Possibilities for Increasing the Use of Machineries Using Computer Assisted Statistical Methods

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http://ime.upet.ro/mi/html/nan_m_.html

Abstract: - Reliability has recently emerged from the quality concept. If quality represents the total of a product's qualities, which make it good for use according to the destination, the reliability represents the capacity of the product to maintain its quality during the entire usage time. Reliability is the quality of the product extended through time. Reliability, maintenance, availability and capacity related aspects have been treated distinctively up to one moment. Analytically, the reliability represents the probability that during a given period of time, a product will be flawless. The technological capability or reliability represents way in which a technological system may realize, on the entire process of fulfilling a mission, the corresponding technological performances for its objectives. A unitary approach, considering all the factors, in accordance to the operating conditions of technical systems, lays the fundaments of an interdisciplinary theory, called the Theory of safety during operation. The safety during operation, S, of a machinery or of a technological system represents the way it will fulfill its mission, being a function of availability A, reliability R, capacity C and maintenance M: $S(t) = r[A(t); R(t); C(t); M(T)]$

Key-Words: - availability, average time for good operation, maintenance, probabilistic diagrams, Duane

1 Introduction

The operation cycle of technological systems contains acceleration, breaking, reversal, and halting phases, inflecting variable loads on the component elements, provoking, both accidental malfunctions, due to conception, manufacture or even exploitation errors, as well as wearing and exhaustion. Generally, during operation, the components of the technological systems come under variable loads, mainly aleatory, which rend their rational dimensioning difficult. Apparently, over dimensioning reduces the over load malfunction risk, but increases costs and components' mass, the dimensioning on supposed average load values leads to increased risk of malfunction.

The availability represents the way in which a product is operational in a certain period of time. Analytically speaking, the availability represents the probability that the mentioned product is operational in that exact moment in time.

The average time for good operation ATGO is a parameter, which helps appreciate the reliability of products with the same operation time until their first malfunction.

Maintenance represents the way in which a malfunctioning product during exploitation may be operational again during a given period of time. Analytically it may be defined as being the probability that a product may be operational again during a given period of time.

We may state now that operational safety of a product, S, represent the way in which it will complete the mission, depending on the availability A, reliability R, on the capability C and maintenance M.

The operation safety concept is rather a new synthesis concept, which will allow a complete treatment of quality characteristics, which describes the action in time of a technological system, during exploitation (figure 1).

Fig.1 The Position of Exploitation Safety Concept

2 Probabilistic Diagram Method

The Probabilistic Diagrams may help determine the analysis of the operation state of a process depending on the correctness of its development.

This method has been introduced by Duane and Crow and perfected by Barringer, a method, which allows the diagnostics of a process regarding the variability (of the constancy in time), showing the flaws of hidden factors without allowing their identification.

According to J.T. Duane's research, the double logarithmical diagram for ATGO dependency, cumulated according to the operation time of a continuous process has a linear allure (Figure 2).

The Duane Diagram interpretation is the following: the difference between the two lines is a sign of the continuity of operation the gradient of the inferior curve represents the indicator of constancy (process variability).

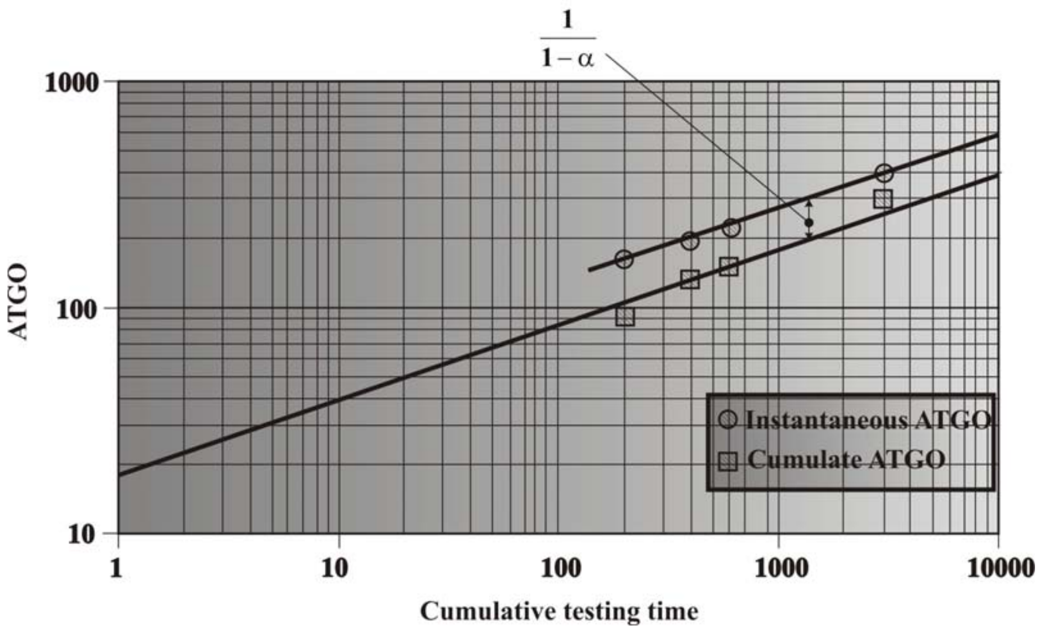

Fig.2 Duane Diagram

$$ATGO_c = \frac{T}{N(T)} \quad (1)$$

Where:

T – the time period for the observation of the process

N(t) – the number of flaws arisen during the interval T.

