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Workers Health and Safety in Bulk Handling Of Grains for Storage in Metallic Silos

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ABSTRACT: *There are a lot of accidents and hazards associated with bulk handling of grains which has continuously pose serious threat to life of workers in the silo facility. It is pertinent to note that these accidents are preventable but normally occur due to human error, ignorance and non-adherence to common safety rules and regulations. The entire workers health and safety in bulk handling of grains in metallic silos was reviewed with respect to various accidents and hazards associated with bulk handling of grains in complexes, their precautionary and preventive measures were explicitly highlighted. The study is expected to create more awareness on the potential hazards associated with bulk handling of grains in metallic silos and to provide specific information on the importance of strict adherence to the use of protective gears so as to avert industrial accidents. The Nigerian government is encouraged to put in place the appropriate machineries and enforce strict laws associated with health and safety of workers in silo facilities all over the nation.*

KEYWORDS: *Bulk grain handling, hazard, metallic silo, safety, workers health*

I INTRODUCTION

Grains are small, hard dry seeds with or without attached nulls or fruits layers harvested for human food or animal feed [1] [2]. Grains can either be a whole grain or refined grain. A whole grain contains the entire grain kernel namely the bran, germ and endosperm while refined grains are milled grain, a process that removes the bran and germ. Harvested grain are largely advantageous over other kinds of staple food crops such as fruits, vegetables, various starchy root and tuber crops because of the ease of storage, handling, transportation and processing. These qualities have allowed mechanical harvest / handling, transport by water or rail, long term storage in metallic silos, and large scale milling or processing in Agro and Agro allied industries for grains [1] [3] [4].Grains can be classified into three major types namely cereals, legumes and oil seeds. Grain cereals include maize, sorghum, millets barley, rice, wheat and other paddy crops. Grain legumes / pulses include peas, beans, peanuts soyabeans and green beans [1] [5] [6]. The behaviour of different classes or types of grain in harvesting, drying, handling, processing and storage differs from one grain to the other due to intrinsic properties of various grains such as, moisture content, hectoliter weight, bulk density, void volume, angle of repose, aerodynamic, physical and mechanical properties. However grain has proven to be the world most dependable source of food to sustain the ever increasing world population [7].

Metallic silos are towers made of metals for storing grains, usually on farm so that grains can be kept fresh [8] [9]. The improved modern storage structures are built using metallic panels. Metallic silos are particularly used for storage of grain, but can be used for other granular / liquid materials ranging from flour, cement and a wide range of other materials. Most metallic silos are high capacity intended for commercial or industrial storage of large quantities of grain. Others are in form of bins with relatively lower capacity in terms of holding grain and are assembled or erected on reinforced concrete platforms [10]. Silos are usually cylindrical in shape with sloping roof. It can be built in a wide range of shape depending on its intended purpose. A typical silo is designed to have one or more manholes for the purpose of inspection, cleaning and others jobs needed to be done inside the silo bin. Big capacity silos that are for long term storage are designed with aeration facilities for aeration of the grains [11] [12]. A group of silos built in rows makes up what is called a silo complex [13]. For a metallic silo to be efficient in storage of grains it must have certain important qualities namely: ability to prevent the entry of pests and rodents into the grain bulk, aeration facilities for forced ventilation, presence of inner ladder for easy access, efficient loading and unloading facilities, efficient temperature and relative humidity monitoring system, ability to keep the grain in good condition without deterioration and good access for inspection of grains.

The aim of this work is to address workers health and safety in bulk handling of grains for storage in metallic silos complexes with respect to certain activities required to precede the exercise from grain reception to discharge. Such activities include, sanitation of silo complexes, cleaning of the silo bins, checking the state and condition of machine/equipment.

