Basics of Proving LPG Meters

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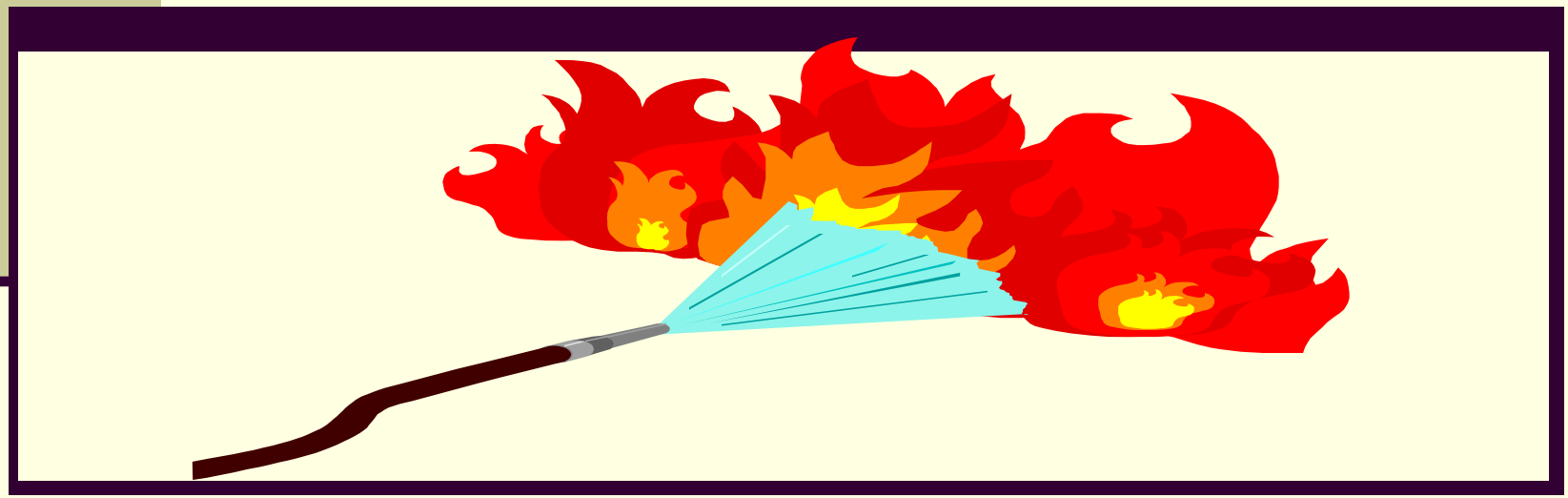
Credits & Acknowledgements

Many of the slides in this presentation were developed by the National Institute of Standards and Technology (NIST) for their LP-Gas Liquid Measuring Systems Course, and adapted for use in this presentation by Scott Simmons, Colorado Division of Oil and Public Safety. Permission was obtained from NIST for their use and adaptation.

Liquefied Petroleum Gas

Safety



The Importance of Safety

- Safety is EXTREMELY IMPORTANT
- This section is one of the most critical in the course
- Cannot be over-stressed
- If you don't learn anything else…learn that safety comes first
- Unsafe practices can harm not only yourself, but <u>also others</u>

Hazards of Testing LPG Devices

- Certain hazards associated with LPG, *however…*
  - Systems are designed in accordance with strict codes and requirements
  - People who operate these systems should be trained for safe operation & response
    - But you sometimes find they aren't trained
    - You need to be prepared in case they are not!
  - Likelihood of an accident testing LPG is no greater than when testing any other device type
  - The consequences are *much more serious*

Protecting Yourself & Others

- Best protection is knowing safety precautions
- Knowledge will be acquired through:
  - Study
  - Classroom
  - Field training
  - Observation
  - Safe practices
- ** The most important tool is your knowledge! **

Protecting Yourself…(cont.)

You must KNOW:

1) Physical & chemical properties of substances you are dealing with

2) How test equipment and metering system work

3) What to expect under various conditions

4) How to identify and avoid development of dangerous situations

5) How to respond in case of emergency to protect:

- Yourself
- Those around you
- The general public

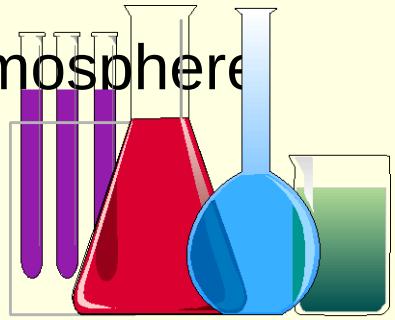
Properties & Hazards of LPG

Properties which make LPG desirable are also those that account for hazards associated with it!

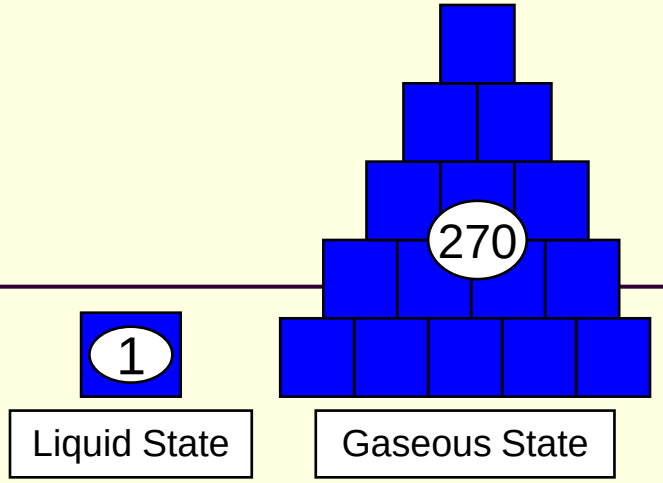
1) Boiling points
   - Below normal atmospheric pressure and temperature
   - - 44^{o} F for propane
   - +32^{o} F for butane

2) Propane boils instantly when exposed to atmosphere (as does butane)

   LPG is liquid <u>under pressure</u> at ambient temperatures!



Properties & Hazards of LPG (cont.)



3) Recall…270:1 ratio

- economically desirable
- but can be a hazard if released uncontrolled into atmosphere

4) Propane Boils in Vicinity of Leaks

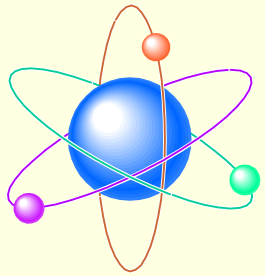
- refrigerant effect
- causes “freeze” burns on contact
- protective goggles and gauntlet gloves are a must!

Properties & Hazards of LPG (cont.)

5) Flammability

- LPG is under pressure
- Release may be rapid and hard to control
- High concentration of flammable gas
- Relatively narrow limits of flammability in air:
  - Propane = 2.2% to 9.6%
    - Anything less than 2.2% or greater than 9.6% concentration will not burn
    - Butane = 1.9% to 8.6%

Properties & Hazards of LPG (cont.)



5) Flammability (cont.)

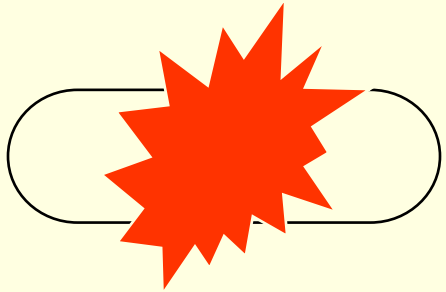
- Narrow limits of flammability contributes to safety of LPG products
- *However*, possibility of ignition is *not* remote
- Treat any release of product as potentially dangerous

6) Both Propane and Butane Are **Heavier** Than Air

7) Odorless

- Odorant such as ethyl mercaptan is added for detection
- Learn to recognize

Rupture of Storage Tank -- What Happens??



- Explosive release of vapor
  - Under normal conditions, pressure relief valves operate
  - Vent excess vapor
- Little danger of happening spontaneously due
  - To construction of tanks
  - But there are other conditions that may threaten structural integrity of tank...

Conditions Threatening Structural Integrity

1) **If Direct Flame on <u>Liquid Area of Tank</u>**
   - As long as no leaks occur, have no immediate danger of ignition
   - As liquid is heated, product vaporization occurs
   - As product vaporizes, pressure in tank increases
   - <u>NOW</u> have a threat to the structural integrity of the tank
   - Pressure relief valves should operate
   - Controlled venting to atmosphere returns tank to safe pressure
   - Valves close again automatically when pressure is reduced

Conditions Threatening Structural Integrity (cont.)

2) If Direct Flame on <u>Vapor Space</u>

- No liquid to cool metal of tank
- Rapid loss of integrity
- Temperature increases in a small area of tank shell
- **RUPTURE** of tank

is often violent

BLEVE

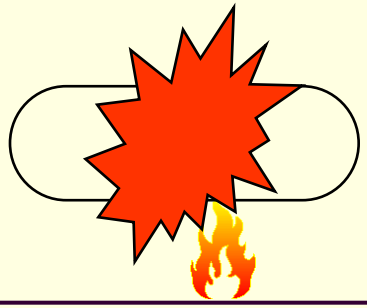
- If the storage tank ruptures, it is called a –

  Boiling **L**iquid **E**xpanding **V**apor **E**xplosion

  or

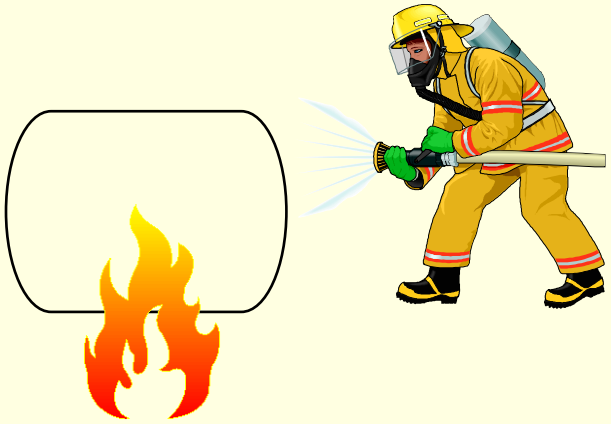
  BLEVE

What to Do ??



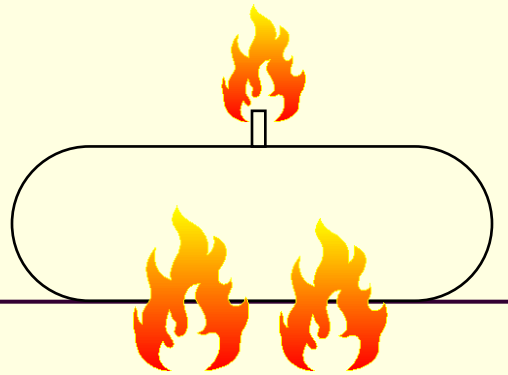
- IF EVER IN DANGER OF RUPTURE, CLEAR AREA <u>IMMEDIATELY</u>!

- **Fire is primary hazard**
  - Threatens structural integrity of tank



- Ignition of clouds is very similar to explosion
- Secondary ignition can occur if the fuel supply is not shut off
- **<u>First priority is to COOL TANK</u>**

What to Do ?? (cont.)



- Extinguish fire ONLY AFTER FUEL SUPPLY IS CONTROLLED
  - otherwise, re-ignition is possible
- When flame burns, it burns off vapor as it is emitted from tank
- If flame is extinguished, but leak still exists, vapors concentrate & can reignite

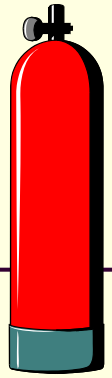
Emergency Equipment-- What YOU Must Have!

- Good idea to keep a checklist with you
- Highly recommended to keep a checklist with the prover
- A list of some absolutely essential equipment...

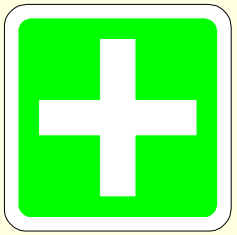
Essential Equipment Overview

1) Fire Extinguisher
2) First Aid Kit
3) Protective Gloves with Gauntlets
4) Protective Goggles
5) Caution Signs
6) Safety Cones
7) Phone Numbers for Emergencies
8) Continuous Supply of Water for Cooling Tank

**Other Items Required by Jurisdiction/Co.??? **

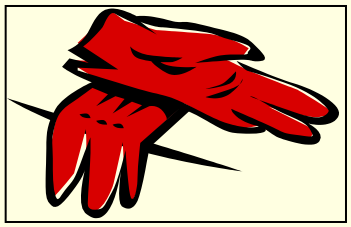


Essential Equipment



1) Fire Extinguisher
   - 18 B:C dry chemical
   - Should be the FIRST THING YOU SET out---don't leave it hooked inside the prover!!!

2) First aid kit
   - Appropriate for inspecting LPG meters
   - Safety officer/local OSHA rep

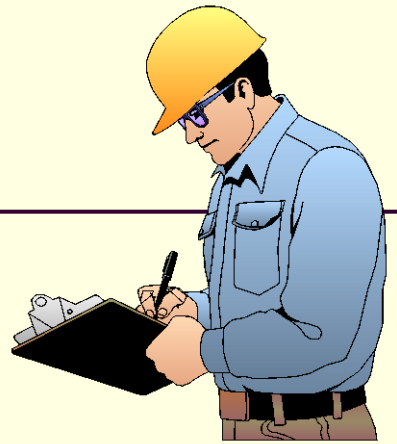


Essential Equipment (cont.)

3) Protective Gloves with Gauntlets
   - should be worn at all times
4) Protective Goggles
   - especially important when working around LPG
5) Caution Signs
6) Safety Cones
7) Phone Numbers for Emergencies
   - Good idea to put on a card and keep in prover
8) Continuous Supply of Water for Cooling Tank
   - Used to cool storage tank

****** Other Items Required by Jurisdiction/Co. ???******

Make Safety a Habit!!!



- Observe safety rules at all times
- Includes use and maintenance of equipment
- Enhance knowledge of the operation and design of metering and testing equipment
- Learn to always anticipate conditions
  use common sense & good judgment!!

Safety Musts

1) No smoking within 100 feet recommended
   - if an employee refuses to cooperate, stop examination and contact owner
2) Look out for leaks
   - STOP EXAM until leaks are fixed
3) Report exposed/faulty wiring
   - STOP EXAM until dangerous conditions are corrected
4) Never leave equipment unattended

Safety Musts (cont.)

5) Eliminate all possible sources of electrical discharge
- Includes clothing
  - Synthetic clothing causes static
  - Synthetic clothing melts at high temperatures; sticks to skin
  - Results in serious burns
- Explosion-proof, non-sparking tools (incl. 2-way radios)

6) Chock prover
- Chock trailer or vehicle to avoid rolling/shifting
- Check again after prover is full of product

7) Ground prover
- Do NOT Cut Off Ground Prong of the Power Supply Electrical Wire!
- Ground prover to the system under test.

8) Regularly inspect prover hoses for wear and damage
- Consider establishing a regular replacement schedule

Safety Musts (cont.)

9) Be sure all connections are tight BEFORE starting test

10) Never disconnect lines without bleeding vapor or liquid between connections

- always bleed off slowly
- don't get in a hurry!

11) If any practice conducted by your jurisdiction is questionable, Contact Your Supervisor Immediately!!

- express your concerns

Other procedures Followed/Required by Your Jurisdiction*

Emergency Procedures — Know What to Do!!

- When hazardous substances are **contained**, they do not pose a threat
- The potential for serious consequences if an accident occurs is very great
- Situations develop very rapidly, therefore, you should know safety procedures by heart

Know What to Do!!

- Firm personnel should be trained in responding to emergencies
  - But don't count on it
  - Be prepared yourself

- Owner/Operator of equipment is responsible for the safety of those who work with it
  - If trained personnel are available to deal with an emergency, Stand By to Assist as Directed
  - Since situations develop very quickly, you should be prepared to take appropriate action while waiting for assistance

How Can You Reduce the Risks?

- Ensure proper installation, operation, maintenance of:
  - Metering equipment
  - Your test equipment
- Keep product contained in system
- Maintain product at normal temperatures and pressures
- **Consequences** of an accident are of most concern
- Risk is reduced if you **know how to react**

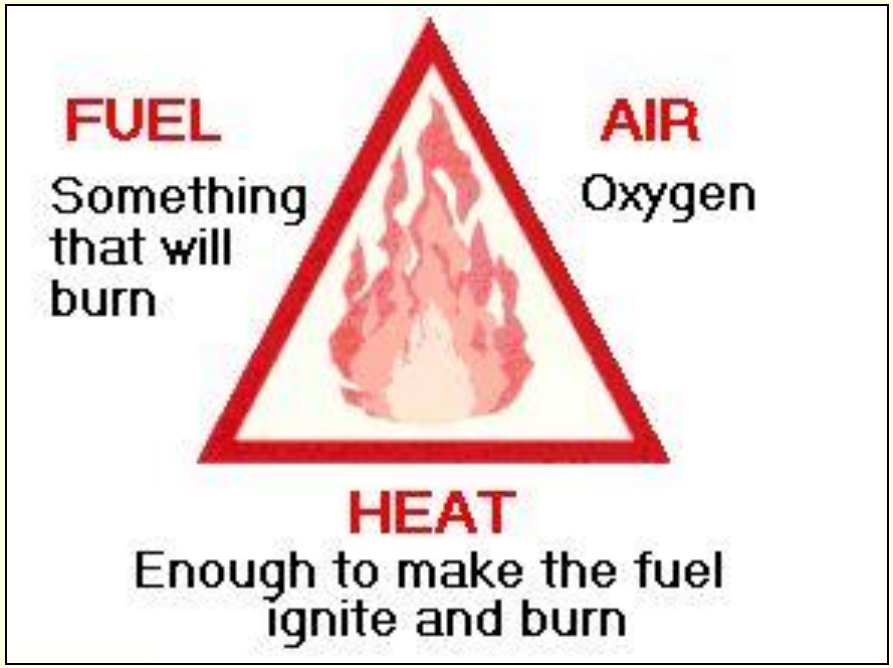
The Fire Triangle

Three elements are needed to start a fire:

1) Fuel
2) Oxygen (Air)
3) Ignition Source

Need all three to have fire.

