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API BULLETIN

ON

LEASE AUTOMATIC CUSTODY TRANSFER

Prepared by Special Project Group on Lease Automatic Custody Transfer
under the auspices of the American Petroleum Institute's
Committee on Crude-Oil Measurements

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FOREWORD

This bulletin, which has been prepared under the sponsorship of the API Committee on Crude-Oil Measurements, summarizes information that has been gained from a study of the experimental and operating systems devised by various companies for automatic custody transfer of crude oil from producing leases. "Automatic custody transfer" consists of the measurement and running of oil from the producers' tanks to the connected pipeline on a completely automatic or unattended basis. To date, the relatively small number of experimental installations do not permit a firm standardization of acceptable practices. This bulletin should therefore be considered as a progress report, issued for the purpose of: 1, advising producing and pipeline companies of what is currently known; and, 2, stimulating further development until generally acceptable methods are in use.

Throughout this bulletin, references are made to *API Standard 2500: "Measuring, Sampling, and Testing Crude Oil"; API Standard 2501: "Crude-Oil Tank Measurement and Calibration"*; and *ASME-API Code 1101: "Code for the Installation, Proving, and Operation of Positive-Displacement Meters in Liquid-Hydrocarbon Service"* (short title: *Petroleum PD Meter Code*). It is intended that these codes be used in all cases where they are applicable, in order to form a sound basis for accomplishing satisfactory automatic custody transfer.

Until a few years ago, all crude oil run from producers' tanks was measured, sampled, and tested by the use of hand tools. For about 30 years the American Petroleum Institute has continuously studied and improved these methods to make them as practical and accurate as possible. In 1954 the Institute approved the use of automatic indicating gages and thermometers on a mutual-agreement basis, and industry is finding them to be accurate and preferable to hand tools in many instances. In recent years, producers have installed automatic devices at lease tank batteries in quite a few fields to eliminate certain monotonous and time-consuming operations. The potential advantages of automatic-custody-transfer systems have led a number of producing and pipeline companies to test the components of which such systems could be made. Also, several companies have constructed and tested full-scale installations of complete automatic-custody-transfer systems.

In many fields it has become apparent that automatic custody transfer offers the potential advantages of:

1. Reduction in required lease storage (which could also mean less evaporation losses and less investment in stored oil).
2. Improvement of measurement accuracy.
3. Reduction of the possibility of error in measurement or in quantity computation.
4. Simplification of computation and accounting procedures.
5. Reduction of time required by pumpers and gagers in making measurements.
6. Improved scheduling of runs on a predetermined basis and made at the most opportune time.
7. Allowing maximum use of other automatic equipment installed primarily for the production operations.

The apparent disadvantages are:

1. Lease equipment needs more precise design and engineering.
2. A more complex system is required.
3. Regular maintenance is required.

The information in this bulletin has been based on evaluation of the experimental automatic-custody-transfer installations which have so far been tested. The practices which it suggests are considered sound and reliable but, since they are based on a limited number of installations, it should be expected that many improvements in these procedures will result from more widespread use of automatic-custody-transfer equipment.

Early standardization of industry practice relating to methods and equipment used in automatic custody transfer is very desirable for three principal reasons: 1, to facilitate establishment of mutual agreement between parties concerned in automatic custody transfer; 2, to reduce the amount of engineering time required in design of automatic-custody-transfer installations; and, 3, to facilitate the periodic inspection of automatic-custody-transfer installations for assurance of their continued satisfactory performance. It is hoped that the information contained in this bulletin will be of assistance in establishing mutual agreement between parties interested in installation of systems operating in automatic custody transfer, and that in so doing it will be of benefit to the industry by leading toward the early establishment of generally accepted good practice.

The material contained herein does not constitute an official code or standard of the American Petroleum Institute; nor is it intended that this material should become part of *API Standard 2500* until such time as industry practice may have become established, and the principles outlined in this bulletin and other principles which may develop in practice have been more generally proved.

The American Petroleum Institute takes no position as to whether or not any method contained herein is covered by an existing patent, nor as to the validity of any patent alleged to cover any such method. Furthermore, nothing contained in this bulletin grants any right, by implication or otherwise, for the manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent; nor does it insure anyone against liability for infringement of letters patent. This bulletin may be used by anyone desiring to do so, but the sponsor shall not be held responsible or liable in any way either for any loss or damage resulting therefrom, or for any violation of any federal, state, or municipal regulations with which it may conflict.

LEASE AUTOMATIC CUSTODY TRANSFER

I—GENERAL

This bulletin is intended to form a basis for mutual agreement between parties concerned in automatic custody transfer of crude oil from producing leases to the connected pipeline. It sets out practices which are intended to provide accurate and reliable measurement and suitable protection against mismeasurement or otherwise faulty operation. Automatic custody transfer, as defined herein, may be used where mutually agreeable to the parties concerned in the transaction and where government or other regulations will permit. This bulletin may also serve as a guide for the installation of equipment to be used in intra-company measurement and in transfer of crude oil on leases or from leases to gathering systems to points of central storage, where regulations permit.

These suggestions are not meant in any way to be restrictive or to retard development of methods found to be either more suitable or more practical than those suggested. Instead, it is hoped that these recommendations will serve as a starting point from which improvements can be made, as developments in equipment and methods warrant.

II—DEFINITIONS

Automatic custody transfer—The automatic determination of quantity and quality* of crude oil in conjunction with the automatic running of that oil into the connected pipeline on an unattended basis and in accordance with any predetermined schedules required.

Cycle—Filling and running of one measuring tank.

Dump—That volume of oil (corrected or uncorrected for temperature) which is delivered to the pipeline in one complete cycle of the measuring tank, or the running of that volume of oil.

Run—A series of dumps or periods of meter measurement, either interrupted or uninterrupted, which are covered by a single run ticket.

III—BASIC SYSTEM REQUIREMENTS

A. General

There are a great number of basic alternative arrangements which could be used to accomplish automatic custody transfer with satisfactory results. It is the purpose of this section to describe the basic requirements that should be met by all systems and to describe some of the various arrangements of equipment for volume measurement which are considered to fulfill these requirements. Optional features which may be desirable under certain conditions are described where appropriate. For convenience, the basic systems are categorized according to the method used for measurement of volume. Briefly, these methods are: 1, parallel-tank measuring; 2, tandem storage with single measuring tank; and, 3, positive-displacement metering.

B. Requirements for All Types

The following list contains the general requirements of any system for automatic custody transfer. Some features are indicated as optional, or to be used by mutual agreement where conditions warrant; and others are applicable where required by regulations.

1. The lease oil handling arrangement must provide ample time for settling to insure that the oil, when measured, is sufficiently stable and free from volatile fractions to permit accurate measurement and, later, conventional

* For the purpose of this bulletin, automatic determination of quality includes any necessary assurance that the oil is merchantable prior to movement of oil from the lease, and automatic sampling for subsequent measurement of quality.

handling and storage without abnormal or excessive losses. The time required for settling is subject to mutual agreement. Depending upon local conditions and the equipment arrangement selected, normal filling or residence time in the system may be ample.

2. Provision must be made for accurate determination and recording of uncorrected volume and average temperature, or of temperature-corrected volume. The overall accuracy of the system must equal or surpass present manual methods.

