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TEMPERATURE VARIATIONS WITH RESPECT TO THE SPECIFIC GRAVITY OF GLASS FRAGMENTS

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Glass fragments often become evidence in criminal investigations, and their identification may present convincing testimony in a case at trial. There is probably not a law enforcement officer in existence who has not at some time or another been faced with the necessity of using glass fragments as evidence. Cases which involve glass comparison range throughout the field of criminal investigation and may include all of the crimes listed in Uniform Crime Reports. The identification of such fragments logically lies within the scope of the technical field of criminal investigation. It may involve optical glass, headlight lenses, safety glass, window glass, or the many types of glass used for other purposes.

A common practice for identification of glass fragments is by the comparison of its physical properties, such as the refractive index, specific gravity, spectrographic analysis, and hardness. Another means is by fitting broken fragments together, which is at present, the only positive means of identification.[1]

All of these physical properties become corroborative when they approach a point common to the comparison particles. The identification so made is proved by the law of probabilities. It has been declared competent evidence for the technical investigator, and he is permitted to state in court, upon proper admission of his qualifications, that the source of two or more samples of glass in question are from a "probable" common source. He is then burdened with the task of explaining to a jury the law of probability and its application to the question. It would appear then to the prudent workers in the field that they should ever be trying to move from the state of "probability" to that of the "factual" identification of evidence presented in criminal cases.

Having experienced a number of trials in which glass frag-

1 Tryhorn, F. G., "The Examination of Glass," Jour. of Crim. Law and Crim. (Pol. Science), *30:* 3 (Sept.-Oct. 1939), 413.

ment identification was given major weight as evidence, and also the fact that many such cases are so serious that a person's life itself is at stake; it appeared that some of the phases seemed not to have been thoroughly covered in the literature and should be explored. Although a number of workers have written upon the phase of specific gravity in reference to glass fragments, there still seems to be some doubt as to the extent to which this particular physical property may be used as corroborative evidence.

Beeman observed in his laboratory that two fragments of glass he was examining had the same specific gravity at one temperature, but did not coincide at others.[2] This observation indicated the desirability of experimenting with temperature variations upon glass fragments from the same source and from similar sources. The data accumulated from initial observations and noted in this paper may be considered only a preliminary attempt to determine if possible a physical fact or facts relative to specific gravity of glass fragments as influenced by temperature. It is commonly understood that temperature changes materially affect the specific gravity of glass. With this point in mind, the following experiment was developed and is here recorded.

The Experiment

Due to the fact that a number of instances wherein beverage type bottle glass came to the personal attention of this writer, it was decided to carry out an experiment with a few common glass sources. Only ten samples were used in this experiment since this was merely an exploration of the possibilities which might be found by such an undertaking. All samples selected were of small size, which made the flotation method of specific gravity determination most practical. S-tetrabromoethane and kerosene were used as balancing liquids. The difference in weight of the samples ranged from 0.04507 grams to 0.24341 grams. Although there is a marked variation in the weight of these samples, each sample was selected because it presented to the unaided eye practically the same size. In 4 tests two samples were taken from each of 4 different beverage bottles. Each bottle was broken and samples of approximately the same size were collected. For one test a sample from two different types of bottles was used. The specific gravity was then determined by weighing the balanced liquid at designated temperatures by the

2 Beeman, J., "The Effect of Temperature Variations on the Determination of Specific Gravity of Glass Fragments," Jour. Crim. Law & Crim. (Pol. Science), *36:* 4 (Nov.-Dec. 1945), 298.

TABLE 1.

Test No.	Sample No.	Source of Specimen	Color of Specimen	Weight of Specimen	Specific Gravity at 20°	37.5°	50°	70°
1	1	Coca Cola	Green	0.04507	2.5352	2.5410	2.5650	2.5977
	2	Walla Walla	Green	0.14030	2.5210	2.5570	2.5710	2.6180
2	3	Coca Cola	Green	0.05703	2.5367	2.5520	2.6005	2.6140
	4	Yakima, Wash.	Green	0.07315	2.5500	2.5605	2.5880	2.6217
3	5	Coca Cola	Green	0.14693	2.5570	2.5617	2.5870	2.6482
	6	Bend, Ore.	Green	0.14305	2.5370	2.5662	2.6000	2.6280
4	7	Whiskey bottle	Colorless	0.16906	2.5160	2.5482	2.5780	2.6067
	8	Coca Cola	Green	0.10003	2.5560	2.5745	2.5910	2.6395
5	9	Whiskey bottle	Colorless	0.16504	2.5160	2.5212	2.5540	2.5932
	10	Whiskey bottle	Colorless	0.24341	2.5240	2.5310	2.5540	2.5940

use of 2 ml. pycnometers. Observations of specific gravity were taken at 20°C, 37.5°C, 50°C and 70°C. A constant temperature water bath of the precision type was used throughout the experiment to maintain temperature control.

