DRAFTED: 12/9/2024

AEM
Association of Equipment Manufacturers

Standards Development — Autonomy

AEM
Association of Equipment Manufacturers

Introduction to Standards

Standards affect everyday life in more ways than users tend to notice. In fact, some might argue that is their exact purpose. Standards allow the functional world to operate in a seamless and uniform manner by improving the likelihood that products are designed and manufactured safely, by promoting product transparency for customers, and by aligning interconnected products so they can function together.

Autonomous equipment is a developing technology that Original Equipment Manufacturers (OEMs) continue to advocate for today. This technology intends on creating a safer working environment for workers, improving productivity, and reducing the need for consumable resources. To enhance the safety, user experience, and efficiency of autonomous equipment, the off-road industry utilizes the industry consensus standards development process.

Definition of a Standard

A standard is an engineering specification that defines materials, products, processes, tests, test procedures, and performance criteria to achieve a specified purpose. For example, American Society for Testing and Materials (ASTM) material standards of fastener types help designers select a specific fastener for a given application. International Organization for Standardization (ISO) noise test standards help when measuring noise values to determine if a regulation requirement is achieved. American Society of Agricultural and Biological Engineers (ASABE) product safety standards are used when designing products to ensure a minimum level of risk reduction is met.

The standards creation process is specifically designed to ensure there is open and balanced participation, with wide recognition, acceptance, and harmonization.

Standards vs Regulations

Standards are specifications that achieve a purpose and are entirely voluntarily established through industry consensus. Regulations are acts, codes, or directives enacted through legislation whose requirements are compulsory. Sometimes, standards are cited within regulations making those standards compulsory. This is entirely dependent on the regulatory body (country, economic union, etc.) and the citation of the standard in the regulation. For example, ASABE S279: Lighting and Marking of Agricultural Equipment on Highways and ISO 12509: Earth-moving machinery - Lighting, signaling, and marking lights, and reflex-reflector devices are referenced in the Department of Transportation 2012 Highway Bill and Agricultural Machinery Illumination Safety Act.

Benefits of Standards

The Association of Equipment Manufacturers (AEM) and its members advocate for and participate in the creation of standards, because standards provide essential values to the industry and the people it serves. Standards improve product and component compatibility. Standards establish minimum requirements for products to reduce product risk and improve product safety. Common tests and test procedures can be found in standards, allowing industries and customers to compare and evaluate products. The standards

creation process is specifically designed to ensure there is open and balanced participation, with wide recognition, acceptance, and harmonization. These specifications help drive and guide the product design process. Additionally, by creating a single set of global requirements, standards can help reduce trade barriers and promote international product marketability.

Standards have been utilized to progress off-road technology for the betterment of safety, productivity, and environmental sustainability since 1968. For example, **ISO3471:2008 - Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements** created specific, consistent, and reproducible means of evaluating the compliance of metallic roll-over protective structures (ROPS) on in-scope earth-moving machines. This standard has saved countless lives in roll-over events and is reviewed every five years to ensure that the content is up to date.

Last reviewed and confirmed in 2023, **ISO10987:2012 - Earth-moving machinery — Sustainability — Terminology, sustainability factors and reporting** has improved the sustainability of the off-road industry and improved productivity. ISO 10987:2012 sets out general principles for addressing the sustainability of the earth-moving machinery and provides an example of a reporting format for sustainability information so that OEMs can communicate in a common way. Just as they have since 1968, off-road industry OEMs continue to raise the tide and lift all boats by coming together and creating standards that enhance safety, productivity, and sustainability of equipment.

Standards have been utilized to progress off-road technology for the betterment of safety, productivity, and environmental sustainability since 1968.

Standards Creation Process

Product standards for off-road equipment typically follow one of following paths, or a combination of these: development by an American National Standards Institute (ANSI) standards development organization (SDO), by ISO or International Electrotechnical Commission (IEC), or national adoption of ISO or IEC standards.

National Standards Development Process

ANSI is the U.S. national standards body. ANSI is not part of the U.S. government but is recognized by it as the accrediting body for U.S. SDOs. ANSI membership includes many SDOs such as ASABE, ASTM, the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers (IEEE), and many more.

ANSI accredits these SDOs to develop American National Standards by using approved procedures and audits them every five years to verify compliance to strict and essential ANSI standard development requirements. These essential requirements are due process, openness to all interested parties, lack of dominance, and balance of interests.

Even though ANSI validates the process by which a standard is developed, it does not review the content of a standard. The content of a particular standard is developed by a working group (WG) within a particular SDO. This WG meets as often as necessary to develop the outline and content of the new standard. Once the WG is satisfied with the draft content, the SDO presents an electronic ballot to members for final review, comments, and corrections.

