Testing Technical Systems in Plant Protection According European Standard *EN 13790* in Republic of Croatia

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SUMMARY

In order to obtain the certificate of tested machinery, two mistblowers (*Hardi Zaturn* and *Hardi Arrow*) are reviewed by the employees of Agricultural faculty in Osijek. This certificate is needed with Croatian entry in the EU and with the inheritance of the *2009/128/EC* and *2006/42/EC* directives. This regulative is provided for mandatory review of technical systems in plant protection (mistblowers and boom sprayers). New laws were introduced in Regulation on sustainable use of pesticides (*NN 142/12*), according to which all devices in crop protection until the November, 2016 must have a label on the regular technical overview. Devices manufactured before 1995, must have a label until November, 2014. Due to the aforementioned problems and approaching deadlines, directive becomes current and they should be given additional significance. So in this paper are presented the main aspects of new regulations.

Key words: mistblower, nozzle, pump, pressure gauge, handler, testing, *EN 13790* standard

INTRODUCTION

According to the new Regulations on sustainable use of pesticides (effective from December, 2012 in Croatia; *NN 142/12*), all technical systems in plant protection must have a label on the regular technical overview. These regulations are already effective on many countries of the EU through the European directive *2009/128/EC* and *2006/42/EC* (Tadić, V., 2013). Therefore, the testing is performed by the European standard for testing technical systems in plant protection - *EN 13790.* According to this standard, the most important parameters to be examined are: nozzle flow, pump capacity, pressure gauge, the return of the liquid into the tank, the number of RPM[1] from PTO[2], and many other parameters that are under visual inspection (Banaj, Đ. et al., 2012; Rotteveel, A., 2012; Wehmann, H.J., 2012). Testing of technical systems in crop protection in some countries of the EU (Deutschland, Belgium,

[1] revolutions per minute, min^{-1}
[2] power take off

Netherlands) began nearly twenty years ago (Van Wenum, J., 2012; Herbst, A., Ganzelmeier, H., 2002), and in others since 2007. (France, Spain, Portugal), Nunes, P. et al. (2012). The main reasons of poor condition of the machines are pressure gauges and nozzles covered over 60% of all faults (Banaj, Đ. et al., 2010). Similar condition is recorded in Belgium (Declercq, J. et al., 2012) where are the most often malfunctions caused by defective pressure gauges (26% of all malfunctions) and nozzles (27% of all malfunctions).

MATERIALS AND METHODS

Testing included two mistblowers, with different system of airflow: axial mistblower (*Hardi Zaturn*) and radial mistblower (*Hardi Arrow*), Figure 1.

Figure 1. Mistblowers *Hardi Zaturn* (left) and *Hardi Arrow* (right)

The tests were carried out with the equipment of Agricultural faculty in Osijek, Department for Agricultural Machinery. Measuring of pump capacity is conducted with the electromagnetic gauge (*Krohne Company*), Figure 2. According to *EN 13790* standard, pump must achieve a minimum capacity of 90% with respect to the nominal.

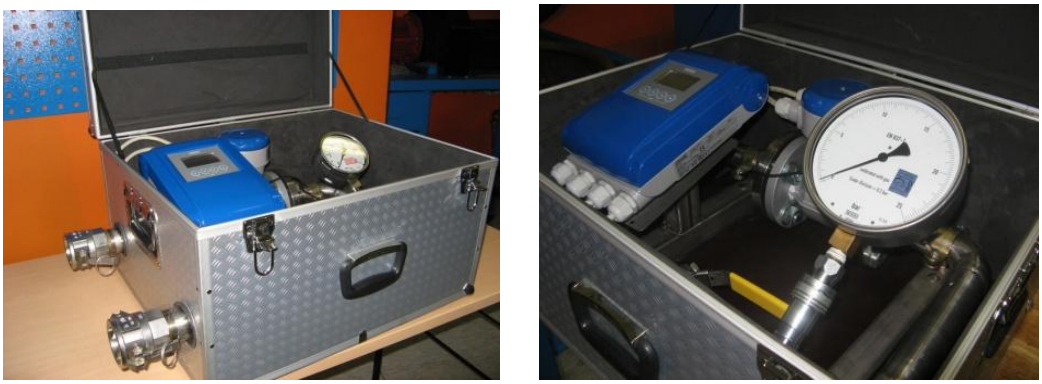

Figure 2. Electromagnetic gauge for capacity of pump

Correctness of the pressure gauge is conducted with measuring on the *Volos* device. This device has a test gauge with working certificate, according to *EN 837 - 1* standard (class of accuracy 06 with measuring range to 25 bar). On *Volos* device (Figure 3.), test pressure gauge is set with the pressure gauge which we must test. According to *EN 13790* standard, all pressure gauges must have a minimum diameter of 63 mm (located on the technical systems in plant protection). The maximum deviation that pressure gauges can generate, according to standard are:

- ± 0,2 bar in measuring range from 0 to 2 bar,
- ± 10 % in measuring range over 2 bar.

