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Job security in a packaging and distribution of hydrochloric acid company

Seguridad laboral en una empresa de envasado y distribución de ácido clorhídrico

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Abstract

Hydrochloric acid is a chemical compound with broad applications in industry, chemistry, mainly used for the manufacture of agrochemicals, veterinary products, production of PVC, the process of demineralization of water, activation of oil fields, process of tanning skins, process of stamping in the textile industry, production of pharmaceuticals as well as applications in the food industry as an additive in the manufacture of gelatin and sugar. In recent years in Mexico, the chemical industry has held between the third and fourth place in the value of GDP is a 10.7% of this (INEGI, 2015). The growth of this industry every year, explains the increase in the demand for the product of the study dedicated to the purchase, storage, packaging and distribution of hydrochloric acid and muriatic. This company raises the need to distribute their areas of production, optimizing the working conditions and the need to expand to implementing a better distribution of plant that guarantees the security of the worker and increase its production capacity and competitiveness.

Job security, Hidrochloric acid, Risks

Resumen

El ácido clorhídrico es un compuesto químico con amplias aplicaciones dentro de la industria, principalmente la química, utilizado para la fabricación de productos agroquímicos, productos veterinarios, elaboración de PVC, el proceso de desmineralización del agua, activación de yacimientos de petróleo, proceso de curtido de pieles, proceso de estampado en la industria textil, producción de productos farmacéuticos así como aplicaciones en la industria alimentaria como aditivo en la fabricación de gelatina y azúcares. En los últimos años en México la industria química ha ocupado entre el tercer y cuarto lugar en el valor del PIB es decir un 10.7 % de este (INEGI, 2015). El crecimiento de esta industria año con año, explica el aumento en la demanda del producto de la empresa en estudio dedicada a la compra, almacenamiento, envasado y distribución de ácido clorhídrico y muriático. Esta empresa plantea la necesidad de distribuir sus áreas de producción, optimizar las condiciones de trabajo y la necesidad de expandirse implementando una mejor distribución de planta que garantice la seguridad del trabajador e incremente su capacidad productiva y competitividad.

Seguridad laboral, Ácido clorhídrico, Riesgos

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Introduction

Hydrochloric acid is a chemical compound, formed by a solution in water of hydrogen chloride gas, it is an acid of high thermal stability with a wide variety of applications, it is considered among the inorganic compounds of greater use and importance on an industrial scale (Acids .info, 2017). It receives a variety of different common names that change depending on the geographical area, so for example it is known mainly in America as muriatic acid, while its common name in Spain is strong water, other names it also receives are: spirit of salt, salt acid, chloric acid and marine acid.

Hydrochloric acid, has as its main characteristics its high corrosive and acidic power, it is also in a liquid state as it is an aqueous solution with a slight yellowish hue. In a gaseous state it weighs more than air and has a smell that irritates the mucous membranes and eyes. It is usually treated in chemistry as a strong acid, since it dissociates completely in the aqueous solution; It is usually used as a reagent. Its pH is usually lower than 1, so it is dangerous and even lethal to humans if ingested, even a small amount. It is naturally present in the gases emitted by volcanoes, which when exposed to air form dense and corrosive white vapors. In addition, gas is also formed by burning some types of plastics, and as soon as it comes into contact with water, the formation of HCl takes place. Chemically, hydrochloric acid is a monoprotic type acid, that is, it only releases one proton (H +). When in an aqueous solution, said ion binds to an H_2O molecule, resulting in the production of an oxonium ion (H_3O +). Along with oxonium, the formation of another ion, chloride (Cl-), is also given. That is why hydrochloric acid can be used in preparations of chloride salts. HCl is an acid considered strong, because when it is in water, it suffers a complete dissociation, it is a strong acid not very dangerous to work if we compare it with other strong acids such as Sulfuric acid, in addition to HCl solutions that have concentrations tights, are usually highly stable, being able to maintain over time, so they can be prepared and preserved for later use. All this, together with that it can be achieved as a reagent in its purest form, makes HCl a reagent widely used to acidify, as well as an acid titrant used in volumetric processes. It has a wide use in chemical analysis for volumetries and for the digestion of various analytical samples.

