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CORROSION PROTECTION IN CHEMICAL PLANTS AND OTHER INDUSTRIAL INSTALLATIONS

CUBA

United Nations Development Programme

CORROSION PROTECTION IN CHEMICAL PLANTS AND OTHER INDUSTRIAL INSTALLATIONS

DP/CUB/74/002

CUBA

Technical report: Corrosion protection

Prepared for the Government of Cuba
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of R. Shirazi, expert in corrosion protection

United Nations Industrial Development Organization
Vienna, 1976

Explanatory notes

Reference to "tons" indicates metric tons.

Reference to "dollars" ($) indicates United States dollars.

A full stop (.) is used to indicate decimals.

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SUMMARY

The present report, "Corrosion Protection in Chemical Plants and Other Industrial Installations" (DP/CUB/74/002), was prepared after observation of conditions at a number of plants in Cuba. During the visits the expert was able to carry out detailed investigations and hold discussions with staff working on corrosion prevention. Detailed reports were prepared by the expert and sent to the plants by the Cuban Chemical Research Centre. The project on which the expert was working served as a basis for starting corrosion protection work and for planning research into corrosion. A surface preparation and painting standard drawn up by the expert will be adopted by Cuba; other standards and material will be sent to the plants concerned. There is now an awareness of the considerable corrosion occurring in plants in Cuba, and it is being combated. In the larger plants positions have been created for corrosion protection engineers. Staff will be trained in the correct use of tools and methods recommended by the expert. A sand-blasting section is being set up in the Chemical Research Centre with the expert's help, and plant personnel will be invited to undergo on-the-job training in sand blasting. A three-man trouble-shooting team is being trained to visit plants, taking with them the necessary equipment, and deal with corrosion problems on the spot.

INTRODUCTION

Atmospheric conditions in Cuba are such that corrosion of plant and transport facilities is a major problem. In chemical plants the situation is even more serious, and corrosion causes considerable economic losses. The country therefore needs the technical capacity to deal with corrosion, and trained staff to carry out anti-corrosion work and research into corrosion and its prevention. A department of corrosion prevention in the Chemical Research Centre of the Ministry of Basic Industry has been working on corrosion since 1970. The United Nations Development Programme (UNDP) is running a project in Cuba aimed at increasing the country's technical potential to handle corrosion problems: the present report is one of several produced during the project. The purpose of the mission on which the report is based was to help develop an awareness of corrosion. The mission was originally to have lasted five months, but was subsequently split: the first part lasted from September 1975 to December 1975; the second part will be completed at the end of 1976. The executing agency for the whole project is the United Nations Industrial Development Organization (UNIDO).

I. RECOMMENDATIONS

An analysis of the study "Corrosion Protection in Chemical Plants and Other Industrial Installations" (DP/CUB/74/002) and the visit to the plants, and a review of the facilities available at the plants and the Chemical Investigation Centre have led to the following recommendations:

1. All corrosion departments in the plants should be expanded to meet present in-plant needs. They should be provided with properly trained personnel and skilled painters, and correct equipment for execution and testing.

2. The department of corrosion protection at the Chemical Investigation Centre should undertake to train plant personnel (see annex I) and should be expanded to give more consultancy services to a larger number of factories. Visits should be made at least three times a year.

3. The Code of Practice for Painting of Ferrous Metals should be adopted and forwarded to the corrosion departments in the plants; this matter should receive top priority.1/

4. The testing site at Varadero should be developed, possibly with assistance from UNIDO for equipment (see annex II).

5. Sand-blasting equipment should be made to specifications; the compressor should be received and connected, and the department should be started.

6. For the effective operation of the laboratories at the Centre it is necessary to air condition at least two rooms containing analytical and measuring equipment. Two 1½ ton air conditioners would suffice. The total cost would be about $ 1.200.

7. The implementation of recommendations 1-6 should be reviewed at the end of 1976, and the scholarships should continue.

1/ A copy of a draft code is on file with the United Nations Industrial Development Organization and may be referred to after de-restriction by the Government of Cuba.