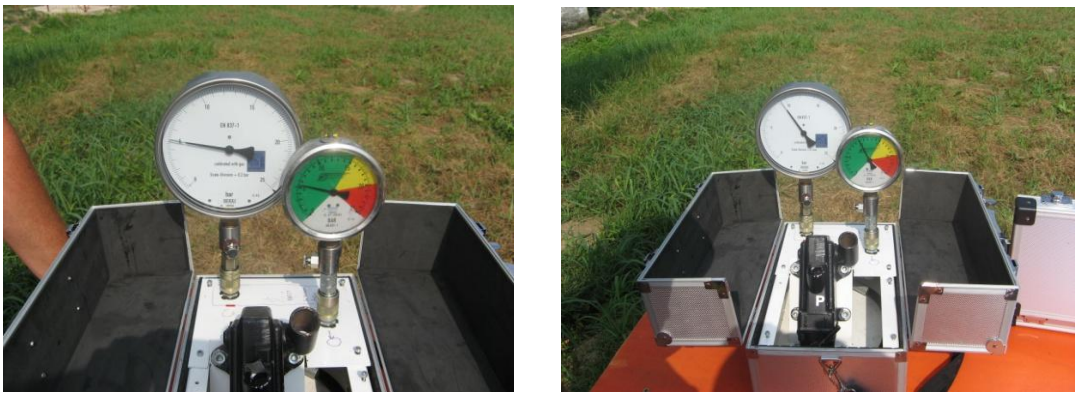

Figure 3. Device for testing working pressure (*Volos*)

The nozzles are first tested in the laboratory on desktop - electronic device, which contains portable computer, device for water flow with valves, *AAMS* (*Advanced Agricultural measuring systems*) flow meter and control pressure gauge, Figure 4.

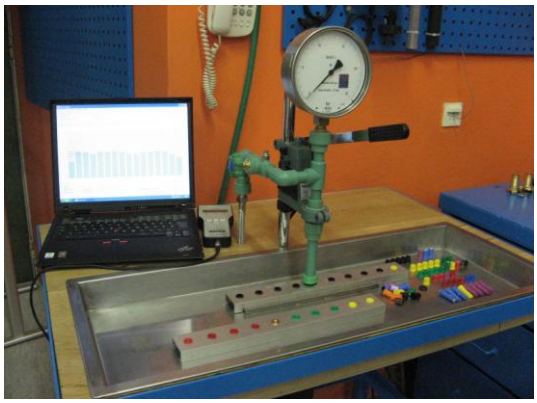

Figure 4. Desktop - electronic device for measuring nozzle flow

The flow measurement of blue, yellow and green *Lecher TR 80* nozzles are conducted. After laboratory flow measurement on desktop – electronic device, nozzles were set on tested mistblowers, and once again flow measurement is conducted, but in exploitative conditions with *Volos II* device, Figure 5.

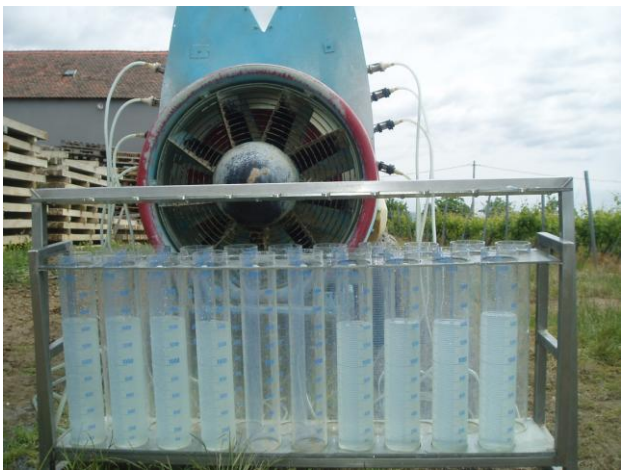

Figure 5. The device *Volos II* for measuring nozzle flow on mistblower

In addition to these three main measurements (pump capacity, nozzle flow and pressure gauge), the measurement of RPM from PTO was carried out with optical meter *Kimo* (two tractors in investigation) and the measurement from liquid turn back into the tank was conducted with *Krohne* flow meter. The integrity of three tanks, occurrence of liquid drippings, and an overview of all the other components of mistblowers was carried out visually.

