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TENSION TESTS WITH CUT RING SPECIMENS

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CONTENTS

TENSION TESTS WITH CUT RING SPECIMENS

Tension tests are recognized as being indispensable to the rubber technologist. They are used as a means of determining the effects of various compounding ingredients and for production control. In addition, they are used to determine the resistance of vulcanizates to deterioration caused by weather, heat, and chemicals.

Procedures for conducting tension tests on rubber vulcanizates are standardized and described in ASTM and ISO documents, as well as state and federal specifications. These methods officially recognize six dies and two cutters for specimen preparation. The dies are used to prepare the dumbbell specimen and the cutters to prepare the ring specimen.

The cut ring tensile specimen has been in existence for over 20 years but has had very little acceptance. Probably the principal reason that cut ring testing did not achieve recognition in this country was the difficulty in preparing a proper specimen and the lack of correlation between data obtained with rings and those obtained with the widely accepted ASTM Die C dumbbell. In addition, the ASTM and ISO cut ring specimens are not satisfactory for materials with a hardness value greater than 80 durometer A. The ASTM and ISO cut rings cannot be prepared from many of these harder compounds because the stress in cutting causes blade breakage.

There have been other problems associated with testing hard materials with the conventional dumbbell specimens: dimensions could not be duplicated consistently when preparing dumbbells because it was impossible to maintain a sharp edge on the cutting die; also, as the tensile strength of an elastomeric compound approaches 4,000 psi, it becomes very difficult to grip the specimen and prevent some slippage or even breaking in the grips. (Many of the urethane compounds have tensile strength which far exceeds 4,000 psi.) These problems are eliminated with the smaller cut ring specimen developed by a ASTM task group about five years ago.

Figure 1 shows the dimensions of the ASTM, ISO and the new ring specimens.

Figure 1

Dimensions of Ring Specimens
Old and New

ASTM - ID = 29.5mm(1.16") - OD = 33.5mm(1.32")

ISO - ID = 44.6mm(1.76") - OD = 52.6mm(2.07")

New - ID = 16.2mm(0.64") - OD = 17.2mm(0.72")

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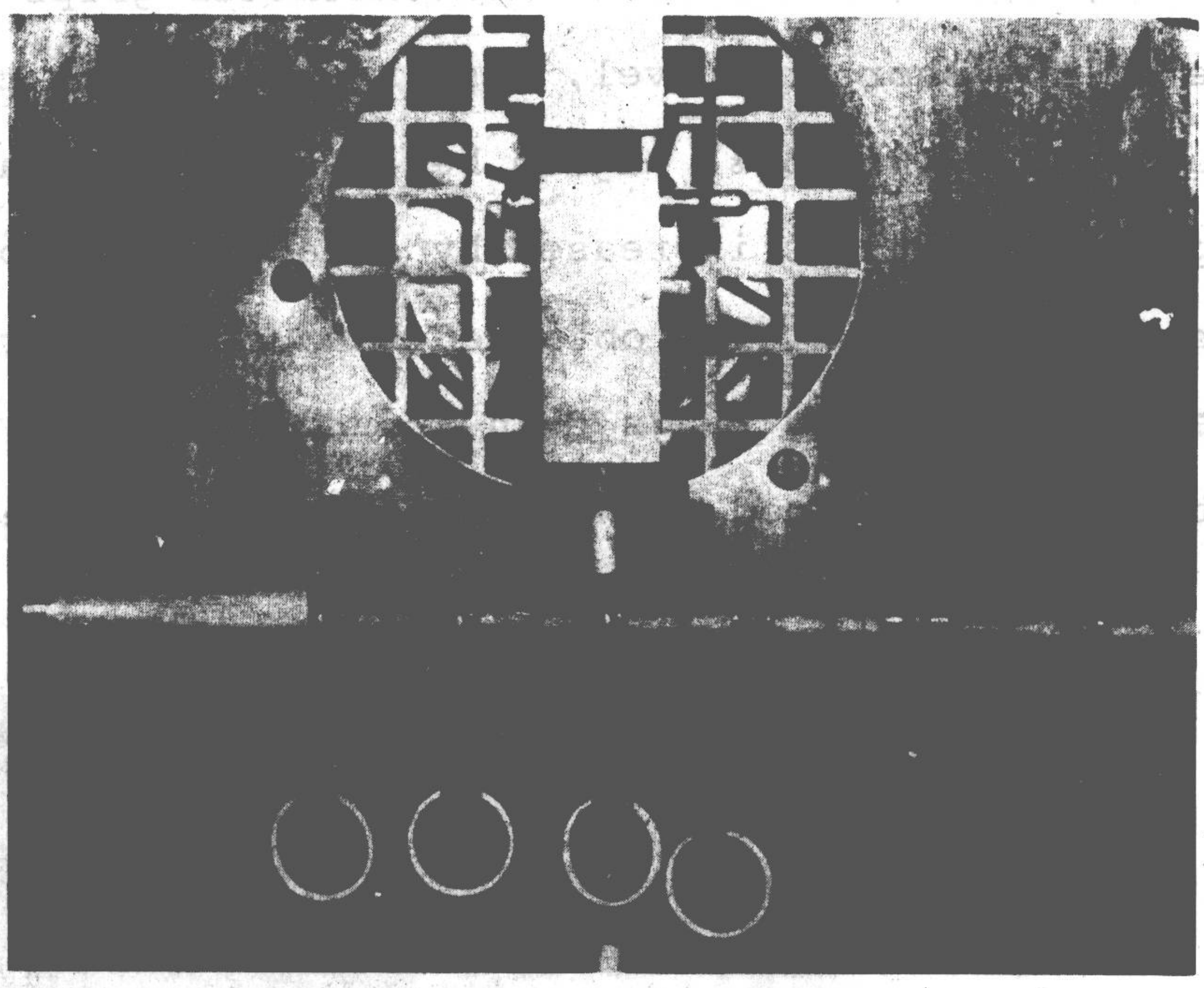
Figure 2 shows a routine setup with a ring specimen and the required test fixtures.

