# Gasoline Storage Tank Evaporative Loss Dynamics

ARID TECHNOLOGIES INC.

## NESCAUM Stage II Meeting

Lisa Rector

1 May 2007

ARID Technologies, Inc.

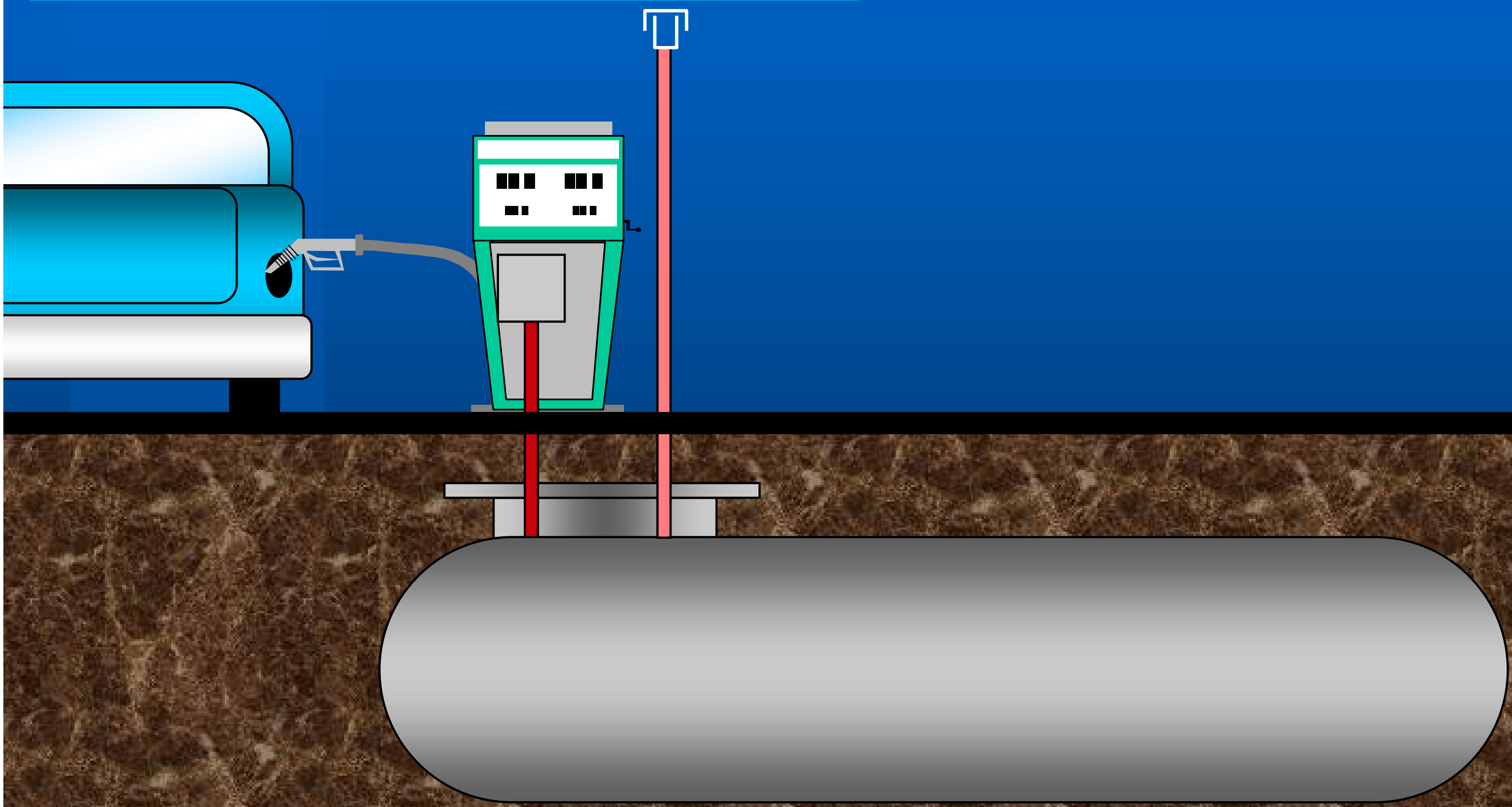
Ted Tiberi

www.ARIDtech.com

# Topics of Discussion

- Evaporative loss dynamics in gasoline storage tanks
- Stage II and ORVR interaction
- Activities in Other States related to Storage Tank Emissions caused by evaporative losses
- Third-party test w/EPA Oversight

# The Uncontrolled System



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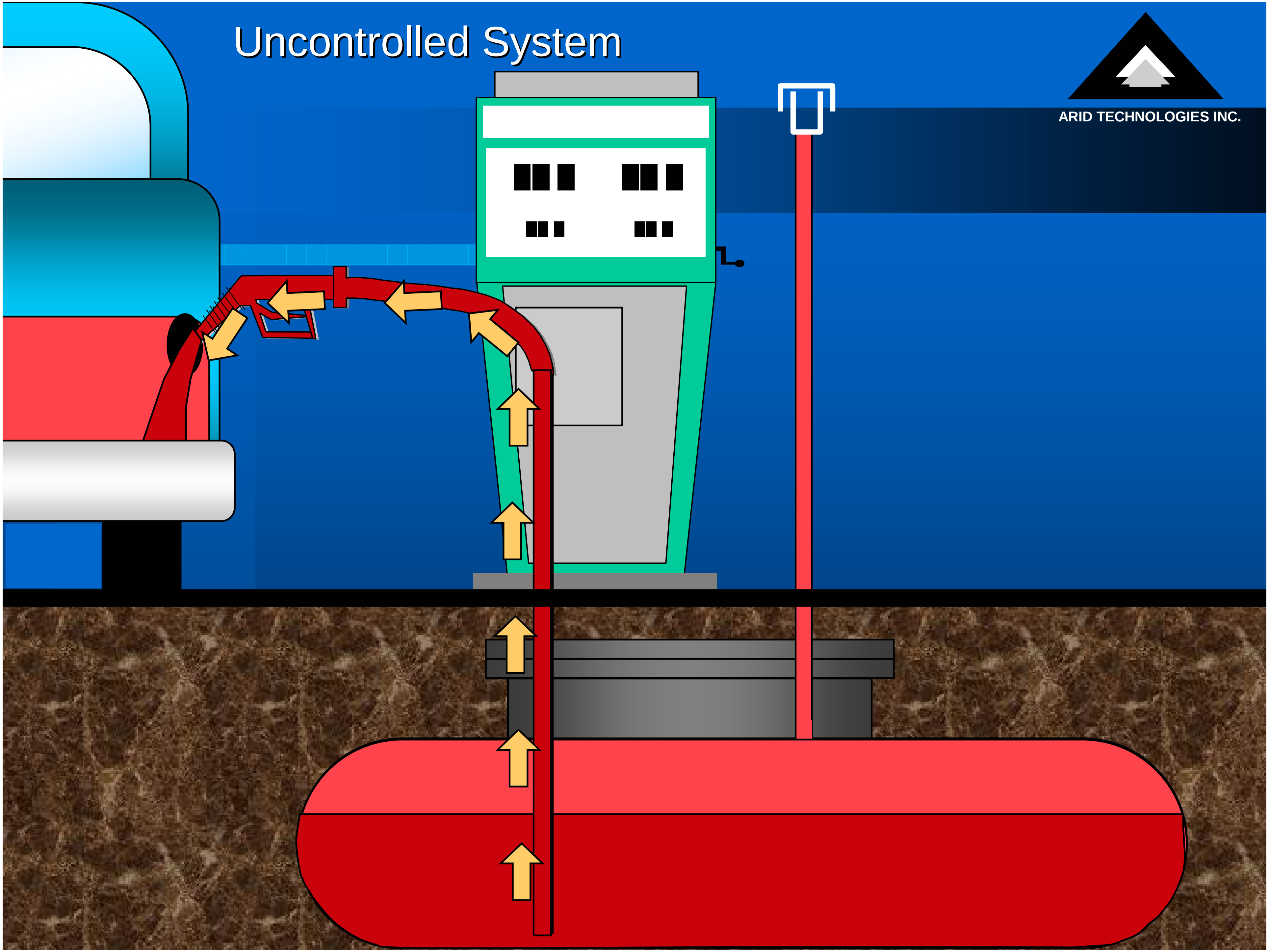

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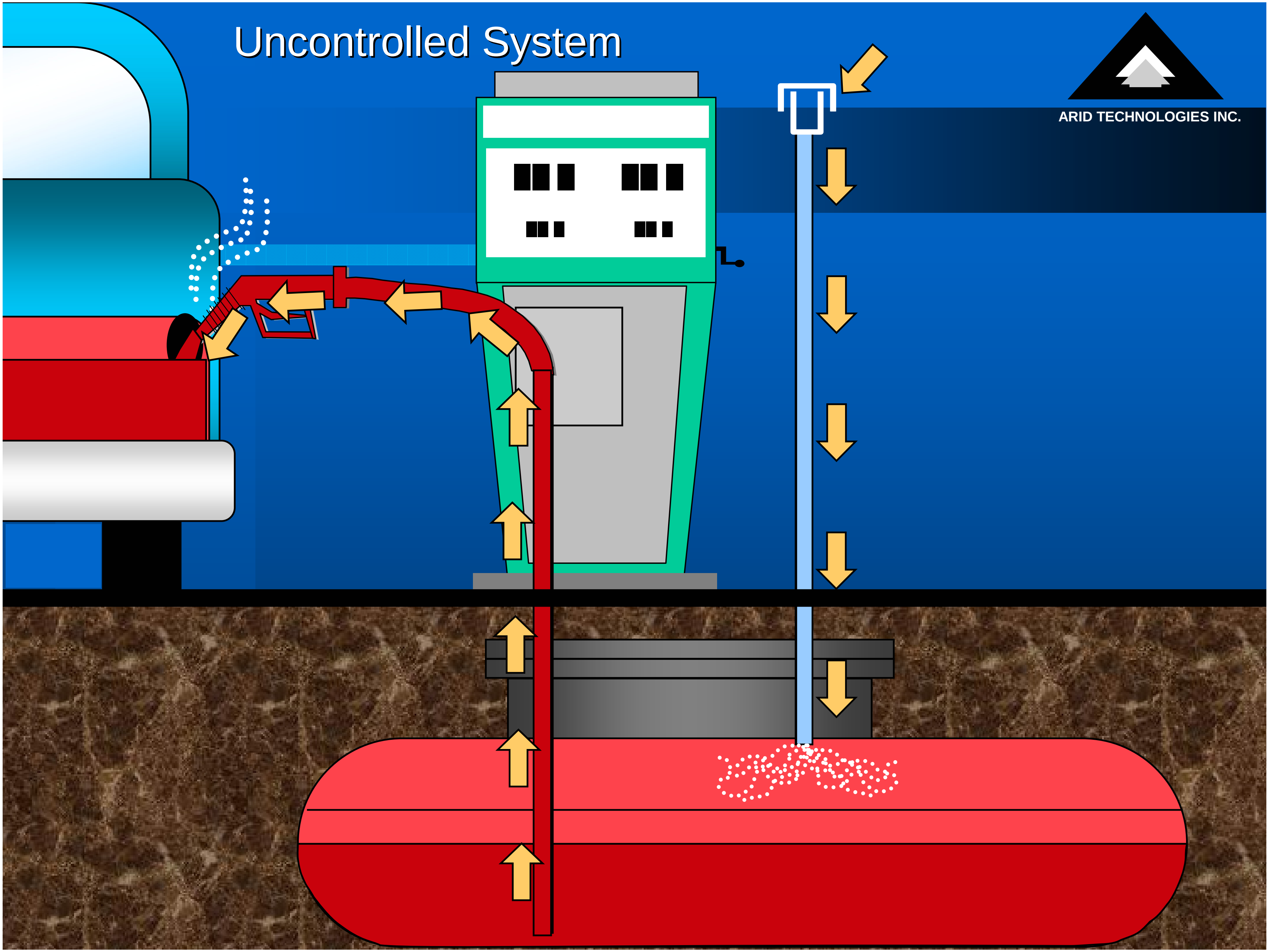

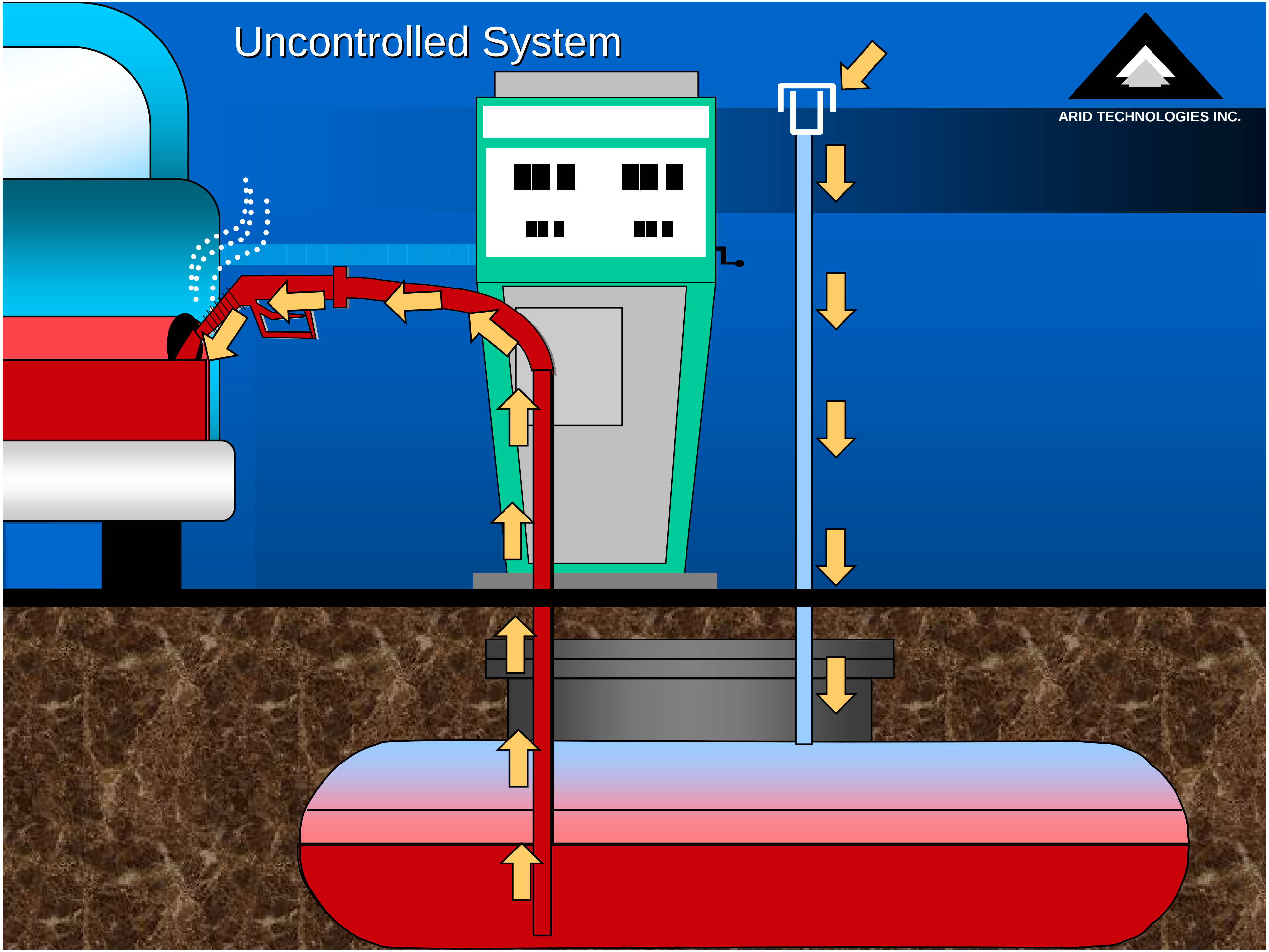
Uncontrolled System
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# Uncontrolled System

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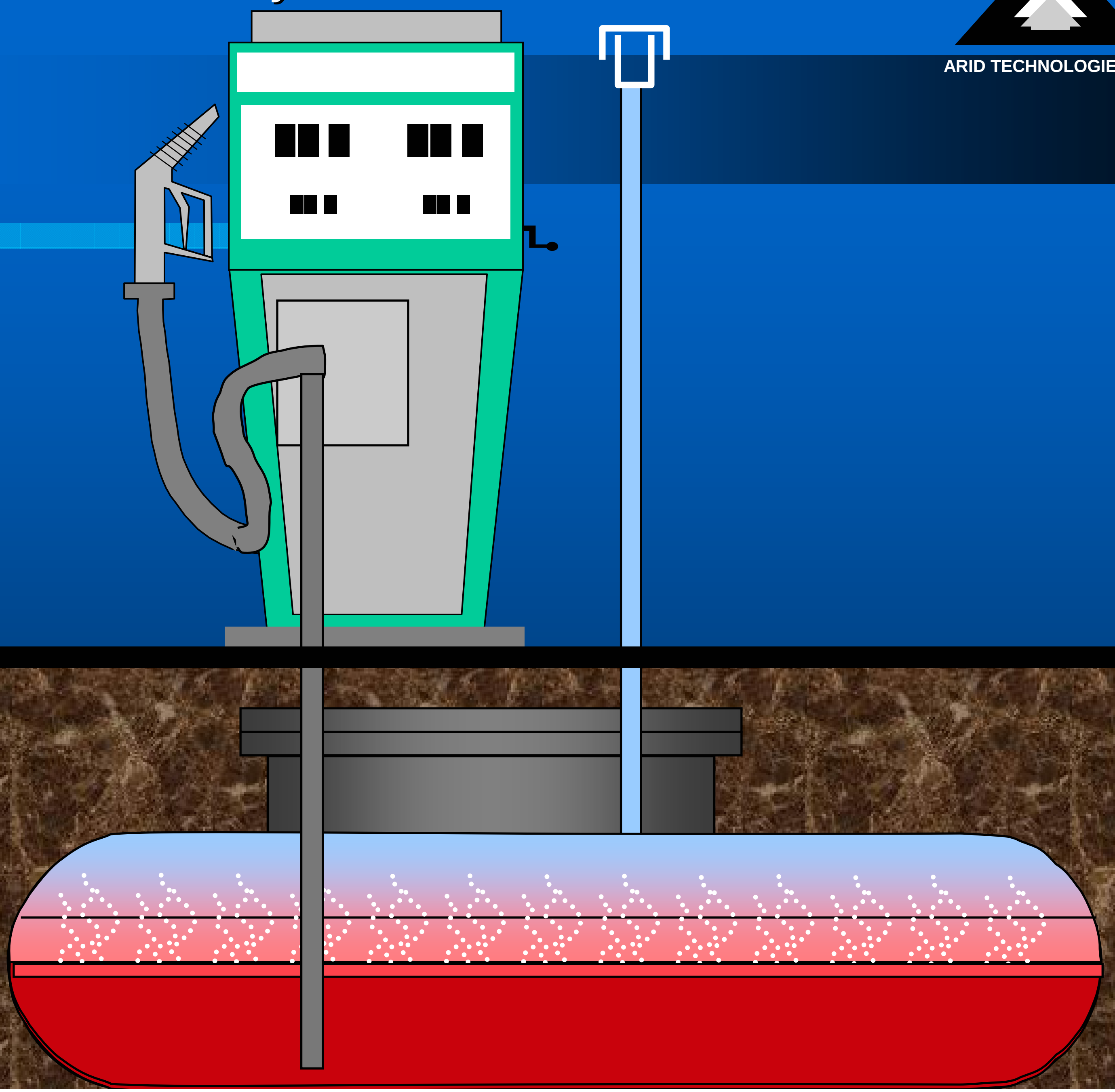

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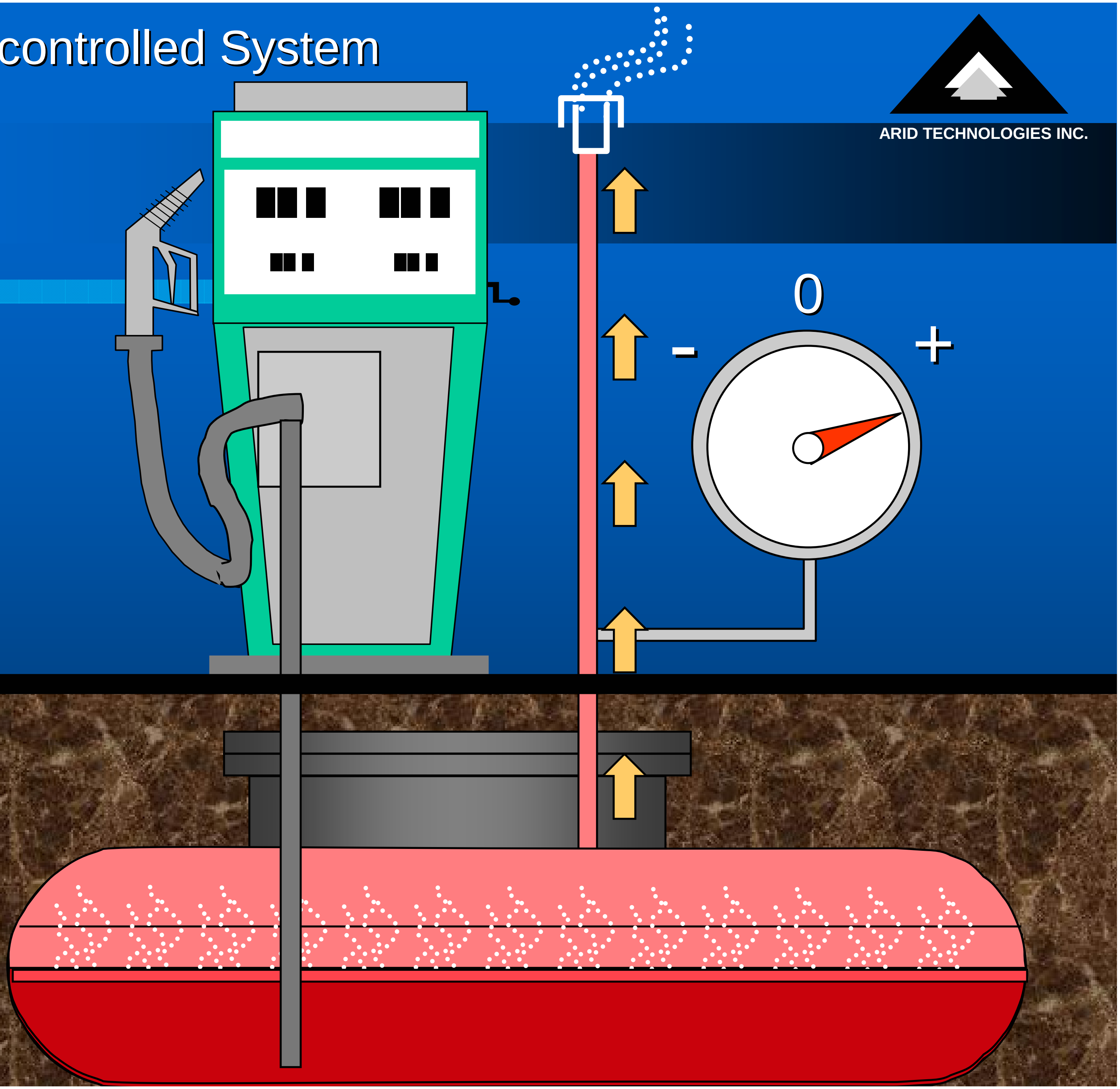

