State of California
Air Resources Board

Method 150

Determination of Hydrocarbon Emissions From Fixed-Roof Crude Oil Process Tanks

Adopted March 28, 1986

Method 150

Determination of Hydrocarbon Emissions
From Fixed-Roof Crude Oil Process Tanks

I. APPLICATION

The following test procedures are for determining the mass emissions of hydrocarbon vapors emitted from fixed-roof crude oil process tanks up to 5,000-barrel capacity during normal processing conditions. Depending on processing conditions, larger tanks may require alternative methods that can handle larger volumes of vapor than provided by this method.

II. PRINCIPLE

During the normal operations at a fixed-roof crude oil process tank, all possible points of emission are checked for vapor leaks. The product throughput is recorded. The volume, concentration, temperature, and pressure of the hydrocarbon vapors emitted through a preselected vent on the process tank are measured. The mass emission of hydrocarbons is calculated from these determinations.

III. TEST CONDITIONS

The process tank (or tanks) should be tested for 24 consecutive hours. However, a multi-day test period may be necessary to accommodate the variety process variables and working conditions to which these tanks are exposed. The Air Resources Board shall have the discretion of testing for longer or shorter periods as may be necessary for properly evaluating the system. Usually as close as possible, the system shall be tested under normal operating conditions, and shall be operated in accordance with established operating procedures.

IV. EQUIPMENT REQUIRED FOR CRUDE OIL PROCESS TANK TESTING

A. Volume meter (six-inch turbine meter) with a capacity to measure 30,000 cfh. (849 m^3/hr).

B. One (1) flow meter (two-inch positive displacement types) with a capacity to measure 3,000 cfh. (84.9 m^3/hr). Another similar flow meter may be required to measure intake volume.

C. Manifold with thermocouple, pressure, and HC analyzer taps for attaching the flowmeters to the vent of the process tank.

D. Pressure/check valve that attaches to the exhaust side of the turbine meter.

E. Pressure relief valve on the exhaust side of the out-breathing positive displacement meter. Set to open just before any of the tank's normal pressure relief valves.

F. Vacuum/check valve for attaching to the inlet side of the in-breathing positive displacement meter.

G. Couplers for attaching volume meters to the manifold.

H. Flexible hose (two-inch) for connecting in-breathing positive displacement meter to vacuum/check valve.

I. One hydrocarbon analyzer (either FID with long capillary or ARB approved equivalent) with an internal operating temperature of at least 200° F (93° C) and a capability of measuring vapor concentrations of 100 percent as propane. The instrument shall be capable of direct analysis of raw vapors from various petroleum products.

J. Two (2) 100-foot sections of heated sample line with controller capable of maintaining the vapor temperature at 225°F (107°C) or higher.

K. One (1) flexible thermocouple or thermister (0-225°F (-17.7°C-107°C) with a recorder system.

L. One (1) pressure sensing device capable of measuring from minus five inches to plus five inches of water with recorder system.

M. Portable combustible gas detector.

N. Barometer.

O. Appropriate containers and devices for collecting grab samples of HC vapor.

P. Appropriate containers and devices for collecting samples of crude product.

Q. Continuous recorders compatible with the output voltages of the analyzers and transducers (i.e., THC, pressure, temperature, etc.) and using strip chart paper with 100 divisions minimum.

V. TEST PROCEDURES

A. The test equipment configuration as shown in Figure 1 shall be designed to duplicate, as close as practical, the original pressure/vacuum conditions of the tank. In general, when replacing existing equipment with test equipment, the test equipment shall not create a burden upon the tank in excess of that originally imposed by the existing equipment.
To avoid creating a potentially hazardous work environment, the test shall be conducted in compliance with safety practices observed by the petroleum industry and with the rules and regulations promulgated by government agencies.

B. Inspect tank and associated equipment including pressure/vacuum for liquid and vapor leaks. A portable combustible gas detector may be valuable for detecting fugitive vapor leaks. Any leaks detected should be noted and an estimate should be made of the quantity of the leak. This information should be recorded in the source test. If an estimate within the accuracy of the test cannot be made, then corrective action must be taken.