Figure 4-1:
Fire Triangle



Source: http://www.bing.com/images

What to Do If…..

NOTE: These are steps that you should take:

only if owner/operator or trained personnel are not able to respond

OR

if instructed to do so by trained personnel

What to Do If…
There is a Leak

Leak, but no source of ignition:

Primary concerns:

- you have **two** of the three elements required for a fire
- want to stop leak and prevent source of ignition

1) Stop leak (if possible)

2) Summon help if needed

3) Turn off all pumps, motors, and any other ignition sources

What to Do If…
There is a Leak

4) Look to see where vapor is likely to settle:
   - does this pose a hazard
   - how can it be resolved
   - warn people away from area

5) Stay on upwind side of system

6) Yield control to emergency personnel when they arrive
   - everyone not assisting kept at least 200 feet away

7) Water sprayed across the path of the vapor cloud

What to Do If…
There is a Leak

8) If you cannot stop the leak
- warn people away
- watch for sources of ignition
- maintain flow of water across the vapor path

9) Do not under any circumstances attempt to move equipment or take other action unless instructed by qualified personnel!!

What to Do If…
There is a Fire

This is much more critical

- depends on the proximity of the fire to the tank

These steps are in addition to the above measures

First determine:

Does the fire pose immediate threat to the tank or the prover's structural integrity?

Fire Does Not Pose a Threat to Tank

- **If fire is sufficiently far away from the tank:**
  - first priority: extinguish the fire
- if source of fire is electrical, shut off power supply
  - if fire is small, put it out with dry chemicals

  Never use water on electrical fire unless you are absolutely sure power is off!!
- if source of fire is solid material, use water
  - *Never use water on a petroleum or flammable liquid fire!!!*

Fire Does Threaten Integrity

first priority: cool the tank

- spray all sides of tank with water--this will cool tank and reduce tank pressure
- spray water on all sides of **upper** part of tank (vapor space); this will cool the vapor space
- lower part (liquid space) is cooled by the refrigerant effect of the liquid and the water draining down the tank's sides

Fire Does Threaten Integrity (cont.)

If pressure relief valve is ignited:

direct water away from it, but **do not extinguish the flame**

if flame is extinguished you can get a secondary ignition which can be more serious

Fire Does Threaten Integrity (cont.)

If external material is the source of the fire:

cooling of tank is still the first priority, especially cooling the vapor space

If possible:

move the source of flame from the tank OR

move the tank from the source of the flame

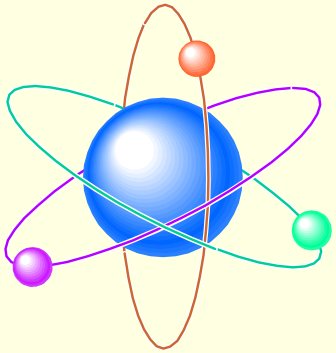
Remember: COOLING OF TANK IS ALWAYS THE FIRST PRIORITY

If tank ruptures, this can lead to a catastrophic situation!!

Liquefied Petroleum Gas

The Nature of LPG Products, Their Storage, Measurement, and Delivery

Liquefied Petroleum Gas

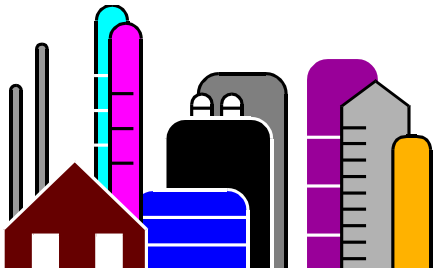


Composition:

- Propane
- Propylene
- Butanes
- Butylenes

Commercial LPG <u>is not</u> a pure product:

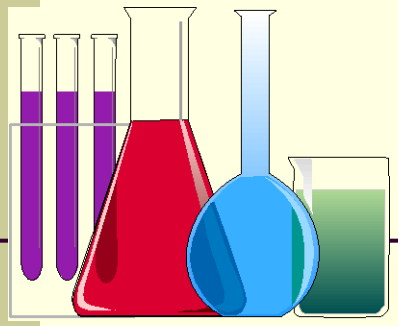
- Propane and other components such as ethane
- Generally more than 90% propane
- Up to 7% - 8% ethane



Use and Value of LPG

- Stored in liquid state and used in gaseous state
- Especially high in rural areas and in agricultural applications
- Also used for
  - Heating
  - Motor fuel
  - Industrial applications

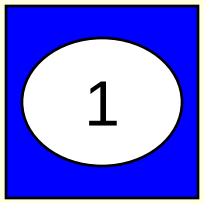
LPG is sold by weight or volume



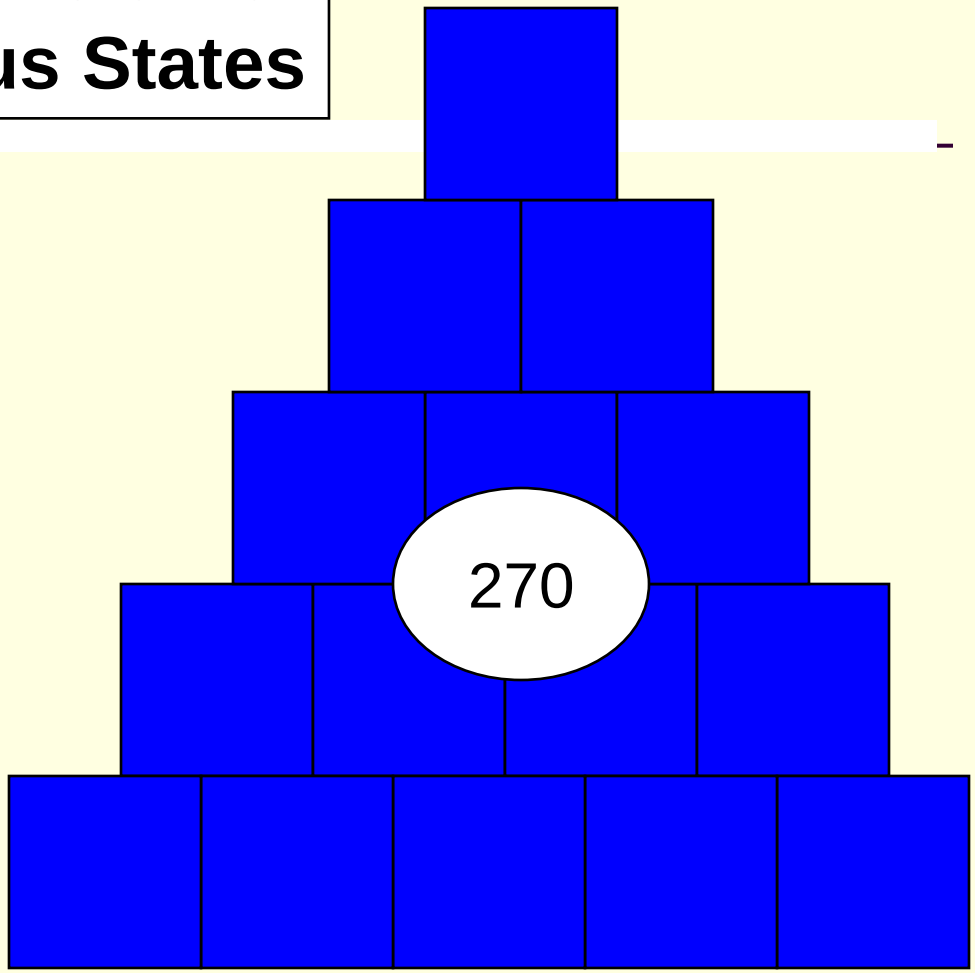
Important Properties of LPG

- Gases at atmospheric temperature and pressure
- Easily liquefied for storage & transportation
- Takes up less space when in liquid than in gaseous form
- Easily reconverted back to gaseous state for use
  - By returning to atmospheric temperature and pressure
  - No special equipment required
  - Cost of liquefication & special storage equipment outweighed by advantages

Comparison of LPG Volume in Liquid vs. Gaseous States



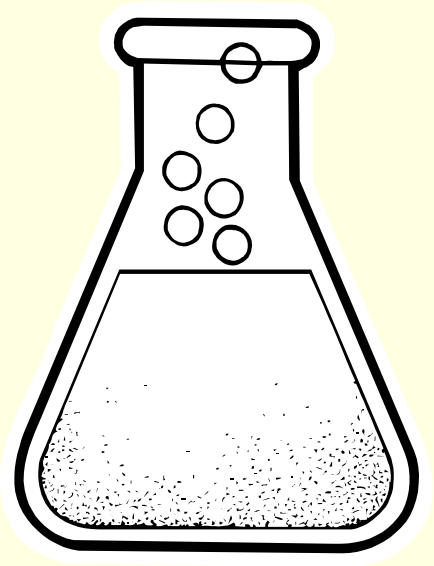
Liquid State



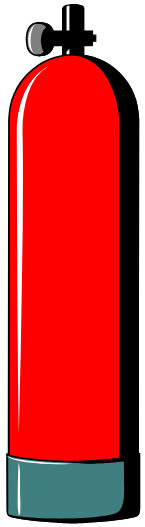
Gaseous State

Liquefying of Gases

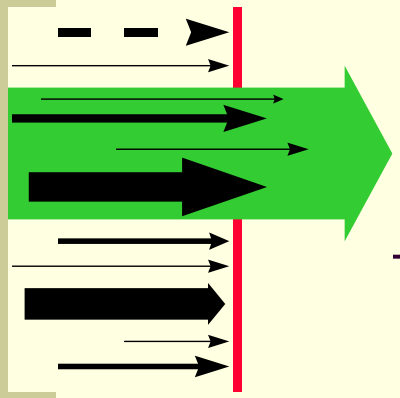
- To be liquefied a substance must be maintained at a temperature below its boiling point



Liquefying of LPG



- Liquefied by refrigeration
- Maintained by pressurization
- Containers fabricated to withstand several times the vapor pressure of propane within the normal temp range



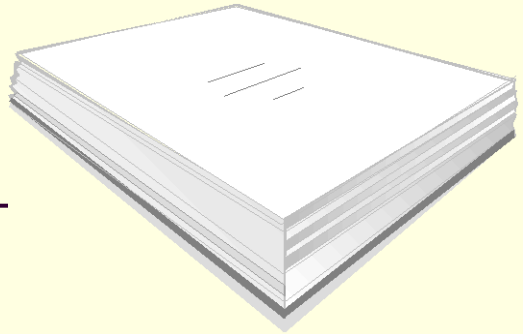
Considerations for Dispensing LPG

- Liquid State Very Important
  - Especially since a particular amount of gaseous propane occupies approximately 270 times the same volume as it would in liquid form
  - Vapor in liquid can result in inaccurate measurement
  - Just like other liquid-measuring devices, do not want product **and** vapor passing through meter

Commercial Transactions

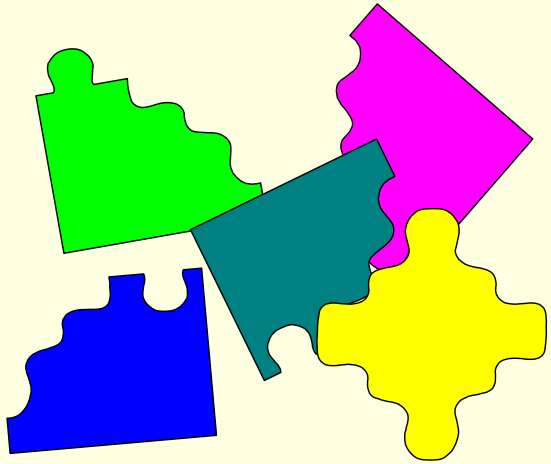
- Often based upon the volume sold at a standard reference temperature of 60 ^{o}F (or 15 ^{o}C)
- Heating/cooling product to 60 ^{o}F (or 15 ^{o}C) is not practical for commercial applications
- Corrections are <u>usually</u> made
  - Use temperature compensator
  - Use correction tables

Some Requirements for an LPG System



- Closed system
- No leakage
- Capable of withstanding established (high) pressures
- Pressures established by ASME (American Society of Mechanical Engineers)
  - Pressure relief valves
  - Permits controlled venting when pressure builds

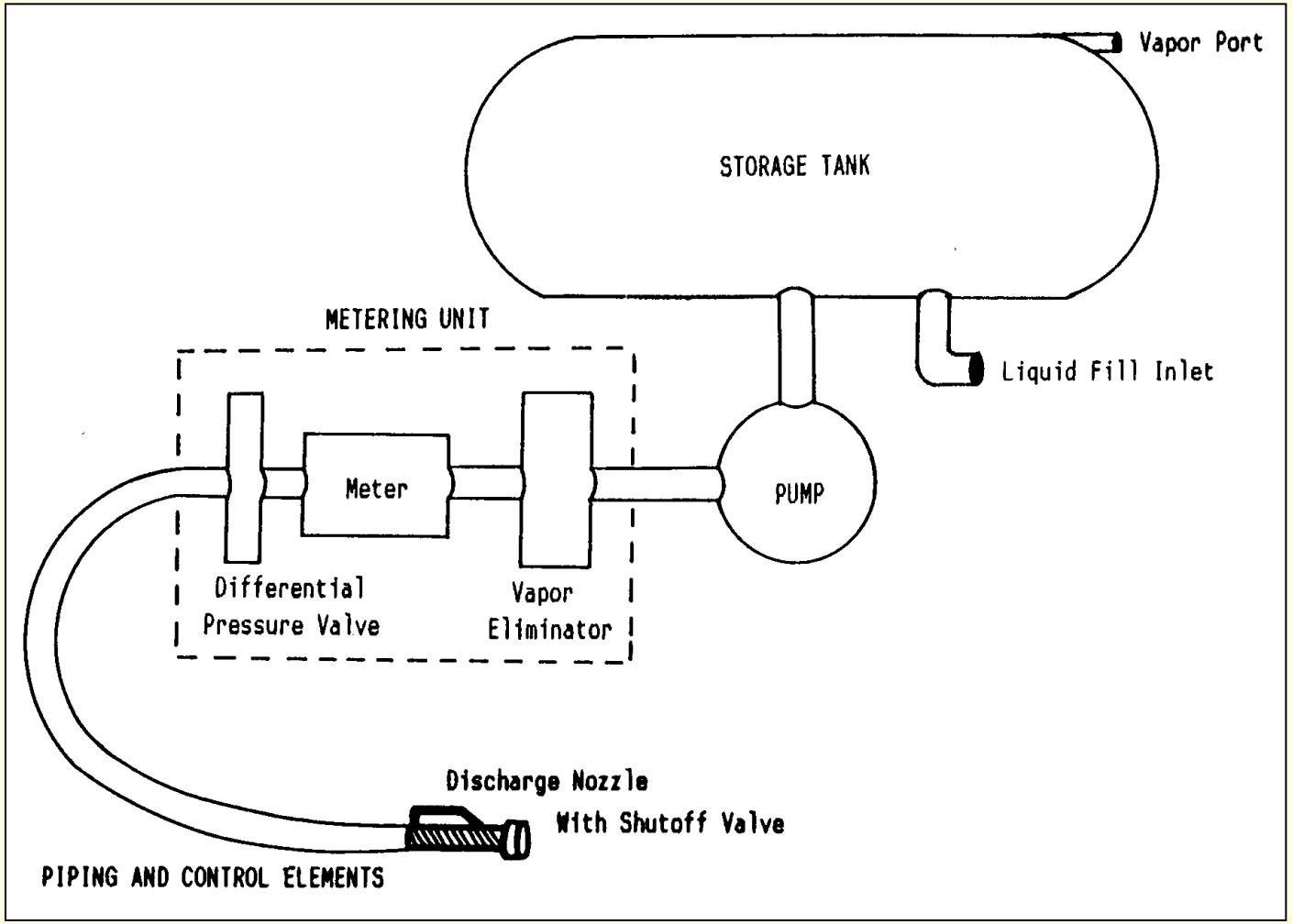
Basic Components of an LPG System



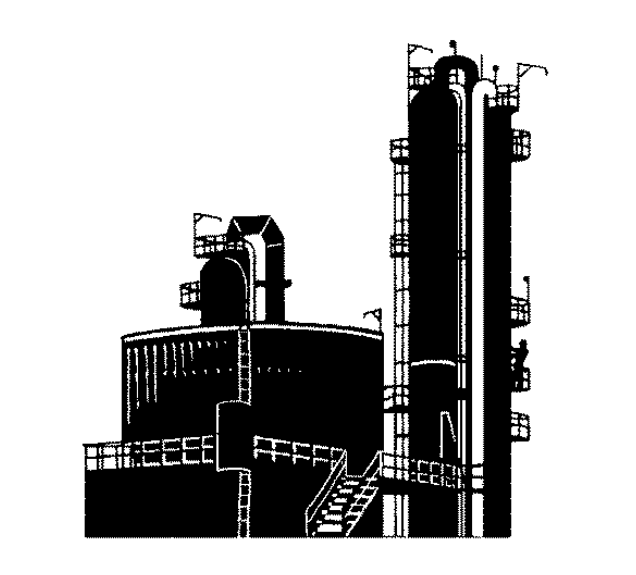
- Four Basic Components:
  1) Storage Tank
  2) Pump
  3) Metering Unit
  4) Piping Connecting Other Components

- Let's Take a Closer Look at the Components…..

