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Fuel dispensers in Slovenia - Between compliance and fairness

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Abstract

High level of public and legal interest concerning fuel dispensers' measurements accuracy is always present. Surveillance of dispensers prior to 2013 reported undesired high error values. To limit possibilities of systematic favoring of single parties Slovenian national regulative was adapted. In year 2013 value of maximum permissible error at periodic verifications for higher flow rates of fuel dispensers was reduced.
After one verification period passed Surveillance service of Metrology Institute of the Republic of Slovenia (MIRS) performed a surveillance of fuel dispensers seeking feedback information on implementation of modified requirements.
On over 150 petrol stations over 300 nozzles serving four different fuel types were controlled at two different fuel flow rates. More than 600 evaluated control results showed among others, that the average measured error at maximum flow rate Q_{max} amounted up to + 0,23 %, depending of the fuel type. Almost all measured errors were in line with the metrological requirements, 76 % of which however appeared to be in favor of the petrol station owner. Average deliveries at Q_{max} were less favorable to an end customer than deliveries at Q_{min}.
After another verification period surveillance was performed again. Average measured errors showed further reduction. Measurements also improved their symmetry.
Compliance of measuring instruments is not hindered by adapted regulative, while level of measurement fairness is apparently elevated.

1. Introduction

Public and legal interest concerning fuel dispensers and their reliable measurements is always strong. Customer complaints and media responses considering doubtful fuel quantity measurements on petrol stations arise occasionally.

The Metrology Institute of the Republic of Slovenia (MIRS) is a body that performs multiple roles: it acts as a legislative advisory, verification office and well as the market surveillance authority. Fuel dispensers are not verified by MIRS itself but by three external enterprises. They are all accredited control bodies and are both authorized and surveilled by MIRS.

Thence the possibility and obligation to survey and react to the market, protect customers and enforce metrological legislative requirements.

As a legislative advisory office, in 2013 MIRS adopted national regulative [1] allowing diminished maximum permissible errors (MPE) for fuel dispensers (Table 1). The idea was to take advantage of technical capabilities of state of the art measuring instruments and limit both excess errors as well as the extent of a potential systematic favoring of a single party.

Table 1: Maximum permissible errors for fuel dispensers prior and after adoption of national regulation in year 2013

	Periodic verification		In-service control	
	< 2013	> 2013	< 2013	> 2013
Q_{min}	0,5 %	0,5 %	1,0 %	0,5 %
Q_{max}	0,5 %	0,3 %	1,0 %	0,5 %

Diesel road fuel demand in EU-28 members is still on the rise and is amounted to 265,3 Mt in 2017 [2]. Shifting measuring results for only 0,1 % i.e. only one fifth of MPE, would therefore represent a significant impact.

To evaluate implementation of adopted regulative after time span of one verification period MIRS surveillance authority performed targeted surveillance on more than 150 petrol stations across Slovenia.

After another verification period passed surveillance was repeated and the impact of the adapted national regulative was validated.

2. Test method

Surveillances were performed by trained MIRS officers following standard surveillance procedure derived from the accredited verification method.

2.1 Standards

According to the fuel flow rate Q of a single control appropriate standard volumes were used. Either $10\ l$, $50\ l$ or $200\ l$ standards (Figure 1) were used. Standards are regularly calibrated with a reference temperature of $15\ ℃$.

Figure 1: Used measurement standards (**$10\ l$** and **$50\ l$**)

2.2 Temperature impact

Albeit annual mean air temperatures in Slovenia (Figure 2) are in general below reference temperature of $15\ ℃$ and one party may potentially be favored it is not required in Slovenia for fuel dispensers to deliver fuel quantities compensated to a reference temperature.

Test measurements are instant and no correction of a measured error due to a difference of a fuel temperature in a fuel dispenser and in a standard is done. Same goes for a correction of an error due to a temperature difference between standard reference temperature and fuel temperature.

Both corrections are transposed into measurement uncertainty. Together with other uncertainty contributions the expanded uncertainty of a measurement with a coverage factor $k = 2$ is estimated to not exceed $U = 0{,}1\ \%$.