3. Provision must be made for representative sampling of the oil transferred for determination of API gravity and the BS&W (sediment and water) content.

4. Means must be provided, if required by mutual agreement, to give adequate assurance that the oil is merchantable before it is run.

5. If required by mutual agreement, control shall be provided over the time of oil entry into the system of the purchaser or his agent.

6. Where regulations require, control shall be provided to stop the flow of oil into the system of the purchaser or his agent at the time, or prior to the time, the allowable is run. To eliminate need for partial dumps from systems using tank measurement, this would normally provide for stopping after the last complete dump which could be made without exceeding the allowable. The correction from the preceding period for the difference between the net oil run and the allowable would be applied to the current allowable control setting.

7. The control and recording system must include "fail-safe features" that will provide adequate assurance against mismeasurement in the event of power failure or the failure of the system's component parts.

8. All necessary controls and equipment must be enclosed and sealed, or otherwise be so arranged as to provide assurance against, or evidence of, accidental or purposeful mismeasurement resulting from tampering.

9. All components of the system which require periodic calibration and inspection for proof of continued accuracy must be accessible and arranged for calibration and inspection at a frequency and following a procedure mutually agreeable to the parties concerned.

10. All usual codes, regulations, and standards covering measurement of crude oil shall be used where applicable. This specifically includes *API Standard 2500, API Standard 2501,* and *ASME-API Code 1101.*

C. Equipment Arrangements

The following general equipment arrangements are suggested as satisfactory for measurement of volume.

1. Volume Measurement in Tanks

Either of two tank arrangements are satisfactory for automatic custody transfer, namely: 1, parallel measuring tanks; or, 2, a single measuring tank in tandem with surge or storage tankage.

The capacity of the measuring tank between the upper and lower control levels can be determined by strapping or by means of liquid calibration. Means should be provided for the accurate checking of control levels to determine whether the level controllers are functioning properly.

The following basic methods are suggested for automatic measurement of volume by tank:

a. *Fixed Volume—Weir-Controlled* (See Appendix 1, Fig. 1 and Fig. 5): With this arrangement, the opening and closing levels are established by draining down to the lip of a weir box. The opening gage is established by first filling to a point slightly above the upper-weir level. After a mutually agreed interval, during which the oil should be properly weathered and the surface of the oil settled and calm, and/or at whatever time the run-scheduling timer will allow oil to be run to the pipeline, the oil will be drained down to the upper-weir level. Simultaneously, the temperature of the oil in the tank will be measured and recorded.

The tank then will open and remain open to the pipeline long enough to assure complete draindown to the lip of the lower weir. At this point the pipeline valve will close and, simultaneously, the temperature of the oil remaining in the tank will be recorded, if required by mutual agreement. The control of levels by use of this weir arrangement is considered to be inherently very sound.

b. *Fixed Volume by Reduced Cross-Section Area:* While as yet untested in automatic-custody-transfer operations, the use of tanks having reduced cross-sectional areas at the desired upper and lower liquid levels has sufficient merit to warrant inclusion in this bulletin. Standard prover tanks for calibrating PD (positive-displacement) meters have used this principle in accurate volume measurement for many years. In recent years, this idea has also been used in metering vessels, particularly for testing oil wells; and indications are that it can be used for the accurate measurement of crude oil.

There are actually two methods for using this type of tank which should prove satisfactory in automatic custody transfer. The first and simplest method is to use the level switches located in the reduced cross-sectional areas to control the full and empty levels by causing the inlet and outlet valves to close. It is essential that this type of measuring tank be equipped with very fast-acting valves to reduce the amount of delay between the time the level switches are actuated and the time the liquid flow has stopped. Means may also be used to reduce the inflow and outflow rates to regulate the overshooting of the control level. The second method operates in a manner exactly like that of tanks using weirs to control levels and is suggested as probably the most accurate method for controlling volumes by level control. This system should combine the high accuracy of both the weir and the reduced cross section.

c. *Varying Volume—Float and Tape:* Float-and-tape (automatic gage) measurement is approved by the American Petroleum Institute as a substitute for manual gaging. This type of measurement appears readily adaptable to automatic custody transfer by an automatic recording of the liquid levels after automatic filling or emptying. Temperature measurement would be necessary at the time of top-level measurement and, in some instances, at the time of bottom measurement. To date, the recording mechanism for the float-and-tape measurement systems has not been tested in automatic custody transfer. This system would have the advantage of facilitating manual or partial runs if required in an emergency.

2. Volume Measurement by Positive-Displacement Meter

a. *Introduction:* The purpose of this section is to outline an acceptable and practical method for obtaining reliable and accurate measurements of lease runs for automatic custody transfer by means of the PD meter. The meter is to be a part of a system of devices arranged in such a manner that custody transfer of lease runs can be automatically made while unattended. This section and Part C of Appendix 1 outline procedures and practices for meter selection, installation, operation, maintenance, and calibration, which are considered essential to accomplish the measuring accuracy and reliability required.

To avoid duplication and prevent confusion, it is considered advisable to make use of *ASME-API Code 1101* where portions of that code are applicable to the type of measurement under consideration.

b. *Types of Meters and Definition of Terms:* PD meters are meters which measure a fluid by separating the fluid into segments and count these segments. These meters displace, or carry through their measuring elements, a fixed quantity plus the slippage for each stroke, revolution, or cycle of the moving elements. The terms pertaining to PD metering which are in common usage within the petroleum industry have been set out in the introduction of *ASME-API Code 1101,* and will have the same identical meaning and significance when used in this bulletin. The meter used should be of a type specifically recommended for crude-oil service.

c. *Arrangement of Meter Facilities:* In general, volume-measurement equipment for automatic custody transfer by PD meter consists of tankage for adequate storage with a meter placed in the line discharging from this tankage to the pipeline. If a pump is used for injection into the pipeline or for recirculation of bad oil and/or tank bottoms, it is suggested that the pump be placed upstream of the meter, with a back-pressure valve located downstream of the meter in order to decrease the possibility of metering free gas.

Under certain conditions it is possible that a pump may not be required. It is essential in this case that the system be so designed as to provide an adequate head at the meter, and to provide a sufficiently constant flow through the meter to insure that the rate of flow is in the accurate range of the meter.

The sampler used in obtaining a representative sample of the metered oil should be placed as near the meter as practicable. A monitor may be connected in the line between the sampler and production tank and used to prevent objectionable quantities of BS&W from being delivered to the pipeline, if required by mutual agreement. A check valve should be used to prevent reversal of flow through the meter. A typical arrangement of equipment and auxiliary controls considered satisfactory for automatic-custody-transfer measurements by PD meters are discussed in Part C of Appendix 1, and are shown in detail in Fig. 7.

IV—EQUIPMENT AND INSTALLATION STANDARDS

A. General Standards, Codes, and Regulations

All existing American Petroleum Institute codes and other codes and government regulations shall be used where applicable in design, construction, calibration, and operation of systems for automatic custody transfer.

B. Control Equipment

Control equipment may be electric, pneumatic, or hydraulic. Components should be high-quality materials which are resistant to moisture, corrosion, and dust.

