Sudan University of Science and Technology
Collage of Graduate Studies

USING INDUSTRIAL RADIOGRAPHY IN PIPELINE

استخدام التصوير الاشعاعى الصناعى فى خطوط الانابيب

These Submited In Partial For Reguirment Of The Degree Of Master In General Physics

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الايـــــة

قال تعالى (اعْلَمُوا أَنَّمَا الْحَيَاةُ الدُّنْيَا لَعِبٌ وَلَهْوٌ وَزِينَةٌ وَتَفَاخُرٌ بَيْنَكُمْ وَتَكَاثُرٌ فِي الأَمْوَالِ وَالأَوْلادِ كَمَثَلِ غَيْثٍ أَعْجَبَ الْكُفَّارَ نَبَاتُهُ ثُمَّ يَهِيجُ فَتَرَاهُ مُصْفَرًّا ثُمَّ يَكُونُ حُطَامًا وَفِي الآخِرَةِ عَذَابٌ شَدِيدٌ وَمَغْفِرَةٌ مِّنَ اللَّهِ وَرِضْوَانٌ وَمَا الْحَيَاةُ الدُّنْيَا إِلاَّ مَتَاعُ الْغُرُورِ)

(الحديد 20)

Dedication

I dedicate this thesis to my parent whom always were beside me. To my Mather & to my supervisor & To my university and my collage of the Science.

Acknowledgment

Thanks, before and after allah. I am very grateful to Dr. Amel Abdallah who supervised this thesis. A lot of thanks are extending to my friends for his great help and kind guidance. Would like thank all doctors at department of physics in sudan university of science and technology. Appreciation to all who helped me during this research.

Abstract

This research desiccation with the issue of radiography in petroleum pipelines. This is to make sure that welding is quality and that there are no defects inside the metal. That ensures the passage of raw safety. Also used radiation test to detect any defect inside the metal. also used some method to inspect like penetrant testing or magnetic participle testing.

المستخلص

هــــذا البحـــث ينـــاقش موضــــوع اســـتخدام التصــــوير الاشــــعاعى الصـــناعى لخطـــوط الانابيـــب البتـــرول. وذلـــك للتاكـــد مـــن جـــودة اللحـــام واماكنيـــة عـــدم وجـــود اي عيـــب داخـــل المعـــدن. الـــذي يضـــمن مـــرور ســـلامة الخـــام. كمـــا تـــم اســـتخدام التصـــوير الاشـــعاعي للتاكـــد مـــن عـــدم وجـــود اي عيـــب داخـــل المعـــدن. يمكـــن اســـتخدام عـــدة طـــرق للكشـــــف مثـــــل اختبـــــار الســـــوائل النفـــــاذة او اختبار الحبيبـــــات المغنطيسية.

Chapter One

Introduction

1.1 Industrial Radiography

Radiographic Testing is a non-destructive testing of component and assemble that is based on differential absorption. the term radiography testing usually implies a radiographic process that produces a permanent image on film or paper. One of the longest established applications of ionizing radiation is industrial radiography, which uses both X radiation and gamma radiation to investigate the integrity of equipment and structures.

Today modern non-destructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality. And checking the good welding.

The welding is a localized coalescence of metals or non-metals produced either by heating the materials to the welding temperature, with or without the application of pressure, or by the alone and with or without the use of filler metal.

1.2 Objective:

Use the industrial radiography testing to good control for the welding quality.

1.3 Problems:

Studies the welding problem before or during or after welding.

1.4 Case Study:

Master's thesis at the University of Karbala discusses the impact of x-rays on human health

1.5 Research Content:

This research content have five chapters. The chapter one desiccation about the Introduction Industrial Radiography & chapter two desiccation about Type of the Radiation and chapter three take about the NDT Method & chapter four desiccation about the Welding Process and chapter five Methodology and Result.

Chapter Two

Type of Radiation

2.1 Introduction:

radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium. This includes:

- electromagnetic radiation, such as radio waves, microwaves, visible light, x-rays, and gamma radiation (γ)
- particle radiation, such as alpha radiation (α), beta radiation (β), and neutron radiation (particles of non-zero rest energy)
- acoustic radiation, such as ultrasound, sound, and seismic waves (dependent on a physical transmission medium)
- gravitational radiation, radiation that takes the form of gravitational waves, or ripples in the curvature of spacetime.

Radiation is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10 eV, which is enough to ionize atoms and molecules, and break chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms. A common source of ionizing radiation is radioactive materials that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Other sources include X-rays from medical radiography examinations and muons, mesons, positrons, neutrons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere [1].

2.2 Ionizing radiation:

Radiation that carries enough energy to liberate electrons from atoms or molecules, thereby ionizing them. Ionizing radiation is made up of energetic subatomic particles, ions or atoms moving at high speeds (usually greater than 1% of the speed of light), and electromagnetic waves on the high-energy end of the electromagnetic spectrum.

Gamma rays, X-rays, and the higher ultraviolet part of the electromagnetic spectrum are ionizing, whereas the lower ultraviolet part of the electromagnetic spectrum, and also the lower part of the spectrum below UV, including visible light (including nearly all types of laser light), infrared, microwaves, and radio waves are all considered non-ionizing radiation.

2.3 Type of Radiation:

There are many type of the radiation include (Gamma Ray, X-Ray, Ultraviolet, Infrared, Microwave).

2.3.1 Gamma Rays:

(also called gamma radiation), are penetrating electromagnetic radiation of a kind arising from the radioactive decay of atomic nuclei. It consists of photons in the highest observed range of photon energy. Paul Villard, a French chemist and physicist, discovered gamma radiation in 1900 while studying radiation emitted by radium. In 1903, Ernest Rutherford named this radiation gamma rays. Rutherford had previously discovered two other types of radioactive decay, which he named alpha rays and beta rays.

