Apparatus and methods for determination of dusts in stack effluents are described

by Louis C. McCabe

SILVERMAN (*5*) recently published a tabular comparison of devices used for stack effluent and aerosol sampling. The A.S.M.E. test code (*2*), adopted in 1941, was designed to cover tests on dust-separating equipment installed with solid fuel-burning furnaces but it has been applied to a much wider field. One of the most thorough treatments of gas and dust measurements (*6*) is Western Precipitation's bulletin. Some modifications of existing sampling methods (*4*) are in use in Los Angeles, where a wide variety of stack sampling problems are encountered.

Impinger method of sampling

In all stack analyses for dust loading, whenever a wettable dust is encountered, the impinger method of collecting the sample is used (Figure 1, *a*) except in instances of very high stack temperature. This apparatus consists of a glass sampling tube, five 500 Smith and Greenburg impingers, and a Whatman paper thimble enclosed in a glass holder for visual observation during the test. Glass sampling tubes of different diameters provide a selective range of sampling rates. In most analyses with the impinger method, borosilicate glass sampling tubes are used, but where moderately high temperatures are encountered Vycor tubes may be used to good advantage. Because dry test meters operate best at a rate not exceeding 2 cubic feet per minute, samples are collected at from 0.5 to 1 cubic foot per minute.

The first impinger in the train is operated dry, and if dust of large particle size is encountered the impinger tube is removed and a tube of large diameter bore is substituted. This procedure collects the large particles and prevents them from plugging the jets in the following impingers.

The second, third, and fourth impingers are operated wet with a known volume of water in each and are maintained in a cooling bath. At the end of the test all collected water is measured and any excess is converted into its vapor volume, which is added to the meter reading. The fifth impinger is operated dry and collects any mist carried over from the wet impingers, thereby ensuring that the Whatman thimble will remain dry. Any dust passing through the impinger train will be collected in the thimble.

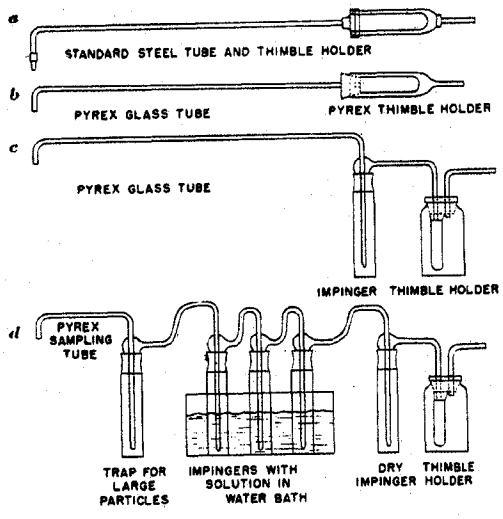

Figure 1. Stack Sampling Apparatus

The use of glass sampling tubes and glass impingers has a two-fold advantage. The dust can be readily seen in the sampling tube and its removal, therefore, is assured. In a wettable dust the largest portion of the sample is collected in the impinger. Because little dust is collected on the thimble, there is less tendency for the pores to become clogged, and the testing pressures are more constant. This results in a more accurate conversion of the meter volume to standard conditions.

MODIFICATION OF IMPINGER METHOD. In addition to the standard method of using five impingers to collect the solids in dust loading analyses, this method is readily adaptable to the collection of oil mists and fumes. Selective solvents such as alcohols, ethers, mineral oils, or carbon tetrachloride may be substituted for the water in the impingers to collect the oil mists. Because of the high evaporation rate, the volume must be carefully measured before and after the test. The vapor volume of any loss must be subtracted from the meter reading, as this volume is not a part of the stack gases.