Apart from its use as a reagent, hydrochloric acid has numerous uses not only because of its strong acid characteristics but also because it is economical, stable, high in water and volatile. Among these uses is the removal of limestone residues (Calcium Carbonate, $CaCO_3$) whose presence can cause fouling and sealing of pipes, in this process limestone dissolves when reacting with hydrochloric acid forming calcium chloride ($CaCl_2$) with release of CO_2 and H_2O. In the branch of organic chemistry, HCl, is used in the synthesis of some organic acids. Another important application for HCl is its participation to regenerate ion exchange resins. In the food industry, HCl is used in the production of gelatin, because it dissolves bone parts. It has wide use in the production of cleaning products, it is used in the treatment of metals, in the treatment of leather as well as in the manufacture of numerous and varied industrial products.

In spite of being highly used, it is not free of harmful effects on health, since HCl, besides being corrosive, is quite irritating to any mucosa or tissue that is in its contact or inhalation. Causing from sore throat to suffocation depending on the exposure time. Some sensitive people cause inflammatory reactions.

When HCl is mixed with bleach, or other oxidizing agents, a toxic chlorine gas is produced. Always depending on the concentration of the acid used and exposure to it, it can cause from mild irritation, to serious burns, either on the skin or in eyes or other areas. Long-term exposure, even at small levels, will cause breathing problems, mucosal irritations and also teeth, which will discolor. The gastric juices that are secreted in the stomach have an HCl content of about 3%, which gives it a role of coenzyme in the digestion of food, to digest proteins and in the hydrolysis of the polysaccharides that we can ingest through the diet. The stomach HCl is produced by the parietal cells of the stomach, which is protected against the action of said acid, but when some of the protection processes fail, the known stomach ulcers occur (Méndez, 2013). Free chlorine is the most commonly used disinfectant, it is classified as an oxidizing agent. When free chlorine is added to water, it quickly reacts with it to form hypochlorous acid (HOCl) and Hydrochloric acid (HCl) according to reaction 1:

$$Cl_{2(g)} + H_2O \rightarrow HOCl + HCl \quad (1)$$

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Although chlorine disinfection is very effective (mainly against bacteria and viruses) and with cost advantages, the use of chlorine has some disadvantages such as the formation of by-products, since chlorine reacts with dissolved organic matter present in the water at disinfect and form trihalomethanes (THM) which are carcinogenic (Mihelcic, J. and Zimmerman J., 2012). The regulations of the World Health Organization for chlorine establish a maximum allowed limit of 5 mg / L and NOM 127 SSA1-1994 of 0.2 - 1.5 mg / L. Chlorine produces water flavor, its detection threshold being 0.6 - 1.0 mg / L. While chemical products can be useful, it is necessary to take measures to prevent and keep under control the potential risks for workers, workplaces and the environment (ILO, 2014).

Occupational safety includes a set of measures and activities developed to minimize or eliminate the risks arising from the performance of a job. Understanding by risk according to the USEPA (United States Environmental Protection Agency, 2001) any possibility of something happening with negative consequences.

The company under study is dedicated to the purchase, storage, packaging and distribution of hydrochloric and muriatic acid, in the presentation of pet and polyethylene bottles in measures of 0.5, 1 and 4 liters as well as 70, 120, and 200-liter gallons.

Every organization is responsible for the safety and health at work (OSH) of its workers and that of other people who may be affected by their activities (Muñoz, 2019).

Nowadays the company does not have the capacity to cover the increasing demand of its products because its productive capacity is limited by the lack of facilities and the poor distribution of plant; and for not having the regulations implemented in its facilities. Consequently, the company sees the need to carry out the plant distribution design based on the current safety guidelines in order to expand by implementing a distribution that guarantees worker safety and the application of the regulations for its correct operation.

Objective

Perform the analysis of occupational safety needs in the design of plant distribution of a hydrochloric acid packaging and distribution company.