Natural sources of gamma rays on Earth are observed in the gamma decay of radionuclides and secondary radiation from atmospheric interactions with cosmic ray particles. There are rate terrestrial natural sources, such as lightning strikes and terrestrial gamma-ray flashes, that produce gamma rays not of a nuclear origin. Additionally, gamma rays are produced by a number of astronomical processes in which very high-energy electrons are produced, that in turn cause secondary gamma rays via bremsstrahlung, inverse Compton scattering, and synchrotron radiation. However, a large fraction of such astronomical gamma rays are screened by Earth's atmosphere and can only be detected by spacecraft. Gamma rays are produced by nuclear fusion in stars including the Sun (such as the CNO cycle), but are absorbed or inelastically scattered by the stellar material, reducing their energy, before escaping and are not observable from Earth as gamma ray. Natural sources of gamma rays on Earth include gamma decay from naturally occurring radioisotopes such as potassium-40, and also as a secondary radiation from various atmospheric interactions with cosmic ray particles.

Gamma rays are produced during gamma decay, which normally occurs after other forms of decay occur, such as alpha or beta decay. An excited nucleus can decay by the emission of an alpha or beta particle. The daughter nucleus that results is usually left in an excited state. It can then decay to a lower energy state by emitting a gamma ray photon, in a process called gamma decay [1].

2.3.2 X- Rays:

X-rays make up X-radiation, a form of electromagnetic radiation. Most X-rays have a wavelength ranging from (0.01 to 10) nanometres, corresponding to frequencies in the range ((30 petahertz to 30 exahertz (3×1016 Hz to 3×1019 Hz)) and energies in the range (100 eV to 100 keV).

X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays.

X-rays were found emanating from Crookes tubes, experimental discharge tubes invented around 1875, by scientists investigating the cathode rays, that is energetic electron beams, that were first created in the tubes. Crookes tubes created free electrons by ionization of the residual air in the tube by a high DC voltage of anywhere between (a few kilovolts and 100 kV). This voltage accelerated the electrons coming from the cathode to a high enough velocity that they created X-rays when they struck the anode or the glass wall of the tube. Many of the early Crookes tubes undoubtedly radiated X-rays, because early researchers noticed effects that were attributable to them, as detailed below.

X-rays can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target, the anode, creating the X-rays.

In medical X-ray tubes the target is usually tungsten or a more crack-resistant alloy of rhenium (5%) and tungsten (95%), but sometimes molybdenum for more specialized applications, such as when softer X-rays are needed as in mammography. In crystallography, a copper target is most common, with cobalt often being used when fluorescence from iron content in the sample might otherwise present a problem.

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube times the electron charge, so an 80 kV tube cannot create X-rays with an energy greater than 80 keV [1].

2.3.3 Ultraviolet:

Ultraviolet (UV) is an electromagnetic radiation with a wavelength from (10 nm to 400 nm), shorter than that of visible light but longer than X-rays. UV radiation is present in sunlight constituting about 10% of the total light output of the Sun. It is also produced by electric arcs and specialized lights, such as mercury-vapor lamps, tanning lamps, and black lights. Although long-wavelength ultraviolet is not considered an ionizing radiation because its photons lack the energy to ionize atoms, it can cause chemical reactions and causes many substances to glow or fluoresce. Consequently, the chemical and biological effects of UV are greater than simple heating effects, and many practical applications of UV radiation derive from its interactions with organic molecules [1].

UV radiation was discovered in 1801 when the German physicist Johann Wilhelm Ritter observed that invisible rays just beyond the violet end of the visible spectrum darkened silver chloride-soaked paper more quickly than violet light itself. He called them "oxidizing rays" to emphasize chemical reactivity and to distinguish them from "heat rays", discovered the previous year at the other end of the visible spectrum[1].

Chapter Three

NDT Method

3.1 Introduction:

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.

In contrast to NDT, other tests are destructive in nature and are therefore done on a limited number of samples ("lot sampling"), rather than on the materials, components or assemblies actually being put into service.

These destructive tests are often used to determine the physical properties of materials such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness and fatigue strength, but discontinuities and differences in material characteristics are more effectively found by NDT.

Today modern non-destructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public [2].

3.2 NDT Methods

Test method names often refer to the type of penetrating medium or the equipment used to perform that test. Current NDT methods are: Acoustic

Emission Testing (AE), Electromagnetic Testing (ET), Guided Wave Testing (GW), Laser Testing Methods (LM), Leak Testing (LT), Magnetic Flux Leakage (MFL), Liquid Penetrant Testing (PT), Magnetic Particle Testing (MT), Radiographic Testing (RT), Ultrasonic Testing (UT), and Visual Testing (VT).

The five most frequently used test methods are VT, PT, MT, RT and UT. Each of these test methods will be described here, followed by the other, less often used test methods.

3.2.1 Visual Testing (VT):

Visual testing is the most commonly used test method industry. Because most test methods require that the operator look at the surface of the part being inspected, visual inspection is inherent in most of the other test methods. VT involves the visual observation of the surface of a test object to evaluate the presence of surface discontinuities. Also to effectively evaluate the quality of weld is to apply that inspection at every step of the fabrication process. The visual testing or inspection is duties will be organized in term of those tasks which are performed before, during, after welding. Using the VT to inspection any defect found in the surface [2].

Figure (3.1) - Visual Inspection Tools

3.2.2 Penetrant Testing (PT):

The basic principle of liquid penetrant testing is that when a very low viscosity (highly fluid) liquid (the penetrant) is applied to the surface of a part, it will penetrate into fissures and voids open to the surface. Once the excess penetrant is removed, the penetrant trapped in those voids will flow back out, creating an indication. Penetrants may be "visible", meaning they can be seen in ambient light, or fluorescent, requiring the use of a "black" light. When performing a PT inspection, it is imperative that the surface being tested is clean and free of any foreign materials or liquids that might block the penetrant from entering voids or fissures open to the surface of the part. After applying the penetrant, it is permitted to sit on the surface for a specified period of time (the "penetrant dwell time"), then the part is carefully cleaned to remove excess penetrant from the surface. When removing the penetrant, the operator must be careful not to remove any penetrant that has flowed into voids. A light coating of developer is then be applied to the surface and given time ("developer dwell time") to allow the penetrant from any voids or fissures to seep up into the developer, creating a visible indication. Following the prescribed developer dwell time, the part is inspected visually, with the aid of a black light for fluorescent penetrants. Use PT to inspection for the surface defects [2].