Considering the equation of the line in figure 2 we may write:

$$y = m \cdot x + c \quad (2)$$

With the ad notations:

$$\begin{aligned} y &= \ln(ATGO_c); \quad x = \ln(T) \\ m &= \alpha; \quad c = \ln(b) \end{aligned} \quad (3)$$

It results:

$$\ln(ATGO_c) = \alpha \cdot \ln(T) + \ln(b) \quad (4)$$

Thus:

$$ATGO_c = b \cdot T^{\alpha} \quad (5)$$

Considering a constant glitch rate during the observation time, the cumulated glitch rate λ_c will be:

$$\hat{\lambda}_c = \frac{1}{ATGO_c} = \frac{1}{b} \cdot T^{-\alpha} \quad (6)$$

Thus we may write that the estimated number of flaws after the time interval T is:

$$N(T) = \hat{\lambda}_c \cdot T = \frac{1}{b} \cdot T^{1-\alpha} \quad (7)$$

where:

- $\hat{\lambda}_c$ - average value of the cumulative glitch rate;
- T -total observation time;
- $\frac{1}{b}$- average value of the cumulative glitch rate at the moment T=1, or in the beginning of the test
- α - increase rate of $\hat{\lambda}_c$, $0 \le \alpha \le 1$.

The instant glitch rate will be:

$$\lambda_i = \frac{dN(T)}{dt} = \frac{1}{b} \cdot (1-\alpha) \cdot T^{-\alpha} = (1-\alpha) \cdot \hat{\lambda}_c \quad (8)$$

Now we may say that the rate of instant good operation time is:

$$\begin{aligned} ATGO_i &= \frac{1}{\lambda_i} = \frac{1}{1-\alpha} \cdot b \cdot T^{\alpha} \\ &= \frac{1}{1-\alpha} \cdot ATGO_c \end{aligned} \quad (9)$$

Asset management, represents a an interdisciplinary field where emphasis is laid on the efficient exploitation of technological systems, following the decreasing of exploitation costs in parallel with obtaining maximum economical effects.

Thus, the process productivity does not represent an absolute performance indicator, if it is not regarded depending on the costs needed to obtain it, and if it has a really high degree of variability.

The time when a process is out of operation actually means the time needed for the activity of maintenance, which lead to the increase of the global cost.

In order to simply, rapidly and efficiently compare the processes and in order to diagnose the processes according to the variability and continuity, the use of probabilistic diagrams is recommended.

The number of classes for which, the histogram is drawn, corresponding to the cumulative operation time on the abscissa, are determined with the following relation:

$$Cls = 1 + \frac{\log_{10}(N_{int})}{\log_{10}(2)} \quad (10)$$

Where:

- Cls – represents the number of classes;
- N_{int} – represents the number of time intervals for which the observation has been made.

The data, on which the histogram is based, are presented in table 1. A histogram may be drawn if the operation hours during a certain period of time for a, certain machinery are considered to be known (e.g. calendaristically speaking) (figure 3) where the cumulative operation time for a certain class is found on the abscissa, and the percentage this time represents in the total operation time is found on the ordinate.

Table 1 - The data of the histogram

Month	Operating Hours
1	409800
2	322700
3	389800
4	140000
5	253000
6	398000
7	396200
8	445300
9	401800
10	369600
11	405200
12	192100

The cumulative time subinterval for which the histogram is realized (the size of histogram line on the abscissa) is determined with the following relation:

$$I_t = \frac{T_{max} - T_{min}}{Cls} \quad (11)$$

Where:

- T_{max} – is the maximum value of the working time for a certain observation period (in our case, in table 1, month 8);
- T_{min} – is the minimum value of the working time for a certain observation period (in our case, in table 1, month 4).

