19 October 2018

Mr. Lou Dinkler
Manager, California Air Resources Board
Monitoring and Laboratory Division
1900 14th Street
Sacramento, CA 95811

Submitted electronically to ldinkler@arb.ca.gov

Re: Proposed Amendments to Enhanced Vapor Recovery Regulations to Standardize Gas Station Nozzle Spout Dimensions to Help Address Storage Tank Overpressure

Dear Mr. Dinkler,

ARID Technologies develops and manufactures the PERMEATOR system that actively manages storage tank pressure while at the same time reducing emissions of VOC's and HAP's. As you know, our system recently passed the extremely challenging battery of tests at our sealed test site in the Sacramento area. These tests included compliance with stringent pressure and emissions standards while simulating pressure while dispensing or PWD for extended time periods at the GDF. We are awaiting issuance of an Executive Order in accordance with our system meeting all of the stated standards and requirements.

While the establishment of a cross-functional working group and encouragement of a cooperative working relationship with automobile, fuel system and nozzle manufacturers is a noble accomplishment, it seems that the overall goal of "addressing storage tank overpressurization" is a missing element in this effort.

If nozzle diameters, sealing surfaces, fixed and tapered zones and internal locking lip depths are completely optimized to yield a theoretically perfectly fitting nozzle boot with zero vapor leakage, it seems that EVR systems, operating in conjunction with high ORVR vehicle populations, will simply reach the negative cracking pressure of the pressure/vacuum (P/V) valves sooner relative to nozzles which are not so tight at the vehicle/nozzle interface. The implication of this effect from the storage tank perspective is to draw in ambient air from the P/V vent valves during busy refueling periods. (For those unfamiliar with this impact; please consider 10 gallons of fuel dispensed to a vehicle; where 2 to 4 gallons of vapor are returned to the storage tank ullage with an EVR vacuum assisted system).

The dynamics within the combined storage tank ullage are determined by relative rates of air ingestion, fuel vaporization and liquid dispensing rate. The fuel dispensing rate "creates more space" within the ullage, while the air ingestion and fuel vaporization rates "occupy space" within the ullage. From ARB internal studies, it seems that the maximum liquid evaporation rates reach on the order of 450 gallons per hour, depending of course on many factors. For CA GDF dispensing fuel at average rates of 2,500 to 3,500 gallons per hour, it is clear that such sites will maintain negative pressures (vacuum) in their ullage space during "open hours". Next, when such sites close at night (or pump much lower fuel volumes in the "off hours"), the air, which was previously ingested, will begin the resaturation process as liquid fuel evaporates to vapor phase fuel. The volume expansion is quite significant, as 1 gallon of liquid gasoline will expand to 520 gallons of vapor at 40% hydrocarbon concentration. This volume expansion is the root cause of the Overpressure (OP) problem at CA GDF. For these sites, the modified nozzle at the vehicle/automobile interface will have no impact on OP Alarms. What will have an impact is a vapor processor that actively manages the tank pressure. [1]

The ARB documents related to this proposed rulemaking note "unexpected pressure driven emissions cause GDF vapor recovery systems not to achieve the performance standards and emission reductions anticipated when EVR regulations were adopted".[2] We can clearly state that such emissions are not unexpected; they are the result of air ingestion via the nozzle/automobile interface or via the P/V vent line. If air ingestion is artificially limited at the nozzle/automobile interface, the P/V vent line will simply make up the difference and provide an alternate route for the air to enter the combined ullage space of the storage tanks. Again, this is the root cause of the OP problem at CA GDF.

For other CA GDF pumping at lower rates, PWD would not be expected until dispensing rates approach approximately 700 gallons per hour. For such lower pumping sites; without modified nozzles, perhaps PWD could be seen at pumping rates of 1,000 gallons per hour. In addition, the average hydrocarbon concentration of the PWD emissions tend to be much lower than the average hydrocarbon concentration of the off-hours emissions, since the vapors vented during closed (or slower pumping periods) have had ample time to reach higher levels of saturation.[3] The net effect is a significantly increased mass emission rate from the off-hours emissions in comparison to PWD emission rates.

Can you please explain how the extensive nozzle improvement initiative impacts the above dynamics?

ARB documents seem to stress the importance of reducing ISD Alarm response costs with implementation of modified nozzles. However, has ARB quantified the level of

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[1] ARID Presentation (attached) from the CAPCOA Quarterly meeting, 25 JULY 2018, SanDiego, CA

[2] Staff Report, Initial Statement of Reasons (ISOR), 4 September 2018, page 1

[3] ARID Presentation (attached) from the CAPCOA Quarterly meeting, 25 JULY 2018, SanDiego, CA, Slide #37

vapor recovery efficiency gain at the vehicle/nozzle interface possible with such nozzles in conjunction with use of ORVR? Next, relative to such potential improvement on collection efficiency, what is the negative impact on vent and fugitive emissions during the off-hours repressurization of the ullage space? Has ARB quantified these impacts as a function of zero leakage nozzle boots? It seems that the net effect on mass emissions should be quantified and compared to the costs incurred in modifying the nozzles. Such an analysis might incorporate low, moderate and high throughput GDF to help Stakeholders understand the sensitivity to the various GDF segments.

We are disappointed that ARB documents refer to some future "Comprehensive Menu of Overpressure Solutions" being available in 2020[4]; we have a commercially robust and proven system available immediately, and we are frustrated that issuance of an Unconditional EO seems to be delayed by ARB. We are bewildered not only by ARB failing to mention anything about relative merits of vapor processing in comparison to the nozzle modification, but also by ARB lacking a sense of urgency in issuing ARID a timely Unconditional EO to mitigate the significant problem of VOC and HAP emissions at California GDF.

As a certified program under Section 21080.5 of CEPA, ARB is obligated, under its own regulations, to consider all alternatives to a proposed regulation and to select the one, which achieves the purposes of the regulation in a manner that has the least adverse impact on the environment.[5]

Sincerely,

Tedmund Tiberi
President & Founder
ARID Technologies, Inc.
www.ARIDtech.com
ttiberi@ARIDtech.com
630-681-8500

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[4] Staff Report, Initial Statement of Reasons (ISOR), 4 September 2018, page 4

[5] California Code of Regulations, Section 60006, states:

> Any action or proposal for which significant adverse environmental impacts have been identified during the review process shall not be approved or adopted as proposed if there are feasible mitigation measures or feasible alternatives available which would <u>substantially reduce those impacts</u>. (Emphasis added)

ARID TECHNOLOGIES INC.

Vapor Recovery Observations and COSTCO Experience with ARID PERMEATOR

CAPCOA Meeting San Diego

25 JULY 2018

Tim Hurlocker, COSTCO

Ted Tiberi, ARID Technologies, Inc.

ARID Background

ARID TECHNOLOGIES INC.

- Entrepreneurial company, Founded 1993
- Deep knowledge of GDF emissions and operations
- Unique solution/diffusion membrane and proprietary data acquisition gear
  - Patents, Publications, Models, & Algorithms
  - CARB Certified, EO G-70-209, October 2006
  - 600 Permeator Systems Installed Globally
    - USA, Japan, Mexico China, Taiwan, S. Korea, Italy
    - Commercially proven and robust system

Purpose

- Purpose of my visit today is to objectively discuss technical aspects of storage tank evaporation, summarize our CA testing and Certification efforts with COSTCO and to share some of the information we've learned

General Overview

ARID TECHNOLOGIES INC.

- Sealed Test Site Cal Expo 471
  - Initiated testing December 2014
  - Completed 180 day operational test end of April 2018
    - Passed all metrics during operational test, including rigorous emissions challenge mode test
      - Air sparged into fuel tanks; inlet concentration up to 78% HC (by vol as C3) and minimum flowrate of 350 gallons per hour
        - Permeator emission factor of 0.001063 lb/1,000 gal is 160 times lower than Healy nozzle factor
        - Healy system emission factor is 228 x higher (. 243 lb/1,000 gal)

Technical Discussion Overview

- Fundamentals of Vapor Generation in gasoline storage tanks
- Pressure Profile from Test Sites and Certification Site
- Emissions Reductions and ISD Parameters
- Practical Implications
- Membrane Basics

Vapor Generation

- Air ingestion reduces hydrocarbon concentration in the vapor (ullage) space of the storage tanks
- The liquid fuel will evaporate in an effort to re-establish the equilibrium hydrocarbon concentration in the ullage space
- The equilibrium hydrocarbon concentration is a function of three primary variables
  - Fuel RVP, Reid Vapor Pressure (function of season)
  - Fuel Temperature
  - Altitude of the Fueling Station

Vapor Generation (cont'd.)

- The vapor growth rate (evaporation rate) is in general proportional to the concentration difference between equilibrium and clean air
- The vapor growth rate occurs whenever a concentration difference exists in the ullage space

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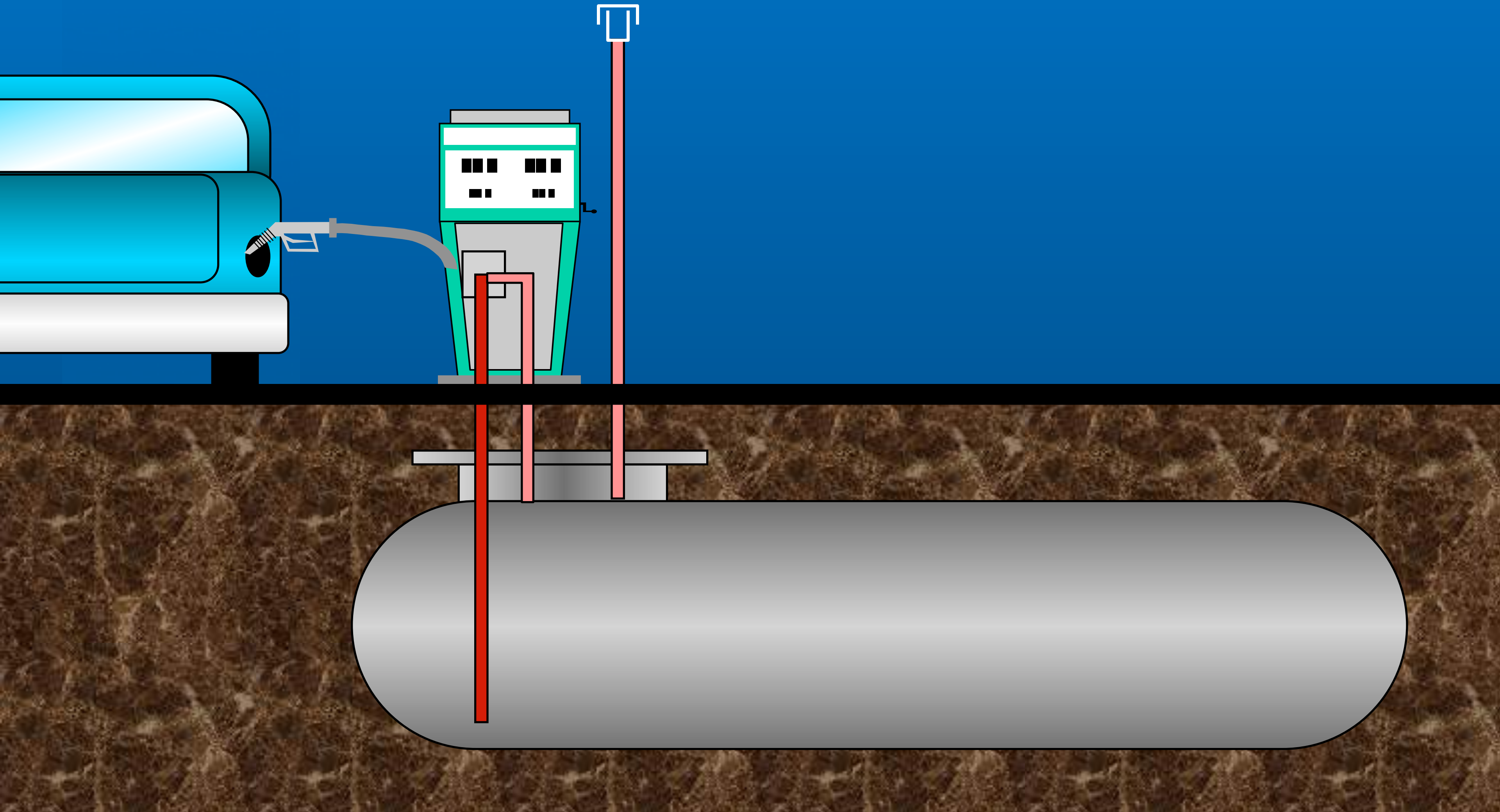
Stage II Recovery Systems



