International standards and product globalization: "we're not in Kansas anymore"

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1. Introduction

In the 1929 classic movie, the Wizard of Oz, Dorothy arrives in the Land of Oz and utters to her dog Toto: "we're not in Kansas anymore" (**Fig. 1**). The phrase is now used in common language to mean: we are no longer in familiar surroundings [2]. The global consolidation of agricultural machinery producers over the last 20 years has changed product development from region specific to a more global approach. For example, machinery producers now need to understand the regulatory compliance requirements in all the markets a machine may be sold during the planning stages of product development. This puts product designer's in unfamiliar and uncomfortable areas of often conflicting requirements.

The increase in global information exchange by the internet and social media is also driving the globalization of markets. The development of larger, more productive agricultural machines produced in lower numbers creates the economic need for fewer product variants. Finally, the North American system of low government regulation and aggressive tort law coupled with search engines and access to global information is driving the need for common safety features across markets. In response to these issues especially in agriculture, North America is trending away from developing and relying on national standards in favor of adoption of international standards. To highlight the opportunities and problems associated with the development and adoption of international standards, let us discuss some examples in the following areas of standardization important to agricultural machines:

- General safety standards e.g. lighting and marking, visibility, braking, etc.
- ROPS: SAE, OECD, ISO, EN, ASABE, OSHA (acronym soup)
- Safety of Electronic Control Systems: ISO 25119, EN 16590
- Testing and performance standards: communication to the market
- Off-road diesel exhaust emission regulations
- Future areas of standardization: Sustainability, Safety of Highly Automated Agricultural Machines, etc.

Let us also discuss the need for standards development to be broad based and inclusive vs. monopolistic or protectionist with regard to both markets and stakeholders. We will also explore how some cultural practices and regional product differences will continue to inhibit international standardization.

Since 1918 in the United States, the American National Standards Institute (ANSI), a non-profit membership organisation, facilitates and promotes voluntary consensus standards and conformance assessment systems [3]. The development of an American National Standard (ANS) is accomplished by ANSI accredited third party Standards Development Organizations (SDOs). The SDO for the

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agricultural industry including agricultural field equipment is the American Society of Agricultural and Biological Engineers (ASABE). ANSI is the U.S. representative to the International Organisation for Standardization (ISO) and also accredits U.S. Technical Advisory Groups (U.S. TAGs). The U.S. TAG develops and transmits the U.S. positions for ballots and activities of the international Technical Committee (TC). ASABE serves as the U.S. TAG for ISO TC23 Tractors and Machinery for Agricultural and Forestry, among others.

Similarly, the Standards Council of Canada (SCC) accredits the Canadian Standards Association (CSA) to serve as Canada's SDO and ISO TAG for the agricultural machinery community.

2. General safety standards

In the U.S., ANSI/ASAE S318 is the current national standard that addresses the safety requirements of agricultural tractors and machines. This standard had its roots as recommendations dating from 1964 and as a national standard from 1973. It is interesting to study the latest version of this standard because it heavily references international standards ISO 4254 series, Agricultural machinery—Safety [4], and ISO 26322 series, Tractors for agriculture and forestry—Safety [5]. In fact, the first two requirements of S318 are that tractors shall comply with applicable parts of ISO 26322 and agricultural equipment shall comply with applicable parts of ISO 4254 unless otherwise specified [6]. The rest of the requirements in the standard then effectively become a list of items that are additive or are in conflict with the norms in the international standards. Happily, this is a relatively short list and we will examine a couple of examples later in this chapter.

It needs to be emphasized that in North America, ANSI/ASAE S318 and by reference, ISO 4254 and ISO 26322 are voluntary consensus standards. There are no regulations or laws that list them as requirements. That said the manufacturer of a product that does not conform to the requirements of these standards accepts considerable monetary risk in the event of an accident. U.S. tort law allows for real and punitive damages if it is shown the manufacturer was negligent in the design or manufacture of the product involved. Failure to conform to industry norms is difficult to defend in these cases. This is also a main driver for North American adoption of international standards because conformance to global norms is easier to defend. If there are national differences in requirements, someone can always maintain that one national approach is better than another. The advent of powerful search engines makes it now much easier to find these differences.