II. THE DEPARTMENT OF CORROSION PROTECTION OF THE CHEMICAL RESEARCH CENTRE

The department began its work early in 1971 with a nucleus of trained staff. Since then it has grown by 300 per cent. Its functions, which should be developed further, are as follows:

(a) To expose treated and untreated metal specimens in various atmospheres, and in working environments for assessment;

(b) To determine the effects of processing and chemical variations on the corrosion resistance of metals;

(c) To consult and advise on corrosion prevention and control at industrial installations;

(d) To make the results of investigations more meaningful by producing written reports;

(e) To develop an exposure station (see annex II);

(f) To advise on surface preparation methods and degrees of finish in surface preparation;

(g) To draft standards for protective coatings;

(h) To conduct training courses for chemical engineers and graduates, and to hold courses for technicians and skilled painters from national, industrial and educational bodies.

UNIDO could be asked to provide assistance in the form of additional equipment to facilitate studies and research. The department has working relations with the corrosion units at Cuba's three universities and with other research centres in the country. Visits and discussions could be arranged during the project.

III. FINDINGS

The long-range objective of the mission was to establish a technical capacity able to cope with corrosion protection problems in chemical plants and other industrial installations. The main activities were conducted along with 12 staff members of the department of corrosion, which helped train them to do the work independently. All visits to the plants were made with staff of the Chemical Research Centre who can now make (in 1976) independent visits for consultancy and write recommendations and reports.

The corrosion department personnel of all the plants visited have adequate theoretical know-how, and are very keenly interested. They are well qualified in their field of work, but need to know the practical aspects of painting. It is not the departments that are to blame, however, since in 90 % of the plants not many able and skilled painters are available. In some plants adequate tools and equipment were available but were not being used because certain parts were not functioning. There was sand-blasting equipment in most plants, for example, but it was out of order and very old. The expert forwarded drawings and specifications of new equipment which has all the safety values and is eight times more efficient. It was also recommended that photographs and charts should be sent to plants for their corrosion departments for better quality control.

The attitude of plant directors and governmental bodies to the recommendations was encouraging.

At the Chemical Research Centre there are good technical personnel who took an active part in the project activities and assimilated the training to continue the programme.

The following factories received reports prepared by the expert and requested a second visit for further consultations:

Fertiliser plant at Cienfuegos. This is one of the new fertiliser plants designed and built by Simon Carves. It was completed in 1972 and put into operation in 1973. The plant employs 2 corrosion engineers and a crew of 12 painters, which is totally insufficient for coping with all the protection required. The corrosion department is well established and doing good work, but needs more skilled painters. The corrosion protection equipment in the factory is old and should be replaced with the equipment, of which models were handed over to the department at Cienfuegos.

Owing to the wrong specifications of paints applied originally by the builders, corrosion has commenced in many areas, but is being corrected with assistance from, the collaboration of and research by the Chemical Research Centre, which has been associated with this plant since 1973, and the corrosion department of the fertilizer plant.

Recommendations were worked out and sent to the factory after a detailed inspection and discussions with all concerned.

Cuba Nitro fertilizer plant of Matanzas. This is the oldest fertilizer plant in Cuba and is heavily corroded in some areas because of insufficient maintenance.

Because of the shortage of skilled painters, workers in other trades are recruited from the plant during shutdowns to do painting. The performance of the newly painted surfaces in the plant was poor, because the quality of surface preparation and correct methods of application are not known by the other trades.

The condition of the structural steel and light steel sections was bad, owing to the heavy fall-out of chemicals. Studies of the panels exposed by the Chemical Research Centre, which has collaborated with Cuba Nitro since March 1973, showed better performance than field applications of the same coatings, which indicates that the personnel doing the work need training. The department of corrosion at this plant should do this by sending representatives to the Chemical Research Centre for two months, to study equipment and methods of protection using organic coatings and metal spray protectives.

One of the most important recommendations made was that the cooling tower woodwork should be dip coated in copper naphthenate solution and overcoated with creosote to minimize the risk of decay.

Another recommendation was that the concrete floors (area 20' x 20') in the bagging area should be covered with a mixture of hard bitumen (18 % - melting point 175°-230°C), ground acid resisting filler (20 %), fine asbestos fibre (7 %), and river quars sand (55 %) as a sample to be studied (see annex III).

Rayonera rayon plant at Matanzas. The Chemical Research Centre has been associated with the plant only since May 1975, but should continue the association in order to produce results. Because of several leakages at the sulphuric acid plant the environment is contaminated with sulphur dioxide which causes heavy corrosion. Faults in the structural design were pointed out by the expert; no structural parts which are being replaced should be installed without adequate surface protection before erection.

Detailed recommendations were made with a proposal for sending personnel from the plant to the Chemical Research Centre for training.

