributed to the success of the committee.

ISA-84.1, Application of Safety Instrumented Systems for the Process Industries

Published in 1996. As told by Angela Summers and Paul Gruhn

Dr. Summers says **ISA-84 has not simply rocked the world** of instrumentation and controls; it has affected process safety strategies across most of the process industry. It spawned an entire industry of specialized professionals and credentialing programs centered around ISA-84 compliance. It also initiated the widespread use of SIL-certified programmable controllers across multiple industry sectors. ISA-84 has become foundational to our current approaches to designing and managing instrumented safeguards.

What is really amazing, says Summers, is how impactful ISA-84 has been to other organizations that write standards and practices. "I have worked with various API, ASME, and CCPS committees on how to address their scope and stay in conformance with ISA-84. I have also worked with government agencies on incorporating ISA-84 into regulatory audits, regulations, and guidance documents."

Summers says that when she joined the ISA84 committee in the 1990s, she was fortunate enough to meet and be mentored by the thought leaders she met there: Ken Bond (Shell), Vic Maggioli (DuPont), Charlie Hardin (Celanese), and Robert Adamski (ExxonMobil). Very quickly, Maggioli, who was the ISA84 committee chair for many years, gave her opportunities to contribute. She joined the IEC 61511 committee in the late 1990s at the request of Sam Mannan, director of the Mary Kay O'Connor Process Safety Center at Texas A&M University until his death in September 2018.

Gruhn says ISA-84.1 (also known as the emergency shutdown systems standard) led to the development of International Electrotechnical Commission (IEC) standards on functional safety, product and personnel qualification programs, new books, new products, new software, and recognition by regulators around the world: "In short, it changed the industry."

Relays have been used in safety applications for almost 100 years, says Gruhn. Solid state systems (that did not use software) were developed by several vendors in the 1970s. General-purpose programmable logic controllers (PLCs) have been used in some safety applications since the 1970s. Safety PLCs have been available since the early 1980s. Yet at that time there was no industry agreement on what steps to include in a project life cycle, how to determine the performance required of a system, how to model the performance of hardware and software, and much more.

The development of a standard was proposed to ISA in the early 1980s. The original charter of the standard was to cover software-based logic solvers only, and field devices were not included in the original scope. The scope was expanded in the early 1990s.

Ten years of deliberation brought consensus on the system life cycle, methods to determine the required system performance (safety integrity level [SIL]), methods to analyze the performance of hardware and what to include in the calculations, factors to include in the design of a system, and factors to consider in the operation, maintenance, and changes of a system. The first edition of the standard, released in February of 1996, was approximately 40 pages long, and had five informative annexes totaling almost 60 pages.

Gruhn says the IEC started developing functional safety standards in the mid-1990s. The ISA84 committee actively participated in the development of the IEC 61511 standard for the process industry. That standard was first released in 2003 and was adopted as ANSI/ISA 84.00.01-2004 one year later with the addition of one sentence. That is a three-part standard; part 1 (the normative portion) was over 90 pages. Part 2 (an informative document) was also over 90 pages. Part 3 (another informative document summarizing various SIL selection methodologies) was over 60 pages.

The Occupational Safety and Health Administration published interpretation letters stating that it considered the first and second editions of the ISA-84 standard as "recognized and generally accepted good engineering practice" (RAGAGEP). The IEC released a second edition of 61511 in 2016. After a one-year period of editorial changes, the ISA84 committee accepted the new standard verbatim (although it added a new U.S. forward in Part 2). It is now ANSI/ISA 61511-2018. The ISA84 committee has also written eight technical reports totaling more than 1,000 pages over the past 15 years. They further explain the standard and ways of implementing its requirements, says Gruhn.

ISA100.11a team

ISA-18.2, Management of Alarm Systems for the Process Industries

First published in 2009. As told by Nicholas P. Sands.

ISA-18.2 changed the world—a very small piece of the world, but a piece, nonetheless. Some companies had alarm management programs prior to the standard. Many more companies have programs now. The control system suppliers have improved the alarm functionality as well, adding shelving functionality, for example. That small part of the world has changed, and it has been kind of cool to be a part of it.

