Manual of Petroleum Measurement Standards Chapter 6—Metering Assemblies

Section 2—Loading Rack Metering Systems

THIRD EDITION, FEBRUARY 2004

REAFFIRMED, AUGUST 2011

AMERICAN PETROLEUM INSTITUTE

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Measurement Coordination

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FOREWORD

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Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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1 Introduction

This standard serves as a guide in the selection, installation and operation of loading rack metering systems for petroleum products, including liquefied petroleum gas. This standard does not endorse or advocate the preferential use of any specific type of metering system or meter.

In general, metering system installations must meet certain fundamental requirements, including those that ensure proper meter type, size, installation and adequate protective and readout devices (such as presets, registers [counters], strainers, relief valves, pressure and flow control valves, and air eliminators, where required). Descriptions of these and other system components are covered elsewhere in this standard or other API standards. Also, to ensure compliance with state laws and regulations the latest editions of NIST Handbook 44, Handbook 12, as well as specific local weights and measures requirements, should be considered.

2 Scope of Application

This standard offers guidance on the design, selection, and operation of loading rack metering systems and associated equipment where liquid hydrocarbons are loaded into vehicle tanks.

3 Pertinent Publications

3.1 REFERENCED PUBLICATIONS

The most recent editions of the following standards, recommended practices, and handbooks are cited in this standard.

API

Manual of Petroleum Measurement Standards (*MPMS*)

Chapter 4.2, "Pipe Provers"
Chapter 4.4, "Tank Provers"
Chapter 4.5, "Master Meters"
Chapter 4.6, "Pulse Interpolation"
Chapter 4.7, "Field-Standard Test Measures"
Chapter 5.1, "General Considerations for Measurement by Meters"
Chapter 5.2, "Measurement of Liquid Hydrocarbons by Displacement Meter"
Chapter 5.3, "Measurement of Liquid Hydrocarbons by Turbine Meters"
Chapter 5.6, "Measurement of Liquid Hydrocarbons by Coriolis Force-Flow Meters"
Chapter 6.6, "Pipeline Metering Systems"
Chapter 7, "Temperature Determination"
Chapter 9, "Density Determination"
Chapter 11.1, "Physical Properties Data"
Chapter 11.2.1, "Compressibility Factors for Hydrocarbons: 0 – 90 API Gravity Range"
Chapter 11.2.2, "Compressibility Factors for Hydrocarbons: 0.350 – 0.637 Relative Density"
Chapter 12.2, "Calculation of Liquid Petroleum Quantities by Turbine or Displacement Meters

RP 1004 — *Bottom Loading and Vapor Recovery for MC-306 Tank Motor Vehicles*
RP 2003 — *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

NIST[1]

Handbook 12 — *Examination Procedure Outlines for Weighing and Measuring Devices*
Handbook 44 — *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*

4 Loading Rack Metering Systems

The loading rack metering systems described in this standard are those that apply to transport-type truck facilities. The rack may be of a single-product/single-meter, single-product/multi-meter, or multi-product/multi-meter design. The design of the rack should allow one meter to be proved without interfering with the other meters involved in the loading operations.

4.1 LOADING RACK METERING SYSTEM INSTALLATION

Loading rack metering systems are designed to deliver accurate quantities of products into transport trucks for the subsequent delivery to remote locations. The metering configurations may consist of single tally meters, single product meters, blend meters and additive meters. Since rack delivery meter volumes are considered in the terminal loss/gain determination, the design, installation and operation of the meters is extremely important. It must be noted that the loading rack is usually the final opportunity to measure accurately, i.e., after the product leaves the loading rack, measurement errors are difficult to correct.

Each meter must be proved under conditions as close to normal as possible. This would encompass the usual delivery

[1]National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, Maryland 20899.

flow rate into a tank prover. Another acceptable consideration is to prove via a pipe prover, with the prover return line delivering to the transport truck. Some designs now include terminal return lines where, following the proving, the fluid is delivered back to the originating tank. When return lines are utilized, ensure that tank head pressure or pump inadequacy doesn't cause an unacceptable decrease in flow rate. Caution should also be exercised to ensure adequate tank pump delivery flow rate so that multiple product activity doesn't cause a drop in flow delivery.

4.2 TOP LOADING

Since State and Federal regulations govern the release of hydrocarbon emissions to the atmosphere, some forms of top loading may not be acceptable.

Top loading (see Figure 1) requires the use of an overhead-loading arm to reach the loading dome hatches on the trucks. Loading arms should be designed to reach all domes on a single-bottom truck to avoid moving the truck. They should be equipped with an extended drop tube and either a deflector end or a 45º cut C tube end that will reach to the bottom of the truck and provide submerged filling. The loading arm should be in the same state of fill—either void or full—at the beginning and end of the loading operation to ensure measurement consistency.

Top loading arms designed to be completely empty when not in use should be equipped with a manual or automatic vacuum breaker located at the high point in the piping and downstream of the loading valve. This provision allows the arm and drop tube to drain after the loading valve is closed.

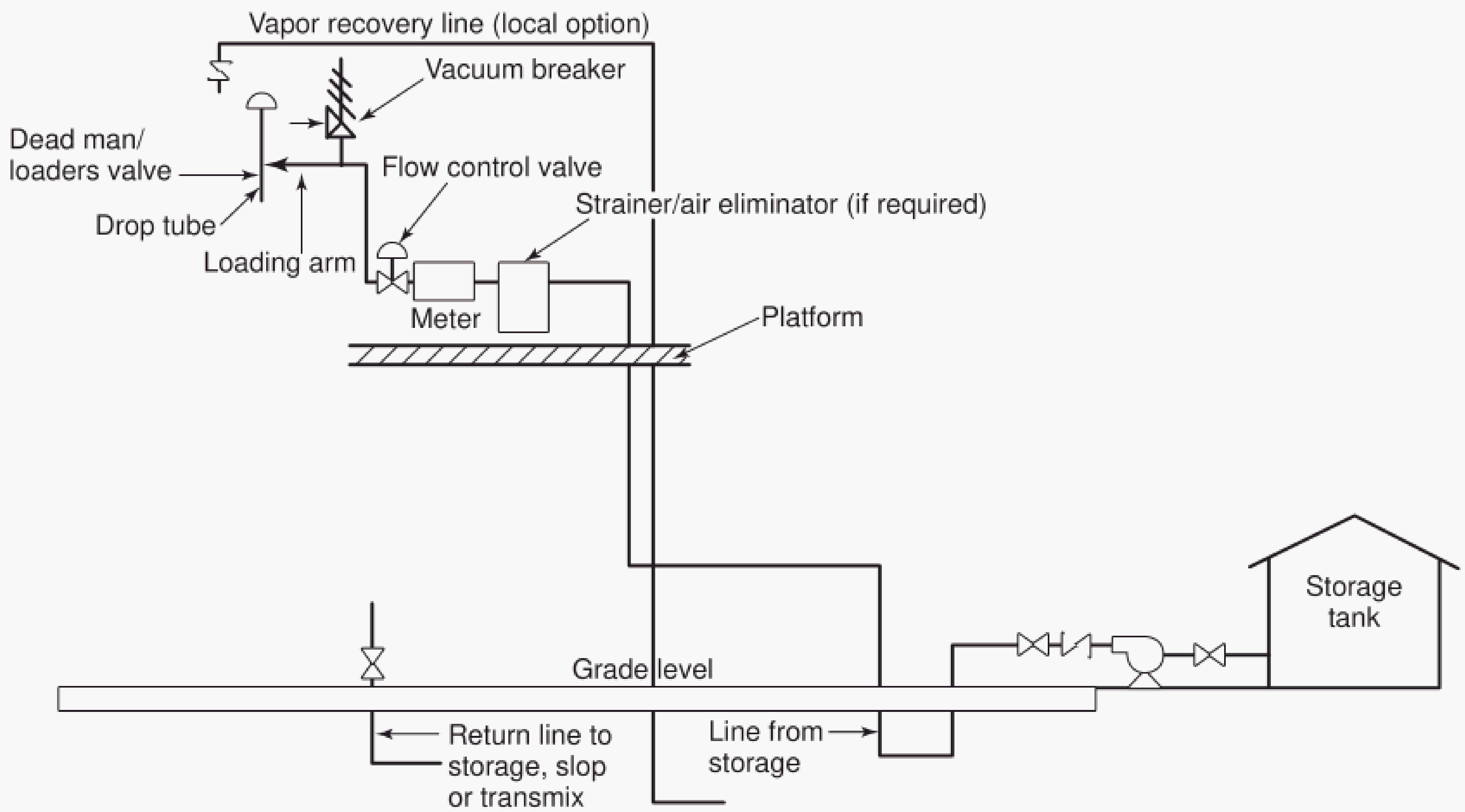
Top loading arms should be designed to swing up to avoid interfering with trucks entering the loading area and should be counterbalanced by a spring or weight to enable easy positioning. When overhead clearance is insufficient for swinging the loading arm, the loading arm must be moved horizontally and the drop tube must be attached and detached at each loading dome on the truck.

Meters for top loading racks can be located on the loading platform or near the ground. When the meter is located below the platform, the meter register shall be located to facilitate the reading of quantities by the truck loader, who shall be positioned to observe the filling of the compartment. A preset device, either local or remote, may be installed in any loading system to expedite loading operations.

Access from the loading rack platform to the top of the truck is usually afforded by ramps, adjustable stairways, or platforms that are hinged to the side of the loading rack platform and can be swung down to the top of the truck. A handrail should be provided for the safety of truck loaders standing on top of the truck or platform.

