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SURVEY ON CORROSION MANAGEMENT IN SELECTED INDUSTRIES IN GHANA

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ABSTRACT

Effective corrosion management is achieved by understanding the forms and types of corrosion in a specific environment before prescribing cost competitive control or preventive measures. Good corrosion management practices can significantly reduce maintenance cost, lower the risk of unexpected failure, extend the periods between inspections, reduce operational and maintenance cost and prolong the lifespan of equipment This paper reports on a survey of the state of corrosion control and prevention practices in randomly selected thirty (30) industries in the Accra-Tema Metropolitan area of Ghana. The industries selected were in the categories of food and drink, metal and metallurgical, chemical and textile, transport and vehicle assembling plants. Marine and the various industrial atmospheres were the major causes of the corrosion. The two predominant forms of corrosion were general attack (uniform corrosion) and pitting-a localized corrosion. Engineering design and material selection were the main corrosion preventive methods adopted whilst the preferred curative method was coating. Cathodic protection was the anticorrosive method least practiced. Cost of corrosion of the companies ranges from 0.1-25% per annum of the total maintenance cost. From this survey it is estimated that the cost of corrosion and corrosion management of Industries in Ghana is a multi-million cedi business.

Keywords: Corrosion management, Industry, Metal, Environment, Coating

1. INTRODUCTION

Corrosion prevention and control is an important field technologically, economically and strategically as one considers development of any country with particular emphasis on restructuring, rehabilitation and revamping of the Industrial Sector.

Significant amount of material (metal) is allowed to corrode away daily because of lack of adequate protection, resulting in loss of billions of cedis. However, a fair percentage of the amount could be saved when the forms or types of corrosion are studied, and the possible causes and solution in a specific environment are given.

According to Fontana (1987), corrosion is the destruction or deterioration of materials (especially metals) because of a reaction with its normal environment. This definition caters for the weathering of timbers and concrete, the leaching of glass and the cracking of plastics. However, metals are still considered to be major materials subjected to corrosion. In this survey report the focus is on metals (e.g. iron/steel, brass/ bronze and Al-alloys). A thorough understanding of the causes, forms and types of corrosion and the items corroding are pre-requisite for the design of an effective anti-corrosion scheme (Bosich, 1970). Moreover, anticorrosion schemes are designed for a specific time period beyond which corrosion could set in. Hence, corrosion cannot be stopped altogether but can be inhibited by application of one or more standard methods (Fontana, 1987).

The standard anti-corrosion techniques could be applied at the initial or later stage of the service life of a piece of metal. In a case where the protection is included at the design stage, it becomes an exercise in corrosion prevention that could be regarded as capital investment. On the other hand, the application of the anticorrosion scheme after corrosion has set in can be referred to as curative (control) and for that matter becomes maintenance or running cost.

Governments, businesses and the private sector in Ghana spend billions of cedis each year on maintenance of structures, equipment and vehicles due to corrosion. Thus, corrosion management is very important especially in a culture where maintenance-culture is taken for granted. The survey was very necessary and important since little had been done on effects of corrosion management in Accra-Tema Metropolitan Area where most of Ghanaian industries operate. Data was collected, analyzed and results discussed to bring out the relevant information on types/forms of corrosion, curative and preventive methods used and cost involved. Some observations are given as well as conclusions and recommendations.

2. MATERIALS AND METHODS

In this survey, a total of thirty-six (36) random sampled industries in Accra-Tema Metropolitan Area of Ghana were selected. Thirty (30) responded to our questionnaires (see appendix for sample questionnaire) and field visits. The categories and number of respondents are:

- Food and Drinks Processing Industries (FDI) 7
- Metal-Metallurgical Industries (MMI) 6
- Chemical and Textiles Industries (CTI) 4

- Transport and Vehicles Assembly Plants (TVI) 6
- Other Services (OS) 7

The field visits to the premises of all the respondent industries aimed, among other things, at obtaining information on: Items corroding, Possible causes of corrosion, Methods of corrosion control and prevention, and Cost of corrosion as a percentage of the total maintenance budget

3. RESULTS

The results of the survey are summarized as follows:
Eighty-six percent (86%) of those surveyed in the food and drink industries practiced engineering design whilst 100% of the respondents in the rest of the industries used engineering design method of corrosion prevention. Material selection is practiced by all thirty industries; Coating is applicable in all categories except in "Other Services" category, where eighty-six percent (86%) practiced it as anti-corrosion method.

