

## CONSIDERATIONS REGARDING THE CONDITIONS OF USING TRACTOR-TRAILER COUPLING DEVICES

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**Keywords:** coupling device, resistance, deformation, mobility, tractor

### ABSTRACT

*Coupling devices can be one of the main causes of accidents on public roads due to the use of inadequate systems (both on tractors and also on trailers or agricultural machinery), this mainly due to the fact that the systems in question were built most of the times without taking into account the national, European and international regulations that are in force. The paper presents a few aspects regarding the coupling (traction) devices, the conditions of use and the tests that are necessary to be performed for approval before being used on public roads.*

### INTRODUCTION

The need to increase transport safety and security is one of the priorities pursued at EU level and in Romania, due to the increasing number of accidents that occur annually in this area.

The safety and security in transportation is one of the important directions pursued at EU level as well as in Romania, due to the number of people using the means of transport especially of numerous accidents that occur annually in this area. In this respect, Romania occupies a leading position in Europe as number of accidents occurred at 1,000 of cars - almost twice the average of the EU countries [1].

In order to reduce as much as possible the injury or death of persons involved, in addition to the solutions of legislative order, administrative and of road traffic have sought solutions by testing of all components that contribute to the increase of transportation safety and security.

In the case of agricultural machines and equipment testings is more special the problem because their use is seasonal, depending on the works that must execute. For resolving this situation at present tend to generalize the tests in simulated and accelerated regime in laboratory conditions.

At internal level and internationally there are a number of rules such as: STAS, SR ISO, ISO, EEC Directives and ECE-UN, with requirements regarding the technical conditions and of mechanical strength of the tractors, of trailers and of some component elements of tractors and trailers (the traction devices), in terms of traffic safety on public roads in Romania and their acceptance into traffic [2].

These coupling elements between tractor and trailer are:

- the traction devices of wheeled tractors;
- the towing eyelets for biaxial or single axle trailer.

The technical conditions and regulated in order to achieve of new coupling systems for tractors, trailers and agricultural and forestry machines, harmonized with the European rules, in order to increase the traffic safety and the degree of interchangeability.

One of the main reasons why it is necessary to study these devices is due to the multitude of accidents caused in operation as well as in circulation by the inappropriate use of coupling systems (on tractors or trailers), that are not achieved in accordance with internal rules and European.

Referring concretely to coupling systems of tractors, of trailers and of machines designed to work in agriculture or forestry, the condition that they be realized and meet the same rules lies, on the one hand from the need to have the possibility of coupling between them of all the equipment of the same type existing on the European and Romanian market and, on the other hand, from the fact that these coupling systems (of linking) are elements of safety in exploitation but especially in road traffic [1].

The development directions known in the art, takes place on the line classification of all types and ranges of products produced under conditions determined by rules, primarily European ones, such as directives and regulations EEC, regional or national, such as the internal rules specific to each country, but elaborated according with the European ones, precisely in order to give a unified note, universality and interchangeability in the use of the products referred [2].

If for the majority of tools and equipment used in agriculture and forestry there is a certain freedom of expression in terms of their achievement (constructive, functional etc.) for the coupling systems, elements that contribute to operational safety and traffic imposes strict conditions by the national and European rules on the construction, operation parameters, mounting conditions etc. which must be respected.

In Romania as well as in other European countries, on the road, in particular, recorded variations from year to year and from country to country depending on engine index rise, the state of the road network, of economic development of the country concerned in general and especially of the motor transport.

Based on some studies on the road traffic with zonal applicability, urban as well as on the entire national road network and of systematization studies of the localities in Romania, yearly the road traffic records substantial improvements. Despite these sustained measures of organization and improvement of the road traffic, the level of road traffic safety especially is still far from being satisfactory, still recording a high number of traffic accidents involving significant damage and loss of human life [5].

An important role in this undesired statistic it has the agricultural and forestry transport represented by the systems tractor - trailer or agricultural machine, although the their participation in the public traffic is occasional.

