CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Literature Survey has been made with more than 50 valuable research papers, journals and text books which described / related about the ‘Safety in Welding’. The various processes involved in welding have been thoroughly studied. The hazards involved in various welding processes, the methods of controlling them, the various personal protective equipments already recommended to use during welding of water wall panels, the standards already established for safe welding with reference to radiation, fumes generation etc have been studied.

Chandrasekaran (2004) says that following the success of ISO 9000, the International Standards Organization has also developed a series of environmental management standards, ISO 14000. These standards have appeared at a time of increased interest by consumers for environmentally friendly enterprises and products. Although the ISO 14000 series does not directly deal with OSH (Occupational Safety and Health) issues, they will probably have a positive impact on the management of OSH in the workplace, due to the link that exists between the work environment and the environment in general. The Boiler Manufacturing Companies where the water wall panels are welded and where this research has been conducted are already having the ISO9000 and ISO14000 certifications.
2.2 INDUSTRIAL HYGIENE

Larry Jeffus (2003) explains about safe practice of welding. Industrial Health is defined as “that science and art that helps preservation of health of the employees who are occupationally exposed to environmental factors or stresses those are specific to their occupation”. The word “hygiene” is derived from the name of the Greek Goddess of health known as Hygeia. Hygeia was regarded as being concerned with the preservation of good health or the prevention of disease. In some ways the term Occupational Hygiene is a better description as health risks occur in all places that people work such as offices, shops, hospitals and farms, not just in places one would think of as industrial.

Following are the scope of Industrial Hygiene.

1. To anticipate, recognize, evaluate and control the environmental factors or stresses arising out during the course of occupation, which may cause sickness, impaired health and well being or significant discomfort among employees and

2. To prevent the incidence of occupational diseases.

The factory, where the research scholar had done his research work has the Occupational Health Scheme (OHS) under Factory Medical Centre. Here the Industrial Hygiene is given top most importance.

2.2.1 Objective of Industrial Hygiene Survey

- To ensure the presence of hazards and potential health risks faced by the employees at worksites.
• To assess potential health risks and to differentiate between acceptable and unacceptable exposures in compliance with standards/regulations.

• To evaluate the adequacy and efficiency of design suggested and implementation of control measures.

• To provide information to correlate the relationships between environmental conditions and health effects.

2.3 HAZARDS OF WELDING

www.MillerWelds.com, “For Arc welding and cutting-Safe Way” (2005), also gives a clear picture of the all hazards in welding. According to Howard (2003), the more common hazards, which apply to all metal working occupations, are accidents resulting from falling, from being hit by moving parts, from exposure to excessive noise, from working around moving machinery, from exposure to hot metal etc.

As described by David Stanton (2003), following are the hazards which are more or less peculiar to welding:

1. Electrical Shock
2. Arc Radiation
3. Fumes And Gases
4. Noise
5. Muskeloskeletal Injuries
6. Fire And Explosion
7. Compressed Gases
8. Confined Spaces
9. Cleaning And Chipping of Welds

10. Tripping And Falling and

11. Engine Hazards

2.3.1 Electric Shock

Howard (2003), says that the electric shock hazard is associated with all electrical equipments. This includes extension lights, electric hand tools, and all types of electrically powered machinery. Use only welding machines that meet recognized national standards. In order to comply with OSHA requirements, manufactures have recently made changes to improve the safety of the welding machines. This includes the covering of the output terminals with insulating devices. Only insulated type welding electrode holders are to be used for shielded metal arc welding. Semiautomatic welding guns for continuous wire processes should utilize low-voltage control switches so that high voltage is not brought into the hands of the welder. In fully automatic equipment higher voltages are permitted.

2.3.1.1 How to Avoid Electric Shock

American Welding Society Fact Sheet No:5 (2003), clearly recommends the following precautionary measures and safe practices to avoid electric shock.

1. Read all instructions, labels, and installation manuals before installing, operating, or servicing the equipment.

2. Train all personnel involved in welding operations to observe safe electrical work practices according to OSHA 1910.332.

