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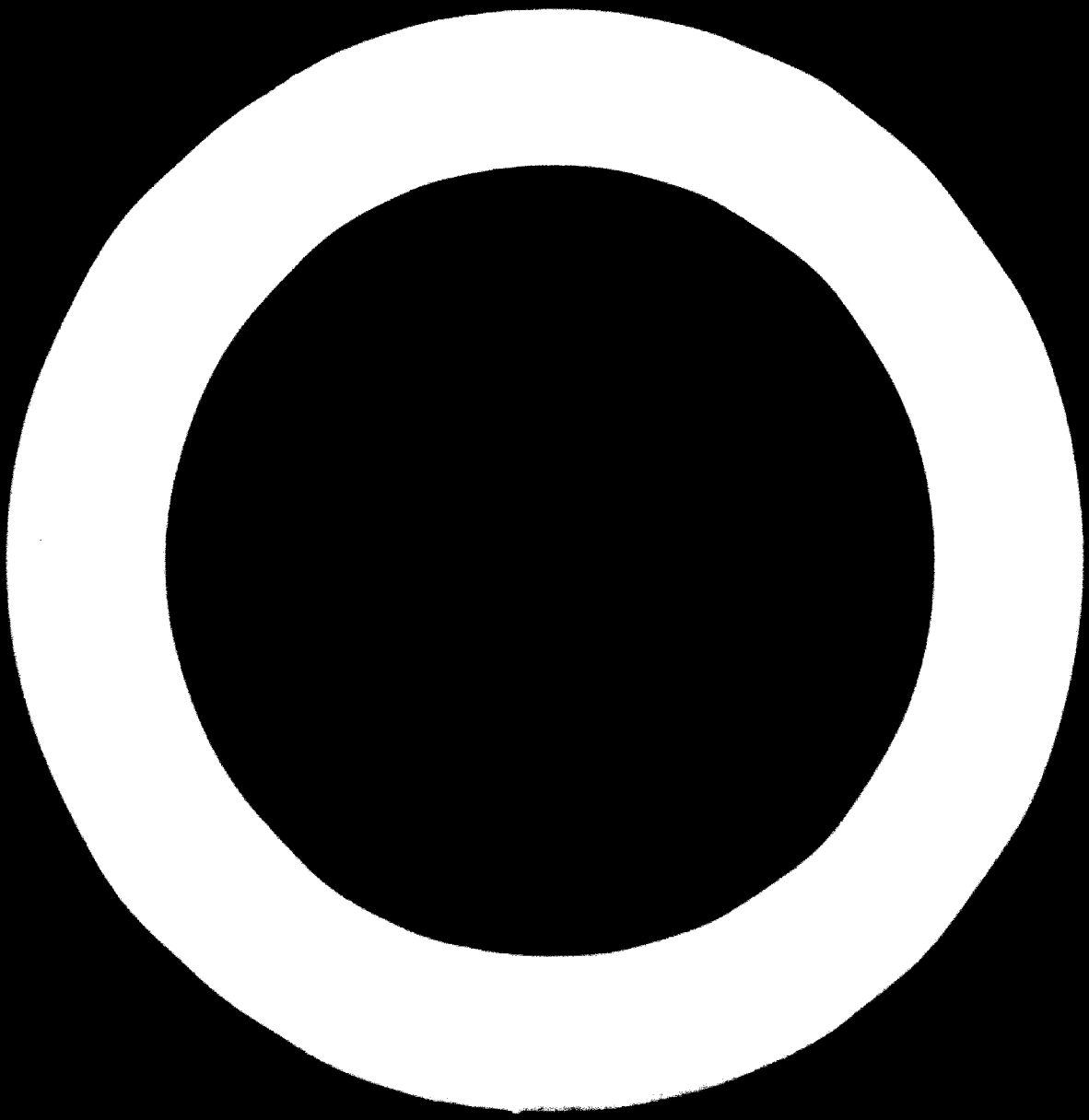

United Nations Development Programme

EXTENSION OF THE POLISH PACKAGING CENTRE

DP/POL/71/517

POLAND

Technical report: Measuring climatic and mechanical hazards occurring during the transport of packed goods

Prepared for the Government of Poland
by the United Nations Industrial Development Organisation,
executing agency for the United Nations Development Programme

Based on the work of Ernst Schmidt, expert in methods of testing climatic and mechanical hazards in the transport of packed goods

