An Introduction to Aerosol Propellants

Diversified CPC International, Inc.

Aerosol Products Do Not Contain CFCs

Aerosol Product System

(Slides in this section courtesy of DuPont)

Aerosol Product System

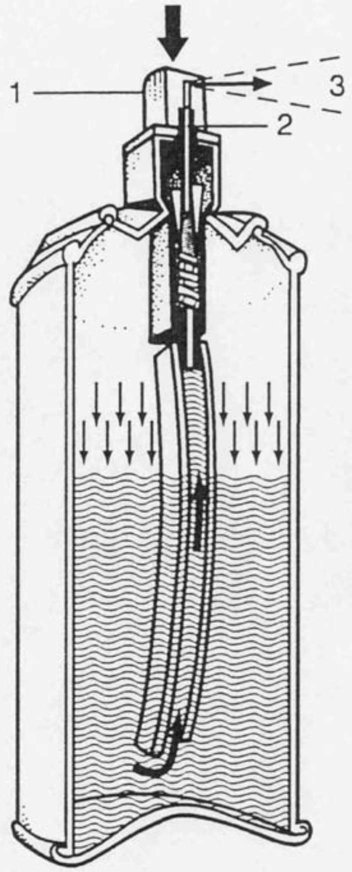
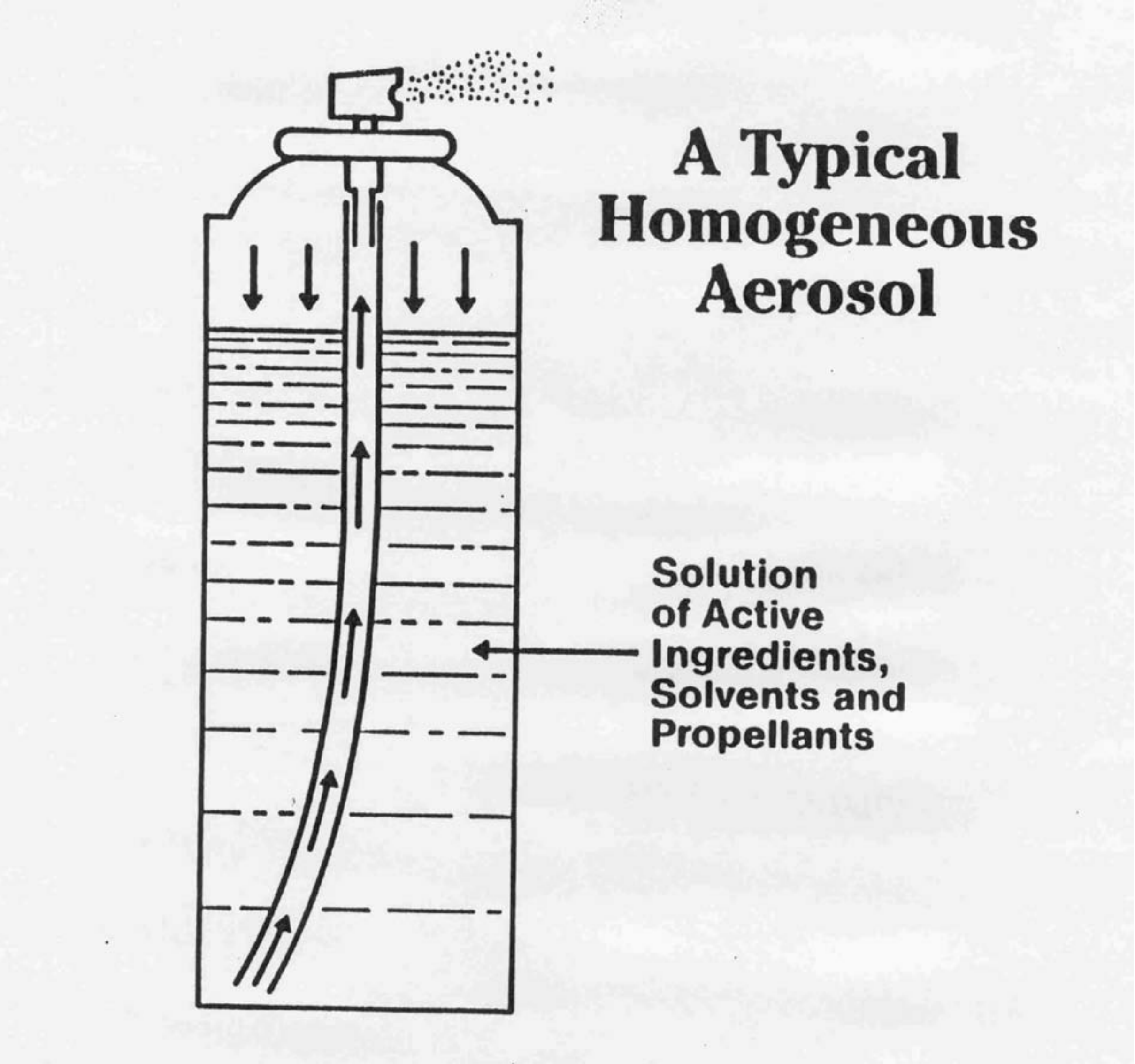


Figure A-1-6 An aerosol can (cutaway view). When the plunger (1) is pressed, a hole in the valve (2) allows a pressurized mixture of product and propellant (3) to flow through the plunger's exit orifice. *(Source: Fire Protection Handbook, 18th edition)*

Aerosol Product System



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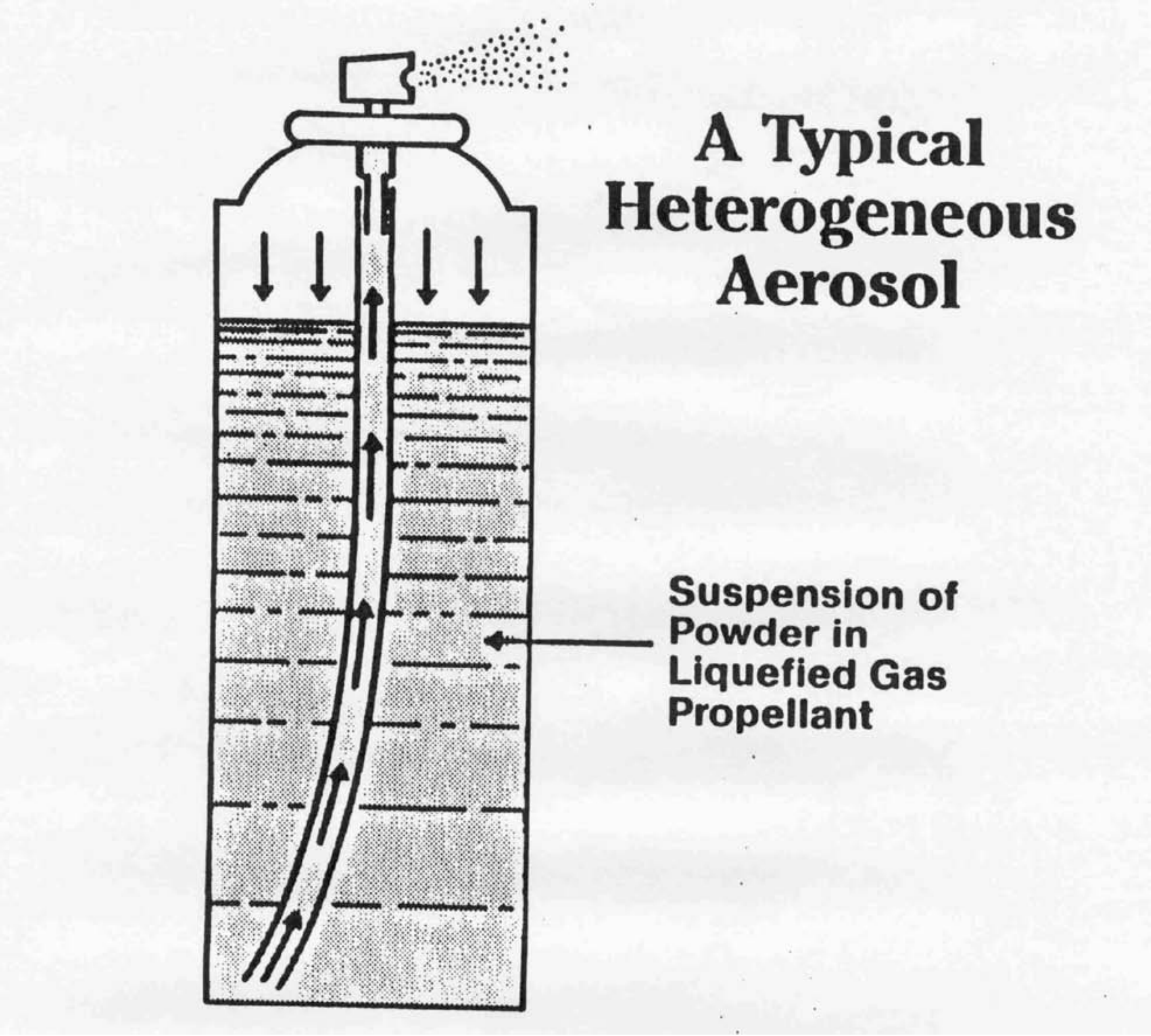

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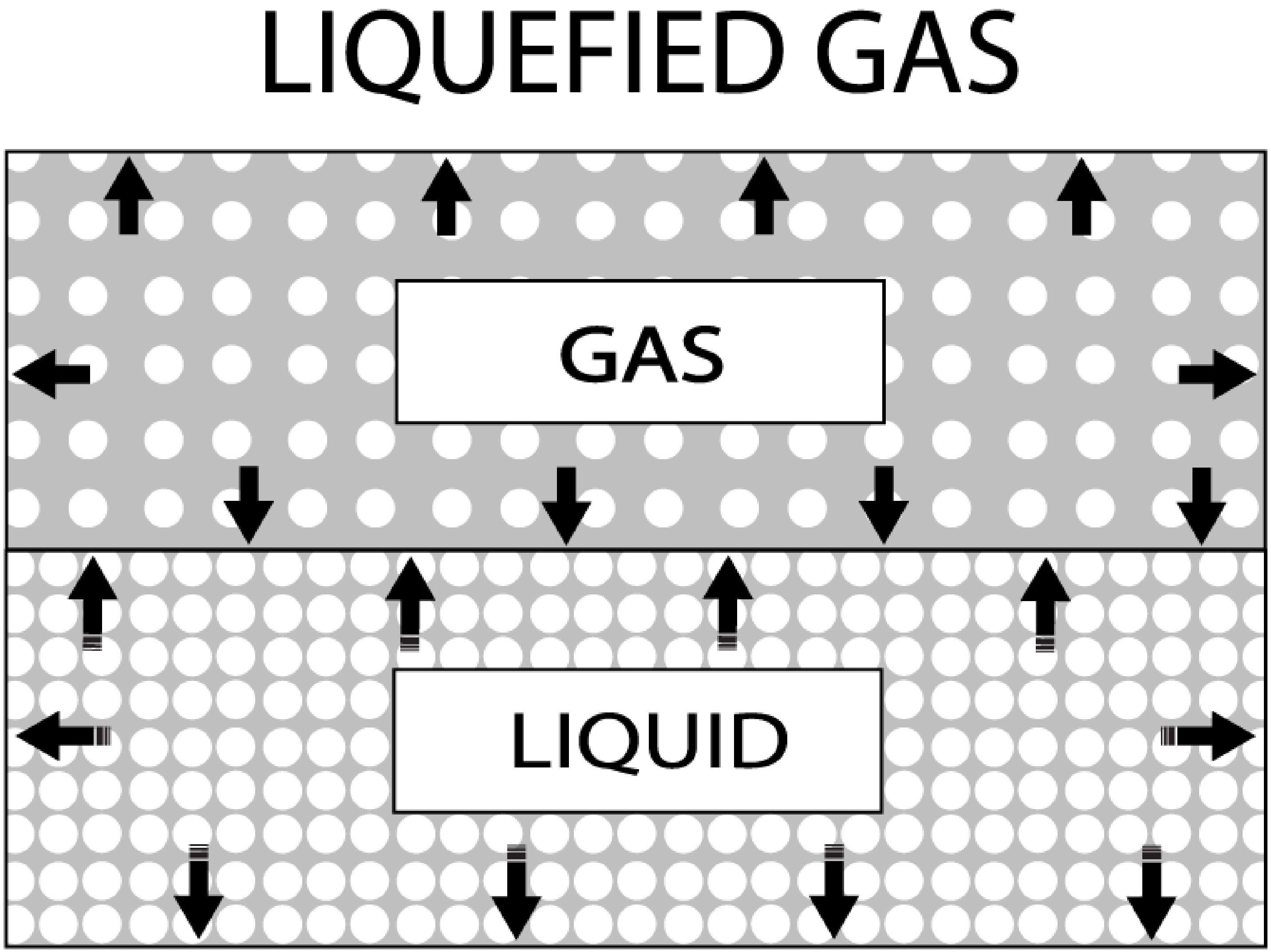
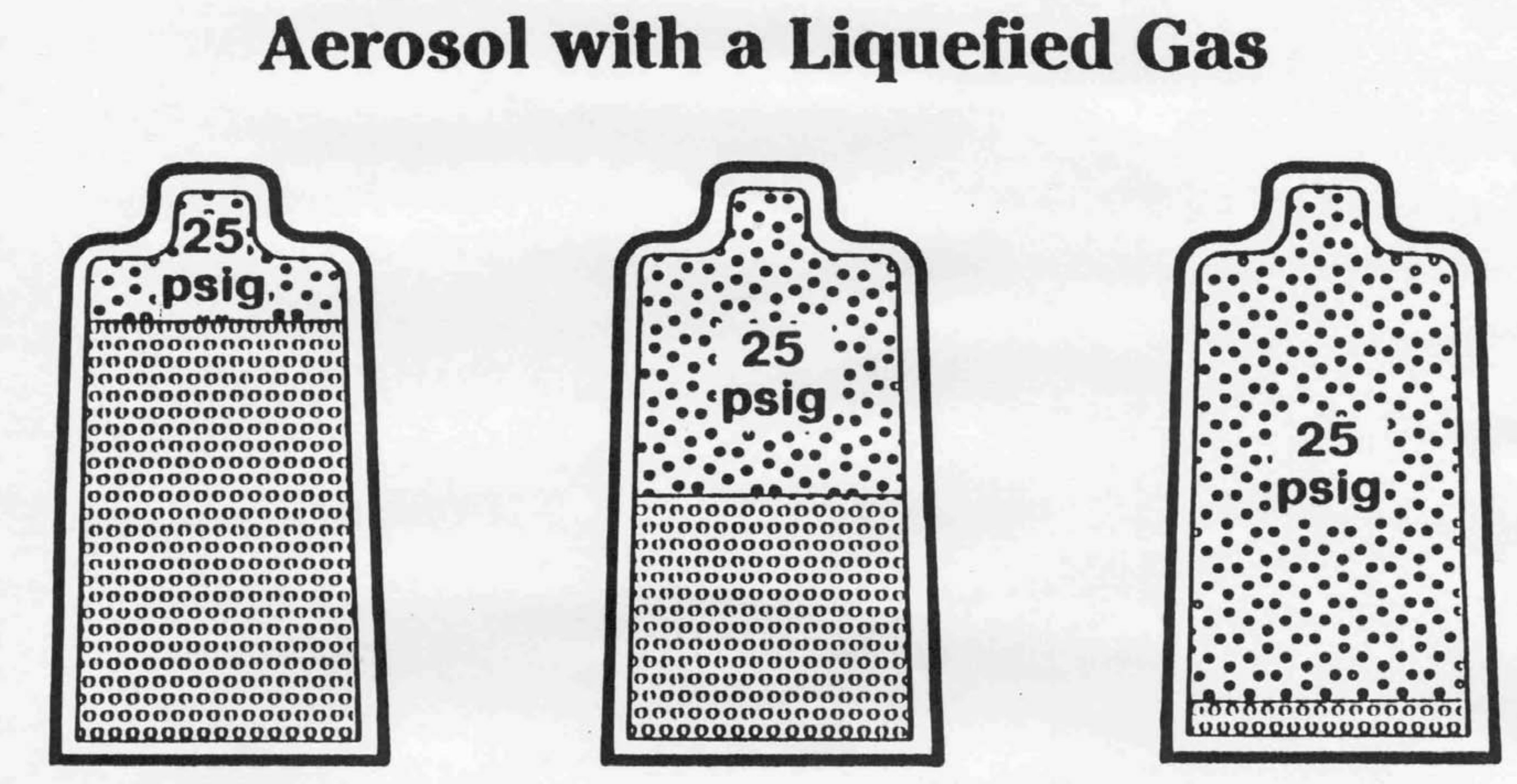
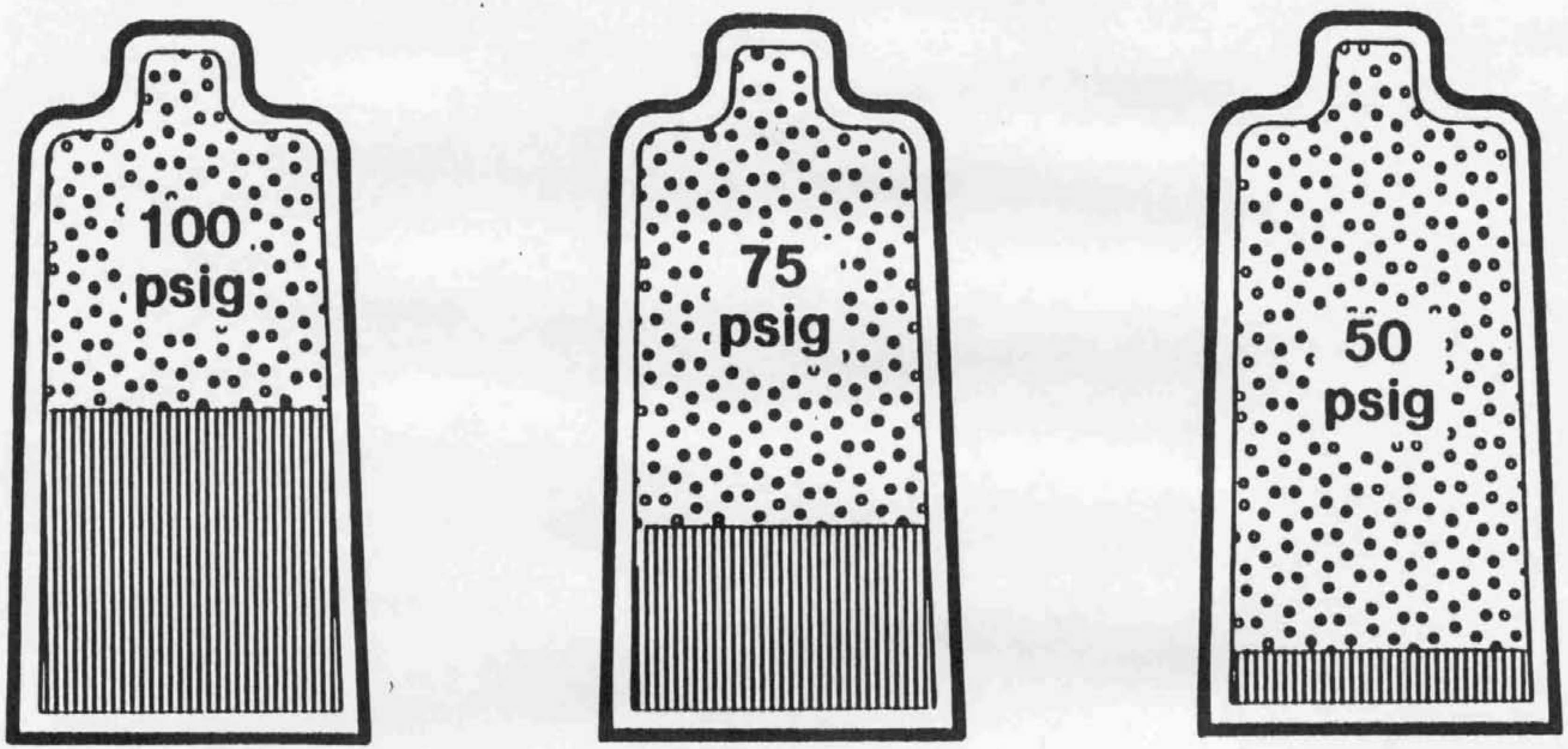