Methodology

The research method used in this project was descriptive, since the first action was to describe the current situation of the company, which starts from the general problems to individuals, where the main problem was identified and described, which starts with the poor distribution of the company's plant which does not guarantee operator safety. Another method used in this investigation is the explanatory one, since the causes of the company's problems were searched, such as that the company does not have defined work areas, the lack of work methods and the presence of occupational accidents, which have an impact in occupational hazards that are present in the daily work in the facilities. The scope of the methodological research is to propose a distribution of facilities that will allow the company to increase its production, guaranteeing worker safety, giving it a better workspace and facilities. The design of the present investigation is not experimental, therefore, the variables of the work were not objects of prior control or corrective in the development of the investigation, leaving the observed events to evidence data without manipulative intervention by the researcher. On the other hand, this study was determined as a field investigation, since the data collection process was carried out in a company in the Tehuacán Region, being a case study. Field research was carried out in characteristic phases of a methodical process and follows the form of the scientific method to solve the problem, this process is as follows (Muther, 1981):

- The clear statement of the problem or task.
- Facts that can be measured.
- New approach to the problem in light of the facts.
- Objective analysis that leads us to a decision.
- Action to get approval and installation.
- Tracking and checking.

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In order to assess the risks and propose corrective and control actions to guarantee occupational safety.

Results

Primary information

The collection of qualitative data from primary sources was obtained directly with interviews with workers and guided observation tours in the visits to the company under study which has a total of ten employees: five operators in the production process and five in management activities , sales, purchases and multiple activities of the company. The interviews were applied to the five operators dedicated to the production process and to three members of the company's trustworthy staff: general manager, sales manager and production manager. The company is classified as microenterprise by its number of workers (DOF, 2002) and has more than 25 years in the market and currently in its product catalog is bottled hydrochloric acid in the presentations of:

- 500 milliliter bottle.
- 1 liter bottle.
- 4 liter gallon.

The process for the packaging of hydrochloric acid, in its different presentations currently consists of 7 stages as shown in Figure 1, which are performed manually, without having clear and adequate facilities for production. The parts used in the process are not manufactured, all are purchased and arrive at the company of suppliers from different cities. The sales market is mainly carried out in the Tehuacán region and the distribution of the products is carried out by the members of the company.

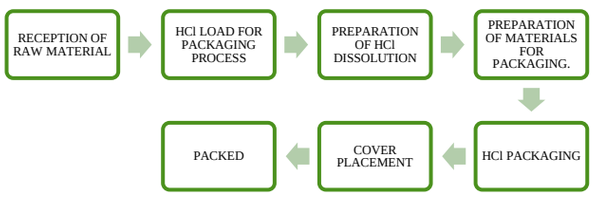

Figure 1 Diagram of the current production process

- Reception of raw material: this process begins with the admission of hydrochloric acid which is received by a worker, this makes the connection of hoses and the manual filling of storage tanks.
- Preparation of HCl: at this point the worker loads the hydrochloric acid to casks, then move them to the production area, for the preparation of the solution.
- Preparation of the HCl solution: the worker adds distilled water to the tanks, dye and mix until the desired characteristics are obtained.
- Preparation of the material to start packaging: the operator places the tools for packaging such as the hoses, keys and tools for production.
- HCl packaging: the operator starts the continuous filling of a batch of bottles, which are arranged on the floor of the work area, the operator performs the sitting operation and filling is done manually.
- Cap placement: the operator goes to the warehouse through the lid bag, returns to its area for the placement of bottle caps, the operation is performed manually.
- Packaging: for the packaging of hydrochloric acid, the operator goes to the warehouse through the package of boxes, the boxes are armed by the worker and then the bottles are packed. After packing and closing the boxes, the operator estiva boxes and takes them to the warehouse of finished product.

The materials involved in the different parts of the process are the following:

- Hydrochloric Acid (HCl) in concentration from 28 ° to 30 °.
- Bottle of: 500 milliliters, 1 liter and 4 liters.
- Bottle cap: 500 milliliters, 1 liter and 4 liters.
- Carton box.
- Tags.

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- Yellow Pigment.
- Paste tape.