Tecnica Cubana pulp and paper plant at Cardenas. This plant has no specific problems. The old conveyor is being replaced; the Chemical Research Centre, which has been collaborating with this plant since June 1975, should suspend painted panels for study near the new conveyor at the base of the high section at ground level.

The Chemical Research Centre is also to provide a paint thickness tester to the corrosion department for checking the thickness of paint films being applied.

The main problem at the plant was the open-air bagasse storage floor, which should be correctly compacted with a sheeps-foot roller, graded to a 2 % slope and treated with a bituminous sand coating (see annex III).

Electro Quimica chemical plant at Sagua. Although this plant has the strongest corrosive atmosphere, it is rather well protected against corrosion and is an example of good organization of maintenance work. The corrosive atmosphere at the plant is the strongest in Cuba; the corrosion department has a mammoth task on its hands and is doing an immense amount of work to ensure proper maintenance. All the paint products which are being used for coatings are locally manufactured in Cuba, and this indicates that, in spite of severe atmospheres, correct surface preparation is being carried out. This is one of the few plants with a good paint maintenance shop and correct over-all supervision of surface applications. Although it looks undermaintained, no effort is being spared to maintain constant production.

The technical personnel consists of two engineers well acquainted with their work; the Chemical Research Centre has been associated with the investigation of the corrosion problems here since January 1975. Photographs of grades of rusting and the ISO pictorial corrosion book will be forwarded to this plant.

A special recommendation was made at this plant for the repair work to the reinforced concrete floors by the cementation method and the addition of chemicals to accelerate the setting and hardening of the grout without interrupting the normal operations of the plant (see annex IV).

Detailed recommendations were worked out and sent to the plant.

IV. CONCLUSIONS

The high cost of replacing metal that has been destroyed by corrosion makes it imperative that those who are responsible for the maintenance of metal structures and equipment, and those who design the metal structure which must be protected, should be thoroughly familiar with the factors that contribute to the satisfactory performance of an applied coating and the factors that impair the integrity of the coating and facilitate the destruction of the metal under the paint film. Selection of the right coating formula does not automatically solve the protection problem. To make sure that the paint will provide as nearly perfect a protection as possible, the metal surface to be coated must be properly prepared and the paint must be correctly applied. Subsequently, for adequate maintenance, the coating must be inspected at regular intervals and must be efficiently repaired.

Protection against corrosion was considered an art in the past: in the light of modern knowledge, it is a science. Painting for corrosion protection should not be considered a necessary evil; it should be considered as an integral step in the process of manufacture of metal structures and equipment.

As a result of the visits and the observations made, the expert concluded that it is essential that the capacities of paint plants be increased to meet local needs without additional imports, and that a quantity of chemical-resistant (e.g. epoxy and vinyl) paints be produced after thorough research and development. At present, such paints have been formulated and tested at the Chemical Research Centre and are especially being used on metal surfaces for protection against corrosive atmospheres.

Corrosion departments with trained engineers exist in the various plants but there is general under-maintenance everywhere owing to lack of skilled painters and lack of standardization in surface preparation methods.

The cost of surface preparation may run from 40 % to 80 % of the total painting cost. The most practical way to reduce painting costs is to keep surface preparation costs as a non-recurring item by selecting paints that deteriorate slowly.

Annex I

THE PAINTER IN INDUSTRY

In many countries the starting wages for an industrial painter are higher than those of an ordinary labourer; a skilled painter may earn as much as an automobile mechanic or, in industry, a shop mechanic. The expert feels that it is quite wrong to classify a skilled painter as "common labour". A skilled painter must know how to treat such diverse surfaces as steel, cast iron, other metals, wood, concrete and the like, he must know what tools to select and how to use them, and he must have a thorough knowledge of the paints or other coatings appropriate to the job to be done. On his work depends to a large extent the life of the structures he paints. The need for fully qualified personnel is obvious in view of the complexity and number of modern protective coatings and the number of operations involved in doing a satisfactory painting job.

Paint has three principal functions:

(a) It preserves the surface and thereby prevents vast economic losses due to corrosion;

(b) It helps to reduce industrial hazards by identifying (by colour) sources of danger or useful facilities in plants or by acting as a fire-retardant or sweat-reducing agent;

(c) It provides colour and helps to make surroundings more pleasing and restful, thereby reducing fatigue and increasing efficiency.