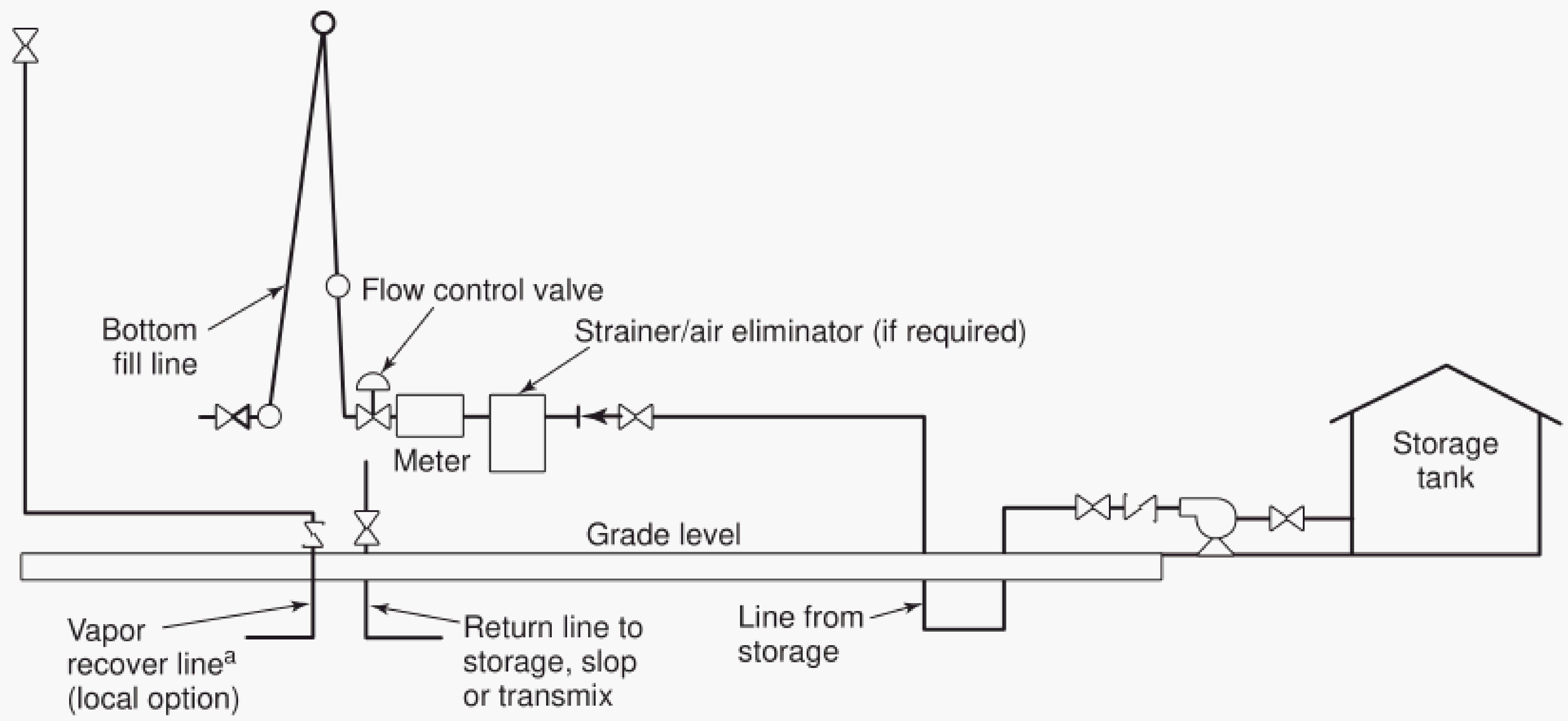
4.3 BOTTOM LOADING

The recommendations for bottom loading (see Figure 2) are described in API RP 1004. During bottom loading, the loader is not required to be on top of the truck. However, since the filling of the vehicle compartment cannot be observed by the truck loader, the system shall be equipped



Note: All sections of line that may be blocked between valves should have provisions for thermal pressure relief.

Figure 1—Installation Diagram—Metered Tank Truck Loading Rack (Top Loading)



Note: All sections of line that may be blocked between valves should have provisions for thermal pressure relief.
[a]As required and approved by environmental regulations.

Figure 2—Installation Diagram—Metered Tank Truck Loading Rack (Bottom Loading)

with a preset device to shut off the flow of product after a predetermined amount has been metered. Also, an overfill shutdown system shall be provided in case too large a volume is entered into the preset device or the vehicle compartment is not empty immediately before loading starts.

4.4 LOAD RACK ACCESSORIES

4.4.1 Strainers

A strainer should be installed upstream of the meter, per manufacturer's recommendations, to trap solid particles that could damage the meter. The strainer shall be checked and cleaned periodically, since an accumulation of solid material in the strainer can restrict flow, creating the potential for product vaporization just upstream of the meter, and could cause the flow rate to differ from the meter-proving flow rate.

4.4.2 Air Eliminators

Air eliminators are required in systems where air can be induced into the system. The air eliminator is located upstream of the meter, and its purpose is to dispose of any air in the delivery line before it passes through the meter. If a system is designed so that significant amounts of air, vapor, or both cannot be introduced, an air eliminator is not required.

4.4.3 Vapor Control

Regardless of the type of loading that is used—either bottom loading or top loading—some vapor will be produced in the truck compartment. The turbulence of the incoming product and the rising liquid level will cause air and vapor to be dispersed either out the top of the truck compartment to the atmosphere or to a vapor-processing system. If the system is equipped with a vapor control system, a check valve shall be installed in the vapor line as mandated by EPA regulations.

4.5 VALVES

4.5.1 Thermal Relief Valves

Thermal relief valves are required to prevent over-pressurization of the metering system.

Any section of the tank-to-loading-rack supply piping that can be isolated by the closing of control valves, block valves, check valves, etc. shall be protected by thermal relief. The integrity of these valves shall be verified periodically because of their potential to impact measurement. Thermal relief lines should be located to minimize the potential for product bypass around the meter, which can affect measurement accuracy. Installation upstream of the main product meter is acceptable provided the product flow control valve will relieve internally when downstream piping experiences excessive pressure.

4.5.2 Isolation/Secondary Shutoff Valves

Inlet/isolation valves are required to shut off flow. Typically, these valves are utilized for maintenance purposes and to minimize the volume of product during drain-down. These valves can be automated and controlled by the secondary overfill protection system. This may reduce the potential for an overflow if the flow control valve fails to fully close when required.

4.5.3 Check Valves

Check valves are required to prevent backflow, siphoning with low tank head, and cross contamination of product during blending applications. When choosing the proper check valve, consider pressure drop and slamming of the flapper, which can cause damage when the valve opens and closes.

4.5.4 Flow Control Valves

Flow control valves must be installed downstream of the meter. These valves should provide a smooth opening and closing and be capable of stable flow control. Additionally, quick operation is required to prevent overfill.

The manufacturer's recommended flow control range should not be exceeded. This could result in poor flow control, unsafe shutoff, inaccurate measurement, and premature wear.

The flow control valve is typically controlled by an electronic preset to reduce the discharge rate at start-up or before shutdown, to control the delivery rate and to shut off the flow at the conclusion of the delivery. Because most flow control valves depend on differential pressure for proper operation, care should be taken to ensure that operating pressures provide for adequate speed of operation.

4.6 LOADING RACK SHOCK

Severe shock to loading rack systems can occur unless certain precautions are taken in the design of the rack delivery facilities, in the construction of the facilities, or in both. Closing the loading or control valve too rapidly causes this shock, called hydraulic hammer. It should be avoided by controlling the closing rate of the valve involved. Emergency shutdown of a bottom loading rack initiated by a high-level shutdown device must be accomplished in a time frame that will prevent overflow. The use of slow-closing valves or the control of the closing rate on the loading arms is recommended to reduce line shock. The occurrence and severity of line shock depend on flow rate, shutdown rate, and length and size of lines. When preset devices are used, a two-stage start-up-and-shutdown valve should be incorporated to start the flow slowly before it allows full flow to develop and to slow the flow down shortly before the final shutoff.

5 Meters

This section covers the characteristics of loading rack meters and discusses only those considerations unique to the design, selection, installation, and performance for refined product truck loading.

Historically, truck loading racks were designed for use with displacement meters; however, technological advances and blending applications have encouraged the introduction of other meter designs such as turbine and Coriolis meters. When retrofitting existing displacement metering systems with turbine and Coriolis meters, care should be taken to ensure proper application of these technologies. At a minimum, to ensure proper operating performance, meters should be installed according to manufacturers' recommended practices. Make certain that any areas that may trap or build up with debris are avoided. Avoid installing the meter at a high point in the piping to prevent trapping air in pockets and causing problems with equipment and perhaps creating safety issues.

5.1 DISPLACEMENT METERS

Displacement meters (API *MPMS* Ch. 5.2) will require some form of signal output, either mechanical or electronic. Note that whenever a meter with a manual calibrator mounted below the pulser is retrofitted with an electronic pulse output device, the calibrator must be removed.

Displacement meters typically can be mounted either vertically or horizontally. Consult the manufacturer for proper orientation or issues of bearing load and wear. Displacement meters do not require flow conditioning. See Figure 3 for a typical installation.

5.2 TURBINE METERS

The performance of turbine meters (API *MPMS* Ch 5.3) is affected by liquid swirl and non-uniform velocity (laminar) profiles that are induced by upstream and downstream piping configurations, valves, pumps, joint misalignment, protruding gaskets, welding projections, additive injection points, thermowell or other obstructions. Flow conditioning shall be used to overcome swirl and non-uniform velocity profiles. Upstream flow conditioning requires the use of a flow conditioning plate, sufficient length of pipe, or a combination of straight pipe and straightening elements. Flow conditioning is required downstream of the meter; generally, five pipe diameters is recommended.

A flow conditioning plate is a perforated plate or wafer that has a unique geometric pattern of holes or openings to provide flow conditioning with a minimum use of space. Flow conditioning plates provide a uniform flow distribution with low turbulence intensity and are designed to eliminate swirl and produce a fully developed velocity flow profile. They function by greatly reducing the scale of turbulence into a large number of small disturbances, which coalesce and rapidly diminish.

The position, size and number of holes in the plate are designed to provide a uniform velocity profile. Any misalignment of the plate could cause errors in registration. Manufacturers often design plates as an integral part of the turbine meter design to ensure alignment. Due to possible misalignment, caution is recommended for plates that bolt between flanges and are not integral to the turbine meter. Periodic inspection of the plate is necessary to prevent fouling, plugging or distortion. Any disturbance of the plate requires that the meter be re-proved.