C. Valves

Valves should be of a type that assure tight shutoff; it is preferred that the valve actuators be of a type, or so arranged, that they will permit interruption of the power supply without causing mismeasurement.

D. Weirs

Weirs for level determination may be either internal or external to the tank. In either case, the lip of the weir should be horizontal and sufficiently long to allow reasonably quick draindown to the fixed level. For external weirs, the top of the opening from the tank should be just above the weir edge for maximum utilization of the tank-opening area and for assurance that syphoning or vapor lock will not occur. The weirs should be firmly fixed to the shell of the tank and adequately braced, so that the vertical distance between the upper and lower weirs remains constant.

E. Counting Devices

Particular attention must be given to the methods used for recording the number of dumps from measuring tanks, so that false counts will not result from interruptions in power. It is recommended that at least two independent methods for counting dumps be utilized. A pressure-recording instrument for recording the "head" in the tank at all times is of a particular value, since it will not only provide a check on the number of dumps made, but will also provide a record of the time the tank takes to fill and empty when it tops out and goes on the line. It also provides evidence that the tank fills and empties completely during each cycle.

F. Meter Installation, Operation, and Proving

Each location and application of meters will require a certain amount of individual consideration and, in general, *ASME-API Code 1101* is used as a guide for the installation, operation, and proving of meters.

Methods for proving meters, such as by master meters or portable prover tanks, as outlined in *ASME-API Code 1101*, may be used by mutual agreement. The automatic-custody-transfer installation shall provide a test spool or outlet for these methods, should the parties concerned elect to use them.

Alternatively, the surge tank may be used as the prover tank, if the following described conditions can be met. A suitable portion of the surge tank should be equipped with sight glasses, graduated scales, and thermometers. The surge-tank portion to be so used should be calibrated by water displacement or other methods yielding equivalent accuracy. The minimum surge-tank capacity so used is established by two factors. First, the diameter should be sufficient to provide the required volume within limits fixed by the second factor; namely, that the value of the maximum gage-glass reading error, when expressed as a percentage of error by volume ratio in terms of depth of surge tank so used, shall not exceed 0.05 per cent by volume, thus establishing the minimum depth of surge tank required. (In general, it is suggested that the minimum surge-tank capacity so used should be not less than ten times the maximum rated volume delivered per minute by the largest meter to be proved. It is also suggested that if the surge tank is to be calibrated by field-strapping methods, the portion of the surge tank used should be free insofar as possible from appreciable changes in volume per increment, caused by items such as manhole boxes, significant intermediate deadwood displacement, etc.)

The suggested frequency of calibration should be such that a deviation of meter factor of 0.05 per cent will be detected.

The calibration record for each meter should be kept on file as long as is the run ticket on which it applies. A copy of each official calibration record should be supplied by the meter owner to each party concerned.

To insure satisfactory accuracy in the metered measurement of liquid hydrocarbons, it is essential that associated meter-operating procedures and interparty understandings and relationships in connection with metered transactions be understood and accepted by all concerned.

The degree of accuracy desired in each installation is the governing factor in determining the extent of operation control. As used in connection with lease automatic-custody-transfer service, the greatest degree of meter accuracy should be sought. For successful meter operation, the proving system shall provide good flexibility, and in all cases the proving of meters shall, as nearly as possible, simulate actual operating conditions.

The accurate operation of meters necessitates very careful handling of the various phases of metering which are affected by temperature. Obviously, precision temperature measurement is a prerequisite of precision metering, whether the temperature is determined by an independent thermometer or indirectly by means of an automatic temperature compensator. Providing a reliable automatic temperature-compensating device can be procured for the meter used, this method of obtaining volumes at the base temperature of 60 F is more desirable than using some temperature-indicating or recording device, and then mathematically reducing indicated volumes to 60 F.

In either case, the coefficient of expansion used must be consistent with agreements maintained between the parties concerned.

V—FAIL-SAFE FEATURES

Fail-safe features and interlocks should be included in the design of an automatic-custody-transfer installation to provide reasonable assurance against mismeasurement.

Insofar as any possible mismeasurement is concerned, the producer must install fail-safe features as requested by the purchaser or his agent. The producer can also install, upon mutual agreement with the purchaser or his agent, other fail-safe devices which he considers necessary to prevent mismeasurement.

A. Suggested Fail-Safe Features

1. Sequence of operation of measuring cycle should be retained in event of power interruption.

2. The valves and control system should be interlocked with the inlet valve and float controls so that it is impossible to open the inlet valve on a tank at any time when this would interfere with accurate measurements.

B. Optional Fail-Safe Features

The producer may install other fail-safe features which he deems necessary to the automatic operation of the lease, provided they do not interfere with accurate measurement, such as:

1. An overflow line above the normal upper-fill height in the measuring tank to provide for overflow of oil into an overflow tank in the event of failure of the upper-level control device.

2. An overflow tank arranged so that oil cannot flow from this tank through an open line into a measuring tank.

3. An upper float in the overflow tank or the measuring tank to initiate lease shutdown controls and actuate an alarm in the event oil reaches the level of the float switch.

4. Manually operated valves may be installed in the discharge line on the downstream side of the discharge valve on the metering tank or tanks. Such valves should be sealed in the open position and used only in case of emergency.

VI—EQUIPMENT ENCLOSURES AND SECURITY

Control equipment should be housed and locked or sealed, if necessary. Automatic valves shall be of such design and so connected that operation can only be accomplished through locked or sealed control equipment.

The producer must install such enclosures and tamperproof devices as required by the purchaser or his agent. In addition to these devices, he may install other tamperproof devices, provided that they do not interfere with accurate measurement.

VII—QUALITY MONITORING

A. Protection against Excessive Water Admission

Deliveries from an automatic-custody-transfer installation are made on an unattended basis, and the samples taken for determination of gravity and BS&W content are not analyzed until the run has been made. For this reason, where there is any reasonable probability that excessive water might be run, e.g., as a result of failure or faulty operation of the dehydration facilities, it is considered advisable to install special equipment to guard against admission of such excessive water into the pipeline.

The type and amount of equipment or procedures selected to provide adequate protection are subject to mutual agreement between the parties concerned, and are generally dependent upon the likelihood of occurrence of objectionable quantities of water, and the limit of BS&W content specified by contract.

B. Protection against Running Bad Oil

The following are suggested methods, procedures, and equipment which can be used singly or in combination to afford protection against running bad oil:

1. A water-cut instrument (dielectric monitor) based on measurement of dielectric constant of the measured stream can be installed in the line to the measuring tank or meter and/or to the pipeline, and used either to divert oil containing excessive water back to the dehydration system for further treating, and/or to stop the flow of oil to the measuring tank or meter or to the pipeline.

2. On tank-measuring systems a dielectric monitor can be installed to monitor a stream taken from a point 4 in. below the pipeline outlet prior to the running of the tank; and the monitor can be set to prevent running if the water content is above a preset limit.

3. On tank-measuring systems where oil is extracted from the measuring tank and circulated past an automatic sampler, a dielectric monitor can be installed to monitor the oil so extracted and can be set to prevent running and, if desired, to recirculate the oil in the tank if the water content is above the preset limit.