3. Do not touch live electrical parts.
4. Have all installations, operations, maintenance, and repair works performed only by qualified people.

5. Properly install and ground the equipment in accordance with the instruction manual and statutory codes.

6. Do not work alone where there are electrically hazardous conditions.

7. Wear dry, insulating gloves in good condition and protective clothing.

8. Insulate yourself from the workpiece and ground by wearing rubber soled shoes or standing on a dry insulated mat or platform.

9. Use fully insulated electrode holders.

10. Do not touch holders connected to two welding machines at the same time.

11. Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or torch cables. Make sure all connections are tight, clean, and dry.

12. Do not wrap cables carrying electric current around any part of your body.

13. Ground work-piece as required by codes.

14. Do not touch an energized electrode while you are in contact with the work circuit.

15. Wear a safety harness to prevent falling if working above floor level where there are no other protective structures such as railings, walls, guard fences, etc.
16. Turn off all equipment when not in use. Disconnect the power to equipment that will be left unattended or out of service.

17. Keep all covers and panels secure in place.

2.3.1.2 Safe use of Welding Equipments

Nadkarni (2001), explains about how to avoid electric shock during welding. The welders must develop the habit of always keeping their bodies insulated from both the work and the metal electrode and holder. They must always wear shoes and gloves. He also emphasizes that all accessories used by the welder are meant to ensure his safety and guard his health.

Howard (2003), also says that electrode leads and work leads should not be coiled around the welding machines, nor should they ever be coiled around the welder. Electrode holders should not be hung where they can accidentally come in contact with other side of the circuit. Electrodes should be removed from holders whenever they are not in use. American Welding Society Fact Sheet No:29 (2004), emphasizes the need for grounding of welding equipments for safe working.

2.3.2 Arc Radiation

Craig Stinchcomb (2000) has clearly outlined the hazards due to radiation in welding. The electric arc emits large amounts of ultra violet and infra-red rays. Both types of rays are invisible to the naked eye just as the same type of rays emitted by the sun is invisible. When welding with the electric arc, there is added danger that the small globules or droplets of molten metal may leave the arc and fly in all directions. These so called sparks range in temperature from 2000°F to 3000°F and in size from very small to as large as ¼ inch. They present a personal burn hazard plus a fire hazard if they fall in inflammable material.
2.3.3 **Fumes and Gases**

Gary (1996), have elaborated the various health effects of Welding and Cutting Fumes. Welding fume is a mixture of particles generated by vaporization, condensation and oxidation of substances which are transferred through arc. The particles are very small and remain suspended in the air for long periods, where they may be breathed. Small particles are respirable which means that they may penetrate the innermost regions of the lung where they have the most potential to do harm. If inhaled, welding fume may be hazardous to health and must be controlled to limits laid down by regulation.

Pires et al (2006) explains about metal transfer modes and source of fumes during welding. There are basically two theories namely,

1) Static Force Balance Theory

2) Pinch Instability Theory.

The Static Force Balance Theory allows a better explanation of arc phenomena. Shane Ashby (2002), says that despite advances in control technology, welders continue to be exposed to welding fumes and gases. The chemicals contained in these fumes and gases depends on several factors,

1) Type of welding being performed
2) The electrode material
3) Type of metal being welded
4) Presence of coatings on the metal
5) Ventilation system available
The major hazards of welding operations have been clearly explained by David Stanton (2003) also as metal fumes, toxic gases, and ultraviolet and infrared radiation. American Welding Safety, Health Fact Sheet No:24 (2004), gives explains about the hazards due to flux materials used in arc welding. Fume particles are formed from vaporization of molten metal. They are very fine in size, generally one micron or smaller, and may join together to form larger particles. Martin et al (1979), also elaborates about the generation of fumes and gases. Andreas et al (1993), also explains about the formation of fumes during welding.

Vicki Bell (2004), reveals that welding fumes may pose risks for lung cancer and nervous system damage. This is because such fumes may contain nickel, chromium, and manganese. Laurel Berman (2006) says that exposure to welding fumes has been associated with a variety of adverse health effects, including Respiratory effects (Bronchitis), Cancer, effects on reproductive organs and Neurological effects. Brayton Purcell (2005), also explains about how to avoid welding fumes.

