

Quality Study Of Self Contained Closed Circuit Breathing Apparatus On The Spanish Market

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Introduction

The great importance that this equipment has for personal protection on being used in situations that involve high risk, made the National Institute for Safety and Hygiene at Work of Spain carry out a study to determine the quality of this apparatus more representative in the laboral field, principally in mines and fires.

The tests were made about two pieces of equipment corresponding to the class without production of oxygen.

The parameters that we observed and determined to be most critical were: carbon dioxide content, temperature of the inhaled air, the operation of the lung governed oxygen supply and the work carried out by the equipment of integral form.

To execute the test with simulated ambient air as similar as possible to the function of the human organism, we were interested at first to know the average of the carbon dioxide contamination produced by the lungs. Therefore, we studied the articles published by the international specialists among whom we point out Silverman and Raven and we see that this average can be approximated without much error to the four percent (4%) in volume. Another interesting subject to be known is the permitted limit of the carbon dioxide in the respirable air or inhalation air. In this point the specialists do not get fully into an accordance and although we understood that this data cannot be given in a sharply and absolute form, we thought that, although with reservation to the specific attitude of the individual to this data could be given within a reasonable average.

The limit that we have found in respect with the carbon dioxide are the same given in the TLVs. USA (0.5% by the TWA and 1.5% to the STEL) and those indicated by the CEN in the preN 145 of

February of 1985, 1.5% in volume when the equipment has incorporated a facepiece. Nevertheless many specialists as: Craig, Forester, Shershow and Lum give an alarm call about the necessity to avoid a

RELACION ENTRE PRODUCCION DE CO₂ Y VOLUMEN MINUTO DEPENDIENDO DE DIFERENTES TASAS DE TRABAJO, PARA UNA PERDIDA DE CARGA DE 64 mm. c.d.a. (✱)

Clases de trabajo	Volumen (l/minuto)	Consumo de O ₂		Producción de CO ₂ (ml/minuto)	% de CO ₂ respecto volumen minuto	
		ml/min	% de V min		%	p.p.m.
Sedentario	9'1	304	3'34	259	2'84	28.400
208 kgm/minuto	19'8	812	4'10	709	3'58	35.800
415 kgm/minuto	27'0	1.159	4'29	1.039	3'55	38.500
525 kgm/minuto	32'0	1.396	4'36	1.274	3'93	39.800
622 kgm/minuto	36'6	1.606	4'39	1.482	4'05	40.500
830 kgm/minuto	48'9	2.052	4'19	1.976	4'04	40.400
1.107 kgm/minuto	64'4	2.591	4'02	2.621	4'07	40.700
1.334 kgm/minuto	81'3	3.033	3'73	3.231	3'97	39.700
1.660 kgm/minuto	90'3	3.245	3'59	3.450	3'82	38.200

TABLA 1

(✱) Silverman, Plotkin, Sawyers and Yancey: "Air Flow Measurements on Human Subjects With and without Respiratory Resistance at Several Work Rates", Arch. Ind. Hyg. Occupational Med. 3: 451, May 1951

contamination something elevated of carbon dioxide (CO_2) because as has been detected principally in sensible persons who with a contamination not too high organic disturbances have been detected such as giddiness, dysnea, hyperventilation, etc., that produces in any persons the favorable conditions to suffer a laborial accident.

Another parameter to be studied in this respiratory protection equipment was the temperature as the elimination of carbon dioxide is carried out by an exothermic reaction was interesting to know in the equipment used in Spain, the level that the users have to tolerate and to know if this average temperature were able to produce situations of human insecurity because some stress will be originated that will cause a lack of reflex in the persons that will drive to an accident. Another interesting aspect was knowing the limits given by the two organizations that protect and regulate this

equipment. Meanwhile in the United States was permitted until fifty-seven degrees centigrade (57°C) during fifteen minutes, the CEN in his preN 145 does not authorize more than forty-five degrees centigrade (45°C).

It was decided to simulate the respiration of a person at moderate work of 622 kilogrameters, has to run over in order to produce some flows similar to the sinous of the characteristic respiration of the persons who were earning out works of equal values to that before mentioned producing to them artificially a contamination in carbon dioxide (CO_2) similar to that one generated by the workers respiration.