The work of the painter is therefore a contribution to production; painting is probably the greatest single item of the cost of maintaining most steel structures. In Cuba there is a great disparity between the wages of skilled painters and the wages of other categories of skilled workers. Painters should be paid more and receive better training if they are to find professional dignity in their work. More painters should be trained. The Government would benefit from the resulting reduction in maintenance costs. The Chemical Research Centre could encourage a trade school, perhaps in the form of an apprentice shop, to which the various industries could send painters for training. It is, after all, easier to improve a painter's skills than to replace parts of a poorly maintained plant.

Annex II

THE VARADERO TROPICAL MARINE EXPOSURE STATION

The protective value of organic or metallic coatings is evaluated by visual observations and by physical and electrical tests on coated specimens that have been exposed for some time to natural weathering conditions (climatic conditions). It is general practice to subject a newly developed coating to exposure testing after laboratory tests have been completed. It is therefore very important to maintain an exposure station on a selected site in Cuba and to ascertain and evaluate the best conditions for running test programmes on organic and metallic coatings.

The choice of site should be governed by the following considerations:

(a) The exposure station should be located at a point approximately 50 metres from the ocean shore;

(b) The station should be placed in an east-west direction so that the prevailing easterly/east-north-east wind blows through the station, to obtain the same conditions throughout the station;

(c) The station should face south and the sea should be on the south side to receive the reflection of the sun and deposits of salt crystals on the front of the panels;

(d) A meteorological station or post should be located sufficiently close to the exposure station to supply all data required;

(e) The station should be located not too far from the Chemical Research Centre in Havana.

The best location for this station, according to expert climatic and geographical studies, is the tip of the peninsula at Varadero, which is ideally suited for intensive research because of the following basic factors:

(a) The pure tropical-sea climate with full radiation from the sun and full re-emission of heat during the night;

(b) The influence of land, town or mountains is negligible;

(c) The wind direction is parallel to the panels and the solar radiation is perpendicular to them;

(d) The difference between air temperature and dewpoint at night is 1.8°–3.5°C throughout the year;

(e) The rains in the Matanzas province are the highest in Cuba (average 1,500 mm obtained from a 40-year study);

(f) The nights are cloudless nearly all year round;

(g) There are no large variations in climatic conditions throughout the year;

(h) There is rich condensation of water due to the extensive re-emission of heat;

(i) A constant tropical marine climatic condition prevails throughout the year.

The destructiveness of this climate is directly related to the controlled temperature and humidity resulting from the moisture of the air and sea-fog. This condition maintains the protective film throughout the year at a uniform high stress, close to the threshold of breakdown. Although a certain level of solar energy is necessary in atmospheric aging, the essential elemente are moisture and condensed water.

In order to set up the station the expert recommends the following:

(a) The site should be correctly selected and fenced off;

(b) The racks should be mounted;

(c) Meteorological instruments should be supplied to measure:

- (i) Radiation energy;
- (ii) Condensed water amount;
- (iii) Wind direction;
- (iv) Maximum and minimum temperatures;
- (v) Relative humidity/dew point;
- (vi) The deficit of saturation in mm of pressure-drop of humidity to the condensation point;
- (vii) Salinity.

Annex III

BITUMINOUS PROTECTIVE ASPHALTS

Bituminous acid-resistant mortars consist of two components: bitumen and a filler. Ground quartz, asbestos, glass fibre, river quartz sand, and ground or crushed hard limestone can be used as the filler. The grain size distribution of the filler is of decisive importance. Different mixtures are used for isolating protective layers and for laying and pointing. The properties of the mixtures can be adapted to requirements.

Mortars to be used for pointing or for bedding bricks should be spread well in a 2 to 3 mm thick layer at a temperature of about 200°C. At 20°C they should have a minimum compressive strength of 30 kg/cm^2, i.e. they should be stiffer and more rigid than the material used for isolating protective layers. This can be achieved by using a coarser grained aggregate (filler) and by reducing the amount of bitumen.

The materials for lining the surfaces of sewers, basins, and the like, should be even stiffer. This can be achieved by sprinkling finely ground quartz flour through a sieve into the material during heating. If desired for strength the steam blown bitumens of grade 85/125 or 90/15 can be employed and the bitumen content can be reduced from 25 % to as low as 18 %.

Acid-resistant bituminous mortar, which has found most widespread application both as bedding and pointing mortar, consists of about 25 % bitumen and 75 % quartz flour.

The desirable properties of bitumens to be used as protective coats are:

Softening point 71° to 90°C (soft bitumens), 175° to 230°C (hard bitumens)
Paraffin content less than 2 %
Ash content less than 1.5 %

Solvents: Kerosene, mineral spirits, benzene, etc.