Forty-three percent (43%) of those in other services industries used insulation whilst all industries surveyed in the food and drink, metal and metallurgical, chemical and textiles, transport and vehicle assembling used insulation; Twenty-nine percent (29%) in the food and drink and eighteen percent (18%) in the metal and metallurgical industries practice environmental treatment (control). All others do not use this method. Only one out of the thirty industries selected for this survey used cathodic protection.

3.1 Food and Drinks Industries

In the food and drinks industries pasteurizes, heat exchangers, boilers, refrigerators, water treatment plants, condenser/evaporators, cookers/dryers, and soldering machine are the major equipment which undergo corrosion. Most of the equipment were made of mild steel, galvanized and stainless steels. Corrosion of the aforementioned materials, were attributed to the high corrosiveness of ammonia, carbon dioxide, soap solution and sodium chloride as well as the mains pipe-water and marine environment.

Some structures including pipelines, bolt & nuts and rails made of mild steel, cast iron, galvanized steel, brass and aluminum were corroded. The marine environment (salt spray), process stream and heat generated and dissipated in some plants contributed to the high corrosion of the structures.

Products corroding also included packaging materials. These materials were made of mild steel plated with tin. The possible causes of corrosive attack were due to acidity, alkalinity and salty nature of the food. Other items observed to have corroded included door fittings, trucks and tractor-trailers. These items were made of mild steel. Corrosion was attributed to general environmental pollution and effluents.

3.2 Metal-Metallurgical Industries

The metal-metallurgical industries experienced corrosion on their electronic component supports, furnace and electrolyzers made from brass, mild steel and refractory linings. Possible causes of the corrosive attack were attributed to the process stream and marine atmosphere. Structures including column/beams, trusses made of mild and galvanized steel and aluminum were also corroding. The causes of corrosion were attributed to industrial atmospheres; exhaust gases, chloride/fluoride fumes, moisture and heat.

Other items/equipment including nails, surface tanks, full-sided trailer, all made from mild steel were also corroding during the survey. The possible causes of corrosion were attributed to the marine atmosphere (high moisture, humid atmosphere and high daytime temperatures).

3.3 Chemical & Textiles Industries

The equipment under attack included reels, weaving, knitting, processing and printing machines and boilers. The equipment were made of materials ranging from mild and galvanized steel to cast iron. The possible causes were attributed to inadequate protective coating, process chemicals; fumes emitted during bleaching and dyeing and smoke from boiler exhaust. Pipelines, made of mild steel, were leaking process streams, waste and chemicals.

3.4 Transport and Vehicle Assembly Plants

At the transport and vehicle assembly plants, equipment and parts such as vehicle bodies, copula furnace, lathe machine and spare parts, headlamp adjuster, slide slip tester were corroding. These were mainly made from mild steel and cast iron. Causes of corrosion were attributed to industrial and marine atmospheres, moisture, poor storage facilities and improper surface preparation before coating.

Structures such as vehicle bodies, structural columns, beam, window frames, rails, and door hinges made from mild steel, aluminum and galvanized steel were observed to have corroded. The causes of corrosion in these cases were attributed to industrial pollution (exhaust gases from nearby plants), moisture, and lack of maintenance.

3.5 Other Services

In this sector, corrosion affected equipment such as cranes, engine blocks, tipper bucket, chassis, grinders, pumps, glue applicator and rollers. These were made of mild, galvanized and stainless steel and cast iron. The possible causes of the attack were attributed to the marine atmosphere (salt spray) and process stream due to the acidic or alkaline mature of fluid and lack of maintenance of equipment. There were structures such as con-

veyors, pipes, and lock gates corroding. These items were made of mild steel and cast iron. The main cause of attack was the marine atmosphere.

4. DISCUSSION

4.1 Anti-corrosion Schemes used in the Selected Industries

From the results of the survey, it was observed that items corroding included structures, equipment, machinery, products and canned finished products. The causes of corrosion in most cases were attributed to attack of various environment; e.g. marine, industrial atmosphere, moisture and polluted soils. In all these cases, the major preventive and curative methods applied or practiced were engineering design, material selection and coating. However, other methods such as insulation, environmental treatment, cathodic and anodic protection could have been considered.