C. Connect the manifold to a vent of the tank (see Figure 1).

D. Connect the volume meters and check valve to the manifold (see Figure 1).

E. Connect the pressure and vacuum relief valves as appropriate (see Figure 1).

F. Connect one end of the heat trace line to the appropriate tap on the manifold. (Fire and safety regulations may prevent direct connection.) Connect the other end of the heat trace line to the hydrocarbon analyzer with recorder.

G. Connect the thermocouple (with recorder) to the appropriate tap on the manifold.

H. Connect the pressure sensing device (with recorder) to appropriate tap on manifold.

I. Manually record hourly readings of the volume meters, temperature, pressure indicators, and hydrocarbon analyzer during the test period on

"Field Data Sheet I" (attached). This is in addition to the information collected by continuous recorders.

J. Hourly record tank throughput, tank temperature, liquid level, barometric pressure, and other information that may be desirable on "Field Data Sheet II" (attached).

K. Collect at least three grab samples of the emitted vapors during the test interval for laboratory analysis. (Analysis should include total hydrocarbons, speciate C_1-C_9 and greater than C_9, and other analyses as may be desired).

L. Collect at least three samples of the crude product (see attached Liquid Sampling Procedure for the recommended method) during the test interval for laboratory analysis. (Analysis of the crude oil layer should include specific gravity (60/60°F), Reid or total vapor pressure, initial boiling point, flash point, and speciate C_5-C_{20}, less than C_5 and greater than C_{20}).

M. Optionally, complete the Fixed Roof Tank Evaluation Form (attached).

N. At the end of the specified time, disconnect all instrumentation, couplers, and the spool from the process tank.

VI. CALCULATIONS

A. Total volume of vapors discharged through the process tank vent.

$$V_s = \frac{V_m \times 528 \times (P_b + P_v/13.6)}{T_v \times 29.92}$$

Where:

V_s = Total volume of vapors corrected to 68°F and 29.92 in. Hg. (Ft^3).

V_m = Measured volume of vapors (Ft^3).
P_b = Average barometric pressure (in. Hg.).
P_v = Average pressure in process tank (in. H_2o).
T_v = Average vapor temperature (°R).

B. Weight of HC vapors vented

$$W_r = \frac{C_r \times V_s \times M_r}{385}$$

Where:

W_r = Weight of hydrocarbons vented (lbs.).
C_r = Average concentration (by volume) of hydrocarbons as a decimal fraction.
V_s = From (A.) above.
M_r = Molecular weight of hydrocarbon used to calibrate hydrocarbon analyzer (lbs./lb.mole).
385 = Volume of 1 lb-mole of ideal gas at 68°F and 29.92 in. Hg. (ft^3/lb-mole)

VII. CALIBRATIONS

A. Flow meters. Standard methods and equipment shall be used to calibrate the flow meters. The calibration curves are to be traceable to the National Bureau of Standards (NBS) standards. Additionally, the flow measuring system is to be calibrated as a unit.

B. Temperature recording instruments. Calibrate prior to test period, daily during the test period and immediately following the test period using ice water (32°F) and a known temperature source of about 100°F.

