

TABLE 3
Unit Refractivity Change (UAR)

Solvent	UAR $\times 10^6$	Solvent	UAR $\times 10^6$
Methyl alcohol	2.5	Heptane	19.2
Ethyl alcohol	5.4	Octane	22.7
n-Propyl alcohol	8.6	Cymene	25.9
n-Butyl alcohol	11.6	Cyclohexane	15.1
Amyl alcohol	14.3	Cyclohexene	14.4
Methyl amyl alcohol	16.7	Cyclohexanol	15.4
Ethyl formate	8.7	Cyclohexanone	13.7
Ethyl acetate	11.6	Methyl cyclohexane	17.5
n-Butyl acetate	18.0	Methyl cyclohexanone	16.3
Amyl acetate	20.4	Benzene	14.4
Ethyl propionate	14.7	Toluene	17.5
Furfural	13.1	Xylene	20.4
Acetone	7.6	Ethylbenzene	20.1
Butanone	10.2	Pyridine	12.7
Pentanone	13.1	Chloroform	11.3
Hexanone	16.1	Carbon tetrachloride	14.6
Hexone	16.6	s-Dichloroethylene	10.8
Heptanone	19.0	Trichloroethylene	13.7
Octanone	21.9	Tetrachloroethylene	16.9
Mesityl oxide	16.3	Ethylene dichloride	11.1
Isophorone	19.2	Propylene dichloride	13.6
Ethyl ether	11.9	Dichloroethyl ether	16.9
Isopropyl ether	17.8	Chlorobenzene	17.5
n-Butyl ether	23.0	Ethyl bromide	9.5
Cellosolve	11.6	Ethylene bromide	14.3
Dioxane	11.3	Ethyl iodide	12.8
Pentane	13.4	Carbon disulfide	11.3
Hexane	16.6	Water	-0.28

The refractivity of a mixture of vapors is the sum of the refractivities of the components. Water vapor gives a negative reading and if it has not been removed from the atmosphere to be sampled, any difference between the humidity of the atmosphere in which the zero point was set and the atmosphere to be sampled must be measured and taken into account.

2. Portable Orsat

The portable Orsat¹⁰ consists of a 100-ml. gas buret and four pipets: one containing sodium hydroxide, one alkaline pyrogallate, one acid cuprous chloride solution, and the fourth being a slow combustion pipet for burning combustible gases. The apparatus is suitable for the determination of carbon dioxide, oxygen, nitrogen, methane, and some other combustibles, including carbon monoxide in high concentration. Concentrations of carbon monoxide high enough to be detected

¹⁰ W. P. Yant and L. B. Berger, *U. S. Bur. Mines Miners' Circ. No. 34*, 1936.

by this device are, however, immediately dangerous to life. The limit of accuracy is 0.2 to 0.3 per cent. The chief application of this device is in the analysis of the atmosphere in mines.

3. Combustion Devices

Combustible Gas Indicators. Combustible gas indicators of numerous kinds are available. In the majority of these instruments the atmosphere to be tested is drawn across a platinum filament which is heated by a dry cell. This filament forms one arm of a Wheatstone bridge and is balanced before use against another heated filament in an inert atmosphere. Any combustible gas in the sample drawn across the hot filament is oxidized or burned catalytically, which burning results in an increased temperature of the filament and a consequent increase in resistance to the flow of electricity. The increase in resistance is proportional to the amount of flammable gases or vapors in the sample and is measured by a meter that has a scale calibrated for certain classes of vapors to give readings directly in percentage of the lower flammable limit. The sensitivity of these devices varies from the less sensitive, calibrated in fourths of the lower flammable limit, to the most sensitive type, calibrated to a few p.p.m. These instruments are very useful in locating sources of combustible gases or vapors and in evaluating fire and explosion hazards. One of the most sensitive type is termed a "benzene indicator." All of them should be checked periodically against known mixtures of the vapor to be analyzed.

Carbon Monoxide Indicators. Carbon monoxide is perhaps most satisfactorily measured by drawing the air to be analyzed, at a constant rate, through Hopcalite, in which sensitive thermocouples are located. The Hopcalite catalyzes the union of carbon monoxide with oxygen to form carbon dioxide, and the heat generated by this reaction is converted to electrical energy by the thermopile and registered by a recording potentiometer or a millivoltmeter.¹¹ The air to be analyzed must be dried by suitable means, and must be freed of interfering combustible gases by drawing it through an activated carbon filter. Hydrogen, methane, and nitrogen dioxide are not readily removed by this treatment and, if present, will yield high results.

Self-contained, portable instruments embodying the above principle are available. These portable instruments are sometimes subject to significant errors caused by variations in humidity and temperature, especially where measurements below 100 p.p.m. are desired. The difficulty of establishing constant zero readings can be lessened by recirculating the air through the instrument. This is especially helpful in cold weather when the air to be measured is warm and the reference air would be cold, or when the reference air is suspected of containing traces of carbon monoxide. Since this instrument is also subject to altitude fluctuations, it is unsuited to measuring low but significant amounts of carbon monoxide in airplanes.

¹¹ S. H. Katz, D. A. Reynolds, H. W. Frevert, and J. J. Bloomfield, *U. S. Bur. Mines Tech. Rep. No. 355*, 1926.

¹² Carbon Monoxide Indicator, Mine Safety Appliances Co., Pittsburgh, Pa.