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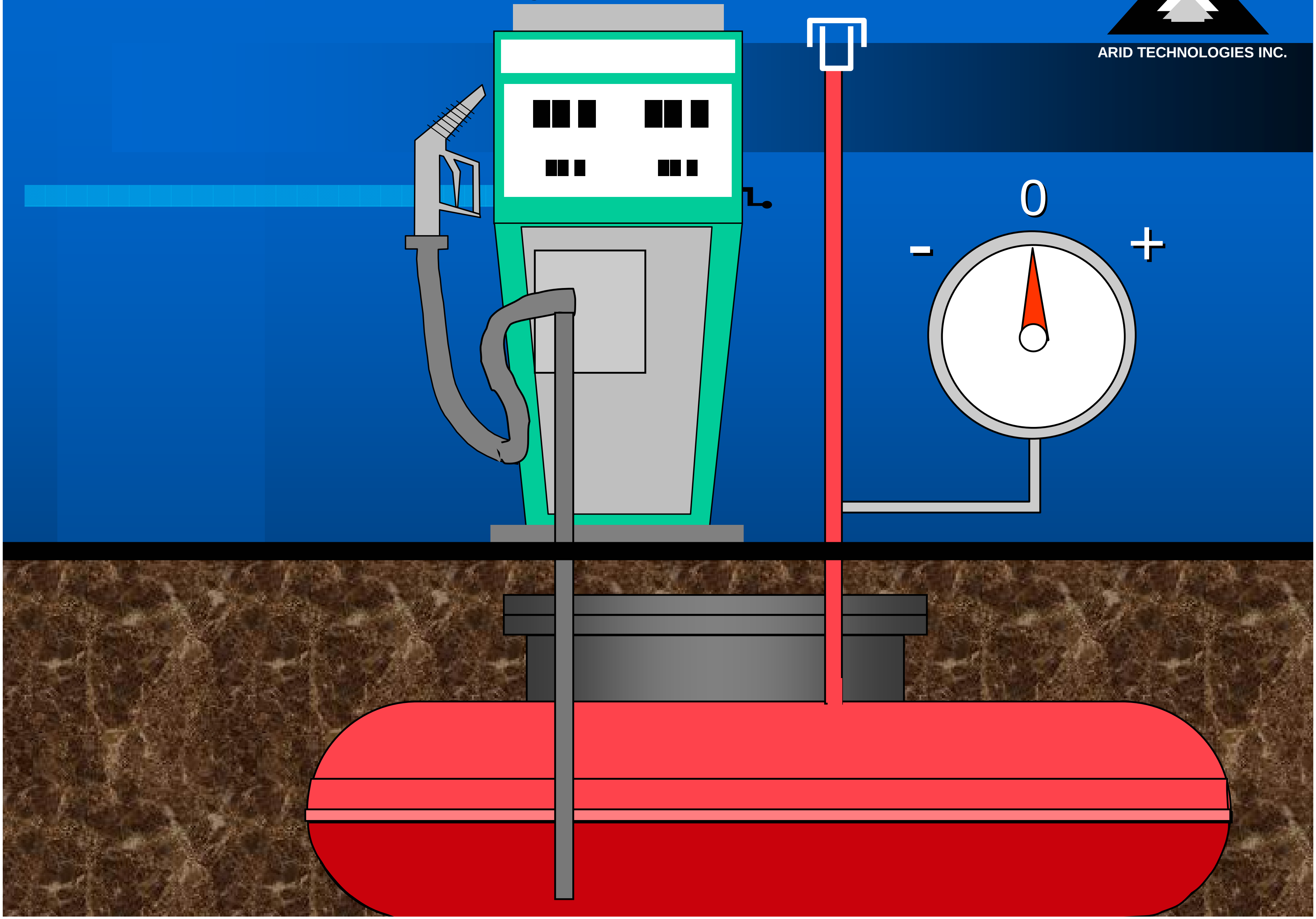


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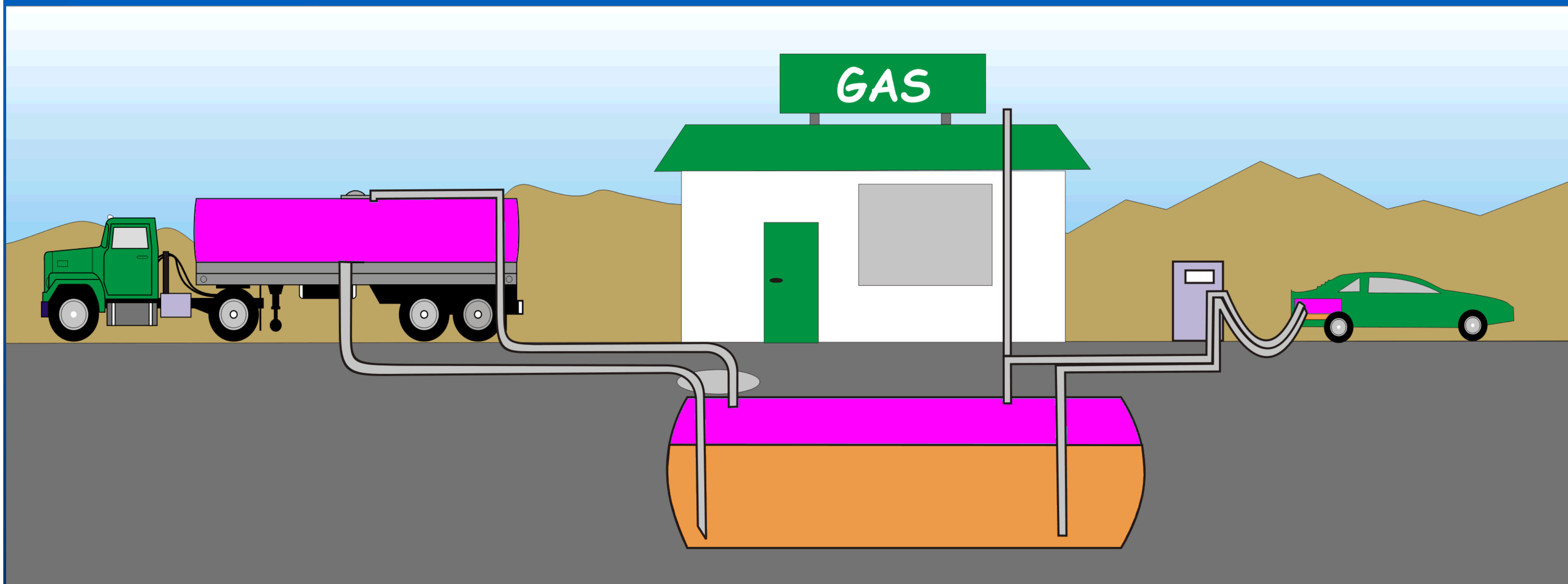
# Vapor Recovery at Service Stations




Stage I

Stage II

# Figure 3: Petrol Station Emissions

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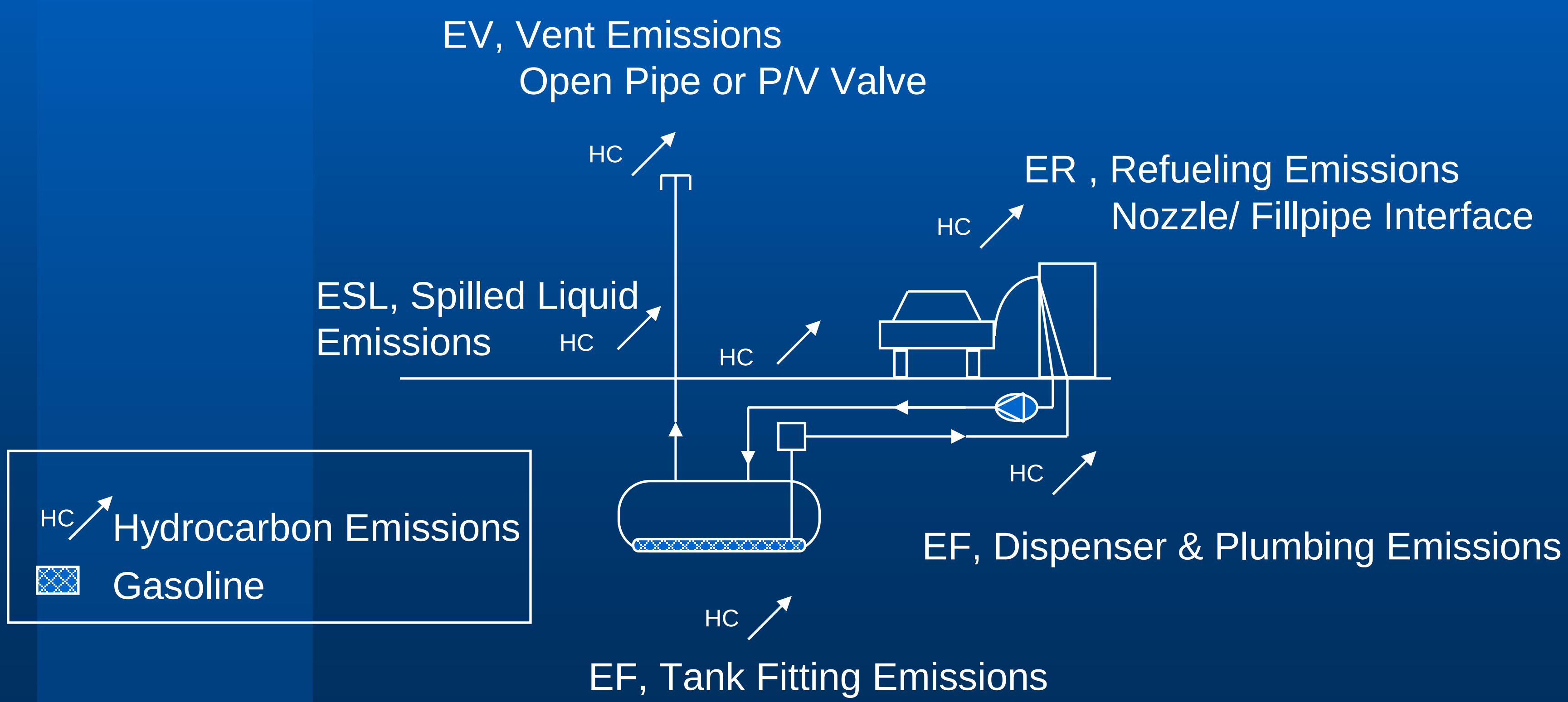

# Primary Components of Gasoline Vapor

## VOC's and HAPS (Hazardous Air Pollutants)

Methane
Ethane
Ethylene
Propane
Cyclopropane
Propylene
Isobutane
N-Butane
Trans-2-Butene
Cyclopentane
Isopentane
N-Pentane
2,3 Dimethylbutane
2-Methylpentane
3-Methylpentane
Hexane
Benzene – known human carcinogen

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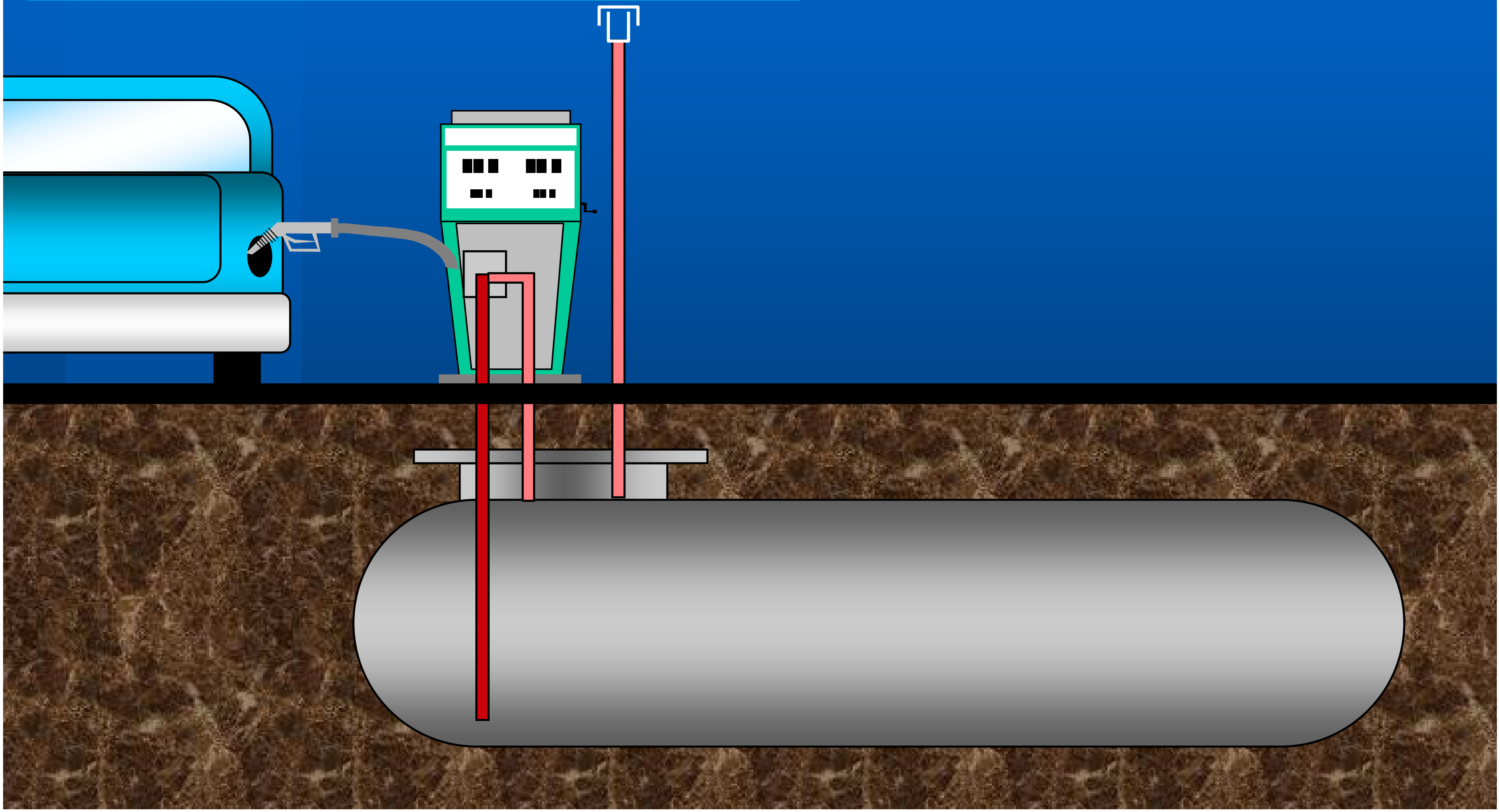
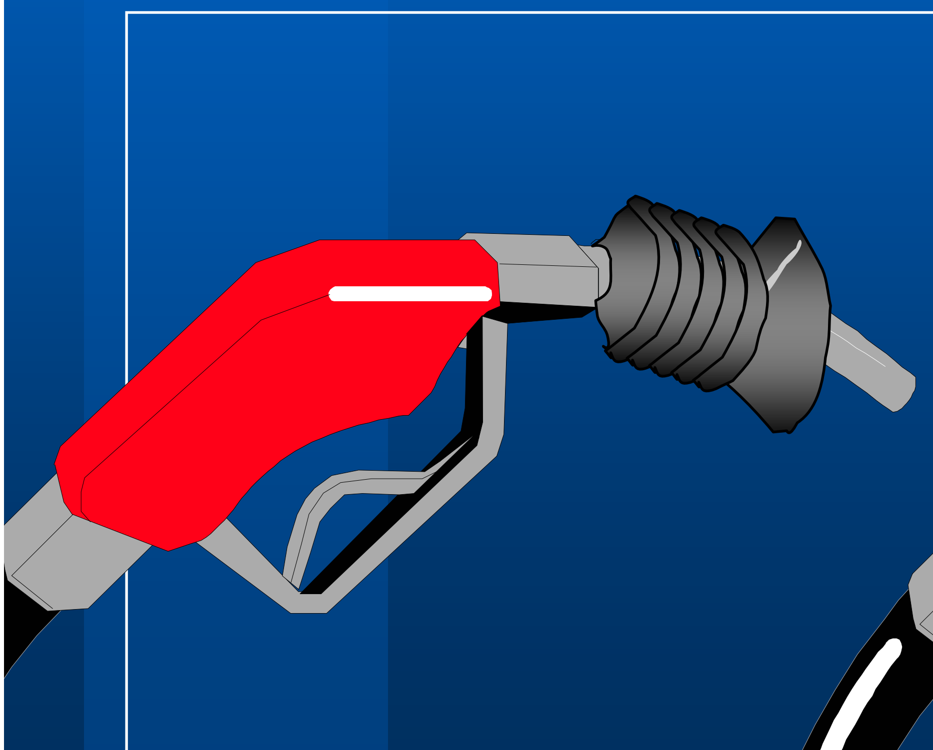
# Stage II Recovery Systems

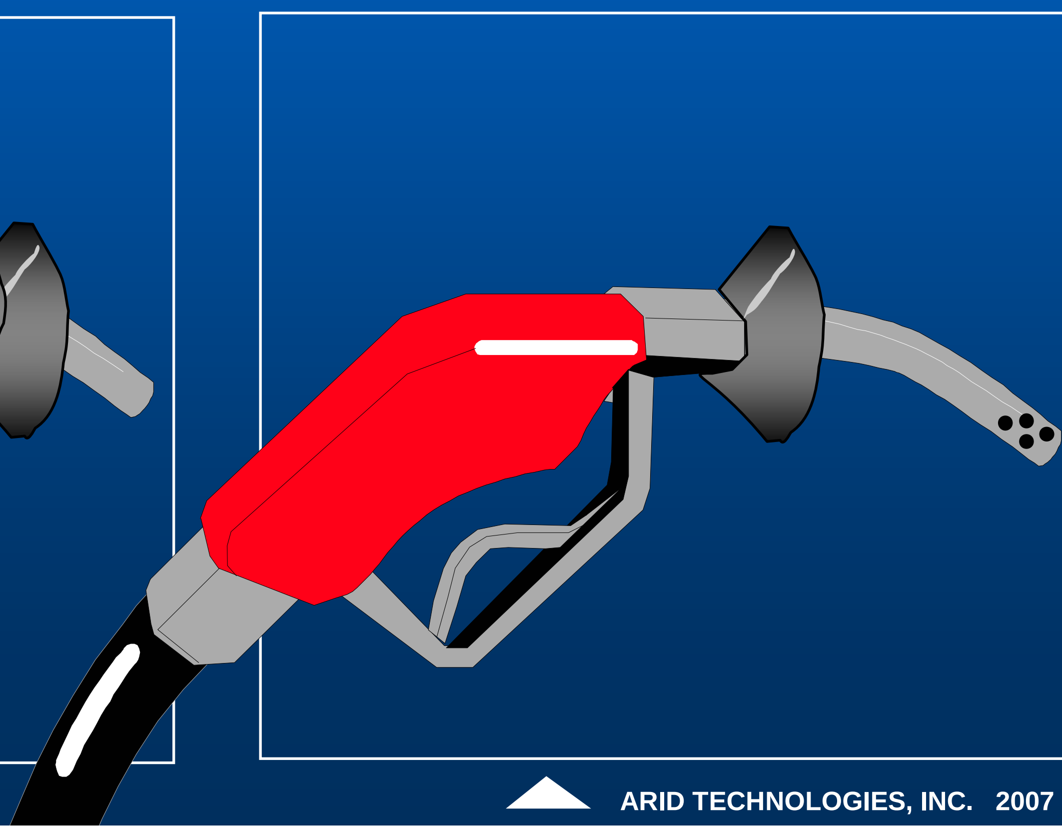


# Stage II Recovery Systems

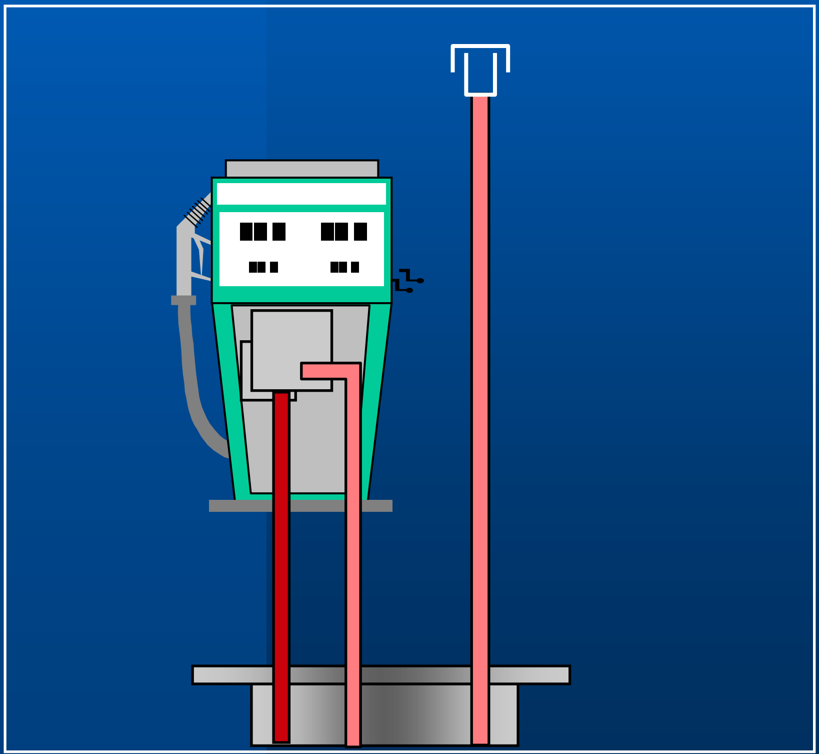
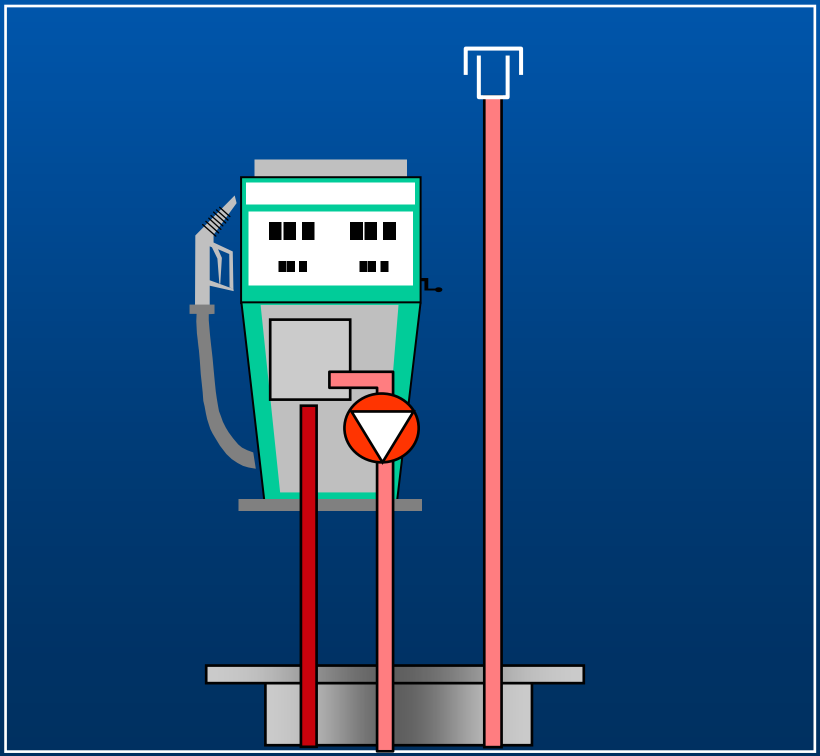
## Balanced System