United Nations Industrial Development Organization
Vienna, 1975

Explanatory notes

The following abbreviations are used in this report:

PRDC Packaging Research and Development Centre

r.h. relative humidity

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CONTENTS

Chapter		Page
	SUMMARY	4
	INTRODUCTION	5
I.	FINDINGS	6
II.	RECOMMENDATIONS	10

Annexes

I.	Procedure for defining the usable room of the climatic chamber	11
II.	Use of the climatic chamber for preconditioning packing materials and packages for which subsequent mechanical testing procedures must be performed	13
III.	Investigating and testing preservatives against corrosion in connexion with the use of a climatic chamber and other equipment	14
IV.	Use of the climatic chamber for alternating climates	15
V.	Use of the climatic chamber for constant climates	16
A.	Testing packages - above all paper-board cases - with a climate of 25°C and 35% humidity	16
B.	Testing packages - above all plastic containers - with a temperature of +40°C	17
C.	Testing water-vapour permeability of packages with a climate of 20°C and 35% humidity	18
D.	Testing heat-conductivity of a package with a temperature of +40°C, +60°C or -40°C	18
E.	Finding out isotherms for water-vapour sorption and desorption	19

SUMMARY

The assignment of the expert formed a part of the project "Extension of the [illegible] Packaging Centre" (DP/POL/71/012).

The expert returned to Poland on a second mission with the specific purpose of instructing local personnel in the maintenance and use of a climatic chamber designed to test packaging materials subjected to climatic changes during transport. He had been unable to accomplish this part of his assignment on his first mission because the climatic chamber had not yet been delivered.

On the return mission the expert completed an important aspect of the work - to devise a procedure for determining the "usable room" within the chamber. In the course of the work, however, he noted some inconveniences and shortcomings of the chamber. Specifically, the water drain in the interior of the chamber did not work efficiently; the connexions between the chamber and the compressor unit were not supplied by the manufacturer and had to be improvised; the voltage within the chamber was 110 V whereas 220 V would have been preferable in a country where few 110 V spare parts are available; wrenches adapted to the inlet valves were lacking; and instructions for maintenance and repair were needed. Finally, there was no ready-made set of curves to control the temperature and humidity so that these values could be adjusted only provisionally.

INTRODUCTION

This is the report of a second mission undertaken as part of the large-scale project "Extension of the Polish Packaging Centre" (DP/POL/71/517). The parent project was requested by the Government of Poland in November 1971 and approved by the United Nations Development Programme (UNDP) with the United Nations Industrial Development Organization (UNIDO) acting as executing agency. The purpose of the project was to improve the efficiency and capacity of the Polish packaging industry to meet an increasing demand for packaging materials and to reduce the reliance of Polish manufacturers on imports of ready-made packages.

The expert was engaged in order to expand research work in climatic and mechanical hazards occurring during the transportation and storage of packed goods, and specifically to train counterpart staff in the methods of testing the effects of these hazards during transport of goods in containers by sea and air. The expert was attached to the State Council of the Materials Economy at Warsaw and worked in co-operation with the Packaging Research and Development Centre (PRDC).

During his first mission to Poland in 1974 the expert was unable to complete a part of his assignment relating to the operation of a climatic chamber for testing packaging under various climatic conditions because this chamber had not yet been delivered. He therefore recommended in the report (September 1974) of his first mission that he return to Poland for two to three weeks to complete the assignment after delivery of the chamber. The purpose of his second mission, which took place from 3 to 15 September 1975, was to instruct counterpart personnel in the maintenance and use of the climatic chamber. His counterparts were Mrs. Wróblewska and Mrs. Zaremska, who were responsible at the Centre for testing and investigations in the field of climatic conditions.

I. FINDINGS

The expert followed in accordance with the sequence of the [illegible] job description.

- [illegible] the climatic chamber type [illegible] II regarding:

(a) Accuracy of control and of programming the technical and climatic parameters of the chamber;

(b) Uniformity of technical and climatic conditions (temperature, relative humidity (r.h.)) in the working part of the chamber;

(c) Conformity of the performance of the mechanisms and installation as checked against the manufacturer's specifications.

With reference to item 1 (a), in order to programme the climatic parameters of the chamber - relative humidity and temperature - prefabricated plastic curves must be used. As there was no curve that could be used as an example, the wanted values of temperature for the dry and the wet bulb thermometer had to be adjusted and fixed by means of some pieces of wire. It is probable that programming by means of prefabricated curves would be sufficiently accurate, reproduceible and convenient, but it is necessary to have ready-made sets of curves for all possible programmes.