Aerosol Product System



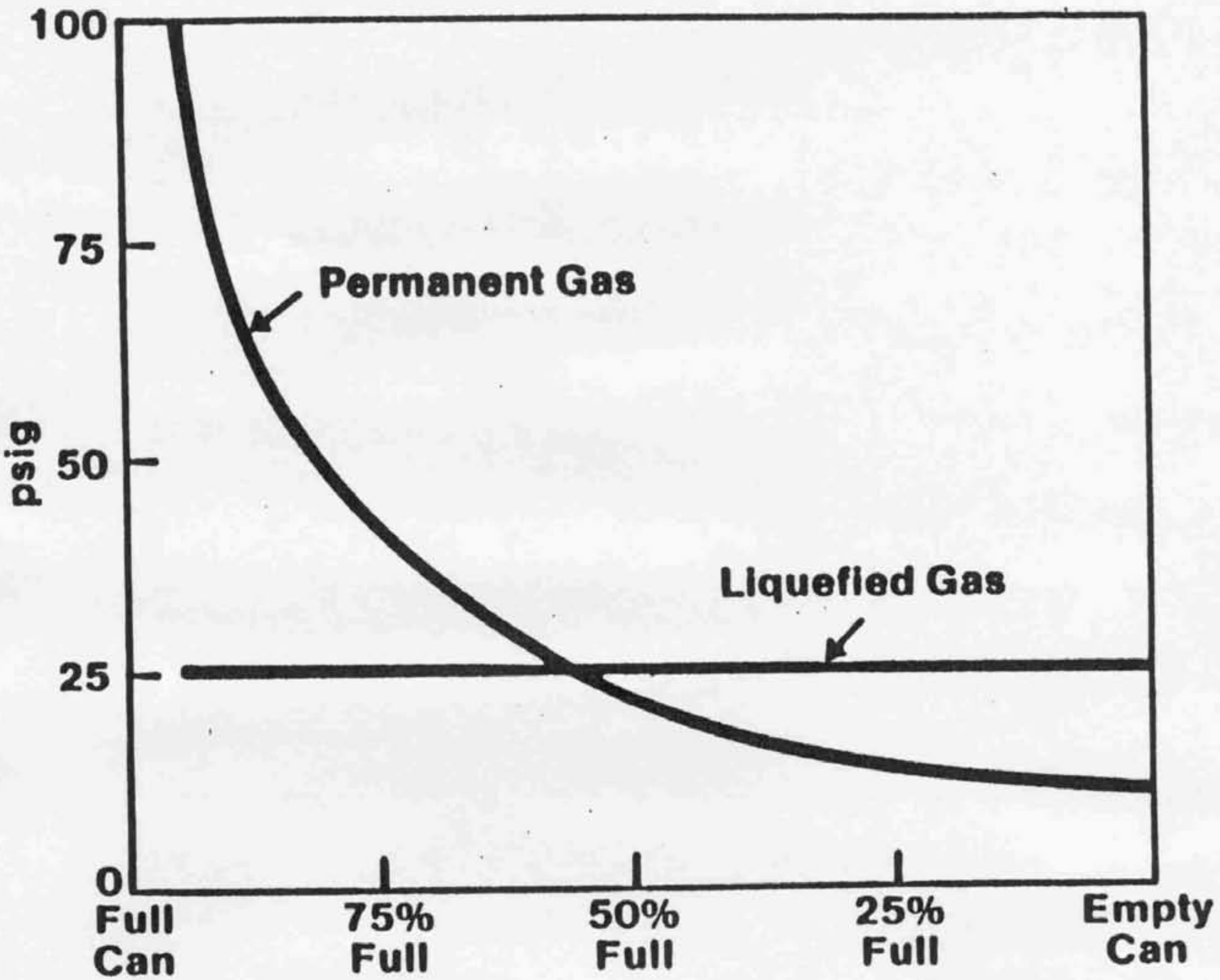
Aerosol Product System

Aerosol with a Permanent Gas

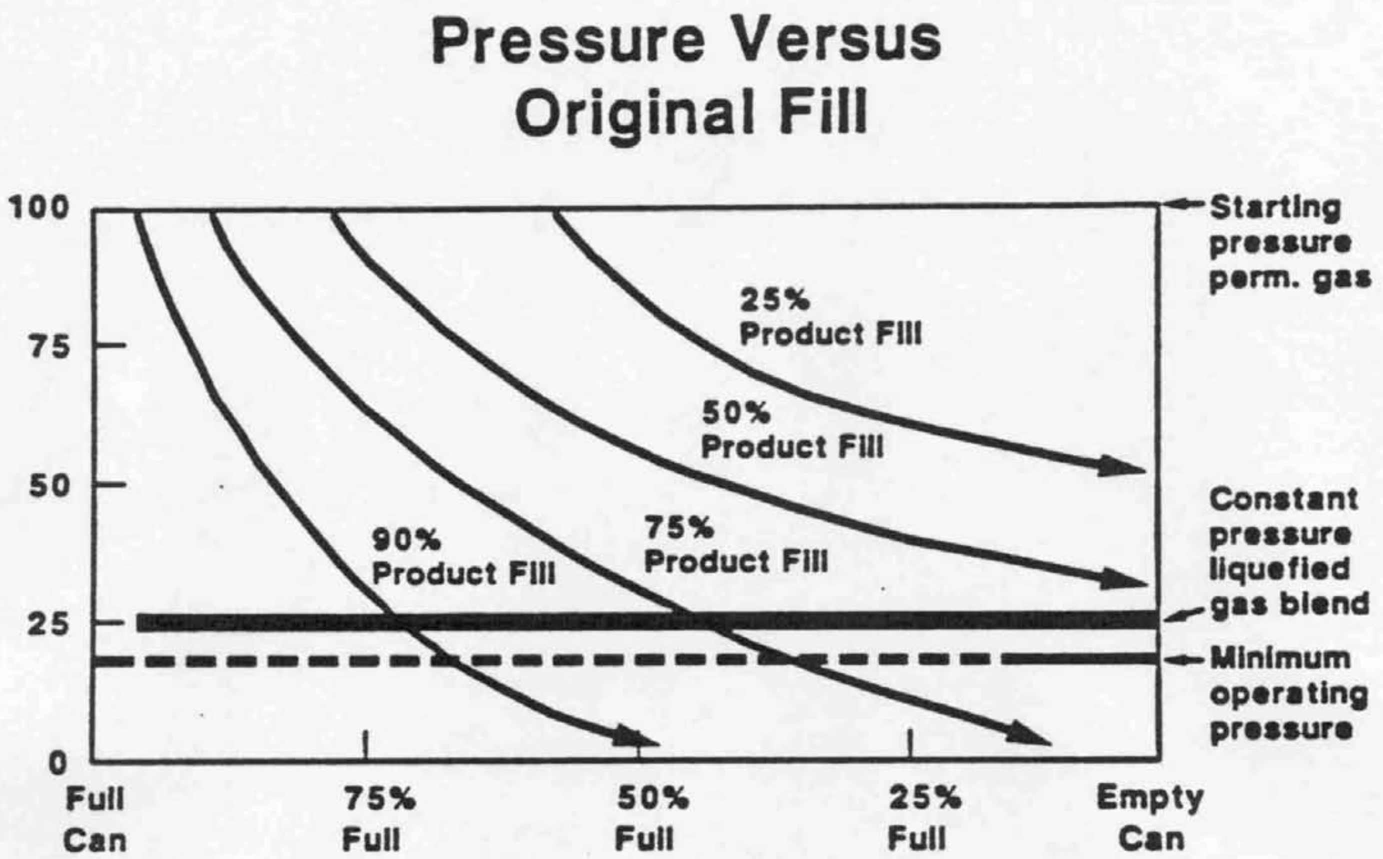


Aerosol Product System

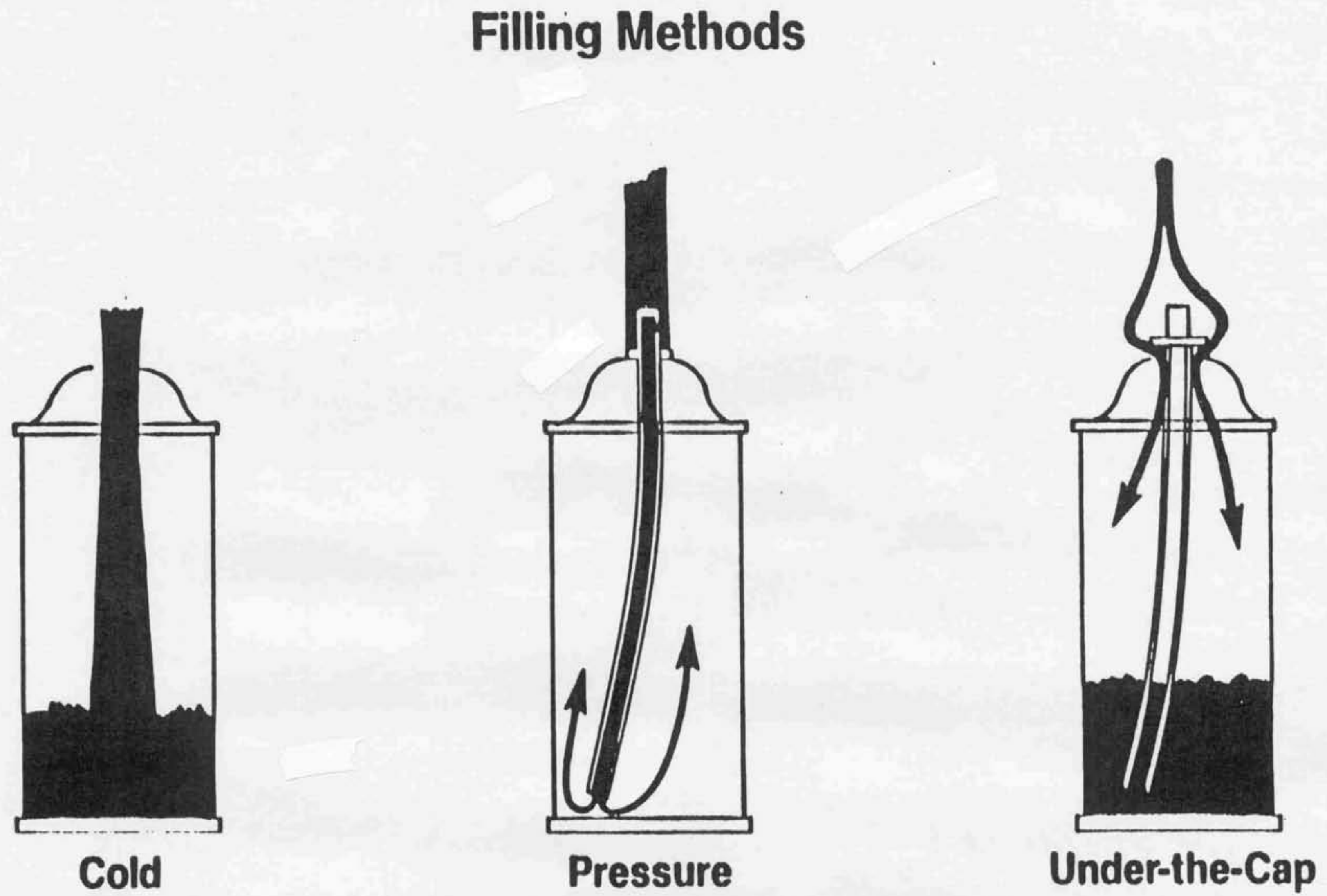
Pressure Drop During Discharge



Aerosol Product System



Aerosol Product System



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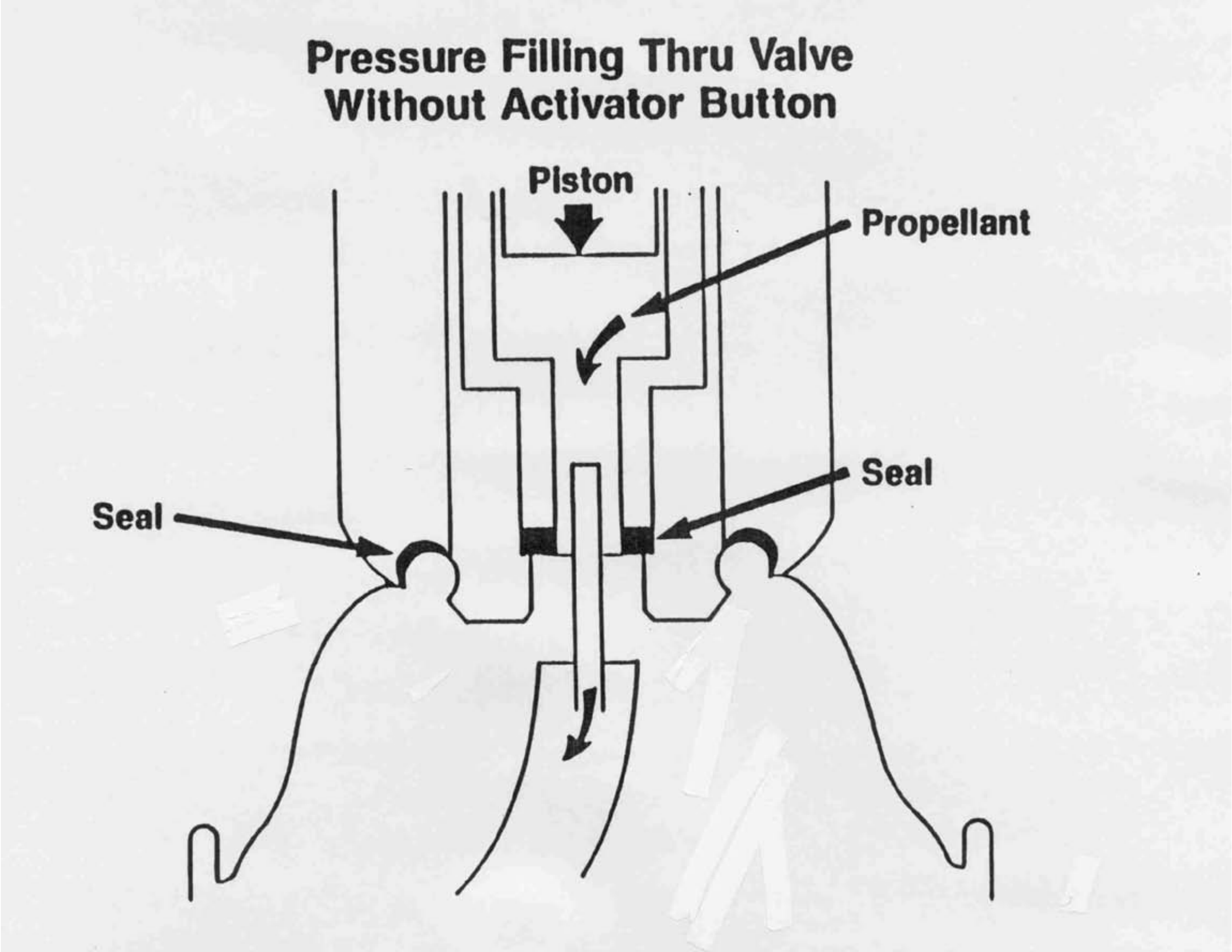
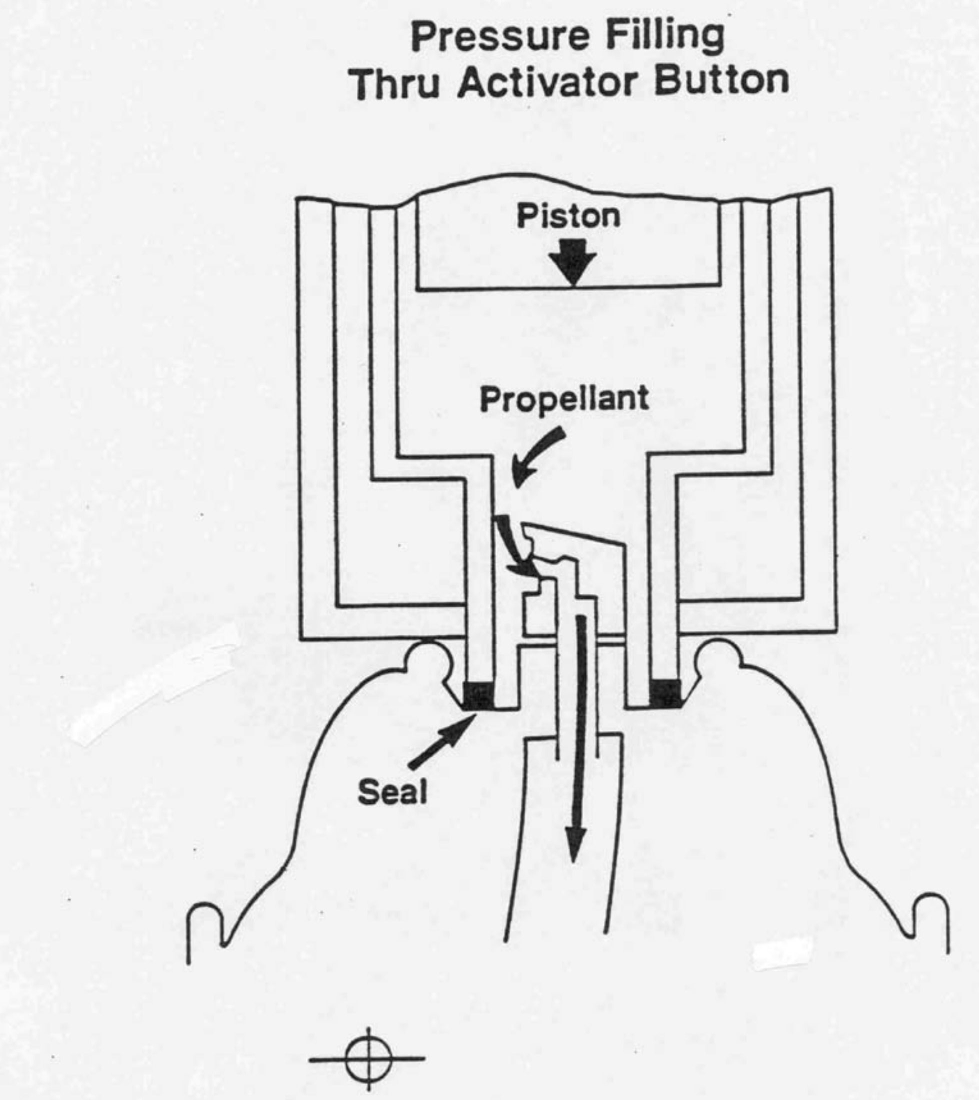
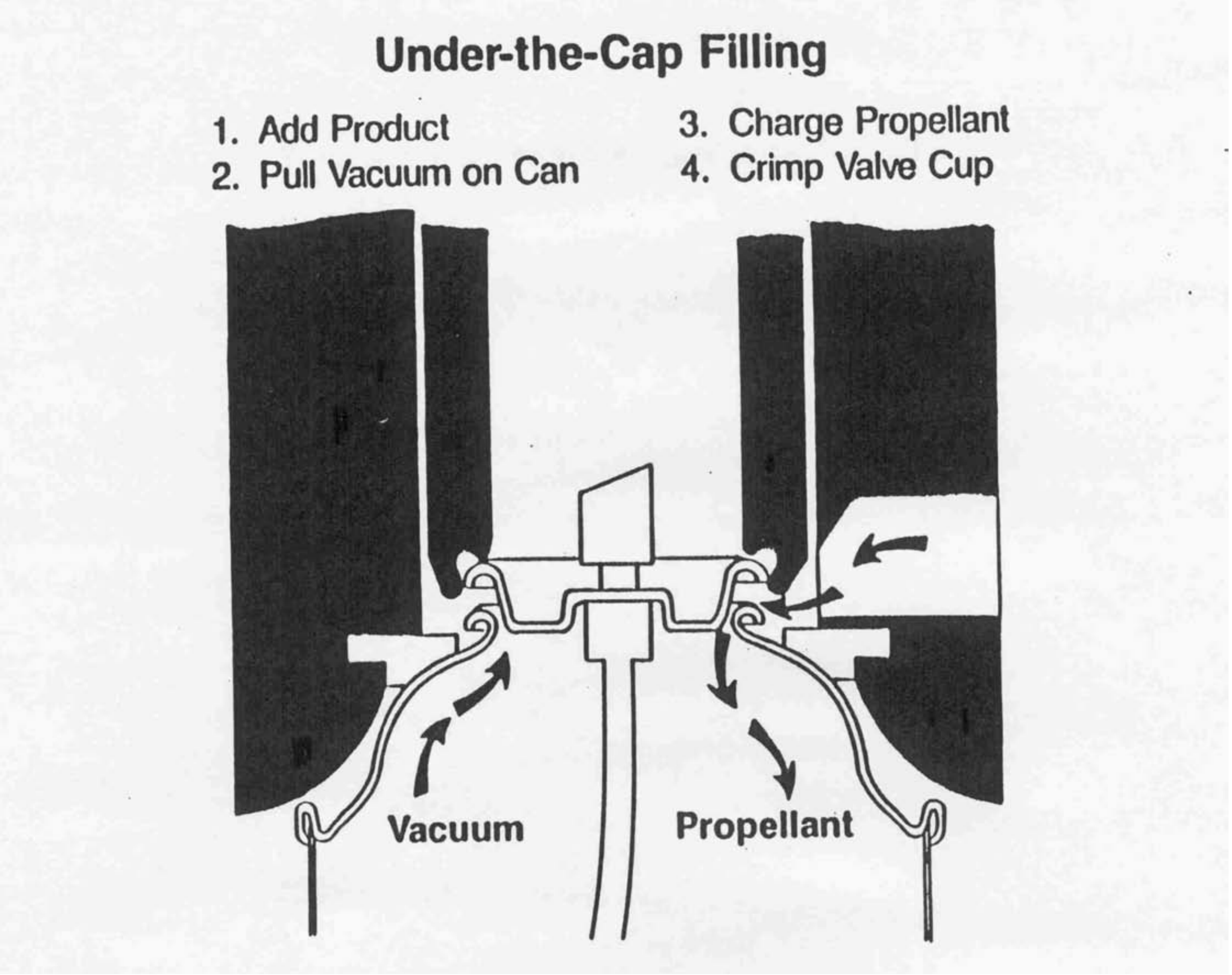


Aerosol Product System



Aerosol Product System



Basic Propellant Properties

Basic Propellant Properties

- **Pressurize the aerosol package**

- **Influence the form in which the product is discharged:**

    - **Foam**
    - **Stream**
    - **Spray**

Basic Propellant Properties

Propellants also can act as:

- Solvent
- Diluent
- Viscosity Modifier
- Freezant
- Refrigerant Refill Liquid
- Electronic Duster
- Alarm Agent (boat horn)
- Specialty Degreaser

Basic Propellant Properties

Properties Conferred to Aerosol Products by Propellants:

- Pressure is created. Normal range is 0.7 to 9.8 bars @ 21.1°C (10 to 142 psig @ 70°F)
- Atomization can be produced. Droplet sizes range from below 1 µm to 125 µm (and higher to include streaming aerosols)
- Improvement in performance. Aerosol insecticides have been reported to be more effective than equivalent pump sprays.
- Flammability is generally increased (except 134a)

Basic Propellant Properties

Properties Conferred to Aerosol Products by Propellants:

- Adjustment of Foam Density: Increasing propellant concentration generally produces lower density foams in the case of mousses, shaving creams, etc.
- Adjustment of Foam Stability: By adjusting the propellant and solvent used, quick breaking foams can be produced, or foams can be created that remain visually unchanged for days.

Basic Propellant Properties

To produce a spray, the propellant must have sufficient dispersive energy to overcome the surface tension of the liquid mixture, plus the cohesive and adhesive forces.

Dispersive Energy of a Propellant is generally related to:

- Pressure
- Molecular weight (lower MW propellants generally exhibit better dispersancy, with exceptions due to interactions of the propellant/solvent system.)

Basic Propellant Properties

Nitrogen gas: Virtually no solubility in liquids

- Will produce only a liquid stream
  - water/saline solution for rinsing hydrophilic contact lenses
  - petroleum distillates (wasp & hornet killers)
- The liquid stream produced by N2, CAIR and similar compressed gases can be converted to coarse sprays by outfitting the valve with a mechanical breakup actuator

Basic Propellant Properties

Carbon Dioxide (CO_2) dissolves up to about 2.6 - 2.9% in petroleum distillates

- Can produce a medium to coarse spray which gets more coarse as the molecular weight of the base product increases.

Basic Propellant Properties

It may be advantageous to use as little propellant as possible to allow the inclusion of a maximum amount of the product. This may not always be practical:

- A larger amount of lower pressure propellant will often give a smoother, less “blasty” spray
- This also allows for the use of valves with a larger orifice - which can be important to help eliminate clogging by powder-containing formulas

Basic Propellant Properties

- Provides more reserve propellant for vapor-tap aerosols and allows for possible product misuse, such as inverting the container.
- Reduces viscosity of the formulation and in some cases reduces or eliminates unwanted foaming tendencies.
- Organic Solvents will exert a pressure-reducing effect on the propellant, possibly necessitating a higher pressure propellant or else a higher concentration of propellant in the formula

Basic Propellant Properties

Aerosol Product Formulation Considerations

- **Vapor Pressure**
- **Spray Characteristics**
- **Solubility**
- **Flammability**
- **Corrosion**

Three Categories of Aerosol Propellants

Basic Propellant Properties

Categories of Aerosol Propellants

- Compressed Gases
- Soluble Gases
- Liquefied Gases

Basic Propellant Properties

Compressed and Soluble Gas Propellants

Compressed and Soluble Gases

Physical and Chemical Properties
Compressed Gas Propellants[1]

Properties	Nitrogen (N_2)	Compressed Air	Carbon Dioxide (CO_2)	Nitrous Oxide (N_2O)
Vapor Pressure (psig 70°F, 21°C) (bar 70°F, 21°C)	N/A[a]	N/A[a]	844.7 (58.2)	759.7 (52.38)
Pressure (psig 130°F, 54°C) (bar 130°F, 54°C)	N/A[a]	N/A[a]	1485 (102.3)	1420 (97.8)
Boiling (°F) (at one atm) (°C)	-320.4 (-195.8)	-317.8[b] (-194)	-109.2[c] (-78.4)	-127.4 (-88.5)
Liquid Density (g/ml)	0.00114[d] (@25°C)	0.00129[d] (@25°C)	0.713 (@25°C)	0.913 (@25°C)
Specific Gravity Gas Density (Air = 1)	0.967	1.000	1.530	1.530
Water Solubility (vol./vol. at 1.00 atm. abs.)	0.015 (@25°C)	0.018 (@25°C)	0.759 (@25°C)	0.588 (@25°C)

Table 9.1

a. Not Applicable. (Gas cannot be condensed by pressure.)

b. Initial boiling point of mixture.

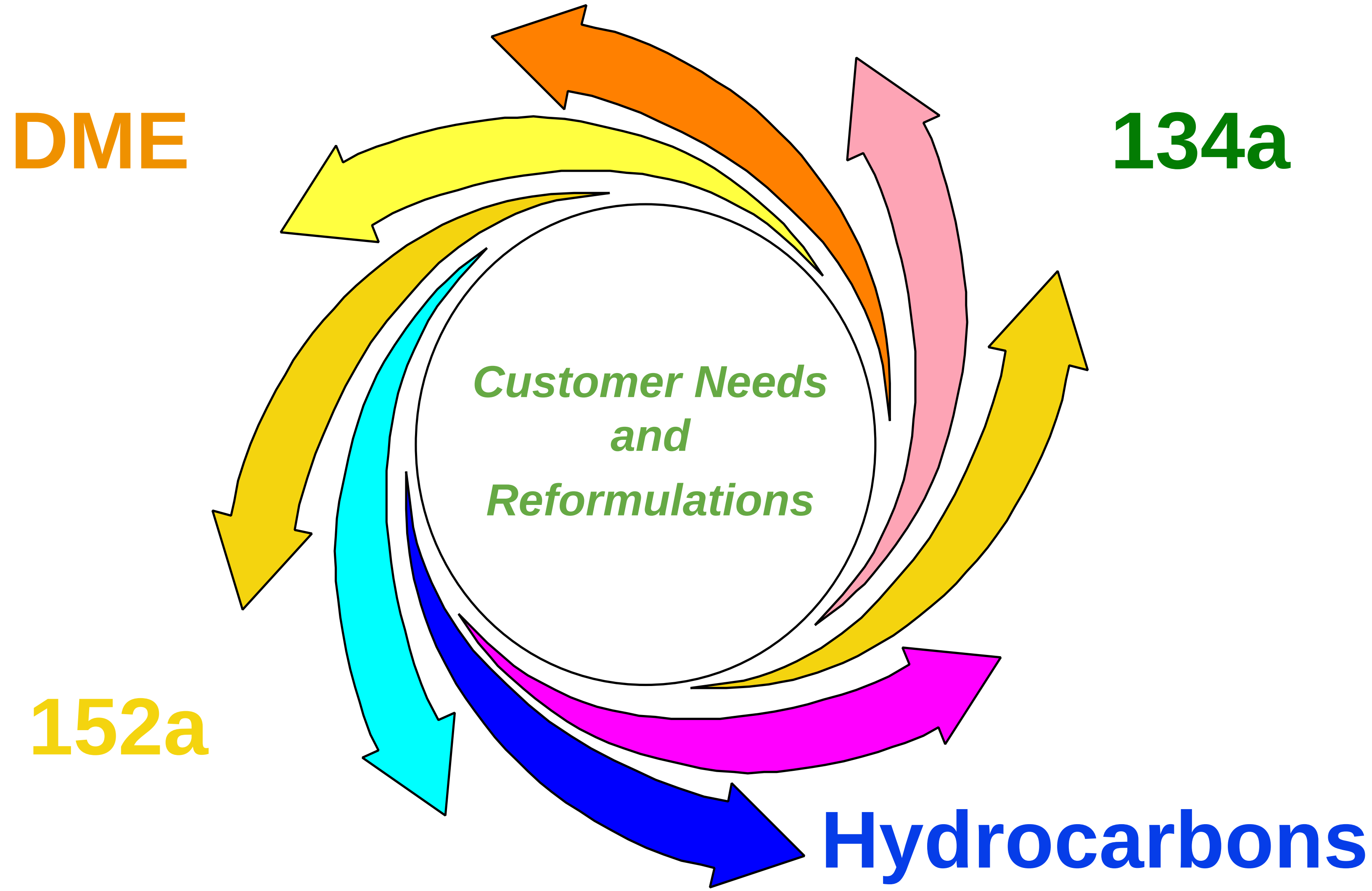
c. Actually, the sublimation point; solid to gas

d. The densities for nitrogen and compressed air are for the gaseous phase, since they cannot be liquefied under pressure at these temperatures.

Basic Propellant Properties

Liquefied Gas Propellants

Liquefied Gas Propellants



Liquefied Gas Propellants

General Liquefied Gas Propellant Comparisons

	Hydrocarbons	DME	HFCs
Flammability	Flammable	Flammable	152a is Flammable 134a is Non-Flammable
Toxicity	Low (OK for Food Products)	Low	Low
Solvency	Poor	Good	Poor
Density	Low	Low	Intermediate
Solubility In Water	Low	High	Low
Environmental	VOC	VOC	GWP (134a only)
Cost	LOW	LOW	HIGH

Liquefied Gas Propellants

VAPOR DENSITIES

of Liquefied Gas Aerosol Propellants (@70 °F)

Liquefied Gas Propellant	*Vapor (lb/ cu.ft)*	*Liquid (lb/ cu.ft)*	*Vapor/Liquid Ratio*	*Vapor/Air Ratio*
Propane	0.116	28.41	245	1.55
Isobutane	0.154	32.36	210	2.05
N-butane	0.155	33.44	216	2.07
DME	0.119	41.18	346	1.59
Dymel 152a	0.171	56.78	332	2.28
134a	0.264	76.26	289	3.52
Air @ 70F	0.075	N / A	N / A	1.00

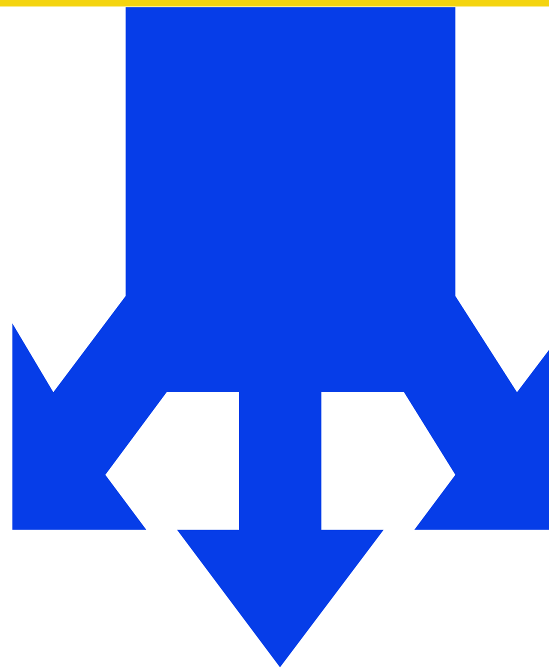
Liquefied gas propellants expand substantially from a liquid to a gas when released to the atmosphere. Vapors are heavier than air.

Liquefied Gas Propellants

Properties of DME and HFC Propellants

	DME	HFC-152a	HFC-134a
Chemical Formula	CH_3OCH_3	CH_3CHF_2	CF_3CH_2F
Molecular weight	46.1	66.0	102.0
Boiling point (°F)	-13.0	-13.0	-15.7
Vapor Pressure @70°F (psig)	63.0	63.0	71.0
Liquid Density @ 70°F (g/cc)	0.66	0.91	1.21
Flammability in air LEL	3.3	3.9	n/a
UEL	18.0	16.9	n/a
Flash Point (°F)	-42.0	-58.0	none
Kauri-Butanol value	60	11	10
Solubility in Water (wt.% @ 70°F, autogeneous pressure)	35.0	1.7	1.0

Propellant Blends
Vapor Pressure



LOW

Shave Cream
Gels and Mousse
Oven Cleaner
Perfume

MEDIUM

Hard Surface Cleaners
Furniture Polish
Deodorant Sprays

HIGH

Air Fresheners
Automotive products
Flying Insect Spray
Spray Paint

Basic Propellant Properties

Hydrocarbon Propellants

Hydrocarbon Propellants

Hydrocarbon Propellants

Organic Compounds

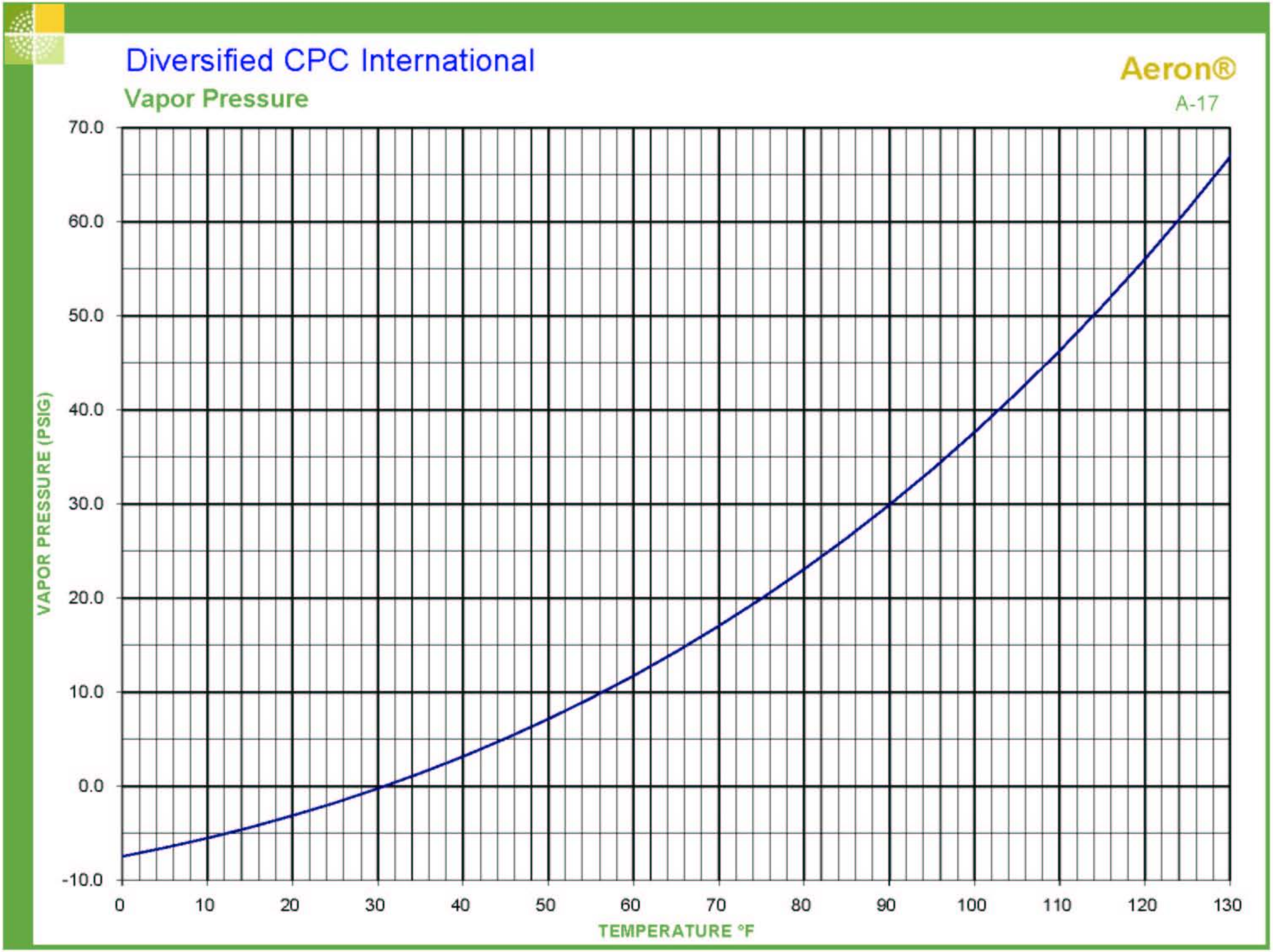
Derived from Natural Gas Liquids
(liquefied under pressure)

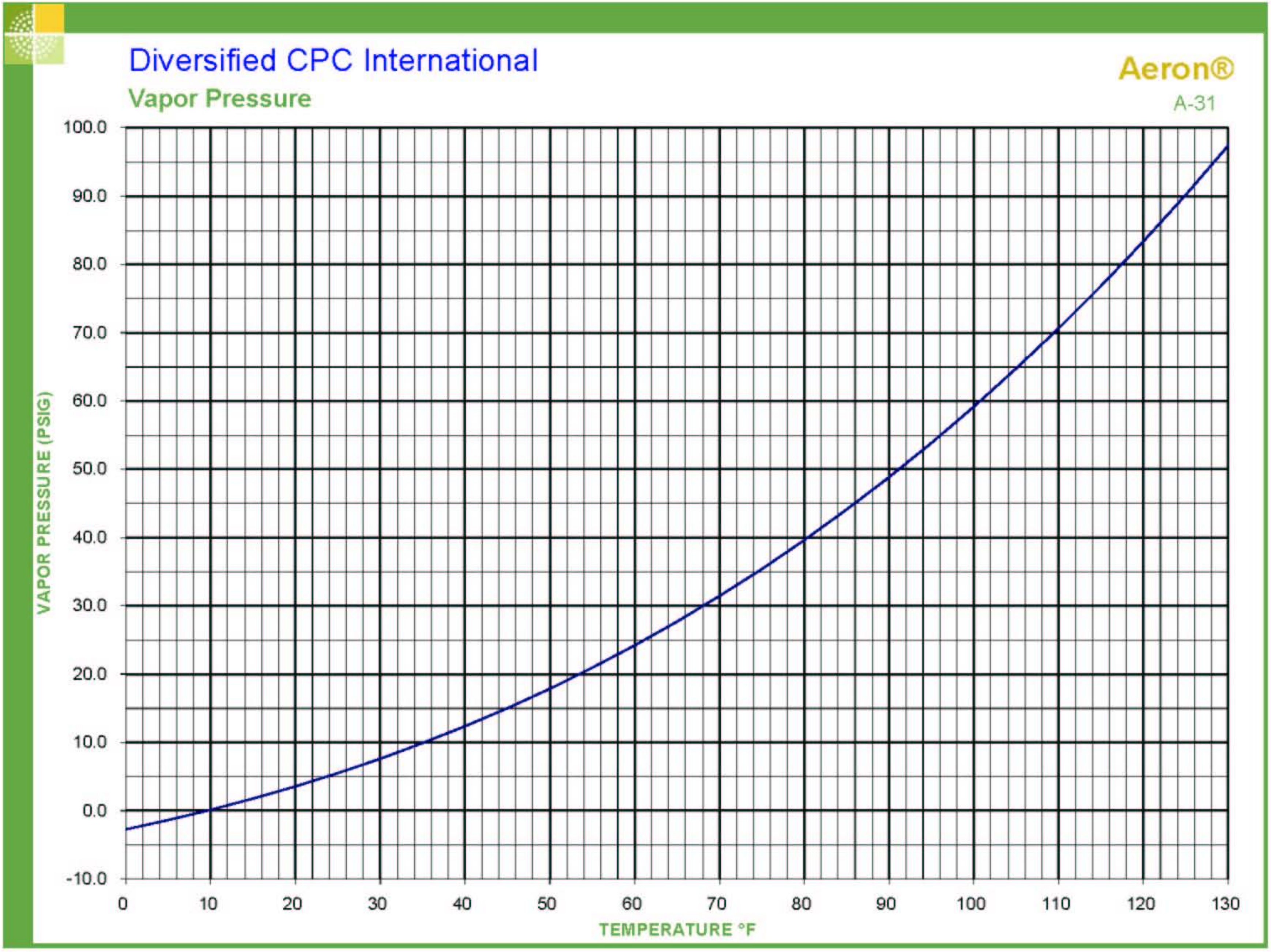
CH_4	Methane
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	Butanes
C_5H_{12}	Pentanes