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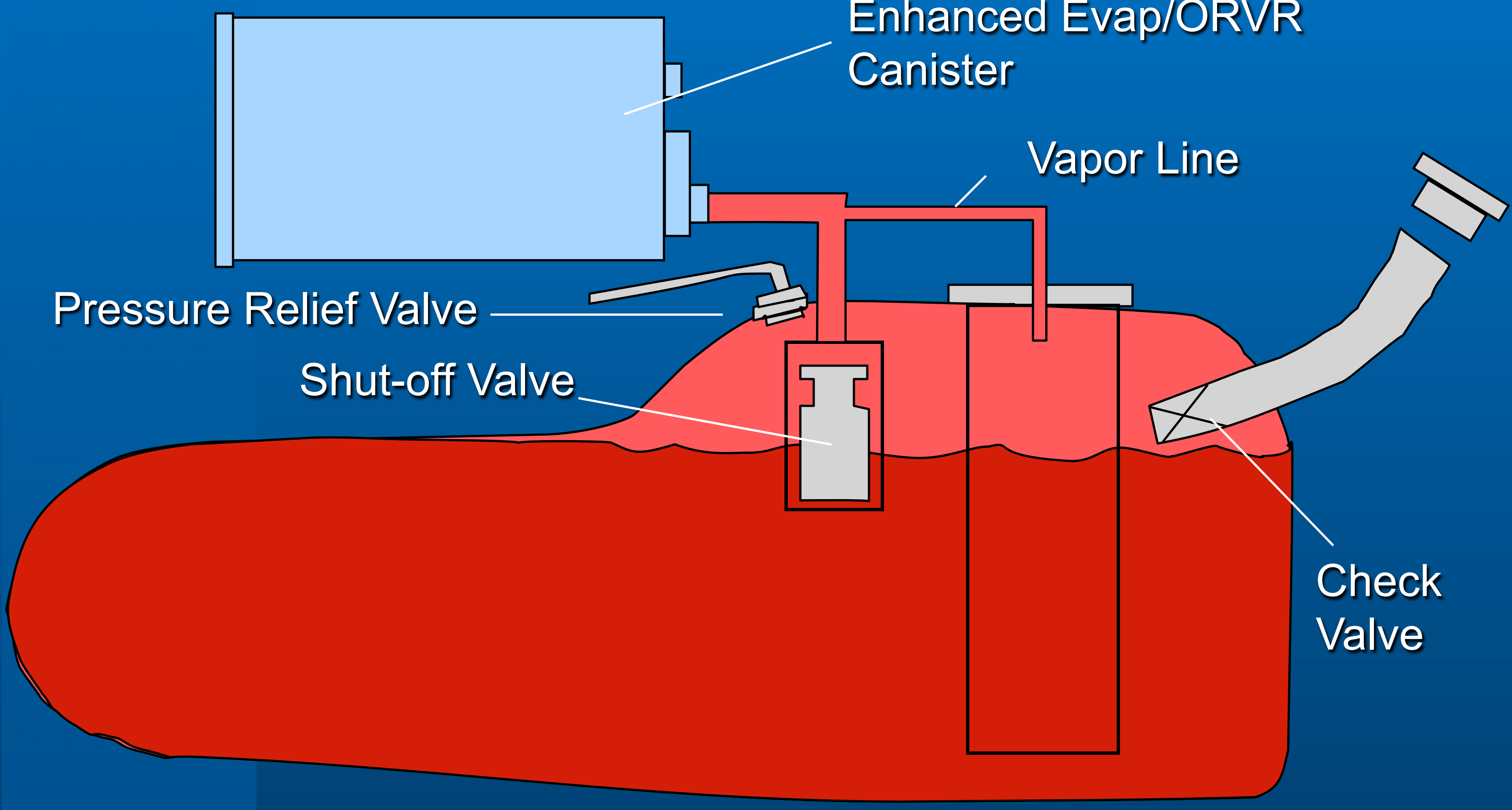
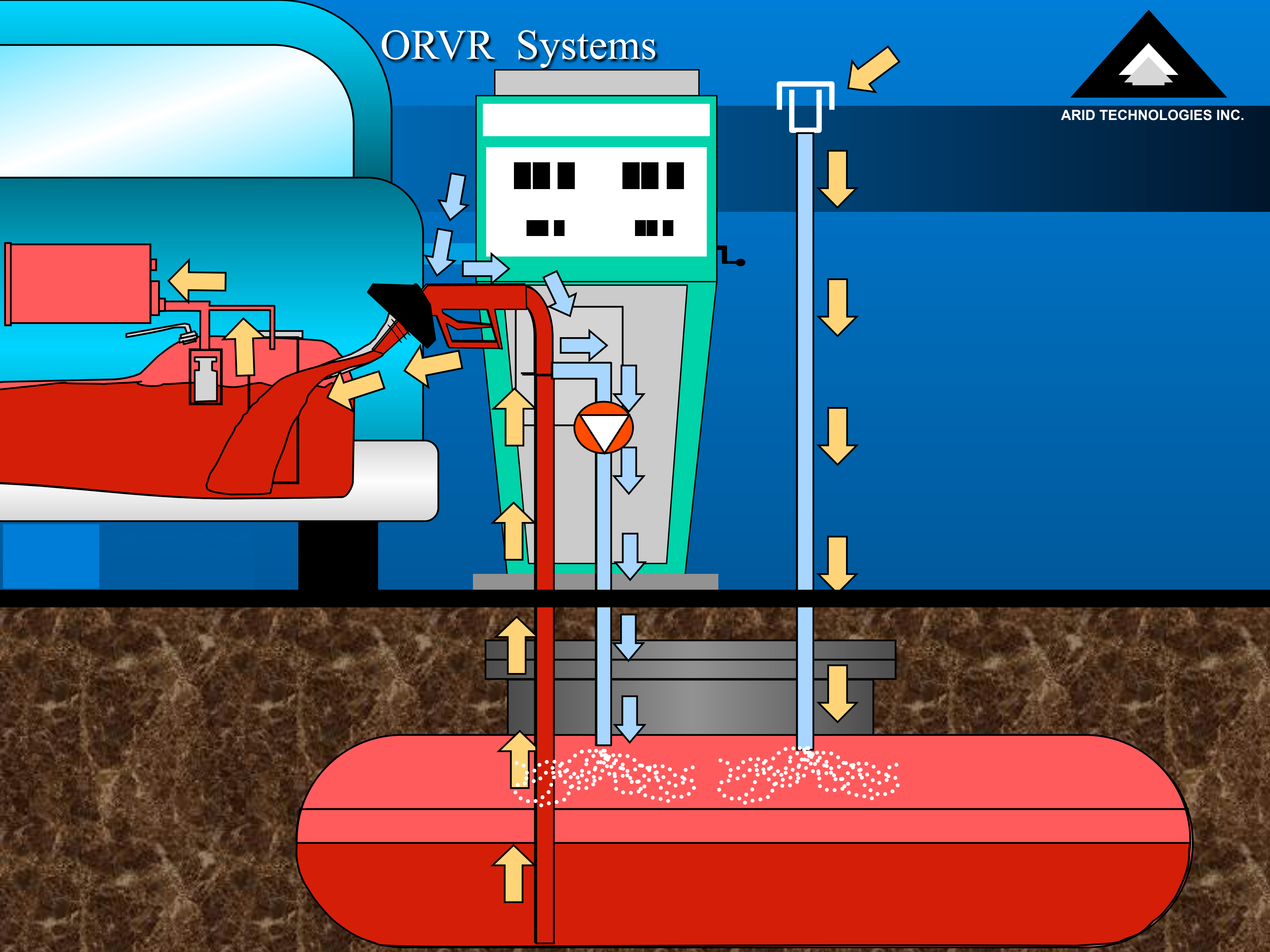
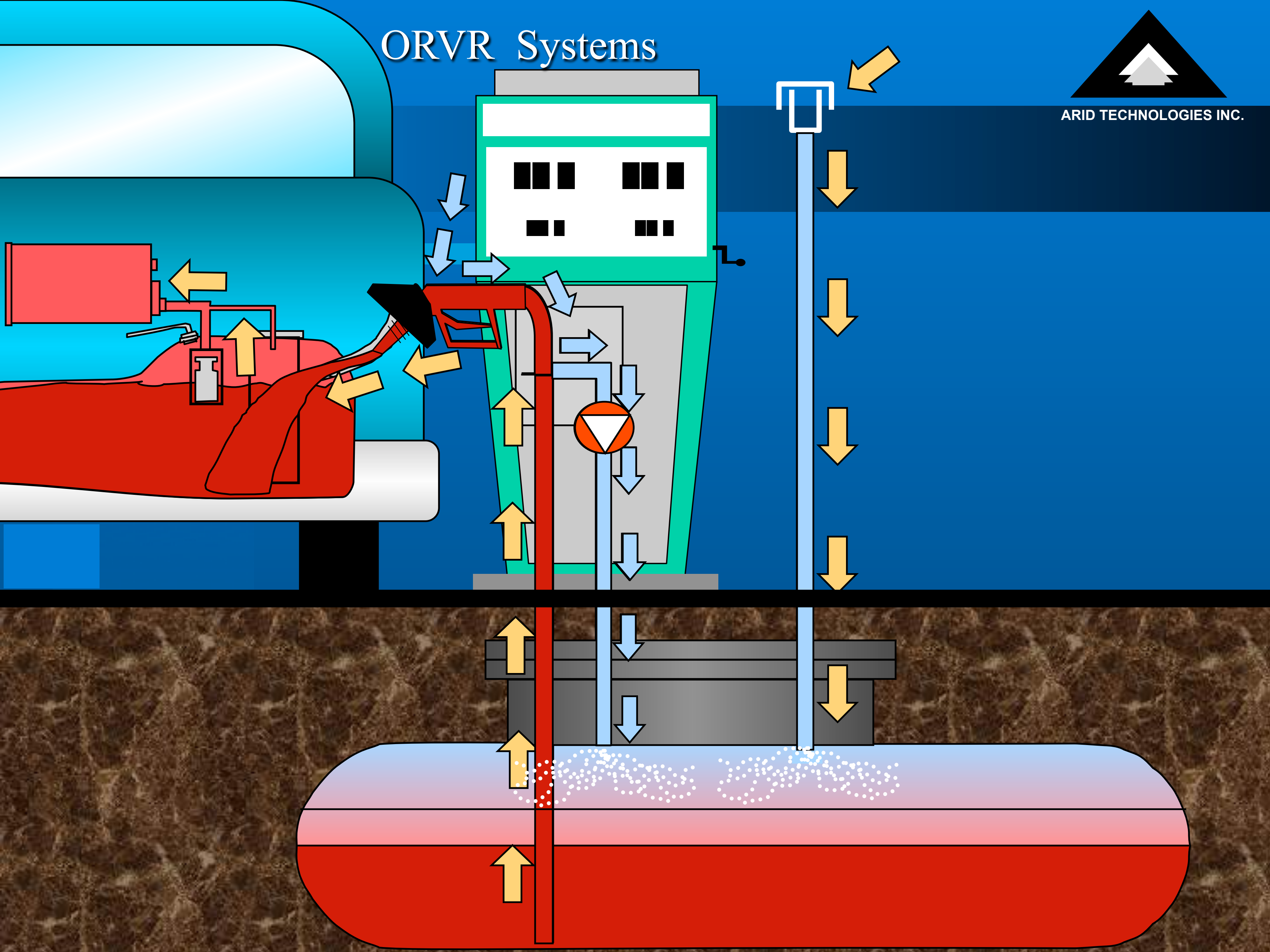
ORVR Configuration




ORVR Systems
ARID TECHNOLOGIES INC.

ORVR Systems



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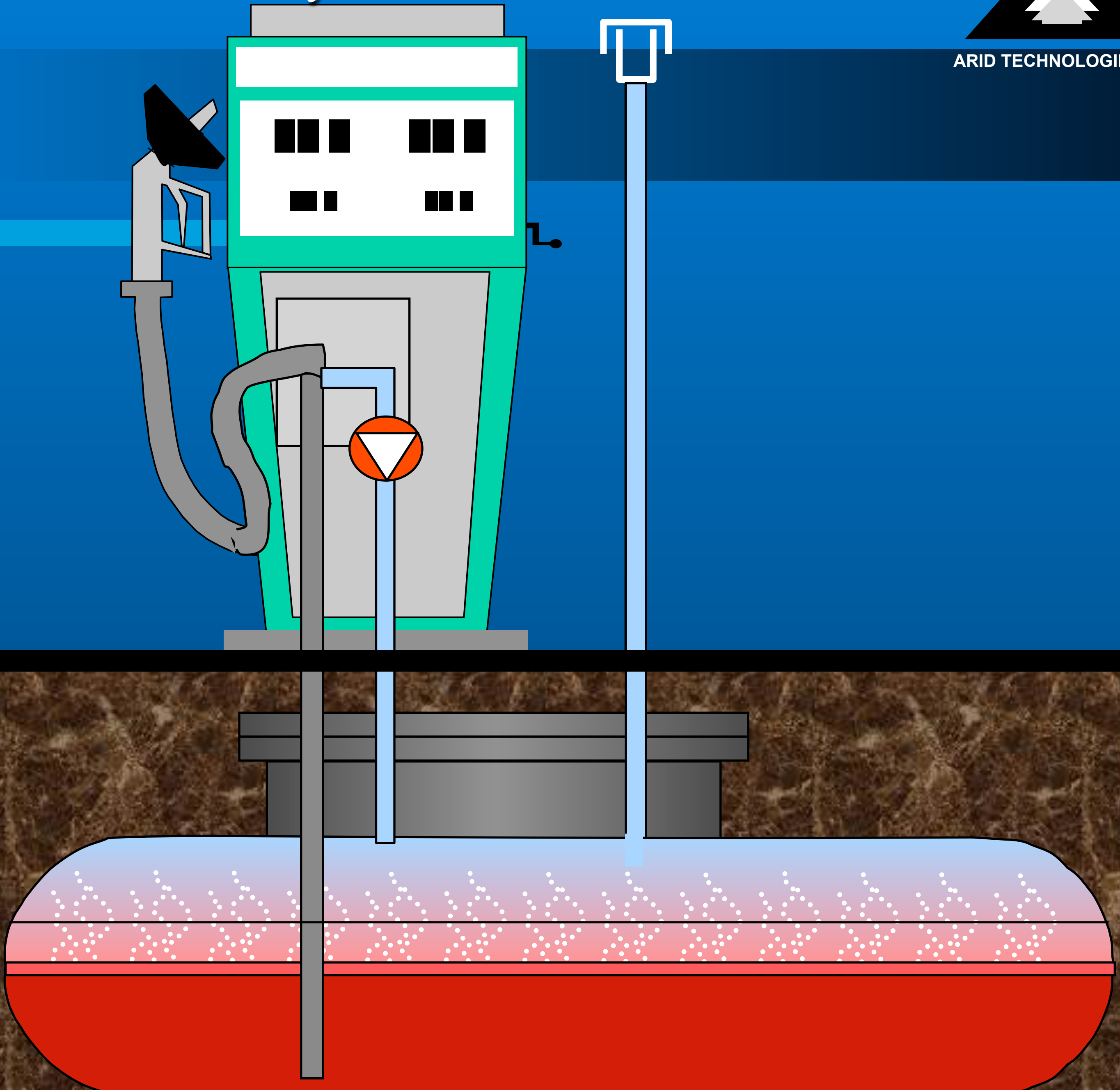
ORVR Systems



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ORVR Systems

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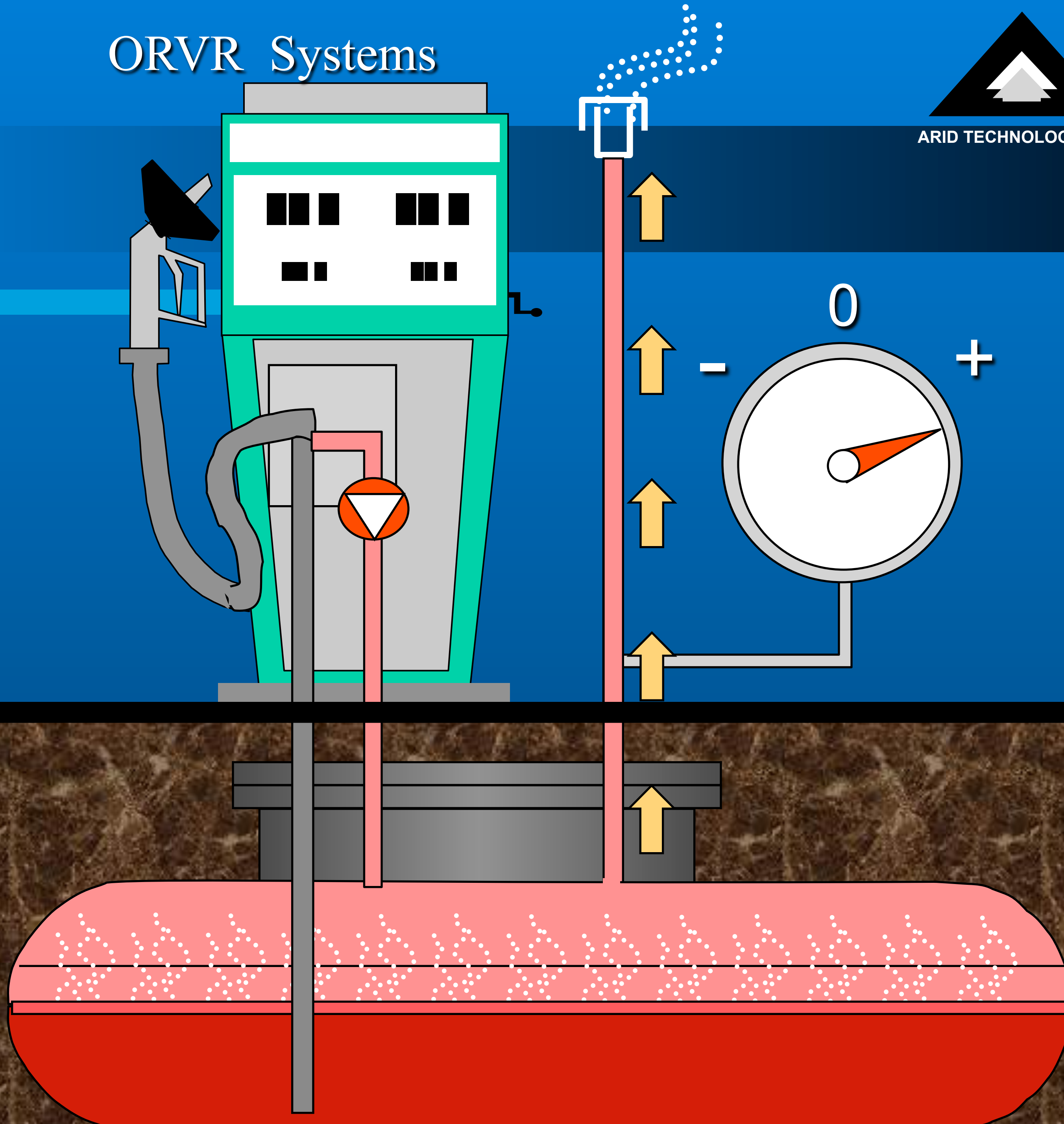
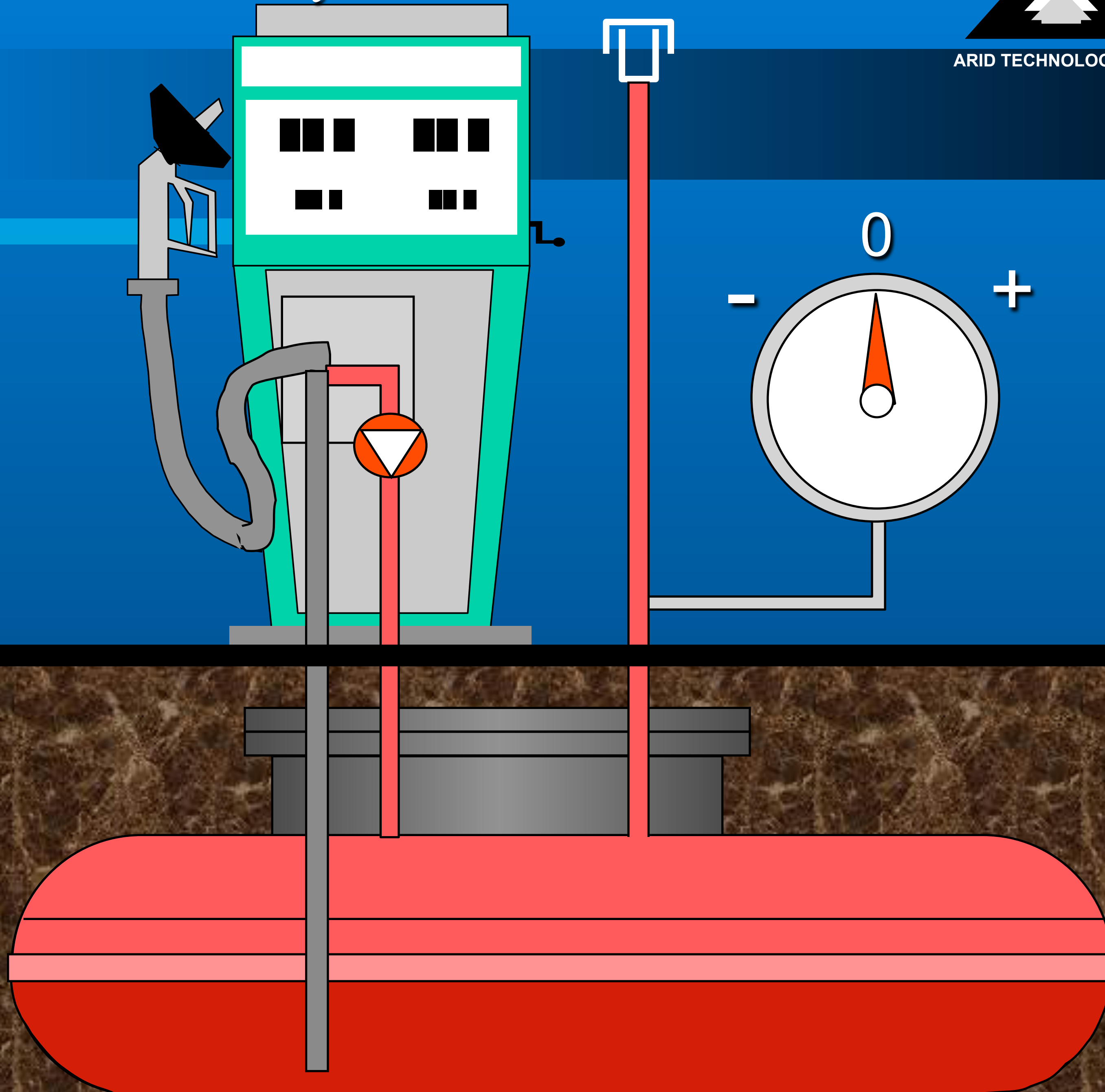


