SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE INFORMATION REPORT

SAE AIR4738

Issued 1992-10-01

Submitted for recognition as an American National Standard

HARDNESS TESTING OF ELASTOMERIC O-RINGS

FOREWORD

Hardness measurements are widely used in industry as a simple way of determining the elastic modulus of elastomers. Hardness tests are referenced in specifications for the following:

a. To specify elastic modulus (stiffness)
b. As a quality assurance measure
c. To determine property changes due to time, heat, or fluid immersion

Standard test methods have been developed which utilize a flat, parallel faced specimen of a minimum thickness, but for quality assurance and property changes it is often desirable to test production O-rings. Two standard methods for testing the hardness of O-rings have been developed and are described in ASTM D 1414, ASTM D 1415, and ASTM D 2240. Test apparatus has also been developed specifically to test O-rings but standard test methods are not available for use with the equipment. The test instruments are generally known as microhardness testers. Hardness measurements on O-rings do not necessarily give the same results as those obtained on standard flat test pieces and the reproducibility of results is poorer.

1. SCOPE:

This SAE Aerospace Information Report (AIR) provides a general description of methods for hardness testing of O-rings including factors which affect precision and comparison of results with those obtained in standard tests.

1.1 Purpose:

To provide information on methods for hardness testing of O-rings.

2. REFERENCES:

2.1 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 1414 Testing Rubber O-rings
ASTM D 1415 Rubber Property - International Hardness
ASTM D 2240 Rubber Property - Durometer Hardness

2.2 Other Publications:

R. P. Brown, Physical Testing of Rubbers, Elsevier Applied Science

RMA Bulletin OR-5 O-ring Hardness

3. DISCUSSION:

3.1 Test Methods:

Due to the difficulty of preparing a parallel faced flat specimen from an O-ring, tests are conducted on the curved surface of the ring. To minimize testing error, it is essential that the apparatus provide:

a. A means of providing a constant load on the indentor
b. Control of the rate at which the indentor contacts the surface of the O-ring
c. A jig to prevent the ring from moving laterally
d. A method of aligning the indentor above the thickest cross-section of the O-ring

Test apparatus is available which meets the above criteria and a suitable jig is described in ASTM D 1414.

3.2 Comparison of Standard and Microhardness Tests on O-rings:

When using a microhardness test instrument on O-rings, the results obtained are not necessarily the same as those obtained on the same compound using a standard test instrument on hardness buttons. Variations in the results between the two methods are influenced by a number of factors.

3.2 (Continued):

a. The indentation force and depth of penetration into the specimen are much less with a microhardness test than with a standard hardness test. Because of these variations in test conditions, the difference in surface and interior hardness of the specimen becomes an important factor in the hardness determination. The effect is particularly pronounced on O-rings which have been post cured in an oven after press cure. The surface may be harder or softer than the interior depending upon the type of cross-linking, oxidation, or reversion which has occurred.

b. Test specimen thickness has an effect on test results with both standard and microhardness tests. Thinner test specimens give higher readings. Since a range of O-ring cross sections may be tested, the results will show more variability than those obtained on a standard thickness test button. Recommendations in ASTM D 1414 are for a minimum cross sectional thickness of 0.25 in (6.4 mm) for a standard durometer hardness test and for cross-sectional thickness under 0.25 in (6.4 mm) the microhardness test of ASTM D 1415 be used. ASTM D 1414 also provides a description of a holding fixture for O-rings during testing and a modification for using two plied O-rings when cross sectional thickness is under 0.13 in (3 mm). However, plying O-rings leads to additional variation in test results.

c. In both standard and microhardness testing it is essential that the indentor contact the test piece at right angles to the surface and in the center of the specimen. The microhardness testers commercially available are provided with systems to ensure correct alignment and centering. Regular maintenance and calibration of hardness test equipment is essential for retention of proper alignment.

d. The hardness change in O-rings measured after fluid immersion, heat age, or functional tests is carried out to predict service life in conjunction with other tests. The results obtained may be different from standard hardness tests on buttons. Oxidation and other chemical reactions are more pronounced at the surface of the test specimen, particularly in short-term tests. If a microhardness tester is used, where the results are greatly influenced by the surface hardness of the test piece, differences from standard tests can be significant, for the same reasons as in 3.2(a).

e. For practical purposes, it is normally assumed the durometer A scale (ASTM D 2240) and the IRHD scale (ASTM D 1415) are similar. This assumption is true for highly elastic rubber (e.g., natural rubber) but for rubber with lower resilience (e.g., nitrile, fluorocarbon), differences of up to 10 points may occur. This applies for both standard and microhardness tests and is caused by differences in application of force and time of readings.

It is important to recognize this difference because most rubber specifications use the durometer A scale (ASTM D 2240) to specify hardness but many laboratories use an IRHD microhardness tester (ASTM D 1415) to test production O-rings. Hardness limits on control tests may require adjustment for different test procedures.