4.2 Engineering Design

Many negative effects of corrosion could have been avoided initially by the introduction and completion of thoughtful design. A case in mind was the absence of vacuum chamber and gas collectors that led to increase in concentration of chloride fumes in an aluminum processing plant. The result was corrosion of sensitive electronic panel and roof trusses and sheets. The drainage systems in the food and drinks industries were so poorly designed that it was common to find pools of water all over the floor. This resulted in some cases serious corrosion of equipment. In addition, some designs did not allow for easy access to all surfaces that might need replacement due to unavoidable corrosion.

4.3 Material Selection

Most of the material selection techniques used in the industries/establishments were solely on the basis of capital investment cost. In one food and drink industry, it could be said that most of the equipment installed over the past 20 years was still in good working conditions. This could be attributed to suitable material selection at the design stage and the consistent periodic maintenance schedule.

Pipelines carrying all types of industrial/plant streams and waste (NH_3, CO_2, steam and water) were affected. This could probably be linked to poor material selection. Dissimilar metals are in some cases joined together without any insulation resulting into severe corrosion. It was observed that fruit juices canned in imported tin plated mild steel containers had dissolution of their lacquer. This could be a possible source of product contamination. Steel beams, aluminum sheets and roof trusses were severely attacked in an Aluminum processing plant due to negligence. As a result, initial material selected for the construction appeared unsuitable. On the other hand, effective maintenance schedule had prolonged the useful service life span of equipment and structures in another Aluminum processing plant.

Products from iron and steel of a metal fabrication plant stood the risk of corrosive attack due to the fabrication methods of cold forming, welding and bending. In this case, stress-concentrated areas in a corrosive environment could lead to sudden failures. Minimizing or applying stress relieving heat treatment to reduce tensile stresses to levels that are not harmful could control this sudden failure.

4.4 Coatings

Coating appears to be universally adopted in all the industries for any corrosion protection, however, it is the most widely abused. Coating failures were associated with the coating itself, application of the coating or the preparation of the surface. Most industries did not follow the manufacturer's specification on the use and purpose of paints. It was erroneously thought that, the more costly a paint/coat, the more effective and suitable the paint/coat would be for the job. A case in mind is a food industry where the painter decided to use nitro-cellulose coat for a job which could be done with an ordinary oil paint which is less expensive but equally effective.

Among the industries covered under the survey it was observed that surface preparation of substrate to be coated was poorly done. This could be due to lack of appropriate equipment, but in most cases it was due to ignorance and negligence on the part of the personnel responsible to instruct, inspect and insist on thorough surface preparation prior to application of coating system. The success of most protective anticorrosion methods, like coatings depend mostly on effective surface preparation, which goes to improve the adhesion of the coating system unto the substrate.

4.5 Environmental Control

The environment includes air, water, hot gases and soil. The treatment of the liquid environment in some industries involves the control of pH by means of chemical dosage. Other industries embarked on water treatment by means of elimination of contaminants by settlements, ion exchange resins, inhibitors and de-aerators. The water supply company employs special backfills for dehumidification of the soil close to their main metallic pipelines so as to eliminate possible microorganisms/bacterial attack.

Generally, the control of the marine, urban and, in some cases, industrial polluted air is not practiced. However, in an aluminum processing plant, scrubbers and special filters are employed to reduce air pollution. In the cases where the industries erected high concrete walls/fences, the intensity of marine influence on the equipment/structures was lower. Sensitive equipment installed in an

air conditioning room was observed to be less attacked by the same environment. Few of the industries/ establishments covered in the survey practised environmental control to reduce pollution and control corrosion.

4.6 Insulation

This method is normally effective when applied alongside other protective methods like coating, cathodic protection and others. However, it requires regular inspection so as to ensure that it does not transfer corrosion to another part of the structure. The choice of an effective insulation material as in the case of coating is still a problem with the industries covered.

4.7 Cathodic Protection

This method of corrosion protection apart from the water company is virtually not practiced by any of the other industries covered. Despite an encouraging result obtained in the past as the major protective method in the Accra-Tema main line, better results could be achieved if regular inspections are carried out to check on the performances and state of the impressed currents, sacrificial anode/cathode and backfills.