Figure 2

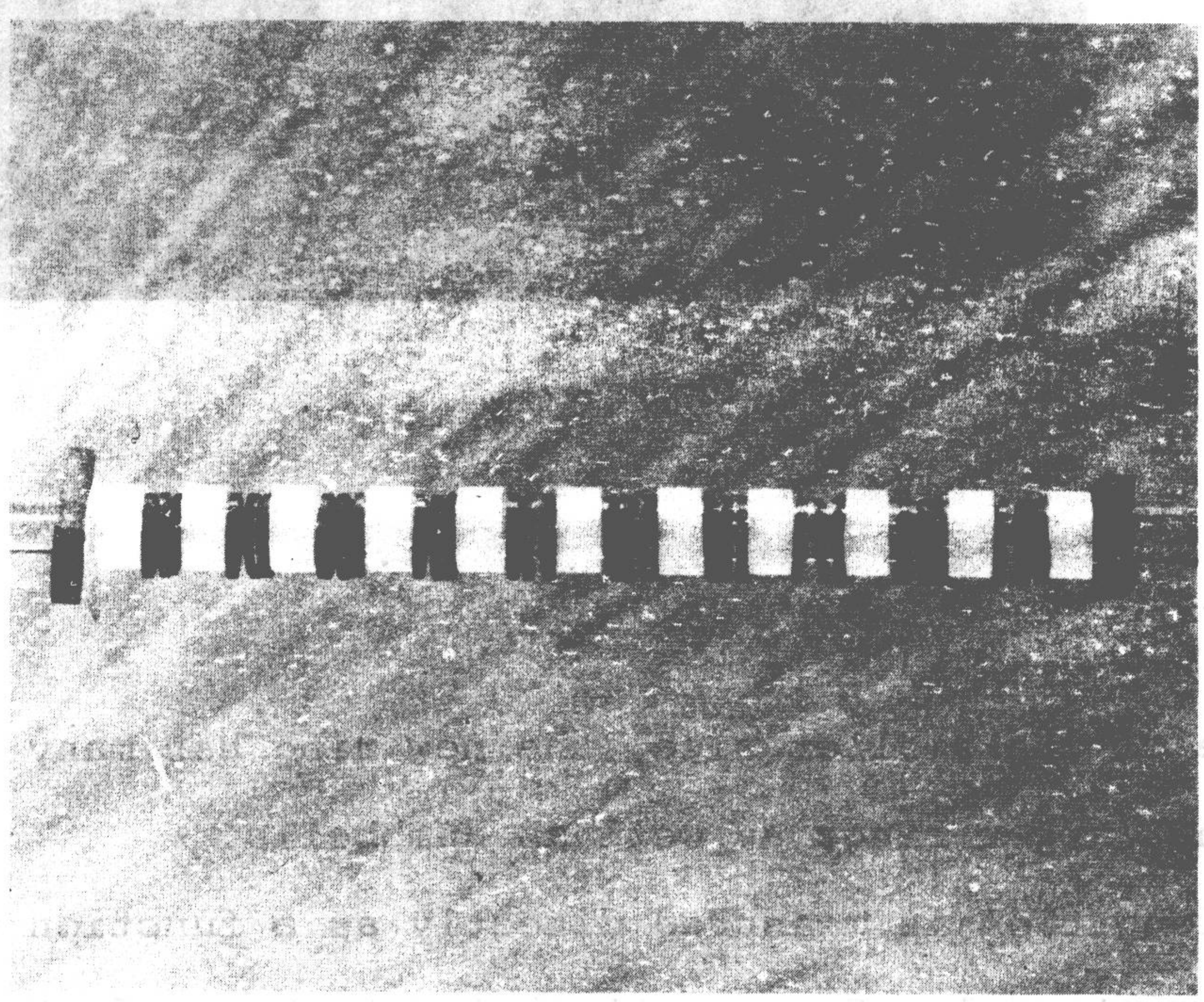


Because of its smaller size, the new ring has many advantages over the larger rings as well as dumbbells.

Elongation is measured directly as a function of machine crosshead travel. Errors attributed to human factors, as in marking elongation increments by eye or with mechanical extensometer, are essentially eliminated with the direct correlation.

The ring and test fixtures were designed so that every 100% elongation would be equal to one (1) inch crosshead travel. With dumbbells, the crosshead travels much further than either of the one (1) inch bench marks or extensometer grips on the specimen. Because of the shorter travel, testing time using the new rings is reduced more than 50%. Again because of the smaller size, oven aging capacity is increased by a factor of approximately 25. More uniform aging is also obtained because air circulation is less restricted around rings than around dumbbells. Figure 3 shows the setup designed to handle the ring specimens during aging.

Figure 3



A 1/2" diameter glass rod is used with 1/4" wide glass spacers and metal tags for identification. This is a simple, inexpensive setup which works very well.

