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API
RECOMMENDED PRACTICES
for
LEASE AUTOMATIC CUSTODY TRANSFER

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AMERICAN PETROLEUM INSTITUTE

New York, N. Y.

#4

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
EXHIBIT No. 4
CASE 2243

API RECOMMENDED PRACTICE FOR LEASE AUTOMATIC CUSTODY TRANSFER

Foreword

a. This Recommended Practice, 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. "Lease automatic custody transfer" (LACT) consists of the measurement and running of oil from the producers' tanks to the connected pipeline on an automatic or unattended basis. This Recommended Practice is issued for the purpose of describing currently acceptable methods for LACT. The practices recommended are considered sound and reliable, but it should be expected that improvements will be made.

b. Throughout this Recommended Practice, references are made to API Standard 2500: "Measuring, Sampling, and Testing Crude Oil"; API Standard 2501: "Crude-Oil Tank Measurement and Calibration"; and API Standard 1101: "Standard 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 standards be used in all cases where they are applicable, in order to form a sound basis for accomplishing satisfactory automatic custody transfer.

c. 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 gauges 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 repetitious and time-consuming operations.

d. In many fields it has become apparent that lease 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 gaugers in making measurements.
6. Improved scheduling of runs on a predetermined basis.
7. Allowing maximum use of other automatic equipment installed primarily for the production operations.
8. Increased operating efficiency and control.

e. The apparent disadvantages are:

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

f. Early standardization of industry practice relating to methods and equipment used in lease 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.
3. To facilitate the periodic inspection of automatic custody transfer installations for insuring satisfactory performance.

It is hoped that the information contained in the Recommended Practice will be of assistance in establishing mutual agreement between parties interested in installation of systems operating in lease automatic custody transfer.

g. 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 Recommended Practice and other principles which may develop in practice have been more generally proved.

h. 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 Recommended Practice 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 Recommended Practice 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.

SECTION I - GENERAL

INTRODUCTION

1. This Recommended Practice 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 recommends practices which should provide accurate and reliable measurement and suitable protection against mismeasurement or otherwise faulty operation. LACT, as defined herein, may be used where mutually agreeable to the parties concerned in the transaction and where government or other regulations will permit.

2. These recommendations are not meant in any way to be restrictive or to retard future development of methods found to be either more suitable or more practical.

DEFINITIONS

1. Lease Automatic Custody Transfer. A Lease Automatic Custody Transfer system is defined as an arrangement of equipment designed for the unattended transfer of liquid hydrocarbons from producing leases to the transporting carrier while providing proper means for quality determination, net-volume determination, and fail-safe operation; and while meeting requirements of accuracy and dependability as defined in Recommended Practices for Lease Automatic Custody Transfer.

2. Cycle. Filling and running of one measuring tank.

3. 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.

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

BASIC SYSTEM REQUIREMENTS

1. General. There are a great number of basic alternative arrangements which could be used to accomplish lease 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. Optional features may be desirable under certain conditions. The basic systems are divided into: (a) measuring tank type systems and (b) positive displacement metering systems.*

2. 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:

a. Stability of Oil. The lease oil handling arrangement must be such that the oil when measured is sufficiently stable and free from volatile fractions to permit accurate measurement and later transportation without abnormal or excessive losses.

b. Volume Correction. Provision must be made for accurate determination and recording of uncorrected volume and applicable temperature, or of temperature-corrected volume. The over-all accuracy of the system must equal or surpass present manual methods.

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

*Velocity type and mass-flow meters may at some future time be adapted to LACT operations.

**There is some work in progress attempting to perfect new means and techniques of determining the BS&W content of oil that has been run, for use in lieu of conventional sampling and testing.

d. Merchantable Oil. Means must be provided if required by either party to give adequate assurance that the oil is merchantable before it is run.

e. Delivery. If required by either party, control shall be provided over the time of entry of the oil into the carrier's system.

f. Allowable. Where regulations require, control shall be provided to stop the flow of oil into the carrier's system at or prior to the time that the allowable is run.

g. "Fail-Safe" Features. 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.

h. Tampering. 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.

i. Calibration. All components of the system which require periodic calibration and inspection for proof of continued accuracy must be readily accessible. The frequency and procedures to be used should be agreeable mutually to the parties concerned.

j. Standards. 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 API Standard 1101.

TEMPERATURE MEASUREMENT

1. Temperature Correction. Correct use of devices to indicate, record, or adjust for oil temperatures is highly important where accurate oil volume measurements are to be obtained. In LACT operations two general methods are used to correct volumes for temperatures; i.e., (a) determine the applicable temperature of each run and to correct the run volume to 60°F, or (b) use a temperature compensator to correct continuously the register or counter reading. All temperature measurements or temperature corrections shall be made in accordance with API Standard 2500 or API Standard 1101.

2. Thermometers Check. All thermometers should be checked frequently enough to assure continued accurate indication by comparing them with test thermometers certified by the National Bureau of Standards.

3. Measuring Tank Type Systems. In these systems use of either temperature compensators or temperature recorders is practical. The temperature-sensing bulb in either case must be located where an average temperature of the individual dump is obtainable. The time elements in the cycle of the system must be such that all parts of the temperature-sensing and transmitting device must stabilize with respect to temperature by the time the temperature indication is recorded or is used to adjust the volume counter. This can be checked by comparing the indications with observations of readings from indicating thermometers installed for that purpose.

SAMPLING

1. Samples. Samples for determination of API gravity and BS&W content shall be obtained by automatic samplers and by procedures as described and set out in Part V of Supplement 1 of API Standard 2500.

2. Measuring-Tank Systems. If mutually agreeable, in measuring tank system it is permissible to take one sample from each dump. Such samples may be commingled and collected for a complete run.

3. Sample Containers. All samples should be collected in closed containers and kept under sufficient pressure to prevent changes in gravity. Mechanical arrangements that allow the determining of the gravity under pressure are permissible, if mutually agreeable.

4. Testing Composite Samples. When samples are transferred from the sample container to testing equipment, every precaution should be taken to insure that the portion of the sample being tested is representative of the sample and of the run.

5. Determining BS&W Content. If mutually agreeable, it is permissible to use devices and procedures that determine the total volume of collected sample and the total volume of BS&W in the sample, and these data can be used to calculate the BS&W content.

6. Recording BS&W Content. If mutually agreeable, it is permissible to use automatic means of measuring and recording BS&W of oil being transferred, provided that such means are periodically calibrated and the results obtained check within a mutually agreed amount with another accepted API Standard method.

PRESENTATION OF MEASURED INFORMATION

1. Procedure. Data from LACT systems include that which automatically is recorded and that which is taken manually at the end of each run. The specific method and procedure for obtaining data and the matter and form for presenting

data shall be determined by mutual agreement and shall comply with any applicable regulations. In general, it is suggested that the procedures be as simple as possible and that they be compatible with the use of conventional run tickets and usual accounting procedures.

2. Preserving Records. In most cases pertinent records and charts, such as calibration reports, need to be stored temporarily for a period of time. The exact procedure should be determined by mutual agreement.

RUN SCHEDULING

1. Scheduling for a Pipeline Load. Pipelines must prorate their capacity among all connected leases. Where LACT operations are contemplated, representatives of the producer and of the receiving carrier should confer in regard to the feasibility of such operations consistent with pipeline load factors. The ultimate in LACT operations is to have continuous delivery from producers' facilities to pipelines. With some types of LACT systems a truly continuous flow is obtainable, while in other types of systems delivery will be a relatively continuous batching operation. Where line load factors are high, careful planning is required. Some considerations are:

a. The periods when line capacity would be available.

b. The producer's ability to have oil ready to deliver.

c. The rates of delivery on an hourly or other time-period basis.

d. In the case of PD metering systems, whether the rate can be maintained within the accurate range of the meters.

e. In the case of measuring tank systems, the time cycle sequences from empty tank to full tank to empty tank.

f. In general, automatic scheduling should improve pipeline load factors.

2. Stopping at Allowables.* Producers as well as receiving carriers are held responsible by regulatory bodies for keeping runs from leases within the allowable where allowables are applicable. Hence, in such cases, provisions must be made to assure that runs from LACT systems do not exceed the lease allowable. In some instances it is feasible to stop delivery manually when or before the allowable has been run and to permit the lease production to accumulate in producers' storage. Mechanical means may also be used to accomplish this end. The system used should meet the following requirements:

a. Tampering. It must be fail-safe, tamperproof, and sealable in such a way that neither the pipeline's representative nor the producer's representative can change the mechanical arrangement without the consent and/or knowledge of the other.

b. Allowable. Any mechanical arrangement used must be capable of being preset for the predetermined volume that will approach but not exceed the lease allowable.

   1. Any mechanical arrangement used must prevent any further movement of oil from the lease when the predetermined volume has been reached until it is manually reset.

   2. It must be adjustable in order to take care of the allowable changes. Any changes to the mechanical devices must be made only when representatives of both parties are present.

c. Check of Delivery. Registers and counters should be visible so that oil deliveries can be checked at any time.

*Certain current state governmental regulations require that particular attention be paid to this section to avoid losing some of the allowable production.

EQUIPMENT AND INSTALLATION STANDARDS

1. Standards and Approvals. All equipment used in LACT systems should be designed, constructed, calibrated, and operated in accordance with applicable API standards, other standards, and codes, and in compliance with governmental regulations. Currently, it is necessary to obtain approval or to obtain exception to statewide rules from regulatory bodies to use LACT in some states.