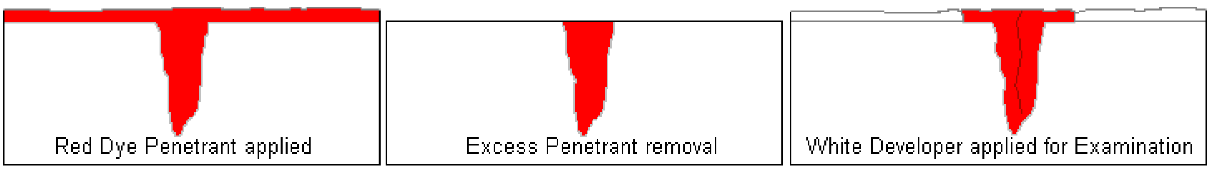

Figure (3.2)- Penetrant testing application

3.2.3 Magnetic Particle Testing (MT):

This particular non-destructive test method is used primarily to discover surface discontinuities in ferromagnetic material. While indication can be observed from subsurface discontinuities very near the surface, they are very difficult to interpret, and often require testing by other methods, other NDE techniques for subsurface discontinuity detection and interpretation. However, surface discontinuities present in a magnetized part will cause the applied magnetic field to create “poles" of opposite sign on either side of the discontinuity.

Magnetic Particle Testing uses one or more magnetic fields to locate surface and near-surface discontinuities in ferromagnetic materials. The magnetic field can be applied with a permanent magnet or an electromagnet. When using an electromagnet, the field is present only when the current is being applied. When the magnetic field encounters a discontinuity transverse to the direction of the magnetic field, the flux lines produce a magnetic flux leakage field. Because magnetic flux lines don't travel well in air, when very fine collared ferromagnetic particles ("magnetic particles") are applied to the surface of the part the particles will be drawn into the discontinuity, reducing the air gap and producing a visible indication on the surface of the part. The magnetic particles may be a dry powder or suspended in a liquid solution, and they may be collared with a visible dye or a fluorescent dye that fluoresces under an ultraviolet ("black") light

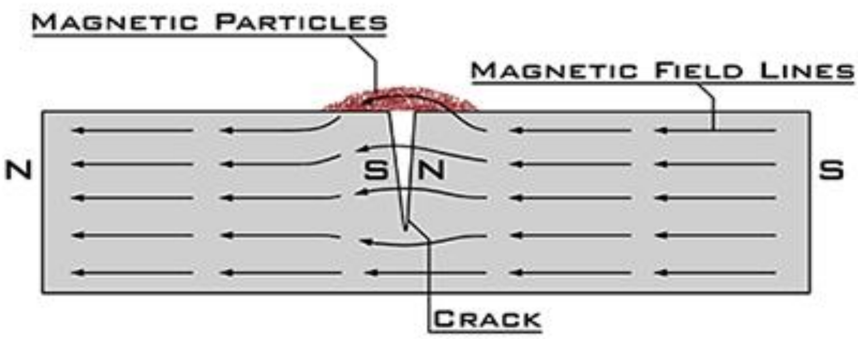

Figure (3.3A) – Magnetic flux line

Most field inspections are performed using a Yoke. As shown in Figure (3.3B), an electric coil is wrapped around a central core, and when the current is applied, a magnetic field is generated that extends from the core down through the articulated legs into the part. This is known as longitudinal magnetization because the magnetic flux lines run from one leg to the other [2].

Figure (3.3B) – yoke.

3.2.4 Radiographic Testing (RT):

Radiography is of vital importance in non-destructive testing. Radiography ensures the integrity of equipment and structures such as vessels, pipes, welded joints, castings and other devices. The integrity of this equipment affects not only the safety and quality of the products used by workers, but also the safety and quality of the environment for workers and the public at large .

Radiography is a non-destructive test method based on the principle of preferential radiation transmission, or absorption. The radiation which passes through a test object will form a contrasting image on a film receiving the radiation transmission, or low absorption, appear as dark area on the developer film.

Use some source for the testing of the radiographic, and lower energy non-particulate radiation is in the form of either gamma radiation or X-rays. Gamma rays are the result of the decay of radioactive material, common radioactive source include iridium 192, cecium137, and cobalt 60. Those sources are constantly emitting radiation and must be kept in a shielded storage container.

X-rays are man -made, they are produced when electron, traveling at high speed, collide with matter. The conversion of electrical energy to X-radiation is achieved in an evacuated (vacuum) tube. A low current is passed through an incandescent filament to produces electrons [2].

Application of a high potential (voltage) between the filament and a target metal accelerates electron across this voltage differential. The action of an electron stream striking the target produces X-rays. Radiation is produced only while voltage is applied to the X-ray tube.

Whether using gamma or X-ray sources, the test object is not radioactive following the test.

Figure (3.4) – gamma source

Subsurface discontinuities which are readily detected by this method are those having different densities than the material being radiated. This includes voids, metallic and non-metallic inclusion, and favourably aligned incomplete fusion and cracks. Voids, such as porosity, produce dark areas on the film, because they represent a significant loss of material density. Metallic inclusions produce light areas on the film if their density is greater than that of the test object. If the inclusion density is loss than the metal, it shows as a dark area on the film.

3.2.4.1 Equipment:

The equipment required to perform radiographic testing begins with a source of radiation; this source can be either an X-ray machine, which requires electrical input, or a radioactive isotope which produces gamma radiation. The isotopes usually offer increased portability. Either radiation type requires film, a light-tight film holder, and lead letters are used to identify the test object. Because of the high density of lead and the local increased thickness, these letters form light areas on the developed film. Image Quality Indicators (IQI), or penetrometers (penny's) are used to verify the resolution sensitivity of the test. These IQIs are usually one of two types: hole or wire. They are both specified as to material type; in addition, the hole type will have a specified thickness and hole sizes, while the wire type will have specified wire diameters. Sensitivity is verified by the ability to detect a given difference in density due to the penetrometer thickness and hole diameter, or wire diameter.