My role in ISA18, along with Donald Dunn, has been as cochair of the ISA18 committee and organizer of chaos. We started in 2003 by rebuilding the committee with real-world experience in alarm management. We added world-class experts like Ian Nimmo, Bridget Fitzpatrick, David Strobhar, and Bill Hollifield, as well as industry experts like Joe Alford, Todd Stauffer, Graham Nasby, Lieven Dubois, and Kevin Brown. We got advice from members of the ISA84, ISA50, and ISA88 committees, and we got to work. After ISA-18.2 was published in 2009, Donald and I shifted from leading the development of the standard to coaching the working group leaders and publishing the work of the committee. We also started working to publish the IEC version of ISA-18.2, IEC 62682.

My involvement with ISA-18 and my role at DuPont have grown together, so I have even become an expert in some areas, using my experience to contribute to standards, and my understanding of standards to improve the practices in my company.

Being a working group and committee leader for an industry-wide global standard has dramatically broadened my perspective. So many people participate from different companies, industries, and countries, and they all bring valuable perspectives.

ISA-101.01, Human Machine Interfaces for Process Automation Systems

Released in 2015. As told by Maurice Wilkins.

ISA-101.01 was being cited even before its release. It is now the go-to standard for HMIs for process automation systems, especially in North America. ISA-101.01 has helped people to move away from classic HMI designs toward more intelligent, high-specification HMIs. Guidelines from the Abnormal Situation Management (ASM) Consortium and the Engineering Equipment and Materials Users Association (EEMUA) in the U.K., including the latest edition of *EEMUA 201 – Control Rooms: A Guide to their Specification, Design, Commissioning and Operation*, cite ISA101 in several places. Greg Lehmann and I have contributed to the review process.

I joined the ISA101 committee in 2008 as a basic committee member and became cochair with Joe Bingham in 2009. Joe was later replaced by Greg Lehmann. We needed some "glue," so Greg and I—with the help of a wonderful group of ISA108 clause editors (Bridget Fitzpatrick, Dale Reed, Tracy Laabs, Dawn Schweitzer, David Lee, Beth Vail, Mark Nixon, Nicholas Sands, Ian Nimmo, and John Benitz)—developed a life cycle for the proposed standard based on ISA-18.2 and ISA-84. This helped us to organize the standard, and things flowed from there. We received many thousands of comments as the standard developed, but we eventually decided to make it the "what" and removed all the "how" into proposed technical reports. The standard was successfully released in July 2015. After that, four working groups were set up—Philosophy and Style Guide; Usability and Performance; HMI for Mobile Platforms; and HMI for Machine Control. The purpose of the working groups is to develop technical reports (TRs) intended to show how to implement the standard.

The initial standard had said that mobile/small platforms were excluded, but by the time the standard was released, these platforms had become ubiquitous. David Board and Ruth Schiedermayer drove the development of the *Usability and Performance* technical report (TR) on a fast timeline, doing most of the work themselves. That TR was released in 2018 and provides a very good companion to the standard. The other TRs are at various stages of development. The standard itself is now out for a reaffirmation vote, with the plan to submit it to IEC for development as a global standard.

ISA-101.01 was approved for development/adoption as an IEC standard in early 2020, which will enable it to become more globally accepted. The IEC standard is being developed by TC65/SC65A WG19, HMI for Process Automation Systems, and the standard will become IEC 63303. I am co-convenor along with Dave Board. The draft is being developed from ISA-101.01, and the ISA101 committee has an IEC C liaison with WG19. This will allow ISA101 to be involved in the development of the IEC standard. ISA101 Co-chair Greg Lehmann is the liaison coordinator. We anticipate this joint ISA/IEC work to be completed in late 2021.

ISA-108 and ISA-112: In development for intelligent device management, SCADA systems

As told by Ian Verhappen and Graham Nasby.

The ISA108 committee is working in a collaborative effort with IEC SC65E WG10 on an important emerging area of automation: intelligent device management. With large amounts of data available from a single device, being able to manage the data and its flow, as well as identify the necessary tools and infrastructure to do so, is important. ISA recently adopted the IEC document as ISA-TR 63082-1:2020 and is now working on Part 2, which will be an International Standard. ISA-108 will enable the community to use this information rather than be overwhelmed by options and stymied by "analysis paralysis." Using the information from intelligent devices will lead to higher returns on control system investments and better use of the skills of overworked support teams.