II BULK HANDLING OF GRAINS IN METALLIC SILOS

Bulk handling of grain in metallic silos involves integrated system of grain management where by several important units function are put together to facilitate efficient storage system. This involves all the activities carried out from the reception of the grains till the grain leaves the silo complex. It includes mechanical handling with various machine and equipment, insect/pest management, monitoring and control of the immediate storage ecosystem, grain reception, cleaning and sanitation [14]. As soon as consignment of grains arrive the silo complex, proper documentation of the grain/supplier is taken and subsequently given numbers, numerically establishing a queue. The first activity preceding documentation is the sampling of the grains. The grains sampling are normally carried out by trained personnel who takes samples randomly from the bags. The samples will then be analyzed in the silo complex laboratory to check for certain parameters that can affect the storability of grains. Such parameters include the moisture content, hectoliter weight, insect damage, broken grains, mould and colour. If the parameters agree with the already set standard from the organization, the consignment is accepted or otherwise rejected. A typical acceptable standard for grains reception into the strategic food reserve silo complexes in Nigeria is as shown in Table 1.

Table 1: Grain reception standard for grains stored in Nigerian silo complex

S/No	Factor	Tolerance Level
1	Percentage moisture content	10 – 12 %
2	Test weight	65–75kg / hectoliter
3	Percentage broken grains	1.0% maximum
4	Percentage insect damage grain	1.0% maximum
5	Percentage foreign matter	1.0% maximum
6	Grain colour	White or yellow maize. White yellow, red sorghum. Cream or yellow soya beans. Endosperm of grains must not be damaged by heat or discoloured.
7	Grain age	Must be from current harvest

Sources: [13]

III. Hazard Associated With Bulk Handling Of Grains For Storage In Metallic Silos

There are various forms of hazards associated with bulk handling of grains for storage in metallic silos complexes some of which include;

3.1.Dust Exposure and Explosion

This is an exceedingly rapid, virtually instantaneous burning or combustion of a given quantity of dust (Plate 1). The rapid combustion is accompanied by an equally rapid rise in pressure as a result of the large amount of heat librated and the volume of gases released. A department of agriculture in January 1980 " in the last 21years stated that there have been at least 250 dust explosion in grain silos and the feed mills in the United State of America. The losses have been enormous with at least 164 deaths, 605 injured and a hundreds of millions of dollars worth properties destroyed [15]. Exposure to dust constitutes a serious health hazard such as inducing lung diseases, dust irritates the eye, can trigger asthma and worsen existing brochutes, pneumoconiosis, and lung cancer [1].

Plate 1: Grain dust at receiving pit
Source: [1]

3.2.Climbing/Falling Hazard

This involves skidding off from stepping platforms which could be ladder, walkway, service platform, basement, silo roof/ manhole and any unsteady stepping object. A fall may inflict a serious health injury depending on the altitude and what the victim fell on. Serious cases has resulted to death instantly, other have left victims with head injuries, broken bones and spinal cord injuries. Many survivors have incurred injuries resulting in permanent deformities. The purpose of grain inspection, grain treatment, carrying out different repairs in the electric motor and other material handling equipment located in the walk ways on top of silo cells, taking of grain samples for rotary analysis, climbing of staffs to the silos roof or to a very high altitude in a silo complex is inevitable. Prevalent silo design/construction has made these problems more complicated. Many silo complexes are designed with poor service platform and walk way, others are as a result of faults emanated during construction in which substandard materials are used or some areas are deliberately excluded in the construction in other to save cost [13].

3.3.Getting Trapped in Flowing Grain/Suffocation Hazards in Grains Silos

Several causes of grain entrapment includes bridge grain, unstable piles, energizing auger for unloading while people are inside the silo, removal of grain flow blockage and cavities. Depending on the grains resistance to flow as a result of excessive moisture and presence of perhaps high proportion of irregular shaped impurities, bad weather conditions or bad bin designs, the grains can form layers across the silo literarily forming a bridge. Grains under this region which are not subjected to these conditions will probably flow easily when unloading starts, thereby creating dead traps known as Cavities. At this point anybody who walks on top of the grain are at risk of being buried in grain as well as suffocation to death, if not rescued. Accidents or entrapment due to unstable piles are less dangerous than cases of cavities. In unstable piles, it takes longer time to submerge victims as a result the chances of survival is more. Untrained rescue attempts to entrapped victims may be a double disaster as both the victim and rescuer may become victims (Figure 1). In Nigeria, there are no available records of victims accidents in silo complexes, but since the establishment of the National Strategic Food Reserve Department of Federal Ministry of Agriculture, there have been only one incidence of death, in which the victim, being a casual worker, died in an attempt to solve a grain flow blockage problem inside a silo [1].