Test

Once we knew all the limits of the principal parameters such as the concentration of CO_2 and temperature, the breathing machine

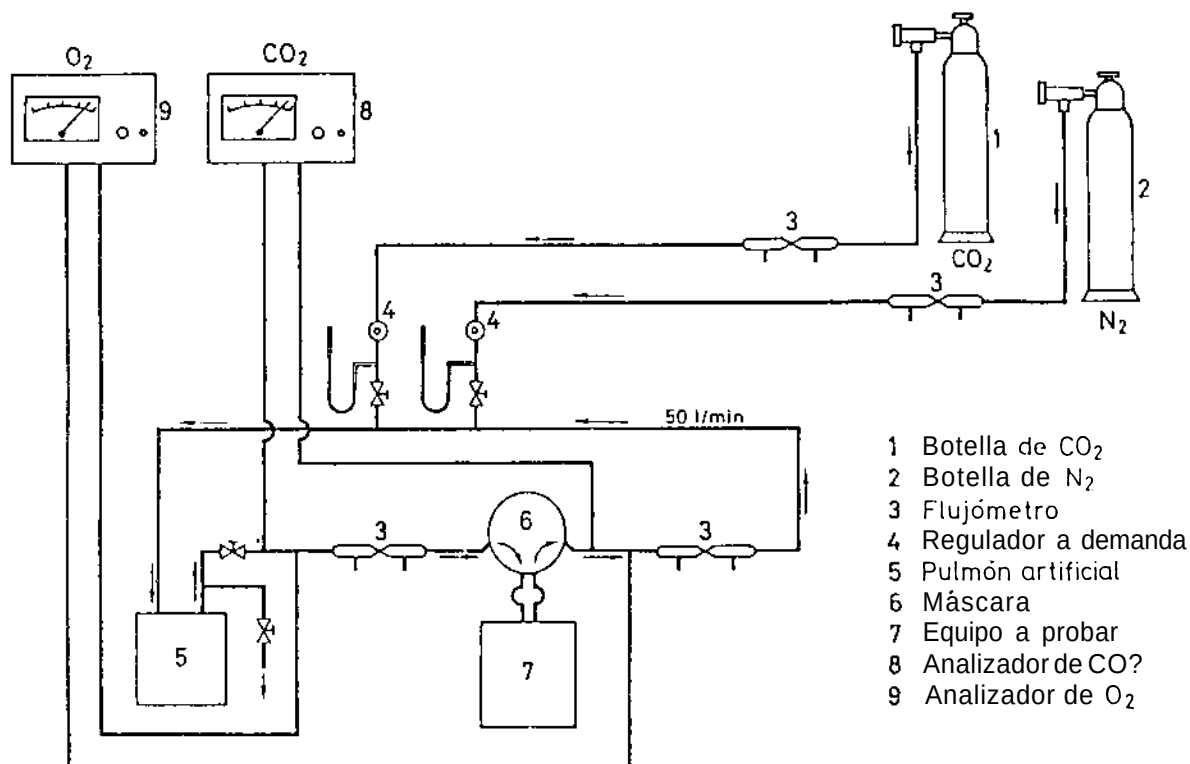
was used to operate the SCBA with and without production of oxygen as follows:

Closed circuit equipment without production of oxygen.

This equipment is characterized due to the elimination of carbon dioxide produced while the respiration by the alkaline-hydroxides or by soda lime. The lack of produced oxygen is compensated by means of a small bottle (2 liters approximately) at a pressure of 200 bars.

The scheme of the mounting effected for the development of these tests is the indicated with the number one of the following components:

- Alternative breathing machine or artificial lung with sinousoidal breathing corresponding to work of 622 kilogrametre at a minute



Esquema n: 1

volume of forty liters (21/strokes x 20 strokes/min.).

- Selenoid valves controlled by a breathing machine.
- Humidifier with psycrometer in order to get a relative humidity in the equipment during the test.
- Carbon dioxide analyzer.
- Oxygen analyzer.
- Meter of pressure and temperature before and after the equipment tested.
- Bottle of carbon dioxide (CO₂) in order to get the desired contamination in the test.
- Meter of flows and keys for regulation and obtention of the flow of the test.
- Bottle of N₂ in order to get a minor

proportion of O₂ in the exhalation air.

