Almen Gage Calibration

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1 Introduction

The Almen gage is used to measure the curvature or arc height of the Almen test strip that has been subjected to particle impacts on one side. The resulting impingement on the test strip causes it to stretch and arch. The resulting measurement is used to determine the blast stream energy or peening intensity.

The Almen gage was invented by J. O. Almen of General Motors Corporation in 1942 and a U. S. Patent was issued in June of 1944 (see Appendix A. for drawing). The original gage used two knife-edge supports for the test strip. However, in November of 1943 Engineers at General Motors revised the original design by replacing the knife-edges with four-ball support and designated the new gage as #2 Almen gage. This same basic design is in use today around the world with only minor modifications.

The Society of Automotive Engineers, SAE, has developed a standard practice for the construction of the gage in document J-442 [1] The present application of the gage includes the use of a digital indicator replacing the original dial indicator and the addition of end-stops to help assure proper positioning of the strip for measurement. The SAE specification gives dimensional data necessary to construct the gage but does not mandate a calibration procedure. This article will address calibration procedures and recommended practices. Three areas are explored.

Calibration of the indicator
Measurement of ball position(s)
Matching gages with special gage block

2 Calibrate the Indicator

Primary importance is often assigned to the dial indicator accuracy and performance and it is often the only element of the gage that is calibrated. Most large aerospace firms and calibration laboratories are capable of calibrating the indicator.

2.1 Commercial Calibration Stand

A commercial indicator calibration stand is shown in figure 1. This is a common tool used to calibrate analog or digital dial indicators and it offers a high degree of precision. Unfortunately it is expensive and time-consuming to use this method of calibration.

Figure 1. Commercial indicator calibration stand

2.2 Calibration Step Blocks

A simpler method of indicator calibration using precision step-type gage blocks can be employed. These blocks, shown in figure 2, have a flat datum reference surface and a slot of precise depth from that surface. Since the gage block is not as long as the Almen strip it is allowed to slide from side to side on the gage platform and thereby allow the indicator tip to rest upon either the datum reference or the slot. This technique precludes having to dismount the indicator from the gage frame, another timesaving feature. Using a set of such blocks with convenient slot depths can provide a quick and easy indicator calibration. [3]

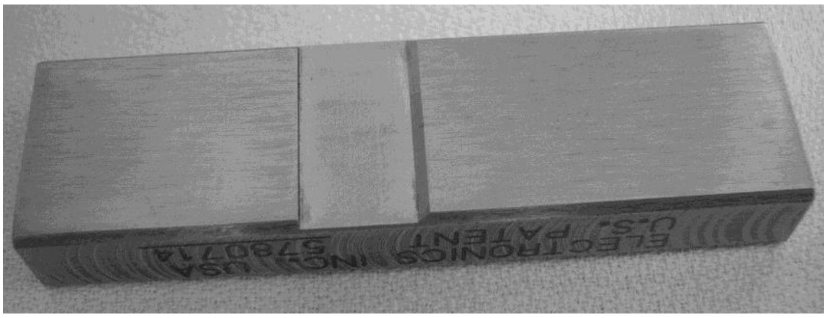

Figure 2a. Step block used to calibrate digital indicator

Figure 2b. Step block to left for zero

Figure 2c. Step block to right for calibration (inch mode)

3 Ball Position

Ball position is very important for proper operation of the gage. In addition to ball placement the condition of the balls, namely flatness, is another important factor in gage accuracy.

3.1 Ball Placement

Incorrect ball placement can contribute to erroneous readings. There are two common methods available to determine if ball placement is within specified limits. One method is to use computer controlled measuring equipment such as a coordinate measuring machine, CMM. These ball position measurements can then be compared to the requirements of J-442 to verify compliance.

A special template, shown in Figure 3 can be used to validate proper positioning of the balls. This type of test is more accurately described as a “conformity” test since no numerical data is generated. It is a go-no-go affirmation of ball placement integrity. The template is placed on the gage and visual inspection should reveal that all four balls are visible within its respective template hole. If any ball is out of position it will be readily apparent upon inspection and the gage can be rejected for non-compliance. Another feature of this particular template is its thickness. It is 2mm thick, the specified minimum ball height requirement. Each of the four balls must extend above the top plane of the template to meet the 2mm ball height requirement and sliding a straight edge over the surface and detecting the “obstruction” presence of each ball easily affirm this.

