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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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SUPPLEMENTARY ASSISTANCE IN THE ESTABLISHMENT OF A LABORATORY AND PILOT PLANT FOR PROTECTIVE COATINGS

[illegible]/CUB/75/002

CUBA

Technical report:
TEMPORARY CORROSION PROTECTION

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

United Nations Industrial Development Organization

[illegible]

United Nations Development Programme

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Technical report: Temporary 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 Jerzy M. Zawadsky, expert in
temporary corrosion protection

United Nations Industrial Development Organisation
Vienna, 1976

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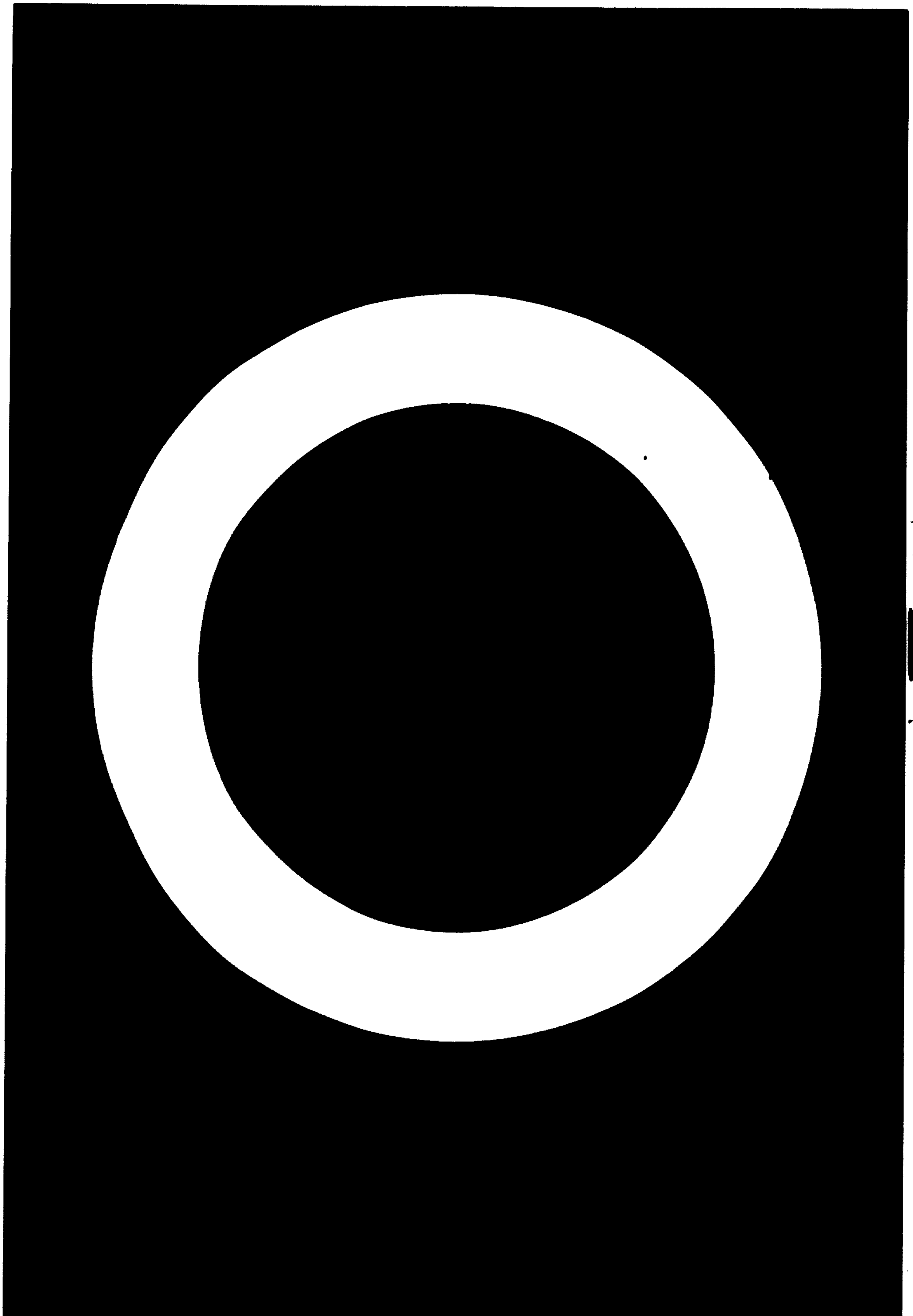
SUMMARY

As part of the technical assistance in the corrosion protection of metals being provided at the request of the Government of Cuba by the United Nations Development Programme (UNDP) in project IS/CUB/75/002, "Supplementary Assistance in the Establishment of a Laboratory and Pilot Plant for Protective Coatings", the United Nations Industrial Development Organization (UNIDO) sent an expert in temporary corrosion protection to the Centro de Investigaciones Químicas (CIQ) in Havana, Cuba. The expert, who spent three months of the autumn of 1975 there as a consultant, confirmed that the tropical-marine environment of Cuba, which features high concentrations of moisture and salt in the air, is conducive to rapid and severe corrosion of metal goods used and stored there. Metal goods are also subject to highly corrosive conditions during the long sea journeys required to bring them to the island. During use, storage or transport, metal articles must be protected by temporary coatings - paint, metal, oil, wax - of a type appropriate for the article and conditions of exposure. Specific recommendations for these coatings are given in this report. Waxes suitable for temporary corrosion protection can, and should, be obtained as a by-product of Cuban sugar production, from sugar-cane press cake. Research on the utilization of sugar-cane wax for corrosion protection and other purposes and the testing of coatings of all types should be undertaken by the Centro de Investigaciones Químicas. The programme of work should include the establishment of an exposure test station at Varadero.