- Breathing apparatus.

The equipment chosen was among the most utilized in the Spanish laboral field that we named by the letters "B" and "C".

The first one was an equipment with a depurater cartridge of sodade lime and with an endurance according to the manufacturer of one hour of utilization.

The second equipment was a model of hours of endurance and with a cartridge of alkaline hydroxide.

The conditions of the test were as follows:

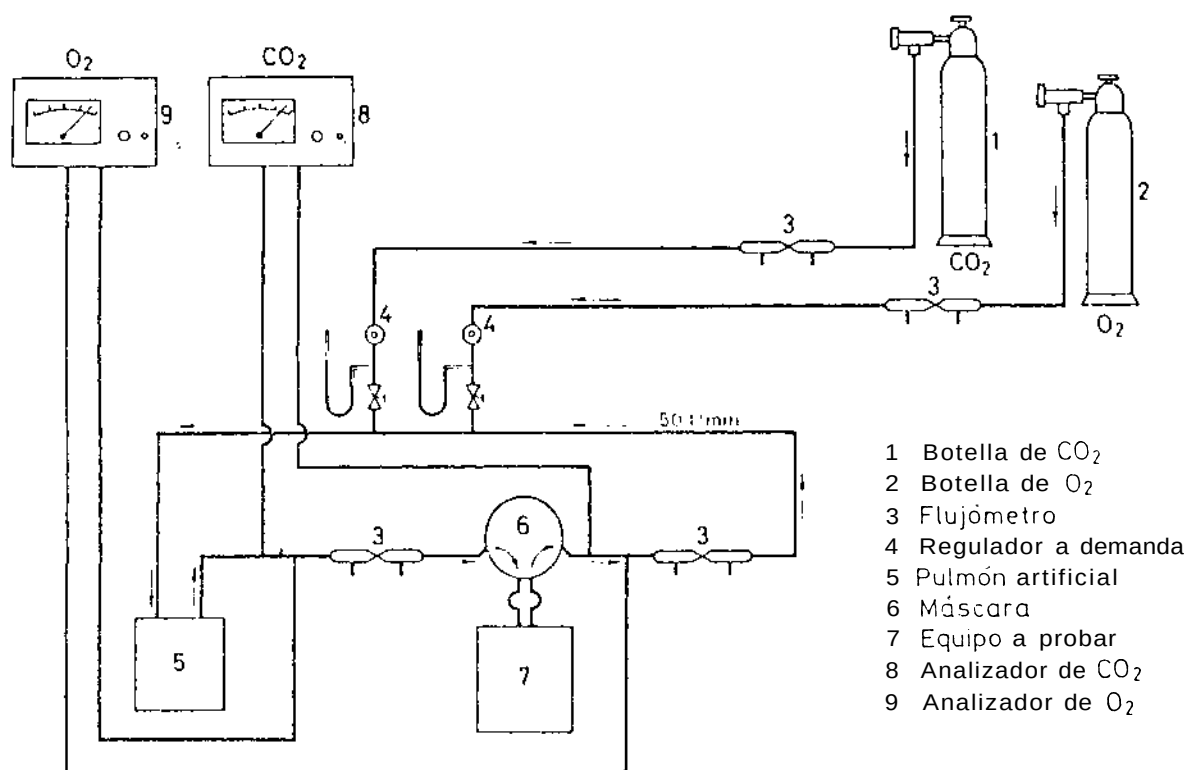
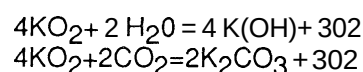
- Concentration of CO₂ in the inhalation air = 4%
- Relative Hymidity = 90 to 100%
- Minute volume = 40 l/min. (21 stroke x 20 strokes/min.)

The results of CO concentrations in the inhalation air are represented in the graphics 1 and 2 and the others belonging to the temperatures in the same air in the graphics 6 and 7. All this data will be analyzed later on.

Equipment of closed circuit with production of oxygen.