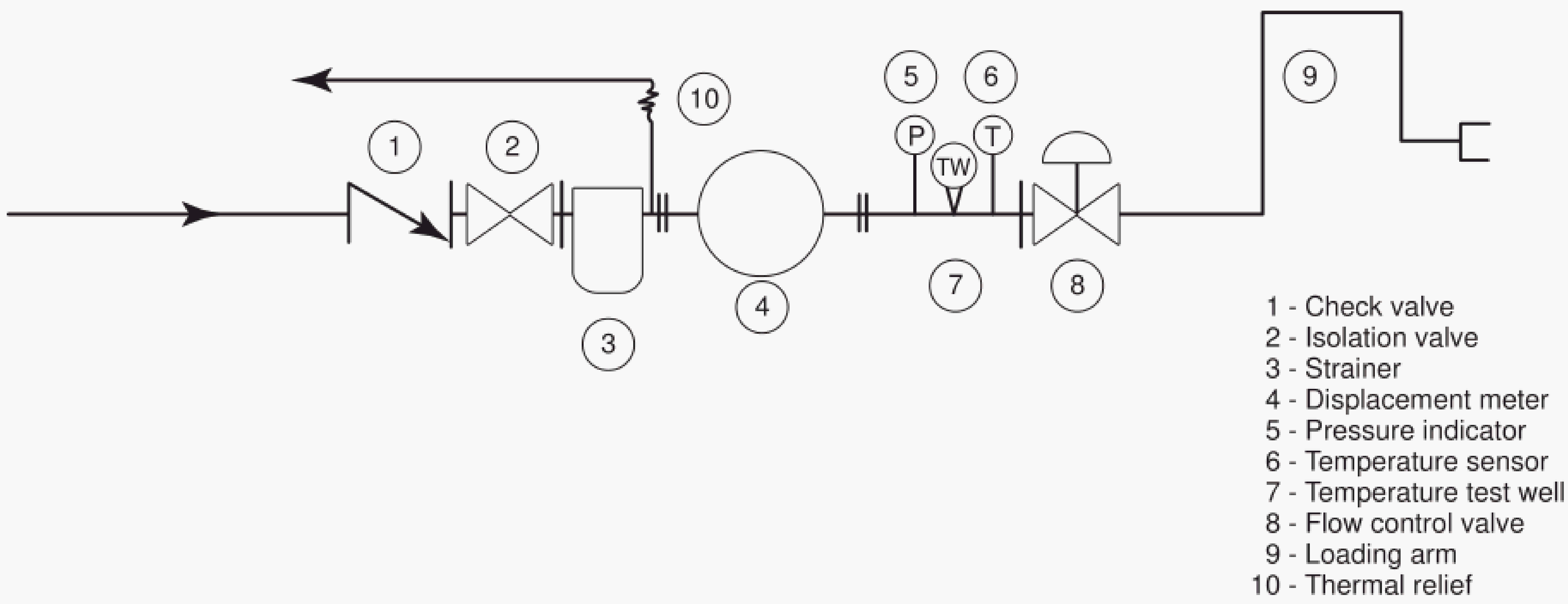


Figure 3—Typical Displacement Meter Loading Rack Configuration

Perforated plates generally have a higher pressure drop than a tube bundle type. The amount of open area may vary by manufacturer, thus affecting pressure drop and flow rate. The effects on delivery rate must be considered when using plates.

Plates can be used in different piping configurations. Meters with plates can be mounted either in the vertical or in horizontal piping.

For loading racks, turbine meters may be mounted either vertically or horizontally; however, a downward flow to a vertically mounted meter is not recommended. In this case, the rotor will not be hydraulically balanced and will ride continuously on the downstream bearing, thus causing added wear and measurement errors.

Turbine meters are more susceptible to problems arising from debris (see Figure 4).

5.3 CORIOLIS METERS

The sensor output signal from a Coriolis meter is not directly usable. The signals from the meter are interfaced with the integral signal processor where they are converted to a pulse output.

Coriolis meters (API *MPMS* Ch 5.6) need to be mounted such that they remain liquid full. Any air in the sensing tubes will create errors in the measurement system. Consult with the manufacturer for specific installation requirements. Coriolis meters do not require flow conditioning (see Figure 5).

A means should be provided to isolate the liquid full meter under no-flow conditions for zeroing purposes, in accordance with the API *MPMS* Ch 5.6.

5.4 ELECTRICAL INSTALLATION

Truck loading systems may include a variety of electrical and electronic accessories. The electrical system shall be designed and installed to meet the manufacturers' recommendations, as well as any local, state, city, national, or company regulations. Caution must be exercised to avoid noise inducement and signal interference with the meter pulse signal, which can adversely impact measurement.

5.5 FLOW RATES

Corporate safety requirements, manufacturer's recommendations, and requirements of NIST Handbook 44 govern allowable flow rates.

Operating at flow rates above the manufacturer's specifications may result in inaccurate measurement, premature wear, cavitation, and unsafe conditions. Some form of detection or preventative method should be used to prevent this condition.

Flow rates below the manufacturer's recommended minimum rates may cause inaccurate measurement and may void any weights and measures approval.

5.6 PRESSURE DROPS

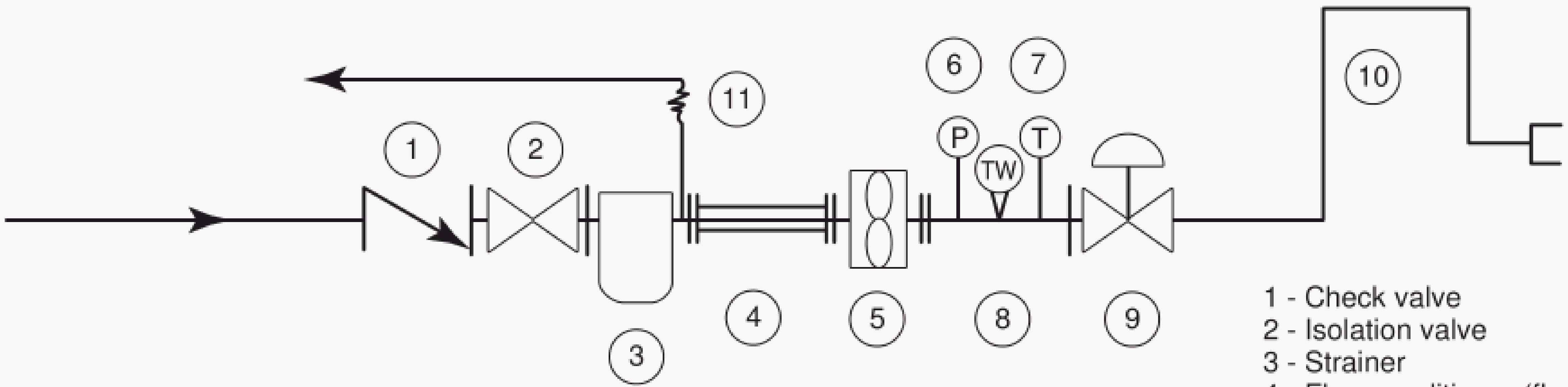
Pressure drop is a major concern for all types of meters. Typically, loading racks run off high volume, low head pumps. If the pressure drop across the metering system becomes too great, it may cause the flow control valve to malfunction. This high pressure drop situation can create cavitation, poor flow control, inaccurate shutdown, and unsafe loading conditions.

Pressure drop calculations should be made for typical loading conditions.

5.7 SIZING OF METER

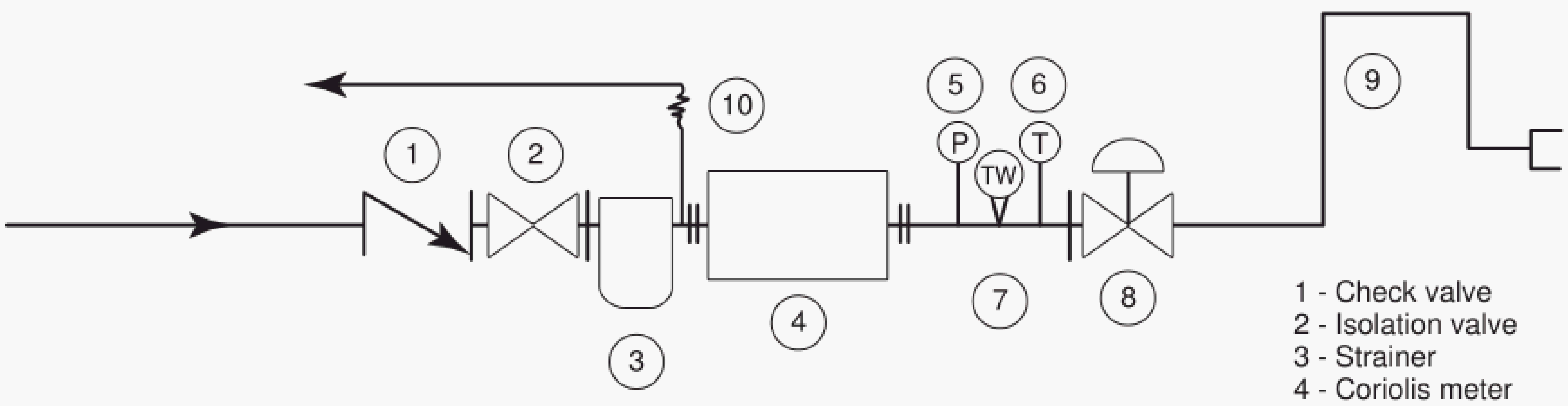
Meter sizing shall be in strict accordance with the manufacturer's recommendations

Meters should be sized to accurately measure flow at minimum and maximum flow rates. Product loading should be done at safe rates and low enough to prevent or minimize splashing, vaporization, and generation of static electricity (see API RP 2003).



1 - Check valve
2 - Isolation valve
3 - Strainer
4 - Flow conditioner (flow conditioning plate or tube bundles)
5 - Turbine meter
6 - Pressure indicator
7 - Temperature sensor
8 - Temperature test well
9 - Flow control valve
10 - Loading arm
11 - Thermal relief

Figure 4—Typical Turbine Meter Loading Rack Configuration



1 - Check valve
2 - Isolation valve
3 - Strainer
4 - Coriolis meter
5 - Pressure indicator
6 - Temperature sensor
7 - Temperature test well
8 - Flow control valve
9 - Loading arm
10 - Thermal relief

Figure 5—Typical Coriolis Meter Loading Rack Configuration

Many loading racks are designed for typical maximum rates of between 500 and 700 GPM. For either bottom or top loading, it is desirable to start the load with a low flow condition to ensure adequate compartment head to minimize splashing, vaporization, and static electricity. Normally the flow range for most truck loading meters will have a maximum 5:1 turndown ratio. This is also required by NIST.

5.8 BACK PRESSURE CONTROL

Conditions that contribute to flashing and/or cavitation of the liquid stream as it passes through the meter can be avoided through suitable system design and operation of the meter. Sufficient pressure within the meter can typically be accomplished by using flow control valves for product meters or backpressure control valves for LPG meters.

