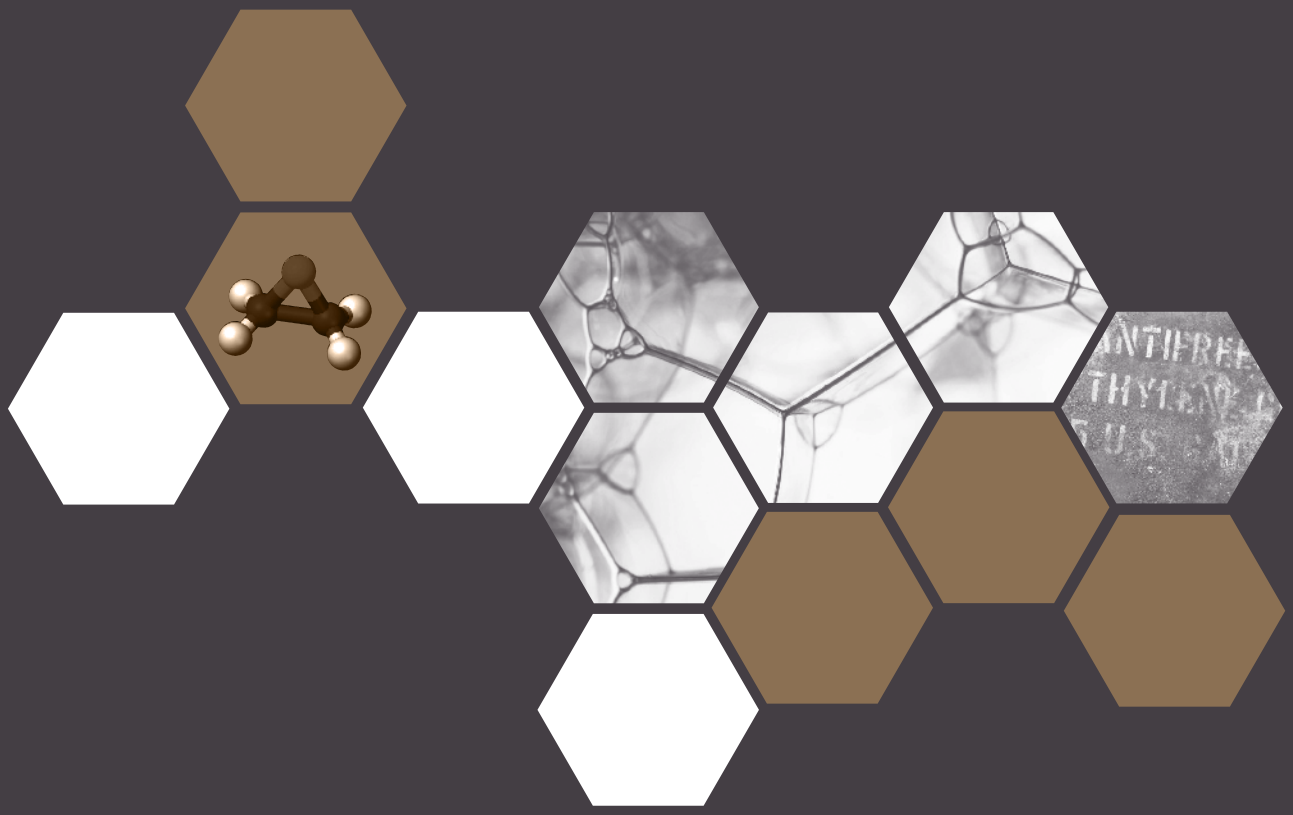
ethyleneoxide

third edition



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To the Reader

Manual Preparation

As members and affiliated companies of the American Chemistry Council, we support efforts to improve the industry's responsible management of chemicals. To assist in this effort, the American Chemistry Council's Ethylene Oxide/Ethylene Glycols Panel supported the creation and publication of this manual. The Panel is comprised of the following companies:

Balchem Corporation/ARC Specialty Products

BASF Corporation

Bayer Material Science LLC

Celanese Ltd.

Champion Technologies

Croda, Inc.