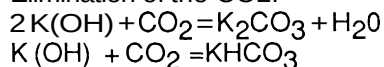
This equipment eliminates the carbon dioxide and at the same time produces some quantity of oxygen doing the contaminated exhalation air to pass through filters generally formed by metallic peroxides of potassium (KO₂) producing a strong exothermic reaction or by sodium chlorate (Nac103) filters. A reaction type could be as follows:

Generation of oxygen:



Esquema n° 2

Elimination of the CO₂:



The scheme of mounting for this test is similar to the latter with the only difference being the corporation of oxygen that meanwhile in the latter proceed from a small bottle in the same equipment here in this case comes from the reaction of the filter. In order to see the quality of this equipment the tests were made with their models named by the letters "D", "E", and "F".

The equipment D was the potassium peroxide (KO₂) with an endurance of sixty (60) minutes. The E was constituted by a filter of clorate with an endurance of one hour and the F also was constitute of KO₂ and endurance of sixty (60) minutes, all this according to the manufacturers.

The test was made with alternative machine or artificial lung under the following conditions:

- Concentration of CO₂ in the exhalation air = 4%.
- Minute Volume = 40 l/min. (2 l/stroke x 20 strokes/min)

The results of concentration of CO₂ in the inhalation air are represented in the graphics 3, 4 and 5 and the temperatures in the 8 and 9. The data are analyzed as follows:

Analysis Of The Results

First we are going to analyze the quality of the equipment in regard to their capacity for eliminating the CO₂ and therefore endurance of the apparatus.

Equipment without production of oxygen

The "B" exceeds the 0.5% of carbon dioxide to the forty (40)

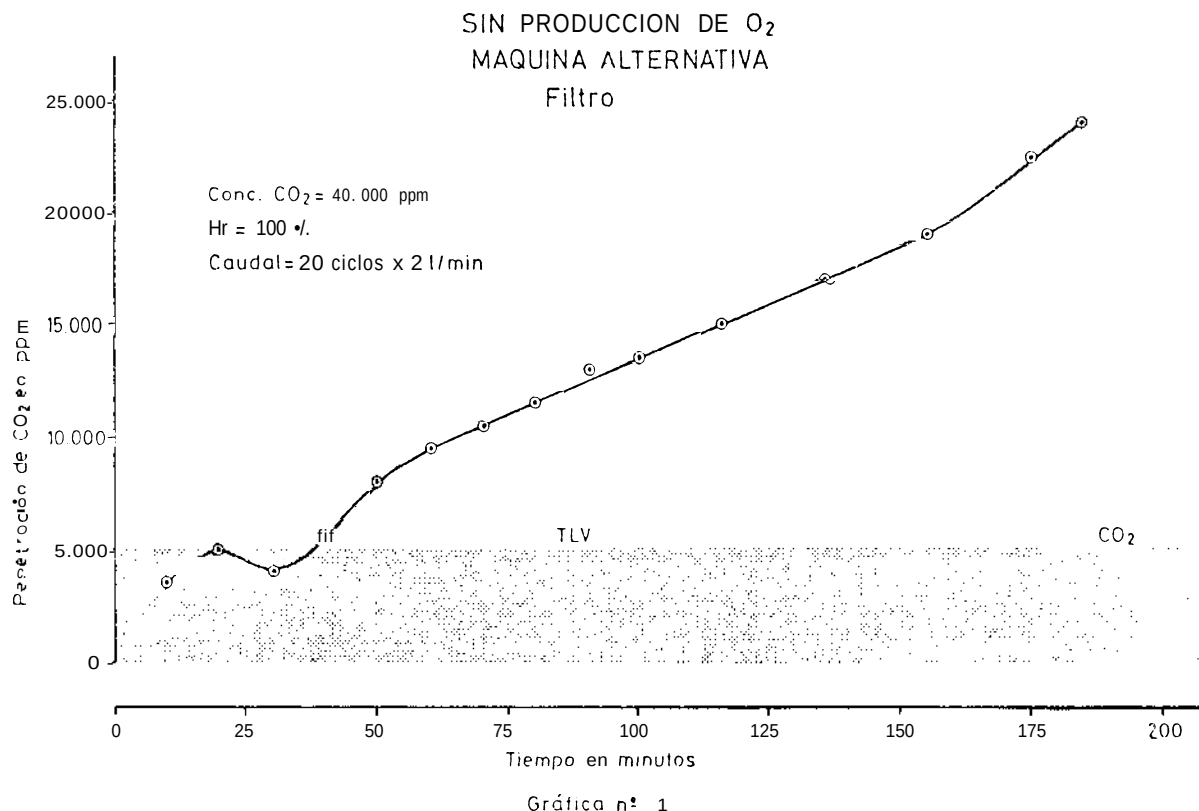
minutes of the working time and the 1.5% from the start of the 115 min. of work, because of that and from the point of view of Europe would be valid if it is used with a mask and it is classified equipment of one hour.