4. To prevent buildup of tank bottoms to an objectionable level, it is suggested that bottoms be circulated back to the dehydration facilities as required by the rate of buildup. This can be done manually on a routine basis, or automatically by recirculation of total bottoms or a portion thereof after each dump or run, or on signal from a bottoms dielectric monitor or another suitable bottoms-sensing device.

C. Calibration and Recalibration

A dielectric monitor shall consist of a device or instrument designed to measure the dielectric constant of the fluid between the electrodes of a probe mounted in the flowing stream. It shall be calibrated in units of per cent BS&W, and shall have a full-scale range not to exceed 5 per cent of BS&W. Although the overall field-calibration checks shall be made against readings of the centrifuge, the instrument should be equipped to allow simple field checking of its internal calibration or operation by switching to one or more self-contained, standardizing, zero-temperature-coefficient capacitors for calibration reference. The instrument shall be of a type which measures true dielectric constant, independent of fluid electrical losses, in order that the effect of salinity of the water content shall not affect the instrument reading. Since the dielectric-constant reading is affected by the temperature* of the measured stream as well as by the per cent of BS&W, suitable temperature compensation should be used where stream temperatures are expected to vary appreciably. The instrument shall not

* Data, to date, indicate that without compensation, a fluid temperature change of 30 F can be expected to result in a change of calibration equivalent to approximately 0.35 per cent of BS&W.

be affected adversely by reasonable or expected variations in supply voltage or frequency or ambient temperature.

To date, data have shown that readings taken on oil which is not moving through the probe tend to drift upward to a false high reading after the probe is energized. Caution should be taken, therefore, to ensure either that the oil is moving through the probe, or that the readings are taken immediately after the probe has been energized. Movement of oil through the probe at some velocity may also serve to keep the probe clean.

The initial instrument calibration shall be made in conformance with the manufacturer's recommendations, and should be based on measurement of the base dielectric constant of a clean, fresh sample of the specific crude to be measured.

Adjustment of the zero-setting for initial field calibration after installation and for all subsequent field recalibration shall be made on the basis of measurement of the BS&W content of the crude by centrifuge, according to *ASTM Method D 96-46*. Readjustment of the span setting, if required, shall be made by checking against the instrument's reference capacitors.

Recalibration as described hereinbefore may be made at mutually agreed intervals or may be requested at any time by either party, if the instrument readings should deviate more than a mutually agreed amount from the BS&W content measured by the field-centrifuge method.

Probe materials should be selected to resist corrosion by the measured fluid. The coaxial cable used to connect the probe and instrument should conform to the recommendations of the manufacturer and should be selected for minimum ambient-temperature error.

VIII—RUN SCHEDULING

A. Scheduling for Pipeline Load

Pipelines must prorate their capacity equitably among all connected leases. Therefore, in many areas where line-load factors are high, special care must be exercised in scheduling automatic deliveries. There are so many factors present in this problem that no attempt will be made to discuss them here. Any producer contemplating the installation of an automatic-custody-transfer battery should confer with representatives of the receiving carrier. They should work out a system of scheduling which would be mutually agreeable and advantageous to each. Some considerations are:

1. Determine the periods when line capacity would be available.

2. Correlate producer's ability to have oil ready with line-space availability.

3. Determine how many barrels per hour can be received by the pipeline.

4. Determine how much time will be required for each tank dump; determine total time-cycle sequence from tank empty, to full, to empty.

5. Correlate items 3 and 4.

It is likely that automatic scheduling should generally improve pipeline-load factors.

B. Stopping at Allowables

Receiving carriers are held responsible by regulatory bodies for keeping runs from leases within the allowable, where allowables are applicable; and, therefore, such carriers must have assurance that the runs from automatic-custody-transfer batteries do not exceed the lease allowable. Any accurate and reliable system may be used, however, should it meet the following specifications:

1. It must be fail-safe, tamperproof, and sealable in such a way that neither the pipeline's nor the producer's representatives could change the setting without the consent and knowledge of the others.

2. It must be able to be preset for the number of tank dumps, or barrels, in the case of PD meters, that will approach but not exceed the lease allowable in barrels as measured by the system (temperature-compensated or not temperature-compensated).

3. When the preset number of barrels or tank dumps is reached, the system must prevent any further movement of oil from the lease.

4. It must be adjustable in order to take care of allowables changes. Such changes should be made only when representatives of both parties are present.

5. Counters should be visible so that oil deliveries can be checked at any time.

IX—SAMPLING

Samples for determination of API gravity and BS&W content shall be obtained by use of automatic sampling equipment and by procedures as described and set out in *API Standard 2500*. Samples may be commingled during the period of a complete run, provided that the resulting sample is truly representative of the total volume run.

For systems measuring volume either by tank or by PD meter, samples may be taken from the tank just prior to opening the pipeline outlet, provided that the variation in volume measured in consecutive dumps does not exceed approximately 5 per cent. Such samples may be commingled for those consecutive dumps constituting a complete run.

Alternatively, for systems measuring volume either by tank or by PD meter, samples may be taken from the tank-discharge stream to the pipelines, provided that the variation between the rate of sampling and the rate of tank discharge does not exceed approximately 5 per cent.

The number and location of tank-sampling points will depend upon the tank size and, in regard to location and dimension, shall conform with the requirements of *API Standard 2500* for installation of sample cocks. Where more than one sample tube is located in the tank, the samples from all tubes (except the clearance sample or monitor tube 4 in. below the pipeline outlet) may be commingled, provided that the sampling equipment is arranged to withdraw equal sample volumes from each tube. By mutual agreement, purging of the sample tubes and sampler will not be required prior to each dump or run, provided that the volume contained by these lines does not exceed 5 per cent of the accumulated sample volume for the complete run.

X—TEMPERATURE MEASUREMENT

Temperature measurement for correction of volume measured by tank or un-temperature-compensated PD meter to standard temperature shall be made in accordance with *API Standard 2500*, "Part IV—Automatic Temperature Devices." Temperature compensation for temperature-corrected PD meters shall conform with *ASME-API Code 1101*.

For measurement by tank, the temperatures measured at the same time that the upper level is measured may be averaged for consecutive dumps in a computation of the corrected volume for the complete run, provided that the variation in uncorrected volume between any dumps in a run does not exceed 5 per cent. By mutual agreement, temperatures of the oil remaining at bottom gage may be required for bottom-gage temperature correction.

For temperature correction of uncompensated PD-meter volumes, the temperature may be taken in the tank just prior to opening to the pipeline through the meter and may be averaged for computation of net volume for the complete run, provided that the volumes run through the meter after each such temperature measurement do not differ by more than 5 per cent.

Alternatively, the temperature in the line at the meter may be recorded and averaged as hereinbefore, provided that the conditions are the same as those described, and provided that the rate of delivery does not vary by more than 5 per cent.

Alternatively, for measurement of variable rates of flow with PD meter and/or variable duration or volume of flow for each flow period, the temperature chart may be driven by the meter, and the average temperature integrated with respect to flow.

Temperature charts, in certain cases, may serve as a secondary check on the count of the number of dumps made in the run.