INTRODUCTION

Technical assistance in the field of corrosion protection of metals was originally a constituent part of the United Nations Development Programme (UNDP) project DP/CUB/72/005 entitled "Assistance in the Establishment of a Laboratory and Pilot Plant for Protective Coatings", begun in 1973, for which the United Nations Industrial Development Organization (UNIDO) was the executing agency. In April 1975, the expert component of that project was removed and placed in a UNDP Special Industrial Services project IS/CUB/75/002. On of the four experts provided by this project, an expert in temporary corrosion protection, arrived at the Centro de Investigaciones Químicas (CIQ), Havana, in September 1975 and spent three months there as a consultant. This report gives his findings and recommendations.

Temporary corrosion protection is a necessity in Cuba because of the hot and humid climate, the salinity of the air in coastal areas and the resultant corrosivity of human hands. These factors would otherwise cause severe corrosion of all metallic items imported into Cuba. Corrosion increases maintenance costs and causes delays in the erection of steel structures and installation of equipment. Limited durability of machined parts and automobile bodies is also a consequence of improper corrosion protection of machinery and new automobiles.

The objectives of the expert's work plan were as follows:

Organization of preliminary experiments and tests and consultation at CIQ

Preparation of a glossary of corrosion terms in English, Spanish and Russian

Climatic analysis, using official data of the World Meteorological Organization, the Observatorio Meteorológico, Havana, and the University of Santiago de Cuba

Prevention of supply to Cuba (by sea) of corroded raw materials, steel structures and machinery (contact with Comercio Exterior, CUBAMETALES, and TRANSIMPORT)

Establishment of temporary corrosion protection laboratory and testing sites

Elaboration of suitable samples of temporary protectives from Cuban sugar-cane wax (contact with Ministry of Sugar Industry (MINAZ))

Protection of motor vehicles during use

The results from the execution of this work plan and the recommendations based on them are summarized in chapter I. The remaining chapters of this report consider several of the items listed above in greater detail.

In association with this project, a technician of CIQ was trained in Poland for two months in techniques of temporary corrosion protection.

When the expert arrived in late 1975, no facilities for realizing practical temporary corrosion protection methods existed in CIQ. In fact no protectives had ever been prepared. In other words, the project had to start from the beginning. It should be mentioned in this connexion, that in the original DP project, only 5% ($1,200) of the funds budgeted for equipment had been provided for temporary corrosion protection equipment.

I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Findings

Technical terminology of and information about corrosion

A glossary of about 90 corrosion terms in English and Russian was prepared by the expert and used by CIQ to prepare a Spanish version. The expert left a collection of informative documents, standards and books about corrosion protection at CIQ.

Analysis of the Cuban climate and its corrosive aspects (chapter II)

As a preliminary to estimating the corrosion agressivity of the Cuban climate, meteorological data for Havana and Santiago de Cuba based on 40 years of records were analysed. The analysis showed that Cuba is a very corrosive region, and Havana may be compared to Colombo, Rangoon and Chittagong in agressivity of climate.

Protection of imported metal goods (chapter III)

General discussions were held with officials at TRANSIMPORT and CUBAMETALES (Comercio Exterior) about suitable means for preventing the delivery to Cuba of metal goods corroded during sea transport. Warehouses and storage places in Havana and Santiago de Cuba ports were visited. Considerable corrosion of steel and machinery that had been stored outdoors was observed. Suitable recommendations for suppliers were elaborated for CUBAMETALES and other Cuban enterprises. The problem of the protection of automobiles in use was also considered and recommendations made.

Utilization of sugar-cane wax for temporary corrosion protection (chapter IV)

General discussions were held with the Ministry for Sugar Industry (MINAZ) concerning sugar-cane wax production in Cuba and the possibilities of using sugar-cane wax for corrosion protection. According to MINAZ, crude sugar-cane wax was at one time produced in Cuba and shipped to the United States of America for refining. Although those operations ceased in 1962, the wax-recovery installation still exists and could easily be put into operation again.

Meanwhile, there is the possibility of obtaining samples of fresh mud filter-cake (cachaza) from sugar factories in December and January. This material contains 15-20% crude sugar-cane wax and could be used for research at CIQ, which would be a continuation of work started there five years ago.

Testing of protective coatings

A condensation table was installed at CIQ and a new tropical testing procedure called the condensation table/horizontal plate method was started. It is now possible to elaborate new Cuban temporary corrosion protectives after estimating their effectiveness by this method.

With the help of another UNIDO expert (B. Shirazi), a meteorological and geographical analysis was made to find a suitable site in Cuba for an exposure test station. The details will be found in Chapter V.

Organization of preliminary experiments at CIQ

The work of three chemists at CIQ on temporary corrosion protection was supervised by the expert. Only a preliminary programme of experiments could be prepared because of lack of time. Two projects were started:

Elaboration of temporary corrosion protective compounds for cars based on the sugar-cane hard-wax fraction (chapter IV)

Comparison of the corrosion agressivity of the hands of workers in Cuba and Poland (chapter VI)

Recommendations

1. Sugar-cane wax refining processes should be elaborated in a new, small pilot plant at CIQ and in the old plant at Chaparra by 1977. The research on wax refining begun five years ago should be resumed. Import of acetone for semi-refining should be approved only for the CIQ pilot plant (semirefination), because it may become possible to use other solvents (e.g. alcohols). Suitable hydrocarbon fractions from reforming processes should be prepared in Cuba at petroleum refineries.

2. Laboratory-scale programmes for the utilization of sugar-cane wax fractions from the Chaparra plant that may be suitable for other branches of industry should be started in different Cuban research institutions or, if started, expanded.

3. Free samples of crude wax, the oil fraction, hard wax and resin should be made available for potential users so that requirements of the world market can be estimated.

4. The recommendations contained in chapter III should be prepared in the form of instructions for temporary corrosion protection of imported metal goods and supplied to all Cuban enterprises that import such items from Europe. The requirements should be made part of shipping agreements for the benefit of the Cuban partner. Similar recommendations should be elaborated by CIQ for Japan-to-Cuba transport conditions.

5. A tropical-marine exposure test station with facilities available for Cuban and foreign factories and research centres should be located in 1976 at Varadero. No progress in development of organic and metallic coatings is possible if they are not tested at exposure sites in controlled conditions. International co-operation in building test stations would be a stimulating factor for CIQ and the Cuban paint industry.

