Legal Requirements Versus Customer Requirements in Machine Cab Design

Lates Daniel(✉)

George Emil Palade University of Medicine, Pharmacy, Science, and Tehnology of Targu Mures, Târgu Mureș, Romania
daniel.lates@umfst.ro

Abstract. This paper deals with the problem of legal requirements related to the requirements formulated by customers regarding the equipment cabs. In order for a cab to be used on roads, it must meet certain requirements that correspond to the directives in force. Customers would like to have the most spacious cab, the widest possible field of vision, ergonomics, while the legislation requires first of all to respect the safety requirements of the passenger and the proper use of the equipment from which it is made. Some of these aspects will be presented in the paper and as a methodology it will start from the legal requirements that are in force.

Keywords: Cab · Homologation · Customer requirements · Legal requirements · ROPS testing · FOPS testing · Field of view · Windows

1 Legislative Framework

The cab is used on any motor vehicle, on wheels or tracks which has at least two axles, the function of which consists essentially in its traction force and which is specially designed for towing, pushing, carrying or operating certain machines, machinery or trailers intended for use in agricultural, forestry, construction, etc. [1].

Approval of a cab means the procedure whereby the approval authority certifies that a type of vehicle, system, component or separate technical unit complies with the applicable administrative stipulations and technical requirements [2].

Approval is required to ensure that the cab meets all technical and safety requirements so as not to endanger the somatic integrity of the driver. The tractor cab is particularly important given that it is the area of the vehicle in which the driver of the vehicle operates, consequently, the component of the vehicle that has exclusive direct contact with it, and in case of accident or failure can damage it. The equipment cab must meet a series of requirements and norms according to ISO Standards, EU Directives and Regulations, but also international ones [3].

Approval authorities shall ensure that manufacturers applying for type-approval comply with their obligations under the Regulation. The homologation authorities homologate only those cabs that comply with the requirements of Regulation 2013–167, art.6. [3].

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2 Customer Requirements

Customers would like to have the most spacious cab, with air conditioning and audio systems as high as possible, field of view as large as possible, the possibility of using outdoor video cameras, ergonomics on the seats, operator seat and passenger with regulation and relaxation possibilities, while the legislation requires first of all to respect the safety requirements of the passenger and those in traffic as well as the part of the compliant use of the equipment of which it is part.

Customers are of the opinion or have reason to assume that the placing on the market or putting into service of the vehicle, system, component or separate technical unit is not in accordance with the regulations or delegated or implementing acts adopted in on that basis, it shall immediately take the necessary corrective action to restore the conformity of the vehicle, system, component or separate technical unit or to withdraw or recall it, as appropriate [3].

The manufacturer's intervention in this process is to inform without delay the approval authority that granted the approval, providing, in particular, details of the non-compliance and the corrective measures taken [4].

3 Cab Design

3.1 Making Design by Manufacturers

Manufacturers shall ensure that vehicles are designed, constructed and assembled in such a way as to minimize the risk of injury to the occupants of the vehicle and others in the vicinity of the vehicle.

- Manufacturers shall ensure compliance of vehicles, systems, components and separate technical units with the applicable requirements set out in the Regulation, including requirements relating to:
- integrity of the vehicle structure;
- systems that provide the driver with visibility and information on the condition of the vehicle and the surrounding area, including windows, mirrors and driver information systems;
- vehicle lighting systems;
- vehicle occupant protection systems, including interior fittings, head restraints, seat belts, doors;
- heating systems;
- devices to prevent unauthorized use;
- vehicle identification systems;
- masses and dimensions;
- rear protection devices;
- lateral protection, etc.

3.2 Field of Vision

These requirements ensure market competitiveness, by constantly pursuing that all components, assemblies and subassemblies of the product are of high performance, instead the machine cab requires a wider field of view (Fig. 1 and Fig. 2) to facilitate when handling the machine, therefore, additional windows are added between the bonnet and the extremities of the tractor to allow the driver of the machine to see exactly where he is stepping on the wheel, in order to avoid certain undesirable accidents during use.

