CHAPTER ONE
THE INTRODUCTION

There are many types of seals used in Nuclear and radiation facilities. Seals are constructed based on polymer materials combined with a number of additives and fillers to provide the required mechanical, hardness and compression set. Many nuclear industry's safety programs showed that the seals had failed in nuclear plants hundreds of times over the last decades [1,2]. International Atomic Energy Authority (IAEA) has reported in several documents this problem to study the failure due to rubber seals in different nuclear and radiation facilities. For instance, cooling pump's seals and transport container' seal failure may have adverse effect on safety.

O-rings are one of the most common seals used in machine design because they are inexpensive and easy to make, reliable, and have simple mounting requirements. Successful O-ring joint design requires a rigid mechanical mounting that applies a predictable deformation to the O-ring.

In Nuclear and radiation facilities, O-ring seals may be used to separate fluids in pumps, valves and switches. They also are part of the system designed to prevent radioactive materials from escaping in an accident, serving as seals for many dozens of hatches, wires or other equipment penetrating the concrete and steel reactor containment building. Thousands of O-ring seals similar to the one that caused the space shuttle disaster are used as seals in nuclear power plants.

The O-ring seal materials are composed of basic rubber and additives, which add on the material with specific properties such as, thermal stability, and antiozonants as well as radiation resistance. However, rubber seals may subject to age. One of the most important factors that determine the speed of seals aging is temperature and radiation. Aging of rubber materials is a very complex subject. There are many variables that can influence the aging behavior of rubber, including: the base rubber type and specific formulation, heat, ionizing radiation, chemicals, ozone, and moisture. The environmental service conditions will induce chemical or physical processes of the rubber material; these processes are the aging mechanisms. The changes in the properties of common seal materials, which can bring about functional failure in the seals, include decrease of tensile elongation, increase of hardness or compression set. As with any material, the service life of an elastomeric seal is truly the point at which the material fails to serve its intended function. In this case, specific leakage rate requirements must be met. Such case in nuclear facilities may lead to catastrophic failure. Therefore, the development of O-ring seals material with good behavior under radiation condition is a must [(3)].

The main degradation factors of seals consist predominantly of long-term irradiation (at rather low dose rates) and temperature, in combination with mechanical stress. The ageing results in a loss of the sealing force and leakage of the surrounding medium. In nuclear facilities, the seal must maintain its functions, not only during normal operation, but also during design basis events, which is in the worst case the loss-of-coolant accident LOCA (the break of a reactor coolant system pipe). During the LOCA and post-LOCA period, the seal is exposed to high doses of ionizing radiation, high temperatures and pressure of a mixture of water, steam and spray solution for a total period of up to 1 year [(4)]. Therefore sealing in valve, pumps and connectors may expose the seal materials to a range of operating fluids and environments.

In most cases, ageing degradation is addressed by routine replacement of elastromic components as apart of the maintenance requirements of the equipment in which they are used. There has not therefore been much work carried out on specific lifetime prediction methods for these conditions. The emphasis has been more on limiting the number of different compounds in use, so that a database of ageing behavior can be built up [(5)].

The requirements for seals in transport container are rather different. Such containers are generally subjected to the IAEA transport regulations [(6)]. These require demonstration that the container will restrict of radioactive material in normal operation and under accident conditions. Under normal operations, the seals need to function adequately during a low temperature transient (down to -40^{o}C) and up to a maximum operating temperature of 40^{o}C [(7-10)].

Elastomeric seals are also being considered for use in radioactive waste packages, where the seals may require being functional for decades before the package is finally placed in a waste repository. Lifetime prediction methods, which can assess their long-term behaviour under both thermal and radiation ageing [10], are being used to establish which materials might be used.

Over the last few years, an understanding of the practical effects of ageing degradation on polymeric components used in nuclear and radiation facilities has been built up. The complexities of real formulated polymers have precluded a detailed knowledge of all of the processes which occur, with a few exceptions.

The aim of the present study is to develop a rubber seal material to withstand the aging under high radiation conditions. Also to provide a scientific methodology for measuring the degradation of rubber seals materials and molded O-ring seals when exposed to gamma irradiation. The experimental work of this study was subdivided into molded sheets and molded O-ring seals from the seals materials selected. Two types of rubber seal material, NBR (Butadiene-acrylonitrile rubber) and EPDM (Ethylene-propylene-diene rubber**)** rubber have been selected for the present study.

Also to determine the effects of irradiation on the O-ring seal performance that manufactured from developed rubber material seals. The developed seals materials are based on adding antiozonants materials in a manner that rise the mechanical and physical properties performance under radiation environment.

This thesis divided into six chapters. The first chapter is an introductory chapter for the work and showing the aim of the work and it's plan. Chapter two surveys the recent literature for seals materials. While chapter three describes the experimental work and the methodology used. Chapter four describes the main results that we got. The discussion of results is presented in chapter five. The main conclusions of the present work are illustrated in the last chapter. The list of References used is located after the last chapter.