6. Spraying equipment for temporary protection of automobiles (3 complete units) should be installed in 1976, with outside technical assistance. Domestic sugar-cane wax preparations, as well as imported products, should be employed.

II. THE CUBAN CLIMATE AND ITS CORROSIVE ASPECTS

This chapter is intended to give the information about the Cuban climate that is needed before an intelligent choice can be made of materials and measures to protect against the corrosive effects of that climate. Some data is presented in tables 1-5 (source: Observ. Nat. bolet. meteor. y climat. (V)I, No. 2, 1965).

Sea water

The ability of sea water to corrode metal is well known. Metal objects are subjected to its attack when they are transported on open decks of ships and loaded or unloaded in ports, especially in bad weather. The corrosivity of sea water is particularly high in the tropics, where alternate splashing and drying maintains a high salt concentration on exposed surfaces. The salt water may also become trapped in crevices or holes in metal equipment and on the outside and inside of packing cases. Machined metal surfaces or raw steel (sheet, pipe, rod) can be seriously damaged in only two days' exposure.

On the sea journey from Europe to Cuba, which lasts 20-40 days, only transport below deck in covered holds gives any guarantee of non-corrosive conditions. Transport on open decks always risks corrosion, even when protective materials are used, since the materials may be damaged and rendered ineffective by careless handling.

In coastal areas, streets and highways are splashed by sea water at certain times of the year and during storms. The resulting high concentration of salt rapidly corrodes the vehicles operated in those areas. Prevailing east or east-north-east winds bring sea fog from the Atlantic Ocean, filling the air with salt-containing particles. These cause heavy losses by the corrosion of metal structures and metal goods transported or stored in the open.

Rain

With its humid, tropical climate, Cuba experiences frequent, heavy rains (see tables 1 and 5). Because of the high humidity at night (table 2), evaporation of rain water is quite slow. Several hours after a rain, the streets may still be covered with puddles, through which vehicles must splash. The presence of water keeps the dew point high (table 2). During the day, however, particularly if the sun comes out after the rain, the relative humidity drops rapidly as the rain water evaporates.

In terms of amount and number of rainy days a month, precipitation in Cuba is comparable to that of Calcutta (India) or Colombo (Sri Lanka) in the monsoon season. However, in Cuba the rain comes at irregular intervals and falls mostly in afternoon storms in a pronounced rainy season (May to October). There can be as much as 60 mm of precipitation in one day.

Rain water falling on wooden cases can leak into them and collect in holes and crevices of any steel structures and machines they may contain. The water evaporates quite slowly from such places, leading to deterioration of the packing material and corrosion of the metal articles.

Humidity

The average diurnal variation of relative humidity over the year above and below the critical value of 80% is shown in figure I. The average number of hours per day during which the relative humidity is at or above this value in Havana varies from 10 in spring to 15 in autumn (table 4).

On the average, the dew point is in the range 21°-25°C in summer and 17°-19°C in winter (table 3). Therefore, to avoid condensation, all metal articles unloaded in Cuban ports should be kept warmer than 19°C in winter and 25°C in summer. Metal goods loaded into ships in Europe in the winter will not warm up sufficiently during the journey to Cuba to avoid strong condensation unless holds are heated. In summer, it is practically impossible to avoid condensation, and the goods must be protected against its effects.

Since nights in Cuba are cloudless nearly the year round, good conditions for thermal re-radiation of heat exist, causing lowering of metal temperature below the dew point. The difference between air temperature and dew point is only 1.8°-3.5°C from May to October and 2.5°-3.5°C from November to April. Condensation is accordingly intense, and it can be assumed that water will cover goods stored outdoors for 4-10 hours every night. Sealed cardboard packages, tight plastic covers and water-tight wooden tops lined with terne-plate or galvanized sheet are recommended to protect such goods.

Table 1. Values of climatic variables at Havana in the period 1926–1965

Month	Air temperature (°C)		Average relative humidity (%)		Precipitation (mm)		Number of rainy days	
	Average daily high	Highest recorded	0800	2000	Average	Maximum recorded	Average	Maximum
Jan.	26.1	32.5	85	79	60.7	451.9	6	15
Feb.	26.8	33.0	83	77	41.4	126.7	5	12
Mar.	27.8	33.8	82	77	47.8	146.9	5	13
Apr.	28.9	34.5	79	77	50.2	145.0	5	12
May	29.7	34.9	80	80	102.3	424.1	8	20
June	30.5	34.6	83	83	145.6	424.1	11	19
July	31.2	33.9	83	83	101.6	192.7	10	18
Aug.	31.5	35.3	85	83	108.4	294.8	11	18
Sept.	31.0	35.5	86	85	149.2	367.2	14	22
Oct.	29.1	34.4	84	83	180.5	668.3	13	22
Nov.	27.3	33.2	83	81	80.6	419.7	9	15
Dec.	26.3	33.0	83	80	51.8	152.6	6	13

Table 2. Diurnal variation of temperature and humidity at Havana
Average values for the period 1926-1965

Hour	Air temperature (°C)		Relative humidity (%)		Dew point (°C)	
	Jan.	Aug.	Jan.	Aug.	Jan.	Aug.
0200	19.9	25.1	85	90	17.3	23.3
0400	19.6	24.7	86	90	17.2	22.9
0600	19.4	24.4	86	91	17.0	22.9
0800	19.8	26.9	85	85	17.2	24.2
1000	23.0	29.7	73	71	17.9	23.9
1200	24.9	30.3	64	70	17.6	24.4
1400	24.7	29.8	65	72	17.5	24.2
1600	24.0	28.9	69	75	18.0	24.0
1800	22.5	27.8	77	79	18.2	23.9
2000	21.6	26.7	79	83	17.7	23.6
2200	21.0	26.1	81	86	17.7	23.6
2400	20.4	25.6	83	87	17.4	23.3

Table 3. Annual variation of temperature and humidity at Havana
Average values for the period 1926-1965