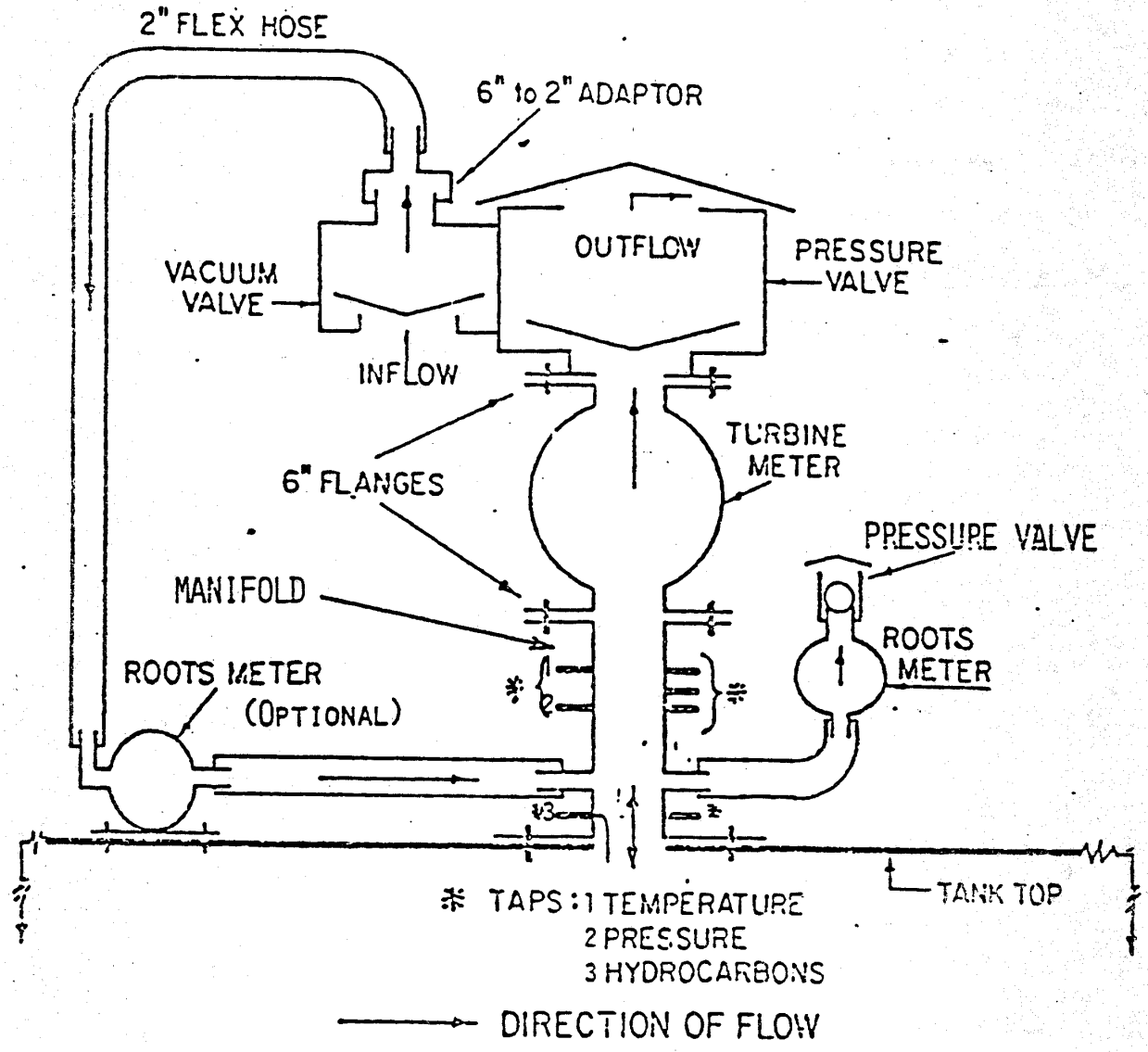
C. Pressure recording instruments. Calibrate pressure transducers immediately before, during, and immediately after test with a static pressure calibration for a range of –5 to +5 inches of H_2O.

D. Total hydrocarbon analyzer. Follow the manufacturer's instructions concerning warm-up time and adjustments. Zero and span the analyzer prior to the test, daily during the test, and immediately following the test with zero gas containing not more than 3 ppm HC and span gases of propane at approximately 30 and 70 percent of full scale.