RESULTS

Results of nozzle flow measuring

In investigation ten new blue (*TR 8003C*), yellow (*TR 8002C*) and green (*TR 80015C*) *Lechler* nozzles *(Ulmer Straße 128, Metzingen, Deutchland)* is used. Flow measurement was repeated four times for each nozzle, and the measurement results are shown in Table 1.

Table 1. Results of measuring nozzle flow

Type of nozzle (*Lechler*)								
TR 80015C			***TR 8002C***			***TR 8003C***		
$\overline{X}$, l/min	σ	*C.V.*, %	$\overline{X}$, l/min	σ	*C.V.*, %	$\overline{X}$, l/min	σ	*C.V.*, %
0,64	0,008	1,32	**0,84**	0,008	0,91	**1,23**	0,011	0,90

By measuring the flow rate, it has been established that green nozzles had an average flow of 0,64 l/min; yellow of 0,84 l/min and the blue ones had the liquid flow of 1,23 l/min. By repeating the measurement of nozzle flow, the results did not vary greatly, so relatively small

coefficients of variation are determined (1,32% for green nozzle, 0,91% for yellow nozzle and 0,90% for blue nozzle). Also, determined average nozzle flows are in correspondence with the results determined on *Volos II* device. According to *EN 13790* standard, permitted deviation of nozzle flow from *ISO 10625* standard can be up to 10% with respect to the nominal capacity. All tested nozzles generate liquid flow in allowable tolerances (*TR 80015C* deviation of 6,80% or 44 ml/min; *TR 8002C* deviation of 5,30% or 45 ml/min and *TR 8003C* deviation of 2,79% or 35 ml/min), and the results are shown in Table 2.

Table 2. Nozzle flow deviation from *ISO 10625* and *EN 13790* standard

Type of nozzle	Average flow*, l/min	Deviation from *ISO 10625*, %	Allowed deviation from *EN 13790*, %	Deviation from *ISO 10625*, ml/min	Allowed deviation from *EN 13790*, ml/min
TR 80015C	0,64	6,80	10	44	60
TR 8002 C	0,84	5,30	10	45	80
TR 8003 C	1,23	2,79	10	35	120

* measuring at working pressure of 3 bar (*ISO 10625* standard)

Results of measuring pump capacity

Pump capacity is determined with the electromagnetic flow meter (*Krohne*) at 540 RPM of PTO. The measuring has repeated four times for each pump (measurement in four minutes with result recording in every minute), and the results are shown in Table 3.

Table 3. Results of measuring pump capacity

	Pump model - *Hardi 363* (capacity of 140 l/min)					
	Hardi Zaturn			***Hardi Arrow***		
	Pump flow, l/min	Deviation from *EN 13790*, %	Deviation from *EN 13790*, l/min	Pump flow, l/min	Deviation from *EN 13790*, %	Deviation from *EN 13790*, l/min
$\overline{X}$	**132,98**	**5,02**	**7,03**	**131,05**	**6,39**	**8,95**
σ	0,28	0,20	0,28	0,24	0,17	0,24
C.V., %	0,21	3,92		0,18	2,66	

By measuring the pump capacity it has been established that the pump installed on *Hardi Zaturn* had an average capacity of 132,98 l/min, and the pump installed on *Hardi Arrow* had an average capacity of 131,05 l/min. During the capacity measurement, the results did not vary greatly, so relatively small coefficients of variation are determined. According to

EN 13790 standard, permitted deviation of pump capacity from mentioned standard can be up to 10% with respect to the nominal capacity. Both of the pumps generate capacity in allowable tolerances (5,02% for pump installed on *Hardi Zaturn* and 6,39% for pump installed od *Hardi Arrow*).

Results of measuring pressure gauge correctness

Measuring of pressure gauge correctness is conducted with the *Volos* device. Measurements were repeated four times for each measuring range, and the results are shown in Table 4.