XI—PRESENTATION OF MEASURED INFORMATION

The method and procedure for recording the measurements obtained by the automatic-custody-transfer system and those measurements taken manually at the end of each run, the procedure for computing net volume, and the manner and form for presenting the resulting information on a suitable run ticket and for storing any records or charts made by the automatic system shall be determined by mutual agreement and shall comply with any applicable regulations. In general, it is suggested that the procedures used be as simple as possible, and that they be compatible with conventional run tickets and usual accounting procedures. There are several methods of recording dumps, temperatures, etc., now being used in connection with automatic-custody-transfer installation, and others are being developed. Eventually, general practice will probably resolve many of the differences; however, until some trend is more clearly established, it is believed desirable to continue the use of the conventional run ticket.

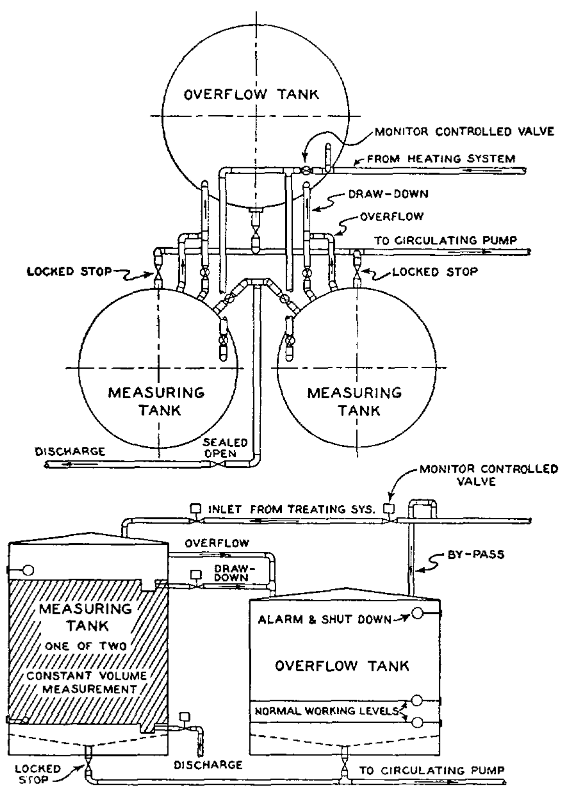
APPENDIX 1

TYPICAL DESIGNS

This section contains diagrams and descriptions of typical arrangements of equipment for accomplishing automatic custody transfer based on the suggestions outlined in the preceding sections of this bulletin. Three typical arrangements are included, one for each of the basic methods described: A. Parallel-Tank Measuring System, B. Tandem-Tank Measuring System, and C. Positive-Displacement Meter System.

These descriptions are intended only to illustrate the basic methods by providing an example of each. They are not meant to be restrictive or to indicate in any way that the methods shown are preferred to others which have been, or will be, developed to accomplish the same basic ends.

The first two of these systems have been built and are operating satisfactorily. The third, covering the use of the PD (positive-displacement) meter, although it is not in operation in exactly this form, is an adaptation of crude-oil metering systems which are operating satisfactorily in similar service.



Schematic Diagram of Parallel-Tank Measuring System with Weir-Controlled Constant Tank Volume.

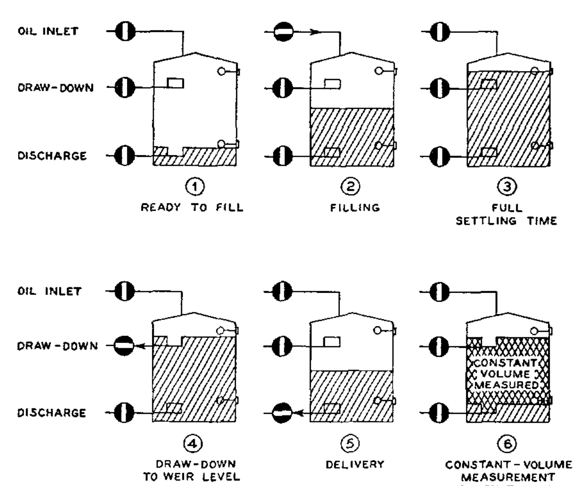
FIG. 1

A. Parallel-Tank Measuring System

A suggested combination of major items of equipment to provide two parallel, alternatively filled and emptied tanks with weir-controlled, constant-volume measurement is shown in Fig. 1. Use of electrically operated valves and controls does not preclude use of pneumatically or hydraulically operated valves and controls, if mutually acceptable.

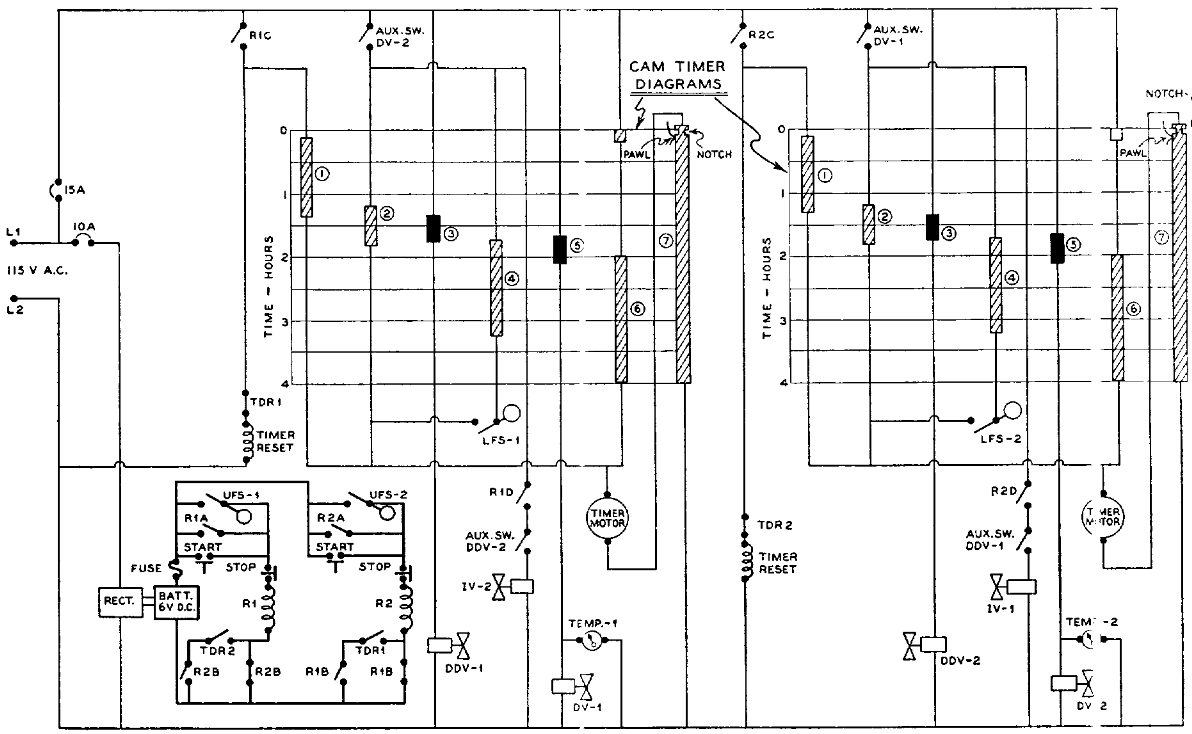
The typical sequence of operation, as shown in Fig. 2, is: 1, tank ready to receive oil; 2, filling; 3, full with incoming oil diverted into empty parallel tank, settling of oil; 4, drawdown of oil over upper weir to establish exact known top gage, activation of temperature recorder; 5, opening of discharge valve, starting of delivery, activation of sampler; 6, oil withdrawn over lower weir to establish exact known lower gage, closing of discharge valve, delivery and sampling completed, tank ready to again receive oil.