Month	Air temperature (°C)		Relative humidity (%)		Dew point (°C)	
	0600	1200	0600	1200	0600	1200
Jan.	19.4	24.9	86	64	17.0	17.6
Feb.	19.4	25.3	86	62	17.0	17.9
Mar.	20.3	26.6	86	62	17.9	18.5
Apr.	21.4	27.6	86	62	19.0	19.7
May	22.5	28.4	89	67	20.6	21.8
June	23.9	29.3	91	71	22.4	23.6
July	24.2	30.1	91	70	22.7	24.2
Aug.	24.4	30.3	91	70	22.9	24.4
Sept.	24.3	29.8	91	72	22.8	24.1
Oct.	23.4	28.0	89	73	21.5	22.8
Nov.	21.6	26.2	87	69	19.4	20.0
Dec.	19.9	25.0	82	68	16.6	18.7

Table 4. **Duration of periods of high relative humidity (RH)**
Average values for the period 1926-1965

Month	Duration (hours per day)	
	RH ≥ 80%	RH ≥ 90%
January	12	–
February	10	–
March	10	–
April	10	–
May	12	–
June	14	2
July	14	4
August	14	4
September	15	2
October	15	–
November	[illegible]	–
December	13	–

Table 5. **Monthly precipitation in the provinces of Cuba**
Average values for the period 1926-1965
(mm)

Month	P. del Rio	La Habana	Matanzas	Las Villas	Camagüey	Oriente	Over-all average for Cuba
Jan.	50	45	39	39	27	38	40
Feb.	46	40	32	32	26	33	35
Mar.	54	49	44	43	40	40	45
Apr.	71	74	81	77	82	74	77
May	172	171	204	182	183	159	179
June	228	218	253	217	202	135	209
July	160	174	202	160	141	91	155
Aug.	186	191	209	179	161	113	173
Sept.	206	211	200	203	187	137	191
Oct.	154	164	162	189	177	175	170
Nov.	52	55	48	54	63	96	61
Dec.	39	34	24	29	27	46	33
Total	1,418	1,426	1,498	1,404	1,316	1,137	1,368

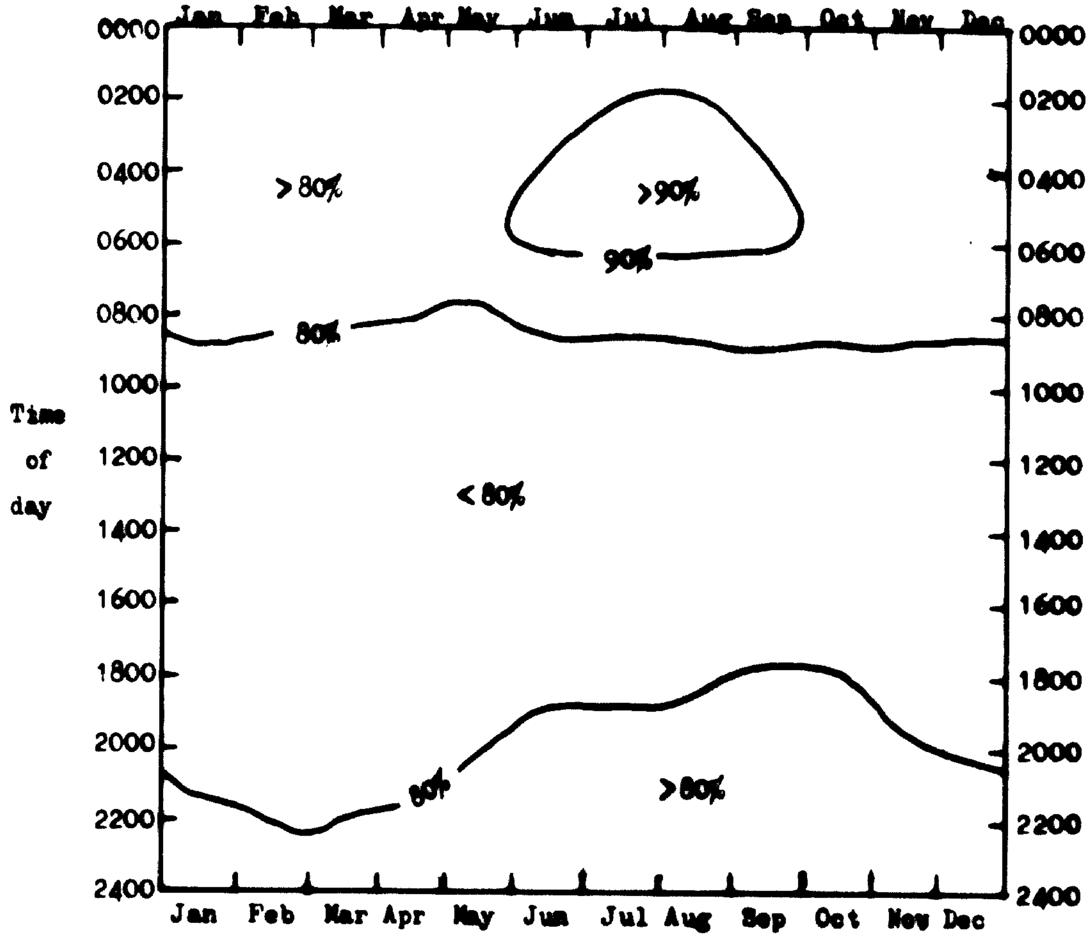


Figure I. Diurnal-annual variation of relative humidity

III. TEMPORARY CORROSION PROTECTION OF GOODS IN TRANSIT, STORAGE AND USE

Protection during transit and storage

Conditions of transport to and storage in Cuba

The methods used to protect goods from corrosion while being transported to or stored in Cuba will depend on the actual transit and storage conditions, e.g., whether goods are subject to the rather severe conditions on open decks of ships or outdoors on land, or to the less severe conditions in holds and warehouses.