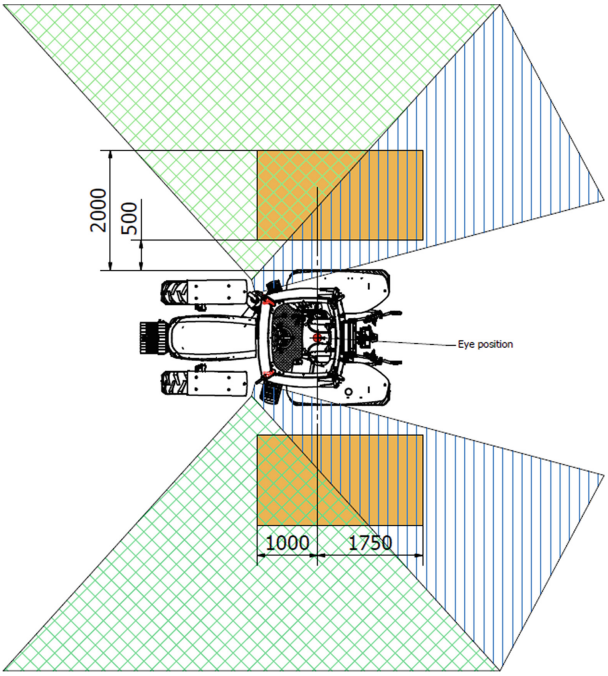

Fig. 1. Side field of vision.

The lighting conditions of a machine must ensure that drivers have optimum visibility during the night of at least 30 m from the reference point of the machine both in front and in the rear, especially for forestry, agricultural and construction equipment.

For an optimal field of vision at night, work projectors are mounted to ensure a lighting surface in accordance with the legislation. These additional projectors can be mounted with a 360º orientation on the inside of the ceiling to ensure extended visibility.

The lighting conditions also include the signal lights corresponding to the road traffic: headlights with road light, with passing light, direction indicator lights, etc.

When choosing the type of cab, the rules concerning the glass elements of the cab must also be taken into account. The glass of the windscreen, rear window and side windows must be a safety glass supported (Fig. 3) by a protective membrane, taking into account the percentage of glass components of the agricultural tractor cabs, the fractions of which in the event of an impact, be of very small dimensions, which do not cause

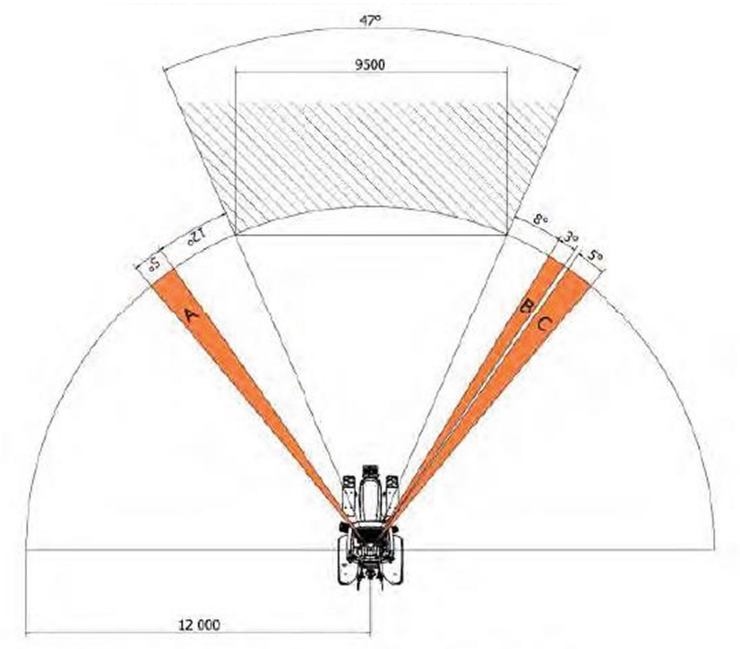

Fig. 2. Field of vision.

injury to the driver, if the membrane is pierced by objects and fails to support the broken glass [3].

Fig. 3. Broken secure windshield.