In Europe, specifically in European Union member states, the safety requirements for agricultural machines fall under the Essential Requirements of the EU Directive 2006/42/EC (known as the Machinery Directive). The European Committee for Standardization (CEN) was given a mandate by the EC to provide a means of conforming to this directive. CEN adopted EN ISO 4254 such that *"compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive"* [7].

The CIS countries, Australia, and China are also tending to adopt ISO 4254 either directly or with deviations.

Based on the above, it can be seen that a designer in Kansas developing an agricultural machine for the global market can be assured that one design that meets the requirements of the local market will also meet the requirements in most global markets for those features in the scope of ISO 4254. But this designer has to be very careful to check the definition of the scope because it is here that specific

exclusions point to where the different requirements lie between Europe and North America. Here is an excerpt from the scope of ISO 4254: *"This part of ISO 4254 is not applicable to hazards related to periodic service, machine conversion and repairs intended to be carried out by professional service personnel, environmental hazards, road safety (e.g. steering, braking), or to the power take-off (PTO) drive shaft; neither is it applicable to guards of moving parts for power transmission except for strength requirements for guards and barriers"* [4]. The last sentence is interesting as it points to an example where a possible cultural difference has driven variation between markets. Agricultural machines in Europe may operate more often with untrained or unauthorized people in the vicinity. Therefore, movable guards require the use of a tool to open to ensure only authorized persons have access and the access is intentional. In North America, due to the generally remote agricultural areas, agricultural machines rarely operate with unauthorized people nearby. The controlling concern in this case is that if a guard is difficult to open for maintenance access because it requires a special tool, it may be disassembled from the machine and therefore be unavailable to protect against the underlying hazard. This exception was placed in the scope in order to facilitate a globally relevant text and with the aim of trying to find a global solution to this issue in future versions of the standard.

Tractors, trailers, and towed machinery in Europe currently fall under EU Directive 2003/37/EC Type Approval and the single directives below it [8]. For trailers and towed machinery, EU 2003/37 applies to road safety only and all other safety aspects are covered by the Machinery Directive 2006/42/EC. The requirements for tractors in ISO 26322 are harmonized with like requirements in the type approval but unlike the direct coupling of EN ISO 4254 with the machinery directive, no mechanism currently exists outside of committee diligence to ensure harmonization is maintained in detail. For this reason, ISO 26322 tends to be used in countries outside of EU while the legal requirement of 2003/37/EC is used directly inside the EU. In the case of tractors, the tractor designer has no recourse but to be intimately aware of both sets of requirements. At the moment, a single design solution will work for the scope of requirements in ISO 26322 and the corresponding requirements in the EU tractor type approval. In this case, the reach of ISO 26322 is limited because it has not been adopted as an EN standard and referenced by the directive. However, a new EU regulation, 167/2013 [9], is being developed to replace the directive 2003/37/EC starting in 2016. While it will reference delegated acts that will initially contain language from the current directives, future development of the delegated acts in this regulation are promised to increase references to EN ISO standards, OECD codes, or UN ECE regulations. This development is being referred to as the Tractor Mother Regulation (TMR).

ISO 4254 and ISO 26322 are examples where international standardization has accomplished good results. Let us now go back to ANSI/ASAE S318 and consider some areas of general safety where the lack of global standardization is a problem.

2.1. Road Safety

In North America, ANSI/ASAE S318 has several requirements for travel on highways. The first is conformance to ANSI/ASAE S279 Lighting and Marking of Agricultural Equipment on Highways [10]. S279 has become referenced in several U.S. state and Canadian province laws and has recently been included in US federal traffic laws. As such it is now a legal requirement in the U.S. and parts of Canada for new machines. In the EU, lighting and marking requirements for agricultural equipment are subject to the laws of individual member states. There are several EEC directives that approximate the content of these laws. ISO 16154, Tractors and machinery for agriculture and forestry--Installation

of lighting, light signalling and marking devices for travel on public roadways, is an international standard that also addresses these requirements. A review of this standards' informative Annex E **(Table 1)** points out that even though the positioning and definition of the components can be normalized, the detail requirements for their use is complex and different between continents and countries [11]. This is an example where we have an international standard but it can only be informative where legal requirements conflict between markets and regions. When we have vehicle requirements that are written directly into laws and regulations, changes for commonality are much more difficult to achieve. This is due to a large increase in stakeholders whose knowledge base is further from the industry. Also, harmonization is difficult to maintain if key requirements are controlled in regional documents.