E. A record of all calibrations made is to be maintained.

FIGURE 1

CALIFORNIA AIR RESOURCES BOARD
Schematic Flow Diagram for
Measuring Hydrocarbon Emissions
From Fixed Roof Crude Oil Process Tanks



150-4

LIQUID SAMPLING PROCEDURE

INTRODUCTION

The sampling method described below has been developed for sampling from fixed-roof tanks and/or sample taps located upstream of the tank. It is the authors belief that this procedure, or one essentially equivalent, is necessary to obtain samples for vapor pressure measurements or light end composition (C-1 to C-6 hydrocarbons) analysis. The method is proposed for use in a study of hydrocarbon emissions from fixed-roof tanks in which emissions correlation with the stored liquid vapor pressure is very desirable. However, the basic method should be applicable to many situations which demand collection of a sample without subsequent evaporation loss. All liquid samples should be obtained immediately prior to starting a test, during a test, or immediately after completing a test, whichever is appropriate for the given test conditions. Samples taken at any other time have to be considered as of no use as they cannot be considered to be representative of the tank's contents during the test period.

SCOPE

This method is designed to avoid evaporation loss while obtaining, storing, and transporting liquid samples.

A. PRECAUTIONS

Vapor pressure and the light end composition are extremely sensitive to evaporation losses. Therefore, when obtaining, storing, or handling samples great care must be taken to ensure having representative samples. Samples which are to be shipped must conform to all applicable federal, state, and local regulations. When samples are obtained from a sample tap by flowing the product through the sample container, all pertinent regulations and precautions against fire, explosion, and other hazards must be observed.

B. SAMPLING EQUIPMENT

(For items 1-5 see Figure 1)

1. Stainless steel sample cylinders with a minimum volume of 300 cc and having valves (needle or ball with at least a ¼ inch opening) at each end.

2. Viton "O" ring equipped Circle Seal Check Valve (Cat. No. 249B-6PP) or equivalent.

3. Seven-foot lengths of 3/8 inch OD stainless steel tubing.

4. Fifty-foot length of 3/64 inch throttle cable with a 3/16 inch N.C. bolt attached to one end.

5. ¾ inch pipe plug with 2 ½ inch long ¼ inch N.C. bolt screwed through it.

6. Appropriate scale with which to weigh the stainless steel cylinders.

7. Suitable connections to allow connecting the sample cylinder to a sample tap if one is available.

8. Wide mouth bottles.

9. Appropriate sampling apparatus to allow lowering a water-filled wide mouth bottle into the tank and inverting it underneath the stock surface.

10. Appropriate range American Petroleum Institute (API) hydrometers.

C. PROCEDURE FOR TANK WITHOUT SAMPLE TAPS

(Refer to Figure 1 for the following instructions.)

1. Insert a clean, dry pipe plug (E) into a clean, dry relief valve (D) and adjust the bolt in the plug to fit firmly against the relief valve. (See NOTE 1.)