The Dow Chemical Company

Eastman Chemical Company

Honeywell

Shell Chemical LP

The development of this manual was led by the Panel's Ethylene Oxide Safety Task Group (EOSTG), a group comprised of producers and users of ethylene oxide. The EOSTG functions to generate, collect, evaluate and share information to support product stewardship with regard to ethylene oxide. The EOSTG formed a manual work group, chaired by Keith Vogel of Lyondell Chemical Company, to lead the development of this document. The following work group members provided significant contributions:

Tom Grumbles	Sasol North America
Susan Jackson	BASF Corporation
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Keith Vogel	Lyondell Chemical Company
Mike Wagner	Old World Industries
John Wincek	Croda, Inc.
Gerald Wise	Shell Chemical LP

Acknowledgements

Many others contributed to the development and editing of this manual, all of whom cannot be listed here; however, the manual work group would like to thank the following individuals for their significant contributions to this publication:

Ralph Gingell	Shell Chemical LP
William Gulledge	American Chemistry Council
Karl Loos	Shell Chemical LP
David McCready	The Dow Chemical Company
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Table of Contents

Figures

Tables

Appendix B Laboratory Compatibility Testing of Elastomers with Ethylene Oxide

An EO producer tested several elastomers (O-Rings) to determine their compatibility with EO. The materials selected included those that are commonly used in the industry along with some that lab data has indicated are incompatible with EO. The test methods used by the producer and the results of the testing are summarized below. The results of the testing – a combination of physical property and mechanical property data - can be used to provide a screening mechanism to aid in the selection of materials or for materials to be investigated further. The data is not necessarily predictive of whether a particular material will be successful or fail in EO service.

Experimental Procedure

The ten O-rings studied are listed in Table B1. The materials were exposed to EO according to the NACE International Standard Test Method TM0196-96 – Chemical Resistance of Polymeric Materials by Periodic Evaluation. The method was followed as closely as possible with some minor modifications made due to the hazards in handling and storing EO. The detailed procedure is further described below.

Four samples of each of the materials tested were prepared in quadruplicates (16 samples total for each material). One sample served as a blank and was not exposed to EO. The other three samples for each material were submerged in liquid EO. The EO was contained in either Teflon-PFA autoclaves or reinforced glass autoclaves (the autoclaves were not expected to have any significant impact on the variables of interest). The first sample of each material was removed after 30 days, the second removed after 60 days, and the third removed after 90 days. The autoclaves were maintained at a constant temperature of 27°C using a temperature-controlled oil bath. The autoclaves were pressured to 480 kPa with nitrogen to ensure the vapor remained in the non-decomposable region.

Upon removal from the EO, the O-ring samples were allowed to degas for 30 minutes, then these samples were sealed in glass vials. This allowed residual EO on the surface to evaporate, thus minimizing the exposure risks of those handling the samples. However, it was not sufficient time for the majority of the EO that had diffused into the polymer matrix of the materials to desorb. Physical and mechanical tests were conducted on the same day the samples were removed from the EO; therefore, the measurements should provide an accurate representation of the effects of EO submersion.

Physical properties were obtained by making accurate measurements of the weight and density of the samples. Density measurements were made using the water displacement method according to ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement. Dividing the weight by the density provided the volume of each sample.

Table B1 O-Rings Selected for Compatibility Testing

O-Ring	Description
Chemraz®[1] 505	Perfluoroelastomer
Kalrez®[2] 1050 LF	Perfluoroelastomer
Kalrez®[2] 2035	Perfluoroelastomer
Kalrez®[2] 6375	Perfluoroelastomer
Parker E515-80 EPR	Ethylene-propylene copolymer
Parker E962-90 EPDM	Ethylene-propylene-butadiene terpolymer
Parker E740-75 EPR	Ethylene-propylene copolymer
Viton®[2]F (V1163-75 FKM75A)	Partial perfluoroelastomer
Nitrile (N304-75 LT Nitrile 75)	Acrylonitrile-butadiene copolymer
Butyl Rubber (Bu-70)	Isobutylene polymer

