Almen Strip Consistency Testing

SUMMARY

Shot peening intensity is the measure of the energy of the shot stream and intensity control is one of the essential means of meeting peening specifications. Intensity is measured using Almen strips. When an Almen strip is shot peened, the residual compressive stress causes the Almen strip to bend or arc toward the peened side. The Almen strip arc height is a function of the energy of the shot stream and is very repeatable. Therefore, for Almen strips to provide reliable and repeatable intensity verification, it is critical that they are consistent in thickness, flatness and hardness.

Electronics Inc. (EI) brand of Almen strips have undergone extensive testing to ensure consistency from lot to lot. Before bringing their Almen strips to market, EI developed a custom air blast test cabinet and shot peened approximately 4,000 strips manufactured over a three-year period. The data was put into histograms for accurate analysis.

The histograms show nearly identical lot-to-lot arc height results. For example, the means range from 11.99 to 12.14 (0.001-inch units) and standard deviations range from 0.096 to 0.185. (Histogram samples are available on page 16.) EI's testing capabilities and test results validate EI's ability to produce reliable Almen strips.

INTRODUCTION

Electronics Inc., a manufacturer of products that control and improve shot peening processes, has been a worldwide supplier of Almen strips for over 21 years. In 2008, EI launched their own brand of A and N Almen strips to meet increasing demand for their strips in the aerospace industry and to better control the quality of the product. During research and development, EI began consistency testing to quantify the strips' performance and to develop documented confirmation that the strips were manufactured under conditions more stringent than SAE J442 specifications.

TESTING METHOD

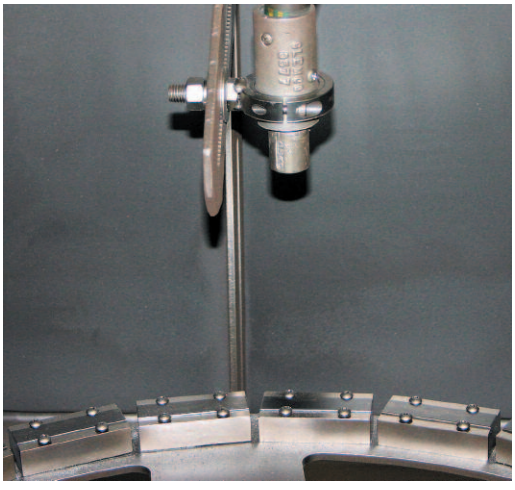
EI built an air blast cabinet with a variable speed rotary table with 26 Almen strip holders, a fixture for adjusting nozzle distance from the strips, a MagnaValve for media flow rate control, and controls to adjust air pressure and table rotation. During testing, the table was rotated at a fixed speed, and the cabinet was set for a specific pressure and constant media flow rate so each strip passed under the blast nozzle at the same angular velocity for the same predetermined number of revolutions.

For each test, a sample size of 40 strips was used. These lots were produced in 2006, 2007 and 2008. EI measured and recorded the prebow of the strips before testing. After each test cycle, the arc heights were measured on a calibrated Almen gage and the prebow compensation was applied. The values were put into histograms for analysis.

TEST RESULTS

Histograms created over the three-year period exhibited nearly identical lot-to-lot arc height results, thereby verifying the uniformity of the product.

Four histograms are available on page 16. Each histogram represents a test completed to verify the performance of an individual lot. The results illustrate the performance consistency of the strips as defined by the nearly identical mean values and the narrow standard deviations.



The Almen strips were tested in an air blast cabinet with a variable speed rotary table with 26 Almen strip holders, a fixture for adjusting nozzle distance from the strips, a MagnaValve for media flow rate control and controls to adjust air pressure and table rotation.

In addition to documented consistency results, this testing program has provided a substantial technical support base for EI's Almen strip customers. EI has available:

- Current lot-to-lot comparison data on EI strips
- Comparisons of EI strips to other strips
- Performance data on other strips
- Analysis on the effect of variations in manufacturing parameters (hardness, thickness, etc.)

EI's research is thoroughly documented. For each test, EI records the scope, setup parameters, procedures, test results and analysis, histograms, saturation curves (where applicable), and a summary conclusion.

EI uses the performance data to answer customers' questions related to process variables and to help customers identify performance problems such as arc height variations and out-of-spec results with non-EI strips.

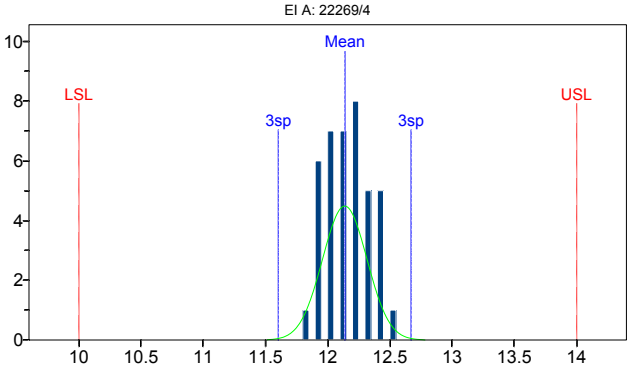
When EI does not have data available on a unique problem, EI will perform tests to analyze a customer's problem or even duplicate, as closely as possible, their process setup.