In order to be approved, the cab must meet a number of conditions in accordance with Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on technical equipment. Looking at things more explicitly, the legislation in force

provides certain regulations and standards directly on the product in question, regulations and rules much stricter and more explicit in the Delegated Regulation (EU) No. 1322/2014 Of the Commission From 19 September 2014 [5], as well as Commission Implementing Regulation (Eu) 2015/504 From 11 March 2015, [6]. This Regulation lays down detailed technical requirements and test procedures for the design, construction and assembly of the vehicle for the approval of agricultural and forestry vehicles and their systems, components and separate technical units, detailed modalities and requirements for type-approval, virtual tests and conformity of production, technical specifications regarding access to vehicle repair and maintenance information, as well as performance standards and technical service evaluation criteria in accordance with Regulation (EU) No 182/2011. 167/2013 [2].

The technical equipment sector is an important part of the construction industry. The cost of a number of accidents caused directly by the use of technical equipment can be reduced by the safe design and construction of technical equipment, its proper handling and maintenance. In order to be considered safe, the equipment must comply with the safety conditions and regulations imposed by the legislation in force. These rules are particularly important, given that it is about the safety of the operator and implicitly his life [3].

In view of the nature of the risks involved in the use of the technical equipment provided for in this Directive, procedures must be established to assess compliance with the essential health and safety requirements of the operator. These procedures must be developed in the light of the degree of inherent danger involved. Manufacturers should bear full responsibility for certifying the conformity of their technical equipment with the provisions of this Directive. However, for certain types of technical equipment, with a higher risk factor, a stricter certification procedure is recommended.

According to Directive 42 of 2006, a process of risk assessment and reduction must be carried out. The manufacturer or his authorized representative must:

- to establish the limits of the technical equipment, which includes the anticipated destination and any possible inappropriate use;
- to identify the dangers that may be generated by the equipment and the dangerous situations associated with them;
- to estimate the risks, taking into account the severity or possible injuries or damage to health and the probability of their occurrence;
- assess the risks in order to establish the need to reduce the risk in accordance with the objective of this Directive;
- eliminate hazards or reduce the risks associated with hazards by applying protective measures [7].

3.3 Performing Virtual Tests

The technical service must provide a test report on the results of the virtual test. The test report must be clear, consistent with the correspondence report and the validation report and must include at least the following elements: creation of a virtual prototype, input data and simulation results in terms of the technical requirements imposed.

3.4 Requirements Applicable to Rops Protection Structures (Roll-Over-Protective-Structure - Against Rolling Over)

Protective structure in the event of an overturning means the structure provided on a tractor with the essential purpose of avoiding or limiting the risks to which the driver is exposed if the tractor overturns during normal use. The ROPS tests (Fig. 4) have the role of ensuring the observance of safety norms regarding the deformability of the cab, this must not have a deformability that enters the free space of the driver and neither its elements or subassemblies which can injure the person by deforming or detaching them when the cab impacts the ground. In this sense, virtual and physical tests are performed that simulate the impact of the cab with the ground from different positions (front, rear, side and vertical) to test the resistance of weldable elements, but also prefabricated elements [9].