The "accuracy of control" for temperature and humidity must be understood as the width of oscillations of the readings for temperature and humidity. It is possible to make the width of oscillations about 1°C by means of adjusting one or the other input control for heating, cooling, humidifying and dehumidifying. The appropriate positions of input control for the different climates should be noted in order to shorten the time needed for adjusting after each change of climate. Input control must be adjusted by observing the oscillations during 100 per cent input and as a consequence of reductions in input.

The assessment of the accuracy of control could be made only on the basis of observations of an empty chamber and for one climate, because after changing this climate the control for humidity and heating broke down. The other climate could not be tested.

With reference to 1 (b), the "working part" of the chamber is that part of the interior of the chamber that can be used when the variations of the predetermined values are not greater than $\pm 1^{\circ}C$ for temperature and 2 per cent for humidity. This part is defined as the "usable room", according to the German term Nutzraum of DIN 50011 and 50012 (see annex I).

Much time was needed to make all preparations for finding out the usable room. Afterwards, other difficulties arose, so that the procedure for defining the usable room could only be demonstrated. The correct definition of the usable room depends on the accuracy of performing each single step as shown in annex I. However, the distance between the (non-material) walls of the usable room and the inner surfaces of the chamber could be assessed as not more than 30 cm, which is quite sufficient.

With reference to item 1(c), the manufacturer's specifications were not comprehensive enough to overcome certain inconveniences in the installation that were observed by the expert:

(a) The chamber was installed on a ready-made horizontal floor, because there was no other order from the manufacturer. As the sheet of stainless steel in the floor of the chamber had no inclination to the drain hole at the rear side of the chamber, and the vertical walls of the chamber were brought into a vertical position on a horizontal floor, condensed water could not be drained completely by the drain hole. The mechanic of the manufacturer indicated that the chamber should be raised some millimetres at the front side. The expert felt, however, that it would then be difficult to open the door;

(b) The varnished sheet near the window in the door of the chamber was already considerably corroded;

(c) The manufacturer did not indicate that a voltage of 110 V should be used in the electrical system. It should have been specified for 220 V since some spare parts for 110 V, e.g. incandescent lamps, are generally difficult to get in Poland;

(d) The connexions between the compressor unit and a box containing the starters for the different units of the chamber were not delivered by the manufacturer and had to be improvised by means of some wires;

(e) A set of wrenches for the nuts, which were manufactured to correspond with the inch system, were needed; in Poland these tools correspond to the metric system in use;

(f) The manual of instructions for the chamber did not provide sufficient information about what to do when a failure occurs. Some instructions covering breakdowns and repairs are urgently needed since a Webber service man is not available in Warsaw.

2. To elaborate the instruction defining testing methods and the ways of chamber use.

In instructing staff members responsible for testing and investigating climatic conditions in the methods of using the chamber, the expert stressed the following main rules:

(a) The questions to be answered by means of the climatic chamber must be formulated exactly and based on a definite task or problem of packaging technology to be solved;

(b) The climatic chamber should be used only if it is thought to be the most appropriate means of solving the problem;

(c) The procedure for using the chamber must be carefully elaborated to ensure that the answer given by it can be used to solve the problem.

The expert developed instruction sheets to cover the main testing and research procedures for using the climatic chamber. Most of these sheets are attached to this report as annexes II-V.

3. To carry out training in the chamber's service and its maintenance.

The expert used the procedure described in annex I in training staff members about servicing and maintenance of the chamber.

4. To consult and assist in the work being carried out in connexion with organizing the sea-test trip.

The problem of testing for a sea trip had been dealt with thoroughly by the expert during his first mission; only a few questions remained. One question referred to the method of positioning the measuring instruments at the different points of the ship. They should be hanging within open crates in an appropriate position at predetermined points in the 'tween-decks and

in the deep hold of the ship. The measuring instruments should be checked and adjusted before the beginning of the voyage and after its conclusion. If a difference of readings were to be found after the trip, the other values registered during the voyage must be corrected after extrapolation between the initial and the final values of the voyage.

With reference to evaluating test specimens with preservatives against corrosion, the expert was guided by the principle that for packaging purposes the surface of a material must not be influenced and deteriorated, especially if this surface had been worked or could corrode. Test specimens for finding out the corrosion-protective properties of preservatives against corrosion should be evaluated after finishing the test, not by weighing them but by describing the amount or percentage of corroded surface. The climate for performing this test in the chamber should [illegible] the climate [illegible] 'tween-decks.