Suggested wiring and control equipment is shown in Fig. 3. Basic control for sequence



Parallel-Tank Measuring System with Weir-Controlled Constant-Volume Measurement; Sequence of Operation in One Tank.

FIG. 2



R = RELY
NUMBER 1 & 2 IN SYMBOLS DENOTE D.C.
RELAYS FOR TANK NO. 1 & TANK NO. 2
LETTERS A,B,C,& D WITH R1 & R2 DENOTE
CONTACTS OPERATED BY R1 & R2
TD = TIME DELAY
UFS & LFS = UPPER & LOWER FLOAT SWITCHES

AUX.SW. = AUXILIARY
IV = INLET VALVE
DDV = DRAW-DOWN VALVE
DV = DISCHARGE VALVE
NORMALLY CLOSED CONTACTS
NORMALLY OPEN CONTACTS

Wiring Diagram of Parallel-Tank Measuring System.

FIG. 3

of operation is obtained through use of a multicam timer (Fig. 4). The function of each cam and the time in which that cam is effectively controlling the operation are also shown.

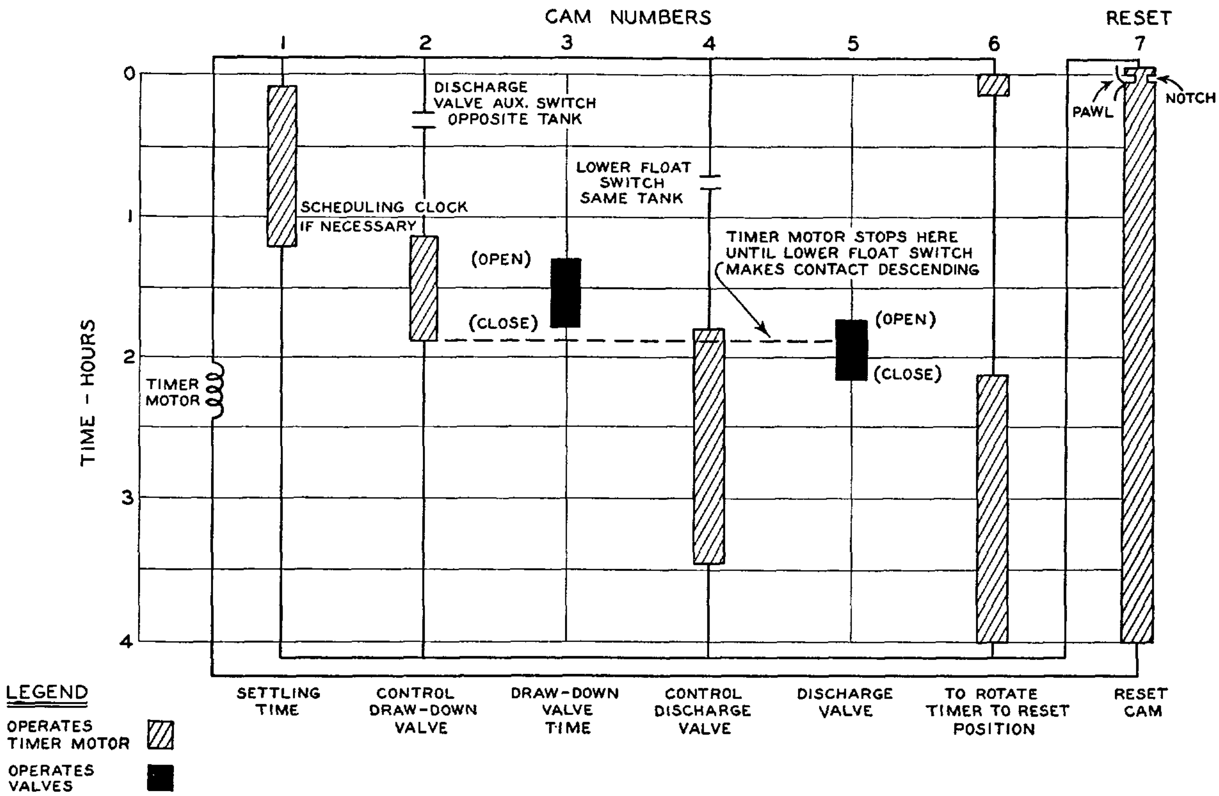
When the oil in a tank filling reaches the upper float, the inlet valve is closed on that tank, and the inlet valve on the opposite tank is opened. Also, the multicam-timer motor is started. No. 1 cam controls the length of settling time; No. 2 cam provides drawdown valve control; and No. 3 cam regulates the time between opening and closing of the drawdown valve. At the time that the drawdown valve closes the discharge valve is opened and rotation of the temperature-recorder chart is started. Cam No. 4 takes over the control of the discharge valve, and cam No. 5 regulates the operation of the discharge valve. The timer motor is stopped shortly after the discharge valve is opened to allow for a non-determinable time, such as might occur in a gravity delivery. The motor is again started through the action of the float switch set immediately above the lower weir. At a predetermined interval after the lower float switch makes contact, the discharge valve closes. The measuring cycle being completed and the tank again ready to receive oil, cam No. 6 rotates to reset position. If necessary, a scheduling clock can be incorporated into the system before drawdown valve control in order to permit scheduling of deliveries.

The minimum fail-safe features included in this design are as follows:

1. Valves are of "normally closed" design.

2. Sequence of operation of measuring cycle is retained in the event of power failure.

3. Interlocking of the valves and control system with the inlet valve and float switches



Measuring Cycle Control—Cam-Timer Diagram of Parallel-Tank Measuring System.

FIG. 4

is such that it is impossible to open the inlet valve on a tank when it is full, when it is being drawn down, or when the discharge valve is open. Fig. 3 shows the location of the interlocks which were used in this system.

Certain optional fail-safe features also included in this design, as shown in Fig. 1, are:

1. An overflow line above the upper float in the measuring tank to provide for overflow of oil into an overflow tank in event of failure of the upper float switch.

2. An overflow tank of less height than the measuring tanks so that oil cannot flow from this tank through an open line into a measuring tank.

3. An upper float in the overflow tank to initiate lease shutdown controls and sound an alarm in the event oil reaches the level of the float switch.

4. Manually operated valves may be installed in the discharge line on the downstream side of the discharge valve on the measuring tanks. Such valves should be sealed in the open position and used only in case of emergency.

With this system, at mutually agreed intervals the pipeline gager and a representative of the producer are to meet at the automatic-custody-transfer battery. The recorded number of runs for each tank is to be taken off recording devices operated independently of the operational controls. The number of runs from each tank times the constant-volume measurement per tank is the total gross oil run per tank during the agreed period. The temperature-recorder chart is to be removed and the temperature of each run listed on the chart and averaged. This chart can also be used as a check of the number of runs. The sample container is to be disconnected and replaced with an empty container. BS&W and gravity of oil in the sample collected over the period are to be determined by usual methods.