Most of these accidents occurred as a result of of an inadequate general technical condition or of some malfunctions to the safety components, including at the coupling systems, of the agricultural and forestry equipments involved.

An important source that can provoke incidents and road accidents is also the fact that some tractors and farm equipment are not provided with proper coupling systems [7].

The coupling systems are devices fitted on the towing vehicle and are used for coupling and towing various trailers and agricultural or forestry machines provided with towing eyelets or coupling forks.

## **MATERIAL AND METHOD**

Over time there have been various classifications of coupling systems, classifications made on the basis of certain criteria considered representative of the authors in question were based on the main technical elements which must be respected when making a right sleeves in terms of operation and of the compatibility between components of the system tractor – machine. These criteria relate primarily to the following:

- the type of the trailer or of the machine in the aggregate;
- the constructive type and functional dimensions of the coupling systems;
- the mounting position on tractor;
- permissible horizontal and vertical loads on the coupling systems.

## RESULTS AND DISCUSSIONS

### 1. Types of coupling systems mounted on tractor

The coupling systems mounted on the agricultural and forestry tractors, in order to towing or coupling of trailers or machinery can be mounted in front or behind the tractor and are classified as follows [3, 4, 6].

#### ◆ Devices mounted in front of the tractor

- ✓ *Towing device - front* – is designed for towing the tractor in case of accidental malfunctions and its support can also have the function of fixing the front counterweights;
- ✓ *Three-point suspension mechanism - front* - is a hydraulically actuated mechanism from the tractor's hydraulic system intended for the coupling of agricultural machinery carried in front of the tractor;
- ✓ *Triangle of coupling - front* - it is intended for coupling the tractor with the machines carried in front of it. It can be mounted to the three-point suspension mechanism or it may be an integral part of the machine which engages.

#### ◆ Coupling systems mounted behind the tractor

The coupling systems mounted behind the tractor are the most numerous and also the most used because most of trailers and agricultural and forestry machines working behind it.

- ✓ *Three-point suspension mechanism - Rear* - is intended for the coupling of the agricultural machines carried behind the tractor and is actuated by its hydraulic system;
- ✓ *Quick coupling mechanism in three points - rear* - is intended for the rapid coupling of the agricultural machinery and is mounted on the three-point suspension mechanism rear.
- ✓ *Drawbar with holes* is a device intended to the coupling of various agricultural machinery towed behind the tractor. The bar is mounted in the lower coupling points specially provided, in the lower coupling points of the three-point linkage or on own supports;
- ✓ *Traction device lower rear for single-axle trailers* - is intended for coupling the trailers with central axle(s) or single axle (trailer with rigid hitch, to which the axle or the group of axles is located behind the center of gravity of the vehicle considered as uniformly loaded); the hitch must not transmit to the coupling device a static vertical load less than 10% of the maximum trailer mass or of maximum 1000 kg (it retains the smallest of these). The actuation of this device is done via the tractor's rear linkage arms.
- ✓ *Traction device lower - rear* - is intended for coupling of towed agricultural machinery. The coupling point is positioned against the PTO axle. The device is mounted behind the tractor and it is independent of the three-point suspension mechanism;
- ✓ *Traction device lower - rear with bolt* - is intended for coupling of trailers by a bolt, having a system of insurance against the accidental switching off;
- ✓ *Traction device lower-rear with a hook* - is intended for coupling of trailers and of agricultural machinery through a hook which can take over also vertical loads having a system of insurance against the accidental switching off;
- ✓ *Traction device upper - rear U type* - is intended for coupling of trailers and of agricultural machinery, having the ability to take over also vertical loads. This type of device can also exist in the version with damper for the shock mitigation and can take over vertical loads.
- ✓ *Traction device upper - rear with automatic coupler* - is generally intended for the coupling of trailers. This type of device can also exist in the version with damper for the shock mitigation. This type of coupling does not take over vertical loads.
- ✓ *Traction device for low trailers* - is intended for towing of low trailers.