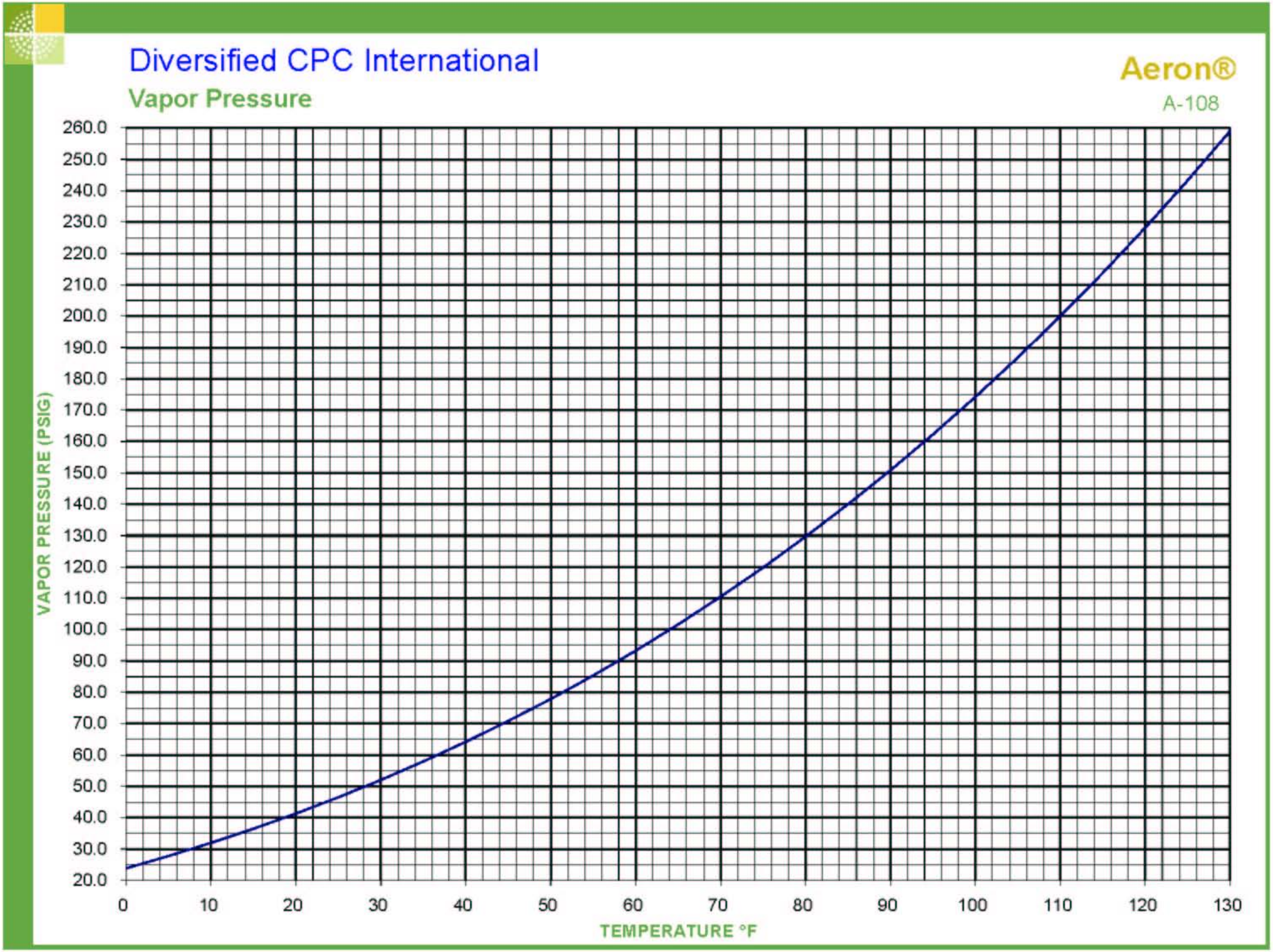
Hydrocarbon Propellants

Properties of the Hydrocarbons

	Propane	I-Butane	N-Butane	I-Pentane	N-Pentane
Chemical Formula	C_3H_8	C_4H_{10}	C_4H_{10}	C_5H_{12}	C_5H_{12}
Molecular weight	44.1	58.1	58.1	72.2	72.2
Boiling point (°F)	-43.7	10.9	31.1	82	97
Vapor Pressure @70°F (psig)	109.3	31.1	16.9	-3.1	-6.2
Liquid Density @ 70°F (g/cc)	0.51	0.56	0.58	0.62	0.63
Flammability in air					
LEL	2.2	1.8	1.9	1.4	1.5
UEL	9.5	8.4	8.5	7.6	7.8
Flash Point (°F)	-156	-117	-101	-60	-40
Kauri-Butanol value	15	18	20	n/a	n/a
Solubility in Water (wt.% @ 70°F, autogeneous pressure)	0.007	0.008	0.008	----	----

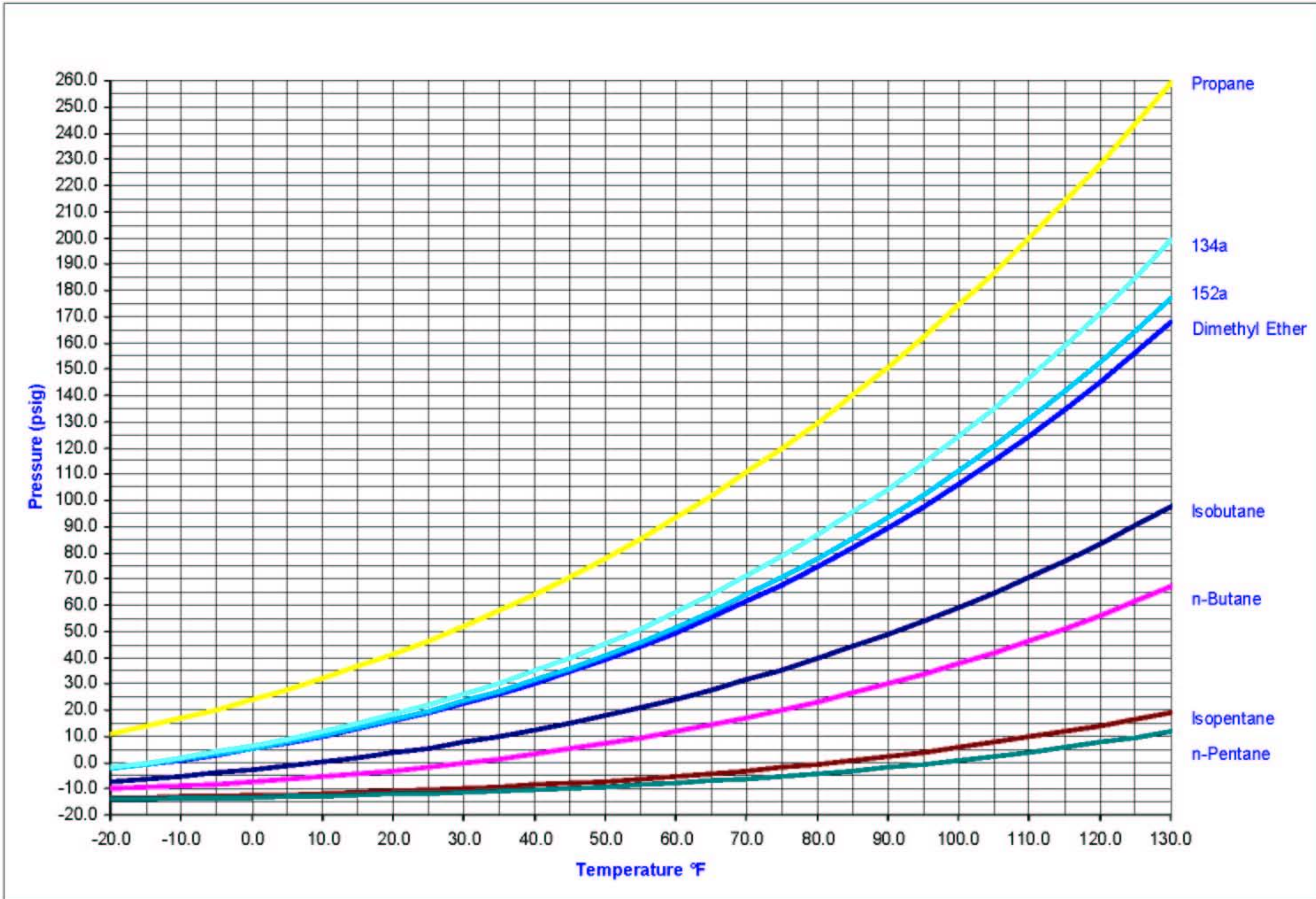

Diversified CPC International
Vapor Pressure
Aeron®
A-17
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
VAPOR PRESSURE (PSIG)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TEMPERATURE °F


Diversified CPC International
Vapor Pressure
Aeron®
A-31
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
VAPOR PRESSURE (PSIG)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TEMPERATURE °F


Diversified CPC International
Vapor Pressure
Aeron®
A-108
VAPOR PRESSURE (PSIG)
260.0
250.0
240.0
230.0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TEMPERATURE °F

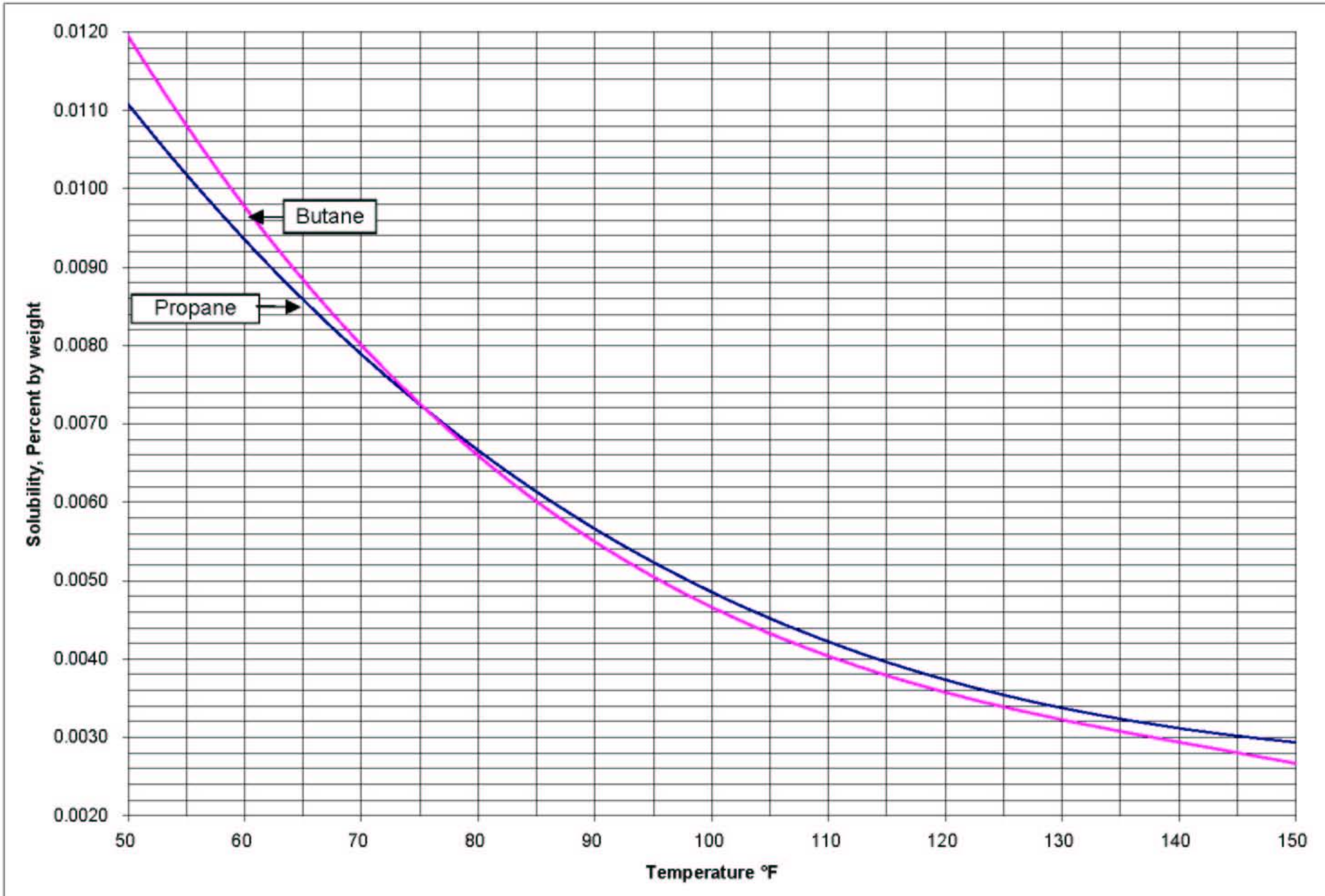
Vapor Pressure of Liquefied Gases

Figure 2



Solubility of Butane and Propane in Water

Figure 4

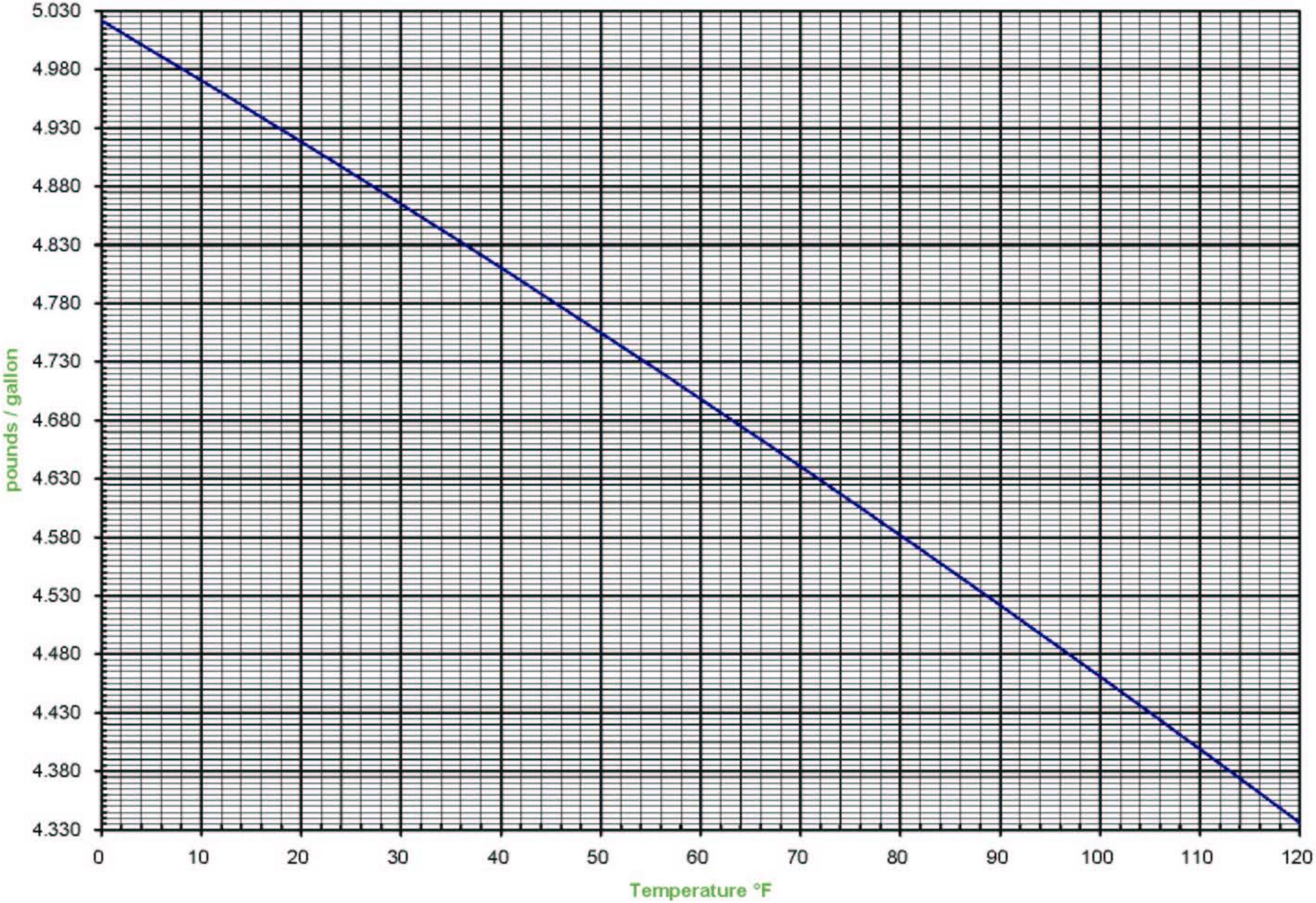


Diversified CPC International

Liquid Density

Aeron®

A-31

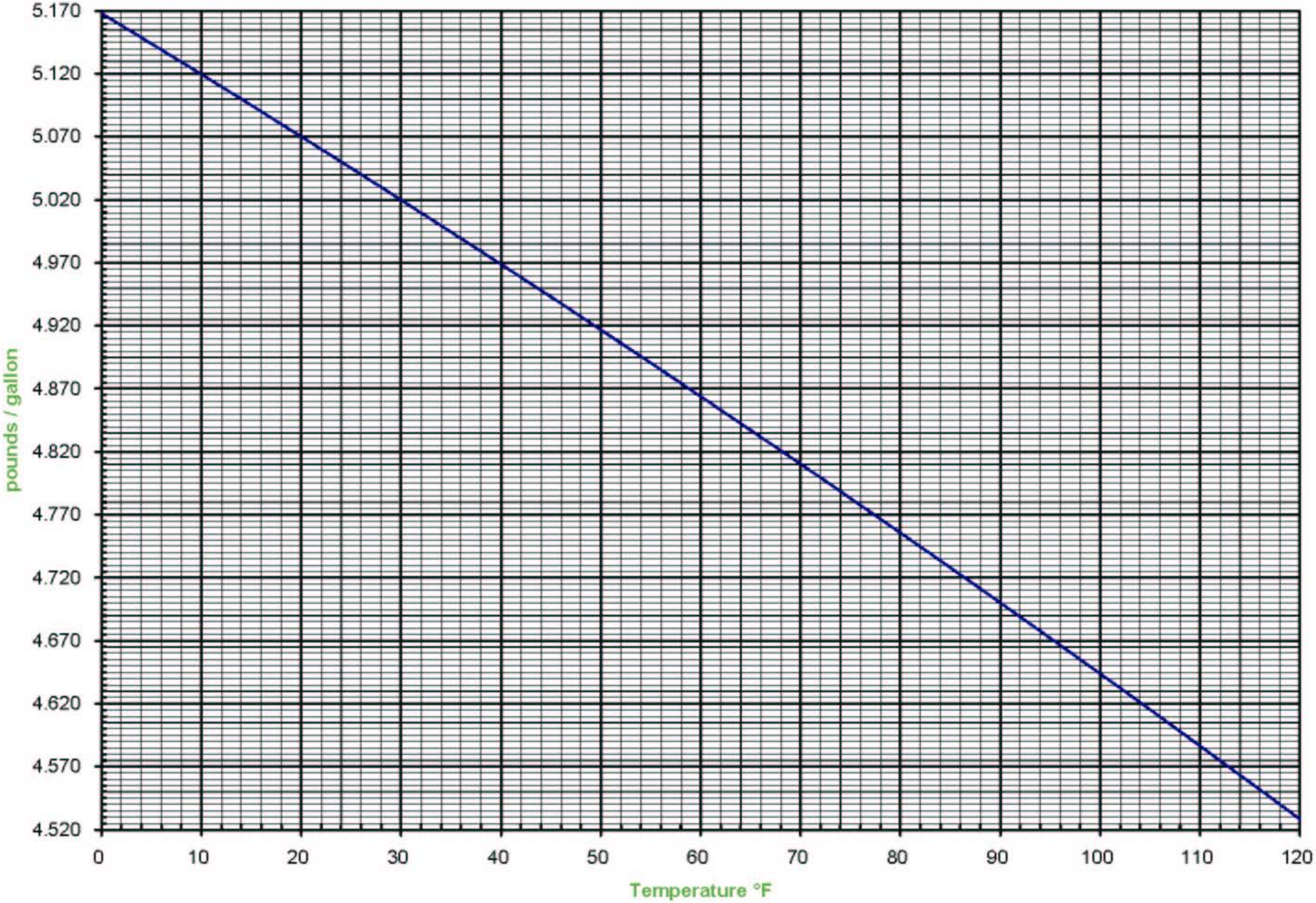


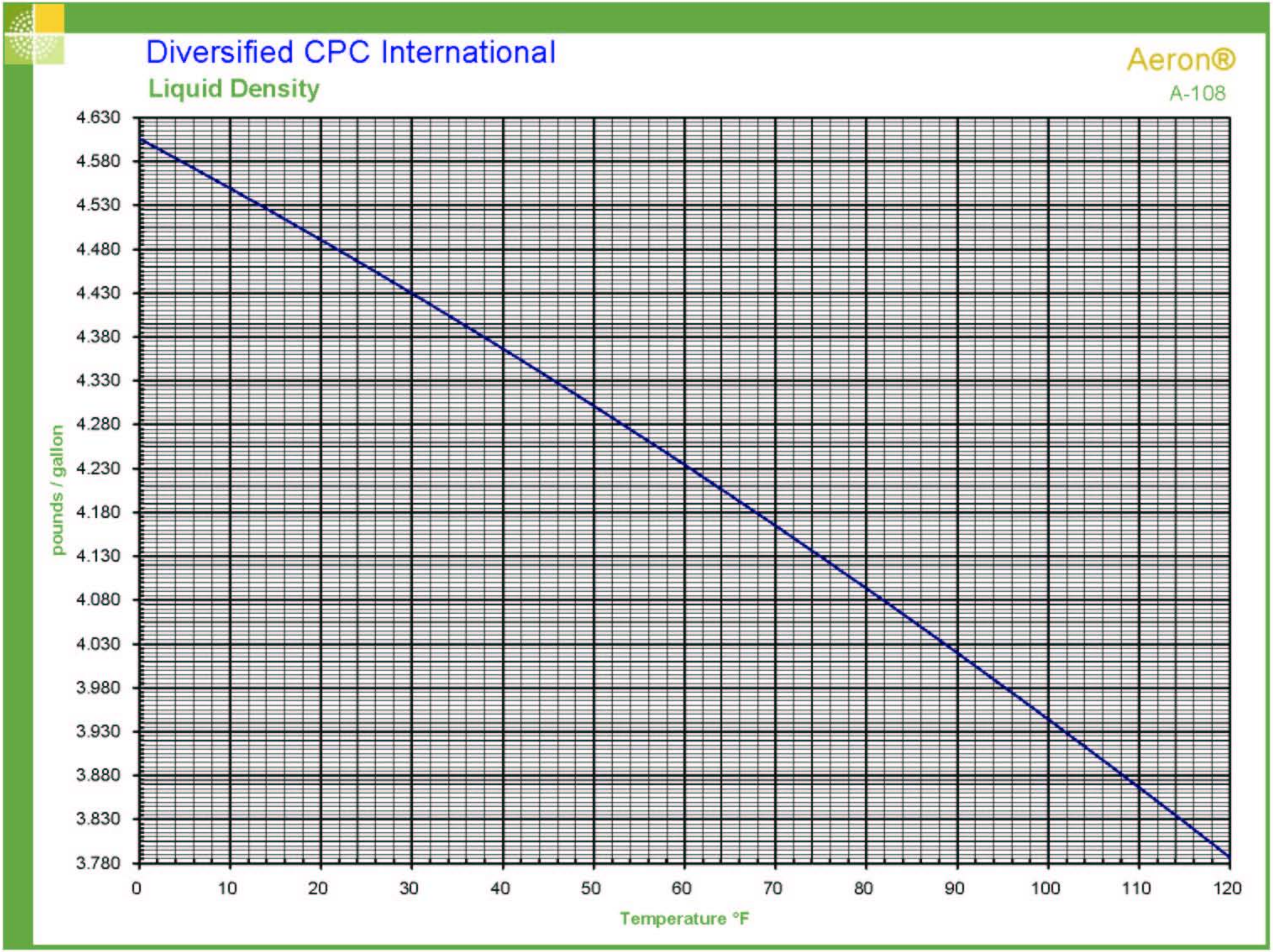
Diversified CPC International

Liquid Density

Aeron®

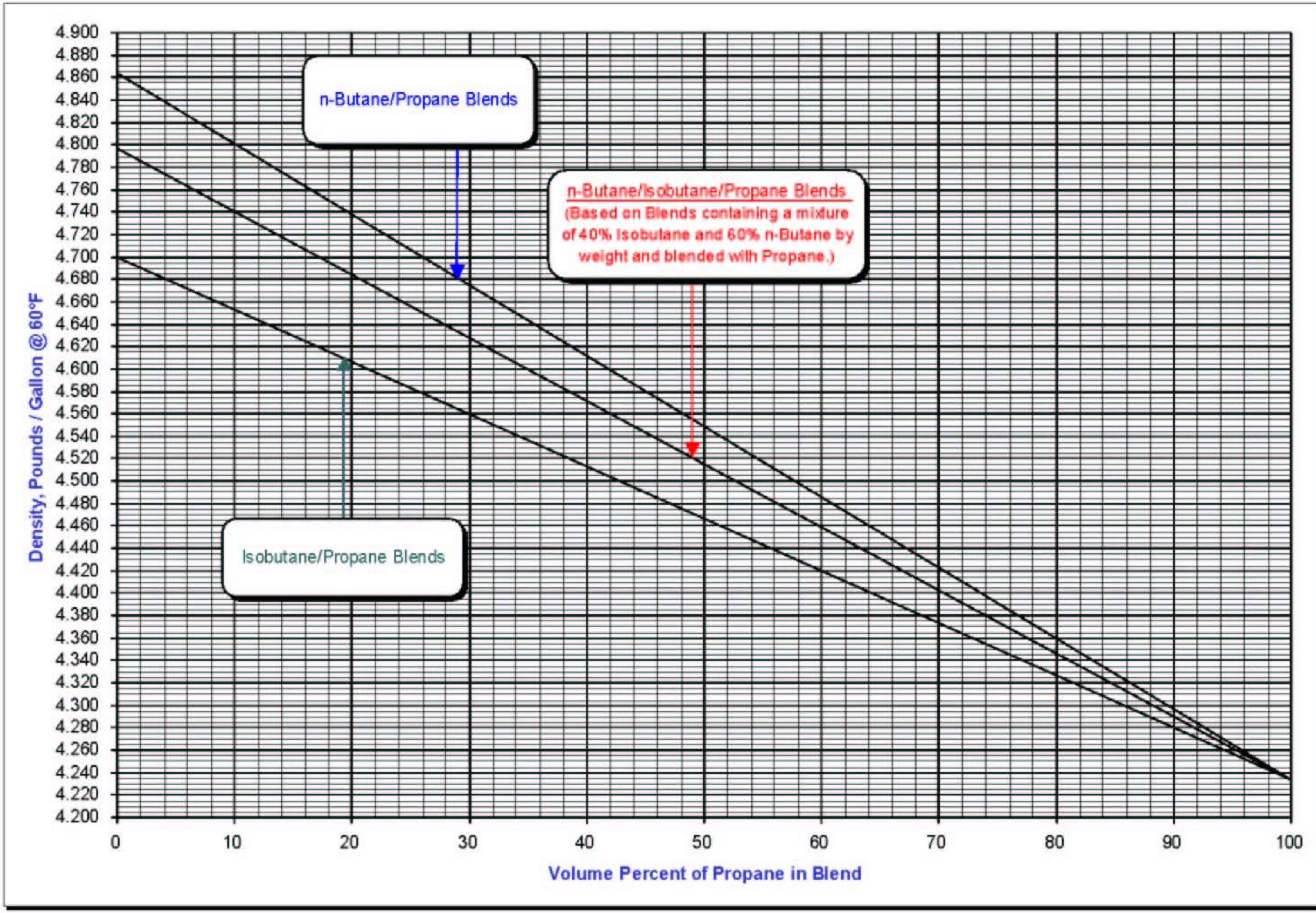
A-17





Diversified CPC International
Liquid Density
Aeron®
A-108
4.630
4.580
4.530
4.480
4.430
4.380
4.330
4.280
4.230
4.180
4.130
4.080
4.030
3.980
3.930
3.880
3.830
3.780
pounds / gallon
0
10
20
30
40
50
60
70
80
90
100
110
120
Temperature °F

Liquid Density of LP Gas Blends

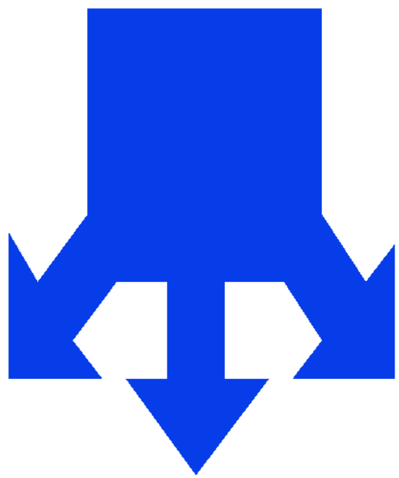


Standard Hydrocarbon Propellant Blends

Standard Hydrocarbon Blends

Hydrocarbon Blend Components

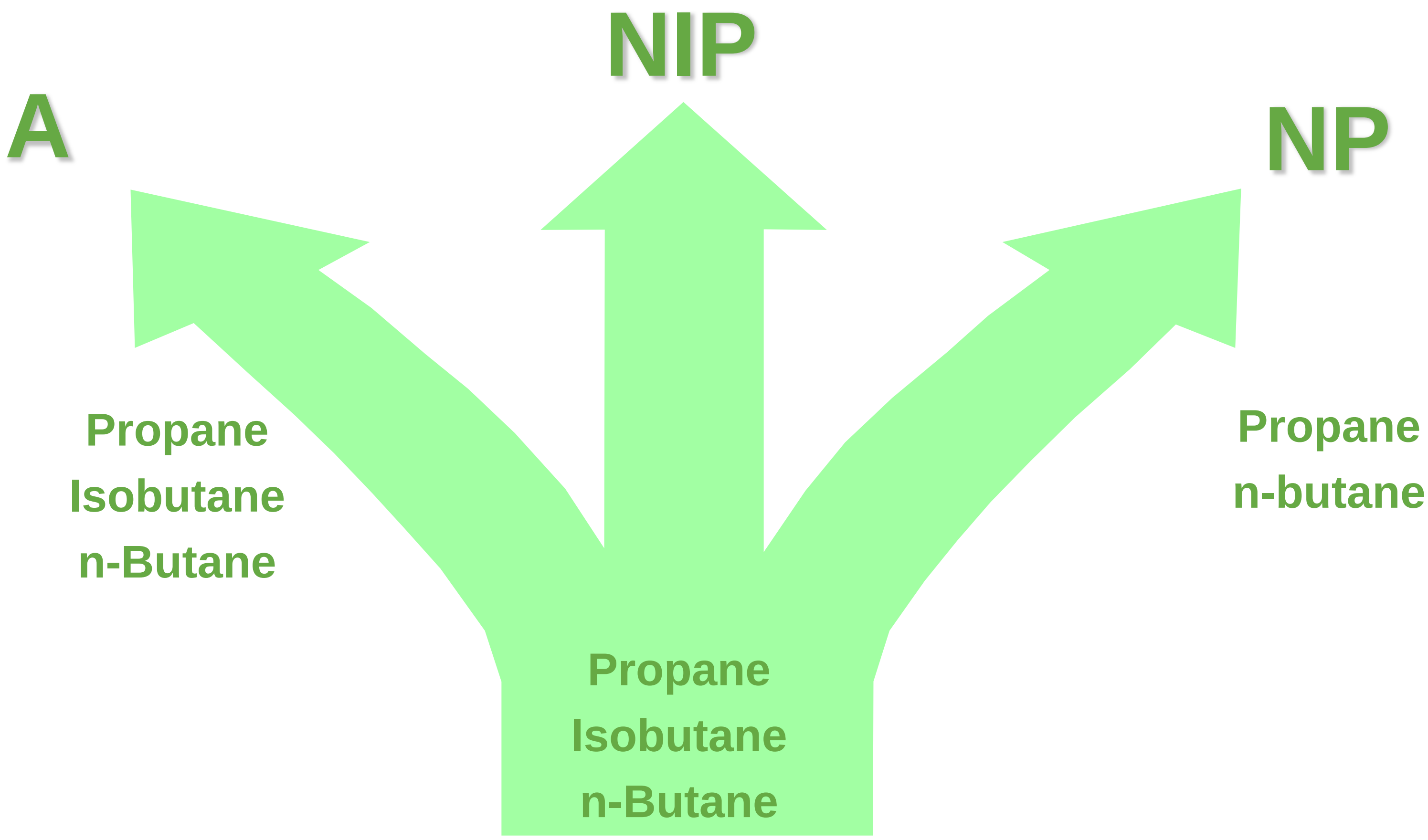
N-Butane A-17



Propane A-108

IsoButane A-31

Standard Hydrocarbon Blends



Diversified CPC International

Three Major Types

Standard Hydrocarbon Blends

Typical Hydrocarbon Blends

- A-46 (15.2% Propane / 84.8% Isobutane)
- NP-46 (25.9% Propane / 74.1% N-butane)
- NIP-46 (21.9% Propane / 31.3% Isobutane / 46.8% N-Butane)

