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THE FAILURE OF FIRE-FIGHTING EQUIPMENT AT FRS ZLÍN REGION

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Review article

Abstract: The paper follows previous work of the author focused on evaluating of operation and maintenance of fire-fighting equipment on the chassis Mercedes-Benz Atego (Jánošík, 2010a) and TATRA (Jánošík, 2010b) in use at Fire Rescue Service in the Moravian-Silesian and Hradec Králové Region. The observation results of car fire-engines on the chassis Renault Midlum in use at Fire Rescue Service Zlín Region with fire trucks by the Polish supplier Wawrzaszek ISS Ltd., Bielsko-Biala, and by the Czech company THT Ltd., Polička, are summarized in this paper. Fire Rescue Service of the Zlín Region consists of four fire departments and is specific with the fact that the fire equipment based on the observed chassis is allocated at all of the departments.

Keywords: Reliability in operation; technique operation; service of technique; maintenance of fire-fighting equipment; Fire Rescue Service of the Zlín Region.

Introduction

Total coverage of the Zlín region is represented by 13 fire protection units of the Fire Rescue Service of the Czech Republic. A group of 13 vehicles type CAS (fire engine) on the chassis-Renault Midlum was selected to monitor traffic and failure. Overview of selected car is given in Tab. 1.

To give an idea it is an intervention fire truck with a total weight of 14 tons with an engine power of 195 kW and measuring approximately 8.0 x 2.5 x 3.3 m (length/ width/height). The average age of monitored vehicles is 6 years. To characterize the workload of the fire-fighting equipment the number of incidents for the years 2007 - 2012 on the monitored fire stations of FRS Zlín Region is shown in Fig 1. (Zavadil, 2013).

Tab. 1 Tracking reports of fire-fighting equipment

	Fire Station	Identification of the Vehicle	Registration Number	Chassis	Extension	Year of manufacture
1	Zlín	CAS 24/2500/250-M1T	1Z7 6958	Midlum 270.15/14 4x2	ISS Wawrzaszek	2004
2		CAS 24/2500/250-M2T	2Z7 8478	Midlum 270.14 P 4x4	ISS Wawrzaszek	2006
3		CAS 15/2000/120-M2Z	3Z3 4693	Midlum 270.14 P 4x4	THT Polička	2007
4	Slavičín	CAS 15/2200/150-M2Z	3Z5 7550	Midlum 270.14 P 4x4	THT Polička	2008
5	Otrokovice	CAS 24/2500/250-M2T	2Z7 8479	Midlum 270.14 P 4x4	ISS Wawrzaszek	2006
6	Valašské Meziříčí	CAS 24/2500/250-M2T	2Z6 2647	Midlum 270.14 P 4x4	ISS Wawrzaszek	2005
7		CAS 15/2200/135-S2Z	3Z5 7540	Midlum 270.14 P 4x4	THT Polička	2008
8		CAS 15/2000/120-M2Z	3Z3 4692	Midlum Medium 4x4, 240.14 P	THT Polička	2008
9	Uherský Brod	CAS 20/2500/300-M2T	3Z2 3957	Midlum Medium 4x4, 280.14 P	ISS Wawrzaszek	2007
10	Uherské Hradiště	CAS 20/2500/250-M2T	3Z6 6297	Midlum 280.14 4x4	ISS Wawrzaszek	2008
11	Kroměříž	CAS 24/2500/250-M2T	2Z6 2649	Midlum 270.14 P 4x4	ISS Wawrzaszek	2005
12		CAS 24/2500/250-M1T	1Z7 6957	Midlum 270.15/14 P 4x2	ISS Wawrzaszek	2004
13	Morkovice - Slížany	CAS 24/3500/200-M2T	1Z6 8059	Midlum Medium 4x4, 220.14 P	ISS Wawrzaszek	2004

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Materials and methods

The Order of mechanical services (Note, 2006) regulates the operation records of the fire-fighting equipment. Each responsible worker of the machine service at the station has a duty to monitor traffic data and vehicle maintenance at each individual station.