A run ticket is then prepared for each measuring tank, showing gross oil run, average temperature and BS&W content, and average indicated gravity.

B. Tandem-Tank Measuring System

A suggested combination of major items of equipment to provide a surge tank (or tanks) and a single metering tank with weir-controlled, constant-volume measurement is shown in Fig. 5. Use of electrically operated valves and controls does not preclude use of pneumatically or hydraulically operated valves and controls, if mutually acceptable.

The typical sequence of operation, as shown in Fig. 6, is: 1, tank ready to receive oil; 2, filling; 3, full with incoming oil produced into surge tank, settling of oil; 4, drawdown of oil over upper weir to establish exact known top gage, activation of temperature recorder and tank sampler (if used); 5, opening of discharge valve, starting of delivery, activation of line sampler (if used); 6, oil withdrawn over lower weir to establish exact known lower gage, closing of discharge valve, delivery and sampling completed, tank ready to again receive oil.

The minimum fail-safe features included with this design are:

1. Valves are of "normally closed" design.

2. Sequence of operation of measuring cycle is retained in the event of power failure.

3. Mechanical and electrical interlocking of the valves and control system with the inlet discharge and drain valves, float switches, and relays is such that it is impossible to open the inlet valve on a tank when it is full, when it is being drawn down, or when the discharge valve is open; it is also impossible to drain oil from the bottom of tank while tank is discharging to the pipeline. Three-way plug valves and mechanical linkages provide positive, easily sealed and checked interlocks, as shown in Fig. 5.

The optional fail-safe features which have been included in the design shown in Fig. 5 are:

1. An emergency float switch located above the normal top level to stop the transfer pump should there be a failure of the normal-level float switch.

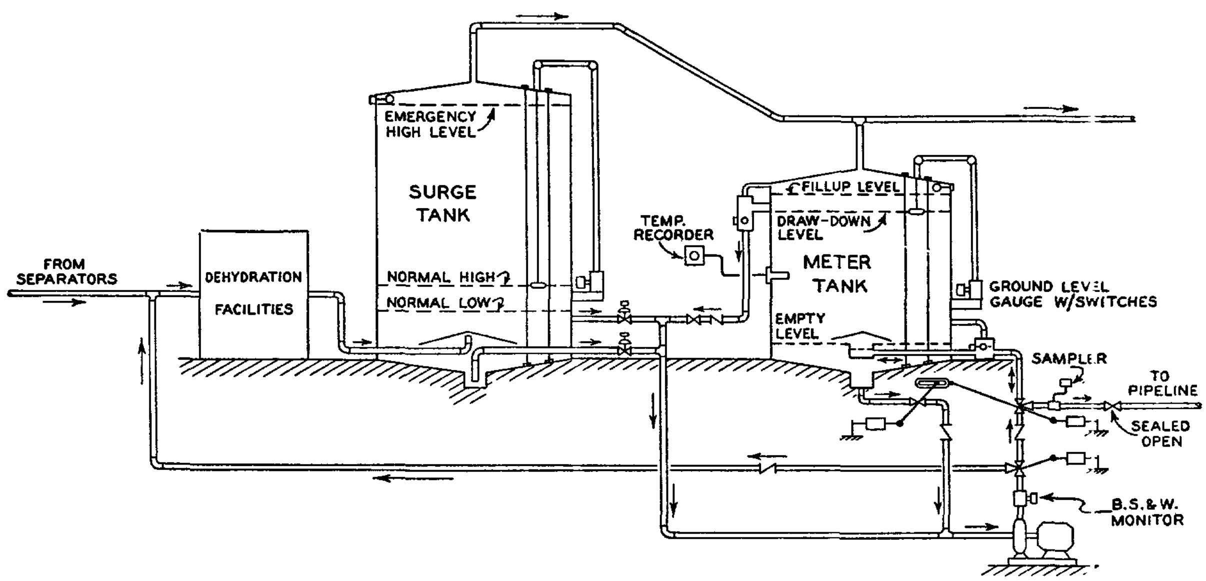
2. A surge tank to produce into while the meter tank is full or on the line in order to permit uninterrupted production.

3. An upper float in the surge tank to initiate lease shutdown controls and sound an alarm in the event oil reaches the level of the float switch.

4. A manually operated valve installed in the discharge line on the downstream side of the discharge valve on the measuring tanks. This valve should be sealed in the open position and used only in case of emergency.

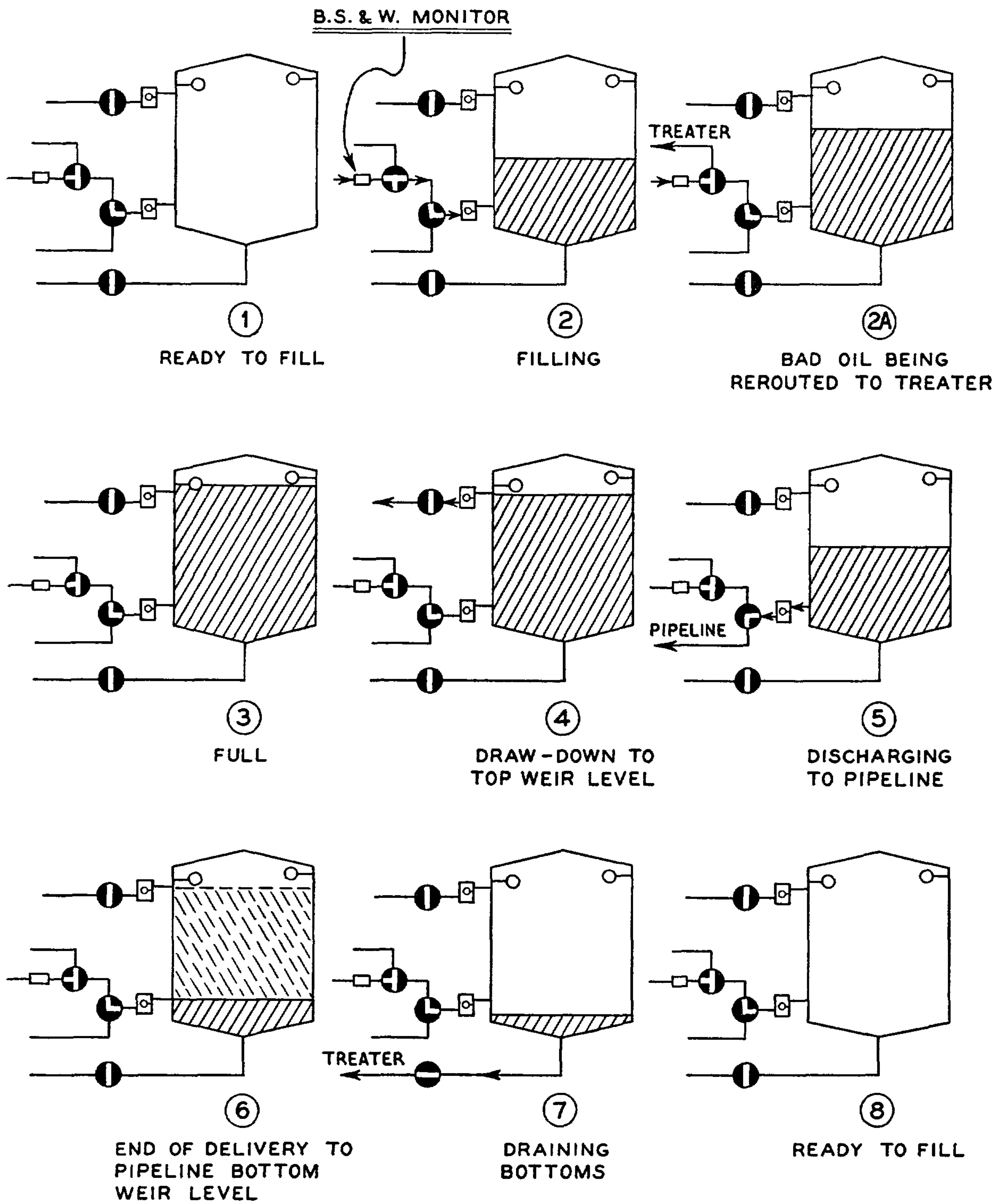
5. A BS&W monitoring system to prevent the entry of non-merchantable oil into the meter tank.