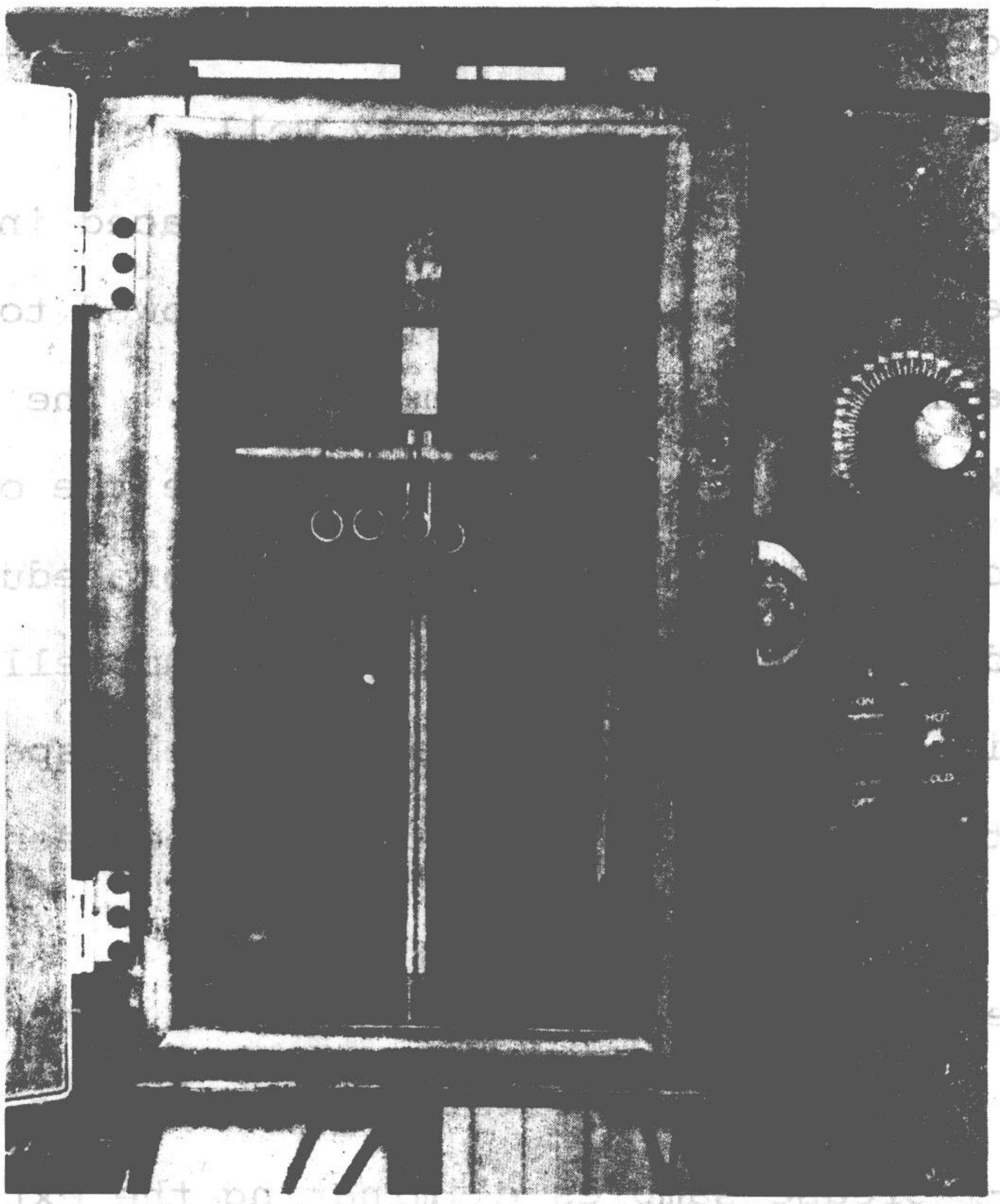
The rod-and-specimen assembly is placed in the aging oven for the specified time, removed, and allowed to cool for the proper time interval at room temperature. The complete assembly is then taken to the tensile tester where the operator removes and tests one specimen at a time. This procedure eliminates some of the handling involved with the aged dumbbell specimens. The reduction in sample volume between dumbbell specimens and ring specimens tends to reduce contamination between samples within the oven.

Another fringe benefit for this size ring is the fact that the center plug can be used for in-lab testing of hardness, weight-and-volume-increase samples eliminating the extra step of cutting out and preparing additional specimens.

Another advantage is for those people who have to prepare tensile specimens from a finished product. When using the small size ring you need a much smaller sample, compared to that needed for dumbbells. This becomes even more important if a lot of test specimens are needed for aging or testing at conditions other than standard.

Figure 4 shows the testing setup using an environmental chamber.

Figure 4



The small specimen size and consequently small chamber make it more practical to accurately determine stress-strain properties at both low and elevated temperatures. This size chamber makes possible excellent temperature control and distribution because of its compactness; at least 9 inches of travel can be obtained with the ring specimen permitting up to 900%

elongation on a specimen. This requires at least 27" of travel in testing Die C dumbbells.

The quality of environmental testing is greatly improved and output is more than tripled with rings as compared to dumbbell specimens. Measuring stress-strain at low temperature is particularly difficult with dumbbells because of fogging on the glass, icing on the inside of the chamber, and the need to measure elongation visually from outside the chamber. These problems are completely eliminated using the ring specimen. It no longer is necessary to observe the test specimen; the sample is placed on the spindles; the machine is started, and the results are recorded.