If we take into consideration the American TLVs, in Spain would not be like an official pattern because it does not reach one hour of working time below the 0.5%. Nevertheless as the STEL is of 1.5% and the resting time of 20 minutes would be nearly in the limits of utilization.

The equipment "C" was tested at 4 and 5% of carbon dioxide but we are going to analyzed only the results obtained with contamination of the 4% of CO₂.

According to the graphic number 2 we may see that the 0.5% exceeds at the 175 minutes and the 1.5% at the 205 minutes.

The manufacturer was considering this equipment of 4 hours and applying the American limitations and



the Europeans as well would be contradicted because of reaching the permitted limits before the 240 mins.

Equipment with production of oxygen

The equipment "D" was tested twice with great disparity results as we see in the graphic # 3. In this one we may see that the 0.5% of CO₂ is reached at the 55 and 10 mins. in the first and second test respectively and the 1.5% at the 72 and 37 mins. according to the test. In no case we may consider good to an equipment with this disparity in the results to be used and taken into consideration that its most propitious results would be considered apt or not depending the American or European point of view.

The equipment "E" shows its results in the graphic number 4 and in this graphic we may see that it reaches the 0.5% of CO₂ at the 15 minutes and the 1.5% at the 49 minutes.

Because of that in no case neither by the CEN nor by the TLVs would be profitable to be used.

The equipment "F" is considered by the manufacturer as of one hour and was made two test with the results shown in the graphic number 5 reaching the 0.5% of CO₂ at the 56 minutes in the first and at more than 80 minutes in the second one and the 1.5% at more than 75 minutes in the first test at many more minutes in the second test because of that under the point of view of the contamination the equipment is apt to be used.

If we analyze the graphics of the temperature reached during the test carried out by the equipment, we may see that the equipment "B", "C", "D", and "E" do not reach the 45 degrees centigrade indicated as limit by the CEN during all the period of the test as it is shown in the graphics number 6, 7, 8 and 9.