Proposals for this climate have been made by the Beratungs- und Forschungsstelle für seemässige Verpackung at Hamburg as a result of its test voyages (see annex III).

II. RECOMMENDATIONS

The expert made the following recommendations:

1. The procedure for defining the usable room of the chamber (see annex I) should be repeated after the testing instruments have been checked and adjusted by appropriate procedures.

2. An instruction sheet on the location of the usable room of the chamber should be drawn up and kept ready for use near the chamber.

3. A list of needed sets of curves for temperature and humidity must be taken from this report and supplemented by the requirements of the different departments of the Packaging Research and Development Centre.

4. A letter should be written to the manufacturer of the chamber covering the following items:

(a) Description of the inconveniences and faults observed in working with the chamber;

(b) Enumeration of parts lacking (wrenches, connexions between the chamber and the compressor unit, maintenance and repair, detailed plans of lines, units, contacts etc.);

(c) A list of sets for climate control as indicated above.

5. The connexions and parts of the control equipment of the chamber should be marked so that they can be found in a plan showing every detail.

6. Every sheet of paper dealing with the chamber should be kept at one place near the chamber.

7. A plan should be made for the use of the chamber showing the kind of tests, the needed time, the needed climate and the ordering department of PRDC.

Annex I

PROCEDURE FOR DEFINING THE USABLE ROOM OF THE CLIMATIC CHAMBER

The "usable room" of the climatic chamber means that part of the chamber that can be used when the climatic conditions are within the tolerated values $\pm 1^{\circ}C$ and ± 2 per cent r.h. Basic information about this procedure may be found in the Webber manual for the chamber, section concerning "Input controllers" and DIN 50011 and 50012.

It would seem convenient to use the following procedure for defining the usable room:

(a) Check measuring instruments planned for use inside the chamber for reading outside of the chamber;

(b) Put at least four instruments for temperature and humidity with their sensors at definite points in the chamber. ("Definite" means that the point where the sensor is situated must be measured, defined and registered in three directions with reference to the chamber);

(c) Shut the chamber and bring into position the set of curves destined for the first testing climate, e.g. $10^{\circ}C$ and 30 per cent and adjust the input controls for cooling and humidifying so that the oscillations of the readings will not be more than $\pm 0.5^{\circ}C$;

(d) Perform at least three measurements beginning half an hour after shutting the chamber and finishing the works according to procedure (c) above. Note them in an appropriate scheme;

(e) If the deviations between the average values of the three measurements according to procedure (d) and the ordered values at the control desk of the chamber are greater than $\pm 1^{\circ}C$ and ± 2 per cent r.h., the usable room is smaller than assumed in installing the first measuring points. In this case the measuring points must be shifted more to the centre. If the deviations are smaller, they can be shifted more to the walls;

(f) Put the second testing climate in operation and perform the same measurements;

(g) After defining the dimensions and the location of the usable room in the lowest plane, lift the measuring points to a plane in the middle height of the chamber, and after that to the highest plane. Repeat the same measurements;

(h) Describe the dimensions and the location of the anechoic room defined according to the above-mentioned measurements on a sheet of paper, add one copy to the file about the chamber and fix one copy ready for use at the chamber itself.

Annex II

USE OF THE CLIMATIC CHAMBER FOR PRECONDITIONING PACKING MATERIALS AND PACKAGES FOR WHICH SUBSEQUENT MECHANICAL TESTING PROCEDURES MUST BE PERFORMED

Preconditioning (according to DIN 55430) is the treatment of a specimen with a special climate if another kind of testing is to follow whose results will depend on climatic conditions. Preconditioning is necessary, therefore, for packages made of paper-board and plastic materials. The time between the end of preconditioning and the following testing procedure must be as short as possible, so that changes in the material properties during this period cannot go beyond small, tolerated amounts.

The time needed for preconditioning should be longer:

(a) The greater the difference between the previous climate and the climate of preconditioning;

(b) The greater the thickness of the walls of the package;

(c) The denser the structure of the walls;

(d) The worse the conductivity for heat and/or humidity of the packaging material.

