**EVALUATION OF ETHYLENE PROPYLENE DIENE MONOMER AND SILICONE RUBBER COMPOUNDS FOR APPLICATIONS IN**

**REPROCESSING PLANT**

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**Abstract**

To study the suitability of using EPDM and silicone rubbers in nuclear fuel reprocessing plant, the EPDM rubber and silicone rubber compounds were prepared and test specimens were fabricated. Both rubber compounds were tested for its mechanical properties. Two sets of test specimens of EPDM rubber compound were taken for study. First set of test specimen was irradiated in gamma chamber followed by exposure to nitric acid (6 M) and the second set of test specimen was exposed to nitric acid (6 M) followed by irradiation in gamma chamber. Samples were taken out of gamma chamber at regular intervals of time and elongation at break were tested. Similar procedure was adopted for silicone rubber compound also. The elongation at break of both the rubber compounds were found to degrade with exposure of radiation. Elongation at break of EPDM rubber compound decreased to 50% of its initial value at dose of 1 MGy and for silicone rubber elongation at break decreased to 50 % of its initial value at dose of 0.1 MGy.

1. INTRODUCTION

For seal applications in nuclear industry elastomers need to be used. Among the elastomers EPDM and silicone rubbers have excellent radiation stability. Both the rubbers can be used for gasket, O-ring application, seal profile, etc in nuclear fuel reprocessing plant where both radiation and acid vapour are present. In order to evaluate the application of EPDM and silicone rubber in nuclear fuel reprocessing plant, a study was carried out to determine the degradation behavior of these two rubbers in radiation and acid vapour environment.

2. EXPERIMENT

**2.1 Materials**

Compounds of EPDM and silicone rubber for gasket application was prepared. Test specimens (tensile – as per ASTM D 412) were fabricated from both the compounds.

**2.2 Radiation and chemical exposure experiment**

Two sets of test specimens each of EPDM gasket and silicone gasket compounds were taken. First set of test specimen of each rubber compound was irradiated in ambient condition (with Co60 as the source which then had dose rate of 4.11 kGy/h, supplied by Board of Radiation and Isotope Technology (BRIT), Mumbai, India) followed by exposure to vapours of nitric acid (6 M) as per ASTM D 471. The time of exposure to vapours of nitric acid was taken equal to the corresponding time of radiation exposure respectively because in actual condition seal will be exposed to radiation and vapours of nitric acid simultaneously and for same time. Similarly the second set of test specimen was exposed to nitric acid followed by irradiation. Test specimens were taken out at regular intervals of irradiation (0.1, 0.5, 1, 2.5, 5, 7.5 and 10 x 106 Gy for EPDM rubber and 0.2, 0.4, 0.6, 0.8 and 1 x 106 Gy for Silicone rubber) and elongation at break was measured.

**2.3 Elongation at break**

Elongation at break value of unexposed and exposed test specimens was tested as per ASTM D 412. Five test specimens were taken for testing in each exposure and average value was recorded.

3. RESULTS

Elongation at break of exposed test specimens of both EPDM and silicone rubber compound was found to decrease with radiation dose because of degradation by chain scission. The values of elongation at break of exposed EPDM and silicone rubber specimens (first set and second set specimens) is plotted against various radiation dose and is shown in fig. 1 and 2 respectively.



Fig. 1 Plot of elongation at break of EPDM rubber compound against radiation dose



Fig. 2 Plot of elongation at break of silicone rubber compound against radiation dose

**3.1 First set of test specimens: Irradiation + chemical exposure**

For EPDM rubber and silicone rubber the elongation at break values at various radiation dose curve fit was done and the degradation of specimen was found to obey the equation 1 and 2 respectively

$y = 75 + 210 e ^{-0.077x}$ (1)

$y = 127 + 354 e^{-0.071x}$ (2)

where y denotes elongation at break at radiation dose of x

As per Standard IEC 544-2 and 4, the radiation tolerance of polymer is the dose at which elongation at break decreases to 50% of its initial value.

Therefore for EPDM rubber substituting y = 140 in equation 1 (since initial elongation at break is 280 %), x is found out to be 15.2 that is radiation tolerance value for the EPDM compound is found to be around 1.52 x 106 Gy.

Similarly for silicone rubber substituting y = 110 in equation 2 (since initial elongation at break is 220 %), x is found out to be 5.6 that is radiation tolerance value for the Silicone compound is found to be around 0.56 x 106 Gy.

**3.2 Second set of test specimens: Chemical exposure + irradiation**

Similarly for the second set of test specimens of EPDM rubber and silicone rubber degradation of specimens was found to obey the equation 3 and 4 respectively

$y = 77 + 213 e^{-0.077x}$ (3)

$y = 125 + 351 e^{-0.071x}$ (4)

where y denotes elongation at break at radiation dose of x

For evaluating radiation tolerance of EPDM rubber substituting y = 140 in equation 3 (since initial elongation at break is 280 %), x is found out to be 15.8 that is radiation tolerance value for the EPDM compound is found to be around 1.58 x 106 Gy.

Similarly for silicone rubber substituting y = 110 in equation 4 (since initial elongation at break is 220 %), x is found out to be 5.7 that is radiation tolerance value for the silicone compound is found to be around 0.57 x 106 Gy.

4. CONCLUSION

Elongation at break was found to decrease with exposure to radiation and acid vapour. This is due to the degradation occurring by chain scission. The EPDM rubber compound can be used in nuclear fuel reprocessing plant up to radiation dose of 1.5 x 106 Gy and silicone rubber compound can be used up to radiation dose of 5.6 x 105 Gy.