ORVR Systems

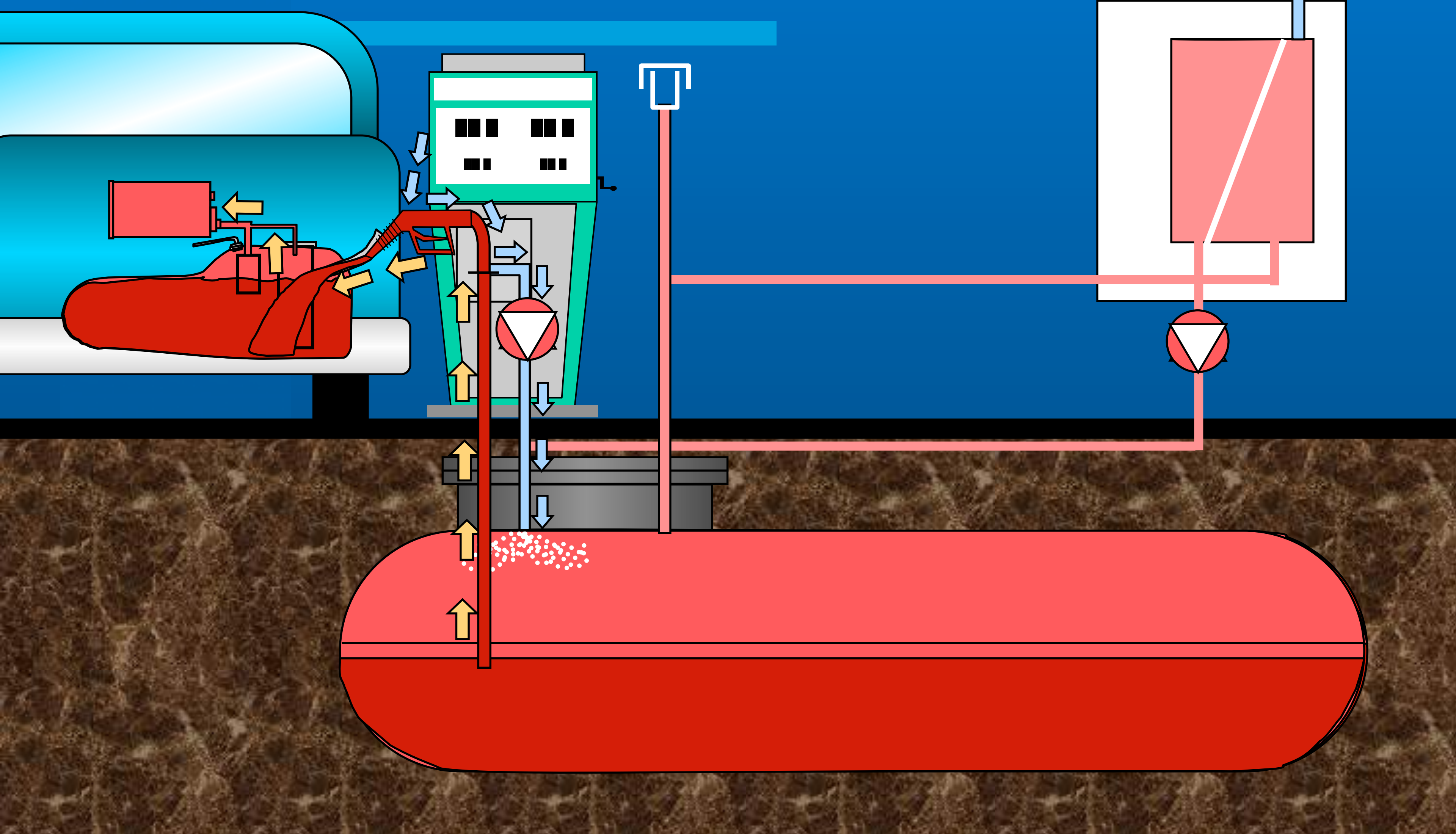


PERMEATOR Function

- Permeator actuates in response to overpressure in the ullage space
- Permeator membrane exhausts a clean air stream to atmosphere and directs a hydrocarbon enriched stream back to the ullage space
- By expelling air and increasing hydrocarbon concentration in the ullage, the evaporation process is reduced or altogether eliminated
- Permeator significantly reduces evaporative emissions while at the same time conserving valuable fuel

Permeator™ Systems

ARID TECHNOLOGIES INC.



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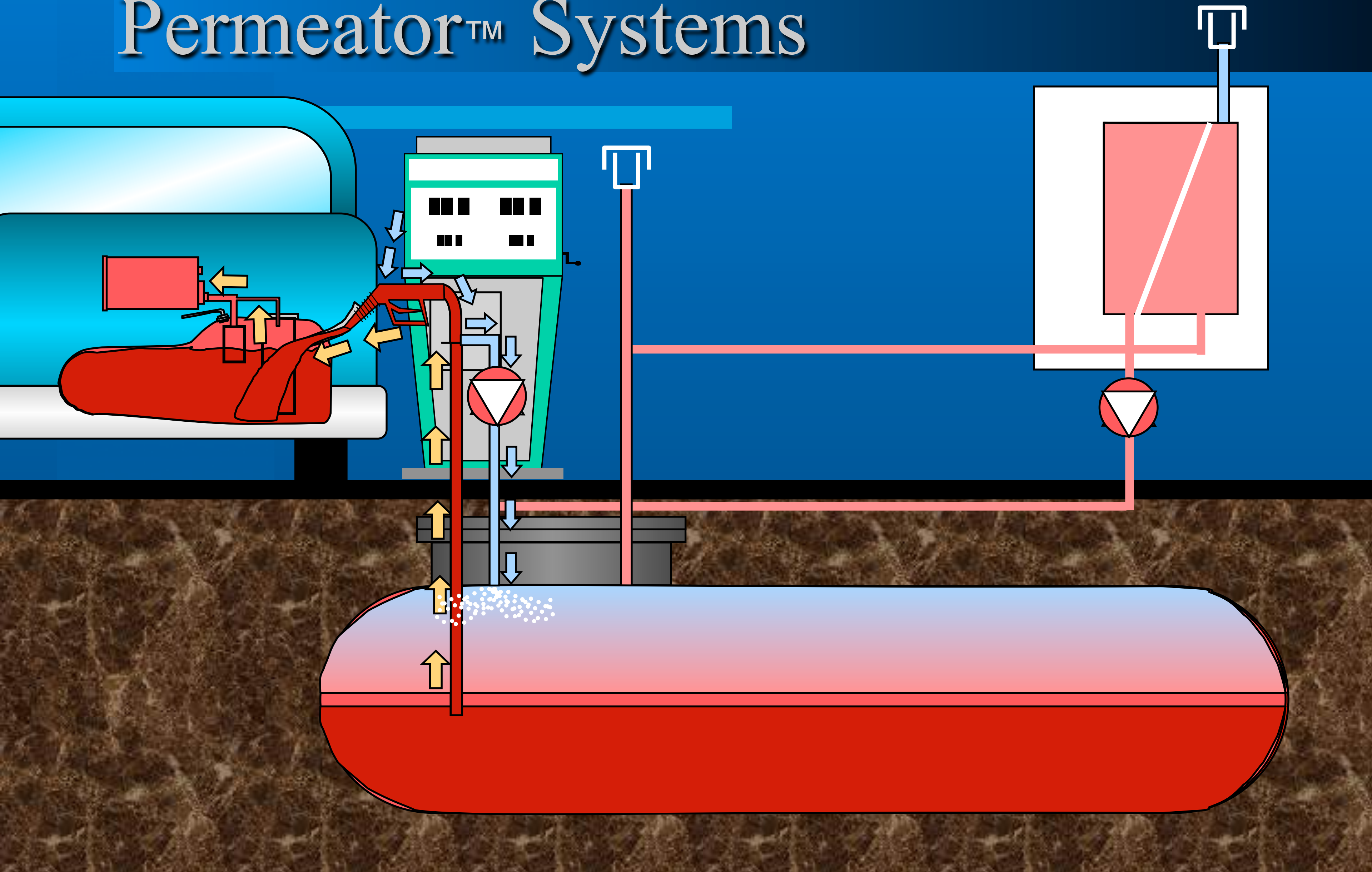
Permeator™ Systems



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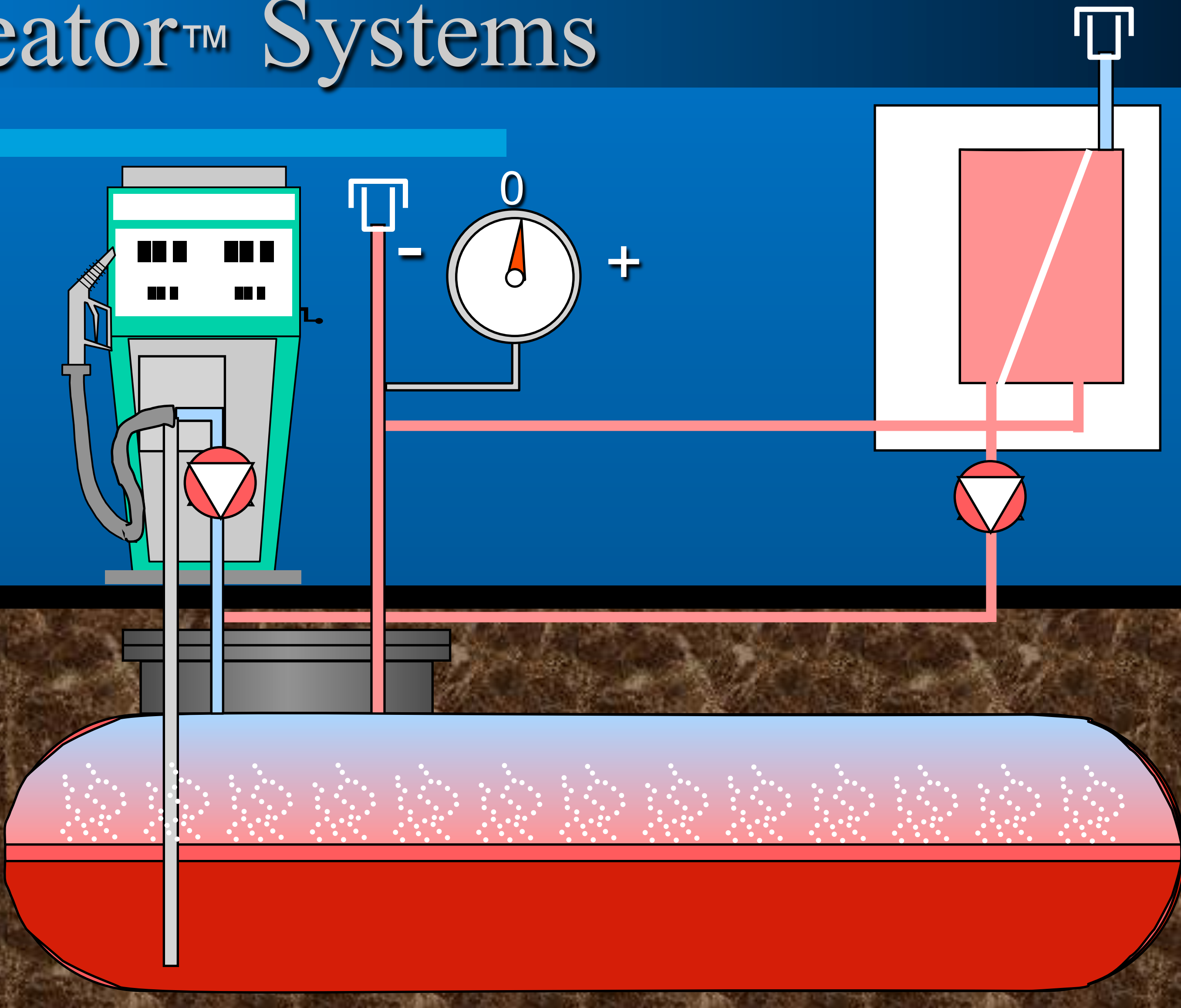
Permeator™ Systems



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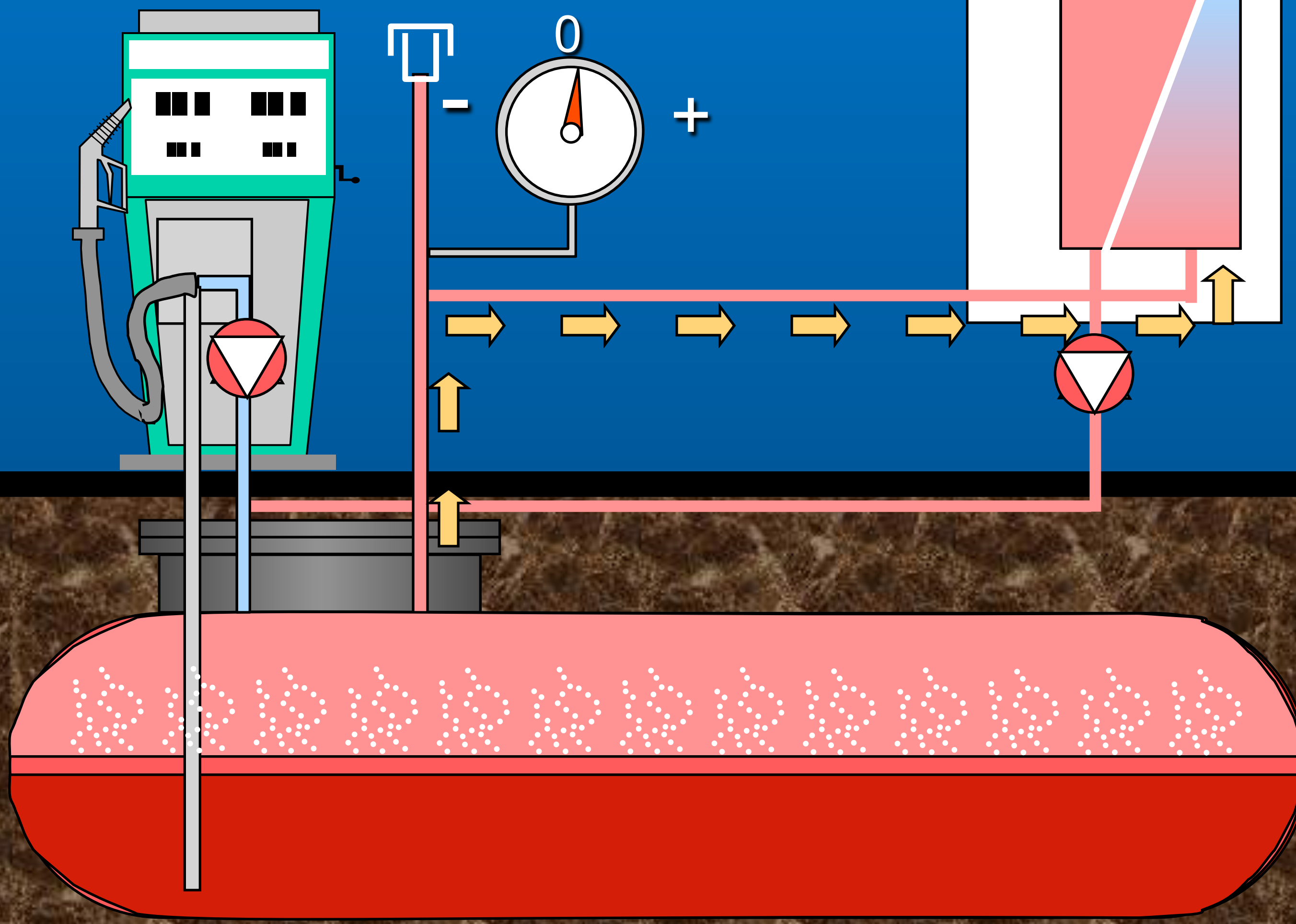
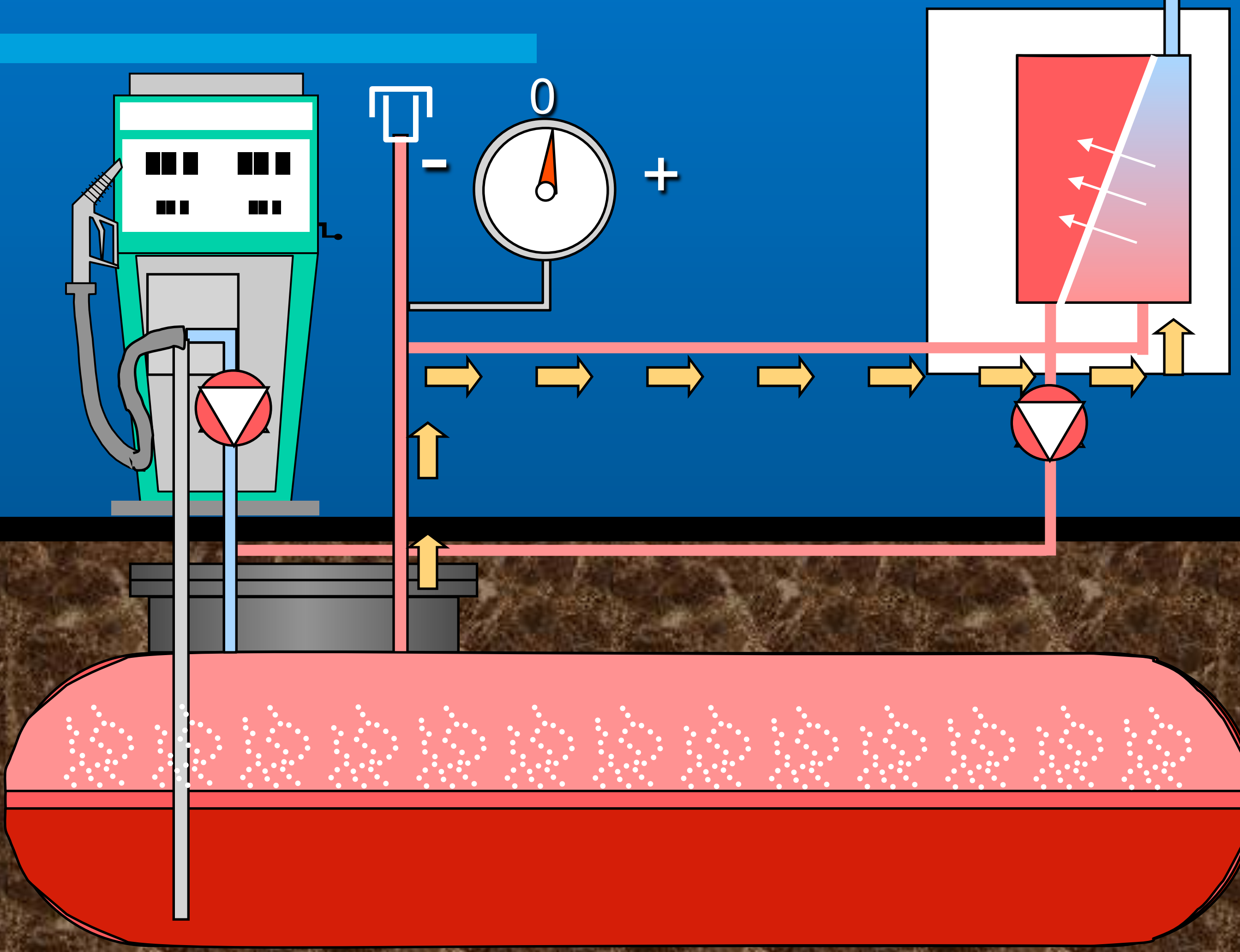
Permeator™ Systems