2.2. Braking

In Europe, the EU harmonized performance requirements for the braking systems of wheeled agricultural tractors are currently specified in Directive 76/432/EEC. This directive was last modified in 1996 and does not address tractors with speeds above 40 km/h or the trailers or towed machinery they pull on highways. These are currently left to national type approvals. Braking on self-propelled agricultural machinery is also handled by national approvals. Work is currently progressing on a delegated act within regulation 167/2013 (TMR) that will add requirements and expand the scope to cover tractors, trailers, and towed equipment up to 60 km/h and above. Also in development is ISO 12933 Agricultural tractors — Safety and performance requirements for braking. This international standard is at draft stage and is likely to be re-formulated pending decisions taken with the braking delegated act of the TMR. The historical national differences within the EU, especially concerning trailer braking, have complicated harmonization efforts.

In North America, ANSI/ASAE S318 references ANSI/ASAE S365, Braking System Test Procedures and Braking Performance Criteria for Agricultural Field Equipment for braking requirements. The scope of this standard includes both tractors and agricultural equipment. For a European designer of tractors marketed in North America, the minimum park brake performance requirement in this standard is particularly noteworthy. To paraphrase, the parking brake needs to hold the equivalent of 2.5 times the maximum weight rating for the tractor on an 18% slope [12]. This is more rigorous than the European equivalent of the maximum weight rating of a tractor on an 18% slope. Again, this difference can be traced back to the cultural practice and requirement for the use of chocks in Europe with no like requirement in North America. Per ANSI/ASAE S365, a trailer may weigh up to 1.5 times the weight of the tractor before trailer brakes are required, hence the parking brake requirement.

Braking is an example where an agreed international standard that could be referenced by regulations should be achievable and if structured sensibly, useful for lower horsepower, lower speed simple tractors as well as high horsepower, higher speed tractors with more elaborate control systems. Also needed is an EN ISO international standard addressing braking on self-propelled agricultural machines.

3. Rollover Protection Systems (ROPS)

ROPS standards and there progression on the international stage over the years is an interesting case study. The development of ROPS is a true success story in improvement of product safety in the agricultural industry. Tractor overturns were and are still a leading cause of fatalities in the agricultural

community. It has been shown in over 27 years of experience that rollovers involving fatalities with ROPS equipped tractors where the operator was wearing a seat belt are extremely rare [13]. Early developments in the Scandinavian countries in the early to mid-1950's had progressed through work in North America in the early 1960's when the first standards were developed. These standards were developed and maintained in the Society of Automotive Engineers (SAE) as well as in ASAE. It is interesting to note that these standards were technically harmonized but still existed as separate standards in two SDO's. Eventually, the problems created by small variations and the extra work involved in maintaining harmonization in two documents ended in an agreement between ASABE and SAE. ASABE now maintains the SAE J2194 standard and has withdrawn its' S519. Work is progressing on national adoptions of ISO 5700 and the eventual withdrawal of SAE J2194 depending on changes by OSHA of recognized standards. The Occupational Safety and Health Administration (OSHA) is the U.S. federal government entity responsible for regulating the workplace for improved worker safety. The regulation still in force in OSHA is CFR29, 1928 which dates back to 1975 and is a copy of SAE J334 circa 1968. See **Table 2** for ROPS standard numbers and their parent organization. Subsequent approvals by OSHA tested to SAE 1194, SAE 2194, ISO 5700, and OECD Code 4 are based on deviation letters stating that these standards afford a comparable level of safety as the original. This situation points out a problem when the inclusion of a standard into a regulation or law is accomplished by a cut and paste of the requirements in the standard. The regulation is then a snapshot in time of the standard and maintenance to accommodate corrections, updates, and improvements subsequently made in the standard involve much additional non-value added work.