1. Registered U.S. Trademark of Green Tweed and Company
2. Registered U.S. Trademark of DuPont Dow Elastomers LLC

Figure B1 Weight Change of O-rings Exposed to EO at 27°C

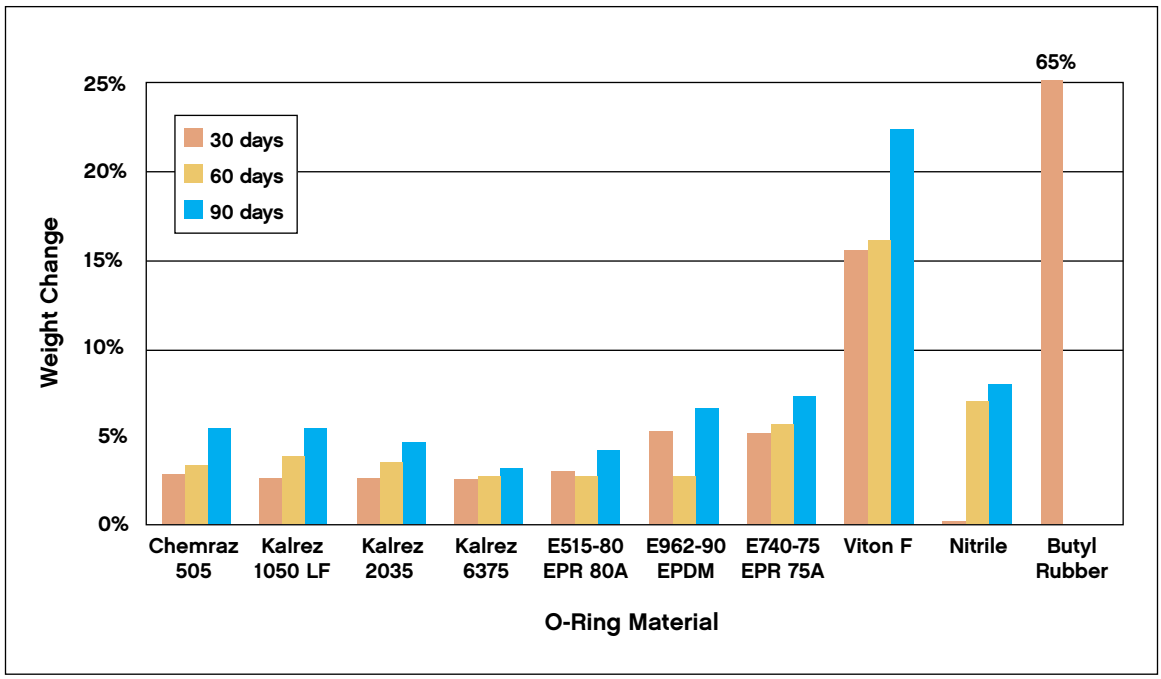
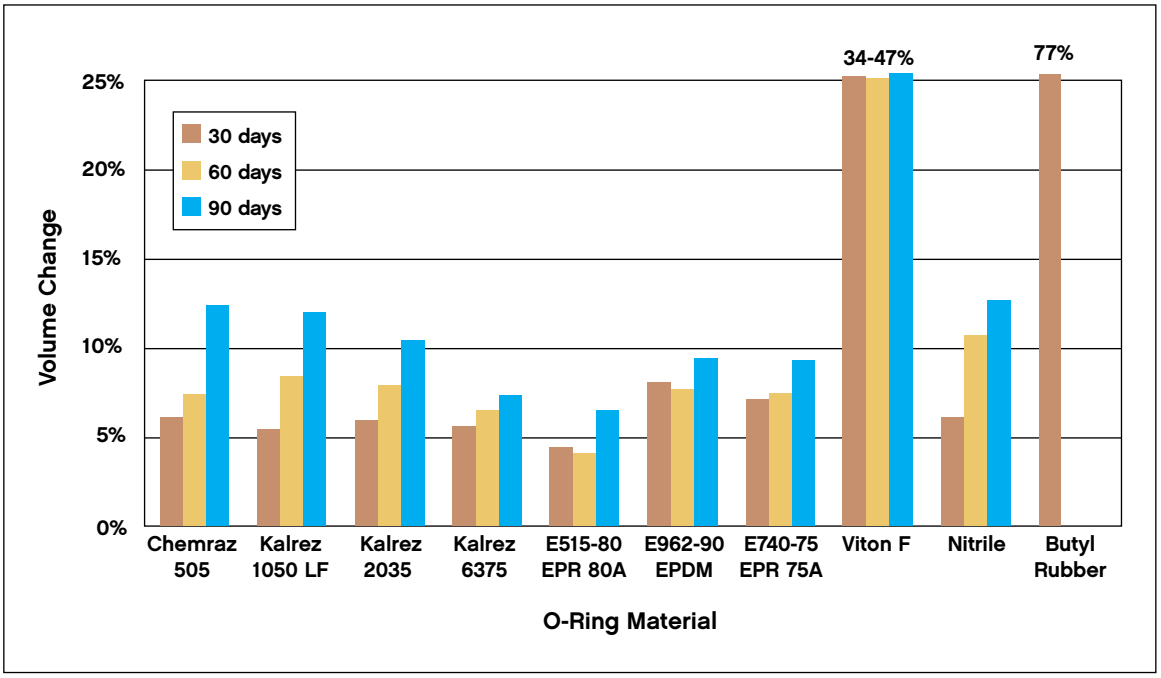


Figure B2 Volume Change of O-rings Exposed to EO at 27°C



Mechanical properties were obtained using an Instron mechanical testing apparatus. Properties of the O-rings were obtained as outlined in ASTM D638 - Standard Test Method for Tensile Properties of Plastics. The O-rings were not cut for analysis according to ASTM D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers: Tension. Therefore, the modulus of the o-ring samples could not be obtained. For these experiments, the O-rings were tested with no additional modifications (all O-rings were size 214).

