FAILURS OF THE POWER SUPPLY SYSTEM OF OPEN – AIR MINE "HRISTO BOTEV" OF MINES "BOBOV DOL" Ltd.

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ABSTRACT
This article deals with safety analysis of the electrical power supply systems in open - air mine "Hristo Botev" of the mines "Bobov dol" – Ltd.. The data of failures are collected and investigated for a two years time period. The failures by reason of events are classified. All statistical researches are carried out using **MATLAB** and **STATGRAPHICS** packages.

INTRODUCTION

The open – air mine "Hristo Botev" is one of the important mines of the company "Bobov Dol" – Ltd. that exploited the coal field basin of the "Bobov Dol" area. This open – air mine includes three sections that are denoted as Ist (first), IInd (second) and IIIrd (third).

The power supply of these sections is independent and is realized by air supply lines with conductors of type AS installed on lattice towers. The first section receives power supply from the substation "Mlamovo" by air electric power line with 6 kV – voltage realized by conductors of type AS 3x35 mm^2 and length of 2000 m.

The second and third sections are connected by power supply from the substation "Babino" by an air electric power line of the same type and voltage. The length of the electric power line of the II (second) section is 2300m and those of the III (third) section is 1500m.

The electric power lines supply same mobile transformer points (MTP) and mobile switching points (MSP). Electric power cable lines from these mobile points (MTP and MSP) supply the loads in the sections.

The data have been collected during the period of twenty three (23) months (about two years) from the massage log journals of the substations "Mlamovo" and "Babino" and operating journals of the dispatchers.

Classification of the failures by reason of events is done and months with maximum number of failures are established. The results are: January 2001 – 31 failures, February - 37 failures, August – 35 failure, November – 27 failures, and March 2002 – 29 failures, April – 27 failures, June – 29 failures, August – 32 failures. The maximum numbers of failures classified by section are as follows: Section I – 239 failures, Section II –

173 failures, and Section III with 145 failures or the total number of the failures is 557.

The data analysis includes: investigation of the reasons of the failure events and the types of the protections that after being activated disconnect the power supply of the load sections in the mine.

It could be emphasized that: the single-phase earth – fault protection was operated for total 426 times, which is 76.5% of the total number of operation of the protections. The over – current protection and current segment (over – current without time delay) protection were operated 100 times and 31 times respectively.

The total number of these disconnections is 23.5% of the total number of failure events. It could be said that the unselective switch – off are 90.8% (506 times) of the total number of failures and as it is in other mines in Bulgaria.
The faults of instrumentations are as follows: faults of the junction boxes yield   27 failures, the electrical breakdown of cable lines yield   12 failures, excavator faults are registered 9 times and one is caused by the kit distribution unit (KDU).

BASIC RESULTS

The results of the statistical analysis are obtained by STASTGRAPHICS package STATGRAPHICS (1996). Table below shows the estimates of the population parameters as follows.

Table 1.Summary statistics

Count	23
Average	24,2174
Median	23,0
Geometric mean	23,1742
Variance	49,4506
Standard deviation	7,03211
Standard error	1,4663
Minimum	12,00
Maximum	37,00
Range	25,0
Coeff. Of variation	29,0374%
Sum	557,0

Frequency tabulation is used for preliminary investigation of the population distribution of the failure sample. The results are represented in Table 2.

Table 2. Frequency tabulation of the failures.

N⁰	Lower limit	Upper limit	Midpoint	Frequency
	-∝	10,0	0	0
1	10,0	15,0	12,5	3
2	15,0	20,0	17,5	4
3	20,0	25,0	22,5	5
4	25,0	30,0	27,5	6
5	30,0	35,0	32,5	4
6	35,0	40,0	37,5	1
	40,0	∝	0	0

Table 2. Continuation.

N⁰	Relative Frequency	Cumulative frequency	Cum. Rel. frequency
	0,000	0	0,000
1	0,1304	3	0,1304
2	0,1739	7	0,3043
3	0,2174	12	0,5217
4	0,2609	18	0,7826
5	0,1739	22	0,9565
6	0,0435	23	1,0000
	0,0000	23	1,0000

Frequency histogram is shown in Fig.1 based on results from table 2.
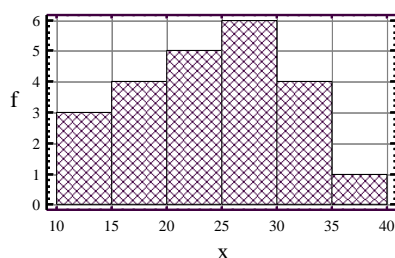

Figure 1. Histogram of the failures.