The preparation of the solution is carried out in the company's facilities, in which hydrochloric acid, distilled water and pigment are added, this solution is carried out in a two hundred liter tambo and as all operations are performed manually. The bottles used for packaging carry a label, with the brand, the name of the product and necessary information, the activity of placing the label on the different bottle presentations is carried out externally:

- External operation: Manual labeling to bottle.

Both operators and managers perform various functions in the company according to its needs, such as: receipt of raw materials, purchases of raw materials, preparation of raw materials, packaging, packaging, loading and unloading of products, sales and administration . The company does not have established processes, in this case the operator with more experience teaches new workers the steps to perform for the filling of bottles since there are no manuals of the process in the company, this brings with it that there is ignorance and doubts about the different activities and the correct way to do them, with the risk that the possible errors entail. Both managers and workers are not clear about the departments that exist in the company, since in the existing areas there are multiple activities, the current facilities of the members of the company only recognize that they have a production area and warehouse of raw material. No worker or manager has received information or training on the management of hydrochloric acid. Recommendations have been received from the supplier regarding the handling of the material, but mainly knowledge about this substance has been obtained over the years, with the daily handling of the product. The high command of the company does not have a clear concept of what a personal protection equipment is and the importance of this, there is a lack of knowledge and little culture on this issue, in addition to the fact that the company provides few elements of personal protection to its workers, the lack of regulations in the company contributes to the operator not using these elements and in the same way the non-application of regulations.

90% of workers consider that they carry out activities that put them at risk, such as the reception of hydrochloric acid, the loading of acid for the packaging process and as such the exposure to this substance, in the interviews we can notice that workers have a concept, although not very deep, of what labor safety means, since for them it is that they have no accidents in carrying out their activities; for this they indicate that the occurrence of accidents is very low, they have had cases of skin irritation, spills on their clothes, splashes in the eyes or spills on the floor, however they do not consider them risky. The managers consider that the treatment of their workers is in a respectful, fair and accessible way, as they seek to provide a pleasant working environment, as well as make them participate in the success of the company for which a positive communication with them is important. They recognize that the tasks and responsibilities of the company are not clear and are unknown to some, due to the lack of organization, the lack of assignment of responsibilities and the lack of an organization chart in the company. They are aware of the danger posed by the operator's exposure to hydrochloric acid, so they seek to improve the company's infrastructure, to offer a better workspace, to have growth and to be a successful company in the region. At the moment the high command of the company, looks for governmental supports for the expansion of his company, with a proposal that guarantees so much the increase of his productive capacity as the labor security. From the analysis of the current problem, the main factors involved in the process were identified and the cause-effect diagram shown in Figure 2 was designed, such as: material, labor, movements, facilities and work tools.

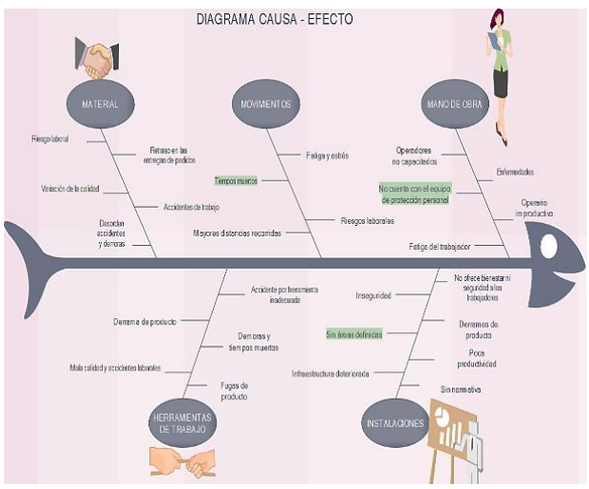

Figure 2 Cause-effect diagram of the current production process

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Of the various problems presented in the company, a histogram was shown, which is shown in figure 3, where it is identified that the origins of the majority lie in the damaged infrastructure that can cause an accident, the lack of defined areas that generate disorder and operations unproductive, as well as the lack of standards applied in the company that result in the lack of guarantee in the worker's safety. Given this situation and taking into account compliance with the Official Mexican Standards (NOM) (table 1) it is proposed to the company:

- Design of the hydrochloric acid warehouse.
- Design of the hydrochloric acid discharge lines.
- Design of a mechanism to capture gases in the hydrochloric acid storage area.
- Proposal for hydrochloric acid storage tanks and use tools for the production process.
- Proposal of personal protective equipment.