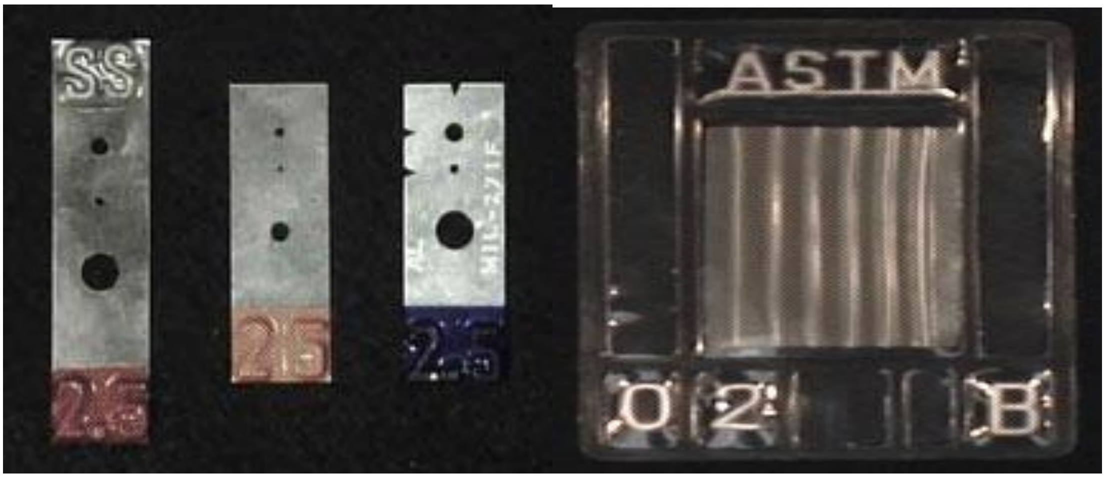

Figure (3.5) – IQI hole & wire type

Film processing equipment is required to develop the exposed film, and a special film viewer with variable high intensity lighting is best for interpretation of the film. Because of the potential dangers of radiation exposure to humans, radiation monitoring equipment is always required [3].

3.2.5 Ultrasonic Testing (UT):

Ultrasonic testing (UT) is an inspection method which uses high frequency sound waves, well above the range of human hearing, to measure geometric and physical properties in materials. Sound waves travel at different speeds in different materials. However, the speed of sound propagation in a given material is a constant value for that material. There are several ways that sound travels through a material, but that distinction is not of importance for a discussion at this level. One type of sound wave, called longitudinal, travels about 1100 feet per second in air, about 19,000 feet per second in steel, and about 20,000 feet per second in aluminium. Ultrasonic testing uses electrical energy in the form of an applied voltage, and this voltage is converted by a transducer to mechanical energy in the form of sound waves. The transducer accomplishes this energy conversion due to a phenomenon referred to as the "piezoelectric" effect.

The generated sound wave will continue to travel the material at a given speed and return to the transducer when it encounters some reflector, such as a change in density, and is reflected. If that reflector is properly oriented, it will bounce the sound back to the transducer at the same speed and contact the transducer. When struck by this returning sound wave, the piezoelectric crystal will convert that sound energy back into an electronic pulse which is amplified and can be displayed on a cathode ray tube (CRT) as a visual indication to be interpreted by the operator.

There are two basic types of ultrasonic transducers. The first is, or straight beam transducers are used to determine material thicknesses or the depth of a discontinuity below the material surface. These transducers transmit the sound into the part perpendicular to the surface of the part.

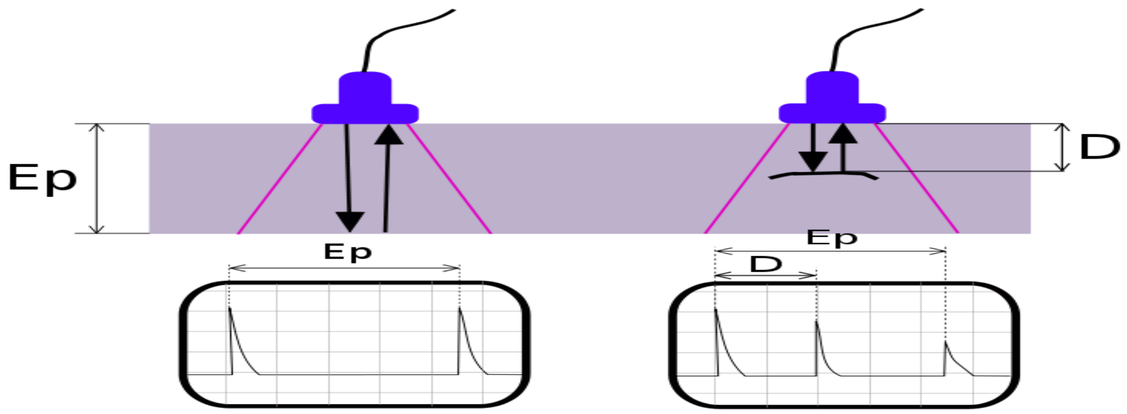

Figure (3.6) – Longitudinal waves

Second Shear waves, or angle beam transducers are used extensively for weld evaluation because they send the sound into the part at an angle, allowing testing to be accomplished without the need for removal of the rough weld reinforcement.

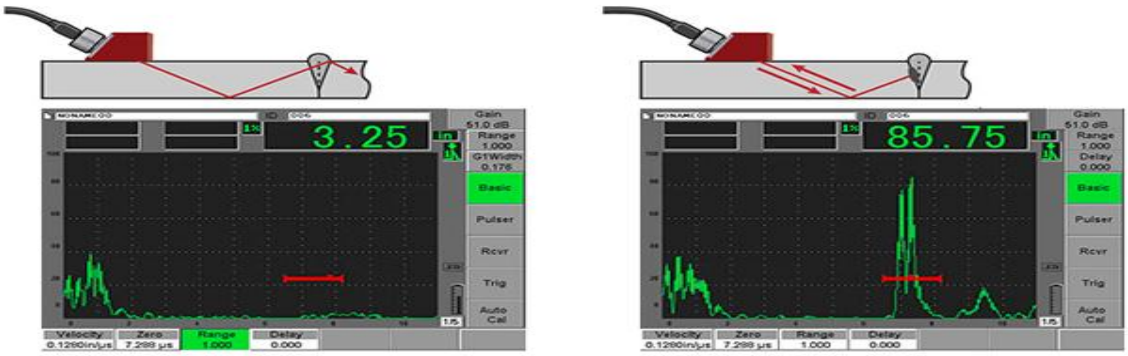

Figure (3.7) – share waves

3.2.5.1 Equipment

The equipment required for ultrasonic testing includes an electronic instrument with either a CRT or digital display. Using an instrument with a CRT, an ultrasonic operator can determine the location, size, and type of many discontinuities. Instruments with digital displays are usually limited to dimensional measurements such as metal thickness. However, when measuring corroded materials for wall thickness, it is best to use an instrument having a scope output for greatest accuracy.