Figure 2-1:
Basic Components of Delivery System

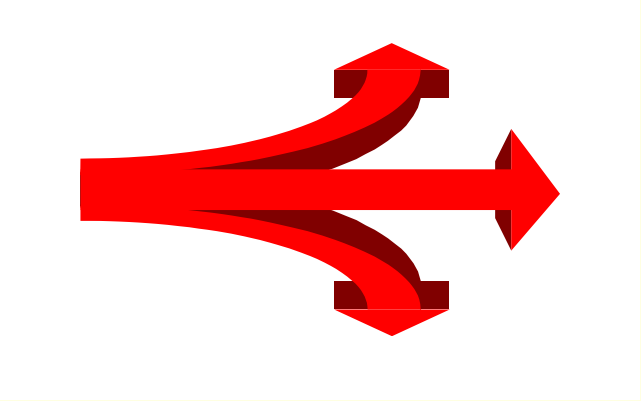


Basic Components - Storage Tank



- Includes:
  - Liquid fill inlet
  - Discharge outlet
  - Vapor port for pressure equalization during filling or meter testing

Components of the Metering Unit



- The Metering Unit:
  - Meter
  - Indicating Element
    - Driven directly by the measuring unit

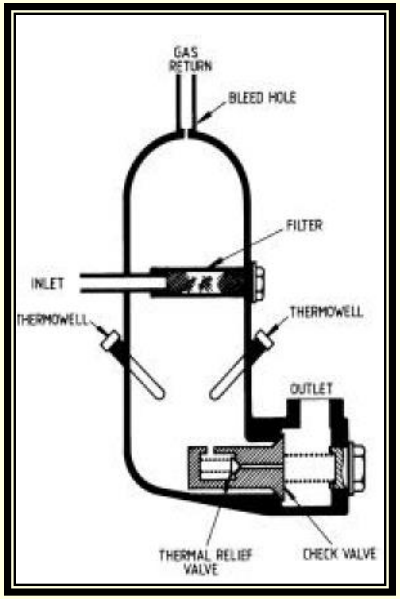
- Last two components of metering unit prevent vapor from passing through the meter…..

Components of the Metering Unit

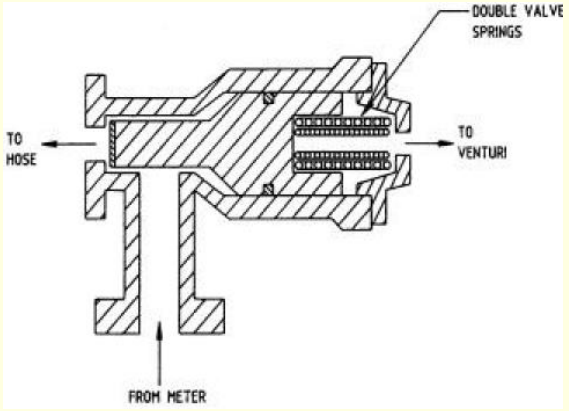
- The Metering Unit:
  - Meter
  - Indicating Element
- Driven directly by the measuring unit

Components of the Metering Unit (cont.)

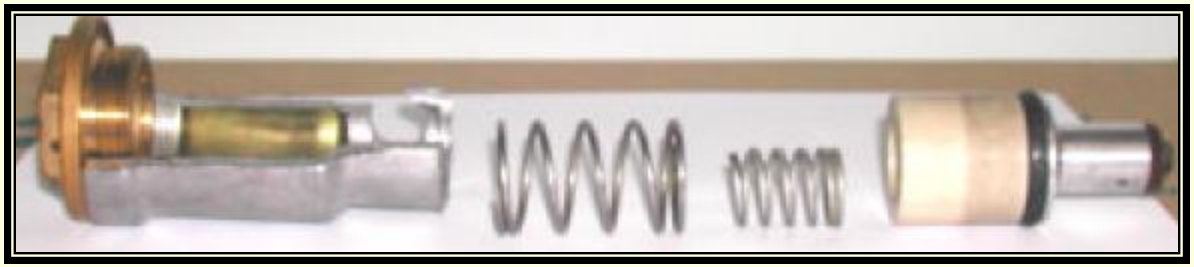
- Vapor Eliminator
  - Separates vapor from liquid prior to meter
  - Returns vapor to storage tank



Components of the Metering Unit (cont.)

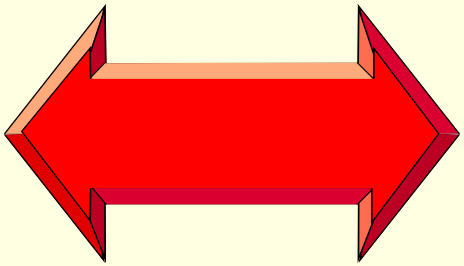


- Differential Pressure Valve
  - Keeps pressure constant
  - Help maintain product in a liquid state
  - Even small pressure differentials can result in some vaporization



Receiving Tanks & Delivery of Product

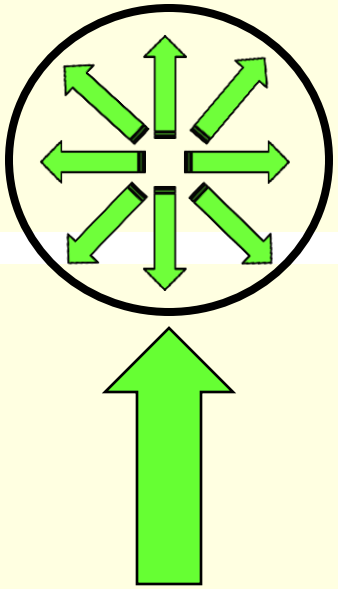
- Product Delivery:
  - Liquid goes into receiving tank
  - Displaces vapor in receiving tank
  - Pressure in receiving tank increases
  - Pressure increases cause vapor in tank to condense to liquid
  - Equilibrium is eventually restored, but NOT INSTANTANEOUSLY



Design of Receiving Tanks – Older Designs

- Got around this by hooking up a vapor line
  - Between the vapor spaces of the delivering tank and the receiving tank
  - This maintains the equilibrium
- However, this is not always equitable…
  - Some product in the form of vapor is returned to the seller

Design of Tanks
Newer Design - Spray Fill



- Spray enters tank, spray cools vapor space
- Promotes condensation
  - (Remember….A decrease in temperature means less pressure is required for product to go to liquid state)
- Causes a reduction of pressure in the tank
- As a result of pressure reduction, tank is easier to fill
  - Most tanks are like this now

Figure 2-3 Spray-Fill Design

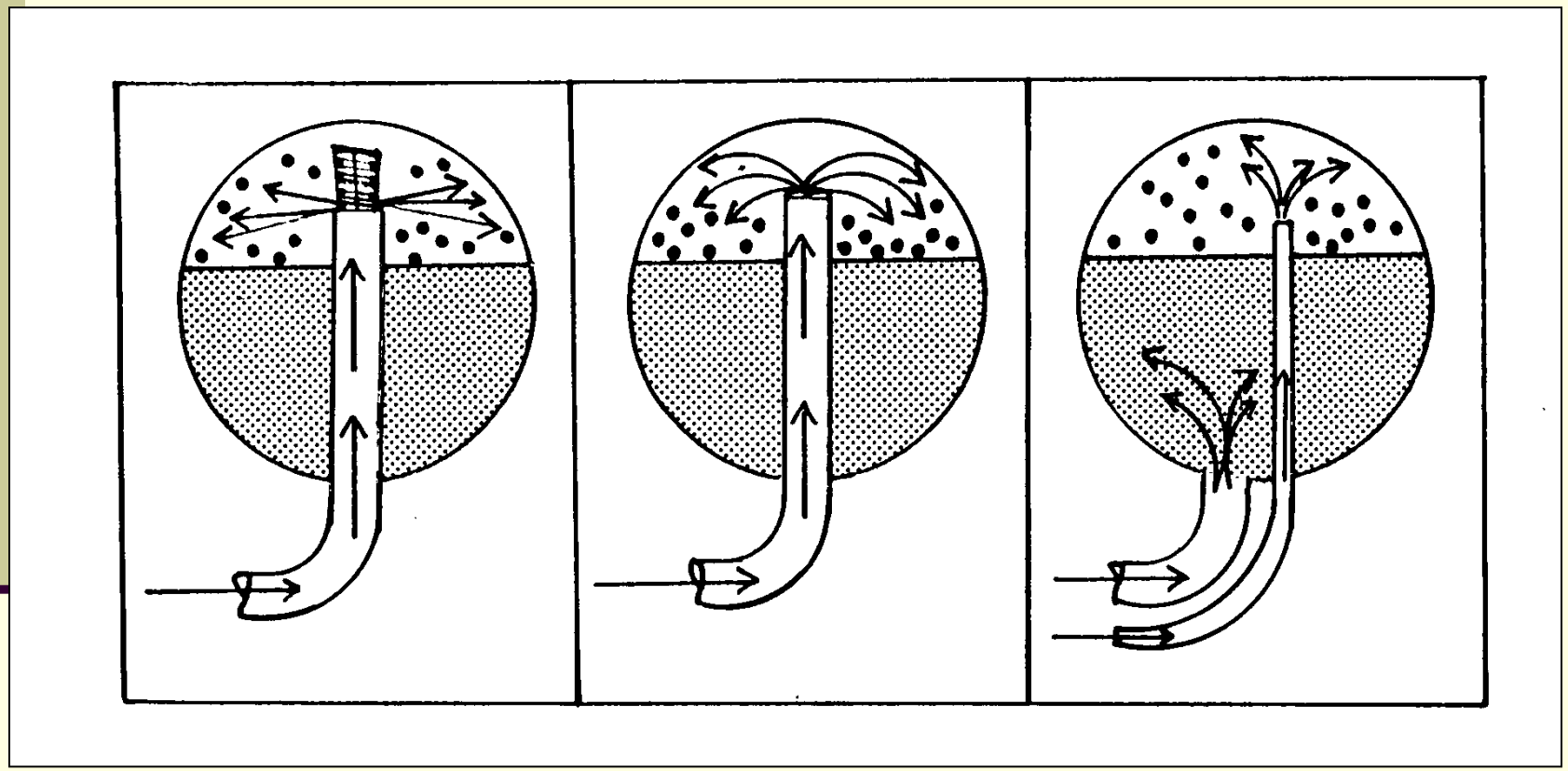


Figure 3-1:
The Intake Line

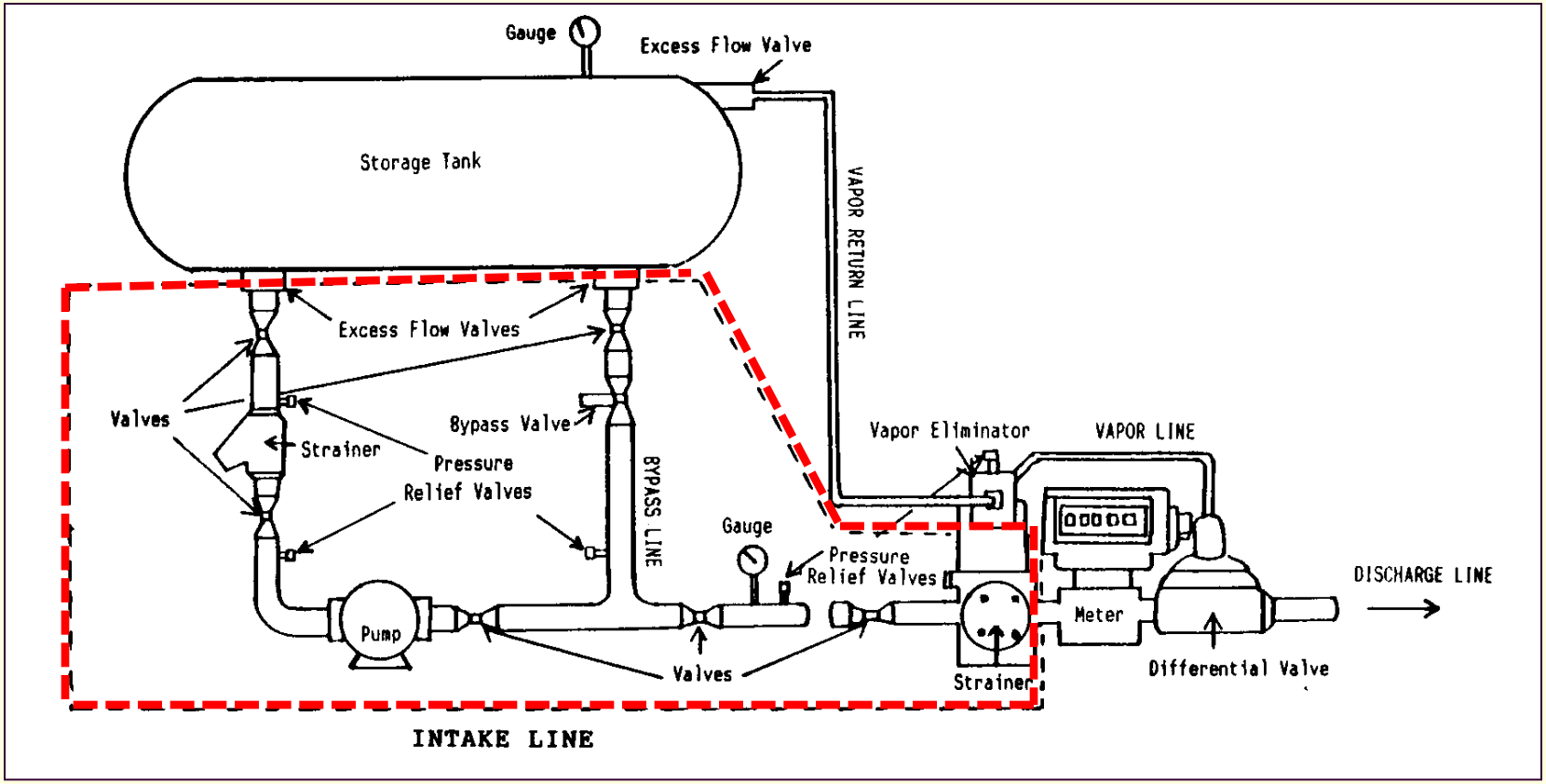
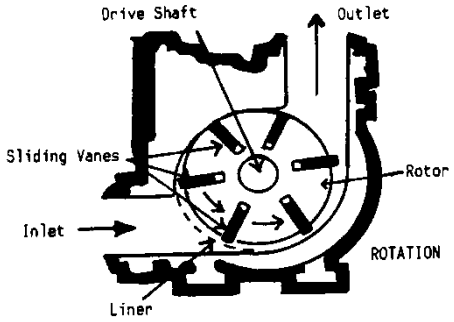
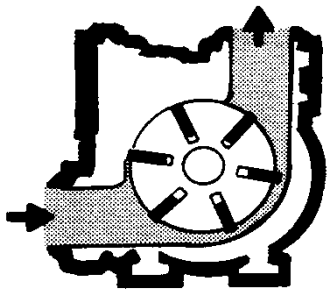
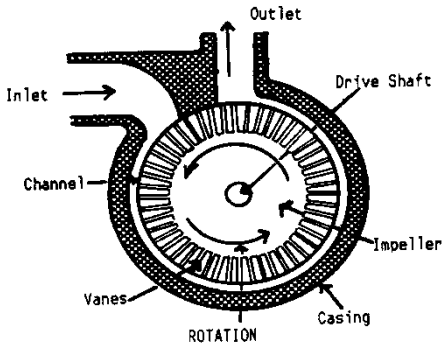


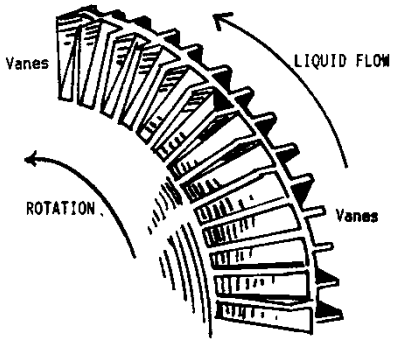
Figure 3-2: Typical Pump Designs



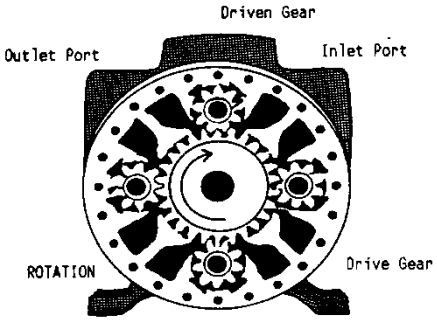


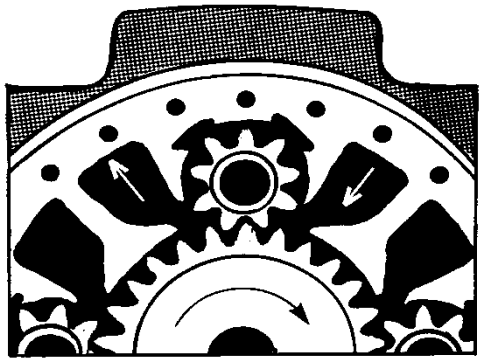
Sliding-Vane Pump





Regenerative Turbine Pump





Gear Pump

Pump Operation

As pump displaces product through outlet, lower pressure is momentarily created at the inlet

Rate of displacement is a function of:

- Pump speed and design,
- Size of the piping at the outlet

Pressure of vapor in the storage tank pushes liquid into intake line

Pump Speed

Can be a critical element in measurement accuracy

If too high, pressure at the inlet falls below the vapor pressure of the product

- Causes some vaporization

Technical term for this vaporization is “cavitation” or also called “flashing”

- Cavitation or flashing is the sudden formation and collapsing of bubbles in the liquid product

Cavitation results in some degree of overregistration of the amount delivered

Overregistration vs. Underregistration

Overregistration

- The metering system indicates *"over"* or *more* than the amount of product that has actually gone through the meter.
- Described as a "minus" or "-" error.
- The customer receives less than the indicated amount.