2.3.3.1 Possible Effects of Over-exposure

American Welding Society, Safety and Health Sheet No:1 (2003), explains about the possible effects of over exposure of Fumes and Gases and how to avoid them. The amount and composition of these fumes and gases depend upon the composition of the filler metal and base material, welding process, current level, arc length, and other factors. Depending on material involved the hazards due to fumes ranges from irritation of eyes, skin and respiratory system to more severe complications. The possibility of more serious health effects exists when highly toxic materials are involved. For example over exposure of Manganese can affect the central nervous system resulting in impaired speech and movement.
2.3.3.2 Chromium and Nickel in Welding Fume

American Welding Society, Safety and Health Sheet No:4 (2003), clearly outlines about the effect of over exposure of the Chromium and Nickel in welding fumes and how to protect against over-exposure.

1. Depending on material involved ranges from irritation of eyes, skin and respiratory system to more severe complications.

2. Effects may occur immediately or at some later time.

3. Fumes can cause symptoms such as nausea, headache, dizziness, and metal fume fever.

4. The possibility of more serious health effects exists when highly toxic materials are involved. For example manganese over exposure can affect the central nervous system resulting in impaired speech and movement.

5. In confined spaces the gases might displace breathing air and cause asphyxiating.

American Welding Society, Safety and Health Sheet No 25 (2003), explains in detail about the hazard of Chromium and Nickel in Welding Fumes, which leads to ‘Metal Fume Fever’, if the welder prolongs in inhaling them. The fume from welding processes may contain compounds of chromium, including hexavalent chromium, and of nickel. The composition of the base metals, the welding materials used, and the welding processes affect the specific compounds and concentrations found in the welding fume. American welding Society, Safety and Health Sheet No: 4 (2003), clearly outlines about the effect over exposure of the chromium and nickel in welding fumes and how to protect against over-exposure.
2.3.3.3 Regulations Relating to Welding Fume

There are limits for total welding fumes and individual components as per ACGIH standards and as per factory rules. [www.osha.gov](http://www.osha.gov), “Personal Sampling and Air Contaminants” (2006), elaborates about the regulations relating to welding fumes. Following are the standards used relating to welding fumes,

2.3.3.4 Maximum Exposure Limit (MEL)

A MEL is the maximum concentration of an airborne substance, averaged over a referenced period, to which people may be exposed under any circumstances. Exposure should be reduced as far as is reasonably practicable and at least as low as the MEL. To assess the reasonable practicability of reducing exposure, the nature of the risk has to be balanced against the cost and effort involved in taking measures to reduce the risk. Hexavalent chromium and nickel compounds are examples of substance occurring in welding fume which have MELs.

2.3.3.5 Occupational Exposure Standard (OES)

An OES is the concentration of an airborne substance, averaged over a reference period, at which according to current information, that it would likely to cause harm to people’s health if they are exposed day after day, Control will be thought to be adequate if exposure is reduced to or below the standard.

2.3.3.6 Threshold Limit Value (TLV)

TLVs are numbers that refer to a safe or tolerable level of exposure below which no significant adverse effect occurs. Those numbers were first
introduced in 1942 by a group called the American Conference of Governmental Industrial Hygienists (ACGIH).

Threshold Limit Value (TLV) is an exposure guideline that has been established for occupational exposure to physical agents of acoustic, electro magnetic, ergonomic, mechanical and thermal nature and to chemical agents of air borne contaminants of chemical compounds. TLVs refer to the maximum time-weighted average concentrations of contaminants to which workers may be exposed for an 8 hour work shift, 40 hrs work week, without injury to health. TLVs define exposure levels related to people employed in the industrial workplace. The TLV recommended for welding inside shop floor is 5 mg/cu.m.

2.3.3.7 Time Weighted Average (TLV – TWA)

Time-Weighted Average is a summation throughout the workday of the product of the concentrations and the time periods for those concentrations encountered in each time interval and averaged over an 8 hours standard workday.