## Vacuum-Assisted System



# Stage II Recovery Systems

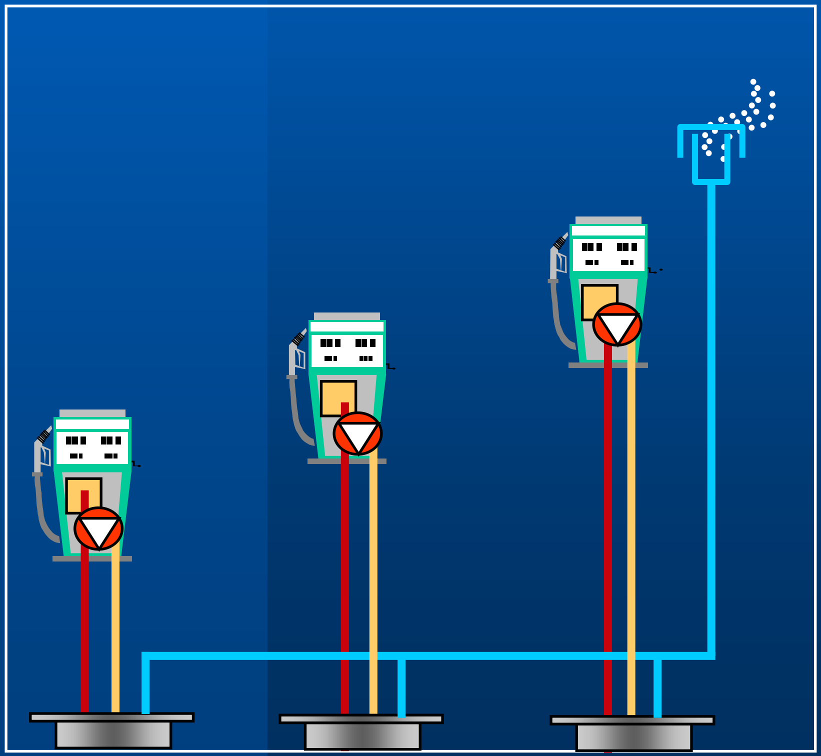
| Balanced System | Vacuum-Assisted System |
| --- | --- |
|  |  |

# Vacuum Assisted Systems



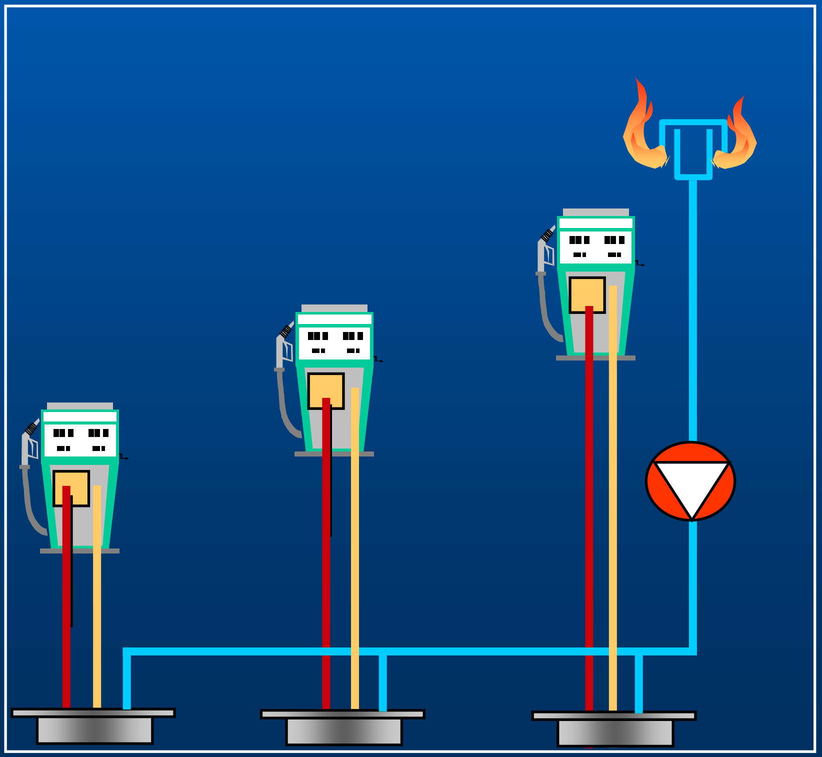
## Dispenser-Based

**V/L = 0.9 - 1.1**

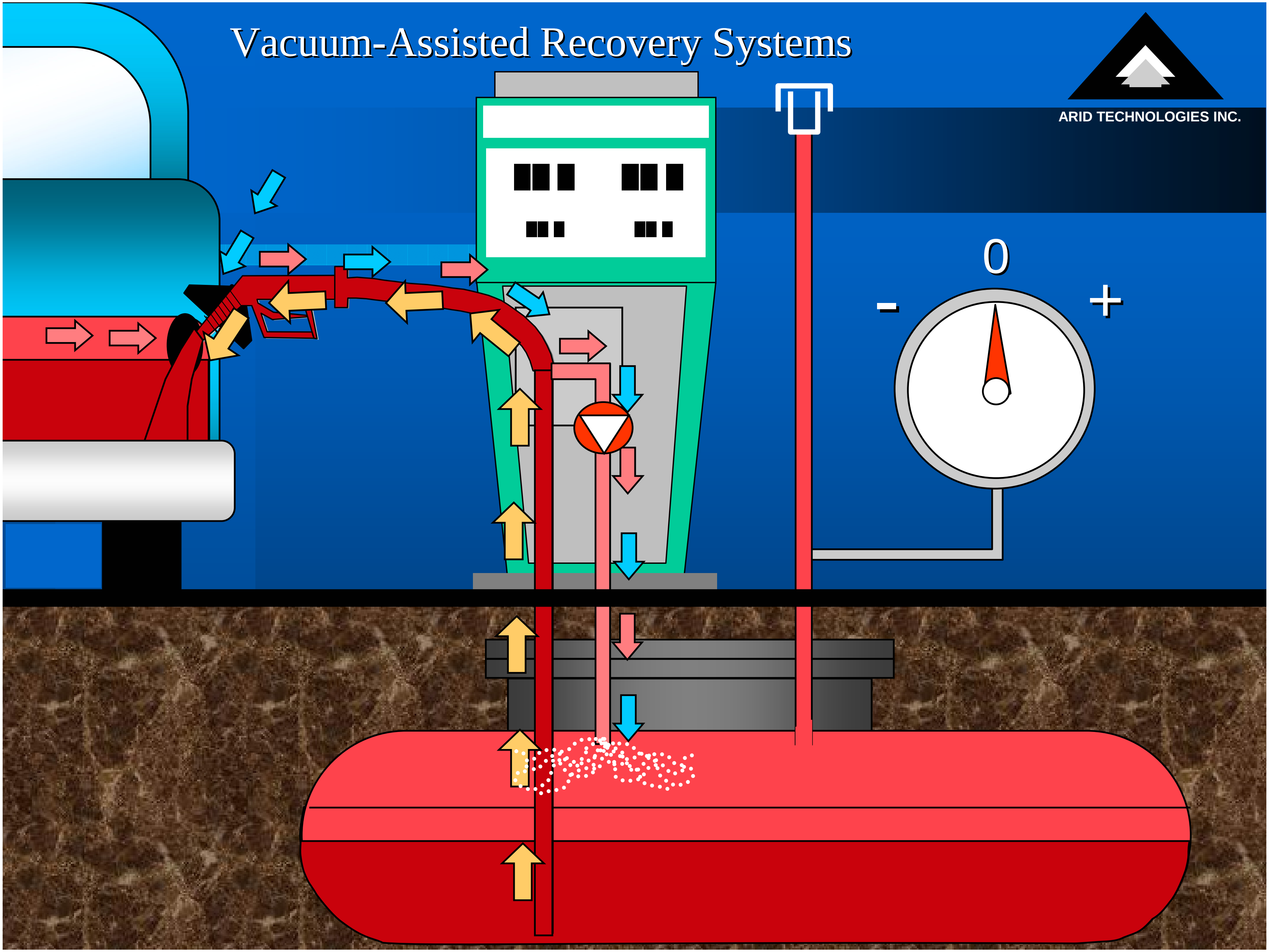


## Centralized

**V/L = 1.3 - 2.5**



# Vacuum-Assisted Recovery Systems



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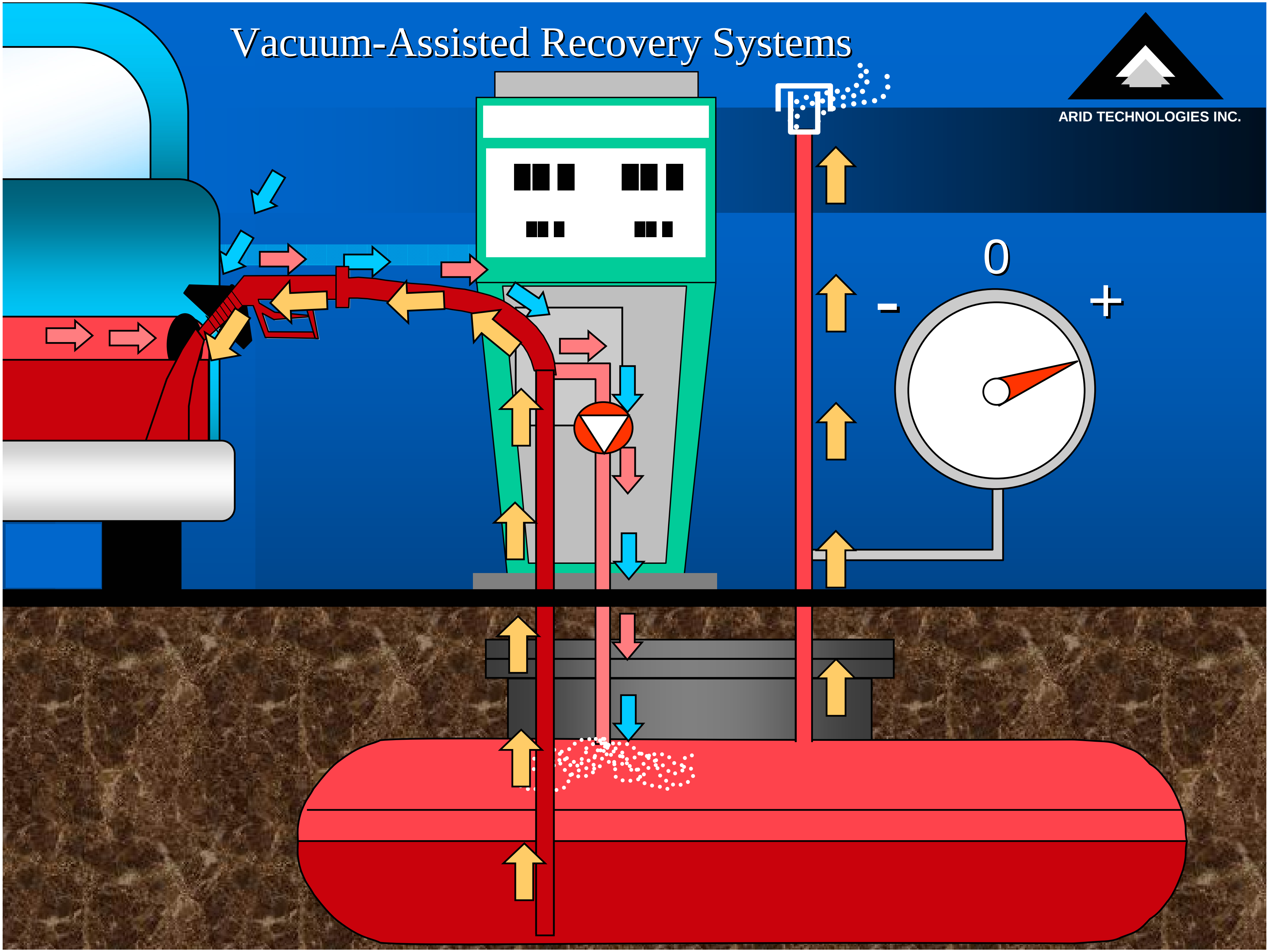

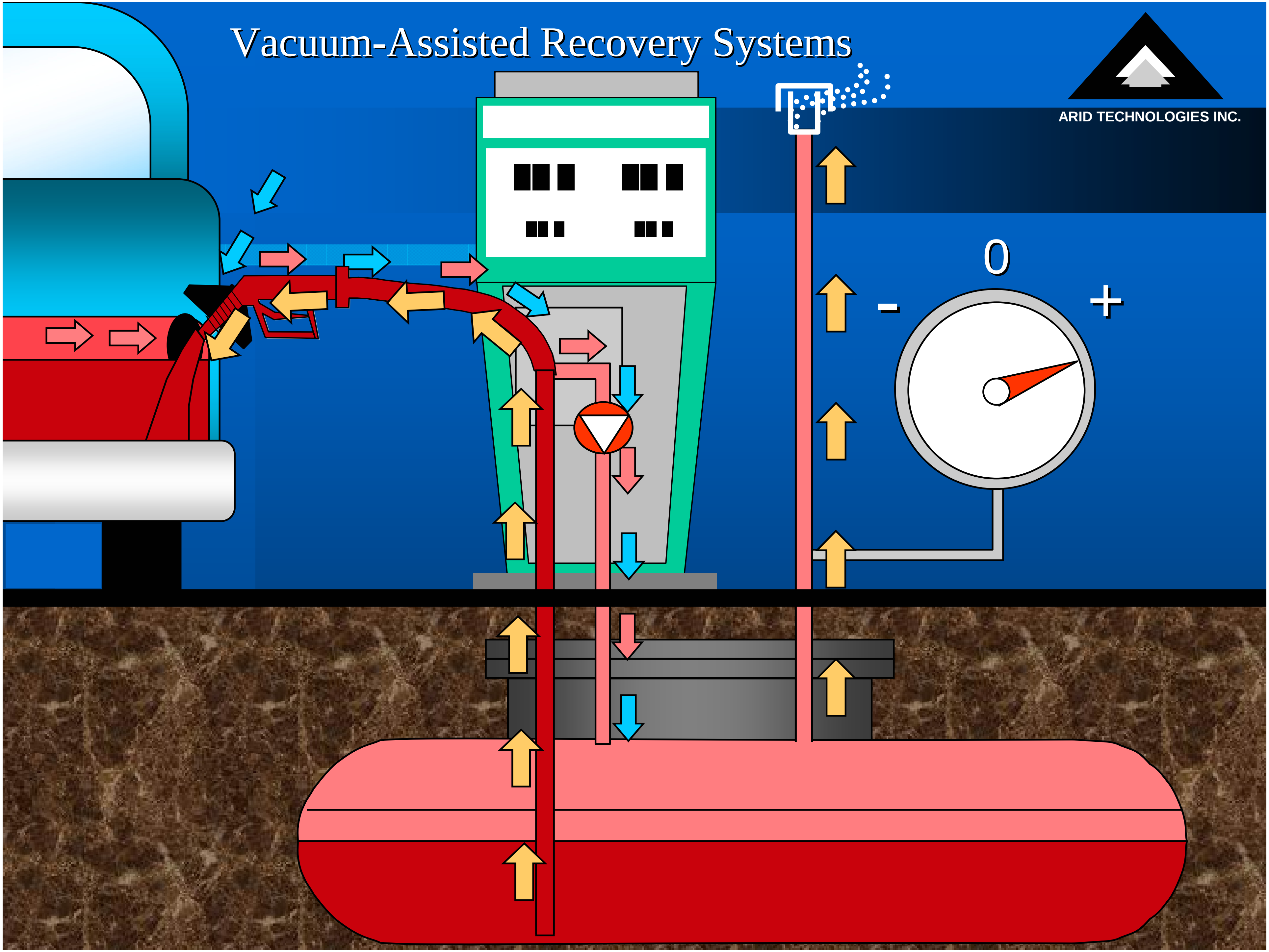
Vacuum-Assisted Recovery Systems
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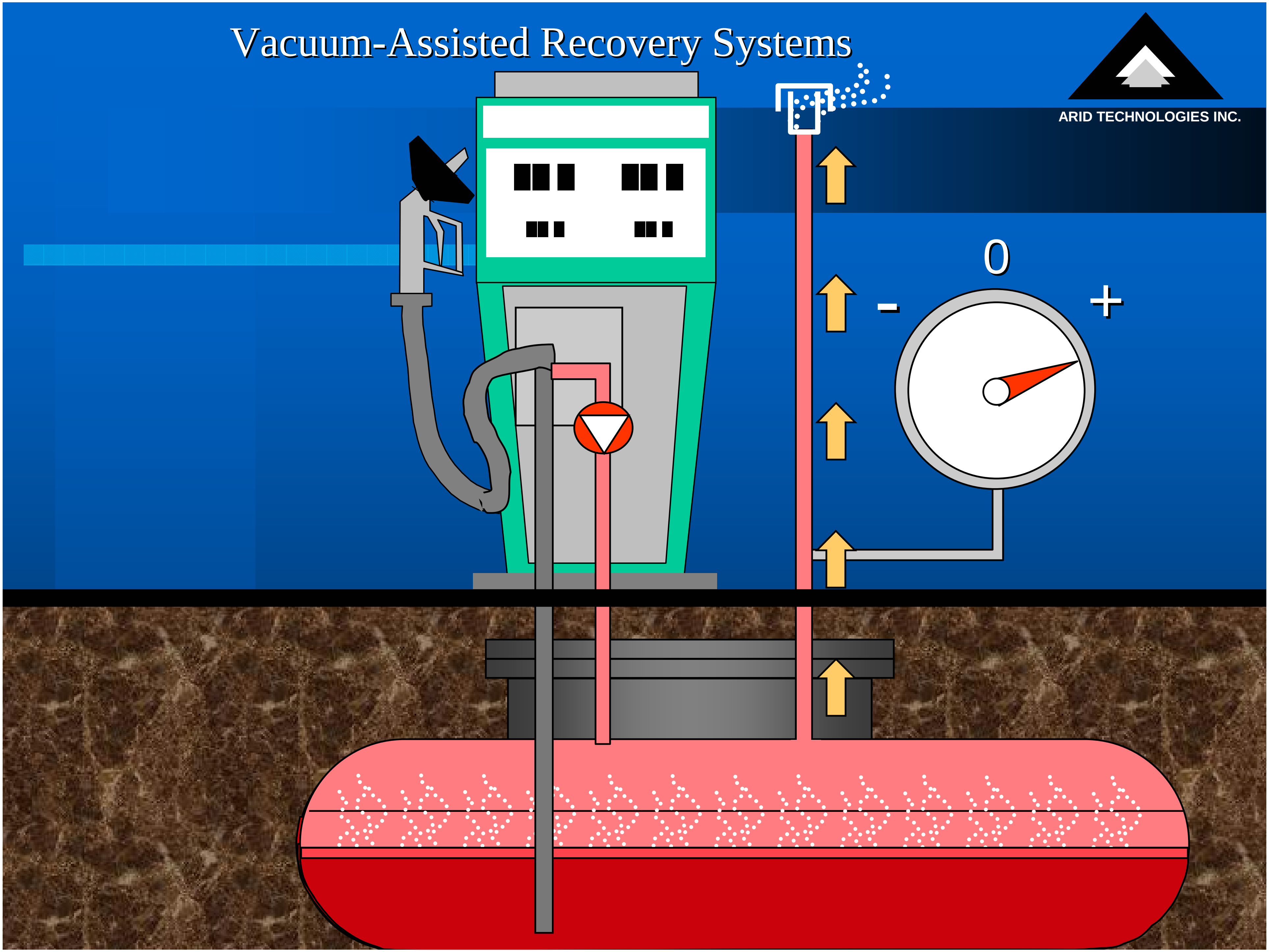
# Vacuum-Assisted Recovery Systems



# Vacuum-Assisted Recovery Systems

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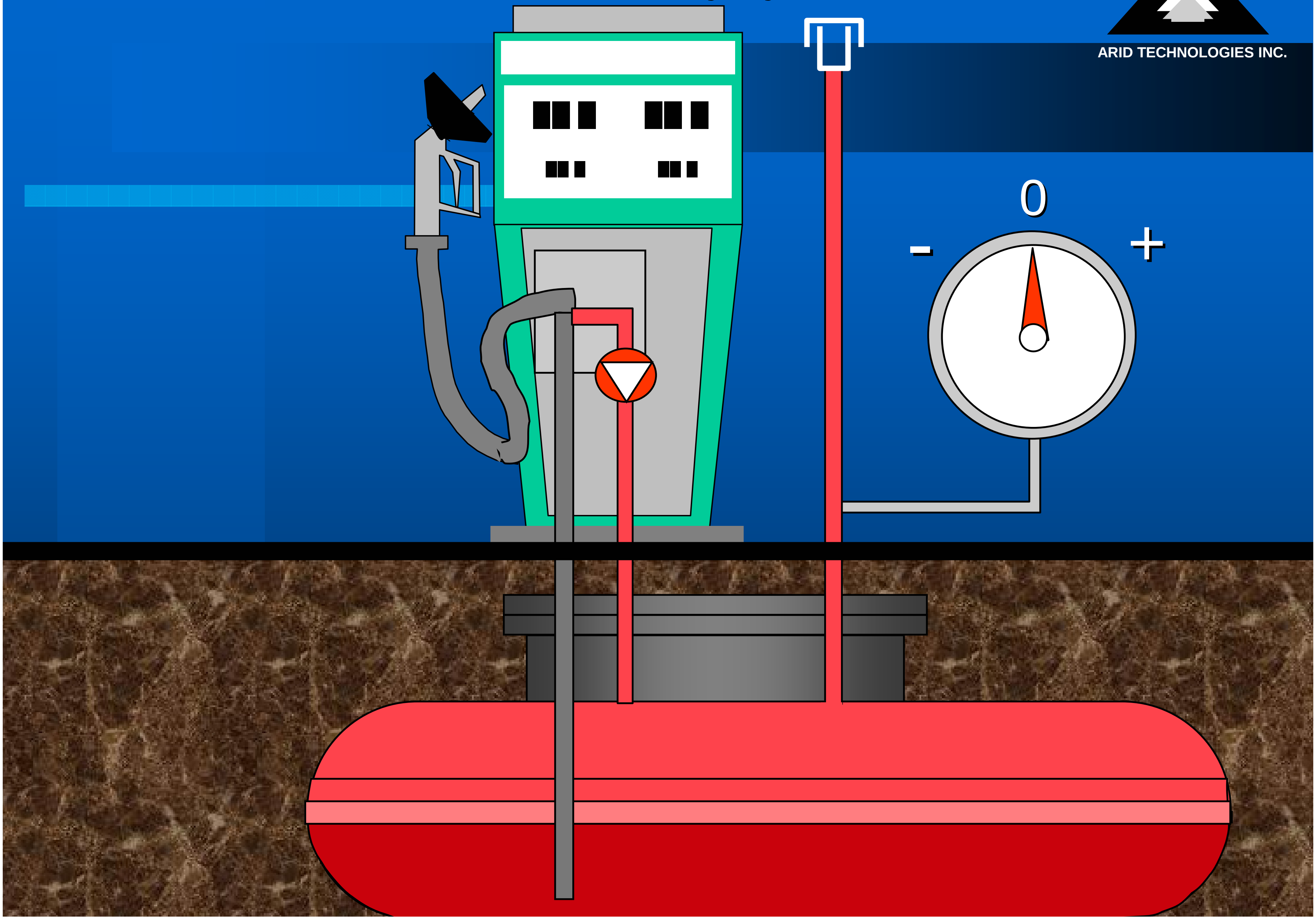