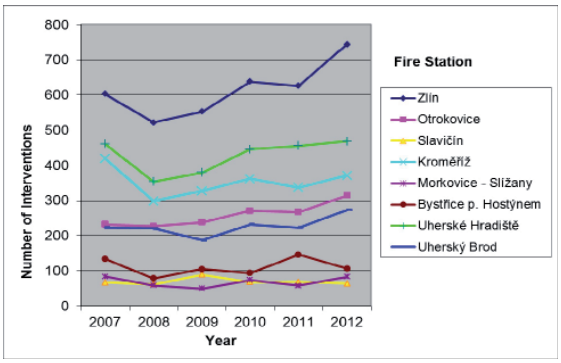

Fig. 1 Fire brigade intervention of the Zlín Region

Work records of the fire-fighting equipment are kept in the journey report and include the date, purpose of journey, current mileage and final mileage, number of working hours (engine hours), refueling and filling fluids, service activities, operation or repair costs and the time during which is the vehicle out of service.

Operational diaries of vehicles kept in a paper form were previously used for this purpose. From 2010, IKIS electronic information system serves this purpose, which forms a central database of vehicles of FRS of the Czech Republic. The necessary data were obtained from this system for the analysis of vehicles operation from their operation start until 30. 9. 2012. Incomplete information about operation was found during processing especially before 2010, where for example data were missing for the whole month. This was primarily affected by the activities of engineers and omitting data on transcription from paper to electronic form during the year 2009. For example in Tab. 2 are given processed and sorted data on the operation and maintenance of two vehicles at the busiest station in Zlín.

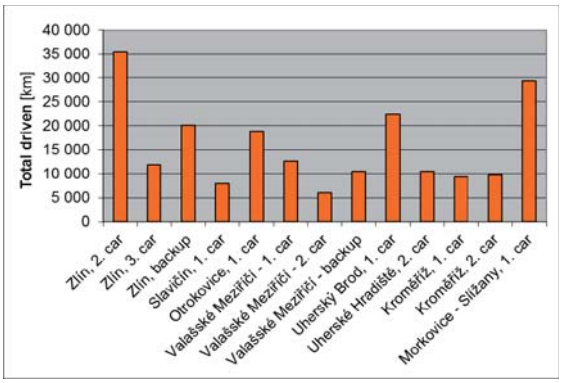

Fig. 2 The total kilometric run over

Tab. 2 Overview of operation of selected cars at the Fire station Zlín

Fire station, classification techniques	Registration Number	Putting into operation	Year	Number of rides	Number of repair fire chassis	Number of repair fire body trucks	Number of operational inspection	Driven [km]	Working hours	Quantity of fuel [litr]	Cost [Kč]
Zlín, 2. car	1Z7 6958	22. 12. 2004	2005	0	1	1	0	5 123	102	0	0
			2006	0	2	0	2	4 596	92	0	0
			2007	0	2	0	2	5 761	115	0	1 450
			2008	0	2	0	2	4 340	87	0	270
			2009	0	1	0	2	3 900	78	0	0
			2010	269	15	6	3	4 618	83	1 684	75 412
			2011	279	9	14	5	3 972	92	1 580	74 830
			2012	217	9	8	4	3 231	54	1 145	73 522
			celkem	765	41	29	20	35 541	703	4 408	225 484
Zlín, 3. car	2Z7 8478	20. 9. 2006	2006	0	0	0	0	2 032	0	0	0
			2007	0	0	0	2	5 100	0	0	0
			2008	0	0	0	3	3 217	0	0	0
			2009	0	2	2	2	3 406	0	0	0
			2010	298	12	4	4	4 413	96	1 968	85 128
			2011	192	9	8	4	3 354	66	1 466	179 744
			2012	220	6	8	3	4 144	54	1 556	92 078
			celkem	710	29	22	18	25 666	215	4 990	356 950

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Fig. 2 summarizes the characteristics of vehicles operation in terms of mileage km. In the total vehicles mileage were considered all types of rides i.e. intervention, economic and training. The average annual mileage of 2700 km was calculated from the obtained values.