This is the time weighted average concentration for 5 normal 8 hour work days or 40 hours work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

\[
\text{Time weighted Average } \text{TWA} = \frac{C_1T_1 + C_2T_2 + \ldots + C_nT_n}{8}
\]

where,

\(T_1\)  =  the time of the first exposure period during the shift

\(C_1\)  =  the concentration of contaminant in period T1
\[ T_2 = \text{another time period during the shift} \]
\[ C_2 = \text{the concentration of contaminant in period T2} \]
\[ T_n = \text{n}\textsuperscript{th} \text{period of the work shift} \]
\[ C_n = \text{the concentration during the period n.} \]

### 2.3.3.8 Short-Term Exposure Limit (TLV-STEL)

This is the maximal concentration to which workers can be exposed for a period of up to 15 minutes continuously without suffering from any of the following,

1. Irritation
2. Chronic or irreversible tissue change
3. Narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduced work efficiency.

A STEL is a 15 minutes TWA exposure that should not be exceeded at any time during a work day, even if the 8 hour TWA is within the TLV. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than 4 times per day. There should be at least 60 minutes between successive exposure at the STEL. The TLV-STEL is not a separate, independent exposure limit. It supplements the TWA limit when there are recognized acute effects from a substance that has primarily chronic effects.

### 2.3.3.9 Ceiling TLV (TLV-Ceiling)

This is the concentration that should not be exceeded during any part of the working exposure. To assess a TLV-C, the conventional Industrial
Hygiene (IH) practice is to sample during a 15 minute period except for those substances that can cause immediate irritation with exceeding short exposures. For some substances for example irritant gases, only one category TLV-C may be relevant. For other substances two or three categories may be relevant depending on their physiological action. If any one of these three TLVs is exceeded, a potential hazards from that substances is presumed to exist.

Following are the facts that should be remembered on TLV levels concerned.

1. The TLV is guide in making a professional judgment.
2. The consequence of exposure in excess of the TLV varies from long term to transient irritation.
3. The environmental and individual factors must be weighted.

2.3.3.10 Material Safety Data Sheets (MSDS) and Labelling

Every consumable must have an associated MSDS which provides amongst other things, the composition of the fume emitted when the consumable is used. Often the MSDS provides information on the occupational exposure limits of the various fume components.

David Stanton (2003), explains about Material Safety Data Sheets (MSDS) and Labelling as, “Every supplier of substances and preparations is required to produce a data sheet listing the hazardous materials, if any, contained in the preparation. This enables the user to assess the risk attached to his intended use of the preparation, and to take appropriate precautions”. He also emphasizes that the following information must appear on all MSDS.
2.3.3.11 Sampling

www.osha.gov (2006), in ‘Sampling and Analysis’ elaborates about the importance of effective and efficient sampling strategies, which require planning and foresight to ensure the most productive and thorough evaluation of contaminations in the workplace. Direct reading instruments provide an excellent mechanism to monitor potential exposures. Effective and efficient sampling strategies require planning and foresight to ensure the most
productive and thorough evaluation of contaminations in the workplace. The following reference provide information about chemical sampling.

The accuracy of the exposure level to hazards mainly depends on the sample collection technique. There are three basic types of industrial hygiene sample collection techniques.

1. Personal sampling: This is the measurement of particular employee’s exposure to hazards during work and rest. The measurement device or dosimeter is placed as close as possible to the hazards entry portal into the body.

2. Breathing Zone: The sampling device is held in the employees’ breathing zone. Air that would most likely be inhaled by the employee enters the breathing zone.

3. General Area: The sampling is placed in a fixed location in the work area that is generally occupied by employees. This type of sampling is also called as environmental sampling.