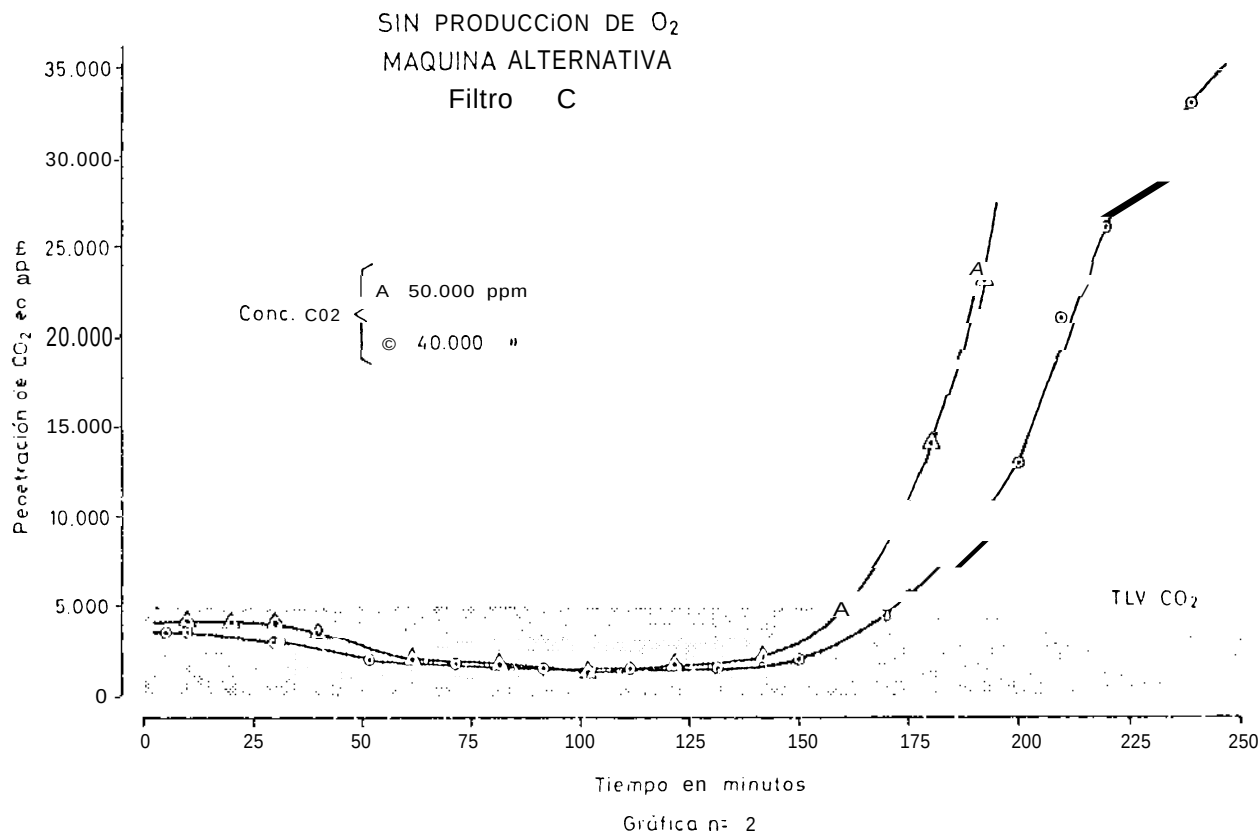
The equipment "F" reaches the

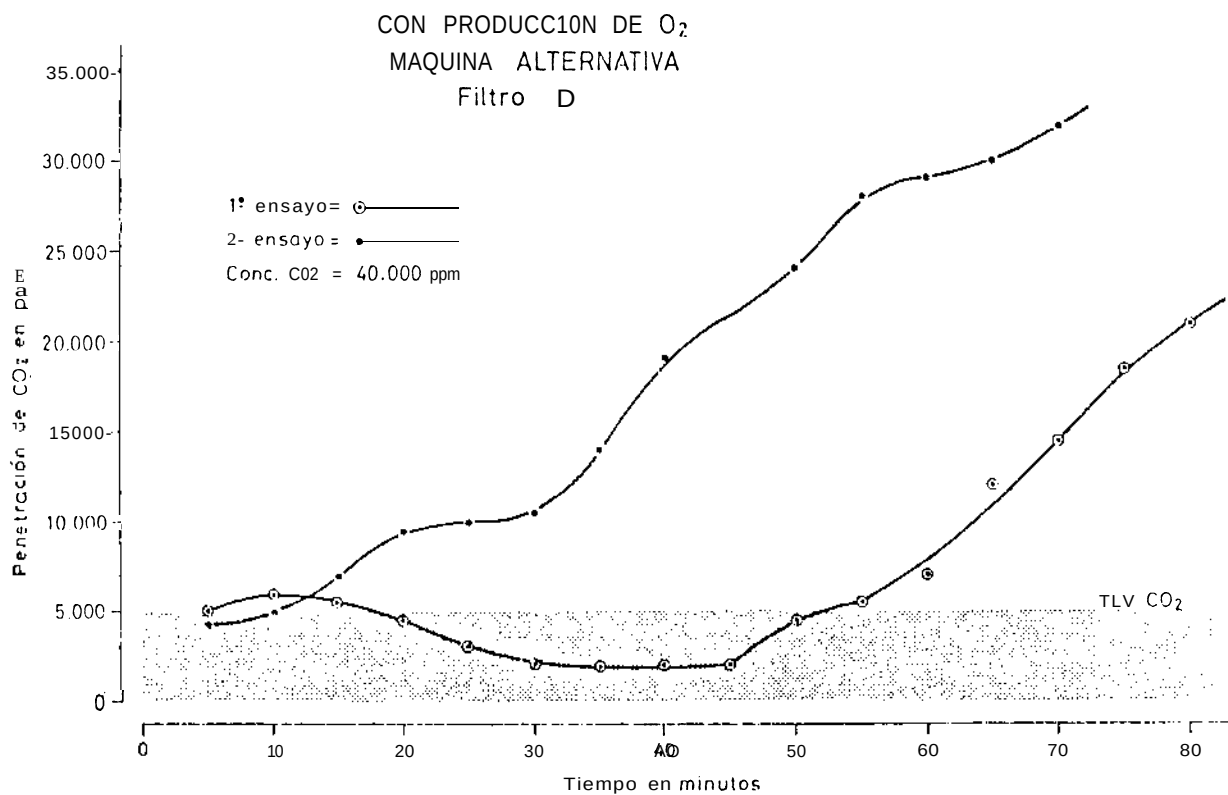
45 degrees centigrade at 47 and 45 minutes in the first and second test carried out because of that according to the CEN would not be utilizable as equipment for one hour.

