GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: July 12, 1973

Project Title: Determine Methods of Measurement of Leakage Rate of Butane from Cigarette Lighter

Project No.: A-232-665

Project Director: Herb Burrows

Sponsor: Scripto, Inc.

Effective July 12, 1973 . . . . . Estimated to run until August 12, 1973 . . . . . .

Type Agreement: Letter dated July 12, 1973 . . . . . Amount: $ 1,000 . . . . . .

SPONSOR CONTACT: John C. Lockwood
Scripto, Inc.
Post Office Box 4847
Atlanta, Georgia 30302

Assigned to Technology Applications Group . . . . . Division

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Engineering Experiment Station

PROJECT TERMINATION

Date December 17, 1973

PROJECT TITLE: **Determine Methods of Measurement of Leakage Rate of Butane from Cigarette Lighters**

PROJECT NO: **A-232-665**

PROJECT DIRECTOR: **Herb Burrows**

SPONSOR: **Scripto, Inc.**

TERMINATION EFFECTIVE: ~~August 12, 1973~~

CHARGES SHOULD CLEAR ACCOUNTING BY: ~~December 31,~~ 1973

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ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

August 23, 1973

Scripto, Inc.
P. O. Box 4847
Atlanta, Georgia 30302

Attention: Mr. John C. Lockwood
Director of Functional Designs

Subject: Progress Report, Project A-232-665, "Determine Methods of Measurement of Leakage Rates of Butane from Cigarette Lighters"

Gentlemen:

In accordance with our discussions with Mr. John C. Lockwood, Mr. Lockwood's letter of authorization dated July 12, and subsequent discussion with Mr. Vogt, we have conducted an investigation into the measurement of leakage rates of butane lighters by weight determination, by volume (bubble) count, and by readings made with a hydrogen detector.

I. Weight Determinations

Table 1 shows weight determinations of 20 lighters. Nos. 1 through 12 were unfilled lighters, which had not been in contact with butane. Nos. 13 and 14 were filled lighters which, by the immersion bubble test, were rated "good". Nos. 15 through 20 were filled lighters rated "slow leaker" by the same test.

Column A is the original weight of each lighter; following these weighings, the lighters were placed in the oven at 55°C (131°F) at 1:25 PM, July 16, 1973. During this test oven temperature varied from 35°C (127.4°F) to 58°C (136.4°F).

Column B shows the weights at 1:25 PM, July 17; i.e., after 24 hours; Column C weights were determined at 2:25 PM, July 18. Weights shown in Column D were taken at 3:00 PM, July 16; those in Column E on July 20, 1973.

Following the weighings on July 20, 1973, the lighters were allowed to remain in the open laboratory at room temperature until 1:30 PM, July 23, or slightly less than 72 hours. As indicated by the (*), Column F, every lighter and empty lighter case gained weight during this period. The lighters were then returned to the oven. Columns G and H show the weights determined at 2:00 PM, July 24 and 3:00 PM, July 25, respectively.

These results are shown for the individual units, rather than as averages, so that the leakage of each lighter may be studied as a function of its residence time at approximately 130°F. It is apparent that attempts to determine losses of butane charge by measurement of weight loss are confused by weight losses due to other factors, possibly surface moisture, as indicated by the unfilled lighters. Other eratic behavior, such as a large loss during one 24 hour period, as compared to other 24 hour periods, further confuse the results. These factors, together with the time required for weight determinations and the large discrepancy between actual loss and total weight, cause us to discredit weight determination as a feasible means of monitoring production items for leakage rates.

II. Volume (bubble count) Determinations

Bubble volume measurements were made by collecting the gas while counting the bubbles. The average bubble volume was 1/50 ml., or 20 µg (20 microliters). The weight of this volume of butane is 35 µg (35 micrograms), or 35×10^{-3} mg.

A loss of 5 mg per day would be measured as 143 bubbles per day (six bubbles per hour, or one bubble each six minutes). This very low frequency of bubble formation would be very difficult to monitor. The lighters rated "slow leakers" by the bubble test generally have minimum rates of at least one bubble per minute; these are easily detected by the hydrogen detector, but are easily missed in mass bubble testing.

Two lighters were selected, one rated "fast leaker"; the other "slow leaker." These were immersed in water at room temperature and the gas collected in graduated cylinders. The "slow leaker" lost 0.8 ml per hour (40 bubbles per hour). The "fast leaker" delivered 8.7 ml per hour (435 bubbles/hour). There were some lighters in those furnished us that had leakage rates in excess of this "fast leaker;" some of these had defective cases.