According to a Soviet specification, the bituminous protective coat should be applied with a spray gun as follows:

	% bitumen	% solvent
First layer	20	80
Second layer	45	55
Third layer	80	20

The following composition (figures shown are percentages) could be used for a base-resistant bituminous mortar:

Ingredient	Layer First	Layer Second	Layer Third
Petroleum bitumen	55	45	35
Asbestos (fine fibres)	5	5	9
Ground base-resistant aggregate (e.g. ground hard limestone	40	50	56

Bituminous base-resistant asphalt:

Ingredient	% by weight
Bitumen (softening point 175°-230°C)	18
Crushed, dense limestone, graded 5 to 8 mm	12
Sand, graded 1,5 to 3.00 mm	26
Sand, graded to 1 mm	26
Fine asbestos fibre	18

Bituminous acid-resistant asphalt:

Ingredient	% by weight
Bitumen (softening point 175°-230°C)	28
Ground acid resistant filler (0.15 mm diam.)	20
Fine asbestos fibre	7
River quartz sand	55

Revolving drum boilers heated to no more than 250°C are used for mixing.

Annex IV

TREATMENT OF CONCRETE

Reinforced concrete on the floors, foundations, etc., should be repaired immediately to the following specifications.

A rich mixture (1:2) of powdered silica sand and acid-proof cement should be used after washing the areas to be repaired by hosing with water or steam cleaning and allowing to dry thoroughly (sand graded 1.5 mm to 3.00 mm).

Flat surfaces should incorporate a slope of 1-2 % for drainage.

Repair work presents on many occasions a task appreciably more difficult than the original installation during construction. A further difficulty arises frequently from the desire to carry out repairs within a very short period without interrupting the normal operations of the plant.

Floors exposed to acids may be covered with acid-resistant stone (quartzite, siliceous sand-stone, andesite, bestaunite, granite, etc.), soil, asphalt, a combination of asphalt and concrete, or flooring tiles.

Dense ceramic materials and products are very popular because of their high resistance to corrosion. These materials stand up well to attack by mineral and organic acids (except hydrogen fluoride and silicon tetrafluoride) and bases in low concentrations at low temperatures.

The basic material of corrosion-resistant ceramics is refractory clay. Uniform shrinkage is ensured by the addition of finely ground fireclay, quarts sand and other additives. Ceramic materials show a high degree of wear resistance, are strong and, owing to their good bonding with mortars, are the principal materials of acid-resistant linings.

Such linings are made by embedding one or several layers of ceramic material into cement mortar, water-glass mortar, bituminous mortar, plastic resin mortar or other mortars, using a similar pointing material.

Their field of application is very wide, and there is virtually no field in corrosion control - except where very high temperatures occur - where an acid-resistant lining of ceramic materials could not be applied.

<u>Compaction of concrete</u>

The significance of dense, high-quality concretes having a minimum permeability as an essential prerequisite for corrosion resistance, and the importance of the principles governing their composition are widely known from long practical experience.

The evaluation of the results of long-term experiments has shown that the higher the cement dosage (and thus the density of concrete), the higher the resistance that can be expected.

An appreciable resistance to corrosion can be attained by a carefully composed, properly compacted concrete. Lean concretes having a loose structure deteriorate under exposure even to a mildly agressive medium.

There is complete agreement between the experts that for resistance to aggressive effects concrete must be, first of all, sufficiently dense. Highly compacted cubes of Portland cement concrete suffered only slight damage after water had been permitted to seep through them for 8 years. Test cubes made with aluminous cement showed no sign of corrosion.

The part of concrete which is most susceptible to corrosion is cement stone. Lean concrete mixes (those containing small amounts of cement stone) are thus theoretically most resistant to chemical attack.

According to a publication by V. M. Moskvin, concretes which, when submerged in water for 6 hours, do not absorb more than 5 % to 6 % of water, may be regarded as fairly resistant. Concrete absorbing up to 10 % of water is more susceptible to attack, while with absorption figures higher than 10 % concrete cannot be considered resistant; it may deteriorate, depending on the nature of the exposure, within a few years or even earlier.

Density, and thus the resistance to aggressive media, can be improved by the following measures:

(a) Increasing the cement content;
(b) Use of a suitable grain size distribution;
(c) Use of plastifiers;
(d) Reduction of the water/cement ratio;
(e) Use of water-absorption shuttering;
(f) Repeated compaction;
(g) Mechanical compaction, vibration.