During his mission, the expert visited storage depots in Havana and Santiago de Cuba and found that, although storage of items not made of steel and iron was essentially correct, there were certain deficiencies in the way steel and iron goods were being handled: Wooden cases containing machines and equipment were frequently found in damaged condition because they were not strong enough to withstand ordinary handling or were improperly handled. The damage was not repaired; as a consequence, water could enter and corrode the metal items inside. Storage periods in ports and transit warehouses tended to be too long, even for items that had been given good temporary protection. Finally, it was found that construction steel was sometimes stored directly on the ground, without wooden supports and covers.

Recommended protective coatings

Table 6 describes recommended paint and metallic coating systems for steel for different transit and storage conditions. It should be noted that only a few of the shop coatings usually applied to steel girders, channels, chassis, assemblies etc. immediately after manufacture are suitable for protection of such items from corrosion in the conditions contemplated here. Furthermore, primers in general have only a limited durability during sea transport on deck and should be used only when the coated items are to be transported in the hold.

In the system PS, a zinc-rich epoxide primer and a top coat of alkyd, chlorinated rubber or epoxy paint are recommended. Other types of paint can be used if the parties involved in the shipment agree. In no case will bitumen paints be accepted, even in holds.

Table 6. Recommended protective paint and metallic coating systems for steel in conditions of sea transport to and outdoor storage in Cuba

System	Conditions for which recommended			
	Sea transport		Uncovered storage outdoors	
	In hold	On deck	1 mo	1–6 mo
PR Sand clean to grade $2\frac{1}{2}$ a/ One coat alkyd red-lead primer or one coat zinc-rich shop primer when used as welding primer b/	x		x	
PR + U Sand clean to grade $2\frac{1}{2}$ a/ One coat primer One coat undercoat suitable for expected working conditions in use	x			x
SPR (40 µm) Sand clean to grade $2\frac{1}{2}$ a/ Two coats zinc-rich shop primer to a thickness of about 40 µm	x			x
PR + U (60 µm) Sand clean to grade $2\frac{1}{2}$ a/ One coat primer One coat undercoat suitable for expected conditions in use to a minimum thickness of 60 µm		x	x	
PS (120 µm) Sand clean to grade $2\frac{1}{2}$ a/ Complete paint system as specified for tropical working conditions c/; minimum thickness 120 µm		x		x
Zn Hot-dipped or metal-sprayed		x		x

a/ According to Swedish standard SIS 055900, Supplement No. 94793.

b/ Wash primers, other zinc chromate primers and one-coat bitumen paints are not acceptable.

c/ Any system lacking an anti-corrosion primer or using bitumen paint as top coat is not acceptable.

Table 7. Recommended types of temporary corrosion protective coatings

Designation	Description	Recommended applications
TP 1a	Hard, solvent-deposited, thin film ($\leqslant$ 20 μm), wax-based	Hand tools, ploughshares, circular saw blades, knives, simple gauges, chromium-plated articles, trim and accessories, decorative painted surfaces and trim of cars, tractors, lorries and buses, painted surfaces of agricultural machines and tools, painted surfaces of engines and compressors, road machinery, chassis of lorries and buses
TP 1c	Hard, solvent-deposited, thick film (> 100 μm) with water-displacing properties	Crankshafts; large spiral springs; machined flages of painted pipes, vessels, boilers, chemical processing equipment sugar processing machines and equipment, steam generators and coolers; screw threads of large bolts; machined faces of metal-working machines, engines, turbines and generators Important: Paper wrappings or covers are necessary for heavy and extremely heavy exposure conditions of transport and storage a/
TP 2b	Soft, solvent-deposited, thin film (10–50 μm) with water-displacing properties	Hand tools with moving parts, small replacement (spare) parts of cars, assemblies, working parts of all machinery, threaded ends of tubes, machined faces of light assemblies, light-alloy sheetings, rod and bar in bundles, cold-drawn steel pipes in bundles, bright steel wire in coils Note: Paper wrappings are advantageous and sometimes necessary.
TP 6a	Oil film, low (20) or high (50) viscosity	Saws, textile machinery, precision mechanisms and assemblies, instruments, very small spare parts, small ball-bearings, needle bearings, fuel pumps, carburettors, cold-rolled steel sheets in packs, blank steel strips in coils, bright wire in coils, rod and bar in bundles, internal surfaces of gear boxes, gear-box assemblies, back-axle assemblies. Important: Proper packaging is essential when this type of low-viscosity protective is used
TP 7	Strippable hot-dip coat	Small, important or costly spares; sharp-edged tools; surgical instruments; gauges; all small spares when long-term protection under severe conditions is necessary

Source: British Standard BS 1133: Sec.6.

a/ See table 8.

Painted motor vehicles and equipment transported on the deck should be given an additional, temporary protective coat of thin wax (type 1a, see below), applied by spraying.

Table 7 describes recommended types of temporary corrosion protective coatings based on waxes and oils and the kinds of articles for which they are appropriate. The table is based on British Standard BS 1133: Sec.6. Which of these types should be used for different conditions of exposure can be determined from table 8, which classifies transit and storage conditions for Cuba according to standards of the Union of Soviet Socialist Republics (GOST 13168-69, sections 3.1-3.3).

Table 8. Severity of exposure of blank metal surfaces in conditions of transport to and storage in Cuba

Exposure type	Sea-transport (Europe-Cuba): On deck: In cases	Sea-transport (Europe-Cuba): On deck: Not in cases a/	Sea-transport (Europe-Cuba): In hold: In cases	Sea-transport (Europe-Cuba): In hold: Not in cases a/	Storage in Cuba for up to six months: Outdoors	Storage in Cuba for up to six months: Indoors	Severity of exposure b/	Recommended protective coating c/
A				x		x	Normal d/	1a, 1c, 2b, 6a, 7
B			x			x	Normal d/	1a, 1c, 2b, 6a, 7
C			x		x		Medium	1a, 2b
D				x	x		Heavy	1a, 2b, 7
E	x				x		Heavy	1a, 2b, 7
F		x			x		Extremely heavy	Paint, e/ hot-dip Zn, e/ 1c f/

a/ Loose or in crates, bundles or coils.

b/ According to GOST 13768-69.

c/ Explanation of type numbers is in table 7.

d/ Applies to Cuba only; not the same as "light".

e/ As in table 6.

f/ Only in conjunction with waterproof wrappings on machined surfaces.