Underregistration

- The metering system indicates *"under"* or *less* than the amount of product that has actually gone through the meter.
- Described as a "plus" or "+" error.
- The customer receives more product than the indicated amount.

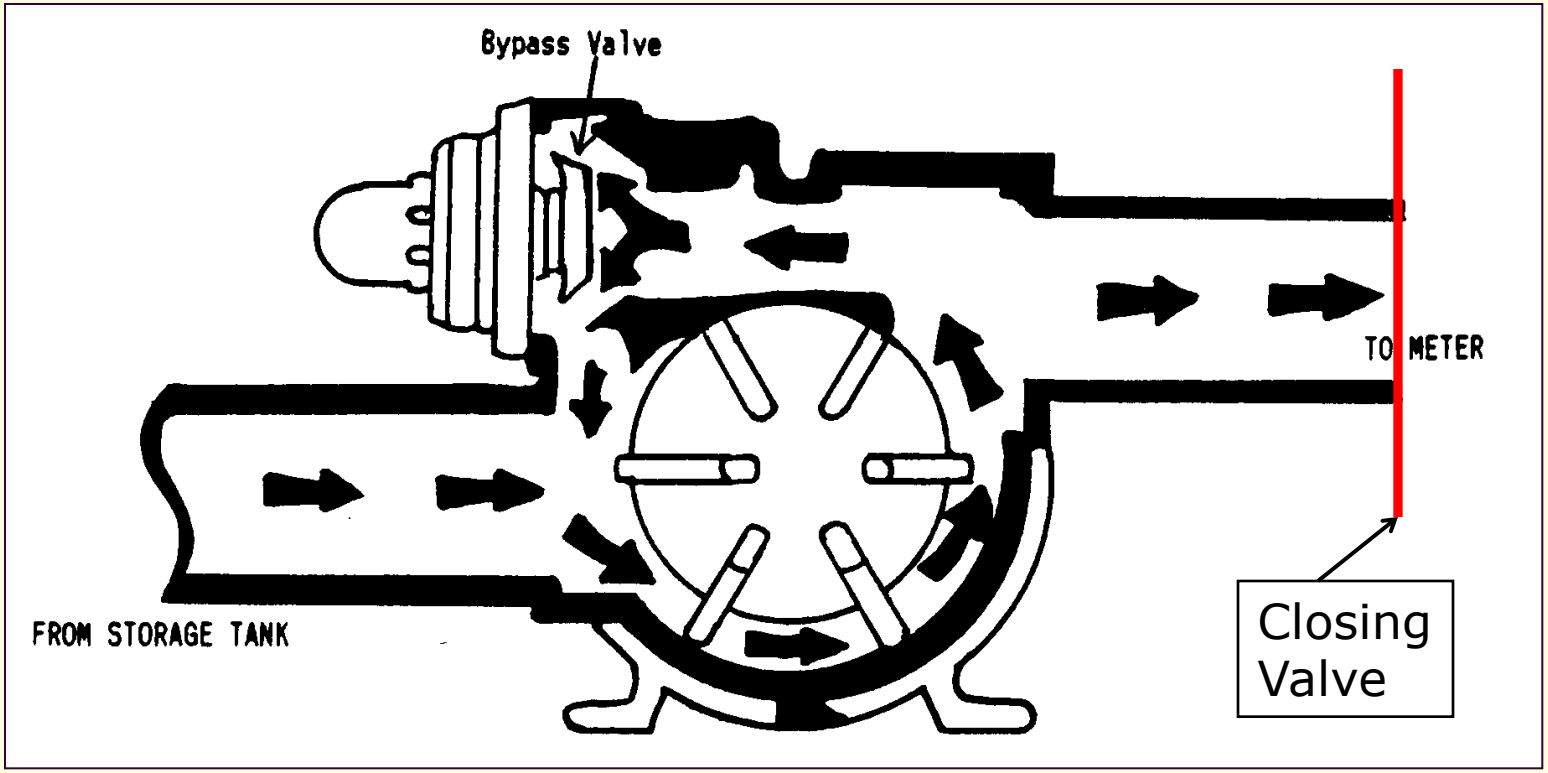
Reducing Cavitation

Suitable length of piping

Proper fittings

Proper size and operating speed of pump

Figure 3-3:
Pump **Internal** Bypass Circuit



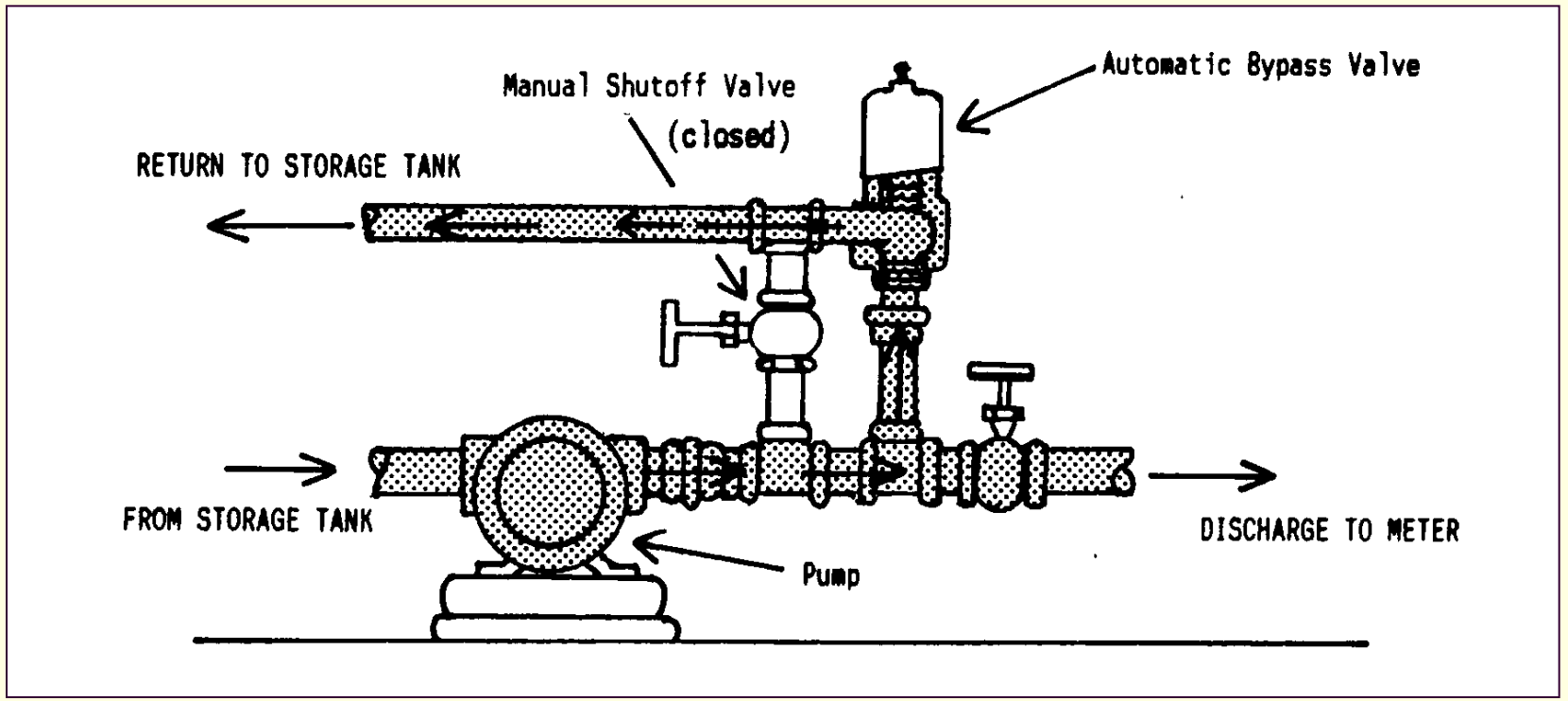
Pump Internal Bypass Circuit -- Function

- Prevents damage to pump when pump is in operation, but no product is being dispensed
- Is built into the pump itself
- Spring loaded
- Pressure inside pump rises as flow is restricted
- Pressure reaches predetermined amount and opens bypass valve
- Valve drops when flow resumes and puts pressure on valve

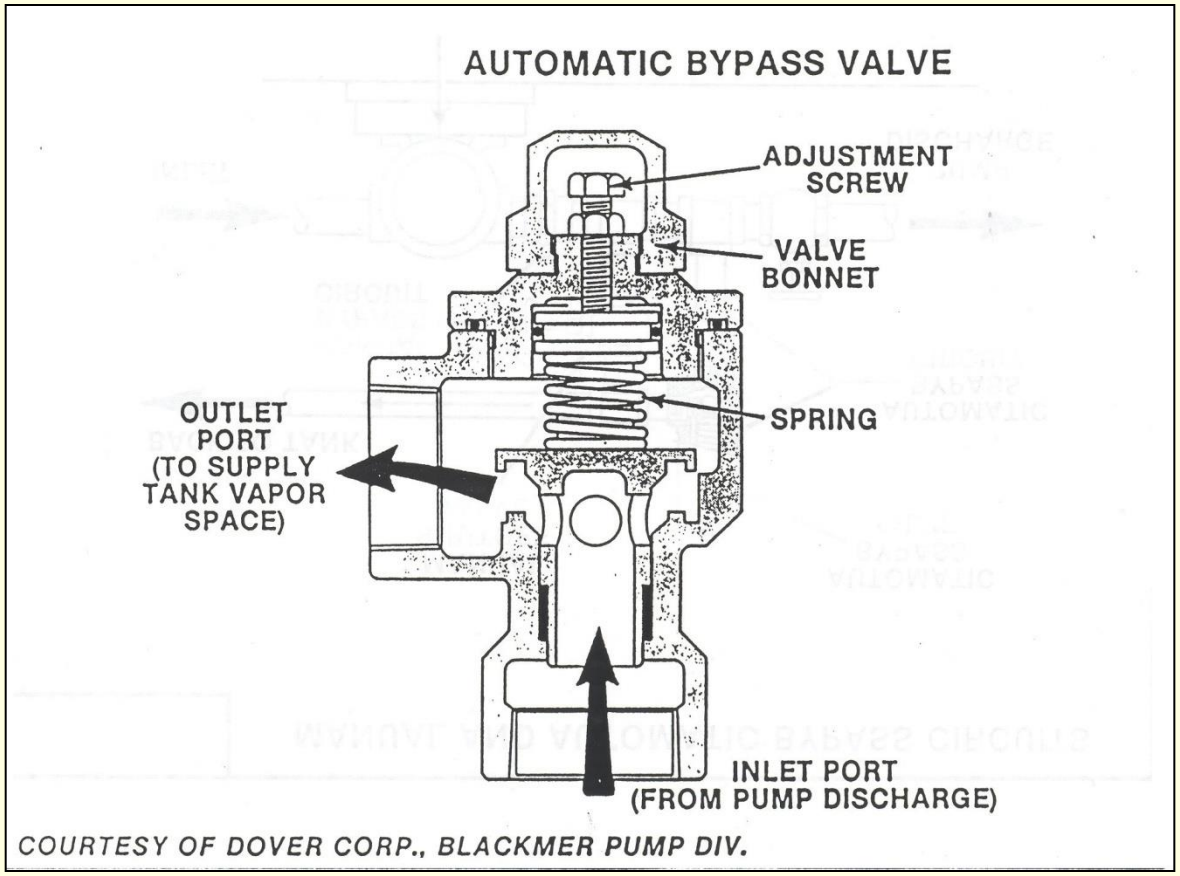
PROBLEM:

- Friction from the product circulating in the internal bypass circuit causes product to heat. This results in some vaporization.

Figure 3-4:
Pump **External** Bypass Circuit



External Automatic Bypass Valve - Example



External Bypass Valve--Functions

Recommended by most manufacturers

Product recirculated through storage tank where vapor rises to the vapor space

- Allows fresh product to be circulated to pump

External bypass valve is set to open at a pressure of:

- Approximately 15-20 psi lower than the internal bypass valve

Also has manual control

- For purging & cleaning lines

Other System Components

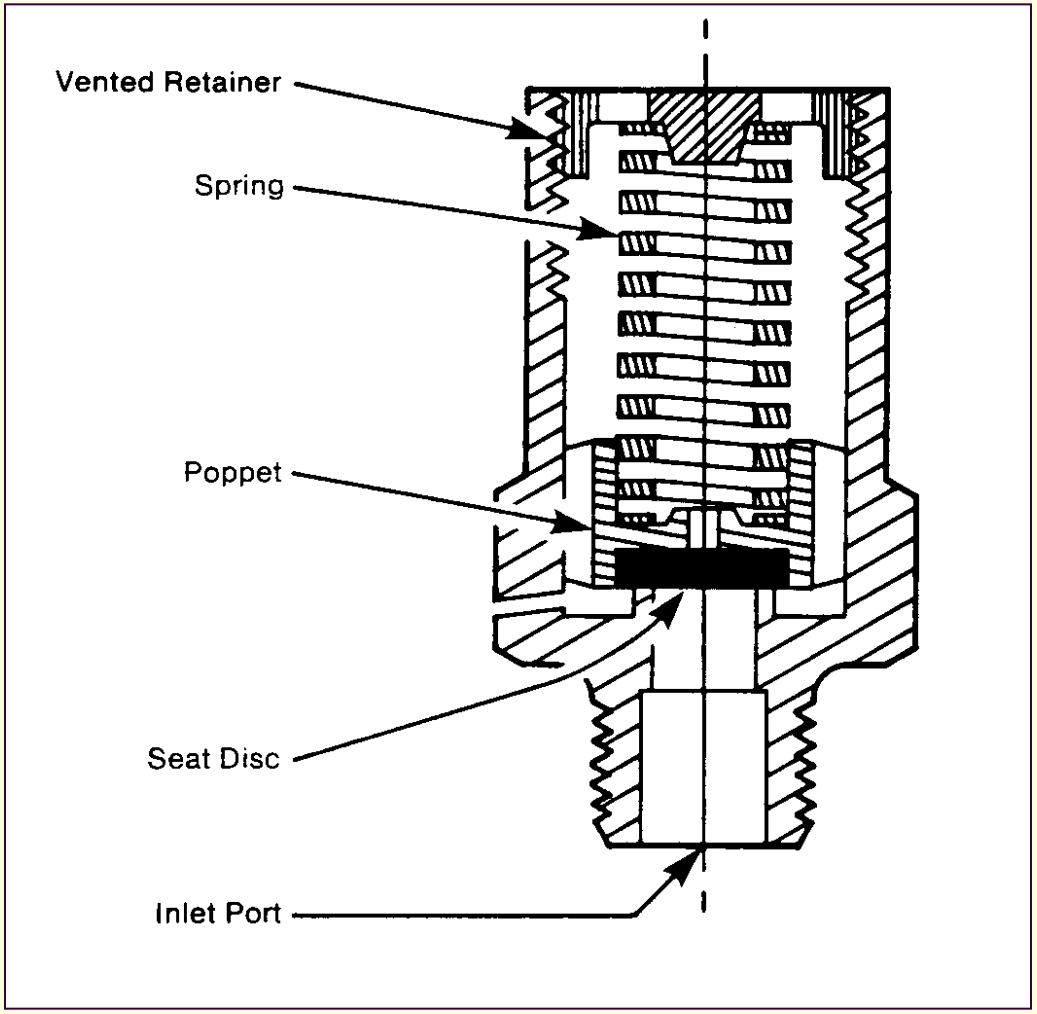
Excess Flow Valve

- Shuts off flow in event of hose/line rupture
- Set to allow flow at normal flow rates
- Closes automatically when normal flow rate is exceeded
- Re-opens automatically when flow returns to normal

Pressure Gauges

- Warns of pressure build-up
- Enables monitoring of pressure for proper operation

Figure 3-5:
Hydrostatic Pressure Relief Valve



Other System Components (cont.)