Standard Hydrocarbon Blends

Typical Hydrocarbon Blends

- A-31
- NP-31
- NIP-31

- A-46
- NP-46
- NIP-46

- A-70
- NP-70
- NIP-70

- A-85
- NP-85
- A-108

Processing

Processing of Hydrocarbon Propellants

1 - Fractionation of Selected Feedstocks

2 - Hydrogenation and Stabilization

- **Conversion of Unsaturated hydrocarbons**
- **Elimination of trace alcohol or peroxide compounds**

3 - Catalytic Desulfurization

4 - Dehydration and Sweetening

Processing of Hydrocarbon Propellants

Processing of Hydrocarbon Propellants

Processing of Hydrocarbon Propellants

Processing of Hydrocarbon Propellants

Processing of Hydrocarbon Propellants

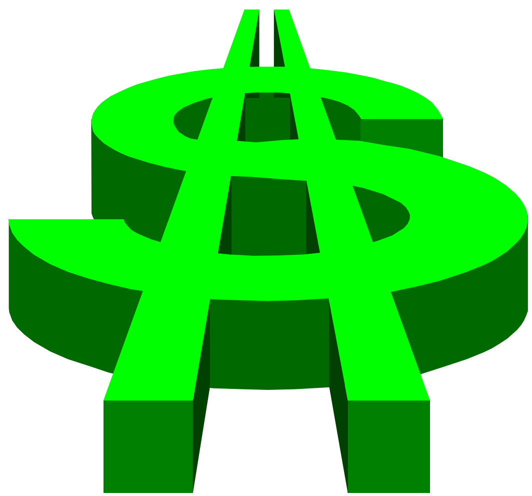
Processing of Hydrocarbon Propellants

Propellant Cost

Cost Comparison

Hydrocarbons
1x

DME
_2x_



152a
4x

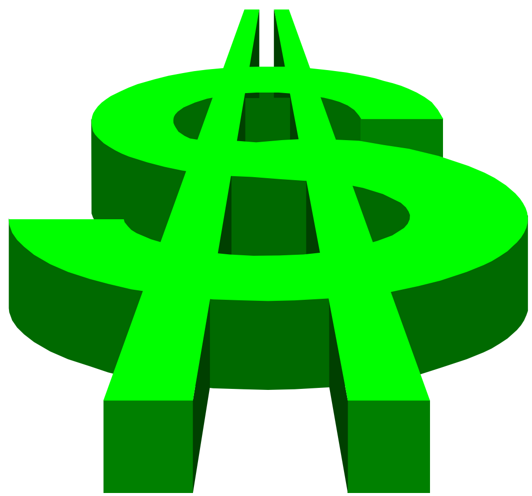
Cost Comparison

Hydrocarbons

1x

DME

2x



152a

4x

134a

5 - 7x

Characteristics of Hydrocarbon Aerosol Propellants

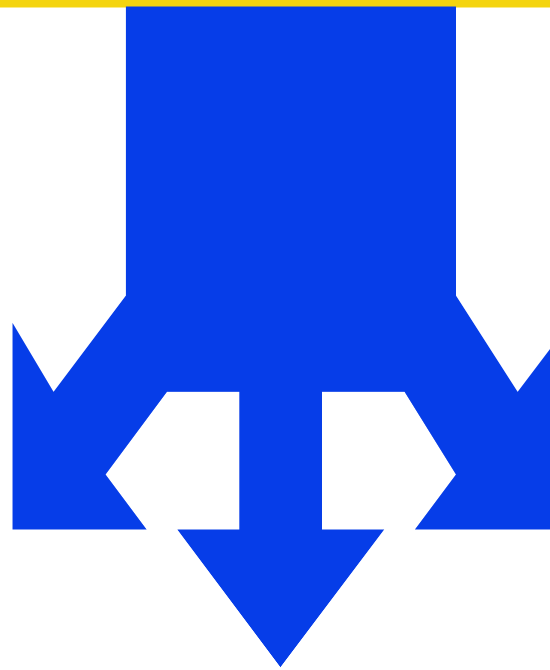
- **Low Relative Cost**
- **Stability and Purity**
- **Low Odor**
- **Range of Boiling Points**
- **Wide Range of Vapor Pressures**
- **Low Toxicity**
- **Versatility and Efficiency**
- **Natural Compounds**
- **Flammability**
- **Environmental (VOC)**

Characteristics of Hydrocarbon Aerosol Propellants

<u>Flammability</u>, the principal disadvantage, <u>is controllable</u>

V O C Issues

Low VOC Propellant Options



Non VOC Propellants

152a

134a

Low VOC Blends

DME - Water Based

DME/HC/Water

HFC/Hydrocarbon

Adjust Pressure

Use higher vapor pressure hydrocarbon propellant and reduce fill volume

VOC Reduction Strategies

- **Add more non-VOC concentrate**
- **Add more water**
- **Replace VOC Solvent with non-VOC solvent**
- **Formulate with a higher vapor pressure propellant and use less gas in the can**
- **Replace VOC Propellant**
- **Formulate based on relative reactivity**

Low VOC (Liquefied Gas) Propellant Alternatives

- **Aqueous Aerosols**
  - DME
  - DME/Hydrocarbon
  - Dymel 152a
  - Dymel 152a/Hydrocarbon
  - Dymel 152a/DME
- **Anhydrous Aerosols**
  - Dymel 152a
  - Dymel 152a/Hydrocarbon

Custom Blends

152a/A17

IsoPentane

152a/A31

A31/IsoPentane

152a/A46

A31/N-Pentane

152a/A17/DME

A17/N-Pentane

134a/DME

152a/A31/DME

A80/DME

134a/A31

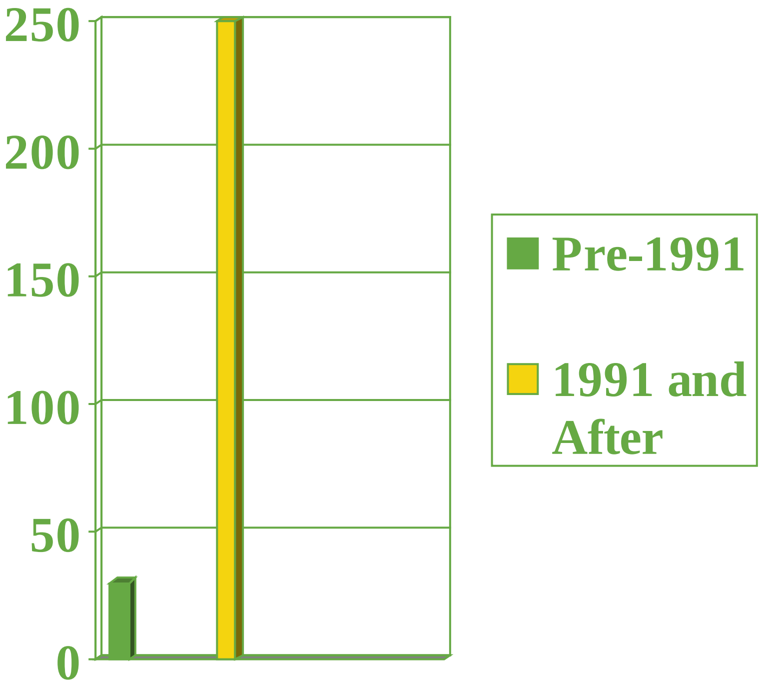
A17/DME

134a/A17

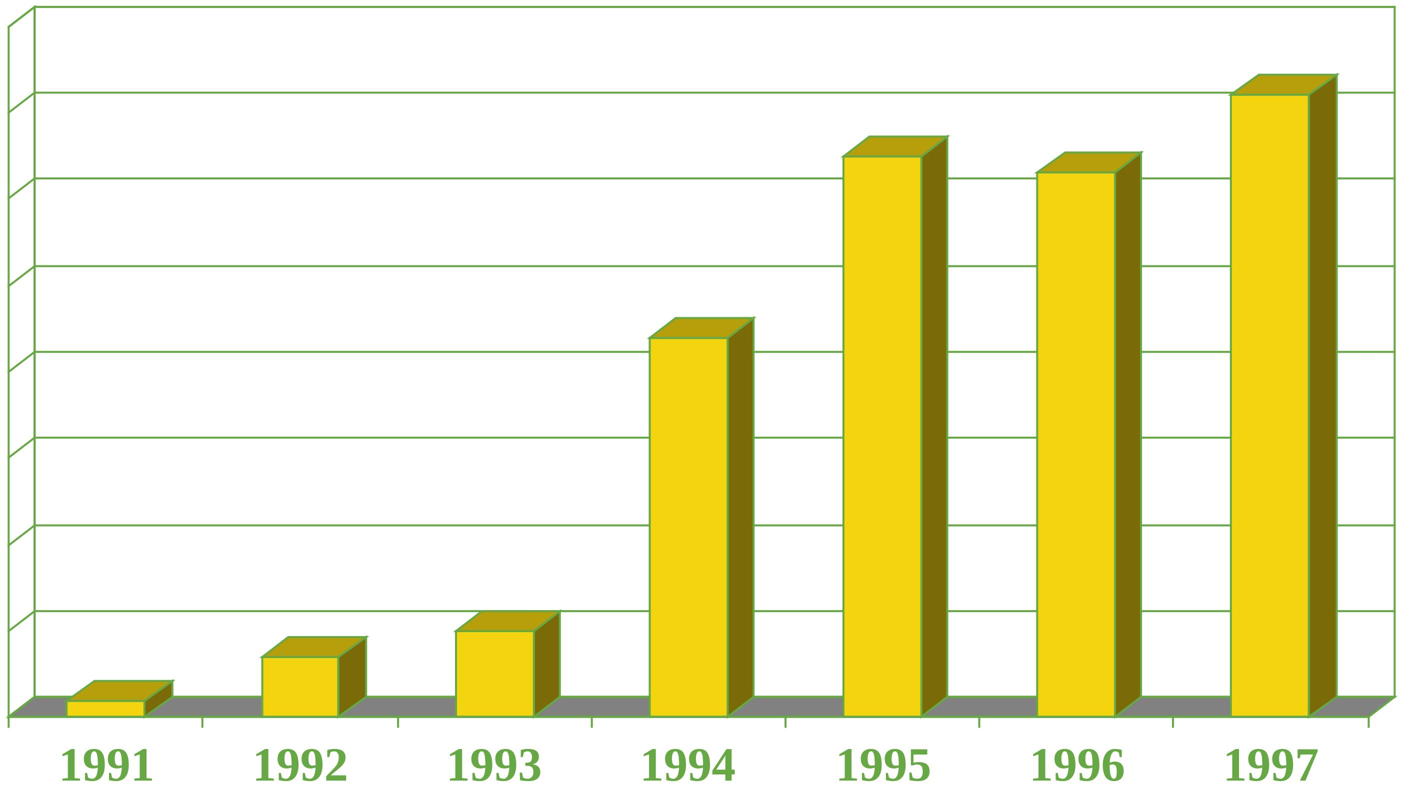
Pentane/DME

Expanding Complexity

- Approximately 30 basic hydrocarbon propellant blends prior to VOC Issue
- Over 250 custom binary (2-part) and ternary (3-part) blends today to meet low VOC demands



Low VOC Propellant Shipments



US EPA Supports Hydrocarbon Propellants

"Hydrocarbons are acceptable substitutes as propellants in the aerosol sector. Hydrocarbons have several environmental advantages over other substitutes. For example, they have zero ozone depletion potential, and because of their extremely short atmospheric residence times, they are estimated to have insignificant impact on global warming. Yet their reactivity contributes to formation of tropospheric ozone. The Agency has assessed this effect, however, and found that the increase in volatile organic compound emissions (VOCs) from these substitutes will have no significant effect on tropospheric ozone formation."

Unfortunately, the US EPA forgot to tell California!

Photochemical Reactivity Concepts

- Reactivity - Measure of a VOC's potential to react in the atmosphere and lead to the formation of ozone
- Use of "lower reactive" VOCs may provide means for ozone reduction benefit where mass-based VOC reductions alone are not sufficient for attainment or feasible
- Flexible approach that gives manufacturers more reformulation options

Maximum **I**ncremental **R**eactivity **S**cale

- Allows comparison of VOC reactivities
- Basis for scale is peer-reviewed
- Scientific basis sufficient to use reactivity in a more detailed manner

NO CFCs
(CAPCO)

It’s OK to Spray !

a

NO CFCs


Aeron
CONTAINS NO CFCs WHICH
NO CFCs
DEPLETE THE OZONE LAYER

Transportation

Delivery of Aerosol Propellants

1 - Truck Transports

2 - Railroad Tank Cars

3 - DOT Cylinders

- **1#   (laboratory sample)**
- **20# (barbecue size)**
- **100#**
- **200#**
- **420#**