## **2. Types of coupling systems for trailers and agricultural and forestry machines**

If for the coupling systems which is mounted on the towing vehicle (tracting) have been identified a variety of types and settings of them, for the towed vehicle (trailers, agricultural and forestry machinery) there are three ways of coupling to the tractor, as follows:

- coupling through the eye (eyelets) for towing;
- coupling by means of the towing fork;
- coupling by means of coupling triangle.
- ✓ *Towing eye* - is a coupling system which is designed to equip trailers and sometimes general and the agricultural or forestry machinery, from case to case, which may have different constructive forms, except the actual coupling element which is standardized both nationally and at European level, situation that will be detailed in the following chapters.
- ✓ *Towing fork* - is intended for coupling of agricultural machinery to the towbar with holes mounted on the three-point linkage or directly on own supports.
- ✓ *Coupling triangle* – is intended for coupling the agricultural machinery carried or semi - carried on the three-point linkage.

### **3. Current stage in the field of coupling systems**

If in the manufacture of tractors and machinery for agriculture and forestry there is a total freedom of expression in terms of the component elements that contribute to operational safety and traffic imposes strict conditions on the construction, operation and mounting positions, all of which set in domestic or European rules to be observed for the achievement of the European Single Market and to harmonize these rules.

However also in the field of safety features are met situations in which partially does not comply the European Norms, this fact is due principally to the following two reasons, namely:

- to the problems of purely technical and technological in the sense that to fully align to the single European rules, the major manufacturers of security features in general and of coupling systems in particular, must develop new technological line of manufacturing, which means additional expenses that even the richest producers can not allow in a short time, which is why the the alignment to the rules mentioned is achieved gradually;
- the tendency of some European countries to oppose the globalization, trend generally manifested from a nationalism exaggerated sometimes, with the clear target to protect the producers, this manifesting itself when is about adoption of these European standards. But generally those countries aspiring to membership statute make efforts and in most cases they did it to adopt and comply literally the rules in the field.

In Romania – the coupling systems for agricultural and forestry tractors and machinery have developed different time, uneven and chaotic, this being due to several factors, among which we can mention: the manifested monopoly on the construction of tractors especially; to the modifications occurred too often concerning the elaboration of the internal norms, norms that were developed by structures that had the obvious interest to protect their products; there were no specialized producers in coupling systems offering to the market a sufficiently wide range designed to meet the needs of the other manufacturers; for the reasons mentioned above, the other producers have tried to solve the problems each as they could, most of the time in disagreement with current regulations, this being the main reason why the collective who coordinates this project decided to solve this stringent problem for the industry of machines designed to agriculture and forestry in Romania.

Internationally – also in the manufacture of coupling systems, as in the whole industry of tractors and agricultural machines performed by the companies of prestige and tradition worldwide, were realized ranges and sizes of the most varied, especially the European market being already saturated, a lot of companies passing their name into the catalogs with safety elements available on the market. Besides the tractor manufacturers, which have every interest to achieve their own coupling systems, are known many other renowned companies having developed a production structure specialized in assemblies and sub-assemblies for tractors and machinery designed to agriculture and silviculture.

Among the best-known companies that produce coupling systems we can enumerate: JOHN DEER, LANDINI, MASSEY FERGUSON, CASE, NEW HOLLAND, STEYR, ZETOR etc., companies that produce tractors and agricultural machinery as primary products and partially coupling systems and ROCKINGER, RIMA, PEITZ, KNOTT etc. which are specialized in components for tractors, trailers and agricultural machines and implicitly in coupling systems. In the following we present some of the products of these companies, with the mention that it identifies all the types presented above, both in classical and in specific forms, depending on their destination.

### 3.1. Coupling systems for tractors

The great tractor manufacturers produce their own and coupling systems for these, generally the tractors are delivered with two or three types of systems, depending on the beneficiary requirements. In Figure 1 is shown the three-point coupling system invented between 1920 - 1926 by Harry Ferguson.



Fig. 1. Three-point linkage on a Ferguson 35 tractor / Rear three-point hitch of a Case IH tractor with implement attached by the drawbar [8]

In Figure 2, 3, 4 are presented the models of the JOHN DEER company.