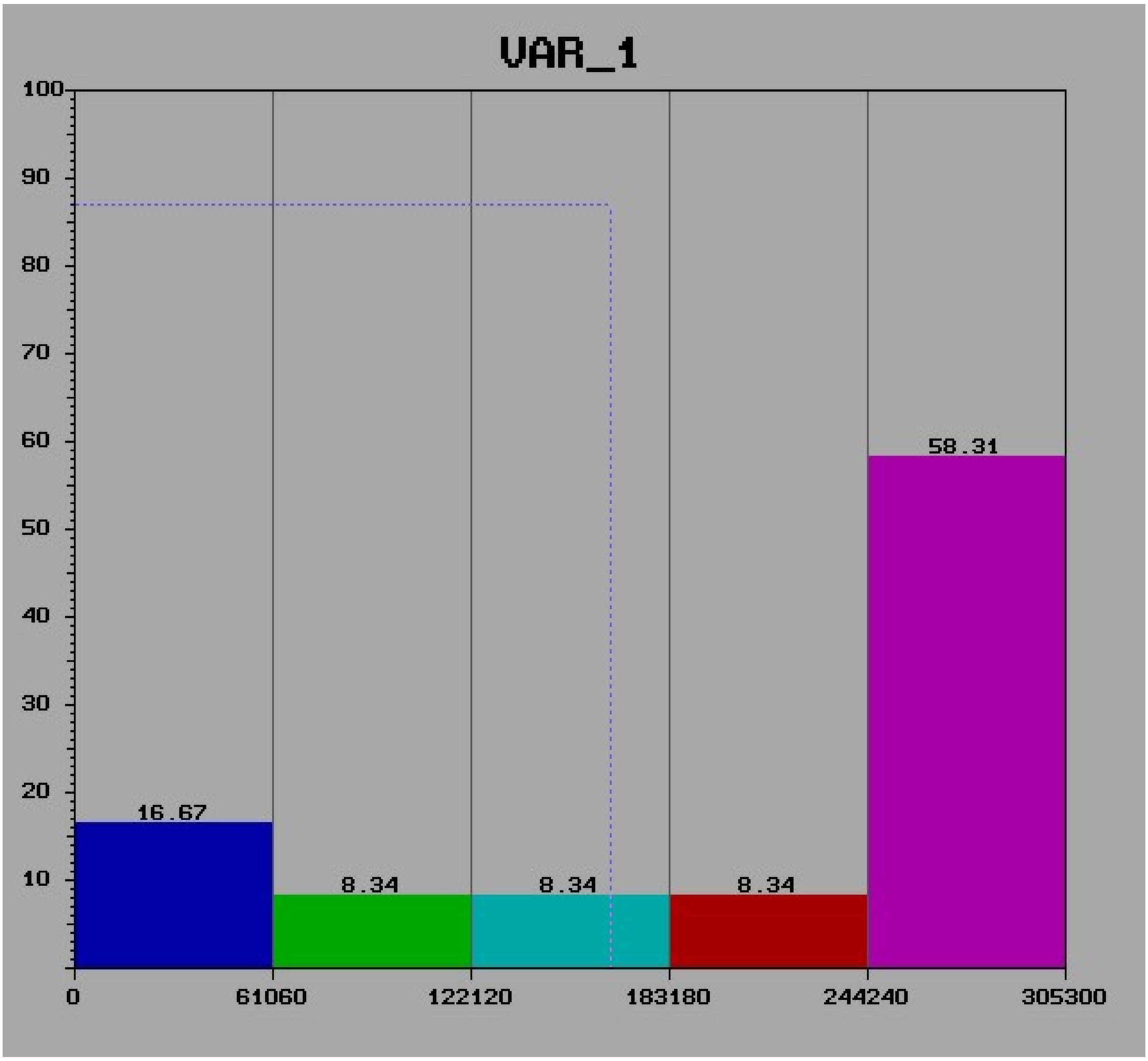

Fig.3 Duane Histogram

Based on the data presented earlier, a Duane diagram has been drawn (Figure 4). The drawn line represents the linear regression for the values from the anterior histogram, and its inclination gives us information regarding the variability of the process.
The application, which realizes the histogram and the Duane Diagram, has been developed in C language on a DOS platform.

The software application has been used for the study of the variability during operation and also for the study of the usage degree of some excavators, which work for the SNLO quarries.