For Europe, The Organisation for Economic Co-operation and Development (OECD), Tractor Codes and Schemes, develops and maintains ROPS codes. OECD consists of 34 member countries, including the U.S. and Canada, and maintains a ROPS certification mechanism through OECD test stations. This ROPS certification is recognized as a means of compliance with EU tractor directive 2003/37/EC. An alternate compliance method is available through third party approval of a test following ISO 5700 requirements. This is important as it provides an alternate competitive method especially for those tractor manufacturers not located in countries with OECD test stations. OECD Code 4 [14] is technically similar to SAE J2194 and is currently technically harmonized with ISO 5700. In fact, an effort was recently made to create a single harmonized ISO/OECD document which could be used by both organizations. This effort was made in response to lessons learned from the North American historical experience with the parallel SAE and ASAE ROPS standards. Even more important where standards are translated into several languages, any subtle language differences between the texts can become real technical misunderstandings between manufacturers, test stations, and regulatory agencies. This effort suffered a political setback and is not progressing currently.

As one can see however, we are presently quite close to a single document that could serve the needs of the regulatory requirements in North America and Europe, the test certification requirements, and tractor manufacturers from around the globe.

4. Safety of electronic control systems

ISO 25119, Tractors and machinery for agriculture and forestry—Safety-related parts of control systems, is a recently developed standard series dealing with the approach to the design and assessment of safety-relevant electrical and/or programmable electronic components. It considers all of the safety life cycle activities from inception to end-of-life for these systems. This international standard is

important to this discussion as it did not start as a regional or national standard but began life directly as an international standard. Its roots can be traced to standards used in industrial machinery and the automotive industry but its differences accommodate the vehicle types, the type of low volume production realities, and manufactures size often found in the agricultural industry.

In order to meet the regulatory requirements to be able to use this standard as a presumption of conformity in the Machinery Directive 2006/42/EC as well as possible reference in the TMR, this standard needed to become a CEN harmonized standard. Hopefully only for the reasons of speed, CEN initiated a parallel standard, EN 16590, which is currently in the voting stages for adoption. EN 16590 is a direct copy of ISO 25119 with a few changes of some "should" recommendations in ISO 25119 to "shall" requirements in EN 16590. ISO TC23 SC19 subcommittee has established a new working group (WG8) to re-harmonize ISO 25119 with EN 16590 by making the same changes (already in the working drafts) as well as provide a section to expand on the concept of "proven in use" used in the automotive industry. The goal (hopefully) is to eventually replace EN 16590 with an updated and CEN harmonized EN ISO 25119 version at the end of the efforts of this new working group.

This situation points to the perception that development of an ISO standard and speed is not synonymous. ISO has made recent structural changes in order to accommodate the changes to a standard that are occasionally required at fast turn-around times. Hopefully, these will help maintain single harmonized and global documents.

5. Testing and performance standards

Some standards are used to communicate relevant harmonized data about a vehicle to the end user. Examples of such standards are the ISO 789 series and OECD Code 2 [16]. The ISO 789 series is currently being revised and is in a working draft stage to harmonize with the latest OECD Code 2 revisions. PTO power, hydraulic power, hydraulic lift, and drawbar power and fuel consumption tests are all examples of standardized information on tractor features that help the end user make informed buying decisions. The State of Nebraska in the U.S. is currently one regulatory body that requires certified OECD tests of tractors to obtain and disseminate this information. However, competition by the manufacturers in the areas of power, fuel economy, and three-point hitch lift performance has maintained demand for the tests by manufacturers in broader markets. In the past, end users were more concerned with peak power and whether a specific tractor delivered the productivity promised. Recently, end user interest has moved toward efficiency. Because of this, interest in efficiency at common partial power use and with mixed outputs is being considered for future revisions of OECD Code 2.

The point of this example is that even where an international standard has enjoyed a long period of global harmonization, factors can arise that can challenge its relevance and cause a change in emphasis. Also of note: standards can foster competition and use it to produce desired results.

6. Off-road Diesel exhaust emission regulations

Europe, North America, and Japan currently have almost harmonized their regulations for non- road diesel engine exhaust emissions. However, managing implementation timing differences and flexibility provisions has added employment to the agricultural industry. EU Stage IIIB and US EPA Tier 4 Interim emission level products are transitioning to Stage IV / Tier 4 Final products within the

next couple of years in these three markets. However, the global situation is more of a challenge. There is general agreement on what each emission level's requirements are and the fuels and testing to support those levels. However, the current emission levels in regulations and the timing of implementation of more stringent emission levels in important agricultural markets are far from harmonized. Refer to **Figure 2** for a simplified view of the global situation. It can be seen that the important markets of Russia, China, India, Australia, and Brazil are moving to more restrictive emission levels but they are not harmonized in those levels or their timing [17]. They range from a Stage IIIA requirement in Russia to a Tier 4 Final requirement in Australia and Stage IIIB levels in Brazil, India, and China (timing for agricultural applications may also differ from other non-road applications and the overall timing is still very fluid).