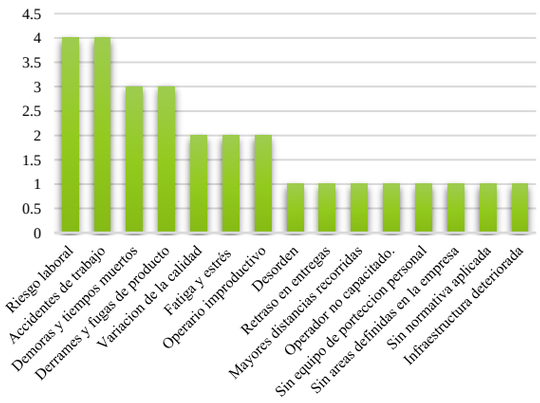

Figure 3 Results Histogram

Of the 42 existing NOMs, 12 are on occupational safety, 8 health, 9 product; 6 of organization and 7 for specific activities.

Official Mexican Standards			
Classification		Denomination	Publication in the Official Gazette of the Federation
SECURITY	NOM-001-STPS-2008	Buildings, premises, facilities and areas in the workplace - Safety conditions	24/11/2008
	NOM-002-STPS-2010	Safety conditions - Prevention and protection against fire in the workplace	09/12/2010
	NOM-004-STPS-1999	Protection systems and safety devices in machinery and equipment used in workplaces	31/05/1999
	NOM-005-STPS-1998	Concerning health and safety conditions in workplaces for the handling, transport and storage of hazardous chemicals With modification project 03/24/2017	02/02/1999
	NOM-006-STPS-2014	Material handling and storage - Occupational health and safety conditions	11/09/2014
	NOM-009-STPS-2011	Safety conditions for performing work at height	06/05/2011
	NOM-020-STPS-2011	Pressure vessels, cryogenic vessels and steam generators or boilers - Operation - Safety Conditions With modification agreement 03/24/2017	27/12/2011
	NOM-022-STPS-2015	Static electricity in the workplace - Safety and hygiene conditions	01/04/2016
	NOM-027-STPS-2008	Welding and cutting activities - Safety and hygiene conditions	07/11/2008
	NOM-029-STPS-2011	Maintenance of electrical installations in work centers - Safety conditions	29/12/2011
	NOM-033-STPS-2015	Safety conditions for work in confined spaces	31/08/2015
	NOM-034-STPS-2016	Safety conditions for access and development of activities of workers with disabilities in the workplace	20/07/2016

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HEALTH	NOM-010-STPS-2014	Chemical agents polluting the work environment - Recognition, evaluation and control	28/04/2014
	NOM-011-STPS-2001	Safety and hygiene conditions in workplaces where noise is generated	17/04/2002
	NOM-012-STPS-2012	Health and safety conditions in workplaces where sources of ionizing radiation are handled	31/10/2012
	NOM-013-STPS-1993	Relating to the safety and hygiene conditions in workplaces where non-ionizing electromagnetic radiation is generated	06/12/1993
	NOM-014-STPS-2000	Occupational exposure to abnormal environmental pressures - Safety and hygiene conditions	10/04/2000
	NOM-015-STPS-2001	High or low thermal conditions - Safety and hygiene conditions	14/06/2002
	NOM-024-STPS-2001	Vibrations - Safety and hygiene conditions in the workplace	11/01/2002
	NOM-025-STPS-2008	Lighting conditions in work centers Modified on 08/20/2015	30/12/2008
PRODUCT	NOM-100-STPS-1994	Safety- fire extinguishers based on dry chemical powder with contained pressure - Specifications	08/01/1996
	NOM-101-STPS-1994	Safety - Chemical foam based fire extinguishers	08/01/1996
	NOM-102-STPS-1994	Safety - Fire extinguishers based on carbon dioxide. Part 1: Container	10/01/1996
	NOM-103-STPS-1994	Safety - Water-based fire extinguishers with contained pressure	10/01/1996
	NOM-104-STPS-2001	Extinguishing agents - Dry chemical powder type ABC based on mono ammonium phosphate	17/04/2002
	NOM-106-STPS-1994	Safety- Extinguishing agents - dry chemical powder type BC, based on sodium bicarbonate	11/01/1996
	NOM-113-STPS-2009	Safety - Personal protective equipment - Protective footwear - Classification, specifications and test methods It was modified on 12/24/2010	16/12/2009
	NOM-115-STPS-2009	Safety in personal protective equipment, protective helmets, classification, specifications and test methods It was modified on 12/24/2010 and 6/7/2013	22/12/2009
	NOM-116-STPS-2009	Safety - Personal protective equipment respirators negative pressure air purifiers against harmful particles - Specifications and test methods It was modified on 12/24/2010	22/12/2009