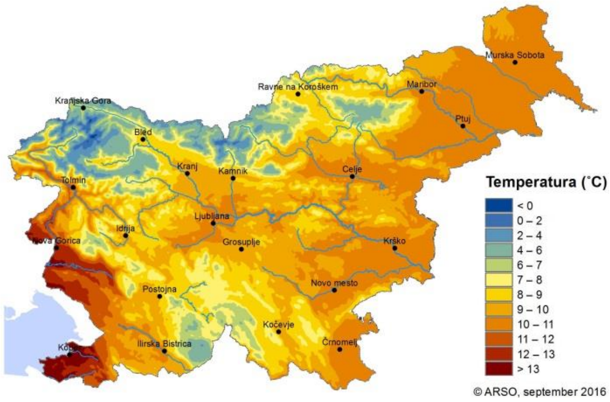


Figure 2: Annual mean air temperature in years 1981-2010 in Slovenia [3]

Measurement error is therefore calculated by Equation (1):

$$Err = \frac{V_d - V_s}{V_s} \times 100\ [\%] \qquad (1)$$

$V_d\ [l]$ … Volume measured by fuel dispenser

$V_s\ [l]$ … Volume measured by volume standard

3. First round of surveillance (2016)

Surveillance of fuel dispensers prior to 2013 detected certain measured errors to be up to 0,7 % or even 0,8 % in favor to fuel distributer. Although measured errors were in general in line with valid MPE (Table 1), MIRS believed customers could be protected even more.

An adapted national regulative with reduced MPE came into force in 2013 and systematic surveillance was done in 2016, i.e. after one verification period time passed. 325 fuel dispenser nozzles located on over 150 fuel stations across Slovenia were surveilled. Fuel dispensers were of eight different producers and delivered four different fuel types. Population of dispensers delivering Diesel and Gasoline 95 was big enough to allow discussion. Due to too small statistical relevance results gained on dispensers delivering Gasoline 100 and Heating Oil are not presented.

3.1 Results of 1st round of surveillance (2016)

Figure 3 presents measured errors of all, i.e. 105, tested fuel dispensers delivering Diesel fuel. Axis X presents consecutive count of a tested nozzle as rearranged for a presentation and axis Y measured errors.

Graph lines present errors measured while testing dispensers at minimum and maximum flow rate: $Err\ (Q_{min})$ – red colored and $Err\ (Q_{max})$ – green colored, bold line. Calculated average measured errors $Avg\ Err(Q_{min})$ and $Avg\ Err(Q_{max})$ are presented by two dashed lines of corresponding colors and line styles. MPE values for in-service control are noted by full black straight lines.

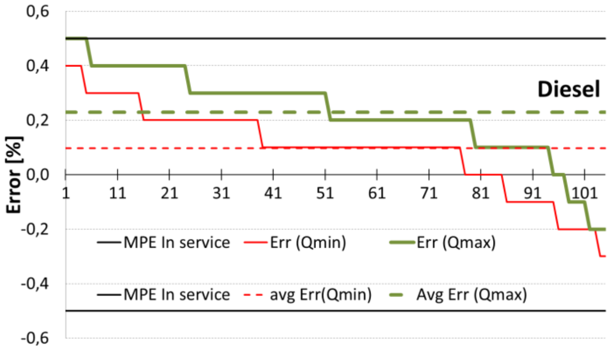


Figure 3: Errors of diesel fuel dispensers, *n* = 105 (2016)

All measured errors complied with MPE requirements for in-service control. Average calculated errors for Diesel nozzles are + 0,10 % for measurements, proceeded at Q_{min} and + 0,23 % for measurements, done at Q_{max}.