2. Types of Controls. Control equipment may be electric, electronic, pneumatic, or hydraulic. Components should be high-quality materials which are resistant to moisture, corrosion, dust, and wear and should be designed for long life with minimum maintenance.

3. Valves. Valves should be of a type that assures 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.

4. Counters. The methods selected and used for counting and recording the number of barrels or dumps in a LACT system require particular attention. It is preferable to have at least two independent counters. The counting systems should be designed so that failures of electric or pneumatic power do not cause false counts. A pressure-recording instrument for recording the "head" in a tank and/or a temperature-recorder can be used to advantage in some systems as a check on oil movements.

5. Ratings. Machines, devices, and components of LACT systems should be installed and used in accordance with established ratings. The various components of a system should be compatible with respect to ratings and with systems to which they are connected.

FAIL-SAFE AND MEASUREMENT CHECK FEATURES

1. Protection against Mismeasurement:

   a. Interlocks. Fail-safe features and interlocks should be included in the design of an LACT system to provide reasonable assurance against mismeasurement. The specific devices used in an installation should be decided by mutual agreement. Interlocks or other means should be used on valves, floats, and controls as needed in a system if mechanical failures in the system will interfere with accurate measurements. It is permissible for either party involved to use any means of this type, provided that it does not interfere with accurate measurements or with the satisfactory operation of the system.

   b. Sequence. In measuring tank systems it is suggested that the sequence of operation of the measuring cycle should be retained in event of failure or interruption of electric or pneumatic power.

2. Equipment Enclosures and Security

   a. Control. 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.

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

c. Seals. Any adjustable device that affects measurement must be sealed and/or locked; and the seal shall not be removed without advising and/or without obtaining the consent of the other party.

QUALITY MONITORING

1. General. Where LACT is used, the composite sample of the oil run is tested for BS&W at the end of the run. Hence, it is possible for bad oil or slugs of water to enter a carrier's system unless some means are provided to prevent it. Some pipelines cannot tolerate more than traces of water in oil, while in other cases the maximum allowable amount of water is of less importance. Where LACT operations are contemplated, the parties concerned should mutually agree on (a) the permissible BS&W content of crude, (b) whether some additional means must be provided to insure against bad oil entering the system, and (c) if used, the type of means.

2. Monitor. The only mechanical means used to date to prevent bad oil from LACT units from entering pipelines employs a device for controlling, indicating or recording the BS&W content of the stream. The only satisfactory device developed so far is an instrument that measures capacitance (dielectric constant). When this device is installed in the line to the measuring tank or meter, it can be used to actuate valves so as to divert the stream containing excessive water back to the dehydration facilities and/or stop the flow to the pipeline.

3. Dielectric Constant Monitors

a. Requirements. A dielectric monitor shall consist of a device or instrument designed to measure the dielectric constant of the fluid between the electrodes of a cell mounted in the flowing 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 percent of BS&W, suitable temperature compensation should be used where stream temperatures are expected to vary appreciably. BS&W monitors should be selected to resist corrosion and fouling by the measured fluid.

b. Effects of Gas. Entrained gas bubbles can cause erroneous measurement. Although this behavior can be used to detect free gas, normally the capacitance cell should be located so as to avoid entrained gas bubbles.

c. Fluid Velocity. The velocity of oil moving through the capacitance cell must be sufficient to prevent drift to a false high reading.

d. Other Factors. Instruments shall not be affected adversely by reasonable or expected variations in supply voltage or frequency or by variations of ambient temperatures.

*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 percent of BS&W.

e. Calibration. The initial instrument calibration should 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 the initial field calibration (after installation) and for all subsequent field recalibrations may be made on the basis of comparison with the BS&W content of the crude determined by centrifuge methods in accordance with API Standard 2500.

CLINGAGE

1. Definition. Clingage, as used herein, is defined as the amount of oil that adheres to the walls of a measuring tank or a volumetric prover tank after draining or during the "empty" phase of an operating cycle. Not enough data are available to make firm recommendations in regard to taking clingage into account in LACT units; however, it needs consideration in some cases to insure accuracy.

2. Correlation. From data available, it appears that the amount of clingage can be correlated with (a) the viscosity of the oil at operating temperatures, (b) the length of drain time, (c) the ratio of surface area to the volume of the tank, (d) ambient conditions, and (e) the type of coating used and the shape of the tank.

3. Drain Time. Prover tanks customarily are calibrated "to deliver" using water and measures certified by the National Bureau of Standards as described in API Standard 1101. This may not give an accurate calibration of the prover tank "to deliver" or "to contain" crude oil after the tank is in service. When using prover tanks to prove PD meters, adequate drain time must be used to insure an accurate "starting" liquid level.

4. Clingage Factor. The problem of clingage should be considered where measuring tanks are used in LACT. The calibration of tanks or the correction of volume factors applied should take clingage into account on a mutual agreement basis. When tanks are calibrated and a clingage factor is included, the basis of determining the clingage factor should be stated on calibration reports and certificates.

5. Test Results. The following general information may be helpful in dealing with clingage questions. It is based on a relatively small number of carefully conducted tests:

a. Tank Size. The magnitude of differences in volume measurements decreases with increases in tank size. In tanks having capacities above about 50 barrels, clingage appears to be negligible except possibly where oils have very high viscosities.

b. Viscosity. Where oil viscosities are less than about 50 SSU at operating temperatures, clingage appears to be negligible. Where oil viscosities are in the range of 60 to 200 SSU at operating temperatures, the amount of error in volume measurements due to clingage in 5- to 20-barrel tanks is in the order of 0.05 to 0.25 percent.

6. Time Delay. Most LACT systems using measuring tanks incorporate time-delay means to insure proper drainage, thereby minimizing clingage effects.

7. Field Checking. One practical method of calibrating measuring tanks to take clingage into account or to correct water calibration is to compare the volume of oil run from surge or lease stock tanks with the volume as determined by the measuring tanks. (This cannot be used where incrustation is a problem in lease stock tanks.) This requires careful and accurate tank strapping

and accurately measuring the oil in lease tanks (including gauging to the nearest 1/16 inch or closer and making temperature traverses in the lease stock tank in conjunction with the top and bottom gauges). PD meters also can be used to check the calibration of measuring tanks where clingage may be a problem, provided the PD meter is carefully calibrated and operated so as to permit its use as a standard means.

SECTION II - MEASURING TANK LACT SYSTEMS

INTRODUCTION

1. Measuring tank LACT systems are described as those systems which utilize tanks or special vessels as the measuring device in the automatic custody transfer of oil from a lease to a transporting carrier.

2. The system is similar to LACT systems using PD meters as the measuring device in that a means must be provided for production surge and a means must be provided to control the movement of oil through the system. A means must also be provided for determination of both the net quantity and the quality of the oil delivered to the transporting carrier. A device should be provided for control of unmerchantable oil on leases where BS&W production is anticipated.

3. This section is primarily concerned with the classification of tank systems in accordance with the types of measuring as presently used. Other designs will be acceptable when so proven.

TYPES OF MEASURING TANKS

1. Initial Systems. The initial LACT systems were developed around the use of the conventional lease tankage primarily to duplicate as closely as possible the then accepted requirements for custody transfer measurements and secondly to permit the use of LACT with a minimum of additional expense for the great number of lease tanks in existence. These early LACT systems employed floats or weirs to control the fixed volumes to be transferred each dump (see Fig. I and Fig. II). Measuring tanks of this design are still acceptable and sometimes used where conventional stock tanks can be economically converted.

2. Present Systems. From these systems evolved the idea of the present measuring tanks which now find general industry acceptance. The tanks differ