Permeator™ Systems



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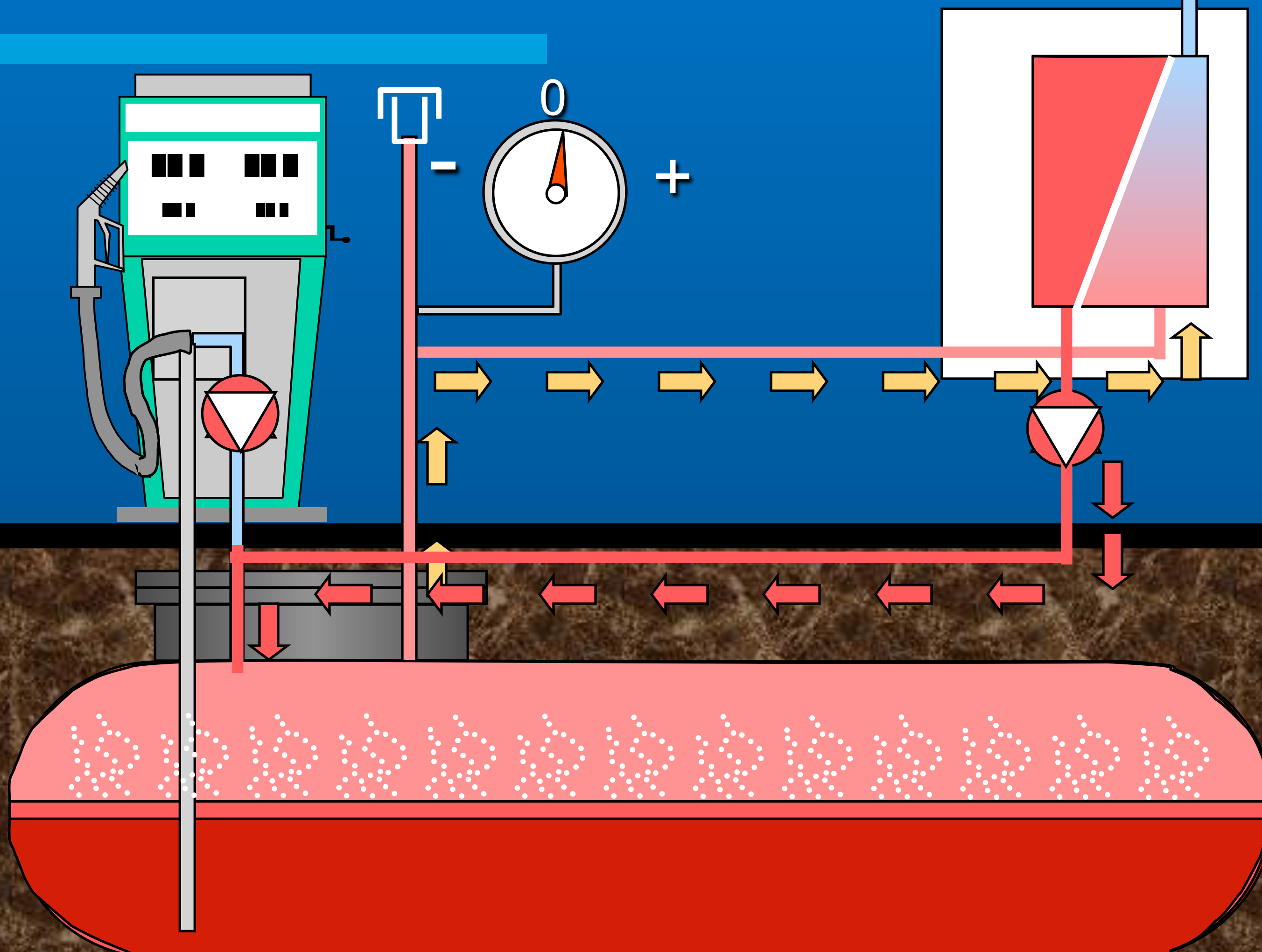
Permeator™ Systems



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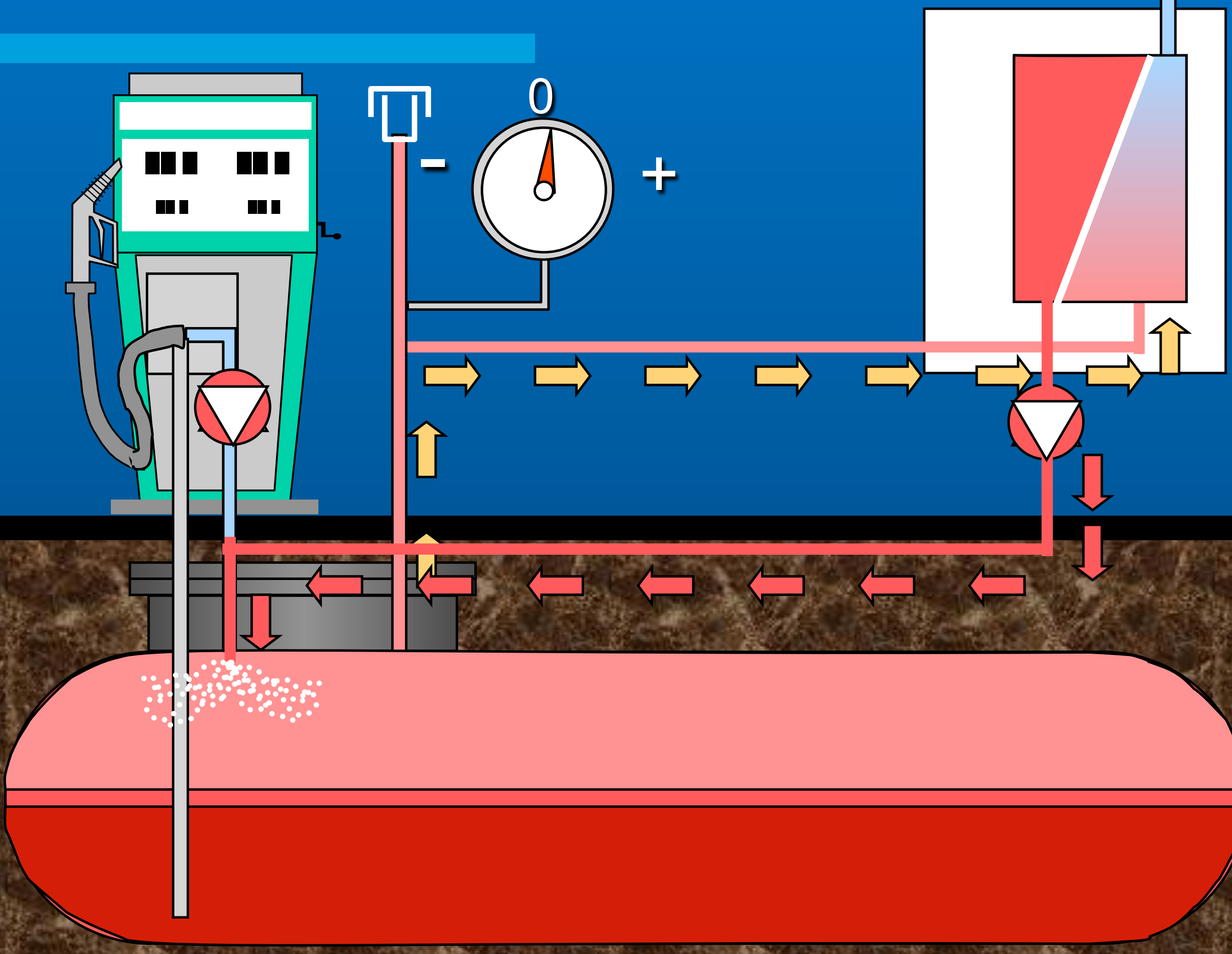

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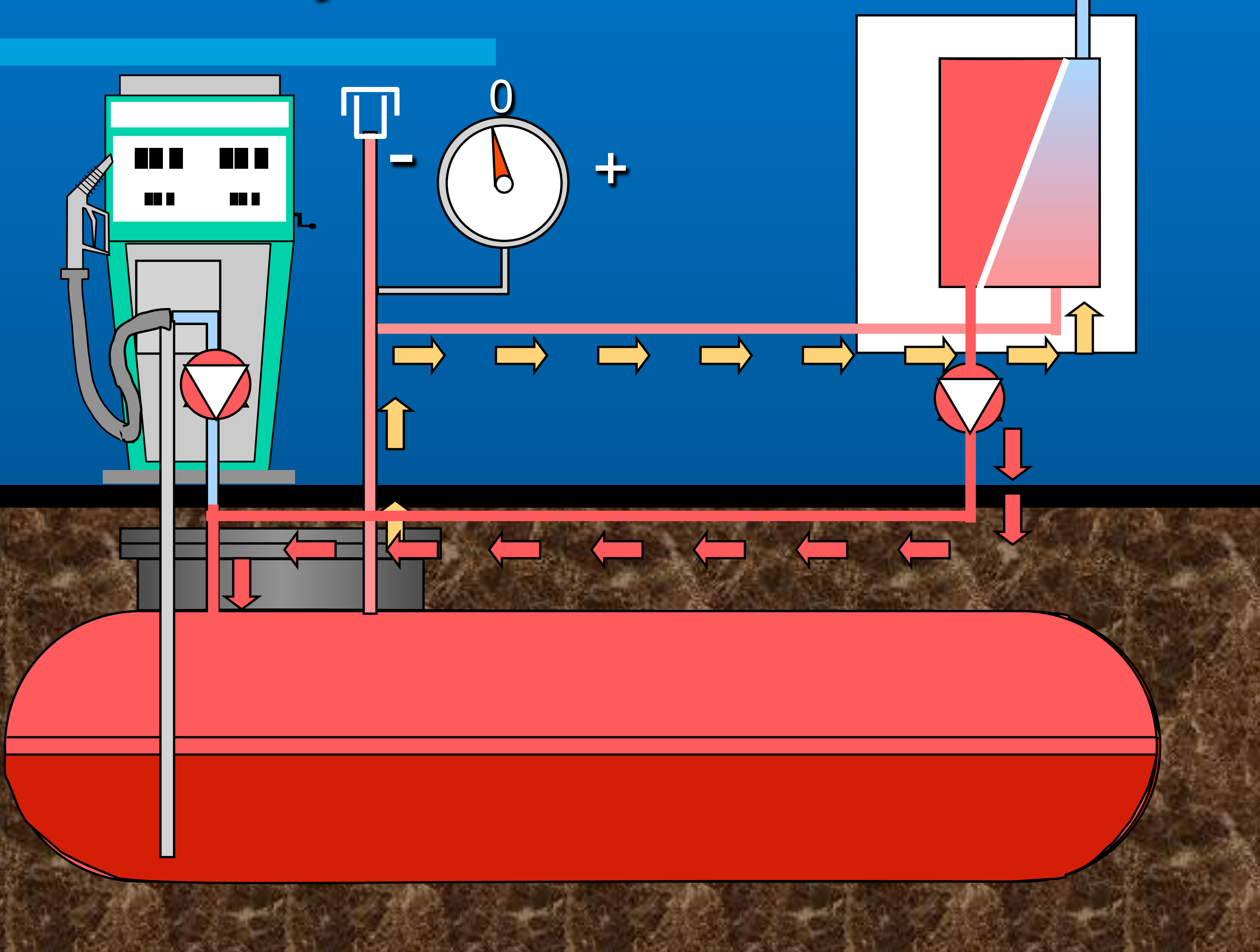
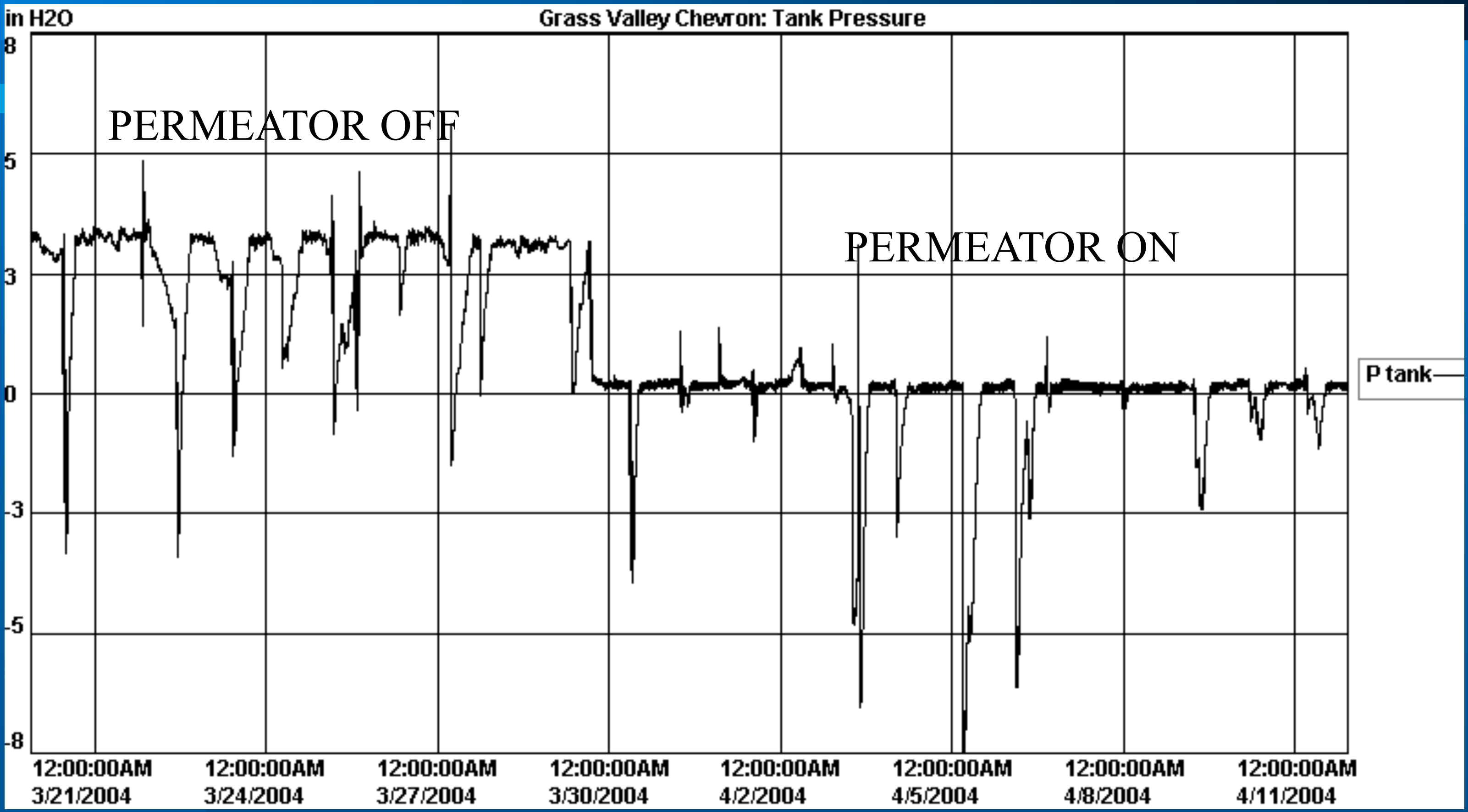
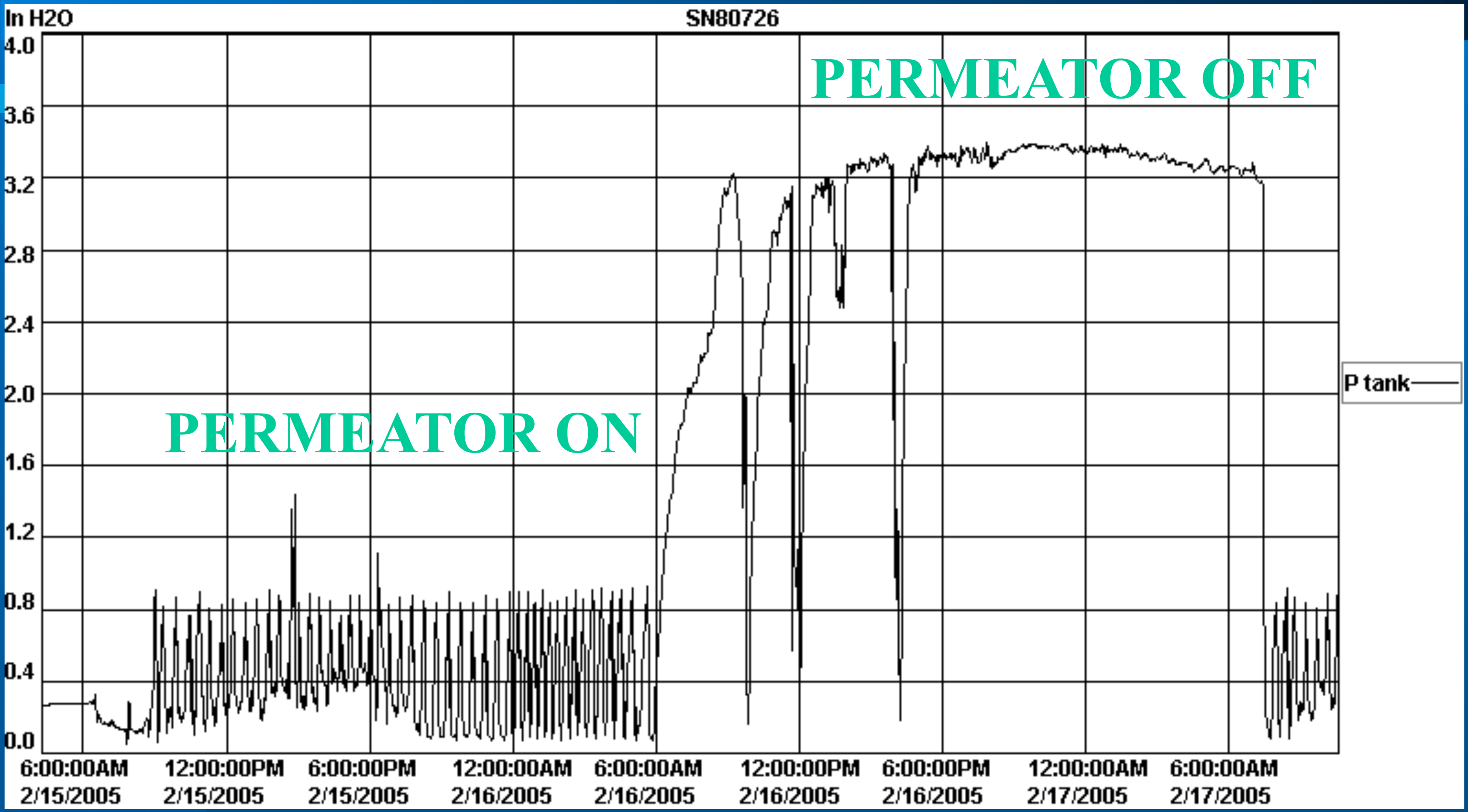