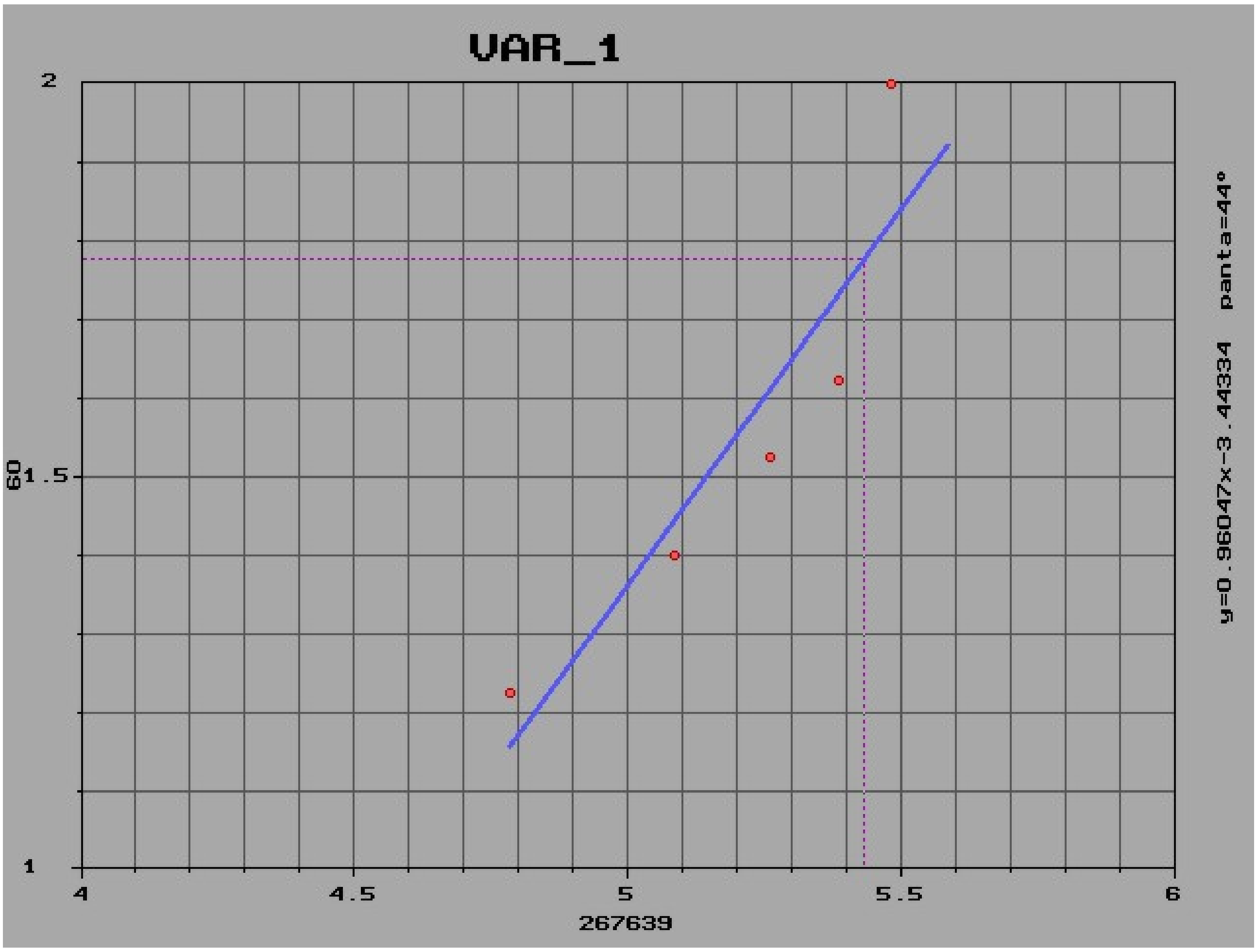

Fig.4 Duane Diagram

3 Conclusions

Classical methodologies exist for the survey of time and capacity use of complex configuration technological systems, allowing the extensive, intensive and global use quantification using a data base which radiographs the operation of the observed system. The disadvantage of these methods derives from the fact that they intercept only the quantitative aspects while leaving aside qualitative ones.

In order to eliminate the above mentioned disadvantages, the paper considers a method based on statistical surveys in the field. This new approach represents effective and delicate means for the study of complex technological systems' operation if it is integrated into a monitoring system, so that managers may be informed on time of the real operation mode of the decision managed system.

The results obtained using the developed application show the simulation to be a useful instrument for the winning, hauling and piling systems operation reshaping, also allowing the possibility to make different forecasts regarding different conditions of operation. The influence of different interruption categories as well as maintenance parameters of the system may also be studied.

The decision of using this kind of method is justified by the accordance of simulated results with reality results.

The developed software is an efficient analysis instrument, available to practitioners, and may also be integrated into a complex monitoring informatics system. The extraction technological systems' operation simulation in brown coal quarries considering the reliability as a base for the forecast of a continuous operation system represents an original approach which unfolds new research directions which will be dealt with in order to increase the usage degree of excavators inside the quarries.

Several results are presented in the annex of the paper (figures 5…19).

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Annex

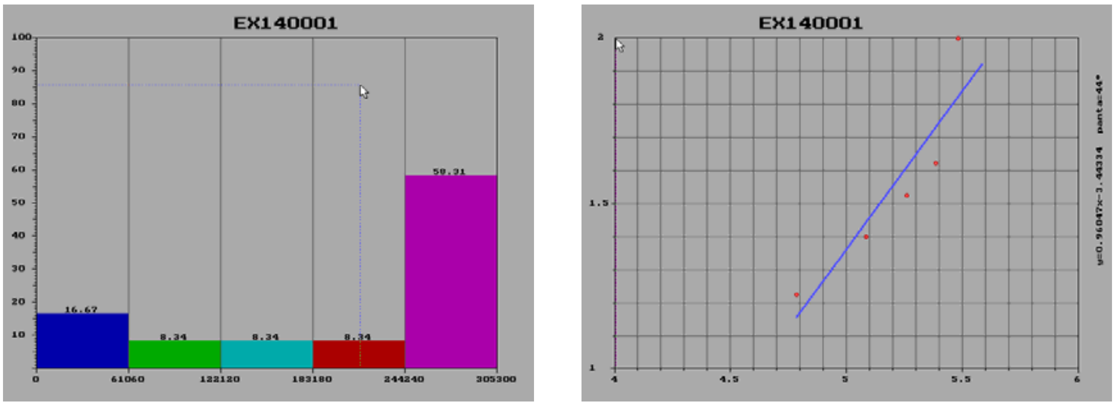

Fig.5 Duane Diagram and Histogram print screens for the E01 Excavator in Jilț South Quarry

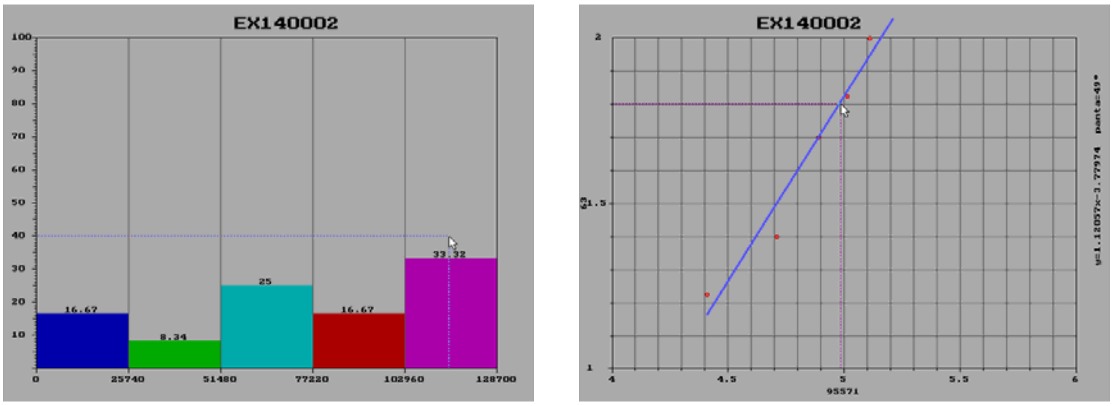

Fig.6 Duane Diagram and Histogram print screens for the E02 Excavator in Jilț South Quarry

