

Acknowledgement

I am extremely grateful to my supervisor, Dr. Abd ElRahman Elhassan Mohamed-Osman, for his precious advices, great support, endless .patience and encouragement through out the study

I would like to express my deepest gratitude and thanks to:

- 1- Sudan Atomic Energy Commission (SAEC)
- 2- Sudan University of Science & Technology College of Radiology
- 3- Radiation Isotopes Center in Khartoum (RICK)
- 4- Ali Al Said (Arkweet) Secondary School Staff

Abstract

In this thesis, the basic methods of Non-Destructive Testing (NDT) were discussed.

In this study, the X-ray machines used in the oil pipeline were compared to that used in medical filed.

From the comparison, it was found that, the machine used for oil pipeline needs high voltage (due to pipeline thickness) and long exposure time, while the one used for medical purpose needs low voltage (due to the nature of tissues) and short exposure time. While the radiographic films differ, and were found to, depend on the voltage used in the technique.

□□□□□□

في هذا البحث استعرضت أساسيات الاختبارات اللااتلافية وأنواعها وتطبيقاتها.

وفي الجولة الميدانية قورن بين جهاز الأشعة السينية المستخدم في المجال الطبي وجهاز الأشعة السينية المستخدم في مجال فحص أنابيب البترول .ووجد أن الجهاز المستخدم في مجال البترول يتطلب فولتية عالية (حسب سمك الأنبوب) وزمن تعريض أطول . بينما يحتاج الجهاز المستخدم في المجال الطبي إلي فولتية أقل وزمن تعريض أقل (لتناسب طبيعة أعضاء جسم)، كما أن الأفلام المستخدمة تختلف باختلاف فرق الجهد المستخدم في العملية.

List of abbreviations

NDT	Nondestructive Testing
D	Density
w _T	Weighting Fact
kV	Kilo voltage
mA	Mill ampere
VT	Visual Examination
MT	Magnetic Particle Testing
PT	Liquid Penetrate Testing
ET	Eddy Current Testing
RT	Radiography
UT	Ultrasonic Testing
LT	Leak Testing
AE	Acoustic Emission
IR	Infrared Thermograph

List of tables

Table (1.1) showing radiographic examination involves examination	10
Table (2.1) showing the X-ray applications at various kV.....	28
Table (3.1) showing film characteristics ASME SE-94	39
Table (3.2) showing film characteristics British standard	39
Table (3.3) showing film characteristics German standard	39
Table (3.4) showing comparison of classes of films from different manufacturer	40
Table (3.5) showing exposure factors for different Agfa gaevert RT films...	40
Table (3.6) showing guide for film selection to radiograph steel (ASTM E94)	41
Table (4.1) showing minimum tube factor	51
Table (4.2) showing the X-ray applications at various kV in pipeline	52
Table (4.3) showing X-ray kV in human organs	52
Table (4.4) showing tissue weighting factor	53

List of figures

Figure (1.1).showing VT examination	4
Figure (1.2).showing MT explanation	5
Figure (1.3) showing PT explanation	7
Figure (1.4) showing a photograph of a cracked training sample.....	8
Figure (1.5) showing eddy current testing ET explantation	9
Figure (1.6) showing radiographic testing RT explanation	11
Figure (1.7) showing ultrasonic testing UT explanation	13
Figure (1.8) showing leak testing LT explanation	14
Figure (1.9) showing acoustic emission AE explanation	16
Figure (1.10) showing infrared thermograph IR explanation	18
Figure (2.1) showing roentgen's first experiments late in 1895 was a film of the hand of his wife, Bertha	19
Figure (2.2) showing electromagnetic spectrum	20
Figure (2.3.a) showing generation of characteristic X-ray	21
Figure (2.3.b) showing generation of characteristic X-ray	22
Figure (2.4) showing X-ray spectrum	22
Figure (2.5) showing electrons bombardment with target	23
Figure (2.6) showing sketch and picture of X-ray tube	24
Figure (2.7) showing the effect of kV and mA on X-ray output	25
Figure (2.8) showing varieties of X-ray tube	25
Figure (2.9) showing various type of X-ray circuit.....	26
Figure (2.10) showing the X-ray control panel andrex from tope	27
Figure (2.11) showing the types X-ray crawlers	30
Figure (2.12) showing X-ray tube use in oil pipelines of Sudan now	31
Figure (3.1) construction of base layer a radiographic films	32
Figure (3.2) showing the layer	33
Figure (3.3) showing characteristic curve	34