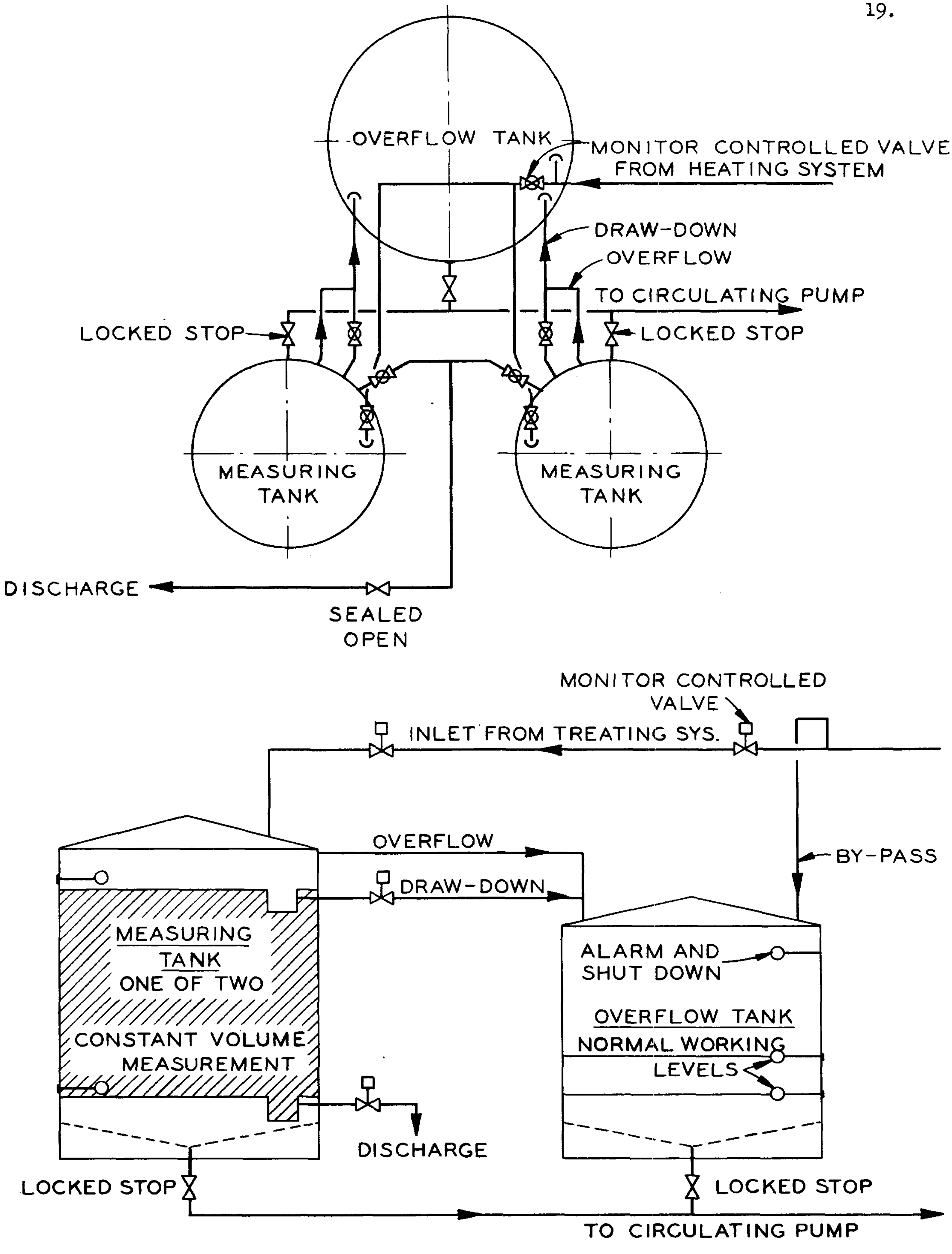


FIGURE I
SCHEMATIC DIAGRAM OF PARALLEL-TANK MEASURING SYSTEM WITH WEIR-CONTROLLED CONSTANT TANK VOLUME

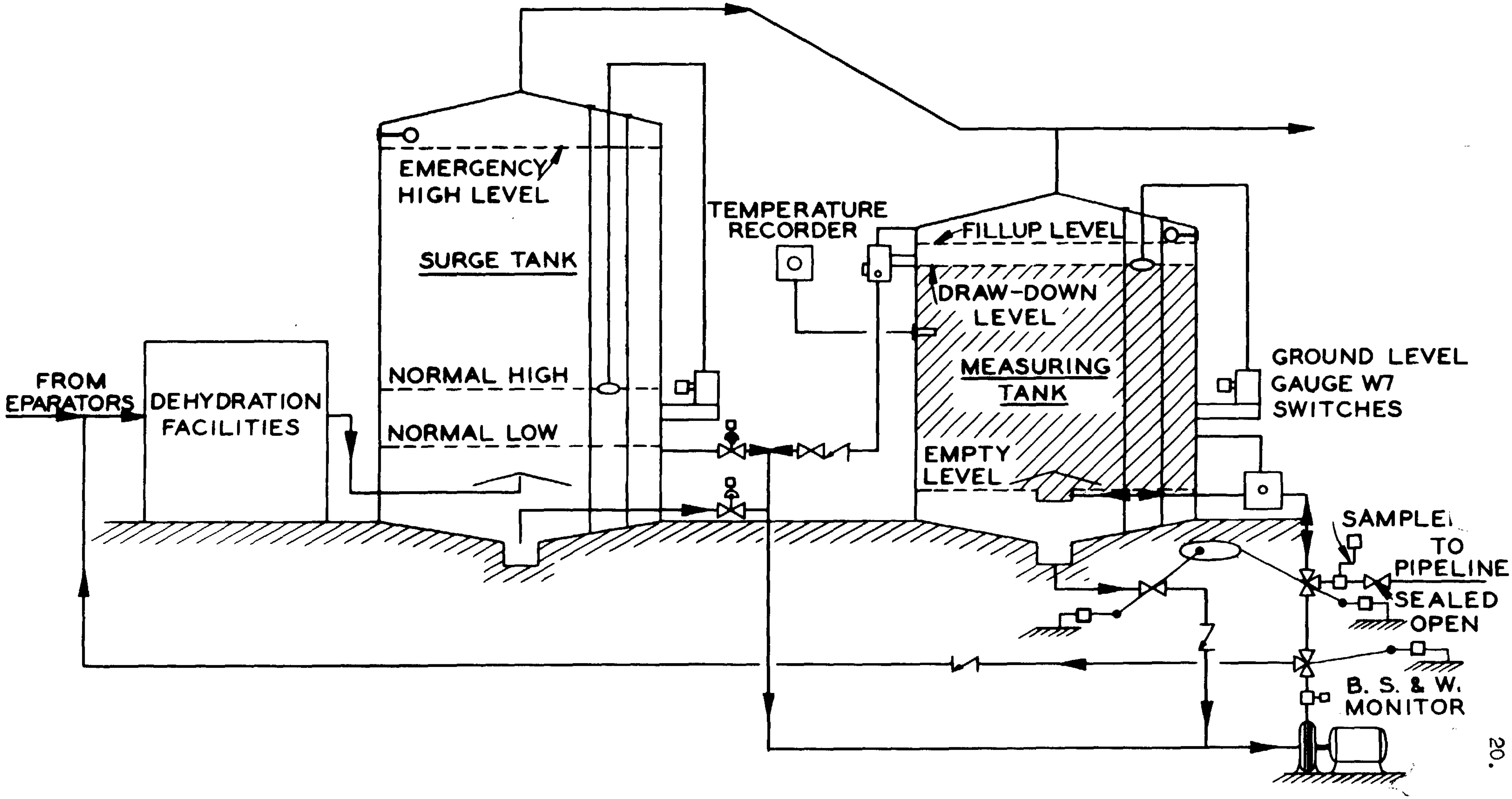


FIGURE II

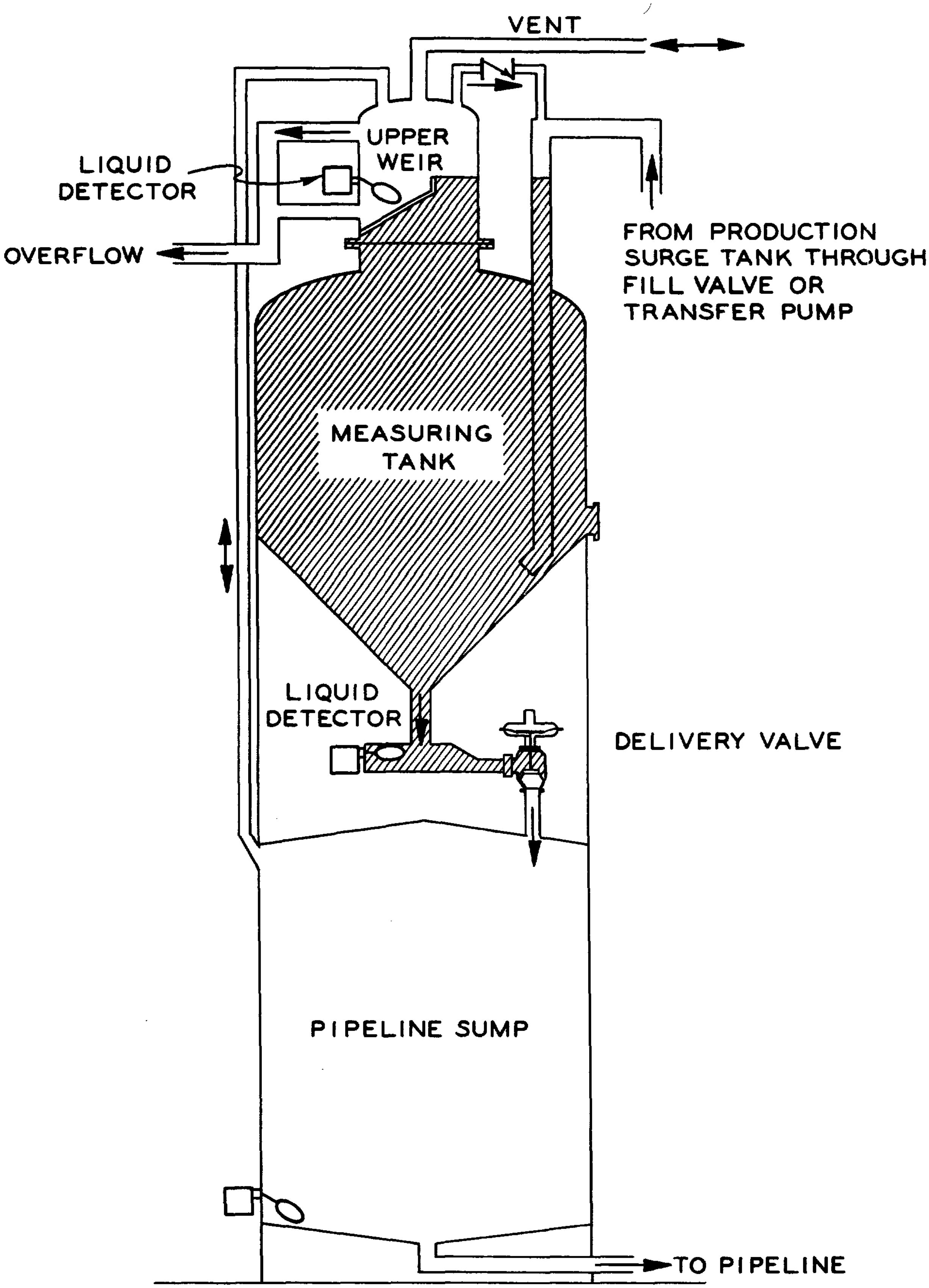
TANDEM TANK MEASURING SYSTEM WITH WEIR-CONTROLLED CONSTANT TANK VOLUME from the adaptation of the conventional tank in that control of the lower liquid level is so positioned as to provide complete drainage of the tank each measuring cycle, thus eliminating the possibility of bottom accumulations within the measuring vessel. These tanks are designed in the following three general forms and are available from many manufacturers:

Measuring Vessel Having Top Weir and Bottom Valve (Fig. III)

1. Manrer of Operation. This vessel is usually an upright cylindrical vessel with a cone top and cone bottom, a semieliptical head and bottom, or any combination of these two configurations. The top section consists of a weir enclosed by a dome to act as an overflow chamber for the weir. A level detector is located in the overflow section at least an inch below the weir level so that the measuring section must fill with liquid and overflow the weir before the level detector comes into action, stopping the fill cycle. Thus, a full measuring chamber is assured each time. A delivery valve in the lower reduced section establishes the exact point of the lower liquid level of the measured volume and is so positioned as to provide complete drainage of the vessel. A level detector or liquid-sensing device is situated in the lower portion of the measuring chamber and controls the action of the delivery valve so that complete delivery is made each dump. The control system interlocks the upper level-sensing device and the lower level-sensing device so that a constant gross volume of oil is delivered during each cycle. The delivery valve represents the point at which the transfer of custody occurs.

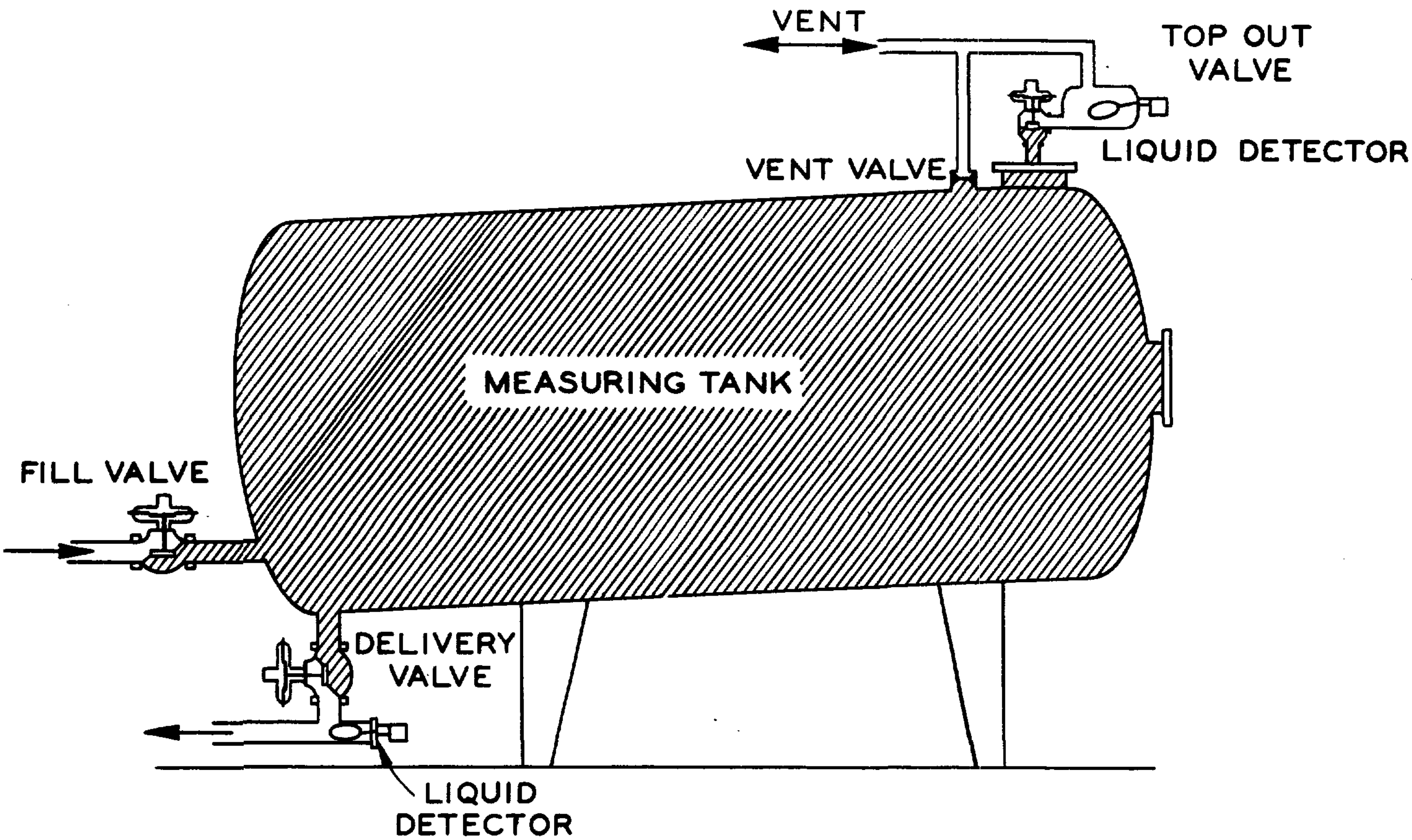
The Totally Contained Volume Chamber (Fig. IV).

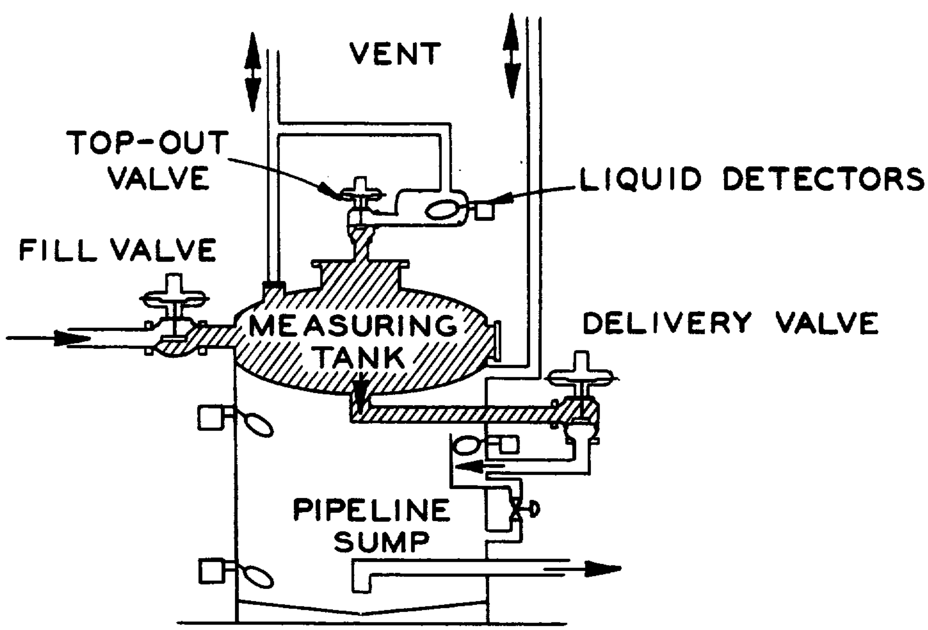
1. Manner of Operation. This vessel takes the form of a vertical or horizontal cylindrical tank with top and bottom reduced in cross section. This vessel contains a valve in each reduced section with level-sensing devices external to



TYPE I

FIGURE III
TOP WEIR, BOTTOM VALVE MEASURING VESSEL





TYPE 2

FIGURE IV
TOTALLY CONTAINED VOLUME CHAMBER

the vessel to control the action of the valves. A valve is also provided in the fill leg. The exact metered volume is contained between the three valves. The delivery valve is the point at which the transfer of custody occurs.

<u>Measuring Vessel Having Level Controls within a Reduced Area (Fig. V)</u>

1. <u>Types</u>. Vessels with reduced-area level control sections are of two general forms:

   a. <u>Vertical Vessel Type</u>. Vertical cylindrical vessels with conical top and bottom having a reduced area and level control in the center of the upper cone and a delivery valve in the outlet of the lower section. A float in the bottom section serves only as valve control. The contained volume of this tank is determined by level-sensing device in the top and the face of the delivery valve in the bottom.

   b. <u>Horizontal Vessel</u>. A horizontal cylindrical vessel with reduced-area sections at top and bottom with level controls in each reduced-area section. The horizontal cylindrical vessel is slanted slightly and is constructed with the upper reduced area on the highest end of the vessel while the lower reduced area is located on the lowest end of the vessel. This provides good drainage and prevents any gas trap. Contained volume of this tank is determined entirely by the level-sensing devices. Transfer of custody occurs at the delivery valve in the lower section.