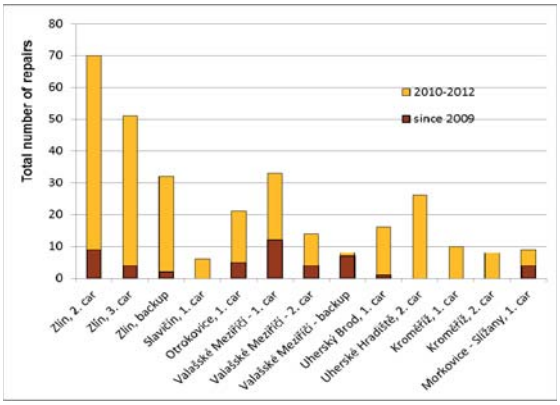

Fig. 3 The total number of repairs

Fig. 3 summarizes the results of the analysis of failures with respect to the reporting period. There are separate data by the end of 2009, when records were kept in a paper form and from 1st January 2010 which has already been recorded in the electronic system.

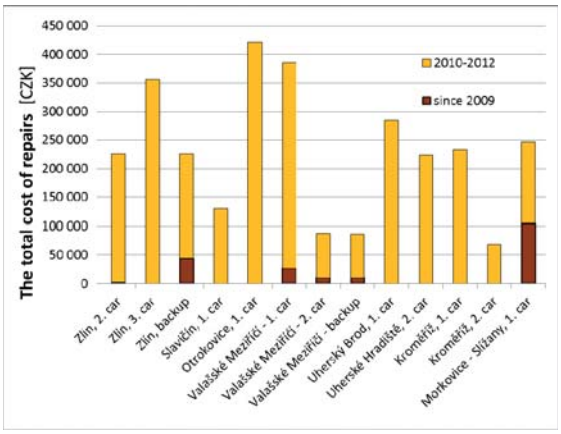

Fig. 4 The total cost of repairs

Fig. 4 in addition in the same way summarizes the total costs of vehicles repair. The increase in the number of recorded failures and thus the repair costs from 1. 1. 2010 does not mean in any case that vehicles had more failures due to the change of evidence records of their operations. This hypothesis will be supported by the conclusion.

Results

To calculate the operating characteristics a method called test plan was selected (Famfulík, 2010). The method of test plan can determine the mean time to failure by a small group of products. If we wanted to verify the entire series and we waited for a fault at all pieces, then we came to the conclusion that we made the destruction of all pieces or waited for an unreasonable time to failure. For these reasons this test is performed only on a limited number of products in advance and if necessary limited to the period of its duration or the number of failures.

To evaluate the failure rate a test plan was selected limited by the time to failure called *t - plan*. The limit of this test is its duration and a random variable is the number of recorded failures. Prerequisite for the test is that the products will be repaired after the failure. The time variable representing the course of the exam is the accumulated working time T_{AKU}, which is the total time during which all the products were in operation while testing. The accumulated working time for the selected *t - plan* is calculated according to the equation:

$$T_{AKU} = \Sigma(\tau_0 - \theta_i) + (n - r) \cdot \tau_0 \qquad (1)$$

where

τ_0 test time, from beginning till occurrence r_0 - such failure,

n number of products included in the test,

r number of faulty pieces,

θ_i the time required to repair the i - th product.

To calculate the operating characteristics by the *t - plan* method time to failure was calculated in monitored vehicles.

Due to the availability and verifiability of the input data of the monitored vehicles their operation was rated from 1. 1. 2010 - 31. 9. 2012. With regard to the data accuracy, the mileage and odometer reading were only considered at the time of failure by calculating the time to failure.

The test time limit τ_0 was established for the limits 1000, 2000, 3000 and 4000 km, which roughly correspond to the annual vehicles mileage. These limits were subsequently converted into time by dividing the distance traveled in kilometers at an average speed of 50 km/h, which is the value with which the FRS of the Czech Republic standardly works. A calculation was subsequently performed according to equation (1) and the calculated accumulated time then back converted into kilometers.

The results of the calculations obviously proved that a fault occurs on the vehicle even before reaching the mileage. The results of calculations of times to failure, depending on the limit for the test period are shown in the graph in Fig. 5.