Other methods of protection

Cementation. The resistance to corrosion and the watertightness of concrete, brickwork and masonery walls can be improved in a very reliable manner by cement grouting. This consists essentially of forcing through boreholes thin cement mortar under pressure into the interior of the structure. The pores and cracks of the structure are thus filled with grout, which, after setting, imparts to the structure monolithic properties. In order to accelerate the setting and hardening of the grout, calcium chloride (in a quantity not exceeding 7 % by weight of cement) may be added. It is obviously of advantage to use more or less sulphate-resistant cement grouts. Where there are cracks of appreciable width, 25 % of hydrated lime may be added, and 2 % to 3 % by weight of casein cement as plasticiser. The grout consistency depends on the size of the cavities and fissures and can be determined only by field trials.

The protection of the foundations and flooring of a plant is very important and proper attention should be given to it. Concrete is commonly used as a construction material and under ordinary conditions protects the reinforced steel.

The steel rods should be adequately covered everywhere, with a depth of cover of about 3 to 4 inches. A layer of impervious coatings around the concrete structure gives good results. A thin coating of cement slurry containing 10 % sodium benzoate helps. If the economics allow, suitable organic (silicone, alkyd, neoprene, urethane, epoxy, coal-tar epoxy, bituminous emulsion, coal tar, asphalt, chlorinated rubber, etc.) or inorganic coatings can be used.

Corrosion of reinforcement in nitric acid plants due to the seepage of nitric acid into the soil can be controlled temporarily if required by digging pits around the area and neutralising the acid with lime.

Kiln-fired clay bricks, or slabs covered by ASTM specification No. C279 could be used.

Suphur mortars containing inert carbon or silica filler have been successfully used in masonry linings, sewer trenches, floors of chemical plants, and elsewhere, as they are relatively cheap and have a good range of chemical resistance, especially towards oxidizing acids.

<u>Silicone films</u>. Silicone films can bridge minor cracks in structures and are good sealants (except against water under hydrostatic pressure) against vapour and moisture, as long as the movements and settlements of the foundation remain small. Silicones are highly water-repellant (hydrophobic) substances which dry rapidly. Water-soluble sodium methyl siliconate can be added directly to concrete or mortar mix. Depending on the required density of concrete, solutions of 2 % to 20 % concentration are used. Methyl silicone oils are not only hydrophobic, but are also inert to most acids. They are thus unaffected by diluted aqueous solutions of mineral acids, hydrochloric acid, nitric acid, and phosphoric acid. Concentrated sulphuric acid and phosphoric acid in small quantities tend to raise the viscosity of the oil which is, however, depolymerized and eventually totally dissolved by larger quantities. Under extended exposure silicone oil is oxidized by concentrated nitric acid, while the viscosity of the oil is reduced after a certain period by dry hydrochloric acid gas. Silicone oils are not affected by liquid ammonia, aqueous solutions of ammonium hydroxide, phenol, molten sulphur, sulphur dioxide, fatty acids, etc.

Surfaces treated with silicone resins dissolved in solvents must be perfectly dry. When using water based silicones (silicone emulsions) the surfaces may be damp (moist) but not wet. Surfaces such as brickwork, tile, rendered concrete, asbestos cement, natural stone, or ceramic materials become perfectly hydrophobic in 3 to 14 days depending on weather conditions.

Silicone coatings require no maintenance. Repair consists of the application of a complete new coating, as discontinuities in a silicone coating, or spots where the hydrophobic effect has ceased to exist, are impossible to detect. Silicones available on the market withstand temperatures from +320° to -80°C without changes in their physical properties.

The following should be remembered during silicone applications:

(a) Highly porous or cracked surfaces should be repaired and smoothed before silicone treatment, which must not be started until the repaired spots have been permitted to dry completely;

(b) Old brickwork surfaces should be cleaned before the silicone is applied. Efflorescences of nitrates and mildew should be scraped off, wider cracks and fissures should be closed, and dusty surfaces should be cleaned with compressed air;

(c) Previous applications of other hydrophobic organic substances, unless all traces are carefully removed, reduce the efficiency of the silicone treatment;

(d) Gypsum, which has a high water absorbing capacity, must be lacquered before the application of the silicone coating;

(e) Surfaces treated with silicone should, as far as possible, be protected against violent rainfall and solar radiation during the period of setting, i.e. a few days;

(f) Care should be taken to avoid direct contact between silicone solutions and the human skin and eyes.

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