Figure 3. Special template to verify position of 4-balls

3.2 Ball Flatness

SAE guidelines now dictate that balls shall be replaced "….whenever any visible signs of flatness are observed." The importance of this is illustrated in Figure 4 that shows a schematic of a gage with a curved test specimen that measures .024 inch deflection or arc height. With balls in a flat condition the resulting gage reading increases. The "ideal" reading of .024 inch has changed to almost .030 inch, approximately 25% increase in reading. [2]

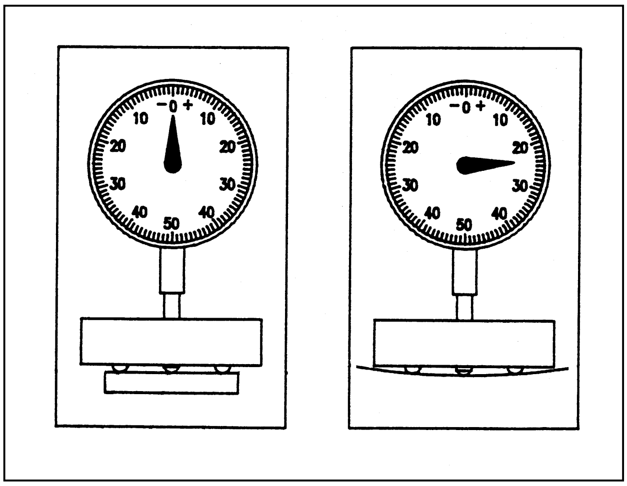

Figure 4a. Reference zero and ideal reading .024"

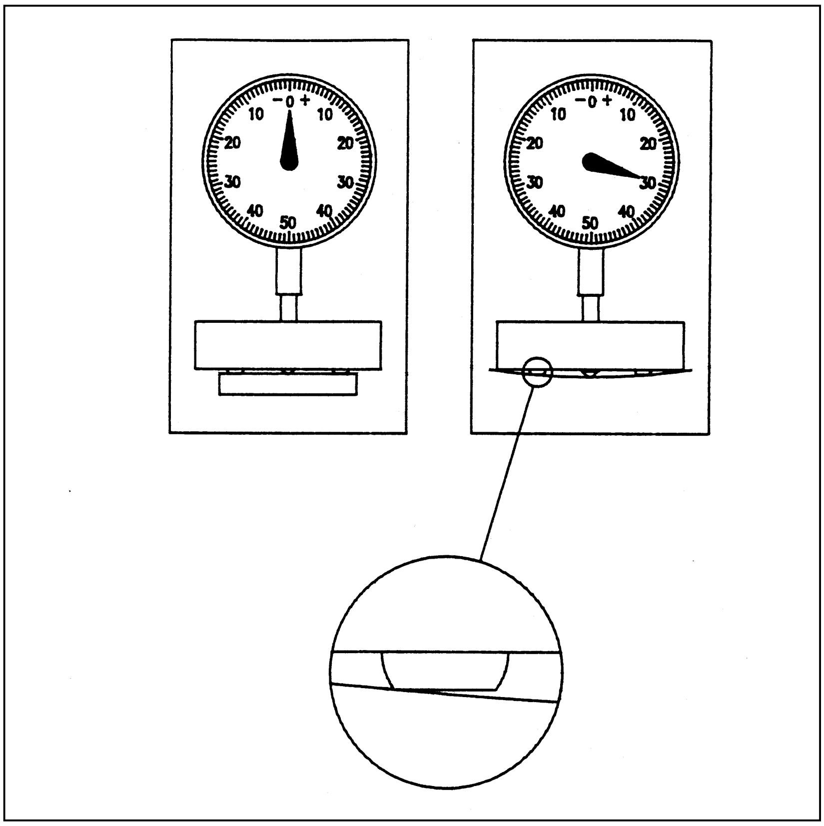

Figure 4b. Flat ball condition results in .030" reading

3.3 Ball Plane Flatness

Another tool is needed to affirm ball plane flatness, which is specified in SAE J-442 to be .05mm. Although it is not difficult to use conventional dial indicators it has been found to be much easier to place a known flat surface, such as shown in Figure 5, onto the measuring position. Individual balls are adjusted for height until the template does not “rock” back and forth or tilt. The ball plane flatness is easily obtainable with this technique. Any non-plane flatness greater than .005mm causes a very noticeable rocking or tilting which can be easily detected.