A suitable transducer couplet will also be necessary for ultrasonic testing. Many different materials are used as couplants; some commonly used couplants are oil, grease, glycerine, water, and cellulose powder or corn starch mixed with water. Transducers are available in a wide variety of sizes. Many transducers are mounted on plexiglass wedges which allow the sound to enter the test object at various angles for shear wave testing. The last equipment requirement is a calibration standard. For material thickness measurements, the calibration standards should be of the same material as the test object and must have known and accurate dimensions. For flaw detection, the calibration standards should meet the above requirements plus contain a machined "flaw," such as a side-drilled hole, a flat-bottomed hole, or a groove. The location and size of this "flaw" must be known and accurate.

Chapter Four

Welding process

4.1 Introduction:

Welding is a localized coalescence of metals or non-metals produced either by heating the materials to the welding temperature, with or without the application of pressure, or by the alone and with or without the use of filler metal. the welding process in order for it to be capable of producing satisfactory welds.

The processes differ from one another because they provide these same features in various ways. So, as each process is introduced, be aware of how it satisfies these requirements.

4.2 Type of the welding:

The are most frequently used welding process are Shielding Metal Arc Welding(SMAW), Gas Metal Arc Welding (GMAW), Flex Core Arc Welding (FCAW),Gas Tungsten Arc Welding (GTAW),Plasma Arc Welding(PAW), Submerging Arc Welding (SAW). Each of these welding process will be described three for this process, followed by the other, less often used welding process.

4.2.1 Shielded Metal Arc Welding (SMAW):

The first process to be discussed is shielded metal arc welding. Even though this is the correct name for the process, we more often hear it referred to as "stick welding." This process operates by heating the metal with an electric arc between a covered metal electrode and the metals to be joined [2].

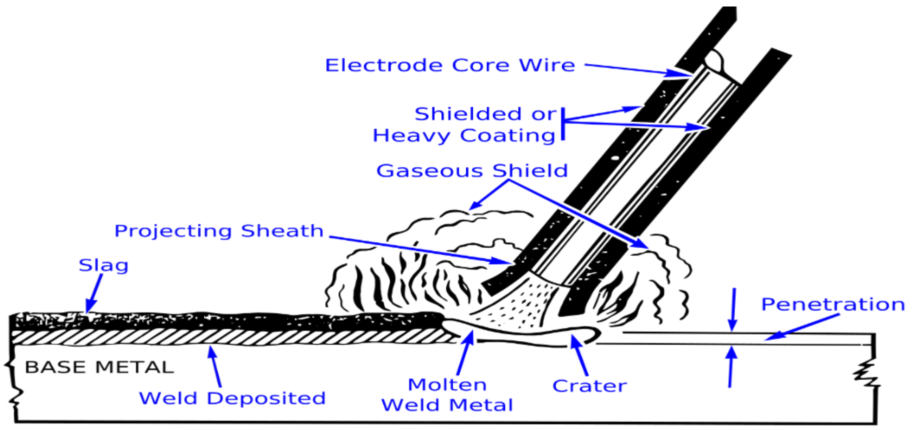

Figure (4.1) – Shielded Metal Arc Welding (SMAW)

This illustration shows that the arc is created between the electrode and the workpiece due to the flow of electricity. This arc provides heat, or energy, to melt the base metal, filler metal and electrode coating. As the welding arc progresses to the right, it leaves behind solidified weld metal covered by a layer of converted flux, referred to as slag. This slag tends to float to the outside of the metal since it solidifies after the molten metal has solidified. In doing so, there is less likelihood that it will be trapped inside the weld resulting in a slag inclusion. The primary element of the shielded metal arc welding process is the electrode itself. It is made up of a metal core wire covered with a layer of granular flux held in place by some type of bonding agent. All carbon and low alloy steel electrodes use essentially the same type of steel core wire, a low carbon, rimmed steel. Any alloying is provided from the coating, since it is more economical to achieve alloying in this way.

American Welding Society Specifications A5.1 and A5.5 describe the requirements for carbon and low alloy steel electrodes, respectively. They describe the various classifications and characteristics of these electrodes.

The identification consists of an "E," which stands for electrode, followed by four or five digits. The first two, or three, numbers refer to the minimum tensile strength of the deposited weld metal. These numbers state the minimum tensile strength in thousands of pounds per square inch. For example, "70"

means that the tensile strength of the deposited weld metal is at least 70,000 psi. The next number refers to the positions in which the electrode can be used. A " 1 " indicates the electrode is suitable for use in any position. A "2" means that the molten metal is so fluid that the electrode
can only be used in the flat position for all welding types and in the horizontal position for fillet welds only. A "4" means the electrode is suitable for welding in a downhill progression. The number "3" is no longer used as a designation. The last number in the designation describes other characteristics which are determined by the.

EXXXX

Figure (4.2) – SMAW Electrode Identification System

The most common quality problems associated with SMAW include weld spatter, porosity, poor fusion, shallow penetration, and cracking. [3].

4.2.2 Gas Metal Arc Welding (GMAW):

The next process to be discussed is gas metal arc welding, GMAW. While gas metal arc welding is the AWS designation for the process, we also hear it commonly referred to as "MIG" welding. It is most commonly employed as a semiautomatic process; however, it is also used in mechanized and automatic applications as well. Therefore, it is very well-suited for robotic welding applications. Gas metal arc welding is characterized by a solid wire electrode which is fed continuously through a welding gun. An arc is created between this wire and the workpiece to heat and melt the base and filler materials [4].