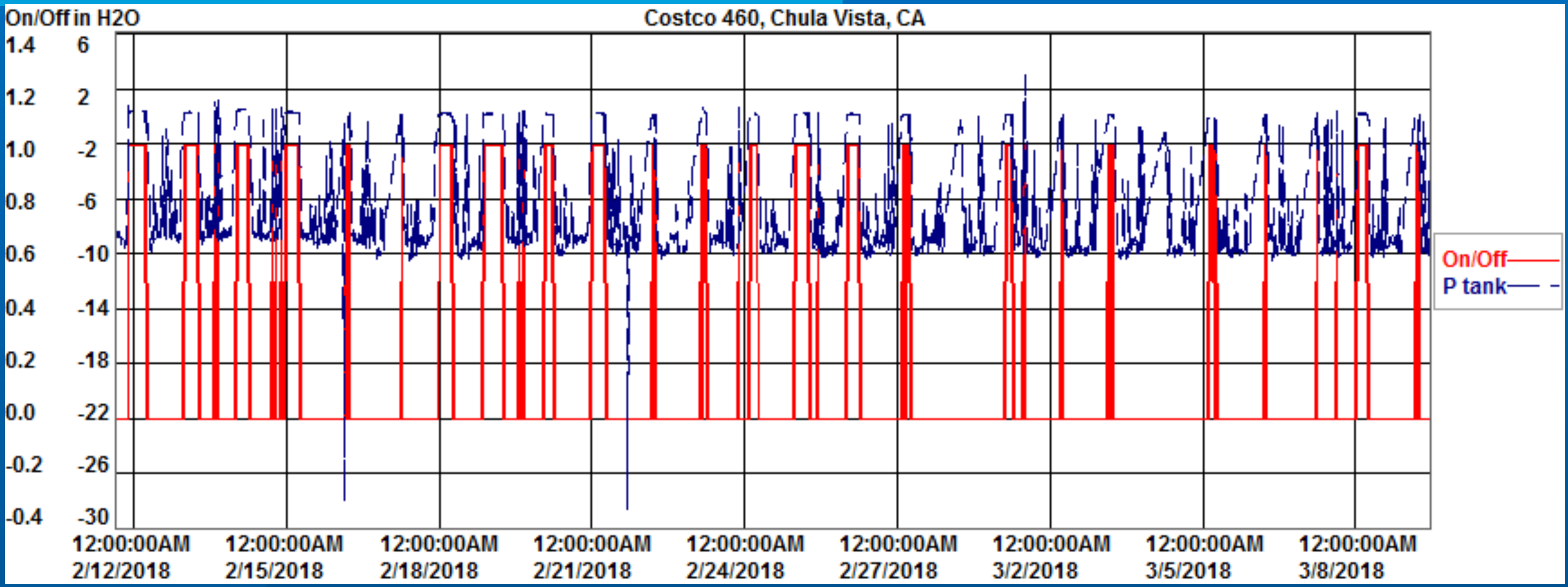


in H2O
Grass Valley Chevron: Tank Pressure
8
5
3
0
-3
-5
-8
PERMEATOR OFF
PERMEATOR ON
P tank
12:00:00AM 3/21/2004
12:00:00AM 3/24/2004
12:00:00AM 3/27/2004
12:00:00AM 3/30/2004
12:00:00AM 4/2/2004
12:00:00AM 4/5/2004
12:00:00AM 4/8/2004
12:00:00AM 4/11/2004

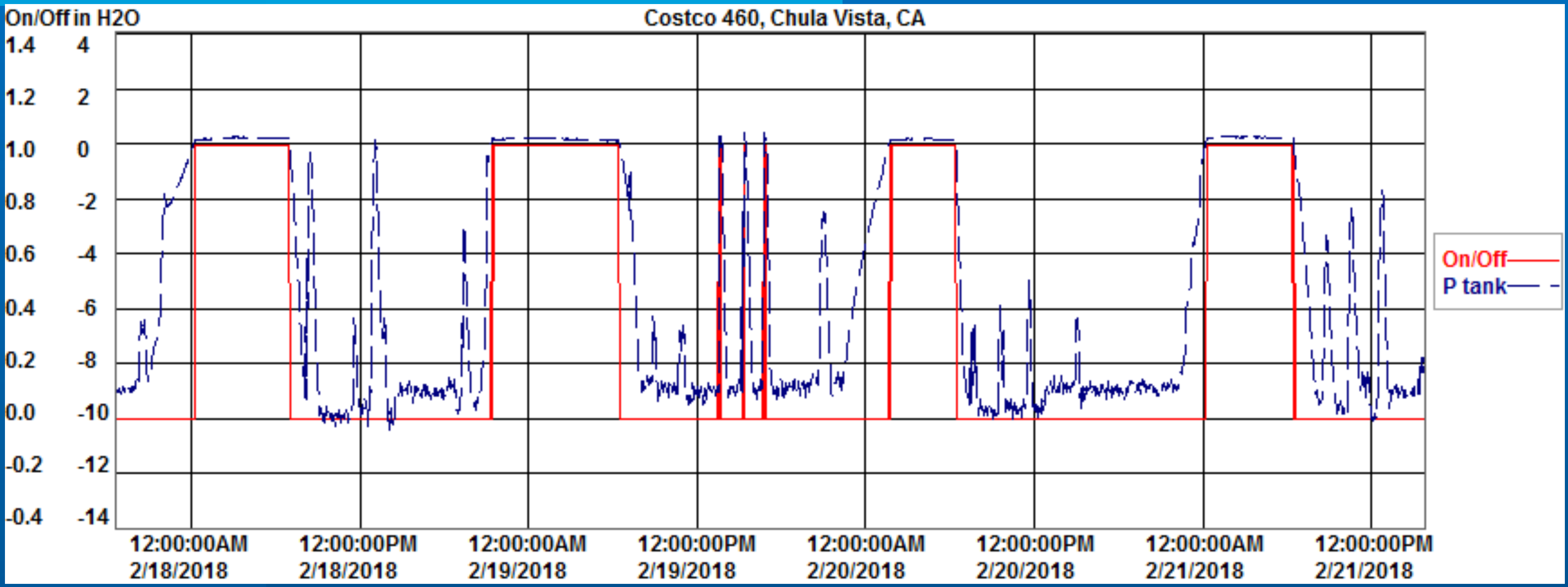
Lantana, Florida Test Site



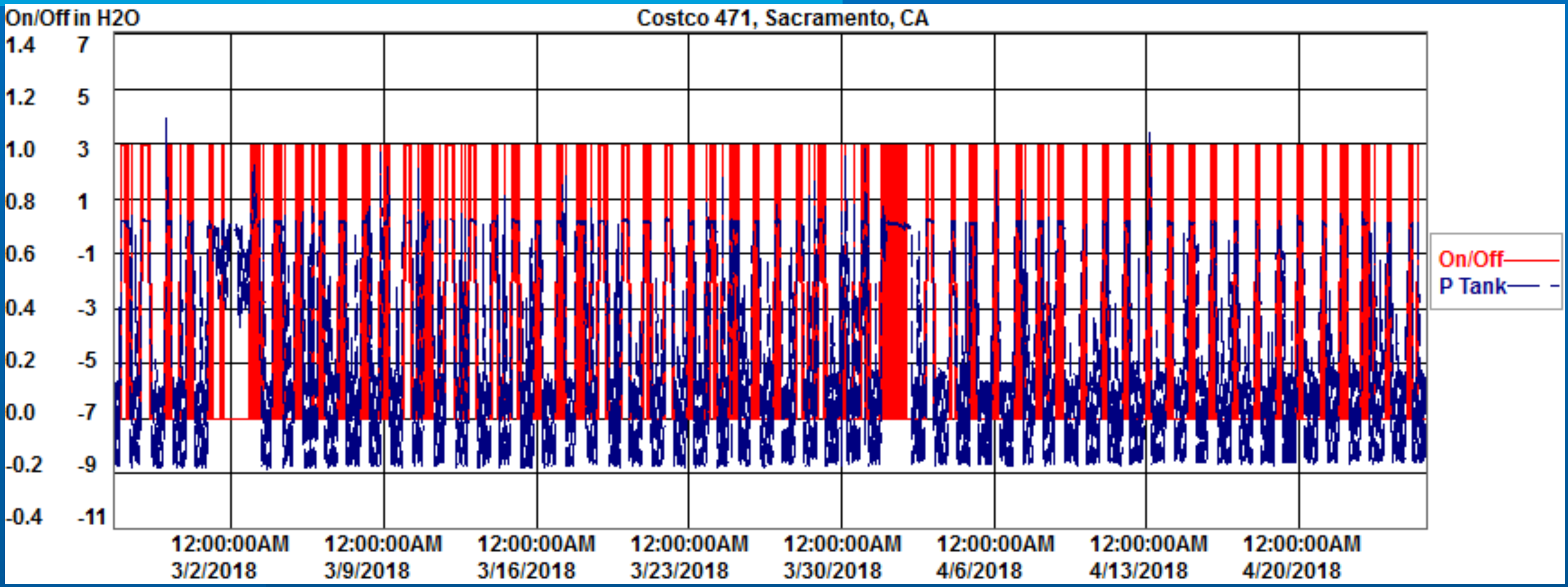
460 Chula Vista



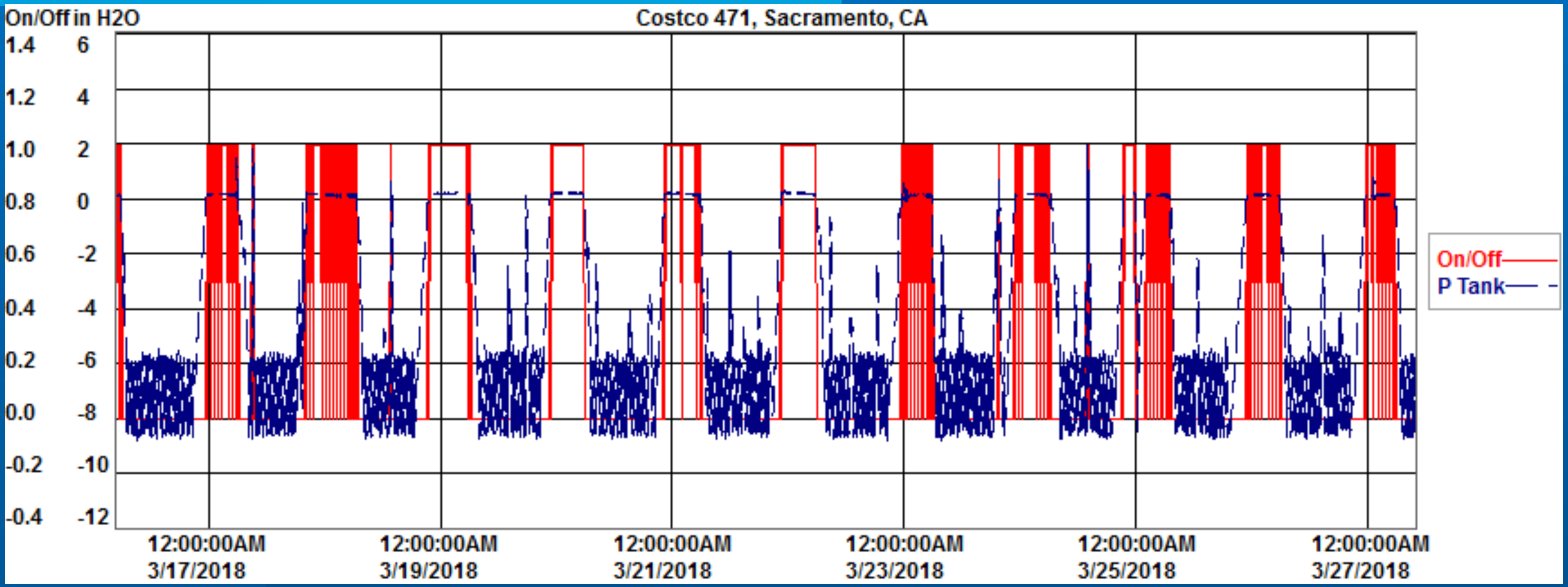
460 Chula Vista



471 Cal Expo


On/Off in H2O
Costco 471, Sacramento, CA
1.4 7
1.2 5
1.0 3
0.8 1
0.6 -1
0.4 -3
0.2 -5
0.0 -7
-0.2 -9
-0.4 -11
12:00:00AM 3/2/2018
12:00:00AM 3/9/2018
12:00:00AM 3/16/2018
12:00:00AM 3/23/2018
12:00:00AM 3/30/2018
12:00:00AM 4/6/2018
12:00:00AM 4/13/2018
12:00:00AM 4/20/2018
On/Off
P Tank

471 Cal Expo

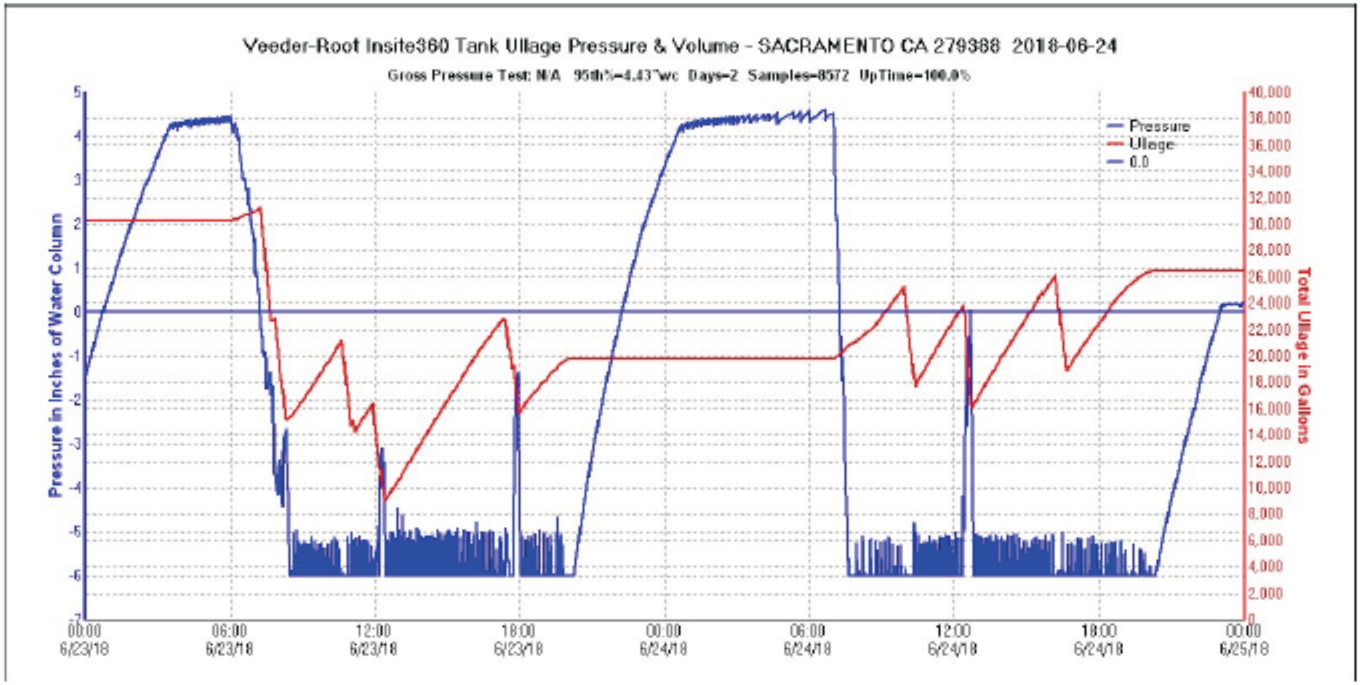

On/Off in H2O
Costco 471, Sacramento, CA
1.4 6
1.2 4
1.0 2
0.8 0
0.6 -2
0.4 -4
0.2 -6
0.0 -8
-0.2 -10
-0.4 -12
12:00:00AM 3/17/2018
12:00:00AM 3/19/2018
12:00:00AM 3/21/2018
12:00:00AM 3/23/2018
12:00:00AM 3/25/2018
12:00:00AM 3/27/2018
On/Off
P Tank