The aims of preconditioning may be:

(a) To achieve "normal" climatic conditions, i. e. the climatic conditions that can be found very often in laboratories in a moderate climate. (Normal climatic conditions according to DIN 50014 are the following: 20°C/65 per cent r.h., 25°C/50 per cent r.h., 27°C/65 per cent r.h., 23°C/55 per cent r.h.;

(b) To produce an extreme climatic situation that is possible during a voyage when mechanical hazards may occur. In this case the test procedure for simulating the mechanical hazards must be performed as quickly as possible, as mentioned above.

Tests of this kind are of the following types:

(a) Drop-testing or other impact-testing of plastic drums after preconditioning $\pm 20°C$, and fibre drums and paper-board cases with 23°C/93 per cent or 40°C/92 per cent or after being rained on (DIN 5547);

(b) Puncture and mullen testing, and generally each short-time testing of packaging material the properties of which depend on climatic conditions.

Annex III

INVESTIGATING AND TESTING PRESERVATIVES AGAINST CORROSION IN CONNEXION WITH THE USE OF A CLIMATIC CHAMBER AND OTHER EQUIPMENT

Preservatives against corrosion must often withstand not only high values of temperature and humidity and frequent changes of climate, but also salt spray, industrial atmosphere, dust, heat radiation etc. In addition, testing procedures that shorten the testing period are preferred. Therefore, the following testing equipment and methods are used:

Salt spray chamber (DIN 50021)
Condensation chamber (DIN 50017)
Condensation chamber with SO_2 (DIN 50018)
Weathorometer (ASTM)

Without additional equipment it is not possible to test the behaviour of packages and packaging materials in climatic conditions occurring on deck of ships and in the open air at any point on the earth, because it is impossible to reproduce or simulate the following influences:

Salt dust
Salt spray
Radiation from the sun
Rain, snow, ice
Gases, e.g. SO_2

To simulate these conditions, the above-mentioned equipment should be used. In a climatic chamber of the type being installed in [illegible], only climatic conditions existing in rooms can be simulated.

Annex IV

USE OF THE CLIMATIC CHAMBER FOR ALTERNATING CLIMATES
(To simulate the conditions in a room undergoing intense variations of temperature and humidity during 24 hours, e.g. in a railway car, an automobile or the 'tween-decks of a ship)

The firm Beratungs- und Forschungsstelle für sachgemässe Verpackung has discovered that the following alternating climates often occur in the 'tween-decks of a ship: 23°C/95 per cent r.h. for 14 hours; heating and dehumidifying for 2 hours; 33°C/65 per cent r.h. for 6 hours; cooling and humidifying for 2 hours.a/

The temperatures may be still higher, up to about 60°C or more, for simulating the climatic conditions in the upper layer of packages stowed in the 'tween-decks of a ship or in a railway car.

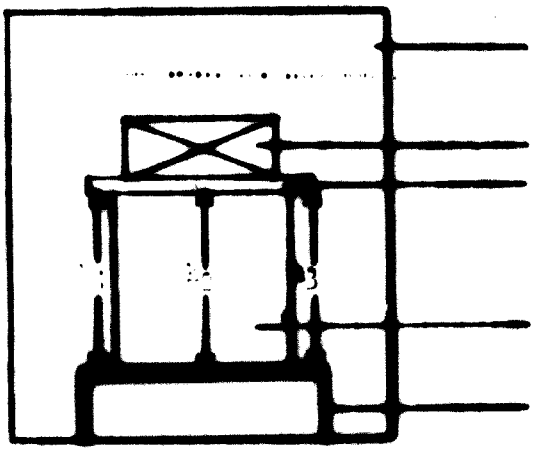
Alternating climatic testing procedures can also be used for testing the protective properties of preservatives against corrosion (see annex III).

a/ See H. Nielke, Verpackungsrundschau, No. 10, 1967, pp. 75-80.

Annex V

USE OF THE CLIMATIC CHAMBER FOR CONSTANT CLIMATES
(i.e. for simulating conditions existing in heaps of cargo stowed in the deep hold of a ship or in a storage hall)

a. Testing packages - above all paper-board cases - with a climate of 20°C and 65% humidity (especially simultaneously with a stacking load on the packages)



Climatic chamber (view from the open door).

Stacking load

Wooden plate

3 x to be tested

Metal crate to lift the box so that it is situated in the usable room of the chamber

Question A

Is this paper-board box appropriate for export purposes overseas?