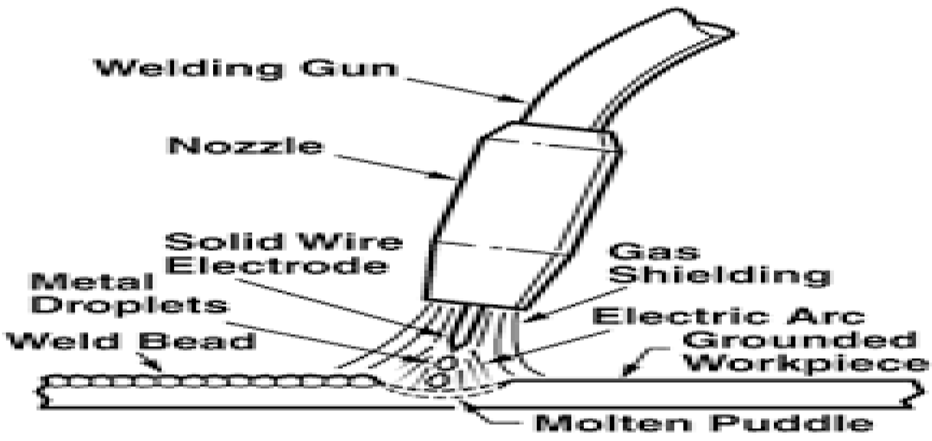

Figure (4.3) – Gas Metal Arc Welding (GMAW)

An important feature for GMAW is that all of the shielding for welding is provided by a protective gas atmosphere which is also emitted from the welding gun from some external source. Gases used include both inert and reactive types. Inert gases such as argon and helium are used for some applications. They can be applied singly, or in combination with each other, or mixed with other reactive gases such as nitrogen, oxygen or carbon dioxide. Many gas metal arc welding applications use carbon dioxide shielding alone, because of its relatively low cost compared to inert gases.

The electrodes used for this process are solid wires which are supplied on spools or reels of various sizes. As is the case for shielded metal arc welding electrodes, there is an approved American Welding Society identification system for gas metal arc welding electrodes. They are denoted by the letters "ER," followed by two or three numbers, the letter "S," a hyphen, and finally, "ER" designates the wire as being both an electrode and a rod, meaning that it may conduct electricity (electrode), or simply be applied as a filler metal (rod) when used with other welding processes. The next two or three numbers state the minimum tensile strength of the deposited weld metal in thousands of pounds per square inch. So, like the SMAW types, a "70" denotes a filler metal whose tensile strength is at least 70,000 psi. The letter "S" stands for a solid wire. Finally, the number after the hyphen refers to the particular chemistry of the electrode. This will dictate both its operating characteristics as well as what properties are to be expected from the deposited weld. Gas metal arc electrodes typically have increased amounts of deoxidizers such as manganese, silicon, and aluminium to help avoid the formation of porosity.

E R X X S – X

Figure (4.4) – GMAW Electrode Identification System

The power supply used for gas metal arc welding is quite different from the type employed for shielded metal arc welding. Instead of a constant
current type, gas metal arc welding uses what is referred to as a constant voltage, or constant potential, power source. That is, welding is accomplished using a pre-set value of voltage over the range of welding currents.
the basic ways in which these four types differ is that they provide varying amounts of heat to the workpiece. Spray transfer is considered to be the hottest, followed by pulsed arc, globular, and finally short circuiting. Therefore, spray transfer is the best for heavier sections and full penetration
weld joints, as long as they can be positioned in the flat position. Globular transfer provides almost as much heating and weld metal deposition, but its operating characteristics tend to be less stable, resulting in increased spatter.
Pulsed arc gas metal arc welding requires a welding power source capable of producing a pulsing direct current output which allows the welder to program the exact combination of high and low currents for improved heat control and process flexibility. The welder can set both the amount and duration of the high current pulse. So during operation, the current alternates between a high pulse current and a lower pulse current, both of which can be set with machine controls. Short circuiting transfer results in the least amount of heating to the base metal, making it an excellent choice for welding of sheet metal and joints having excessive gaps due to poor fit-up. The short-circuiting transfer method is characteristically colder due to the electrode actually coming in contact with

the base metal, creating a short circuit for a portion of the welding cycle. So, the arc is intermittently operating and extinguishing. The brief periods of arc extinction allow for some cooling to occur to aid in reducing the tendency of burning through thin materials. Care must be taken when short circuiting transfer is used for heavier section welding, since incomplete fusion can result from insufficient heating of the base metal.

As mentioned, the shielding gases have a significant effect on the type of metal transfer. Spray transfer can be achieved only when there is at least 80%
argon present in the gas mixture. CO2 is probably the most popular gas for GMAW of carbon steel, primarily due to its relatively low cost and its excellent penetration characteristics. One drawback, however, is that there will be more spatter which may require removal, reducing operator productivity. The versatility offered by this process has resulted in its use in many industrial applications [3].

4.2.3 Flux Cored Arc Welding (FCAW):

The next process to be described is flux cored arc welding. This is very similar to gas metal arc welding except that the electrode is tubular and contains a granular flux instead of the solid wire used for gas metal arc welding. welded with the self-shielded FCAW process and a closeup of the arc region during welding [3].