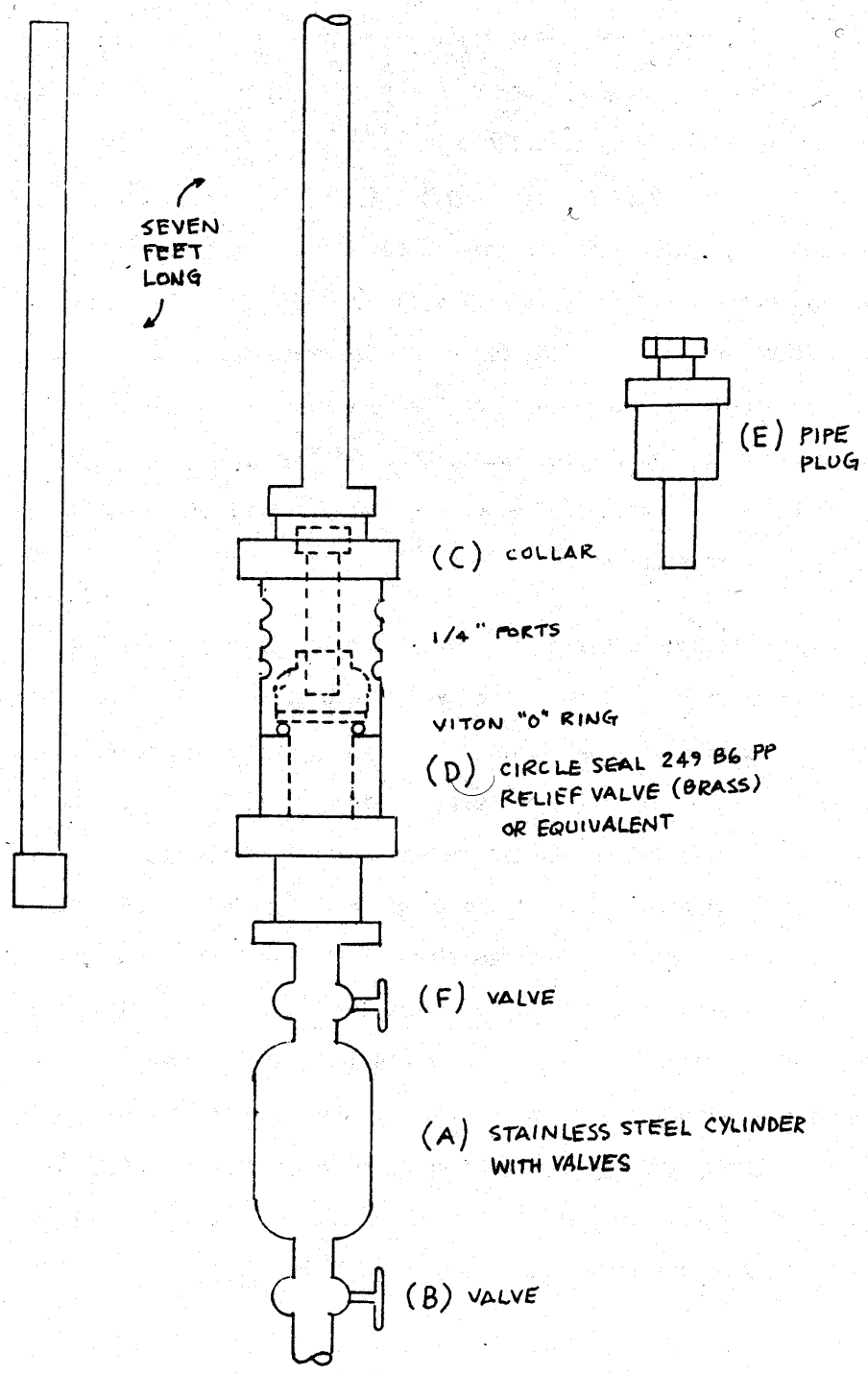


FIGURE 1

LIQUID SAMPLING PROCEDURE

150-13

EEB 04-87

2. Attach this clean, dry relief valve assembly to a clean, dry, preweighed sample cylinder. Open needle valves (B) and (F) and evacuate the entire assembly by suitable means to 1mm Hg or less, absolute. Close the needle valves. It is essential to have a high vacuum in the sampling system when a sample is being taken to ensure filling the cylinder liquid full. If the cylinder and check valve assembly have no minor leaks then the system can be evacuated in a laboratory and the vacuum will be maintained for several days. Alternately, one could have a good vacuum pump and a tilting McCloud gauge (to check the vacuum obtained) and do the evacuation in the field immediately prior to sampling.

3. When ready to obtain a sample remove the pipe plug (E), attach the throttle cable bolt to the relief valve, and attach a clean, dry 3/8 inch O.D. stainless steel tubing to the relief valve assembly. Open valve (F) and submerge the evacuated cylinder 3 to 5 feet (See NOTE 2) below the surface of the liquid then pull the throttle cable to open the relief valve and allow liquid to enter the cylinder. Allow the relief valve to close before removing the filled chamber from the tank. Clean the liquid from the sampling system as it is removed from the tank. Close valve (F) and detach the relief valve assembly. Weigh the sample cylinder and from the liquid weight and the liquid gravity (as supplied by the tank operator or measured on site (See NOTE 2)) calculate the volume of the liquid in the cylinder. If the cylinder is less than 95% full then another sample is to be taken.

4. Hold the sample cylinder in a vertical position and open the bottom valve to drain off a small amount of product so that the cylinder meets the Department of Transportation regulations for shipment. DO NOT OPEN TOP VALVE OR ALLOW AIR TO ENTER THE SAMPLE CYLINDER.