As many as 18 cut ring specimens can be prepared from one 4"x6" tensile slab; therefore, visible imperfections in the slab are far less likely to prejudice test results than in the case of dumbbells.

The data from the small size ring correlates very well with data from the Die C dumbbell as shown in Figures 5 and 6.

Figure 5

Rings Versus Dumbbells
Original Stress-Strain Data

Neoprene

	Hds.	100%	300%	Tensile	Elongation
Dumbbells	62	540	-	1060	200
Rings	62	580	-	1100	210
Dumbbells	65	530	3200	3470	320
Rings	65	500	2950	3380	330
Dumbbells	69	360	1420	1910	410
Rings	69	360	1310	1850	420

EPDM (NORDEL®)

	Hds.	100%	300%	Tensile	Elongation
Dumbbells	56	320	1830	2750	390
Rings	56	360	1830	2700	370
Dumbbells	60	250	1850	2120	330
Rings	60	300	1760	2200	350
Dumbbells	62	290	1100	1890	530
Rings	62	290	1130	1890	520

HYPALON®

Dumbbells	69	610	740	820	360
Rings	69	600	800	860	330
Dumbbells	73	1150	2160	2340	340
Rings	73	1040	2300	2360	330
Dumbbells	78	1080	1310	1440	370
Rings	78	990	1330	1400	350

VITON®

Dumbbells	75	880	-	2160	170
Rings	75	770	-	2100	190
Dumbbells	84	2500	-	2600	100+
Rings	84	2320	-	2620	120
Dumbbells	88	830	-	1670	280
Rings	88	880	-	1730	270

Urethane

Dumbbells	86	1320	2610	4430	380
Rings	86	1280	3500	5770	410
Dumbbells	97	1620	2930	5180	420
Rings	97	1890	3780	7070	420
Dumbbells	97	1700	3020	5300	410
Rings	97	1940	3960	7400	420

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Silicone

	Hds.	100%	300%	Tensile	Elongation
Dumbbells	54	200	560	1150	500
Rings	54	200	540	1130	500
Dumbbells	65	320	740	1080	270
Rings	65	340	790	1150	280
Dumbbells	70	450	880	1010	230
Rings	70	410	860	1040	250

Butyl

Dumbbells	72	290	810	1170	510
Rings	72	290	830	1170	500
Dumbbells	76	340	920	1170	480
Rings	76	410	1010	1190	420

HYCAR

Dumbbells	68	410	1710	2320	590
Rings	68	430	1690	2450	560
Dumbbells	68	430	1760	2300	550
Rings	68	450	1710	2360	530