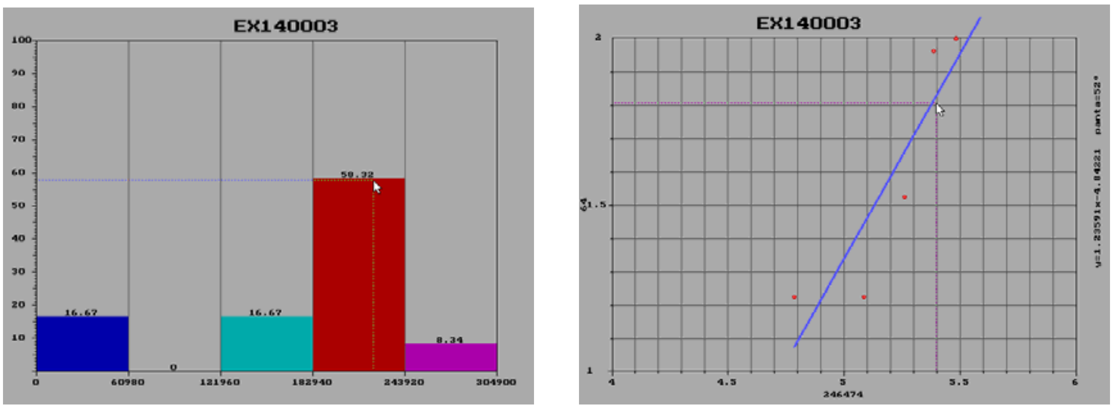

Fig.7 Duane Diagram and Histogram print screens for the E03 Excavator in Jilț South Quarry

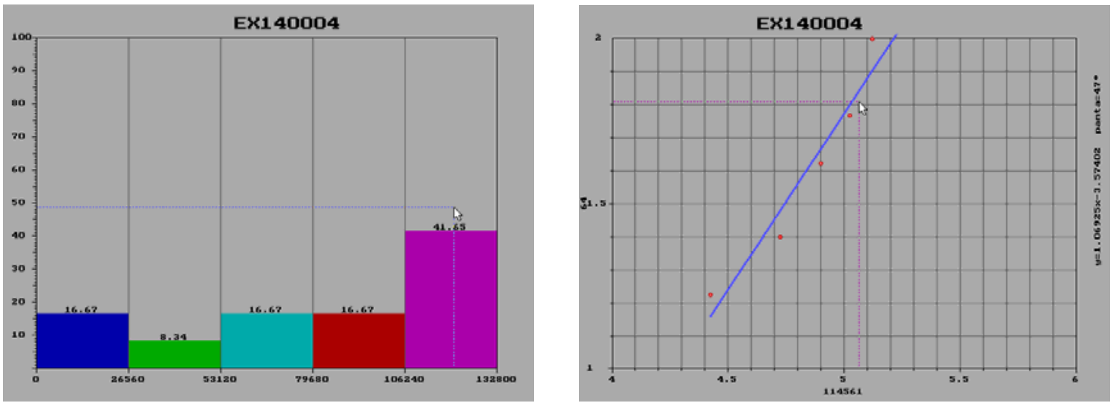

Fig.8 Duane Diagram and Histogram print screens for the E04 Excavator in Jilț South Quarry

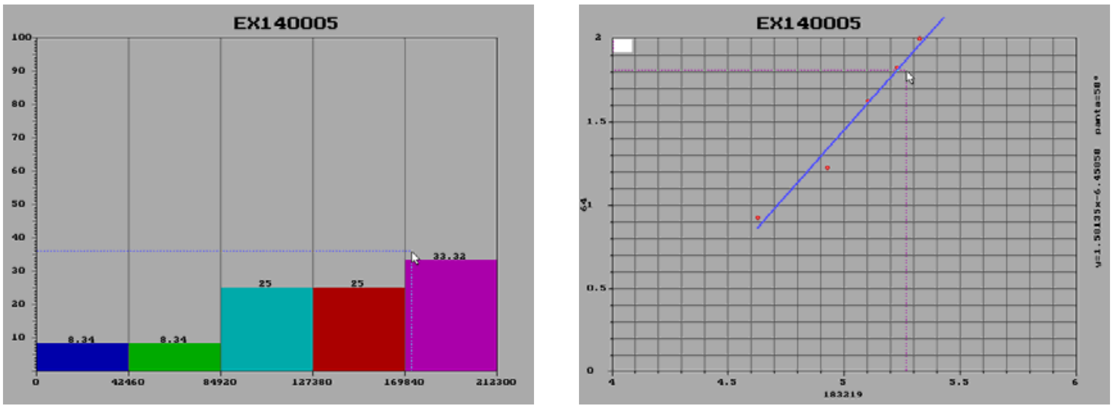

Fig.9 Duane Diagram and Histogram print screens for the E05 Excavator in Jilț South Quarry