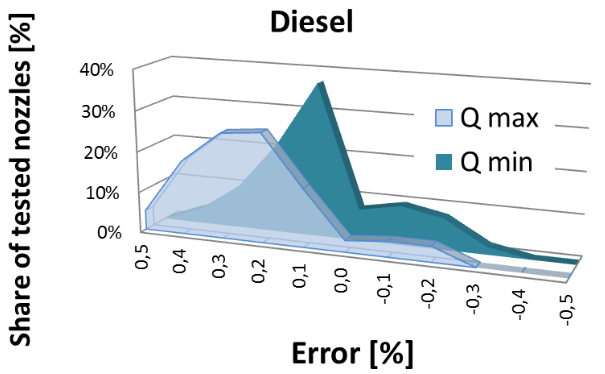
Values of calculated average errors belonging to nozzles delivering both considered types of fuel and for both fuel flow rates are given in Table 2.

Table 2: Average measured errors of 1st surveillance round (2016)

Fuel	No. of tests	$Avg\ Err\ (Q_{min})$	$Avg\ Err\ (Q_{max})$
Diesel	105	+ 0,10 %	+ 0,23 %
95	103	+ 0,10 %	+ 0,15 %

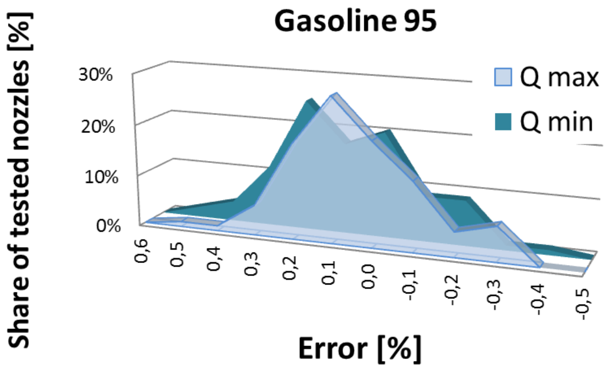
If average errors measured at Q_{min} are in a range of expanded measurement uncertainty, average errors measured at Q_{max}, at which flow rate most of deliveries are done, reach up to half the value of MPE for in-service control. All average errors, however, are compliant. Single measurements exceeding relevant MPE are very rare and sporadic.

More descriptive perspective on gained results is achieved by presenting a density distribution of share of tested nozzles with a certain value of measured error. Distributions are presented separately for two test fuel rates Q_{min} and Q_{max} and for both fuel types (Figure 4 and Figure 5). On figures also values of relevant average measured errors are stated.



$Avg\ Err\ (Q_{min}) = +0.10\ \%$ $Avg\ Err\ (Q_{max}) = +0.23\ \%$

Figure 4: Share of tested nozzles with a certain error for both flow rates – Diesel (2016)



$Avg\ Err\ (Q_{min}) = +0{,}10\ \%$ $Avg\ Err\ (Q_{max}) = +0{,}15\ \%$

Figure 5: Share of tested nozzles with a certain error for both flow rates – Gasoline 95 (2016)

A fact that all density distributions of shares of tested nozzles with a certain error values are highly or yet barely moderately skewed (Table 3) and besides that have a same sign, deserved further attention.

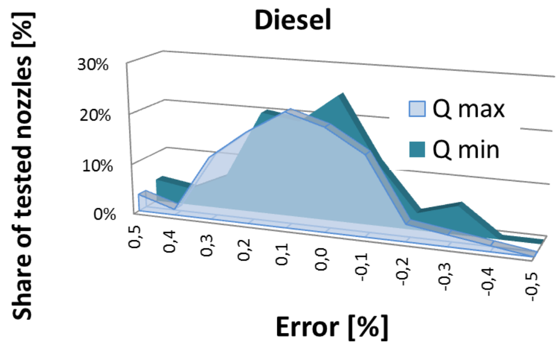
Table 3: Skewness coefficient of 1st surveillance round

Fuel	$skewness\ coeff.\ Q_{min}$	$skewness\ coeff.\ Q_{max}$
Diesel	0,905	1,796
95	1,014	0,840