Hydrostatic Pressure Relief Valves

- Perform crucial safety function
- Placed between two shut-off valves
- They must be at every place this occurs in system where LPG is contained or “trapped”
- Set to open at a certain critical pressure
- If temperature rises from sun or high heat and pressure increases, they open to release pressure from expanding product

Location of Pressure Relief Valves (& Shut Off Valves) in System (from Fig 3-1)

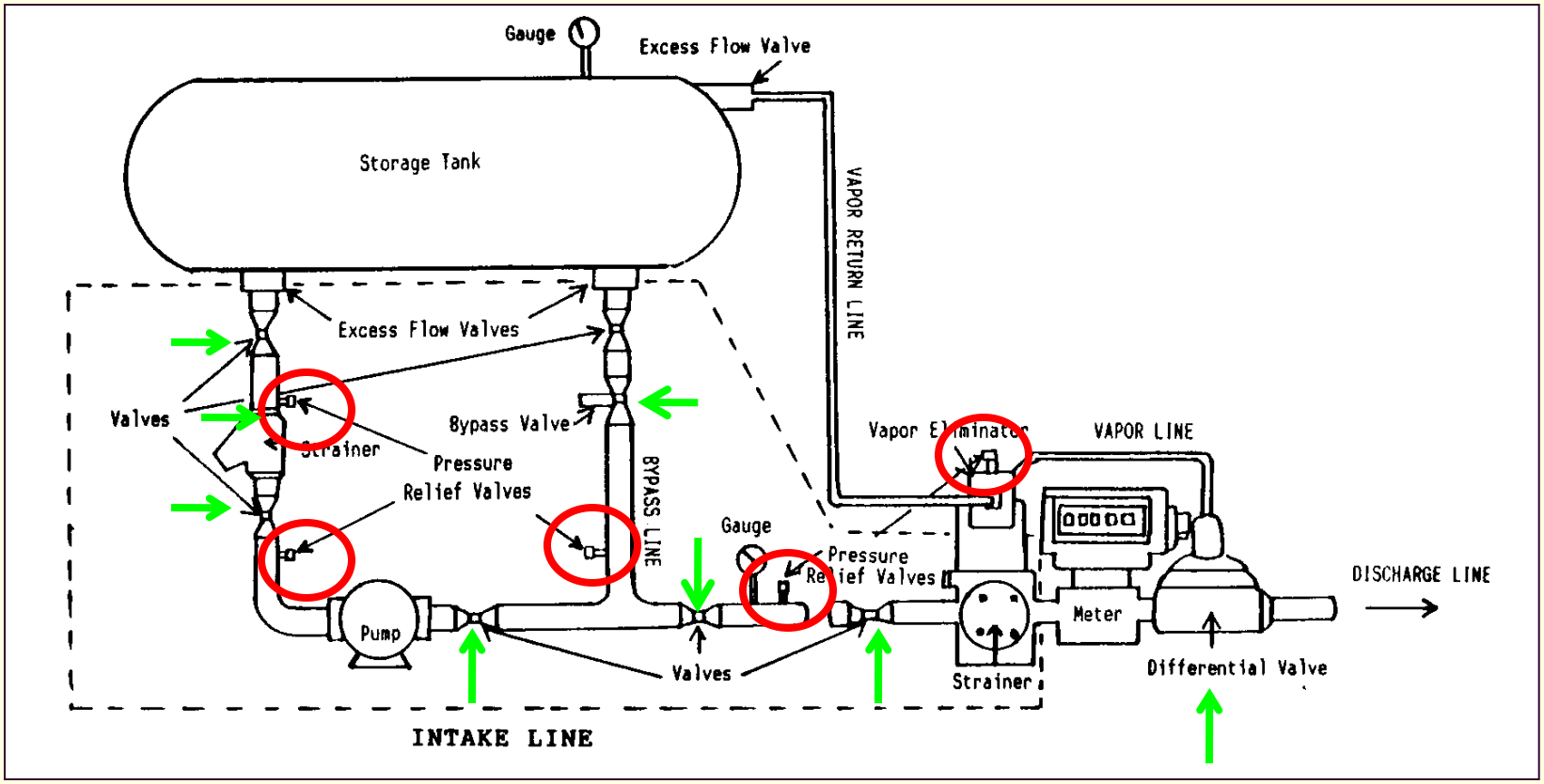
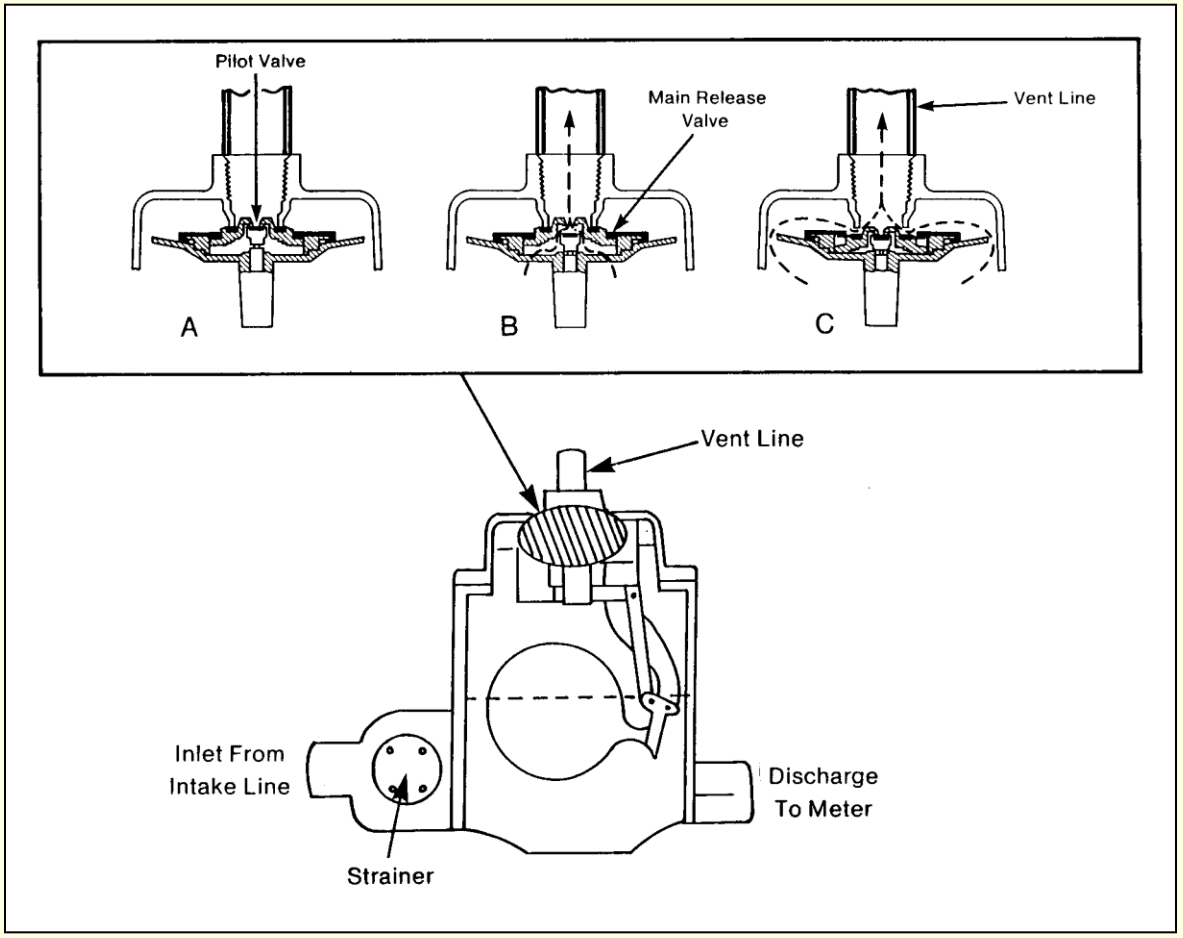


Figure 3-6:
Typical Vapor Eliminator



Vapor Eliminator -- Functions

Removes vapor prior to the meter

Last line of defense against vapor caused by restrictions, etc.

Basic operation

- Float in chamber of air eliminator
- Liquid flows into chamber and vapor bubbles rise to the surface
- When float drops below a certain level, valve opens to vent vapor
- Vapor carried back to vapor space of storage tank
- As vapor is removed, level of liquid flowing in rises, float rises, & valve closes
- Cycle begins again

Entrained air very difficult to remove

Other System Components

Strainers

- Trap solid contaminants
- Must be kept clean to avoid restrictions & vapor production

Valves

- “Service valves” in lines
- Can be shut to close off sections of piping to work on lines or for emergencies
- Must also have pressure relief valves between two valves per NFPA codes
- Cannot be used to divert product
- Must be kept in full open position to avoid restricting flow

Figure 3-7: PD Meter Design - Example 1

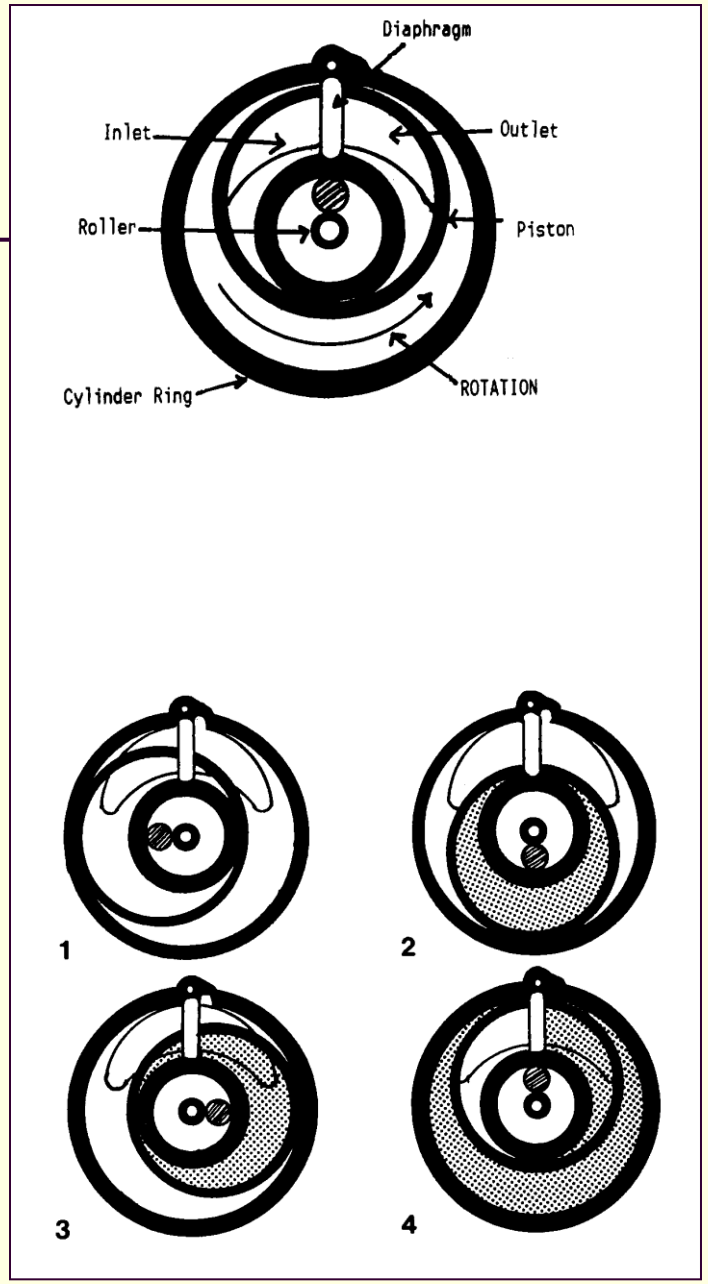


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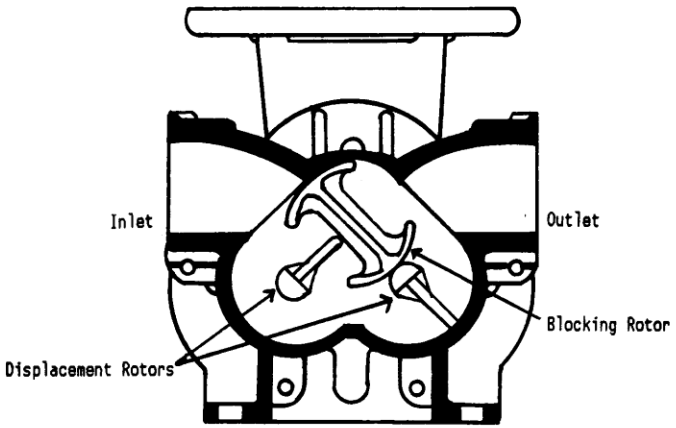
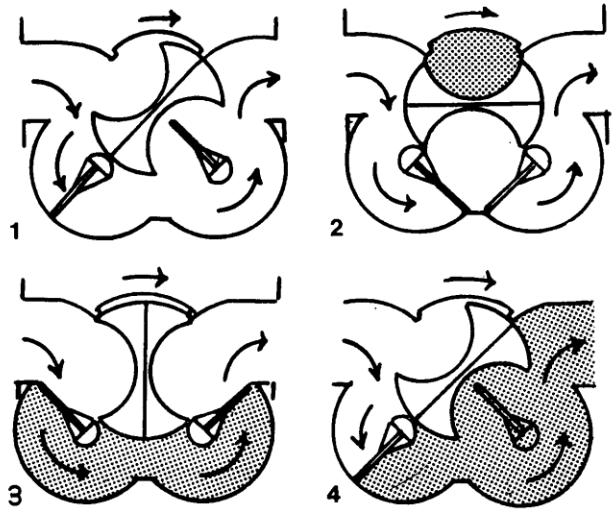
Figure 3-8: PD Meter Design - Example 2





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Positive Displacement Meters

Liquid momentarily separated into segments of known volume

Same number of segments pass through meter on each revolution

Segments are rejoined after the meter and flow to the discharge line

Fluid flow drives meter's moving parts

Volume is determined from number of meter revolutions & the quantity per revolution

Meter Errors

Simple design means relatively few causes of error

Typical causes of errors:

- Presence of vapor in product
- Solid contaminants
  - Widens clearances
  - This is why strainer is important
- Small amounts of slippage
  - Can be offset by meter adjustment to some extent
  - Increased at low flow rates

Meter Adjustments

Made through the register element

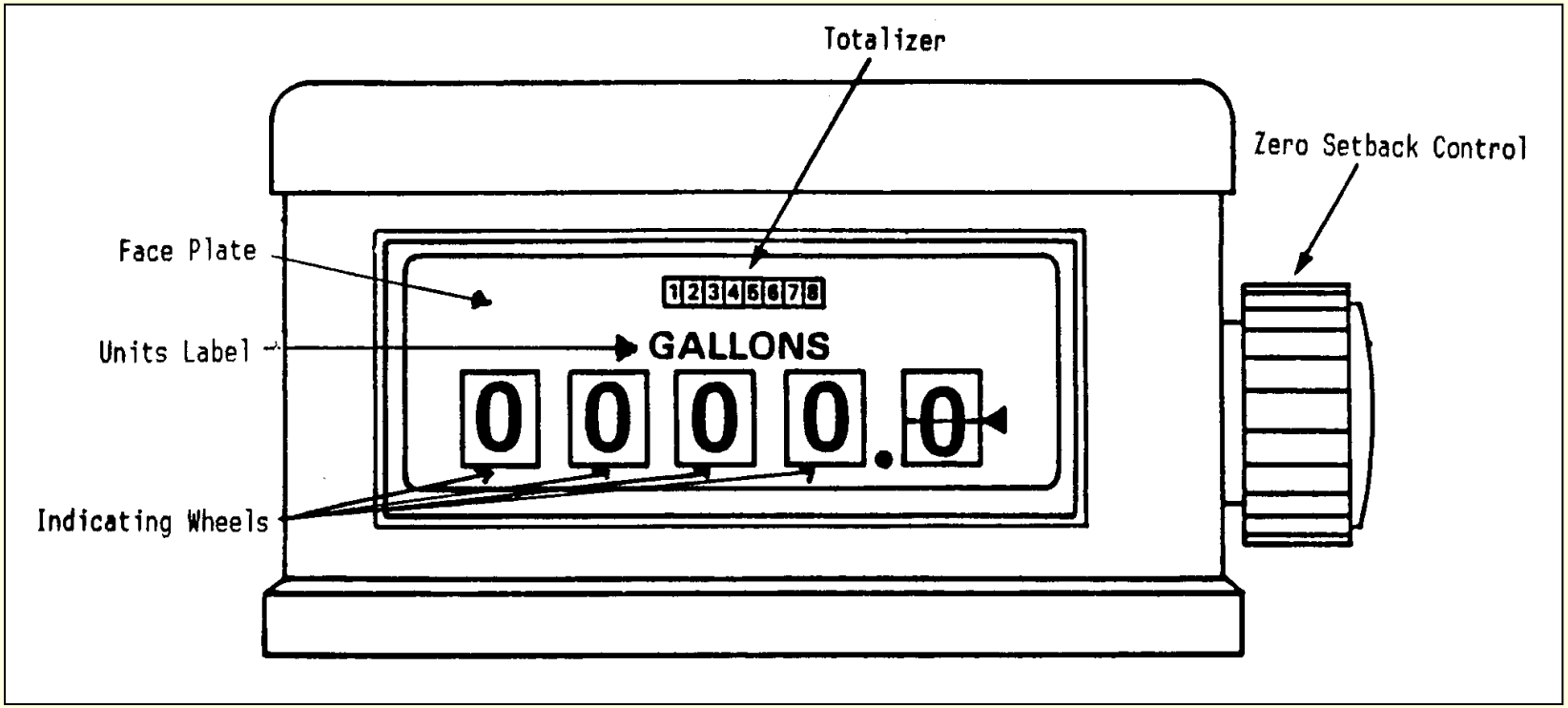
- Register “counts” the number of revolutions of the meter

Can offset slippage at low flow rates

Ineffective when meter is badly worn

Adjustments can be mechanical or electronic

Figure 3-10: Mechanical Indicator



Mechanical Registers

Wheel type:

- Series of wheels
- One wheel per digit
- Wheel segmented with numbers & lines
- Revolving meter shaft

Gear train transfers revolution of meter to the indicating elements (to right-hand wheel)