The labels in figure are: **x** – number of the failures, **f** – frequency of the failures.

It could be assumed from the preliminary calculation of the parameters by Bekeron (1975) and the shape of the histogram that the failure data comes from normal distribution, gamma or Weibull distributions.

Two tests are run to determine whether the variable of the failures can be adequately modeled by a normal distribution, gamma or Weibull distributions.

The chi-square test divides the range of the investigated variable into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of the variable and the CDF (cumulative distribution function) of the fitted theoretical distribution.
In this case, the following P – values are derived:

- Normal Distribution,
  Kolmogorov-Smirnov test $P[\lambda] = 0,108506,$
  Pearson test $P[\chi^2] = 0,903116$;
- Gamma Distribution,
  Kolmogorov-Smirnov test $P[\lambda] = 0,11685,$
  Pearson test $P[\chi^2] = 0,799386$;
- Weibull Distribution,
  Kolmogorov-Smirnov test $P[\lambda] = 0,110309,$
  Pearson test $P[\chi^2] = 0,319974$.

Probability density functions are represented as follows:

- Normal Distribution,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}.e^{\frac{-(x-\mu)^2}{2\sigma^2}} ,$$

where μ is mathematical expectation (population mean), σ is standard deviation ;
- Gamma Distribution

$$f(x) = \frac{\lambda^k.x^{k-1}}{\Gamma_K}.e^{-\lambda x} ;$$

- Weibull Distribution

$$f(x) = a.b^{-a}.x^{b-1}.e^{-\left(\frac{x}{a}\right)^b} , x \geq 0,$$

where a is scale parameter , and b is shape parameter of the distribution.

Probability density functions of discussed distribution are shown if Figs. 2,3 and 4.
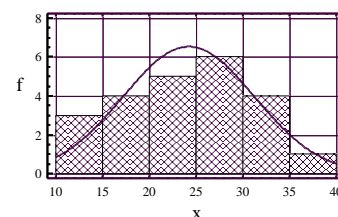

Figure 2. Approximation fit of the normal distribution.

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The parameters of the distribution are: μ=24,2174, σ=7,03211.
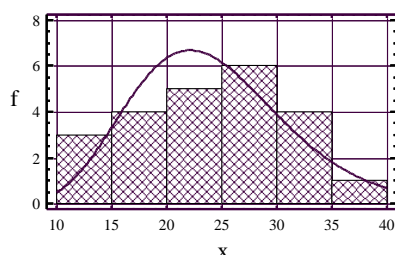

Figure 3. Approximation fit of the gamma distribution.

The parameters of this distribution are: λ=0,475705, k=11,5203.

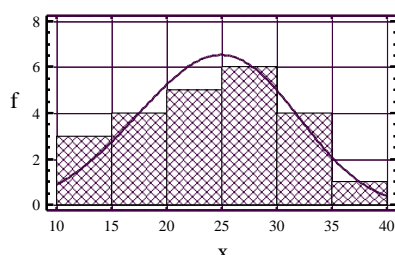*Figure 4. Approximation fit of the Weibull distribution.*

The parameters of the distribution are: a=26,7817, b= 3,98877

The labels in figures are: **x** – number of the failures, **f** – frequency of the failures.

CONCLUSIONS

The following conclusions could be drown so far:

1. The lack of information about "unselective switches" is difficult problem for data analysis of the power supply system.

2. The larges number of the failures appears in the first section it is 239 failures or 42.9% of the total failure number.

3. The earth – fault protection is operated in 75% of the total failure number. This fact shows that the problems are due to some equipment element such as cable lines, distribution boxes, junction boxes, switching points, mobile switching point et. s.

4. The summary statistics are obtained based on the failure sample.

5. The P –value ($P\left(\chi^{2}\right) = 0,903116$) of the chi-square test shows that the population distribution is normal with 90% confidence interval. The additional investigation of the data will reveal the usability of the other derived distributions.

6. The result from this investigation shows that the design problems of the equipment units are very important for the reliability of the power supply system.

REFERENCES

Magnugistics Inc., Statgraphics, User Guide,1996.

Bekeron P. G., Methods of the data analysis of statisticall information for reliability of the mining power supply systems, I, M.,M, 1975 (in Russian)

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