Table 4. Results of measuring pressure gauge correctness

Measuring range, bar	***Hardi Zaturn***				***Hardi Arrow***			
	Agromehanika Cl. 1,6 – 63 mm				*Wika EN 837-1,* 100 mm			
	$\overline{X}$, bar	*C.V.*, %	Deviation*, %	Deviation*, bar	$\overline{X}$, bar	*C.V.*, %	Deviation*, %	Deviation*, bar
3	**3,05**	1,89	1,64	0,05	**3,13**	1,60	4,00	0,13
5	**5,05**	1,14	0,99	0,05	**5,13**	0,98	2,44	0,13
10	**10,13**	0,49	1,23	0,13	**10,25**	0,56	2,44	0,25
15	**15,23**	0,33	1,48	0,23	**15,20**	0,54	1,32	0,20
20	**20,25**	0,29	1,23	0,25	**20,33**	0,25	1,60	0,33

*Deviation from *EN 13790* standard

With conducted measurements of pressure gauge correctness (pressure gauges installed on *Hardi Zaturn* and *Hardi Arrow* mistblowers), based on the results showed in Table 7., it is determined that both of tested pressure gauges are working within the allowed deviations according to *EN 13790* standard.

Results of other measurements

According to *EN 13790* standard, during the work of tested mistblower, liquid flow back into the tank should be 10 - 15% with respect to the volume of the tank. So, minimal liquid return must be 100 l/min for both of the tested mistblowers (tank capacity of 1.000 l). The measuring is conducted with the *Krohne* flow meter with four time repetition for each mistblower (measurement in four minutes with result recording in every minute), and the results are shown in Table 5.

Table 5. The return of the liquid in the tank

Hardi Zaturn – tank volume of 1.000 l				*Hardi Arrow* – tank volume of 1.000 l			
Pump capacity, l/min	Working pressure*, bar	Total nozzle flow**, l/min	Theoretical return of the liquid, l/min	Pump capacity, l/min	Working pressure*, bar	Total nozzle flow**, l/min	Theoretical return of the liquid, l/min
132,98	6,90	18,60	114,38	131,05	6,90	18,60	112,45
Measured liquid return into the tank							
$\overline{X}$, l/min	*C.V.*, %	Liquid return, %	Min.***, l/min	$\overline{X}$, l/min	*C.V.*, %	Liquid return, %	Min.***, l/min
114,16	0,30	**11,41**	100	111,82	0,26	**11,18**	100

*Adjusted operating pressure
**10 nozzles *TR 8002C* in operation
*** Minimum required return of liquid according to *EN 13790* standard

Determined average liquid return into the tank for *Hardi Zaturn* mistblower is 114,16 l/min (or liquid return is 11,41%), and for *Hardi Arrow* mistblower is 111,82 l/min (or liquid return is 11,18%). With these results, both of the tested mistblowers ensure the required standard. With the main measurements, under the visual inspection are following parameters: cleanliness of the filter and his mark, occurrence of dripping/leaking of liquid during and after operation, integrity of the tanks, PTO and fan protection, integrity of pipes and other. With visual inspection, all systems of mistblowers show compatibility with the *EN 13790* standard. During the testing, *Hardi Arrow* was aggregated with *Fendt 209P Vario* tractor, and *Hardi Zaturn* was aggregated with *John Deere 5615F* tractor. On both of the tractor we measured the RPM of PTO (optical meter from *Kimo Company*, model *CT100 O*), Table 6.

Table 6. The results of measuring PTO rotation

Repetition	*Fendt 209P Vario*		*John Deere 5615F*	
	Measured number of rotation, min^{-1}	Deviation*, %	Measured number of rotation, min^{-1}	Deviation*, %
1.	536,00	0,74	539,00	0,19
2.	537,00	0,56	539,00	0,19
3.	536,00	0,74	538,00	0,37
4.	538,00	0,37	537,00	0,56
$\overline{X}$	**536,75**	**0,60**	**538,50**	**0,32**

* Deviation from number of PTO rotation according to control panel of tractor

At *Fendt* tractor we determined an average speed of 536,75 min^{-1} from PTO rotation (deviation of 0,60% to the control panel of the tractor), and at *John Deere* tractor this number was 538,50 min^{-1} (deviation of 0,32% to the control panel of the tractor).

CONCLUSION

By testing of both sprayers (*Hardi Zaturn* and *Arrow*) according to *EN 13790* standard, it is concluded that the machines are technically correct and they are performing an application within the limits of permissible deviation. Both of the machines are recorded and entered into the FIS system and they received a label on performed technical overview.

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