In the absence of a manufacturer's recommendation, the numerical value of the minimum pressure at the outlet of the meter may be calculated with the following expression, which has been commonly used. The calculated pressure has proven to be adequate in most applications, and it may be conservative for some situations.

$$P_b \approx 2\Delta P + 1.25P_e$$

where

P_b = minimum backpressure, pounds per square in. gauge (psig),

ΔP = pressure drop through the meter at the maximum operating flow rate for the liquid being measured, pounds per square in. (psi),

P_e = equilibrium vapor pressure of the liquid at the operating temperature, pounds per square in. absolute (psia), (gauge pressure plus atmospheric pressure).

6 Blending

This section discusses the design, selection, installation, operation, performance, and maintenance of product blending systems at truck loading racks.

The two primary blending systems used are sequential blending and ratio blending.

6.1 SEQUENTIAL BLENDING

6.1.1 Splash Blending

Splash blending is accomplished by manually loading individual components in the proper proportion according to the finished product recipe. Components are normally added one at a time through discrete product meters and loading arms (see Figure 6).

6.1.2 Automatic Sequential

Sequential blending is accomplished by loading individual components in the proper proportion according to the finished product recipe. This is accomplished by opening product line block valves one at a time through one meter/load arm position in a set sequence to complete the finished product (see Figure 7).

6.2 RATIO BLENDING

6.2.1 Off Rack Ratio Blending

Off rack ratio blending, otherwise known as wild stream (see Figure 8) or header (see Figure 9) blending, is accomplished by simultaneously combining two or more products while metering the slipstream component along with the blended combination. The final blend proportions are maintained by controlling the rate only through the slipstream meter to ensure its proper proportion of the overall volume. This is accomplished in the main supply header upstream of the loading rack. This process is typically automated.

6.2.2 On Rack Ratio Blending

On rack ratio blending is accomplished by simultaneously combining two or more products through dedicated unique meters in respective amounts and flow rates according to the finished product recipe. This is accomplished at the individual loading position while delivering into a truck. This process is typically automated (see Figure 10).