Transportation
- Trucks -

Transportation - Trucks

Transportation - Trucks

Transportation - Trucks

Transportation - Trucks

Transportation - Trucks

Transportation - Trucks

Transportation
- Rail Cars -

Transportation – Rail Cars

Transportation
- ISO Containers -

Transportation – ISO Containers

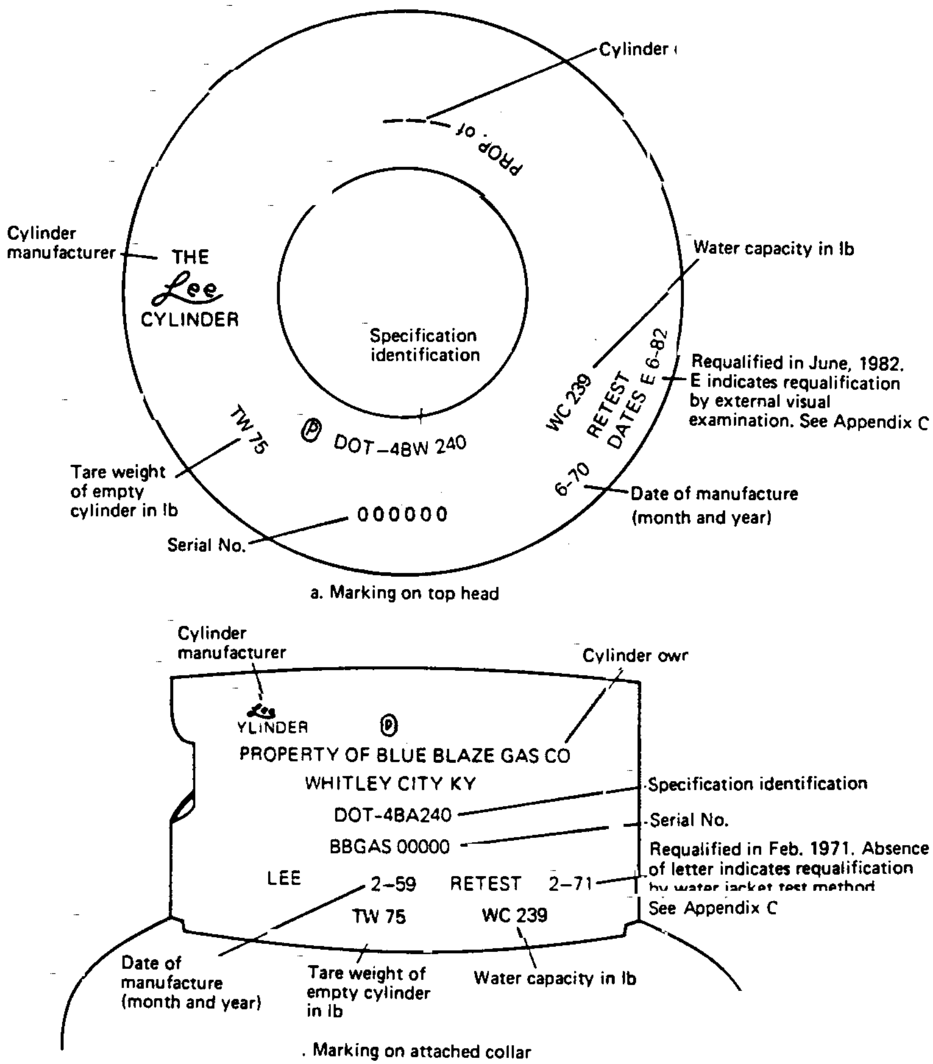
Transportation – ISO Containers

Transportation – ISO Containers

Transportation
- Cylinders -

Transportation - Cylinders

Transportation - Cylinders



Liquefied Gas Propellant Tank Farm Operations

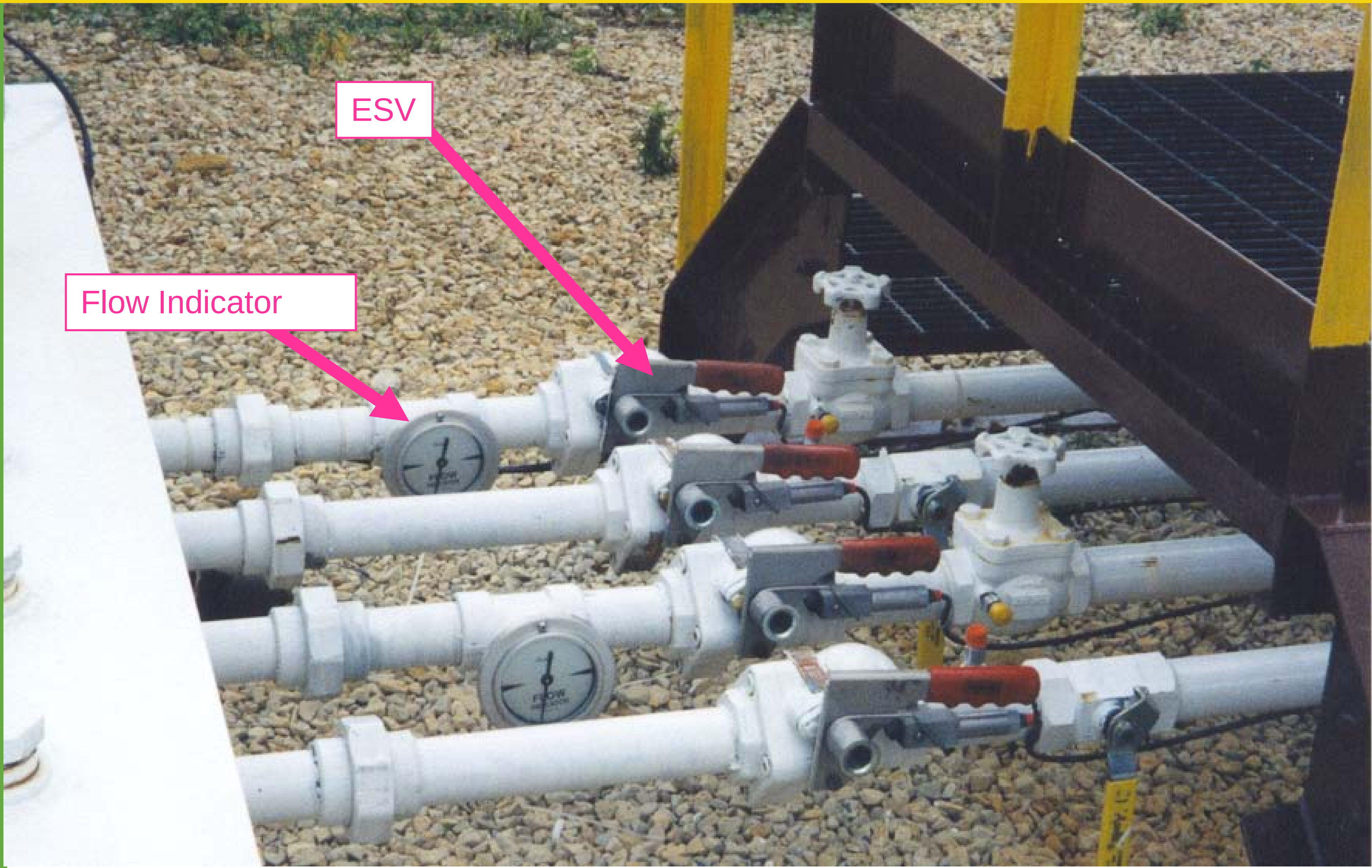
* Propellant Delivery and Unloading

Tank Farm Operations

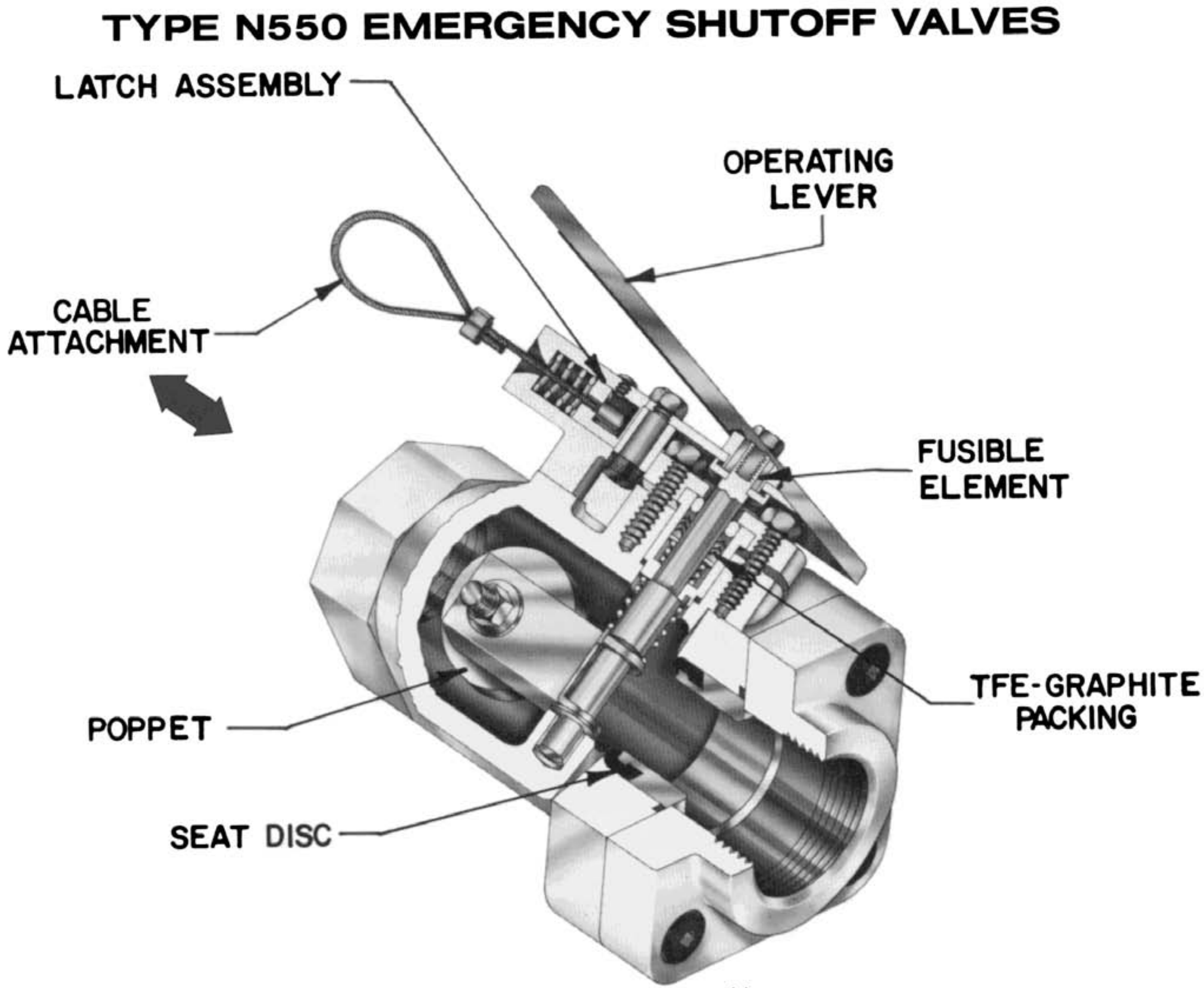
Tank Farm Operations

Tank Farm Operations

Tank Farm Operations



Tank Farm Operations

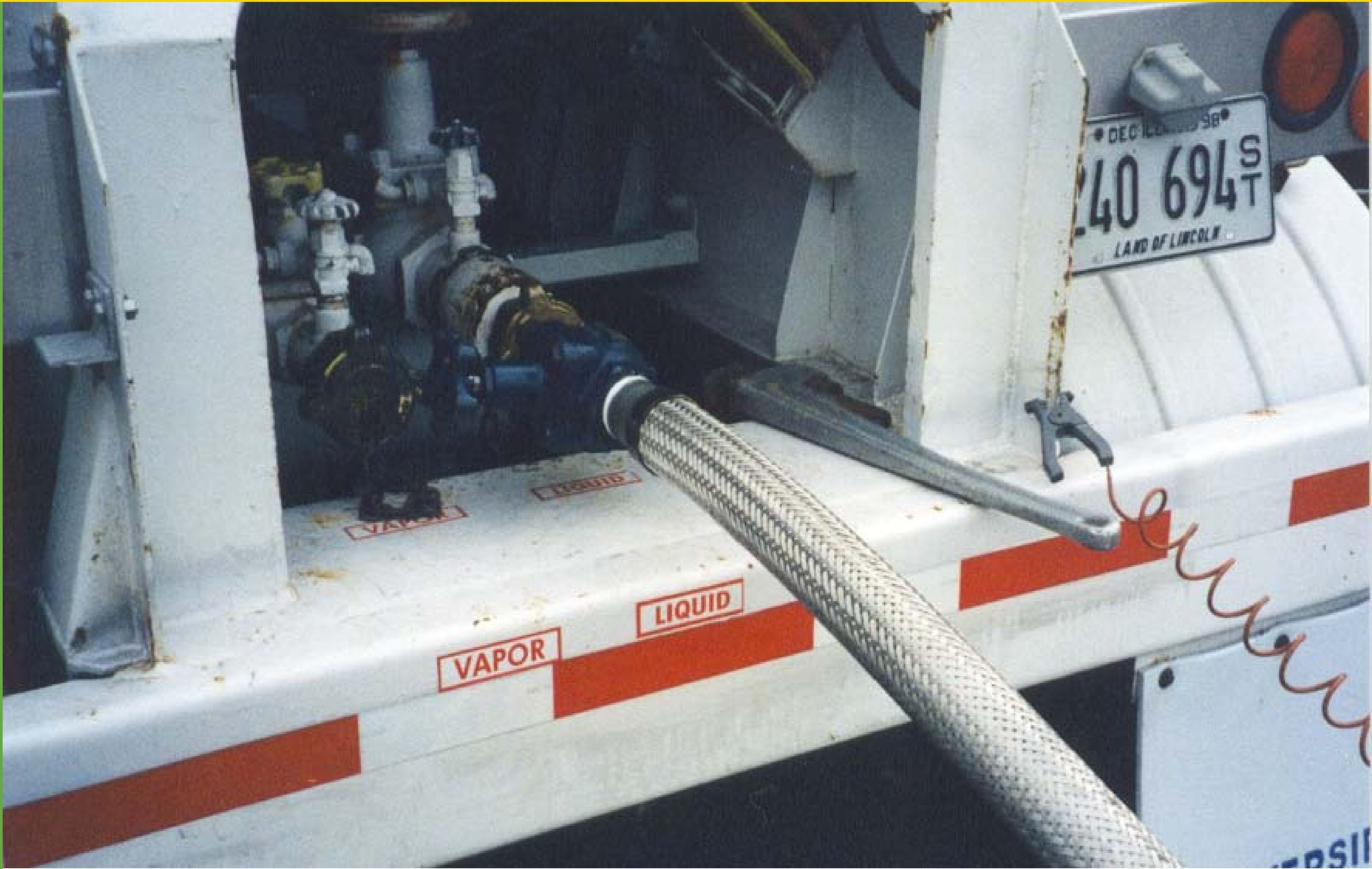


Type N550 in the open position

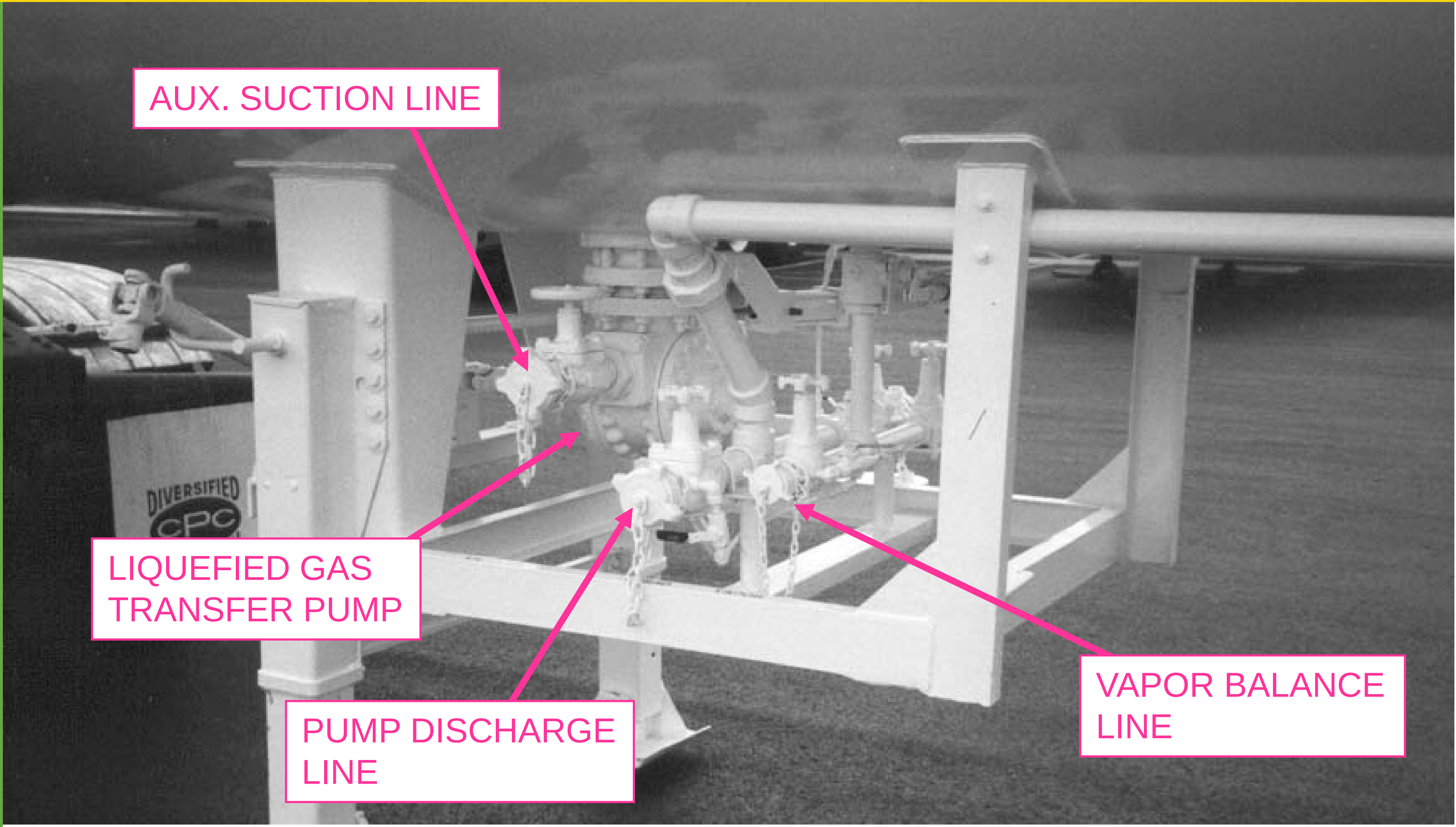
Tank Farm Operations

Tank Farm Operations

Tank Farm Operations



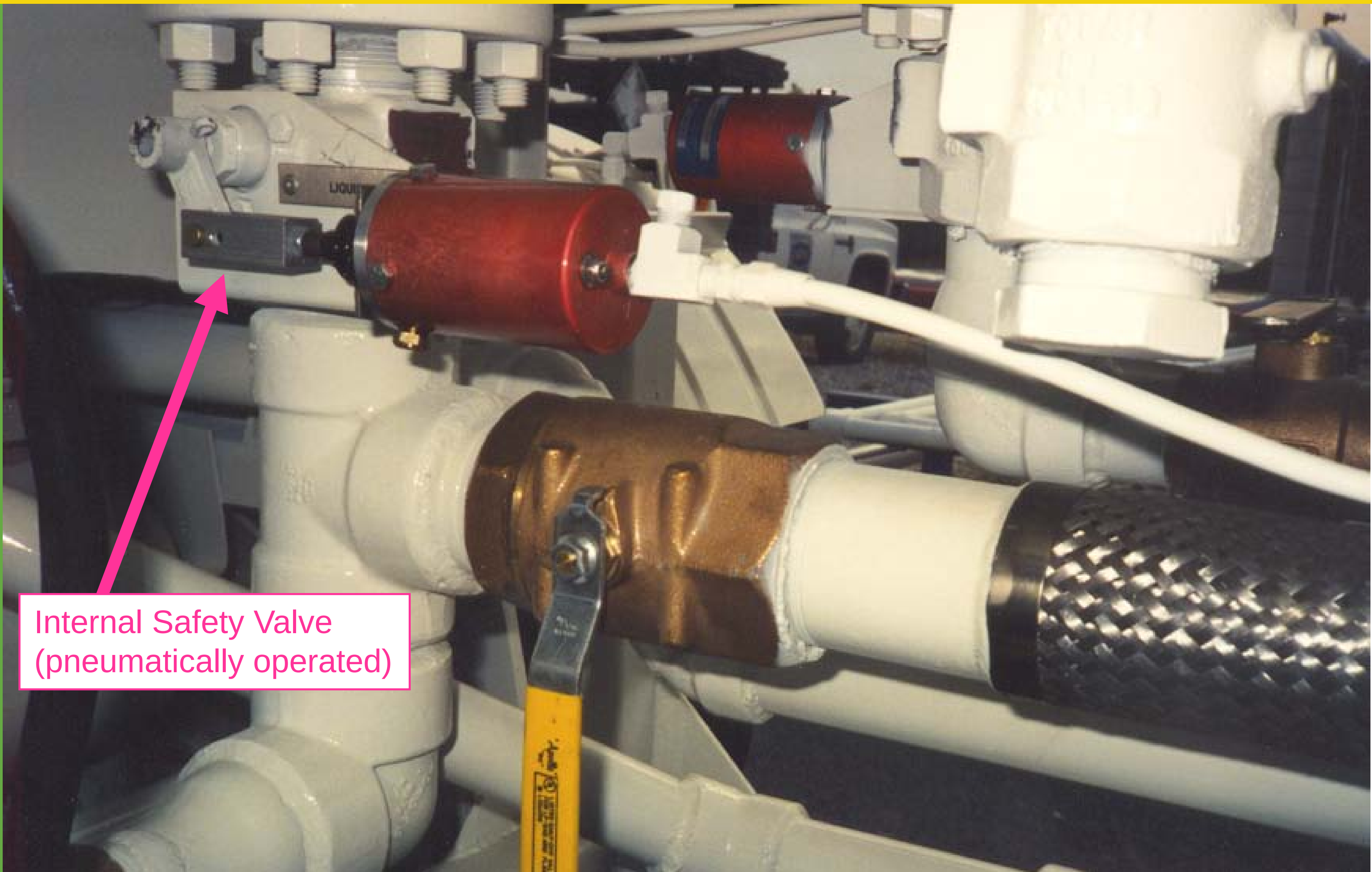
Tank Farm Operations



TRANSPORT TRUCK PUMP - PTO DRIVEN

Tank Farm Operations

Tank Farm Operations



Tank Farm Operations

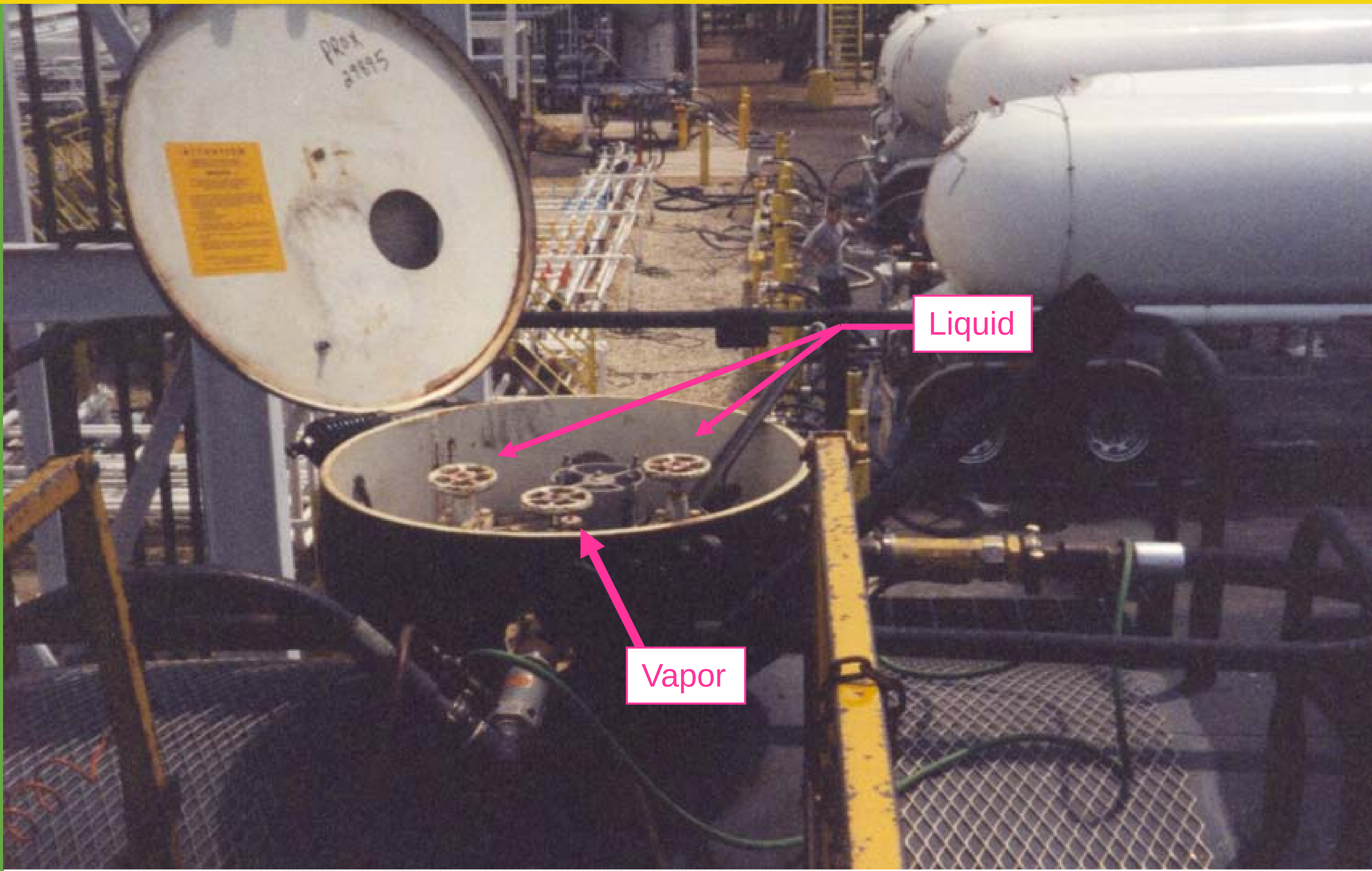
Tank Farm Operations

Tank Farm Operations

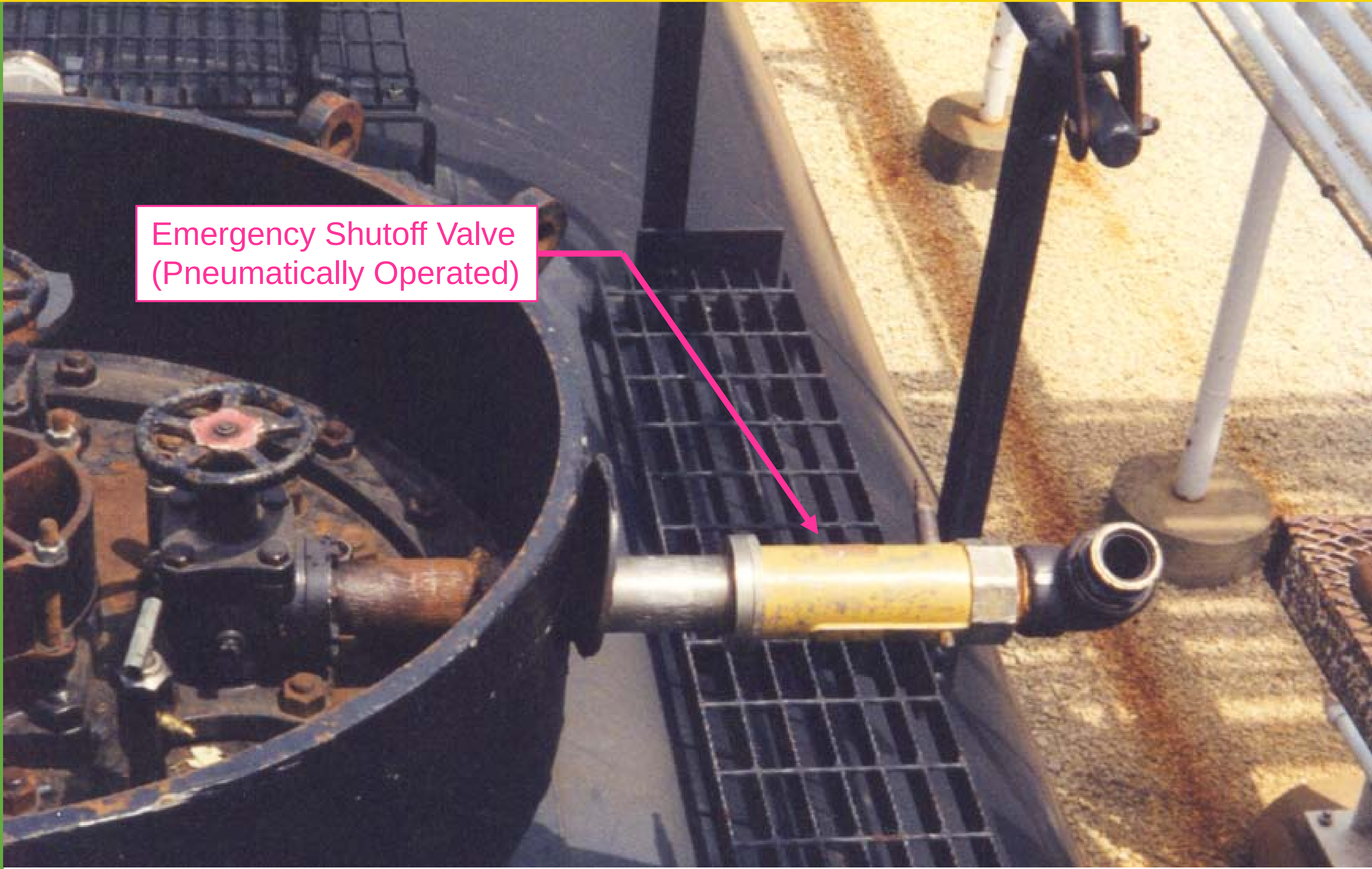
Driver must remain with the vehicle during the entire unloading operation!

An attendant from the customer should remain close by as well to react quickly to any plant-related issues that may arise.

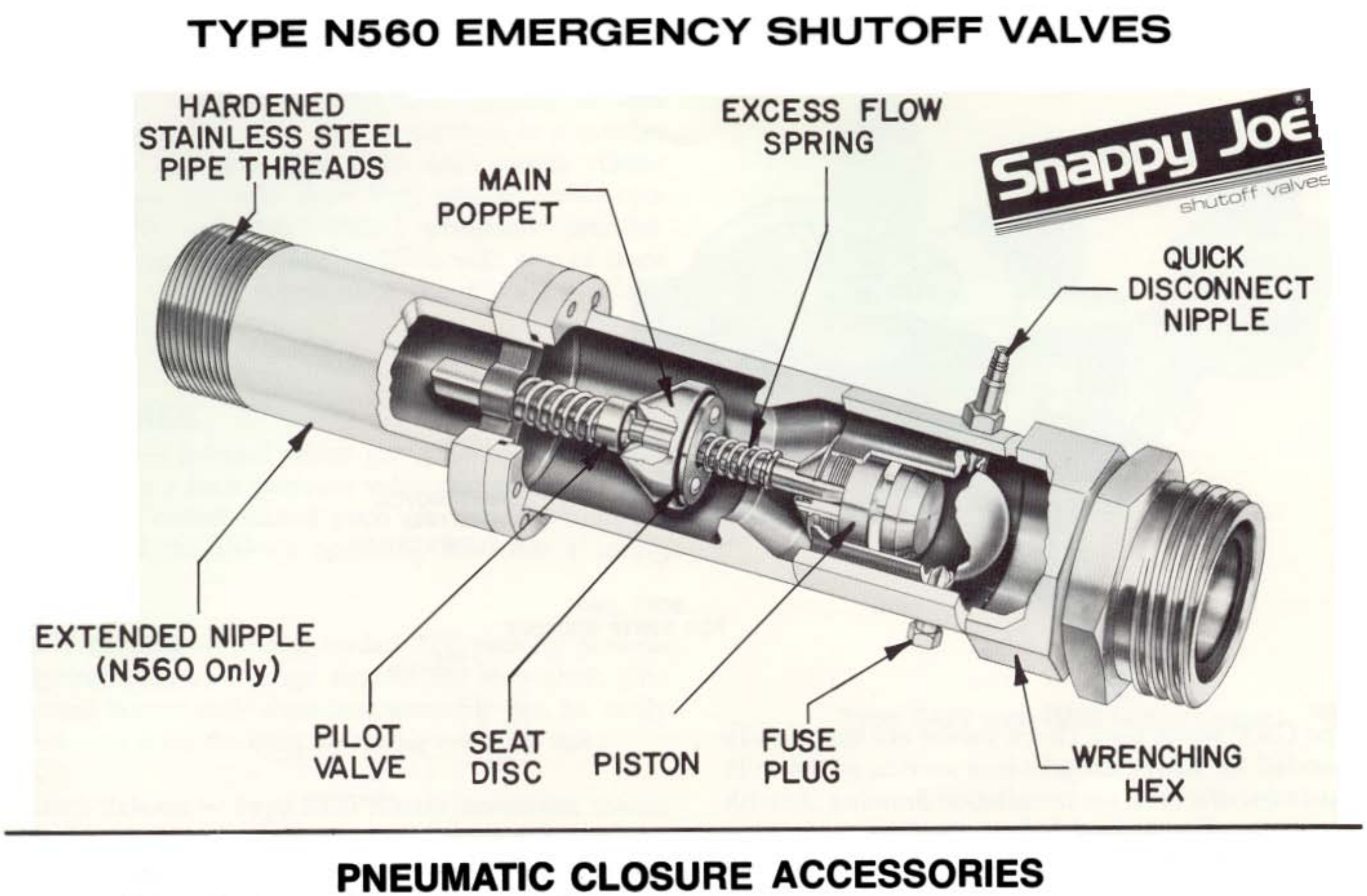
Tank Farm Operations



Tank Farm Operations

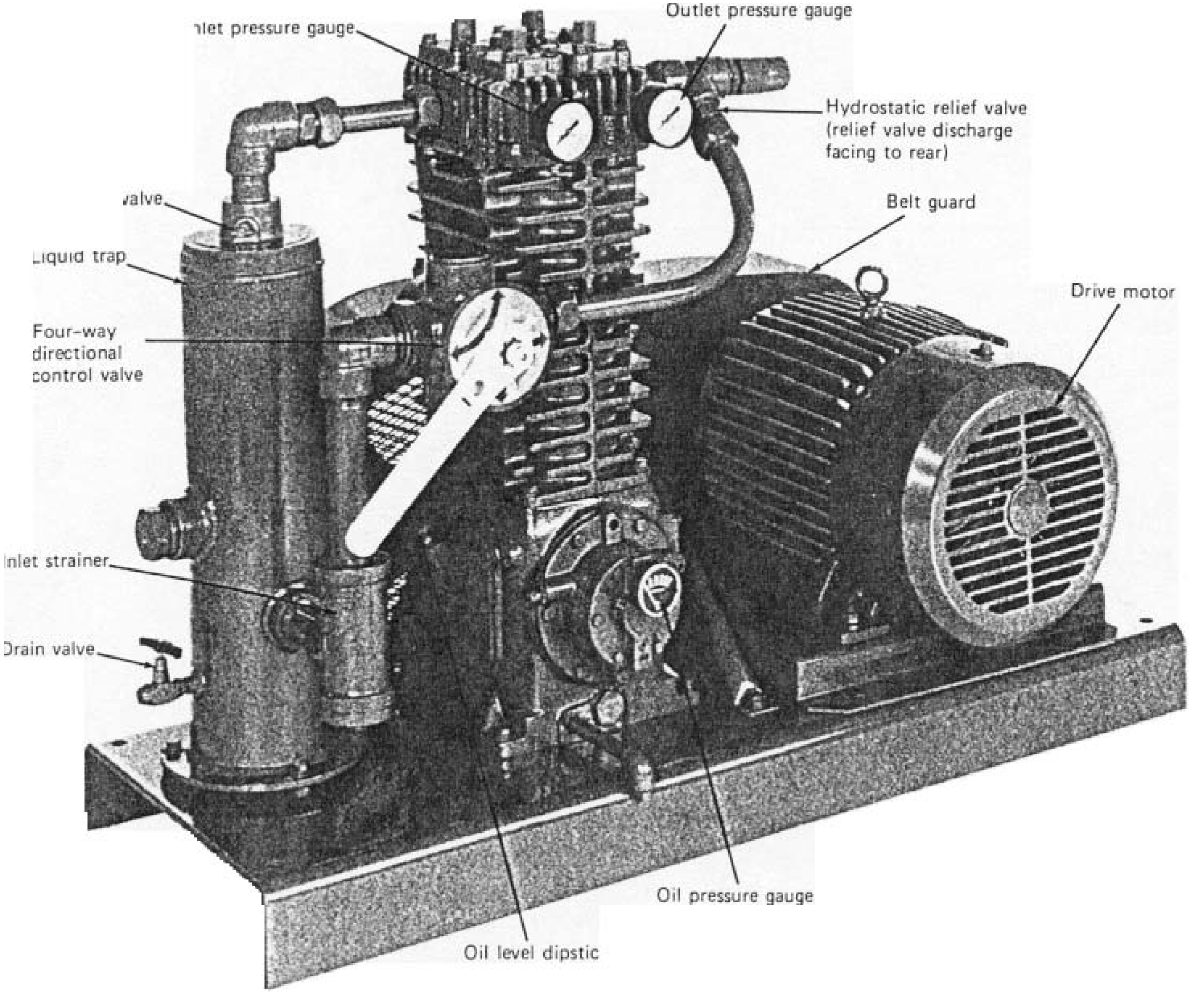


Tank Farm Operations



FISHER CONTROLS TANK CAR ESV

Tank Farm Operations



GAS TRANSFER COMPRESSOR

Tank Farm Operations

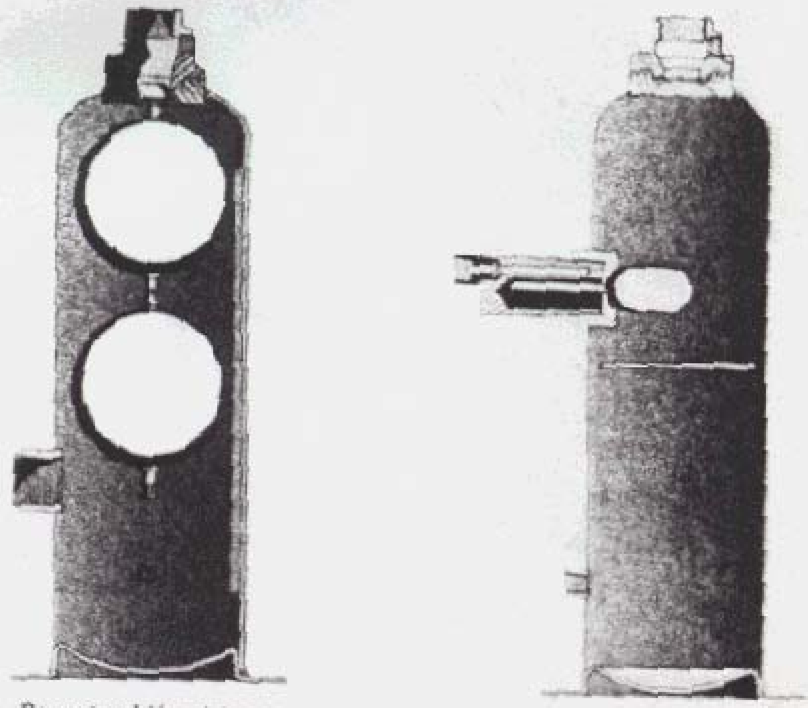


Figure 2.21(b) Compressor Liquid Traps. In part (a), the floats rise with the liquid level and close the valve at the top. In part (b), the float actuates a switch which shuts off the compressor motor.

LIQUID TRAPS FOR COMPRESSOR SUCTION LINE

Tank Farm Operations

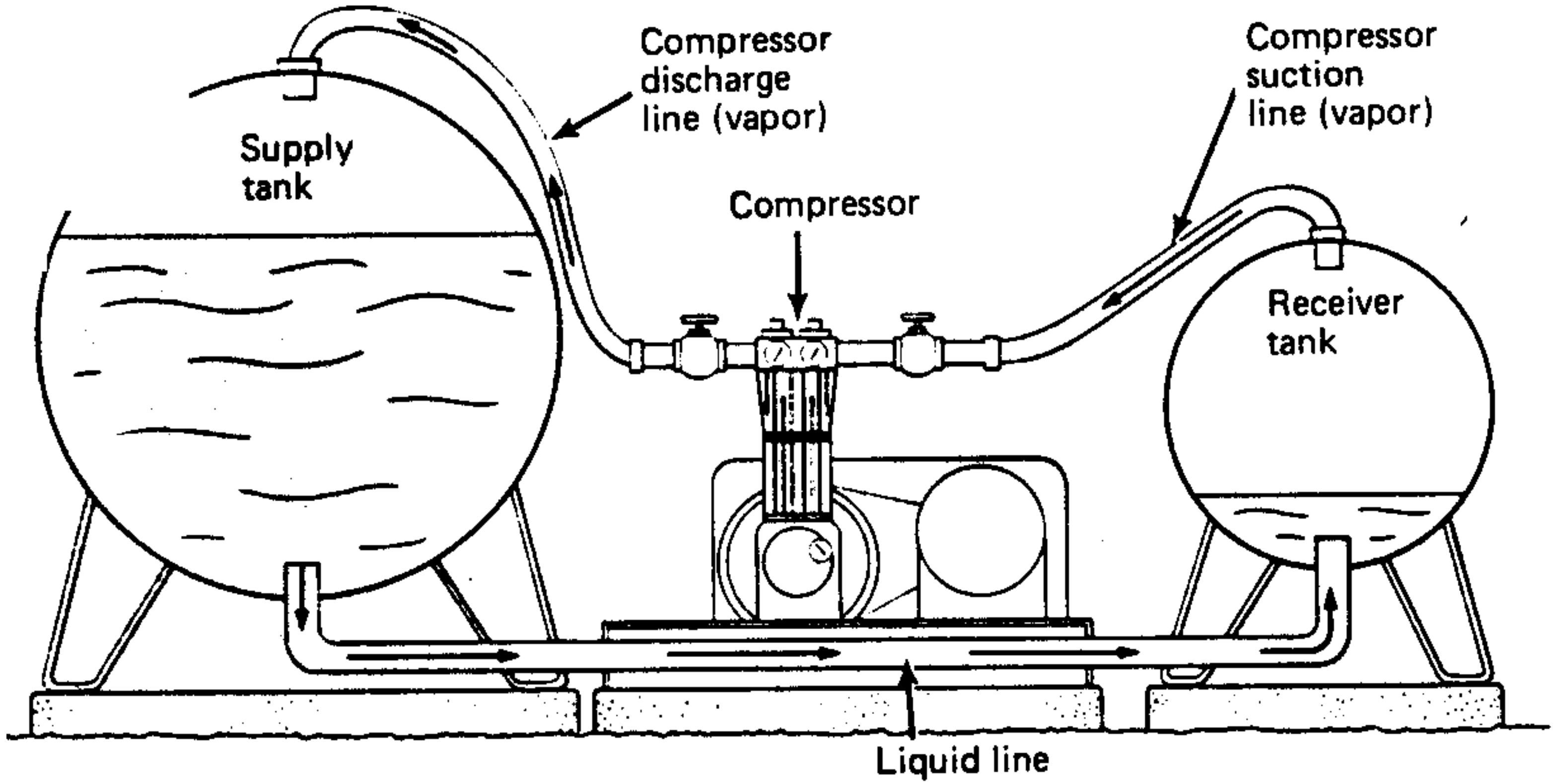
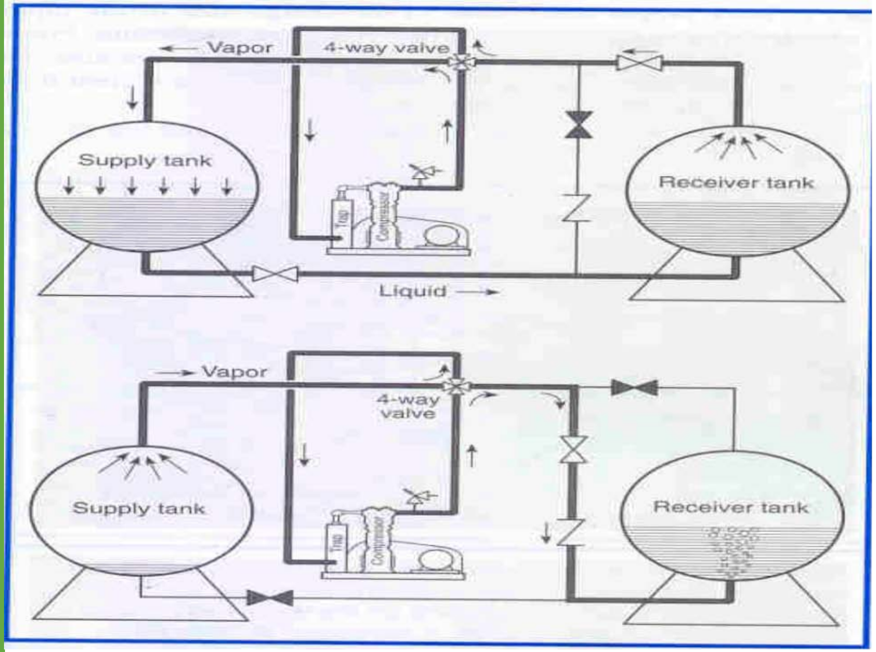


Figure 3.12 Transferring with Compressors.