The hazard level is evaluated with proper selection of equipment and analytical methods (e.g. Colorimetric methods, titrimetry and instrumental techniques such as UV Spectro Photometer, Gas Chromatography, Real Time Monitors, Multi-gas Detectors using electrochemical, IR and catalytic sensors etc.) [www.smianalytical.com](http://www.smianalytical.com), “Air Sampling for Hazardous Dust and Welding Fumes” (2004) elaborates about the air sampling equipments to be used for sampling hazardous dust and welding fumes. The selection of equipments is based on,

1. Characteristics of the hazard
2. Interferences
3. Required accuracy and sensitivity
4. Method complexity
5. Sampling area

6. Sample duration

7. Regulatory requirement

Prior to conducting chemical sampling a survey protocol should be developed. The protocol should include the following:

1. Purpose of the survey. Why the survey is being conducted and what is desired outcome? Background information such as previous surveys, operational or equipment changes should be referenced.

2. Where to sample. This identifies expected exposure sites. It is based on where chemicals are stored, transported, and used at the sites, and what ventilation and airflow patterns exist.

3. What to sample. This is based on available information. What are the potential chemical hazards?

4. Who to sample. This is based on knowledge of the potential exposure sites and the various job requirements at the site. What job classification or specific individual should be considered for monitoring? Workers with the greatest potential for exposure must be included.

5. How many samples should be collected. Consider the number of exposure sites, job classifications, and potential chemical hazards. How many samples are necessary to assess the various exposure hazards?

6. How will the samples be collected and analyzed. After the determining the potential hazards, what published methods are available, and which ones will provide the most meaningful
data. Is there a potential for other chemical hazards in the area and meaningful data.

2.3.4 Noise

Noise is an unwanted and unpleasant sound. In welding, cutting and allied operations, noise may result from the process, the power source, or other equipment. Howard (2003) explains about noise hazard in welding industry. Air carbon arc cutting and plasma arc cutting are examples of processes which are frequently noisy. Engine-driven generators may also be quite noisy. Excessive noise is a known health hazard.

Scientifically, noise is composed of several frequencies and involves random changes in frequency or amplitude. Sound waves are produced when the air is mechanically disturbed. Sound is measured by its frequency (pitch high or low) and intensity (loudness). Practically noise is unwanted or unpleasant sound.

2.3.4.1 Impulse or Impact Noise

The sound with a rise time of not more than 35 milliseconds to peak intensity and 1500 milliseconds for the signal’s decay is called noise. Decibel (dB) is the unit for measuring sound. It is a relative scale of sound pressure level. The level indicates that the given quantity has a certain level above a certain reference quantity.

2.3.4.2 Effects of Noise

1. Psychological effects (noise can startle, annoy and disrupt concentration, sleep or relaxation)

2. Interference with communication
3. Physiological effects (noise induced loss of hearing or aural pain when the exposure is severe.

2.3.4.3 Ear Protection

The welding environment can be very noisy. The sound level is at times high enough to cause pain and some loss of hearing if the welder’s ears are unprotected. Hot sparks can also drop into an open ear, cause severe burns.

American welding Society, Safety and Health Sheet No: 3 (2003), explains about the effect of over exposure to noise during welding and how to protect against over-exposure.

2.3.4.4 Occupational Noise Standard

Permissible Exposure Limit (for 8 hrs) of 90 dB is followed in most of the industries. No exposure in excess of 115 dB sound pressure level is permitted. Most standards and guidelines concerning noise exposure are based on an 8 hour work shift and also provide levels for shorter working days. This Noise exposure limit for work shifts is considered as per the recommendation given in ISO standard.

2.3.5 Musculoskeletal Injuries

Welders have an increased prevalence of musculoskeletal complaints, including back injuries, shoulder pain, tendinites, reduced muscle strength, carpel tunnel syndrome, vibration white finger, and knee joint diseases. Work postures (especially welding overhead, vibration and heavy lifting) can all contribute to these disorders. These problems can be prevented by,
1. Proper lifting
2. Not working in one position for long periods of time
3. Keeping the work at a comfortable height
4. Using a foot rest when standing for a long period
5. Locating tools and materials conveniently
6. Minimizing vibration

2.3.5.1 **Ergonomics in the Welding Environment**

The Welding environment introduces many challenges to the field of ergonomics, many of which are now just being understood, not only by the manufacturing / processing sector, but by the medical profession as well. American Welding Society Sheet No: 13 (1998) clearly outlines the problems faced by welders.