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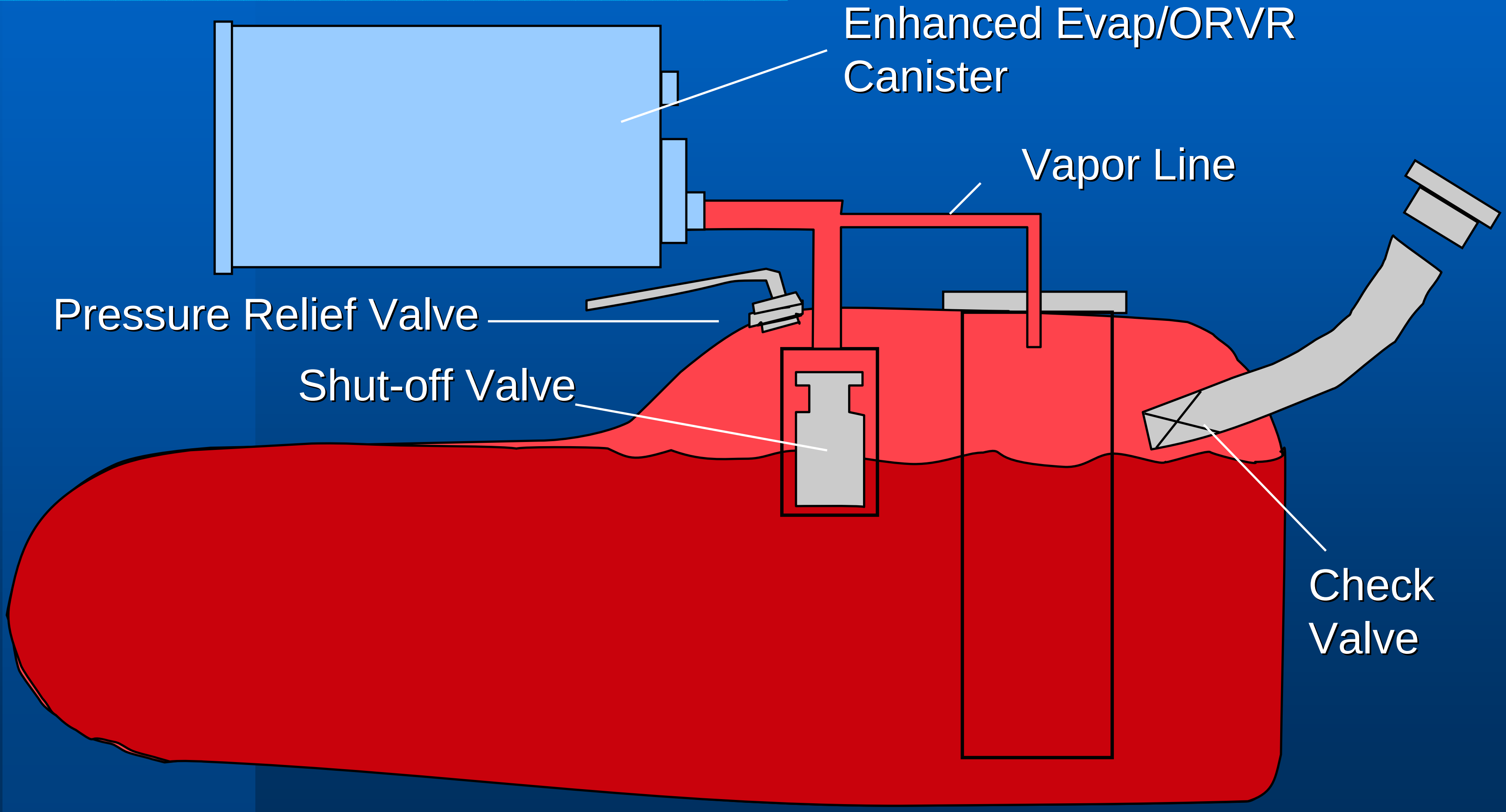
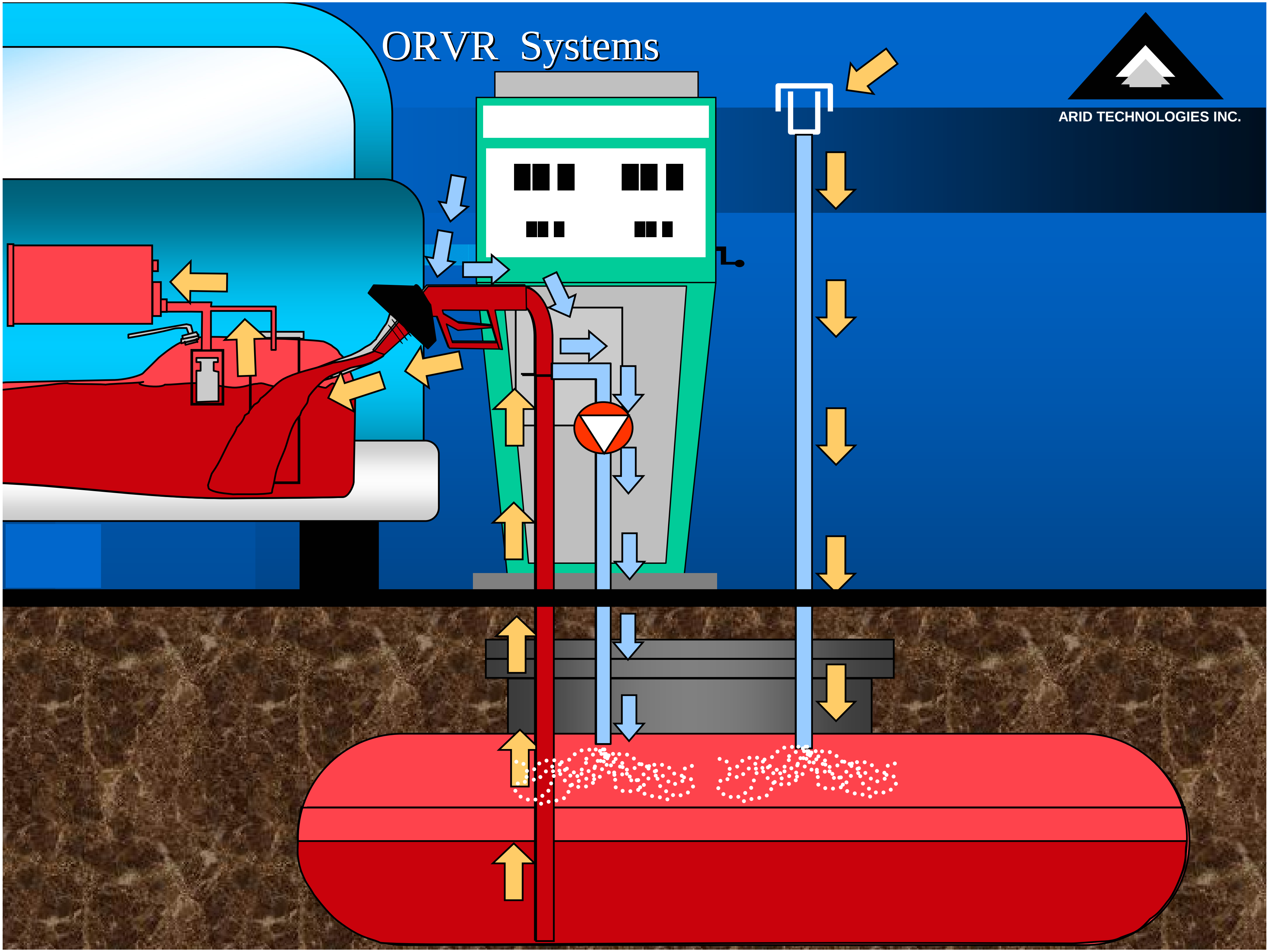
# ORVR Configuration




ORVR Systems
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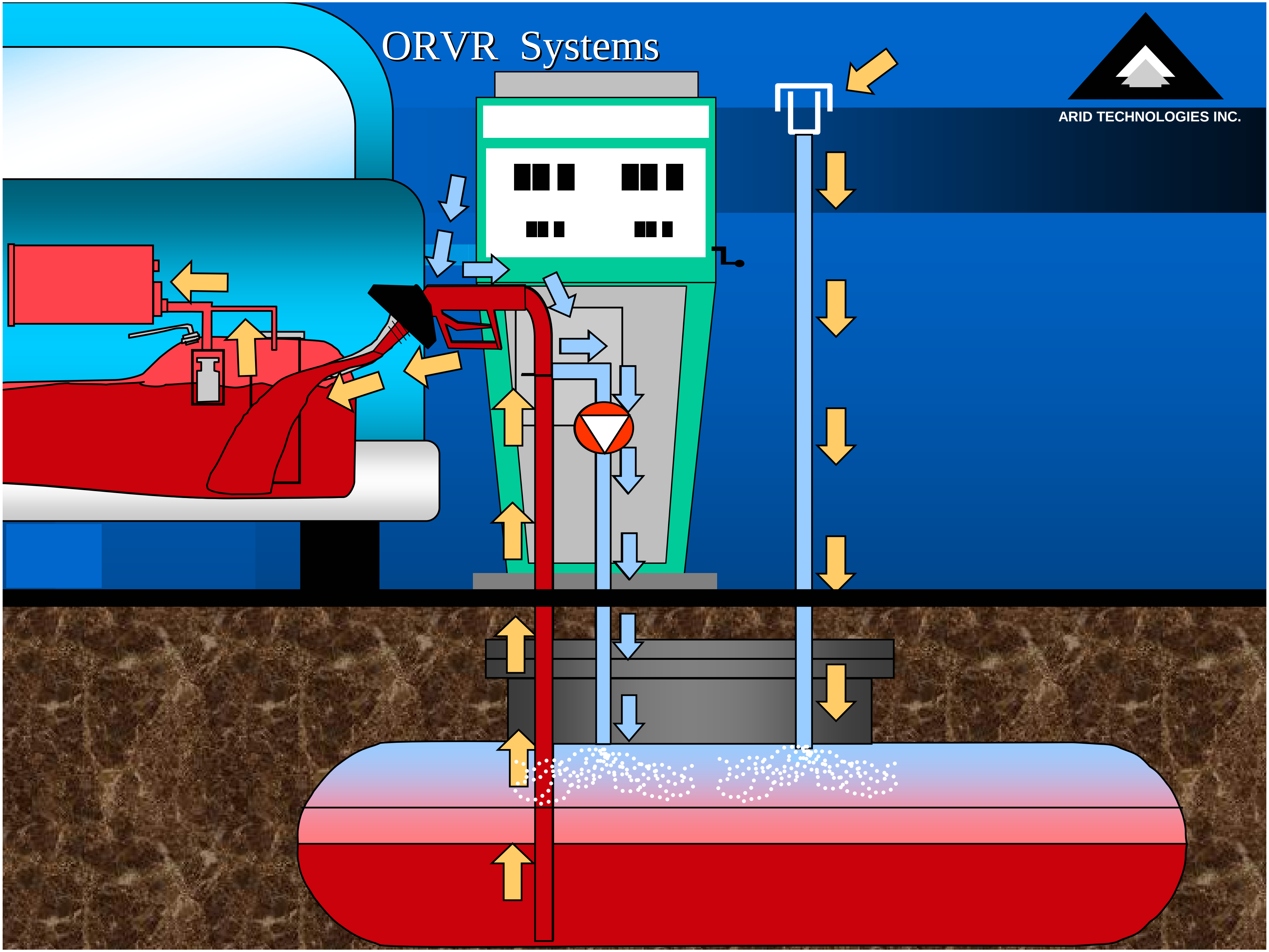
# ORVR Systems



# ORVR Systems

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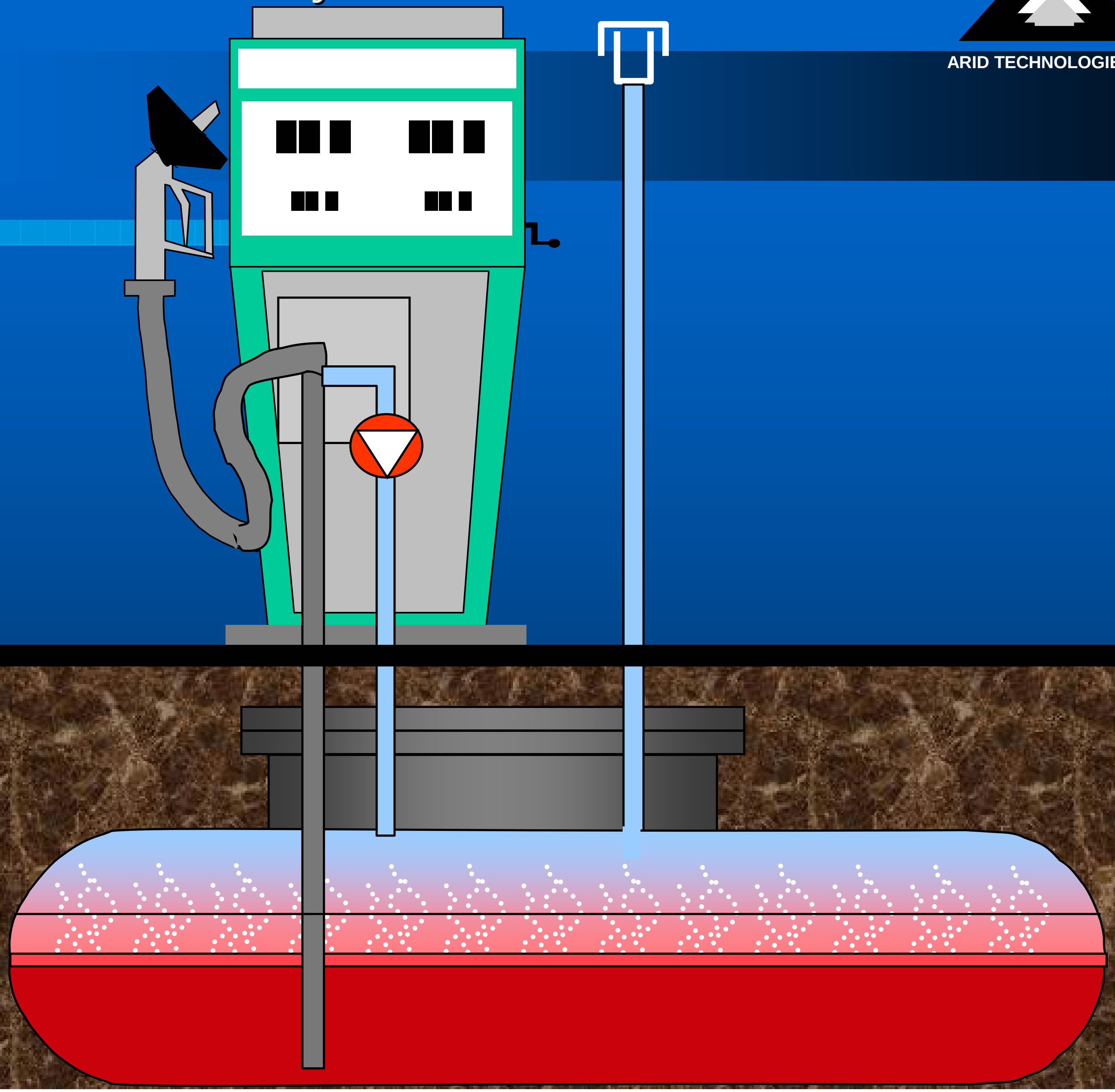
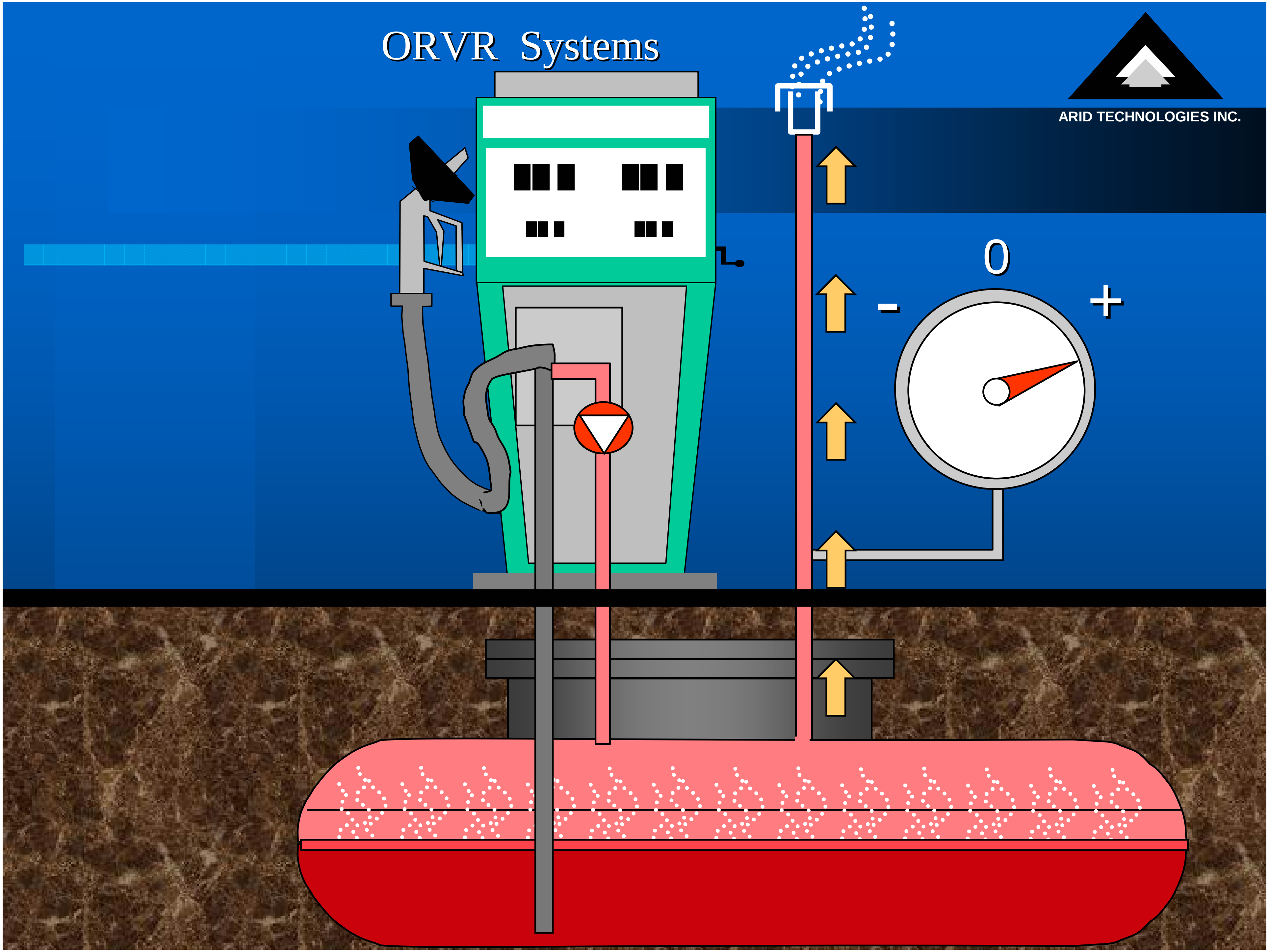


# ORVR Systems



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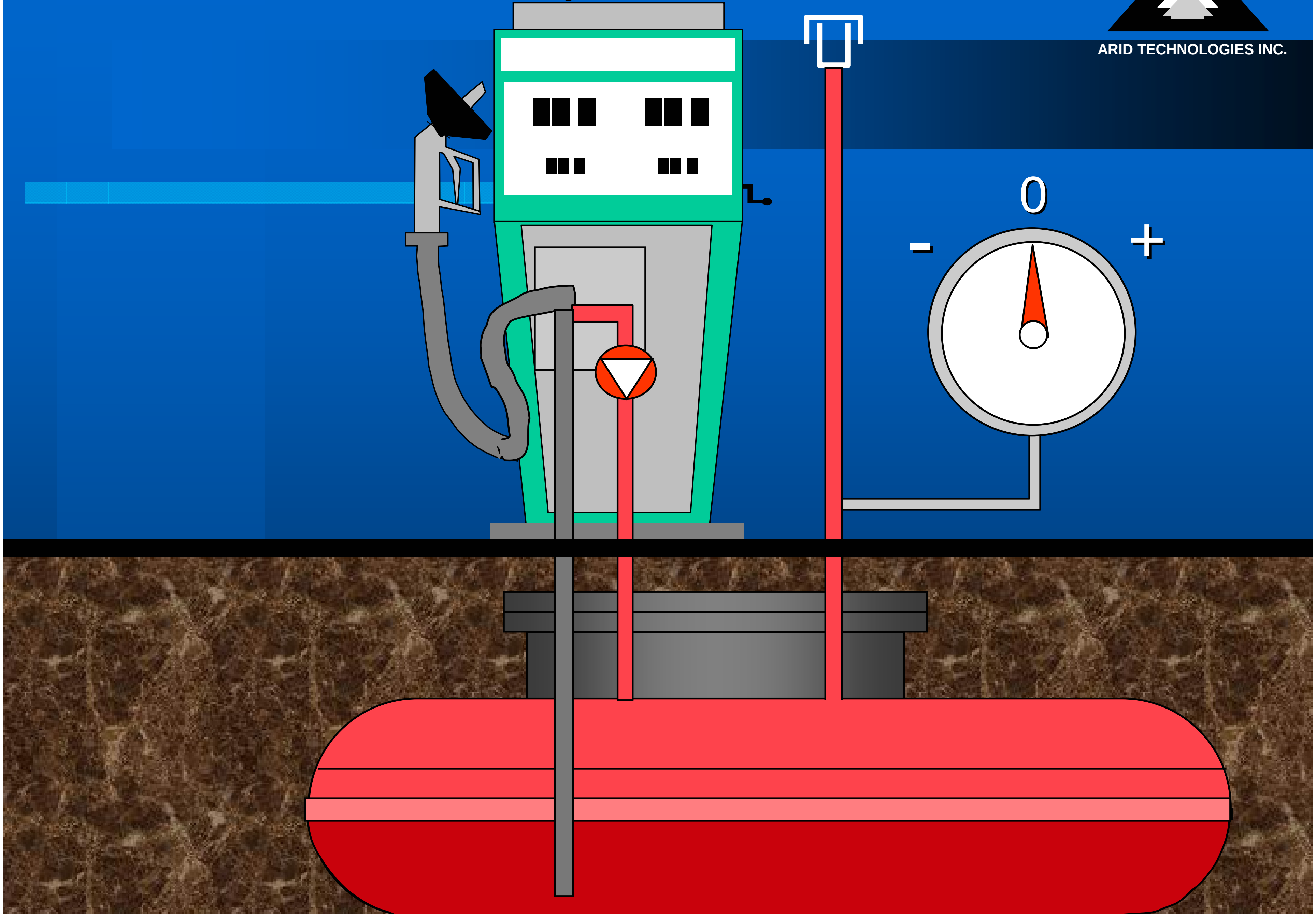
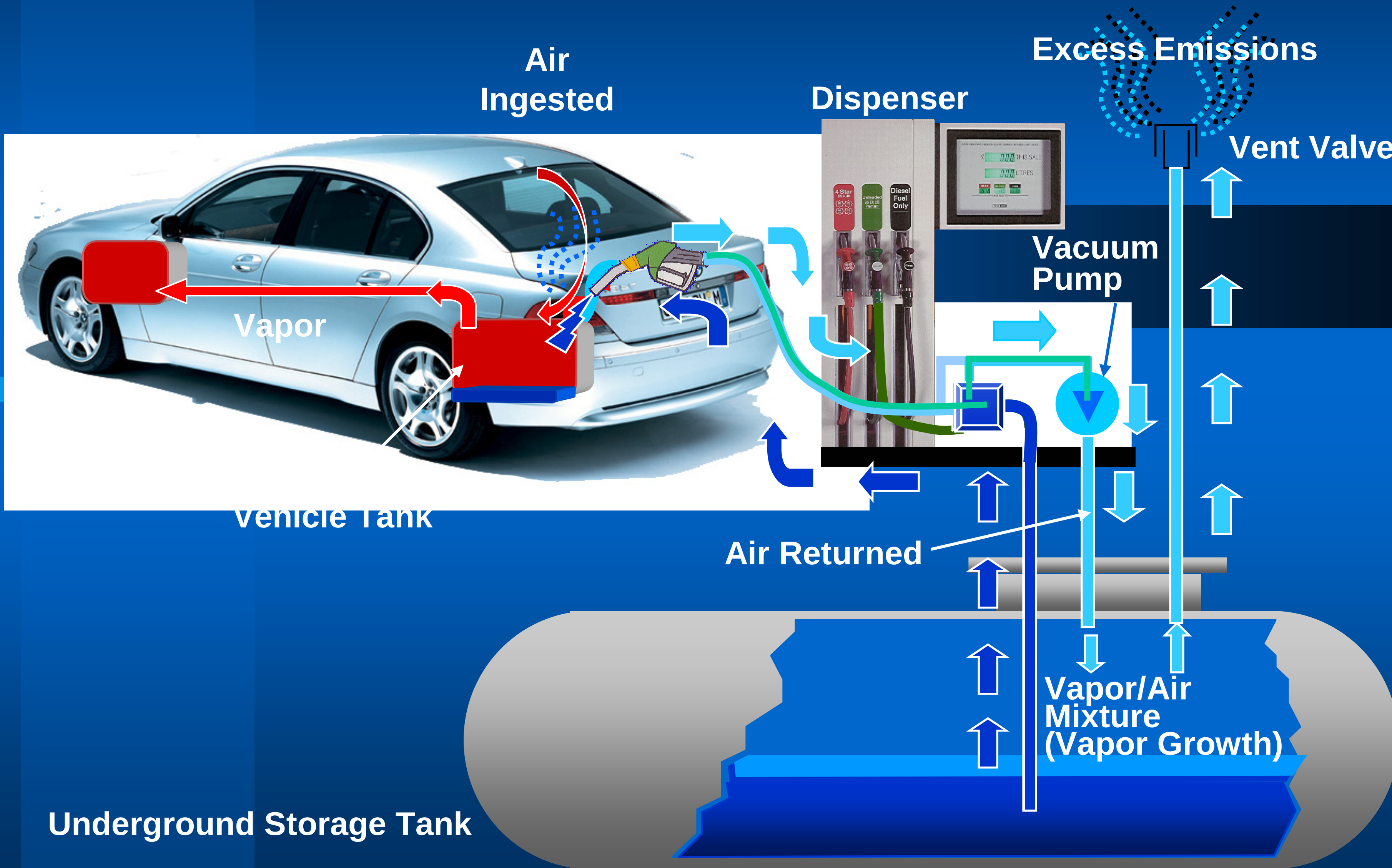


# ORVR Compatibility

– Onboard Refueling Vapor Recovery, or ORVR, provides for collection of the refueling vapors in a carbon canister on the vehicle.  It performs the same function as a Stage II vapor recovery system for newer cars.