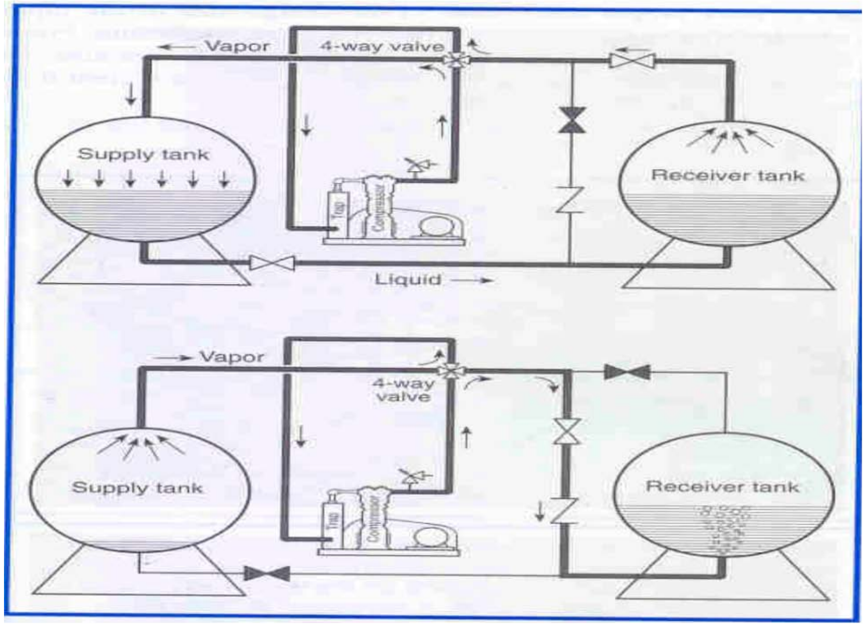
(For Tank Car Unloading, the “Supply Tank” is the Tank Car and the “Receiver Tank” is the Propellant Storage Tank)

Tank Farm Operations



Liquid Transfer Using a Gas Compressor

(Tank Car Unloading)



Vapor Recovery

Operations

Propellant Storage Tanks, Equipment and Safety Systems

Storage Tanks, Equipment, & Safety Systems

Storage Tanks, Equipment, & Safety Systems

Storage Tanks, Equipment, & Safety Systems

Storage Tanks, Equipment, & Safety Systems

Storage Tanks, Equipment, & Safety Systems

Table 3-2.2.2

Water Capacity Per Container Gallons (m^3)	Minimum Distances: Mounded or Underground Containers [Note (d)]	Minimum Distances: Aboveground Containers [Note (f)]	Minimum Distances: Between Containers [Note (e)]
Less than 125 (0.5) [Note (a)]		None [Note (b)]	None
125 to 250 (0.5 to 1.0)	10 ft (3 m)	10 ft (3 m)	None
251 to 500 (1.0 + to 1.9)	10 ft (3 m)	10 ft (3 m)	3 ft (1 m)
501 to 2,000 (1.9 + to 7.6)	10 ft (3 m)	25 ft (7.6 m) [Note (c)]	3 ft (1 m)
2,001 to 30,000 (7.6 + to 114)	50 ft (15 m)	50 ft (15 m)	5 ft (1.5 m)
30,001 to 70,000 (114 + to 265)	50 ft (15 m)	75 ft (23 m)	(¼ of sum of diameters of adjacent containers)
70,001 to 90,000 (265 + to 341)	50 ft (15 m)	100 ft (30 m)	
90,001 to 120,000 (341 + to 454)	50 ft (15 m)	125 ft (38 m)	
120,001 to 200,000 (454 to 757)		200 ft (61 m)	
200,001 to 1,000,000 (757 to 3 785)		300 ft (91 m)	
Over 1,000,000 (3 785)		400 ft (122 m)	

Storage Tanks, Equipment, & Safety Systems

MANUFACTURER'S DATA PLATE FOR LPG STORAGE TANK

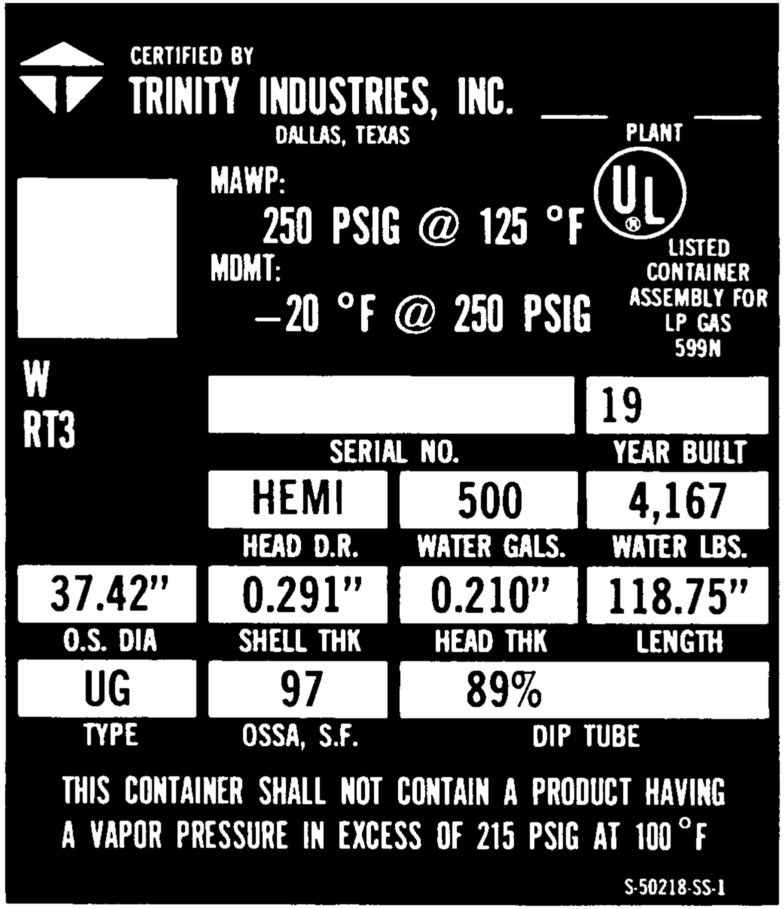


Figure 2.8 **Marking Required by 2-2.6.5 as Given on a Nameplate. Container listing [in this example, by Underwriters Laboratories Inc. (UL)] is optional.**

Storage Tanks, Equipment, & Safety Systems

MANUFACTURER'S DATA PLATE FOR LPG STORAGE TANK

Storage Tanks, Equipment, & Safety Systems

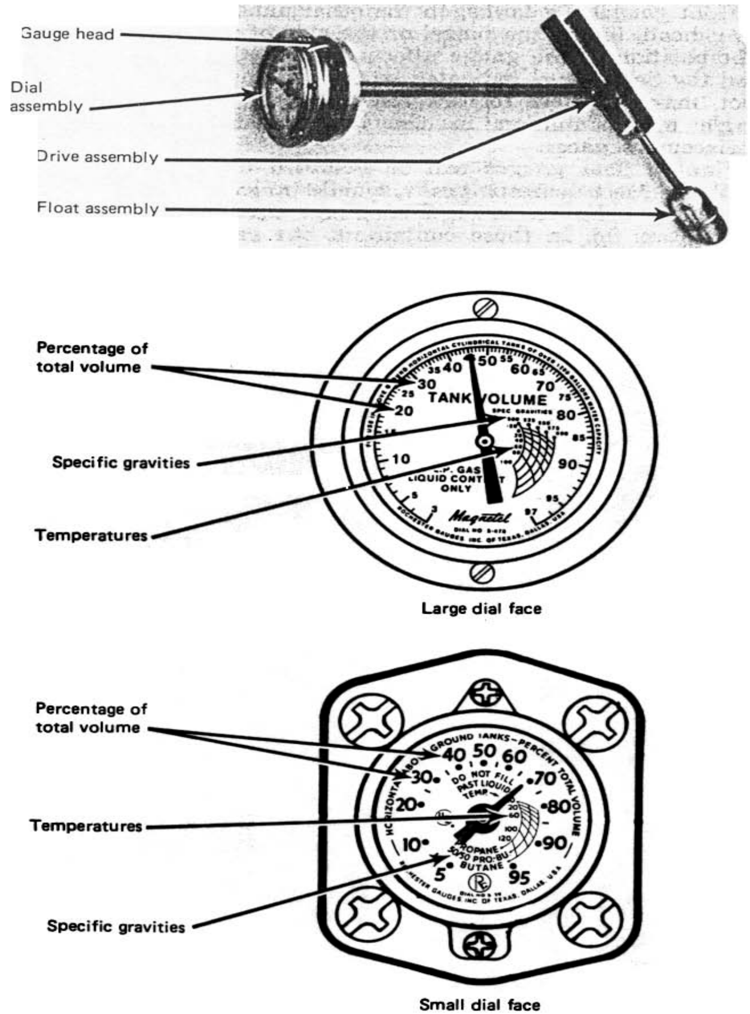
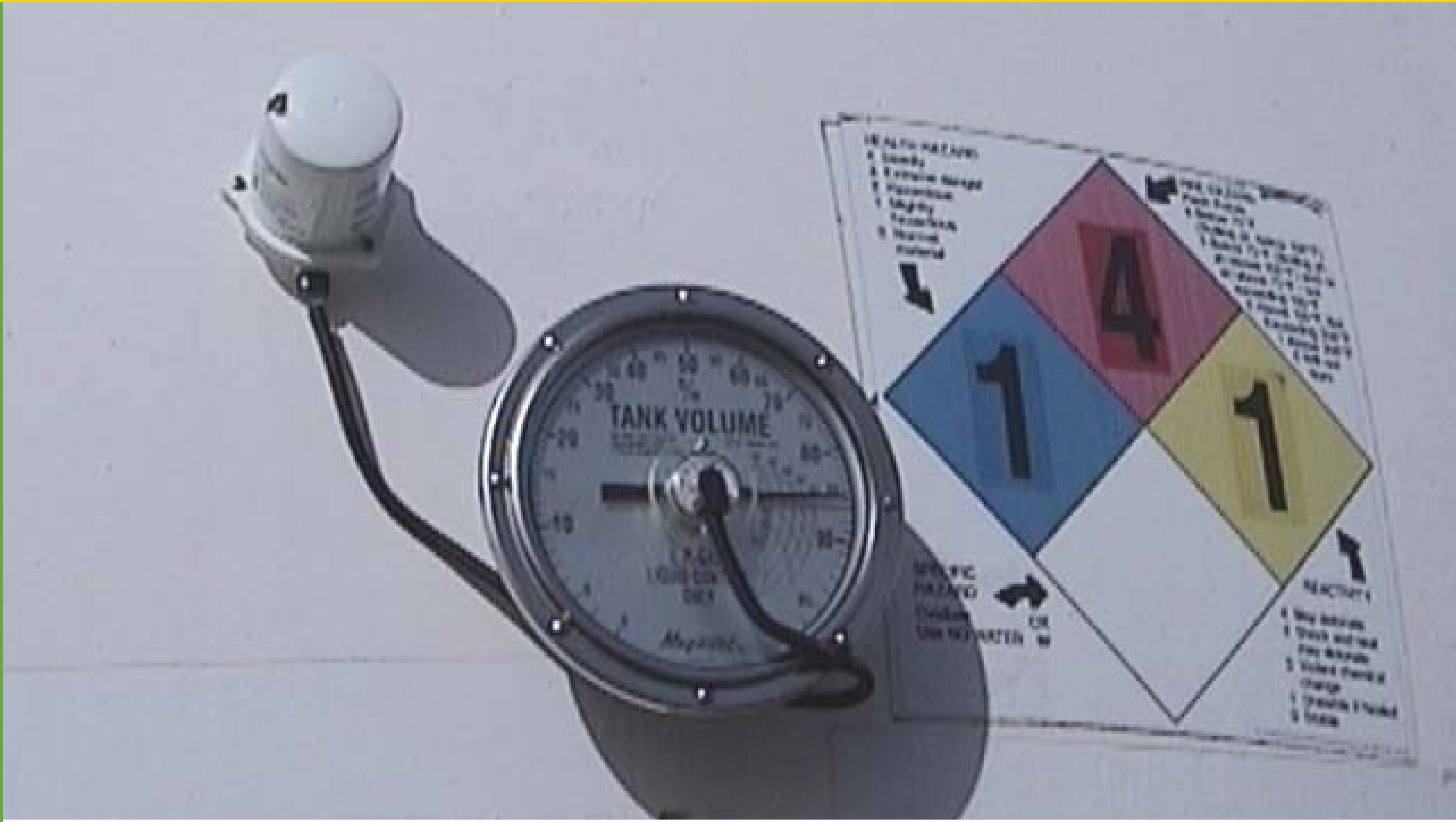


Figure 2.17(c) Float Type of Variable Liquid Level Gauge.

Storage Tanks, Equipment, & Safety Systems



Liquid Level Gauges

Storage Tanks, Equipment, & Safety Systems

Liquid Level Gauges

Storage Tanks, Equipment, & Safety Systems

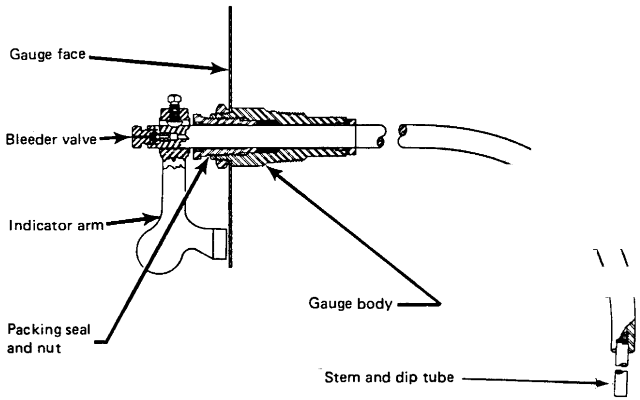


Figure 2.17(a) Rotary Type of Variable Liquid Level Gauge.

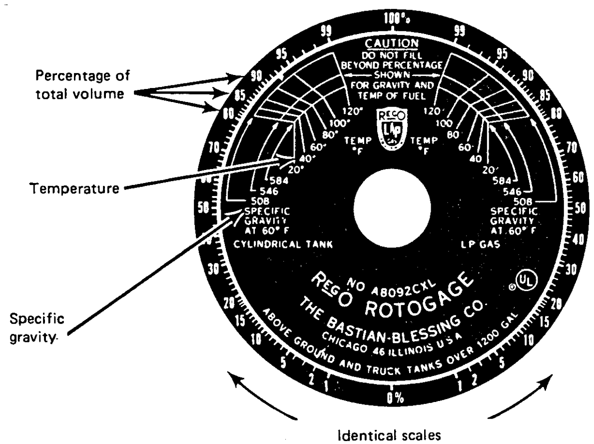
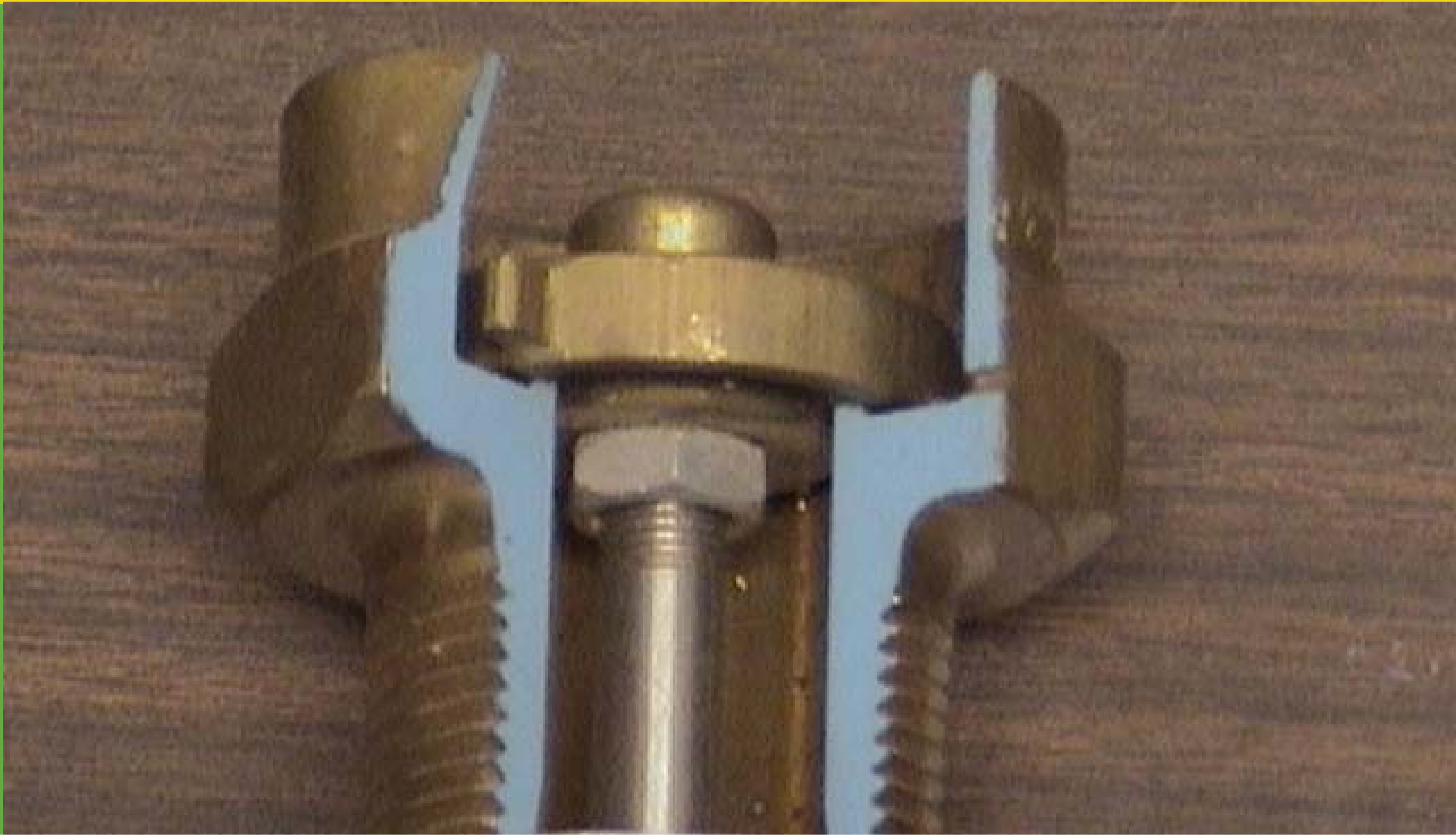


Figure 2.17(b) Rotary Gauge Face.

Storage Tanks, Equipment, & Safety Systems

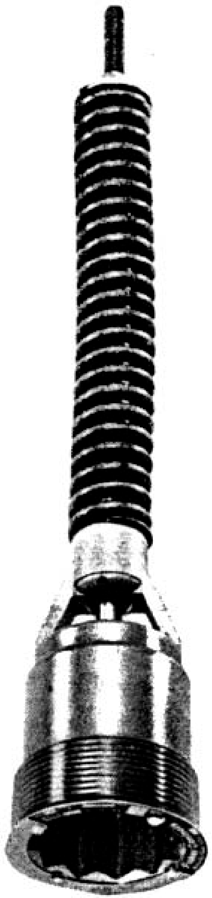
SAFETY RELIEF VALVES

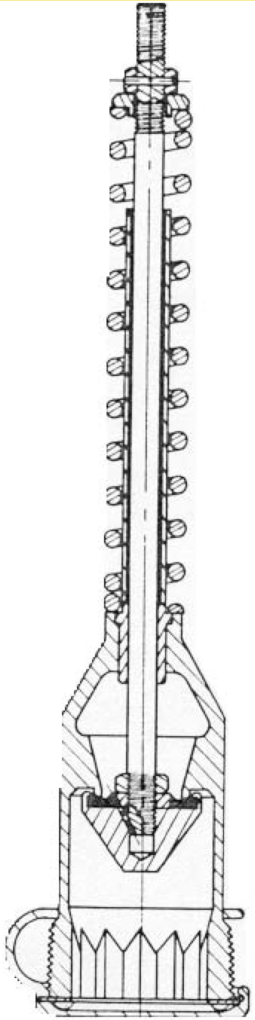
Storage Tanks, Equipment, & Safety Systems



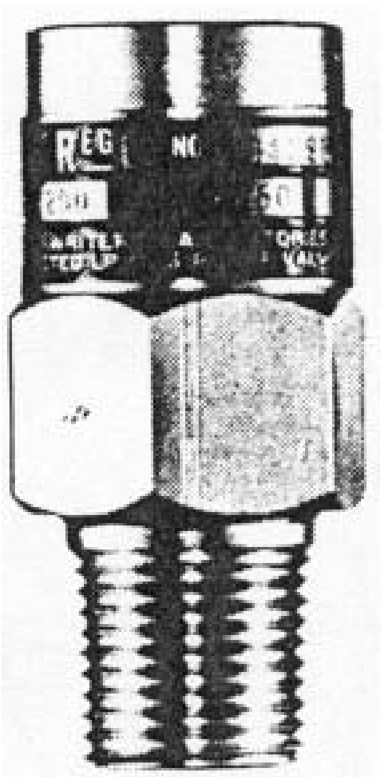
SAFETY RELIEF VALVES

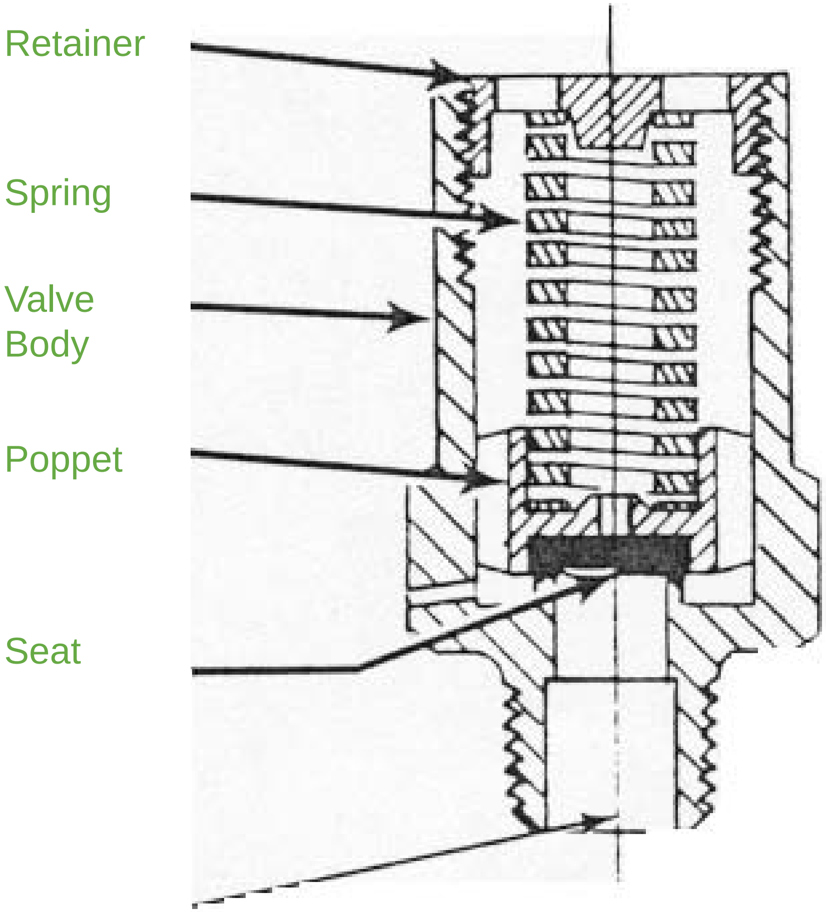
Storage Tanks, Equipment, & Safety Systems





INTERNAL SPRING SAFETY RELIEF VALVE





EXTERNAL SPRING RELIEF VALVE

Storage Tanks, Equipment, & Safety Systems

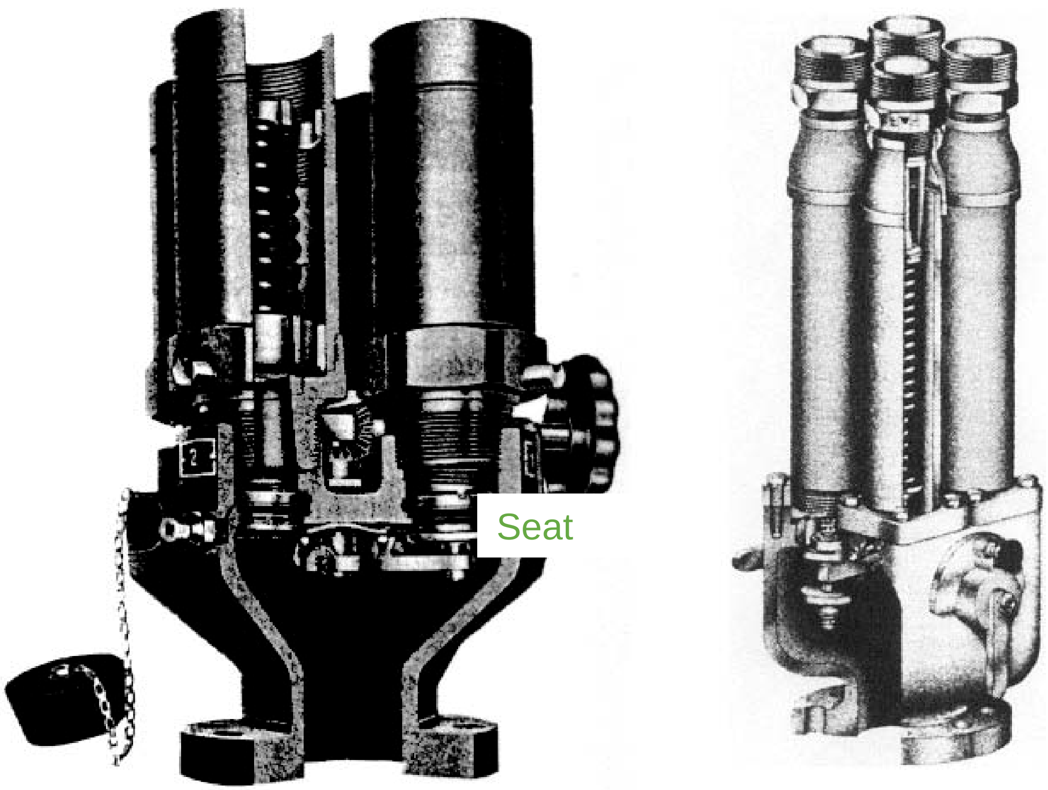
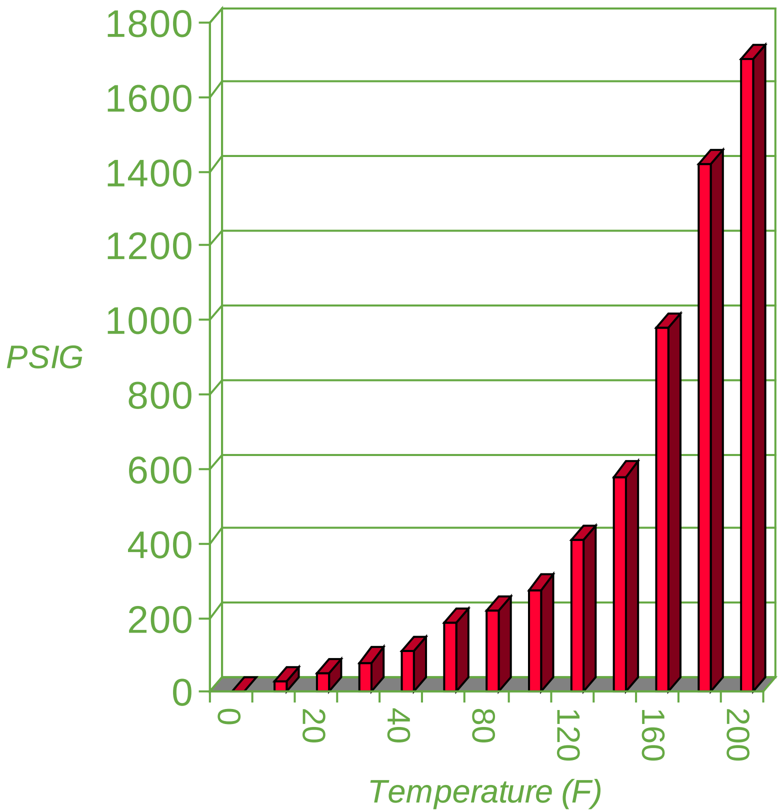


Figure 2.12 ASME Container Relief Valve Manifolds. The container requires three relief valves. The manifold contains four. By manipulating the handwheel or lever, an internal clapper-type valve can be rotated to isolate any one of the four relief valves for testing, maintenance, or replacement.

Storage Tanks, Equipment, & Safety Systems

Storage Tanks, Equipment, & Safety Systems

Pressure Rise in a Constant Volume Vessel or Pipe



- ***Pressure Increase from 24 to 1800 psig as temperature rises from 0 to 200 °F***

(Basis-100% Propane Liquid Full at 130 °F)

Storage Tanks, Equipment, & Safety Systems

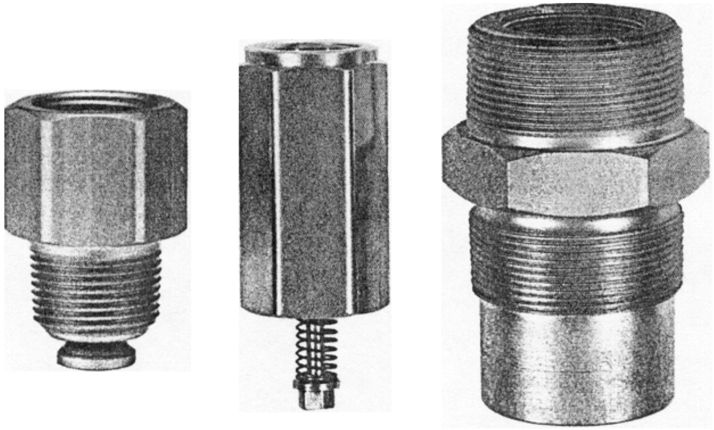


Figure 2.13(b) Various Excess-flow Check Valves.

stopped or reversed. Both valves of double backflow check valves shall comply with this provision.

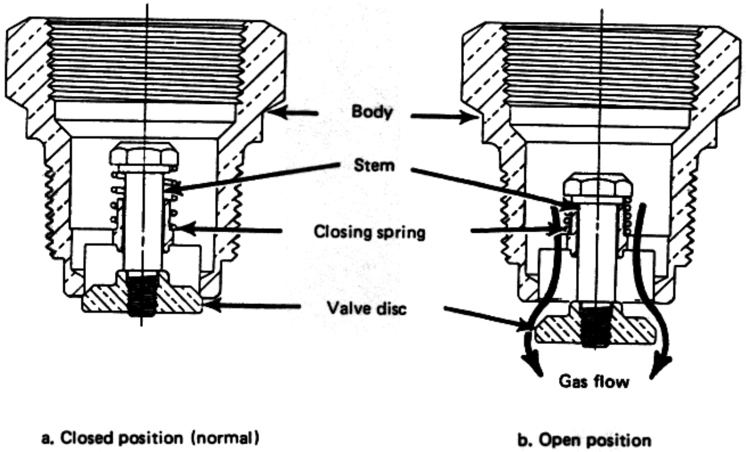
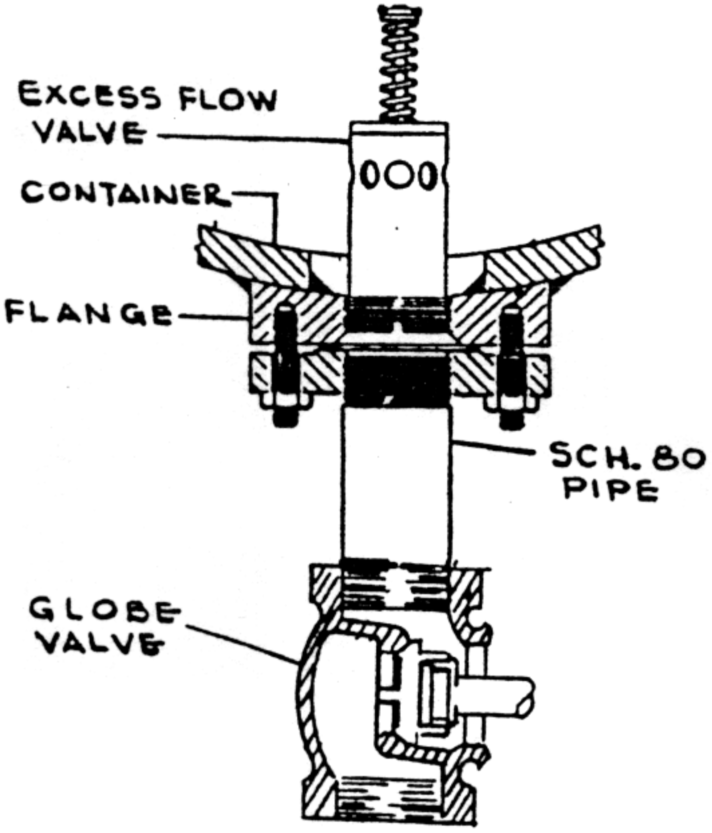


Figure 2.14 Operation of Backflow Check Valve.

Storage Tanks, Equipment, & Safety Systems



NOZZLE DETAIL "B"

N. T. S.

Storage Tanks, Equipment, & Safety Systems

Storage Tank Safety Valves

Storage Tanks, Equipment, & Safety Systems

Storage Tank Safety Valves

Storage Tanks, Equipment, & Safety Systems

Storage Tank Safety Valves

Pipe and Pipe Fittings

- Carbon Steel schedule 80 pipe and 2000# forged steel fittings are recommended to be used throughout the propellant storage and handling system for maximum safety and maintenance flexibility.
- Pipe joints may be threaded, flanged or welded. Welded joints are preferred to minimize the potential for leaks, especially in long piping runs or piping that is hard to reach for inspection.

