

LABORATORY AND PLANT

Need of a New Table for Specific Gravity and Per cent of Glycerol¹

By L. W. Bosart

CHEMICAL DIVISION, PROCTER & GAMBLE CO., CINCINNATI, OHIO

Various tables have been published showing the relation of the specific gravity and per cent glycerol on purified glycerol. Of these, the tables of Gerlach, Nicol, Lenz, Strohmer, Fabian, Metz, and Skalweit may be mentioned.

In discussing the various tables, Lewkowitsch quotes Morawski as authority for the statement that "Gerlach's and Skalweit's values agree among themselves and with the results of elementary analysis."² For the sake of convenience, Gerlach's and Skalweit's tables from 100 to 90 per cent are here given:

GERLACH			SKALWEIT		
Glycerol Per cent	Sp. Gr. 15°/15° C.	Sp. Gr. 20°/20° C.	Glycerol Per cent	Sp. Gr. at 15° C.	
100	1.2653	1.2620	100	1.2650	
99	1.2628	1.2594	99	1.2625	
98	1.2602	1.2568	98	1.2600	
97	1.2577	1.2542	97	1.2575	
96	1.2552	1.2516	96	1.2550	
95	1.2526	1.2490	95	1.2525	
94	1.2501	1.2464	94	1.2499	
93	1.2476	1.2438	93	1.2473	
92	1.2451	1.2412	92	1.2447	
91	1.2425	1.2386	91	1.2421	
90	1.2400	1.2360	90	1.2395	

A. Grün and T. Wirth³ determined the specific gravity of glycerol which had been purified by distilling twice in vacuo and drying over phosphorus pentoxide for 5 mo. They found $1.2653 = 0.0001$ at 15°/15° C. This is the figure given by Gerlach for pure glycerol, and they therefore concluded that Gerlach's table was the most trustworthy. This is undoubtedly true as far as the table for 15°/15° C.⁴ is concerned, and yet certain facts must be taken into consideration that tend to show that the results are not as accurate as desirable. It must be considered that Gerlach's determinations were made by displacing glycerol with a plummet, a means which must have been very crude as compared to the pycnometer method which is now almost universally used for this work, and with which quite accurate results to the fourth decimal place are possible. His plummet displaced 86.500 g. water and 109.45 g. pure anhydrous glycerol, both at 15° C. The specific gravity of pure glycerol was therefore

$$\frac{109.45}{86.50} = 1.2653.$$

According to the figures given in Gerlach's paper⁵ he made determinations on 100 per cent glycerol, 90 per cent, etc., that is, at every 10 per cent. It is significant that the digit in the fourth place is always 0 except with 100 per cent and 10 per cent glycerol, and in the latter case, the digit is 5. It is apparent that Gerlach made no attempt to figure his results closer than the third decimal except in the two cases mentioned, which was quite correct if the fourth decimal place was not significant with the method he used. For percentages between 100 and 90 per cent, between 90 and 80 per cent, etc., the specific gravity was obtained by interpo-

lation. Here, however, he has carried his figures out to the fourth decimal place, which gives the table an appearance of accuracy which does not exist. Despite these defects, the figures appear to be fairly close to the truth.

In a communication to the writer A. C. Langmuir, who was chairman of the subcommittee on glycerol analysis of the AMERICAN CHEMICAL SOCIETY, stated that in his opinion Gerlach's table was the most accurate of those published and was nearly correct in the higher concentrations. He also stated that on a sample of glycerol elaborately purified he had obtained 1.2653 for 100 per cent and 1.2524 for 95 per cent, both at 60° F., thermometers and weights calibrated by the U. S. Bureau of Standards. 1.2653 at 60° F. would equal 1.2655 at 15° C., and 1.2524 at 60° F. would equal 1.2526 at 15° C. It will be seen, therefore, that Gerlach's table, which gives 1.2653 for 100 per cent glycerol and 1.2526 for 95 per cent glycerol at 15° C., agrees very closely with the results of Langmuir.