Tractors and machinery designed with Stage IIIB and Stage IV technology engines have had a much larger effect on the machine design than earlier emission stages. Also, these engines and emissions equipment added significant cost to the product. Manufacturers generally have chosen to add new features and benefits to these machines so there is more value added to offset the costs of emission improvements. This now leaves manufacturers with a dilemma: continue producing previous lower feature designs for these lower volume markets alongside new designs with the explosion of parts and logistics that creates; or re-certify de-tuned new designs for lower emission levels.

Consider another point regarding global standardization: harmonization of the implementation timing of a global standard is important to reduce variation. Implementation timing can also cause barriers to trade across markets.

7. Future areas of standardization

The following are some examples of international work underway in new areas of standardization in agricultural machines. These are not meant to be an exhaustive list but are examples of standardization efforts begun at the international level on a broad basis.

A recent initiative in the area of sustainability has produced an effort by ISO TC23 WG4 to develop an industrial process standard similar to ISO 9000/9001 quality management standards. This work is early in development at committee draft stage (ISO CD 17989-1) at this writing. The standard focuses on the design, development, and production of agricultural machinery and how to consider three performance indicators of sustainability: economic, environmental, and social. This is a standard that will be designed to encourage continual improvement.

ISO TC23 SC3 is currently developing (working draft stage) a standard ISO WD 18497, Highly Automated Agricultural Machine Safety. The intent of this standard is to provide guidance in safety aspects of the development of agricultural machines that can operate without an operator present. Properly developed, this guidance will not only be useful to developers of these machines but also help define the regulations that will undoubtedly arise in this area.

8. Conclusions

International Standards help companies access new markets, level the playing field for developing countries, and facilitate free and fair global trade. They ensure that products and services are safe, reliable, and are of good quality. They are strategic tools for business that reduce costs by minimizing

waste and errors, and increasing productivity.

From the examples above, we have seen that the scope of standard is an important device that can at best define the limits and breadth of the standard and at worst be used to carve out regional exceptions to harmonization. The more exceptions and deviations an international standard has, the more product variations are created, and the more explanations that are required to an uninformed judge or jury.

The road safety standards teach us that if a standard competes with local regulations, its usefulness is maintained only as long as harmonization is maintained. The strength and usefulness of an international standard is proportional to the breadth of its adoption and inversely proportional to national deviations in requirements and limitations of scope. If possible, regulations that reference international standards are preferable because any changes in requirements are accepted by all stakeholders in one text. Paraphrasing or translation errors due to maintenance of multiple texts do not exist. There is no time lag when requirements change because multiple documents are not maintained.

The ROPS standards instruct us that with large effort and perseverance, an international harmonized standard developed from many entrenched regional standards referenced by multiple regulatory bodies may even be possible.

Differences in implementation and adoption timing between the market regions where standard is used can have an effect on true product commonality and barriers to markets.

Developing international standards may not be fast but it is getting faster. Also, standards need to evolve in order to maintain relevance. The communication revolution has provided the tools needed to more easily include global stakeholders in standards development and to more readily maintain and develop relevant standards.

Going forward, if product designers had portfolios of applicable international standards that were adopted and referenced where needed by national or regional bodies and that allowed access to the global marketplace, they would be in familiar and comfortable places.

References

[1] **QuotesPics,** 2013. Available at: http://quotespics.com/toto-ive-got-a-feeling-were-not-in-kansas-anymore-2/. Accessed 4 October 2013

[2] **Wiktionary,** 2013. Available at: http://en.wiktionary.org/wiki/not_in_Kansas_anymore. Accessed 4 October 2013

[3] **American National Standards Institute,** 2007. Overview of the U.S. Standardization System, Second Edition. Available at: http://www.ansi.org/about_ansi/introduction/introduction.aspx?menuid=1

[4] **ISO 4254** (all parts)**,** Agricultural machinery—Safety, ISO, Geneva, Switzerland