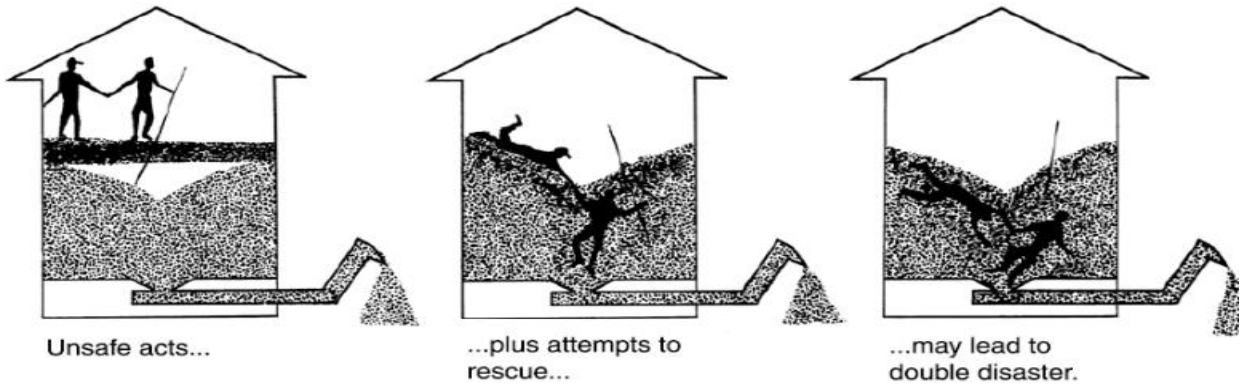

Figure 1: Implication of entrapment from grain in metallic silo
Source: [1]

3.4.Hazards Associated with Mechanical moving Parts/Electrocution

In a typical silo environment about 80 % of the entire job/activities are being performed by machines/equipment with mechanical moving parts/component. It includes all the material handling equipments, like elevators, conveyors, augers, and pneumatic equipments. Others are the cleaner, dryers, bagging plant, chemical/dust dispensers and cyclones. Accidents in this area which has been recorded are largely due to human errors, unauthorized alteration of design by silo workers, silo design errors and carelessness among the silo staff. Every equipment with mechanical moving parts are designed to have covers to prevent human contact when in operation, but silo attendants normally keeps it open for the purpose of easy observation for malfunctioning parts, which sometimes pays off, but at other times it can be dangerous and deadly. Quite a number of workers have lost fingers and even limbs because some operators powers on the machines without knowing or forgetting that repairs is ongoing on the same machine/equipment. On several occasion staff while falling from a height in an accident falls into open working mechanical moving parts of machine because they are not covered. A human contact with a mechanical moving part usually results in injury [1] [15].

Electrocution is an accident that rarely occurred in a silo facility, but whenever it occurs, it is so devastating and causes instant death. Electrocution is the act that injure or kills by passing electric current to a human body [16]. The cause in a silo facility includes; rat eating up wires, major electrical faults that bridges wires and inexperience electrical personnel in attempt to carryout repairs. The seriousness of any electrocution case depends on the capacity of voltage in the given areas. The most serious areas include the transformer areas, the change over, the generator and the control panel. Direct contact in these areas can cause instant death while other areas may be mild.

3.5.Hazard Associated with Handling of Chemicals

Several hazards associated with proper and improper handling/exposure to chemicals may be internal or external. The health effect of hazardous chemicals are often less clear than the physical hazard especially from chronic exposure [15]. Silo attendants always come in contact with chemicals such as insecticides and fungicides. Contact through inhalation often affects the lungs, since they are the most common route of entry for gases vapour and particles. Chemicals inhaled into the lungs can harm the internal tissues or be absorbed into the blood stream. Continuous exposure and inhalation may result to headache, dizziness, eye and throat irritation and loss of consciousness, drowsiness or collapse. Long term effect of exposure includes loss of sight, poor reproductive ability, psychological problems that can even lead to death or madness. Hazards associated with handling of chemicals are preventable, but often occurs due to carelessness, non compliance of the common safety laws in the silo facility like the use of protective gears [17].