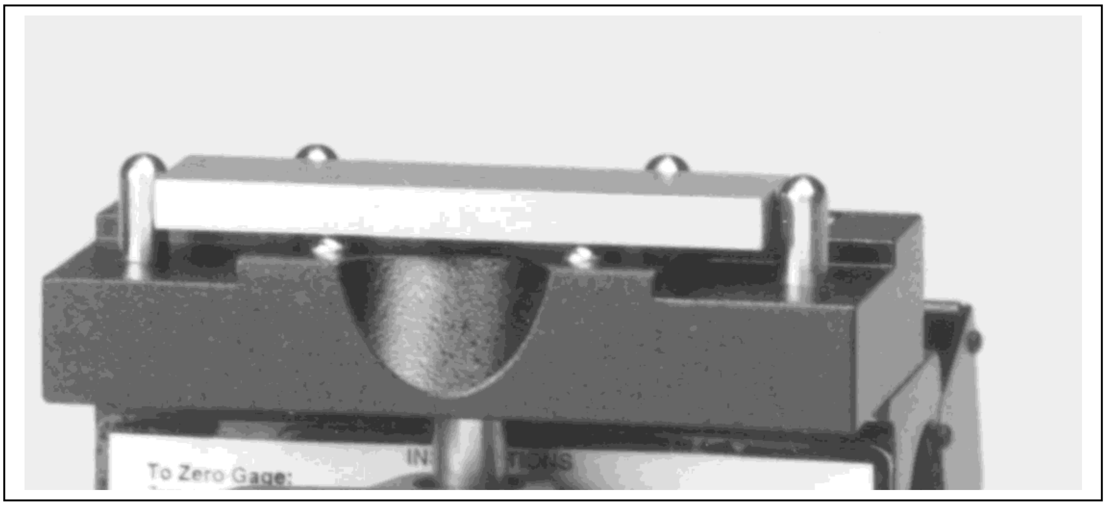

Figure 5. Flat block used for checking for ball plane flatness

4 Matched Calibration Gages

Manufacturing tolerances in such a complicated device can result in non-uniform readings from gage to gage even though the gage is technically “in compliance” with the construction requirements. It would be desirable to offer “matched calibrated gages”, especially when a gage might be taken out of service and its replacement might give different readings. Such an opportunity exists when using the calibrated curved block.

A special curved block was reviewed by the National Institute for Standards and Technology (NIST) in Washington, DC and a value with an estimate of uncertainty was assigned to the block. After placing the curved block into measuring position the gage can be re-calibrated to match the value of the curved block, thus assuring gage-to-gage reproducibility. [4]

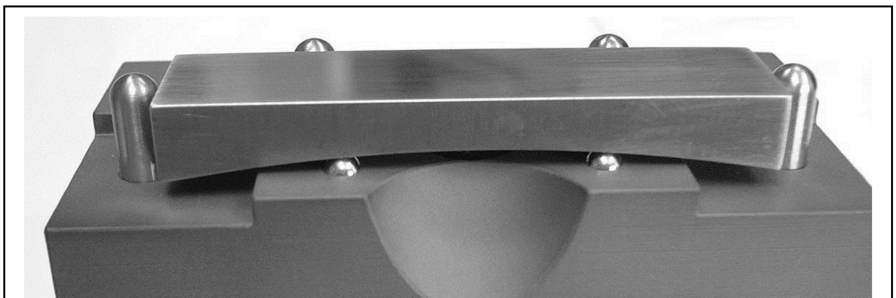

Figure 6. Curved block used to calibrate matched gage sets

4 References

[1] SAE J-442 (Dec **2001**) Test Strip, Holder and Gage for Shot Peening, The Society of Automotive Engineers, Warrendale, PA, USA

[2] Champaigne, J, Almen Gage Accuracy and Repeatability, **1993** Oxford, England Proceedings of Fifth International Conference on Shot Peening 16-27

[3] Champaigne, J, U S Patent 5,780,714 **1998** Calibration Apparatus and Method for Shot Blast Intensity Measurements

[4] Champaigne, J. U S Patent 6,289,713 **2001** Method of Calibrating Gages used for Measuring Intensity of Shot Blasting

Appendix A

Almen, J. O. U.S. Patent 2,350,440 **1942**