RVP, Temperature Example

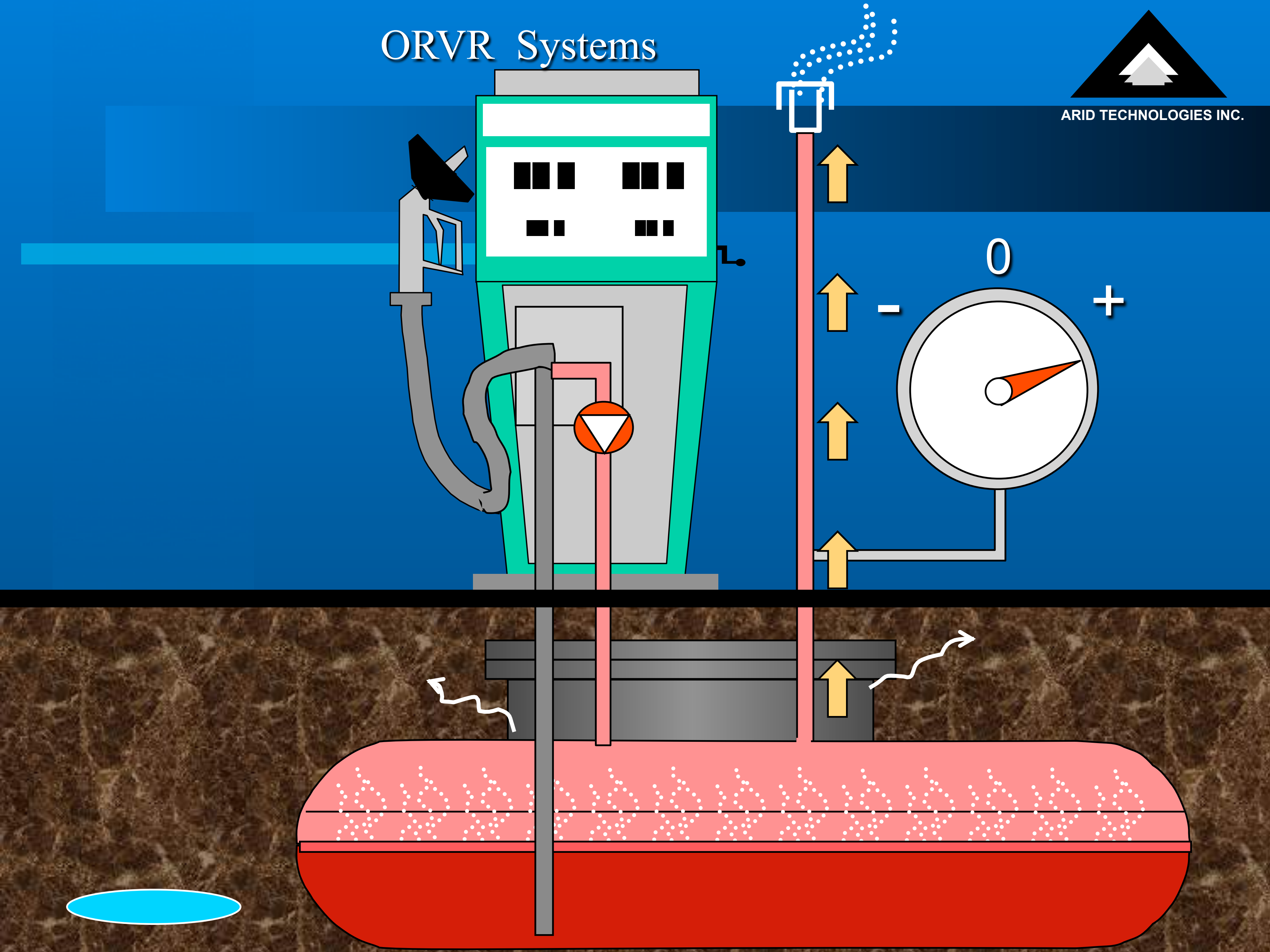
RVP	Temp	Vapor Pressure	Comment
9	74	6.03	JUNE
12	54	5.67	DEC

Implication: EVAP loss problems are not limited to only Winter RVP Fuel

PERMEATOR DeActivated



ORVR Systems



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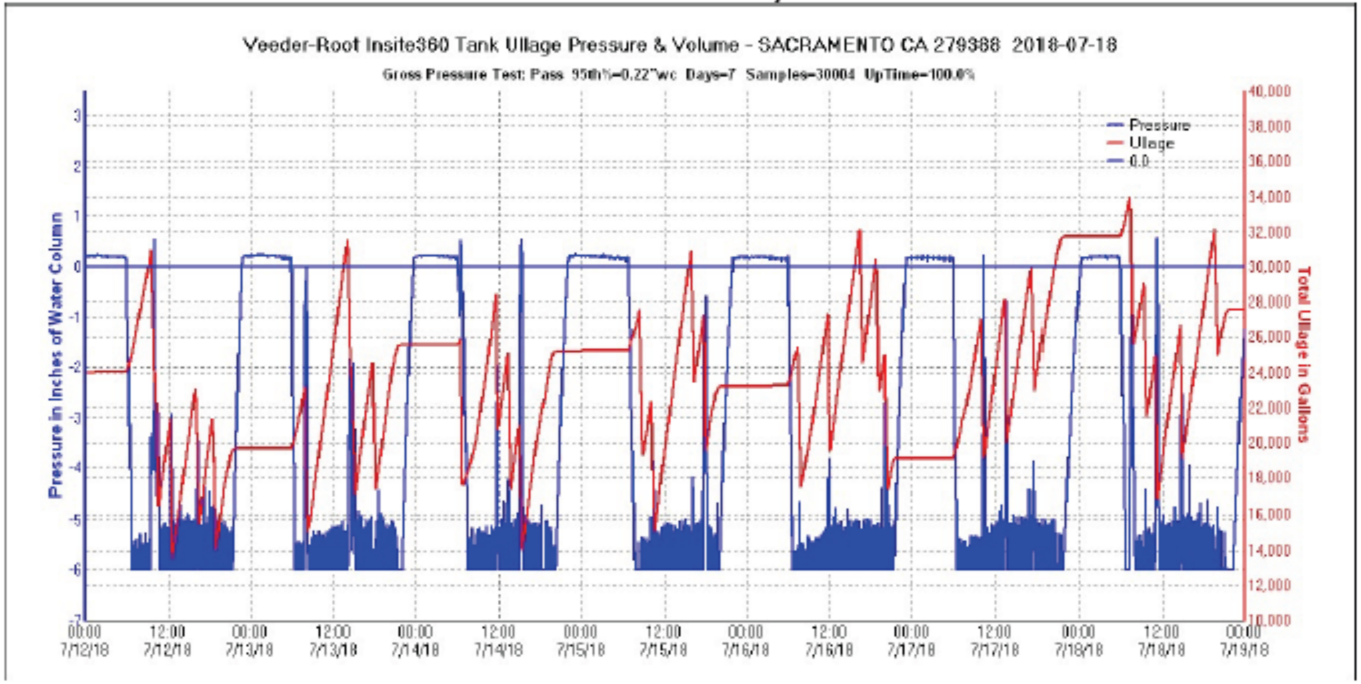
PERMEATOR ON/OFF



Some Field Data

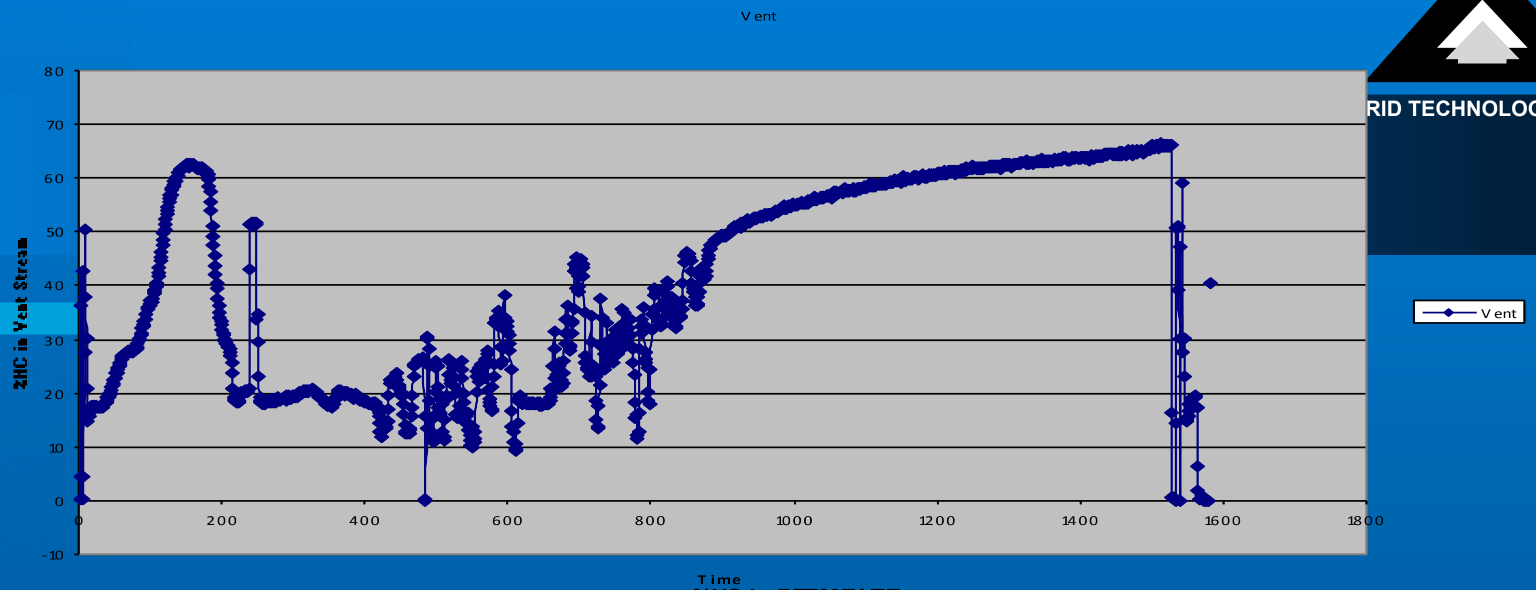
- The measured vapor growth rates from the CA GDF using ARID PERMEATOR
  - 150 GPH to 450 GPH (gallons per hour)
- The liquid fuel pumping rates from the CA GDF using ARID PERMEATOR
  - 2,200 to 3,800 GPH (gallons per hour)
- The vapor growth process generates molecules in the vapor phase (increased vapor volume) and the liquid pumping process creates space to "store" the vapor phase volume generated

Field Data (cont'd)

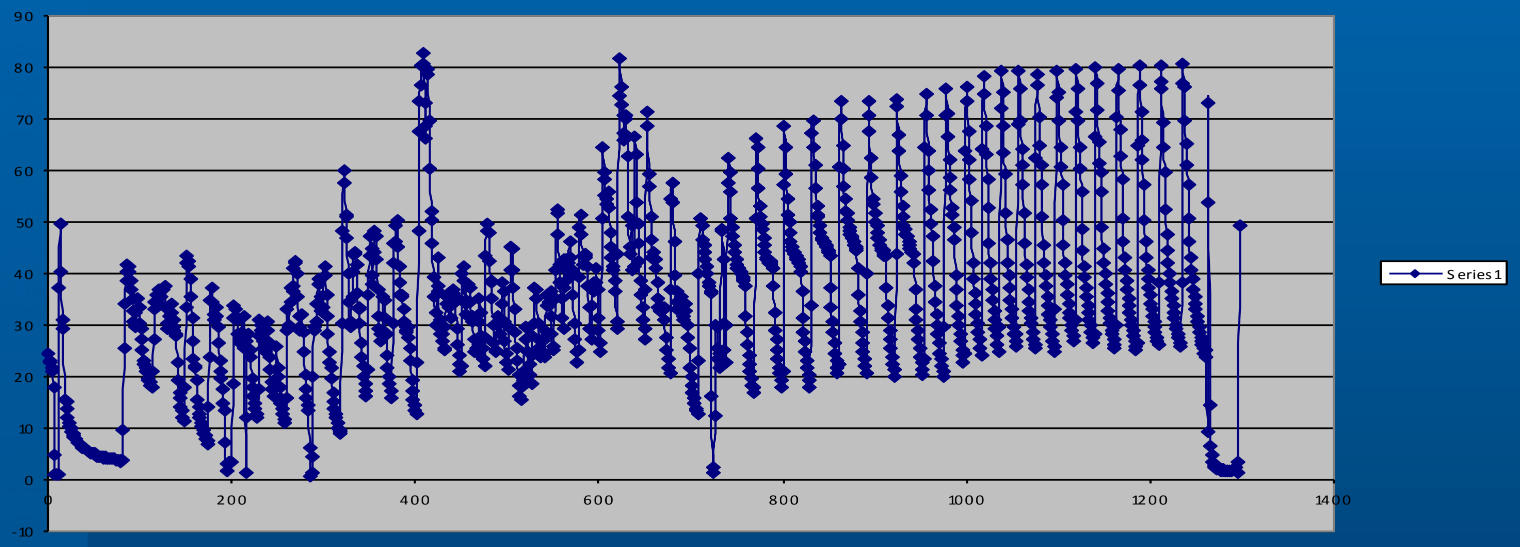
- If the liquid pumping rate exceeds the sum of the vapor growth rate and the air/vapors ingested by the Stage II system, the pressure in the storage tanks will be reduced until the negative cracking pressure of the P/V valves is reached
  - The effective V/L of the HEALY system is about 0.25; so for 1,000 gph of liquid pumped, the Healy system will return about 250 gph of air/vapor mixture
- While operating at the negative cracking pressure of the P/V valves, atmospheric air is ingested via the vent lines

Implications

- GDF with liquid dispensing rates greater than 2,000 gph are unlikely to show PWD
- The pressure increase is not during dispensing but rather in the off-hours when the liquid dispensing rate is reduced or altogether eliminated (GDF is closed)
- Healy CAS (buffer tank) has maximum volume of 400 gallons
  - At evaporation rate of 200 gph; the Healy tank is "filled" in 2 hours; leaving approximately 6.5 hours for constant vapor emissions
  - At evaporation rate of 300 gph; the Healy tank reaches capacity in 1.3 hours; leaving approximately 7.2 hours for constant vapor emissions
- The off-hours vapor emissions are of relatively high hydrocarbon concentration since the ullage space concentration increases up to the equilibrium hydrocarbon concentration level



%HC in PERMEATE



Dynamics and Nozzle Tightness

- If nozzle/automobile interfaces are not “tight”, excess air may be ingested by the nozzle
  - If the liquid pumping rate is much greater than the sum of the excess air/vapor and the evaporative rate, the storage tank pressure will remain negative (under vacuum) and atmospheric air will be ingested
- If the nozzle/automobile interface is perfectly “tight”, excess air may not be ingested by the nozzle
  - If the liquid pumping rate is much greater than the sum of the air/vapor and the evaporative rate, the air ingestion is simply “shifted” from the nozzle as a source to the vent line via the P/V valve since the storage tank pressure will remain negative (under vacuum)

Vapor Emissions at GDF

- Refueling Emissions
  - At the nozzle/vehicle interface
- Storage Tank Emissions
  - Vent Emissions
    - Via the P/V valve
  - Fugitive Emissions
    - Via point sources, function of tank pressure

ISD Purpose

- Early detection
- Corrective action
- Real Impact on emission reductions
- *If a system has fundamental design flaws, ISD cannot "monitor-in" improvements*

ISD Parameters

- Pressure: 75th percentile Degradation
  - CP-201 limit is 0.5 iwc
  - In use limit is 0.3 iwc
- Pressure: 95th percentile Degradation
  - CP-201 limt is 1.5 iwc
  - In use limit is 1.3 iwc
- Vapor Containment Leakage: 7-day value
  - CP-201 limit is 9.0 cfh at our Sealed Test site
  - In use limit evaluated at 2iwc

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Practical Implications

- Total Emissions = Vent + Fugitive
- HEALY CAS Vent Emissions
  - – Assume GDF “closed” 8.5 hours per day
  - – Assume EVAP growth rate of 200 gph
    - Healy Tank filled in 400 gal/200 gph = 2 hours
    - Unmitigated venting = 8.5-2 = 6.5 hours/day @ 200 gph
      - Vent volume: 200 gph x 6.5 hrs/day = 1,300 gal vapor/day
      - Assume 50% HC by vol
        - Mass of vent emissions
          - 66/386*0.5*1,300/7.48= 15 lb/day

Practical Implications

- Fugitive Emissions as function of Pressure
  - Table 9.1, Q vs. P; Assist system; 19-24 nozzles
    - (A.) P tank 0-1.00 iwc; Q = .432 CFH (pass of 0.3 iwc threshold; 0-.299)
    - (B.) P tank 0-1.00 iwc; Q = .535 CFH (fail of 0.3 iwc; 0-.350)
    - (C.) P tank 2-3.50 iwc; Q = 5.95 CFH (HEALY)

Practical Implications

- (A) Mass Emissions Fugitives
  – .432 * 7 * 66/386* 0.5= 0.258 lb/day
- (B) Mass Emissions Fugitives
  – .535 * 7* 66/386 * 0.5 = 0.320 lb/day
- (C) Mass Emissions Fugitives
  – 5.946 * 6.5* 66/386 * 0.5 = 3.3 lb/day
    - *ISD Cost effectiveness interval 24 hr/day*

Practical Implications

- TOTAL Emissions
  - (A) 0 + .258 = 0.258 lb/day ARID, ISD Pass
  - (B) 0 + .320= 0.320 lb/day ARID, ISD Fail
  - (C) 15 + 3.3= 18.3 lb/day HEALY, CARB Approved
- Savings: C vs A; 18.3 - .26 = 18.04 lb/day
- Savings: C vs B; 18.3 – .32 = 17.98 lb/day

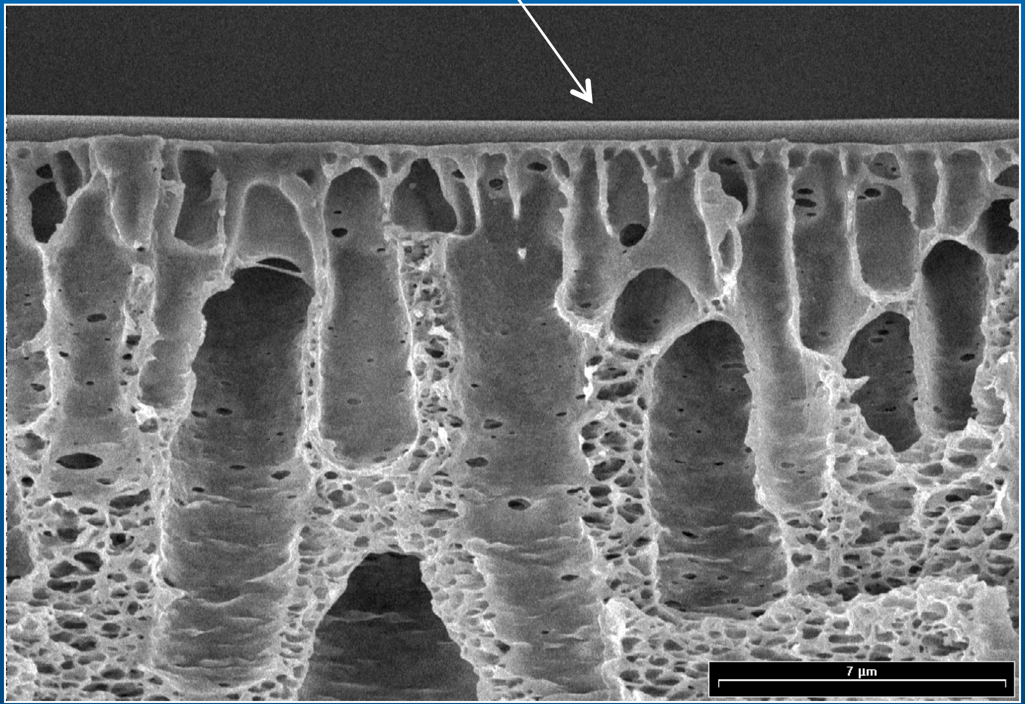
Practical Implications

- Total Mass Emission of HEALY CAS vs ARID PERMEATOR System
  - Ratio of Healy Emissions/ARID Emissions
    - 18.3/.26 = 70: 1
      - If EVAP rate is 300 gph; this ratio is 117: 1