The ISA-112 supervisory control and data acquisition (SCADA) standard will help define how all the disparate parts of a control system can be and are linked together to form a single system able to communicate machine-to-machine as well as machine-to-human. With the increasing distribution of controls to the edges of a control system, being able to integrate those controls using best practices captured in this series of documents will help achieve that goal across a wide range of industries.

Work on the first ISA-112 SCADA systems standard is not completed yet, but according to Graham Nasby, a leader in the water/wastewater community, it is still having a major impact on how SCADA systems are designed, used, and implemented in several sectors. For example, large water utilities in Ontario, Canada, are already using the ISA-112 framework for managing large automation projects and SCADA master-planning activities. Many other water utilities, sewerage districts, oil/gas companies, and other organizations are now starting to look at the ISA-112 SCADA framework for managing their automation assets, he says. There is a need for this sort of guidance, and ISA112 is working to provide it.

ISA-106, Procedures for Automating Continuous Process Operations

As told by Bill Lydon.

Process plants are complex, and the majority of those in operations management agree that good operating people are valuable. Automation professionals can support knowledgeable operators with well-engineered system applications to keep production running efficiently—particularly when seldom-used procedures are required and unexpected problems occur.

Automating and clearly documenting functions that are well defined and deterministic enable operators to focus on the most important tasks, problems, exceptions, and unexpected issues. Automation professionals can take advantage of the work of ISA106, which is focused on achieving these goals with standards, recommended practices, and technical reports on the design and implementation of procedures for automating continuous process operations.

The ISA-106 models define how to capture information about physical assets, from the enterprise level to an individual device, and the requirements that define a procedure. They establish the functional requirements for the automated procedure and tie these requirements directly to objects in the physical model. The lower the level, the more detailed the association between procedures and objects. The implementation module defines a set of ordered tasks, which may have their own subtasks to perform step-by-step in a defined order.

Larger activities, such as plant startup or shutdown, are important. However, the same tools can be used for more routine procedures, such as isolating and starting up a redundant pump system, performing online maintenance on a piece of equipment, or even something as "simple" as performing an in-line valve performance test. All of this normally requires communication with someone physically at the asset to verify, or in some cases, manually intervene in, the process.

Procedural automation can be used to capture and share corporate knowledge, including best practices, and to minimize errors with a resulting decrease in incidents, improvement in safety, and increase in throughput. This is particularly important with an aging workforce and the difficulty in finding experienced operators.

Safety statistics show the majority of incidents not related to outright mechanical failures happen during abnormal situations, primarily unit startups and shutdowns. When an infrequent operation is required and key individuals are not available, inexperienced operators can be left to follow inadequate or incorrect instructions. Something can get out of control, leading to an abnormal condition with the undesirable outcomes of equipment damage, environmental release, injuries, and fatalities. By applying ISA-106, a single process plant, a complete facility, or even an entire company can achieve significant improvements in operational efficiency and safety. ■

ABOUT THE EDITOR

Renee Bassett is chief editor for *InTech* magazine.

View the online version at www.isa.org/intech/20201003.

ISA-76.00.02-2002: NeSSi

Regarding ISA-76.00.02-2002, *Modular Component Interfaces for Surface-Mount Fluid Distribution Components – Part 1: Elastomeric Seals*, this document was created in 2002 at the request of and with the help of Exxon, Swagelok, Parker, and additional users and vendors.

There was a call for a small-sampling platform that was not tube based and on which devices from multiple suppliers could be used. No vendor was willing to invest in it until the basic platform was defined in an open standard, so they would not have to make different products for different vendor footprints.

The result was the development of this standard—commonly known as NeSSi (the New Sampling Sensor Initiative)—and many vendors have made products to fit on this platform. This standard has also been published as an IEC standard (IEC 62339-1 Ed. 1).

James F. Tatera's on-line process analysis experience includes more than 27 years with a major international chemical company and years of consulting through his own firm and others. He is one of the original Certified Specialists in Analytical Technology (CSAT) and an active member of ISA and ACS. He is involved in U.S. and international standards activities and was the ANSI USNC Technical Advisor to IEC SC 65D (Industrial Process Measurement and Control – Analyzing Equipment). Additionally, he is an ISA Fellow, trainer, and winner of several honors and distinctions in the field of process analysis.