Figure 6

Rings Versus Dumbbells
Aged Stress-Strain Data

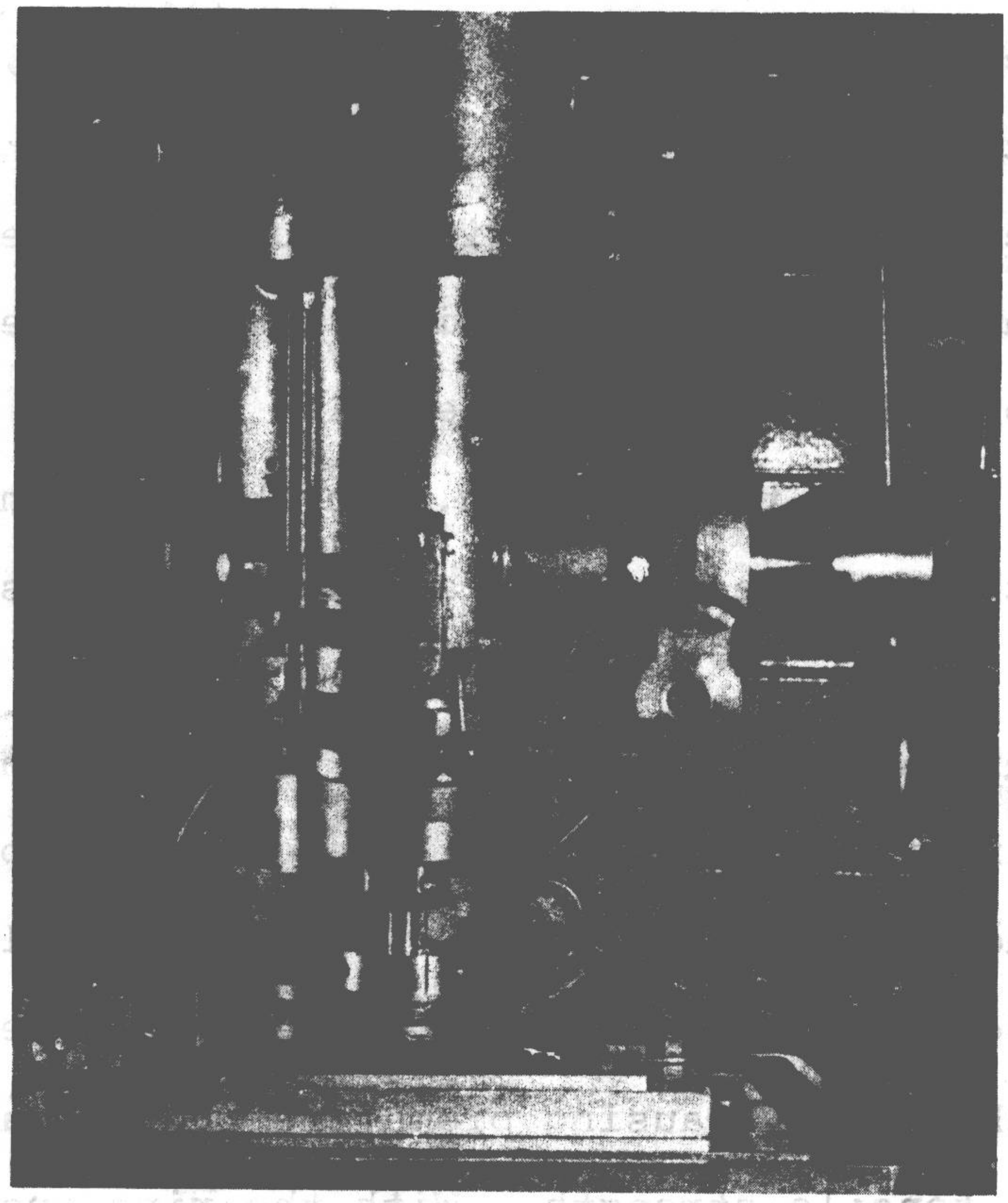
	100%	300%	Tensile	Elongation
Neoprene - Aged 70 hrs. @ 100°C Oven				
Dumbbells	1220	-	1550	150
Rings	1310	-	1710	150
Dumbbells	520	1580	2320	480
Rings	590	1600	2210	470
NORDEL® - Aged 70 hrs. @ 121°C Oven				
Dumbbells	1300	2100	2330	180
Rings	1440	2400	2550	170
Dumbbells	1050	-	2760	220
Rings	1170	-	2900	230
HYPALON® - Aged 70 hrs. @ 100°C Oven				
Dumbbells	680	-	1480	280
Rings	630	-	1530	260
Dumbbells	1670	-	1820	120
Rings	1640	-	1730	120
VITON® - Aged 70 hrs. @ 277°C Oven				
Dumbbells	430	-	1310	220
Rings	410	-	1600	290
Dumbbells	750	-	1740	210
Rings	800	-	2050	220

By this comparison of data, the agreement was well within the generally accepted specification tolerances. When agreement between the two test specimens was not obtained, as in the case of the urethanes, the dumbbell specimen was not of proper size or slippage occurred in the grips. Dumbbell specimens tend to be of slightly different dimensions than the die because of spreading or dullness. ASTM specifies only the dimension of the die itself and not the specimen. In the cut ring test, the specimen itself is measured to assure dimensions are within tolerance.

Another significant difference favoring rings: when dumbbells are inserted into grips, they must be properly aligned as to depth and direction of pull. If the dumbbell specimen is not in nearly perfect alignment, more stress will be applied to one edge than the other, causing premature rupture and inaccurate readings of tensile strength. With the ring specimen there are no grips or alignment problems to be concerned with.