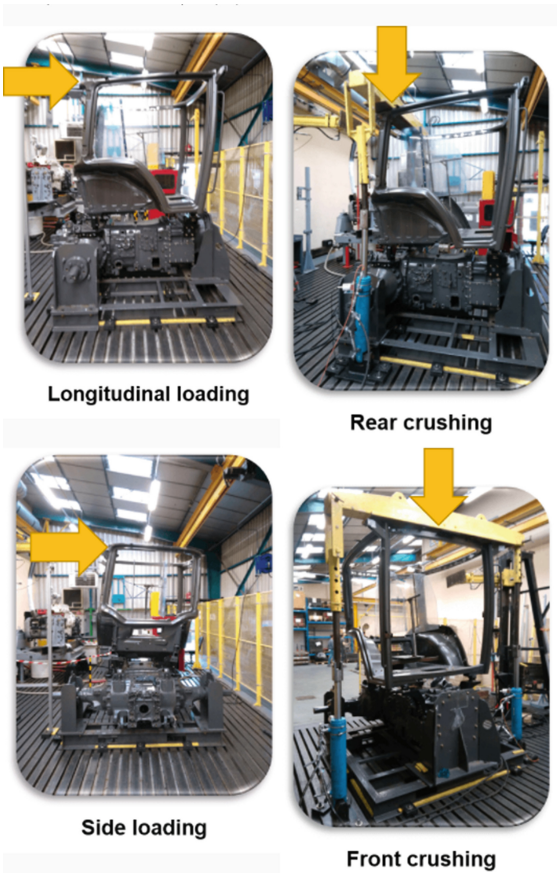

Fig. 4. The four phases of the ROPS test [8].

The ROPS test (Fig. 5). is not a "dynamic" test by sending a car into the wall. We use a hydraulic cylinder to push slowly cab beams in four directions (rear push, side

push, rear flattening, front flattening). By regulating manually the pressure inside the hydraulic cylinder through the piloting system (third party manufacturer), and knowing its section area, the test operator is able to control the force/displacement and energy injected into the cab to follow the homologation standard [8].

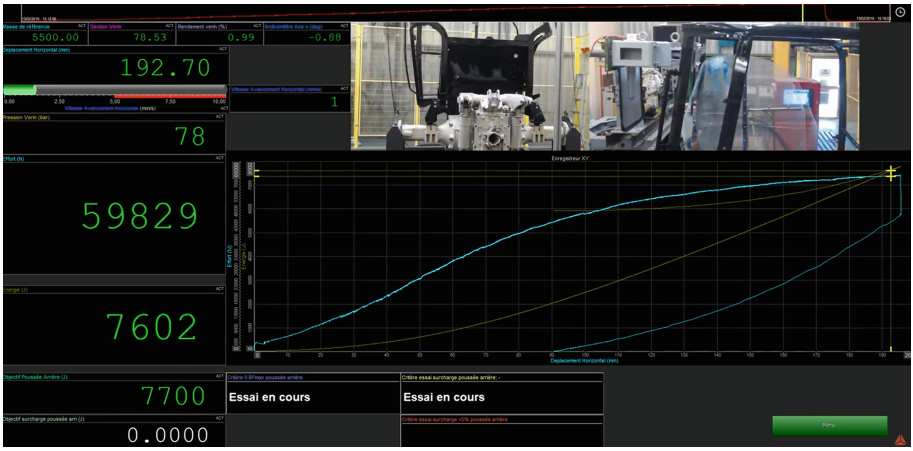

Fig. 5. ROPS cab testing [8]

3.5 Requirements for FOPS Protection Structures (Falling-Objects-Structure - Resistance in Case of Heavy Objects Falling from Above)

Assembly which protects, in the event of a fall of objects, the area above the head of an operator in the driving position. The protection structure may be manufactured by the tractor manufacturer or by an independent company. In both cases, the test is valid only for the tractor model which has been tested.

The protection structure must be tested for each tractor model on which it is to be mounted [3]. The protective structure under test shall include at least all components that transfer the load from the impact area with the falling object used for the test to the safety area. The protective structure under test must be rigidly attached to the test bench at its normal points of attachment (Fig. 6).

Fig. 6. FOPS cab testing [10].

4 Conclusions

The legislation is the one that says its last word, while the clients are the only ones who can come up with proposals and suggestions that are analyzed by the specialist and then regulated by law in terms of security and operator comfort. The regulations established at European and international level want to regulate a process of studying the risk and reducing it.

Machinery manufacturers must manufacture cabs that comply with the regulations in force and meet customer requirements, but these requirements must not be above the law.

The legislatively regulated visual field wants the cabs to have the best possible overview both front and side and rear so that the operator of the equipment can observe any road danger.

ROPS and FOPS tests add to the operator's safety in case of overturning or falling objects, and not to endanger his life. The ergonomics of the cab also depend on the cab manufacturer and his experience, who will consult with customers so that the stress is as low as possible and the handling of the machine is a pleasure.

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