To answer this question, the following procedures could be used:

(a) The stacking height is calculated by the formula

$F = \frac{H - h}{h} \cdot G/kg'$, where F is the height of the stacking and G the weight of a filled package of the same kind as that to be tested;

(b) Arrange the interior of the chamber according to the formula;

(c) Measures $h_{1,2,3,4}$ as shown above, beginning after one day and then after one, two, three and four weeks;

(d) The differences $\Delta h_{1,2,3,4}$ after a definite time, e.g. four weeks, must be calculated: $\Delta h_1 = h_1 - h_0$ etc.

(e) If the average difference of the four sides of the box is too great,

e.g. more than 20 mm, the load **must be** diminished or question A must be answered to the effect that the box is not appropriate for the planned purpose.

Question B

What is the ratio of the long-time stacking load and the short-time compression load **that a package can withstand?**

To answer this question, the following procedure should be followed:

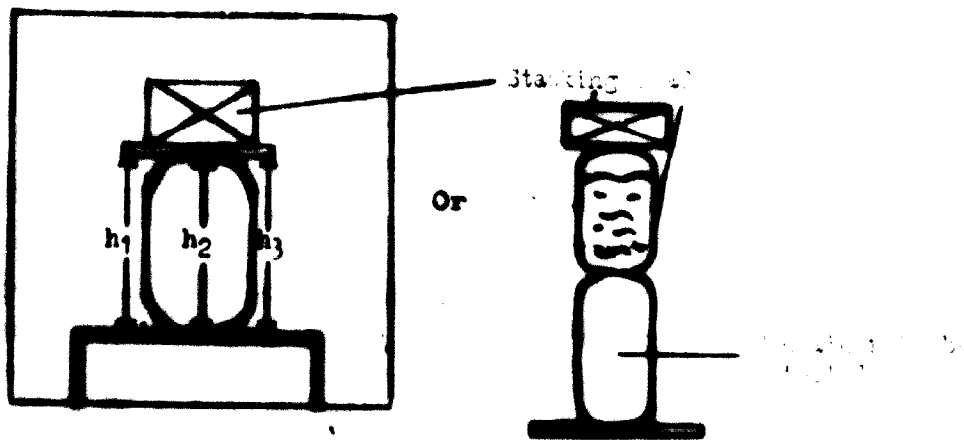
(a) Arrange the chamber as in question A;

(b) Find out the maximum weight G that can be placed on the box without the box breaking down or $\Delta h > 20$ mm;

(c) Test a box of the same type and, after conditioning at the temperature used for procedure (b), by short-time [illegible];

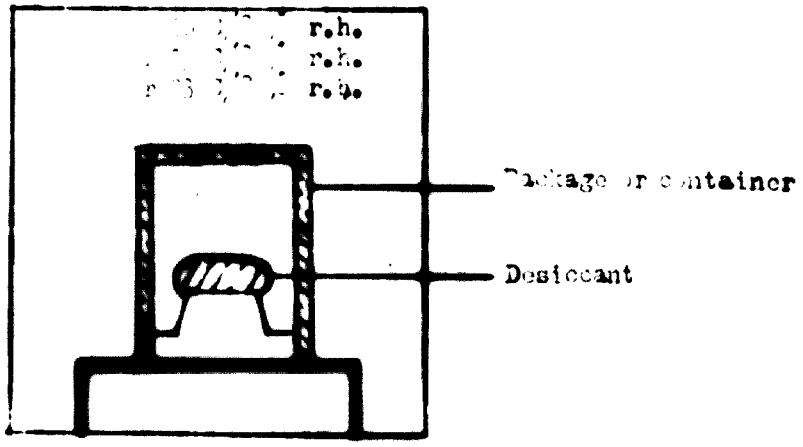
(d) Calculate the ratio asked.

B. Testing packages - above all plastic containers - with a temperature of +40°C with a stacking [illegible]



The procedure is about the same as for A.