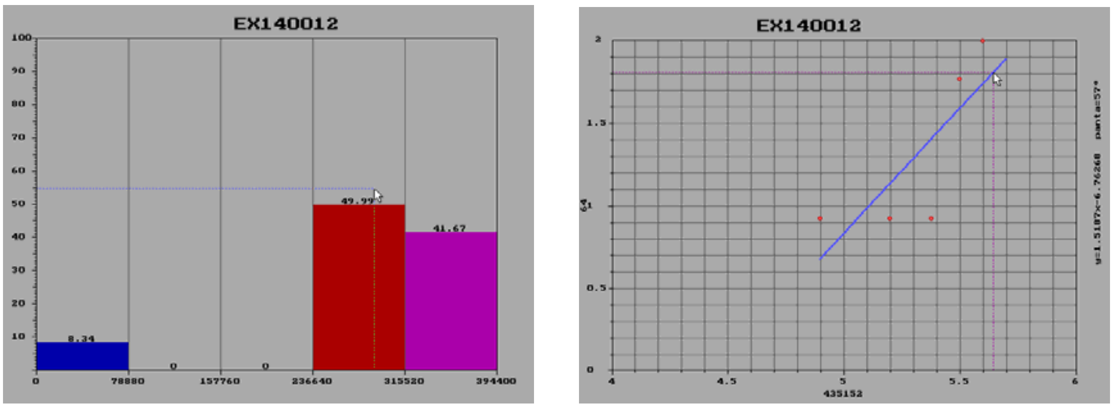

Fig.10 Duane Diagram and Histogram print screens for the E12 Excavator in Jilț South Quarry

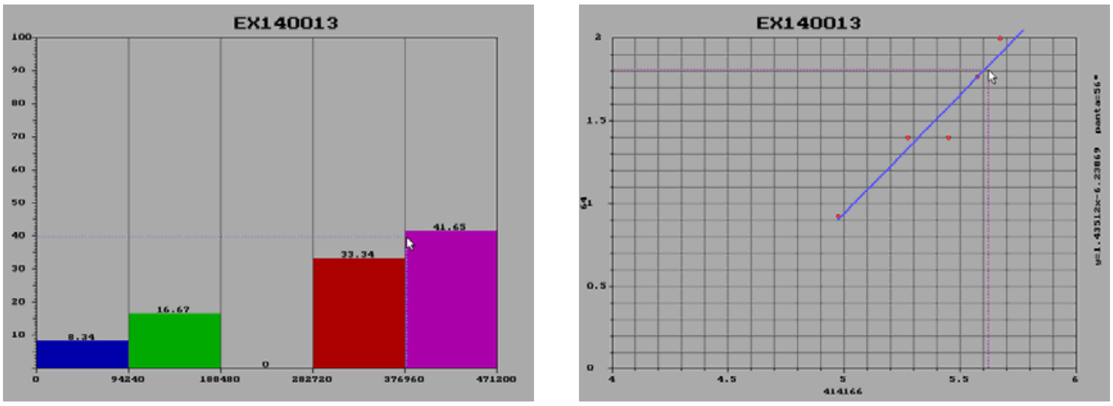

Fig.11 Duane Diagram and Histogram print screens for the E13 Excavator in Jilț South Quarry

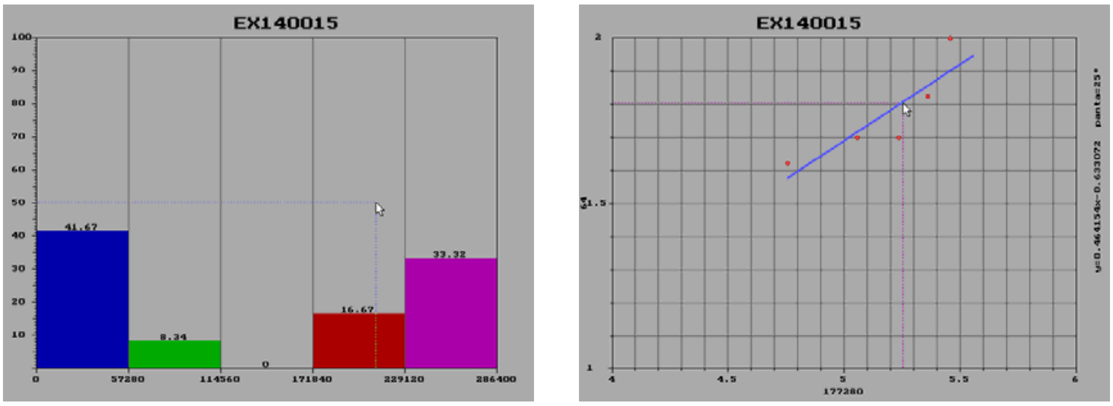

Fig.12 Duane Diagram and Histogram print screens for the E15 Excavator in Jilț South Quarry