– Minimizing impact of air ingestion while refueling ORVR equipped vehicles

# Module 3
# ORVR/Phase II Compatibility



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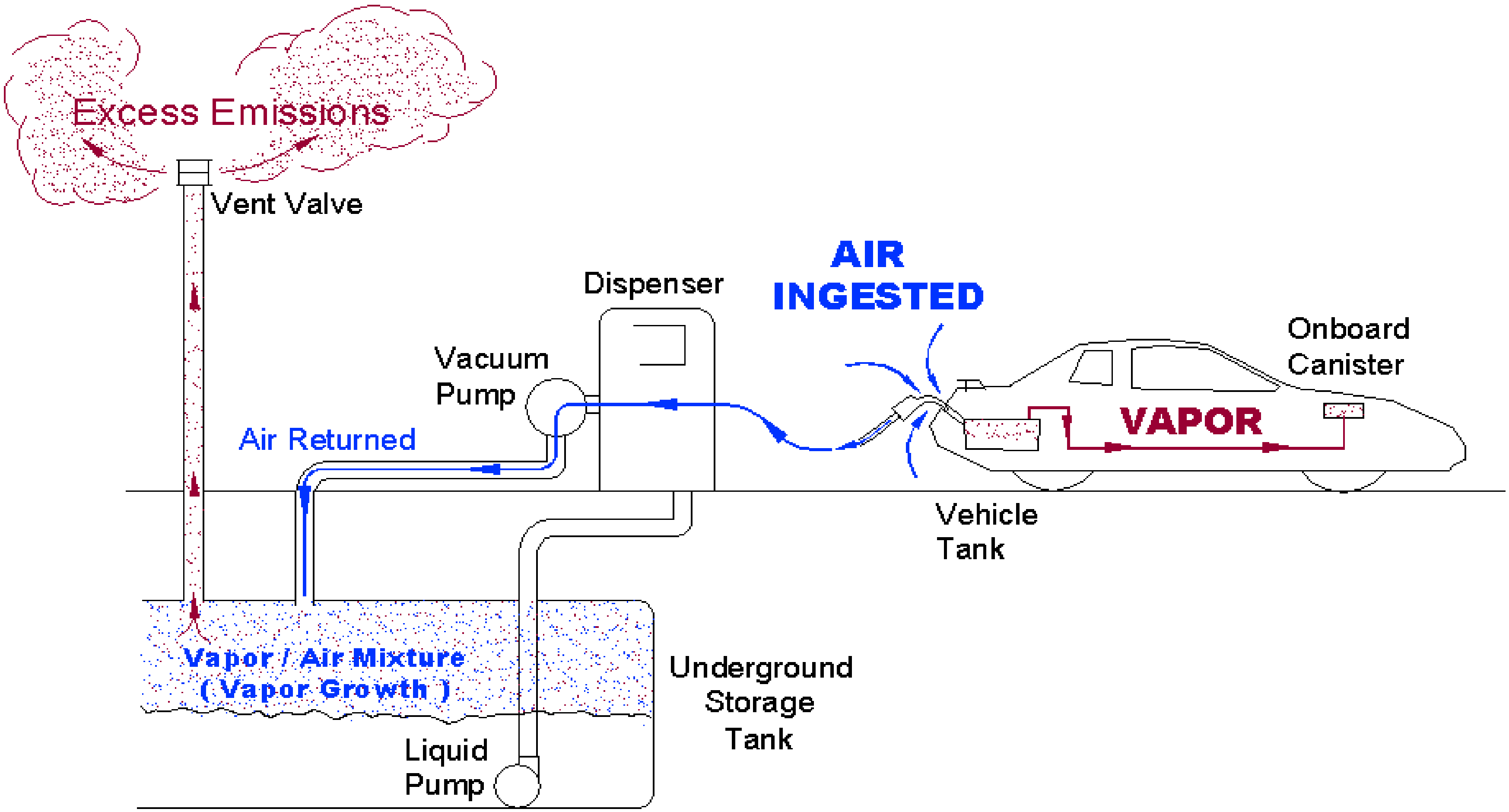
# ORVR - Phase II Incompatibility



# Onboard Refueling Vapor Recovery or "ORVR"

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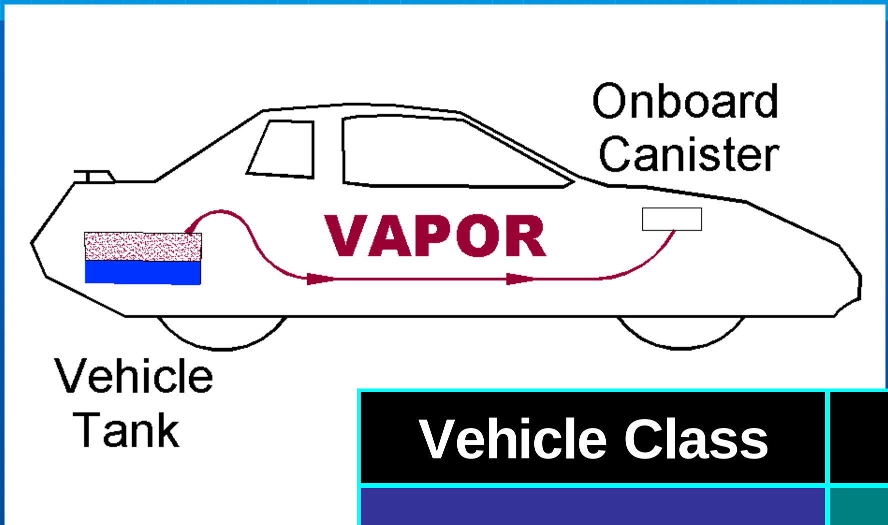
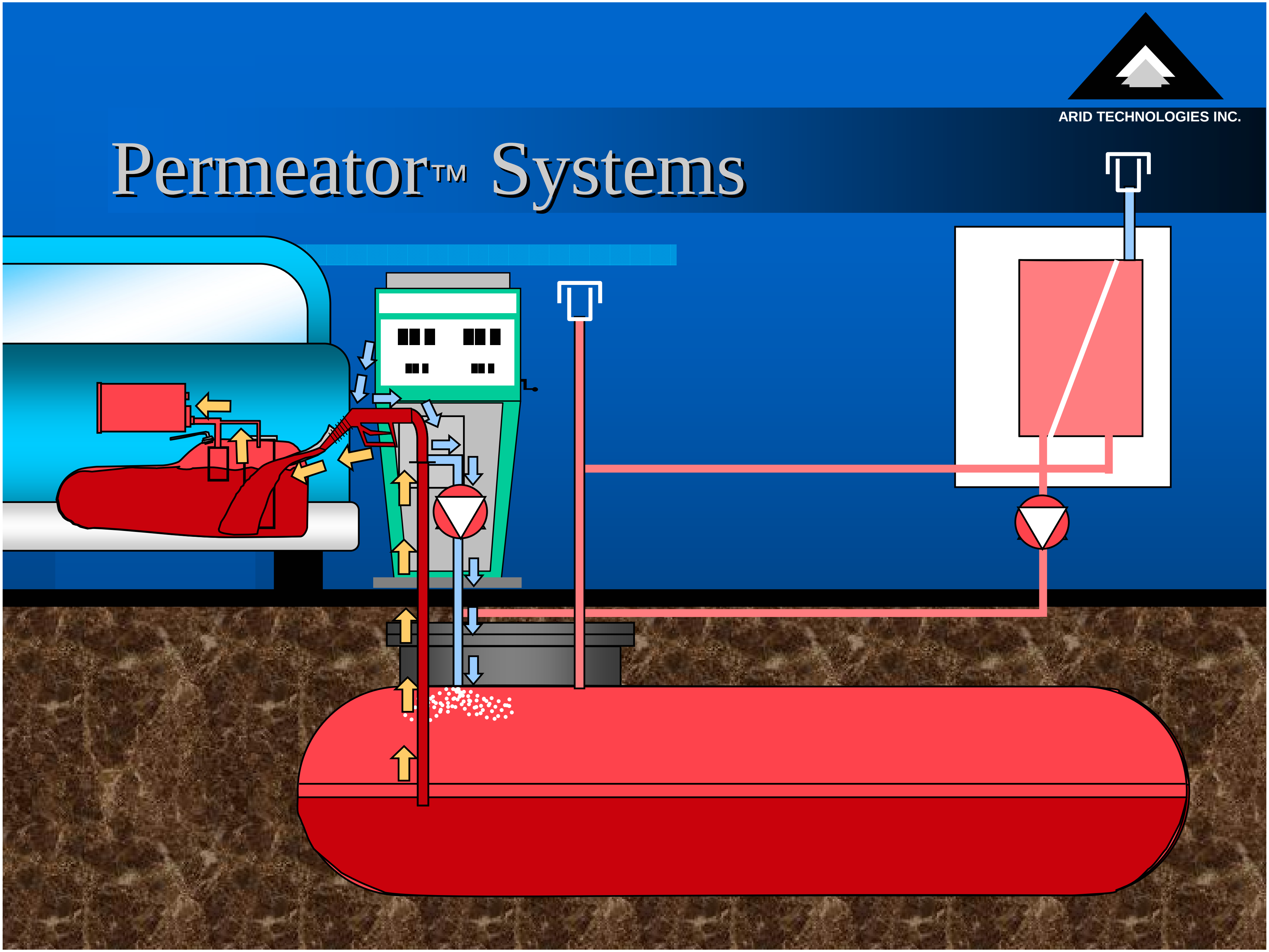



| Vehicle Class | 40% | 80% | 100% |
|---|---|---|---|
| Passenger | 1998 | 1999 | 2000 |
| LD Trucks & MDV (<6000 lbs) | 2001 | 2002 | 2003 |
| MD Vehicles (6001-8500 lbs) | 2004 | 2005 | 2006 |

# Permeator™ Systems



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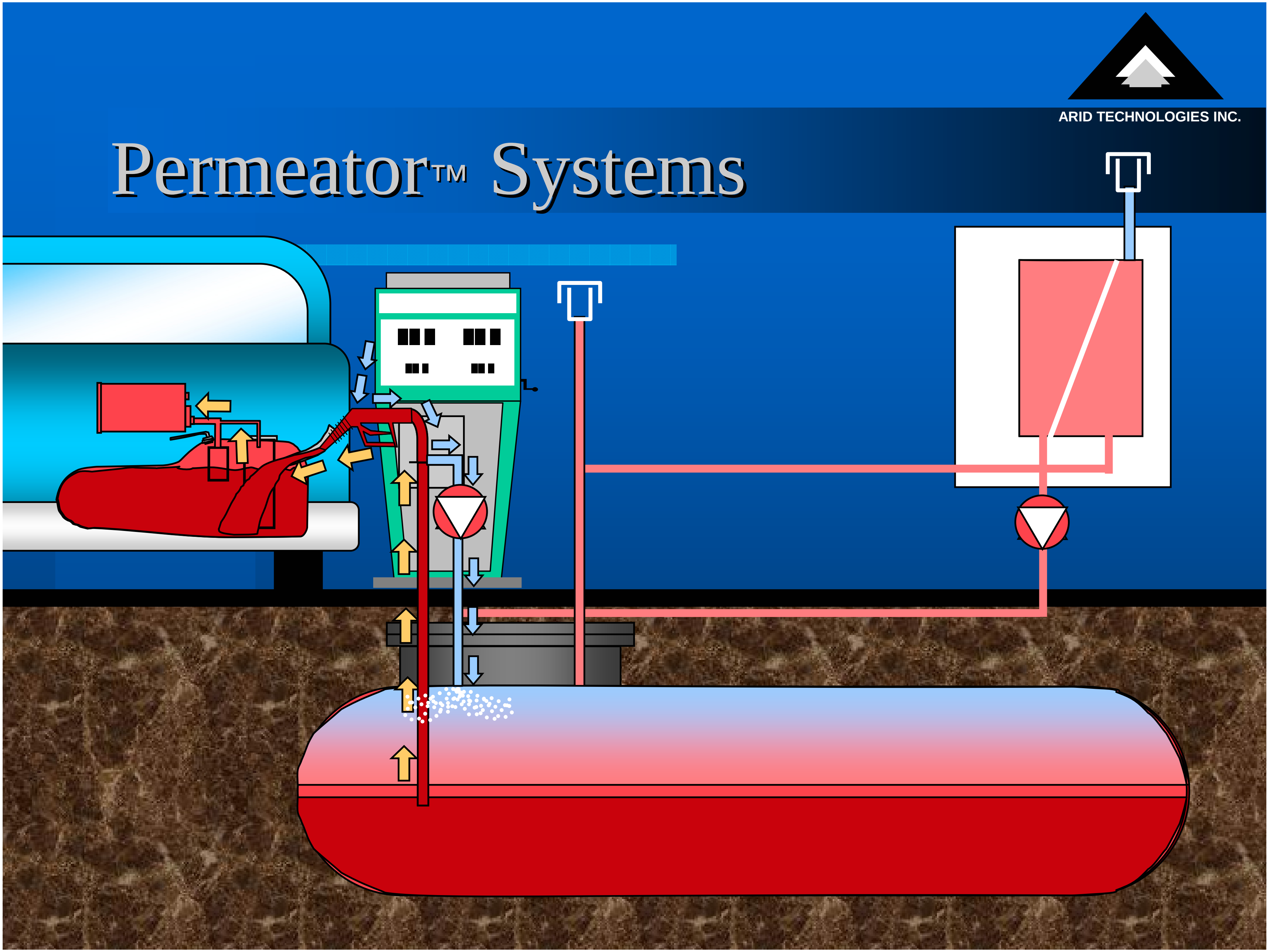

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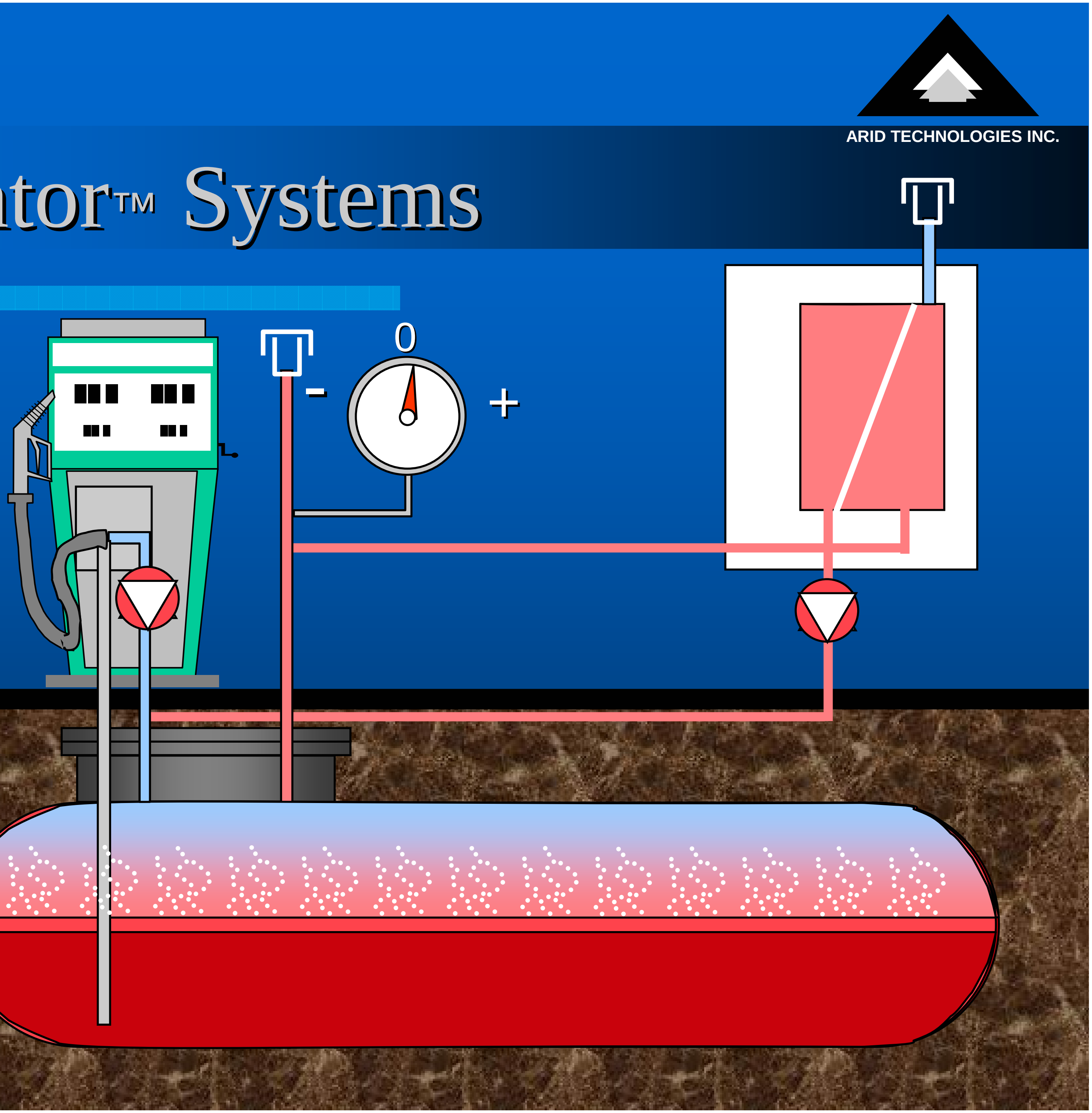

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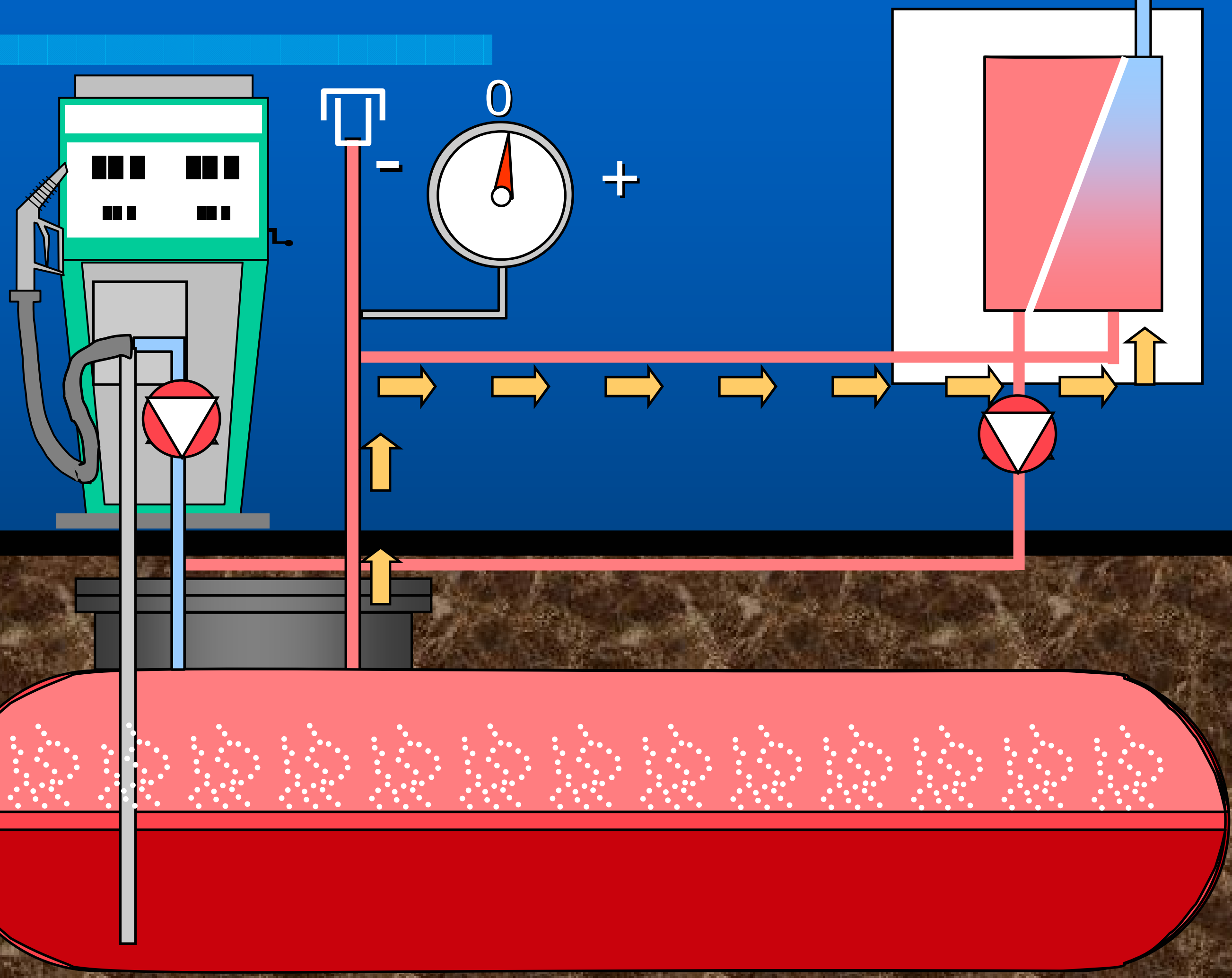