<u>TANK ARRANGEMENTS</u>

1. <u>Classification</u>. Measuring-tank systems may be placed in two general classifications. Class 1 systems (Fig. VI) are intermittent-delivery systems and Class 2 systems (Fig. VII) are continuous-delivery systems, as established

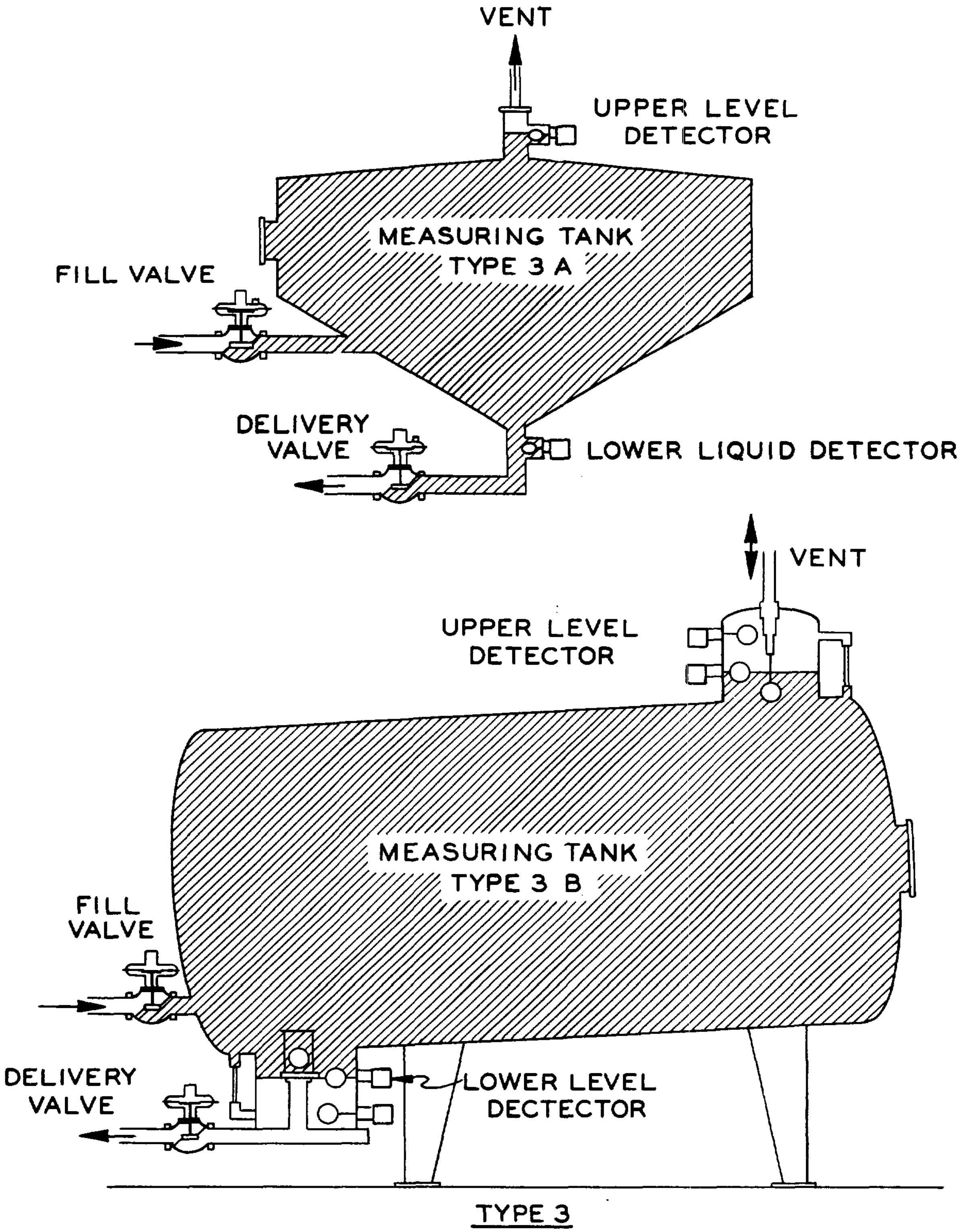
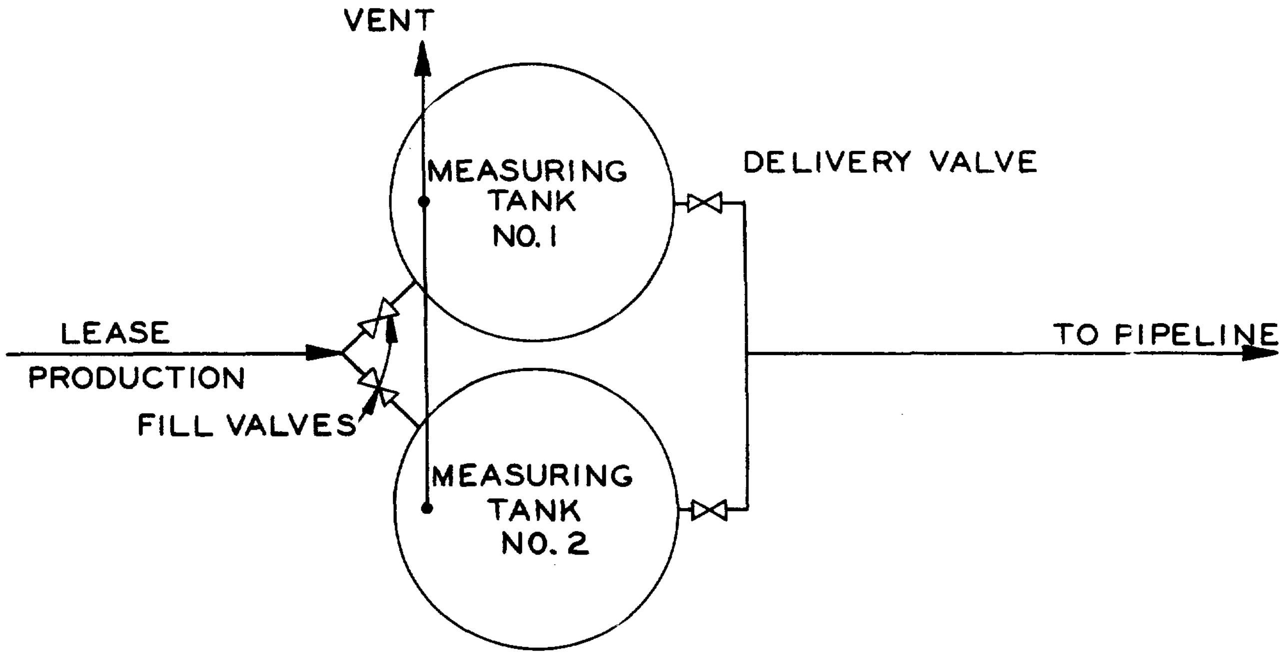
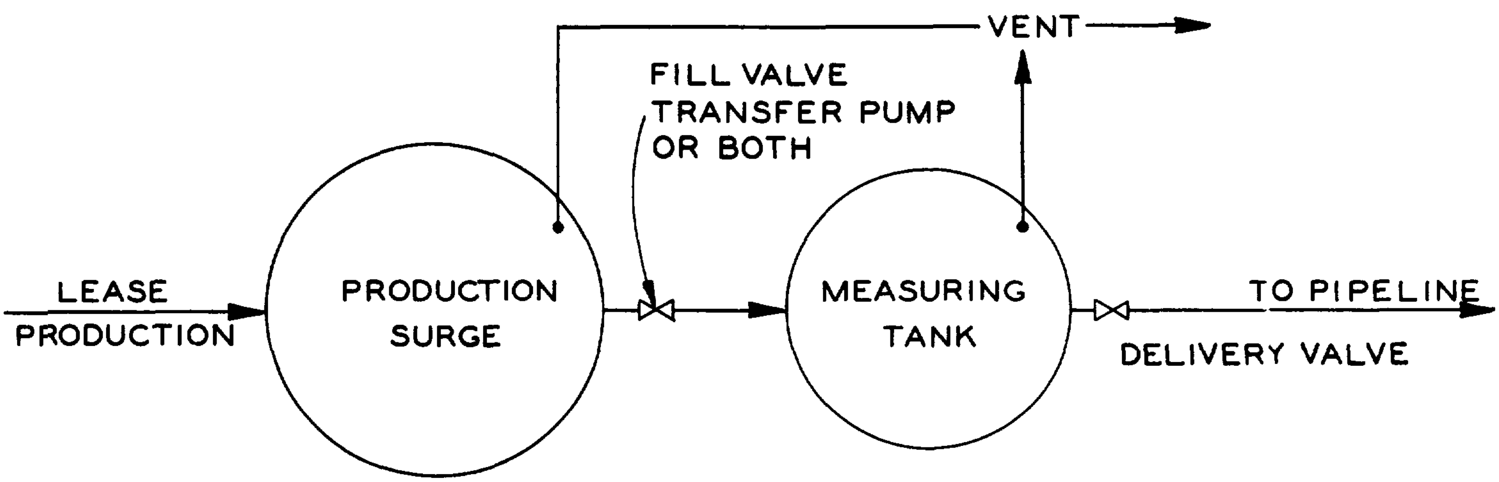