4.8 Cost of corrosion as a percentage of maintenance budgets

It was estimated that the percentage cost of corrosion to total maintenance cost in industries covered ranges from 0.1 - 25%(Obiri et al. 1999). The estimates excluded hidden cost that could be the cost of interference with production programs, loss of products, contamination of product and safety. These figures appear high because in most industries surveyed, there were no maintenance schedules. Consequently, most maintenance work is carried out only when corrosion has set in. This will definitely require expensive methods to arrest the problems. The cost of protection would have been less if for example appropriate coating systems had been effected according to schedule.

In addition, the high cost could be linked to unnecessary coating schedules code-named in some industries as "general rehabilitation" or "painting", which involved painting of buildings, structures and equipment yearly irrespective of the fact that some equipment might need only cleaning or washing regularly. In most industries, the accounting system was such that it did not show a separate entry for cost on corrosion thereby making the estimation of percentage cost on corrosion to total maintenance quite difficult. For example, in an Aluminum plant with severe corrosion problems the figure 0.05% appears to be an underestimation.

In the southern sector of Ghana where marine influence is so high, corrosion cost should be given serious consideration. In a brewery with the figure 12% per annum, it was observed that inspite of such relatively high cost, it was more effective to maintain the plant at that rate than to build a new one. The plant is over 40 years old.

4.9 Observations

During the survey a number of corrosion protection problems were identified to be basically technical, economic and human in nature. These were:

1. Lack of qualified personnel at the supervising levels with capacity to supervise corrosion work and attend to details. Consequently, problems go undetected and are ignored or in most cases they are not recognized as typical corrosion problems.
2. Inadequate corrosion protection and monitoring equipment had made personnel play on their hunch instead of on thorough analysis of possible causes after assessing the problem.

The budget for total maintenance was inadequate and as such the allowance towards corrosion control and prevention was grossly inadequate.

5. CONCLUSION

From the survey results and discussion we can draw the following conclusions:

- Almost all the industries covered experienced two major attacks; uniform and localized corrosion on equipment, structures and products.
- The main causes of corrosion were due to the marine and various process streams in the industries concerned.
- Engineering design, material selection and coating were identified as the dominant anti-corrosion method in use.
- Cathodic protection is the least anti-corrosion method in use in the survey.

6. RECOMMENDATIONS

The survey team would like to make some recommendations especially to those institutions covered.

- There is the need to cultivate the corrosion protection culture (c.f maintenance culture) in industries/ establishments through dissemination of information, workshops and seminars.
- Protective/industrial coatings manufactured in Ghana or import need to be standardized and classified to aid their selection
- There is the need to monitor corrosion in selected local industries to serve as baseline data

- Corrosion prevention should begin right on the drawing board-i.e. by engineering design
- The accounting system should provide adequate funds for corrosion management.

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REFERENCES

H.A. Obiri and P.D. Dzamboe (1999), Corrosion Prevention and Control in Ghana - A Survey Report, CSIR-IRI report, Dec 1990, revised August, 1999

Joseph Bosich (1970), Corrosion Prevention for Practicing Engineers,

Mars **G (1989).** Corrosion Engineering, Fontana

APPENDIX-Questionnaire

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Survey on corrosion Prevention and Control

1). Have you in a way detected or noted any corrosion (rust, wear or other (specify) in your industry/ establishment?
Yes or **No:** If yes underline whichever item is appropriate
i) Equipment ii) structures iii) products iv) Other (please specify)

2).

Item No.	Item corroding (eg equipment, structures etc)	Possible causes of corrosion	Materials used in construction	Operating Temperature (°C) Min & Max	Type of process/ operation

3. Name other specific causes of corrosion in your establishment (e.g. chemical, pH, impurities,other(specify)
.....
.....
.....

4. Is there a maintenance section at your industry/ establishment, Yes or No?

5. If yes, does it undertake the prevention and control of corrosion? Yes or No?

6. If yes to question above, then state method(s) applied

Item No.	Item corroding	Method of corrosion control & Prevention	Remarks

7. What are the principal products and /or services offered? (e.g canned fish, wax prints, water, other (specify)
.....
.....

8. Have you experienced plant shutdowns due to corrosion of equipment/structures Yes or No?
.....
.....

9. Have you experienced products contamination due to corrosion, Yes or No ?.....

10. What is the cost estimate due to corrosion prevention at your establishment/industry per annum e.g. cost due to method of prevention? Local currency component; Foreign currency component

11. What is the percentage cost of corrosion to total maintenance cost of your establishment/industry?
.....
.....

12. Name and address of establishment
.....
.....
.....

Signed:.....

Officer-In-Charge