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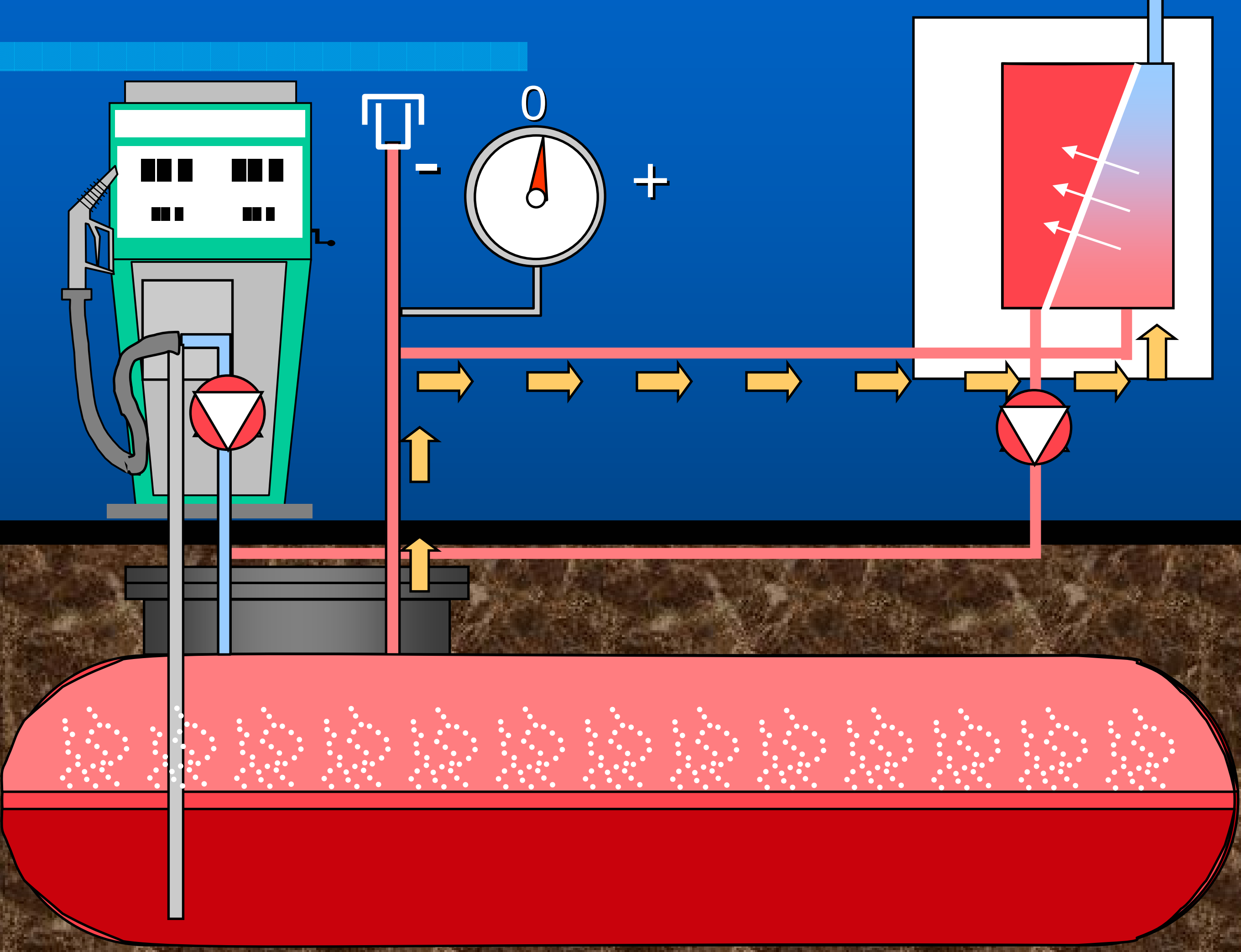


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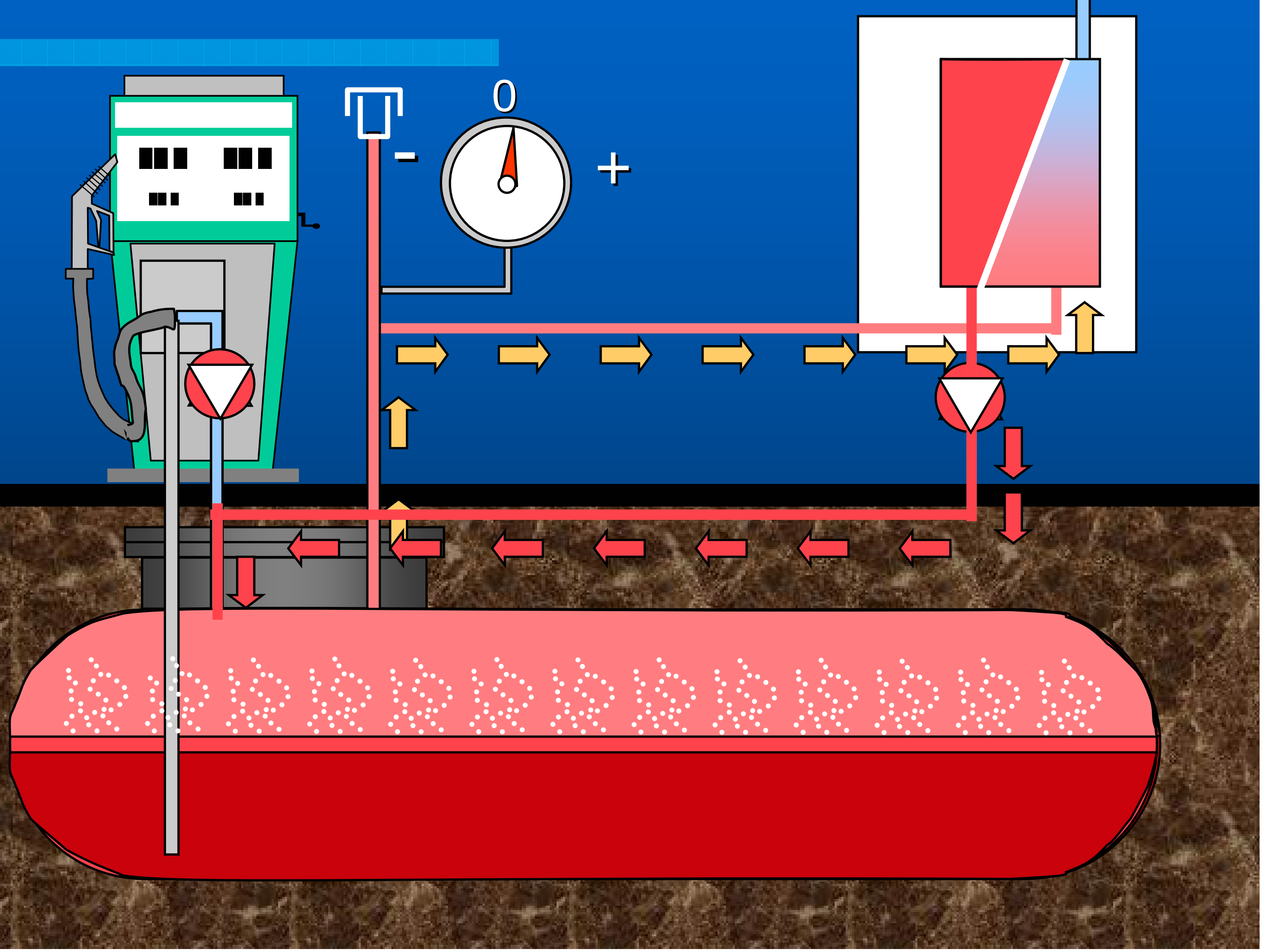

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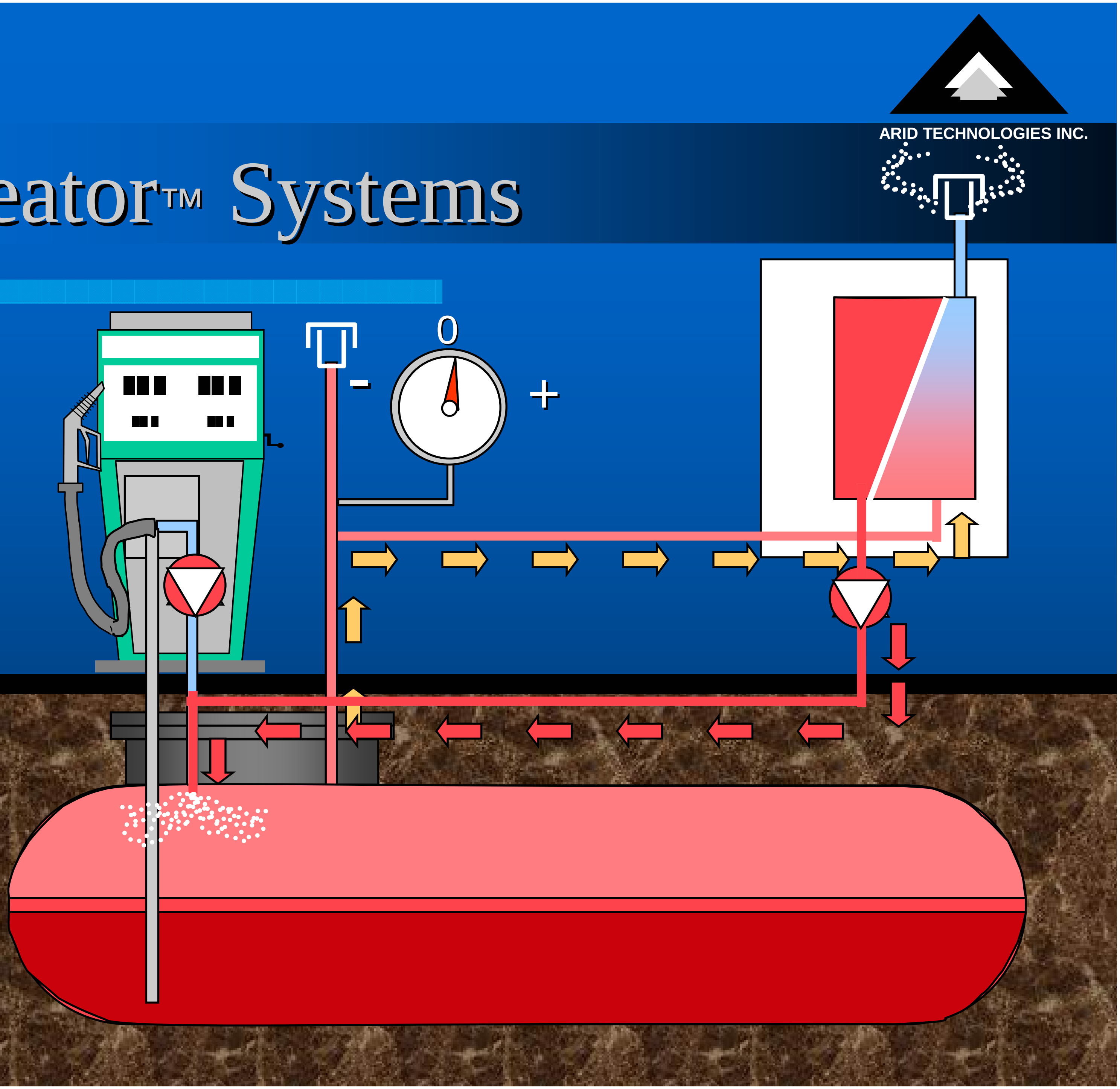

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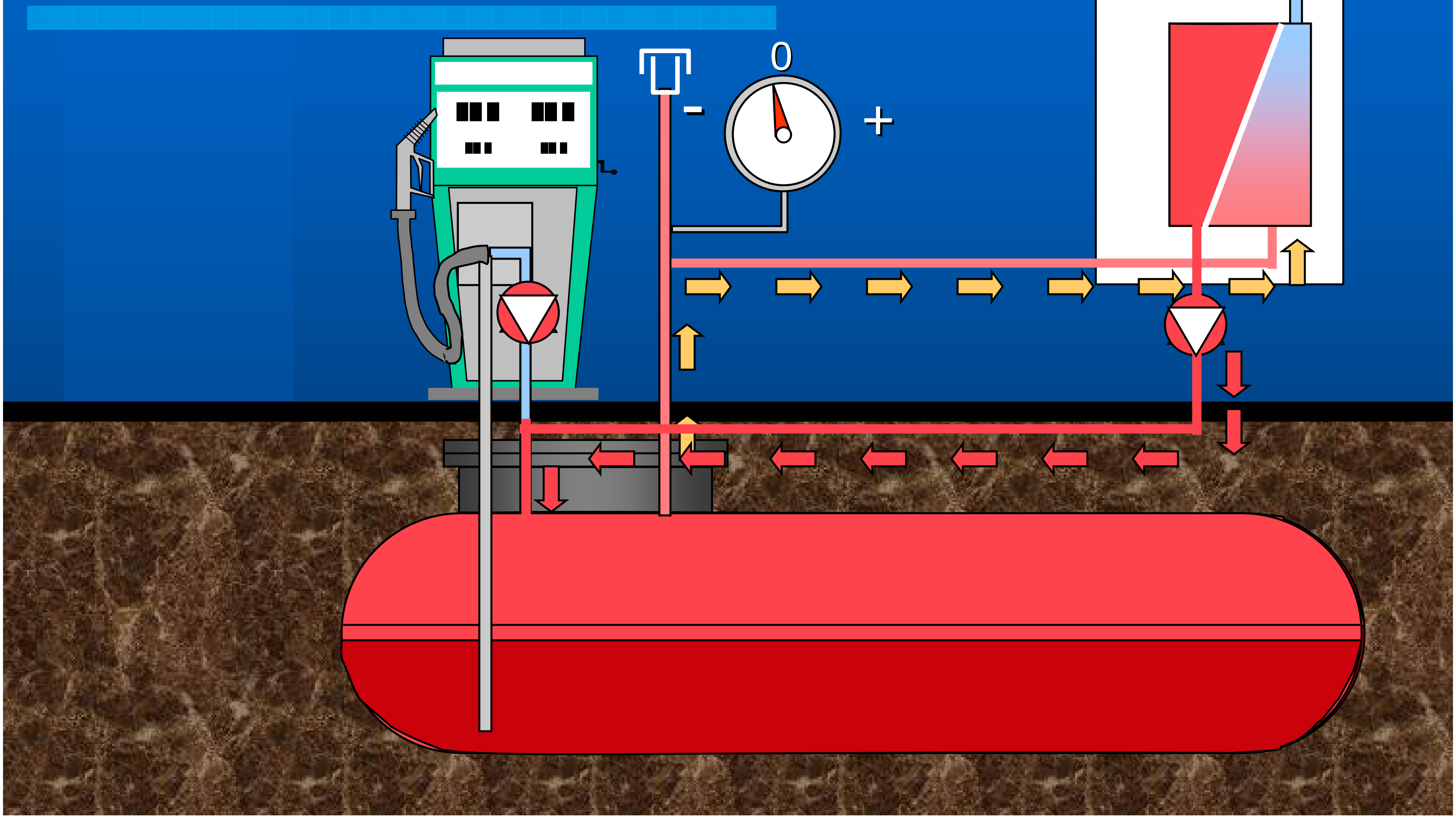
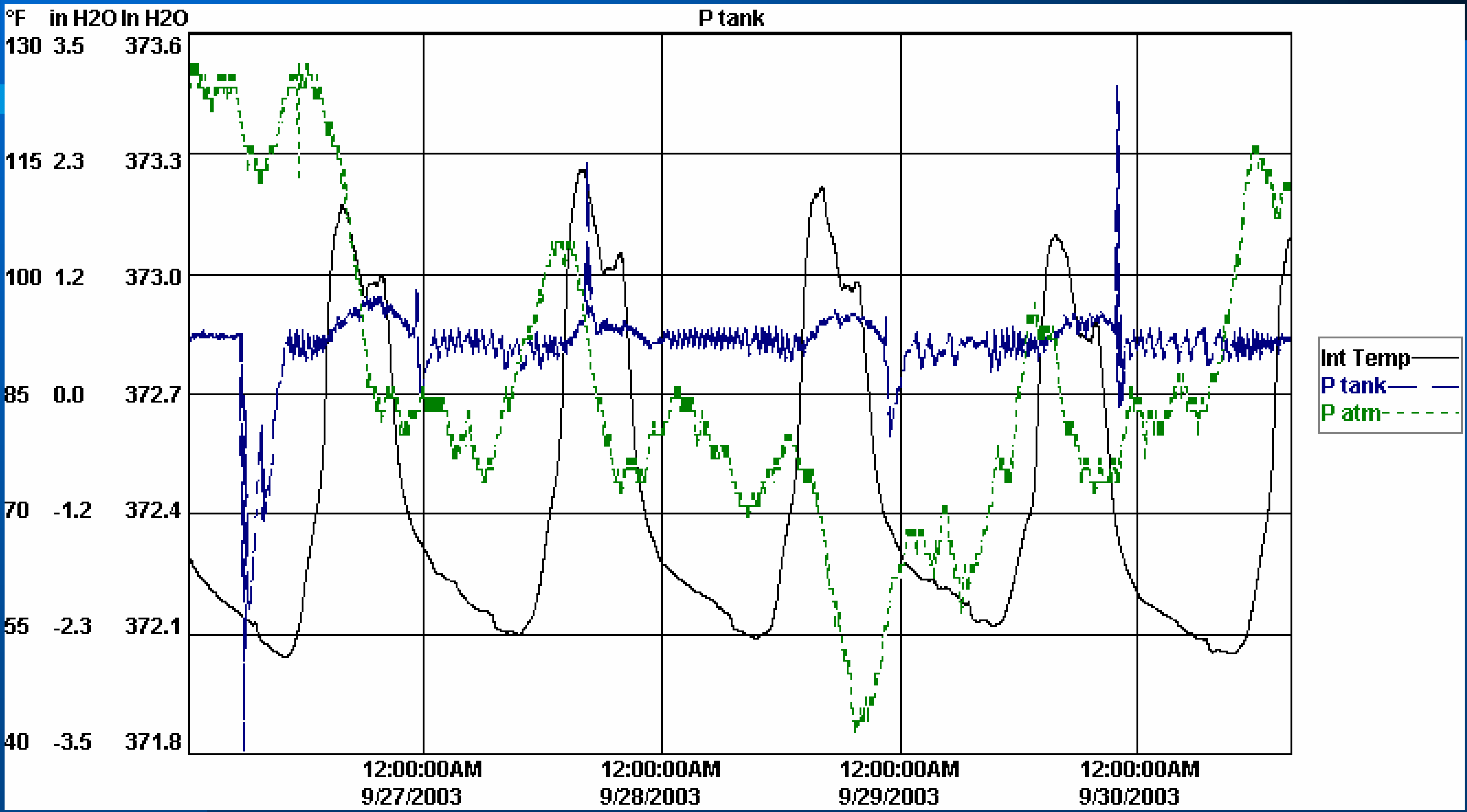