FIGURE V
MEASURING VESSEL WITH
LEVEL DETERMINATION IN REDUCED AREA

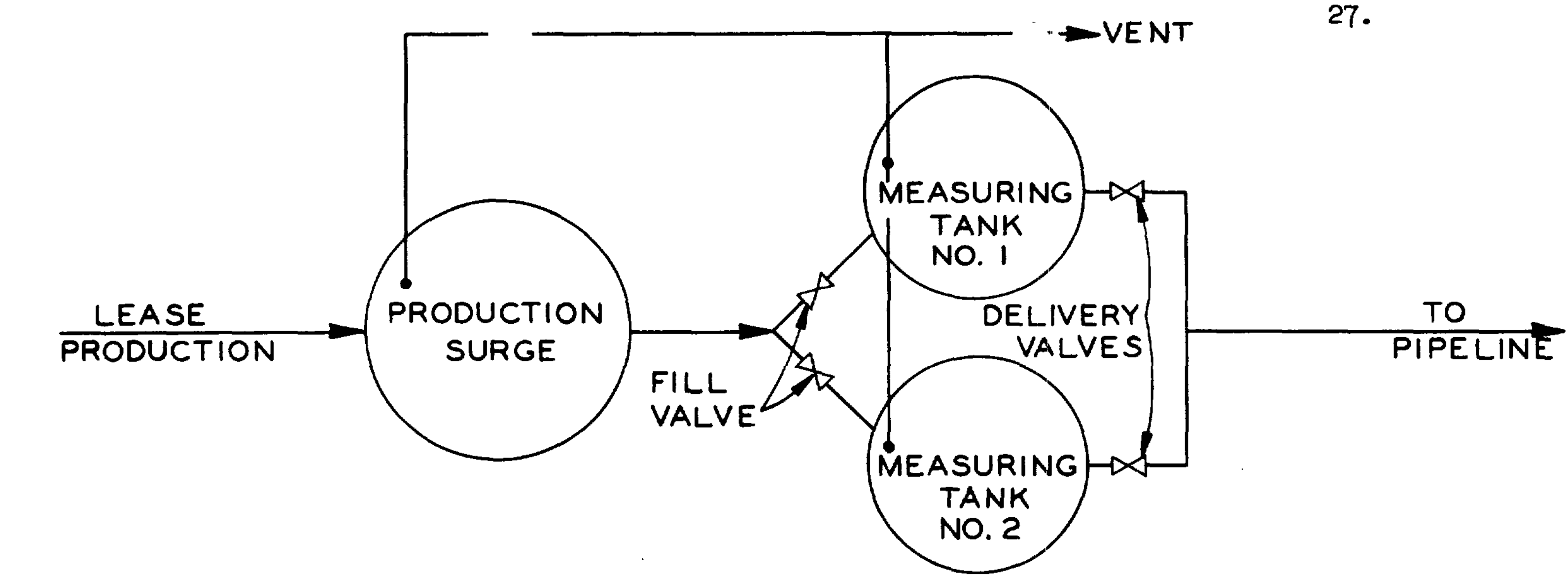


(A) DOUBLE MEASURING TANK-NO SURGE

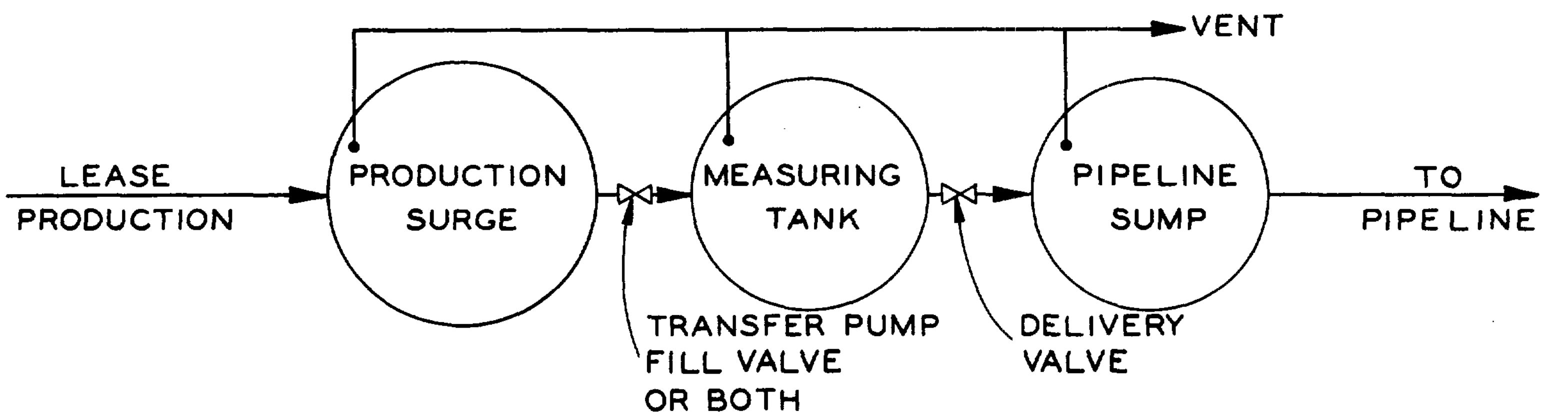


(B) SINGLE SURGE WITH SINGLE MEASURING TANK

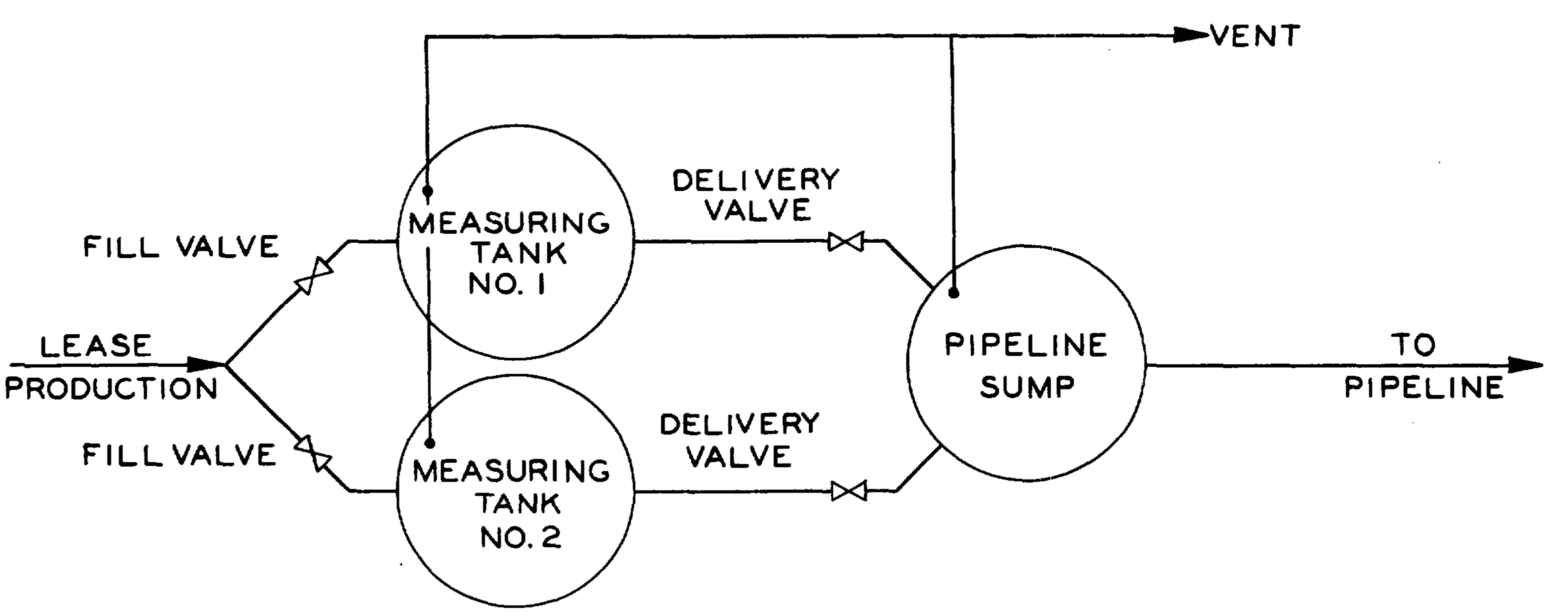
FIGURE VI
CLASS I
TYPICAL SYSTEMS FOR INTERMITTENT
DELIVERY TO PIPELINE



(A) PRODUCTION SURGE WITH TWO MEASURING TANKS



(B) PRODUCTION SURGE WITH MEASURING TANK & PIPELINE SUMP



(C) TWO MEASURING TANKS WITH PIPELINE SUMP

FIGURE VII

CLASS II

TYPICAL SYSTEMS FOR CONTINUOUS DELIVERY TO PIPELINE by their ability to make either intermittent or continuous delivery to the transporting carrier.

2. Intermittent Delivery. Assuming that all systems will be required to handle production from the lease continuously and intermittent delivery is permissible, a minimum system must include at least two vessels. These vessels may be arranged as two measuring tanks in parallel where the measuring tanks are large enough to provide needed production surge capacity or a production surge vessel and one measuring tank in series (Fig. VI).

