

**Sudan University of Science and Technology**  
**College of Graduate Studies and Scientific Research**



**Safety system in nuclear reactor**

نظام السلامة في المفاعل النووي

*A thesis submitted in partial fulfillment for the requirements*

*Of master degree in nuclear physic*

**BY:**

Ahmed Abdalla Ali

Supervisor:

Ahmed Alhassan Alfakki

December 2019

# الاستهلال

قال تعالى

(وَإِذْ تَأَذَّنَ رَبُّكَ لَيَبْعَثَنَّ عَلَيْهِمْ إِلَى يَوْمِ الْقِيَامَةِ مَنْ يَسُومُهُمْ سُوءَ  
الْعَذَابِ ۖ إِنَّ رَبَّكَ لَسَرِيعُ الْعِقَابِ ۖ وَإِنَّهُ لَغَفُورٌ رَحِيمٌ )

(الأعراف) (167)

# **Dedication:**

**To the spirit of my mother**

**To My Father**

**To MY All Brothers All Sisters**

**To My All teachers**

# Acknowledgements

*First and foremost , I would like to express my deepest gratitude to*

*Prof: Hassan I. Shaban*

*Prof: Mohamed Ahmed H. altyeb*

*D. Ahmed al Hassan AL faki*

*Engineer: tariq*

*Engineer: tariq algezooly*

*Engineer: Mohamed Abdall*

*Police major: Hishan Osman*

*Police Captin: Abo baker Awad Al eed Okasha*

*Deep thanks to my family for their consistent mental support finally ,*

*I would like to thanks my friends.*

## ملخص البحث

تمت مناقشه أنظمة التحكم وسلامتها في المفاعلات بالتركيز علي اعتبارات السلامة أعطيت الاهميه لخصائص المفاعل وخصائص نظم التحكم والسلامة ونظام التشغيل وكذلك الحوادث ذات الصلة. ادت الخبرة في البحث في نظم التحكم وكذلك في سلامتها إلى تطوير مبادئ عامه ،تستخدم هذه المبادئ في تحديد سلامة المفاعل وهذه المبادئ مع بعض التعديلات المناسبه يجب ان تشكل الأساس للسلامة في التحكم اوذلك "والأنظمة للأنواع الأخرى من المفاعلات بما لحاليه في ذلك مفاعلات "القدرة المتقدمة حديثه التصميم

## **ABSTRACT:**

Reactor control and safety systems were discussed with emphasis on safety considerations. Consideration was given to the importance of reactor characteristics, control and safety system characteristics, the operational program of the reactor, and credible accidents, in determination of the operation safety. Experience with research reactor control and safety systems have led to the development of certain general principles that determine the reactor safety. These principles, with suitable modifications, should be applicable to establishing the safety of control and safety of the systems for other reactor types, including present power reactors and advanced designs.

## Content:

Items	Page NO.
الايه	VI
Dedication	II
Acknowledgements	VI
Abstract (العربية)	VI
Abstract (English)	VI
Contents	VI
List of figures	VIVI
<b>CHAPTER ONE: Nuclear Radiation</b>	
1.1 Introduction	1
1.2 Types and Sources of Radiation:	1
1.2.1 Non-ionizing radiation	1
1.2.2 Ionizing radiation	2
1.2.2.1 Alpha particle radiation ( $\alpha$ )	2
1.2.2.2 Beta particle radiation ( $\beta$ ):	2
1.2.2.3 Photon radiation (gamma [ $\gamma$ ] and X-ray).	3
1.2.2.4 Neutron radiation (n):	3
1.3 Natural sources of ionizing radiation:	4
1.3.1 Exposure from cosmic radiation:	5
1.3.2 Exposure from terrestrial radiation:	6
1.3.3 Exposure through inhalation:	6
1.3.4 Exposure through ingestion:	6
1.4 Artificial (man-made) sources of ionizing radiation:	7
1.4.1 Medical sources:	7
1.4.2 Industrial sources:	8
1.5 Nuclear fuel cycle:	8

1.6 Health Effects of Radiation Exposure:	9
<b>Chapter Two: Effect of Nuclear Radiation to Human and Environment</b>	
2.1 Introduction:	10
2.2 Effects of Ionizing Radiation:	10
2.3 Radiation Units:	10
2.4 Physiological Effects of Acute Radiation Exposure:	11
2.5 Effect of Smoking on Radiation Dose:	12
2.6 Long Term Effects of LOW Radiation Doses:	12
2.7 Safety in nuclear reactor	12
2.7.1 Introduction:	12
2.8 Literature Review:	14
2.8.1 Reactor Characteristics Important in Control System Design:	14
2.8.2 Kinetic Behavior of Reactors:	15
2.8.3 Reactor Protection:	16
2.9. The IAEA Safety Standards:	17
2.9.1 Background	17
2.9.2 Safety Fundamentals	18
2.9.3 Safety Requirements	18
2.10 Control and safety of nuclear reactors	19
2.11 Reactor Characteristics Important in Control System Design	19
2.12 Safety Systems	20
2.13 startup consideration	23
<b>Chapter Three: Safety of Nuclear Power Plants</b>	
3.1 Introduction	24
3.2 Safety Features of Nuclear Power Plants	24
3.2.1 The major engineering safety features to cope with LOCA	24
3.2.2 The ECSS of a pressurized water reactor consists	24
3.3 Physical Barriers of a Light Water Reactor	24



3.4. Design Basis Accidents (DBA)	25
3.5 Design Base Accidents (DBA) or “Postulated Initiating Events” (PIE)	25
3.6. Beyond Design Basis Accidents (BDBA)	26
3.7. Safety Concept - Basic provisions	26
3.7.1 Design Basis Accidents	26
3.7.2 Beyond Design Basis Accidents	26
3.8 Concept of defense in depth	27
3.8.1 Protection Goals	27
3.8.2 Accident Analysis	27
3.8.3 Target values for existing NPPs	27
3.9 Design and Construction of Nuclear Installations	27
3.10 Future Requirements Commonly shared principles for all types of NPPs and for all countries	28
3.11 EPR safety objectives, motivated by the continuous search for a higher safety level, involve reinforced application of the defense-in-depth concept <sup>3</sup>	28
<b>Chapter Four: Conclusion and Recommendation</b>	
4.1 Conclusion:	30
4.2 Recommendation:	31
4.3. Reference:	32
<b>List of figures</b>	
Figure 1.1: Penetration abilities of different types of ionizing radiation.	4
Figure 1.2 Natural sources (81%) include radon (55%), external (cosmic, terrestrial), and internal (K-40, C-14, etc.)	5
Figure 1.3 A gamma camera used in nuclear medicine, for diagnosing illnesses	7
Figure 1.4 A portable nuclear gauge	8
Figure 1.5: McClean Lake Uranium Mine (Saskatchewan):	9