Our experience in making leak determinations by the bubble method in our laboratory leads us to the opinion that this method is quite satisfactory for initial screening of moderate to high leakers, but would be difficult and time consuming for the discrimination of slow and very slow leakers.

III. Hydrogen Detector Determinations

The sponsor supplied us with a portable "Cosmos Hydrogen Detector" for determinations in our laboratory. The instrument, as we received it, was set at its maximum sensitivity; a concentration of 250 [illegible] of butane would drive the needle off the scale. Consequently, the instrument could be used only on exceedingly slow leakers.

A set of five lighters was selected for initial tests, and readings were made at intervals of one hour, with the results shown in Table 2.

TABLE 2

"Cosmos" Readings on Some Butane Lighters

Time (hrs.)	Lighter Number 1	2	3	4	5
0	0.3	4.3	2.0	2.3	3.9
1	0.26	1.0	1.5	1.2	5.0+ (off scale)
2	0.15	0.0	1.0	0.0	2.8
3	--	0.0	0.8	0.0	2.5

With the exception of the reading on No. 5 at one hour, all readings diminished with time, indicating gradual self-sealing of the leaks.

The detector unit gives readings in terms of parts per million of gas in the detection chamber, when related by the linear-logarithmic scale pair shown on the left-hand ordinate of the Cosmos chart. For example, gas concentrations corresponding to meter readings are shown as:

"5" = 400 ppm
"4" = 165 ppm
"3" = 68 ppm
"2" = 28.5 ppm
"1" = 11.9 ppm, etc.

A specific ppm level is reached by leakage of gas into the chamber, which has a capacity of 142 ml. less the volume occupied by the lighter, which is approximately 20 ml (without firing mechanism), leaving a free volume of 122 ml. A lighter leaking 5 mg per day would result in a level of 19.5 ppm in one minute in this chamber. The scale reading would be approximately 1.55. This is obviously a much more accurate determination than would be obtained in the bubble counting method (one bubble in six minutes).

Decreasing the size of the detection chamber increases the rate of response of the instrument. Were the effective free volume of the chamber to be reduced to 24.4 ml., the above determination would require only 12 seconds, instead of one minute. We have confirmed this effect by experiment.

The sensitivity (accuracy) of the instrument may also be increased by substituting a more precise meter. The sensitive element is one which operates upon the principle of adsorption of the gas onto a surface, with resultant difference

in electric potential between that surface and a standard surface. This potential difference is measured on a voltmeter. The sensitive element is one which is also used in fire detection devices. We have adapted one of the latter into an instrument which performs the same function as the Cosmos, but has a smaller detection chamber and more precise meter. This instrument has been used to confirm results obtained with the Cosmos.

IV. Calibration of the Hydrogen Detector

A standard butane concentration for calibration was prepared by injecting 257 µl of butane into a 343 ml. cylinder containing nitrogen gas at 44.1 psi. The resulting mixture contained 250 ppm of butane.

The cosmos instrument was modified by reducing the volume of the detector chamber to approximately the volume of the detector unit. The gas was then allowed to flow slowly through this reduced chamber, whereupon the response of the needle was very quick and steady.

The original setting of the needle was such that 250 ppm drove the needle off the scale. Calibration consisted in readjusting the sensitivity to bring the position of the needle to 4.5, the value corresponding to a reading of 250 ppm. It is recommended that this procedure be used periodically in recalibration of all instruments used for detection of butane leakage.

V. Conclusions and Recommendations

On the basis of the preceding results, we conclude that the only feasible procedure for detecting and measuring butane loss from lighters, except for gross screening of production line items, is by use of a hydrogen detector, such as the Cosmos portable unit, or the automatic device now in use by the sponsor.

Such units, however, are of questionable reliability unless the geometry of the detection chamber is carefully designed and the sensitivity of the detector is accurately calibrated. Suggestions for accomplishing these objectives are described in the above report.

On the basis of these findings, design of an automatic inspection machine appears to be entirely feasible. Such a machine would be fed directly from the production line, would monitor leakages in all units at any specified temperature for any required length of time, and would reject all units that showed leakages above a prescribed value.

As a quick and easy gross screening method, the bubble method now used by the sponsor appears to be quite satisfactory.

Respectfully submitted,

[redacted]

W. H. Burrows
Project Director

WHB/edh