3. Continuous Deliveries. In order to minimize the load on a transporting carrier's facility it is recommended that Class 2 systems (Fig. VII) be provided in most instances. Continuous delivery or Class 2 systems require the use of three vessels. These vessels may be arranged as follows:

a. Two Measuring Tanks, No Sump. A production surge tank with two parallel measuring tanks.

b. One Measuring Tank. A production surge tank with one measuring tank and pipeline sump in series.

c. Two Measuring Tanks, No Surge. Two parallel measuring tanks connected to a pipeline sump.

4. Recommended System. Of the three systems shown as Class 2 systems, Figure VII, the single-measuring-tank system is the least complicated from the standpoint of fail-safe interlocks and simplified control components and is recommended.

5. Rate Fluctuation. The systems are designed so that accuracy is not affected by fluctuations in delivery rates up to and including the maximum capacity of the unit.

SPECIAL REQUIREMENTS

1. General. Measuring tanks are emptied with no means provided to wipe the interior surfaces clean. Therefore, volume cannot change due to surface wear. The problem of incrustation and surface clingage must be dealt with in some manner.

2. Incrustation. Incrustation may be controlled and in most cases has been successfully prevented by applying to the interior surface of the measuring tank a baked-on phenolic coating, a catalytically set modified phenolic or epoxy coating, or ceramic coatings. Other materials will be acceptable when so proven.

3. Clingage. The effect of clingage may be determined by actual measurement of the run down volume in a measuring tank after the delivery valve is closed. Measurement should be made at normal operating temperatures and sufficient time allowed to satisfy the parties concerned. Correction for clingage shall be applied to the vessel calibration factor.

4. Valves. Valves used to control liquid to or from a measuring tank must be constructed with soft seats. The valves must be checked periodically to assure that the seat closes bubble tight. All valves which are used to contain the predetermined volume in a measuring tank should be either normally closed or adequately interlocked to prevent mismeasurement in the event of power failure or instrument gas-supply failure. Limit switches or pilot control should be properly applied to these valves in order to provide such interlock control. In the measuring tank described as Type 1, Figure III, which uses a transfer pump to fill, the interlock must be provided between the delivery valve and the transfer pump power circuit.

5. Level Detectors. Level detectors need be only as sensitive as the particular system requires, but in all cases must be reliable. Level detectors which

control multiple circuits in the control and interlock system must be equipped with switches or pilots properly designed so that mismeasurement does not occur, even though maladjustment may develop.

6. Calibrated Volume. All valves which confine a measured volume and all level detectors which are within the measured confines of the vessel should be attached with a type coupling which will allow removal and replacement without altering the calibrated volume of the measuring vessel. Either shop or field calibration is acceptable.

DATA HANDLING

1. General. The ultimate in automatic volume measurement is the adaptation of fully BS&W compensated and temperature-compensated data readout. Temperature-compensated data readout is presently available to all measuring tank systems. Temperature averaging, BS&W averaging and gravity averaging equipment is currently available to measuring tank systems which when applied to a gross volume counter provide complete data readout and may eliminate the need for a proportional mechanical sampler. Many systems currently in operation employ the individual temperature recorded system with a gross dump counter. The latter systems require manually calculated volume-temperature corrections, but may be found adequate in many cases. A pressure-head recorder is very desirable as a gross volume check on the measurement cycle or in the event a mismeasurement occurs.

RECALIBRATION OF VESSELS AND COMPONENTS

1. Inspection and Volume Recalibration. A means of inspection should be provided on each measuring vessel. Vessels should be inspected periodically. Recalibration is not necessary unless inspection indicates that the volume obviously has been changed. Recalibration may be requested by either party.

2. Temperature Instruments Calibration. Temperature instruments shall be recalibrated at mutually agreed intervals using a certified test thermometer to

correlate two or more temperatures within the normal operating range. Correlation should check within 1% of the maximum range of the instrument. This calibration must be performed with the instrument temperature element and the certified test thermometer immersed in a temperature controlled liquid bath. Temperature instruments should be checked for proper adjustment at frequent intervals by simply comparing the recorder temperature reading with that of an approved ASTM or API thermometer during normal operation.

MINIMUM MEASURING TANK VOLUME

1. Maximum Capacity. The maximum capacity of the various measuring tank systems will be governed by the size of the measuring tank or tanks, the speed of response in the temperature system, the time required for proper elimination of entrained gas and adequate draindown. Care should be exercised in sizing the unit so that the time elapsed between the fill and dump cycle is sufficient to obtain a stabilized temperature reading.

2. Delivery Rate. The measuring tank system possesses the inherent ability to deliver at any rate up to the maximum capacity as determined above. This rate may be controlled throughout the capacity range by the ability of the transporting carrier to receive oil.

VENT SYSTEM

1. Vent Lines. Vent lines in the system should be of adequate size to prevent abnormal buildup of pressure or vacuum on any vessel in the system during any sequence in the operating cycle. Adequate protection against liquid movement through the vent system must be provided.

SECTION III - METER SYSTEMS - POSITIVE DISPLACEMENT METERING

INTRODUCTION

1. The purpose of this section is to outline and recommend acceptable and practical methods of obtaining reliable and accurate measurements of lease runs by means of the positive displacement meter system. The PD meter is a part of a system of devices arranged in a manner such that custody transfer of lease runs or other stocks can be automatically and continuously made while unattended.

2. This section discusses procedures and practices for meter selection, installation, operation, maintenance and calibration which are considered essential to accomplish the measuring accuracy and reliability required.

3. It is recommended that API Standard 1101 be used where portions of that standard are applicable. This section is not intended as an independent effort to standardize PD metering of crude oil but more as an adaptation of PD metering as one of the acceptable methods of obtaining the volume measurement for Lease Automatic Custody Transfer Service.

DEFINITION OF TERMS

1. Manner of Operation. Positive displacement meters are meters which measure a fluid by separating the fluid into segments and counting 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.

2. Standard 1101. The terms pertaining to PD metering which are in common usage within the petroleum industry have been set out in the Introduction of API Standard 1101 and will have the same meaning and significance when used herein.

SELECTION OF POSITIVE DISPLACEMENT METERS

1. Data Needed. Each location and application of meters will require a certain amount of individual consideration. It is recommended that the following pertinent data be defined and analyzed before selecting a meter and planning an installation for a particular service:

   a. Range. Range of operating rates of flow.

   b. Pressure. Maximum pressure which meter will have to withstand.

   c. Liquid Characteristics. Type of liquid or liquids meter will measure including viscosity, corrosiveness, RVP and API gravity.

   d. Temperature. Ambient and fluid temperature range under which meter will operate.

   e. Temperature Compensation. The applicability of automatic temperature compensation.

   f. Abrasive Materials. The amount of abrasive and size of particles and water which will ultimately reach the meter.

   g. Register. Type of register or printer desired.

2. Selection. After analysis of the foregoing data, the selection should be in accordance with the manufacturer's recommendations for a meter fulfilling the requirements.

3. Capacities. The meter manufacturers have established recommended flow rates for various sizes of meters of their manufacture and should be consulted for their specific recommendations.

INSTALLATION OF POSITIVE DISPLACEMENT METER SYSTEMS

1. General Arrangement. A recommended arrangement of equipment for automatically measuring lease runs by the positive displacement meter method is shown

in Fig. VIII. The location of each item of equipment should be such that it will properly perform the function for which it is intended depending on existing circumstances.

The schematic arrangement shown will provide satisfactory results under most conditions and is intended to be used only as a guide for meter systems installations. Under certain circumstances the arrangement of equipment should be altered to meet the requirements. For example, the choice of a three-way or a conventional valve to control flow to the pipeline will influence the location and arrangement of other items of equipment. The location of the monitor sensing element which detects nonmerchantable liquid must be such that it will be in the stream regardless of the type control valve selected. The sampler should be located in a position to adequately sample the custody transfer stream without influencing the accuracy of the meter measurement.

2. Specific Requirements. Some important considerations regarding meter installations are as follows:

a. Air Elimination. The installation should be such that air or gases will not be introduced into the system through holes, leaky valves, packing glands of pump shafts or connecting lines. In all installations which are conducive to the passage of air or gas, adequate air elimination equipment should be installed ahead of the meter. Such equipment shall in no case be of smaller rated maximum capacity than that of the pump or feed lines and shall provide complete air elimination, assuring a liquid-filled meter. Vapor outlet lines from air eliminators should be installed for suitable disposal of the vapor.