4. Second round of surveillance (2019)

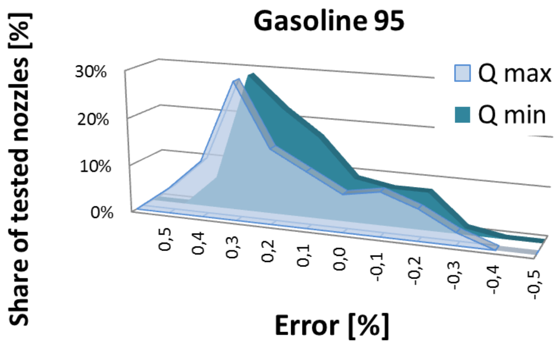
After another verification period passed, effect of adapted MPE value was validated in 2018 and 2019. Only Diesel and Gasoline 95 delivering nozzles were surveilled. Sample size was approximately three quarters of the 1st round sample size.

Density distributions of the share of tested Diesel and Gasoline 95 nozzles with a certain value of measured error are for both flow rates presented on Figure 6 and Figure 7. Values of relevant average measured errors are also stated.



$Avg\ Err\ (Q_{min}) = +0,07\ \%$ $Avg\ Err\ (Q_{max}) = +0,08\ \%$

Figure 6: Share of tested nozzles with a certain error for both flow rates – Diesel (2019)



$Avg\ Err\ (Q_{min}) = +0,16\ \%$ $Avg\ Err\ (Q_{max}) = +0,14\ \%$

Figure 7: Share of tested nozzles with a certain error for both flow rates – Gasoline 95 (2019)

Meanwhile implementation of new measures continued to be supported by intense promotion and continuous trainings of verification bodies and instrument owners.

4.1 Comparison of results of 1st and 2nd round of surveillance

The compared average measured errors values at Q_{max} of the 2nd surveillance round were except in one case lower as the average measured errors of the 1st surveillance round (Table 4).

The skewness coefficient values show that the 2nd surveillance round density distributions of shares of tested nozzles with a certain error values are significantly less skewed in case of Diesel (Table 5). In case of Gasoline 95 nozzles skewness factors are enlarged. However, the absolute values of reduction of skewness factors at Diesel nozzles are approximately four times bigger than the absolute values of enlargements at Gasoline 95 nozzles.

Table 4: Compared average measured errors of 1st and 2nd surveillance round

Fuel	No. of tests	Surveillance round	$Avg\ Err\ (Q_{min})$	$Avg\ Err\ (Q_{max})$
Diesel	105	1st	+ 0,10 %	+ 0,23 %
	89	2nd	+ 0,07 %	+ 0,08 %
95	103	1st	+ 0,10 %	+ 0,15 %
	76	2nd	+ 0,16 %	+ 0,14 %

Table 5: Compared skewness coefficient of 1st and 2nd surveillance round

Fuel	Surveillance round	$skewness\ (Q_{min})$	$skewness\ (Q_{max})$
Diesel	1st	1,796	0,905
	2nd	0,794	0,434
95	1st	0,840	1,014
	2nd	1,000	1,368

Effectiveness of the adapted regulative in terms of improved trust and expectations of final customers was confirmed by in generally lowered average measured errors. Improved or at least maintained skewness classes of density distributions of measured errors offered further support to such findings.

To achieve these results, set goals were strictly followed and verification procedures performed with enhanced attention. Fuel dispensers' technical capability proved that enforcement of strictly set metrology rules is feasible.

5. Compiled results compared

Compiling all measured results gained on fuel dispensers for both considered fuel types with the only criteria of fuel flow rate (Q_{min} or Q_{max}) contributed to enlarged sample size and enhanced reliability of result comparison. 208 measurement results of the 1st round were compared to 165 results of the 2nd round of surveillance.

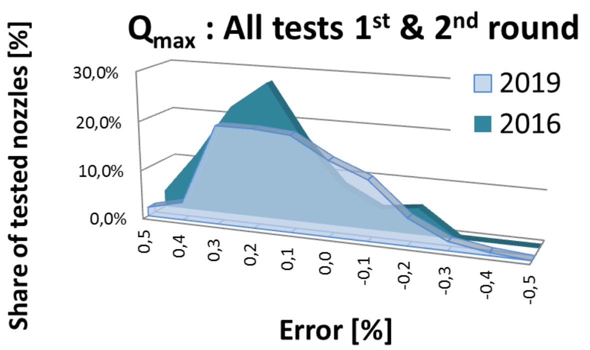
Calculated average measured errors of all results for a single flow rate in a single surveillance round along with skewness coefficients of corresponding density distributions are presented in Table 6.