All comments from voting and non-voting members must be addressed. This comment process might lead to a revision of the document and another ballot until all comments have been addressed and voting members have demonstrated consensus on and approval of the new standard. Public comments (see below re: ANSI) must also be addressed. This process is also reviewed by an oversight committee within the SDO and once its approval is received, the standard is submitted to ANSI for final approval.

For standards that are to be published with the ANSI designation, ANSI must inform the public through its Standards Action platform about this standard development work and must give the public the opportunity to comment on the developing standard. There is one public review period of 30 days after the standards development project is approved within the SDO and another public review period of 45 days after the WG draft of the standard has been circulated for comments within the SDO. After final approval of the standard within the SDO, ANSI will review and approve the standard within two weeks if compliance with the ANSI standard development process is confirmed.

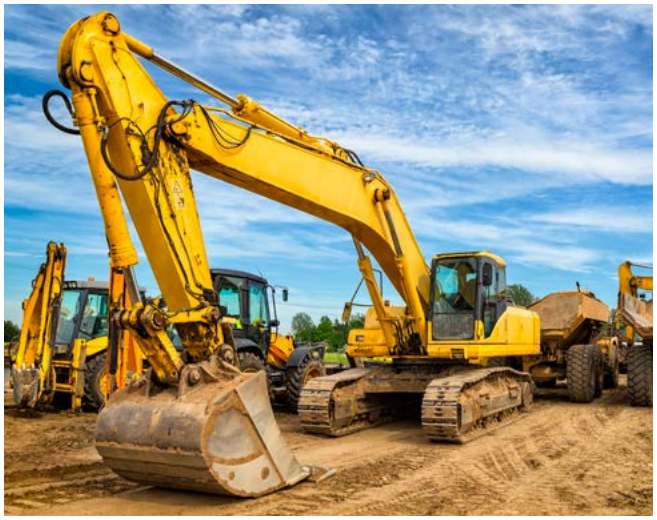
For additional information regarding National Standards Development, watch the video below:

National Standards Development through ASABE

International Standards Development Process

ISO and IEC both, as their names suggest, are international standards bodies. Members of ISO and IEC are countries, not individuals, typically represented by their national standards body (ANSI for the U.S.).

U.S. Technical Advisory Groups (U.S. TAGs) are the U.S. national mirror committees to ISO and IEC international committees. They are established by U.S. SDOs, accredited through ANSI, and form the U.S. position for ISO and IEC committees. U.S. TAGs can request that ISO or IEC adopt a published U.S. (or other national) standard by incorporating the content into an ISO and IEC standard. A national standard can also become an international standard simply by other countries acknowledging that they use this standard as well (de facto).



ISO or IEC standards are drafted and balloted in very similar fashion to U.S. national standards, except that each member country, not individual committee member, provides comments for the draft via its national mirror committee.

A consensus approval or disapproval vote together with consolidated comments is then submitted to ISO or IEC through the representative national standards body (i.e., ANSI for the USA). When the completed ISO or IEC standard is published, this standard can be adopted as a national standard.

Please see below in Image 1 the various stages of the ISO Development Process:

NWIP (New Work Item Proposal)

↓ Proposal from 1 member, for acceptance: market relevance score >15, simple majority of P-members, 5 P-members participating, 5 experts named

WD (Working Document)

↓ Define project leader and working group , bulk of the drafting work is typically done as WD

CD (Committee Draft)

↓ Gather national comments, for acceptance consensus or support or 2/3 of P-members. If necessary second CD

DIS (Draft International Standard)

↓ 5 Month voting time, for acceptance 2/3 P-members and no more than 1/4 negative votes (in case all P-members vote positive a FDIS is not necessary (if necessary 2 month for the 2nd DIS)

FDIS (Final Draft International Standard)

↓ For acceptance 2/3 P-members posititve, no more than 1/4 votes negative. YES/NO vote, only editorial comments, 2 month

ISO Standard

↓ Review standards, confirm, revise, withdraw (for new standards there is a 3-year review, thereafter 5-yearly)

5-Yearly Review

Image 1: A visual representation of the ISO Development Process Stages

For additional information regarding International Standards Development, watch the video below:

International Standards Development through ASABE

Participating in International Standard Development

ISO country members consist of national standards bodies and represent their country in ISO work. ISO country members can choose whether they want to be part of a particular ISO Technical Committee (TC) and select their level of involvement. P-member country participants actively participate by voting on the standard at various stages of its development. O-member country participants can observe the standards that are being developed, offering comments and advice.

Standards are developed by TCs, or Sub Committees (SCs) or Working Groups (WGs) by following ISO standard development stages. The technical experts are put forward by the ISO country member (national standards body).