Observations

It was observed that only two samples had the same specific gravity at 20°C. These two samples were not from the same source. It was also noticed that two samples had the same specific gravity at 50°C, and were from the same source. It was also noticed that the two samples having a like specific gravity at 50°C had a nearly like specific gravity at 70°C. The difference being only 0.0008.

It has been noted that particle size may materially affect the specific gravity.[3] In this respect, it was noted that in test 1, table 1, specimen No. 2 was the heaviest by 0.09523 grams. However, specimen No. 1 had the greater specific gravity by 0.0142. In test No. 2 specimen No. 4 possessed the greater weight by 0.1612, and specimen No. 4 also had the greater specific gravity by 0.0133. In test No. 3 specimen No. 5 had the greater weight by 0.00388 grams and specimen No. 5 also had the greater specific gravity by 0.030. In test No. 5 specimen No. 10 had the greater weight by 0.07837 and specimen No. 10 also had the greater specific gravity by 0.008.

It is indicated that particle size does not affect the specific gravity in a proportional way. In one instance the greater weight possessed the smaller specific gravity in relation to two samples of glass from the same source. However, in four tests, the greater weight was coincident to the greater specific gravity.

It was noted that the specific gravity increased in all cases as the temperature increased. There did not appear to be a ratio between the increase in temperature and the increase in specific

3 Op. Cit. note 2.

gravity. It is stated that the linear expansion of glass is constant between the temperatures of minus 191°C and 500°C.[4] Therefore, the changes in specific gravity is probably not due to the thermal expansion as the temperature is raised. The specific gravities for the 10 samples were plotted on a graph at the indicated temperatures and it was noted that in 6 cases, namely specimens 1, 3, 4, 5, 9, and 10, that the increase in specific gravity from 20°C. to 37.5°C. was small, and from 37.5°C. to 70°C. the increase was more rapid and approximated a straight line. With respect to the other four specimens Nos. 2, 6, 7, and 8, the progressive specific gravity increase was nearly in a straight line from 20°C. to 70°C.

Summary

It has been shown that specific gravity may be used to determine the chemical composition of glass. It has been shown that it is possible to predict with considerable accuracy the density of a glass from the composition of that glass. It is known also that compositions of various glasses may be determined from the densities.[5] Specific gravity determination is used as a control of composition of glass at the time it is manufactured at the factory. It is noted, however, that in these control methods the glass is first submitted to a re-anealing process before specific gravity determinations are made. It has also been shown that the cooling process to which glass is submitted may influence the specific gravity and that differences in the same sample have varied as much as 0.065.[6]

If the criteria collected in these few samples may be used to base a conclusion, then it would appear that specific gravity comparisons would be of doubtful value unless some method is devised other than that which has been stated in the literature up to the present time. It also indicates that further studies should be made on this subject in an attempt to arrive at a method by which such a physical fact could be used to advantage in determining identity. Since specific gravity changes due to composition of glass is seven times greater than corresponding refractivity changes[7], specific gravity would be a better criterion if a

[4] Peters, C. G. & Cragoe, C. H. "Measurements on the Thermal Deletation of Glass at High Temperatures", Bureau of Standards, Scientific Paper No. 393, (Aug. 1920) 455.

[5] Glaze, F. W., Young, J. C., & Finn, A. N. "The Density of Some Soda-Lime Silica Glasses as a Function of the Composition.", Bureau of Standards Jour. of Research, *9:* 6, (Dec. 1932) 799.

[6] Young, J. C., Glaze, F. W., Faick, C. A., & Finn, A. N. "Density of Soda-Potash-Silica Glasses as a Function of the Composition." Bureau of Standards, Jour. of Research, *22:* 4., (April 1939) 455.

[7] *Op. Cit.*, Note 5, p. 803.

constant could be found. It is not the intention of this writer to minimize the use of specific gravity as a physical determinant in identification, but on the contrary, at the outset, it was intended that these experiments might offer more conclusive proof to the use of specific gravity as an identifying factor. Since specific gravity is used as a composition control in Soda-lime-glass by the manufacturer, there should surely be some procedure by which investigators in criminal investigations could use this means to determine identity beyond the point of mere corroboration.