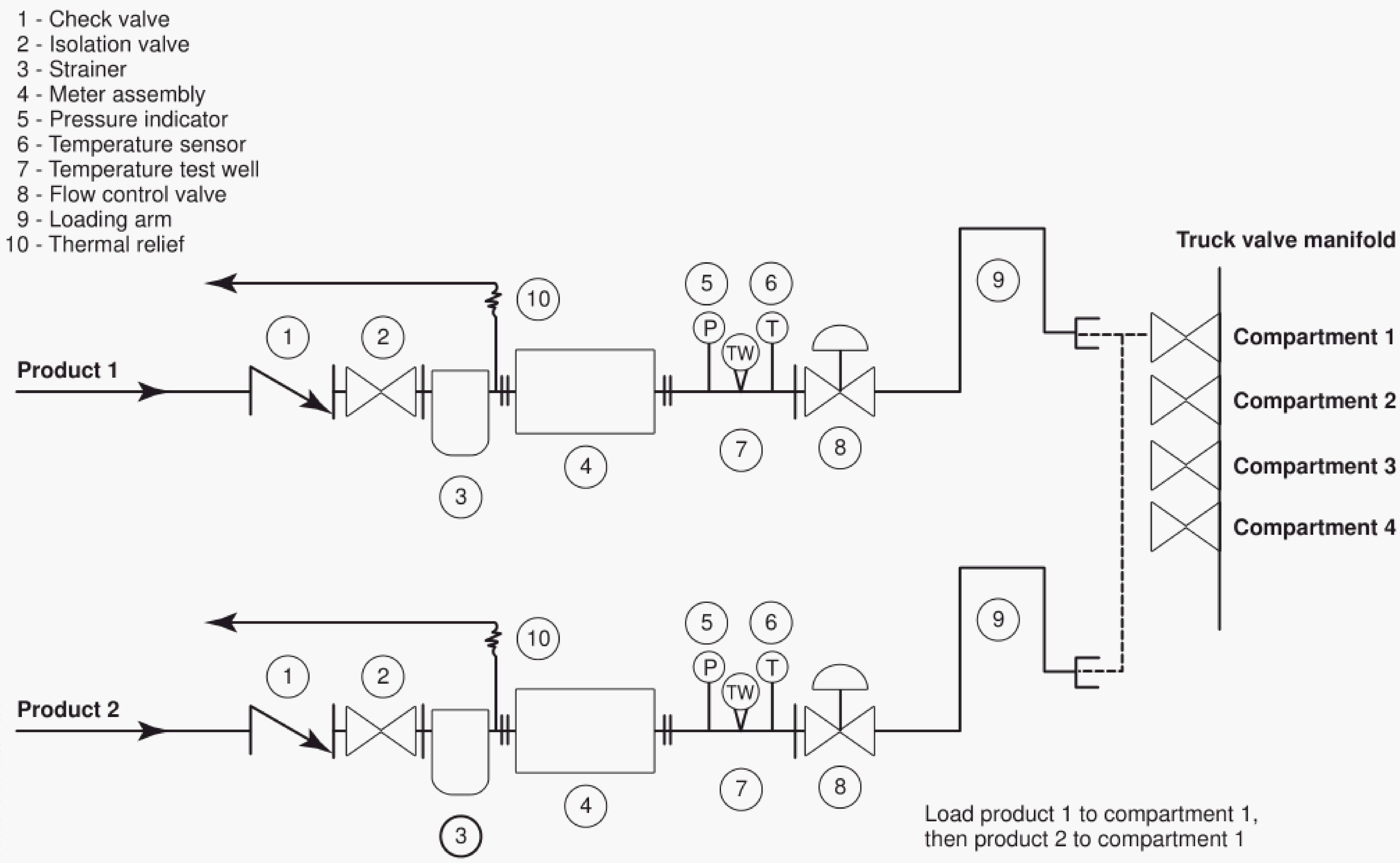


Figure 6—Typical Splash Sequential Blending

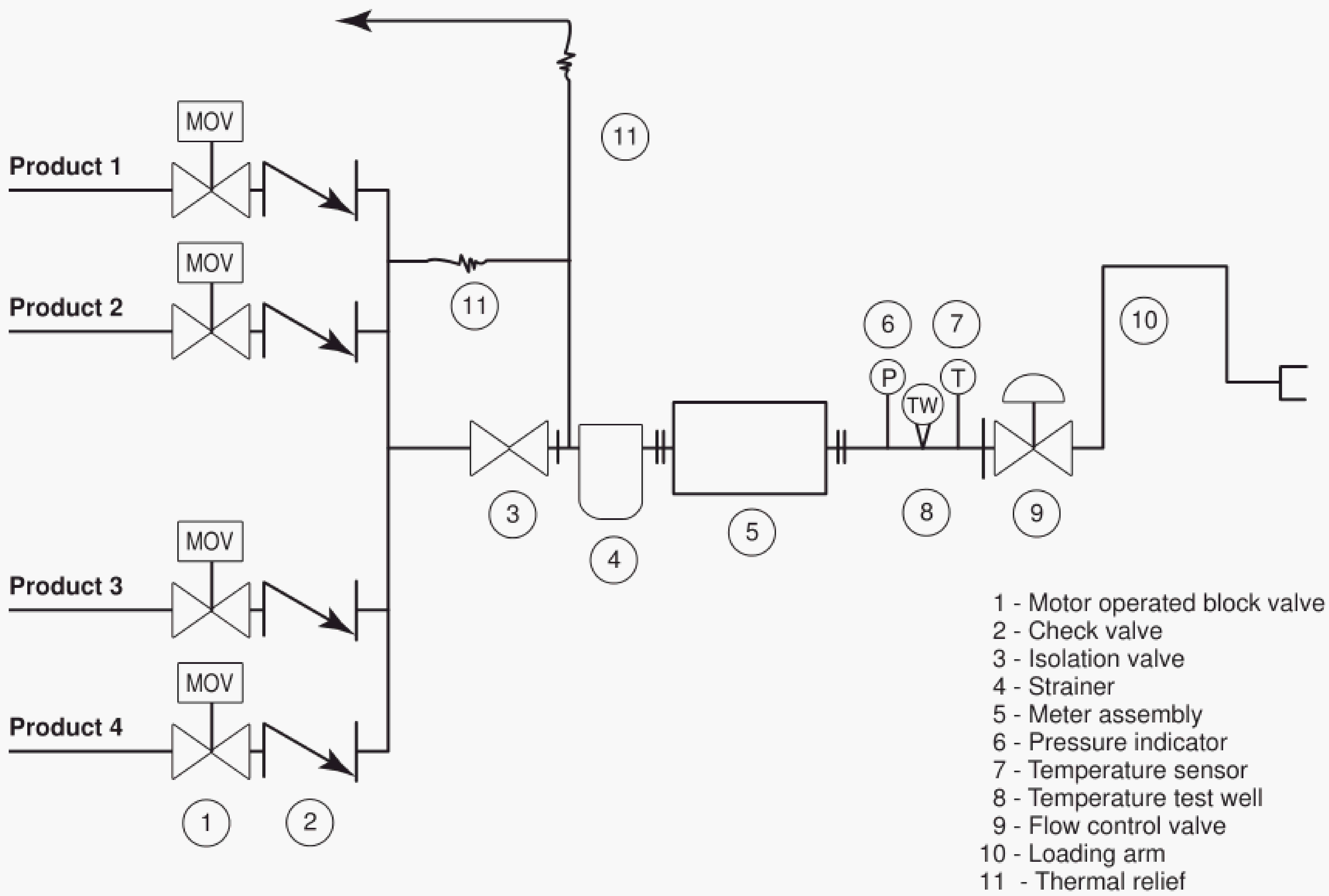


Figure 7—Typical Automated Sequential Blending

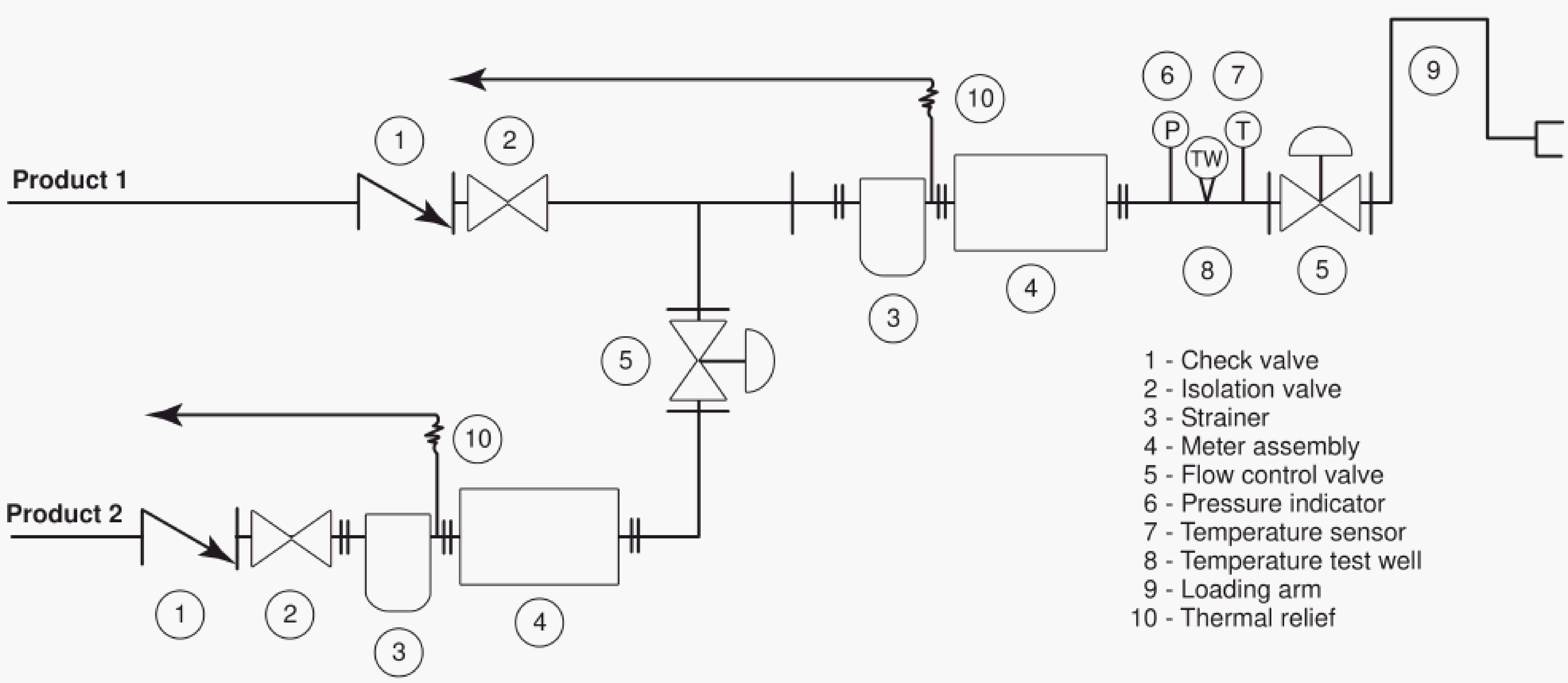


Figure 8—Typical Wild Stream Blender, Off Rack/On Rack

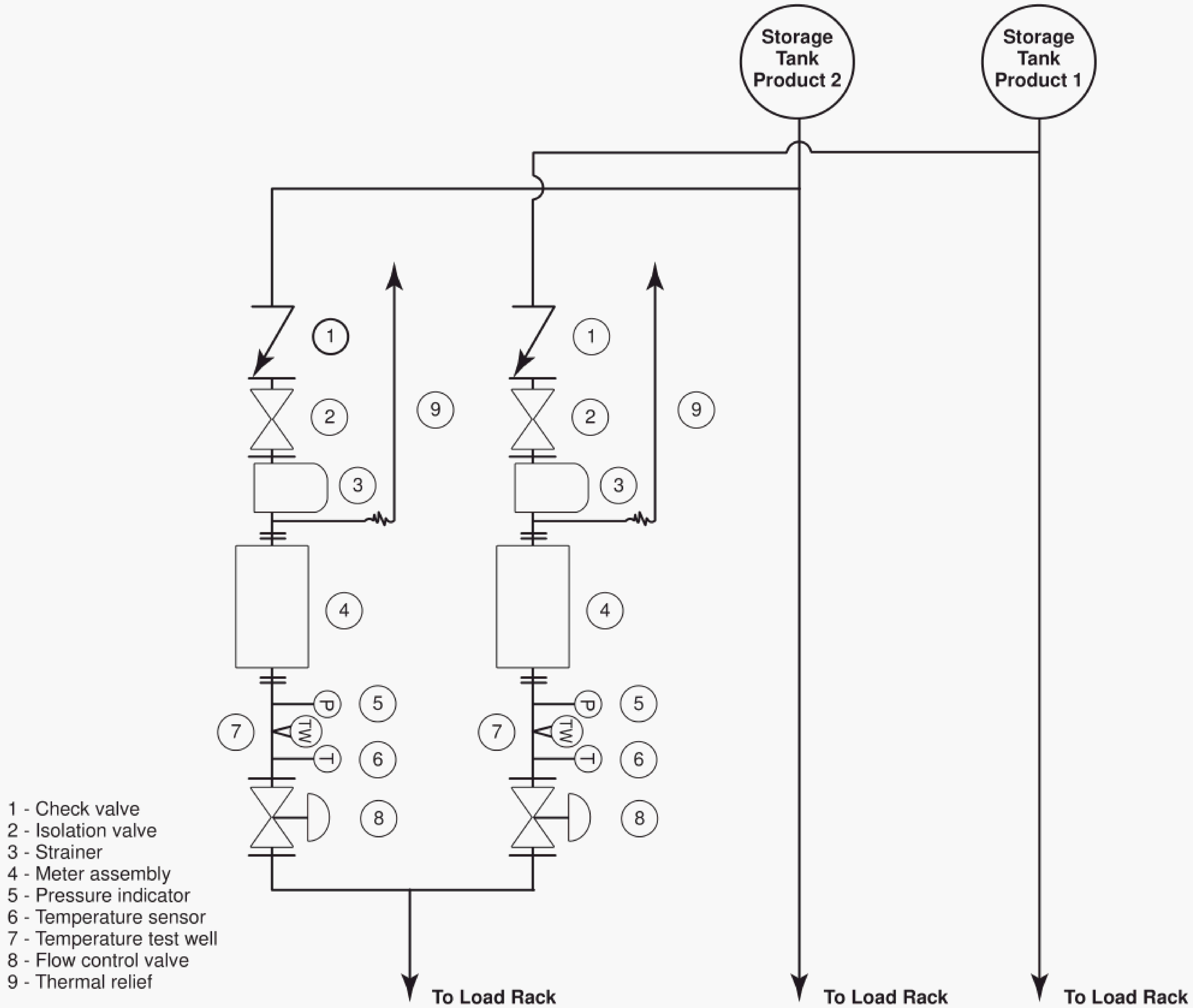


Figure 9—Ratio Blending—Off Rack Header Blending

6.3 DESIGN CONSIDERATIONS

The design of refined products blending systems for truck loading racks should consider the following:

6.3.1 Load Rack Layout

Consideration should be given to the physical configuration of the loading rack, including the number of islands, product availability, and piping configurations.

The number of islands will depend upon expected terminal throughput and planned terminal operation. Design should include provisions for future expansion.

Consideration should be given to the number of arms per product for terminal utilization and product availability at each load spot. In some facilities, blending may only be required during certain times of the year so there may be no need for every arm to blend. The number of arms per product is also affected by pumping capacity.

The logistics of product headers and manifolds is critical. Piping should be minimized to reduce pressure loss. Typical loading rack pumps are low head (low pressure) and any additional pressure loss will reduce resultant flow rates. Piping downstream of the physical blend location should be minimized to reduce or eliminate product degradation and

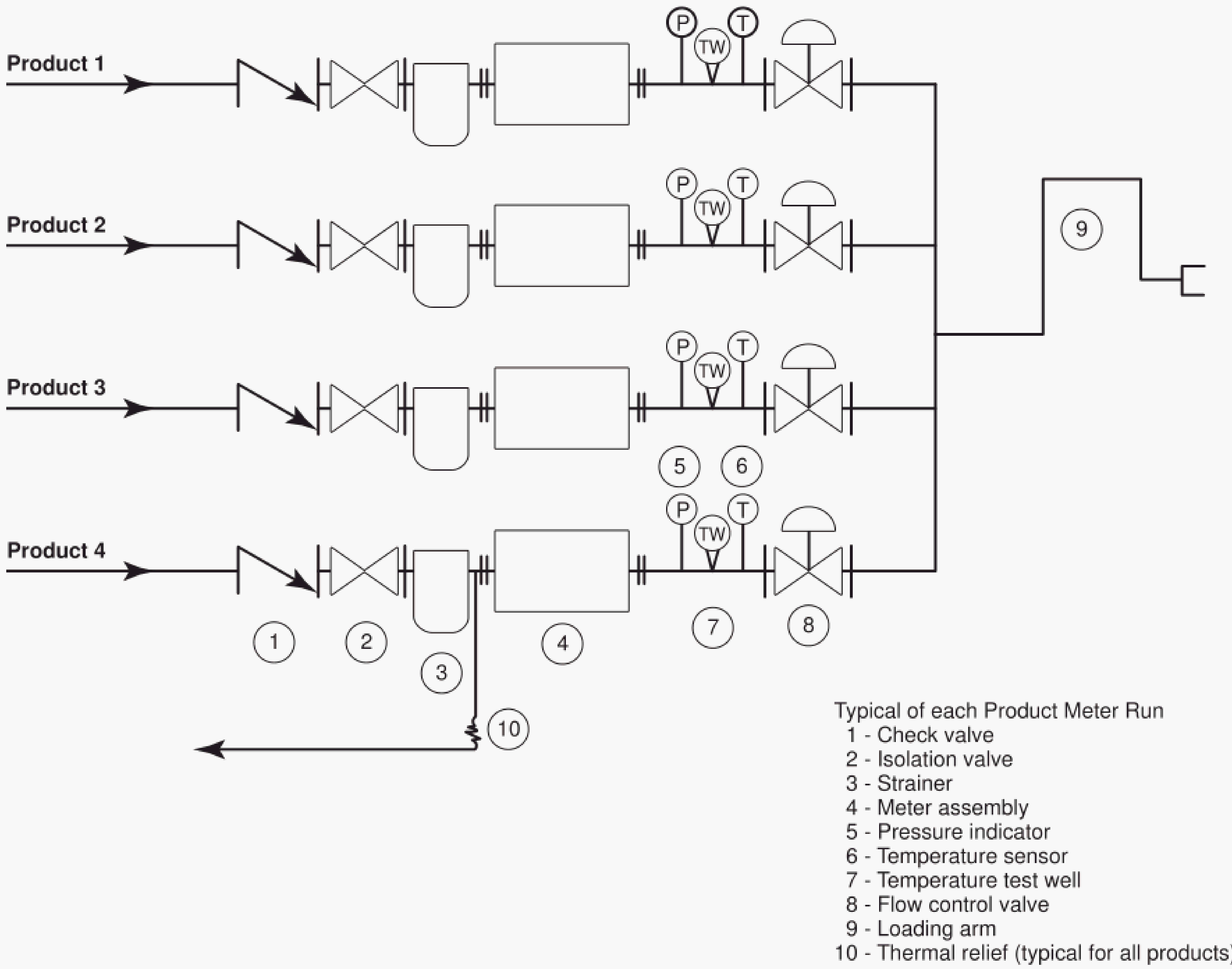


Figure 10—Typical Automatic Multi-product On Rack Ratio Blending

contamination. High spots where vapors can collect should be eliminated.