[5] **ISO 26322** (all parts), Tractors for agriculture and forestry—Safety, ISO, Geneva, Switzerland

[6] **ANSI/ASAE S318.17 JUN2009**. Safety for Agricultural Field Equipment, **4.1-4.2**, ASABE, St. Joseph, Michigan

[7] **EN ISO 4254-1:2013.** Agricultural machinery—Safety, **Annex ZA**, CEN, Brussels, Belgium

[8] **Directive 2003/37/EC** of the European Parliament and of the Council, 2003. Type-approval of

agricultural or forestry tractors, their trailers and interchangeable towed machinery, EC, Brussels, Belgium

[9] **Regulation (EU) No 167/2013** of the European Parliament and of the Council, 2013. Approval and market surveillance of agricultural and forestry vehicles, EC, Brussels, Belgium

[10] **ANSI/ASAE S279.17 JUL2013**. Lighting and Marking of Agricultural Equipment on Highways, ASABE, St. Joseph, Michigan

[11] **ISO 16154: 2005**, Tractors and machinery for agriculture and forestry —Installation of lighting, light signalling and marking devices for travel on public roadways, **Annex E,** ISO, Geneva, Switzerland

[12] **ANSI/ASAE S365.8 MAY2007.** Braking System Test Procedures and Braking Performance Criteria for Agricultural Field Equipment, **9.2.2**, ASABE, St Joseph, Michigan

[13] **Job R., 2008.** Roll-Over Protective Structure Development; an Industry Perspective, **12-13, Table 1,** ASABE Paper 83751, 2008 ASABE Annual Meeting, ASABE, St. Joseph, Michigan

[14] **OECD Code 4, 2012**. OECD Standard Code for the Official Testing of Protective Structures on Agricultural and Forestry Tractors (Static Test), OECD, Paris, France

[15] **ISO 25119 (all parts), 2010.** Tractors and machinery for agriculture and forestry--Safety-related parts of control systems, ISO, Geneva, Switzerland

[16] **OECD Code 2, 2012**. OECD Standard Code for the Official Testing of Agricultural and Forestry Tractor Performance, OECD, Paris, France

[17] **Cummins Emission Solutions, 2012**. Off-Highway Emissions Regulations, Bulletin 4973778, Cummins Emission Solutions, Columbus, IN, USA