Pipe and Pipe Fittings

- Piping must be designed and installed in accordance with NFPA 58 and ASME B31.3 *Chemical Plant and Petroleum Refinery Piping.*
- Cast Iron fittings <u>must not be used</u>. (Malleable or ductile iron may be used for equipment handling liquefied gas propellants).
- All materials must be inert to the chemical action of the propellant.
- Metal or Spiral wound metal gaskets required.

Pipe and Pipe Fittings

- Piping should be installed above ground and must be well supported and protected against damage.
  - Buried piping requires special protective coating systems and cathodic protection. Buried piping is generally not recommended due to corrosion, settling and difficulty with leak detection. For buried piping considerations, see NFPA 58, Chapter 3 (section 3-2.12)
- Grounding of the piping system is recommended.
- Piping Systems must be properly labeled.

Pipe and Pipe Fittings

- Elastomers
  - Hydrocarbons and Hydrofluorocarbons
    - Buna-N, Neoprene and Butyl Rubber acceptable
  - Dimethyl Ether (DME)
    - Teflon® is a suitable plastic sealant
    - Kalrez® and Ethylene Propylene (EP) are the best elastomers for DME service

Storage Tanks, Equipment, & Safety Systems

Forged Steel Sch. 80 Pipe and 2000# Fittings

Storage Tanks, Equipment, & Safety Systems

2-5.2 Pumps.

2-5.2.1 Pumps shall be designed for LP-Gas service and may be of rotary, centrifugal, turbine or reciprocating type.

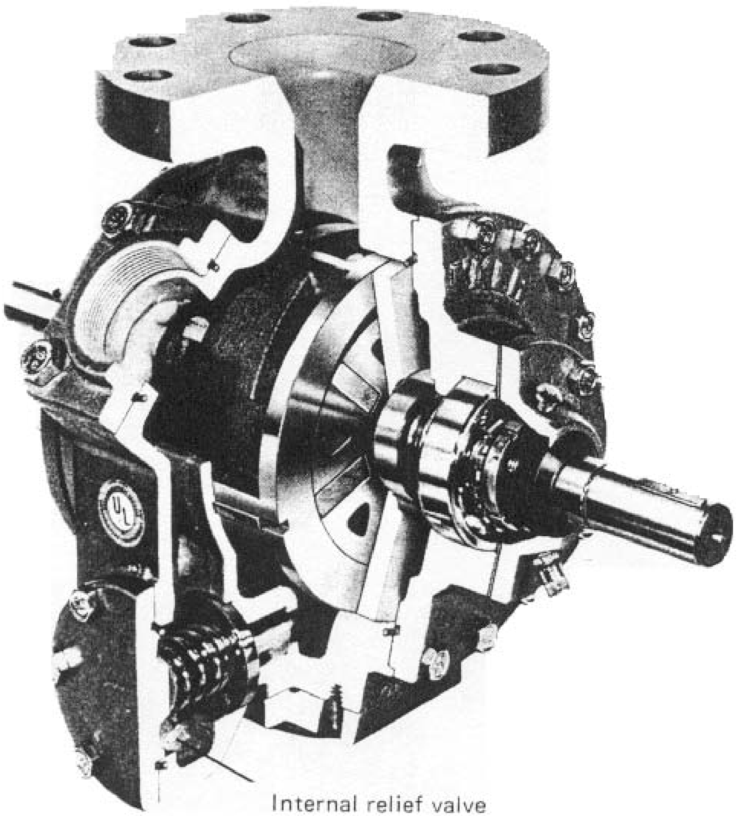
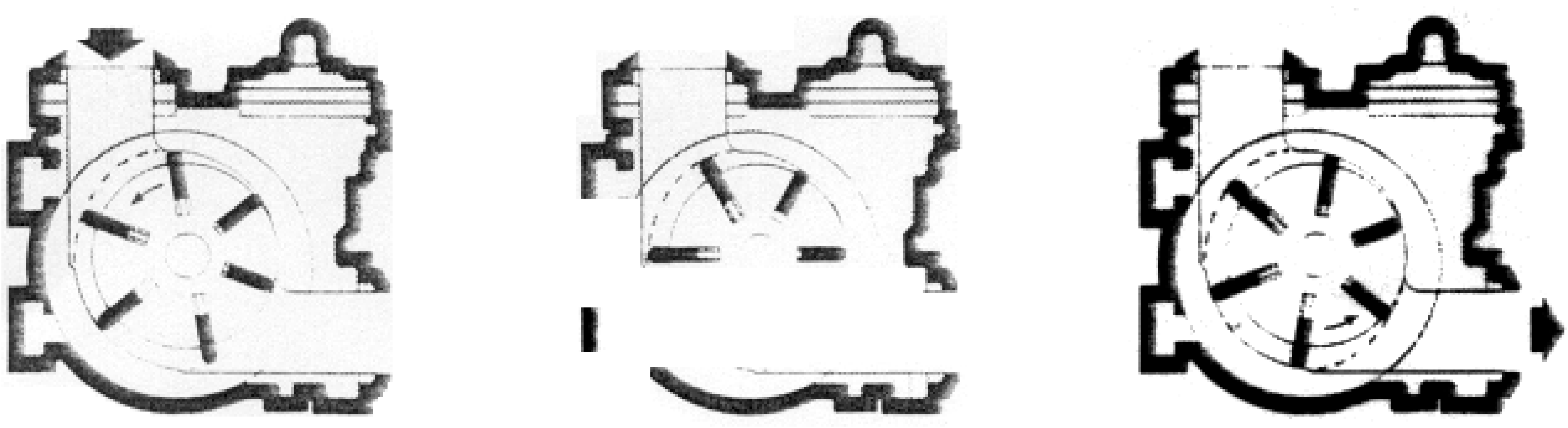


Figure 2.20(a) Sliding Vane Positive Displacement Pump.

Storage Tanks, Equipment, & Safety Systems



a. Vanes move out, trapping liquid at the pump inlet.

b. Liquid is transferred toward the outlet between the vanes.

c. As the vanes move back into their slots, liquid is discharged through the outlet.

Figure 2.20(c) Operation of Sliding Vane Pump.

Storage Tanks, Equipment, & Safety Systems

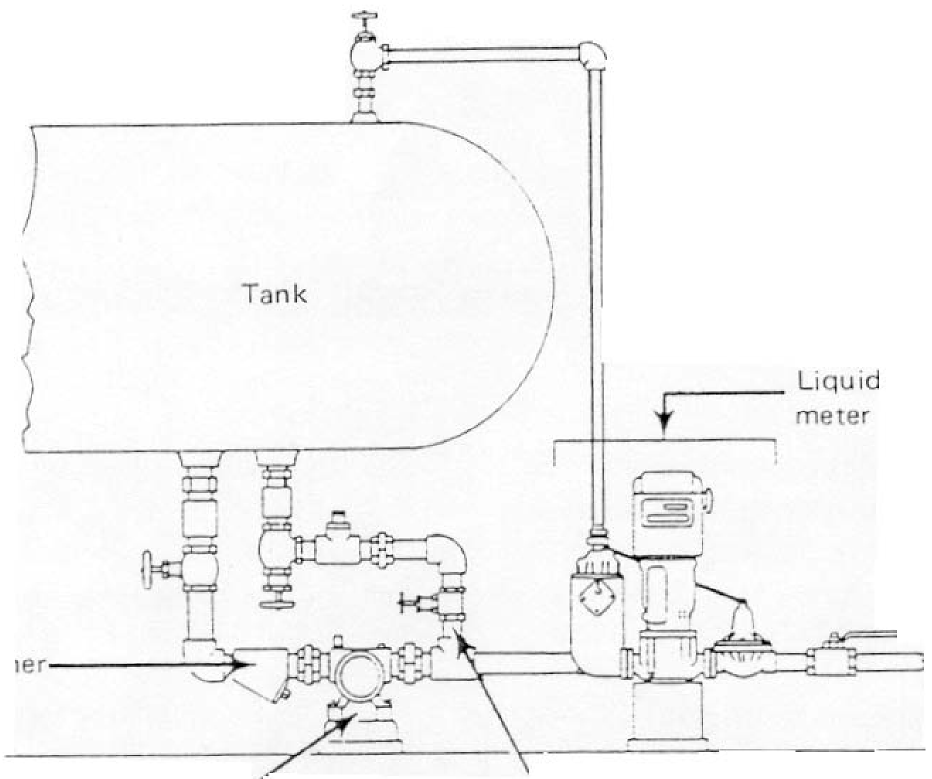
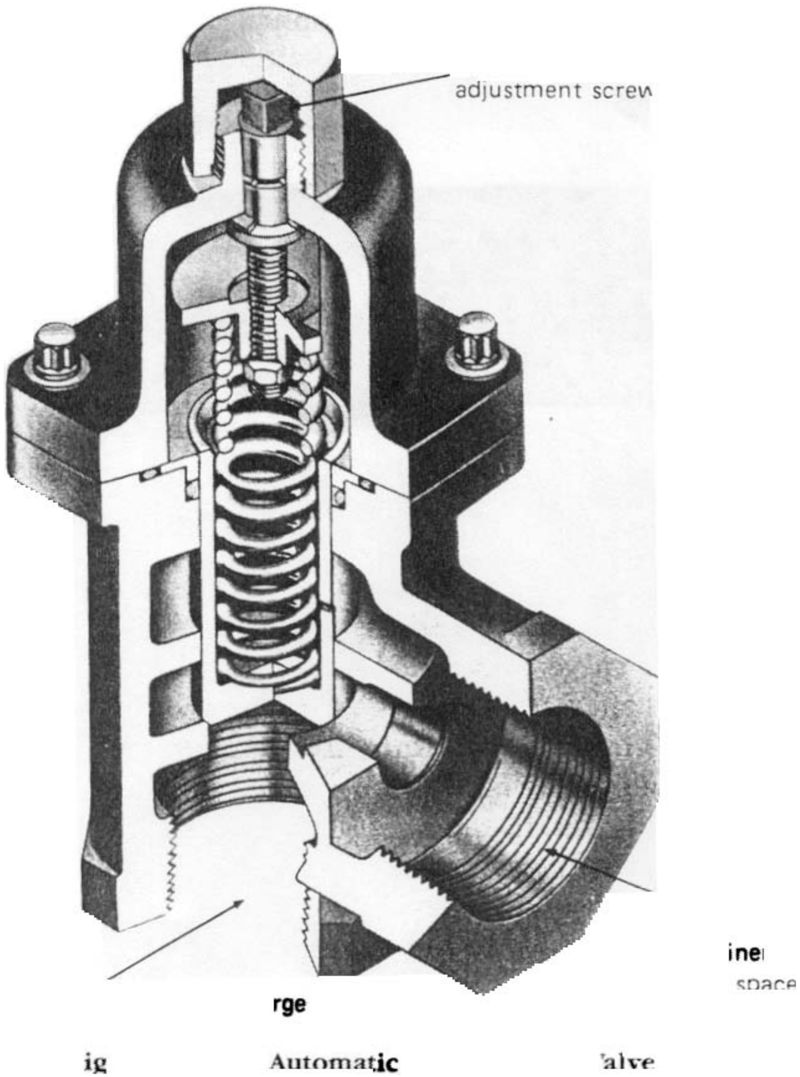


Figure 3.11(b) Typical Pump and Meter Installation.

Storage Tanks, Equipment, & Safety Systems



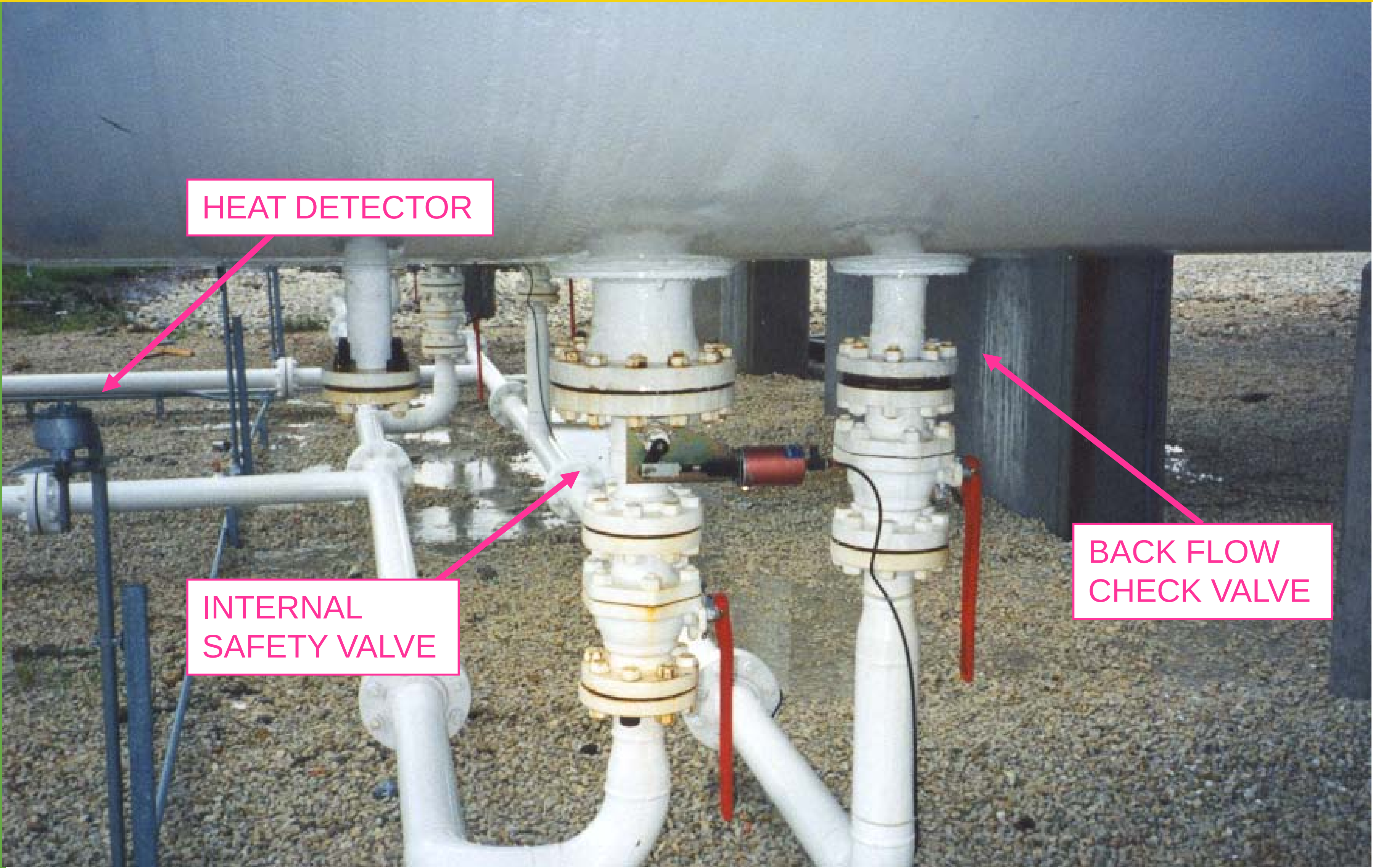
Storage Tanks, Equipment, & Safety Systems

Theoretical Maximum Release
of Liquefied Flammable Gas

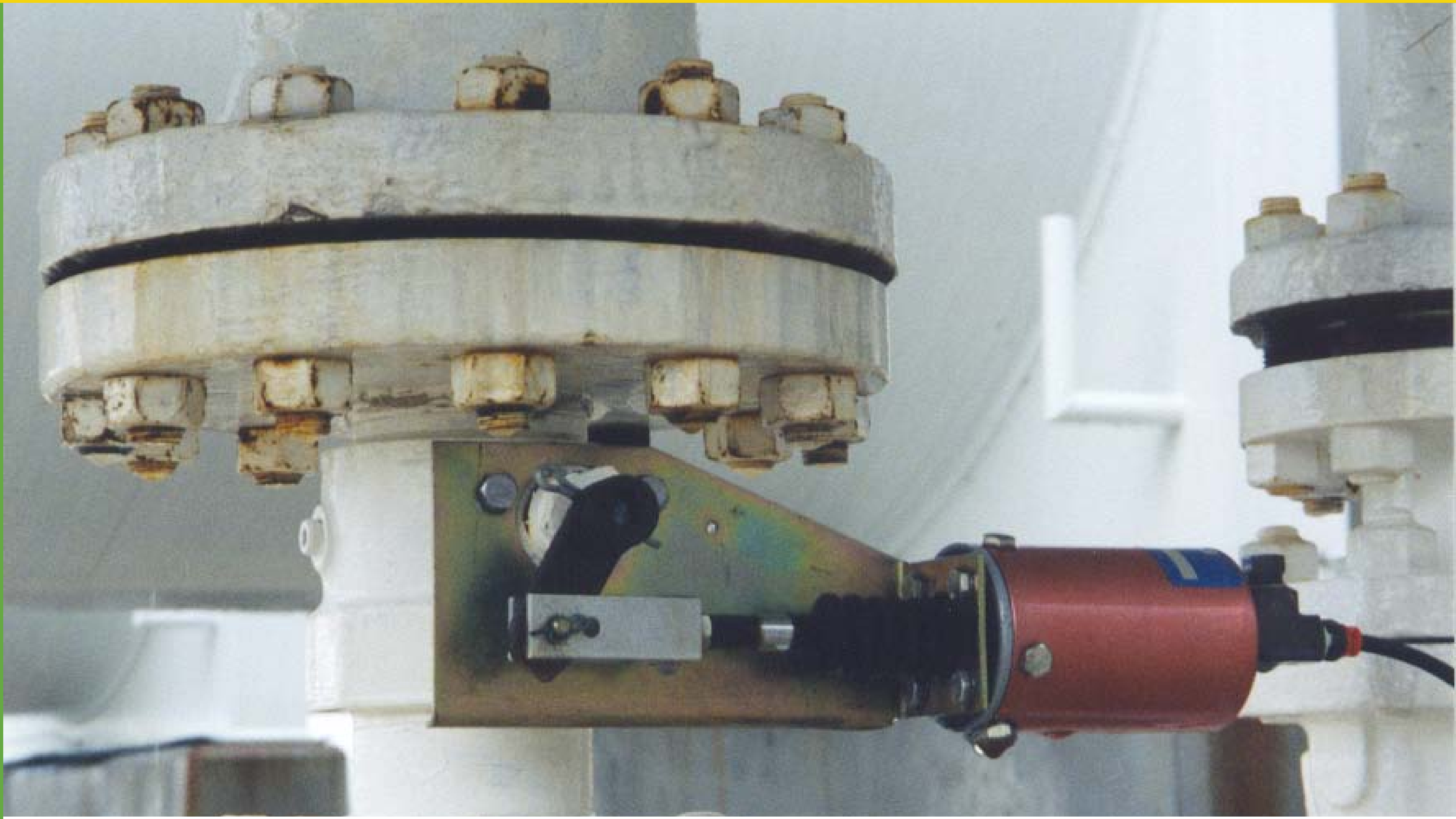
The theoretical maximum release of 3 different hydrocarbon propellants @ 70 °F to the atmosphere through a 0.25” diameter opening has been calculated to be:

Hydrocarbon	Pressure (psig)	Vapor (ft3/sec)	Liquid (gal/min)
Propane	108	12.20	28.60
Isobutane	31	5.94	14.39
N-butane	17	4.66	10.50

Storage Tanks, Equipment, & Safety Systems



Storage Tanks, Equipment, & Safety Systems

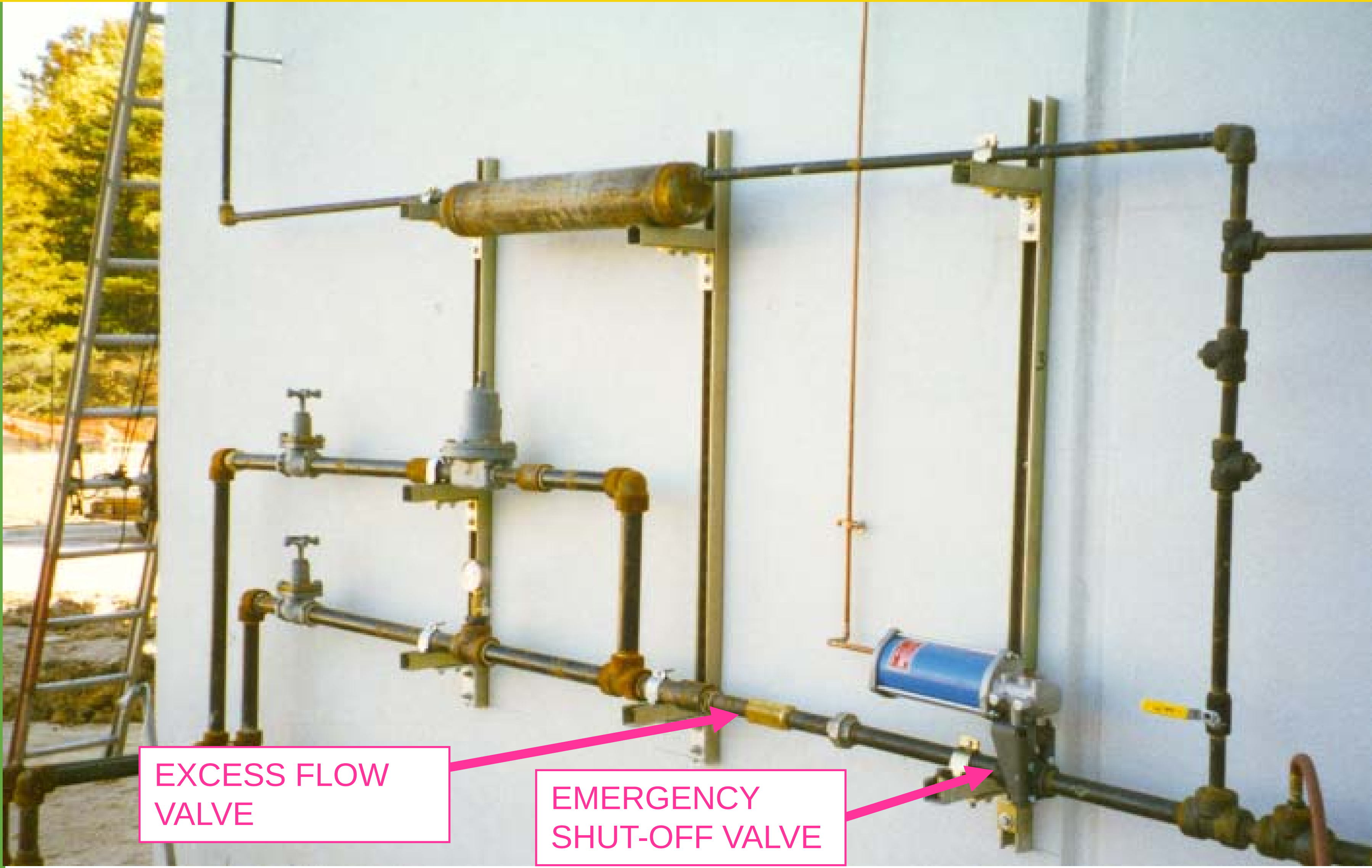


FISHER CONTROLS INTERNAL SAFETY VALVE
(PNEUMATICALLY ACTUATED)

Storage Tanks, Equipment, & Safety Systems

REMOTE STATION FOR ESVs

Storage Tanks, Equipment, & Safety Systems



Fire Protection

Flammability of Common Aerosol Propellants

- LEL and UEL (lower and upper explosive limits) are tabulated below

Propellant	LEL	UEL
Propane	2.2	9.5
Isobutane	1.8	8.4
N-Butane	1.9	8.5
Dimethyl Ether	3.4	18.0
Dymel 152a	3.9	16.9
R 134a	non-flammable	

- Auto ignition temperatures range from 662 °F for DME to 940 °F for Propane. *(Note: The temperature of an idly burning cigarette is over 1000 °F).*

Fire Protection

Fire Protection

Automatic Detection Systems

Automatic Detection Systems

General Safety Practices

- **Unlike LPG used in fuel applications, flammable liquefied gas propellants are Colorless and Odorless gases. You cannot smell a gas leak.**

- **Consideration should be given to installing automatic detection systems such as combustible gas detectors, Infrared flame detectors, and rate-of-rise temperature detectors. These systems can be used to automatically close shut-off valves, activate plant alarm systems, notify emergency personnel and activate fire protection systems in the event of an emergency.**

Automatic Detection Systems

COMBUSTIBLE GAS DETECTORS

Automatic Detection Systems

sieger

SEARCHLINE 500
Open Path Infrared Hydrocarbon Gas Detector

BENEFITS:
- Unrivaled open area coverage
- Low maintenance
- Low installation costs
- Impervious to catalytic poisons
- Can operate in gas saturated environments
- No moving parts
- Easier decisions on siting of detectors

Sieger, the world leader in combustible gas detection, presents SEARCHLINE 500 - an intensely practical gas detection system incorporating all the experience of over 30 years in gas detection and of many hundreds of open path installations throughout the world.

SEARCHLINE 500 combines infrared technology with the latest in microprocessor technology to provide a system of hydrocarbon gas detection that is uncomplicated in operation and requires minimal maintenance.

The basis of SEARCHLINE 500 open path gas detection is simple - you are more likely to detect significant leaks of hydrocarbon gases with open monitoring than with any other system of comparable price available today.

Sieger SEARCHLINE 500's innovative technique projects an infrared beam over distances of between 35 and 650 feet, detecting potentially explosive or environmentally harmful leaks of hydrocarbons anywhere in the beam. This is true whether the escaping gas is of a localized high concentration or of a lower concentration over a wider area - either way you need to know about the leak, and either way SEARCHLINE 500 will provide an alarm.

Seiger SEARCHLINE 500 units are available approved and certified to North American CSA and UL standards. SEARCHLINE 500 offers a 4-20 mA signal output which is compatible with standard PLC or DCS systems. The output is also compatible with a variety of Sieger control equipment.

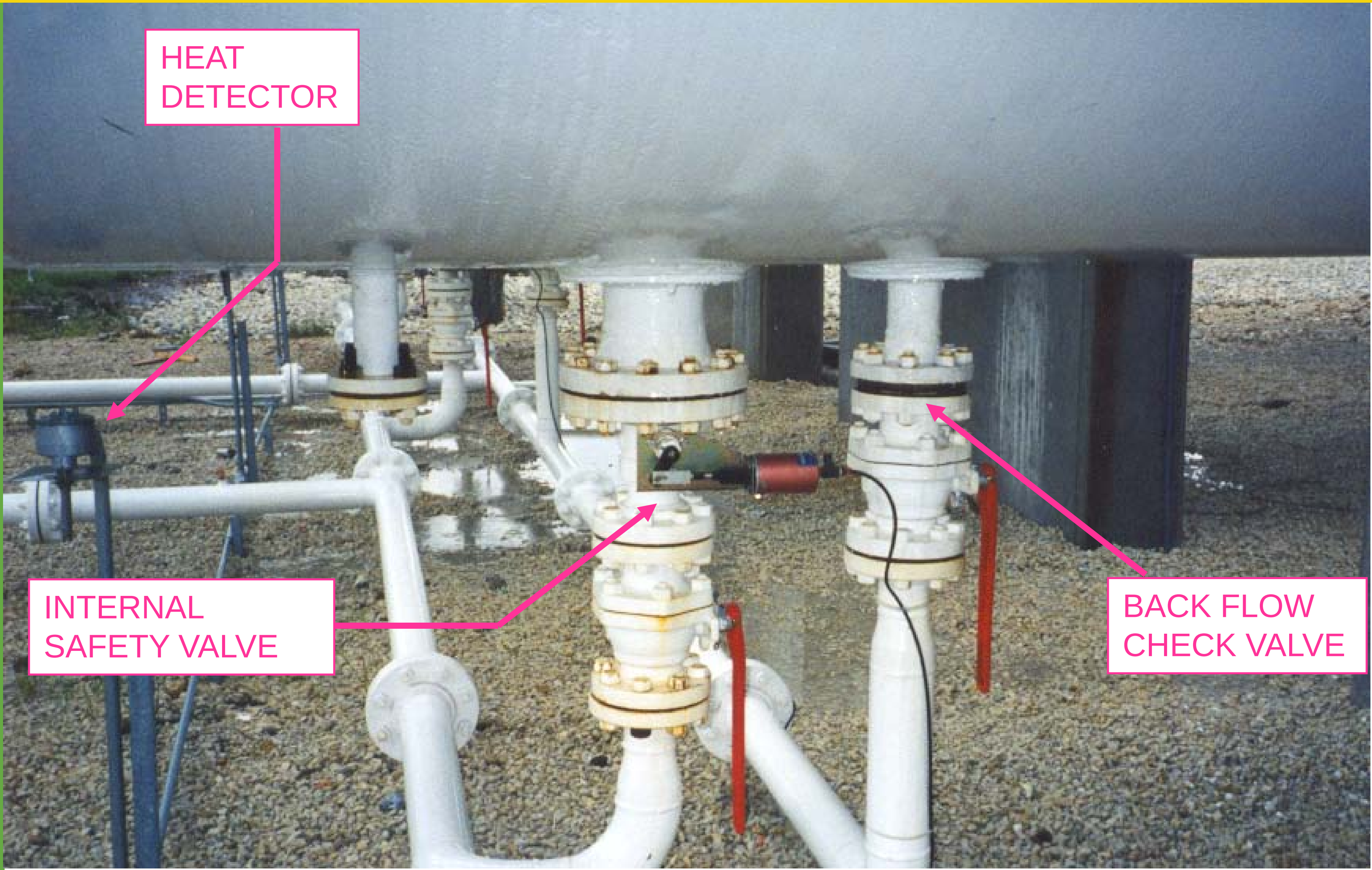
Quality assurance is assessed to ISO 9001, and is backed by a most committed worldwide sales and service organization, itself assessed where appropriate to ISO 9002.

THE GIFT OF SIGHT!

