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NATIONAL BUREAU OF STANDARDS
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LOSSES OF GASOLINE IN STORAGE AND HANDLING

The National Bureau of Standards receives many inquiries regarding the extent of the losses which may be expected in the storage and handling of gasoline, and in order to summarize the available information and expedite the answering of these inquiries, this letter circular has been prepared. There appears to have been little research of a comprehensive nature on handling and small scale storage losses and much of the published information is applicable only under very restricted conditions and to specific types of equipment. Much suggestive information, based on large scale storage, may however be found in Bureau of Mines Bulletin 379, 1934.

Evaporation Losses (Ref. 1)

Evaporation losses on stored gasoline will depend upon (1) the vapor pressure of the gasoline, (2) the storage temperature, (3) the volume of vapor space in the tank, and (4) the amount of air circulation into or out of the tank.

If any vented tank or container is partially filled with gasoline at a constant temperature and at a constant barometric pressure, a sufficient amount of gasoline will evaporate to saturate the air in the tank. During this process, the air and vapor will expand somewhat and part of the mixture will escape through the vent. The escaping mixture will be mostly air, since the vapors are heavier than air and will tend to remain close to the liquid surface.

When this equilibrium has been reached, the pressure in the tank will remain the same as that outside and there will be no escape of gasoline vapor, except such as takes place by slow diffusion from the vent. If the vent is as small as practicable, losses of gasoline under these conditions are extremely slow and usually negligible. In the unusual case, where the temperature is above the boiling point of the gasoline, the vapor will continue to escape and losses may be large.

However, constant temperature and barometric pressure are not to be expected. If the temperature rises, an additional amount of gasoline will evaporate, there will be an expansion in the volume of gases and of gasoline in the tank, and some of the vapor and air will be forced out of the vent. If the

temperature falls, the contraction in volume of gases and of the gasoline in the tank will draw in fresh air which in turn will become saturated with vapor. Fluctuating temperatures therefore result in a gradual loss of vapor from a partially filled tank. This process is commonly called 'breathing'. The losses will be somewhat proportional to the volume of vapor space in the tank, and a tank nearly full will lose much less than one which is nearly empty. Losses of this kind in a vented tank above ground may be considerable due to daily temperature changes. For underground storage tanks, the temperature changes are probably negligible, except when a fresh supply of gasoline is added.

Changes in barometric pressure have much the same effect as changes in temperature. When the barometer rises, fresh air is forced into the tank and when it falls, some of the air-vapor mixture is forced out. In this case also, the loss is proportional to the vapor space and a tank nearly full suffers only slight losses. Such losses, due to changes in barometric pressure, occur both in underground and exposed tanks.

Breathing losses may be reduced by underground storage, and by automatic vent valves on the tanks. Under favorable conditions of suitable equipment and underground storage at 60°F or below, such losses should not be more than a few percent of the tank capacity per year. For storage in exposed tanks, these losses may be somewhat greater.

Considerable information on evaporation losses in large tank storage has been obtained by the Bureau of Mines (Ref. 2). Two very interesting papers on losses in this type of storage may also be found in the Proceedings of the American Petroleum Institute (Ref. 3). Losses from exposed tanks may be minimized by the use of insulated roofs, by painting the tanks with aluminum or other reflecting paints, by covering the outside of the tank with aluminum foil or other shiny material and by the use of rubber balloons attached to the vent, to permit expansion and contraction of the vapors without appreciable loss.

The above considerations are concerned exclusively with the losses which occur after the gasoline is in the tank, and are applicable both to conditions of long time storage and to conditions where portions of the gasoline are withdrawn from time to time. An additional loss, however, occurs in the operation of filling the tank with a new supply.

Assume a 1000-gallon tank nearly empty. It will contain from 1 to 5 gallons of gasoline in the form of vapor depending on the temperature and vapor pressure of the gasoline in

the bottom of the tank. If this tank is then filled with fresh gasoline, the vapor is forced out of the vent and lost. This loss appears to be practically unavoidable, except with those types of hydraulic systems where the vapor space is always kept at a minimum. In the usual type of storing and dispensing system, up to about 0.5 percent of the previous tank full may be lost on refilling.

Thermal Expansion

All gasolines expand with increase in temperature and contract in volume when the temperature is lowered. On the average, the volume of gasoline changes approximately 1 percent for every 17°F change in temperature. More accurate values for the volume change with temperature may be found in the National Standard Petroleum Oil Tables (Ref. 4), or in the Abridged Volume Correction Tables (Ref. 5).

In the wholesale transactions involving large shipments of gasoline, it is customary to take into consideration the volume change with temperature, and to correct all volumes to a standard temperature of 60°F. If this correction were not applied, differences would result in individual transactions, but if shipments were made both in hot and cold weather, such differences would tend to compensate each other over a period of a year.

In retail transactions, and in tank truck deliveries to service stations, it is not customary to take into consideration the volume change with temperature. The number of gallons of gasoline measured into a service station tank may differ appreciably from the number of gallons which can be withdrawn for sale, there being a loss to the filling station in summer and a gain in winter. This loss or gain is the result of changes in volume which amount to approximately 1 percent for each 17°F difference in the actual temperatures of the gasoline at the time of its purchase and the time of its sale. The extent of the net loss or gain over a period of one year will depend upon the climatic conditions in the locality in which the filling station is situated and upon the relative volumes of sales during different seasons of the year.

Retail Measuring Devices

In general, retail gasoline measuring units are well designed, and when properly installed, adjusted, and operated, may be expected to yield accurate results. Weights and measures officials of the majority of jurisdictions, when testing these devices in use, reject devices having errors in excess of approximately ±0.5 percent. The user of a measuring unit

may readily check its accuracy as frequently as desired, by the use of a standard 5-gallon test measure, and thus guard against inaccuracies which may develop as a result of use, and which may sometimes be in the direction of overmeasure and sometimes in the opposite direction.

General Considerations

In the handling of gasoline at the present time, losses due to evaporation must be considered as normal. In underground storage, all losses due to evaporation should not exceed 1 percent and are usually not more than 0.5 percent of the total gallonage handled. With exposed storage tanks, the evaporation losses may range from 1 to 2 percent. In the case of the retail operator, there are volume losses in hot weather and volume gains in cold weather due to thermal expansion of the gasoline.

For any particular dealer, whether large or small, it should be practicable to arrive at a figure representing normal losses for his particular operations and equipment, by carefully kept records over a period of several weeks at various seasons of the year. If the losses so arrived at appear excessive, attention should be directed towards errors in measuring devices or towards possible leaks in storage tanks and accessory piping.

References

1. Dickinson, National Petroleum News, October 19, 1932, p. 25.

2. U.S. Bureau of Mines Reports of Investigations Nos. 2766, 2834 and 3138; and Bulletin 379.

3. Chenicek and Whitman, Proc. A.P.I., Vol. 11, Sect. III, p. 4, Dec. 31, 1930; Herthel and Mendius, Proc. A.P.I., Vol. 10, Sect. II, p. 21, Jan. 3, 1929.

4. National Bureau of Standards Circular C410, obtainable from the Superintendent of Documents, Government Printing Office, Wash., D. C., at a cost of 20 cents per copy.

5. National Bureau of Standards Supplement to Circular C410, obtainable from the Superintendent of Documents, Government Printing Office, Wash., D. C., at a cost of 5 cents per copy. A similar abridged volume correction table, under the designation D206-36, may be obtained from the American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pennsylvania.