3.6.Hazards Associated with Fire/Fire Outbreak

Fire Hazard associated with bulk handling of grain in silo includes, explosion of dust or grains if it comes in contact with igniting medium, ordinary fire outbreak due to poor electrical wiring, cigarette smoking, or whirl wind fire during the dry season. Due to the peculiar nature of silo facility environment, any kind of fire outbreak will cause severe damage because grain itself act like a fuel. The ease of igniting bulk quantity of grain is almost the same with flammable liquids and solid. The complicating aspect of fire outbreaks in handling of bulk grain in metallic silos is the fact that it is accompanied with explosion. In event of explosion in a silo complex, inside the silo cell or other auxiliary bins like the hospital bins, anybody within is at serious risk due to the effect of the explosion. Other serious risk associated to fire hazards and explosion includes panic and stampede, it is one of the rarely recorded kinds of hazards but whenever it happens losses will be within the range of millions and multimillion naira [1].

3.7.Truck Loading and Unloading Hazard

Truck loading and unloading hazard includes these hazards associated with loading and unloading of bags of grains in the silo complex. Though occurs rarely, the dangers associated can be serious especially in the area of loading. Loaders can fall while trying to load or unload in the intake pit. Vehicles can hit stationary objects or equipment while trying to turn inside the warehouse. In a particular incidence in Minna silo complex warehouse, a truck coming to lift grains hit the door of the warehouse while trying to drive in and the collapsible warehouse door fell down and broke the leg of a silo worker. Accidents in the warehouse can be with stationary object, packed pallets and or with stacked grains or empty bags or when grains are stacked so high, which makes them unstable. However, truck loading and unloading hazards are preventable since the causes are often as a result of carelessness, lack of supervision and commitment to work, the use of high number of casual worker who has little or no training to their assigned task [15].

IV. PREVENTIVE MEASURES FOR RESPECTIVE HAZARDS

4.1.Prevention from Dust Explosion

Eliminations of three flammable components (dust, air and source of ignition) that lead to explosion in a controllable manner are important precaution to be encouraged. There should be no smoking around the silo facility. Naked lights should not be used to work in a silo facility, bush fire should be controlled by performing fire tracing yearly in and outside the fence. The importance of controlling dust in a silo complex is very essential. This includes dust within the building, on machinery and surfaces likely to generate heat. All the firefighting equipment like hydrants, fire extinguishers should be effective and tested during regular fire fighting drills which is advocated for all silo facilities. Efforts should be made after every exercise in the silo complexes to dispose dust by either burning or complete evacuation out of the silo complex. Vacuum cleaner can be used to suck out dust from remotes areas.

Pressure releases vents should be provided for enclosed storage tanks. Fire suppressants sensor could be installed inside all the silos. Dusts exposures are critical to human health as it can cause irritation of the skin and the eye, aggravation of bronchitis and other diseases associated with the respiratory system. However, the only effective preventive measure is by the use of protective gear called Dust Respirator. Respirator is a protective gear that covers both the nose and mouth designed specifically for the control of dust inhalation in a dust prone environment.

4.2.Prevention of Accident as a result of Climbing/Falling Hazard

Climbing/falling hazards are regular causes of accidents in silo facility which can be prevented by ensuring that workers always completely kitted with protective gadgets before embarking on any job in the silo area. The provision of life belt is essential especially if the worker is climbing to a high altitude or inside a bin. Rigid and well-spaced platforms which are walk ways expected to be incorporated in design to enable workers have enough room to carry out repairs on top of the silo bins. Silo workers should ensure working as a team (Figure 2).