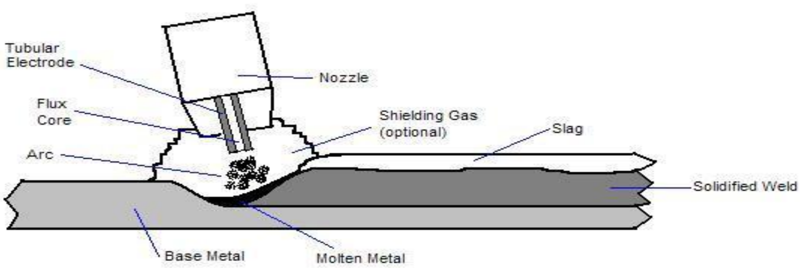

Figure (4.5) – Flex Core Arc Welding (FCAW)

It shows the tubular electrode being fed through the contact tube of the welding gun to produce an arc between the electrode and the workpiece. As the welding progresses, a bead of solidified weld metal is deposited With flux cored arc welding, there may or may not be an externally-supplied shielding gas, depending upon what type of electrode is used. Some electrodes are designed to provide all of the necessary shielding from the internal flux, and are referred to as self-shielding. Other electrodes require additional shielding from an auxiliary shielding gas. With FCAW, as with other processes, there is a system for identification of the various types of welding electrodes, of each electrode type shows that the designations refer to the polarity, shielding requirements, chemistry and welding position. An identification begins with the letter "E" which stands for electrode. The first number refers to the minimum tensile strength of the deposited weld metal in ten thousands of pounds per square inch, so a "7" means that the weld metal tensile strength is at least 70,000 psi. The second digit is either a "0" or a "1." A "0" means that the electrode is suitable for use in the flat or horizontal fillet positions

only, while a " 1 " describes an electrode which can be used in any position. Following these numbers is the letter "T" which refers to a tubular electrode.

This is followed by a hyphen and then another number which denotes the particular grouping based upon the chemical composition of deposited

weld metal, type of current, polarity of operation, whether it requires shielding gas, and other specific information for the category.

E X X T- X

Figure (4.6) – FCAW Electrode Identification System

the self-shielded types are better suited for field welding where wind could result in a loss of gaseous shielding. Gas shielded types are typically used where the need for improved weld metal properties warrants the additional cost. Gases typically used for flux cored arc welding are CO_2, or 75% Argon—25% CO_2, but other combinations of gases are available. FCAW has gained wide acceptance because of the many advantages it offers. Probably the most significant advantage is that it provides high productivity in terms of the amount of weld metal that can be deposited in a given period of time. It is among the highest for a hand-held process. This is aided by the fact that the electrode comes on continuous reels which increases the "arc time" just as with gas metal arc welding [3].

Chapter Five

Methodology and Result

5.1 Introduction:

Radiographic Testing is a non-destructive testing of component and assemble that is based on differential absorption. the term radiography testing usually implies a radiographic process that produces a permanent image on film or paper. Although in abroad sense it refers to all forms of radiographic testing. [5].

5.2 Devices and tools:

Radiation Source, picket densitometer, lead screen film, Image Quality Indicator (IQI).

5.2.1 Radiation source:

The radiation source is high-energy like X- ray machine or radioactive source (Ir 192, Co-60) penetrating radiation are those restricted to that part of the electromagnetic spectrum of wavelength less than about 10 nanometres. Radioscopic source have the advantage that they do not need a supply of electrical power to function, but they cannot be turned off. Also it is difficult using radioactivity to create a small and compact source that offers the photon flux possible with a normal sealed X-ray tube. In Co-60 or Cs-137 have only a few gamma energies, which makes them close to monochromatic. The photon energy of Co-60 is higher than Cs-137, which allows Co source to be used to examine thicker section of metals than those that could be examined with Cs.

Figure (5.1) Radiation Sources with Accessory

5.2.2 Film For Testing.

X-ray films for general radiography consist of an emulsion-gelatin containing radiation sensitive silver halide crystals, such as silver bromide or silver chloride, and a flexible, transparent, blue-tinted base. The emulsion is different from those used in other types of photography films to account for the distinct characteristics of gamma rays and x-rays, but X-ray films are sensitive to light. Usually, the emulsion is coated on both sides of the base in layers about 0.0005 inch thick. Putting emulsion on both sides of the base doubles the amount of radiation-sensitive silver halide, and thus increases the film speed. The emulsion layers are thin enough so developing, fixing, and drying can be accomplished in a reasonable time.

Figure (5.2) Film for Testing

5.2.3 Processing The Film.

As mentioned previously, radiographic film consists of a transparent, blue-tinted base coated on both sides with an emulsion. The emulsion consists of gelatine containing microscopic, radiation sensitive silver halide crystals, such as silver bromide and silver chloride. When x-rays, gamma rays or light rays strike the crystals or grains, some of the Br- ions are liberated and captured by the Ag+ ions. In this condition, the radiograph is said to contain a latent (hidden) image because the change in the grains is virtually undetectable, but the exposed grains are now more sensitive to reaction with the developer.

When the film is processed, it is exposed to several different chemicals solutions for controlled periods of time. Processing film basically involves the following five steps.

- Development - The developing agent gives up electrons to convert the silver halide grains to metallic silver. Grains that have been exposed to the radiation develop more rapidly, but given enough time the developer will convert all the silver ions into silver metal. Proper temperature control is needed to convert exposed grains to pure silver while keeping unexposed grains as silver halide crystals.
- Stopping the development - The stop bath simply stops the development process by diluting and washing the developer away with water.
- Fixing - Unexposed silver halide crystals are removed by the fixing bath. The fixer dissolves only silver halide crystals, leaving the silver metal behind.
- Washing - The film is washed with water to remove all the processing chemicals.
- Drying - The film is dried for viewing.

Processing film is a strict science governed by rigid rules of chemical concentration, temperature, time, and physical movement. Whether processing is done by hand or automatically by machine, excellent radiographs require a high degree of consistency and quality control.

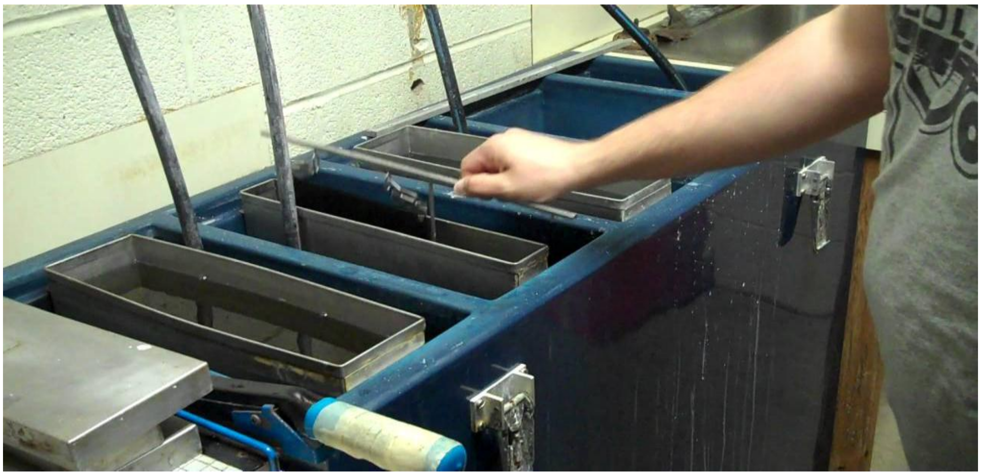

Figure (5.3) Processing the Film Tools.