6.3.2 Pumping Capacity and Flow Rates

Achievable flow rates at a facility are dependent upon the considerations in Section 6.3.1 as well as pumping system capacity. Consideration must be given to product flow and pressure demands on pumping systems. Without adequate pressure or flow capacity, loading operation parameters can suffer adverse consequences.

A typical product load profile consists of a low flow start-up (to minimize splashing, vaporization and static electricity build-up), a high flow component, and then a low flow component just prior to shutdown to minimize system shock and the chances of overfill. The valve that controls the load profile depends on sufficient product pressure and flow to operate properly. If product pressure falls too low due to insufficient pump capacity, the flow control valve may not close as quickly as desired. Likewise, if product flow is not sufficient, the flow control valve may open more than desired and lose its ability to properly control the flow rate.

Insufficient pumping capacity can also affect meter accuracy by causing changes in flow rate and pressure.

Consideration must be given to the quality of the blend. EPA regulations provide for testing the blended product and recording the data. Blend quality must be maintained to meet clean air regulations and product standards, since off-spec blends may be costly and unusable. When required flow rates cannot be met to maintain necessary recipe ratios, the blend accuracy can be affected. If rates become too low, the control valves will have difficulty maintaining accurate control. Flow rates that are too low may also be out of the accuracy range of the meter. Both instances will cause inaccurate measurement and blends. Certain types of blending demand very tightly maintained flow rates and pressures to ensure proper blend percentages. Ratio blending is dependent upon proper hydraulic conditions. Wildstream ratio blending (see Figure 8) requires that the slipstream product pressure be at least 25% higher than the mainstream product in order to ensure accurate blending. Sufficient pressure in the system is required to provide adequate backpressure on the meter to prevent cavitation and inaccurate measurement.

To help maintain proper rack flow and pressure characteristics, it is common to stage pumps based on the number of arms being loaded at a given time. For example, with three pumps in parallel on a product header, one pump may run to satisfy two arms, the second pump would start to meet demand for a third and fourth arm, and the third pump would start for demands five and above.

6.3.3 Meter and control valve sizing

All meters and control valves have minimum and maximum ranges with respect to both flow rate and pressure. It is imperative that these ranges are not exceeded under any loading circumstances. The anticipated loading rates with single as well as multiple loading arm operation should be verified. Consult the manufacturer for meter and valve sizing and recommendations.

Finished product recipe components can vary greatly in both the volume and rate that they are loaded. It is necessary to be certain that any recipe and the associated percentages of the components of the recipe fall within the linear and repeatable flow ranges of the meter and control valve.

6.3.4 Contamination

Contamination can affect both the final blended product and the stock product. A load arm used for any type of blending will have product between the preset control valve and the load arm coupler. If the load arm is a multiple product arm where blended and straight products are available, the last product delivered in the recipe is typically the highest octane available at that location. Lower octane products left in this section of piping may be sufficient to contaminate the next load. This length of piping should be as small as possible to minimize octane giveaway. Since the products at a given load arm are manifolded either upstream in the case of sequential blending, or downstream in most cases for ratio blending, it is necessary to provide check valves in each line to prevent back flow and line contamination.

Audit trail methods are necessary to track each component of the blend and the blended product itself. EPA regulations must be consulted to determine requirements. This is also true for fuel additives and dyes.

7 Additives

Additives are added to the main products dispensed at the loading rack as required during loading operations to enhance engine performance and meet EPA regulations. These additives may be proprietary or common among multiple suppliers. Any additives dispensed must be accounted for based on the required additive to main product ratio over a specified time period. Additives include dyes for tax-exempt use of product, detergents to assist in cleaner fuel burning, and odorants for LPG applications. Additive injection may be accomplished using mechanical piston-based injectors or electronically controlled meter-based injectors. The system shall be capable of being monitored to provide alarms and shutdown during upset conditions.

7.1 LOCATION OF INJECTION POINT

The additive injection equipment should be located as near as possible to the point of custody transfer at the loading rack to reduce tubing pressure drop and facilitate ease of calibration.

Additives may be injected upstream or downstream of the main custody transfer meter. However, if injected downstream of the main product meter, additional product accounting is required to account for additive volumes.

7.2 ADDITIVE METERS

Additive is typically metered using a small volume oval or spur gear type positive displacement meter. The meter may be outfitted with a pulser for electronic control and monitoring. High-resolution meters should be used for measurement of small amounts of additive with an electronic pulse resolution of over 2,000 pulses per gallon. Higher resolutions of over 5,000 pulses per gallon can be used for smaller amounts such as with dye injection. Additive tubing can be 1 in. or less to support additive injection with main product flow rates of 600 GPM and typical additive treat rates between 0.2 – 1 gallons per thousand.

7.3 CALIBRATION OF ADDITIVE INJECTION

The additive meter or cylinder should be calibrated using a calibration port on the additive injector panel to cycle a suitable amount of additive into a known calibrated container for comparison with the reported amount from the load rack electronics. A spring-loaded backpressure valve or equivalent should be used on the calibration port to simulate downstream line pressure as much as possible when proving metered additive panels.

A meter K-factor should be determined when using an electronic system to correct for inaccuracies. Mechanical cylinder volume adjustments are required when using piston-based injectors. The calibration test should be repeated until the reported amount dispensed and the measured amounts are within the required tolerance (typically 2%).

For multiple stream additive injectors using a single additive meter, the loading rack electronics should be able to support a meter K-factor entry for each additive due to possible changes in additive viscosity that may affect meter calibration. Any calibration device must have the required resolution to meet the calibration resolution requirements.

7.4 MULTIPLE ADDITIVES

For multiple additive applications where more than one additive is required at the load arm, the additives can be injected using a dedicated injector panel per additive or multiple additive injector panel. The multiple additive injector panel may only support a single meter and will not support more than one additive dispensed at a time. The loading rack electronics can be configured to deliver the exact amount of additive before a configured volume reaches the preset amount. This volume is normally the volume of liquid required to flush the load arm from the point of additive injection to coupling with the vehicle. Once the additive is dispensed, an additive flush pump can be activated to provide the additional line pressure required to flush main product through the additive panel assembly. For instances where additives may be selected by product recipe, it is advisable to complete the additive injection by a predetermined volume prior to the end of load to allow the dispensed additive to flush into the vehicle and offer clear product for the next batch.

7.5 ADDITIVE ACCOUNTING

A printout of total amounts of additives dispensed by individual vehicle compartment should be available from the loading rack accounting system. This data may be included in the communications interface to the terminal automation system for the option of including additive amounts on the bill of lading and for EPA-required inventory reporting purposes. Additive injectors may be equipped with display totalizers to provide manual readouts of additive volumes.

8 Meter Proving

8.1 METHODS

The method used for proving loading rack meters (volumetric prover, pipe prover, or master meter) will determine loading rack design requirements. In choosing a proving method factors such as time constraints, truck lane dimensions, number of meters, and availability of product return lines should be considered. Meter calibration adjustments should be set via electronic or mechanical calibrators so that the meter totalizer will reflect a meter accuracy that is as close to unity as possible and within the tolerances stated in NIST Handbook 44, by local weights and measures authority, or by internal company requirements. For custody transfer loading rack operations, net meter proving and standard volumes should be utilized when required by Handbook 44, Section N.5. The proving frequency may be based on throughput volume, time, weights and measures requirements, seasonal temperature changes, historical meter performance, or a combination of these factors. In addition, meters should be re-proved when subjected to repairs or changes that may affect measurement accuracy. When using electronic presets with multiple flow rate configurations, the establishment of multiple meter factors may be required. This is particularly true when low flow start-up and shutdown sequences are employed to prevent system shock and static electricity generation (see API RP 2003). All provers must have a valid NIST certification and should be periodically re-certified according to API *MPMS* Ch. 4.7 or company guidelines to ensure volume accuracy.

Each meter must be periodically proved under operating conditions as close to normal as possible. This would encompass the usual delivery flow rate into a tank prover. Another acceptable consideration is to prove via a pipe prover with the prover return line delivering to the transport truck. Some designs now include terminal return lines where, following the proving, the fluid is delivered back to the originating tank. When return lines are utilized, ensure that tank head pressure or pump inadequacy doesn't cause an unacceptable decrease in flow rate. Caution should also be exercised to ensure adequate tank pump delivery flow rate so that multiple product activity doesn't cause a drop in flow delivery.

8.1.1 Volumetric Provers (Tanks or Cans)

The volumetric prover method is the most widely accepted method by weights and measures officials. This method provides a direct volumetric comparison between the test meter and a NIST-certified vessel. Care should be taken when selecting a tank prover for rack meter proving. Variables such as size, construction material, and design should be considered. It is recommended that only volumetric provers meeting the design criteria prescribed in NIST Handbook 105-3 and API *MPMS* Ch. 4, Section 4 be utilized. It is also important to ensure that normal operating conditions are reproduced during the proving process. Vapor recovery hoses and grounding equipment should be connected prior to beginning the process and flow rate stability should be achieved.

Loading rack systems typically incorporate low flow startup and shutdown sequences to reduce static electricity (see API RP 2003) and system shock. These changes in flow rates can affect meter accuracy and are included in each calibration run. Due to the size difference of the prover and truck compartments, the accuracy of the calculated meter factor may be adversely affected for meters with poor linearity. Therefore, prover size, truck compartment size and meter linearity should be considered when utilizing the volumetric prover method. When meter linearity is not sufficient, it is recommended that meter factors be utilized to correct for inaccuracies for each operational flow rate (i.e., low and high flow rates). To help correct for the above inaccuracies the low flow rate factor should be established and applied prior to proving at the high rate.