Figure 1 - "We're not in Kansas anymore". *Source: [1]*

Figure 2- Global Emissions Regulations. *Source: [17]*

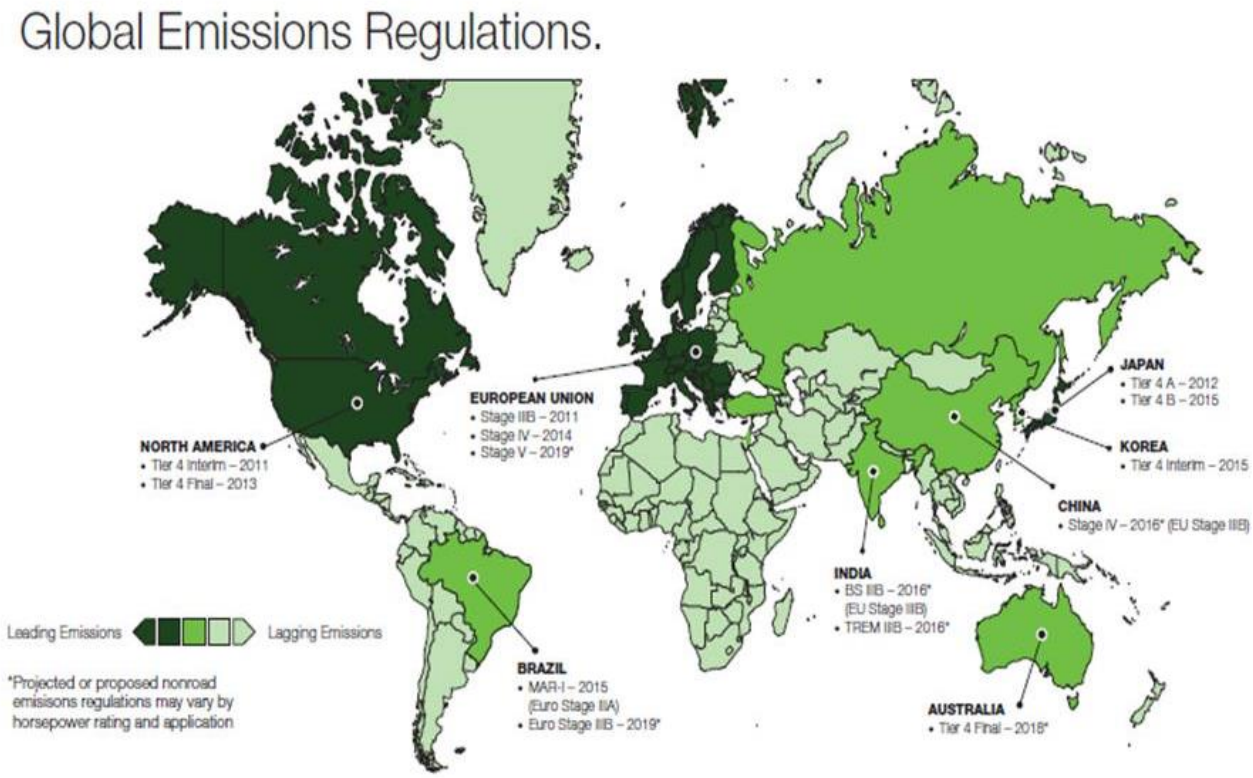

Table 1 - Other requirements for lighting and marking devices, *Source: [11]*

Requirements for the presence of lighting and marking devices are the subject of various regional standards and/or regulations. For information, these are summarised as follows for the EEC and North America.

EEC requirements			
Device	**Tractor**	**Self-propelled machine**	**Trailer, trailed or mounted implement**
Dipped-beam headlamp	R	R	NP
Main-beam headlamp	O	O	NP
Work lamp	O	O	O
Reversing lamp	O	O	O
Front-position lamp	R [a b]	R [a b]	R [a b c]
Rear-position lamp	R [b]	R [b]	R [b d]
End-outline marker lamp	NP/O [a e]	NP/O [a e]	NP/O [a e]
Stop lamp	R [o]	R [o]	R [o]
Front direction indicator lamp	R [q]	R [q]	O
Rear direction indicator lamp	R [q f]	R [q f]	R
Hazard warning signal	R [g]	R [g]	R
Special warning lamp	O/R [h]	O/R [h]	O/R [h]
Rear registration-plate lamp	R	R	R
Front fog lamp	O	O	O
Rear fog lamp	O	O	O
Rear retro-reflectors	R [b i]	R [b i]	R [b i]
Rear fluorescent marking	NR	NR	NR
Front retro-reflector	NR	NR	R a
Side retro-reflector	R [j k l]	R [j k l]	R [j k l]
Slow-moving vehicle emblem	O/R [h]	O/R [h]	O/R [h]
Signaling panel	R [h m]	R [h m]	R [h m]
Implement connector	O [n]	O [n]	O [n]

R--Required O--Optional NP--Not permitted NR--No requirement

[a] Colour shall be white for front facing devices.
[b] Distance from outer edge shall be no greater than 400 mm.
[c] Required if the distance between the outer edge of the towed vehicle and the outer edge of the position lamp of the towing vehicle exceeds 400 mm.
[d] One required if width u1,20 m; two required if width > 1,20 m.
[e] Not permitted if width u 2,10 m; optional if width > 2,10 m.
[f] Tractors and self-propelled machines designed to tow trailers shall have turn indicator tell-tale(s) to indicate trailer turn indicator operation.
[g] Tell-tale for hazard warning shall be red.
[h] Dependent on national regulations.
[i] Shall have two not higher than 1 200 mm above ground.
[j] Colour shall be amber.
[k] Required if vehicle length exceeds 6 000 mm.
[l] May be fitted on centre of wheel(s).
[m] Required on vehicles > 2,55 m. wide.
[n] Required only if the self-propelled machine is designed to tow a trailer or trailed implement.
[o] Not less than 500 mm apart. This distance may be reduced to 400 mm if the overall width is less than 1 400 mm.
[q] Arrangement (see Directive 78/933/EEC, Appendix 3).