5.2.4 Safety Hazard.

Ionizing radiation is an extremely important NDT tool but it can pose a hazard to human health. For this reason, special precautions must be observed when using and working around ionizing radiation. The possession of radioactive materials and use of radiation producing devices in the United States is governed by strict regulatory controls. The primary regulatory authority for most types and uses of radioactive materials is the federal Nuclear Regulatory Commission (NRC). However, more than half of the states in the US have entered into "agreement" with the NRC to assume regulatory control of radioactive material use within their borders. As part of the agreement process.

For most situations, the types and maximum quantities of radioactive materials possessed, the manner in which they may be used, and the individuals authorized to use radioactive materials are stipulated in the form of a "specific" license from the appropriate regulatory authority. In Iowa, this authority is the Iowa Department of Public Health. However, for certain institutions which routinely use large quantities of numerous types of radioactive materials, the exact quantities of materials and details of use may not be specified in the license. Instead, the license grants the institution the authority and responsibility for setting the specific requirements for radioactive material use within its facilities. These licensees are termed "broadscope" and require a Radiation Safety Committee and usually a full-time Radiation Safety Officer.

Figure (5.4) Safety Hazard Sing

5.3 Methodology:

The source is often a very small object, which must be transported to the work site a shielding container.it is normal to place the film in industrial radiography, clear the area where the work is to be done, add shielding (collimators) to reduce the size of the controlled area before exposing the radioactive source. see the figure (4.6) and then switch on and setting the time between (2 – 2.5 sec) and then star the radiation source and chick the densitometry.

Figure (5.5) Gamma Radiation Source.

The radiographer stay from safe distance after start the radiation source and calculate shooting time between (2 – 2.5 sec) and replicative for the step more than two. And see the result.

5.4 Results:

After The radiographic and processing the film and checking the viewing

See the incomplete penetration is a weld bead that start at the root of the weld groove. These types of defect occur when the welding procedures are not adhered to possible causes include the current setting, arc length, electrode angle, and electrode manipulation.

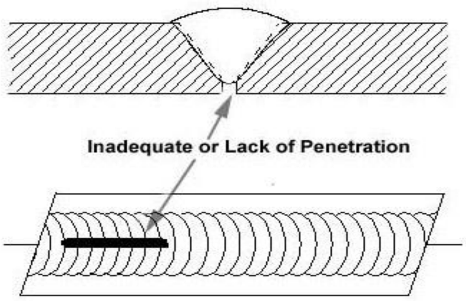

Figure (5.6A)

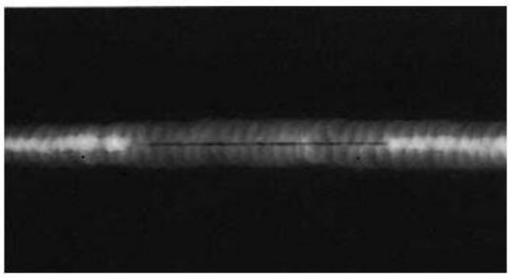

Figure (5.6B)

Figure (5.6) lack of penetration

Figure (5.7) Film After Repair Lack of Penetration

5.5 Discussion:

The Figure (5.6A) above this for welding plate not complete full penetration welding in the end of the root plate but see the figure (5.6B) the image dark area in canter the image after shooting radiation testing (RT) they are two type of the shooting deepened on the source side.

First, there are is the panoramic, one of the four single- wall exposure /single wall view(SWE/SWV) arrangement. This exposure is created when the radiographer place the source of radiation at the canter of a sphere, the radiographer would then place film cassettes on the outside of the surface to examined. The exposure arrangement is nearly ideal -when properly arranged and exposed, all portion of all exposed film will be of the same approximate density [5].

The second is a double wall exposure / single wall view (DWE/SWV) arrangement. Another is the superimpose (where in the source is placed on one side of the item, not in direct contact with it, with the film on the opposite side). This arrangement is usually reserved for very small diameter piping or parts.

After the processing the film, this canter line by the code or stander you have limitation. in the American pipeline institute (API 1104) this code for the acceptance criteria [5].

The cause of the Lack of penetration happening due to too low welding current by increasing the amperage and low travel speed, joint design, root gap to small.

To prevented this cause for lack of penetration use good current welding and prepare the good joint design.

After repair the defect (lack of penetration) use some tools like grinding cutting to open this defect until root, but some electrode (E6010) for the welding root. after complete the weld, use another method of the NDT like penetrant testing (PT) between passes to chuck any surface defect, the second passes is filling pass use the electrode (E8010), finally use third pass to caver the welding plate.

After finish the welding but the plate 24 hours at least to relaxation and to prevented delay cracking. Use the radiation testing to chuck the repair joint and compare the defect with first figure and ascend figure.

The Figure (5.7) the film after processing and the when the booting in chemical acid is developer the film stay in this chemical (4 to 6 min). and also depended in the source activity (if the source is high cure the time is decries). after that butt in water to cleaning and then butting in the fixer stay in (10 to 15 min). the finally butting under the viewer to chick any defect or any discontinuity.

Figure (5.7) see no any lack of penetration after repair, see the figure in the centre line is welding root without any defect.

5.6 Conclusion:

The Industrial radiography is indispensable to the quality assurance required in modern engineering practice and features Industrial radiography is extremely versatile radiographic testing can be use some detect the defect and discontinuity in the industrial in the surface or inside the metal.

5.7 Recommendations:

Finding a new way to do a radiological survey without the effect of a perpetrator to avoid permanent exposure to radiation during an operation.

Wear protective devices to detect the amount exposed to work during the works.

Dimensions of the location of the radiation source while at work.

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