# Grass Valley Chevron



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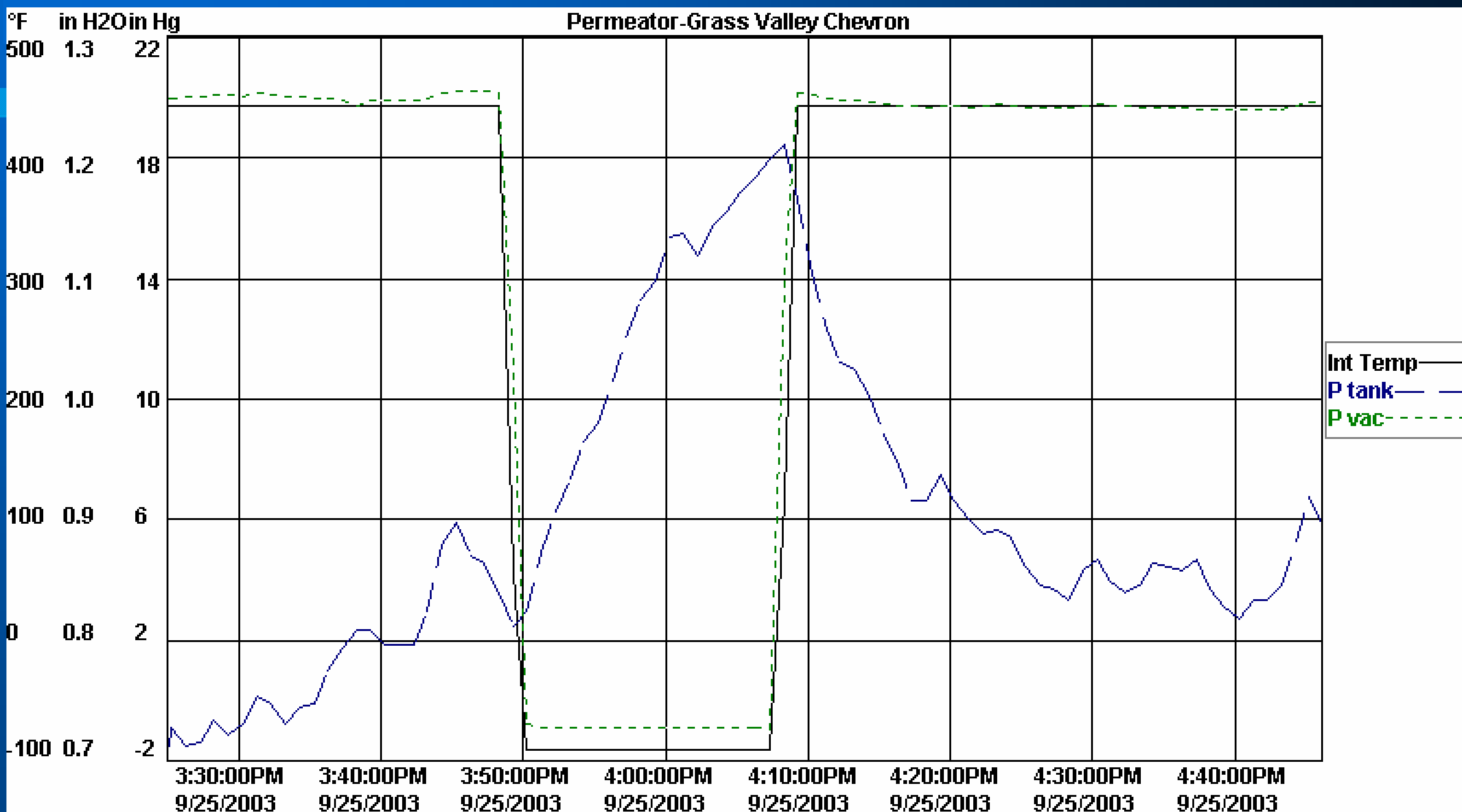
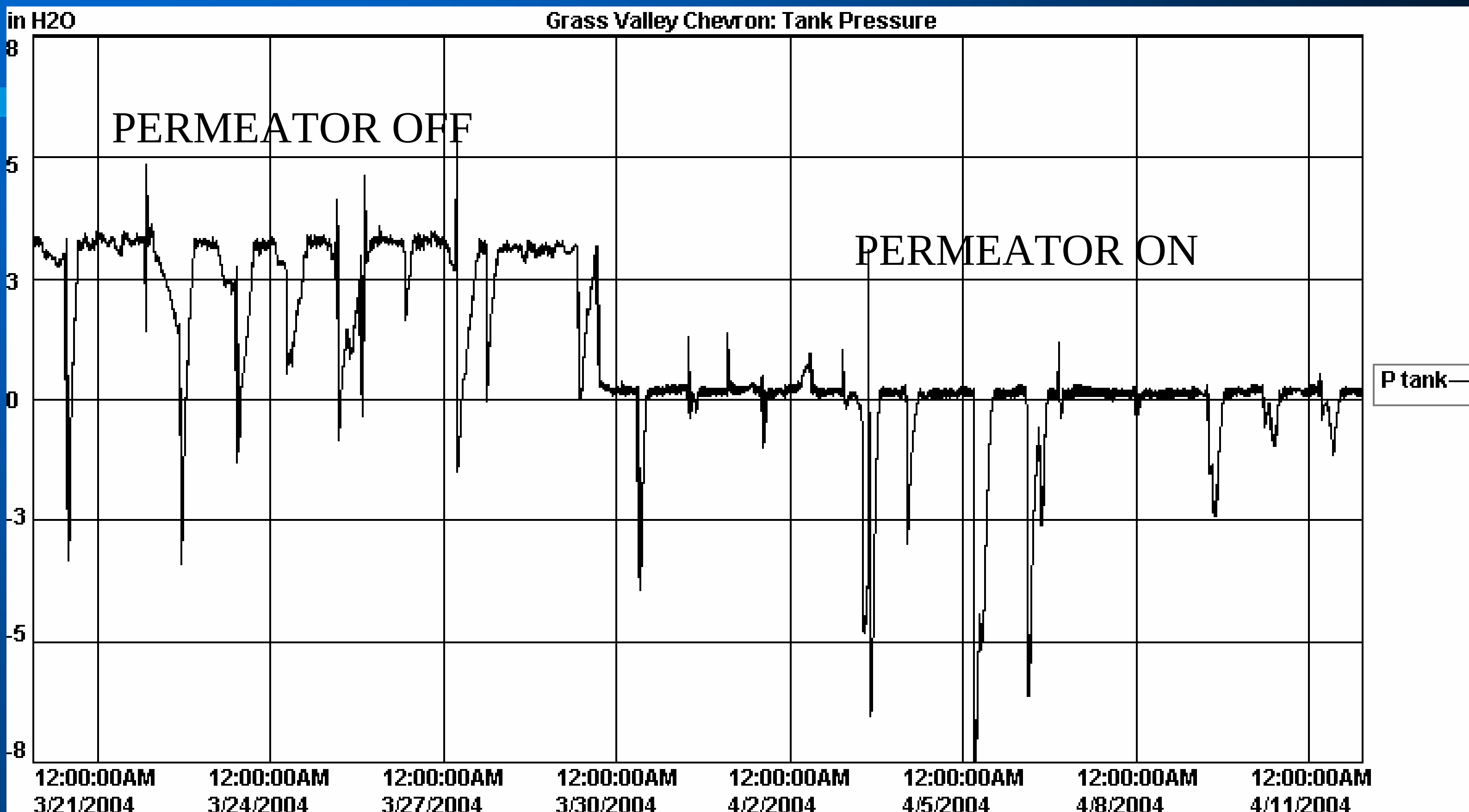
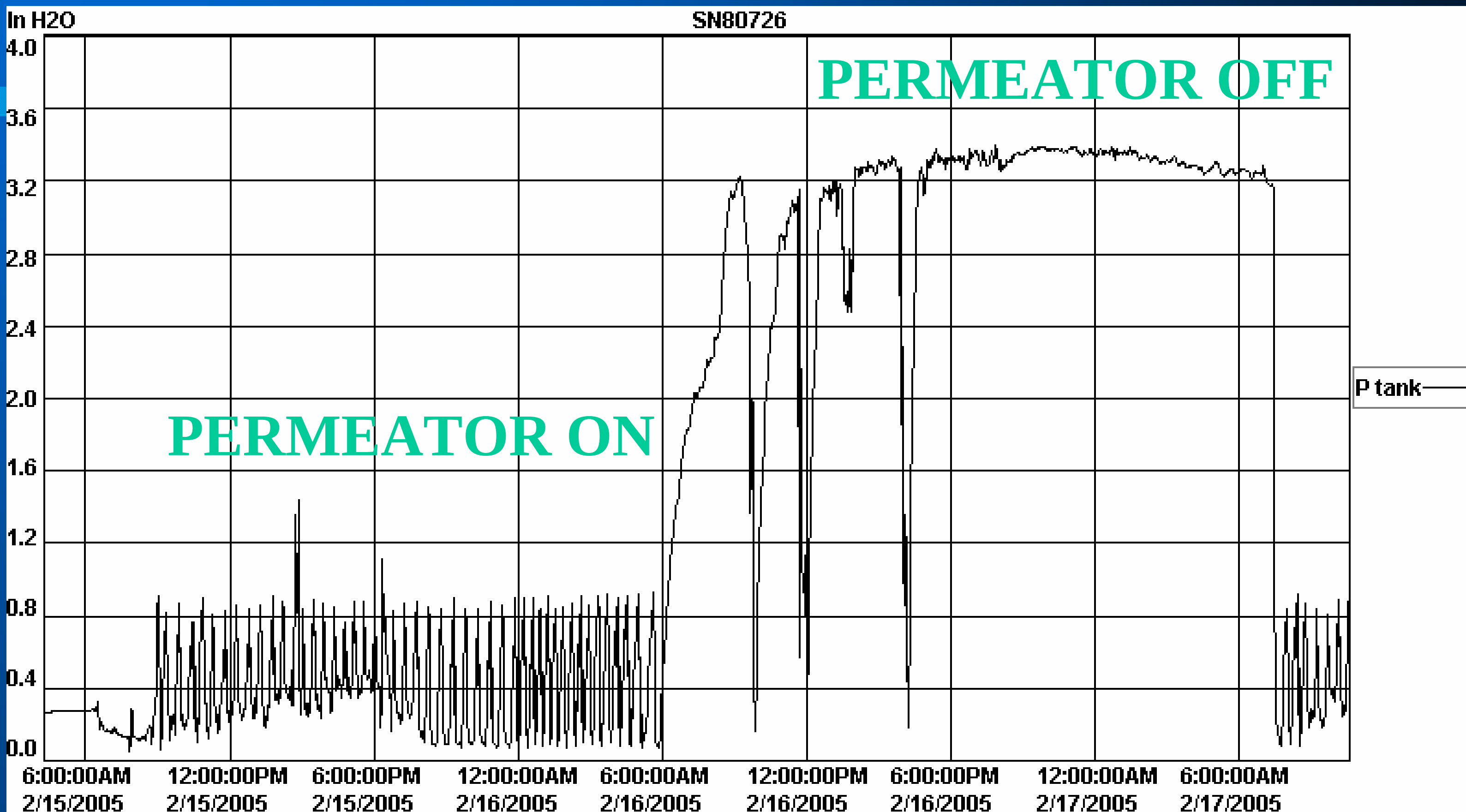



in H2O
Grass Valley Chevron: Tank Pressure
PERMEATOR OFF
PERMEATOR ON
P tank
8
5
3
0
-3
-5
-8
12:00:00AM 3/21/2004
12:00:00AM 3/24/2004
12:00:00AM 3/27/2004
12:00:00AM 3/30/2004
12:00:00AM 4/2/2004
12:00:00AM 4/5/2004
12:00:00AM 4/8/2004
12:00:00AM 4/11/2004

# Lantana, Florida Test Site

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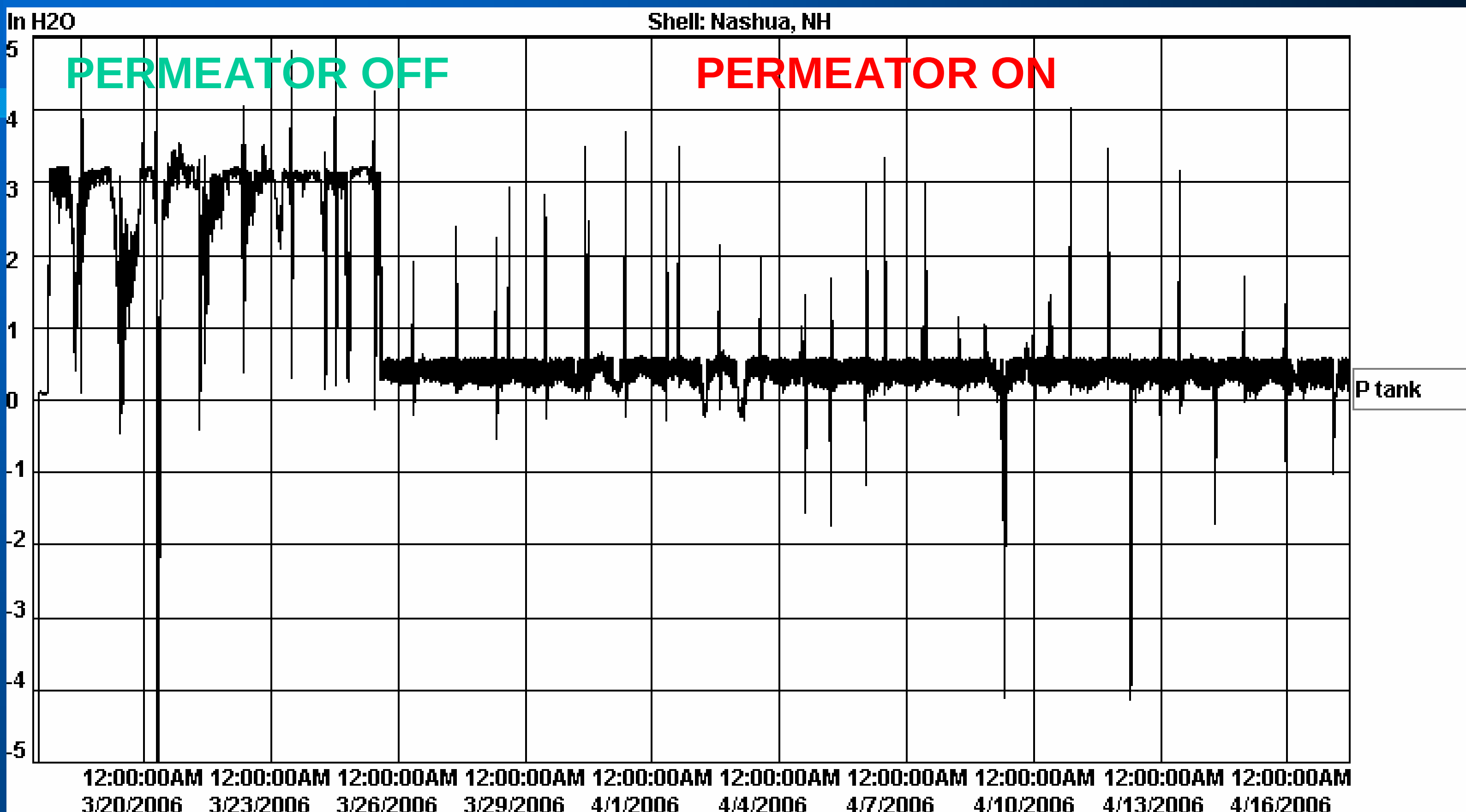

# Typical Run Cycles

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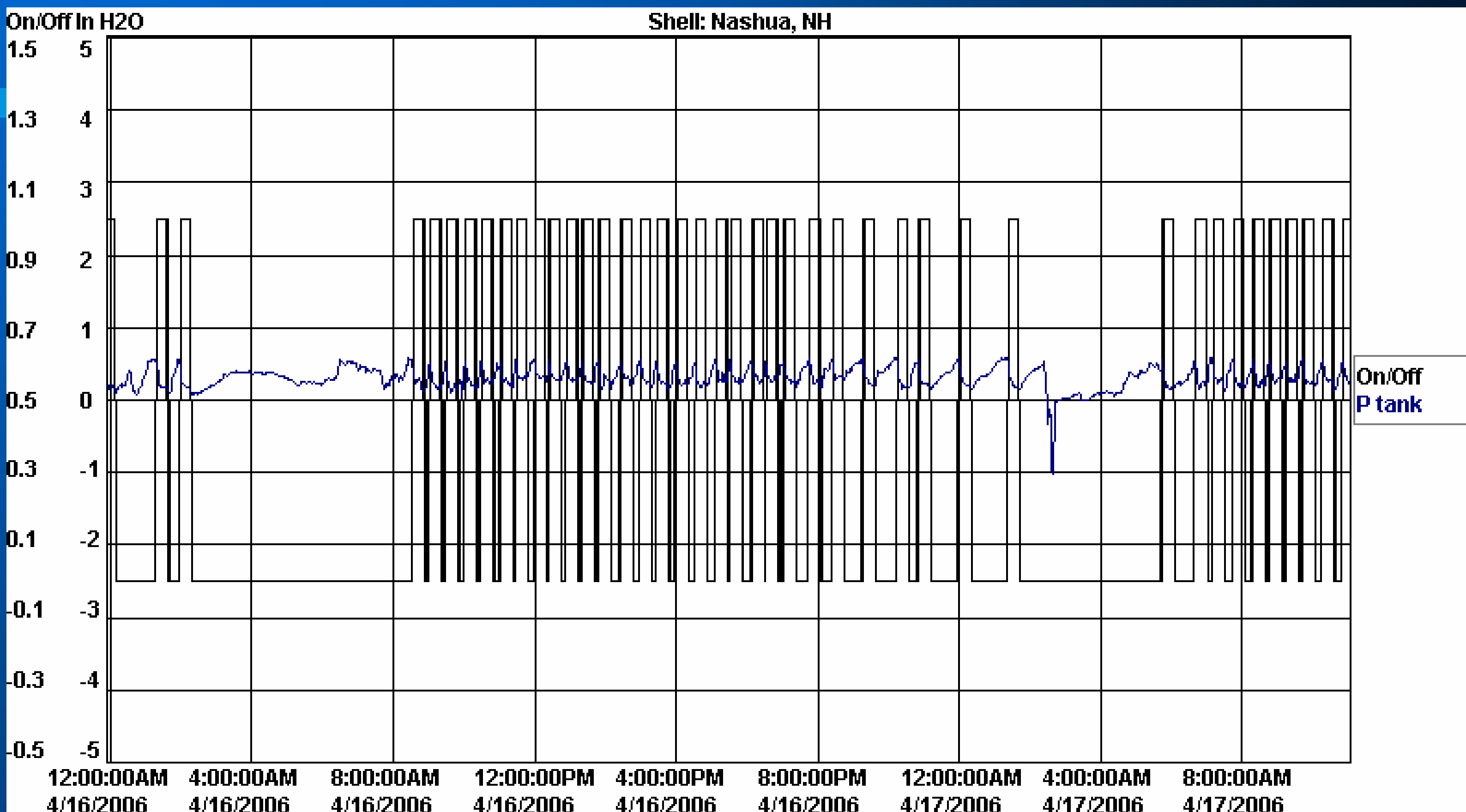
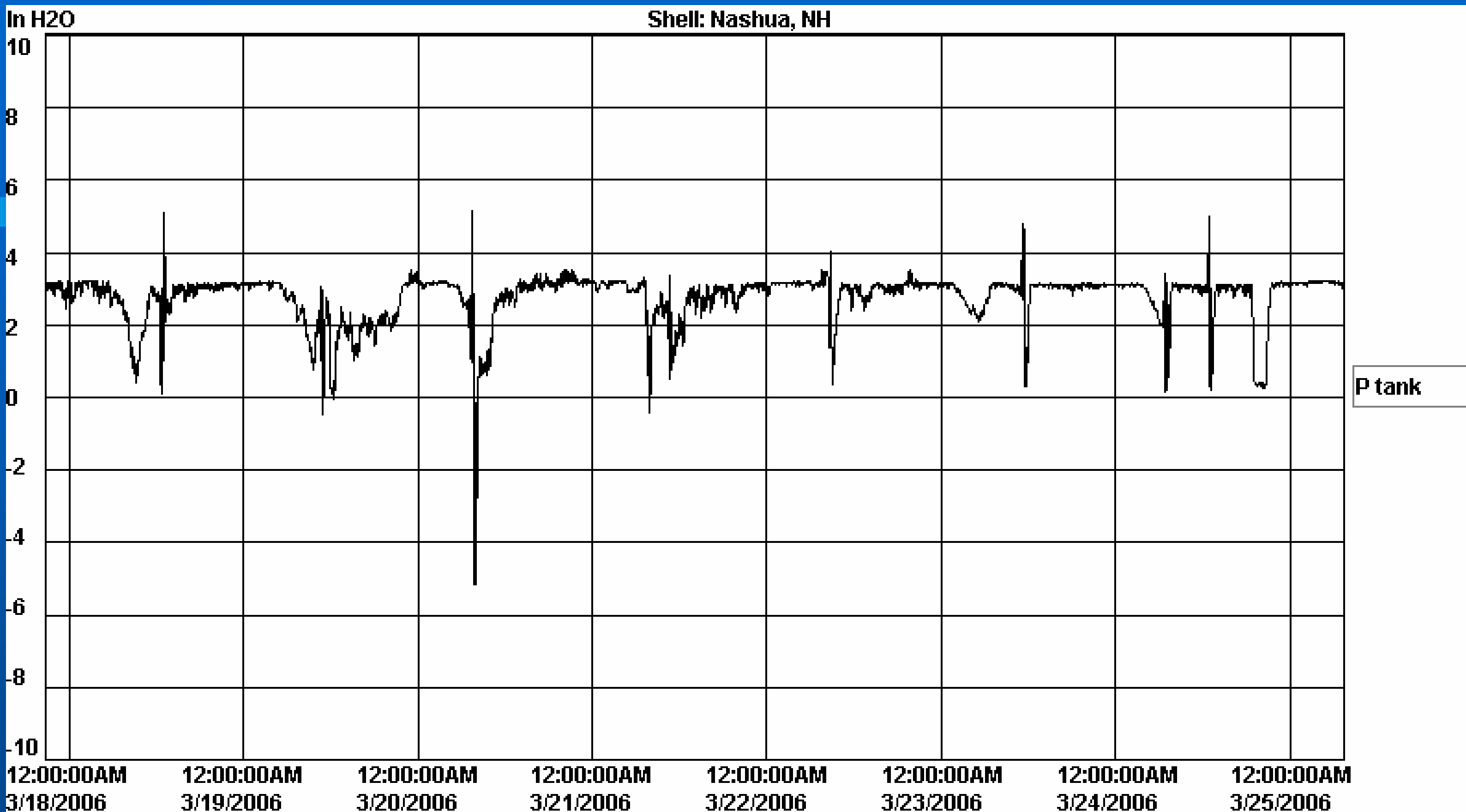



On/Off: On = 1.0 and Off = 0.0

# PERMEATOR OFF Summary: Avg. P tank = +2.79 inches H2O

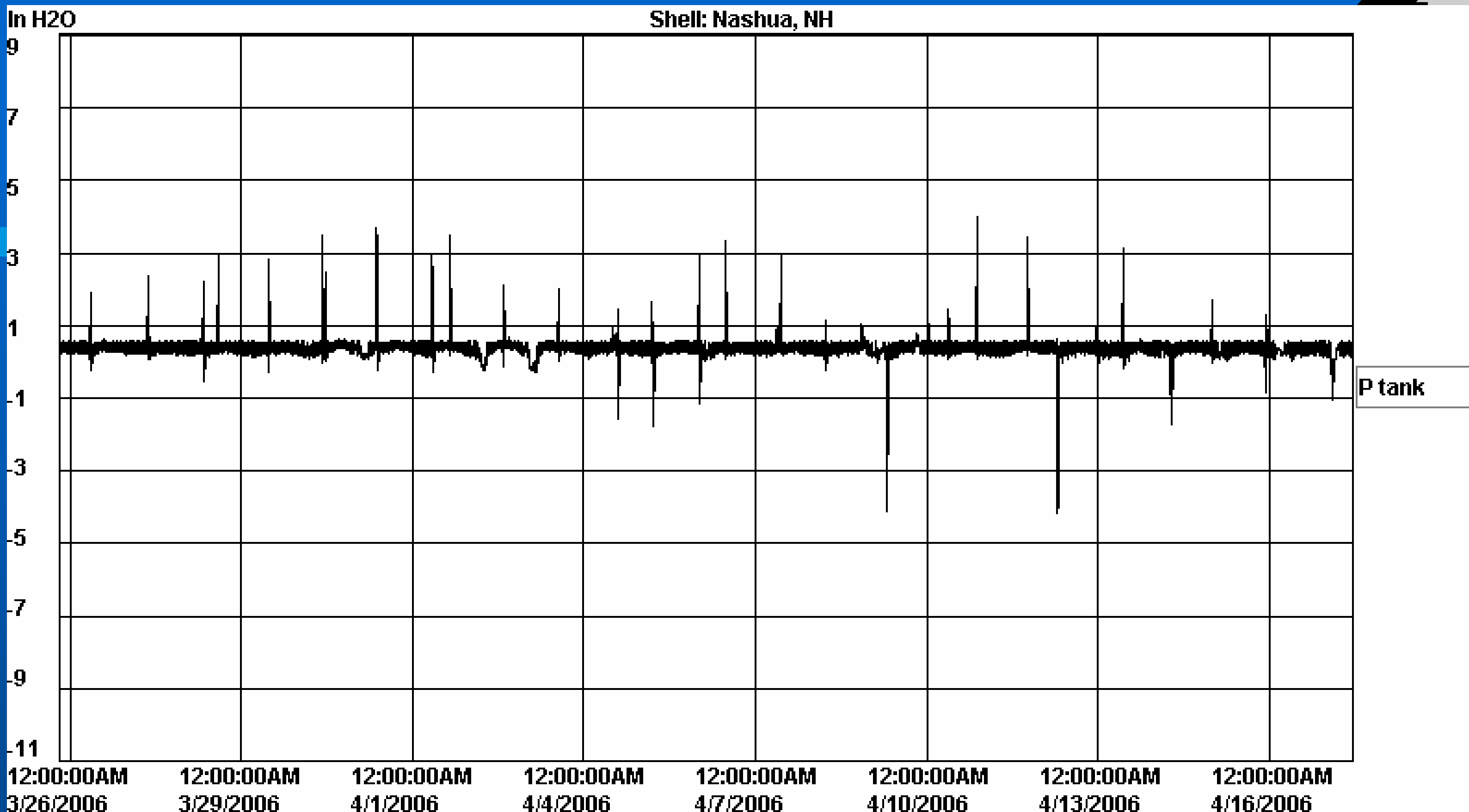



SHELL12.TRW

Start Time: Mar/17/2006 8:58:44 PM
End Time: Mar/25/2006 7:28:44 AM

| | Description | Rate | Readings | Low | Mean | High | Range | Units |
|---|---|---|---|---|---|---|---|---|
| File: | SHELL12.TRW | 120 | 5356 Pts | | | | | |
| 7 | P tank | | | -5.13 | 2.79 | 5.17 | 10.29 | In H2O |

# PERMEATOR ON Summary: Avg. P tank = +0.37 inches H2O




**SHELL12.TRW**

**Start Time: Mar/25/2006 2:16:43 PM**
**End Time: Apr/17/2006 11:06:43 AM**

Average Duty Cycle **66% time ON (16 hours/day)**

| | Description | Rate | Readings | Low | Mean | High | Range | Units | |
|---|---|---|---|---|---|---|---|---|---|
| File: | SHELL12.TRW | 120 | 16466 Pts | | | | | | |
| 0 | On/Off | | | 0.00 | 0.66 | 1.00 | 1.00 | Off | On |
| 7 | P tank | | | -4.12 | 0.37 | 4.05 | 8.17 | In H2O | |

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# What do we know?

- Evaporation losses are caused by air ingestion into fixed roof storage tanks
- Even with Stage I vapor balancing operations, excess emissions occur due to vapor growth
- Evaporative vapors escape the storage tank system and are emitted to the local surroundings
- Magnitude of evaporative losses is typically 0.10% to 0.50% of throughput; value depends upon RVP, Temperature and air ingestion volume

# Impact of Storage Tank Evaporative Losses



- Storage tank pressures are elevated and the tanks typically operate at the cracking pressure of the p/v valves for extended periods of time
- Elevated pressures result in vapor leaks above and/or below grade
- Vapor leaks above grade are air emissions
- Vapor leaks below grade can become air emissions or lead to water contamination


Grass Valley Chevron Site
Grass Valley, CA

PERMEATOR Installation
Grass Valley, CA

# PERMEATOR Unit

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PERMEATOR Control panel.