North American requirements			
Device	**Tractor**	**Self-propelled machine**	**Trailer, trailed or mounted implement**
Dipped-beam headlamp	R	R	NP
Main-beam headlamp	O	O	NP
Work lamp	O	O	O
Reversing lamp	O	O	O
Front-position lamp	O	O	O
Rear-position (tail) lamp	R	R	R [a]
End-outline marker lamp	O	O	O
Stop lamp	O	O	O
Front direction indicator lamp	R [l m]	R [l m]	R [b l m]
Rear direction indicator lamp	R [l j m]	R [l j m]	R [b l j m]
Hazard warning signal	R [h]	R [h]	R [b c h]
Special warning lamp	O	O	O
Rear registration-plate lamp	O	O	O
Front fog lamp	O	O	O
Rear fog lamp	O	O	O
Rear retro-reflectors	R	R	R [d]
Rear fluorescent marking	R if W > 3,7 m	R if W > 3,7 m	R if W > 3,7 m
Front retro-reflector	R if W > 3,7 m	R if W > 3,7 m	R if W > 3,7 m
Side retro-reflector	O	O	R if L > 5 m
Slow-moving vehicle emblem	R	R	R [e]
Signaling panel	O	O	O
Implement connector	R [f]	R [f]	R [g]

R--Required O—Optional NP--Not permitted

[a] Required if the rear position (tail) lamp on the propelling machine is obscured.
[b] Required if the corresponding lamp on the propelling machine is obscured.
[c] Required if the width of trailer, trailed or mounted equipment is greater than 3,70 m in road transport configuration, or if the equipment extends more than 7,60 m to the rear of the hitch point, or if the equipment extends more than 1,80 m to the left or right of the centreline and beyond the left or right extremity of the propelling machine.
[d] Required if the trailer, trailed or mounted equipment extends more than 1,20 m to the rear of the hitch point of the propelling machine, or if the equipment (including front mounted equipment) extends more than 1,20 m to the right or left of the centreline of the propelling machine. No retro-reflectors are required on the rear of front mounted equipment for a horizontal distance of 1,20 m on either side of the centreline of the propelling machine.
[e] Required if the trailer, trailed or mounted equipment extends more than 5 m to the rear of the hitch point of the propelling machine, or if the slow moving vehicle emblem on the propelling machine is obscured.
[f] Tractors and self-propelled equipment not primarily used with agricultural trailers, trailed or mounted equipment are excluded from this requirement.
[g] The connector location and cable length shall be compatible with the location of the receptacle on the tractor or self-propelled machine.
[h] Lamps shall flash in unison at a rate at least 20 flashes per minute less than the turn indication flash rate.
[i] When a turn is signaled, the direction indicator lamps opposite the direction of the turn shall become steady burning and the direction indicator lamps in the direction of the turn shall flash at a rate of 85 to 110 flashes per minute. Turn indication shall over-ride the operation of the hazard warning signal.
[j] Additional rear facing red or amber lamps conforming to SAE J2261, mounted according to the requirements for rear-position lamps shall operate in conjunction with the turn indicator lamps. The additional lamp on the side in the direction of the turn shall flash in unison with the direction indicator lamps. The additional lamp on the side opposite the direction of turn may remain off, or on, or become brighter but shall not flash. These lamps may be reciprocally incorporated with the rear-position lamps. They shall not flash as part of the hazard warning signal.
[k] Required if width of equipment is greater than 3,70 m in road transport configuration.
[l] Required if the equipment extends more than 5 m to the rear of the hitch point of the propelling machine in road transport configuration
[m] Distance from outer edge shall not be greater than 400 mm when road transport width is greater than 3,70 m.

Table 2 - ROPS Standard Numbers and Their Effective Date, *Source: [13]*

Org.--Year	1960-1969	1970-1979	1980-1989	1990-2000	2000-201-
ASAE/ASABE	S305-S306 (1968)	S306.3-S336-S383	S519(1987)		
SAE	J333(1968)-J334(1968)	J334-J168(1970) J1194(1975)	J2194(1987)	J2194	J2194
US OSHA	---	CFR29,1928 (1975)	CFR29,1928	CFR29,1928	CFR29,1928
ISO	---	---	3463/5700 (1981)	3463/5700	3463/5700
OECD	Code 3 (196-)	Code 3	Codes 3 & 4 (1984)	Codes 3 & 4	Codes 3 & 4