8.1.2 Pipe Provers (10,000 Whole Pulses or Greater)

Pipe provers can provide a convenient, accurate, and expeditious method for calibrating loading rack meters. Care should be taken to ensure that the pressure drop created by the prover's piping, valves, and hoses, does not reduce the flow rate to an unacceptable level during proving. In addition, the prover shall be sized large enough to deliver the required pulse count prescribed in API *MPMS* Ch. 4, Section 2, or pulse interpolation shall be employed (see API *MPMS* Ch. 4, Section 6).

8.1.3 Pipe Provers (Less than 10,000 Whole Pulses)

As with pipe provers generating 10,000 whole pulses, pipe provers generating less than 10,000 whole pulses can be an expeditious method for proving loading rack meters. This prover uses a relatively small volume of product during each proving run and employs pulse interpolation. These devices can be very compact and are conducive to proving directly into an awaiting delivery truck. Meter factor determination is accomplished using the same requirements described in the above section.

8.1.4 Master Meters

The master meter method involves the use of a master meter that has been calibrated immediately prior to its use and will serve as a standard to determine the accuracy of another meter. A master meter shall be proved in products and conditions similar to the normal flowing conditions of the meter with which it will be compared. It should be recognized that proving uncertainty is increased when using the master meter method. Refer to API *MPMS* Ch. 4, Section 5 for more information on master meter proving.

8.2 PROVING CONDITIONS

Loading rack meters should always be proved under the same conditions experienced during normal operation. These conditions include product type (density and viscosity), flow rate, pressure, and operating temperature. Significant product temperature changes may affect meter accuracy and require additional meter proving to compensate for liquid density changes and dimensional changes to measurement equipment material. Local weights and measures regulatory agencies may require that special procedures be followed during proving operations.

Inappropriately sized supply pumps or piping systems may cause a reduction in flow rate when multiple risers of the same product are in service. Special procedures may have to be developed to ensure that normal operating conditions are achieved during the proving process. In addition, normal operating parameters may require adjustment in order to ensure consistent flow rates during heavy demand periods. These procedures may include using multiple meter factors and step flow rate control to ensure meter accuracy during periods of varying flow rates. Another option is to limit the maximum loading flow rate at each loading arm to ensure stable flow rates during multiple lane demands.

Corrections for temperature shall be made for any changes in volume resulting from the differences in liquid temperatures between time of passage through the meter and time of volumetric determination in the prover.

During meter proving using pipe or master meter provers, the prover pressure shall be maintained at a level high enough to prevent product vaporization in the prover.

8.2.1 Proving When Transport is at Atmospheric Pressure

When the normal custody transfers are made into a truck at 0 psig, and the loading rack design does not use pressure transmitters to correct the meter pressure to 0 psig, a composite meter factor will have to be applied to ensure system accuracy.

This can be accomplished in either of two ways.

1. In the first method, both the meter and prover volumes are corrected to standard pressures (0 psig) while proving. The resulting meter factor is then multiplied by the liquid compressibility factor (CPL) of the meter (using nominal operating pressure), creating a composite meter factor to replicate the normal custody transfer.
2. In the second method, the meter pressure is disregarded while proving, with the resulting meter factor incorporating the CPL at the meter; however, if the prover is at a pressure other than zero then the prover's volume shall be corrected to standard pressure to replicate the normal custody transfer.

For both methods, meter pressure fluctuations should be negligible, so that the meter pressure effect will be consistent when making normal custody transfers and when proving.

8.2.2 Proving When Transport is above Atmospheric Pressure

When the normal custody transfer is made into a truck with the meter pressure corrected to 0 psig, both the meter and the prover volume shall be corrected to 0 psig when proving.

8.3 PROVING OF BLENDING SYSTEMS

Blending systems generally incorporate an electronic preset or flow computer to control the process. The preset or flow computer measures the volume of each component and assures the proper mixture by automatically controlling individual control valves. Today's electronic presets typically have the capability of applying multiple meter factors to correct for changes in flow rates and product type. Care should be taken to ensure that each loading scenario is understood and duplicated during meter proving.

8.3.1 Sequential Blending

In order to ensure accuracy during this process, the single meter used for sequential blending will have to be proved for each product and at each flow rate. To help ensure homogeneous mixtures, systems may be configured to alternate the components in a sequence that divides the required volume of a single component into two stages to assist with mixing (e.g., for midgrade gasoline, the regular component volume can be divided into two separate stages: one before and one after the premium gasoline).

During the blending operation each component product will typically cycle through low flow startup and shutdown and continuous high rates. These set points must be known and accounted for during meter proving.

8.3.2 Ratio Blending

Due to the fact that multiple products are simultaneously flowing during ratio blending, product measurement can be adversely affected by the piping configuration and flow control. Flow rates will at times vary during the loading process due to backpressure caused by competing streams. The electronic presets are configured to achieve a final mixture ratio and often will significantly reduce the flow rate for one stream to allow the other(s) to deliver the required quantity. When this occurs, individual meters can be subjected to substantially reduced flow rates, causing inaccurate measurement.

Minimum and maximum flow rates must be determined and limited to facilitate meter proving. The proving process must include all possible flow scenarios to help ensure accurate measurement. A method to address this issue is to use meter factor linearization.

8.4 DENSITY OF PRODUCT

The density of the metered product must be determined to ensure that correct expansion factors for temperature and density are used in the calculations. (See API *MPMS* Ch. 11, Section 1.) The density should be checked when tanks are changed or when new batches of product are received. In cases where electronic calculating programs are used, the density is used for net calculations as well as proving and should be frequently checked to ensure that density has not changed and the correct value has been entered into the program. (See API *MPMS* Ch. 9.)

9 Electronic Preset

9.1 OPERATIONS

Load rack operations can be controlled using an electronic preset. This device is a batch controller specifically designed for automated loading rack operations. It can operate in either a standalone or automated mode when interfaced with a Terminal Automation System (TAS). It provides the required measurement data during loading for the bill of lading printout by the TAS, or by the shared printer in standalone mode. The electronic preset can support ratio and sequential blending operations or straight product loading and includes a staged flow profile required for vehicle loading. Additional typical preset functions include:

- Measurement of flow with selectable units of measurement including mass, gross volume, net volume, temperature, pressure and density.
- Configurable flow profiles to maintain accurate flow rates within the specified meter(s) range of operation for accurate measurement at all times.
- Flow control with discrete inputs and outputs to associated flow control and measurement devices.
- Support for multiple additive injection control and monitoring for products where additives or dyes may also be required.
- Printout or archival of all measured product data, with no loss of data in the event of power loss during loading operations.
- Configurable levels of alarm messaging.
- Safety permissives that prevent operation during upset conditions.
- Interface with meter proving operations.

9.2 FALL BACK FLOW RATE

If operational conditions prevent the preset high flow rate from being achieved or maintained, a predetermined fallback flow rate may be applied. A fallback rate is applied to reduce the flow to a controllable level. This will ensure that the speed of operation of the loading valve is sufficient to prevent overfill. The number of flow rates can be adjusted to meet the particular installation requirements but normally would be set at decreasing flow rates between the programmed high and low rates. Once conditions permit, the electronic preset can automatically return to the desired flow rate. For configurations where a fallback flow rate is used, the meter should be calibrated at this fallback flow rate.

9.3 METER FACTOR LINEARIZATION

When a reduction in flow rate occurs due to operational conditions, measurement accuracy can be adversely affected. For typical operations where flow rates may vary, it is advisable to prove the meter at multiple flow rates. At least two flow rates should be used: a slow flow rate for initial flow and a high flow rate at which the majority of product will be loaded. The electronic preset should be able to select the meter factor closest to the flow rate being used or provide a linear interpolation between two adjacent factors.

9.4 SECURITY

Safeguards should be included to prevent improper changes to weights and measures parameters. A protect switch, mechanical construction and/or an electronic audit trail should be utilized for this purpose. The protect switch and mechanical construction should allow placement of weights and measures seals through the switch and enclosure. The program protection switch must make all weights and measures parameters that affect measurement read only and inaccessible unless this switch is activated. The electronics enclosure should not be accessible without first breaking the seal to visibly indicate violation of sealed status. The preset electronics should be programmable to prompt for a unique password to select modes of operation for programming, standalone operations, TAS operations, and proving. (See Handbook 44, Table S.2.2.)

10 Temperature

Measurement of product temperature as it is being metered is essential when the volume of the product metered is to be corrected to a volume at a standard reference temperature of 60ºF (15ºC). Temperature measurement and calibration/verification procedures should be performed in accordance with API *MPMS* Ch. 7.

10.1 ELECTRONIC TEMPERATURE DEVICES

Many types of temperature devices are available. Accuracy requirements, mechanical limits, operating limits, ambient conditions, and individual preferences must be considered when selecting a temperature device to be used for temperature determination on a metered stream. A temperature sensor should be selected to meet the temperature discrimination requirements of API *MPMS* Ch. 12.2.

10.1.1 Resistance Temperature Detectors

Resistance Temperature Detectors (RTDs) are the most commonly used devices for load rack metering systems. RTDs maintain their accuracy for longer periods and are more accurate than thermocouples; therefore, they are the preferred and recommended choice for temperature sensing. RTDs are specified based on their intended applications and required accuracy. Various materials are used for the sensing element such as copper, nickel and platinum. The most commonly used RTD is the industrial 100 Ω platinum, which has long term stability and good linearity with the appropriate alpha constant selected. These are typically interfaced with transmitters, presets or the TAS.

10.1.2 Transmitters

Temperature transmitters, where used, should have the narrowest available span, which covers the anticipated temperatures during load rack operations. Typically, this range is 0º to 150ºF. Whenever possible, the range should be selected so that normal temperature will be in the middle of the range.

Digital (smart) transmitters are generally used in applications that require a high level of performance in terms of stability, wide range, and accuracy. Care should be taken to meet transmitter specifications for selection, installation and operation.

10.2 LOCATION OF TEMPERATURE SENSOR

The placement of the temperature sensor is critical to accurate temperature measurement. A dedicated temperature sensor shall be installed for each meter and located as close as possible to that meter if not in the meter body itself so that the measured product temperature can be determined. The sensor should be located immediately downstream of the meter or upstream of the meter consistent with flow conditioning requirements. Due to the potential of flow profile disturbances with the sensor thermowell being located upstream of a turbine meter, locating the sensor downstream of the meter and upstream of the control valve is the preferred location.