The way the equipment worked apart from the conceits previously described was correct in a general form.

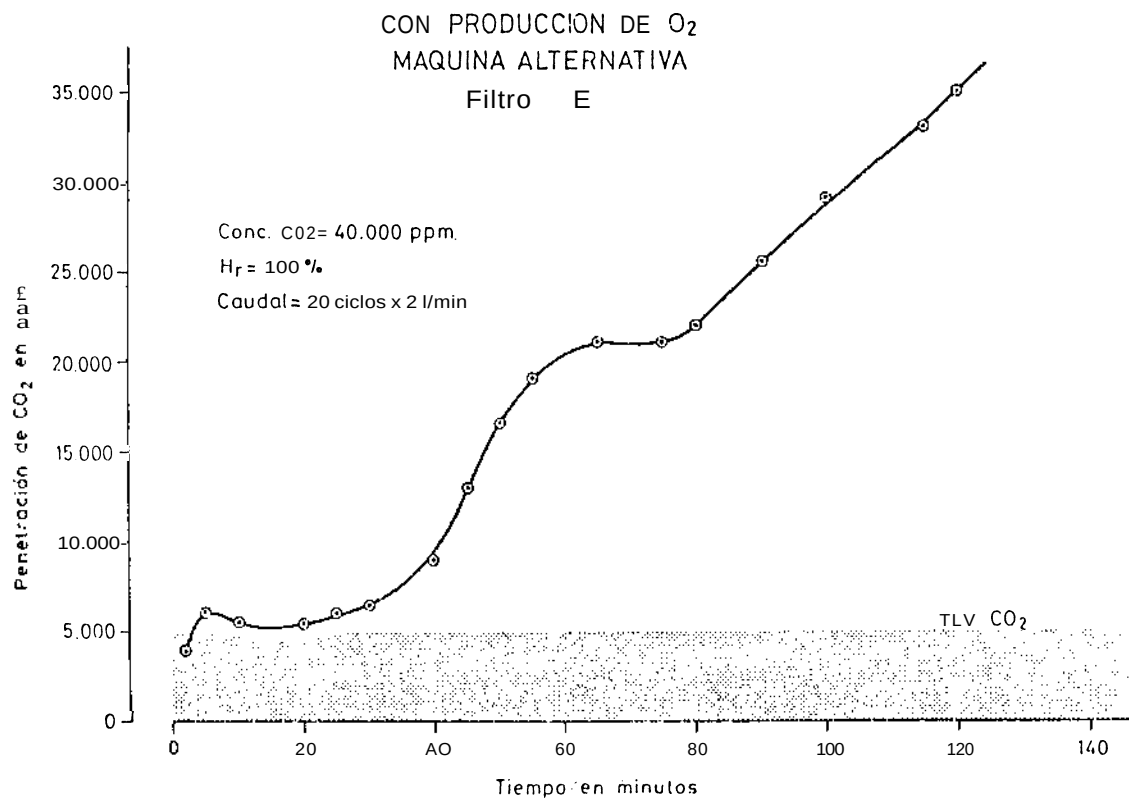
Conclusions

The equipment utilized in Spain and from which the most significant were chosen, showed with as many failures in reference to the retention of CO₂ and in one case in which it is correct the temperature rises above the 45 degrees centigrade, because of that it is necessary that as soon as possible standards would be carried out and published concerning this equipment in order to accomplished with the minimum requirements established in Europe for their use.





Gráfica n° 3



Gráfica n° 4