The problems resulting from poor Ergonomics are,

1. Repetitive Motion Disorder (RMD)
2. Cumulative Trauma Injury (CTI).
3. Lower Productivity.
4. Lower Quality.
5. Worker Dissatisfaction.

Ergonomics, also called human factors engineering, involves designing the workspace to fit the needs of the workers, rather than trying to make workers adjust to the workplace. When a workplace is designed properly, the worker performing the task feels comfortable with the job both physically and psychologically. Quality and production increases, and all parties benefit from the improved conditions.
2.3.6 Fire and Explosions

Welding, cutting and allied processes produce molten metal, sparks, slag and hot work surfaces. These can cause fire or explosion if precautionary measures are not followed.

American Welding Safety, Health Fact Sheet No: 6 (1998), gives very elaborately about the hazards due to fire and explosions. The Main Causes of Fires in Welding and Cutting Flying Sparks are,

a. Sparks can travel up to 35 feet (10 meters) on a horizontal direction from the work area.

b. Sparks can pass through or become lodged in cracks, clothing, pipe holes, and other small openings in floors or partitions. Figure 2.1 shows that Flying Sparks while welding is carried out.

Figure 2.1 Flying Sparks While Welding is Carried Out
2.3.7 Compressed Gases

David Stanton (2003) has elaborately given the hazards due to compressed gases. Gas welding and flame cutting use a fuel gas and oxygen to produce heat for welding. For high-pressure gas welding, both the oxygen and the fuel gas (acetylene, hydrogen, propane, etc.) supplied to the torch are stored in cylinders at high pressure. According to Bob Cunningham (2002), the use of compressed gas cylinders poses some unique hazards to the welder. Acetylene is very explosive. It should be used only with adequate ventilation and a leak detection programme. Oxygen alone will not burn or explode. At high oxygen concentrations, however, many materials (even those that are difficult to burn in, air such as normal dust, grease, or oil) will burn or explode easily.

To use compressed gas cylinders safely, it is important that they are stored properly, handled correctly, used with the correct equipment, and that the properties of the gases they contain are fully understood. American Welding Safety, Health Fact Sheet No:30 (2004), gives very elaborately about the hazards due to cylinders. Cylinders with their high internal pressure [upto 2,500 pounds per square inch gauge (psig)], are very hazardous when exposed to damage of falling over or tipping, heat, electric circuits, motion, or vibration – anything that can cause a weakness or crack in the cylinder wall or shell. Such damage can cause the cylinder to rupture and explode sending sharp metal pieces, like shrapnel, blasting through the area.

2.3.8 Confined Spaces

American Welding Safety, Health Fact Sheet No:11 (1998), gives very elaborately about the hazards due to confined space. At many different confined places welding, cutting, and heating are required. Bob Cunningham
(2002), also explains in detail about the hazards of welding in confined spaces. Confined spaces have the following characteristics:

1. Limited space – difficult for entry or exit.
2. Poor Ventilation – lack of safe breathing air and possible accumulation of hazardous gases, fumes, and particles.

2.3.8.1 Reason for Serious Injuries from Welding in Confined Spaces

1. Fire
2. Explosion
3. Electric shock
4. Exposure to hazardous air contaminants
5. Asphyxiation.

2.3.8.2 Required Actions before Start of Work in a Confined Space

1. Open all covers and secure them from closing.
2. Test confined space atmosphere for (i) suitable oxygen content, (ii) no combustibles or reactives.
3. Isolate lines by capping or double valving and venting—keep vents open and valves leak-free.
4. Lock out all systems not required during welding, cutting, or heating.
5. Provide means for readily turning off power, gas, and other supplies from outside the confined space.
6. Protect or remove any hazardous materials or materials which may become a physical or health risk when heated or exposed to an arc.