Right-hand wheel turns with meter shaft

Each complete revolution of right-hand wheel increments next higher wheel

Fixed indicator--pointer

Figure 3-11:
Right Hand Indicating Wheel

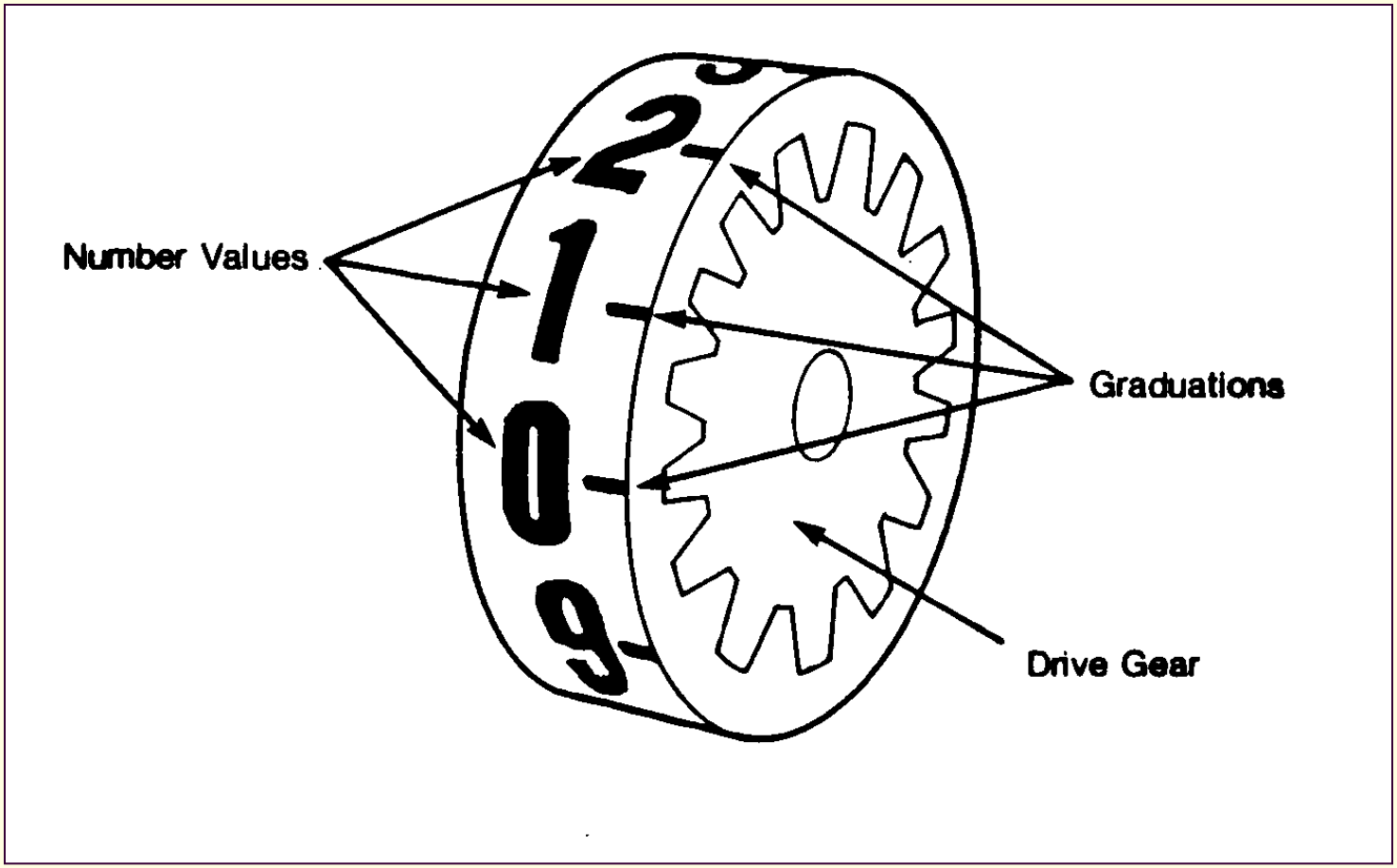
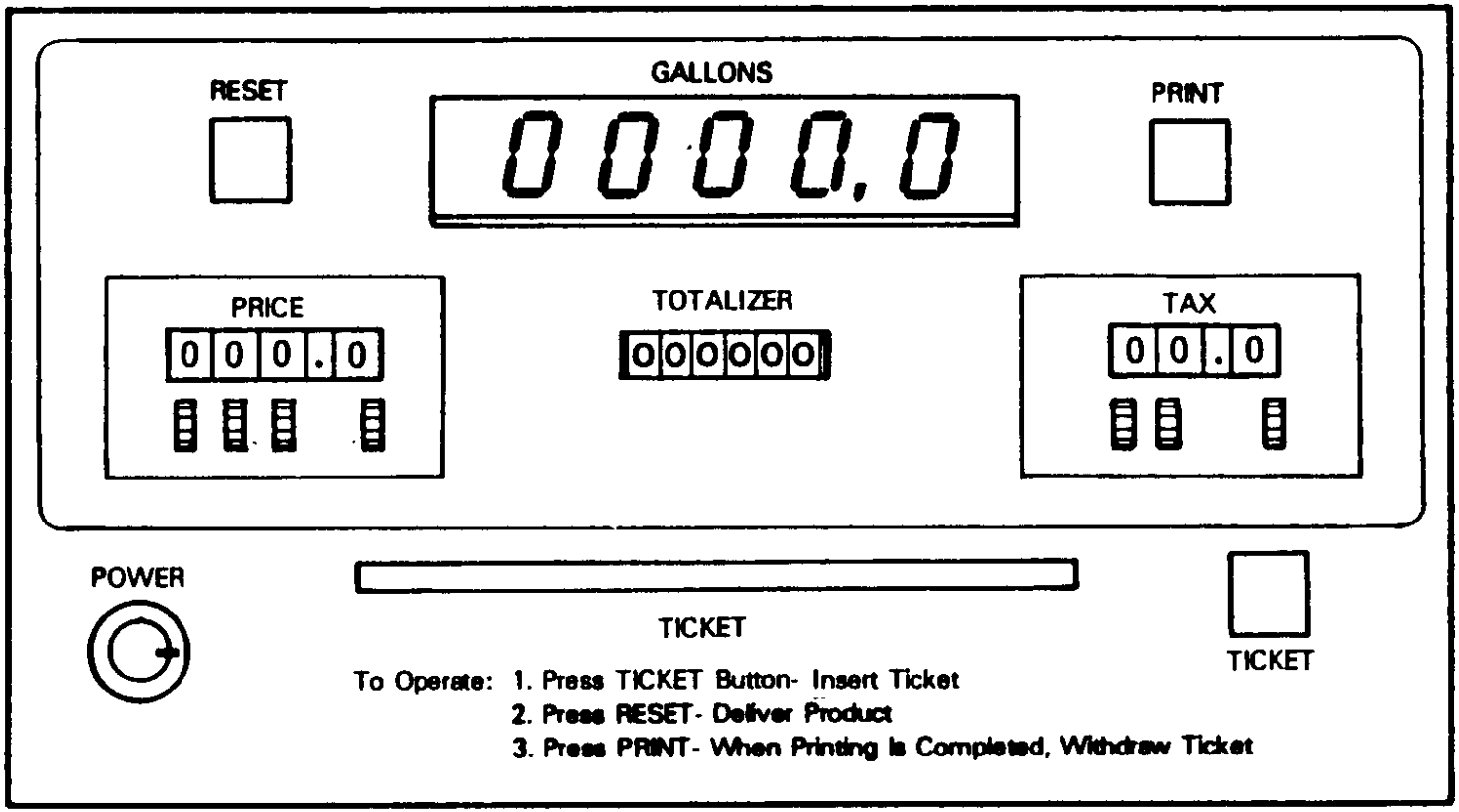


Figure 3-12: Electronic Indicator



Electronic Indicators

Fewer moving parts

Often more features and information:

- Computing capability
- Multiple calibration points
- Data communication

Mechanical motion of the shaft is transformed into a digital signal

Accomplished by means of a pulser

Other Device Features - Reset

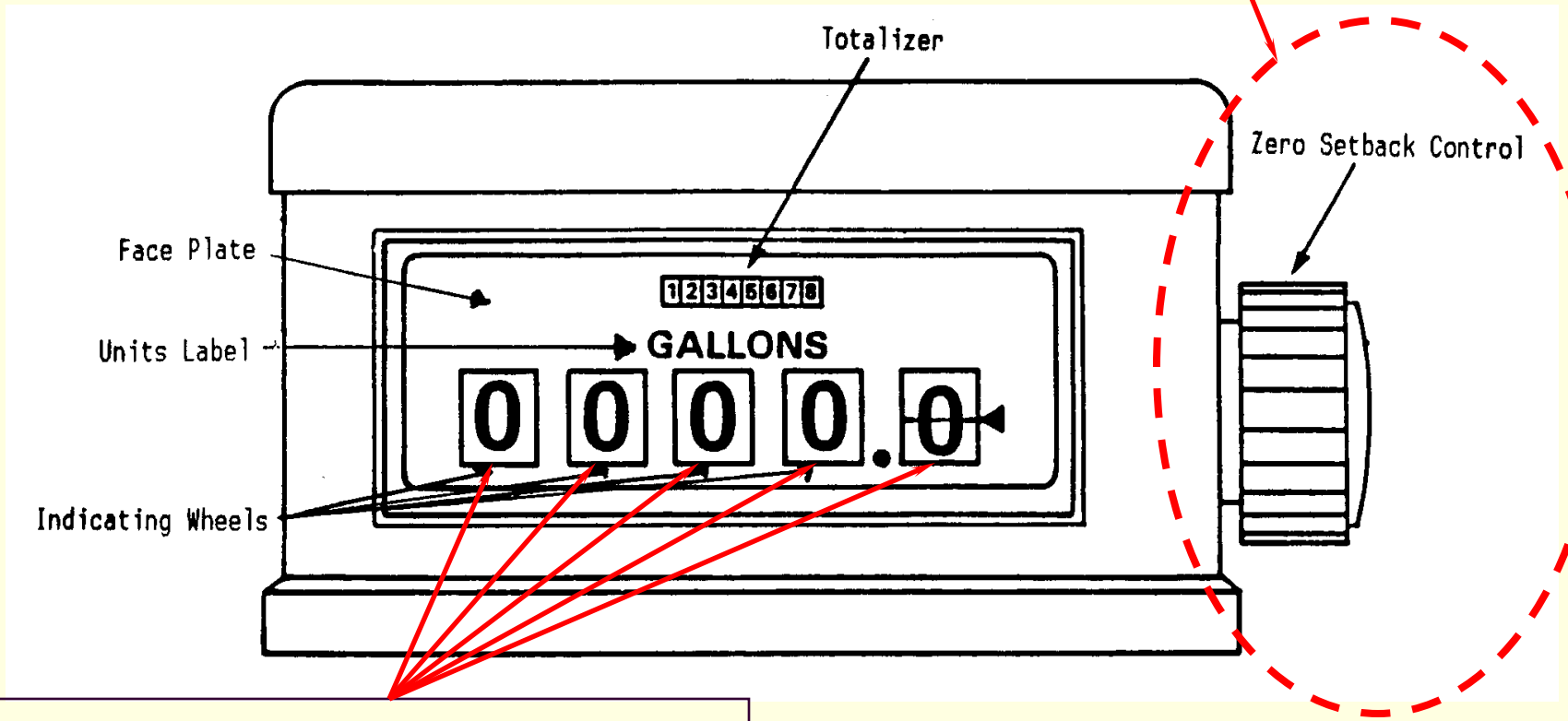
Returns indications to zero (per H44)

- Knob on an analog
- Pushbutton on a digital

Cannot display values during the reset operation if indications advance to zero

- Do not want readable values during reset
- Shutters or blanking are used

Mechanical Indicator Reset (from Figure 3-10)



Shutters drop to obscure indications during reset

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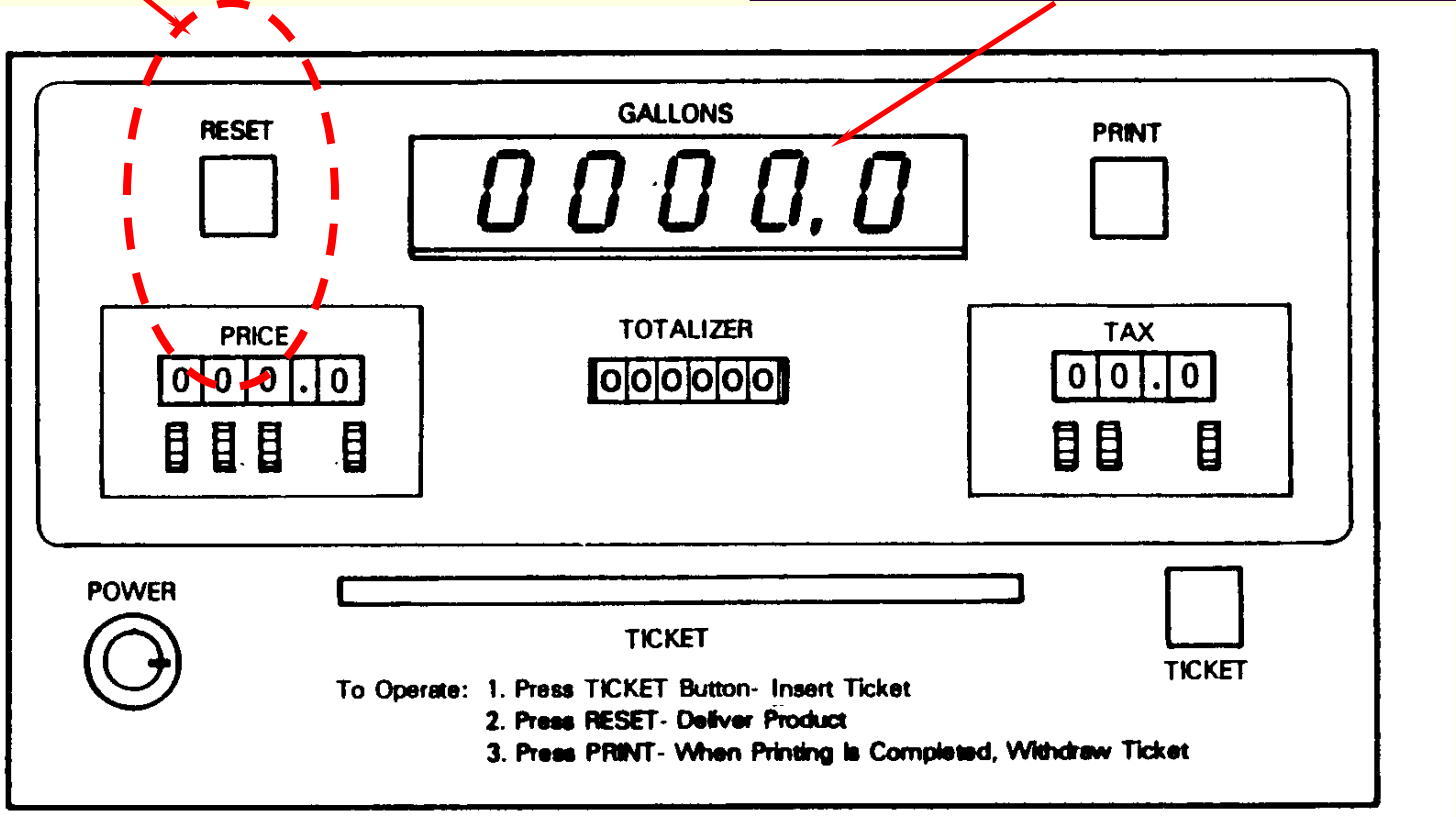
Electronic Indicator Reset (From Figure 3-12)

Reset

Indications blank during reset operation



Other Device Features - Totalizers

Totalizers keep track of total product

Used for:

- Inventory control
- Detect theft & loss
- Testing

Meter Adjustments Through the Indicator

Register is adjusted to bring the indication of the delivery as close as possible to a zero-error condition

Excessively worn meter may not be capable of adjustment

Adjustments through digital indicators:

- Performed electronically
- Calibration factors based on errors observed during testing
- Some have multiple point calibration

Meter Adjustments (cont.)

Adjustments through mechanical indicators:

- "Change gear" mechanism in some models
  - Rate of revolution is altered by changing gears
- Another design adjusts the speed of the output shaft to the register over a range
  - May use a calibrated dial to accomplish this
- Mechanical adjustors are located between the meter and the register

Ticket Printer

Required for all vehicle-mounted systems (UR.2.6)

- Requirement became retroactive in 1994

Driven directly by the register:

- Mechanically or
- Electronically

Some have capability to print prices, tax, dates, etc. calculated by the register

Temperature Compensation

LPG expands in volume by approximately 1% per every 5 F increase in temperature

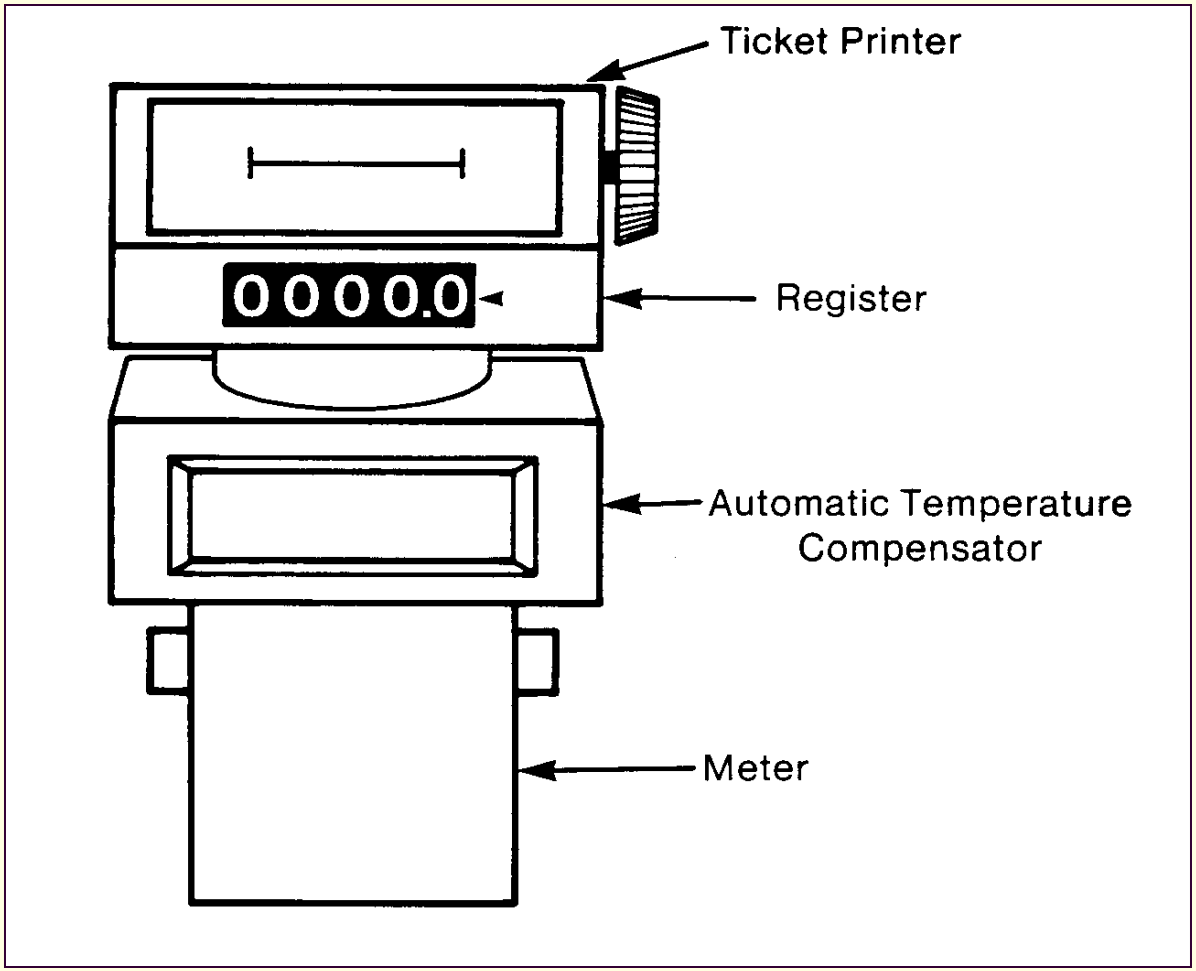
Manual or automatic temperature compensation

Correct volume of product to 60 F

Automatic temperature compensators (ATC's)

- Reduce manual errors
- Automatic adjustor
- Temperature sensed by a device installed in the meter or intake line
- Usually located between the meter and the register in the "meter stack"
- Usually equipped with some means for preventing it from being deactivated and should be sealed

Figure 3-20:
The Meter Stack



Temp Compensation -- Method of Sale

H44 does not require ATC, however….