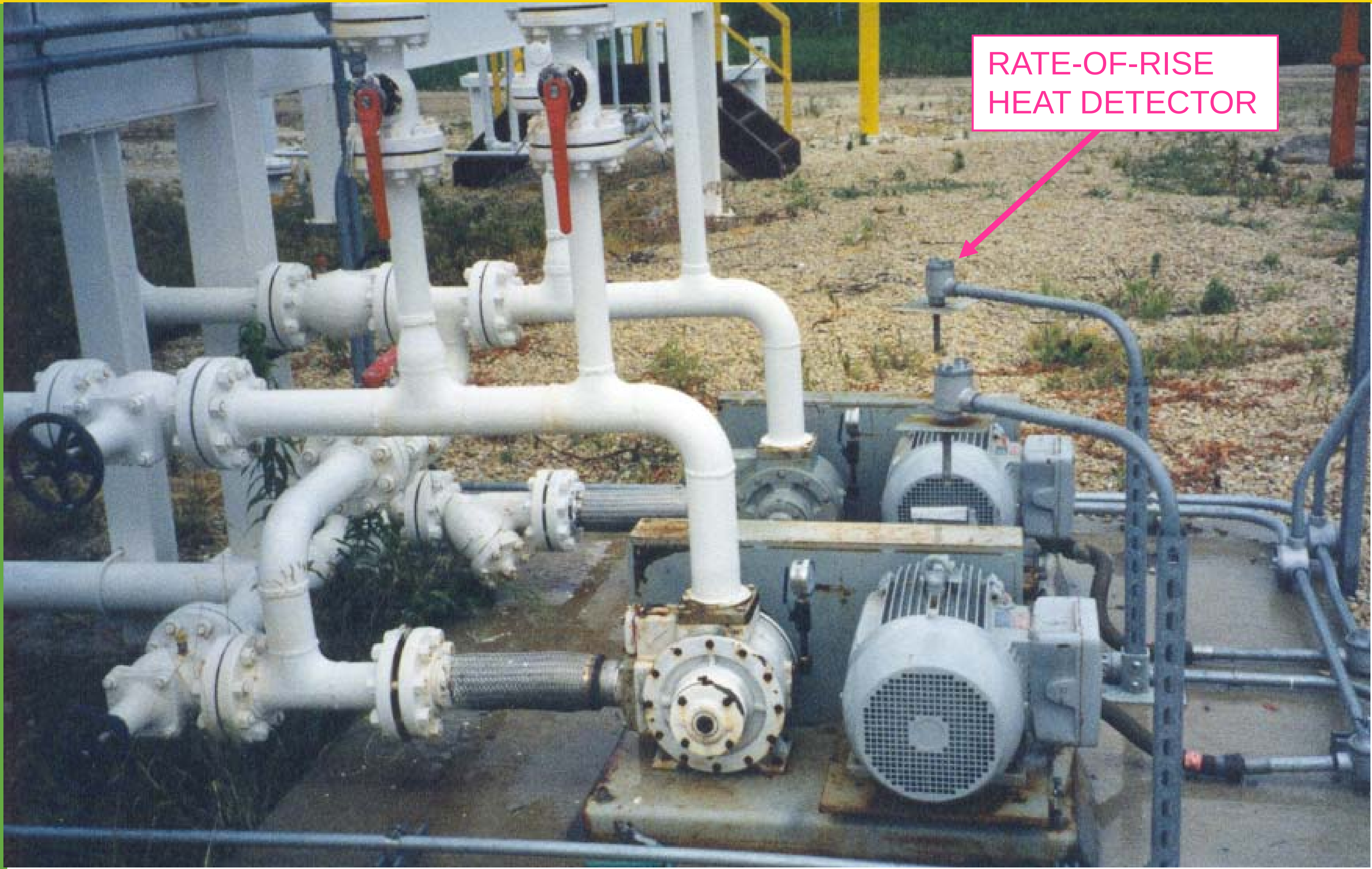
Automatic Detection Systems

RATE OF RISE HEAT DETECTOR

Automatic Detection Systems



Automatic Detection Systems



Automatic Detection Systems

IR FLAME DETECTOR

Fire Protection
Water Deluge Systems

Water Deluge Systems

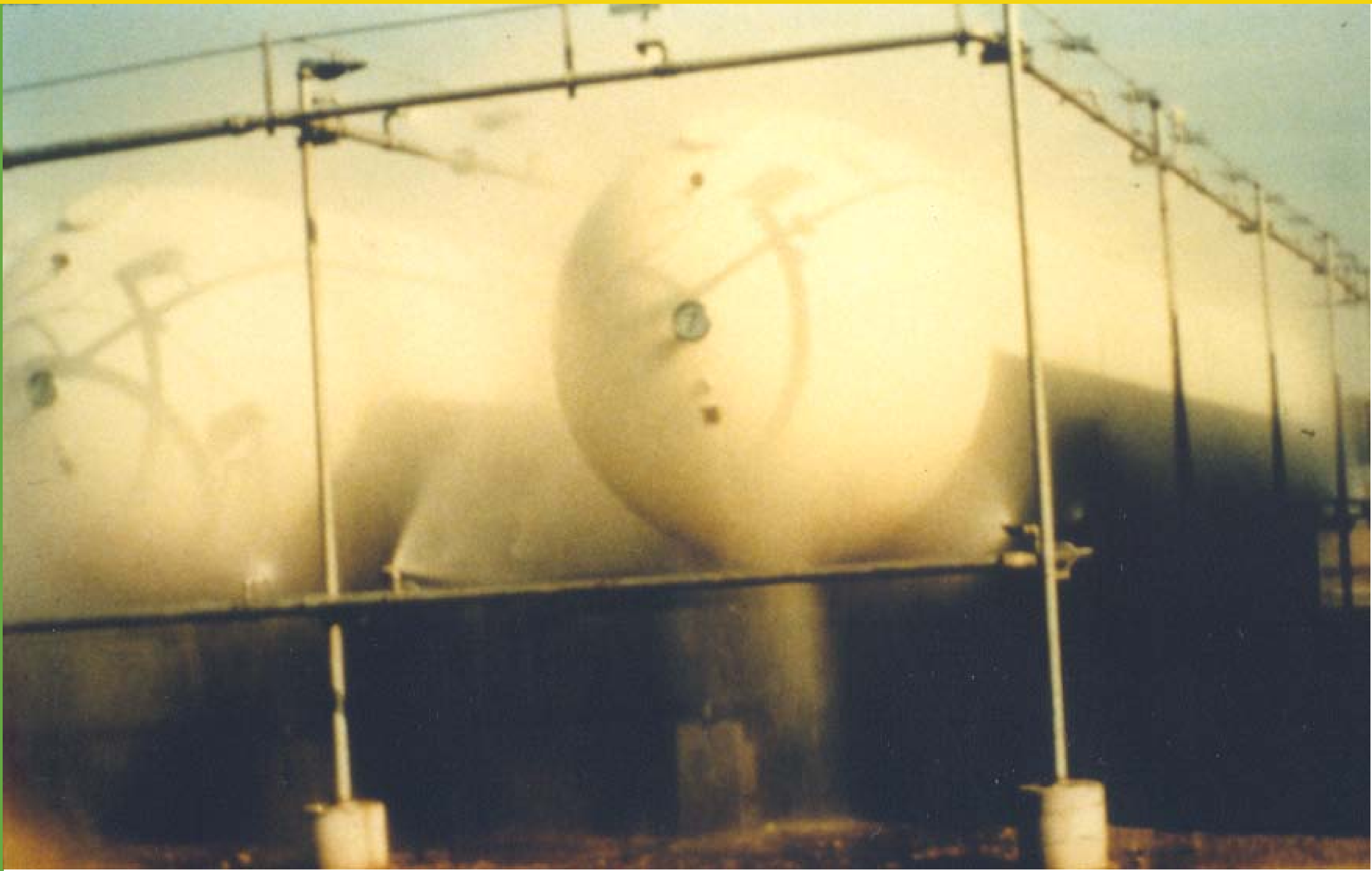
Water Deluge Systems

Water Deluge Systems

Water Deluge Systems

Water Deluge Systems

Water Deluge Systems

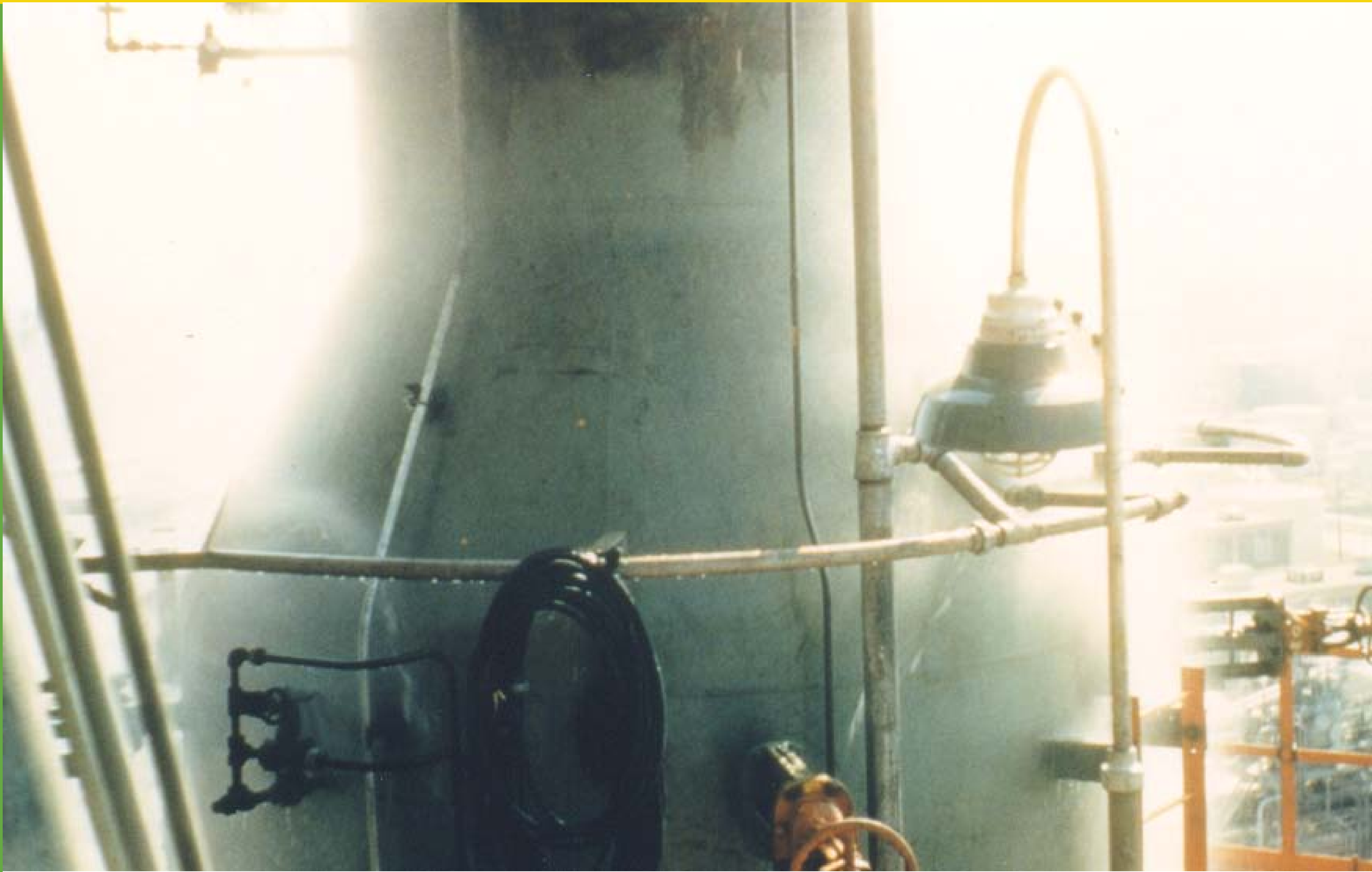


Water Deluge Systems

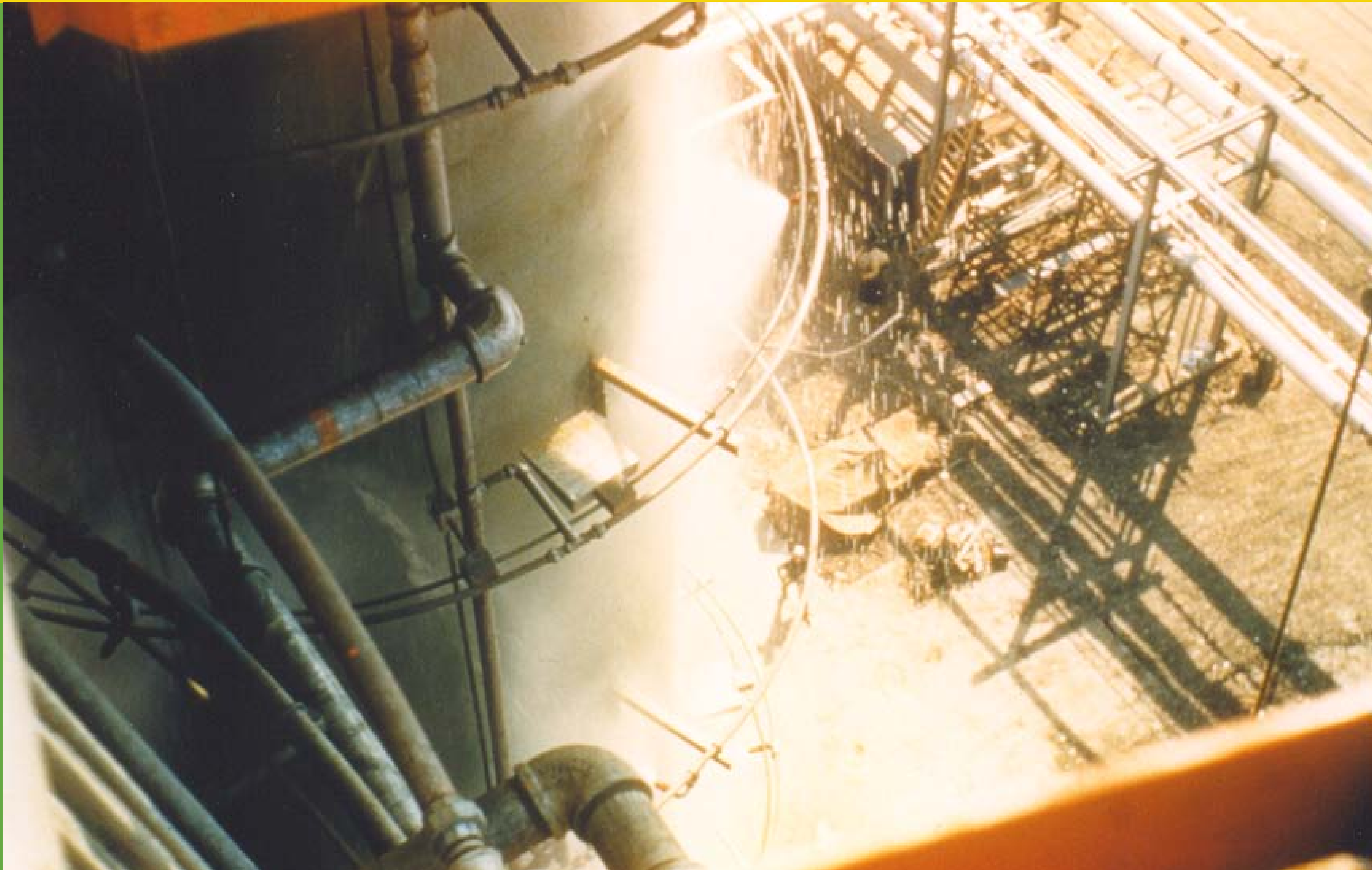
Water Deluge Systems

Water Deluge Systems

Water Deluge Systems



Water Deluge Systems



Water Deluge Systems

Water Deluge Systems

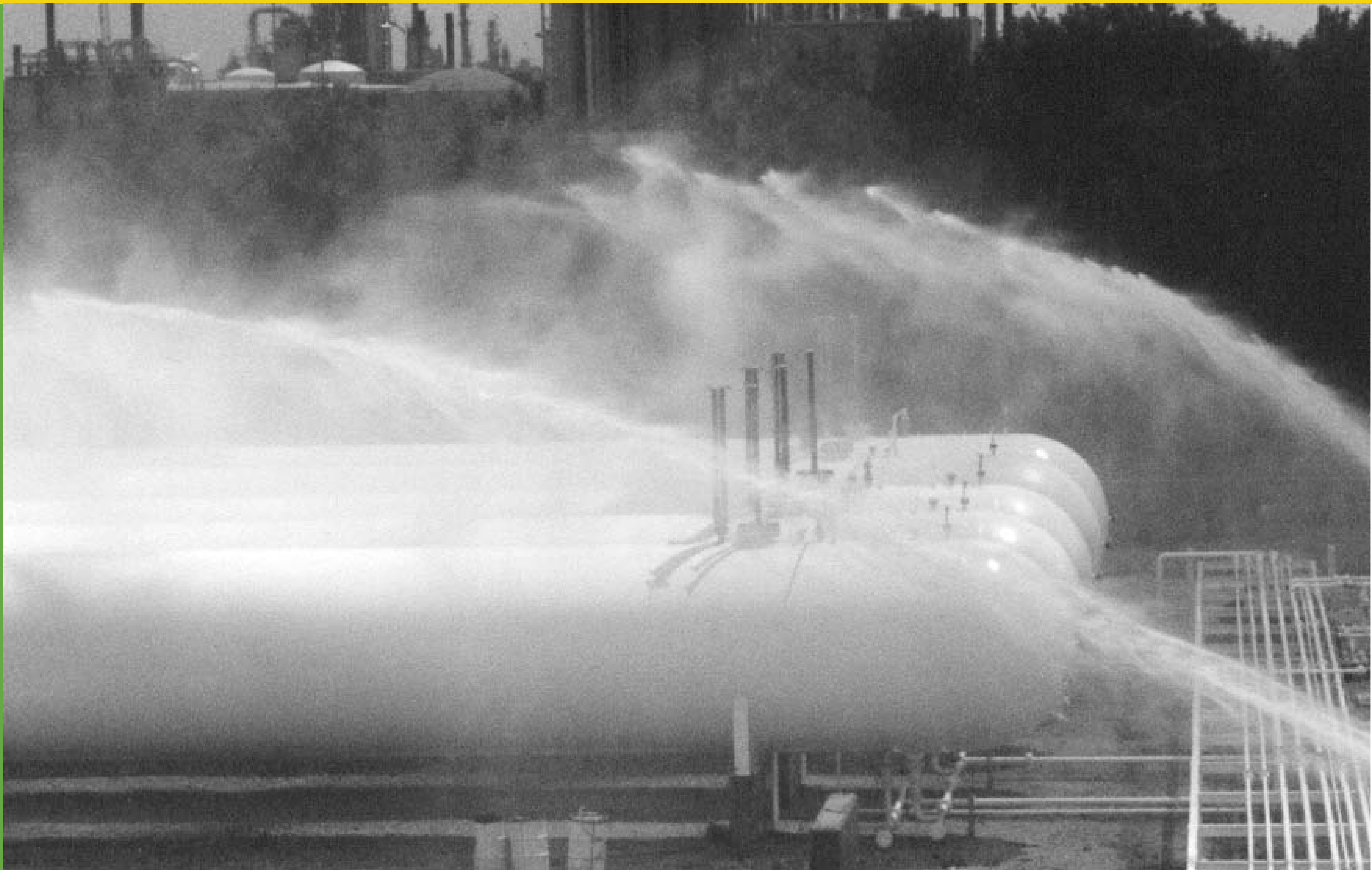
Water Deluge Systems

Fire Protection
Water Cannons / Monitor Nozzles

Water Cannons / Monitor Nozzles

Water Cannons / Monitor Nozzles

Water Cannons / Monitor Nozzles



Water Cannons / Monitor Nozzles

Fire Protection Insulation

Fire Protection - Insulation

Fire Protection - Insulation

Fire Protection - Insulation

Fire Protection
Mounded Storage

Mounded Storage

Mounded Storage

Mounded Storage

Mounded Storage

Mounded Storage

Fire Protection
Underground Storage

Underground Storage

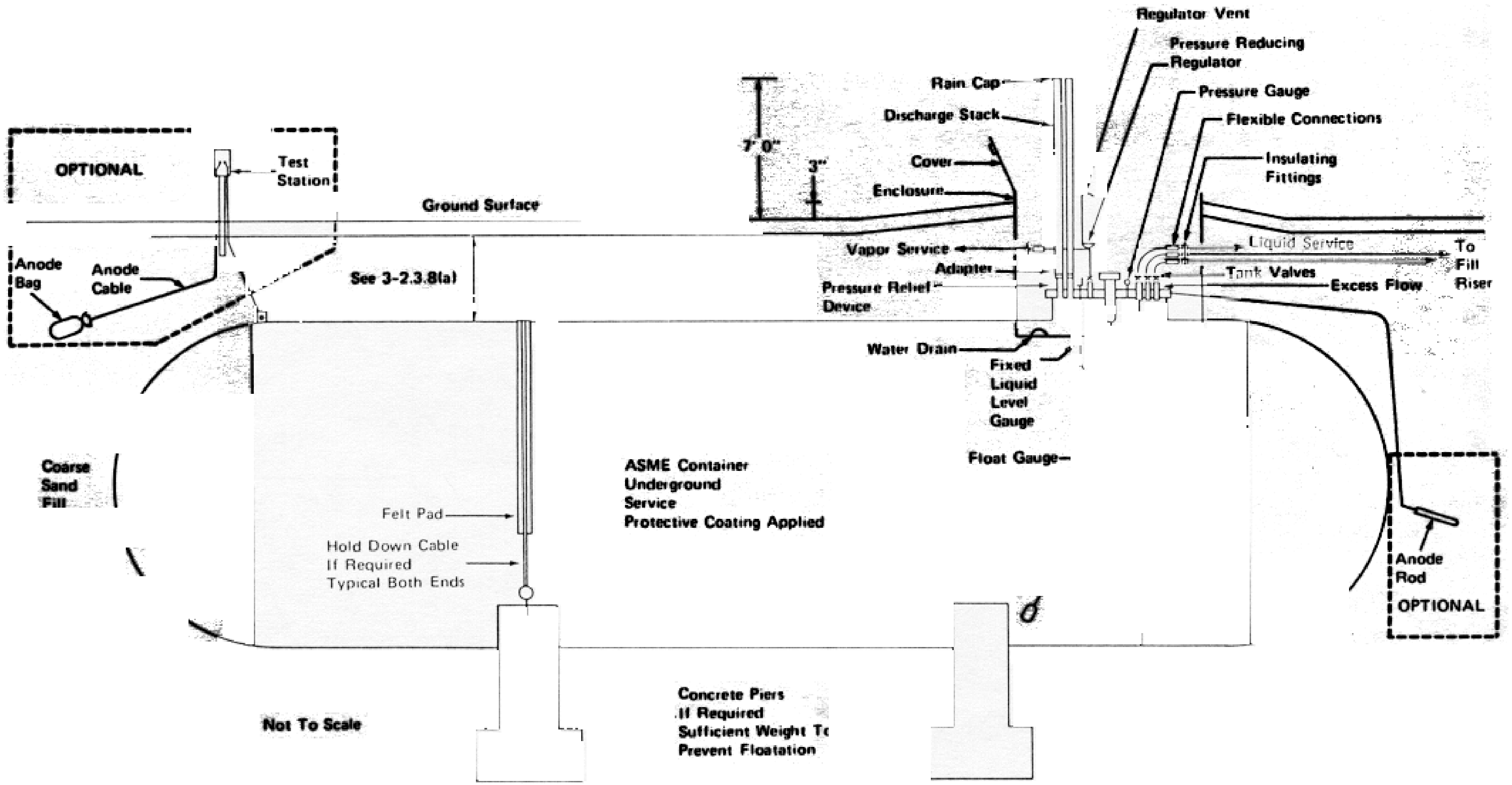
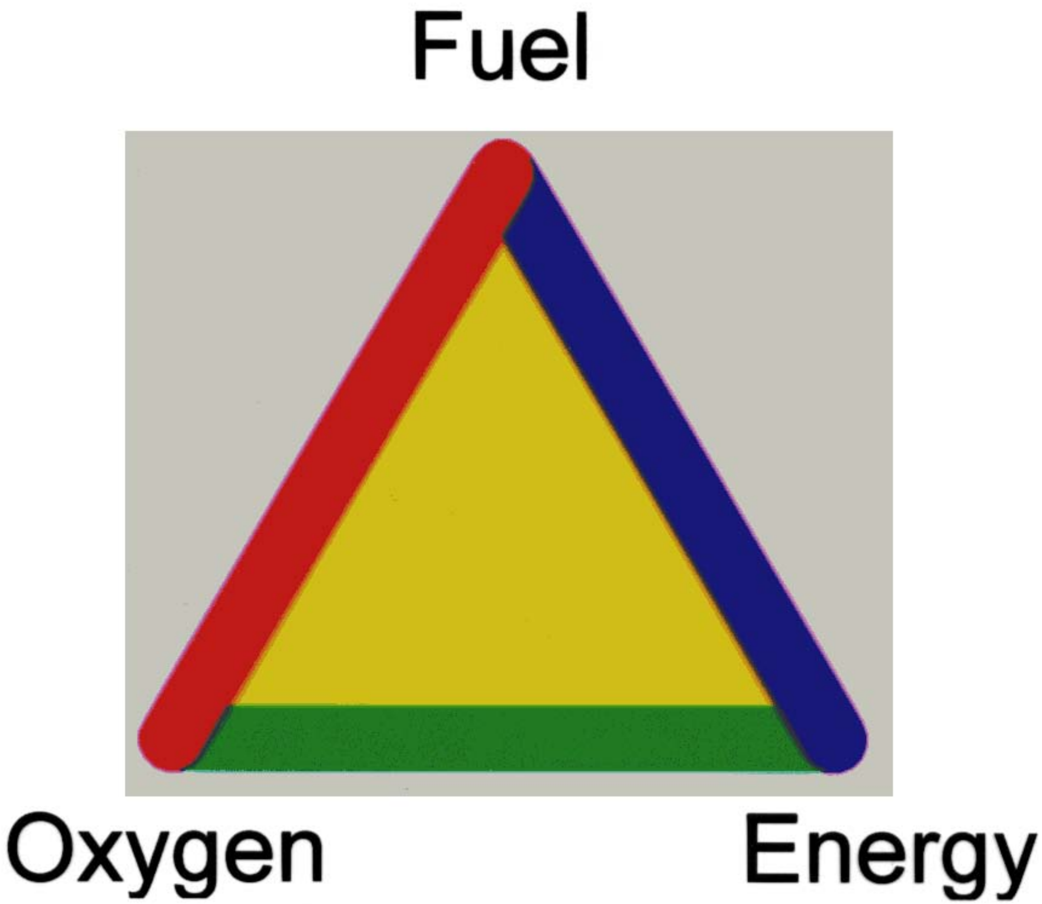


Figure 3.5(a) Typical Large ASME Container Underground Installation. Cathodic protection is not always needed.

Propellant Tank Farm Safety
General



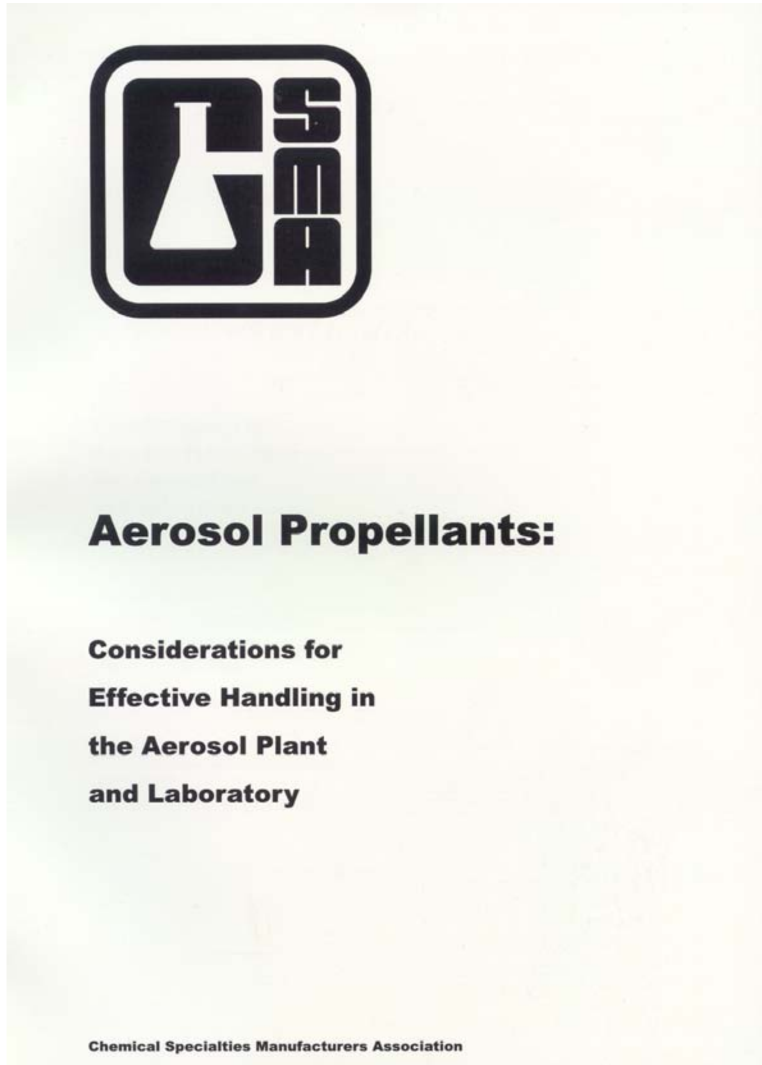
The Fire Triangle

Propellant Tank Farm Safety

Codes and Safety Guides

- **NFPA 58: LP Gas Code**
- **NFPA 30B: Manufacture and Storage of Aerosol Products**
- **CSMA Publication:**
  "Hydrocarbon, Dimethyl Ether and other Propellants: Considerations for Effective Handling in the Aerosol Plant and Laboratory"
  (new edition published in 1999)

Propellant Tank Farm Safety



Aerosol Propellants:

Considerations for Effective Handling in the Aerosol Plant and Laboratory

Chemical Specialties Manufacturers Association

Propellant Tank Farm Safety

Safety Issues with Flammable Liquefied Gas Propellants

- **Flammable**
- **Liquefied Gas**
- **Sudden Release of Pressure**
- **Low Boiling Points**
- **Expansion Ratio**
- **Heavier than Air**
- **Vapors are Colorless and Odorless**
- **BLEVE**

Propellant Tank Farm Safety

General Safety Practices

- **Proper Pressure Ratings for Storage Tanks and Equipment**
- **Storage Tanks must be fitted with safety relief valves set to discharge at container design pressure**
- **Storage Tanks must have liquid level, pressure and temperature gauges**
- **Container openings for Liquid and Vapor service must be fitted with excess flow or backflow check valves as appropriate**

Propellant Tank Farm Safety

General Safety Practices

- Hydrostatic relief valves must be present between isolation valves where liquid could be trapped in the piping.
- There must be emergency shut-off valves and protective bulkheads at transport loading and unloading stations.
- At least one 20 lb. BC type portable fire extinguisher should be located at the storage area.
- Adequate Fire Protection must be provided for storage tanks.

General Safety Practices

- **Electrical Equipment and connections must be explosion proof (NEC Class I, Division I or II, Groups C & D). Note: Group D for Hydrocarbon propellants and HFCs; Group C for Dimethyl Ether (DME).**

- **There must be adequate clearances between propellant storage containers, other groups of storage containers, buildings, and flammable liquid storage areas. See NFPA 58 for details.**

- **Security Fencing with at least two separate access gates should be present around storage tanks or around the entire facility.**

General Safety Practices

- **Consideration should be given to installing automatic detection systems such as combustible gas detectors, Infrared flame detectors, and rate-of-rise temperature detectors. These systems can be used to automatically close shut-off valves, activate plant alarm systems, notify emergency personnel and activate fire protection systems in the event of an emergency.**

Regulations

Regulations

Environmental, Health, & Safety Issues

- **Title V - Clean Air Act Operating Permits**
- **OSHA PSM - Process Safety Management**
- **EPA RMP - Risk Management/Worst Case Scenario**
- **Yearly Emission Reporting**
- **Right-to-Know Reporting**
- **Employee Training**

An Introduction to Liquefied Gas Aerosol Propellants

Diversified CPC International, Inc. offers custom regulatory compliance programs to meet OSHA PSM (*process safety management)* and EPA RMP (*risk management program)* regulatory requirements.

Diversified CPC International, Inc. can meet all your high purity aerosol propellant requirements

Visit our website at www.diversifiedcpc.com for more information on our products.

ISO 9000:2000

Channahon, Illinois

Sparta, New Jersey

Questions

Thank you

for

sharing this time with us !