7. Continuously Ventilate and monitor confined space to ensure that and gases

2.3.9 Cleaning and Chipping Welds

Welding, chipping, wire brushing, and grinding cause sparks and flying metal. As welds cool, they can throw off slag. American Welding Safety, Health Fact Sheet No:8 (1998), gives very elaborately about the hazards due to cleaning and chipping of welds. Approved safety glasses with side shields even under the welder’s welding helmet. Cleaning and chipping of welds should not be done with bare hands. Welders’ Hand Gloveses must be worn by the welder whenever the cleaning and chipping is done.

2.3.10 Tripping and Falling

Welding, cutting and associated processes take place in a wide variety of locations under many different conditions. Bob Cunningham (2002), elaborates about the hazards involved in welding from an elevated platform. American Welding Society, Safety and Health Fact Sheet No.9 (1998), explains elaborately about the hazard of Tripping and Falling. Welding and cutting occur in shops and factories on the floor level, on high steel in skyscraper construction, in pits, vats, mines, tanks, ship compartments, and literally everywhere that metals are joined or cut.

2.3.10.1 Causes of Tripping and Falling

1. Poor housekeeping of materials, equipment, hoses and tools.
2. Scattered parts and pieces either left over or waiting for use.

3. Failure to use approved safety belts and harnesses or incorrect use of them when working above floor level.

4. Electric shock from faulty equipment.

5. Sudden loud noises or shouts.

6. Incorrect or improperly used or installed safety equipment such as ladders, guardrails, scaffolds and nets.

7. Failure to wear proper personal protective wear such as skin-resistant soles on shoes to meet the needs of the job.

8. Horseplay or unsafe actions, such as tossing tools to each other or bumping someone in a precarious position.

9. Restricted vision caused by needed safety gear such as welding helmets and safety goggles.

10. Failure to fully understand the hazards, such as toxic fumes, when entering a pit, tank, or compartment.

2.3.11 Engine Hazards

Engine fuel plus flames or sparks can cause fire or explosion. All machines with moving parts must be guarded to prevent worker’s hair, fingers, clothing, etc. from getting caught. The welder’s hands, hair, loose clothing, and tools should be kept away from moving parts such as fans, belts, and rotors. All doors, panels, and guards of the welding equipment should be closed and secured.

When machinery is repaired by welding or brazing, power must be disconnected, locked out, and tagged so that the machinery cannot start up accidentally.
2.3.12 Evaluation of Welder

Meckley and Petroski (1990) have worked towards developing the skilled welders. The ingredients of the skilled personal that can mean the success or failure of a business are difficult to find. This is especially true in welding industry. Weber (1990) has compared the welders training around the globe. There was a need to improve the welders training / competence all over the world. Ballis and Dehaven (1979) has done analysis of metal transfer in shielded metal arc welding. All welding codes require a welder to make welds in accordance with qualified welding procedure. Unfortunately many important welding techniques are not described in the welding procedure. Good welder know techniques which help them produce quality welds.

2.3.13 Hazard Control

According to Howard (2003), all welding and cutting processes produce undesirable by-products, such as harmful dusts, fogs, fumes, mists, gases, smokes, sprays or vapors. The primary objective has be to prevent these contaminants from forming and collecting in the atmosphere. This will be accomplished as much as possible by engineering and design control measures such as water tables for cutting, and local ventilation. Production of welding by-products cannot be avoided. They are created when the temperature of metals and fluxes is raised above the temperatures at which they boil or decompose. Most of the by-products are recondensed in the weld. However, some do escape into the atmosphere, producing the haze that occurs in improperly ventilated welding shops. Some fluxes used in welding electrodes produce fumes that may irritate the welder’s nose, throat, and lungs.

David Stanton (2003) narrates the various concepts of controlling the hazards at the workplace can be summarized as follows:
1. Substitution with less harmful material
2. Process change
3. Enclosure of process
4. Isolation of process
5. Wet methods
6. Local exhaust ventilation
7. General exhaust ventilation
8. Dilution ventilation
9. Increase the distance between source and worker
10. Enclosure of employee
11. Personal monitoring devices
12. Personal Protective Equipments (PPE)
13. Training and health education.