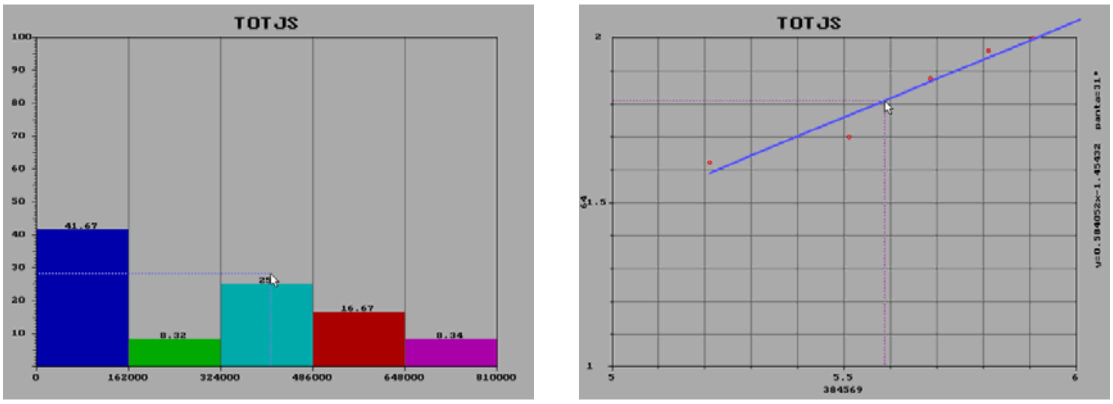

Fig.13 Duane Diagram and Histogram print screens for Jilț South Quarry

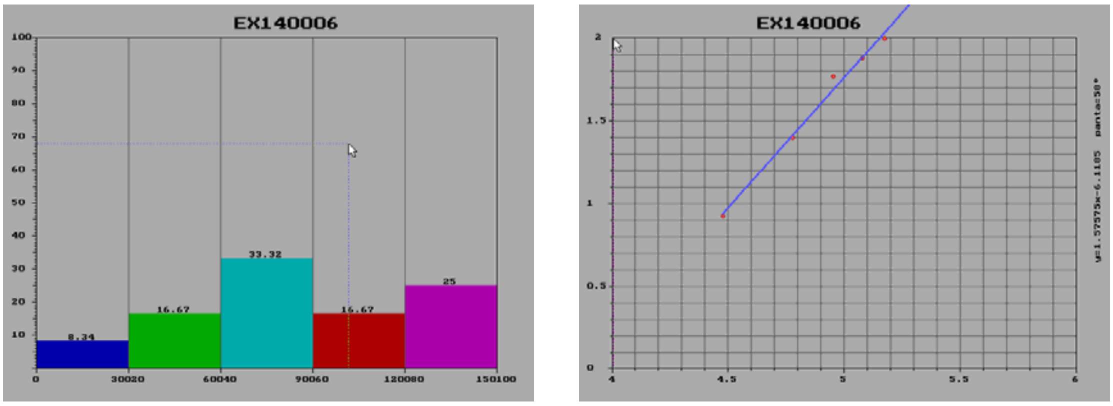

Fig.14 Duane Diagram and Histogram print screens for the E06 Excavator in Jilț North Quarry

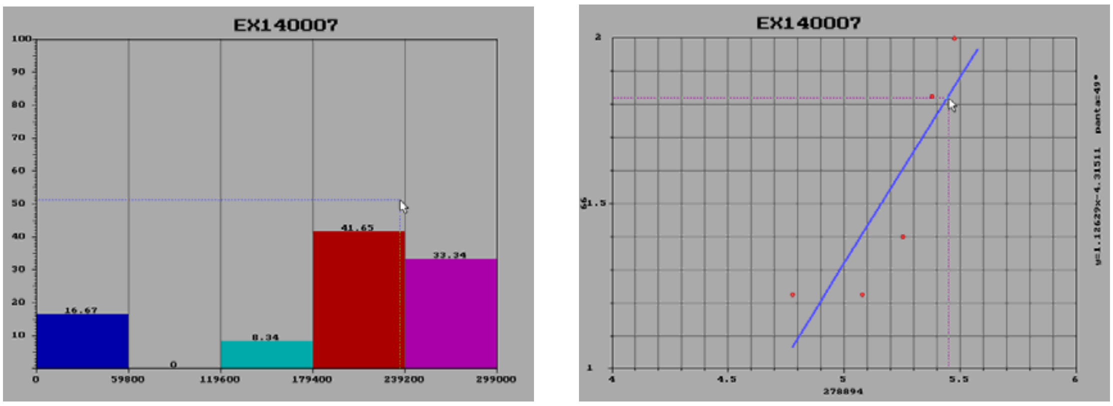

Fig.15 Duane Diagram and Histogram print screens for the E07 Excavator in Jilț North Quarry

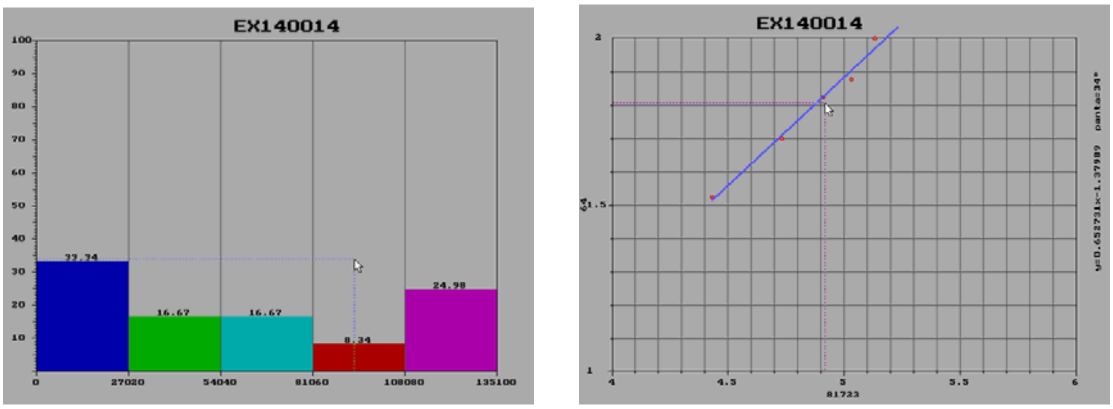

Fig.16 Duane Diagram and Histogram print screens for the E14 Excavator in Jilț North Quarry