The equipment used for cutting ring specimens is shown in Figure 7.

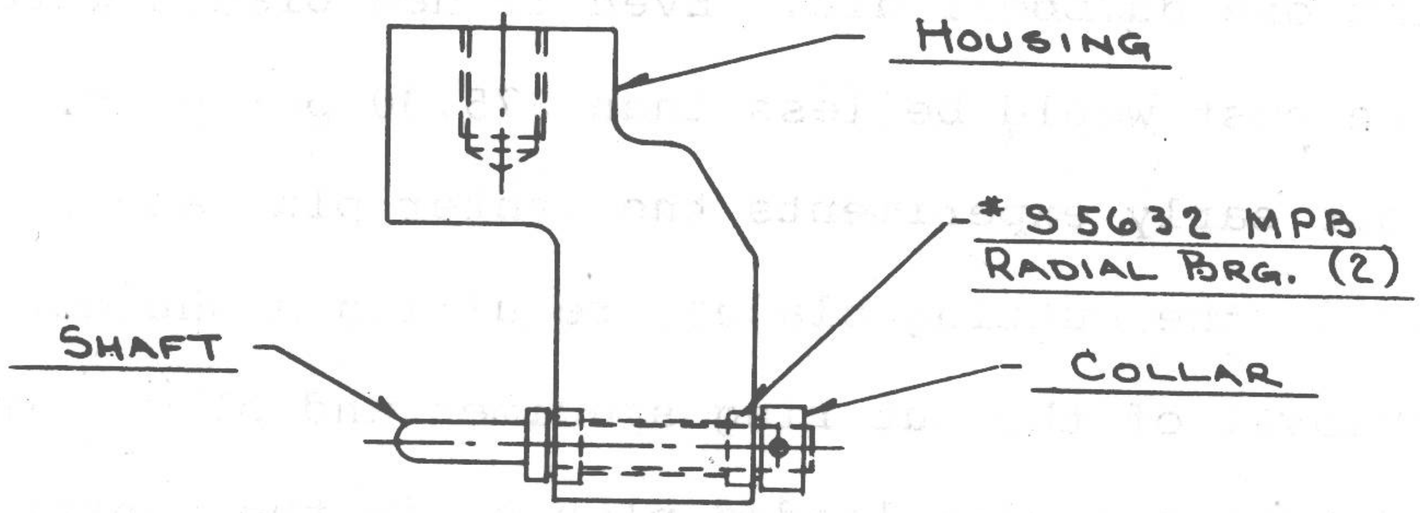
Figure 7



A drill press with a spindle tolerance of ± 0.0005" is an absolute necessity to get the precision required. It should be equipped with a variable speed drive and a milling table. Once the slab is positioned on the hold-down system it need not be removed until all test specimens have been cut. Without the milling table, it would be necessary to remove the slab and reposition it under the cutter after every cut.

The test fixtures, shown in Figure 8, were developed by the ASTM Task group. The spindles are mounted in radial bearings and do not require any lubricant between the spindle and specimen. This free movement minimizes the local stresses in the specimen.

Figure 8



We have found, with the smaller ring, that as long as the blade is sharp enough to cut a specimen at all that ring will meet the radial width tolerance of 0.040 ± 0.002". When the blade becomes dull or otherwise damaged, it becomes impossible to prepare a specimen, and new blades must be installed.

The ring cutting blades can be installed by a laboratory technician in less than five minutes. The blades are inexpensive; for most laboratories, a year's supply would cost less than sharpening one dumbbell die. Even if new blades were installed daily, the cost would be less than $75.00 per year.

In our early experiments the center plug and ring tended to "hang up" in the cutting blades, requiring a shutdown and the manual removal of the cut ring specimen and plug. This was corrected with a spring-loaded plunger in the center of the cutter shaft between the two blades. This causes both the ring specimen and plug to remain in the sample sheet or slab until the technician removes the ring for testing.

Figure 9 shows the cutter with the spring loaded plunger.

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