Table 6: Compared average errors and skewness coefficients of compiled results for both surveillance rounds (1st and 2nd)

	Average error [%]		Skewness coefficient	
	2016	*2019*	*2016*	*2019*
Q_{max}	0,19	0,11	0,938	0,338
Q_{min}	0,10	0,11	1,000	0,093

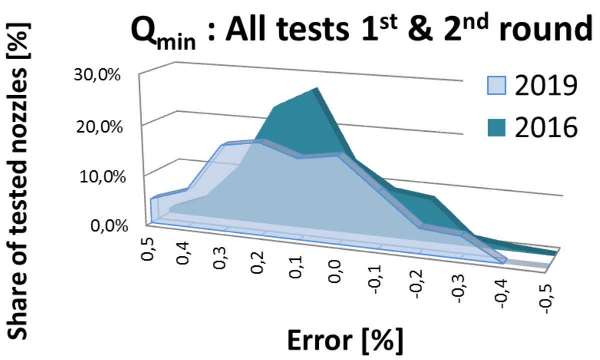
Density distributions of share of tested nozzles with a certain value of measured error are presented separately for two test fuel rates Q_{min} and Q_{max} and for both surveillance rounds on Figure 8 and Figure 9. Values of relevant average measured errors are also stated.

Values confirm visual observations of Figure 8 and Figure 9. Average measured error is significantly diminished for in praxis mostly operated flow rate Q_{max}. Besides that, values of average errors for both flow rates are already in a vicinity of expanded measurement uncertainty value of used method.



$Avg\ Err\ (Q_{max})[2016] = +0{,}19\ \%$ $Avg\ Err\ (Q_{max})[2019] = +0{,}11\ \%$

Figure 8: Share of tested nozzles with a certain error ($\boldsymbol{Q_{max}}$) - summary of results of both fuels and both surveillance rounds



$Avg\ Err\ (Q_{min})[2016] = +0{,}10\ \%$ $Avg\ Err\ (Q_{min})[2019] = +0{,}11\ \%$

Figure 9: Share of tested nozzles with a certain error ($\boldsymbol{Q_{min}}$) - summary of results of both fuels and both surveillance rounds

Different skewness coefficient values reflect well improved symmetry of measured results.

Both findings confirm eligibility of metrology rules modification. Owners of fuel dispensers are capable of ensuring compliance of their measuring instruments and customers can expect results with decreased deviations.

6. Conclusion

In 2013 reduced values of MPE for fuel dispensers in use and in service were introduced in Slovenia's national regulative. Change pursued the idea of MID annex VII Art. 2.8 [4] trying to prevent favoring any party and systematic exploitation of allowed MPE. MIRS believed state of the art measuring instruments are capable of fulfilling such requirements.

Thorough and successful implementation of new MPE values was supported by intense promotion, continuous trainings and regular surveillance.

A resume of over 1000 measurement results accomplished in two consecutive rounds of surveillance of fuel dispensers reports significantly lower average measured errors and enhanced symmetry of results. High levels of technical capability of measuring instruments were confirmed. Along with competent skills of verification officers the fulfilment of stricter metrology requirements was enabled. Expectation of a significant step towards enhanced equity of measurements bringing a satisfaction to all parties was therefore justified.

To confirm present results, MIRS will continue with the surveillance of fuel dispensers increasing their population number. Surveillance results can be enriched by added criteria like a micro location of a fuel dispenser on a petrol station, year of production of a fuel dispenser, type and producer of measuring instrument, temperature conditions, etc.

Current observations are satisfactory and encouraging enough to aim for maintaining stable values of average measured errors. Even further shifts of those values as well as enhanced symmetry of measured results may be anticipated.

Compliance of measuring results shall therefore be guaranteed while their fairness improved.

References

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