Whatever protective materials are used should be of high quality and specified by their manufacturers for use in the tropics.

Table 9 gives recommendations for the temporary corrosion protection of prefabricated steel products transported in ship holds.

Protective packaging

Many products must be protected by packaging, as well as by coatings. British Standard 1133 (sections 8 and 9) and the USSR standard GOST 13168-69 (section 3.4) give packaging rules for protection against sea water, high humidity and condensation. (See annex I for a list of applicable standards.) The packaging materials in table 10 are recommended in the absence of a written agreement between shipper and consignee about a specific mode of packaging.

The following important supplemental points can be made:

(a) The moisture content of the wood used for packing cases must be 20% or less. For certain types of precision equipment and instruments the upper limit should be 18%;

(b) Cases should be as small as possible consistent with adequate strength and rigidity to simplify the waterproofing problem;

(c) Wooden cases and crates should be reinforced with metal and bound with straps;

(d) Oak, beech and chestnut should not be used in the construction of wooden cases;

(e) Plywood and insulating board are unacceptable materials for any part of a packing case;

(f) The preferred case is lined with metal on the outside of the top and the inside of the bottom. The metal should be commercial terne-plate gauge 10-30, or hot-dip galvanized sheet, gauge 28, 1.25 oz Zn per 2 sq ft of surface. The metal should be bent by the "single-edge" method ("Scotch style"). The lined top and bottom should be fabricated separately and nailed on with galvanized roofing nails. After nailing, the nail-heads should be sealed with molten wax or a high-melting grease that melts above 65^{0} C;

(g) Clusters of 3/4-in. drainage holes should be bored through the bottoms of cases, especially if spare or dis-assembled parts are placed in the bottom;

Table 9. Temporary corrosion protection of prefabricated steel products while in transit from Europe to Cuba in ship holds

Product	Protection a/	Packaging
Hot-rolled angles, channels, bars, flats and rods	None; paint or metal coatings only when specified	Unwrapped bundles up to 2 t
Hot-rolled sheets	None; shop-primer on sand-blasted steel only when specified	Unwrapped metal-sheet packaging up to 2 t
Hot-rolled plates	None	Unwrapped bundles or loose
Hot-rolled bars: tool, high-speed and stainless steels	TP 2b; protection of stainless steel by oil or wax solution acceptable	Unwrapped bundles up to 2 t
Cold-rolled sheets	TP 6a	Metal-sheet packages up to 2 t wrapped in reinforced crepe paper cemented with bitumen
Cold-rolled strips in coils	TP 6a	Wooden cases; kraft paper, waxed crepe banding and jute wrappings
Cold-drawn bars: carbon alloy steels	TP 2b	Wooden cases up to 2 t wrapping not essential
Bright wire in coils	TP 2b or TP 6a b/	Wooden cases; kraft paper, waxed crepe banding and jute wrappings
Galvanized wire in coils	None	Waxed crepe banding and jute

Table 9 (continued)

Product	Protection a/	Packaging
Black welded pipe in bundles	None; paint or metal coatings only when specified	None
Welded pipe	Protective oil with lanolin content c/	Wooden cases
Cold-drawn seam-less pipe	Protective oil with lanolin content c/	Wooden cases
Cold-rolled or cold-drawn pipe in bundles	TP 2b	Reinforced crepe paper cemented with bitumen banding
Stainless-steel pipe	None	Wooden cases

a/ See tables 6 and 7.

b/ For welding electrodes, welding wire and wire for electrical purposes use vapour-phase inhibiting (VPI) protective plus paper.

c/ When cleaning of interior surfaces of pipe is not possible or use of mineral oil is not acceptable (pipe for food industry), another type of protective should be selected (vapour-phase inhibiting, lanolin solution).

(h) Inner faces of cases should be lined with waterproof material fastened between panels and frame members;

(i) Reinforced polyethylene film is recommended for enclosing textile machinery, automatic metalworking machines, welding equipment, power generators, engines and steering systems. It is also good for covering stored metal goods and cases containing machinery;

(j) The use of sealed packages made of plastic film or laminated barrier materials and containing desiccant can be considered for sensitive instruments, but only if the supplier takes the risk;

(k) Wax-sealed paperboard boxes are recommended for small parts. The melting point of the sealing wax should be higher than 65°C. Petrolatum-ceresin mixtures are also recommended (GOST 13168-69, supplement 6);

(l) Corrugated fibreboard boxes are not acceptable for packaging unpainted metal articles;

(m) Paper used for wrapping metal articles must not contain more than 0.05% chloride (as NaCl) and 0.25% sulphate (as Na_2SO_4), and the pH of a water extract should be in the range 6.0-8.0;

(n) Paperboard used for packaging metal articles must not contain more than 0.05% chloride (as NaCl) and 0.15% sulphate (as Na_2O_4), and the pH of a water extract should be in the range 5.5-7.5.

<u>Protection during use</u>

Passenger cars imported into Cuba become corroded in only one or two years because of the climatic conditions (chapter II). These cars are generally of unit body-frame construction, which is not durable in such corrosive conditions of service. The problem is quite important because the vehicles, which are imported, are costly. Corrosion can be prevented only by repeated applications at regular intervals of certain temporary protectives. Unfortunately, neither the protectives nor the equipment for applying them exists in Cuba. The names of representative protectives and equipment and their suppliers are given in annex II, together with the recommended application intervals.