About Histograms

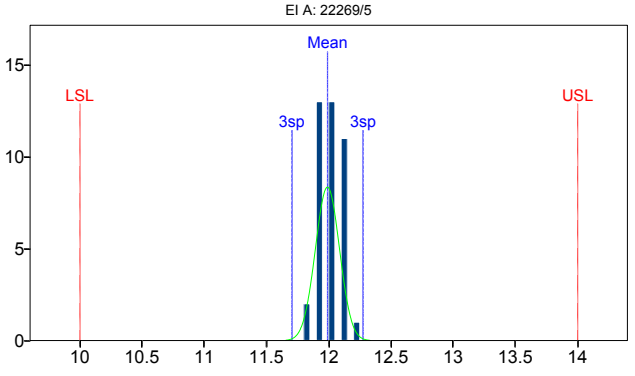
A histogram is a graphical display of tabulated frequencies, shown as bars. It shows what proportion of cases fall into each of several categories. A histogram differs from a bar chart in that it is the *area* of the bars that denotes the value, not the height of each bar as in bar charts.

About Mean Value and Standard Deviation

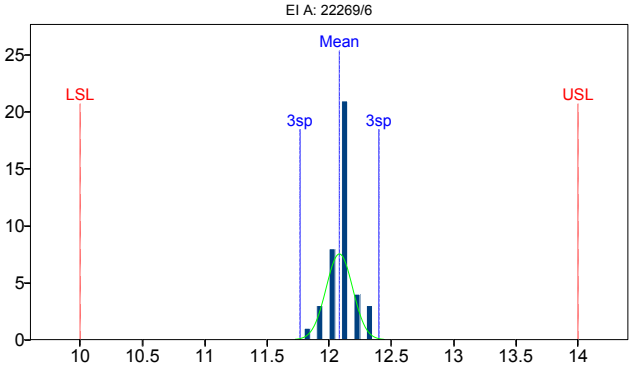
The mean is the sum of the observations divided by the number of observations. The mean describes the central location of the data, and the standard deviation describes the spread. The standard deviation is a statistic that tells how tightly all the examples are clustered around the mean in a set of data. When the examples are tightly grouped together and the bell-shaped curve is steep, the standard deviation is small. When the examples are spread apart and the bell curve is relatively flat, that signifies a relatively large standard deviation. In the case of the Almen strip testing, the tight standard deviation signifies the consistency of the arc height reading.



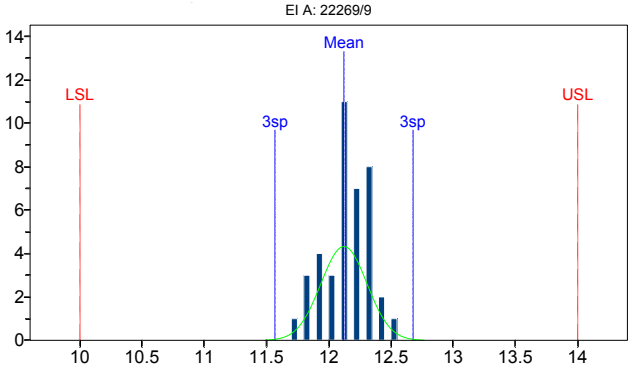
Samples:	40	Cpk:	3.491	3sp Lim:	(11.604, 12.671)
Mean:	12.1375	Cp:	3.748		
Std Dev:	.17786	Cpm:	2.951	Spec Lim:	(10, 14)
Skewness:	.1112			Est % out:	(.0000, .0000)



Samples:	40	Cpk:	6.943	3sp Lim:	(11.703, 12.277)
Mean:	11.99	Cp:	6.978		
Std Dev:	.095542	Cpm:	6.939	Spec Lim:	(10, 14)
Skewness:	.021447			Est % out:	(.0000, .0000)



Samples:	40	Cpk:	6.033	3sp Lim:	(11.765, 12.4)
Mean:	12.0825	Cp:	6.293		
Std Dev:	.10595	Cpm:	4.941	Spec Lim:	(10, 14)
Skewness:	-.17042			Est % out:	(.0000, .0000)



Samples:	40	Cpk:	3.389	3sp Lim:	(11.569, 12.676)
Mean:	12.1225	Cp:	3.61		
Std Dev:	.18465	Cpm:	2.997	Spec Lim:	(10, 14)
Skewness:	-.33498			Est % out:	(.0000, .0000)

Each histogram represents a 40 piece sample size with the x-axis as the arc height of the strip after peening and the y-axis indicating the number of samples measured at that value. (Note: arc height values x .001 inches)