C. Testing water-vapour permeability of packages with a climate of [illegible] humidity



(a) [illegible] as shown above;

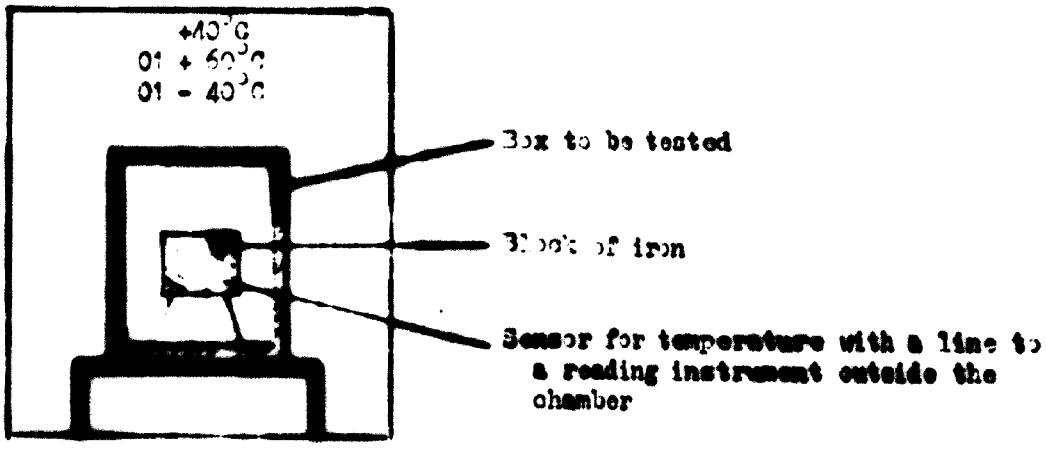
(b) Check the weight $G_{...}$ of the desiccant after being completely dried (G_0) and after one day (G_1), two days etc.;

(c) Plot the weights above the time;

(d) Water-vapour permeability of the package is the ratio $\Delta G / \Delta$ time.

(... after the description of this method written by the Swiss Packaging Institute.)

D. [illegible] heat-conductivity of a package [illegible] temperature of +40°C, + 60°C or − 0°C



(a) Arrange the chamber as shown above;

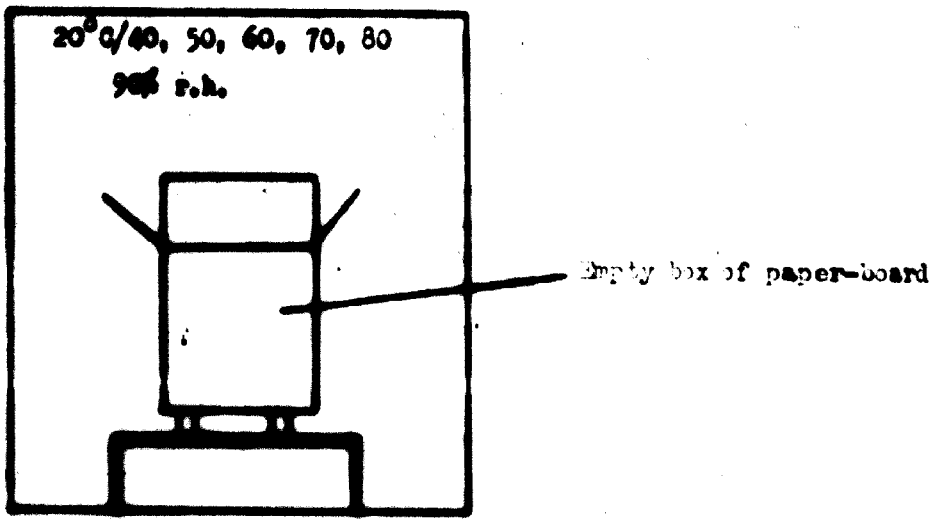
(b) Measure the temperature of the iron block t_0, t_1, t_2, t_4, t_6 after 0, 1, 2, 4, 6 days;

(c) Calculate the heat energy stored in the iron block corresponding to the the temperature;

(d) Plot the heat energy H_0, H_1, H_2, H_4, H_6 above the time;

(e) Heat-conductivity can be calculated as the ratio $\frac{\Delta H}{A \cdot \Delta \text{ time}}$ where A is the surface of the box except the bottom side and Δ time is one day of the linear part of the curve.