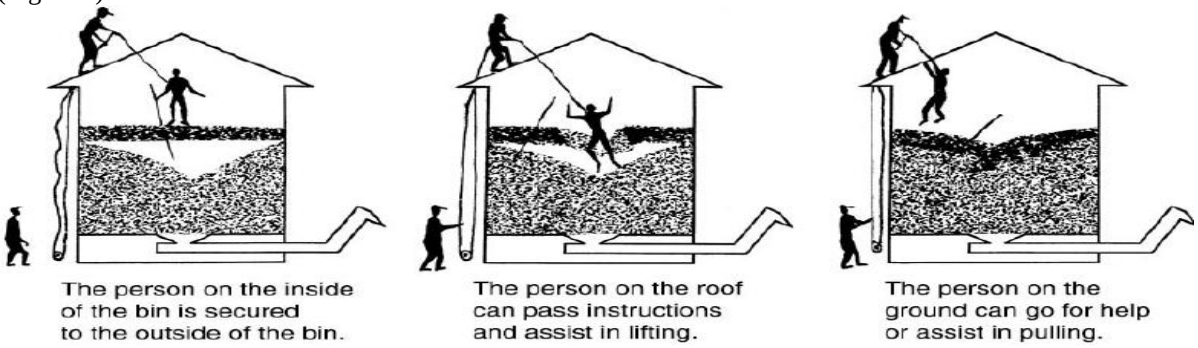

Figure 2: Teamwork in silo facility for safety precaution
Sources: [15]

4.3.Precautionary Measures from Getting Trapped in Flowing Grain / Suffocation Potential

Victims may be more than one if an inexperienced worker tries to rescue an entrapped victim because he is likely to be trapped also. Preventive measures to forestall this kind of accident include:

- Employers working in grain handling facilities should never work alone, because they are exposed to significant occupational safety health hazards that includes, falls, electrocution, engulfment, auger entanglement and dust explosion. Working with a partner ensures that help is available in case of accidents or an unstable pile accident (Figure 2).
- Notice of "Man inside bin" should be placed before grain bin entry and all equipment power source station should also be shut down and lock out while observer outside the silo bin should also continuously monitor and keep track of the employee inside the bin.
- Workers should be prohibited from walking down the grain as a practice or similar practice of making grain to flow.
- Precaution should be taken upon entry into the top of a silo bin by walking near the silo wall, walking through the centre should be avoided. The pre-use inspection on all rescue equipment should be made readily available for use.
- It should also be ensured that the silo bin entrant wear all the protective gear and casual workers should not be allowed into a bin, since records has shown that casual workers / younger staff are mostly the victims of accidents over the years.
- Other safety measures required immediately an entrapment inside the bin occur includes, calling the fire service or any emergency rescue team, aeration facility should be turn on while grinding machines should be used to lacerate the sides of the bin from the base as much as possible to allow grains flow out and Emergency Action Plan (E.A.P) should be implemented.

4.4.Preventive Measures from Mechanical Moving Parts / Electrocution/Welding

Prevention of mechanical hazard is encouraged by inter locking each emergency stop switches so that machines cannot start unless the master control is reset. It is necessary to isolate an electric motor from power source before carrying out maintenance or repair on the machine. Welding inside the grain store and around the bin should be prohibited while provision of suitable fire extinguisher should be readily available before welding.

4.5.Prevention of Hazard Association with Use of Chemical

Chemical hazard contaminations are mainly by ingestion, touch and inhalation. The major protective gear for each of these must be used when working or having any contact with the chemical. Chemical respirator must be used while working in chemical treated or fumigated areas. Hand gloves, coverall, industrial boots and safety goggles must be used while spraying or fumigating a particular area in the silo facility. Silo attendant should wash their hands and even bath after working with chemicals. Chemical store should be located far away from workers rest room/changing room and other living areas in the silo complex. Proper health and safety training should be organized for the staff of silo complex especially the personnel whose schedules is more of handling of chemicals. Respective chemical antidotes must be made available in the silo facility sick bay in case of accidental ingestion of chemical and to ensure prompt proper medication for victims.

4.6.Prevention of Loading and Unloading Hazard

Hazards associated with loading and unloading of trucks can be prevented with the following precautionary measure: prohibiting non-staff, visitor personnel into the welding and unloading areas. Stacking should be done properly to avoid creating unsteady piles or stacked that could be a potential death trap to workers.

V. CONCLUSION

A holistic approach to issues, concerning workers health and safety in the handling of bulk grains in metallic silo makes this sector look like a dead trap. Several accidents have been reported to have occurred in silo complexes in developed countries of the world, resulting in death of most of the victims. Similarly, in developing countries of the world, such accidents are also inevitable even though such silo complexes are still very few. In Nigeria, where the bulk grain handling facilities are few and are owned by the `government, these occurrences are also bound to happen. There are however, no with accurate information on such accidents and moreover, most organizations will rather conceal such story of victims in their facility. Hence staffs of silo complex are encouraged to prevent these hazards and accidents, by the use of protective gears and work to as a team in the complex.

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