If, however, we consider Gerlach's table for 20° C., we find there is something very decidedly wrong. The following table shows Gerlach's figures for 100 and 95 per cent glycerol at 15° C. and 20° C., and also their values calculated for 20° C. and 25° C., assuming Gerlach's values for 15° C. to be correct and using the correction for expansion of glycerol given by Comey and Backus:¹ 0.00061 for 20° C., and 0.000615 for 25° C.

Glycerol Per cent	GERLACH		CALCULATED	
	15° C.	20° C.	20° C.	25° C.
100	1.2653	1.2620	1.2634	1.2617
95	1.2526	1.2490	1.2507	1.2490

The specific gravity of 95 per cent glycerol at 25° C., 1.249, given in the Pharmacopeia, agrees with the calculated value. The value 1.2490 for 95 per cent glycerol at 20° C. given by Gerlach is, therefore, obviously incorrect. The same is true of 100 per cent glycerol, for which Gerlach's value at 20° C. is quite close to the calculated value at 25° C. A number of tests made on glycerols of lower densities (from 90 to 40 per cent) agree closely with Gerlach's values at 15°, but the values for 25° were approximately those of Gerlach at 20°. It would seem fairly well established, therefore, that Gerlach's table for 20° is in reality approximately correct for 25°.

It would be a very valuable contribution to the study of glycerol if some one were to get out a new set of tables based on accurate determinations made with the best modern facilities. In September 1911, the subcommittee on glycerol analysis of the SOCIETY reported that a new specific gravity table had been prepared, using as a basis a sample of C. P. glycerol which was shown to be practically anhydrous (within a few hundredths of a per cent).² We do not know what has become of this table and, as far as we know, it has never been published. Certainly if it was not completed, a new one should be prepared.

CONCLUSIONS

It has been shown that the most reliable table for specific gravity and per cent glycerol is that of Gerlach at 15° C. This is sufficiently accurate, at least in the higher concen-

¹ Received March 14, 1921.

² "Chemical Technology and Analysis of Oils, Fats, and Waxes," 5th Ed., 3, p. 384.

³ *Z. angew. Chem.*, 32 (1919), 59; *J. Soc. Chem. Ind.*, 38 (1919), 295a.

⁴ Hereafter whenever the temperature is given at which a specific gravity determination has been made, it will be understood that water at the same temperature is taken as unity and the temperature given simply with one figure, as for example, 20° C. instead of 20°/20° C.

⁵ *Chem. Ind.*, 1884, 277.

¹ THIS JOURNAL, 2 (1910), 16.

² *Ibid.*, 3 (1911), 860.

trations, for practical purposes, but the fact that Gerlach did not attempt accuracy in the fourth decimal detracts from his work.

Gerlach's table for 20° C. should be discarded entirely, but it is not likely that this temperature is used to any extent, the temperatures mostly in use being 15° C., 15.5° C., 25° C., and 60° F.

New tables should be prepared for these temperatures, but until this is done the following rule can be adopted with the assurance that one will not be very far from the truth:

For 15° C. use Gerlach's table for that temperature; for 15.5° and 60° F. deduct 0.0002 from the specific gravity shown in Gerlach's table for 15° C. (for the higher percentages); and for 25° C. use Gerlach's table for 20° C.

The Sewage Testing Station of the Illinois State Water Survey Division¹

By Edward Bartow

DEPARTMENT OF CHEMISTRY, STATE UNIVERSITY OF IOWA, IOWA CITY, IOWA

The Illinois State Water Survey began the study of the activated sludge process of sewage treatment in November 1914, and had progressed by stages through bottle experiments, experiments in a box 9 in. square and 4 ft. deep, comparative experiments in four tanks 3 ft. 6 in. square and 10 ft. deep, all on the fill and draw system, to experiments in the original Champaign septic tank 18 ft. by 49 ft. and 9 ft. deep, working on the continuous flow system.

Combined with the study of the process were studies of the amount of oxygen in the influent and effluent air, the bacterial flora, and the fertilizer value of the sludge formed.