Table 10. Recommended packaging materials for metal goods shipped to or stored in Cuba

Material	Substance (g/m^2)	Recommended for
Kraft paper, waxed or laminated with polyethylene film	40–30	Small metal articles protected with oil, wax solution or greases light spares; ball-bearings; tools
Kraft paper, waxed crepe	180–220	Heavy spares and assemblies, heavy roller-bearings, bright steel wire in coils (small gauge), a/ bright steel strips in coils a/
Kraft paper laminated with bitumen, crepe	250–280	Cold-drawn or cold-rolled steel bars and rods in bundles Cold-drawn or cold-rolled steel pipes (small gauge) in bundles a/
Reinforced crepe paper cemented with bitumen	350–400	Cold-rolled steel sheets, cold-drawn or cold-rolled steel pipes (heavy gauge) in bundles a/
Waterproof paper laminated with bitumen or pitch layer	170–190	Lining of wooden cases (terne-plate or galvanized steel sheet should also be used)
Waterproof laminated paperboard	over 150	Small metal articles b/
Reinforced plastic film	variable	Covers for machines in wooden cases and as waterproof shed for metal goods when only outdoor storage is possible

a/ As banding.

b/ As boxes.

IV. UTILIZATION OF SUGAR-CANE WAX FOR TEMPORARY CORROSION PROTECTION

Solutions of sugar-cane wax can be used for temporary protection of blank steel and machinery (e.g., automobiles, lorries, road equipment, agricultural machinery) and as a supplementary protective coating on painted articles, especially in cavities. Emulsions of sugar-cane wax are useful as cleaners and polishes with residual protective properties for decorative chrome-plated trim and household articles and fixtures. In fact, the wax may be used as a substitute for carnauba, beeswax and lanolin, which are now hard to get.

Cuba should consider the production of sugar-cane wax not only for domestic use but also for export. But it is necessary to elaborate suitable recovery, extraction, refining and modification methods to convert the crude wax to a product that can be used for corrosion protection. Preparation methods for protectives and cleaning agents also need to be elaborated for the special purposes of the domestic and export markets.

The amount of Cuban sugar-cane wax available is estimated at 25,000 t/a. About 10% of this can be used for corrosion protection. Recovery from sugar-cane is estimated as 0.3 kg from each ton of sugar-cane or from 9 kg air-dried press cake. The cost of the wax would be $300-$500 per ton, depending on quality.

Australia, India and the United States of America are important producers of sugar-cane wax.1/ Pilot plants have been built in those countries and in China, Pakistan and the Philippines.2/

It is recommended that the present work in CIQ be extended by organizing a research group to conduct laboratory and pilot-plant studies of the dry recovery and utilization of sugar-cane wax for corrosion protection.

1/ Chemical Abstracts 52:766i, 53:4777b, 63:16589g, 67:65739a, 73:26876x, 75:22909d.

2/ Chemical Abstracts 56:10431c, 59:15468a, 62:9337b.

The expert and a CIQ research assistant visited the wax recovery and refining plant at Chaparra, which has been out of operation since 1962, to see if the existing installations can be used to obtain a refined hard wax for corrosion protection. They found that the equipment is suitable for recovery of wax from cachaza (press cake) and for refining using the alcohol method. The electrical equipment appears to be in good order, but some maintenance work will be required before the distillation units and extractors are ready to operate. A quality control laboratory outfitted with new instruments is needed

Annex III contains technical specifications for three types of sugar-cane wax preparations intended for temporary corrosion protection of automobiles.

V. EXPOSURE TEST STATION FOR THE EVALUATION OF PROTECTIVE COATINGS

The durability of a protective coating cannot be determined solely by laboratory tests. Visual observation and physical and electrical testing of coated specimens that have been exposed to natural weathering for a certain period of time must be employed. It is therefore important to choose a site for this testing where conditions representative of a tropical marine climate exist. The site should also meet the following requirements:

(a) It should be located approximately 50 m inland from the ocean shore;

(b) It should be possible to orient the test station east-west, so that the prevailing easterly winds can sweep through the station and provide the same conditions at every point in the station;

(c) The sea should be to the south of the station, and the test panels arranged to face south so that they will receive full sun and maximum exposure to salt crystals from the sea;

(d) Accurate meteorological data for the site should be available;

(e) The test station should be conveniently close to CIQ (Havana).

The UNIDO expert has established that Varadero, which is on the Peninsula de Hicacos 120 km east of Havana, meets the requirements above. Some of its climatic characteristics are:

(a) The difference between air temperature and dew point at night is 1.3-3.5 degrees Celsius all year round;

(b) The nights are cloudless almost all year;

(c) There is heavy dew because of pronounced radiative cooling at night;

(d) The rainfall in the area is the highest in Cuba, averaging 1,500 mm a year;

(e) Land formations and human settlements in the vicinity have a negligible effect on the climate.

Instruments to measure the following meteorological variables will be required at the Varadero site:

Radiant energy

Amount of condensation

Wind direction and speed
Maximum and minimum temperatures
Relative humidity
Dew point
Saturation deficit
Salinity

The establishment of an exposure test station at Varadero would not only insure rigorous testing of and intensive research on coatings for temporary corrosion protection but also provide high-quality studies and observations that would be useful in other branches of tropical research.

VI. SWEAT CORROSION

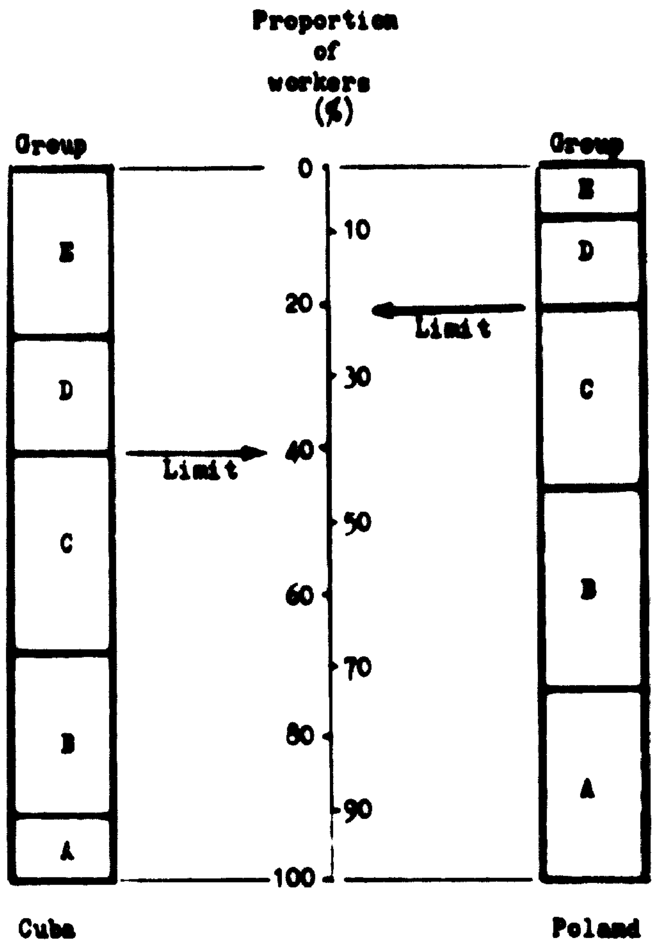
Sweat corrosion is the corrosion of metal surfaces caused by contact with human skin. It markedly increases the deterioration of many metal articles in the course of normal use, such articles as pins, needles, jewellery, watches, tools, instruments - in short, any item in the home, office or vehicle that is frequently handled with bare hands. Since hands are often sweaty in the tropics, the appearance of all metal articles used there is spoiled in a short time; they turn dull, acquire tarnish or become pitted.