Fig. 2 a. Suspension mechanism front [9]



Fig. 2 b. Rear upper coupling [9]



Fig. 3 a. Quick Coupling Mechanism + coupling bar [9]



Fig. 3b. Quick coupling for single axle trailer [9]



Fig. 4a. Rear lower bolt device [9]



Fig. 4 b. Lower back Device with ball [9]

At the SIMA exhibition - Paris 2015, John Deere has won a silver medal at the Innovation category for the system AutoConnect (figure 5), designed to connect fully the tractor with the agricultural aggregates without that the operator to leave the tractor seat. It allows the automatic coupling of hydraulic, electrical and of power systems.

Figure 6 presents a front coupling triangle pattern for agricultural machinery carried, manufactured by the GOLDONI company.



Fig. 5. AutoConnect System [10]



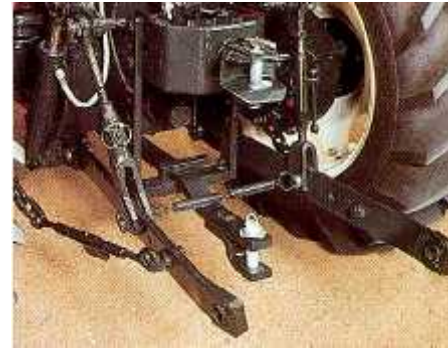
Fig. 6. Front coupling triangle [11]

Figure 7 presents some coupling systems mounted on tractors made by the company MASSEY FERGUSON. In Figure 8 are presented coupling systems of the company ZETOR.





**Three-point suspension mechanism**  
**Fig. 7. Rear upper coupling automatic, coupling bar [12]**



**Fig. 8. Rear upper coupling, coupling bar [13]**

In figure 9 there are presented some coupling systems mounted on tractors manufactured by VALMET company.



**Fig. 9. Three-point suspension mechanism, rear lower coupling with hook, coupling bar [14]**

ROCKINGER and GKN Walterscheid companies are famous for the coupling systems (Figure 10 and 11), the devices, and the security elements and not merely made by these for tractors and road trains.



**Fig. 10 - Coupling systems made by the Rockinger company [15]**



**Fig. 11. Coupling systems made by the GKN Walterscheid company [16]**

In Figure 12 are shown coupling systems manufactured by the Danish company He-Va ApS:



Fig. 12. Coupling systems [17, 18]

The Indian firm Mahindra manufactures coupling systems (figure 13) for equipping the tractors with power ranging between 15-85 HP.



Fig. 13. Coupling systems produced by the company Mahindra [19, 20, 21]

In Figures 14 and 15 is shown the automatic coupling system equipping the Fendt Vario tractors with powers between 70-400 HP.



Fig. 14. Rear coupling system Fendt Vario [22]



Fig. 15. Front coupling mechanism Fendt Vario [22]

## CONCLUSIONS

The links between the towing vehicles and towed vehicles are connecting mechanical elements of a particular importance for the safety of the traffic on the public roads, which operated improperly may become generators of traffic accidents as a result of their tearing, when the towed vehicle remains without the directional control and can collide with other vehicles from traffic or with other obstacles met in its way.

The coupling systems are mounted on the towing vehicle and are used for the coupling and towing of various semitrailers and farm technical equipment fitted with towing eyelets or coupling forks, generally kinematic couplings.



The coupling systems of tractors, trailers and the equipments intended to work in the agricultural field impose the condition that these to be carried out and to meet the same standards on the one hand to exist the possibility of coupling between them of all the machinery of the same type existing on the market, and on the other hand, from the fact that these coupling systems (link) are elements of safety in exploitation but especially in the road traffic. For the coupling systems, elements that contribute the functional safety and traffic are imposed strict conditions through national and international norms regarding the construction, the operational parameters, mounting conditions etc. which must be strictly observed.

#### ACKNOWLEDGMENT

The work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/187/1.5/S/155536, within the project entitled „Knowledge, innovation and development through doctoral scholarships" (CID-Doc).

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