Uniform Method of Sale of Commodities Regulation, NIST Handbook 130:

- Requires sale of LPG based on 15 C or 60 F
- For metered sales by the gallon:

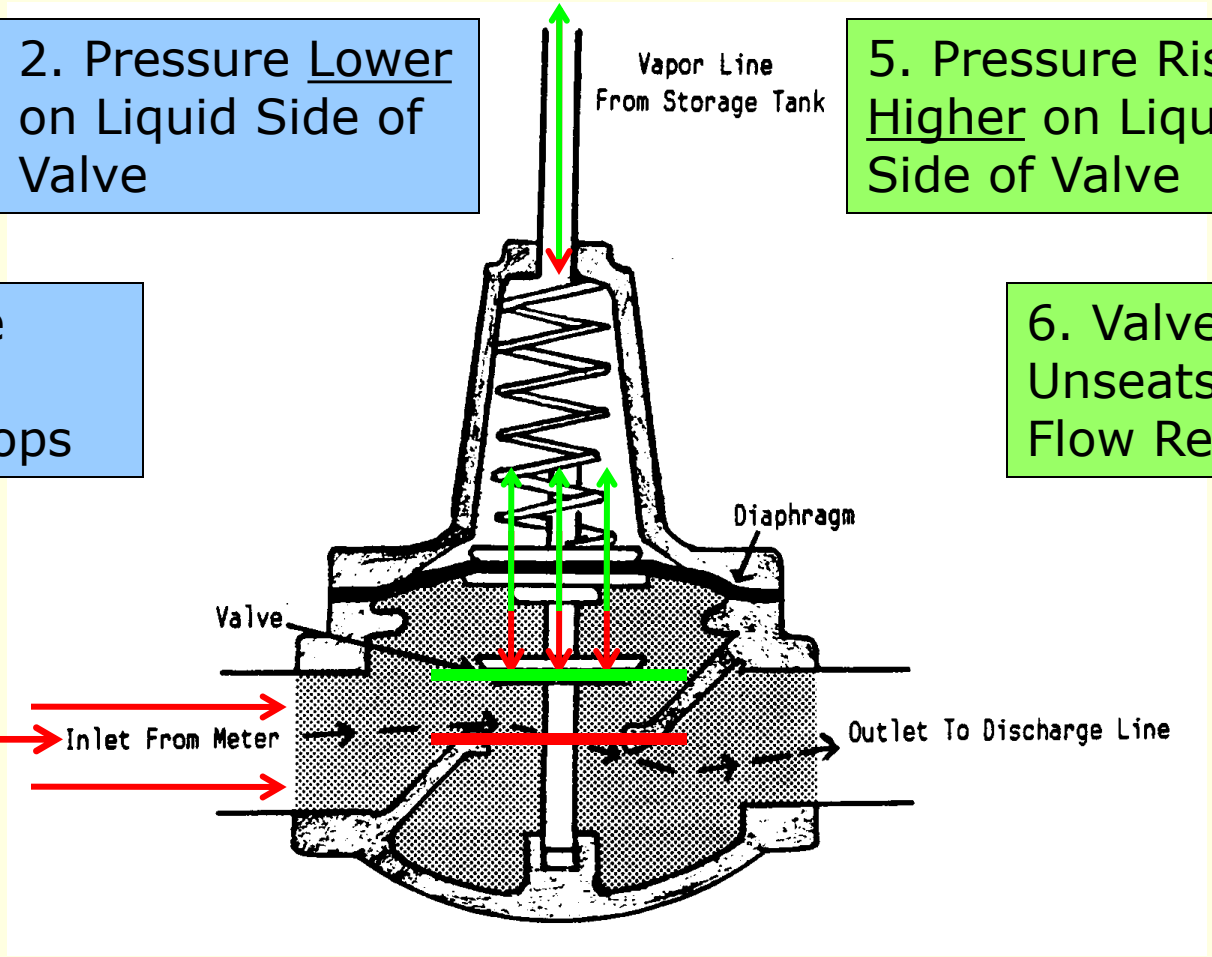
  For devices with a manufacturer's maximum rated capacity of more than 20 gallons per minute must have ATC

Uniform Method of Sale of Commodities Regulation

2.21. Liquefied Petroleum Gas. - All liquefied petroleum gas, including but not limited to propane, butane, and mixtures thereof, shall be kept, offered, exposed for sale, or sold by the pound, metered cubic foot [See NOTE 7] of vapor (defined as 1 cu ft at 60 F), or the gallon (defined as 231 cu in at 60 F). All metered sales by the gallon, except those using meters with a maximum rated capacity of 20 gallons per minute or less, shall be accomplished by use of a meter and device that automatically compensates for temperature.

(Added 1986) (NIST Handbook 130)

Figure 3-21: Differential Pressure Valve



The Discharge Line-- Differential Pressure Valve

Located just ahead of the meter outlet

Also known as the “differential valve” or “differential backpressure valve”

Maintains back pressure

- Works on principle of balanced pressure
- Serves to maintain sufficient level of pressure upstream of meter
- Prevents pressure from being bled into the discharge line during periods of nonuse

Differential Pressure Valve (cont.)

Helps minimize product vaporization

- Increases efficiency of air eliminator

Automatic in design

Example in Figure 3-19:

- Top chamber is connected to a vapor line running to vapor space of tank
- Bottom chamber is filled with liquid product that has passed through the meter

Differential Pressure Valve – Basic Operation

When pressure on the liquid side of the diaphragm is lower than or equal to the pressure of the vapor (and liquid) in the storage tank:

- A spring holds the valve closed
- Liquid product can not pass through to the discharge line

When pump operates, pressure on liquid side of diaphragm will rise

- Diaphragm is forced up
- Valve is unseated and product flows through to discharge line

Valve will close again when pressure of liquid is balanced with pressure in the tank

Discharge Line or Hose

Carries metered product to the receiving tank

Must be a “wet hose” system

- i.e., full of liquid at all times
- Shut-off valve at end to prevent hose from being drained

Since liquid can be trapped between end shut-off valve and differential pressure valve, need a pressure relief valve between the two valves

Liquefied Petroleum Gas Meter Test and Equipment

Chapter 5 -- General Introduction

Safe, accurate, and efficient proving is possible only if the inspector:

- has proper equipment, and
- is knowledgeable

"Quick Fix" NOT ACCEPTABLE

- Hazardous nature of product -- don't take chances
- Create a potentially dangerous situation
- Wasting time of owner and jurisdiction
- Be prepared before you start!

General--Intro. (cont.)

Inspector has primary responsibility for maintaining test equipment

- Prover is a field standard & is a precision device
- Neglect can render prover inaccurate

Basic Equipment

- Set-up, use, and maintenance of equipment
- Will review & practice this in field training

Basic Equipment

1) One or more dry chemical B:C fire extinguishers
2) First aid kit
3) Protective goggles and gauntlet gloves
4) Caution signs, markers, safety cones
5) Calibrated field standard prover of correct capacity for type of metering & standard fittings
6) Heavy duty 3-wire, 100’ extension cord (size 10 neoprene-covered)
7) Electrical receptacle wall plug AC ground tester
8) Grounding cable

Basic Equipment (cont.)

9) Complete set of adaptors for LPG fittings
   - Suggested list in APPENDIX B
10) Matched & accurate liquid glass or digital thermometers:
   - -30^{o} F to 130^{o} F
   - 1^{o} F increments
   - At least 12” in length
   - Accurate to within +/- 0.5^{o} F
   - At least 6 thermometers at all times
   - Important to be matched
   - 1^{o} F difference can result in as much as 40 cubic inches of error in readings

Basic Equipment (cont.)

11) Ethylene glycol, bulb syringe
12) Pipe joint compound
13) Hand tools and tool box
14) Stop watch
15) Temperature and pressure correction tables for prover
16) ASTM Table 24 for temperature corrections
17) NIST HB 44 and other applicable codes and regulations
18) Report forms
19) Lead and wire seals, tags, seals, etc. as needed
20) Equipment checklist and emergency numbers to keep with prover

Basic Equipment (cont.)

LPG Field Standard Prover -- General

Largest and most expensive piece of equipment you are using

Precision liquid measuring device

Provides high degree of accuracy and reliability when correctly maintained and used

LPG Field Standard Prover Design & Operation

Designed & constructed according to NIST OWM specifications

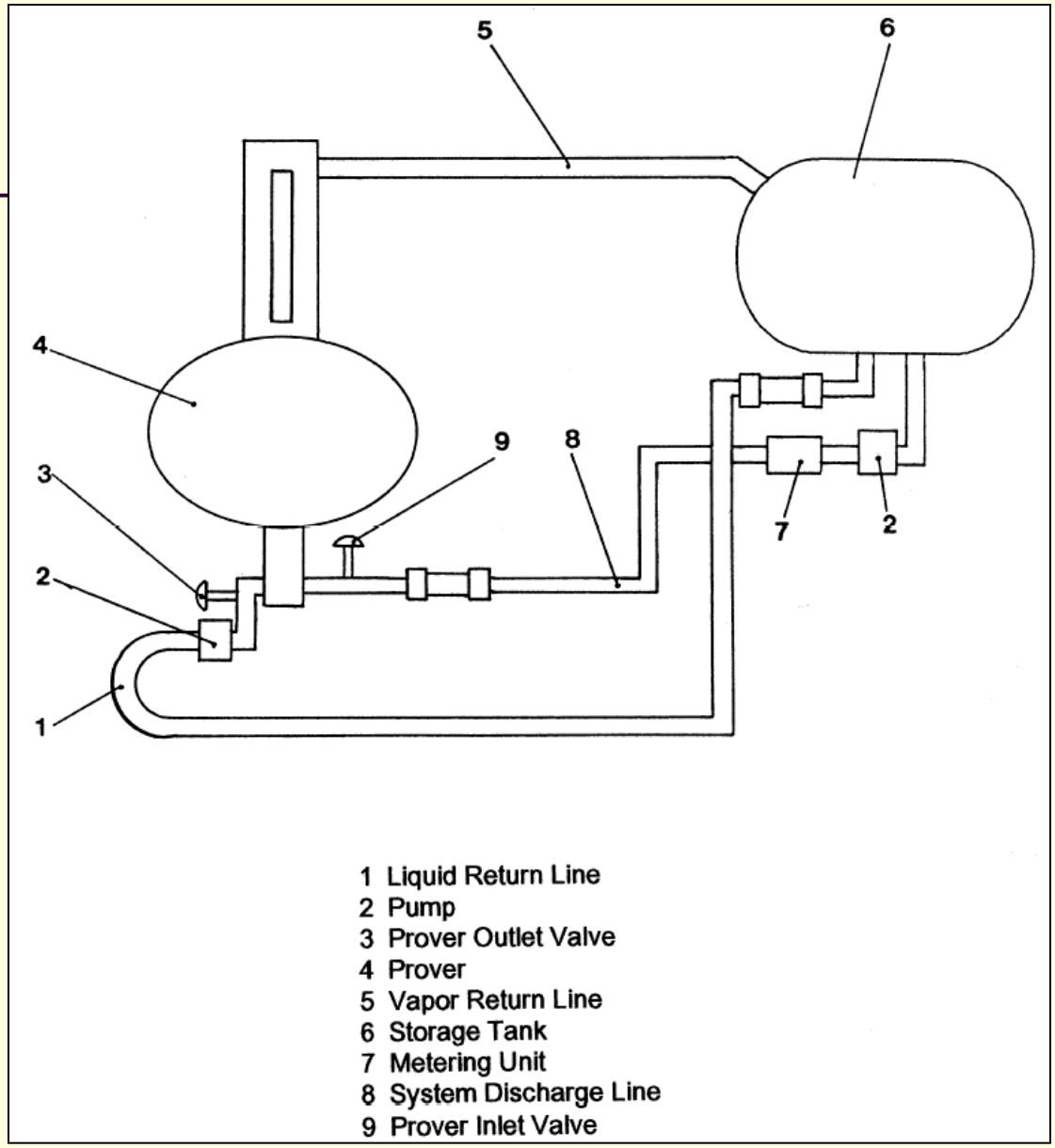
NIST HB 105-4

- Modifications no longer permit bleeder valve
- OWM may reconsider this in future edition

Should be calibrated and periodically re-certified according to NIST IR 7383 or procedures of your jurisdiction

LPG Field Standard Prover Design & Operation

Figure 5-1: LPG Prover & Metering System Components



LPG Liquid Prover -- Overview

Three basic connections:

1) Liquid supply line from system tank to prover
2) Liquid return line from prover to system tank
3) Vapor return line from top of prover to top of vapor space of system tank

Stationary or mounted on bed of a truck or trailer

Must withstand working gauge pressures of at least 250 psi

Vapor Return Line

- Opened after liquid discharge & return lines are connected
- Closed before taking reading
- Allows vapor initially in prover to be pushed back into system tank
- If vapor in prover were to remain, pressure from incoming liquid would cause condensation
- Necessary for testing; not possible to determine amount of product resulting from vapor condensation
- Commercial transaction: vapor in the receiving tank belongs to customer
- Spray fill tank (“new”) design enables efficient delivery
  - Promotes condensation
  - Reduces pressure

LPG Liquid Prover-- Other Points

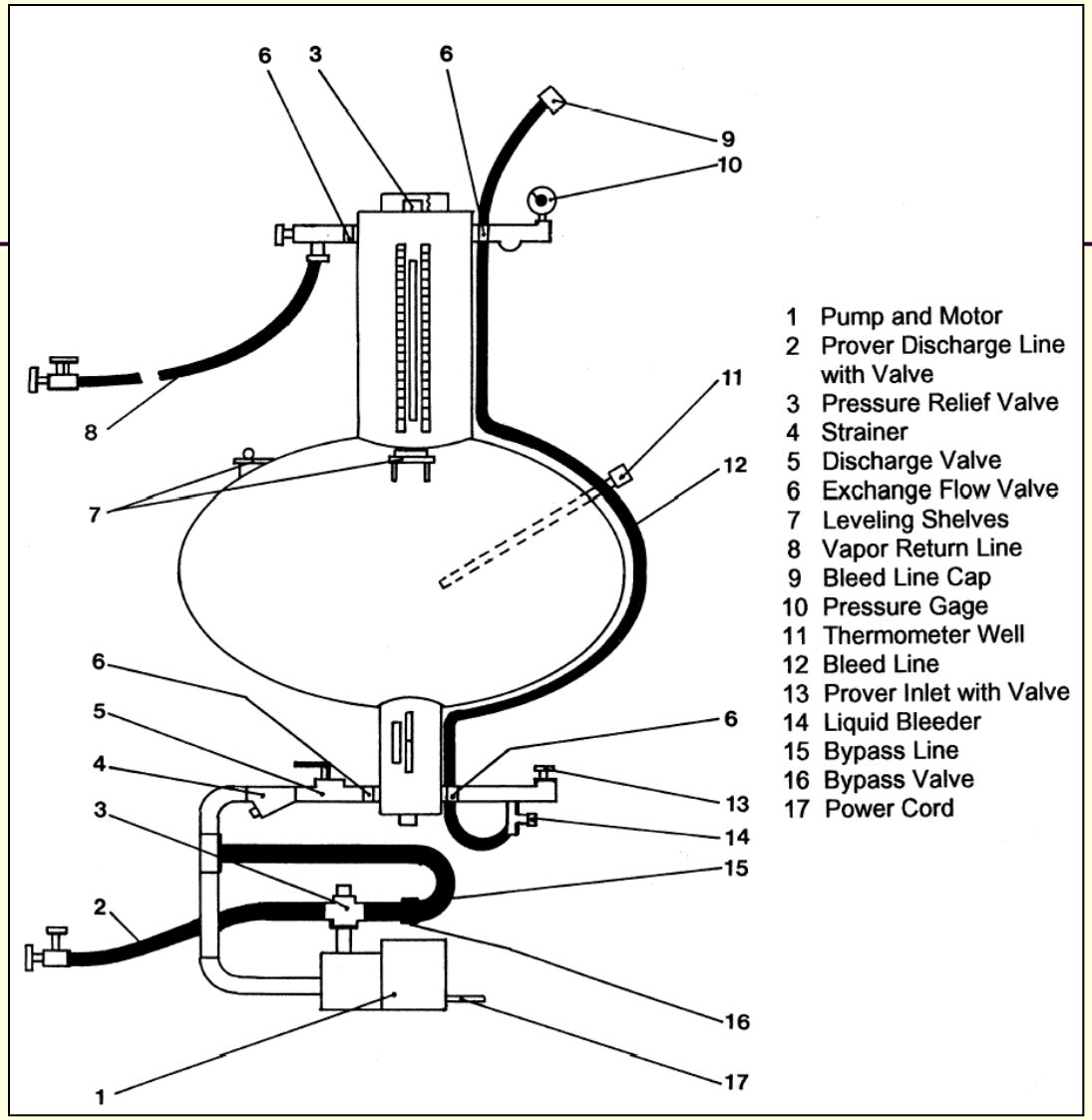
Pump, Motor, and Hoses

- Must be suitable for use with LPG products
- All electrical connections must be Explosion-Proof
- Valves, fittings, gauges suitable for use with LPG

Capacity

- Suitable for application
- Common sizes are 25-, 50-, &100-gallon

Figure 5-2: LPG Liquid Prover



LPG Prover Components

1) Body - spheroidal
2) Upper neck gauge
3) Lower neck gauge
   - Monitor for product level
   - For zeroing prover
4) Strainer
   - Traps contaminants
   - Cleaned regularly
5) Pump bypass circuit
   - Protects pump
   - Set to open when pressure at the pump outlet is too high

     e.g., Between end of delivery & when the pump is turned off

LPG Prover Components (cont.)