Sweat corrosion is also troublesome in many manufacturing, assembly, control and packaging operations, particularly in industries where precision is important, as in optical, electronic and precision machining workshops. A frequent annoyance is to find fingerprints "etched" into the finely machined or polished surface of an item when it is removed from its package.

To some extent, sweat corrosion in use can be minimized by designing articles so that the parts that are handled are made of corrosion-proof material (gold, platinum, stainless steel, plastic) or a material that can be easily cleaned and polished (brass, bronze). In industry, sweat corrosion can be fought by assigning workers whose hands are especially corrosive to other tasks, application of certain chemical preparations to the hands and greater attention to corrosion protection of the metals themselves (increasing protective-coat thickness, using inhibitors and water-displacing additives).

Sweat corrosion is actually an environmental factor that varies from place to place. It depends not only on the climate but also on the physiological characteristics of individuals. Fortunately, the corrosivity of human hands can be tested by a simple electrical method.

Figure II shows the results of tests on the hands of workers doing precision work in Cuba and Poland. Whereas 40% of the Cuban workers fall in the "corrosive" and "extremely corrosive" groups, only 20% of the Polish workers do. The problem of sweat corrosion is obviously much more acute in Cuba and will require careful consideration of preventive measures.



Division into corrosivity groups as follows:

Below limit	Above limit
A Not corrosive	D Corrosive
B Neutral	E Extremely corrosive
C Slightly corrosive	

Figure II. Comparison of corrosivity of hands of workers doing precision work in Cuba and Poland

Annex I

PACKAGING STANDARDS

British Standard 1133

Section 6 (1966). Packaging Code. Temporary protection of metals during transport and storage against corrosion.

Section 7 (1967). Packaging Code. Paper and board wrappers, bags and containers.

Section 8 (1950). Packaging Code. Wooden containers.

Section 19 (1966). Packaging Code. Use of desiccants in packaging.

GOST 13168-69 Moscú 1971

Conservación de los artícules metálicos (incluyendo los equipos de gran envergadura)

Annex II

TEMPORARY CORROSION PROTECTION OF AUTOMOBILES

Application schedule

Annually

Spray a protective such as "Tectyl ML" (Valvoline Oil Company) into hollow sections of the body (doors, girders, box sections, door sills). Amount required: 2 kg per automobile.

Spray a coat of a protective such as "Tectyl Chassis" (Valvoline Oil Company) or "Bitex" (Chema, Warsaw) on the car under-body and chassis. Amount required: 4 kg per automobile.

Monthly

Apply a wax finish to the outer surfaces of the car body and polish. Typical product: "Universal Schutzwachs GLOBO" (GLOBO-Werke, Rudebeul, German Democratic Republic). Amount required: 0.2 kg per automobile.

Application equipment

Hydrodynamic pump (1:20)

Airless sprayer, with fittings suitable for application of coatings to car underbodies and inside hollow sections, such as supplied by Spraying Systems Company (United States).

Annex III

PROTECTIVE COATINGS FOR AUTOMOBILES BASED ON SUGAR-CANE WAX

Three types of temporary protective coatings are used for automobiles:

(1) Hard wax in benzine solution (5-7%), applied on decorative paint and chromium-plated bumpers

(2) Soft wax in benzine solution (15-20%), with anticorrosion additives, for protection of internal surfaces in box sections of body

(3) Wax, resin and bitumen in benzine solution (35-45%) for under-body protection when impact and abrasion resistance are important

(See annex II for information about application of these coatings.)

The wax vehicles for the three types can be obtained by suitable refining and modification of sugar-cane wax and should have the following properties:

(a) For type 1 - hard-wax fraction, hardness 5-7 by ASTM D 1321 penetration test or [illegible]0-[illegible]5 by the Shore Durometer; melting point 70° C; obtained by refining crude sugar-cane wax or melting hard sugar-cane wax with other waxes (candelilla, esparto, ozokerite, microcrystalline paraffin waxes);

(b) For type 2 - soft, semi-refined wax fraction, hardness 15-17 ASTM or 50-60 Shore; obtained by semirefining with acetone;

(c) For type 3 - a melt of bitumen (Cuban, not too soft) with hard and semi-refined wax fractions to obtain a final hardness of 10-15 ASTM or 60-70 Shore; should be readily soluble in a benzine obtained in reforming with these properties: boiling point 140°-1[illegible]0° C, low aromatic content (20%), flash point (AP) 40[illegible] C.

All wax fractions should be prepared by solvent extraction of crude sugar-cane wax to isolate all or part of the oil fraction from the resin fraction (the fraction used in type 1).

In formulation, only type 2 needs corrosion inhibitors, which may be naphthenic acid soaps or zinc tetraoxychromate pigment (1-2% of the dry residue). Viscosities (Ford No. 4) and drying times should be:

Type	Viscosity (sec)	Drying time (min)
1	15-20	10
2	20-25	30
3	100	60

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