Membrane Separation for Gases & Vapors

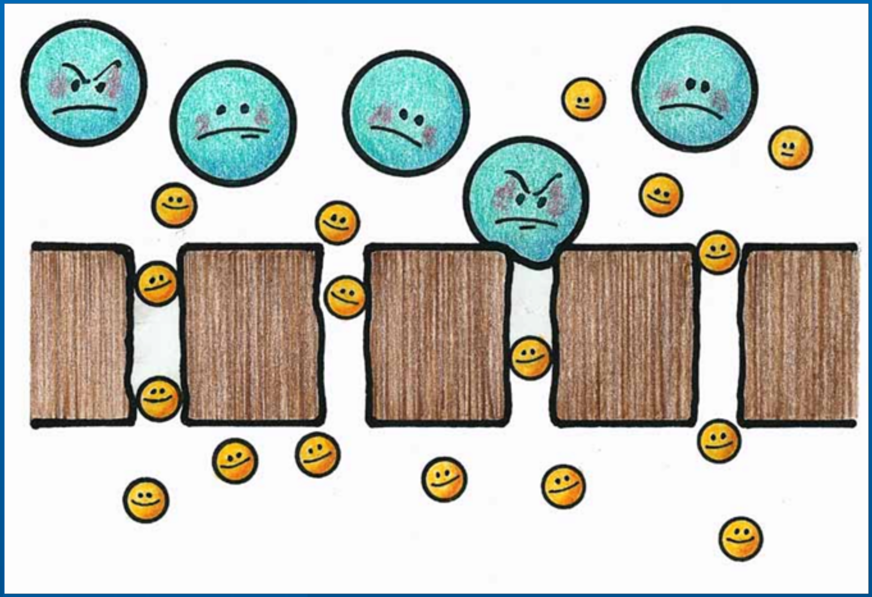
Selectively Permeable Layer

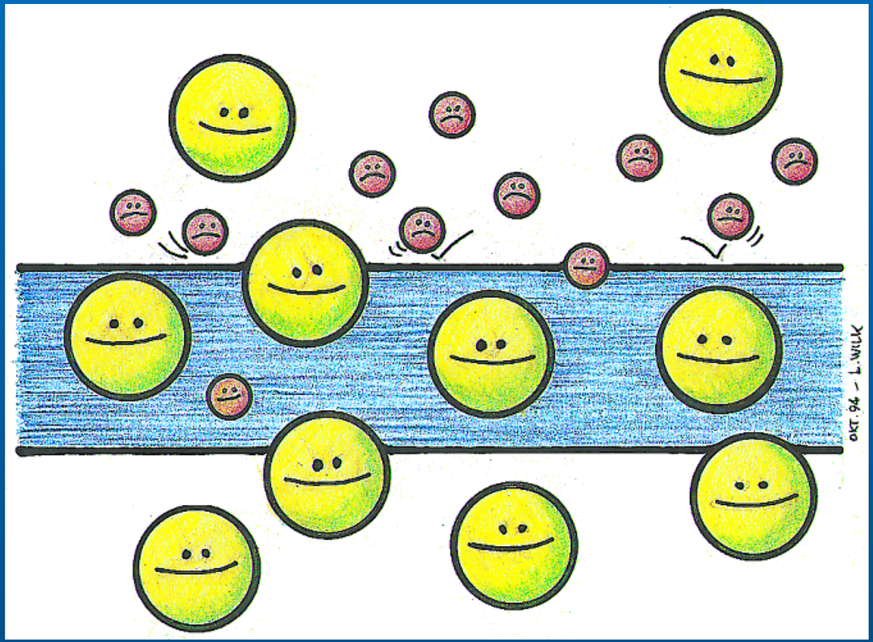
Porous Support



Membrane Separation Principles

ARID





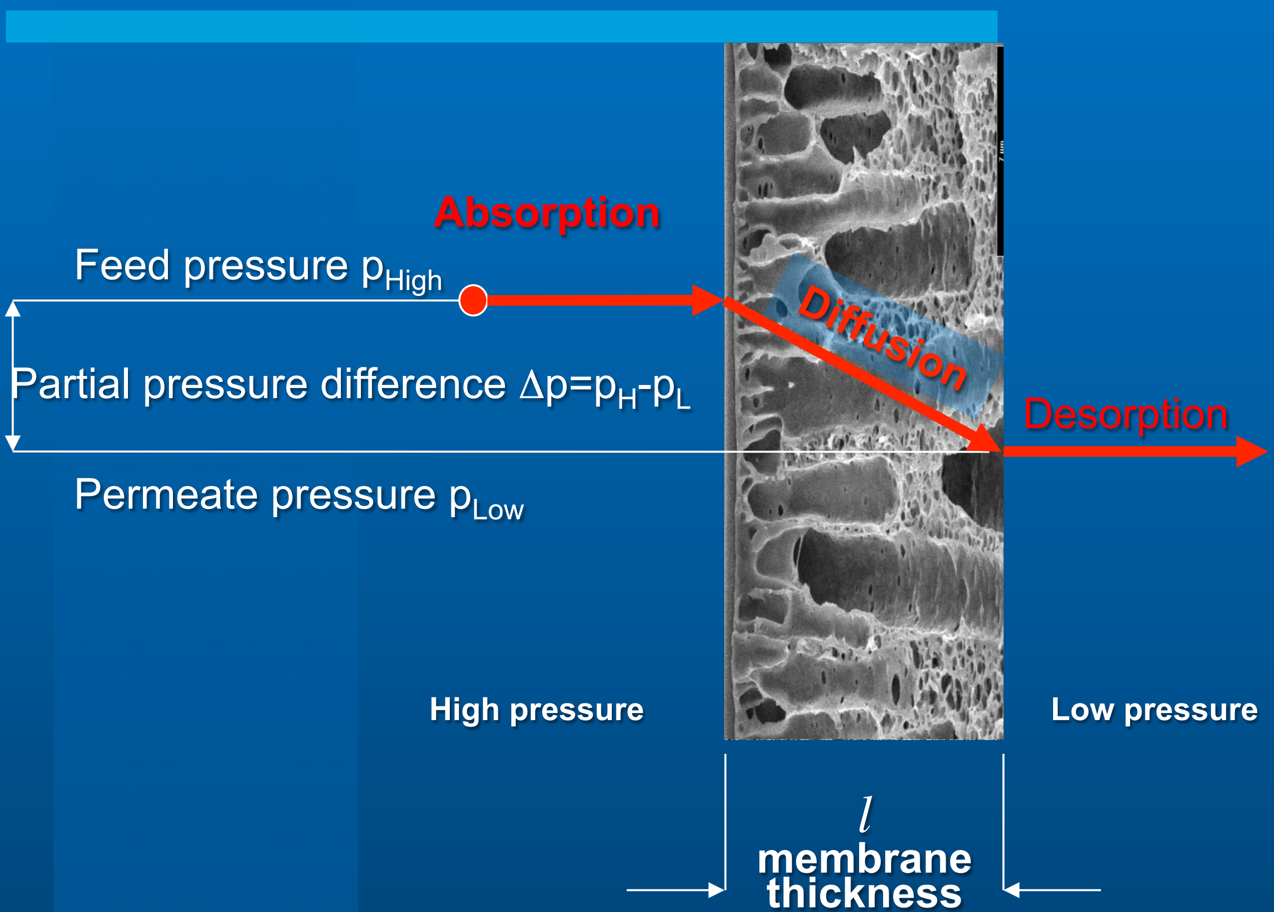
pore structure model

solution - diffusion model

e.g. nano- micro, -ultrafiltration

e.g. Gaspermeation, Reverse Osmosis

Transport Model



Transport steps:

1) Absorption into the polymer matrix on the membrane surface

2) Diffusion of the dissolved gas through the membrane

3) Desorption from the membrane back side

Solution & Diffusion

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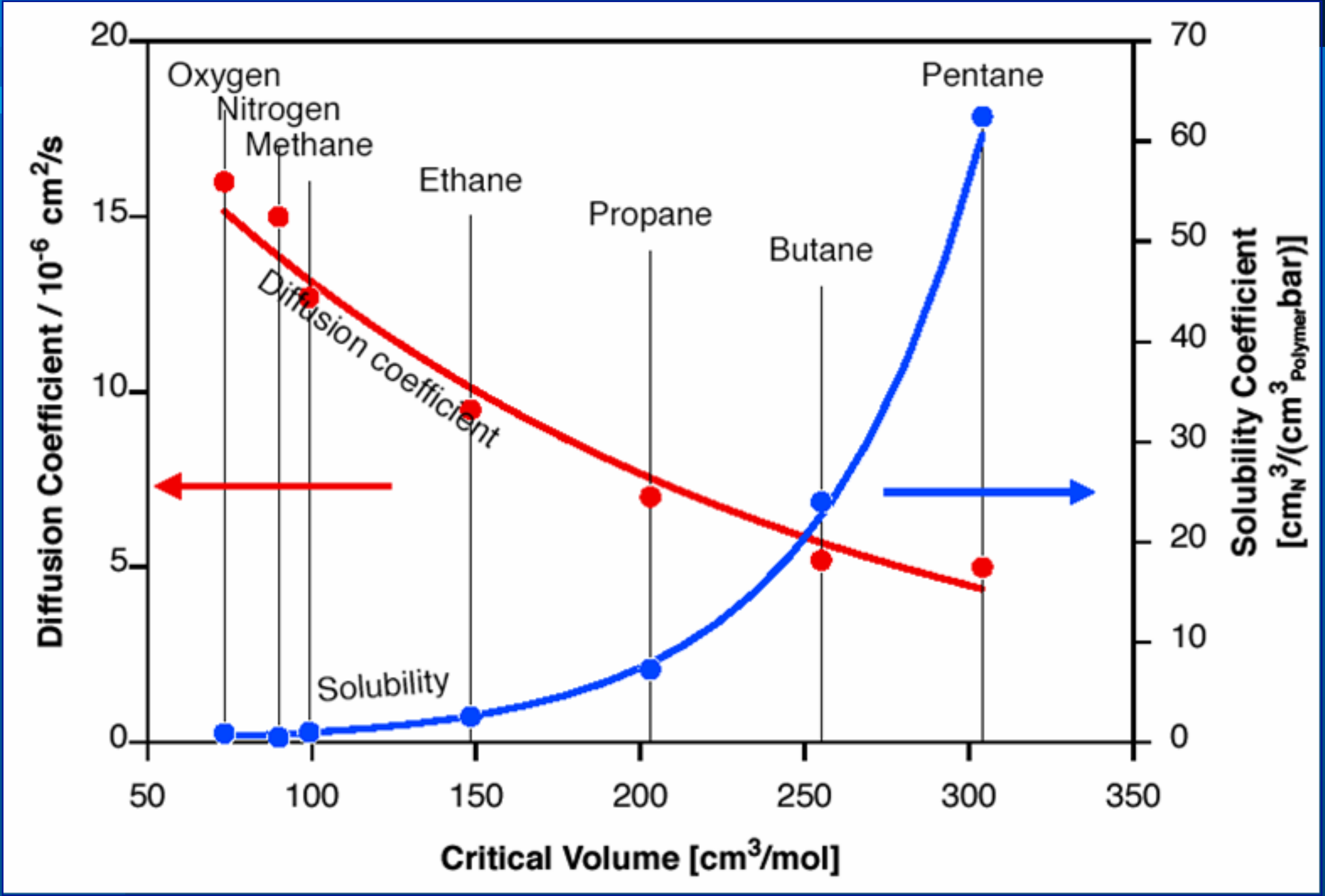

Figure 1: Membrane Fundamentals

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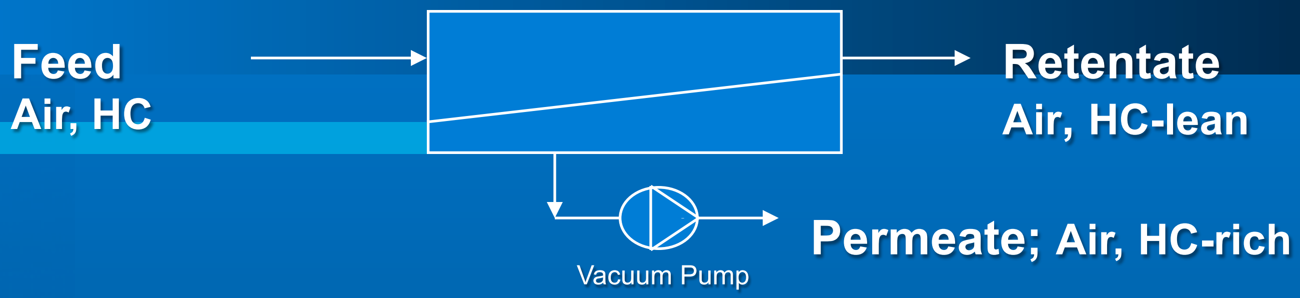

1. $J_i = P_i/L\ (p_{if} - p_{ip})$
2. Permeate Flowrate = $J_i \times A$
3. Selectivity i/k = P_i/P_k

Where;
J_i = Flux of component i ; ft3/(ft2-hr)
P_i/L = Permeability ; ft3/(ft2-hr-psia)
L = Membrane thickness ; ft
p_{if} = partial pressure of component i in the feed ; psia
p_{ip} = partial pressure of component i in the permeate ; psia
A = Membrane surface area ; ft2
Selectivity = ratio of Permeabilities of two components ; dimensionless
HC = Hydrocarbon vapor

Source: Membrane Handbook, Van Nostrand Reinhold, New York, NY, 1992, p. 57.

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Selectivities of Hydrocarbons vs. Nitrogen