Thermowells should be used in dynamic temperature measurement to isolate the liquid material from the temperature sensor. To provide the fastest thermal response, the thermowell should be filled with an appropriate amount of heat-conducting material when possible. When using thermowells, spring-loaded RTD probes (typically 316 SS) should be used to apply pressure where the probe tip touches the well and increases heat transfer. See API *MPMS* Ch. 7.

10.3 TEMPERATURE CORRECTION

Weights and measures authorities require that the weighted average product temperature be printed on invoices for customers that are billed at net standard volume. For this reason, a temperature correction system should be used. In addition, automatic temperature correction can greatly aid facilities in the reconciliation of product inventories. The most common methods of automatic temperature correction are outlined below. In both cases, it is important that the temperature measuring device is properly calibrated according to Section 13.4 of this standard.

Some systems continue to use automatic temperature compensation devices (e.g., ATC/ATG). The use of these devices is acceptable for truck loading rack operations per NIST Handbook 44; however, it is not recommended.

10.3.1 Presets

Most electronic preset instruments are capable of correcting gross volumes for temperature. When using the preset to perform volume correction, the temperature measuring element is connected directly to the preset, and the preset calculates net standard volume based on a measured temperature. When utilizing this type of volume correction, it is imperative that the preset applies the proper volume correction factor for the given product based on the appropriate tables from API *MPMS* Ch. 11.1. It is also imperative that the proper product gravity is input when calculating the volume correction factor.

10.3.2 Terminal Automation Systems

Most terminal automation systems are capable of correcting gross volumes for temperature. In this case, the temperature measuring element is connected either directly to the preset or directly to the terminal automation system through some other electronic device to relay the measured temperature to the automation system. The automation system then calculates net standard volume based on the reported temperature. When utilizing this type of volume correction, it is imperative that the management system applies the proper volume correction factor for the given product based on the appropriate tables from API *MPMS* Ch. 11.1. It is also imperative that the proper product gravity is input when calculating the volume correction factor (see *MPMS* Ch. 9).

10.4 CALIBRATION/VERIFICATION OF TEMPERATURE DEVICES

Additional information regarding the calibration/verification of temperature devices may be found in API *MPMS* Ch. 7. All temperature measurement devices used for custody transfer shall be calibrated and periodically verified against reference standards to ensure accuracy. A certified thermometer or a thermometer that is traceable to a NIST thermometer shall be used to calibrate/verify the field temperature device. The certified test thermometer shall be graduated with scale marks at intervals not greater than twice the discrimination requirements of the temperature measuring instrument.

A test thermowell, filled with an appropriate amount of heat-conducting material, should be located immediately adjacent (typically no more than 12 in.) to the temperature sensor to facilitate verification of the sensor with a certified thermometer or other traceable means. The test thermowell enables verification to confirm whether or not the temperature device is operating within acceptable parameters, or requires calibration, repair or replacement. Verification testing shall be conducted by comparing the measured value (as read by the tertiary device) at normal conditions of each input variable to the value determined by the traceable reference standard.

Optimally, the calibration and verification of the temperature device should consist of at least three temperature points at uniform intervals over the operating range of the device, using a temperature-controlled source such as a temperature bath. Alternatively, the temperature device should be verified at the operating temperature and, if needed, an offset entered into the preset or TAS.

Calibration of electronic temperature devices should be performed in accordance with the recommended procedure provided by the manufacturer.

10.4.1 Frequency

After initial calibration, subsequent calibration/verification should be conducted to ensure temperature instruments in custody transfer service are working within the tolerances of this chapter and that of API *MPMS* Ch. 7. Typically, these calibrations/verifications are conducted at least quarterly.

10.4.2 Offsets

Offsets are needed to adjust RTD readings that do not use transmitters to provide for a single point calibration.

11 Pressure

Pressure measurement is required whenever the loading rack meter is being proved with a pipe prover or master meter, to account for the elevated pressure of the prover and in some cases the meter. The difference between the pressure during proving operations and normal operations must be accounted for, resulting in a combined meter/pressure factor typically known as a composite meter factor. For example, a 10 – 12 psig change in pressure for regular gasoline typically results in a 0.01 percentage correction to the volume. For LPG, this same change in psig results in a 0.05 percentage correction to the volume.

Pressure measurement is not applicable when proving with a tank prover, because a tank prover replicates typical loading operations.

For LPG loading rack operations, pressure measurement is necessary for both meter proving and ticket volume determination.

11.1 LOCATION OF PRESSURE MEASURING DEVICE

When correction for elevated meter pressure is required, a pressure measuring point should be provided between the meter and flow control valve. The pressure measuring device can be either a pressure gauge or an electronic transmitter.

11.2 CALIBRATION

The pressure measuring device shall be verified on a periodic basis using a NIST certified reference standard.

11.3 TOLERANCE

Typically, the pressure measuring device should agree within half the measuring increment interval with the certified reference standard. If it does not agree, the measuring device shall be re-calibrated.

11.4 USE OF CALCULATIONS

API *MPMS* Ch. 12, Section 2, Part 3, "Meter Proving Calculations" and Ch. 11, Section 2, Part 1 shall be used to calculate the pressure correction factor (Cpl) for light oils.

API *MPMS* Ch. 12, Section 2, Part 3, "Meter Proving Calculations" and Ch.11, Section 2, Part 2 shall be used to calculate the pressure correction factor (Cpl) for LPG.

12 Grounding Systems

When required by API RP 2003, a grounding system for static electricity shall be interlocked with the electrical system so that the product cannot be loaded without the grounding system being engaged. This precaution against ignition will minimize the accumulation of static electricity on the tank truck shell but cannot ensure the dissipation of all static electricity within the system. Grounding the tank truck does not prevent the accumulation of static electricity in a liquid with poor conductive properties.

13 Overfill Protection Systems

For bottom loading, an automatic tank truck overfill protection system shall be interlocked with the electrical system so that the product cannot be loaded without the overfill system being engaged. This precaution will minimize the chance of truck compartment overfill by closing the flow control valve when product is sensed at a specified level in the tank truck compartment. It is important that truck sensor heights are selected to provide enough compartment room to allow the control valve time to close without product spillage.

For top loading, an automatic overfill protection system is not required. Top loading typically requires an operator/driver to be on the tank-loading platform and have manual control of a spring-loaded "dead man" valve during the filling cycle.

14 Sealing

All meter system accessories affecting the accuracy of volume measurement should be sealed, and all outlets or connections through which unmeasured withdrawal is possible should be sealed. Recent developments from NCWMs (National Conference on Weights and Measures) and NIST allow either electronic audit trails or sealable switches where electronic systems are installed.

The mechanical adjusting mechanism of the meter and readout, if used, should be sealed to prevent or detect tampering.

15 Terminal Automation System

When utilized, the Terminal Automation System (TAS) manages product distribution at the terminal. Product is tracked separately for each supplier, and product throughput is automatically reconciled over a configurable period, normally set to every 24 hours. Reports are automatically generated for each supplier and access to information is fully password-protected. Automatic tank gauge systems can be connected to the TAS to provide a comparison between physical tank inventories versus calculated inventory based on throughput. Any differences are reported as gain/loss amounts for that period. The TAS should include the ability to account for bulk movements of product within the terminal and product receipts or transfers to and from the terminal.

The TAS can support both order-driven operations with preset amounts automatically downloaded to the electronic preset, and allocation-based operations where drivers enter a customer number and the required preset amount of product on the electronic preset. This amount is checked against the customer's product allocation before the load is authorized. The TAS should be capable of supporting unmanned operations at all times. Messages displayed at the loading rack should be simple and easy to understand to help reduce loading times.

15.1 CARD SYSTEMS

The terminal automation system may include the option to provide controlled access to and from the terminal using a card reader device installed at convenient locations where controlled access or activity must be logged within the terminal. The card reader device may include a display to view message prompts and a keypad to enter data based on the messages displayed. The card reader devices are connected to the TAS to provide real-time communications for data entry validation. The operator or driver is responsible for placing the card in the card reader for a successful read to validate the card data, and for entering any unique PIN numbers or additional information required. Cards can be used as a single device with additional prompts for supplier, customer, and vehicle information, or multiple cards can be used to provide this information. Data provided from the cards is used for security and also can be printed on the bill of lading.

15.2 CALCULATIONS

The TAS includes the ability to provide net volume calculations based on the approved API standard. Some products require the use of unique algorithms or their thermal coefficient of expansion. These calculations must be in strict compliance with API *MPMS* Ch. 12.2, Ch. 11.1, and Ch. 11.2.

15.3 SECURITY

The TAS must include multiple levels of password protection with log of user access by date and time and user ID. Any changes to the TAS configuration should be clearly traceable using an event log file and printout. An audit trial file and printout is also included to show all transactions of product movement at the terminal.

15.4 BILL OF LADING PRINTERS

Bill of lading printers are connected to the TAS and print the bill of lading upon completion of load. Multiple bill of lading printers may be required to support printout of bill of lading at preferred locations or per supplier. No vehicle can leave the terminal without a bill of lading. The option should be available to withhold the bill of lading if loading information is not correct; this is especially important for additive amounts included with the main product. Requirements for information on the bill of lading vary by state and company. Data can include Department of Transportation information relating to the particular products.

16 LPG

LPG loading rack metering systems require the same selection, installation and meter proving requirements of loading rack metering systems for other petroleum products.

Notable exceptions would be the use of air eliminators and excess flow valves. Air eliminators are not used in LPG systems. The system pressure is maintained to ensure the product remains in a liquid phase. Excess flow valves are safety devices used to stop flow in the event of a broken hose connection.

16.1 BACK PRESSURE

The backpressure shall be adequate to keep the fluid in the liquid phase. For measurement purposes the pressure at measurement temperature should be twice the pressure drop across the meter at maximum operating flow rate, or at a pressure 125 psi higher than the vapor pressure at a maximum operating temperature, whichever is lower. (See API *MPMS* Ch. 5.3 and Ch. 6.6.)

16.2 ODORIZATION

A system should be provided to inject the proper amount of odorant, if required. A means of verifying that the stenching equipment is functioning properly should be provided. Two independent means of verifying odorization are recommended.

Except where specifically excluded for special uses, odorant must be added to LPG to serve as a warning agent in the event of a leak. The amount of odorant should be indicated on the delivery ticket.

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