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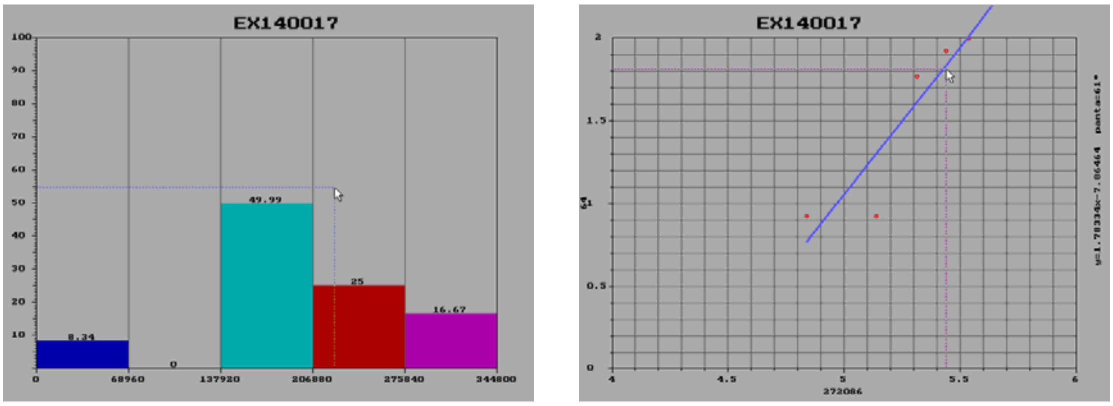

Fig.17 Duane Diagram and Histogram print screens for the E17 Excavator in Jilț North Quarry

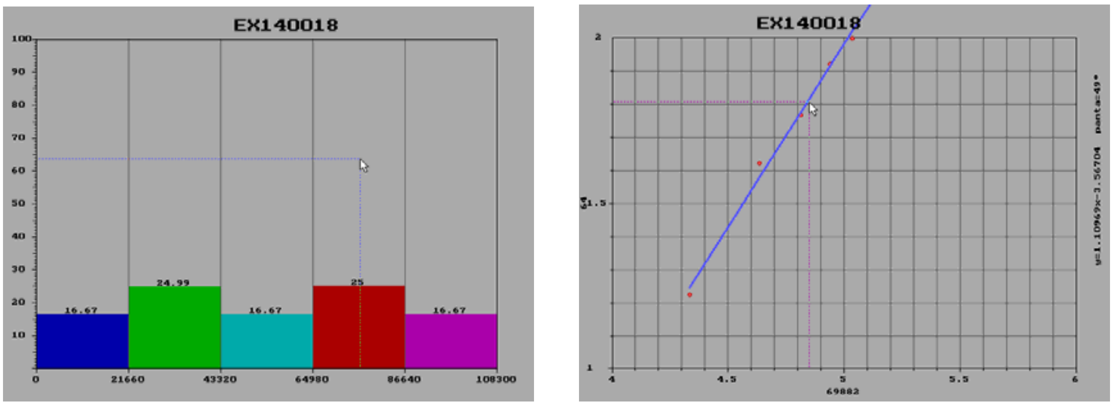

Fig.18 Duane Diagram and Histogram print screens for the E18 Excavator in Jilț North Quarry

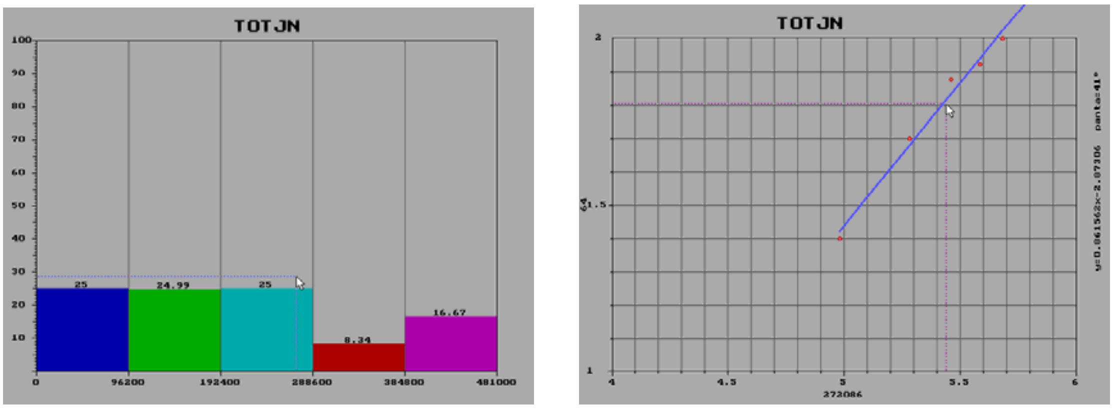

Fig.19 Duane Diagram and Histogram print screens for Jilț North Quarry