# Volume Increase Required to Offset Contribution Margin Loss Due to Evaporation

Problem:
For a typical station pumping 2 million gallons per year with a pump selling price of $2.90 per gallon and a cost of $2.80 per gallon (wholesale + taxes), how much additional gasoline must the station sell to recoup the loss in contribution margin due to evaporation of 0.25 % of throughput ? How about a station with a pump price of $3.25 per gallon with a cost of $3.15 per gallon ? (Assume the evaporation rate and annual throughput are the same as above).

Volume (to make up margin loss) = ((P1/(P1 - P2)) ( X ) ( Y ) where;
P1 = Selling price at the pump, ($/gallon)
P2 = Cost per gallon (wholesale + taxes), ($/gallon)
X = Annual volume sold (gallons)
Y = Fraction lost to evaporation

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# Shoku, Japan

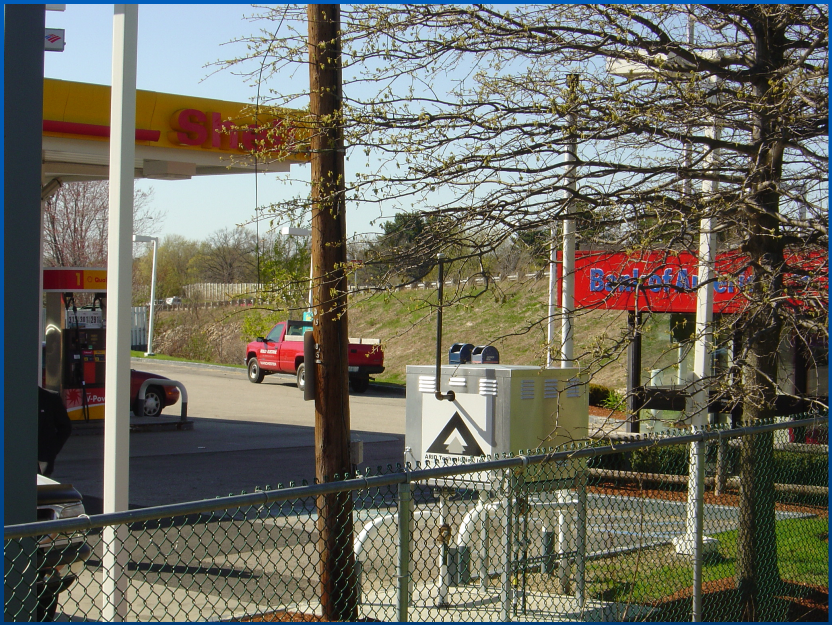
# Nagoya, Japan

ECHNOLOGIES INC.

# Saitama, Japan


ARID Technologies, Inc.

# Shell: Nashua, NH

# Chevron: Reno, Nevada

# COSTCO: Pembroke Pines, FLA



# High’s Dairy: Deale, MD

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# Sunshine CITGO: Miami, FLA

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# WAWA, Glen Mills, PA

ARID TECHNOLOGIES INC.

# WAWA, Claymont, DE

ARID TECHNOLOGIES INC.

# WAWA, Edgewater, MD

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# Activities in Other States

- State of Vermont, Dept. of Conservation (Shively) uncovered significant vapor leakage originating in an in-tank monitor probe riser. Vapors were introduced directly into the indoor store space.
- State of Maryland, Department of the Environment (Meade) has attributed MTBE contamination of drinking water wells to below grade vapor leaks.

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# Other States (cont’d.)

- State of New Hampshire, Department of Environmental Services (Lynn) has correlated MTBE groundwater contamination with elevated storage tank pressures
- Texas TCEQ has initiated a third-party certification program for ORVR Compatibility

# Maryland Regulations

- Beginning 26 January 2005
  - New, replacement or upgraded UST
    - double walled piping for product, vapor and vent piping
    - have a containment system at both tank top and under product dispenser
    - test for leaks all spill catch-basins yearly
    - test for leaks all containment sumps every two years

# ORVR Systems

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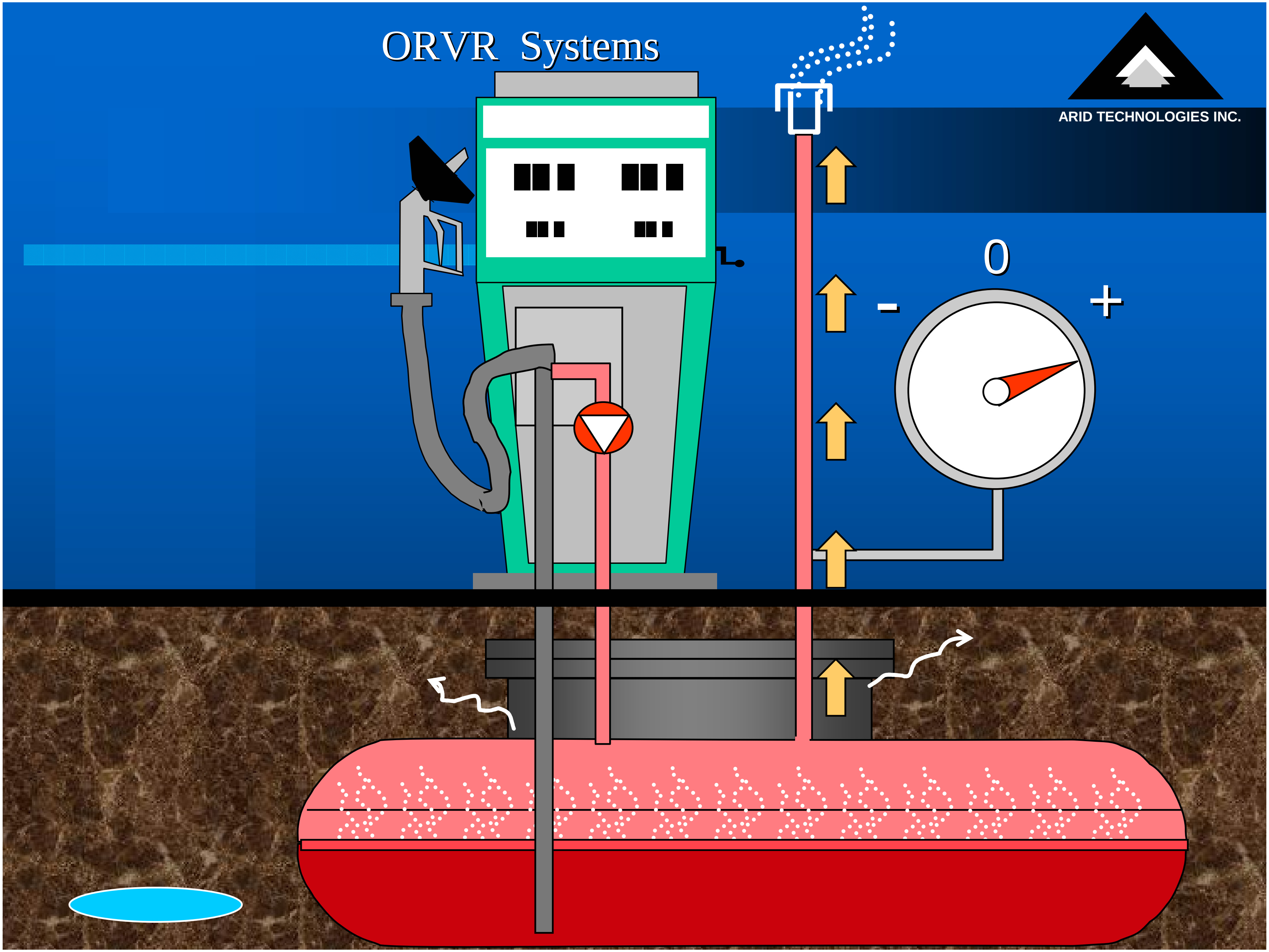

# Maryland Regulations (cont'd)

- High Risk Groundwater Use Area
  - New systems
    - submit documents to demonstrate the storage system does not pose a threat; OR
    - test the system for vapor leaks, using MDE protocol, prior to start-up
    - use interstitial monitoring
    - implement one of the following

# Maryland Regulations (cont'd)

- Install three or more groundwater monitoring wells (2" diameter wells are acceptable);
- Install a pressure control device; or
- Install a Soil Vapor Extraction System
- Also, UST's with a capacity > 2,000 gallons or for multiple tanks in the same tank excavation install four monitoring pipes connected in a manner that allows for the rapid installation of a soil vapor extraction system

# TCEQ's View on Vapor Recovery

- Existing systems yield adequate vehicle vapor recovery efficiency
- In-use efficiency of existing sytems could be improved through more frequent testing and by increased oversight of individual tests
- ORVR compatibility is a significant issue in Texas due to the very high percentage of vacuum assist vapor recovery systems in the state (>90%) and due to the high proportion of ORVR vehicles (approx 45% in 2005)

# Current TCEQ Rules

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- Third party certification
  - Evaluation of systems and components independent of CARB
  - Requires an independent testing organization using a nationally recognized protocol
  - System must demonstrate equivalent or better efficiency than currently approved systems
  - TCEQ will review third-party evaluation and determine whether the system or component will be approved for use in Texas

# Cities and Counties Impacted

- Houston/Galveston
  - Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller
- Beaumont/Port Arthur
  - Hardin, Jefferson, and Orange
- El Paso
- Dallas/Ft. Worth
  - Collin, Dallas, Denton, and Tarrant

# ORVR Compatibility Timetable

- All installations of Stage II vapor recovery systems in select counties installed on or after 1 April 2005 must be ORVR compatible
- All Stage II vapor recovery systems installed in select counties before 1 April 2005 must be upgraded to an ORVR compatible system no later than 1 April 2007

# PETROLEUM MARKETER CHALLENGES

1. Compliance
   - **Meet current and anticipated future regulatory requirements using an approach which will minimize overall expenses and minimize interruptions to refueling**

2. Economics
   - **Install technology which provides a savings in wet stock inventory  that exceeds the expenses associated with the equipment**
   - **Investigate a Metered Volume approach to provide incremental revenue at deal operated stations**

# Benefit Summary for PERMEATOR System

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# 1. Direct Economic Benefits

- Increase in salable product volume by 0.10 to 0.50 % of throughput
- Generation of emissions offsets to satisfy New Source Review for upstream projects
- Trading discrete emissions reductions credits, DER's
- Increased operating margins
- Investment tax credits
- Lease payment tax shields

# 2. Indirect Economic Benefits

- Increased health and safety of employees and customers
- Proactive installation of system provides favorable public opinion and product differentiation
- Cleaner air as VOC emissions are dramatically reduced
- Compliance with ORVR Compatibility regulatory requirements

# Third Party Test w/EPA Oversight

# Test Site Conditions

- Average overall V/L = 0.97
- ORVR Population via CARB penetration figures = 38.9%
- Gasoline RVP = 11.1 psia
- Storage Tank Temperature = 74 F
- Altitude = 25 feet above sea level

# Third Party Test Results

- 1.) Measured loss of gasoline with P/V valves OFF = 21.31 gallons per day
- 2.) Measured loss of gasoline with P/V valves ON = 11.08 gallons per day
- 3.) Predicted loss with ARID's proprietary Evaporative Loss Model (ELM) = 23.12 gallons per day
- 4.) Predicted loss using ELM for year 2014 = 58.04 gallons per day

# Results Compared to 1999 CARB Study



- With P/V valve “ON”:
  - 1.53 to 2.60 x higher than Gilbarco results
  - 22.90 to 38.77 x higher than Dresser/Wayne results
- With P/V valve “OFF”:
  - 12.04 times higher than Dresser/Wayne results

# Additional Observations

- Average emissions for a single refueling facility over period 2005 to 2014 = 33.8 tons per year
- Evaporative loss rate when the station is closed for business exceeds the evaporative loss rate when the station is open for business
- ARID's PERMEATOR recovery efficiency measured at 99.27%

# Additional Observations (cont'd.)

- Discrepancy between measured losses with the P/V valves "ON" vs. "OFF" are due to fugitive leaks
- Overfill drain valve in fill bucket of premium storage tank was leaky at elevated pressure
- Components may "pass" the leak decay test at +2.0 iwc, but exhibit leaks at higher pressures which are still below the p/v valve setting of +3.0 iwc

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# Delivery Impact on P tank and Pulse Counts
Typical Impact and Extreme Impact

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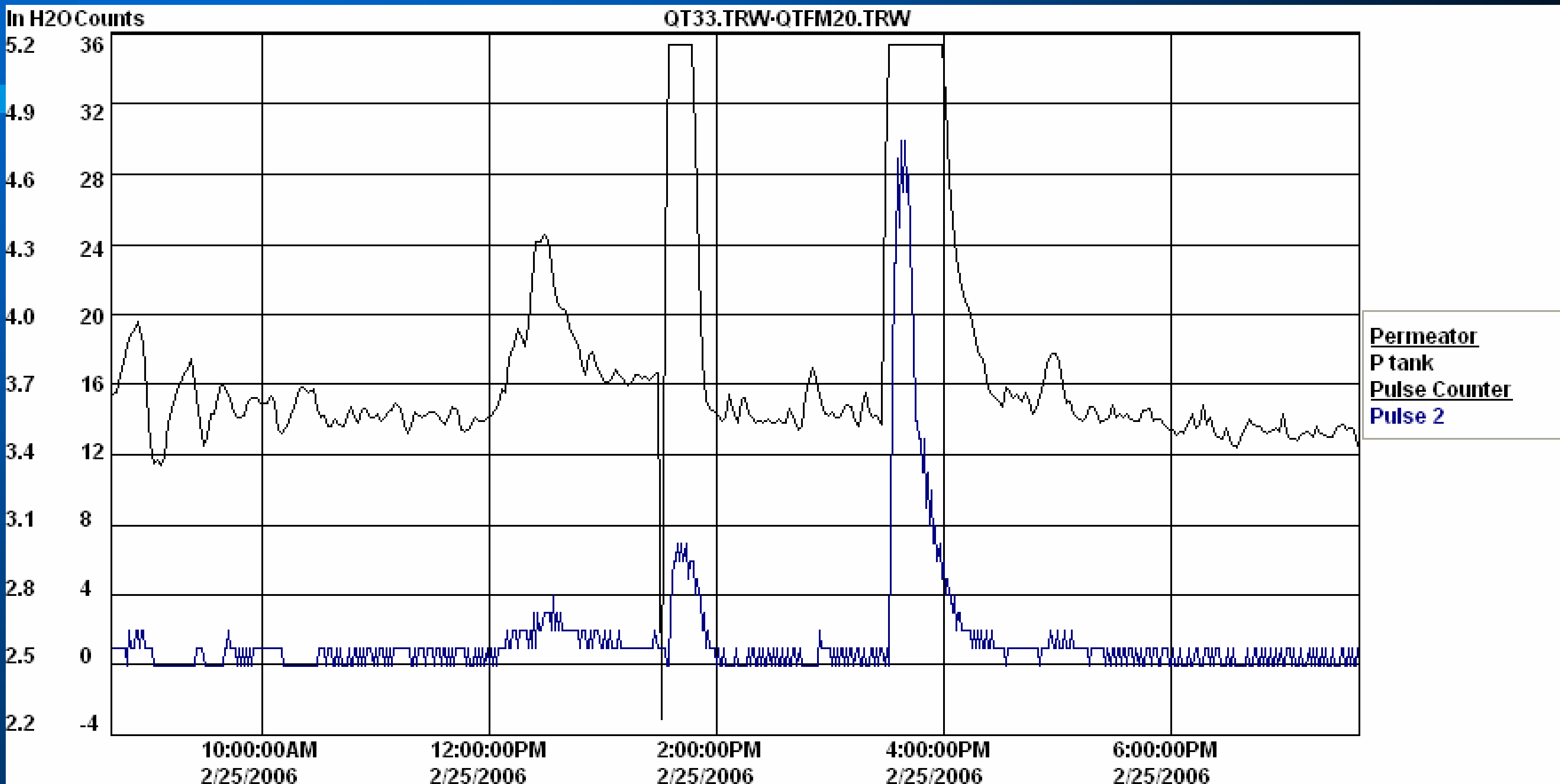

# Typical Delivery Impact

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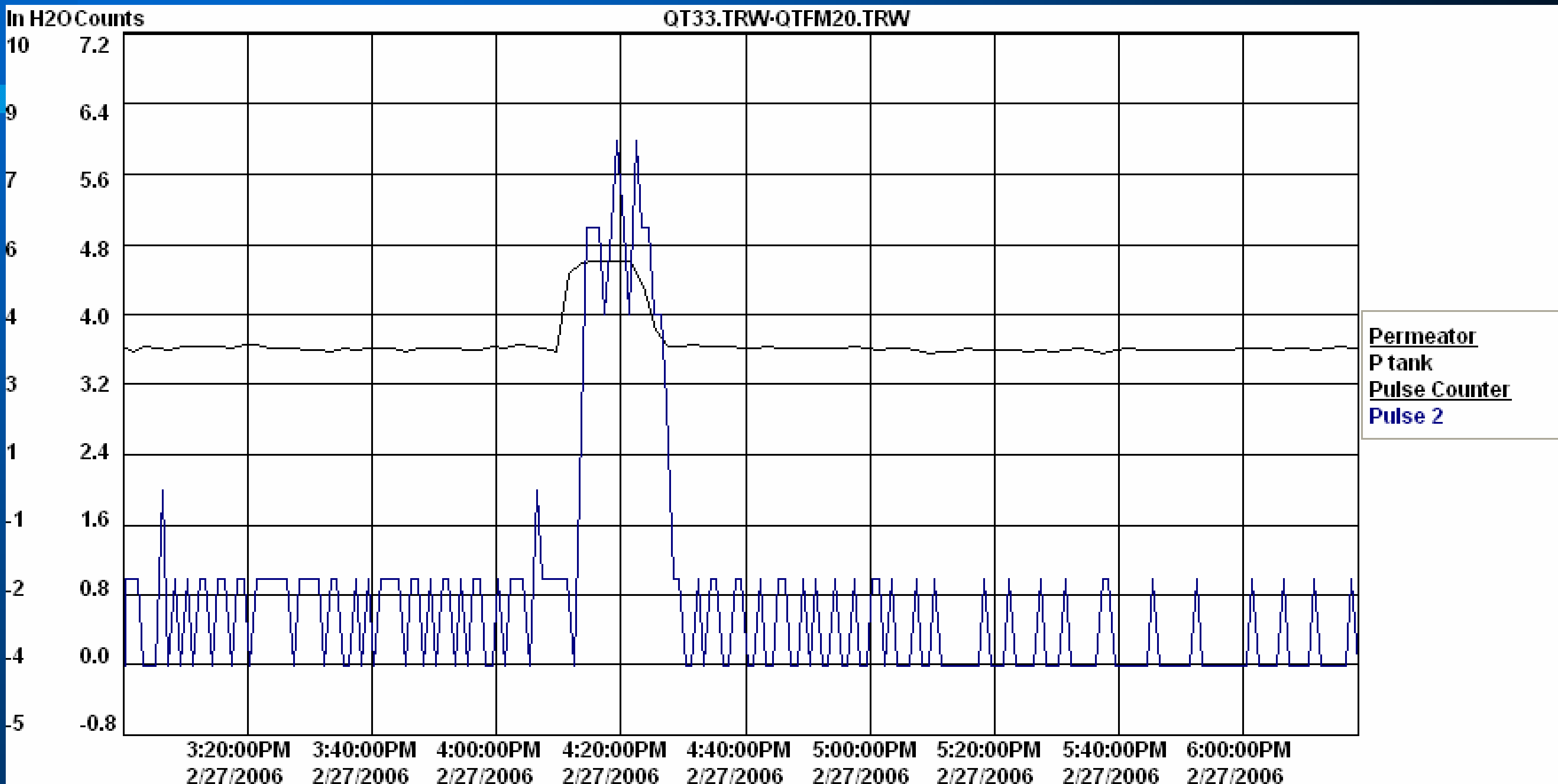

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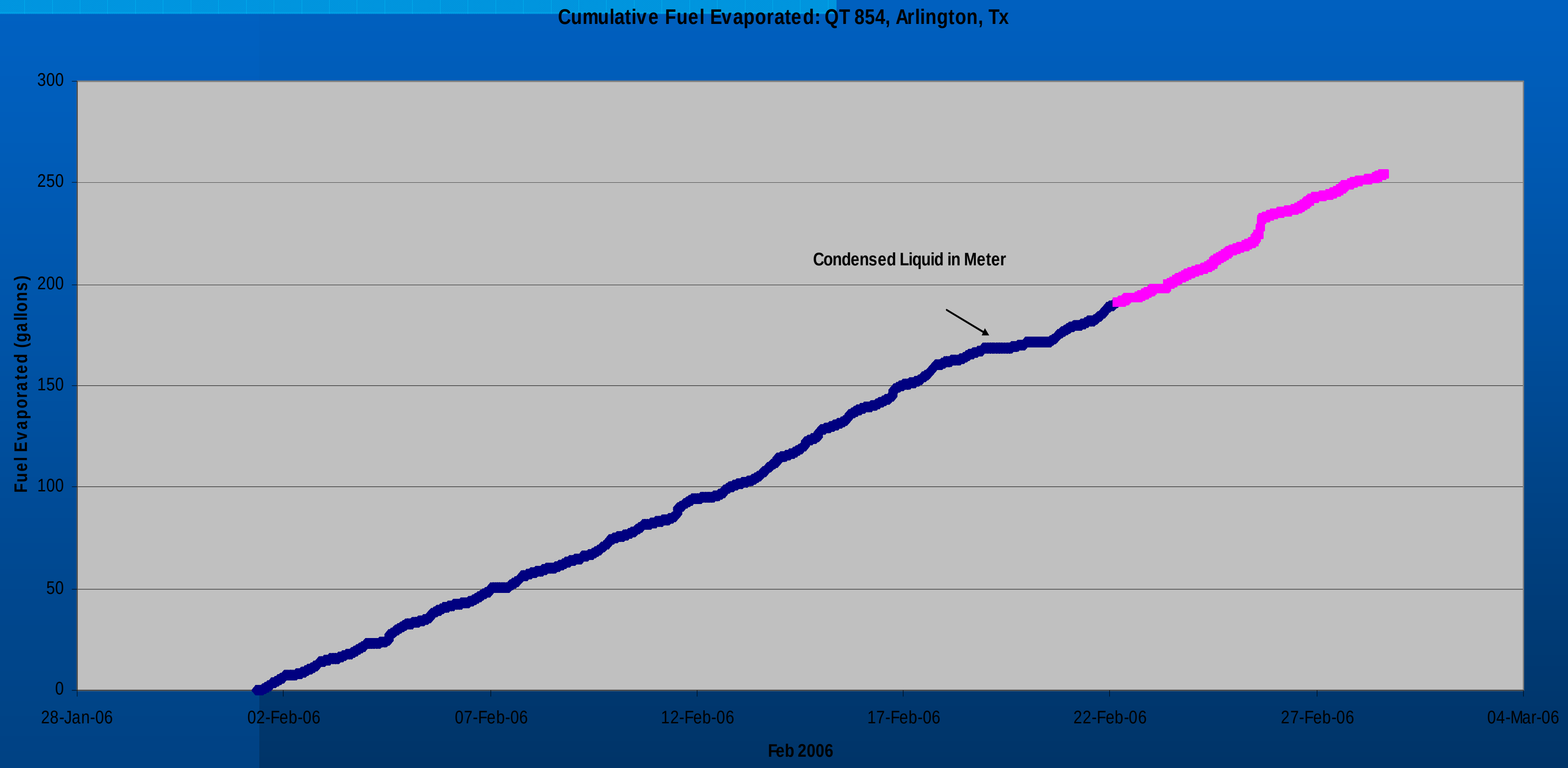

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SPECIAL PLATE REQUIRED
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WILL BE TOWED.
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