POSITIVE DISPLACEMENT METER SYSTEM

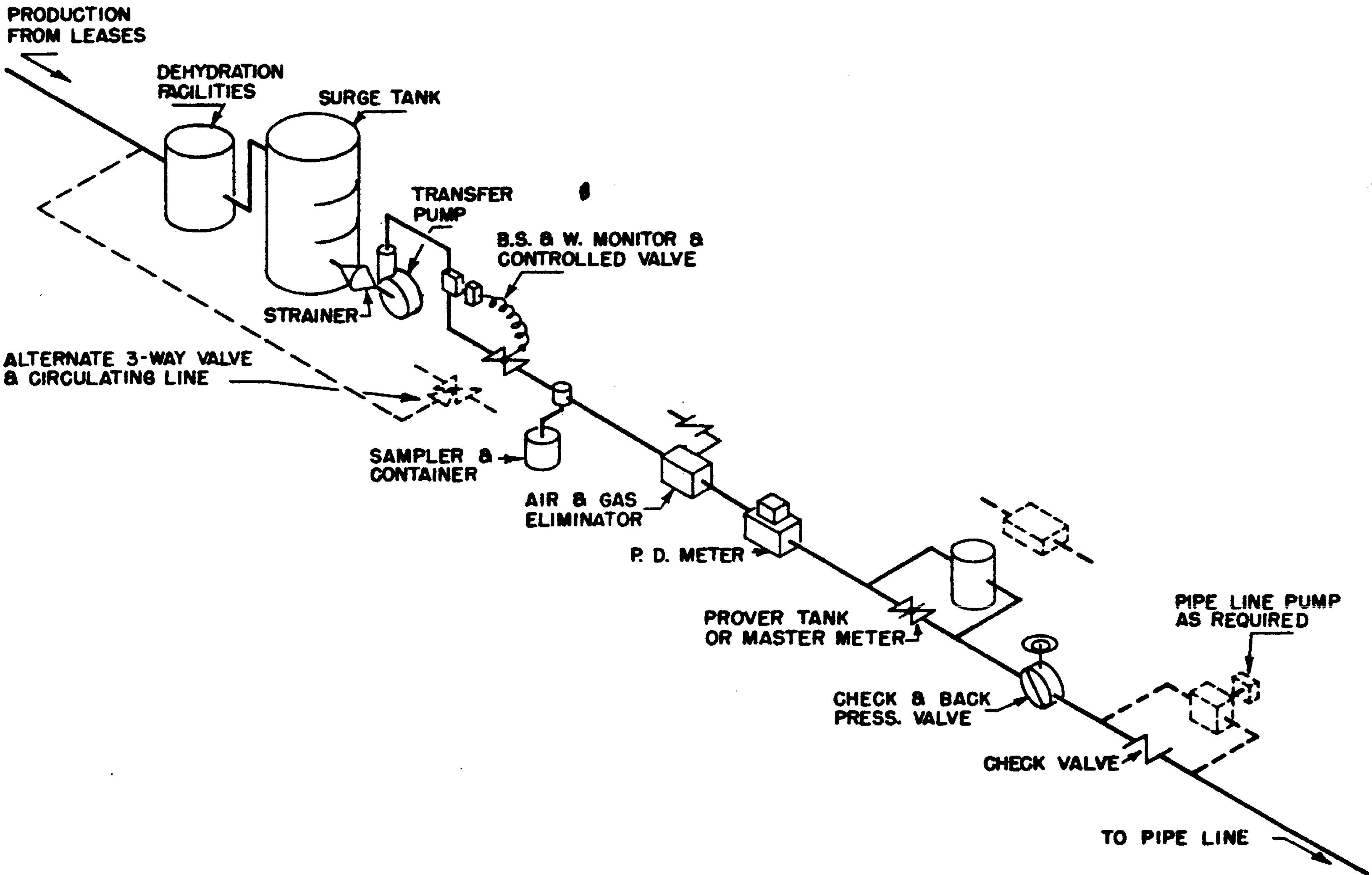


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FIGURE VIII

b. Flow Reversal. The piping system should be arranged to prevent reversal of flow of liquid through the meter.

c. Vaporizing of Stream. Any condition which tends to increase the turbulence of the system should be designed to ~~minimize~~ the possibility of vaporizing the stream.

d. Surges. Meters subjected to pressure pulsation or surges should be adequately protected by surge tanks, expansion chambers or similar devices; and no meter shall be subjected to shock pressures which are greater than its maximum rated working pressure.

e. Proving. Meter installations should be equipped with either manual or automatic means to permit proving at normal operating conditions.

f. Accuracy Range. All meter installations should be designed so that the flow rate through every meter is held between the maximum and minimum limits within which the desired accuracy is obtainable.

g. Bypasses. Any unmetered bypass around a meter or battery of meters shall be provided with a suitable means to prevent undetected flow around the meter.

3. Gross Check. A method should be provided for a gross check on the meter system to make certain that all liquid that passes the meter is indicated on the counter or printer. Some of the methods in use are:

a. Two meters in series.

b. Spot-gauging in tanks or comparison with production testing facilities.

c. Pulse counters on the meter.

d. Use of temperature or pressure recording instruments to detect flow through the meter.

METER PROVING FACILITIES AND PROCEDURES

1. Proving Facilities. Meter accuracy is dependent on the proving facilities provided,and the type of facilities required for accurate proving var several factors such as characteristics of the fluid, pressure or available, flow rates, and ambient temperature. Once adeq are provided, then accurate proving procedures mus

2. Methods. Methods of proving me ule **Prover Tanks as** outlined in API St atic Custody **Transfer Installation** sho these alternate methods, should t d.

2. Methods. Methods of proving meters such as Master Meters, Portable Prover Tanks, or Prover Tanks permanently installed at the LACT installation, as outlined in API Standard 1101, should be used. The Automatic Custody Transfer Installation should provide a test spool or outlet for these alternate methods, should the parties concerned elect to use them.

3. portion of the Surge Tank equipped nd thermometers and calibrated by the water ise strapping method outlined in applicable API as a prover tank if agreeable to the parties concerned. The m ity of the calibrated section of such prover should be ten times the max um volume delivered per minute by the largest meter to be proved. The distance between the opening and closing levels and the provision for determining the opening and closing readings should be sufficient to detect variations of .05%.

4. Proving Frequency. The frequency of calibration should be determined by meter-factor behavior and the degree of accuracy required. It is recommended that PD meters be calibrated at least once per month.

5. Calibration Records. The calibration record for each meter should be kept on file as long as the meter ticket to which it applied. A copy of each official calibration record should be supplied ~~by the meter owner~~ to each party concerned.

6. Meter Factor Record. The ticket on which the metered quantity is reported should have space provided for the meter factor and the number of the calibration record which supports the meter factor on the ticket.

METER SYSTEM OPERATION

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

2. Degree of Accuracy. The degree of accuracy desired in each installation is the governing factor in determining the extent of operating 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 complete flexibility, and in all cases the proving of meters should as nearly as possible simulate actual operating conditions.

3. Temperature Determination. 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 between the parties concerned.

4. Operation and Maintenance. There are many details in the successful and accurate operation of displacement meters in the field which cannot easily be described in a text or manual but which are essential to good metering. They are items which the meter operator must acquire through training and experience in the field. They include such things as quality meter repair and maintenance work, elimination of human errors, the detection of leaking valves, recognition of air or gas troubles, flow rates, meter reading, temperature reading, etc. Operating practices outlined in API Standard 1101 are recommended as a guide for good metering results.

5. Basic Requirements. Basically, a PD meter system should be designed and operated such that it complies with requirements of paragraph 2, Section I, page 5.

6. Components. A suggested combination of major items of equipment to provide automatic measurement by the positive displacement meter method is shown in Figure VIII. The system, as shown, has no provision for automatically handling nonmerchantable liquid when it reaches the monitor and, therefore, requires manual attention under such circumstances. A system employing a recirculating system including a diverting valve by which nonmerchantable liquid can be treated is acceptable providing it is designed properly.

7. <u>Recommended Sequence of Operation</u>. Recommended sequence of operation will vary slightly depending on the type of pipe line facility connected and the operating schedule of the pipe line. Details should be worked out for each installation; however, the following is recommended as a guide for a system which does not make use of recirculating arrangement. Recommended sequence for:

a. <u>Normal Delivery to a Gravity Flow Pipe Line - Nonscheduled Operation</u>.

1. When the liquid level in the surge tank reaches normal high working level, the transfer pump starts and the controlled valve opens to the pipeline admitting flow through the meter.
2. When the valve reaches its open-to-pipeline position, the automatic sampler is energized and begins sampling.
3. Under normal conditions, delivery to the pipeline continues until the liquid level reaches the normal low level position.
4. Then, the controlled valve closes the pipeline outlet, the transfer pump stops and the automatic sampler is de-energized.

<u>Non-Merchantable Oil Interruption</u>. After the delivery to the pipeline has begun, should nonmerchantable oil flow continuously past the BS&W monitor for a predetermined time interval, the transfer pump is automatically stopped and:

1. The valve closes, stopping flow to the pipeline.
2. The automatic sampler is de-energized.
3. The controls should lock out the transfer equipment until the nonmerchantable liquid has been treated out to meet specifications.

b. <u>Normal Delivery to a Pressurized Pipeline - Nonscheduled Operation</u>.

1. When the liquid level in the surge tank reaches normal high working level, the transfer pump starts, the valve opens to the pipeline admitting flow to the meter.

2. When the valve reaches its open-to-pipeline position, the pipeline pump starts and the automatic sampler is energized.
3. Under normal conditions, delivery to the pipeline continues until the liquid reaches the normal low-level position.
4. Then the valve closes the pipeline outlet and the transfer pump stops.
5. The pipeline pump is shut down and the sampler de-energized.

Non-Merchantable Oil Interruption. After the delivery to the pipeline has begun, should nonmerchantable oil flow continuously for a predetermined time interval past the BS&W monitor, the delivery shall be automatically interrupted;

1. The valve shall close.
2. The pipeline pump is shut down and the sampler is de-energized.
3. The controls should lock out the transfer equipment until the nonmerchantable oil has been treated out to meet specifications.

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 should 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.