6. Periodic pumping-out of tank bottoms to prevent buildup.



Tandem-Tank Measuring System with Weir-Controlled Constant Tank Volume.

FIG. 5



NOTE:

DRAIN VALVE & TANK FILL-DISCHARGE 3-WAY VALVE MECHANICALLY LINKED TO PREVENT ACCIDENTALLY OPENING DRAIN VALVE WHILE OIL IS BEING DELIVERED TO THE PIPELINE.

Tandem Measuring and Surge Tanks with Weir-Controlled Constant-Volume Measurement; Sequence of Operation.

FIG. 6

7. Predetermined counters to limit the number of tanks run during any time interval.

With this system, at mutually agreed intervals the pipeline gager and a representative of the producer are to meet at the automatic-custody-transfer battery. The recorded number of runs for each tank is to be taken off recording devices operated independently of the operational controls. The number of runs from each tank times the constant-volume measurement per tank is the total gross oil run per tank during the agreed period. The temperature-recorder chart is to be removed and the temperature of each run listed on the chart and averaged. This chart can also be used as a check of the number of runs. The sample container is to be disconnected and replaced with an empty container. BS&W and gravity of oil in the sample collected over the period is to be determined by usual methods.

A run ticket is then prepared for each measuring tank, showing gross oil run, average temperature and BS&W content, and average indicated gravity.

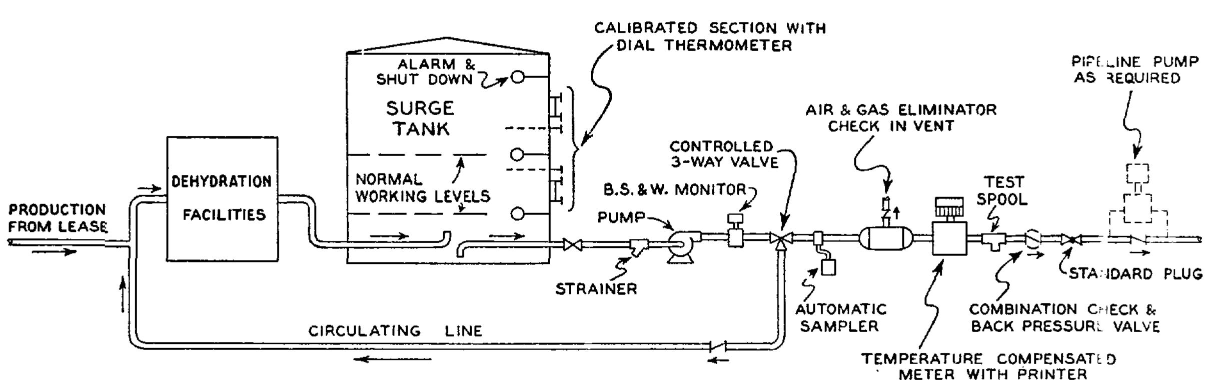
C. Positive-Displacement Meter System

A suggested combination of major items of equipment to provide automatic measurement by the positive-displacement meter method is shown in Fig. 7. The sequence of operation will vary slightly, depending on the type of pipeline facility connected and the operating schedule of the pipeline. The typical operating sequence for two types of automatic measurement to the pipeline is outlined as follows:

a. *Normal Delivery to a Gravity-Flow Pipeline—Nonscheduled Operation:* When the liquid level in the surge tank reaches normal high-working level: 1, the circulating pump starts and circulates the liquid from the surge tank back to the dehydration facilities for three minutes after the monitor indicates that the BS&W content is within permissible limits; 2, the three-way valve opens to the pipeline, admitting flow through the meter; 3, when the three-way valve reaches its open-to-pipeline position, the automatic sampler is energized and begins sampling, as mutually agreed; 4, under normal conditions, delivery to the pipeline continues until the liquid level reaches the normal low-level position; 5, the three-way valve closes the pipeline outlet and opens to the return line; 6, the automatic sampler is de-energized; and, 7, the circulating pump continues to circulate for five minutes, then is shut down.

After delivery to the pipeline has begun, should non-merchantable oil flow for two minutes continuously past the BS&W monitor, the delivery shall be automatically interrupted and, 1, the three-way valve shall switch the flow from the pipeline to the dehydration facilities; 2, the automatic sampler shall be de-energized; 3, circulation from the surge tank to the dehydration facilities shall continue until merchantable oil has flowed over the BS&W monitor for three minutes; then, 4, the flow shall be switched back to the pipeline and the delivery continued, as under normal conditions.

b. *Normal Delivery to a Pressurized Pipeline—Nonscheduled Operation:* When the liquid level in the surge tank reaches normal



Positive-Displacement Meter System.

FIG. 7

high-working level: 1, the circulating pump starts and circulates the liquid from the surge tank back to the dehydration facilities for three minutes after the monitor indicates that the BS&W content is within permissible limits; 2, the three-way valve opens to the pipeline, admitting flow to the meters; 3, when the three-way valve reaches its open-to-pipeline position, the pipeline pump starts and the automatic sampler is energized; 4, under normal conditions, delivery to the pipeline continues until the liquid reaches the normal low-level position; 5, the three-way valve closes the pipeline outlet and opens to the return line; 6, the pipeline pump is shut down and the sampler de-energized; and, 7, the circulating pump continues to circulate for five minutes, after which it is shut down.

After the delivery to the pipeline has begun, should non-merchantable oil flow for two minutes continuously past the BS&W monitor, the delivery shall be automatically interrupted and, 1, the three-way valve shall switch the flow from the pipeline to the wash tank; 2, the pipeline pump is shut down and the sampler is de-energized; 3, the circulation from the surge tank to the wash tank shall continue until merchantable oil has flowed over the BS&W monitor for three minutes; then, 4, the flow shall be switched back to the pipeline and the delivery continued, as under normal conditions.

c. *Normal Delivery to a Pipeline—Scheduled Operation:* Some pipeline systems are operated on a schedule whereby it is desirable to admit delivery only during a certain interval of time. For this condition the operation sequence shall be the same as for nonscheduled delivery, except that a time-interval controller shall be added to the circuit which overrides the normal high-working-level control.

APPENDIX 2

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3M—August 1956