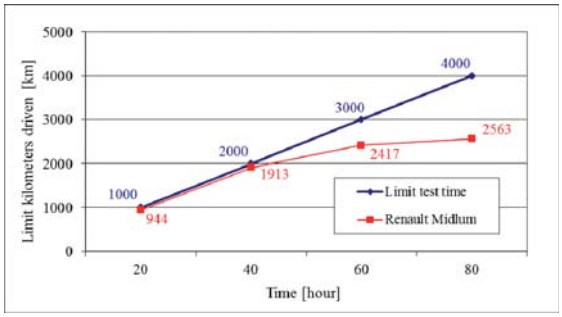

Fig. 5 Times to failure of Renault Midlum vehicles

Discussion

The difference between the marginal test time and the calculated average value, in which a fault occurs, increases with increasing test time. This is obviously due to the fact that during a longer period of time failure occurs on more vehicles. Failure rate for individual vehicles affects the period during which the vehicles are included in outgoing activities and also their workload. The fact, that tracked vehicles are not absolutely identical and in operation for variously long time (from the year of manufacture 2004 till 2008) and with different workloads, undoubtedly distorts the results. Under the current conditions of operation record of fire-fighting equipment seems to me practically impossible to achieve the ideal condition for reliability calculation of FRC vehicles of the Czech Republic.

The first reason is the diversity of techniques resulting from its continuous development and innovation. The other significant reason is collection of input data, especially their availability and in some cases "hand" evidence and their completeness.

Conclusion

In the next step the vehicles data on the chassis Mercedes-Benz Atego of the Moravian-Silesian Region and the vehicles on the chassis TATRA TERRN°1 of the Hradec Králové region were due to a comparison updated and processed for the years 2010 and 2012. The calculation results are shown in Fig 6.

Before the reader makes a clear conclusion it should be noted that for vehicles TATRA TERRN°1, the input data were provided by the extract of operational logs carried out by a machinery service member of Hradec Králové Region, where a program IKIS has been used only marginally, while by the vehicles on the chassis Mercedes-Benz Atego the data was exported from the electronic information program IKIS.

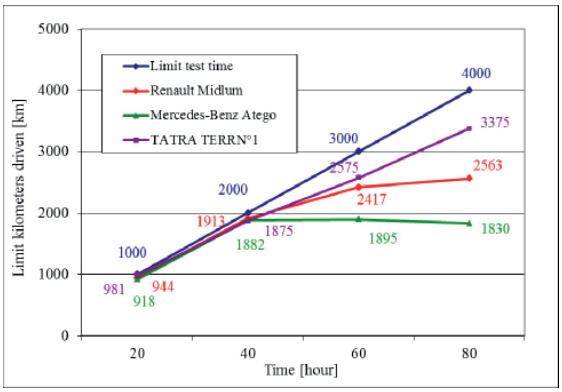

Fig. 6 Compared time to failure

Tab. 3 Comparison of techniques and their operational parameters

			Renault Midlum	Mercedes-Benz Atego	TATRA TERRN°1
Number of vehicles	[piece]		13	11	8
Oldest vehicle	[year]		9	10	18
Youngest vehicle	[year]		5	5	5
Average time in use	[year]		7	9	11
Average kilometric run over	[km]	2010	3 130	5 479	3 522
		2011	2 907	4 620	3 421
		do 30. 9. 2012	2 831	3 968	3 425
The total number of failures	[piece]	20 hod	7	8	3
		40 hod	12	12	8
		60 hod	21	14	12
		80 hod	37	22	20

We can state with a slight exaggeration that there is rather a statement in comparing the results of accurate records for vehicles Renault and Mercedes-Benz versus "hand" evidence in the case of vehicles TATRA. To illustrate the comparison of fire trucks to tracked chassis Tab. 3 summarizes their basic operating data.

With regard to the "hand" extract of vehicles service and the calculation results which are shown in Fig. 6 you can´t help thinking that by the TATRA vehicles were not provided all information about faults and probably were "left out" those faults that were not considered important or were not recorded

at all. In the stated figure can be seen almost linear time to failure, which copies the limits test period, compared to realistically falling curves of the two other types of vehicles. In addition, the vehicles tracking TATRA were the oldest age and were not provided any information about any of their refurbishment.

Practical recommendation for units Fire and Rescue Service emerged from the obtained results - to insist on keeping the vehicles operation records in electronic form.

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