The results obtained were very good, and the continuance of the work was planned, when it became necessary to discontinue it almost completely because several of the staff were called upon to enter the Army. The same conditions existed almost everywhere, and little that was new had been learned about the process by the fall of 1919, when members of the staff returned to the Division.

A small appropriation had been made for the biennium 1917-19, which was not used and had been reappropriated for the biennium 1919-21. With this as a nucleus the testing station is being revived. The Division funds have been supplemented by contributions or loans of instruments, apparatus, and machinery. The several Sanitary Districts in the State have promised their cooperation and support. Several manufacturing concerns have loaned apparatus for the work. Tanks, machinery, a blower, a filter press, a continuous filter, and a dryer have been obtained in this way.

It is not proposed to confine the experimental work to the activated sludge process, but to try other methods of sewage treatment as time and funds permit. Many cities in Illinois are located on large streams into which a partly purified sewage can be emptied. It is therefore proposed to construct and test the efficiency of methods of primary treatment, such as the Doten tanks used in the Army, the separate digestion tanks used by the Housing Corporation, and other similar schemes that may be developed.

Owing to the limited amount of funds, all of the schemes cannot be tried at once, and it has been decided to make a study first of the Dorr-Peck modification of the activated sludge process, with additions so that the process will be complete from the raw sewage to the clarified and purified effluent, and the dried sludge ready to be used as a fertilizer.

The plant is located on land belonging to the city of Champaign, near the outfall of the Champaign sewer. The site is well adapted to the purpose. Before entering the distributing chamber, formerly used in connection with the Champaign septic tank, the sewage is about on a level with the ground, and after passing the manhole the by-pass is enough lower to allow the sewage drawn from the upper level to flow by gravity through a small grit chamber, and

through any screening devices that are to be tested, and then to return to the sewer.

SCREENING

Only one screen has been installed, used by the designers for screening tannery wastes. The water passes from the outside to the center of a revolving drum. The drum is rotated at such a rate that some of the screened liquid is carried up the inside of the drum, and flows out through the holes in the screen, thus automatically cleaning the outside surface of the screen. While it is planned to have each part of the plant large enough to treat 100,000 gallons of sewage daily, the screen will be large enough to handle 200,000 gallons, and it will be possible to test its capacity, as the branch tapped into the main sewer will carry 400,000 gallons. There are two notable advantages in the arrangement of the system:

1—The amount of sewage that can be screened is not limited by the capacity of pumps.

2—The pumps will deliver screened sewage and there will be no danger of clogging the suction pipe.

An extra drum will be provided so that, with practically no loss of time, the drums can be changed and different sizes and different arrangements of holes can be tried.

PUMPING

The screened sewage passes from the interior of the drum through an opening in one end to the pump pit, from which it is delivered to the aeration compartment of the tanks by two centrifugal pumps having a combined capacity of 200,000 gallons. It is proposed to limit the flow, at least at first, to 100,000 gallons daily.

AERATION

The sewage enters the lower part of a cylindrical tank 17 ft. in diameter and 13 ft. deep. The tank is divided horizontally into two nearly equal parts by a tray, which is slightly higher in the middle than at the edges. The air is forced into the aeration chamber through filter plates arranged in an inscribed square. Any sludge that may settle to the bottom is carried by scrapers toward the circumference. The air carries the sludge and sewage to the under side of the tray, which holds the air in suspension, as it travels toward the center to a level above that of the liquid in the tank. As the air escapes part of the liquid passes down a central downcast well into the lower compartment to be mixed again with the incoming sewage, and part passes into the upper compartment that serves as a settling chamber. Holding the air in the lower compartment below the tray has resulted in a great reduction of the amount of air required. According to tests made at Mt. Vernon, N. Y., the process will operate with one-third of the air required when it is allowed to rise directly to the surface and escape.

SLUDGE SEPARATION

Part of the liquid from the upcast well passes over the outer rim, which can be raised and lowered to get the proportion desired in the settling chamber. In the settling cham-

¹ Presented before the Division of Water, Sewage, and Sanitation at the 60th Meeting of the American Chemical Society, Chicago, Ill., September 7 to 10, 1920.