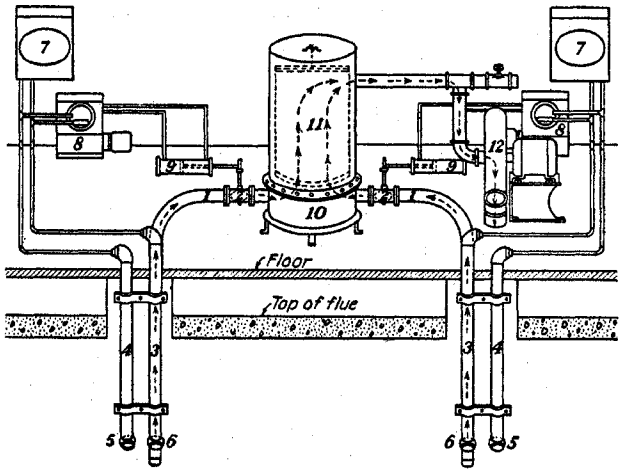

Figure 2. General Arrangement of Automatic Multiple Smoke Sampler

1-1. Sampling pipes
2-2, 9-9. Butterfly dampers
3-3, 4-4. Impulse lines
5-5, 6-6. Piezometer rings
7-7. Differential pressure recorders
8-8. Controllers
10. Filter holder
11. Filter fabric
12. Suction system

If the stack gases are wet, extra impingers need not be used to wet the solids. Stack gases from a spray tower is an example of a test of this nature. In tests of this type only one impinger is necessary to collect the excess water and to prevent the thimble from becoming wet (Figure 1, *b*). In practice, sufficient water is placed in the impinger just to wet the impinger plate at the start of the test.

Where the fumes are not wettable and the only moisture present is the product of the (*Continued on page 78 A*)

combustion of the fuel, impingers provide little or no advantage, except to cool the gases. Tests on nonferrous operations, particularly zinc oxide fumes from brass foundries, are typical examples. In tests of this nature, a glass sampling tube connected directly to a glass thimble holder has proved successful (Figure 1, *c*). The simplicity of this apparatus provides for quick, multiple testing.

STANDARD STEEL SAMPLING TUBE. The standard stainless steel sampling tube (Figure 1, *d*) with extra tapered nozzles of different diameters for selective meter rates and the metallic thimble holder are standard equipment. This type of apparatus is used where high temperatures are encountered. In order to cool the gases as much as possible and to prevent the thimble from becoming charred, an extra length of stainless steel tubing surrounded by a metallic water condenser has been used to advantage.

DETERMINATION OF VELOCITY AND VOLUME OF GASES. The velocity of the stack of flue gases is determined by a standard Pitot tube and an Ellison differential pressure gage if the velocities are 10 feet per second or more. In the few cases where flue velocities are less than 10 feet per second, the differential gage reading is so small that accurate readings cannot be made, and an anemometer, calibrated to give the reading directly in feet, is used.

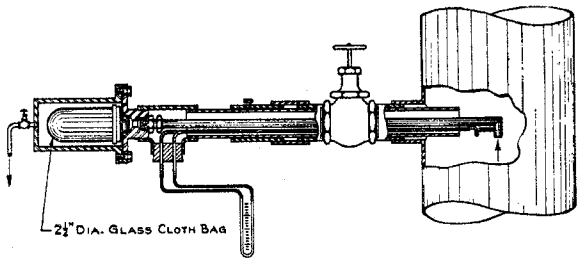

Figure 3. Improved Dust-Determination Apparatus Equipped with Pressure-Indicating Nozzles

In some instances the dust loading is heavy enough to cause serious plugging of the small holes in the standard Pitot tube and therefore give erratic static pressure readings. A special Pitot tube may be constructed with a larger static pressure opening which faces 180° from the similar opening in the velocity head tube. These tubes do not give the same differential pressure as recorded by the standard tube and each tube must be calibrated against a standard tube before use. Once calibrated, however, the calibration remains constant for the life of the tube.

AUTOMATIC AND STATIC PRESSURE STACK SAMPLERS. An improved automatic sampler (*3*) (Figure 2) for accurate determination of dust losses is in use in smelter operations of the American Smelting and Refining Company and a heavy-duty apparatus (*1*) (Figure 3) with static pressure-indicating nozzles has been developed by the Bethlehem Steel Company for determination of dusts on open hearth, boiler, and sintering plant stacks.

Literature cited

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(6) Western Precipitation Corp., Los Angeles, Calif., *Bull.* **WP50**, 4th ed. (1948).