Tensile properties are basic material properties that can be used to characterize changes in the mechanical property of a material. Comparison of a material's tensile properties before and after exposure to EO is expected to provide an indication of the ability of that material to maintain its mechanical properties. Therefore, this measurement provides a relatively quick and simple means to characterize samples before and after EO exposure.

Results and Discussion

The results of the physical measurements of the o-rings are shown in Tables B2 and B3. These compare the percent weight gain and percent volume gain for each of the O-rings after periods of 30, 60, and 90 days. For the samples that are off scale in Tables B2 and B3 (butyl rubber for weight change and viton F and butyl rubber for volume change), the actual values are listed above the bars in the chart. Also, only the results of the 30-day sample are shown for butyl rubber. After 30 days, the sample was swollen and degraded to the point that it was not necessary to perform the measurements for the 60 day and 90 day samples.

It is important to note that the EO absorption of the O-rings is a time-dependent behavior and varies with the material. For example, the nitrile O-ring exhibits decidedly less weight gain and volume swell after 30 days than the Parker E962-90 EPDM O-ring. However, after 90 days of exposure, the opposite is true, with Parker E962-90 EPDM O-ring exhibiting fewer changes in physical properties than the nitrile O-ring. Therefore, the expected duration that an O-ring will be in service is of paramount importance when selecting a suitable O-ring for a given application.

The mechanical properties of the O-rings are shown in Tables B4 and B5. Ultimate strength, or tensile strength (Table B4), is the measured stress of the material at its breaking point while ultimate strain (Table B5) is the maximum deformation of the material just prior to the breaking point. Most of the O-rings showed significant decreases in tensile strength upon exposure to EO compared to the unexposed, control samples. By comparison, ultimate strain measurements revealed much smaller percentage changes between the exposed and unexposed samples.

Figure B3 Tensile Strength of O-rings Exposed to EO at 27°C
(control samples were not exposed to EO)

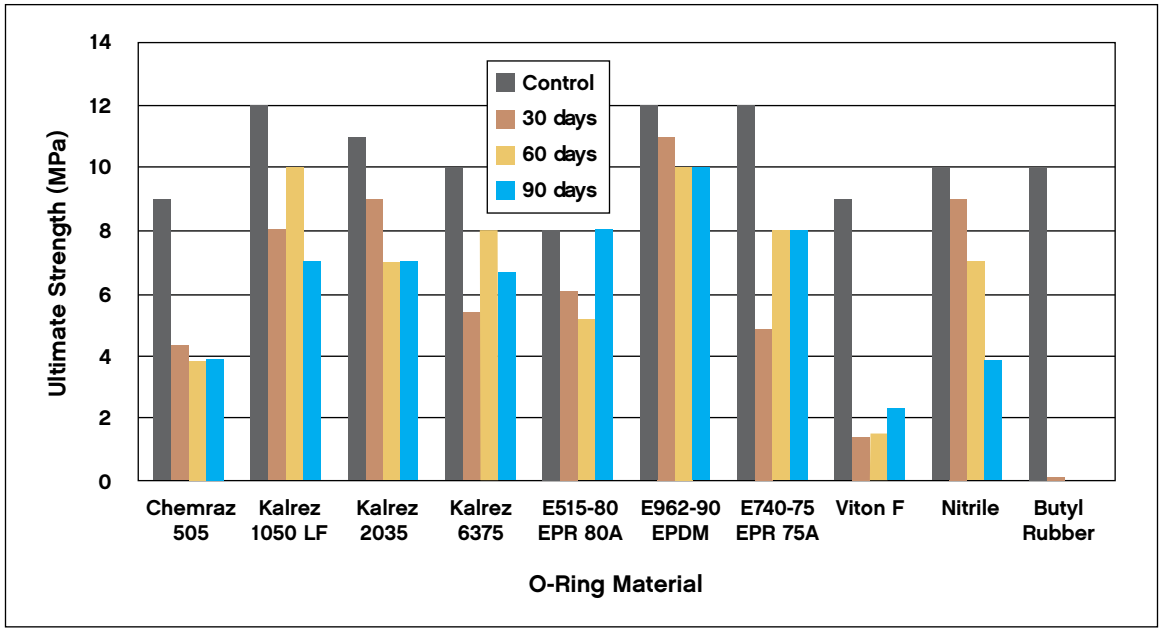


Figure B4 Maximum Deformation of O-rings Exposed to EO at 27°C
(control samples were not exposed to EO)