II. Finding out isotherms for water-vapour sorption and desorption (In this connection an investigation may be made of the dependence of certain properties of paper-board on its water content)



(a) Arrange the interior of the climatic chamber as shown above. (The paper-board must be completely dry before putting it into the chamber.) The weight, G_0, of the dried box must be checked;

(b) Check the weight of the box after two days at 20°C/40 per cent r.h. It may be assumed that after this time the water content of the box will correspond to the climate outside;

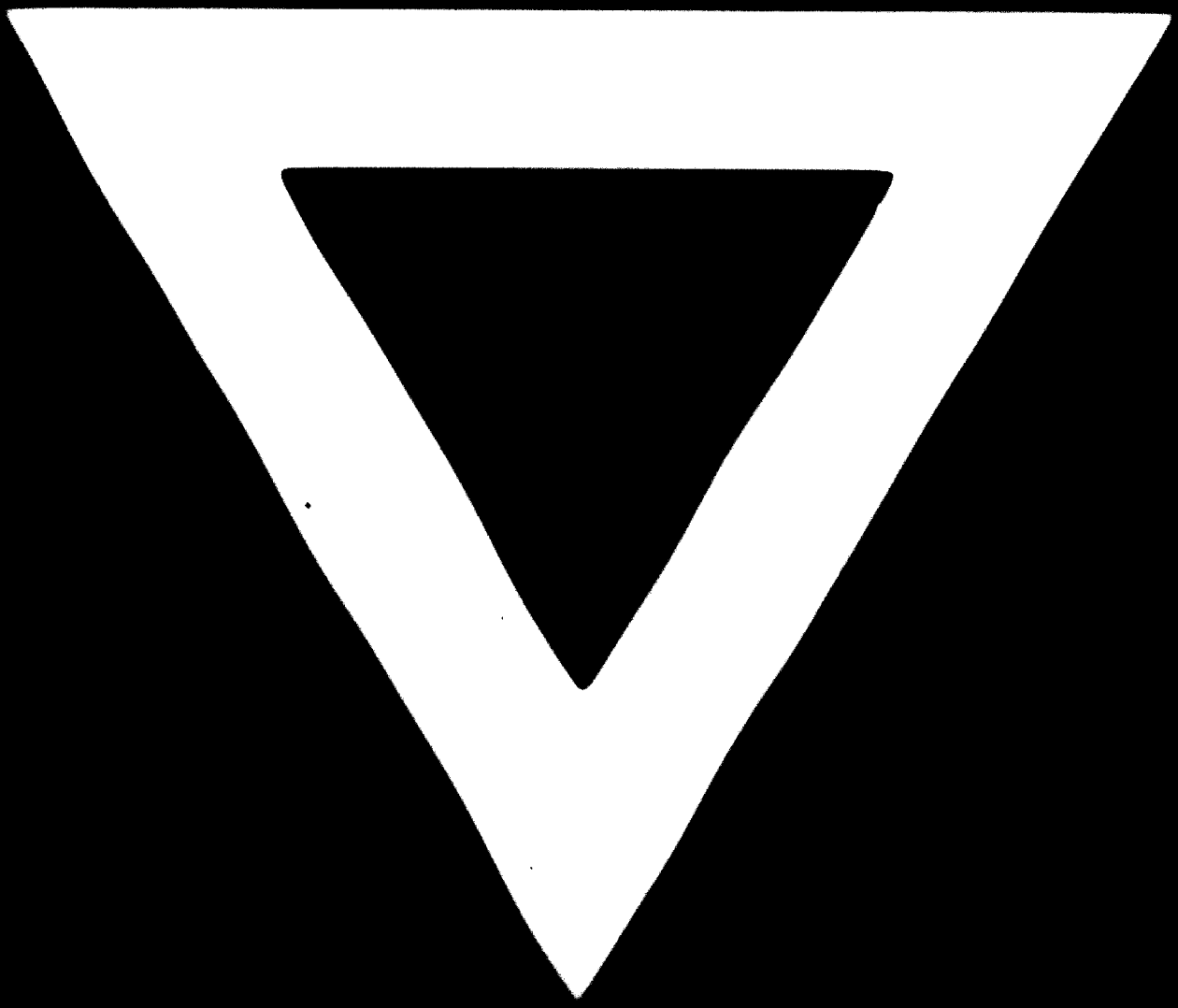
(c) Change the climate to 20°C/50 per cent r.h. and repeat checking the weights after two more days;

[illegible] with the [illegible] climates marked above;

[illegible] the difference [illegible] weight $\Delta_{40} = \mathfrak{Z}_{40} - \mathfrak{Z}_{0}$, $\Delta_{50} =$ [illegible]; [illegible] corresponding relative humidity. [illegible]. The [illegible] can be used for other [illegible].

[illegible] investigations may be [illegible] for finding out the dependence of [illegible] resistance tests on the water content of the package, and the [illegible] of the surrounding atmosphere, by putting additional boxes of [illegible] and testing them one after the other after their [illegible].

[redacted]



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