Figure (3.4) showing film speed	35
Figure (3.5) showing characteristic curve for three different films (relative speed)	36
Figure (3.6) showing film contrast	36
Figure (3.7) showing film contrast at $D = 3.2$	37
Figure (3.8) showing contrasts at different exposures/densities	37
Figure (3.9) showing contrasts for two different films at the same exposure film A has better contrast than film B	37
Figure (3.10) showing film gradient against density for different films	38
Figure (3.11) showing film screen	42
Figure (3.12) showing guide variation of intensification factor with kV	43
Figure (3.13) showing guide typical darkroom layout	44
Figure (3.14) showing guide manual processing tank	45
Figure (3.15) showing development time against developer temperature	47
Figure (3.16) showing guide development time temperature relation	48

Contents

Title	Page
Acknowledgement	i
English abstract	ii
Arabic abstract	iii
List of abbreviations.....	iv
List of tables	v
List of figures	vi
(Chapter one: Non-Destructive Testing (NDT	
Definition non-destructive testing	1 1.1
Discontinuity	1 1.1.1
Defects	1 1.1.2
Methods of NDT	1 1.2
Classification of NDT methods	2 1.3
Surface	2 1.3.1
Volumetric	2 1.3.2
Other	2 1.3.3
Visual examination	2 1.4
Principles	2 1.4.1
Applications	3 1.4.2
Magnetic particle testing	4 1.5
Principles	4 1.5.1
Applications	5 1.5.2
Liquid penetrate testing	6 1.6
Principles	6 1.6.1
Applications	6 1.6.2
PT example	7 1.6.3
Eddy current testing	8 1.7

Principles	8 1.7.1
Applications	8 1.7.2
Radiographic testing	9 1.8
Principles	9 1.8.1
Applications	10 1.8.2
Ultrasonic testing	11 1.9
Principles	11 1.9.1
Applications	12 1.9.2
Leak testing	13 1.10
Principles	13 1.10.1
Applications	14 1.10.2
Acoustic emission	15 1.11
Principle	15 1.11.1
Applications	15 1.11.2
Infrared thermographs	16 1.12
Principles	16 1.12.1
Applications	17 1.12.2
Electrical	17 1.12.2.1
Mechanical	17 1.12.2.2
IR explanation	17 1.12.3
Chapter Two: X-ray Physics	
History	2.1
.....	19
Types of X-ray radiography devices	20 2.2
Generation of X-ray	20 2.3
Components for X-ray production	22 2.4
Electron source	23 2.4.1
Electrons acceleration	23 2.4.2
Parameters determining X-ray output	24 2.4.3
X-ray machine components	26 2.5

X-ray control panel Andrex	27 2.5.1
Control panel-safety features	27 2.5.2
X-ray applications at various kV	28 2.5.3
Leakage radiation	28 2.5.4
Safety for X-ray machine	28 2.5.5
Safety requirement for X-ray machine	29 2.5.6
Maintenance of X-ray machine	29 2.5.7
X-ray crawlers	29 2.6
Chapter Three: Radiographic Films	
Radiographic films	32 3.1
Base layer	32 3.1.1
Emulsion layer	32 3.1.2
Protective layer	33 3.1.3
Films classification	33 3.2
Film characteristics	33 3.3
Features of characteristic curve	34 3.4
Characteristics of film	34 3.5
Film density.....	34 3.5.1
Fog density	34 3.5.2
Film speed	35 3.5.3
Characteristic curves for three different films (relative speed)	35 3.6
Film contrast	36 3.6.1
Film graininess	38 3.6.2
Film classification	38 3.6.3
Exposure factor.....	40 3.7
Film packaging	41 3.7.1
Film storage.....	41 3.7.2
Film screen	42 3.7.3
Types of screen	42 3.7.4
Darkroom and film processing facilities.....	43 3.8

Dark room facility	43	3.8.1
Safe light	44	3.8.2
3.8.3 Wall ceiling and floor	44	
Loading bench	44	3.8.4
Steps for film processing	45	3.8.5
Preparation prior to processing	45	3.9
Loading film	45	3.9.1
Unload the exposed film	46	3.9.2
Film development	46	3.9.3
Step for development	47	3.9.4
Rinsing	47	3.9.4.1
Fixing	47	3.9.4.2
Washing	48	3.9.4.3
Drying	48	3.9.4.4
Composition of developer	49	3.10
Typical developer formulation	3.11	
.....	49	
Stop bath	49	3.11.1
Fixer composition	50	3.11.2
Typical fixer formulation	50	3.11.3
Typical replenished formulation	50	3.11.4
Chapter Four: Comparative		
The comparative	51	4
The X-ray output	51	4.1
Voltage (kV)	51	4.2
Mill amperage (mA)	52	4.3
Exposure	52	4.4
Weighting factor	53	4.4.1
Films	53	4.5
Radiographic screens	53	4.6

Lead screen	54 4.6.1
Fluorescent screen	54 4.6.2
Fluorometallic screen	54 4.6.3
Image formation	55 4.7
Conclusion	56 1
Future work	56 11
References	57 111