D. <u>PROCEDURE FOR TANKS WITH SAMPLE TAPS</u>

1. If tank sample taps are available then select the tap that is the closest to being 3 to 5 feet below the liquid surface. (See NOTE 2.) Open this tap and allow liquid to flow through it to a suitable receptacle until the residual tap line liquid is completely flushed out.

2. Connect a clean, dry evacuated sample cylinder to the tap with suitable connections. (See NOTE 1.) The cylinder MUST be connected to the sample tap in such a way that it can be filled from the bottom. In general this will probably require having some clean, dry pipe and elbows available which can be used to enable connecting the tap to the bottom cylinder valve. This precaution ensures that any gas formed by flashing when the liquid enters the evacuated cylinder will subsequently be completely flushed out of the cylinder. It is particularly important to

observe this precaution when sampling from a tap where the liquid being sampled is under a positive pressure. Connect a hose to the top cylinder valve to run the excess liquid sample into a suitable receptacle. The sample is then taken by: (a) first opening the tap, (b) second opening the cylinder valve nearest the tap, and (c) third opening the cylinder valve furthest from the tap allowing liquid to flow through the cylinder to the suitable receptacle.

3. When the five liquid volumes have passed through the cylinder isolate the sample by reversing the above operations, i.e. (a) first close the cylinder valve furthest from the tap, (b) second close the valve closest to the tap, and (c) third close the tap valve and then disconnect the cylinder from the tap.

4. Hold the sample cylinder in a vertical position and open the bottom valve to drain off a small amount of product so that the cylinder meets Department of Transportation regulations for shipment. DO NOT OPEN TOP VALVE OR ALLOW AIR TO ENTER THE SAMPLE CYLINDER.

E. PROCEDURE FOR SYSTEMS REQUIRING UPSTREAM SAMPLING

1. If immediately prior to the test tank the liquid product goes through a unit where a pressure reduction occurs then a liquid sample may have to be taken upstream of this unit. Upstream sampling is required for the following three circumstances: (a) the vapors formed in the unit flow directly into the test tank vapor space, (b) because of the reduced pressure entrained gas enters the test tank with the liquid product, or (c) because of the reduced pressure gas bubbles from the liquid as soon as the liquid enters the test tank.

2. If none of the foregoing three circumstances occur the test tank can be sampled by either of the two methods previously described (C or D).

3. If ANY of the circumstances described in E-1 above is true then the liquid sample MUST be taken from a sample tap UPSTREAM of the unit where the pressure reduction takes place. When a suitable tap has been located the sample can be obtained by the techniques given in D above.

NOTE 1:

After each use the sampling apparatus should be thoroughly cleaned with 1,1,1-trichloroethane, or other appropriate solvent, then with a light hydrocarbon solvent. Following the final cleaning the apparatus should be thoroughly dried to remove all traces of the solvent.

The cleaning of the check valve assembly, tap connections, and any part of the apparatus through or over which liquid might pass in going into the sample cylinder is absolutely necessary.

NOTE 2:

Before a liquid sample is taken one should obtain from the tank operator as much information as possible about the tank contents. Of crucial interest is the gravity(ies) of the stock(s) in the tank. Particularly with crude oils it is possible that crudes having more than 2 degrees API gravity difference may be present in the same tank. If this occurs the lighter crude will float on the heavier crude and since evaporation takes place from the surface the liquid sample should consist of only the lighter crude. If the tank operator does not have the appropriate information then liquid samples should be obtained at the following depths below the liquid surface: 1 to 2 inches, 1 foot, 2 foot, 3 foot, and 5 foot. These samples can be taken in wide mouth bottles by the water displacement method. The API gravity of each sample is then determined on site. If there is no appreciable gravity difference then a liquid sample can be taken in a stainless steel cylinder between 3 to 5 feet below the liquid surface. If there is more than 2 degrees API difference in the gravities then the sampling location should be chosen so that the lightest liquid is sampled. The sample can be taken by method D if a sample tap is available at the correct depth, otherwise the sample has to be taken by method C.