Table 1 NOM summary of work safety, health and product

From the proposed departments an analysis of the relationship between them is shown in Figure 4, the criteria to rate the intensity of relationship are based on the need and importance of the proximity between departments.

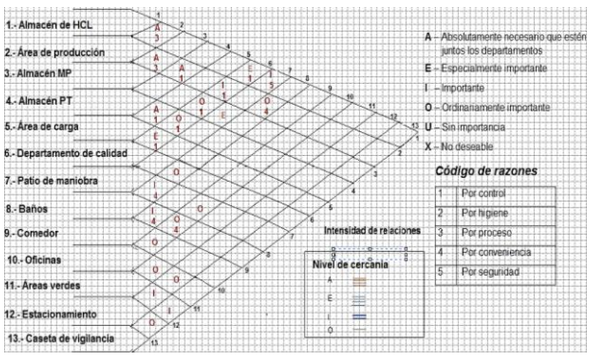

Figure 4 Department Relationship Analysis

The proposed plant distribution that complies with the regulations and consequently guarantees occupational safety is shown in Figure 5.

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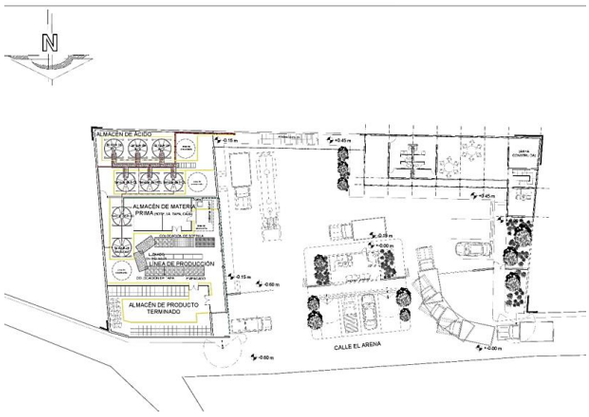

Figure 5 Distribution plant

A good distribution should be complemented with adequate training on occupational safety and the use of personal protective equipment (epp) as they are:

- Mask for inorganic vapors.
- Neoprene gloves or long cane rubber.
- Wide vision and safety glasses.
- Personal protective clothing for corrosive chemicals.

Conclusions

Workers who are in direct contact with hazardous substances have the right to work in safe and healthy working conditions, they must also be duly informed, trained and protected. Given the risks involved in working with hydrochloric acid, it is necessary to emphasize the importance of occupational safety and the needs of any company, including SMEs, to implement these measures. Work spaces must be safe and protect workers, since the work is essential for life, development and personal satisfaction, but in some cases the performance of work activities represents a risk to the health of the worker and even for the environment in general. The obtaining of primary data allowed to obtain a diagnosis of the current state of the company and to know how to work, to know more about the process and aspects of worker safety. The proposal of the new warehouse generates important changes throughout the process, in addition to reducing the contact of the worker with hydrochloric acid, the collection of gases decreases the leakage of particles of the substance in the environment

The proposed process allows the elimination of 50% of unnecessary activities, in addition to improving the flow of materials and operators, and reducing the risk of accidents. For the design of the plant, aspects of flow were considered mainly, in order to facilitate movements and improve logistics within the company, observing the applicable regulations. The application of the results will increase worker safety, improve organizational aspects in the company and implicitly improve production aspects.

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