Alkanes

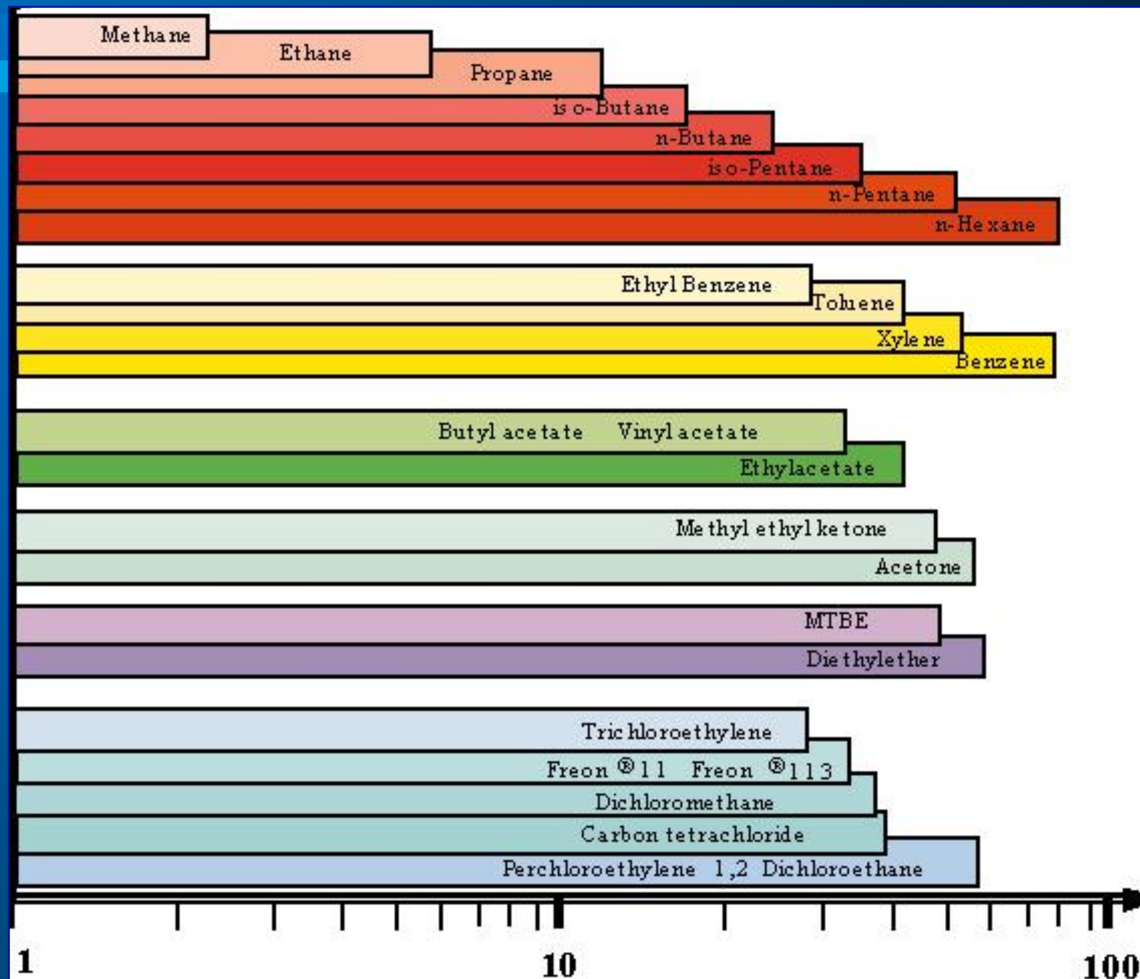
Aromatics

Acetates

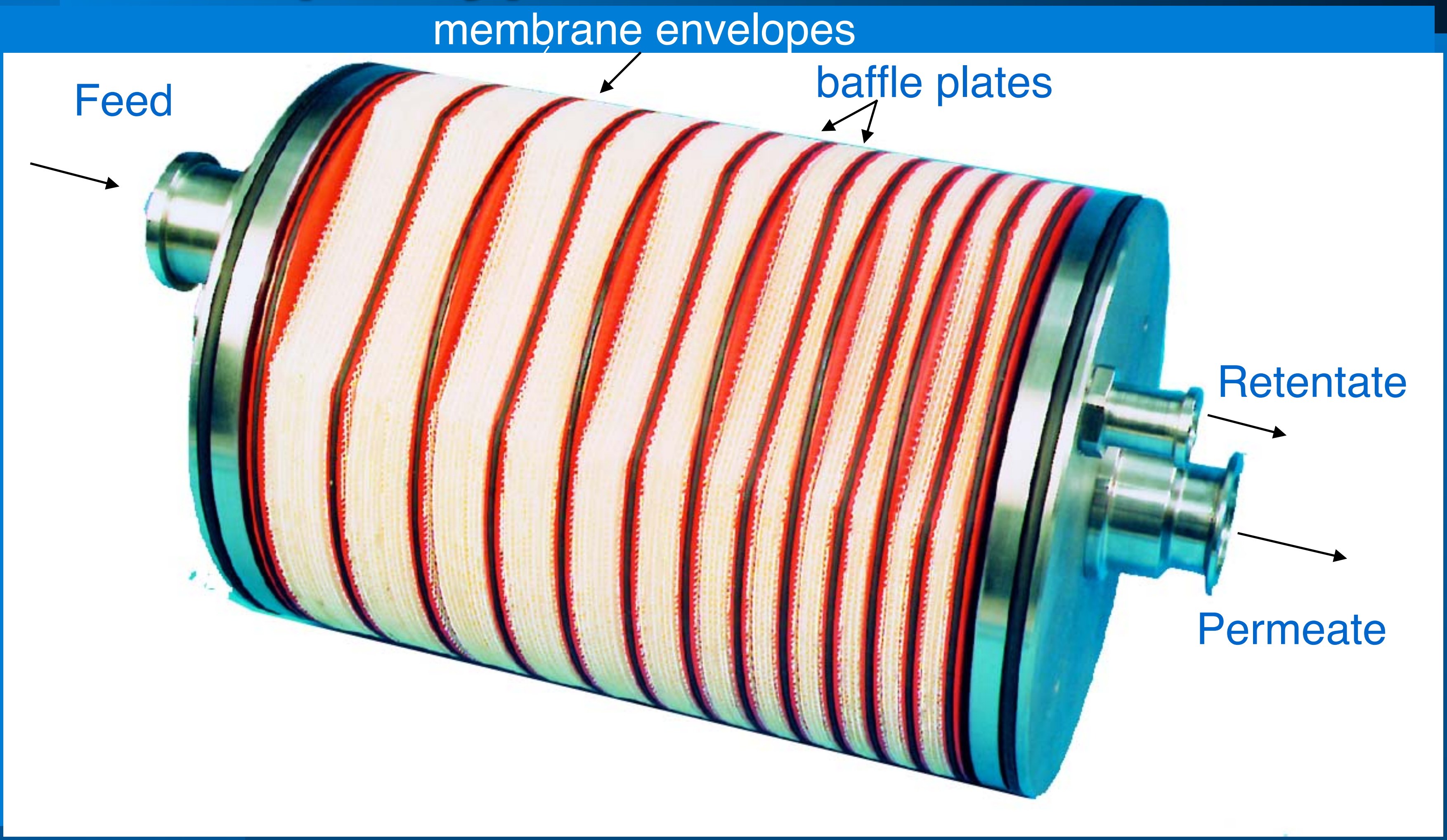
Ketones

Ether

Chlorinated Hydrocarbons



Envelope Type Membrane Module



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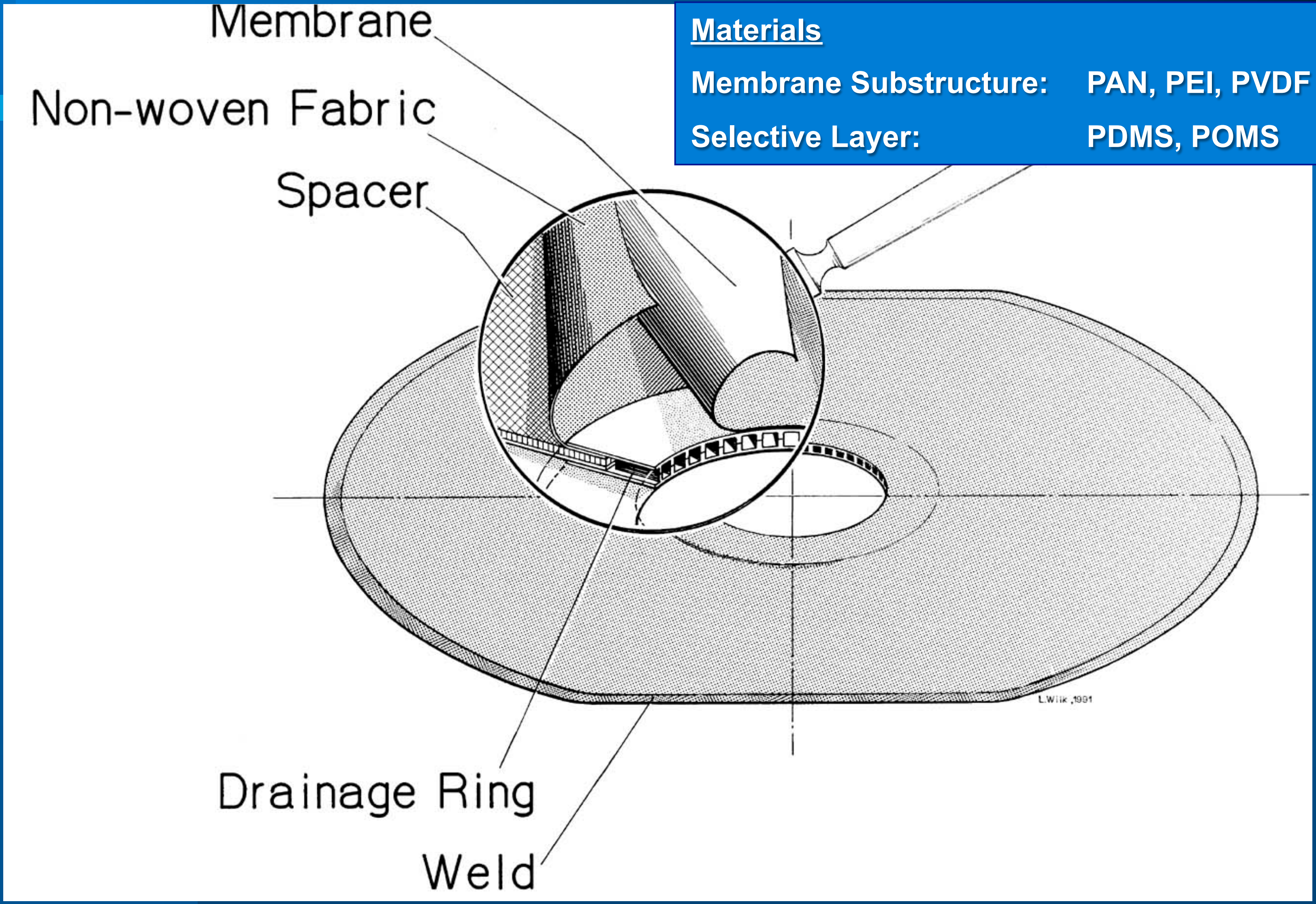
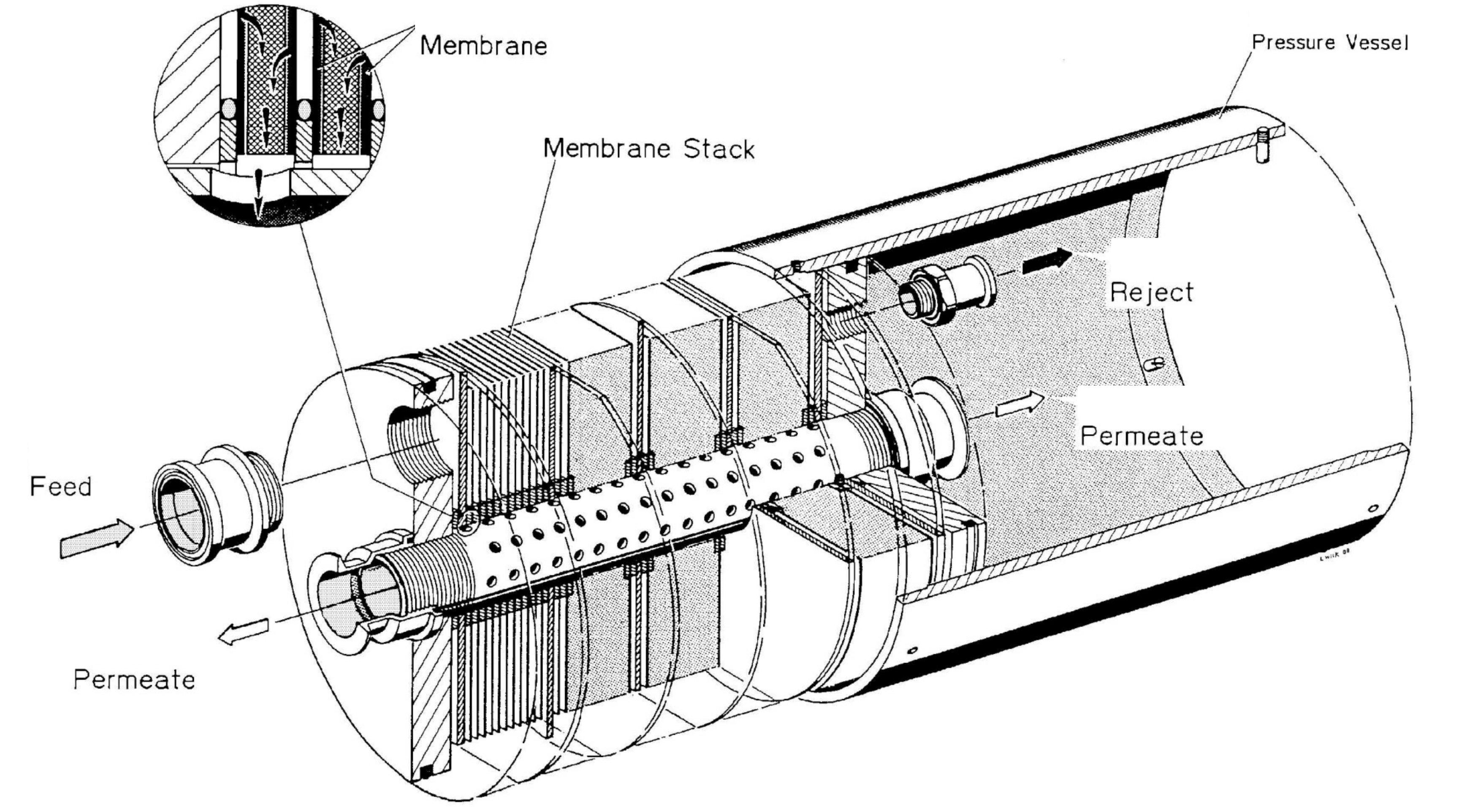
ARID Membrane Envelope



Materials

Membrane Substructure:	PAN, PEI, PVDF
Selective Layer:	PDMS, POMS

ARID Membrane Module



Chula Anomalies

Chula Alarms from ISD monthly reports:

Date	Alarm	Value
12/06/2017 @ 12:00:56	Degrd Press Warning	0.30
12/22/2017 @ 12:00:52	Gross Press Warning	1.33
12/23/2017 @ 12:00:47	Gross Press Warning	1.34
01/09/2018 @ 12:00:56	Gross Press Warning	1.35
02/14/2018 @ 12:00:40	Degrd Press Warning	0.30
02/15/2018 @12:00:29	Degrd Press Warning	0.31

CP 201 limits 0.5"wc and 1.5"wc respectively for Degrd and Gross

HEALY CAS

REPORT DATE: NOV 2016

WARNING ALARMS

DATE	TIME	DESCRIPTION	READING	VALUE
16-11-28	00:00:25	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.84
16-11-21	00:00:24	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.62
16-11-14	00:00:17	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.55
16-11-07	00:00:51	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.69
16-11-05	00:00:39	VAPOR CONTAINMENT LEAKAGE	CFH@2 INCHES WC	13.46
16-11-04	00:00:17	VAPOR CONTAINMENT LEAKAGE	CFH@2 INCHES WC	9.52

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HEALY CAS

REPORT DATE: DEC 2016

WARNING ALARMS

DATE	TIME	DESCRIPTION	READING	VALUE
16-12-26	00:01:39	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.91
16-12-19	00:01:07	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.87
16-12-12	00:01:21	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.96
16-12-05	00:01:21	CONTAINMENT GROSS OVER PRESSURE	WEEKLY 95%	3.86

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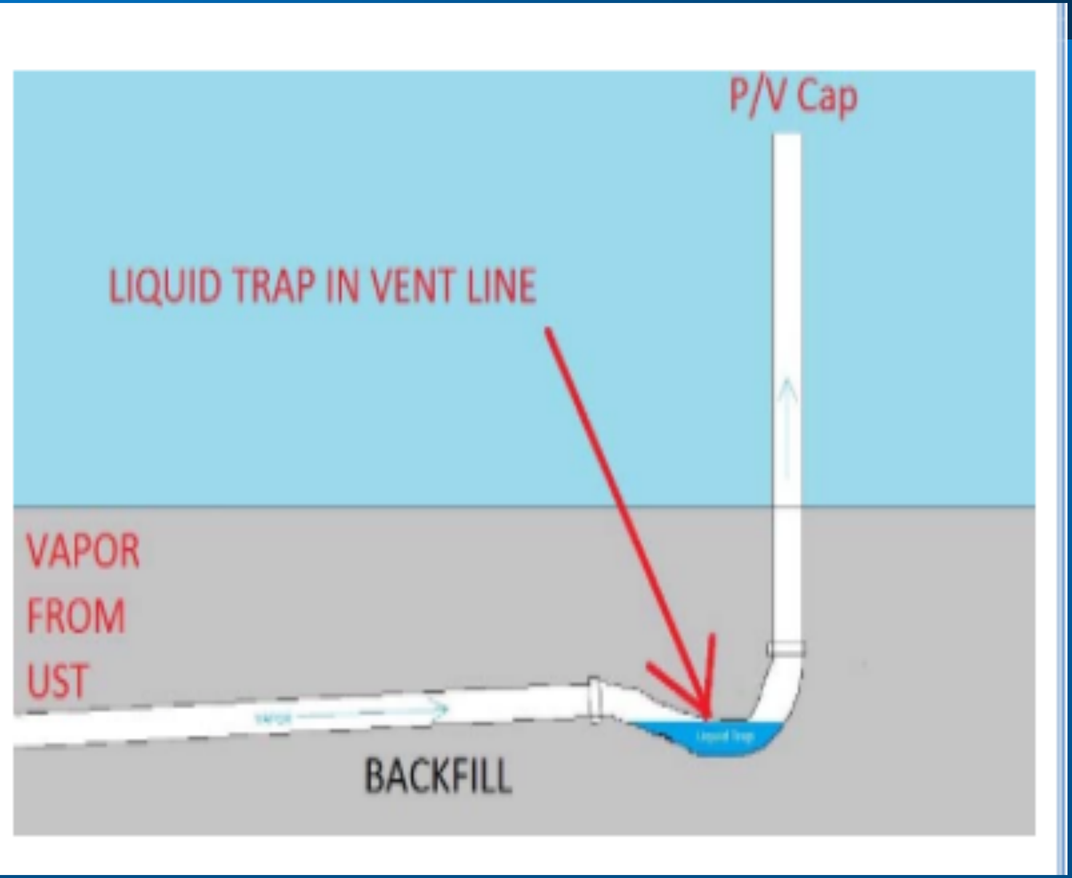
JAN 2017 (HEALY CAS)

WARNING ALARMS

DATE	TIME	DESCRIPTION	READING	VALUE
17-01-25	00:00:47	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	3.96
17-01-18	00:00:45	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	3.92
17-01-11	00:00:40	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	4.02
17-01-10	00:00:43	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	4.01
17-01-09	00:00:55	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	3.92
17-01-02	00:00:55	CONTAINMENT GROSS OVER PRESSURE WEEKLY	95%	3.91


P/V Cap
LIQUID TRAP IN VENT LINE
VAPOR
FROM
UST
BACKFILL

Conclusion: Healy CAS vs ARID PERMEATOR

- CARB Approved HEALY system is a known polluter
  - Significant emissions presently occurring at GDF using the HEALY CAS
- Recent challenge mode testing shows that off-hours evaporative loss problem is not limited to Winter Grade Fuel only (year round problem; with very large emissions and human health implications)
- PERMEATOR system is robust and proven
  - Avoids emissions
  - Yields savings in salable product
  - Reduces risk of soil and/or groundwater contamination
  - Stakeholder seeks to proactively implement
  - Rapid financial payback for high throughput GDF
    - PERMEATOR system met stringent challenge mode emissions test imposed by ARB
      - Up to 78% HC Feed Stream (by vol as C3)
      - Nominal volumetric rate of 350 gph

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PWD

- The observation of so-called "PWD", pressure while dispensing occurs when the liquid dispensing rate is slightly lower than the sum of the air/vapor ingestion rate plus the evaporation rate
  - Example: V/L ratio 0.50; Fuel Pumping rate 500 gph, evaporation rate, 300 gph;
    - 500 < 500 x 0.5 + 300 ; PWD can occur
  - Example: V/L ratio 0.50; Fuel Pumping rate 3,000 gph, evaporation rate, 300 gph
    - 3,000 > 3,000 x 0.5 + 300 ; PWD cannot occur