In most cases, the technical experts that develop ISO standards work in the field in which the TC, SC or WG is focused. They may have expert knowledge, but they're not isolated professors of theory. They understand and anticipate the challenges of their sector, using standardization as a tool to create a level playing field that benefits everyone.

If you are interested in getting involved, contact your national standards body. Contact details can be found in the list of national country members. Companies and individuals are not eligible to join ISO as country members.

Published ISO and IEC standards (and draft standards available for public comment) can be found on their respective websites.

- **ISO Published** – ISO - Store
- **ISO In-Progress** – Draft standards for public comment
- **IEC Published** — IEC Store

The ISO world is extensive and can be daunting to new members. Here are some ISO Technical Committees that AEM and its technical expert members are heavily involved in:

- **ISO/TC 23** - Tractors and machinery for agriculture and forestry
- **ISO/TC 82** - Mining
- **ISO/TC 110** - Industrial trucks
- **ISO/TC 127** - Earth-moving machinery
- **ISO/TC 195** - Building construction machinery and equipment

Autonomy Standards

The off-road industry continues to advocate for the advancement of autonomous equipment due to the numerous benefits this technology provides. This technology enhances product safety by removing operators from hazardous or remote sites and reduces the number of people and resources required on site. Autonomous equipment allows for more efficiency, consistency, and sustainability in operations and contains the potential for near-continuous operation resulting in the reduction of operational delays. All these improvements are also paired with the benefits of reduced machine damage and downtime due to misuse and overloading.

Autonomy-Focused Published Standards

Much work has already been done to advance autonomous technology for manufacturers, consumers, the public, and all other stakeholders. See below some existing autonomy-focused published standards:

Agricultural Machinery and Tractors

- **ISO 10975** - Auto-guidance systems safety requirements
- **ISO 18497-1 to -4** - Agricultural machinery and tractors — Safety of partially automated, semi-autonomous, and autonomous machinery

Earth-Moving Machinery and Mobile Road Construction Machinery

- **ISO 15143** - Worksite data exchange
- **ISO 15817** - Safety requirements for remote operator control systems
- **ISO 16001** - Object detection systems and visual aids – Performance requirements and tests
- **ISO 17757** - Autonomous and semi-autonomous machine system safety
- **ISO 21815** - Collision warning and avoidance
- **ISO 23724** - Remote stop function for mining equipment
- **ISO 23870** - Secure high speed mobile data communication gigabit onboard speed

Autonomy-Focused In-Progress Standards

There is also much work still to be done and the industry continues to work toward a better tomorrow. See below some autonomy-focused standards that are still in progress:

Advance Automated Mining Systems

- **ISO 3502** - Reference framework and architecture for advanced automation and autonomy

Agricultural Dairy & Livestock Machinery

- **ISO 3991** - Robotic feed systems — Safety

Earth-Moving Machinery and Mobile Road Construction Machinery

- **ISO 7334** - Taxonomy and vocabulary for automation and autonomy
- **ISO TS 15143-4&5** - Worksite data exchange: Parts 4 & 5
- **ISO 21815-4&5** - Collision warning and avoidance: Parts 4 & 5

Road Vehicles

- **ISO TS 22133** - Test object monitoring and control for active safety and automated/autonomous vehicle testing - Functional requirements, specifications, and communication protocol

Smart Community Infrastructures

- **ISO 37181** - Smart transportation by autonomous vehicles on public roads

About the Association of Equipment Manufacturers (AEM)

AEM is the North America-based international trade group representing off-road equipment manufacturers and suppliers with more than 1,000 companies and more than 200 product lines in the agriculture and construction-related industry sectors worldwide. The equipment manufacturing industry in the United States supports 2.3 million jobs and contributes roughly $316 billion to the economy every year.

AEM's robust history began 125-plus years ago from a unique vantage point – its industry segments came together to create a fundamentally more powerful voice and advocate for the off-road equipment manufacturing industry.

AEM built on the successes and continued the legacy of its founding groups – the Construction Industry Manufacturers Association (CIMA) and the Equipment Manufacturers Institute (EMI). Both groups had a common goal – advocating for better roads that brought products to market faster, safer, and more efficiently.

For more than a century, AEM has provided a manufacturer forum for industry-wide action that transcends individual member company size, product line, or individual business concerns. Companies participating in AEM work together for the betterment of the industry and public needs, at the state, national, provincial, and international levels. In enabling growth together, AEM and its members build momentum for equipment manufacturers and the ag and construction markets they serve.

6737 W. Washington Street, Suite 2400 | Milwaukee, WI 53214-5650 | aem.org