6) Thermometer well
- Temperature of liquid to make temperature corrections
- Expansion of prover shell dependent upon shell material

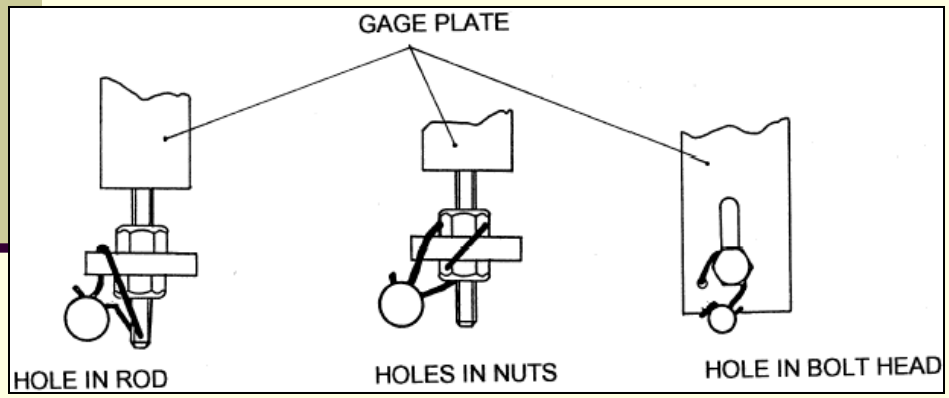
7) Pressure gauges
- To make pressure corrections
- Every prover responds differently to pressurization

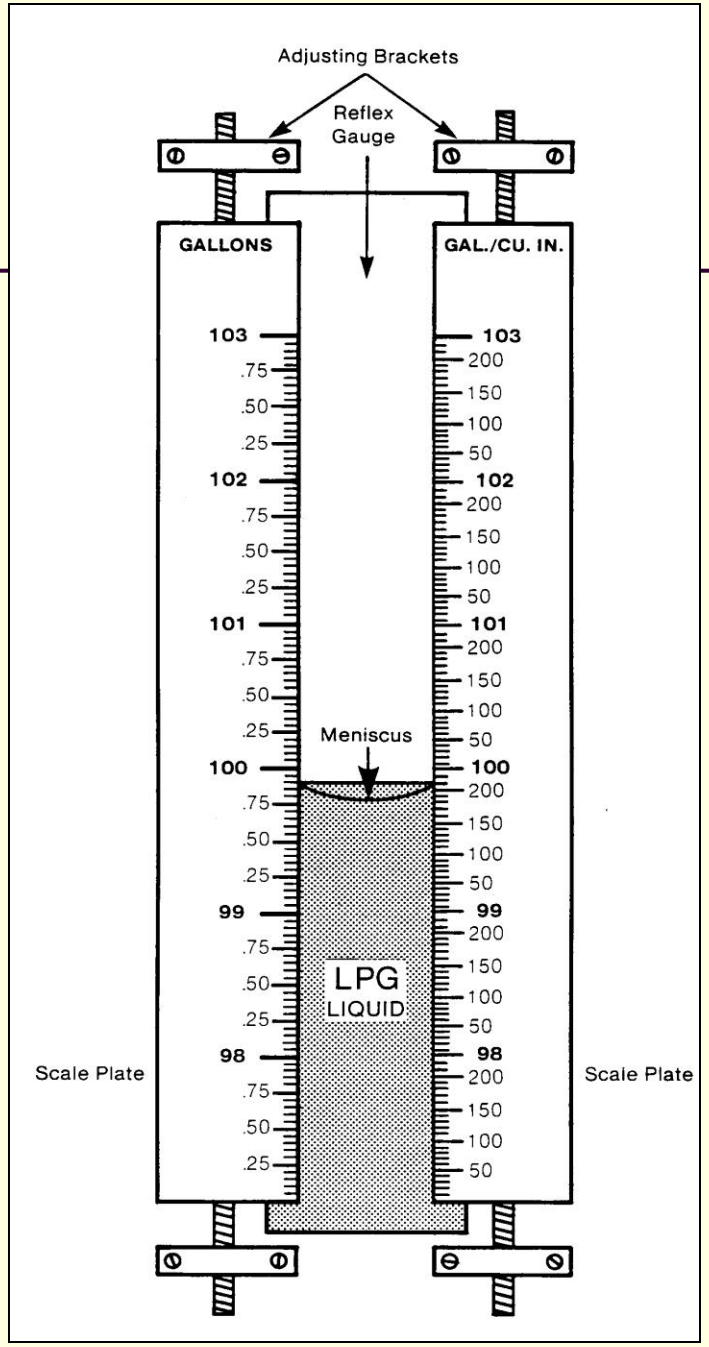
    Each prover has its own ***unique*** pressure correction table!

8) Leveling shelves

9) Bleed line and bleeder valve
- To bleed small quantities of product when zeroing prover

Figures 5-3 & 5-5: Prover Gauge and Scale Assembly and Seals





Scale Plates

Mounted on adjustable brackets

Sealed in position with wire seals

Decimal gallon readings are used in calculations

- Converted to cubic inches later, if needed

Smallest graduated interval

- ≤ 0.05 gallons on a 100-gallon prover
- ≤ 0.02 gallons on a 50-gallon prover
- ≤ 0.01 gallons on a 20-gallon prover

Scale Plates - Range

Range should be no less than 4% of the nominal capacity of the prover

Graduated both above and below by not less than 1.5% of the nominal capacity

Example of a 100-gallon prover:

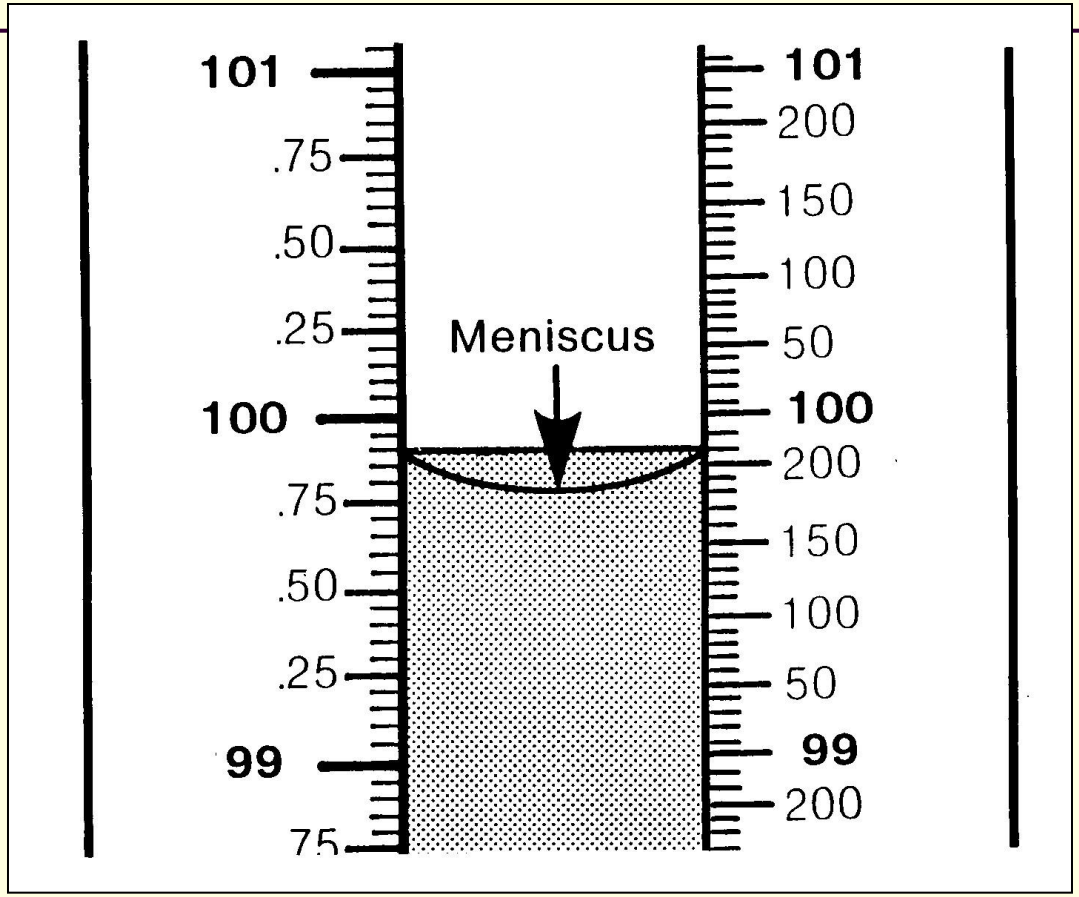
- 100 gallon prover
- Range of entire scale no less than 4% = 4 gallons
- Graduations above and below no less than 1.5% = 1.5 gallons

Reading the Prover-- The Meniscus

Capillary action of glass tube results in meniscus

Prover is read at eye level, reading the bottom of the meniscus

Figure 5-4: Reading the Prover Gauge



Setting Up the Prover-- Notes

Several of these steps should be performed by the operator, not the inspector

Require operator to stand by during test since he is most familiar with equipment being tested

- If inspector may be held responsible for any resulting damage if operating equipment or making connections

Setting Up the Prover-- Procedures

Remember: Safety First!!!

Position the prover:

- Away from source of ignition
- On stable surface
- Near power source
  - Confirm the power source is grounded
  - Be sure prover return pump operates before pumping product into the prover
- Location should enable you to see meter, register, & prover indications as you operate the prover valves

Position fire extinguishers within easy reach

Do Not Leave Them in the Prover!!

Set-Up Procedures (cont.)

Chock and level prover trailer or vehicle

- Check chocks and level again with product in the prover

Position warning signs and safety cones

Ground the prover to a suitable ground

Check fittings for adaptors required before proceeding

Note and record totalizer

Inspect temperature wells for dirt and debris

- Clean & fill

Check prover & bleed valves

- Be sure they are closed tight

Set-Up Procedures (cont.)

Set-Up Procedures (cont.)

Have operator:

- Connect the system delivery hose to prover inlet line
- Connect vapor return line to system vapor connection
- Connect prover liquid return line to system liquid inlet

Check for tight connections; valves & bleeders are closed

Open vapor return line valves SLOWLY to avoid abrupt pressurization of prover

Observe pressure gauges

- Install thermometers in (meter) and prover

Set-Up Procedures (cont.)

Why Wet the Prover?

LPG provers are CALIBRATED TO DELIVER

- Contain slightly more than their rated capacity when full

Have clingage on sides

Impractical to remove clingage between test drafts

- Will use a drain period of 30 seconds during testing
- Duplicates prover calibration

What Does Wetting the Prover Accomplish?

Must wet prover for each meter

Wets inside of prover

Forces evacuation of left-over vapor

Brings temperature of prover to that of the liquid

Wetting The Prover -- An Unofficial Test

Not an official test

Still record pressure readings

The cause of divergent pressure readings must be remedied before proceeding

Usually restriction in vapor line from undersized hose

Significant divergence will invalidate test results

Wetting the Prover

1) Have operator activate and engage the system pump

2) Open the prover inlet valve SLOWLY

3) As liquid fills prover, note pressure readings
   - Balanced condition must be maintained
   - Cause of more than about 5 psi divergence must be corrected before proceeding

4) Close prover liquid inlet valve when product reaches capacity line in neck gauge

Wetting the Prover (cont.)

Wetting the Prover (cont.)

5) Have the operator disengage the system pump

6) With prover full of liquid:

- Level prover
- Raise bed so vehicle wheels are not resting on ground
- Check chocks on trailer or prover to prevent shifting

7) Open prover liquid return line valve SLOWLY

8) Start prover return pump

Wetting the Prover (cont.)

Wetting the Prover (cont.)

9) Monitor lower neck gauge level

- When liquid level appears in the top of the lower sight gauge, QUICKLY CLOSE LIQUID RETURN LINE

10) Start stopwatch

11) Turn off prover pump

12) During 30-second drain, ZERO the Liquid Level in the Lower Neck Gauge

- If above zero line, use bleed valve in liquid inlet line to bleed off excess
- Have operator start pump and add additional product if below zero line

Test Drafts

Similar to wetting prover

Require at least three or more drafts

Before beginning delivery:

- Check for correct zero on prover
- Slightly above zero is okay
- Slightly below, re-zero
- Have operator start pump
- Reset register indications

During Delivery

Monitor pressure gauges

Change of more than 5 psi from initial, halt test & start over

- Change in pressure may cause condensation--invalidates test results

Monitor Flow rate

- Start timing at 10 gallons
- Make sure you are operating within rated minimum and maximum flow rates of device

During Delivery (cont.)

Except for temperature compensated runs, note & record temperature readings at the meter at 1/3 & 2/3 of prover capacity

Close prover inlet valve to stop delivery (meter indication) at even gallon or as soon as possible after liquid appears in the upper neck gauge

- Convenient (but not necessary) to stop meter indication at prover capacity

After Delivery

1) Close vapor return line to fix temperature and pressure inside of prover

2) Have the operator turn off the system pump

3) Record prover pressure and temperature

4) Recheck level and record meter & prover readings
   - Wait until bubbles subside before taking a reading


09/


GALLONS
0025.5
DO NOT RESET WHILE COUNTING


09/07/2016


DELIVERS 25 GAL TO ZERO
09/07/2016

After Delivery (cont.)

4) (cont.)

- Bubbles indicate a pressure differential exists
- May be necessary to flush prover one or more times to reduce differential

5) Open vapor return line

6) Return product to the delivery system

- Observe correct drain procedure & 30-second drain period

Prover Maintenance -- General

Note & report immediately to your supervisor:

- Any damage which has occurred to prover
- Abnormal performance, especially leaks

Repairs to be made only by qualified personnel

Have prover recalibrated if necessary following repairs

- Should have a regular re-inspection/recalibration program for your prover

Prover Maintenance Following Each Use

Bleed vapor and liquid lines if they are to be removed

- Not necessary with hard-mounted lines
- Do only in area where there is no danger of ignition
- LPG is heavier than air; always direct venting of vapor in an upward direction

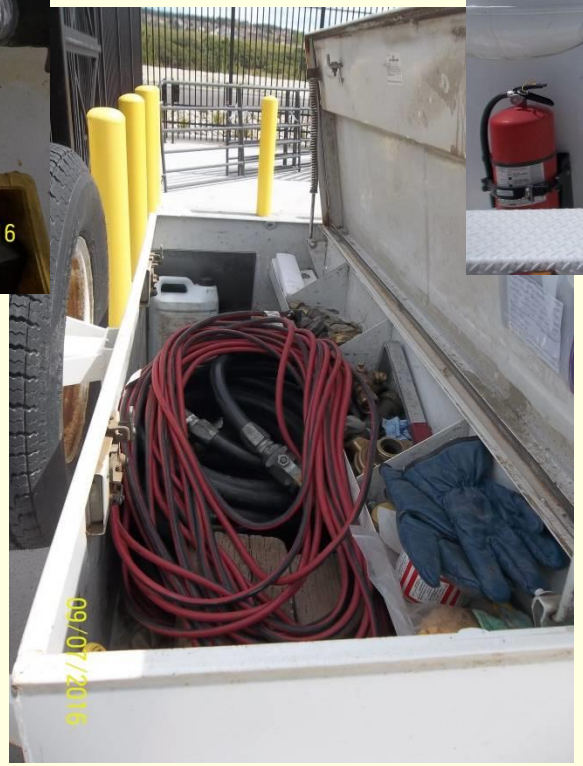
    Dissipates to prevent collection of dangerous vapors

Store hoses carefully and avoid crimping

Clean dirt from fittings (do not drag on ground!)

Cap all connections on prover

Prover Maintenance Following Each Use



Prover Maintenance…(cont.)

Cover thermometer well

- NEVER leave thermometer in well while transporting prover

Clean & store thermometers carefully

Check & clean strainer in liquid return line regularly

DO NOT bleed prover to atmospheric pressure

- Water-laden air may enter prover and condense--causes rusting and corrosion

Follow manufacturer's instructions for lubricating pump, return valves

Questions?

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